Swedish Electromobility Centre

Annual Report 2024

Swedish Electromobility Centre

The national research centre for electrification of transportation.

An arena for Sweden's industry, academies, and society to create new technology, insights, and competence for the future.

Established 2007
Stage V 2022-2027

Annual report 2024

Swedish Electromobility Centre, March 2025

https://emobilitycentre.se

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Together we create the electromobility of the future

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Welcome to contact us for a discussion.

A time for reflection

This year SEC reached its Stage V halfway mark. This is an excellent time to reflect on where we are heading next, to make improvements and fine tune processes. The goal is to be a robust center well equipped to meet the challenges in an increasingly unpredictable world.

In 2024 we have held several workshops to identify what is needed for electromobility to reach its full potential, as well as working on organizational improvements.

In the spring, as part of the work with the SEC road map, a cross-theme workshop was held to identify milestones necessary for a successful implementation of large-scale electromobility. Some sixty experts from academia and industry met to work with the challenges that lie ahead of us, the solutions needed and the necessary timeframe. While many conclusions can be drawn from this work, and analysis is still ongoing, it's obvious that a lot needs to happen soon. It's therefore of utmost importance to keep up speed, even if we now face setback due to circumstances in the world.

What is working well and what can be improved halfway through stage V - was the topic of a workshop held by the program council in the fall. The suggested improvements are currently being processed by an appointed working committee to further strengthen SEC as a platform for research and support for the future transport system.

Uncertain times require secure solutions. SEC has therefore initiated a focus group on resilience, which held its first workshops during this fall. Resilience has become an increasingly important area, both from a climate adaptation and a security perspective. The goal is to integrate resilience aspects into all our research areas.

Considering the ongoing global challenges it's important to reflect on what is happening and how this may affect our work. To address this matter, SEC has started a group working with internationalization. From the first meeting, held this fall, it's evident that we have representatives in many international organizations. Together we should be able to map out important trends and needs to feed them into our work.

The SEC road map was launched in connection to our E-mobility days in Linköping in August. It can now be found on our webpage. Our road map must be a living document, we rely on all of you to help us keep it updated as we together navigate this increasingly unpredictable world in the quest for sustainable electrified mobility.

As always, thank you all for contributing with a lot of energy and commitment to our Centre!

Linda Olofsson, SEC Director

Navigating with a steady pace

Nils-Gunnar Vågstedt, chairman of SEC, reflects on 2024

In last year's annual report, I talked about the world being a challenging place to live in with darks clouds forming at the horizon. Unfortunately, those clouds have not yet dispersed but rather increased in size and become more unpredictable. These uncertain times have not affected our research, but it's important that we observe and analyze what the ripple effects may be.

With this said, I know that Swedish Electromobility Centre is a very robust vessel that can navigate through rough weathers keeping a steady pace. It's a very well recognized organization with high quality research and activities. If we buckle up and continue the fine work, I'm sure that we can continue the progression of e-mobility.

Organizational improvements

In 2024 we can see that stage V has started to gain momentum with much of the funding launched. So, the upcoming years will be very exciting to follow. We have continued to work on different organizational processes to make SEC more stable and streamlined. However, it's a research organization, and it must still be dynamic and agile, so the aim is not to become a perfect managed administrative body.

Looking ahead, we want to find ways to scale up the centre's research activities. Here, collaborating with other stakeholder and associated projects looks like a promising path to me. Another thing that I hope we can improve is the recruitment process of PhD students. These often take a long time, and delays are a vulnerability for SEC.

The snowball effect

The e-mobility snowball is now getting so big that I believe it's just a matter of time before it starts rolling on its own. But we are not quite there yet, and incentivizing measures are still needed to support e-mobility. For the time being lowered gas prices have been a halting factor. However, the costs for CO_2 emissions will inevitably increase thus making electric vehicles a better choice also from an economic standpoint.

Driving range and charging options are getting better and better. Running out of energy in EVs are now more of a perceived problem than a real one, even though it can get congested on certain occasions. However, if e-mobility is going to be widely accepted all drivers must feel comfortable and secure. Those thinking of buying EVs now are not as accepting to certain inconveniences as early adopters.

The commercial truck market on the other hand is like a different ball game compared to consumer EVs. Haulage companies want the most economical way to transport goods, so it's a pure numbers game. Higher purchase prices or longer stops can be motivated if gains can be made elsewhere to lower the total cost. A key enabler to make heavy electric trucks work in practice is to improve the charging infrastructure. In Sweden we have come reasonably far but Europe is lagging a bit.

Being remote but not uninformed

Since I moved to Brussels, I've had a harder time to attend events in Sweden. One thing that I missed out during 2024 was our very own conference E-mobility Day. Listening to excellent presentations and meeting all fantastic people is for me one of the highlights. While still being a bit remote the coming years I will follow the progress closely. One way to keep me informed is the omEV newsletter which I, and many of my colleges, find very insightful.

Swedish Energy Agency

Funding SEC since 2007

Klaas Burgdorf, SEC's research program manager at the Swedish Energy Agency, believes that the centre has had a very good year. Emphasizing the relevancy of all projects and the many formidable results that have been presented.

"I have really enjoyed the new lunch seminars held in a dialogue form, which I have found to be a very productive concept. The E-mobility day in Linköping was, as always, another great opportunity to stay updated with all the research taking place. Unfortunately, everyone has limited time and can't participate in all events, even though the willingness is there. A personal reflection is that a better common usage of certain generical models could increase both reliability and efficiency for the overall research done in the centre."

Resilience has been a highlighted topic during 2024, and SEC has started a focus group to explore this area. Klaas thinks that this shows SEC's ability to adapt and stay relevant.

"I'm very impressed with what the focus group on resilience has accomplished during the year. Resilience has been somewhat of a hype, but clear definitions and system strategies have been absent. Therefore, I was glad that the first workshops started out with the basics and have then gradually built from there. Resilience is, as many other things, a matter of cost and priorities. Should Sweden do this journey on its own or together with other countries? There are many things to discuss and reflect upon. However, I'm glad that authorities have now started to take this issue more seriously even though it has been an abrupt wake-up call."

Klaas also gives his thoughts on what implications the recent world development may have on e-mobility.

"Some areas like raw material supply chains will most likely be affected. We also know that increased prices, which the tolls will cause, have negative effects on the willingness to buy electric cars. Incentivizing structures have also changed which has caused a setback. When it comes to international collaborations, everything is now a bit uncertain. Preferably you want long stable relationships in these types of commitments, and I think that everyone will be a bit cautious and just orient themselves. From a research and innovations perspective, it will probably not affect stage V but could do so in the next phase."

Swedish Electromobility Centre is one of eleven competence centres, funded by the Swedish Energy Agency, with the purpose of helping to accelerate the energy transition. The leadership forum has been a way to facilitate coordination between the centres.

"We have now concluded the 'leadership forum' where all the competence centre leaders have met for discussions and knowledge sharing. For example, we did a SWOT-analysis workshop that I think came out very well. Even though it wasn't the initial purpose, the leadership forum has turned out to be a good way to avoid the silo effect. I'm a bit concerned that there now is a gap in the coordination between the centres between this stage and the start of the next one."

Moving forward

Swedish Electromobility Centre was formed in 2007 and a lot has happened in e-mobility since then. For every progress made, electric vehicles have become more desirable and reasonable to choose. Research advancements are continouosly contributing to further establish electric vehicles as the obvious choice for everyone.

SEC has always addressed current research questions to move e-mobility forward. However, it's also important to look ahead and explore possible future scenarios.

Resilience is a topic of increasing interest as EVs now start to be an integral part of the transport system in combination with a less predictive world. SEC has therefore started a focus group discussing resilience and its implications on e-mobility.

Our goal is to be an **internationally distinguished** centre of excellence, renowned for its competence in building, researching, and developing sustainable technology for electrification, for all types of vehicles – on land, at sea, or in the air. We will therefore accelarete our efforts to further broaden our network outside of Sweden.

***The vision** is that electromobility, together with renewable electricity generation, reaches its full potential for serving as a building block of the sustainable society of the future.*

SEC’s unique model

SEC encourages knowledge sharing and collaboration. Here, competitors work together, contributing collectively to Sweden’s role in the electrification of the transport sector. This collaborative spirit not only leads to breakthroughs but also plays a role in education, fostering competence and capacity important for the continued advancement of electrification.

The mission of SEC is to accelerate the development and implementation of electric propulsion technologies into the transport ecosystem by maximizing their applicability, versatility, and efficiency, while minimizing their overall impacts on the environment, human health, and natural resources, and strengthen the Swedish industry’s competitiveness.

The industry’s view of SEC

→ Being the hub in Sweden for applied research in electrification of transport.

→ Contributing to coordination gains across academia and industry but also across SEC and with other centre formations in adjacent areas.

→ Being a recruitment base at licentate/doctoral level and at senior research level.

→ Being a platform and trustful network that work for mobility between industrial and academic researchers, thus facilitating bi-directional knowledge transfer.

→ SEC should continue to be a catalyst that accelerates the electrification of vehicles.

→ SEC should continue to deliver world class research results.

SEC’s task towards academy

→ Gather and build long-term knowledge in relevant areas for vehicle electrification and development of associated charging infrastructure.

→ Bring industry and university partners together, in order to develop free, strong and creative research environments. Initiate and finance relevant research projects and themes.

→ Disseminate the knowledge generated within the centre by providing courses within the framework of postgraduate programs.

→ Create knowledge that can be used in undergraduate programs at each university and with industry partners.

→ Create value by organising meetings and networking venues.

→ Deepen knowledge exchange between automotive companies and companies in the electrification field, and universities.

→ Help increase the level of knowledge in relevant areas.

Objectives

Create interdisciplinary projects

80% of all projects that last for two or more years and are funded by SEC must meet at least one of the criteria below:

- The project must plan and work to ensure that the researcher or PhD student will work for a limited time on-site at one of the industrial partners.
- The project must plan and work for international exchange.
- The project must touch on and collaborate with experts from a field other than its main field.

Offer an interdisciplinary research environment

- SEC must offer researchers, PhD students, and those working on degree projects from industry an interdisciplinary research environment.
- The industrial parties must also have the opportunity to participate in SEC's PhD courses.

Be scientifically competitive

- SEC's projects must be scientifically competitive internationally. SEC must, on average over the period of the stage, publish at least thirty reviewed articles in international journals and/or at conferences every year.

Disseminate knowledge & research findings

- The theme groups must convene 1–2 times every month, host 2 seminars/term, and SEC must arrange an activity that concerns all theme areas every year.

Collaboration

- SEC must be involved in at least two projects with other centres or research organizations or major international collaboration projects with operations that can be linked to SEC.

Supply the field with key competences

- Half of the SEC-funded research projects that last for two years or more must be PhD student projects.
- The PhD student should be involved in the PhD Student Network and SEC's planned PhD courses.

SUSTAINABLE DEVELOPMENT GOALS

Swedish Electromobility Centre activities have strong connections to several of the UN Sustainable Development Goals adopted in 2015. These are the five most direct interrelations.

No.7 Sustainable energy for all
Electrifying all or parts of the vehicle fleet enables the energy for these transports to come from several different sources, with low greenhouse gas emissions, in contrast to the current system and its dependence on fossil fuels. Not only does the centre work for an electrification of vehicles. The centre also works for integrating electric mobility and transportation in the full energy system in a sustainable and supportive way.

No.8 Decent working conditions and economic growth
Industrial activity in the field of electromobility is increasing significantly. Most, if not all, vehicle manufacturers have hybrid vehicles, rechargeable hybrid vehicles or fully electric vehicles in their model portfolio. Subcontractors to vehicle manufacturers are also affected. By strengthening the competence and capacity within electromobility in Sweden, SEC contributes to economic growth in the country. It also leads to employees in Sweden, that are included in the Swedish labour laws with, for instance, the right to unionise and with monitored working conditions.

No.9 Sustainable industry, innovations, and infrastructure
Research, innovation and technological progress are the key to developing sustainable solutions for both economic and environmental challenges in the development of electromobility. There is a strong connection between the industries and the research projects funded by SEC.

No.11 Sustainable cities and communities
A very important part of the pursuit of sustainable cities is high utilisation of the city's surface through densification and efficient transport systems for both goods and people. Electromobility plays several roles here. Many of the centre's projects include sustainable logistics, human factors in emobility, and the connection between the vehicle and the cities' and communities' energy systems.

No.13 Fighting climate change
Climate change is a real and undeniable threat to our entire civilisation. An electrification of a larger proportion of the world's vehicles, in combination with climate friendly electricity production has great potential to significantly reduce the transportation sector's total carbon dioxide emissions.

Key performance indicators

Gender balance and media presence are KPIs addressed on pages 20–21 respectively 54–55. SEC also arranged the conferences Electromobility Day during 2024.

STAGE V 2024

54
journal & conference papers

35 master thesis

9 post-doc meriting

18 PhD and licentiate
(8 SEC-financed, 10 associated, mid-seminars included in licentiate)

36 international collaborations

69 program council reports*

17 theme workshops

5 cross-theme workshops

1 university workshops

*Including 10 associated PhD student and licentiate presentations

Stage V total KPI targets:
journal & conference papers, 150
master thesis, 100
theme workshops, 75
PhD and licentiate, 25
international collaborations, 10
program council reports, 100
conferences, 5
gender-balance, 60/40 ratio
media presecence, 10

STAGE V 2022–2024

143
journal & conference papers

81 master thesis

17 post-doc meriting

29 PhD and licentiate
(10 SEC-financed, 19 associated, mid-seminars included in licentiate)

49 international collaborations

131 program council reports**

45 theme workshops

9 cross-theme workshops

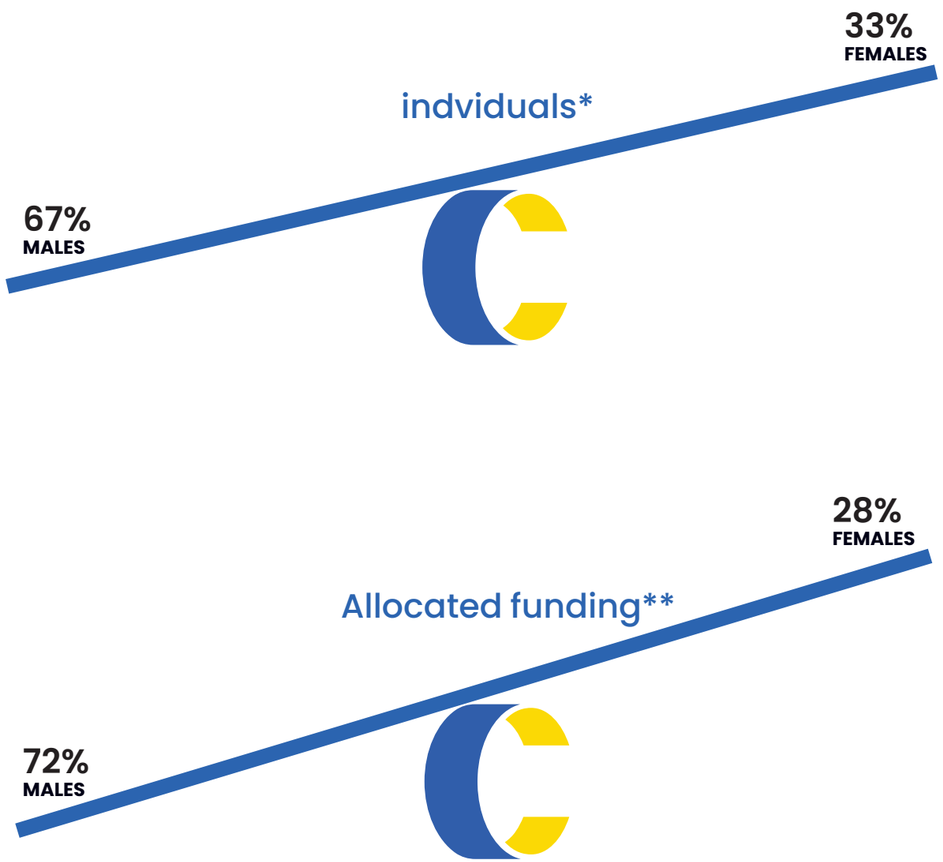
5 university workshops

**Including 18 associated PhD student and licentiate presentations

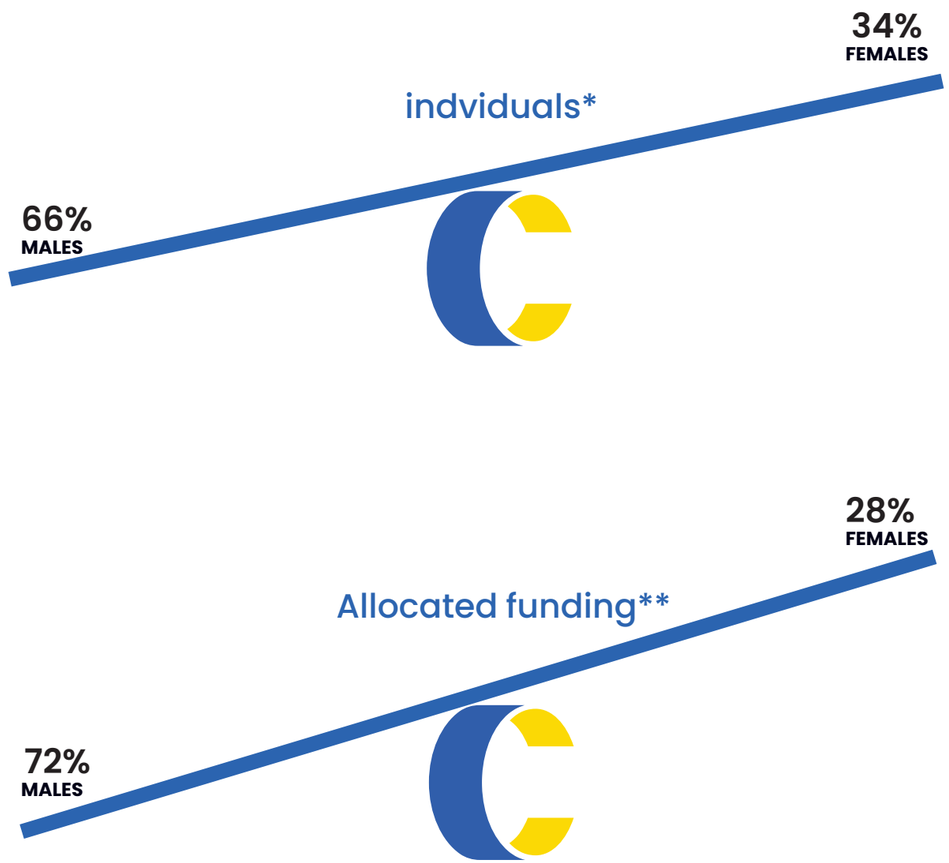
Gender balance

SEC needs to increase the number of females during stage V, since the the aim of a 60/40 balance is not yet reached. There is also an imbalance between individuals and allocated funding.

Stage V - 2024



Stage V - 2022–2024



* Based on number of SEC project participants.
** Based on SEC project funding distribution between males and females.

THEME AREAS

The theme areas are the core of SEC. These constitutes of activity groups where researchers from all partner entities collaborate. To cover the full landscape of the growing fields related to e-mobility, the centre has identified and established five theme areas.

Theme 1
Swedish Electromobility Centre
Intelligent Vehicles & Systems

Theme 2
Swedish Electromobility Centre
Electric Drives & Charging

Theme 3
Swedish Electromobility Centre
Energy Storage

Theme 4
Swedish Electromobility Centre
Environment & Society

Theme 5
Swedish Electromobility Centre
Vehicle–Grid Interaction

Theme 1

Swedish Electromobility Centre

Intelligent Vehicles & Systems

The thematic area of Intelligent vehicles and systems addresses total cost optimization of the vehicle system, focusing on energy efficiency and ownership experience. Addressing this requires knowledge about the customer, the vehicle, its subsystems, and its surroundings.

This is done by utilizing tools, like mathematical modeling, dynamic simulation, performance analysis, control design, and optimization on vehicle system level and fleet level, i.e., design and control of systems and systems of systems. The methods, tools, and techniques developed focus on reducing development time and effort while striving for system optimality.

RESEARCH ADVANCEMENTS

The projects have evolved around understanding and characterizing the customers, the vehicles, its subsystems, and its surroundings to address the core question.
The two ongoing theme research projects were concluded during the year, having addressed the topics of modeling and control of electrified vehicles for complete powertrain performance improvement, including thermal systems for heating and cooling of powertrain components. The theme area has in projects developed an open-source simulation platform for the analysis and design of electric and fuel cell vehicles. It is still undergoing development and validations in the ECOTS project. The platform and state-of-the-art thermal systems included were presented at E-Mobility day in 2024, and it is also available for download, and the documentation is available as an open access paper. The theme researcher Luigi Romano received a National Science Foundation grant for postdoc research at NTNUI in Trondheim and UCSD in San Diego (1+1 year). Other achievements have been in the characterization of external factors, like wind and road resistance, which was a theme for a thematic workshop.

Researchers from the theme have been active in providing material for students and supporting engineers in their life-long learning in the area of model-based systems engineering and electromobility.

NATIONAL AND INTERNATIONAL ATTENTION

Project members have attended different conferences to spread information and present interesting research results. The main channel during the year for communicating research results to the scientific community is internationally high-ranked journals and conferences. Researchers attended, among others, the IEEE ITSC in Canada. The paper by F. Hashemniya et.al. from the SEC project “Diagnostics of dynamically configurable battery systems” received the best paper award at the Prognostics and Health Management Conference (PHM24) in Stockholm, Sweden.

CHALLENGES AND POSSIBILITIES

Total ownership experience is an overarching theme and goal for the area. It is related to technology selection and utilization for onboard vehicle system energy. It is not limited to just energy used for the propulsion of the vehicle, it also includes energy usage in vehicle subsystems, like heating and cooling of batteries or electric machines, like HVAC systems. In addition, there is an interplay with charging and route planning that influences the complete experience of driving and owning. This means that the methods and tools needed to address the challenge cannot be by studying the individual systems in the vehicle, but needs to address the system as a whole, i.e., system of systems. A central part of the research utilizes dynamic models, computational methods and simulation techniques to study system properties and optimize the ownership experience, to get attractive, energy-efficient electromobility solutions.

Connected vehicles and machine learning are techniques that open up new possibilities for the electromobility area. Data and information about the vehicle and the outside world, provide system knowledge of how the vehicle is used, where it will go, and how the traffic situation ahead of the vehicle is, gives new opportunities, and a lot of functions that are using this knowledge are being developed right now. Vehicle manufacturers already have information-sharing systems in the vehicles on the market. This gives an excellent platform for developing new system functionality, such as route management planning, charging planning, traffic flow control, etc.

BUSINESS INTELLIGENCE

Electrification, automation and digitalization are the mega trends in the area. Research is done in basic research on the development of methods and tools for addressing the design of systems of systems, like numerical optimization, learning from data, simulation, and control design. To ensure the usefulness of these methods and tools to all parties within the Swedish Electromobility Centre, the theme’s projects adapt and use such general methods on hybrid and electric vehicles. To cope with the multi-disciplinary challenges, the combination of knowledge on general methods and application know-how is the core, which is the foundation that the theme area relies on.

Swedish Electromobility Centre
Intelligent Vehicles & Systems

PROJECT SPOTLIGHT

Intelligent trip planners can alleviate range anxiety and reduce travel time

The acceptance of electrical vehicles is dependent on long travels being time competitive and predictable. Range anxiety and fear of queuing at charging stations are serious concerns for switching to electrical vehicles. "Charge" is a project developing a novel intelligent trip planning system that can save energy, reduce total trip time and remove unpredictable factors that can cause unease for drivers and passengers.

Current online trip planners provide rather simple information like locations of charging stations and estimated charging time. These planners presume that fast charging is available immediately and that the vehicle battery is at optimal temperature range, which often is not the case. By incorporating historical data, intelligent control strategies, predictive information from vehicle to vehicle and vehicle to infrastructure communication, it's possible to create a more intelligent trip planner.

Novel overall approach

E-mobility trip optimization is mainly related to four sub-areas. The onboard energy management system, the thermal management system, the eco-driving system, and coordination of electricity charging. The "Charge" project does not propose new structural solutions in each individual sub-area, instead it takes a novel holistic approach.

"This holistic approach is rather new and is anticipated by the industry. Trip planners today are very basic and can be improved a lot by developing stochastic models from historical data. Such models can then be used to make predictions about chargers and power availability at the stations. If we also combine the stochastic models with real-time communication between vehicles and charging stations, the predictions can become even more accurate," says Lorenzo Montalto, PhD student at Chalmers University of Technology.

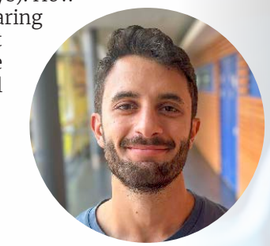
Simulated driving scenarios using real-car navigation system

Augmented reality experiments will be conducted using the real-car navigation system with a simulated scenario for a fleet of ten vehicles driving from Gothenburg to Uppsala. The project will combine real-time eco-driving, energy and thermal management from the vehicle perspective, and charging from both the vehicle and infrastructure perspective.

Stochastic models will be developed on anticipated distribution of charging cost, power availability, waiting time and overstay cost at charging facilities. Open-source tools will be used as a proof of concept for the initial development and for most of the published results. The final algorithms that are meant to run onboard the vehicles will be custom developed and will likely not be open source.

91 percent reduction in computational execution time

"From a technical point of view, I think it's possible to see these intelligent planners implemented in just a few years from now. Lately, we have been focusing on reducing the computational time needed to run such trip planners and managed to reach a reduction in the average execution time of about 91 percent (from about 80s to about 7s). However, when it comes to sharing data, other concerns must be taken into account, like privacy issues and the will to share such data among different stakeholders," says Lorenzo Montalto.



Theme 2

Swedish Electromobility Centre
Electric Drives & Charging

Theme 2, "Electric drives and charging," covers the electric energy transfer and conversion technologies necessary for electrified transportation on roads, water, and air. Most of these technologies refer to electric machines and power electronic solutions for the design, control, operation, and diagnostics of the propulsion system, the onboard charging equipment, and the auxiliary systems in the vehicles.

Theme 2 research activities span a broad area and use various methodological tools. Numerical analysis of electromagnetic/thermal/fluid dynamics problems and simulation of dynamic models and control solutions cover most project cases. Component integration into a dynamic system model is also performed with suitable software platforms. Prototyping and laboratory testing are essential for the activities using real-life conditions testing.

Research advancements
Francisco Márquez-Fernández, SEC theme 2 leader, did a presentation during Almedalen in June 2024, focusing on electrification strategies for municipalities and regions, and their implications in the overall transport system resilience. This presentation was part of a seminar arranged by the Arctic Centre of Energy, in which the Swedish Security & Defence Industry Association (SOFF) and the utility company Skellefteå Kraft participated. The Swedish Energy Agency arranged an online conference on "Accelerating Electrification: Connecting the Nordic Countries" together with the Swedish Transport Administration and the Nordic Council of Ministers in November 2024. Francisco Márquez-Fernández was invited to talk about the potential vulnerabilities but also strengths than electrification brings along in terms of preparedness. The conference featured invited speakers from Sweden, Denmark, Finland and Iceland, and was followed by more than 500 people. Moreover, 14 peer reviewed journal and conference papers have been published in associated projects to theme 2.

National and international attention
Theme 2 leader Luca Peretti's research on magnet-free electrical machines was selected to be on the Royal Swedish Academy of Engineering Sciences "100 list". The research projects in the list have been estimated to have great potential to create benefits, through commercialization, business and method development or societal impact.

Challenges and possibilities
The theme covers all kind of electrical energy conversion and the inherent high efficiency is crucial. Reducing losses further is a challenge and the research has to consider many conflicting aspects like total cost of ownership and the cost for the equipment's environmental impact. It is important not to do sub-optimization when advancing the performance.

- There are a vast number of possible designs of electrical machines and power electronics. There is a tendency to increase the voltage levels in order to work with lower current levels. This puts high demands on insulation and building technologies and can also create higher electrical noise levels. To solve the emerging problems a multi-disciplinary approach is important.

- To enable an omni-present charging eco system both stationery charging and electric roads must be considered. The cost is of paramount importance and new technologies that have the potential to become cheaper are of interest to investigate, e.g. Gallium-nitride based power electronics.

- Raw materials and supply chains for electric/electronic component manufacturing are under special consideration. Mayor political and economic initiatives have been started. An example is the European Raw Materials Alliance, established in 2020 as an industrial alliance dedicated to securing a sustainable supply of raw materials in Europe, supporting a circular economy.

Business intelligence
The electrification of the transport system is an important enabler for the necessary de-carbonization of society. After a few years of impressive growth there is now a small decline in the rate of advancement. However, the trend is clear and the manufacturers are still focused on electrifying the vehicle fleet. The geopolitical scene makes it important to diversify the possibilities for electrification and the selection of primary fuel. Theme 2 then becomes even more important as it is the enabler for efficient energy conversion regardless whether the primary energy comes from fossil fuel, hydro, nuclear or whatever. The roadmap of the theme reflects the huge efforts industry and academia are devoting to achieving the transition.
The perils of material supply drive the manufacturers to look into alternative component solutions. There is a trend to explore both old and new types of electrical machines that have the potential to use less of e.g. rare-earth element magnets.
Energy efficiency, or rather the ever reduction of energy losses, is still of prime interest. This is emphasized by the trend of higher and higher charging power levels. For heavy-duty vehicles the Megawatt Charging System (MCS) is now becoming popular with possibilities to charge with up to 3,75 MW. In US, there is an increased use of the North American Charging System (NCAS) as it has been opened up for a broader field of customers.
Electrification in the marine sector is also progressing where hydrofoil solutions have been shown to increase transport efficiency greatly.

Swedish Electromobility Centre
Electric Drives & Charging

PROJECT SPOTLIGHT

Electric motor plus hydraulic pump fusion for electrification?

Mobile work machinery, like wheel loaders and excavators, stands for about seven percent of Sweden's total carbon dioxide equivalents. A large part of the energy in these machines is passing through hydraulic pumps. There is a need to improve today's electro-hydraulic pump units since they are unnecessarily large and inefficient.

The project Electric motor plus hydraulic pump fusion for electrification explores the most advantageous concepts to combine an electric motor with a hydraulic pump by addressing the criterions weight, volume, noise, and efficiency. Thomas Heeger is PhD student in the project.

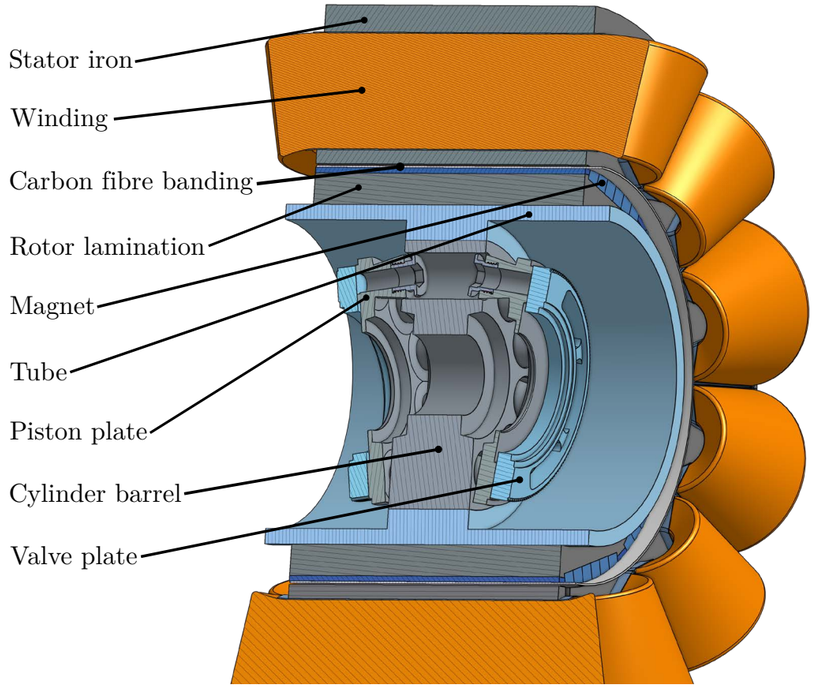
First, who are you, Thomas?
"I'm originally from Cologne, Germany. I have my master's degrees from my home country where I also worked for some time as a development engineer at an automotive supplier, focusing on lubrication oil pumps. In late 2020 I joined this PhD project on electro-hydraulic pumps at Linköping University."

What motivated this project?
"The motivation comes from the need to improve fuel consumption and reduce emissions. By decoupling the speed of the oil pump from the combustion engine, we can run the pump at the optimal speed for each operating point, minimizing energy input. This is crucial for meeting EU emission norms and reducing fuel costs. The aim is to combine a hydraulic pump with an electric motor into one compact module. This integration is intended to improve the compactness, efficiency, and noise behavior of the system. It is also an enabler for more advanced hydraulic systems, in which sharing losses which originate from supplying multiple actuators at different pressure levels from the same pump can be reduced. Hydraulics are very power-dense, and by placing the hydraulic pump within the volume of the electric motor, we can maximize compactness."

What are some of the challenges you face in this project?
"I see three main challenges in this project.

First, traditional hydraulic pumps have been developed to match the capabilities of combustion engines. To fully exploit the potential of electric motors, the hydraulic pumps need improved efficiency, increase their speed range to support both lower and higher speeds, allow energy recuperation, and become less noisy.

Second, there are some obvious benefits when integrating the hydraulic pump in the core of the electric motor, for example increased compactness, the elimination of some components such as a coupling, a pair of bearings and shaft seals, as well as reduced external leakage and reduced churning losses at high speeds. However, this integration comes with many design choices, which require compromises. For example, one can either allow oil to enter the "air gap" of the electric motor, or install sealings to avoid this. An oil flow through the air gap can be used to add some cooling, but as oil has a higher viscosity than air, a larger air gap is needed to limit viscous losses. However, a larger air gap reduces the electro-magnetic performance of the machine. On the other hand, installing seals to protect the air gap from oil introduces additional components, and increases friction losses. We are currently updating our test rig to be able to test a prototype of an integrated machine.



The third main challenge is noise, which generally is a very complex topic. Counter-intuitively, removing the combustion engine which was the noisiest component can create new noise issues, as the noise from other components, especially the hydraulic pump, becomes more audible. Both the electric motor and the hydraulic pump create noise, and this depends on their individual designs, but also on their interaction. Knowledge on which effects contribute to noise at which frequencies for each machine is expected to be helpful to evaluate the first prototype. "

How do you see the future of this technology?
"I believe that integrating hydraulic pumps with electric motors will become more common as we continue to improve the technology. This approach not only enhances efficiency and compactness but also aligns with the industry's move towards electrification. Companies like Volvo are already showing interest in these developments, which is very promising."

More information:
"I plan to defend my PhD at the end of this year. That would be a nice Christmas present. For those who want to know more until then I would recommend my licentiate, or a recently published paper where we show the integrated machine. You are also welcome to contact me."

Licentiate: Design of Electro-Hydraulic Energy Converters : With Focus on Integrated Designs and Valve Plate Rotation
Paper: Methodology for Dimensioning of Integrated Electro-Hydraulic Machines

Theme 3

Swedish Electromobility Centre

Energy Storage

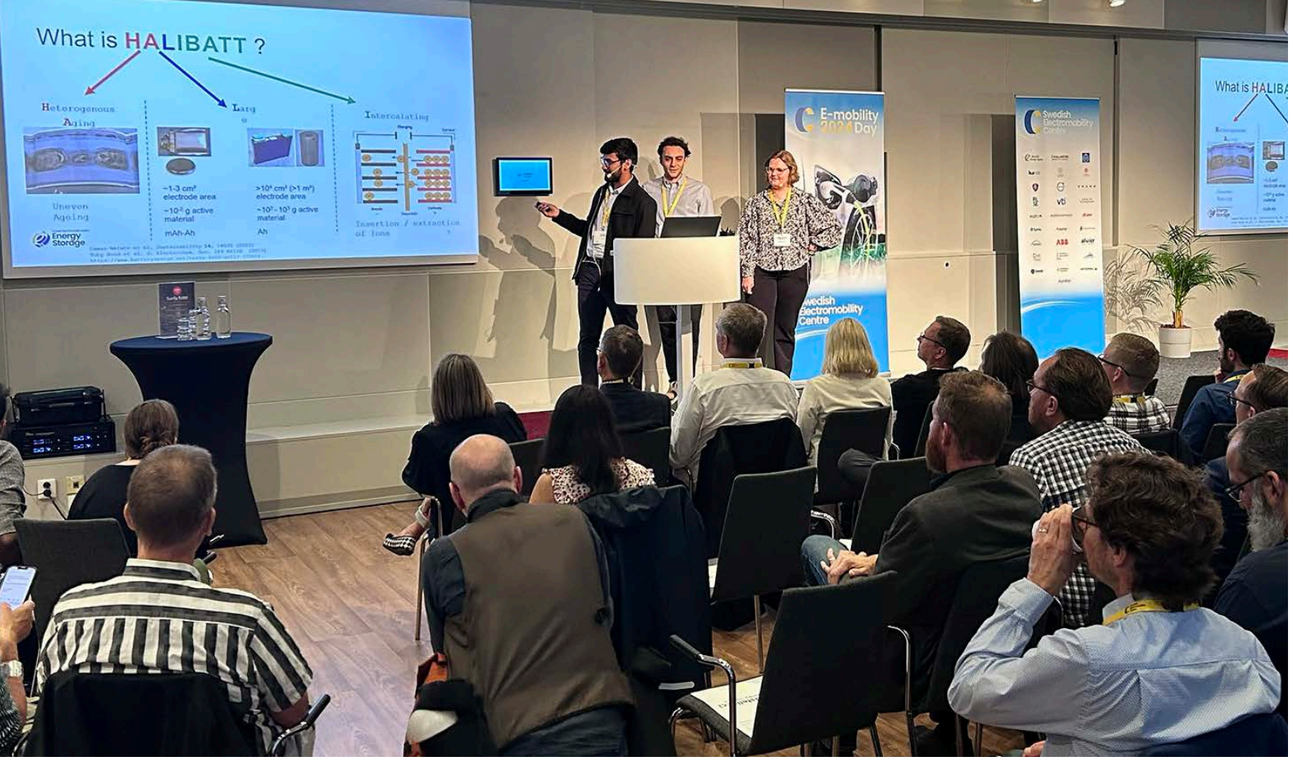
Within the Energy storage theme, the focus is to understand the energy storage units of different batteries and fuel cells when used in electric vehicles, in order to find more sustainable and better performing solutions. This ranges from materials, components and functionality of the electrochemical cells, to their integration with the vehicle and monitoring during use. By more profound knowledge, ageing can be mitigated, energy losses kept at a minimum, safety be assured, and health maintained.

Research advancement within 2024
The SEC projects running during 2024 have revolved around methods for determination of battery ageing, testing procedures and protocols, different forms of modelling, system safety and diagnostics, and novel battery and fuel cells types targeting vehicles. A couple of the PhD student projects that were started already within stage IV within the thematic area were now finalized and the students awarded PhDs: on fuel cell performance prediction and on gas evolution in Li-ion battery cells. Our project on control and modelling accelerated, and a new industrial PhD was recruited. Moreover, the large-scale project on heterogeneous ageing, HALIBatt, took significant steps forward and is currently involving three PhD students. Our thematic research project on intermediate temperature fuel cells continued and produced interesting results on this topic.
There are also multiple PhD students and post-docs involved in other Theme 3 projects, spanning the many dimensions of battery and fuel cell research. Several of these included collaboration with industrial PhD students at different SEC partners.
Theme 3 has also organized a number of physical meetings and online events during 2024, to highlight research within the area and stimulate research interactions. In October, a much successful workshop on Battery Safety was organized at the RISE facility in Borås, and in December a workshop on System Control in Battery Production and Management was organized at Chalmers in Gothenburg.

National and international attention
There has been no shortage of interest in the battery area from media, decision makers and the general public during 2024. First, large efforts have been made to raise the overall competences and put Sweden at the forefront as a research nation through the COMPEL initiative. This involves SEC partners to a large degree, and can hopefully involve even more in the future. Second, the European EV industry has had a tough year, but the European battery industry an even tougher. The accelerating development has experienced an obvious turn, and there are also large fears for Europe losing out in the international competition with both China and North America. Considering the amounts of jobs at stake, there is plenty of need for the expertise SEC can provide in this area. There exist national strategies to ensure that the entire value chain for EV batteries develops, and that Sweden can take a leading role in the ongoing green transition. Swedish research and SEC researchers within energy storage are highly competitive by all international comparisons and have important roles in formulating and implementing the strategies. Maintaining these strategies, and enforcing them, will be necessary for keeping pace with the international development. Competence centra such as SEC and Batteries Sweden here has a key role to bridge between industry, academia and policymakers.
In parallel with batteries, interest for hydrogen has also increased. In the hydrogen strategy for a climate-neutral Europe communicated by the European Commission, hydrogen has been identified as a key contributor in the mitigation of climate change. The need for Europe for a more robust energy system based on renewable resources has become even more apparent through the war in Ukraine, which has resulted in an even greater focus on hydrogen. The strategy is to make green hydrogen along with electricity the main energy vectors that enables a zero-emission Europe. While hydrogen as an energy carrier can be utilized in many parts of the energy system also outside of transportation – and where the perhaps strongest drive is seen today – it then becomes important to obtain synergetic intersectoral effects by integration of hydrogen into the existing systems for energy and transport. With falling costs and improved infrastructure for hydrogen, which can be foreseen in this transition, there are better chances for implementations also in the EV sector through hydrogen powered fuel cells. For road-bound vehicles, the focus is primarily on trucks, but the technology can be competitive also for ships, aviation and rail-bound transport.

Challenges and possibilities
The different levels of maturity for different energy storage solutions, i.e. batteries and fuel cells, means that the challenges and possibilities are fundamentally different. For batteries, the main challenges today for the European and Swedish industry is making cost-efficient, reliable and competitive battery cells. The very high volume of batteries being produced puts an extra focus on critical raw materials, materials processing, cell production and recycling. The maturity of the technique and its large-scale implementation also means that safety and lifetime issues become more critical, while the growth of the industry generates large needs for education in the area. Nevertheless, the complexity of the battery cell chemistry and its inherent materials renders it necessary to continue to perform research and diagnosis, and also incremental improvements can generate exceptionally large impacts on the overall energy system. Challenges regarding lifetime, diagnosis and predictions still remain, and depend intrinsically on the battery cell chemistry. Moreover, sustainability, lack of raw materials and increasing costs are emerging as issues for the Li-ion technology, which also motivates the interest in alterative battery and fuel cell technology.
Fuel cell-powered vehicles are in an earlier phase of commercialization than battery-powered vehicles, and important issues revolve around system integration, costs and the design of auxiliary systems. As with batteries, lifetime and predictability are important, and linked to the continued development of improved catalysts and membranes.

Business intelligence
With the current crisis for the European – and in particular the Scandinavian – battery industry, it is important to keep a few facts in mind. First, society do need large volumes of batteries for the green transition. The current overproduction of cells will not remain if we will meet our climate targets. Secondly, Sweden and neighbouring countries are highly ranked as ideal countries to produce batteries, partly due to the robustness and environmental impact of the energy system. And battery production is energy intense. Third, battery technology is also pointed out by the European Commission as a key technology, where Europe need to be self-reliant. And finally: the competences are vast in Sweden, and not only located to one single producer. This should open up for Swedish battery manufacturing, not least due to strong possible integration with the vehicle industry.
At the same time, battery technology is developing, especially targeting challenges associated with the supply chains and the creation of closed-loop systems. Novel Li-ion battery cell chemistries strives towards both higher electrochemical performance and more sustainable materials (Si/C composite anodes, Ni-rich and/or Co-free cathodes). While Na-ion batteries seem to approach market introduction more rapidly than expected, solid-state systems seem to face further challenges and not as rapid maturity as forecasted. When electrification spreads to the entire transport area, new challenges arise in, for example, the marine sector and in aviation. The technical solutions from road transport cannot simply be copied. The balance between energy storage in batteries and in hydrogen needs to be analysed. A major challenge for fuel cells to become more important in the field of transport is linked to the availability of a hydrogen infrastructure. The importance of infrastructure issues will therefore grow, in the same way that charging and electricity grids are already key issues for battery vehicles. Already today we can see how regions are investing in leading this development. In the discussion of batteries versus fuel cells, it is important to understand that the conditions for electrification differ greatly between different regions and countries. The Swedish automotive industry has a strong focus on exports, and must maintain a broad perspective in order to remain competitive.
It is also evident that there is a large need for educational efforts, not least re-education of labour in the current vehicle industry, to supply the emerging industry with competences.



Agnes, Daniel, and Aamer presenting during E-mobility Day.

Swedish Electromobility Centre
Energy Storage

PROJECT SPOTLIGHT

Heterogenic ageing in large intercalation batteries

The ageing of automotive lithium-ion batteries has been studied in many collaborative projects between industry and academia, resulting in new improved battery design and usage. Even so, there are still a considerable extent of unevenness, or "heterogeneity", in degradation phenomena on several levels observed in the batteries. This heterogeneous ageing is still not well understood, and there is a need to to find the reasons behind it to mitigate these problems in the future.

The goal of the research project HALIBatt, Heterogenic Aging in Large Intercalation Batteries, is to quantify, explain, and describe the uneven distribution of cell ageing observed in various large cells. An improved understanding of the root causes of this heterogeneity, as well as methods to diagnose and ultimately predict it, would help improve model development and lifetime prediction, provide insight to OEMs in developing battery systems, and ultimately contribute to a more effective use of battery materials.

Cell teardown analyses from previous research have revealed that spatial heterogeneity presents numerous scientific and technological development challenges. Additionally, phenomena such as ageing between the two sides of an electrode coating have not been fully captured or predicted by current battery models, at least not with spatial discretization. Furthermore, heterogeneity along the length of a wound electrode has not been well studied. In general nowadays manufacturers are producing bigger batteries than in the past, which can be the cause of, or at least enhance, the heterogeneity of degradation

The scope of HALLIBatt is a joint effort and a broad collaboration between industry and academia with different complementing competences involving four PhD students.

Battery cycling
The main battery cycling is done by PhD student Daniel Poposki at Chalmers University of Technology and Volvo Group Trucks Technology.

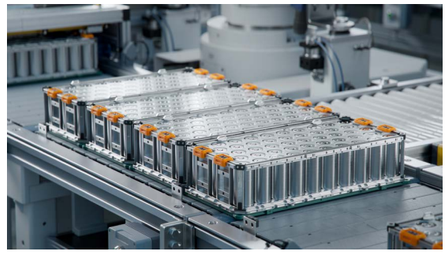
"My work mainly revolves around experimental studies on how batteries age and perform in various conditions, as well as gather data that can be utilized for creating useful models of the battery. Observation of heterogenic degradation within large format battery cells can in some cases correlate with temperature gradients that occur within the battery. Focus is therefore on deepening the understanding of how thermal aspects affect the performance and lifetime of battery technologies that are newly emerging in the market, in collaboration with all HALIBatt partners," says Daniel Poposki.

Post-mortem analysis
The cycled batteries will then be handled for post-cycling characterization, which is mainly done by PhD students Aamer Siddiqui and Agnes Matilda Mattson.

"My work mainly involves conducting teardowns and post mortem analysis. Teardown enables me to separate/segment each material and analyse them with various post mortem tools. Such as electrochemistry, BIB SEM, image analysis, OLSA, and various other techniques. This helps to answer questions regarding ageing mechanism and understand the degradation. A large part of my contribution also goes towards developing these methods," says Aamer Siddiqui, PhD student at Scania.

Agnes-Matilda Mattsson's work with the cycled batteries is with focus on X-ray diffraction. Agnes is a PhD student at Uppsala University, an organisation with a strong history and culture within this area.

"X-ray diffraction is an efficient method when characterizing heterogenous ageing in battery cells. We will analyse the influence of temperature, pressure, and cycling protocols from cells provided by the industry partners Volvo and Scania. One project that will take place this autumn is the investigation of ageing using X-ray diffraction to create a map of the electrodes. With this method we can study the heterogeneity both on the electrodes, but also throughout the cells," says Agnes-Matilda Mattsson.



Developing mathematical models for prediction
The insights from the post-mortem analyses will be utilized to develop mathematical models for prediction of hetereogenous aging. These models can then be used in the industry to handle batteries in the most optimal way which will avoid deterioration and in the end extend battery lifetime. Gian Marco Trippetta is a PhD student at KTH Royal Institute of Technology in Stockholm, and his main role is within this area.

"Agnes and my work are overlapping but I'm mainly in charge of developing the models. So far the results are only on an experimental stage, but I hope to present more in the beginning of next year. It's an exciting and important project and I enjoy the collaboration with other academics and the industry. If we can understand, interpret, and predict the mechanism that cause heterogeneity, it has a lot of potential to improve battery lifetime," says Gian Marco Trippetta.

Theme 4

Swedish Electromobility Centre
Environment & Society

The Environment & Society theme area explores electromobility from societal and environmental perspectives, seeking to provide a knowledge base for the construction of strategies and policies toward sustainable solutions, both in industry and government.

Research is developed into four strategic areas. The first, labelled as understanding technology diffusion and its impact on personal mobility, transport services, and society, studies how technology adoption affects personal mobility, transport services, and society at large. Its core is the interaction between technology, stakeholders, and the mechanisms driving development in both passenger and freight transportation. The second area, securing resource availability through efficient resource use and circularity, explores strategies to ensure the availability of raw materials for electromobility by promoting efficient resource use and the implementation of circular material flows. The third area, environmental impact assessment, aims to steer technological development toward minimizing environmental footprint. Finally, the fourth area, evaluation of policies and legislation to speed up sustainable electrification of transport, studies the policies and legislation designed to accelerate sustainable transport electrification, emphasizing the potential side effects and conflicts between targets.

Research advancements within 2024

Overall, fifteen projects were on course during 2024, seven funded by the SEC and eight in association. The theme provides funding for two academic PhD students and one industrial PhD student, while seven of the associated projects link additional PhD students to the theme.
PhD student Muhit Chordia at Chalmers, active in a project in the environmental impact assessment strategic research area, joined a group of international colleagues representing strong research environments at the Imperial College London, the Faraday Institution and Minviro Ltd, all in the United Kingdom, and co-authored an article titled "Think global act local: The dependency of global lithium-ion battery emissions on production location and material sources" in the "Journal of Cleaner Production". Three of the projects ongoing during 2024 are expected to finish during 2025, with publications reporting research achievement expected during the first semester of the new year.
Ongoing work in the other PhD student projects in the same strategic area includes a study of the environmental and resource impacts of future battery chemistries. Research in coupled to circularity is carried out to investigate the potential role of batteries into circular flows of materials. Research in other areas advances the knowledge for novel business models for logistics of electrified truck fleets. Related research is also being developed to understand the system-level impacts of electrification of freight transport.

National and international attention

In March 2024, theme leader Anders Nordelöf from Chalmers presented at an evening seminar at the Swedish Parliament arranged by the Society for Members of Parliament and Researchers (RIFO), on the topic of electrification of the transport sector and the different challenges and opportunities coupled to

establishing sustainable supply chains for the road vehicle fleet. Among the other presenters, SEC had additional presence on the podium through Professor Daniel Brandell from Uppsala University, theme leader of theme Energy Storage.

The theme-associated project E-charge, which brings together leading industrial companies to make significant investments in the electrification of heavy road transport, has received funding for the next stage. The focus will be on scaling the use of electrified trucks to understand how the system is affected when a large part of the fleet becomes electrified. The project will also address consequences in the logistics systems when many trucks need to charge at the same time as well as the inclusion of Megawatt Charging Systems.

Challenges and opportunities

The deployment of electric vehicles (EVs) presents both challenges and opportunities across social, economic, technical and environmental domains. The transition to EVs must consider social challenges such as public acceptance, equitable access, and integration with other urban mobility. Financially, scaling up EV adoption requires investment in infrastructure, such as charging networks, while keeping vehicles affordable for diverse groups of the population. Technologically, advancements in battery efficiency and grid resilience are critical to support widespread adoption. Regarding the environmental dimension, EVs must ensure effective greenhouse gas emissions mitigation, which is linked to low carbon electricity. At the same time, the availability of critical raw materials remains an area of high attention.

In terms of possibilities, electromobility may offer new jobs and stimulate innovation in energy storage and smart grid technologies, while also catalyzing the use of batteries in a circular economy, resulting in environmental footprint reduction over time.

Business Intelligence

Recent advancements in electromobility include significant improvements in battery energy density, which enhance vehicle range and performance. However, it is also notable that battery chemistries with energy densities in the lower end, but which avoids several scarce resources, gain in popularity. One example is lithium-ion battery cells using iron and phosphate in the positive electrode. Another is sodium-ion batteries. Among the new battery technologies being studied in the upper energy density range, solid-state batteries exhibit high potential.

In the realm of business models, the electrification of fleet operations is gaining traction. Companies are adopting Mobility as a Service (MaaS) frameworks, integrating electric buses and vehicles to reduce emissions and operational costs. This shift not only promotes sustainability but also opens new avenues for revenue generation and customer engagement. These developments underscore a global commitment to advance electromobility through technological innovation and strategic business transformations.

Swedish Electromobility Centre
Environment & Society

PROJECT SPOTLIGHT

Life Cycle Assessment of V2X

Life-cycle assessment (LCA) is essential for evaluating the environmental impacts of products throughout their life cycle. This project focuses on Vehicle to X (V2X), which explores using electric vehicle batteries for purposes beyond driving, such as bi-directional charging. By addressing challenges like methodology, energy efficiency, and battery degradation, this research aims to close knowledge gaps and provide a better understanding of V2X's environmental impacts, leading to more sustainable solutions.

Pedro, can you tell us a bit about your background?
"My name is Pedro Anchustegui Balner and I'm from Mexico where I studied mechatronic engineering. I wanted to do a master abroad, and in 2017 I started the Industrial Ecology program at Chalmers. My thesis was about life-cycle assessment on end-of-life for tires, and was done at Volvo Cars. There I started to work as a purchaser, and then later switched to Volvo's sustainability centre. When I saw the posting for this PhD project on life-cycle assessment on Vehicle to X, I knew it was something that would really interest me."

What Is the project about?
"Using electrical vehicles for other purposes than just driving is expected to be part of the infrastructure the coming years. Vehicle to Grid is the concept where the car can push electricity back to the power grid, while Vehicle to X, or vehicle to everything, means that the car battery can be used to charge all sorts of applications. Vehicle to X can also refer to the car's communication with other entities, but my focus is on bi-directional charging. In the project I will investigate different solutions and potential applications for Vehicle to X, and assess life-cycle effects with focus on different environmental impacts."

What are the main challenges?
"When it comes to life-cycle assessment it's in this case very much a methodology challenge. Suddenly the car has two functions so life-cycle assessment becomes more complicated.

How do we reconcile the total impact when combining the function of the traditional car, and the car as a battery? This allocation of impacts is something that we need to explore more, so that we can make decisions that result in more representative life-cycle assessments. Vehicle to X is also a rather new technology so there are still many uncertainties about future solutions. When it comes to the technical side a big problem with bi-directional charging is efficency. The energy loss is twice as high since every loss you have when charging also occur when discharging. Another problem is battery degradation that will most likely increase due to more frequent charging cycles. This is an area with a lot of ongoing research, which is a good thing of course, but, without consensus, it also makes data for life-cycle assessments more uncertain. Then you also have to consider that the car still needs to be able to serve as a car and not just as a stationary battery. Otherwise people will not accept that it's used for Vehicle to X."

What do you hope to achieve?
"Today there are considerable knowledge gaps when it comes to life-cycle assessment of Vehicle to X. Hopefully we can close those gaps to achieve a better overall understanding of the pros and cons, which in the end will lead to better overall solutions."

Theme 5

Swedish Electromobility Centre
Vehicle–Grid Interaction

The core mission of Theme 5 is to analyze and facilitate Vehicle-Grid Integration. This is achieved through research in four strategic areas: charging at lower power levels, charging at higher power levels, charging infrastructure from a systems perspective, and finally, need and use of energy storage in power systems.

In the past year, the group actively engaged with stakeholders through workshops and seminars on bidirectional charging, and held regular meetings to drive research and collaboration.

Research advancements within 2024
During 2024 a new theme research project "Quantifying Harmonics Caused by Smart Charging and V2X" was approved. This project aims at investigating and mapping harmonics caused by smart charging and V2X to raise awareness about the implications of integrating smart EV charging and V2G technologies in parking facilities.

National and international attention
Throughout 2024, Theme 5 actively promoted SEC and its research on vehicle–grid interaction to a diverse audience, encompassing Swedish and international stakeholders, university students, and doctoral candidates. We facilitated workshops and meetings, featuring speakers with varied interests in the field, with a primary emphasis on the advantages and obstacles of bidirectional charging. For example, activities involved the Municipality of Utrecht (Netherlands) and the national PAVE project. Additionally, researchers disseminated their findings through presentations at various international conferences and events.

Challenges and possibilities
The integration of electric vehicles (EVs) with the power grid has seen explosive growth in recent years, with 2024 marking a pivotal point in this dynamic landscape. Research and development across various fronts continue at a rapid pace, creating both exciting opportunities and complex challenges. The sheer speed of technological advancement remains a significant hurdle. By 2025, a substantial portion of the vehicle fleet is already electric, and the market continues to evolve, demanding agile and adaptable solutions.
Furthermore, the increasing electrification of sectors beyond transportation, including existing and new industries, places immense pressure on existing grid infrastructure. Meeting this escalating electricity demand requires substantial grid modernization and expansion. However, these projects often have lengthy lead times. Therefore, prioritizing near-to-midterm charging solutions and assessing the necessity for supplementary infrastructure is crucial.
Despite these challenges, the electrification of transportation offers significant advantages. Primarily, it fosters a more sustainable transportation ecosystem and holds the potential to enhance grid stability. As renewable energy sources, such as solar and wind, become dominant, grid flexibility is paramount. Smart charging strategies, enabling flexible EV charging schedules, can effectively manage fluctuations in renewable energy generation. Moreover, the potential of Vehicle-to-Grid (V2G) technology is becoming increasingly realized. Utilizing EV batteries as distributed energy storage can provide valuable grid support, contributing to frequency regulation and peak shaving. In the future, the focus should shift to scaling these technologies and establishing robust frameworks for their implementation, ensuring that EVs play a central role in the ongoing energy transition. The development of standardized communication protocols and robust market mechanisms are also vital to maximize the potential of V2G and smart charging. We are now in a phase of implementation and refinement, moving from research to real world application.

Business intelligence
Business intelligence within the electric vehicle–grid interaction sector focuses on the practical application of data to optimize grid operations and capitalize on the evolving energy landscape. Distribution network operators are actively implementing grid flexibility solutions, driven by real-time data analysis and forecasting. The monetization of Vehicle–to–Grid (V2G) services is an area of growing interest, with emphasis on developing market mechanisms and ensuring seamless integration with grid operations. Data-driven strategies are guiding the deployment of charging infrastructure, while consumer behavior insights are crucial for successful smart charging programs. Business intelligence also plays a vital role in shaping regulatory policies and navigating the increasingly competitive market. Essentially, the emphasis is on leveraging data to optimize resources, manage the dynamic nature of EV charging, and contribute to a sustainable energy transition.

Swedish Electromobility Centre
Vehicle–Grid Interaction

PROJECT SPOTLIGHT

High power charging – when, where and how

High power charging is a necessity for the electrification of heavy vehicles such as long-haul trucks, maritime vessels, electric flights and for a "fully" electrified car fleet. The amount of power needed and the effects on a system level are not fully known.

The project "High power charging – when, where and how" investigates possibilities, limitations, and show different charging scenarios. Christoffer Aalhuizen is PhD student in the project.

What is your background Christoffer?
"I have a dutch surname, Aalhuizen, from my grandfather but I'm born and raised in Dala-Järna, hometown of the legendary Swedish cross-country skier Gunde Svan. I have studied both engineering and economics at Uppsala University where I now conduct my PhD studies. In between I worked for the municipality and companies calculating costs for transitioning to a fossil-free vehicle fleet, something that I found very interesting, and is one of the reasons that I now pursue a PhD within this area."

Explain what the project is about
"Heavy vehicles used in commercial transporation and industry have battery sizes from 600 kWh or higher. They also need to be charged fast to be economically competitive, preferably no longer than 45 minutes which is the stipulated resting time for truck drivers. Fast charging of long-haul heavy vehicles will likely require chargers capable of providing more than 1 MW, yet how this fast charging affects the power system is something that we don't have any reliable models for today. The aim is to investigate how the grid can meet the requirements from the vehicles and how the vehicles can meet the requirements from the grid, and what possibilities they have to strengthen each other. We will focus on the interface between grid and vehicle and vehicle to vehicle and on the charging infrastructure needed in weak grids, where we are going to do simulations in combination with fast charging, local production and storage."

What are the main challenges?
"Fast charging with high power requires a high voltage output with significant peaks and drops that affect the whole systems. The presumption is that the closer a charging station is to the power source the better. Many transportation routes follow the same pattern which leads to charging "hot-spots". Finding suitable locations for these "hot-spots" is one challenge. Other locations like harbours, airports and mines are rather fixed and are often found far out in the grid. Then we must perhaps have other types of local flexible solutions."

Why not just use bigger cables?
"Haha, well, bigger cables makes things easier with power output, but it's also very costly so I don't see that as a pragmatic solution, at least not short-term. We will probably need different types of storage and auxiliary solutions to handle the large variations. This project is mainly about modelling requirements so we don't have all the solutions right away. What we hope to achieve is to establish common grounds for vehicles and grid to enable high power fast charging."

When are you presenting your findings?
"I'm currently finishing up drafts for two papers, one about potential power peaks at airports with electrical aircrafts and one of a model estimating power requirements from the power grid for charging long-haul heavy duty electric trucks. On a similar note you can also read this article where I collaborated with RISE where we estimated the effects from implementing charging of electric aircrafts, photovoltaics and a small airport a battery energy storage at a small airport": https://doi.org/10.1016/j.apenergy.2023.121946t

Doctoral Network

The SEC Doctoral Student Network has been growing in 2024 and activation of PhD students has been well welcomed as we have seen a high attendance on our activities this year. The network has reached about 200 active PhD students with a representation of all corners of Sweden and universities.

During 2024, the network has coordinated a variety activity which have aimed at learning, activation of students, and enabling them a platform to meet and share experiences and ideas.

Webinars
The webinars are held monthly with invited guest speakers touching upon relevant areas of electromobility research. The webinars are intended to spread new knowledge and inspire. In 2024, we have held six interactive webinars with lecturers from industry and academia: Harrison John Bhatti, VTI presented "Developing an Understanding of Electrifying the Transportation System from a Systems Perspective"

Thomas Nyström, RISE presented "Design for Longevity: How to create longer lasting products for circular offerings?".

Tayana Ortix Lopes, Chalmers presented "Circular supply chains and future scenarios for electric vehicle batteries".

Henrik Engdahl, Volvo Trucks presented "Who is who in electric trucking?".

Nils-Gunnar Vågstedt, Scania presented "30 years of persistence. Reflections and outlook from my contribution to innovation".

Magnus Granström, SAFER presented "SAFER, the one and only collaboration platform for Road Safety in Sweden".

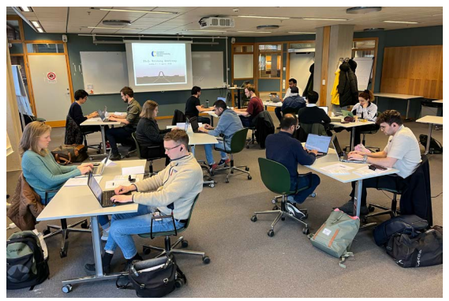
Summer School
The Summer School 2024 on Components and Systems for Electromobility with an emphasis on electric battery and fuel cell vehicles was successfully held between 10-14 June, at Hooks Herrgård near the beautiful lake Hokasjön, Jönköping County. Five intensive days with learning, testing, and networking.

21 doctoral students were welcomed from across all Swedish universities and industrial partners of SEC, representing a solid mix of university research, industrial perspectives, as well as gender balance. On 28 August, the doctoral researchers convened again at Linköping University to present their project outcomes from the course assignment, which was designed with a real-world engineering issue at hand.

Excellent lectures by: Lars Eriksson, LiU, Jonas Fredriksson, Chalmers, Francisco Márquez-Fernández, LU, Luca Peretti, KTH, Anders Nordelöf, Chalmers, Henrik Gillström, LiU, Valeria Castellucci, Uppsala University, Mikael Lantz, LU, Henrik Ekström, KTH, Mario Valvo, UU, Olof Samuelsson, LU

The PhD course is intended for PhD students within the SEC Doctoral Student Network, and employees of the SEC industrial partners in the field of e-mobility. The Summer School consists of lectures and practical exercises related to the five themes in SEC. Next Summer School is planned for 2026.

Writing Bootcamp
On the 2–4 April the Swedish Electromobility Centre doctoral student network arranged a successful PhD Writing Bootcamp. The bootcamp provided the participants with a focused environment and practical learning methods for productive writing. Throughout the event, participants engaged in eight "writing snacks," dedicated sessions aimed at refining their academic research communication.



A highlight of the bootcamp was a surprise visit from Ulf Ellervik, renowned for his appearances on the TV show Fråga Lund and acclaimed author of 11 popular science books. Ellervik shared invaluable insights and offered his best writing tips, inspiring participants to elevate their academic writing.

Study visit at Scania
Scania R&D welcomed 17 PhD students to their facilities in Södertälje, Stockholm on 6 December for a full day immersive learning experience. The program included a study visit to the Chassis assembly where students got to see the process of electric trucks assembly as well as demo driving Scania's line of trucks including two electric trucks with load. In addition, the students held a PhD interactive seminar discussing PhD journey and the relevance of stakeholders and research communication. The students were also invited to a mingle dinner to meet the network members and exchange experiences.

New partner

AUROBAY

We are very happy to have Aurobay as a new program partner. Aurobay's ambitious sustainability goals and extensive expertise on powertrains is a great contribution to the SEC network.

Aurobay is a global supplier of propulsion technology, and has factories in both Sweden and China. In Sweden the plant is located in Skövde and there is an R&D center in Gothenburg.

Alexandra Tokat is technical expert in electromagnetics and electric machine design working at the R&D center in Gothenburg. Alexandra has a background as a researcher at Swedish Electromobility Centre, and has been one of the driving forces to the partnership.

"It's really important for us at Aurobay to be a part of the research community. Speaking from personal experience I know that there is a lot to gain from collaborating and networking within SEC. We need to meet people, have pre-studies and research projects that can give us different and new perspectives. Electromobility is not something that we can do alone, we have to do it together," says Alexandra Tokat.

Aurobay's largerst business is within hybrid electric powertrains, but they are also working with pure electric and combustion technologies as well as sustainable fuels.

Aurobay has the capability to assemble e-machines and electric drives in the Skövde Motor Factory. Furthermore, the hybrid electric drives have electric machines, therefore we have a lot of competence in this area, but we want to expand the knowledge and improve the efficiency and applications. Aurobay is working towards net zero with synergies and not exclusion. So, we are not disregarding from any technology that can help us reach that target. However, we certainly want to increase our efforts to improve electric propulsion since it will play an important part in reaching these targets," says Alexandra Tokat.

Focus group

RESILIENCE

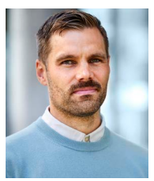
SEC has started a focus group on resilience and electromobility. Jens Hagman from RISE and Fran Márquez Fernández from VTI lead the work together with a small core group. All SEC partners are welcome and encouraged to participate. Region Skåne, as an invited member, contributes with valuable insights as one of Sweden's largest public authorities.

The focus group had its starting meeting in August. So far it has held two webinars, and the plan is to have a few more before the end of the summer. The insights from the work will be summarized in a final workshop to start discussions on what role resilience may play in SEC's research themes.

A sign of maturity?
The group grew out of discussions partly due to increasing concerns about the geopolitical and climate stability in the world, but it can also be seen as a sign of electromobility's maturity.

"We have pretty much been occupied with making electromobility work the last ten years, so resilience has not been a priority for most people. When electrical vehicles now start to get more accessible and common in society, disturbances have a larger effect. What the unrest in the world has done is to put a spotlight and a sense of urgency on this matter," says Francisco Márquez-Fernández.

Francisco Márquez-Fernández



Jens Hagman

Starting from scratch
Resilience can be a wide concept, and the focus group's first task was to discuss about its meaning and implications.

"It's been important for us to start from scratch, to create a common understanding of what resilience means. When we talk about resilience it's about the ability to handle disruptions that have large implications on a societal level. The causes can vary but the common denominator is that it's something that traditional risk management can't handle based on known probabilities and consequences. It's basically an event of some sort that you really can't have detailed plans for," says Jens Hagman.

Robustness, the ability to withstand attacks, is perhaps the first that comes to mind when talking about resilience, but flexibility is as important.

"Obviously, it's better to have a robust rather than a fragile system. However, resilience is also about adaptation and recuperation if, or when, the system crashes. A system that is flexible can go back to a functional status much faster than a rigid one," says Francisco Márquez- Fernández.

Whose responsibility is resilience?
A resilient society involves many cooperating actors, which inevitably raises questions concerning responsibility. Something that might seem easy on paper can, in reality, become ambiguous when facing a chaotic disruptive event.

"Since this is a very complex topic it's important to have discussions and also work with case based scenarios, which is something we plan to do during this fall. We are very happy to see so many partners, together with Region Skåne, taking this matter so seriously", says Jens Hagman.

Is it a threat to electromobility?
Can increased concerns for resilience become a threat for the implementation of electromobility?

"When facing uncertainty, it can be easy to fall back on existing knowledge and habits. So, there is a risk, but you can also see this as an opportunity to create a more resilient society. I would say that for Sweden, with all its potential for e-mobility, it's better to take advantage of its strengths," says Francisco Márquez- Fernández.

Test Centers

SEEL, Swedish Electric Transport Laboratory,

is a collaboration between RISE and Chalmers. Within this initiative, three state of the art test facilities were inaugurated in September 2023, which now are all in full operation.

Martin G.H. Gustavsson is Research Director for SEEL, primarily overseeing operations in Gothenburg and Nykvarn.

"It has been quite a journey and it feels great that we now are up and running. During the first year of operations we have had many satisfied customers. SEEL would not exist if it wasn't for the large industrial interest and most activities have so far come from this sector. Academic research has not yet been so extensive, so far, but I'm confident it will increase as we progress. One of the main purposes for SEEL is to be an arena where academy and industry can meet."

All three locations have excellent prestanda testing opportunities, but Borås is unique when it comes to safety critical testing. Magnus Ling is Sales Manager at the facility in Borås.

"Borås safety testing facility is the only in the world that's fully enclosed, which makes a big difference compared to other test environments. It's been a challenge to build since handling exhaust fumes, explosions and other hazards in confined spaces is very complicated. The advantage is that the test results are more accurate and repeatable. We have had a variety of both Swedish and foreign corporations and organisations coming here pushing the limits of their electric engines and batteries. SEEL cover all the market needs and we have done everything from thermal testing complete cars to small battery cells. We have seen a growing interest for battery management systems and early incident detection."

Swedish Electromobility Centre held a workshop at SEEL in Borås. The workshop was part of Energy Storage, Roadmap Theme 3, and focused on a critical aspect of electromobility in the future: battery safety.

Heart Aerospace conducted electric engine tests in December 2024 at Nykvarn. Watch it on their Youtube channel:
https://www.youtube.com/watch?v=4SI93Dib1-U

https://www.ri.se/en/seel
https://www.linkedin.com/company/seel-swedish-electric-transport-laboratory/

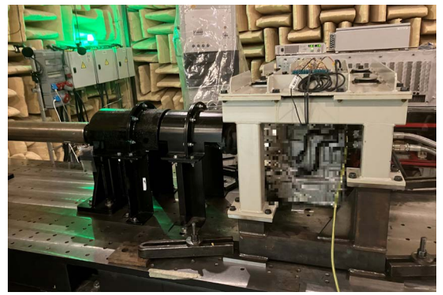
At the Alstom Test and Technology Centre in

Västerås in Sweden's Lake Mälaren region, solutions for green e-mobility are developed and delivered globally. The new office building in front of the existing Alstom factory and the largely expanded Powerlab for testing complete electric powertrains were both inaugurated in 2023.

Open to external parties, this lab was something that the SEC project "Design of rare earth element free motors part 2", made use of during 2024.

In a collaboration between Uppsala University, Alstom and Scania, The purpose has been to find alternative techniques for electric motors eliminating the need for rare earth element magnets (REE-magnets). A prototype with a ferrite motor has therefore been designed, constructed and tested. Professor Sandra Eriksson and PhD student Marcelo Silva from Uppsala University have been testing the prototype at Alstom's new facility in Västerås.

"The lab has been fantastic! It's very well organized with a professional staff and we have felt really welcomed. Everything was rigged to fit our needs and it takes some effort to test an motor like this. It would be very hard for us if we had to build a similar rigg from scratch at Uppsala University. We are very happy that we got this opportunity made possible through SEC," says Sandra Eriksson.



The test results from the motor, which is a protoype built by Scania, have surprised in a postive way.

"We tested the motor for several weeks and received a lot of valuable data. This data is still being analyzed, and there aren't any published results yet. But I can say that it looks very promising. The expected torque and speed were reached with surprisingly high efficiency (98%). There were low torque ripple and no detected demagnetization. It's been very exciting to see that the design and calculations match up to real tests," says Sandra Eriksson.

https://www.alstom.com/

Collaborations

Collaboration is essential for the progression of e-mobility, and is strongly encouraged. Associated projects, and other forms of collaboration, are great opportunities for knowledge sharing and expansion of the network. Here are some examples of organisations and projects that SEC worked with in 2024.

BASE

BASE (Batteries Sweden) is a VINNOVA-funded competence Centre. SEC and BASE complement each other since BASE has a focus on the materials within the cell and has battery industry as partners and SEC contribute with knowledge in how to apply it in electromobility. The strongest connection between the centres is through SEC Theme 3, both in terms of the participating universities (Uppsala, KTH, Chalmers), industries, and key people.

BATTERY 2030+

European research initiative with the vision of inventing the sustainable batteries of the future. SEC is a supporting organisation to BATTERY 2030+. It actively gave support in designing the vision, aims and goals of the BATTERY 2030+ initiative and roadmap. SEC also gives input to the activities in the initiative as a part of the European battery eco-system that can ensure the uptake of new knowledge and technologies.

IFP

IFP Energies Nouvelles is a major research and training player in the fields of energy, transport and the environment. SEC collaborates through having theme leader Lars Eriksson as a teacher in the French institute's courses and the institute also contributes with researchers who are participating in to SEC connected PhD students' grading committees.

SEDDIT

Sensor informatics and Decision-making for the Digital Transformation constitutes a platform for collaboration between universities and companies to conduct research and education in digital societal transformation with the aim of strengthening Sweden's competitiveness. There is an overlapping environment between the SEC researchers and the SEDDIT researchers and many of the centre's industrial partners also have a good collaborating environment.

PUSH

Production, Use and Storage of Hydrogen is an Agenda 2030 Research Centres funded by SSF , Swedish Foundation for Strategic Research, and was started in 2020. The main goal of the research centre is to address scientific and technical hurdles impeding the widespread use of hydrogen in sustainable energy systems, by combining activities on production, storage and distribution, and use of hydrogen in a single coordinated research effort. PUSH activities focus mainly on new concepts and research issues with a longer time horizon. For example polymer-based fuel cells that work at slightly higher temperatures, which if implemented would impact the system design in vehicles. By the fact that several of the doctoral students and faculty members active in PUSH also participate in SEC activities and the doctoral network, a mutual transfer of knowledge takes place.

EVS/AVERE

AVERE, a European association representing and advocating for electromobility on behalf of the industry, academia, and EV users at both EU and national levels, organizes the Electric Vehicle Symposium, EVS, every year. Together with other actors SEC is part of the Swedish organization supporting Avere for the EVS 38 in Gothenburg 2025. SEC has participated in the Swedish delegations for EVS 35 and EVS 36 to market Swedish activities in electromobility. The main contribution from SEC in EVS38 will be to the scientific program but we also collaborate to market the event.

E-Charge

E-Charge is a national project for electrification of heavy-duty trucks on long-distance routes. SEC has both been active in the application phase of the project and there are also researchers from SEC's projects active in E-Charge. SEC participates with researchers and industrial partners. SEC is also part of the steering committee. In November E-charge 2 was launched with the purpose to further accelerate the transition to a future logicist system.

REEL 2

REEL 2 is a national initiative where leading Swedish actors have joined forces to accelerate the transition to electrified, emission-free heavy transport on our roads. Within the venture, we establish, run, and evaluate around 60 different regional logistics flows in varying types of driving assignments. SEC participates with researchers and industrial partners.

SAFER

SEC and SAFER Vehicle and Traffic Safety Centre are in close regular dialogue concerning supporting each other in the development of the centres and possible collaboration. SAFER has initiated a network focused on accidents with vehicles with alternative fuels. SEC participates with one representative in the network to monitor how the cooperation in this field can be increased between the centres.

SEEL

SEEL Swedish Electric Transport Laboratory is a test center for research and development in the field of electromobility owned and run by Chalmers and RISE as a joint venture. SEEL consists of three facilities - in Gothenburg (Söve), Nykvarn and Borås. The aim is to consolidate efficient knowledge development and improve the conditions for collaboration in the field of electrified transport in Sweden and Europe. SEC's director has participated in an external steering group, and been part of the inauguration.

Alstom Mobility & Innovation Lab

A centre that concentrate Alstom's innovation capabilitis in Sweden and enable collaboration across industries, higher education institutions, and start-ups. SEC researchers have used the facilites to test prototypes.

EARPA

Several partners of SEC are part of EARPA, European Automotive Research Partners Association, a community of leading European independent R&D providers in the automotive sector. SEC Director Linda Olofsson is a member of the executive board. EARPA foresight groups support R&I frame programmes and policy decisions through high level position papers and EARPA collaboration groups facilitate successful R&I proposal development.

Swedish Transport Agency

SEC Director Linda Olofsson is a member of the board.

Swedish Transport Administration

Magnus Lindgren from the Swedish Transport Administration is adjunct to the SEC program council and invited to the center activities.

ACE

VTI has involvement in the Arctic Center of Energy which is an ambitious initiative to accelerate society's sustainable energy transition. Through cutting-edge research and groundbreaking education, the center creates the knowledge and abilities required to succeed with the electrification of society.

SweBIIC

A consortium, consisting of RISE, Uppsala University, Chalmers, and the Blue Institute, has conducted a preliminary study on the conditions for establishing SweBIIC – a research and technology infrastructure for scaling up battery production.

Competence centres

SEC management has participated in the Swedish Energy Agency's "Leadership forum" to exchange knowledge and experience with other competence centres funded by the Swedish Energy Agency.

Outreach & Communication

The interest for electric cars has reached far beyond early adopters to the majority. Many have questions about driving range, battery safety, second hand value, vehicle-to-grid, and other concerns before switching to an electric vehicle. This has made it even more important for SEC to be accessible and communicate facts and research progress within e-mobility.

SEC is a virtual centre organisation with activities all over Sweden. The communication efforts are meant to increase the knowledge of what is going on in all of the five themes, participating universities and industries. The outreach activities are also strengthening the brand and in the long-run contributes to the impact of e-mobility in society.

SEC Newsletter
SEC's newsletter has over 3,000 subscribers which mostly are professionals in the partner organisations. The newsletters contain news about ongoing SEC-funded projects, opportunities, partners and upcoming events. The main purpose is to get engagement from all partners and increase collaborations and knowledge sharing.

Workshops and seminars
The centre has workshops arranged by the theme groups, lunch webinars for the PhD students, workshops in collaboration with external partners. The largest SEC event was E-mobility Day in Linlöping in August.

Global Watch
The omEV newsletter and podcast is a global watch service run through SEC. The newsletter is sent three times a week and new podcasts are out almost every month. It gathers, analyses and shares information and keeps you updated on the latest from the world of e-mobility and what may influence Swedish mobility development.

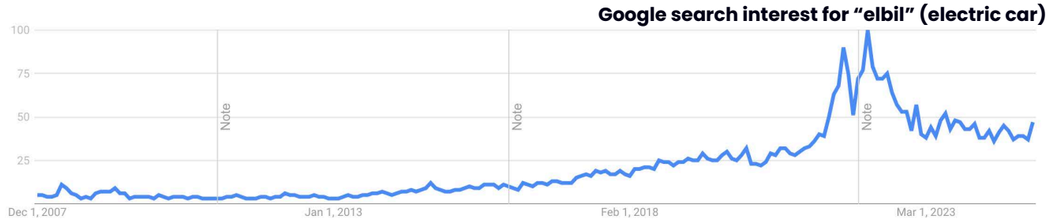
External events
SEC's representatives continously participate at external events and activities.

LinkedIn
SEC's LinkedIn page has up to date about 2,850 followers. The purpose is to gain attention to a wider audience.

https://www.linkedin.com/company/emobilitycentre

Media
SEC representatives takes active part in the public debate and appears regularly in both Swedish and international press.

Google search interest for "elbil" (electric car)



The search interest for electric vehicles has steadily been increasing during the last 15 years with a surge around 2022. Even though there is a drop in the curve it's still relatively high.
Source: Google trends

Media coverage

The term "Swedish Electromobility Centre" had a total reach of 55.8M potential readers from various media outlets during 2024*. 44.5M comes from a mention in Sina News related to the conference EVS 38. Below is a selection of articles with SEC mentions and researcher participation.

"Sverige behöver de utländska forskarna"; Svenska Dagbladet, 15 Jan
https://www.svd.se/a/4o2OwV/swedish-electromobility-centre-sverige-behover-de-utlandska-forskarna

Undvik eltorsk i jultrafiken – så maxar du elbilsbatteriet, 23 Dec
https://www.sverigesradio.se/artikel/undvik-eltorsk-i-jultrafiken-sa-maxar-du-elbilsbatteriet
https://www.expressen.se/nyheter/sverige/tre-tips-sa-maxar-du-elbilsbatteriet/

Krisen för elbilar – "snarare en anpassning", 28 Sep
https://www.norran.se/ekonomi/artikel/expert-krisen-for-elbilar-kan-sla-ut-satsningar-som-northvolt/lq40knkr

Se hur forskaren på Chalmers svarar om framtiden för elbilar och utveckling, 25 Nov
https://www.svt.se/nyheter/lokalt/halland/tre-fragor-om-elbilar-och-utveckling

AI-controlled stations can charge electric cars at a personal price; Electronic Specifier, 1 June
https://www.electronicspecifier.com/industries/automotive/ai-controlled-stations-can-charge-electric-cars-at-a-personal-price

DB Schenker testkör tunga elektriska transporter; it-hållbarhet, 11 Oct
https://it-hallbarhet.se/db-schenker-testkor-tunga-elektriska-transporter

"Elektrifieringen av de tunga transporterna"; Infrasverige, 14 Oct
http://www.infrasverige.se/elektrifieringen-av-de-tunga-transporterna

Sina News mention, 15 Oct (English translation not available)
https://k.sina.com.cn/article_5350692712_13eed1768001018gj6.html

"VTI och Linköpings universitet firar tio år av framgångsrik samverkan"; Dagens Näringsliv, 25 Oct
https://www.dagensnaringsliv.se/20241025/273787/vti-och-linkopings-universitet-firar-tio-ar-av-framgangsrik-samverkan

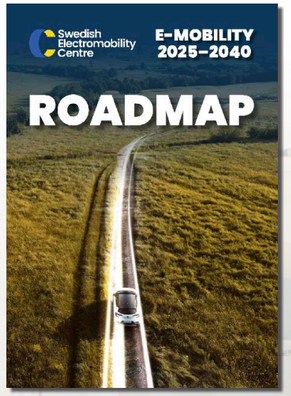
"Elbilars däckslitage ska granskas"; Expressen/Teknikens Värld, 8 Nov
https://teknikensvarld.expressen.se/nyheter/miljo-och-teknik/elbilars-dackslitage-ska-granskas

Samarbete och spets – så tar Göteborg täten i batteriracet; Dagens Infrastruktur, 13 Dec
https://www.dagensinfrastruktur.se/2024/12/13/samarbete-och-spets-sa-tar-goteborg-taten-i-batteriracet/

**Source: Meltwater (an online media, social and consumer intelligence company).*

Roadmap & Milestones

In March SEC held a workshop in Gothenburg to define and plot important e-mobility milestones for 2025-2040 . The day started with an insightful and inspirational introduction of Scania's scenario work by Tiva Sharifi. The workshop was followed up with online discussion meetings, and has resulted in 12 defined milestones visualized in SEC's roadmap.



The milestones are available in SEC's roadmap, and are planned to be presented at the EVS 38 conference in Gothenburg, 2025.

Milestones

- Affordable EVs
- Reliable EVs
- Resource EVs
- Recyclable EVs
- Robust power grid
- Accessible and reliable charging infrastructure
- Standardized communication
- Effectively integrated EVs in the grid
- Sufficient competence supply
- Healthy working conditions
- Self-sufficient semiconductor production in Europe
- Self-sufficient battery production in Sweden (Europe)

E-mobility 2024 Day

An opportunity for all SEC partners to network and hear about the latest research.

The E-mobility Day conference took place in Linköping 27–28 August.

It was excellently hosted by Lars Ericsson and Henrik Gillström from Linköping University. The conferene was a well-attended event with many insightful presentations and engaged interactions from the audience. Topics of discussion were how to model the electromobility system best, be it on the microscale as well as on the macro-level, and how could different models be combined to better determine for example grid capacity and charging infrastructure needed for implementation.

The poster session was well-visited during the coffee breaks with lively networking about project results.

Workshops & Seminars

Workshops, seminars and study visits are an important part of SEC. Cross-theme activities provides a great opportunity for knowledge sharing and possible collaborations. This is an overview of some key events held throughout the year.

Motion resistance modeling
A workshop on motion resistance modeling, covering rolling resistance, air resistance, and grade resistance. These factors significantly impact vehicle driving range, and numerous models for characterizing rolling and air resistance have emerged in recent years.

Axial-flux electrical machines in traction applications
This workshop included a teardown of the YASA motor, a leading axial-flux machine in the automotive industry. Participants discussed opportunities and challenges, identified research gaps, and explored future project ideas.

Online workshop on ICEM '24 conference
An invitation was extended to colleagues in the electrical machines community to share impressions and findings from the ICEM '24 conference held in Torino. The online workshop facilitated collaborative discussions among attendees.

Additive manufacturing of electrical machines
The workshop included a visit to RISE facilities to gain firsthand experience on manufacturing possibilities. Participants concluded the day with a joint exercise to identify research topics and collaboration opportunities.

Sodium batteries for automotive applications
This workshop explored the current status and future prospects of sodium-based batteries, which are promising alternatives to lithium-based batteries. Challenges for their widespread deployment were identified.

System control in battery production and management
In collaboration with Batteries Sweden (BASE), this hybrid session covered topics such as model-based battery manufacturing optimization, smart battery technology, data-driven survival modeling, and innovative battery management approaches.

Workshop at SEEL in Borås
Battery Safety Research and Testing Participants were invited to SEEL in Borås for a workshop on battery safety research and testing, including a visit to the SEEL battery-safety-lab.

Towards electrification of marine transports
This open online seminar focused on the electrification and use of alternative fuels for marine propulsion. Invited speakers shared insights from their work in the transition away from fossil fuels in the marine sector.

Flex services – with the user in focus
This seminar highlighted the potential of EVs to provide flexibility services to the grid, focusing on user perspectives. The workshop included a presentation from Zeekr followed by a discussion.

Cross-theme workshop with SCALE (Smart Charging ALignment for Europe)
This workshop provided insights into the SCALE Project, including an overview of the project, the Energy Planning Tool for charging infrastructure rollout, real-world experiences with EV users, and joint procurement for V2G activities. A Q&A session followed.

Cross-theme seminar on resilience in an electrified and digitalized transport system
The newly started SEC focus group on Resiliene organized this seminar to raise awareness and improve knowledge on resilience. Dr. David Daniels (VTI) presented work published as a MIT Joint Program for Global Change Report "Designing Resilience for Multi-System Dynamics of Future Transportation".

Polestar's path towards sustainable electromobility - A lunch seminar at UU
Polestar, the young Swedish electric car company, presented how it will continue driving the change towards sustainable electromobility.

Battery modeling and aging-sensitive management
Presented the latest results on data-driven battery modelling using linear parameter-varying models.

Data regulation and electromobility
VTI invited workshop on EU-regulation within the areas data sharing, cyber security, and AI related to it's effects on electromobility.

Magnus Karlström editor in chief

omEV Newsletter

2024 has been a year with many facets, including geopolitical tensions, concerns about Europe's competitiveness, lower raw material prices, and continued development of more cost-effective batteries.

Despite discussions about a weak electric vehicle (EV) market in 2024, global sales of plug-in vehicles increased by 25% to 17.7 million. However, sales in Europe declined slightly, and in Sweden, the decline was even more pronounced. The global market was dominated by increased sales in China. Battery-electric vehicles (BEVs) have likely reached price parity with internal combustion engine (ICE) vehicles in terms of purchase price in China. The surge in plug-in hybrid (PHEV) sales in China is particularly noteworthy.

Sales of heavy-duty electric trucks and buses also increased globally. An estimate suggests that around 94,000 heavy-duty vehicles (weighing over 6 tons) were sold in 2024, marking a 60% increase compared to 2023.

Battery prices at the pack level declined in 2024, with an estimated average of $115 per kWh. Additionally, LFP battery cells are now available for as low as $40 per kWh. This decline is driven by lower raw material prices, increased overcapacity—mainly in China—but also by technological advancements in production, product development, and vertical integration. Total battery production capacity increased to 1.45 TWh per year. China continues to dominate in cell production and key components.

Several policies and regulatory measures have been introduced to support and develop the battery industry. In 2024, the focus has been on diversifying the supply chain, accelerating domestic industry, and increasing control over the value chain. In China, much of the policy effort has aimed at reducing overcapacity. In the U.S., the Inflation Reduction Act (IRA) has driven an increase in domestic battery production capacity while also limiting China's ability to sell its products in the American market. In Europe, the EU has imposed tariffs on Chinese EVs. The battery industry has intensified its focus on cost reduction due to heightened competition and significantly lower market prices.

Regarding charging infrastructure, interest in vehicle-to-grid (V2G) technology has increased. Other widely discussed topic include resilience. For heavy-duty vehicles, discussions often revolve around ensuring grid capacity for charging.

Europe has experienced declining growth since the turn of the millennium, with productivity levels lower than in the U.S. and a relatively weak position in emerging technologies. Ursula von der Leyen tasked Mario Draghi with analyzing the EU's competitiveness. In his report, Draghi proposed a stronger focus on linking the green transition with competitiveness, increasing funding for research, coordinating policies at the EU level, and significantly raising annual investment levels in the EU. The implementation of parts of the Draghi report will likely have a substantial impact on Sweden and electromobility.

omEV is a newsletter and podcast about electric road vehicles. It's funded by Swedish Energy Agency and hosted by Swedish Electromobility Centre. https://www.omev.se

In research, the **number of publications** in the electric vehicle field is **rising sharply**. Globally, China and India are increasingly dominating in terms of publication volumes. Sweden's contribution to research on vehicle electrification—as well as in three key enabling technologies: batteries, electric machines, and fuel cells—remains relatively stable at around 1% of global output.

India also experienced strong economic growth in 2024 and increased its focus on electromobility. The country aims to build a domestic battery industry and is particularly interested in electrifying smaller vehicles. In South America, China strengthened its position by increasing its ownership of mines while also building up vehicle and battery production. More broadly, a clear trend in 2024 was China's substantial investment in the Global South. This can be seen as an indicator that this part of the world will grow in importance as electromobility enters its next phase and becomes truly global.

Partner Council

Members	
Anders Palmqvist	Chairman (Chalmers)
Annika Borgenstam	KTH
Marcus Lindahl	Uppsala University
Per Dannetun	Linköping University
Heiner Linke	Lund University
Magnus Berg	Vattenfall
Elna Holmberg	Volvo Group
Erik Dahlberg	Scania
Stefan Christiernin	Volvo Cars
Gabriel Domingues	BorgWarner
Per Stavered	Zeekr
Dmitry Svechkarenko	ABB
Katarina Öqvist	Epiroc
Andreas Bodén	PowerCell
Jonas Jansson	VTI
Arnaud Contet	TitanX
Boel Ekergård	University West
Hans Kling and Alessandro Dell´Amico	SAAB Group
Magnus Forsén	Alstom
Elin Eriksson	IVL
Peter Thelin and Heléne Sarbrant	E.ON
Peter Öhman	Lindholmen Science Park
Jens Hagman	RISE
No representative	X Shore
Jenny Frodelius Lang	Polestar
Pontus Fyhr	Alvier Mechatronics
John Nilsson	Swedavia
Jan-Ola Olsson	Aurobay

Co-opted members	
Linda Olofsson	SEC
Ellen Olausson	SEC
Klaas Burgdorf	Swedish Energy Agency

Program Council

Members	
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Niklas Legnedahl	Zeekr
Robert Eriksson	Volvo Cars
Elna Holmberg	Volvo Group
Tiva Sharifi	Scania
Tomas McKelvey	Chalmers
Lina Bertling Tjernberg	KTH
Öivind Andersson	Lund University
Maria Huge-Brodin	Linköping University
Cecilia Boström	Uppsala University
Lina Nordin	VTI
Boel Wadman	RISE
Maria Rosqvist, E.ON	stakeholder's representative
Ganesh Chandramouli, Alstom Group	stakeholder's representative

Co-opted members	
Linda Olofsson, Director	SEC
Ellen Olausson, Dep. Director	SEC
Jonas Fredriksson	Chalmers
Lars Eriksson	Linköping University
Fran Márquez-Fernández	Lund University
Mats Leksell	KTH
Daniel Brandell	Uppsala University
Björn Eriksson	KTH
Henrik Gillström	Linköping University
Anders Nordelöf	Chalmers
Mikael Lantz	Lund University
Valeria Castellucci	Uppsala University
Magnus Karlström	SEC - omEV
Klaas Burgdorf	Swedish Energy Agency
Magnus Lindgren	Swedish Transport Administration
Dmitry Svechkarenko	ABB
Arnaud Contet	TitanX
Andreas Bodén	PowerCell
Katarina Öquist	Epiroc
Christian Gruffman	Vattenfall
Gabriel Domingues	BorgWarner
Boel Ekergård	University West
Hans Kling and Alessandro Dell´Amico	SAAB Group
Magnus Forsén	Alstom Group
Elin Eriksson	IVL
Pär-Ola Andersson and Heléne Sarbrant	E.ON
Peter Öhman	Lindholmen Science Park
No representative	X Shore
Jenny Frodelius Lang	Polestar
Tua Högnäs and Pontus Fyhr	Alvier Mechatronics
John Nilsson	Swedavia
Alexandra Tokat	Aurobay

International scientific board

Anna Teyssot, Verkor, France
Giorgio Rizzoni, Ohio State University, US
Keith Hardy, Argonne National Laboratory, US
Patrick Plötz, Fraunhofer ISI, Germany

Management Group & Staff

Linda Olofsson
Director

Ellen Olausson
Deputy Director

Jens Hagman
RISE

Jonas Fredriksson
Theme 1

Lars Eriksson
Theme 1

Luca Peretti
Theme 2

Francisco Márquez-Fernández
Theme 2 & VTI

Göran Lindbergh
Theme 3

Daniel Brandell
Theme 3

Anders Nordelöf
Theme 4

Henrik Gillström
Theme 4

Valeria Castellucci
Theme 5

Mikael Lantz
Theme 5

Liridona Sopjani
Coordinator Doctoral Student Network

Anna Abelius
Administrator and Events coordinator

Pia Karlsson
Financial Officer

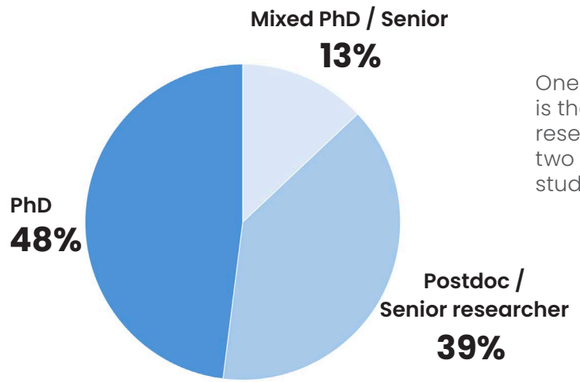
Angelika Adlercreutz
Financial Officer

Marcus Folino
Communications Officer

Magnus Karlström
Editor in Chief omEV

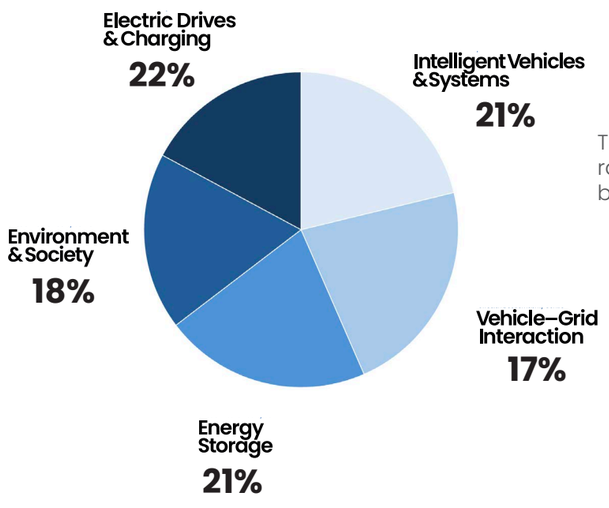
Centre Finance

Project types



One of the centre's objectives is that half of the SEC funded research projects, that last for two years or more, must be PhD student projects.

Project distribution



The number of projects are rather evenly distributed between the five themes.

Cash funder distribution in SEC associated projects

SEC associate projects plays an important part for expanding knowledge and experiences within the electromobility research community.

*The Knowledge Foundation, Statens Vegvesen, FFI (Strategic Vehicle Research and Innovation), Volvo Group

Appendix

Projects 2024 (46 in total)

Project title	Theme(s)	Project manager	Partners	International collaboration	Females	Males
ACTUAL grid and road simulation for e-mobility (extension)	5, 2	Francisco Marquez-Fernandez	LTH, KTH, Volvo Cars, Volvo Group, E.ON, Scania, Zeekr		1	2
Air System Modeling for Efficient FCEV – ASMEF	1, 3	Öivind Andersson	LTH, LiU, Volvo Group		1	1
Alternative PFAS free binders and electrolytes	3, 4	Stacy Trey	UU, Volvo Group		4	4
CHARGE – Charging and Trip Planning of Electric Vehicles	1, 5	Nikolce Murgovski	Chalmers, UU, VTI, Volvo Cars, Zeekr, E.ON	TU Delft, The Netherlands, Azita Dabiri; TU Eindhoven, The Netherlands; Emilia Silvas, ETH, Switzerland, Christopher Onder; Indian Institute of Technology, Jammu, India, Nalin Kumar Sharma; Indian Institute of Information Technology and Management Gwalior, India, Rajan Chaudhary and Sri Niwas Singh		3
Cost & Benefit Analysis of V2G Scenarios	5, 1, 3	Jonas Hellgren	RISE, LiU, Volvo Cars, E.ON, Vattenfall			3
Dansmästaren Project – Smart Charging Strategies	5	Valeria Castellucci	UU, Zeekr, Volvo Cars	Politecnico di Milano, Italy, Giambattista Gruosso	2	2
Data REgulation And electroMobility (DREAM)	4	Jeanette Andersson	VTI, Volvo Cars, Zeekr, Scania		2	2

Project title	Theme(s)	Project manager	Partners	International collaboration	Females	Males
Design and Control of Brushless Excitation for EESMs	2	Yujing Liu	Chalmers, Volvo Group, Volvo Cars		3	7
Design of rare earth element free motors for electromobility – Part 2	2, 4	Sandra Eriksson	UU, Alstom Group, Scania	EU-projects GENIUS and BEETHOVEN	2	1
Diagnostics of dynamically configurable battery systems	1, 2	Mattias Krysander	LiU, Scania	Rennes University, Rennes, France, Albert Benveniste, Benoît Caillaud, Mathias Malandain; Helmut-Schmidt-Universität / Universität der Bundeswehr Hamburg, Germany, Alexander Diedrich	1	2
Durability effects of high frequency pulse charging	3, 2	Torbjörn Thiringer	Chalmers, Volvo Cars			4
ECOTS – Evaluation and Control Of Thermal management Systems	1, 2, 3	Lars Eriksson	LiU, Volvo Group, TitanX, Epiroc, Volvo Cars	University of Salerno, Italy; Jilin University in Changchun, China		3
Eddy current effects in electrical steel	2	Pär Ingelström	RISE, Chalmers, LTH, Volvo Cars, Volvo Group		1	6
Electric motor + hydraulic pump fusion for electrification	2, 1	Liselott Ericson	LiU, Volvo Group	Purdue University, USA; Volvo Construction Equipment, South Korea	1	1

Projects 2024

Project title	Theme(s)	Project manager	Partners	International collaboration	Females	Males
E-machine design and environmental impact - part 2	2, 4	Torbjörn Thiringer	Chalmers, VTI, UU, Volvo Group, BorgWarner, Volvo Cars, Alvier Mecatronics, Aurobay		4	4
Energy Management Strategies for Electrified Vehicles Under Traffic Uncertainties	1	Jonas Fredriksson	Chalmers, Zeekr, Scania, Volvo Group, Volvo Cars			2
Fossil-free long-haul trucks in Europé	4	Maria Grahn	Chalmers, Volvo Group, Scania, TitanX	California State University, Los Angeles, USA, David Blekhman; Colorado state University, USA, Juan Felipe Rodriguez Rueda	2	3
Fuel Cell Performance Prediction	3	Rakel Wreland Lindström	KTH, ABB, PowerCell, Volvo Group		2	3
Fuel Cell Performance Prediction – Continuation	3	Rakel Wreland Lindström	KTH, PowerCell		2	3
FUTURITE – Ferrite synchronous motors for future electromobility	2, 1, 4	Sandra Eriksson	UU, Alstom Group, Scania	University College London, Pedram Asef; EU-projects GENIUS and BEETHOVEN	2	1
Gas analysis of large-format EV batteries	3	Erik Berg	UU, Scania, Volvo Group	BMW Group, J Scharf, C von Lüders, FM Matysik, J Wandt		3
Heterogenic Ageing in Large Intercalation Batteries (HALIBatt-KTH) – KTH	3	Rakel Wreland Lindström	KTH, Scania, Volvo Group, Zeekr, Volvo Cars	Kyushu University, Japan, scholarship from STINT and Japan Society for Promotion of Science	1	3

Projects 2024

Project title	Theme(s)	Project manager	Partners	International collaboration	Females	Males
Heterogenic Ageing in Large Intercalation Batteries (HALIBatt-UU) – Uppsala	3	Fredrik Björefors	UU, Volvo Group, Scania, Zeekr, Volvo Cars	Kyushu University, Japan, scholarship from STINT and Japan Society for Promotion of Science	2	2
High Power Charging: When, where and how? – Part 2	5	Karin Thomas	UU, Scania, Volvo Group, Zeekr		1	1
How to test V2G technology	5, 1, 3	Jonas Hellgren	RISE, LiU, E.ON, Volvo Cars, Scania, Zeekr, Vattenfall			3
INSLIFE – Prediction of lifetime for a sustainable insulation system for electromobility applications	2	Sandra Eriksson	UU, LTH, Polestar, Volvo Group, Scania		1	2
Investigate battery degradation via LSRI techniques	3	Simone Sala	RISE, Scania, Volvo Group		1	3
LEAR – Robust LEArning methods for electric vehicle Route selection	1, 2, 5	Balazs Kulcsar	Chalmers, Volvo Group			3
Life Cycle Assessment of Large-Scale Lithium-Ion Battery Production and Recycling – Part 2	4	Anders Nordelöf	Chalmers, Zeekr, Volvo Cars, Volvo Group, Scania	Universiteit Leiden, The Netherlands		3
Life Cycle Assessment of vehicle-to-x	4, 2, 5	Anders Nordelöf	Chalmers, Volvo Cars	Infineon Technologies AG, India, and TU Munich, Germany	2	1
Logging of Electric Vehicles – Characterization of Charging Patterns and Grid Impacts	5, 4	Maria Taljegård	Chalmers, Volvo Cars, Zeekr	Geotab	1	2
ML Assisted Ageing Predicition and Adaptive Modelling for BMS	3	Torsten Wik	Chalmers, UU, Volvo Group, Volvo Cars, Epiroc, Zeekr, ABB	National Renewable Energy Laboratory, CO, USA, Donal P. Finegan	1	5

Projects 2024

Project title	Theme(s)	Project manager	Partners	International collaboration	Females	Males
Modelling of a PMSM accounting for 'position harmonics' and control in order to establish the possibility of reducing ripple and keeping highest possible efficiency	2	Torbjörn Thiringer	Chalmers, Volvo Cars, Alstom Group, Aurobay			4
Multi-criteria optimal motion control of automated EVs	1	Wenliang Zhang	KTH, Volvo Cars	University of Freiburg, Germany, Moritz Diehl	2	2
Optimal energy management of second life batteries	1, 3, 5	Jonas Hellgren	RISE, Volvo Group			2
Planning Support for Electric Vehicles based on Optimal Control	1	Lars Eriksson	LiU, Scania, Volvo Group	Ohio State University, Columbus, OH, USA; University of Alabama, Tuscaloosa, Alabama, USA; TU Wien, Vienna, Austria; TU/e, Eindhoven, The Netherlands; University of Salerno, Salerno, Italy; Kyungpook National University, Daegu, Korea		1
Practical LCA-models for strategic and critical EV minerals	4	Anders Nordelöf	VTI, Volvo Group, BorgWarner	BorgWarner, Germany	1	1
Quantifying Harmonics Caused by Smart Charging and V2X	5, 2	Alexander Wallberg	UU, Volvo Cars, Zeekr, Vattenfall		3	6
Resource-Effective Batteries and Charging for BEVs	4, 3	Kristina Holmgren	RISE, VTI, Volvo Cars, Zeekr		3	3
Reversed Li-trapping cycling	3, 5	David Rehnlund Maibach	UU, Polestar		1	4
Sustainable axial flux motors for vehicle applications	1	Sonja Tidblad Lundmark	Chalmers, Volvo Cars, Volvo Group		3	2

Projects 2024

Project title	Theme(s)	Project manager	Partners	International collaboration	Females	Males
Testing, Analysis and Design of Axial Flux Motors for Vehicle Applications	2	Sonja Tidblad Lundmark	Chalmers, ABB, Volvo Group, Volvo Cars	Summer school in Modena, Italy, organ-ised by Motor vehicle University of Emilia-Romagna, University of Modena and Reggio Emilia, Fondazione Demo center, and Committees of the IEEE IES, IEEE PELS, and DORNA Project	3	2
Total loss minimization algorithms in electric drives for e-mobility	2	Luca Peretti	KTH, Volvo Cars, Zeekr, ABB			1
Tyre wear and particle emissions of electric vehicles – a review of test methods and influencing parameters	4, 1	Mats Gustafsson	VTI, Volvo Cars		1	3
Tyre wear and tyre particle emissions from electric vehicles	4, 1	Mats Gustafsson	VTI, Volvo Cars,		2	3
V2G to manage variations in the electricity system – environmental performance	5, 4	Maria Taljegård	Chalmers, Volvo Cars, Zeekr		2	1

Associated projects 2024 (26 in total)

Project name	Funder	Theme(s)	Project manager	SEC partners	Other partners
Battery lifetime prediction	FFI	1, 3	Faisal Altaf	Chalmers, Volvo Group	
Low carbon transport solutions	Statens Vegvesen	4, 5	Maria Taljegård	Chalmers	
User behaviour informed optimal control for vehicle-home-grid integration	Swedish Energy Agency	5	Changfu Zou	Chalmers, Polestar	
Condore – Customer-oriented operations research for electrification	Swedish Energy Agency	1	Viktor Leek	Linköping University, Scania	Ragn-Sells, DAGAB
Data-driven lifetime extension and performance optimization for vehicle battery systems	Swedish Energy Agency	3	Changfu Zou	Chalmers, CEVT	
Energy efficient propulsion system	Swedish Energy Agency	2	Léon Löwered	Chalmers, CEVT	
Energy efficient thermal management	Swedish Energy Agency	1	Kristian Nicklasson	Chalmers, CEVT	
EPOS – Electric Powertrain OptimiSation for Vehicles and Fleet	Swedish Energy Agency	2	Mats Alaküla	Lund University, BorgWarner	Haldex
FEAT – Fleet management for efficient and sustainable electric micromobility systems	Swedish Energy Agency	1	Jiaming Wu	Chalmers	
High performing circular battery flows	Swedish Energy Agency	4	Patricia van Loon	Chalmers, Scania, Volvo Cars	Nilar, Umicore, Göteborg Energi, LTS
Life cycle assessment of future battery chemistries – high storage capacity without scarce resources?	Swedish Energy Agency	4	Rickard Arvidsson	Chalmers	
Multi-Scale Modelling the Interfacial Chemistry in Solid-State Batteries	Swedish Energy Agency	3	Daniel Brandell	Uppsala University	Karlstad University

Project name	Funder	Theme(s)	Project manager	SEC partners	Other partners
Optimization of electrical machines based on new standardized drive cycles	Swedish Energy Agency	2	Sandra Eriksson	Uppsala University	
Sustainability transitions in urban goods distribution: local arenas as enablers of technology diffusion	Swedish Energy Agency	4	Thomas Magnusson	Linköping University	
Towards safe energy communities – Protected data collection and data sharing for demand flexibility at Dansmästaren	Swedish Energy Agency	5	Valeria Castellucci	Uppsala University, Vattenfall, Volvo Cars	Uppsala Parkerings AB, Uppsala kommun
Business models for electrified logistics	Swedish Transport Administration	4	Maria Huge-Brodin, Magnus Blinge	Linköping University, Scania	
Effekter av laddinfrastruktur på benägenheten att köpa laddbar bil	Swedish Transport Administration	4	Ida Kristoffersson	VTI	
EVÅLUTION – Elektrifieringens utveckling ur ett åkeriperspektiv	Swedish Transport Administration	4	Jessica Wehner	VTI, Linköping University	
System-level impact of electrification on the road freight transport system – a System Dynamics approach	Swedish Transport Administration	4	Anna Pernestål	KTH, Linköping University	
TRACER – Transport DemAnd Centric Decision Support for Electric ChaRging Infrastructure and Planning Operations	Swedish Transport Administration	1	Győző Gidofalvi	KTH, Scania	
Electrification for sustainable energy system – Educational project	The Knowledge Foundation	5	Boel Ekergård	Uppsala University, Högskolan Väst	
E-charge System demonstration of electrified long-haul transports	Vinnova	4	Gunnar Ohlin	Linköping University, ABB, Vattenfall, Volvo Group	Tommy Nordbergh Åkeri, Circle K, OKQ8, ICA Sverige AB, DB Schenker

Associated projects 2024

Project name	Funder	Theme(s)	Project manager	SEC partners	Other partners
REEL 2 Våg 1 – Systemdemonstrationer av Regionalt Elektrifierad Logistik	Vinnova	4, 5	Andreas Josefsson	Lund University, Chalmers, Linköping University, Scania, Volvo Group	CLOSER vid Lindholmen Science Park, Einride etc. (around 30 partners are involved in the project)
Electromobility in smart cities	Vinnova, Swedish Energy Agency	3, 4, 5	Rafael Waters	Uppsala University, Vattenfall	Uppsala Parkerings AB, STUNS
Modelling of electric power systems in electric vehicles	Volvo Group	2	Mats Alaküla	Lund University, Volvo Group	
TVS Modelling	Volvo Group	2	Per Widek	Lund University, Volvo Group	

Events 2024

Event name	Date	Theme(s)/ Academic Partner	Event type
Seminarium: Logging of electric vehicles – characterization of driving and charging patterns	2024-01-09	Theme 5	Theme workshop
Polestar's path towards sustainable electromobility – A lunch seminar at Uppsala university	2024-02-28	Uppsala University	University workshop
Milstolpar för framtidens storskaliga elektromobilitet	2024-03-12	Theme 1, 2, 3, 4 and 5	Cross-theme workshop
Seminarium: Towards Electrification of Marine Transports	2024-04-17	Theme 4	Theme workshop
Workshop: The Future of Theme 2 and Visit to Alstom	2024-04-23	Theme 2	Theme workshop
Seminarium: Electrical Machines Project Update	2024-05-14	Theme 2	Theme workshop
Workshop inom datareglering	2024-05-20	VTI	Theme workshop
Workshop: Motion resistance modeling	2024-05-28	Theme 1	Theme workshop
Workshop: Sodium batteries for automotive applications: Current status and future prospects	2024-05-30	Theme 3	Theme workshop
Workshop: Additive Manufacturing of Electrical Machines	2024-06-11	Theme 2	Theme workshop
MSc Thesis Bonanza	2024-06-11	Theme 3	Theme workshop
Seminarium: MSc Thesis Bonanza of SEC Theme Environment & Society	2024-06-17	Theme 4	Theme workshop
MSc Thesis Bonanza	2024-06-18	Theme 1	Theme workshop
E-mobility Day	2024-08-27/28	SEC	SEC Centre Conference
Thomas Ekström, Försvarshögskolan	2024-08-30	VTI and RISE	Cross-theme workshop
Workshop: SEC stage V half-time - SEC Program council	2024-09-24	Theme 1, 2, 3, 4 and 5	Cross-theme workshop
Workshop on ICEM '24 conference	2024-10-02	Theme 2	Theme workshop
Cross-theme workshop with SCALE	2024-10-08	Theme 4 and 5	Cross-theme workshop
Workshop: Battery Safety	2024-10-09	Theme 3	Theme workshop
Workshop: Axial-flux electrical machines in traction applications	2024-11-06	Theme 2	Theme workshop
Seminarium: PAVE V2G Pilot Project in Sweden (Yuki Kobayashis projekt)	2024-11-07	Theme 5	Theme workshop
Fokusgrupp Resilience	2024-11-07	VTI and RISE	Cross-theme workshop
Seminarium: Patrick Plötz	2024-11-15	Theme 4	Theme workshop
SCSSS 2024	2024-11-19/20	SEC and TECoSA Centre (KTH)	Collaboration event
Workshop: System Control in Battery Production and Management	2024-12-13	Theme 3/SEC + BASE	Theme workshop

Peer reviewed journal articles and conference papers 2024

Title	Author(s)	Journal	doi or other reference
A Model Predictive Control Method With Adaptive Weighting Factors for Enhancing Performance of Modular Multilevel Converters	C. Tang and T. Thiringer	IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 12, no. 4, pp. 3887-3899, Aug. 2024	doi: 10.1109/JESTPE.2024.3415491
A Novel Energy Management Strategy for PHEV Considering Cabin Heat Demand Under Low Temperature Based on Reinforcement Learning	K. Li et al.	IEEE Transactions on Transportation Electrification, vol. 11, no. 1, pp. 3062-3077, Feb. 2025	doi: 10.1109/TTE.2024.3434521
A Physics-Informed Cold-Start Capability for xEV Charging Recommender System	R. Orbay et al.	IEEE Open Journal of Vehicular Technology, vol. 5, pp. 1457-1469, 2024	doi: 10.1109/OJVT.2024.3469577
A Stochastic Theory of Longitudinal Dynamics and Energy Consumption of Road Vehicles	L. Romano, K. Podgórski, C. Emvin, P. Johannesson, J. Fredriksson and F. Bruzelius	IEEE Transactions on Intelligent Vehicles	doi: 10.1109/TIV.2024.3435980
A Study in Additive Manufacturing of Windings for Traction Machines	S. Estenlund, E. Adolfsson and S. Hosseini	2024 International Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM), Napoli, Italy, 2024, pp. 1302-1308	doi: 10.1109/SPEEDAM61530.2024.10609139
Midway Review	Alice Jansson	Luleå University of Technology, 2024	-
An Analysis of Vehicle-to-Grid in Sweden Using MATLAB/Simulink	Jennifer Leijon, Jessica Santos Döhler, Johannes Hjalmarsson, Daniel Brandell, Valeria Castellucci, Cecilia Boström	World Electric Vehicle Journal. April 2024; 15(4):153	doi: 10.3390/wevj15040153
An open data-based model for generating a synthetic low-voltage grid to estimate hosting capacity	Therese Lundblad, Maria Taljegård, Niclas Mattsson, Elias Hartvigsson, Filip Johnsson	Sustainable Energy, Grids and Networks 39 (2024) 101483	doi: 10.1016/j.segan.2024.101483
Attention On What Is Important: Improving Neural Encoders for Routing Problems (Licentiate thesis)	Attila Lischka	Chalmers University of Technology, 2024	https://research.chalmers.se/en/publication/542454

Peer reviewed journal articles and conference papers 2024

Title	Author(s)	Journal	doi or other reference
Challenges for multi-quadrant hydraulic piston machines	Thomas Heeger, Samuel Kärnell, Liselott Ericson	Energy Conversion and Management: X, Vol. 22, Artikel 100578	doi: 10.1016/j.ecmx.2024.100578
Computationally efficient algorithm for optimal battery preconditioning and charging of electric vehicles	L. Montalto, N. Murgovski and J. Fredriksson	IEEE Conference on Intelligent Transportation Systems. Edmonton, Canada, 2024	-
Control-oriented 2D thermal modelling of cylindrical battery cells for optimal tab and surface cooling.	Peprah, G. K., Wik, T., Huang, Y., Altaf, F., & Zou, C.	In IEEE American Control Conference (ACC), pp. 4651-4656 (2024, July)	-
Control-oriented Model for Thermal Energy Management of Battery Electric Vehicles	Prashant Lukor, Nikolce Murgovski, Mikael Larsson	IEEE Transactions on Vehicular Technology	doi: 10.1109/TVT.2024.3508022
Core Loss Tracking of Stator Core Testing via Inverse Jiles-Atherton Hysteresis Model	L. Colombo, A. Reinap, J. Ryan and P. Fyhr	2024 International Conference on Electrical Machines (ICEM), Torino, Italy, 2024, pp. 1-8	doi: 10.1109/ICEM60801.2024.10700080
Correlation as a method to assess electricity users' contributions to grid peak loads: A case study	Carl Flygare, Alexander Wallberg, Erik Jonasson, Valeria Castellucci, Rafael Waters	Energy, Vol. 288, February 2024, 129805, ISSN 0360-5442	doi: 10.1016/j.energy.2023.129805
Data-driven battery aging diagnostics and lifetime extension (PhD thesis)	Yizhou Zhang	Chalmers University of Technology, 2024	https://research.chalmers.se/publication/543724
Decoupling Degradation at the Electrode Interfaces in Prussian White Full Cells	C Misiewicz, AE Ulander, T Melin, A Hall, EJ Berg	Advanced Materials Interfaces, 2024, 2400854	doi: 10.1002/admi.202400854
Direct air cooled hollow windings: Performance enhancement of electrically excited machines (PhD thesis)	Samuel Estenlund	Lund University, 2024	https://portal.research.lu.se/en/publications/direct-air-cooled-hollow-windings-performance-enhance-ment-of-elec
Dispatchable Battery Swapping System with Centralized Charging and Renewable Energy Generation	E. Wallander and F. J. Márquez-Fernández	2024 IEEE International Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles & International Transportation Electrification Conference (ESARS-ITEC), Naples, Italy, 2024, pp. 1-6	doi: 10.1109/ESARS-ITEC60450.2024.10819821

Peer reviewed journal articles and conference papers 2024

Title	Author(s)	Journal	doi or other reference
Distributed cooperative control of two electric vehicles in hilly terrain	N. K. Sharma, J. Rogestedt, J. Rehn, H. Hjelm, A. Ramadhan, R. Chaudhary, N. Murgovski, and S. N. Singh	2024 IEEE Int. Conf. Interdiscip. Approaches Technol. Manag. Soc. Innov. IATMSI, vol. 2, Mar. 2024, pp. 1–5	doi: 10.1109/IATMSI60426.2024.10502640
Dynamic Control, Parameter Identification and Field Current Estimation for Electrically Excited Synchronous Machines (PhD thesis)	Bowen Jiang	Chalmers University of Technology, 2024	https://research.chalmers.se/en/publication/543355
Efficiency Evaluation of a Conductive Electric Road System With Respect to Traffic Characteristics	D. Wenander, F. J. Márquez-Fernández and M. Alaküla	IEEE Transactions on Vehicular Technology, vol. 73, no. 4, pp. 4694-4704, April 2024	doi: 10.1109/TVT.2024.3362533
Electrifying road freight: With whom to coordinate and why? (Licentiate thesis)	My Jobrant	Linköping University, 2024	https://liu.diva-portal.org/smash/get/diva2:1909113/FULLTEXT01.pdf
Energy and time optimal control of autonomous vehicles by using Frenet frame modelling and over actuation	Wenliang Zhang, Lars Drugge, Mikael Nybacka, Jenny Jerrelind, Derong Yang, Rudolf Reiter, Jonathan Frey, and Annika Stensson Trigell	16th International Symposium on Advanced Vehicle Control (AVEC' 24), 2024, pp. 447–453	doi: 10.1007/978-3-031-70392-8_64
Energy efficiency of hydrogen for vehicle propulsion: On- or off-board H2 to electricity conversion?	Tatiana Santos Andrade, Shangwei Zhou, Jia Di Yang, Nimananda Sharma, Rhodri Jervis, Torbjörn Thiringer	International Journal of Hydrogen Energy, Volume 92, 2024, Pages 1493-1499	doi: 10.1016/j.ijhydene.2024.10.349
Enhancing the Stability and Performance of Ni-rich Cathode Materials through Ta Doping: A Combined Theoretical and Experimental Study	F Monsees, C Misiewicz, M Dalkilic, D Diddens, A Heuer	Physical chemistry chemical physics (2024, accepted), 2025, 27, 834-843	doi: 10.1039/D4CP03911D
Environmental life cycle impacts of lithium-sulfur and sodium-ion batteries (Licentiate thesis)	Sanna Wickerts	Chalmers University of Technology, 2025	https://research.chalmers.se/publication/540911/file/540911_Fulltext.pdf
EV charging load forecast using LSTM: A case study at a multi-functional building in Uppsala, Sweden	Marina Martins Mattos, Alexander Wallberg, Renan Maciel, Martina Tibaldi, Rafael Waters, Valeria Castellucci	IET Powering Net Zero Week, Birmingham, UK, 3-6 December 2024, Volume 2024, Issue 32	doi: 10.1049/icp.2024.4504

Peer reviewed journal articles and conference papers 2024

Title	Author(s)	Journal	doi or other reference
Experimental Evaluation of Submodule Losses in Battery-Integrated MMCs with NLM and PSPWM	Arvind Balachandran, Tomas Jonsson, Lars Eriksson	2024 IEEE Applied Power Electronics Conference and Exposition (APEC)	doi: 10.1109/APEC48139.2024.10509105
Exploring the Potential Demand Side Flexibility of a Microgrid: A Case Study at a Multi-Functional Building in Uppsala, Sweden	Martina Tibaldi, Alexander Wallberg, Marina Martins Mattos, Rafael Waters, Valeria Castellucci	IEEE ESARS-ITEC Europe 2024, Naples, Italy, 26-29 November 2024	doi: 10.1109/ESARS-ITEC60450.2024.10819865
Exploring various facets of modelling solid-state electrolytes (Licentiate thesis)	Melania Kozdra	Uppsala University, 2024	-
Fault Diagnosability Analysis of Multi-Mode Systems	Fatemeh Hashemniya, Benoît Caillaud, Erik Frisk, Mattias Krysander, Mathias Malandain	IFAC-PapersOnLine, Volume 58, Issue 4, 2024, Pages 210-215, ISSN 2405-8963	doi: 10.1016/j.ifacol.2024.07.219
Formation of a Cathode Electrolyte Interphase on High-Voltage Li-ion Cathodes	C Misiewicz, K Edström, EJ Berg	Chemistry of Materials 36 (2024) 9729-9740	doi: 10.1021/acs.chemmater.4c01872
Gas evolution in large-format automotive lithium-ion battery during formation: Effect of cell size and temperature	J Scharf, C von Lüders, FM Matysik, C Misiewicz, J Wandt, EJ Berg	Journal of Power Sources 603 (2024) 234422	doi: 10.1016/j.jpowsour.2024.234419
Geometry Optimization of an Interior Permanent Magnet Machine for Minimal Life Cycle Cost in City, Rural and Highway Driving	E. Jansson, T. Thiringer and E. A. Grunditz	2024 International Conference on Electrical Machines (ICEM), Torino, Italy, 2024, pp. 1-7	doi: 10.1109/ICEM60801.2024.10700412
Harmonic Characterization of Electrically Driven Pumps	Thomas Heeger, Martin West, and Liselott Ericson	Global Fluid Power Society, GFPS PhD Symposium 2024, 17 till 20 June 2024	-
Highly thermal conductive graphene-based heatsink tailored for electric propulsion SiC-based inverter	Sepideh Amirpour, Raik Orbay, Torbjörn Thiringer, Majid Kabiri Samani, Georgios Mademlis, Daniel Larsson, Andreas Andersson	Applied Thermal Engineering, Volume 243, 2024, 122548	doi: 10.1016/j.applthermaleng.2024.122548
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Identifying Parameters for Aging-Adaptive Battery Management (PhD thesis)	Moritz Streb	KTH, 2024	https://kth.diva-portal.org/smash/get/diva2:1828178/FULLTEXT01.pdf
Improved Parametric Representation of IM From FEM for More Accurate Torque Predictions: Simulations and Experimental Validations	M. -J. Hsieh, E. A. Grunditz and T. Thiringer	IEEE Transactions on Industry Applications, vol. 60, no. 5, pp. 6660-6671, Sept.-Oct. 2024	doi: 10.1109/TIA.2024.3403806
Influence of AFIR's charging station spacing requirement on heavy-duty vehicle electrification rate	Ingelström, M., & Marquez Fernandez, F. J.	12th Symposium of the European Association for Research in Transportation, Aalto, Finland	https://transp-or.epfl.ch/heart/2024/abstracts/hEART_2024_paper_8935.pdf
Influence of Flux Barrier Shape and Mechanical Constraints on Field-Weakening Performance in Double-Layer Interior Permanent Magnet Machines	E. Jansson, T. Thiringer and E. A. Grunditz	IEEE Transactions on Energy Conversion, vol. 40, no. 1, pp. 30-42, March 2025	doi: 10.1109/TEC.2024.3421954
Influence of state of charge window on the degradation of Tesla lithium-ion battery cells	Nildari Roy Chowdhury, Alexander J. Smith, Kristian Frenander, Anastasiia Mikheenkova, Rakel Wreland Lindström, Torbjörn Thiringer	Journal of Energy Storage, Volume 76, 2024, 110001	doi: 10.1016/j.est.2023.110001
Infrastructural requirements for indirect and direct electrification of road transportation (Licentiate thesis)	Therese Lundblad	Chalmers University of Technology, 2024	https://research.chalmers.se/publication/540673
Integrating an Energy Management System in a Multifunctional Building to Enable E-mobility (PhD thesis)	Alexander Wallberg	Uppsala University, 2024	https://www.diva-portal.org/smash/get/diva2:1897396/FULLTEXT01.pdf
Low platinum fuel cell as enabler for the hydrogen fuel cell vehicle	Tatiana Santos Andrade, Torbjörn Thiringer	Journal of Power Sources, Volume 598, 2024, 234140	doi: 10.1016/j.jpowsour.2024.234140
Machine learning-based lifelong estimation of lithium plating potential: A path to health-aware fastest battery charging.	Zhang, Y., Wik, T., Bergström, J., & Zou, C.	Energy Storage Materials, 74, 103877.	doi: 10.1016/j.ensm.2024.103877
Mapping an Optimum DC-Link Voltage across the Entire SiC-Based EV Drive Regions Using a Synchronous Boost DC-DC Converter	Amirpour, S., Thiringer, T., and Xu, Y.	SAE Technical Paper 2024-01-2218, 2024	doi: 10.4271/2024-01-2218

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Measurements of the Electric Properties of the Current Collector in a Conductive Electric Road	D. Wenander, F. J. Márquez-Fernández and M. Alaküla	2024 ELEKTRO (ELEKTRO), Zakopane, Poland, 2024, pp. 1-6	doi: 10.1109/ELEKTRO60337.2024.10557093
MINN: Learning the dynamics of differential-algebraic equations and application to battery modeling	Huang, Y., C. Zou, Y. Li, and T. Wik	IEEE Transactions on Pattern Analysis and Machine Intelligence	doi: 10.1109/TPAMI.2024.3456475
Modeling and Control of Electrical Multiphase Machines for Pole-Transition and Fault-Tolerance (PhD thesis)	Yixuan Wu	KTH, 2024	https://www.diva-portal.org/smash/get/diva2:1906380/SUMMARY01.pdf
Modelling, parameter identification and aging-sensitive management of lithium-ion batteries in heavy-duty electric vehicles (PhD Thesis)	Malin Andersson	KTH, 2024	https://kth.diva-portal.org/smash/get/diva2:1841945/FULLTEXT01.pdf
Moving from a 3D Axial Flux Machine Model to 2D Considering the Impact of End Leakage Flux	V. Puttaraj, S. T. Lundmark and T. Thiringer	2024 International Conference on Electrical Machines (ICEM), Torino, Italy, 2024, pp. 1-7	doi: 10.1109/ICEM60801.2024.10700366
Negative correlation peak shaving control in a parking garage in Uppsala, Sweden	Alexander Wallberg, Valeria Castellucci, Carl Flygare, Emil Lind, Egil Schultz, Marina Martins Mattos, Rafael Waters	Applied Energy. December 2024; Vol. 375, 124082	doi: 10.1016/j.apenergy.2024.124082
On the relation between performance and permanent demagnetisation in spoke type machines with ferrite magnets	Silva, M.D., Eriksson, S.	IET Electr. Power Appl. 18(8), 912–923 (2024)	doi: 10.1049/elp2.12448
Online acoustic emission sensing of rechargeable batteries: technology, status, and prospects	Inti Espinoza Ramos, Amina Coric, Boyang Su, Qi Zhao, Lars Eriksson, Mattias Krysander, Annika Ahlberg Tidblad, Leiting Zhang	Journal of Materials Chemistry A	doi: 10.1039/d4ta04571h
Optimizing Thermal Energy Management in BEVs via Distributed Optimization (Licentiate thesis)	Prashant Lokur	Chalmers University of Technology, 2024	https://research.chalmers.se/publication/542709

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Probabilistic Modelling of EV Charging Impact on the Sub-transmission Grid	A. Jansson, O. Samuelsson and F. J. Márquez-Fernández	2024 International Conference on Renewable Energies and Smart Technologies (REST), Prishtina, Kosovo (UNMIK), 2024	doi: 10.1109/REST59987.2024.10645382
Probing the Gaseous Phase in Batteries: Big and Small (PhD thesis)	Casimir Misiewicz	Uppsala University, 2024	https://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1903710&dswid=-2518
Reducing the Environmental Impact of Large Battery Systems with Conductive Electric Road Systems—A Technical Overview	Wenander D, Alaküla M	World Electric Vehicle Journal. 2024; 15(2):59	doi: 10.3390/wevj15020059
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Safety margin for Li-plating free fast-charging of Li-ion batteries considering parameter uncertainty	Y. Cai, Li, Y. and T. Wik	IEEE Conference on control technology and applications, Newcastle upon Tyne, England, August 21-23, 2024	doi: 10.1109/CCTA60707.2024.10666522
State of health estimation for lithium-ion batteries under arbitrary usage using data-driven multimodel fusion	Zhang, Y., Wik, T., Bergström, J., & Zou, C.	IEEE Transactions on Transportation Electrification, 10(1), 1494-1507 (2024)	-
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The Electrification of Material Moving Machines: An Overview of Opportunities and Challenges Regarding Noise	Liselott Ericson and Thomas Heeger	IDEAS 2024 , 24-27 November 2024 Recife, Pernambuco, Brazil	-
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The potential of V2G - logging av EV driving and charging patterns	Yuki Kobayashi, Maria Taljegard, Filip Johnsson	EVS37, 2024	-
The sensitive aspects of modelling polymer-ceramic composite solid-state electrolytes by molecular dynamics, simulations	M. Kozdra, D. Brandell, C.M. Araujo, A. Mace	Physical Chemistry Chemical Physics, 26 (2024) 6216	doi: 10.1039/D3CP04617F
Thermal modelling and control of lithium-ion batteries (Licentiate thesis)	Godwin Peprah	Chalmers University of Technology, 2024	https://research.chalmers.se/en/publication/542498
Think global act local: The dependency of global lithium-ion battery emissions on production location and material sources	Kallitsis, E., Lindsay, J. J., Chordia, M., Wu, B., Offer, G. J., & Edge, J. S.	Journal of Cleaner Production, 449, 141725	doi: 10.1016/j.jclepro.2024.141725

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