Annual Report

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 IV 2019-2023 Stage V 2022-2027

Swedish Electromobility Centre, March 2024

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Layout: Marcus Folino

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Together we create the *electromobility of the future*



DO YOU WANT TO BECOME A PARTNER? Welcome to contact us for a discussion.

Towards the future

Despite increasing concerns in our surrounding world, 2023 was from the center's perspective a very productive and rewarding year. It all started with our SEC road map where we stepped out into the future.

We saw a good future based on the United Nations' Sustainable Development Goals, where we have managed the climate transition, and live in balance with the earth's resources. This included a very large portion of transport being electrified.

How we in Swedish Electromobility Centre will contribute to reach this good future was presented to an international audience at the EVS36 in Sacramento, illustrated by three examples on how we build research areas, disseminate knowledge to society, and support large-scale demonstrations.

Building prototypes, testing, failing, rebuilding, and repeating the process are also paramount to succeeding in the transformation of the transport system. Therefore, we were very excited by the inauguration of new test facilities by our partners, SEEL Labs and the Alstom Mobility and Innovation Lab. This will greatly support necessary solutions needed for the transition.

In August we met for fun and rewarding conference days in Kista. A remarkable day, Nils-Gunnar Vågstedt, our chairman of the board summarized Roads to the Future. It was a pleasure to listen to all the distinguished international speakers giving us the latest perspectives on the electric vehicle as new player in the grid.



On the second day in Kista, E-mobility Day, a selection of our projects presented exciting results. During the autumn, we then continued to take part in the Centre's productivity when a large number of projects gave final reports and presentations. The accumulated knowledge generated was impressive!

Furthermore, our International Scientific Advisory Board took part in evaluating our project portfolio. Their recommendations will further strengthen the development of our theme areas and the Centre to achieve the good future envisioned in our road map.

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

Linda Olofsson, SEC Director 🕻

We have achieved remarkable results



Nils-Gunnar Vågstedt, chairman of SEC, reflects on 2023

I think we all can see that the world continues to be a challenging place to live in. When dark clouds are forming in the horizon it's natural to feel a bit worrisome. However, humans are resourceful and I'm confident that we can face the problems and continue our journey towards a more peaceful and sustainable society. Consequently, and on many important areas, I do see that the sun breaks through those dark clouds.

Swedish Electromobility Centre, or SEC, for its part, has had a great year, delivering some fantastic research results and becoming a more professional entity every day. The centre continues to broaden its reach to many new and influential collaborators. The number of associated projects and references to SEC research is increasing, which shows that we are making significant impact and are on the right path.

Harvesting time

We are currently entering a phase of stability in the transition from stage IV to stage V. Concluding stage IV really feels like harvesting



time with all the deliveries being realized. I'm truly impressed by the dedication and hard work that has contributed to these amazing research results. Everyone has delivered above and beyond expectations and it's been a privilege to witness. Sometimes it has felt like I was attending parties rather than academic research presentations because of all the happy faces and stimulating dialogue among the receiving partners. Jokes aside, our serious work now continues and I'm very confident that we will see many excellent results from stage V in the future.

System level and upscaling

When SEC started it was a lot of focus on the research of technical aspects and that progress will certainly continue. Following the increased technical advancements we've seen, there is a growing need to look at electromobility on a system level and upscaling. These areas are not researched nearly enough which also means that we can look forward to a lot of progress. Most relevant is to bridge together the technology based research to the wider scooped system oriented research.





A bridging example of a very promising collaboration is the contribution from SEC research to the flagship project E-Charge. Besides technical challenges, this collaboration include system issues and up-scaling. This bridging approach is essential to make something as complicated as electric heavy long-haul truck transportation work in the real world.

The outlook into the future is most inspiring. We see for instance how new battery technologies point in the direction of reducing scarcity of materials and environmental impact from the production cycle. Swedish battery research stand out on an international level, with Natrium based batteries from more environmental friendly materials than the Lithium based. Further we see how the e-mobility also grows into new transportation areas like air transport and waterways.

The contours of the picture are emerging

Electromobility has made significant strides, yet there is much left to accomplish. Comparing our progress to a puzzle, we may only have placed about 100 pieces in a 1000-piece jigsaw. To add complexity, we do not have all pieces visible yet to complete the full picture. This might sound like we haven't come that far, but the initial stages are always the hardest, and we must remember that it was not that long ago we started carving out the first pieces. Even though we have many left to place, and some may still need adjustment, we are now at a time where we can see the contours of the entire picture. This can accelerate the progress and open new areas that was previously not imagined. This is very inspiring to me!



The Swedish Energy Agency has been funding SEC from start. During 2023 stage IV was concluded resulting in many scientific achievements being presented. SEC is now going forward with stage V ending in 2027.

Klaas Burgdorf, SEC's research program manager at the Swedish Energy Agency, is impressed by the centre and its achievements.

"You can tell that SEC has been around for a while. It's a well set-up organization with a lot of professionalism in all its parts and has continuously delivered great value. 2023, with stage IV coming to an end, was a remarkable year with many significant scientific results and brought new competences that will help enabling electromobility."

"We have a major demographic challenge"

The transition to electromobility requires a supply of new competences and Klaas Burgdorf means that SEC plays a particularly important role in this matter.

"If we can't keep up with the competence supply Sweden risks losing much of its attractiveness as an industry nation as well as the associated welfare. On top of the urgent acceleration of the green transition, we have a major demographic challenge when it comes to filling the gaps from the soon retiring baby boom generation. Besides being an important node of knowledge in electromobility, we appreciate and applaud SEC's contribution to higher education."

The transition to electromobility is a main path to fossil fuel-free transportation but it's also an important economic issue.

"Large-scale transition to electromobility is disruptive. Successful adaptation will also depend on our ability to achieve competitive large-scale production both in Sweden and Europe," says Klaas.

"Electric aviation is an area of interest today"

During 2023 Swedavia, the Swedish airport owning and managing company, became an SEC network partner and Klaas is very positive.

"The growth of partners is an important indicator of how well the centre works, and I think that Swedavia is a welcome addition! Electric aviation is an area of interest today and there are a lot of areas to research. For one thing we have the upcoming demands for charging infrastructure at airports." "It will be interesting to follow the development the coming years. There are many technological advancements happening still, which is very exciting. I think it will be closer to 2040 than 2030 before we can see a more mature and standardized market."



Driving societal transformation

Swedish Electromobility Centre has since its formation in 2007 established itself as Sweden's leading collaboration hub for research in electromobility. With the steadfast support of the Swedish Energy Agency, the centre engages a diverse spectrum, including vehicle manufacturers, suppliers, electric grid operators, academia, and research institutes.

Unique role

At the core of SEC's progress is a unique model that 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.

Continuously evolving

SEC evolves continuously, and has broadened its initial focus on roads to also include offroad, air, and water applications. Swedavia, who owns, operates, and develops a network of Swedish airports, is a key actor in the electrification of air travel. We are therefore very glad to now have them onboard as partner of SEC, strengthening the centre even further.

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SEC's task towards academy

- → Gather and build long-term knowledge in relevant areas for vehicle electrification and development of associated charging infrastructure.
- \rightarrow Bring industry and university partners together, in order to develop free, strong and creative research environments. Initiate and finance relevant research projects and themes.
- \rightarrow Disseminate the knowledge generated within the centre by providing courses within the framework of postgraduate programs.
- \rightarrow Create knowledge that can be used in undergraduate programs at each university and with industry partners.
- \rightarrow Create value by organising meetings and networking venues.
- → Deepen knowledge exchange between automotive companies and companies in the electrification field, and universities.
- \rightarrow Help increase the level of knowledge in relevant areas.

The industry's view of SEC

- \rightarrow Being the hub in Sweden for applied research in electrification of transport.
- → Being a recruitment base at licentate/doctoral level and at senior research level.
- \rightarrow Being a platform and trustful network that work for mobility between industrial and academic researchers, thus facilitating bi-directional knowledge transfer.
- \rightarrow SEC should continue to be a catalyst that accelerates the electrification of vehicles.
- \rightarrow SEC should continue to deliver world class research results.

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

SUSTAINABLE GUILON

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.





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.

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. The longterm goal is to ensure electromobility is the cornerstone for transition to a sustainable society. **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.

How to get there

Six objectives

To make Swedish Electromobility Centre's work towards its vision and goals concrete, and measure how well the centre performs, there are six objectives, with connected KPIs, measured on an annual basis.

The objectives and the KPIs have been chosen in dialogue with the Swedish Energy Agency to support the overall goals of the centre in terms of the scientific excellence of the research, industrial applicability, and societal impact, both in terms of results and the need for qualified workers.





Five themes

The centre has established five main research themes within electromobility that, in theme and cross-theme collaborations are catalysts for an electrified and fully fossil-free mobility sector.

The theme road maps, with identified knowledge gaps and strategic research areas, form the basis for the project calls and through the SEC funded projects, the themes contribute to fulfilling the goals of the centre.

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.
- \rightarrow 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.

2 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.



→ 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.

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ves



 \rightarrow 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

 \rightarrow 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.

6 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.
- \rightarrow The PhD student should be involved in the PhD Student Network and SEC's planned PhD courses.

Disseminate knowledge & research findings

KEY performance indicators

Gender balance and media presence are KPIs addressed on pages 24–25 respectively 62–63. SEC also arranges the conferences Electromobility Day, every year, and Roads the Future, every other year. Almost all KPIs for the entire stage IV have been reached even though the stage ended prematurely.

2023 journal & conference papers master thesis theme PhD and licentiate 6 (6 SEC-financed, 0 associated, nid-seminars included in licentiate) Patent applications international

program council

reports

STAGE IV



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collaborations

Stage IV total KPI targets: journal & conference papers, 120; master thesis, 20; theme workshops, 20; PhD and licentiate, 25; international collaborations, 5; patent, 4; program council reports, 15; conferences, 4; gender-balance, 60/40 ratio; media presecence, 12



Stage V total KPI targets: journal & conference papers, 150; master thesis, 100; theme workshops, 75; crosstheme workshops, 25; university workshop, 10; PhD and licentiate, 25; post-doc meriting, 15; international collaborations, 10; program council reports, 100; conferences, 5; gender-balance, 60/40 ratio; media presecence, 10

STAGE V



Gender balance

The level of gender balance has increased during stage IV and the 60/40 goal was almost reached for the latter part of the stage. SEC needs to continue working on the gender balance to increase the number of females during stage V.



Individuals* Males 68% Allocated Males 69% funding**

The under-represented sex should not be less than 40%

Stage V - 2022-2023



Individuals* Males 68% Allocated Males 69% funding** *The under-represented sex* should not be less than 40%

* Based on number of SEC project participants.

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

* Based on number of SEC project participants.

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













To cover the full landscape of the growing fields related to electromobility, the centre has identified and established five theme areas. The theme areas are the core of SEC with activity groups where researchers from all partner entities collaborate. Each area is led by two theme leaders, from different universities.



Swedish Electromobility Centre Intelligent Vehicles & Systems

Swedish Electromobility Centre Electric Drives & Charging



swedish Electromobility Centre Environment & Society



Theme area Intelligent Vehicles and Systems addresses total cost optimization of the vehicle system, with a focus 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 or fleet level, i.e., design and control of system of systems. The methods and techniques developed focus on reducing development time and effort while striving for system optimality.

RESEARCH ADVANCEMENTS WITHIN 2023

The projects have evolved around understanding and characterizing the customers, the vehicle, its subsystems, and its surroundings to address the core question. During 2023 the theme researchers have 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 fuel cell vehicles. The platform was presented at a theme workshop and will be used in an international benchmark contest in control design at the IFAC World Congress 2023.

The theme area researcher, Luigi Romano, successfully defended his PhD thesis in September 2023. Other achievements have been in the characterization of external factors, like wind and road resistance, as well as the analysis of electric all-wheel drive concepts and control design for optimized fast charging of battery electric vehicles.

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 spreading information and presenting interesting research results. The main channel during the year for communicating research results to the scientific community is internationally high-ranked journals.

In 2023, the theme leader Lars Eriksson received the "Håkan Frisinger Award for Excellence in Transportation Research" for his strong scientific credentials and his efforts in making research results readily available through the publication of textbooks and open-source software and models.

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 megatrends in the area. Basic research is done on the development of methods and tools for addressing the design 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.





The health check that will extend battery lifetime

The battery is a critical part in an electric vehicle's lifetime. One bad cell could shorten the life of the battery with years. With the new reconfigurable battery type that is under development and its diagnostics tools, the bad cell can be found and replaced or isolated without having to change the whole battery, which extends the lifetime and value of the vehicle.

In the project "Diagnostics and supervision of dynamically reconfigurable battery systems", PhD student Fatemeh Hashemniya, at Linköping University, is developing ways to check the health status of reconfigurable batteries.



"You could say we are developing tools to look for diseases in these new kinds of batteries, to be able to fix them before they break. We need to be able to keep track of the health of the battery from day one and forward", says Fatemeh Hashemniya.

High pressure and temperature may lead to failure

Keeping the batteries healthy is a very important life extender for electric vehicles. Worn out or damaged batteries shorten the life of the whole car, since the battery is such a major cost in the vehicle. "One problem in today's battery packs is that the cell in the middle is experiencing very high pressure and temperature, which may lead to failure. And when that cell gets damaged it can also ruin the other surrounding cells. In reconfigurable battery packs you will be able to treat specific cells. Our job is to keep track of when the cell needs treatment or be replaced", says Fatemeh.

Keeping the batteries happy

The plan is that the project will provide a tool to add to the battery management system to keep them safe. Fatemeh Hashemniya is expecting results that are ready to be applied by the end of her PhD project.

"Two years ago, when I joined SEC there was a big kick off meeting in Uppsala and I remember that one of the key speakers said, "we are here to keep our batteries happy". That was really beautiful, because what we are doing now is working on keeping our batteries happy. I am really excited for coming experiment results that we will have together with Scania", says Fatemeh.

Scania is a collaboration partner from the centre, and Atlas Copco is also collaborating in the project.







Theme area 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.

The theme's 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 within 2023

Within LTH Profile Area The Energy Transition, which is in charge of coordinating SEC related activities at LTH, Prof. Mats Alaküla (theme 2) and Prof. Olof Samuelsson (theme 5) delivered a presentation at the Almedalen political event entitled "Electromobility on the rise – are we keeping up?" in June 2023.

Moreover, 7 peer-reviewed articles in highly reputable conferences (all IEEE and IET) and 1 IEEE Transactions in Industrial Applications have been published in associated projects to Theme 2.

National and international attention

The associated project Evolution Road (electric road system pilot in Lund) was featured on BBC News in June 2023, in a piece called "The electric roads that charge your car as you drive" (The electric roads that charge your car as you drive - BBC News - YouTube)

On the national side, on the initiative of the Swedish Government and the Swedish Defense Forces, SEC and Theme 2 have been contacted to discuss critical challenges that the Defense Forces see in the electrification of the transportation sector. In February 2023, SEC and Theme 2, together with the Swedish Defense Forces, organized a workshop on "Charging infrastructure and electromagnetic compatibility".

Challenges and possibilities

Transportation electrification is ineluctably continuing its growth, and with it, the size of the related societal issues is also growing.

The fast-charging infrastructure with even higher power requirements is still a concern from an electromagnetic compatibility point of view. The chargers are realized by switching power electronics and thus a source of high-frequency noise that can be conducted and radiated, especially in charging sites with many fast chargers. A similar reasoning also applies to various forms of electric roads. The Swedish Defense Forces have identified a need to discuss technical solutions to ensure that these disturbances are kept within controlled limits. These limits protect digital communication but may also apply to the safe operation of pacemakers, autonomous vehicle navigation systems, and more.

The energy supply network is still too fragile to support a wide growth of electric transportation. The increasing integration of the electric vehicle fleet and its inherent need for a charging infrastructure integrated into the existing grid system requires significant actions toward ensuring a safe and reliable energy supply for society. In case of a shortage of grid capacity and a fully deployed electric transport system, how can we prioritize the energy supply and secure a certain level of continued transport?

Raw materials and supply chains for electric/ electronic component manufacturing are under special consideration in the EU and globally. 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, and addressing the EU Green Deal. There is, however, significant room for improvement in the design of electric/electronic components to reduce the dependence on critical materials.

Business intelligence

The e-mobility trend has no slowdown, and it is a "make or die" decision for companies operating in the road transport sector. All the research topics in the Theme 2 roadmap reflect the huge efforts industry and academia are devoting to achieve the transition. Significant work is still devoted to drivetrain design for maximized efficiency, reliability, and recyclability, with a growing number of solutions appearing for the charging topic.



The situation is still slightly different in the marine and aerospace sectors due to the inherent complications of the applications.

In the marine sector, the electrification of large and small (leisure) boats is accelerating despite a significant energy density issue. Batteries are not energy-dense enough for the requirements posed by the water resistance. Fuel-cell-based solutions or battery-fuel-cell hybrid concepts are in the pilot stage. The hydrofoil boat concept has been revitalized and generates interest in the small boat sector due to the significantly lowered energy requirements compared to a conventional electric boat.

In the aerospace sector, power and energy density targets are even worse than marine applications and require significant re-design work of electric machines and power electronics converters.

However, the industrial scenario is vibrant in both the marine and aerospace, with several start-ups and well-established companies working on electrifying aircraft and boats.





Lifetime evaluation of silicon carbide power modules

The shift from silicon to silicon carbide in power modules promises lower power losses, increase power density and offer superior heat dissipation with advance packages. At KTH Royal Institute of Technology, Bhanu Singh, a PhD student, and supervisor Staffan Norrga, specializing in power electronics, evaluate lifetime aspects of the new type of module, in an SEC funded project.

Silicon versus silicon carbide

Traditional power modules for heavy electric trucks use silicon-based Insulated-Gate Bipolar Transistors (IGBTs). However, new modules are increasingly adopting silicon carbide-based Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs). Singh believes that the silicon carbide alternative might initially present less reliability due to distinct mechanical properties but acknowledges that the advance packaging and materials could allow better exploitation of the full potential of silicon carbide.

Advanced power modules and their advantages

More and more new advanced power modules that utilize new materials are being used. They promise better heat dissipation, which is essential as it enables modules to operate at higher losses. Higher heat dissipation means more generated heat is transferred to the environment, improving module performance. Moreover, these advanced packages can operate at higher power densities, an attractive feature for electric vehicle manufacturers who aim to use less silicon carbide in their packages.

"Advanced packages offer better heat dissipation, so the heat that is generated inside the power module will be transferred to the environment. They offer better thermal performance, you can operate the module at higher power density," says Bhanu Singh.

The road to increased power density

In an ambitious roadmap, car manufacturers plan to increase power density up to 100 kilowatt per litre. This would result in higher losses, generating more heat inside the modules. Therefore, the need for advanced packaging is paramount to dissipate the resulting heat efficiently, ensuring the continued functionality and longevity of the power modules.

Challenges and progress

Despite the progress, Bhanu's project faces some hurdles. The validation of lifetime models and the fabrication of custom power modules have been delayed due to long lead times for semiconductor dies. Singh estimates that his project is 60–70% complete, with validation remaining the significant unfulfilled component.

Invaluable connections

Working with the Swedish Electromobility Centre has given Singh opportunities to connect with industry professionals, learn from fellow researchers, and gain different perspectives.

Despite the challenges, Bhanu remains enthusiastic about his work's potential impact, contributing to a greener and more efficient future.



"I feel very good working with the Swedish Electromobility Centre. I have been able to make a lot of contacts. I've attended all the SEC conferences like 'Roads to the Future' and 'E-mobility Days' and met many people there. The best thing was the Autumn School which I attended in 2021. I met many professors and PhD students from different universities and learned a lot from their projects as well. Overall, it has been a really nice journey with the Swedish Electromobility Centre", says Bhanu Singh.



Illustration by Bhanu Singh



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 its 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 2023

The SEC projects running during 2023 have revolved around testing procedures and protocols, different forms of modelling, system safety and diagnostics, and novel battery and fuel cells types targeting vehicles. A number of PhD student projects that were started within stage IV within the theme area are now seeing major research output: on fuel cell performance prediction, on gas evolution in Li-ion battery cells, and control systems for temperature behaviour. A cross-disciplinary project on non-uniform ageing that involved PhD from several universities and industrial PhDs was also started during 2023. Moreover, two theme researcher projects progressed significantly during 2023: on solid-state batteries and on intermediate temperature fuel cells.

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 2023, to highlight research within the area and stimulate research interactions. Some of these have also been done with other SEC theme areas. Theme 3 also contributed to the PhD Summer School and to the Electromobility Days and Roads to the Future conference.

National and international attention

Batteries as energy storage solutions for electric vehicles continue to draw considerable attention, and is now very high on the political agenda, not least within the context of the current European energy challenge. A clear need for education in the battery/EV area has been identified, with academic SEC partners identified as suppliers of skilled personnel to this emerging industry. Battery production is continuing to being scaled up in Sweden, and now comprise several actors in the Swedish landscape. So called "Gigafactories" are being built or being planned at four different sites in Sweden, also involving SEC partners – either themselves, in joint venture activities or in close collaboration with cell manufacturers. Also academic SEC partners are highly active in this development. Apart from the strongly dominating Li-ion technology which increase rapidly in volumes are also other battery technologies seeing emerging production, e.g. Na-ion, where massive steps have been taken towards up-scaled production. This development stimulated the Swedish government to push for large-scale educational and research efforts in the battery area in the autumn budget 2023, thereby involving SEC universities.

Considering the financial resources and human capital being channelled to the battery sectors, there has been no shortage of media attention, and thematic leaders and profiled researchers associated with SEC appearing both locally, nationally and internationally in media as experts on this development. Moreover, raw materials for batteries been highlighted as a fundamental critical issue, which has sparked further media attention and a focus within industry to focus on alternative materials and cell chemistries. Internationally, SEC partners in the energy storage area has been very active and visible in several European research projects, e.g. Battery 2030+.



In parallel with batteries, interest for hydrogen and depend intrinsically on the battery cell has also ramped up. In the hydrogen strategy chemistry. Moreover, sustainability, lack of raw for a climate-neutral Europe communicated by materials and increasing costs are emerging as the European Commission, hydrogen has been issues for the Li-ion technology, which motiidentified as a key contributor in the mitigation vates the interest in alterative battery and fuel of climate change. The need for Europe for a cell technology. more robust energy system based on renewable resources has become even more apparent Fuel cell-powered vehicles are in an earlier through the war in Ukraine, which has resulted phase of commercialization than battery-powin an even greater focus on hydrogen. The ered vehicles, and important issues revolve strategy is to make green hydrogen along with around system integration, costs and the electricity the main energy vectors that enables design of auxiliary systems. As with batteries, a zero-emission Europe. While hydrogen as an life-time and predictability are important, energy carrier can be utilized in many parts of and linked to the continued development of the energy system also outside of transporimproved catalysts and membranes. It is also tation, it then becomes important to obtain important to remember that most fuel cell synergetic intersectoral effects by integration of vehicles also use batteries, and that the balance hydrogen into the existing systems for energy between the two ways of storing energy is part and transport. Thus, it is quite evident that of the optimisation of the propulsion system. hydrogen based on renewable electricity will be available at a competitive cost also for trans-**Business intelligence** With the Li-ion battery truly pushing the portation purposes and a natural consequence of this is that the interest in electrification of production limits, there are novel aspects the transport sector with the help of hydrogen which become critical in terms of supply powered fuel cells still is of large interest. For chains and closed-loop systems. Novel Li-ion road-bound vehicles, the focus is primarily on battery cell chemistries are targeting both trucks, but interest in ships, aviation and railhigher electrochemical performance and more bound transport is growing steadily. sustainable materials (Si/C composite anodes,

Both in batteries and hydrogen, national strategies are emerging to ensure that the entire value chain develops and Sweden can take a leading role in the ongoing 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.

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 generally are different. For batteries, the very high volume of batteries being produced puts an extra focus on critical raw materials. materials processing, cell production and recycling to close the loop and provide cost-effective and sustainable solutions. The maturity of the technique and its large-scale implementation also means that safety issues become more critical, while the growth of the industry generates large needs for education in the area also outside of the traditional student groups. 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,

Ni-rich and/or Co-free cathodes), which also applies for other vehicle-related future battery chemistry. 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 now 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, and 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.





Aging fingerprints in the 3D structure of the electrode

Currently, nickel is used in high-performing lithium-ion batteries as a replacement to resource-scarce elements like cobalt. However, the form and structure of the battery materials with high nickel content appears to change at higher State of Charge and temperature, thus limiting its lifetime and posing safety concerns. By using XRD tomography, a 3D image stacking technique, the electrode aging can be better understood.

High-performance electric vehicles have adopted Ni-rich layered LiNixCoyAlzO2 (NCA) as a positive electrode material. However, there is a problem with unwanted changes in the electrode morphology under aging, such as particle swelling or crack development. The goal of the project XRD tomography of elec-trodes from Ni-rich Li-batteries, conducted by Anti Liivat from Uppsala University, has been to better understand the fast aging of these novel electrodes if cycled under extended State of Charge window and temperature.

Provides detailed pictures

It has remained a challenging task to characterize these unwanted changes by using conventional techniques, since these only access the electrode-electrolyte interface or a small part of the volume. This project uses state-of-the art tomographic techniques for reconstructing the bulk, three-dimensional particulate structure of lithium-ion battery electrodes. Tomography provides detailed pictures of the internals of an electrode and is easily accessible in micrometre-resolution with contemporary tomographic equipment. The focus has been on visualization and quantification of irreversible changes in electrodes collected from commercial cells with the help of the industrial partner. For tomography, tiny, mm-size samples need to be obtained from these electrodes without causing material cracking and delamination.

Different results compared to other projects

Electrode swelling was not detected in any of the samples as their thicknesses were about 68 micrometers within the error margin. This is different from that observed in earlier projects where fast charging or long-term cycling led to approximately 10% increase in electrode thickness. This difference can be attributed to the stronger resistance of cylindrical cells to expansion. However relative mildness of cell aging conditions cannot be ruled out either. Aging-caused particle cracking in the electrode were not confirmed since a similar amount of such particles were found in the unaged samples as well.

"The results show that the core integrity of the electrodes in cylindrical cells holds well under moderate aging by varying the State of Charge. We could not find any dramatic changes in NCA electrode morphology unlike observed in earlier studies for NMC-type materials in more demanding aging," says Anti Liivat.







ent charging cycles. The brightness is proportional to the density of the electrode. Al-foil (120–150 units), dense active material (ca >190 units), smaller (<4um) particles together with binder and carbon (ca 140–190 units) shown by the histogram (right).



Theme area Environment & Society investigates electromobility from a societal and environmental perspective. All activities aim to guide devel-opment and policy work towards sustainable electromobility.

The work is conducted in four strategic research areas:

The first, understanding technology diffusion and its impact on personal mobility, transport services, and society, focuses on the interplay between technology and different actors, and the mechanisms that govern its development, both for passenger and freight transportation.

The second, securing resource availability through efficient resource use and circularity, covers strategies to secure the raw materials of electromobility by promoting circular material flows.

The third, assessment of environmental impact, involves guiding ongoing development towards minimized environmental burdens.

Within the fourth area, evaluation of policies and legislation to speed up sustainable electrification of transport, possible side-effects, goal conflicts and cost-efficiency of different policies are studied.

Research advancements within 2023

In total twenty projects, ten funded by the center (whereof three were linked to SEC stage IV which was ending 2023) and ten assocsiated, ran within the theme area during 2023. Within this scope, the theme provides funding for three PhD students. Four theme researcher projects ran at university or institute as there were some overlaps between projects of this category due to previous project extensions. Another ten projects are linked as secondary to the theme and coordinated within another theme area – seven of these are funded Ph.D. projects (in theme areas 2, 3 and 5) and three associated projects.

While several of the theme funded projects were recently started or building new foundations for investigations after many deliveries in 2022, a noteworthy achievement was identified within an associated project in the environmental assessment strategic research area.

PhD student Sanna Wickerts and colleagues published a life cycle assessment study of future battery chemistries in the highranked journal "ACS Sustainable Chemistry & Engineering" (Impact Factor: 8.4) entitled "Prospective Life Cycle Assessment of Lithium-Sulfur Batteries for Stationary Energy Storage." Ongoing work in the funded PhD student projects in the same strategic area included an initiation of investigations of vehicle-to-grid solutions, as well as a broadening of the scope of research in life-cycle considerations of lithium-ion batteries, covering new cell formats and chemistries, compared to previous results.

Within the first strategic research area, two of the theme researcher projects has explored heavy vehicles, focusing on the charging and refueling needs of long-distance trucks, as well as the prerequisites for electrification of freight transport more in general. Associated projects include environmental assessments, innovation system studies, circular economy studies, and transport system analysis, i.e. covering all strategic research areas.

As every year, activities within the theme group have been ongoing with recurring theme group meetings, two longer on-site meetings, a set of open online seminars, and the yearly "Master thesis presentation bonanza".

National and international attention

In December, Chalmers theme representative and project leader Frances Sprei did a live interview on local Swedish radio P4 Göteborg, where she was asked about the actions needed to achieve climate targets in Gothenburg city, building on experiences from her SEC funded research work. Sprei, also a member of Gothenburg's climate council, highlighted the need to ban the use of fossil-powered cars and introduce more car-free zones in central Gothenburg.



In two opinion pieces published in Göteborgs-Posten in December, she further discussed ways to reduce emissions from the transport sector in Gothenburg and proposed an introduction of an environmental zone 3 in the city center (i.e. primarily electric vehicles access), a specific reserved lane for electric trucks on Hisingen, and that the municipality facilitates the expansion of charging infrastructure, especially for apartment buildings.

Earlier in the year, theme leader Anders Nordelöf visited popular energy transition podcast "Solcellskollen" and answered questions about cobalt mining in the lithium-ion battery supply chain, and broader questions about the long term need for different metals used in different technologies for vehicle electrification, drawing upon learnings from both funded and associated SEC projects.

Challenges and possibilities

The EV technology and adoption is evolving more rapidly every year. This implies new challenges for society, which are tackled within the theme 4 research projects. Many knowledge gaps persist and identifying environmental and socio-technical barriers for electrification technologies and support measures to overcome, work around or avoid these barriers, to enable a rapid large-scale transition of the transportation sector, remains a core task of the theme area.

To find solutions where we can enable a substantial scale-up of electric vehicles and vessels, with the smallest environmental impacts and the most efficient resource use, is and will remain important to enable the introduction of new technologies.

During this fast transition, theme 4 must remain excellent in our research and relevant in our topics, to create understanding for our partners on the keys to societal acceptance and continued difficult, but necessary strive for enhanced sustainability, especially when related to resource extraction and resource availability.

Business Intelligence

The implementation of electromobility is progressing rapid in several part of the transportation sector, driving new complexity in turn requiring technical, behavioral, commercial, and governmental adaptation, necessitating that a systems perspective is added to the state-of-the-art knowledge. Along with electrification, increasing levels of vehicle automation, logistics as a service as well as carpooling and shared mobility (ride sharing services) are prevalent trends that have emerged simultaneously in the transport sector the last few years. While technical advancements in the field are enabling these parallel transitions, they are also based on innovative business models and governed by policy directives. In addition, several powerful information technology tools are rapidly being developed. These enable data collection and processing in very large quantities using AI and sensor technologies, e.g., for route optimization, and blockchains are promoted for providing traceability upstream in the life cycles of components, linking to responsible sourcing of key raw materials.





Unveiling the environmental impacts of large-scale lithium-ion battery production

In this SEC funded project, Chalmers PhD Student Mudit Chordia sheds light on the critical factors influencing the life cycle of these energy storage devices. The investigation aims to unravel the complex web of environmental impacts associated with the production and recycling of lithium-ion batteries.

Mudit Chordia's initial objective was to map the lithium-ion battery production (LIB) processes and identify the processes with the highest energy demand and environmental impacts. As the study progressed, he realized that due to upscaling of production and use of low carbon intensive sources of energy for cell production, the highest environmental impacts were occurring upstream (i.e., raw material extraction and processing) from cell production.

The project ultimately encompassed an analysis of the supply chains for key raw materials, particularly lithium, which is currently the dominant technology for EV applications and are also an important input in several upcoming battery chemistries.

Addressing efficiency and minimizing environmental footprint through low-carbon-intensity sources

The preliminary findings emphasize the critical role of the upstream supply chain in driving environmental impacts. As LIB production scales up, economies of scale lead to improved material and energy efficiency and overall

reduced impacts from cell production. Furthermore, by employing low-carbon-intensity sources for battery production, the environmental footprint can be further minimized.



"Environmental impacts tend to be higher in the upstream phase where the raw materials used in lithium ion batteries are mined, extracted, and processed, especially when cells are produced at large-scale using low carbon intensive sources of energy," says Mudit Chordia.

In such cases, Chordia tried to understand how the situation differs in different regions that supply the raw materials for LIBs. For some of the mining and processing activites, it might be quite possible to have renewable electricity instead of fossil-based electricity, which lowers the overall environmental impacts. However, some processing activities might require large amounts of heat which might be exclusively sourced from burning fossils making it challenging to reduce overall environmental impacts. Specific to lithium extraction in the salars in South America, water use is identified as an environmental challenge.

Balancing greenhouse gas emissions and local pollution issues throughout the supply chain

Chordia stresses the importance of addressing both greenhouse gas emissions and local pollution issues throughout the supply chain. While the upstream mining processes are often the major polluters, the significance of addressing emissions during battery produc-



tion should not be overlooked. Comparing low-carbon-intensive regions like Sweden and high-carbon-intensive regions like South Korea, the need for holistic environmental management strategies is evident.

Chordia's study serves as a timely contribution to the ongoing discussions surrounding the environmental impacts of lithium-ion battery production. By shedding light on the complex supply chains and inherent challenges, this research lays the groundwork for future improvements in sustainable battery manufacturing processes and contributes to the ongoing global efforts.



The number of electric vehicles is rapidly increasing in society as is the current and future demand for electric power and electricity. This will have a significant impact on the operation of the power system, as electrification of other sectors is expected – such as industry and the built environment.

The main mission of theme 5 is to conduct research in key areas related to this Vehicle-Grid Integration to promote collaboration and knowledge sharing. The research in theme 5 is divided into four strategic research 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.

During 2023, the theme group organized and participated in a number of different activities for theme members as well as for a wider audience. For example, workshops and seminars were organized to discuss - with different stakeholders - challenges and opportunities related to bidirectional charging. In addition to these events, the theme group meets regularly to discuss current or potential research projects and other activities related to the topic.

Research advancements within 2023

During 2023, three new research projects were initiated within the theme: How to test V2G technology, Cost and Benefit Analysis of V2G Scenarios, and Logging of electric vehicles - characterization of charging patterns and grid impacts. Moreover, two projects already running in the theme have been granted prolongation. Several projects have been associated to SEC and theme 5 during this year, from PhD projects on safe energy communities and demand flexibility, to projects on education in electromobility for sustainable energy systems.

National and international attention

During 2023, theme 5 presented SEC and its research to different Swedish and international stakeholders, as well as to students and PhD students at different universities. The theme organized workshops and meetings where speakers with different interest in the vehicle-grid interaction research area were invited. The focus has been mainly on benefits and challenges with bidirectional charging. Furthermore, new industrial partners have joined the theme group. Finally, the researchers of the theme group presented their findings at international conferences and events.

Challenges and possibilities

The activities in this field have increased significantly over the past few years and a lot of research and development work is being carried out in different fields at the same time. This ongoing development is both exciting and challenging to study in this area because many factors are subject to change. Another challenge is that development is rapid - within the next few years we expect to have a large proportion of electric vehicles on the road - and new solutions will be needed in the near future. Along with the growth of the electric vehicle fleet, other sectors, such as industry, are also predicted to increase electricity demand. Therefore, the electricity system needs to be improved and expanded to meet the increasing demand for electrical energy. Typically, it takes time to achieve significant



grid reinforcement, for many projects taking several years. Therefore, it is important to examine the charging solutions that the electricity system can handle in the short to medium timeframes, and research whether additional infrastructure is needed.

The electrification of the transport sector also brings many opportunities. Firstly, it contributes to a more sustainable transport system but can also create a more sustainable electricity system. Our electricity generation will increasingly rely on non-dispatched energy sources, which will also force us to think about how we consume electricity. If we have flexible loads, such as electric vehicle charging, and can plan when to turn them on and off, we can better accommodate electricity generation. Additionally, if we can use the energy stored in EV batteries to support the grid and other systems, such as V2G, then EVs can play an even bigger role in the energy transition.

Business intelligence

Today, there are many challenges in the field of vehicle-grid interaction and there are many innovative solutions to meet the future energy needs of electric vehicles. The public and private sectors are committed to continued research and investment in this area. Grid capacity is attracting more attention than ever. As the electrification of transportation systems progresses, together with society as a whole, larger cities face significant grid capacity challenges. At the same time, more and more distribution network owners are realizing that they need to create flexibility in their systems to avoid having to make large investments in their existing networks. They also recognize that the transport sector can not only be a burden to the network but should be also an asset.





Policies guiding the integration of electric vehicles and charging stations into power grids

SEC researchers are on a quest to unearth the intricacies of policy constraints and opportunities and fast-track the electrification of transportation systems in Sweden. The SEC funded project "Vehicle-grid interaction from a policy perspective" concentrates exclusively on the interaction between electric vehicles, charging stations, and power grids from a policy perspective.

Petra Stelling is a researcher at Lund University and VTI, The Swedish National Road and Transport Research Institute. She and her project colleagues aim to understand the legislation that regulates how EVs and charging stations are connected to the grid. The goal is to uncover hindrances and possibilities that can assist in addressing the issues of EV charging infrastructure.

"We are looking at both EU regulations, which dictate what Sweden can do, as well as national laws. In some cases, planning and construction laws may apply, and environmental codes may come into play, especially for larger stations or when solar cells or battery storage are involved," says Petra Stelling.

Looking across borders

The team has not only studied domestic regulations but also those in other countries, including Norway, the Netherlands, Germany, the UK, and the US, specifically California. These countries are frontrunners of EVs and the aim is to see if they have laws, policies, and strategies to be inspired by. One example they have discovered is that three of the studied countries have publicly accessible maps showing grid capacity, something that has been demanded also in Sweden.

Flexibility: a key element

One of the most interesting areas Stelling and her team have uncovered in their research is the potential for flexible solutions. This concept has taken center stage in the current EU legislation.

"There is a suggested update of the EU regulations that involves flexibility which may facilitate more flexibility services, but has not been ratified yet."





The Swedish parliament, Riksdagen.

Stelling and her colleagues are looking at regulations at both a broader level and specific cases that could facilitate flexible solutions. However, she acknowledges that while new proposals are emerging, the area needs more attention to accelerate electrification.

Bridging the gap between academia and industry

Stelling is hopeful that the research will produce concrete results, such as academic articles and conference presentations. However, more importantly, it could influence the legislative landscape. *"We hope to reach lawmakers themselves with the prepared groundwork for new laws."*

The road ahead

As the project moves towards its conclusion by the end of 2023, Stelling and her colleagues are preparing for the next steps, which include studying specific cases to identify regulatory tweaks that could facilitate the deployment of EV infrastructure. Working within the framework of the Swedish Electromobility Center has provided the opportunity to extend her network and to discuss the topic with other researchers and industry representatives. This collaborative environment has enabled her to gain new perspectives and insights together with the project partners.

According to Stelling, the complexity of policy formulation isn't merely about drafting laws. She stressed, "You need to think about what effects the law will really have before you adopt it. A thorough impact assessment is necessary. It's a long process."

However, she remains optimistic about the future, envisioning a more flexible, regulated, and electrified future.





The Doctoral Student Network is open for all PhD students in Sweden who study aspects of electrification of electromobility. The network is an arena for collaboration and networking between PhD students and stimulates their interaction with Swedish industry.

The network arranges a variety of popular and well attended activities every year.

Summer School

The annual Summer School was held in Falkenberg on the 21–25 August. The participants, PhD students and engineers from SEC partners, had a week of lectures and practical exercises together with theme leaders and other teachers. The students enjoyed the mix between lectures and exercises, as well as the beautiful location near the sea. There were 28 participants, 4 employees from SEC partner companies and 24 PhD students (both academic and industrial). There were quite a large group from Chalmers, but also from KTH, Uppsala, Linköping, Luleå and industrial PhD students from Scania, RISE and Volvo.

Webinars 2023

About once a month the PhD doctoral network invites to a lunch webinar. Every time with a

relevant topic and a lecturer, most of the time from one of the centre's partners. In 2023 there were 6 webinars.

Electromobility Systems-Design Project

During the spring the course "Electromobility Systems - Design Project" was held. During the course the students do a group project and attend seminars and lectures given by Anders Grauers. It is manly an online course but the student got to meet physically during the Volvo Cars study visit.

Study visit at Volvo Cars

Volvo Cars welcomed the SEC PhD students to their facilities in Gothenburg. The program included a study visit to see their labs and experience how they work at Volvo Cars, as well as discussions with their electromobility specialists.

We thank Therese Eriksson

In October Therese Eriksson passed the coordinator torch to Liridona Sopjani. Therese has been working as coordinator for little over more than one and a half years, and has done an excellent job organizing courses, dinners and study visits. SEC wish her all the best in her future endeavors!

"It's been great working with all the wonderful PhD students and organise events for them together with everyone at SEC. The PhDs are our future and guiding them within SEC and the electromobility area has been a privilege," says Therese Eriksson.

And welcome Liridona Sopjani

SEC welcomes Liridona Sopjani as the new coordinator of the Doctoral Student Network. Liridona is currently working as a senior researcher at RISE Research Institutes of Sweden in the Department of Mobility and Systems.

"I'm curious to see how the network of doctoral students can serve as a bridge to develop new research programs through activated participation of doctoral students across Sweden in issues of transport system changes," says Liridona Sopjani.





Valeria Castellucci, Therese Eriksson and Daniel Brandell



Swedavia new partner

Swedish airports are preparing for electric flight and are at the same time on the way of becoming climate neutral. We are therefore very happy to have Swedavia as new network partner in Swedish Electromobility Centre.

S wedavia, the Swedish airport owning and managing company, has the ambition to become carbon neutral. The two main ways to reach the goals are through full electrification of the passenger's way from home to airport, where they collaborate with taxi and bus companies to minimize the climate impact, and through preparing the airports for electric flight.

To reach their climate ambitions they need to cater for charging infrastructure for landbased electric vehicles as well as flight. This means multiple challenges on many different levels, such as mobile heavy vehicle fast charging, charging infrastructure for landbased vehicles, electromagnetic compatibility, energy storage, customer interaction and regulatory issues. Swedavia's airports contain challenges interesting for most of SEC's themes. The company is looking at innovative energy storage solutions as well as charging, vehicle and grid interactions and user behaviour, but above all, security is prioritized.

"Everything we do needs to be in compliance with the strict safety and security measures that are required on airports, one example being electromagnetic compatibility," says John Nilsson.

Swedavia start as network partners, but the hopes are to get more involved in SEC's projects and collaborations.

"There are many areas where we look forward to learning from SEC's partners as well as contributing with our knowledge. In fact, we are also already collaborating with many of the centre's partners in other projects," says John. "We need to ensure that the sustainable flights of the future can start and land on our airports. One aim is to be an energy hub by 2030 which means that we need to be prepared for providing both land and air with energy in a sustainable way."



John Nilsson, senior strategist at the unit Sustainable development, Swedavia.



Battery swapping

The focus group B-SWAP was centered at the cross-theme topic of battery swapping technology for electrical vehicles. Representatives of more than seven SEC partners participated in the meetings which have given valuable insights and identified possible future research areas.

-SWAP, the first ever focus group formed at SEC, was initiated and lead by VTI, The Swedish National Road and Transport Research Institute. The industry, academy and institutes were well represented, with Epiroc, RISE, Linköping University, Scania CV, E.ON, Lund University and CEVT actively involved with in-kind contributions.

A total of ten meetings were held, every few weeks between October 2022 and June 2023 and were open for all SEC members organisations. Each meeting was attended by on average 12 participants, and one master thesis was completed during that time.

The topic of battery swapping was considered of suitable interest for a focus group as it has not received a lot of earlier coverage and includes parts that are relevant for all five themes in SEC while at the same not being actively addressed in neither of them. The objective was to explore and evaluate the technique from a Swedish perspective, including identifying research gaps and specific questions to address in future projects.

The discussions were broad and covered both technological and other aspects. Furthermore, the topic was set in context of different perspectives in different transport segments, such as for example two-wheelers, cars, heavy vehicles, machinery, electrical grid side.

The first battery swapping station for cars opened, by the Chineses company Nio, right after the focus group started. Up to date there are now 30 battery swap stations across Europe and 8 in Sweden.

Svetla Käck, senior researcher at VTI, has lead the focus group's work.

"All the meetings have been well attended and it's obvious that this is a topic many are curious about. There is so much research than can be done in this area."

- \rightarrow Battery swapping solutions have several advantages, such as to separate the vehicle and the battery life cycles; providing a gentle impact on the grid or the possibility to electrify at sites with weak grid connections; optimizing land usage; as well as features that allow possibilities to support the grid, and so on.
- \rightarrow There are also barriers, such as the need for developing standards and being included in regulations.
- → Swapping solutions are quickly increasing internationally, and have now appeared in Sweden, making them part of the electrification landscape (see illustration on p. 52). They are complementary to other electrification technologies and should be explored further.



VTI has also recently finished a project looking at this technology particularly for heavy duty vehicles and is also a member of ongoing IEA initiative with collaboration on the topic of battery swapping. https://vti.diva-portal.org/smash/get/diva2:1826965/FULLTEXT02.pdf

avoiding any waiting for charging beyond few minutes; the possibility





New test facilities

"Building prototypes, testing, failing, rebuilding, and repeating the process are paramount to succeeding in the transformation of the transport system. Therefore, we are very excited by the inauguration of new test facilities by our partners, SEEL Labs and the Alstom Mobility and Innovation Lab."



The inauguration of Alstom Mobility and Innovation Lab took place in Västerås on 5 October 2023.

Swedish Electric Transport Laboratory (SEEL) SEEL, a collaboration between

Chalmers and RISE with the aim to accelerate the evolution of electrified transports, has opened three test facilities.

The largest is situated at the Säve Airport in Gothenburg and meets the needs of developers of electrified cars, trucks, buses, aircraft, and ships.

In Nykvarn the emphasis of work will be on research and testing in the field of battery technology, and dynamic testing of electric powertrains for heavy vehicles.

Safety tests will be the focus of the Borås facility, related to charging, short circuits, vibrations, mechanical shock, extreme temperatures, and fire risks.

Alstom Mobility and Innovation Lab

Alstom, a global leader in sustainable mobility, broke ground on a green e-mobility innovation centre in the Lake Mälaren region. The ongoing transition to electrified transportation creates the need for additional testing capacity.

The core of the new centre's operations will be the opening of Alstom's lab in Västerås to external parties interested in testing and developing electrical drive systems. Doing so, Alstom will help to accelerate the transition to an emission-free future through cross-industry collaboration. The climate-smart mobility innovations of the future will result from cross-fertilizations between industry, universities, and start-ups.

Collaborations

SEC is growing in many ways, in members, in project funding, but also in collaboration with other centres and with associated projects. These are some of the organisations and projects the centre collaborated with in 2023.

BASE

BASE (Batteries Sweden) is a VINNOVAfunded 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 inventin 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. In 2022 BATTERY 2030+ was granted an extension for yet three more years.

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.

LINK-SIC

This is a centre based at Linköping University that focus on control technology, signal processing, and diagnosis of general technical systems. There is an overlapping environment between the SEC researchers and the LINK-SIC 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 Cent-res funded by SSF (Swedish Foundation for Strategic Research) that was stared 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 EVS38 in Gothenburg 2025. SEC has participated in the Swedish delegations for EVS35 and EVS36 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.

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, 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, SEC was part of the grand opening and in November SEEL hosted the SEC program council meeting including a tour of the facility in Gothenburg.

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

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.

Lars Eriksson awarded with Håkan Frisingers scholarship

We congratulate Professor Lars Eriksson on the prestigious "Håkan Frisinger Award for Excellence in Transportation Research" which he receives for his signifcant contributions in transportation research.

Lars is professor in Vehicular Systems at the Department of Electrical Engineering at Linköping University, and theme leader for the area Intelligent Vehicles and Systems. Lars has a long tradition of making research results easily accessible and has several collaborations with industry in general models and product oriented research projects resulting in several solutions integrated and used by global truck manufacturers.

The award consists of an individual prize of SEK 300,000 and a period as visiting researcher at a university located in Sweden, including a grant of SEK 500, 000 for a VREF Visiting Researcher Programme of to the university hosting the visiting researcher. In this case granted Uppsala University, Ångströms Laboratory that will welcome Professor Lars Eriksson's research program on electromobility.

"Lars Eriksson's strong scientific record is combined with a significant contribution to industry. He is often making research results easily accessible and available through the release of textbooks as well as open-source software and models. Many of the world's most prominent companies in the transportation manufacturing industry are using the model libraries provided by him. Lars also has a strong teaching and supervision record in Sweden and internationally. His proposed programme at Uppsala university will provide excellent opportunities for scientific collaboration to improve the knowledge, efficiency, and overall sustainability of the electric vehicle (EV) battery, which is at the core of electromobility," writes Jan-Ingvar Jönsson, rector of Linköping University, in his nominating letter.

"It's an old dream if mine to receive the Håkan Frisinger Award, and it's something that I have strived towards during my research career. So, I feel very honored, happy, and grateful for this acknowledgement."

From Japan

Swedish Electromobility Centre caught Yuki Kobayashi's attention when he was looking for research information within electromobility. When a PhD student position opened at Chalmers he decided to apply.

to Sweden

grew up in Kyoto and Osaka in Japan where he received a B.A. and M.S. degrees in urban management engineering from Kyoto University. He worked as a researcher at Nissan in Yokohama between 2018 and 2023. He was not unfamiliar with Sweden since he had done a research exchange year at KTH in Stockholm in 2016.



"I'm really into electromobility and I understood that if I



"I like Sweden, it's a comfortable country and I enjoy the worker-friendly working conditions here. The biggest difference is that in Japan you can find anything anywhere conveniently, but in Sweden, the cities are more relaxing instead. Yes, I enjoy the different culture."

Yuki's research is about understanding charging and driving patterns in a Vehicle to Grid perspective. Analyzing data from EV owners will help understand opportunities and challenges within EV charging and what impacts it has on the electricity grid.

"I have a positive prospect for electromobility in the world. Especially electric cars for private use and car sharing. Sweden has come further in this remark compared to Japan. The Japanese car market is a bit different from Sweden. Highly efficient plualess hybrid electric vehicles are dominant, and you can see many cubic cars for four passengers called kei," says Yuki.

wanted to expand my knowledge in this area, SEC was a good place to be at. Besides, the PhD community looked really fun."

Outreach & Communication

Society's interest for e-mobility has constantly been increasing over the years. It's therefore important for SEC to be open and communicate both to a wider audience as well as to professionals. SEC and its participants continously takes an active part in the public debate and various outreach activities.

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 the combined Roads to the Future & E-mobility Day in Kista in August (see pp. 66-67).

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 gather, analyse and share information and keep you updated on the latest from the world of e-mobility and that may influence Swedish mobility development (see pp. 64–65).

External events

SEC's representatives continously participate at external events and activities (see p. 91).



SEC's LinkedIn page has up to date about 2,000 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. Concluding stage IV (Jan 2019 to March 2022) SEC had a total of 34 appearances in public media outlets. That is well above the summarized KPI target of 12 SEC in media published achievments and apperances.

Svenska Dagbladet DEBATT | FORSKNING "Sverige behöver de utländska forskarna"



Mer pengar till batteriforskning: 2500 nya ingenjörer ska utbildas sorn: "Vi kommer att göra mycket värdefull forskning

Media appearances 2023

"Så smutsigt är elbilsbatterier - nu ska det bli grönare"; Sveriges Radio

"Mer pengar till batteriforskning: 2500 ingenjörer ska utbildas"; TV4 https://www.tv4.se/artikel/6mArfRhbEznlBbavLaWDki/mer-penaar-till-batteriforsknina-2500-nva-inaenioerer-ska-utbildas

"Northvolt to bring sodium-ion batteries to european market"; Chemistry World https://www.chemistryworld.com/news/northvolt-to-bring-sodium-ion-batteries-to-european-market/4018576.article

"Batteriteknik blir framtidens industri"; Dagens industri https://www.di.se/nyheter/ny-batteriteknik-blir-framtidens-industri/

"Sverige behöver de utländska forskarna"; Svenska Dagbladet* https://www.svd.se/a/4o20wV/swedish-electromobility-centre-sverige-behover-de-utlandska-forskarna

"El cobalto no es el único culpable de la salud en las baterías de iones de litio"; Nuevoperiodico https://nuevoperiodico.com/el-cobalto-no-es-el-unico-culpable-de-la-salud-en-las-baterias-de-iones-de-litio/

"Kobolt är inte den enda hälsoboven i lithiumjonbatterier", Ny teknik https://www.nyteknik.se/debatt/kobolt-ar-inte-den-enda-halsoboven-i-litumjonbatterier/2053425

"Sodium-ion batteries offer promising technology"; Maintworld https://www.maintworld.com/Asset-Management/Sodium-ion-batteries-offer-promising-technology

"Rapport sågar Japans strategi för vätgas"; Ny teknik https://www.nyteknik.se/japan-topp-vatgas/rapport-sagar-japans-strategi-for-vatgas/1604148

"Så går det till när DB Schenker elektrifierar den tunga trafiken"; Dagens infrastruktur, IT-retail https://www.dagensinfrastruktur.se/2023/10/02/sa-gar-det-till-nar-db-schenker-elektrifierar-den-tunga-trafiken/ https://it-retail.se/sa-aar-det-till-nar-db-schenker/





https://sverigesradio.se/avsnitt/sa-smutsigt-ar-elbilsbatteriet-nu-ska-det-bli-gronare

Magnus Karlström editor in chief

omEV Newsletter

2023: A year of growth and innovation

The automotive sector is currently in the midst of a transformative evolution, which is characterized by a series of trends that are collectively reshaping the terrain of personal and commercial transportation. At the forefront of this revolution is the rapid progression towards electrification. This trend is manifested through a substantial uptick in the adoption of electric vehicles (EVs), a change propelled not only by advancements in battery technology and the expansion of charging infrastructures but also by robust policy support.

n hedding light on this shift, the consulting firm BloombergNEF (BNEF) has presented **U** a comprehensive analysis in their new report, Zero-Emission Vehicles Factbook, detailing e-mobility's evolution in 2023. Regarding the global vehicle fleet, after 2023, there are 1.57 billion road vehicles (encompassing passenger cars, buses, trucks) actively in use. This figure represents a 2 percent increase over the previous year. Notably, 41 million of these vehicles are rechargeable or equipped with fuel cells, comprising 3 percent of the total fleet. Delving deeper, 29 million of these are either battery electric or fuel cell vehicles, with a striking 16.3 million located in China and 6.6 million in Europe. The rest are plug-in hybrids.

Sales

In terms of sales for the year 2023, the industry saw 94 million road vehicles being sold worldwide. Significantly, 14 million among these are rechargeable or fuel cell vehicles—a 36% surge from 2022. The market share for rechargeable or fuel cell passenger cars stood at 16 percent for the first half of the year. More specifically, battery electric passenger cars accounted for 11 percent, a notable rise from 3 percent in 2020. Similarly, plug-in hybrids captured 5 percent of the market, up from 2 percent in 2020, while fuel cell vehicles comprised less than 0.1 percent. Geographically, China led with a 27 percent share, followed by the EU at 22 percent, the USA at 8.8 percent, and Japan at 3.6 percent, with China's sales surpassing policy mandates.



omEV is a newsletter and podcast about electric road vehicles that has been published since 1997. It's released 2–3 times per week with summer and winter breaks. omEV is funded by Swedish Energy Agency and hosted by Swedish Electromobility Centre.

BNEF's report also highlights the sales of rechargeable or hydrogen-powered heavy vehicles in the first half of 2023, totaling 240,000 units, mostly smaller heavy vehicles. Additionally, 17,000 medium and heavier trucks, either rechargeable or hydrogen-powered, were sold, with China once again taking the lead by accounting for eighty percent of these sales.

Investments

On the investment front, global funding is experiencing a significant uptick. A staggering 1,600 billion USD has been invested globally in rechargeable and hydrogen-powered vehicles, alongside their associated infrastructure, from 2016 to the first half of 2023. The year 2023 alone is poised to witness an investment surge to the tune of 685 billion USD, indicating a fifty percent increase from the previous year. Parallel to these advancements, battery production capacity is on an upward trajectory. The current global capacity for battery production stands at 2.2 TWh/year for existing and under-construction facilities. This is a fourfold increase from the capacity that existed in 2020.

Battery development

Furthermore, a noteworthy development in the sector is the decline in battery prices. The average cost of a battery pack for vehicle companies is estimated at 139 USD/kWh in 2023, representing a decline of 14 percent compared to the previous year. Lastly, examining the trends in battery chemistry, Lithium Iron Phosphate (LFP) batteries are becoming increasingly prevalent. In 2023, LFP batteries made up 40 percent of the batteries utilized in electric vehicles, a considerable leap from the 17 percent share they held in 2020. BNEF also highlights the trend of sodium batteries.

E-mobility Day & Roads to the Future

Electric Vehicles as new players in the grid

SEC's international electromobility conference Roads to the Future addresses the latest research and cutting-edge technology within the field of electromobility. Highlighted this year was important aspects of the integration of a growing electric fleet into the electricity grid, based on reliability, robustness, and resilience. Current issues such as preparedness and priorities were also discussed as well as charging and buffering demands on the grid, the infrastructure, and the batteries.

The conference days took place in Kista outside Stockholm on 29-30 August. Roads to the Future had a program entitled "Electric Vehicles as a New Player in the Grid". Klaas Burgdorf at the Swedish Energy Agency set the scene with his introduction stressing the importance of vehicle-to-grid integration.

Keynote speakers

Keynotes were delivered by Keith Hardy, Technical Advisor on International Cooperation at Argonne National Laboratory, and Anna Teyssot, Chief Sales & Marketing Officer at Verkor. Verkor has been on a recent journey building a Gigafactory in Dunkirk which related to Anna Teyssot's speech on "Solving the Gigafactory challenge, the building of a European ecosystem". Keith Hardy talked about how we can build even smarter charging infrastructure in his speech "Technical Recommendations for Government-Funded EV Charging Infrastructure".

Straightforward on hydrogen

David Cebon, Professor in Mechanical Engineering and director for centre for sustainable road freight at Cambridge University, raised a lot of discussion in his straightforward talk on how hydrogen is too expensive and inefficient for heavy transport in the electric road system.

No more flight shame?

Electric aviation has gained a lot of attention in the recent time. Simon Reinberth gave the audience an insightful talk about Heart Aerospace journey to develop a regional electric airplane with a seating capacity of 30 passengers.

The battery performance hype

Matthew Lacey, senior advisor at Scania, warned about hyping battery performance from lab results and reminded everyone how far the distance is to full scale production.

Earth metals and EVs as a transport of energy

The need for electric motors free from rare earth metals was stressed by Ali Emadi, professor at McMaster University. Chih Feng Lee, Project Manager & Developer at Polestar, proposed that we see an electric vehicle also as a transport of energy in the time and space domain.

E-mobility Day

The E-mobility Day conference, open only to SEC partners, is a day where the researchers and project leaders present the latest results within the centre. 14 projects from the five research themes were presented and the topics spanned from challenges with lithium-based solid-state batteries, and energy management strategies, to systems perspectives of high-power charging. Magnus Burman is an excellent moderator.



Pavid Cebon spoke about energy and road freight.

SEC annual report 2023

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IVL
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Alvier Mechatronics
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Also part of the council during 2023: Charlotte P Björkman, UU Jan Palmér, Scania Stefan Petterson, RISE

Co-opted members

Linda Olofsson Ellen Olausson Klaas Burgdorf

SEC	
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Energi- myndighete	en

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

Also part of the council during 2023: Johan Hellsing, CEVT Fernanda Marzano, Scania Maria Grahn, Chalmers Arne Nåbo, VTI

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Management Group & Staff

Arne Nåbo VTI

(Jan-March)





Ellen Olausson

Deputy Director

Linda Olofsson Director



Jonas Fredriksson Theme 1



Lars Eriksson Theme 1



Jens Hagman RISE (June-)





Francisco Márquez-Fernández Theme 2 & VTI (April–)





Anna Abelius

Administrator

Pia Karlsson Financial Officer





Magnus Karlström Editor in Chief om EV



Göran Lindbergh Theme 3

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Daniel Brandell Theme 3



Mikael Lantz Theme 5



Luca Peretti

Theme 2

Anders Nordelöf Theme 4



Valeria Castellucci Theme 5



Magnus Blinge Theme 4





Marcus Folino Communications Officer (Oct-)



Mats Tiborn Communications Officer (Jan-June)



Liridona Sopjani Network (Oct-)



Therese Eriksson Coordinator Doctoral Student Coordinator Doctoral Student Network (Jan-Oct)

Centre Finance

SEC project types



SEC project funding distribution between the theme areas



In 2023, the project portfolio included a total of 88 projects, of which 58 were SEC financed projects and 30 projects associated with SEC. Efforts have been made towards a more even distribution of projects between the different research themes, and this is now starting to show.

Cash funder distribution in SEC associated projects

Vinnova	8%	
Other*	17%	
Swedish Tran Admininistra	17%	
Swedish Ene Agency	58%	
SEC associate for expanding the electrome		

*Mistra, The Knowledge Foundation, Statens Vegvesen, Swedish Foundation for Strategic Research, Volvo GTT

2

nsport ation



e projects plays an important part g knowledge and experiences within obility research community.

Appendix

Projects 2023 (58 in total)

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
ACTUAL grid and road simulation for e-mobility	2, 5	Francisco Marquez- Fernandez	Lund University, KTH, CEVT, E.ON, Scania, Vattenfall, Volvo Group, Volvo Cars		Manchester University	IV	1	2
Additive Manufacturing of Stator Windings	2	Mats Alaküla	Lund University, RISE, Volvo Group, BorgWarner, ABB			V	0	6
Air System Modeling for Efficient FCEV – ASMEF	1, 3	Öivind Andersson	Lund University, Linköping University, Volvo Group			V	1	1
Arcing as the Ignition Source in Malfunctioning Batteries	3	Elna Heimdal Nilsson	Lund University, Volvo Cars, CEVT			V	1	1
CHARGE – Charging and Trip Planning of Electric Vehicles	1, 5	Nikolce Murgovski	Chalmers, Uppsala University, VTI, Volvo Cars, CEVT, E.ON		TU Delft, TU Eindhoven and the TNO institute in The Netherlands	V	0	3
Chemical quenchers for inhibition of battery fires	3	Elna Heimdal Nilsson	Lund University, Uppsala University, Volvo Cars			IV	2	2
Circular battery systems	4	Jonas Holmborn	KTH, Scania, Volvo Cars, CEVT			V	-	-
Combining physical and data-based modelling to under- stand material failures in rechargeable lithium ion batteries	3	Peter Broqvist	Uppsala University, Scania, Volvo Cars		BIGMAP, EU	IV	1	3

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
Cost & Benefit Analysis of V2G Scenarios	1, 3, 5	Jonas Hellgren	RISE, Linköping University, Volvo Cars, E.ON, Vattenfall			V	0	3
Dansmästaren Project – Smart Charging Strategies	5	Valeria Castellucci	Uppsala University, CEVT, Volvo Cars, E.ON, Vattenfall	Uppsala Parkerings AB, STUNS, Charge AMPS, Uppsala Municipality		V	2	2
Data exchange between vehicle and power system for optimal charging	5	Jennifer Leijon	Uppsala University, CEVT, Vattenfall, Volvo Group, Volvo Cars			IV	1	0
Data REgulation And electroMobility - DREAM	4	Jeanette Andersson	VTI, Volvo Cars, CEVT, Scania, ABB			V	1	2
Design of rare earth element free motors for electromobility	2	Sandra Eriksson	Uppsala University, Scania		EU-consortium	IV	2	1
Design of rare earth element free motors for electromobility – Part 2	2, 4	Sandra Eriksson	Uppsala University, Alstom Group, Scania		EU-project	V	2	1
DFN-model of Hard Carbon for Na-ion Batteries	3	Evelina Wikner	Chalmers, Uppsala University, Volvo Group, CEVT, Volvo Cars			V	3	5
Diagnostics and supervision of dynam- ically configurable battery systems - DiConBatt	1, 3	Mattias Krysander	Linköping University, Scania	Atlas Copco	Hycomes team, Inria, Univ Rennes, CNRS, IRISA, Rennes, France	IV	1	2

Projects 2023

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
ECOTS – Evaluation and Control Of Thermal management Systems	1, 2, 3	Lars Eriksson	Linköping University, Chalmers, Volvo Group, Titan X, Epiroc, Volvo Cars		USA, Netherlands, Austria, Italy and South Korea	V	0	3
Electric motor + hydraulic pump fusion for electrification	1, 2	Liselott Ericson	Linköping University, Volvo Group		University of Sheffield	V	1	2
Electric vehicle charging strategies and grid management – interaction with the electric grid	4, 5	Maria Taljegård	Chalmers, CEVT	Ellevio, Energiforsk, Profu, Statens Vegwesen		IV	2	2
E-machine design and environmental impact	2, 4	Torbjörn Thiringer	Chalmers, VTI, Uppsala University, Volvo Group, BorgWarner, Volvo Cars, Alvier Mechatronics			V	5	3
E-machine design for enhanced recyclability and minimized envi- ronmental impact	2, 3, 4	Torbjörn Thiringer	Chalmers, ABB, CEVT, Volvo Cars			IV	5	4
Energy Management Strategies for Electrified Vehicles Under Traffic Uncertainties	1	Jonas Fredriksson	Chalmers, CEVT, Scania, Volvo Group, Volvo Cars			IV	0	2
Environmental Assessment of Electromobility Charging systems	4	Anders Nordelöf	Chalmers, CEVT, Scania, Volvo Group, Volvo Cars			IV	0	2
Evaluation and optimi- zation of materials for IT-PEMFC	3	Björn Eriksson	KTH, ABB, PowerCell, Scania, Volvo Group			IV	0	1
Fossil-free long-haul trucks in Europé	4	Frances Sprei	Chalmers, Volvo Group, Scania, Titan X			V	3	0

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
Fuel Cell Performance Prediction	3	Rakel Wreland Lindström	KTH, ABB, PowerCell, Volvo Group		Paul Scherrer Institute (PSI), Switzerland	IV	2	5
Gas analysis of large-format EV batteries	3	Erik Berg	Uppsala University, Scania, Volvo Group			V	0	1
Heterogenic Ageing in Large Intercalation Batteries (HALIBatt- KTH) – KTH	3	Rakel Wreland Lindström	KTH, Uppsala University, Chalmers, VTI, Scania, Volvo Group, CEVT, Volvo Cars			V	1	3
Heterogenic Ageing in Large Intercalation Batteries (HALIBatt-UU) – Uppsala	3	Fredrik Björefors	Uppsala University, Chalmers, KTH, VTI, Volvo Group, Scania, CEVT, Volvo Cars			V	2	4
High Power Charging – When, where and how?	5	Karin Thomas	Uppsala University, CEVT, Scania, Vattenfall, Volvo Group			IV	1	1
High Power Charging: When, where and how? – Part 2	5	Karin Thomas	Uppsala University, Scania, Volvo Group, CEVT, Vattenfall			V	1	1
How to test V2G technology	1, 3, 5	Lars Fast	RISE, Linköping University, E.ON, Volvo Cars, Scania, CEVT, Vattenfall	SEEL		V	1	9

Projects 2023

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
Investigation of wind- ing configuration and leakage inductance on electrical machine performance in terms of torque ability and ripple as well as iron loss	2	Sonja Tidblad Lundmark	Chalmers, ABB, Scania, Volvo Group, Volvo Cars			IV	2	1
LEAR – Robust LEArning methods for electric vehicle Route selection	1, 2, 5	Balazs Kulcsar	Chalmers, Volvo Group			V	0	5
Life Cycle Assessment of Large-Scale Lithium- Ion Battery Production and Recycling	4	Anders Nordelöf	Chalmers, CEVT, Scania, Volvo Group, Volvo Cars	Northvolt AB, Stena Recycling International AB		IV	0	3
Life Cycle Assessment of Large-Scale Lithium- Ion Battery Production and Recycling – Part 2	4	Anders Nordelöf	Chalmers, CEVT, Volvo Cars, Volvo Group, Scania	Northvolt AB, Stena Recycling International AB		V	0	3
Life Cycle Assessment of vehicle-to-x	2, 4, 5	Anders Nordelöf	Chalmers, Volvo Cars, Vattenfall			V	2	2
Logging of Electric Vehicles – Characterization of Charging Patterns and Grid Impacts	4, 5	Maria Taljegård	Chalmers, Volvo Cars, CEVT		Vrije University, Belgium	V	1	2
Measurements and modelling of thermal and electrical behavior of labscale/industry prototype Li-Ion cells	2, 3	Torbjörn Thiringer	Chalmers, Uppsala University, CEVT, Polestar, PowerCell, Scania, Volvo Group, Volvo Cars			IV	5	6

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
ML Assisted Ageing Predicition and Adaptive Modelling for BMS	3	Torsten Wik	Chalmers, Uppsala University, Volvo Group, Volvo Cars, Epiroc, CEVT, ABB			V	0	1
Modelling of a PMSM accounting for 'posi- tion harmonics' and control in order to establish the possibil- ity of reducing ripple and keeping highest possible efficiency	2	Torbjörn Thiringer	Chalmers, Volvo Cars, Alstom Group			V	0	3
Multi-criteria optimal motion control of automated EVs	1	Wenliang Zhang	KTH, Volvo Cars		University of Freiburg in Germany	V	2	2
NVH Analysis and Mitigation in Electrical machineS - NAMES	2	Francisco Marquez- Fernandez	Lund University, ABB, CEVT, E.ON, Scania, Volvo Group, Volvo Cars, Epiroc, Bombardier, Saab			IV	1	0
Online health diag- nostics of inverters for commercial vehicle drive systems	2	Staffan Norrga	KTH, Scania			IV	0	1
Optimal energy man- agement of second life batteries	1, 3, 5	Jonas Hellgren	RISE, Volvo Group			V	0	2
Performance and ageing of Li-based solid-state batteries	3	Mario Valvo	Uppsala University, Scania, Volvo Cars	Partners from Batteries Sweden (BASE)		IV	3	2
Planning Support for Electric Vehicles based on Optimal Control	1	Lars Eriksson	Linköping University, Scania, Volvo Group		USA, Netherlands, Austria, Italy and South Korea	IV	0	2

Projects 2023

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
PMaSynRM for Heavy Duty Application	2	Sonja Tidblad Lundmark	Chalmers, LTH, Uppsala University, Volvo Group, Volvo Cars, CEVT			V	2	2
Prerequisites for electrification of freight transports.	4	Henrik Gillström	Linköping University, BorgWarner, CEVT, Scania, Titan X, Vattenfall, Volvo Group, Volvo Cars	Bring, Logistikkluster Östergötland		IV	0	1
Real-time observation of side-reactions: Understanding and predicting the lifetime characteristics of Li-ion cells	3	Erik Berg	Uppsala University, KTH, Scania, Volvo Group		PowerCo GmBH and BMW	IV	0	1
Resource-Effective Batteries and Charging for BEVs	3, 4	Kristina Holmgren	RISE, VTI, Volvo Cars, CEVT			V	4	3
Swedish Electromobility Centre Färdplan – övergripande målbild	1, 2, 3, 4, 5	Stefan Pettersson	RISE, Chalmers, VTI, Lund University, Uppsala University, KTH, Linköping University, Scania			V	5	10
Testing, Analysis and Design of Axial Flux Motors for Vehicle Applications	2	Sonja Tidblad Lundmark	Chalmers, KTH, ABB, Volvo Group, Volvo Cars			IV	3	2
Thermal modelling and fault prognosis for Li-ion battery systems	3, 4	Changfu Zou	Chalmers, Scania, Volvo Group		National Data Center of New Energy Vehicles, China, and Geely Automotive	IV	0	4

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	International Collaboration	Stage	Females	Males
Total loss minimization algorithms in electric drives for e-mobility	2	Luca Peretti	KTH, Volvo Cars, CEVT, ABB			IV	0	2
Tyre wear and particle emissions of electric vehicles – a review of test methods and influ- encing parameters	1, 4	Mats Gustafsson	VTI, Volvo Cars			V	1	3
Vehicle-grid inter- action from a policy perspective	5	Mikael Lantz	Lund University, VTI, CEVT, E.ON, Scania, Vattenfall, Volvo Group, Volvo Cars			IV	2	2
XRD tomography of electrodes from Ni-rich Li-batteries – aging fingerprints in the 3D structure of the electrodes	3	Anti Liivat	Uppsala University, Lund University, Scania			IV	1	3



Projects Stage IV 2019-2023 (42 in total)



Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	Internationel Collaboration	Females	Males
A Model and Simulation Platform for Electric Vehicle Systems with Motors, Power Electronics, Batteries and Fuel Cells and their Heating and Cooling Needs	1, 2	Lars Eriksson	Linköping University, Lund University, SAAB, Scania, Titan X, Volvo Group, Volvo Cars			0	10
A Pre-Study for Manufacturing Effects in Electrical Machines	2	Joachim Lindström	Chalmers, Lund University, BorgWarner, CEVT, Volvo Group, Volvo Cars	Surahammars Bruk		0	8
ACTUAL grid and road simulation for e-mobility	2, 5	Francisco Marquez- Fernandez	Lund University, KTH, CEVT, E.ON, Scania, Vattenfall, Volvo Group, Volvo Cars		Manchester University	1	2
Charging behaviour and infrastructure need for plug-in electric vehicles	4	Frances Sprei	Chalmers, Volvo Cars	UC Davis	Germany, California, International EV policy council, Delaware	1	1
Chemical quenchers for inhibi- tion of battery fires	3	Elna Heimdal Nilsson	Lund University, Uppsala University, Volvo Cars			2	2
Combining physical and data-based modelling to understand material failures in rechargeable lithium ion batteries	3	Peter Broqvist	Uppsala University, Scania, Volvo Cars		BIGMAP, EU	1	3
Cost-benefit Optimized ChArging INfrastructurE	5	Gyözö Gidofalvi	KTH, Vattenfall		Massachusetts	1	2
Data exchange between vehicle and power system for optimal charging	5	Jennifer Leijon	Uppsala University, CEVT, Vattenfall, Volvo Group, Volvo Cars			1	0

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	Internationel Collaboration	Females	Males	
Design of rare earth element free motors for electromobility	2	Sandra Eriksson	Uppsala University, Scania		EU-consortium	2	1	
Diagnostics and supervision of dynamically configurable battery systems - DiConBatt	1, 3	Mattias Krysander	Linköping University, Scania	Atlas Copco	Hycomes team, Inria, Univ Rennes, CNRS, IRISA, Rennes, France	1	2	
Electric vehicle charging strat- egies and grid management – interaction with the electric grid	4, 5	Maria Taljegård	Chalmers, CEVT	Ellevio, Energiforsk, Profu, Statens Vegwesen		2	2	
Electromobility Scenarios	1, 4	Anders Grauers	Chalmers, KTH, Linköping University, Lund University, Uppsala University			1	2	
E-machine design for enhanced recyclability and minimized environmental impact	2, 3, 4	Torbjörn Thiringer	Chalmers, ABB, CEVT, Volvo Cars			5	4	
Energy Management Strategies for Electrified Vehicles Under Traffic Uncertainties	1	Jonas Fredriksson	Chalmers, CEVT, Scania, Volvo Group, Volvo Cars			0	2	
Environmental Assessment of Electromobility Charging systems	4	Anders Nordelöf	Chalmers, CEVT, Scania, Volvo Group, Volvo Cars			0	2	
Evaluation and optimization of materials for IT-PEMFC	3	Björn Eriksson	KTH, ABB, PowerCell, Scania, Volvo Group			0	1	
Evaluation of an electro-me- chanical linear actuator in heavy-duty applications	1, 2	Lars Eriksson	Linköping University, ABB, Epiroc, Volvo Group	Cascade Drives		0	1	

Projects Stage IV 2019-2023

Projects Stage IV 2019–2023

Theme(s)

3

3

1, 2

5

2

Project

Anneli

Rakel

Wreland

Öivind

Karin

Sonja

Thomas

Lindström

Andersson

Manager

Jedenmalm

SEC Partners

KTH, Lund

PowerCell, Scania, Volvo Group

KTH, ABB,

PowerCell,

Chalmers, KTH, ABB, CEV,

PowerCell, Scania, Volvo

Group

Uppsala

University,

CEVT, Scania, Vattenfall, Volvo Group

Chalmers, ABB,

Chalmers,

Scania, Volvo Group

Volvo Group

Lund University,

University, ABB,

Other Partners Internationel

Collaboration

Paul Scherrer

Institute (PSI),

Switzerland

Females Males

7

5

6

1

5

2

0

1

2

Project title

Fuel cell durability prestudy

Fuel Cell Performance Prediction

Fuel Cells in Vehicle Systems

High Power Charging – When,

Investigation of winding config-

Vehicles with Aftertreatment

Systems

where and how?

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	Internationel Collaboration	Females	Males
Modelling and control of com- plex AWD BEV architectures	1, 2	Nikolce Murgovski	Chalmers, BorgWarner, CEVT, Volvo Cars		Netherlands, China	1	3
NVH Analysis and Mitigation in Electrical machineS - NAMES	2	Francisco Marquez- Fernandez	Lund University, ABB, CEVT, E.ON, Scania, Volvo Group, Volvo Cars, Epiroc, Bombardier, Saab			1	0
Onlline health diagnostics of inverters for commercial vehicle drive systems	2	Staffan Norrga	KTH, Scania			0	1
Performance and ageing of Li- based solid-state batteries	3	Mario Valvo	Uppsala University, Scania, Volvo Cars	Partners from Batteries Sweden (BASE)		3	2
PETECI: Predictive Energy and Thermal management of Electric vehicles with Connectivity to Infrastructure	1, 5	Nikolce Murgovski	Chalmers, Volvo Cars		Netherlands, Switzerland, China	0	3
Planning Support for Electric Vehicles based on Optimal Control	1	Lars Eriksson	Linköping University, Scania, Volvo Group		USA, Netherlands, Austria, Italy and South Korea	0	2
Power systems integration of electric vehicles for balancing power support through all-dc systems	2, 5	Massimo Bongiorno	Chalmers, Volvo Cars		Technical University of Catalonia, University of Padova, Aalborg University, University of	0	3

uration and leakage inductance on electrical machine perfor-		Tidblad Lundmark	Scania, Volvo Group, Volvo					of Electric vehicles wit Connectivity to Infras
and ripple as well as iron loss			Curs					Planning Support for E
Life Cycle Assessment of Large-Scale Lithium-Ion Battery Production and Recycling	4	Anders Nordelöf	Chalmers, CEVT, Scania, Volvo Group, Volvo Cars	Northvolt AB, Stena Recycling		0	3	Control
			VOIVO CUIS	AB				Power systems integro
Measurements and modelling of thermal and electrical behavior of labscale/industry prototype Li-Ion cells	2, 3	Torbjörn Thiringer	Chalmers, Uppsala University, CEVT, Polestar, PowerCell, Scania, Volvo Group, Volvo Cars			5	6	power support throug systems
Modeling, System Analysis, and Control of Hybrid Electric	1	Lars Eriksson	Linköping Unviersity,		Netherlands, France	0	3	



Projects Stage IV 2019-2023

Projects Stage IV 2019-2023

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	Internationel Collaboration	Females	Males
Prerequisites for electrification of freight transports.	4	Henrik Gillström	Linköping University, BorgWarner, CEVT, Scania, Titan X, Titan X, Vattenfall, Volvo Group, Volvo Cars	Bring, Logistikkluster Östergötland		0	1
Real-time observation of side-reactions: Understanding and predicting the lifetime characteristics of Li-ion cells	3	Erik Berg	Uppsala University, KTH, Scania, Volvo Group		PowerCo GmBH and BMW	0	1
Road resistance estimation for improved range estimation	1	Mikael Askerdal	Chalmers, CEVT, Volvo Group, Volvo Cars	SMHI, RISE		0	2
Switchable pole phase drive systems for electromobility	2	Luca Peretti	KTH, ABB, Scania		Italy	0	2
Testing, Analysis and Design of Axial Flux Motors for Vehicle Applications	2	Sonja Tidblad Lundmark	Chalmers, KTH, ABB, Volvo Group, Volvo Cars			3	2
Thermal modelling and fault prognosis for Li-ion battery systems	3, 4	Changfu Zou	Chalmers, Scania, Volvo Group		National Data Center of New Energy Vehicles, China, and Geely Automotive.	0	4
Total loss minimization algo- rithms in electric drives for e-mobility	2	Luca Peretti	KTH, Volvo Cars, CEVT, ABB			0	2
Towards electrification of freight transports	4	Henrik Gillström	Linköping University, Scania, Titan X			0	1
Vehicle-grid interaction from a policy perspective	5	Mikael Lantz	Lund University, VTI, CEVT, E.ON, Scania, Vattenfall, Volvo Group, Volvo Cars			2	2

Project title	Theme(s)	Project Manager	SEC Partners	Other Partners	Internationel Collaboration	Females	Males
XRD tomography of electrodes from Ni-rich Li-batteries – aging fingerprints in the 3D structure of the electrodes	3	Anti Liivat	Uppsala University, Lund University, Scania			1	3



Projects Stage IV 2019-2023

Associated projects 2023 (30 in total)

Project title	Funder	Theme(s)	Project Manager	SEC Partners	Other Partners
Ageing of Lithium-ion Batteries with Nickel-Rich Cathodes for Electromobility (ALINE)	Swedish Energy Agency	3	Matthew Lacey	Uppsala University, Chalmers, KTH,IVL, Scania, Volvo Group, Volvo Cars	
BAMSE – Battery Ageing sensitive Management SystEm	Swedish Energy Agency	3	Matilda Klett	KTH, Scania	
Battvolt – Batteristyrning med dynamisk konfigurering och styrbar utspänning	Mistra Innovation	1, 2	Lars Eriksson	Linköping University, Chalmers, Scania	SEM AB
Blood Batteries, Social Life Cycle Impacts of Lithium Ion Batteries	Swedish Energy Agency	4	Rickard Arvidsson	Chalmers	
Business models for electrified logistics	Swedish Transport Administration	4	Maria Huge- Brodin, Magnus Blinge	Linköping University, Scania	
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	
E-charge System demonstra- tion 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
Effekter av laddinfrastruktur på benägenheten att köpa laddbar bil	Swedish Transport Administration	4	lda Kristoffersson	VTI	
Electrification for sustainable energy system – Educational project	The Knowledge Foundation	5	Boel Ekergård	Uppsala University, Högskolan Väst	
Electromobility in smart cities	Swedish Energy Agency, Vinnova	3, 4, 5	Rafael Waters	Uppsala University, Vattenfall	Uppsala Parkerings AB, STUNS
Energy efficient propulsion system	Swedish Energy Agency	2	Léon Löwered	Chalmers, CEVT	

Project title	Funder	Theme(s)	Project Manager	SEC Partners	Other Partners
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
EVÅLUTION – Elektrifieringens utveckling ur ett åkeriperspektiv	Swedish Transport Administration	4	Jessica Wehner	VTI, Linköping University	
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	
Low carbon transport solutions	Statens Vegvesen	4, 5	Maria Taljegård	Chalmers	
Multi-Scale Modelling the Interfacial Chemistry in Solid- State Batteries	Swedish Energy Agency	3	Daniel Brandell	Uppsala University	Karlstad University
Operational Network Energy Management for Electrified Buses	Swedish Energy Agency	1	Balázs Adam Kulcsár	Chalmers	
Optimization of electrical ma- chines based on new standard- ized drive cycles	Swedish Energy Agency	2	Sandra Eriksson	Uppsala University	
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)
STORM – Smart freight TranspOrt and logistics Research Methodologies	Swedish Energy Agency	4	Frances Sprei	Chalmers	

Associated projects 2023

Associated projects 2023

Project title	Funder	Theme(s) Project Manager SEC Partners		SEC Partners	Other Partners
Sustainability transitions in urban goods distribution: local arenas as enablers of technolo- gy diffusion	Swedish Energy Agency	4	Thomas Magnusson	Linköping University	
System-level impact of elec- trification on the road freight transport system – a System Dynamics approach	Swedish Transport Administration	4	Anna Pernestål	KTH, Linköping University	
Ti3C2Tx MXene in Li- and Na-ion batteries	Swedish Foundation for Strategic Research	3	Kristina Edström	Uppsala University, Linköping University	
Towards safe energy communi- ties – 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
Tracer – Transport DemAnd Centric Decision Support for Electric ChaRging Infrastructure and Planning Operations	Swedish Transport Administration	1	Gyözö Gidofalvi	KTH, Scania	
TVS Modelling	Volvo GTT	2	Per Widek	Lund University, Volvo Group	



Events 2023

Event name	Date	Theme(s)	Event type
Charging infrastructure and EMC	2023-02-07	2	Workshop
Volvo Cars at Uppsala University	2023-03-01	UU	University workshop
Battery fires	2023-03-23	3	Workshop
Can agriculture be electrified?	2023-04-24	4	Workshop
Perspectives on ageing in E-lectromobility – mechanisms, models, and mitigation	2023-05-03	1, 2, 3	Cross-theme workshop
Thesis bonanza	2023-06-15	1	Workshop
Thesis bonanza	2023-06-12	4	Workshop
Dansmästaren Project - A status update	2023-08-31	5	Workshop
Bidirectional Charging	2023-10-04	5	Workshop
Swedish and European climate targets and the transition of the transport sector, and Firm-system interactions in the transition to electrified goods transportation	2023-10-20	4	Workshop
SEC and LTH profile area Energy Transition	2023-11-17	LU	University workshop
Lunchträff om elektromobilitet	2023-12-07	VTI/LIU	University workshop
On the environmental potential of a more circular economy	2023-12-11	4	Workshop
Speed prediction and traffic flow modeling	2023-12-14	1	Workshop
Aggregators' point of view on V2GOnline Zoom	2023-12-18	5	Workshop

Peer reviewed journal articles and conference papers 2023

Title	Author	Journal/Conference	DOI	Title	Author	Jo
IDCNN as an approximation model for torque optimiza- tion for spoke type electrical machines	M. D. Silva, S Eriksson	short paper IEEE COMPUMAG 2023	-	Analyzing the Impact of Die Positions inside the Power Module on the Reliability of Solder Layers for Different Power	B. P. Singh et al.	24 Co Mi Ph
A 2D Macro-homogenous MEA model for PEMFCs	Marcus Ringström	Piero Lunghi conference 2023: European Fuel Cells and Hydrogen	-	Cycling scenarios		Mi Mi 20
A framework to describe electri- fication of logistics systems	Gillström, H. & Grauers, A.	Logistics research network conference	-	Automated electrolyte formu- lation and coin cell assembly	Yik JT, Zhang L, Sjölund J, Hou X, Svensson PH, Edström K, et al	Di 20
A method to build energy-met-	L. Romano, M.	In Proceedings of the 2023	doi: 10.1109/VPPC60535.2023.10403383	battery research	eastrom k, et al.	
ric-optimal (EMO) classification systems for road transport missions	Raatnimidal, F. Bruzelius, et al.	IEEE Venicle Power and Propulsion Conference, Milan, Italy		BATTERY 2030+ and its Research Roadmap : A Bibliometric	Ahlgren P, Jeppsson T, Stenberg E, Berg E,	BA Re
Agent-Based Investigation of	Karlsson, J. & Grauers, A.	Energies 2023, 16(6), 2793	doi: 10.3390/en16062793	Andrysis		
of Public Chargers for Electric Long-Haul Trucks				Challenges in the actor network when upscaling use of elec- tric freight trucks in logistics	H. Gillström	EC
Agent-Based Investigation of	Karlsson, J. & Grauers, A.	Energies 2023, 16(12), 4704	doi: 10.3390/en16124704	systems		
of Public Chargers for Electric Long-Haul Trucks				Common Mode Current Measurements in Traction Systems for Electric Vehicles	P. Widek and M. Alaküla	IEE In 50
An Alternative to Determine IM	Meng-Ju Hsieh, Torbjörn	2023 IEEE International	doi: 10.1109/IEMDC55163.2023.10239094	Comparison of Simulation	Sandra Eriksson	
Magnetic Saturation Using Two- Stage Flux-Decay Test by FEM	miniger	Conference (IEMDC)		Methods for Angular Dependency when Modeling	Marcelo D. Silva	IIN
Analysis of the Performance	B. P. Singh et al.	In Proceeding 29th	doi: 10.1109/THERMINIC60375.2023.103258780	Competing Ethylene Carbonate	Lundström P. Gogoi N	Ic
Technologies of SiC Power Modules during Power Cycling Test	International Workshop on Thermal Investigations of ICs and Systems, Therminic 2023			Reactions on Carbon Electrode in Li-Ion Batteries. Journal of the Electrochemical Society	Hou X, Berg E	Ele 20
Analysis of voltage control using V2G technology to support low voltage distribution networks	Mattos et al.	s et al. IET Generation, doi: 10.1049/gtd2.13066 Transmission & Distribution 2023;1-25		Computationally Efficient Approach for Preheating of Battery Electric Vehicles before	Ahad Hamednia, Jimmy Forsman, Nikolce Murgovski	IF4 56 66
				Fast Charging in Cold Climates	Viktor Larsson, Jonas Fredriksson	

urnal/Conference	DOI
Ath International onference on Thermal, echanical and Multi- nysics Simulation nd Experiments in icroelectronics and icrosystems, EuroSimE 223	doi: 10.1109/EuroSimE56861.2023.10100764
gital Discovery 023;2(3):799–808.	doi: 10.1039/d3dd00058c
ATTERY 2030+ and its esearch Roadmap: A bliometric Analysis. hemSusChem 2023;16(21)	doi: 10.1002/cssc.202300333
CIU 2023	-
EE Transactions on dustry Applications, vol. 9, no. 2, pp. 2061-2068	doi: 10.1109/TIA.2022.3223631
TERMAG 2023	doi:10.1109/ INTERMAGShortPapers58606.2023.10305028
ournal of the ectrochemical Society 023;170(4).	doi: 10.1149/1945-7111/accb6e
AC-PapersOnLine, Volume 6, Issue 2, 2023, Pages 530-6635	doi: 10.1016/j.ifacol.2023.10.363

Title	Author	Journal/Conference	DOI	Title	Author	Journal/Conference	DOI
Conceptualisations of incum- bent firms in sustainability transitions: Insights from organ- isation theory and a systematic literature	Magnusson, T., & Werner, V	Business Strategy and the Environment, 32(2), 903-919	doi: 10.1002/bse.3081	Development of simplified air drag models including cross- winds for commercial heavy vehicle combinations	M. Askerdal, J. Fredriksson & L. Laine	Vehicle System Dynamics 2023	doi: 10.1080/00423114.2023.2213786
Conceptualising electrified logistics systems through an actor perspective, presented at Logistics research network	Jobrant, M., Gillström, H., & Sallnäs, U.	Logistics research network conference, Edinburgh	-	Distributed Eco-Driving Control of a Platoon of Electric Vehicles Through Riccati Recursion	R. Lacombe, S. Gros, N. Murgovski and B. Kulcsár	IEEE Transactions on Intelligent Transportation Systems, vol. 24, no. 3, pp. 3048-3063	doi: 10.1109/TITS.2022.3224389
conference	Drive Cycle Evaluation and E. A. C		E. A. Grunditz and M.	2023 IEEE International	doi: 10.1109/ESARS-ITEC57127.2023.10114883.		
Conflict-free Charging and Real-time Control for an Electric Bus Network	R. Lacombe, N. Murgovski, S. Gros, B. Kulcsár	In Proceedings of IFAC World Congress	doi: 10.1016/j.ifacol.2023.10.366	Consumption of PM Motors for a Typical Battery Electric City Bus	Alatalo	Conference on Electrical Systems for Aircraft, Railway, Ship Propulsion and Road Vehicles & International Transportation Electrification Conference (ESARS-ITEC), Venice, Italy	
Control-oriented 2D thermal modelling of cylindrical bat- tery cells for optimal tab and	Godwin K. Peprah, Torsten Wik, Yicun Huana, Faisal Altaf	American Control Conference	-				
surface cooling	Changfu Zou			Effect of Drive Cycle Quantification on Electric Motor Efficiency	E. Lind, D. Bergman, S. Eriksson	12th International Conference on Power Electronics, Machines and Drives (PEMD 2023), Brussels, Belgium, pp.96-104	doi: 10.1049/icp.2023.1984
Creating Temperature Dependent Free-Energy Functionals for Multi-scale Modelling of Electrode Materials	Souzan Hammadi	XXII Brazilian Symposium on Theoretical Chemistry	-				
Decarbonizing road freight transport – A systematic literature review on the haulier's perspective	Brunner, S., Haag, L., Huge-Brodin, M. & Kjellsdotter Ivert, L.	27th Logistics Research Network (LRN) Conference, Edinburgh, Scotland	-	Electromobility Impact on the Power Grid - Base Case for Probabilistic Modelling	A. Jansson, O. Samuelsson, and F. J. Márquez-Fernández	2023 IEEE Transportation Electrification Conference & Expo (ITEC), Detroit, MI, USA: IEEE, Jun. 2023, pp. 1–6.	doi: 10.1109/ITEC55900.2023.10186933.
Designing Temperature Dependent Free Energy Functionals for Multi-Scale	Souzan Hammadi	FEMS EuroMAt 2023	-	Electro-thermal Models of Power Modules for Stochastic Optimization of Inverters	H. Bydén, E. Bourniche, G. Domingues, M. Alaküla, A. Leblay and F. Marquez	2023 IEEE Transportation Electrification Conference & Expo (ITEC), Detroit, MI, USA, 2023, pp. 1–6	doi: 10.1109/ITEC55900.2023.10187060.
Designing temperature depen- dent free energy functionals for multi-scale modelling of electrode materials	Souzan Hammadi	CMAT 2023 11th international Conference on Materials for Advanced Technologies, Singapore	-	Energy Distribution Diagram Used for Cost-Effective Battery Sizing of Electric Trucks	Karlsson, J. & Grauers, A.	Energies 2023, 16(2), 779	doi: 10.3390/en16020779
Detecting voltage shifts and charge storage anomalies by iron nanoparticles in three-electrode cells based on converted iron oxide and lithium	Valvo M, Chien Y-C, Liivat A, Tai C-W	Electrochimica Acta 2023;440	doi: 10.1016/j.electacta.2022.141747	Evaluating electrolyte addi- tives in dual-ion batteries: Overcoming common pitfalls	Kotronia A, Asfaw HD, Edström K.	Electrochimica Acta 2023;459	doi: 10.1016/j.electacta.2023.142517

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iron phosphate

Peer reviewed journal articles and conference papers 2023

Peer reviewed journal articles and conference papers 2023

Title	Author	Journal/Conference	DOI	Title	Author	Journal/Conference	DOI
Evaluating stationary fast charging needs for a full-elec- tric long-haulage truck fleet in Sweden using Multi-Agent based simulation	Ingelström, M.	Transportation Research Board 103rd Annual Meeting	-	Maximum Torque Control Operating Points Estimation for Variable-Speed IM Applications by Parameter-Based Model	Meng-Ju Hsieh, Torbjörn Thiringer	IECON 2023- 49th Annual Conference of the IEEE Industrial Electronics Society	doi: 10.1109/IECON51785.2023.10311892
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Institutional embedding in the making: translating sustainabil-	Onufrey, K., Werner, V., Magnusson, T.	International Sustainability Transitions Conference, Ut recht	-	infrastructure need using EV contribution			
tional contexts	onal contexts			Online electrochemical mass spectrometry on large-format Li-ion cells	Misiewicz C, Lundström R, Ahmed I, Lacey MJ, Brant W, Berg E	Journal of Power Sources 2023;554	doi: 10.1016/j.jpowsour.2022.232318
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Prospective life cycle assess- ment of lithium-sulfur batteries for stationary energy storage	Wickerts S, Arvidsson R, Nordelöf A, Svanström M, Johansson P	ACS Sustainable Chemistry & Engineering, 11, 26, 9553-9563	doi: 10.1021/acssuschemeng.3c00141		Stochastic modeling of mission stops and variable cargo weight for heavy-duty truck	L. Romano, C. Emvin, F. Bruzelius, et al.	In I IEE Prc Mil
Prospective life cycle assess- ment of sodium-ion batteries made from abundant elements	Wickerts S, Arvidsson R, Nordelöf A, Svanström M, Johansson P	Journal of Industrial Ecology	doi: 10.1111/jiec.13452		System perspective for large- scale implementation of electromobility - the Swedish	Olofsson L.	361 Vel an
Public Charging Infrastructure Requirements for Long-haul Battery Electric Trucks (LBETs) considering Environmental Targets of EU Countries	?	15th Trans-Atlantic Infraday Conference, Paris, France	-		Electromobility Centre, 36th International Electric Vehicle Symposium and Exhibition (EVS36) Sacramento, California, USA, June 11-14, 2023		Sa
Rapid determination of sol- id-state diffusion coefficients in Li-based batteries via intermit- tent current interruption method	Chien Y-C, Liu H, Menon AS, Brant WR, Brandell D, Lacey MJ	Nature Communications 2023;14(1)	doi: 10.1038/s41467-023-37989-6		The effect of oxygen partial pressure and humidification in proton exchange membrane fuel cells at intermediate temperature	Martina Butori, Björn Eriksson, Nikola Nikolić, Carina Lagergren, Göran Lindbergh, Rakel Wreland Lindström	Joi Soi 56: 03
Resolving high potential struc- tural deterioration in Ni-rich layered cathode materials for lithium-ion batteries operando	Mikheenkova A, Gustafsson O, Misiewicz C, Brant WR, Hahlin M, Lacey MJ	Journal of Energy Storage 2023;57	doi: 10.1016/j.est.2022.106211		The potential for V2G based on logged EV driving and charging patterns in Sweden	Kobayashi Y., Taljegard M. & Johnsson, F	36 Ve an Sa
Robotised screening and char-Svensson PH,acterisation for acceleratedYushmanov P, Tot A, Kldiscovery of novel Lithium-ionL, Berg E, Edström K	Svensson PH, Yushmanov P, Tot A, Kloo L, Berg E, Edström K	Chemical Engineering Journal 2023;455	doi: 10.1016/j.cej.2022.140955		Transportation Goes Electric – Exploring the Potential of Smart Charging Strategies for Airports	?	361 Vel Exh
plattery electrolytes: Building a platform and proof of principle studies					Water-in-salt electrolytes made saltier by Gemini ionic liquids for	Tot A, Zhang L, Berg EJ, Svensson PH, Kloo L	Sci
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