Swedish Electromobility Centre

The national research centre for electrification of transport

The Swedish Electromobility Centre
Annual Report 2022

Swedish summary

Swedish Electromobility Centre 2022

2022 var ett år då mycket hände i vår omvärld. Det gav oss nya viktiga insikter i vårt arbete med elektromobilitet såsom behovet av att säkerställa tillgång till fossilfri energi och behovet av resiliens hos våra transportlösningar.

Det senare underströks av att beredskaps- och försvarsfrågor dök upp som viktiga frågor att hantera för samhället i och med kriget i Ukraina. Vi måste tänka tillförlitlighet, robusthet och motståndskraft. Samtidigt måste vi hålla hög hastighet i implementeringen av elektromobilitet.

Parallellt med att vi har anpassat oss till denna nya verklighet under året har vi också startat SEC:s femte etapp med en stor utlysning under våren, vilket resulterat i nästan 45 miljoner kronor till femton projekt. I augusti höll vi kick-off för den nya etappen med en framåtblickande workshop i Lund med 110 deltagare i samband med vårt event E-mobility Day. Under året höll våra temaområden mer än tjugo workshops som behandlade allt från tillverkning av elektriska maskiner till integration av transport- och energisystem. Som en del av vårt arbete inom Elektrifieringskommissionen stod SEC även värd för en workshop om strategiska forskningsområden för elflyg, sammanfattad i en rapport till Regeringskansliet.

2022 välkomnade vi flera nya partners till centret; X shore, RISE, Polestar och Alvier Mechatronics, som alla bidrar till att göra centret starkare. Centret har vuxit under flera år. För att anpassa oss till denna tillväxt arbetade vi under året med att förbättra organisationen, bland annat med en ny ledningsgrupp bestående av temaledare och representanter från RISE och VTI. Centret förstärktes också med en biträdande föreståndare, Ellen Olausson. Nu är vi ännu bättre rustade att ta oss an de utmaningar som väntar 2023.

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SEC is growing. Here Director Linda Olofsson in a discussion about how to integrate our new partners, at the August Kick off.

Improving for success

A year goes by so very fast, especially when there is so much important and urgent work to do as it is within electromobility. 2022 has truly shaken us with new insights. The need for secure green energy supply is essential to reach sustainability via electrification in general, and for electromobility to reach its full potential as solution for sustainable transport.

Preparedness and defence issues have surfaced as important issues to deal with for society. We must think 3R: reliability, robustness, and resilience. At the same time, we must maintain high speed in the implementation and the up-scaling of electromobility.

As we have adjusted to this new reality during the year, we have also started SEC's fifth stage with a large call for proposals this spring, resulting in almost SEK 45 million to fifteen projects.

In August we held our Kick off conference including a forward-looking workshop in Lund, with 110 participants. In our theme areas near twenty workshops were held during 2022, on topics ranging from manufacturing of electrical machines to integration of transportation and energy systems. As part of our work within the Electrification commission, SEC also hosted a workshop on strategic research areas for electric aviation, summarised in a report to the government office.

In 2022 as new partners we welcomed Alvier Mechatronics, Polestar, X Shore, and RISE who all contribute to making the centre stronger.

The centre has grown over several years. To adapt to this growth, we worked to improve the organisation in 2022, among other things with a new management team consisting of theme leaders and representatives from RISE and VTI. The centre was also strengthened with a deputy director, Ellen Olausson. Now we are even better equipped to take on the challenges that await in 2023.

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

Linda Olofsson,
Director, Swedish Electromobility Centre

E-mobility at the core of society's challenges

The Swedish Electromobility Centre has for many years gathered the main stakeholders and knowledge providers from academia, industry and society to, in the start, collaborate for preparing Sweden and the world for the electrification, that was sighted in the horizon.

Now just a few years later electrification is here, with all its possibilities and challenges, and the centre is Sweden's leading collaboration hub for research in electromobility. With the Swedish Energy Agency as its main funder, the centre still gathers the main academia in the field as well as Swedish industry but has both widened and deepened its span now including the full range from vehicle manufacturers and suppliers to electric grid operators, and publicly funded research institutes.

The SEC model allows knowledge and competence to be shared and to grow in a unique way, where competing companies work side by side to achieve the breakthroughs that are needed for Sweden to lead the electrification of the transport sector, and at the same time educate students and create competence and capacity within the key area of electrification.

> *Sweden's leading collaboration hub for research in electromobility*

Naturally, being an appreciated place for emobility collaboration in the midst of the energy transition, SEC kept on growing in partners in 2022, now also including the electric boat manufacturer X Shore, RISE Research Institute of Sweden, Alvier Mechatronics, experts in electric drive lines, and the fully electric car manufacturer Polestar. They are now contributing to an even wider and deeper spectrum of knowledge and experience from all aspects of the ever-growing field of electromobility.

Vision

The vision of SEC 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.

Goal

Our goal is to be an internationally distinguished centre of excellence, renowned for its competence building, research, and development of sustainable technology for electrification, for all types of vehicles – on land, at sea or in the air. The long-term goal is to ensure electromobility being the cornerstone for transition to a sustainable society.

Mission

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

The SEC Kick off in August 2022 gave the inspiration to move forward in a growing organisation with new challanges. Nils-Gunnar Vågstedt in the doorway to the right.

2022 SEC became more robust

Together we accelerate research

2022 was a challenge for society in large. A war started in Europe, economic downturn and an energy crisis followed. Demand for electricity keeps getting higher due to the increasing electrification of the transportation sector, as well as for all parts of Swedish and European industry. At the same time the Swedish Electromobility Centre geared up in to a fifth stage, changing the range of the stages to longer journeys from a four-year to a five-year cycle. This has been quite demanding challenge for all participants in the centre, both on the administrative side as well as in our research groups and projects. On the positive side, we now have a more robust centre, able too work in a long-term perspective with less need for stopping and restarting.

The longer cycles will help the centre to become more established and help the researchers becoming even more established within their respective fields. The continuously growing number of partners also bear evidence of the centre as a respected and established entity within electromobility and electrification in general.

SEC grows stronger

I always view the centre as being a magnet that attracts the great people and the great minds that all our partners contribute with. This magnet grows stronger and stronger and I am proud to see how the collaboration within our centre intensifies.

Even actors that are clear competitors at the market exchange ideas in a beautiful way in our research program. It is so nice to see the engagement that all partners have and the interest for each other's knowledge. When we collaborate, our strength is that we are able to see beyond our corporations, and also meet as people, curios to learn from each other.

The centre is not an administrative construction. No, instead it is made up of all knowledgeable people within the centre who identify themselves as part of the centre.

People with excellent knowledge is also one of the centre's main products. There is a screaming demand for competence within electromobility and I am proud to say that the centre delivers on that demand as more and more researchers graduate each year. In 2022 we granted 12 new PhD projects with new students that in time will be ready to take steps into deepened academic and industrial research.

We will all remember 2022 as challenging. In my own daily life, I have noticed that cost of energy and electricity became common matter to discuss over the dinner table, raising questions on how to act to mitigate its effect. I am sure most of you have the same experience.

> *A magnet that attracts the great people and the great minds*

Our centre has an important role to give back to those funding us, society. We must continue to support society with the knowledge that we have and that we produce, through reports, invitations to our seminars and conferences, participation in relevant contexts with important social actors, the electrification commission and more. I look forward to 2023 with excitement. We will move forward in a even more positive and smarter way.

Nils-Gunnar Vågstedt
Chairman of the SEC board

SEC received renewed funding

When the agency opened a call for competence centres for a sustainable energy system in 2021, SEC became one of the 11 granted centres, starting 2022.

The Swedish Energy Agency has been funding SEC from start. “SEC is a piece of the puzzle in Sweden’s climate transition”, says Klaas Burgdorf, SEC’s case manager at the Swedish Energy Agency.

The Swedish government has made the assessment that it is important for the country to have a significant role in the development of electromobility, as a part of the electrification and the climate transition. “It is important to establish competence and technical solutions for the transition, and at the same time include a high level of ambition regarding resilience and economic success. SEC is an important piece of the puzzle in that sense”, says Klaas Burgdorf.

Adjusting to a new reality

SEC was in earlier called SHC, Swedish Electric & Hybrid Vehicle Centre. Back then focus was mainly on technology, but as electromobility in society grew larger, the centre followed.

“The issues around electromobility have grown a lot since then, and the centre has been really good at widening its scope and adjust to the new reality, by also taking a societal and an energy systems aspect into the research”, says Erik Svahn, SEC’s previous case manager at the Swedish Energy Agency.

The centre’s PhDs, students and the knowledge that is increasing within the partner companies is an asset to the country. As society is going through a change in the energy system toward more electrification and new technologies such as digitalisation, SEC’s contribution regarding competence supply is important to the Swedish Energy Agency.

Competence supply

“The ability to produce this competence is one important reason for SEC to get renewed trust and renewed funding from the Swedish Energy Agency. The way the centre just keeps on growing in partners is another indicator of how well the centre works”, says Klaas Burgdorf.

> *“The issue around electromobility has grown a lot*

As the need for climate transition technology is getting more and more acute, impact of research results is getting more attention from funders, both national and on an EU level. One thing the EU is asking its member countries to improve is the ability to industrialise results.

“We need to not only measure technology readiness level, but also measure manufacturing readiness level. There is, in general, often a gap between research results and what industry needs and I believe SEC can help to close that gap”, says Klaas Burgdorf.

SEC’s task towards academy is to:

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

Bring industry and university partners together, in order to develop free, strong and creative research environments.

Initiate and finance relevant research projects and themes.

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

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

Create value by organising meetings and networking venues.

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

Help increase the level of knowledge in relevant areas.

The industry’s view of SEC’s role is:

SEC is the hub in Sweden for applied research in electrification of transport.

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

SEC is a recruitment base at lic/doctoral level and at senior research level.

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

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

SEC should continue to deliver world class research results.

SUSTAINABLE DEVELOPMENT GOALS

SEC contributes to the development of a sustainable society. The activities of SEC have a strong connection to several of the Sustainable Development Goals adopted by United Nations in 2015. The five most direct interrelations are presented on next page.

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 its contribution to total carbon dioxide emissions.

SEC contributes to speeding up the transition into enabling 100% fossil-free energy in the transport sector through the SEC-funded projects. Contributing to the fight against climate change lies at the core of SEC's purpose, taking on as the main mission to accelerate the development and implementation of electric propulsion technologies into the transport ecosystem by maximising their applicability, versatility, and efficiency, while minimising their overall impacts on the environment, human health, and natural resources, and strengthen the Swedish industry's competitiveness.

Five themes to achieve the goals

The centre has established five main research themes within electromobility that, in thematic and cross-thematic 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.

Objectives and KPIs

To make the SEC'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.

Objective 1

Interdisciplinary projects

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

- The project shall pave way for the researcher or PhD student to work for a limited time on site at one of the industrial partners. SEC also encourages industrial researchers to work at one of the academic partners for a limited time within the project.
- The project must plan and work for international exchange.
- The project must touch on and collaborate with expertise from a field other than its main field.

Objective 2

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 get the opportunity to participate in SEC's planned PhD courses.

Objective 3

Scientific competitiveness

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

Objective 4

Dissemination of knowledge and research findings

The thematic areas must convene thematic group meetings once per month, and SEC must arrange an activity that involves all thematic areas every year.

Objective 5

Collaboration

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

Objective 6

Competence supply

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

Key Performance Indicators

In the spring of 2022, SEC started its fifth stage with the planning of several new exciting research projects that are now in the starting phase, including 11 new doctoral projects. At the same time, the projects from stage IV are in their final stages, which has resulted in a large number of scientific publications and conference contributions. All projects from stage IV will be completed in the coming year 2023 at the latest.

Stage IV during 2022

35 journal & conference papers

25 master thesis

2 theme workshops

3 PhD and licentiate*

19 international collaborations

1 Patent application

28 Reports to Program Council

* 3 SEC-financed, 0 associated

Stage V during 2022

46 journal & conference papers

14 master thesis

18 theme workshops

4 PhD and licentiate*

5 international collaborations

6 Postdoc meriting

9 Reports to Program Council

1 SEC annual conference
E-mobility Day + Kick off

* 0 SEC-financed, 4 associated

Total KPI fulfillment stage IV 2019-2022

104 journal & conference papers

68 master thesis

33 theme workshops

14 PhD and licentiate*

51 international collaborations

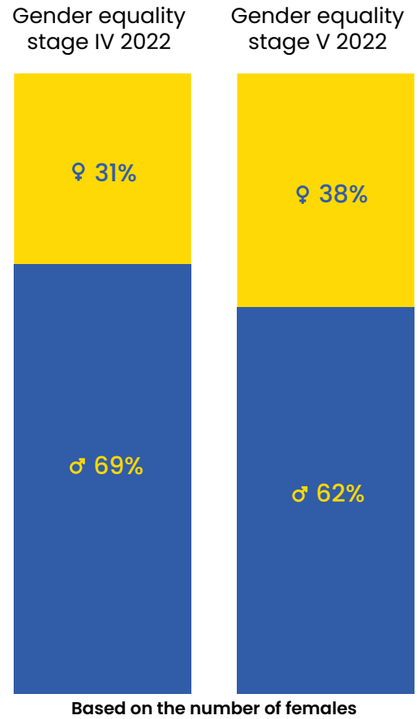
4 Center conferences

2 Patent applications

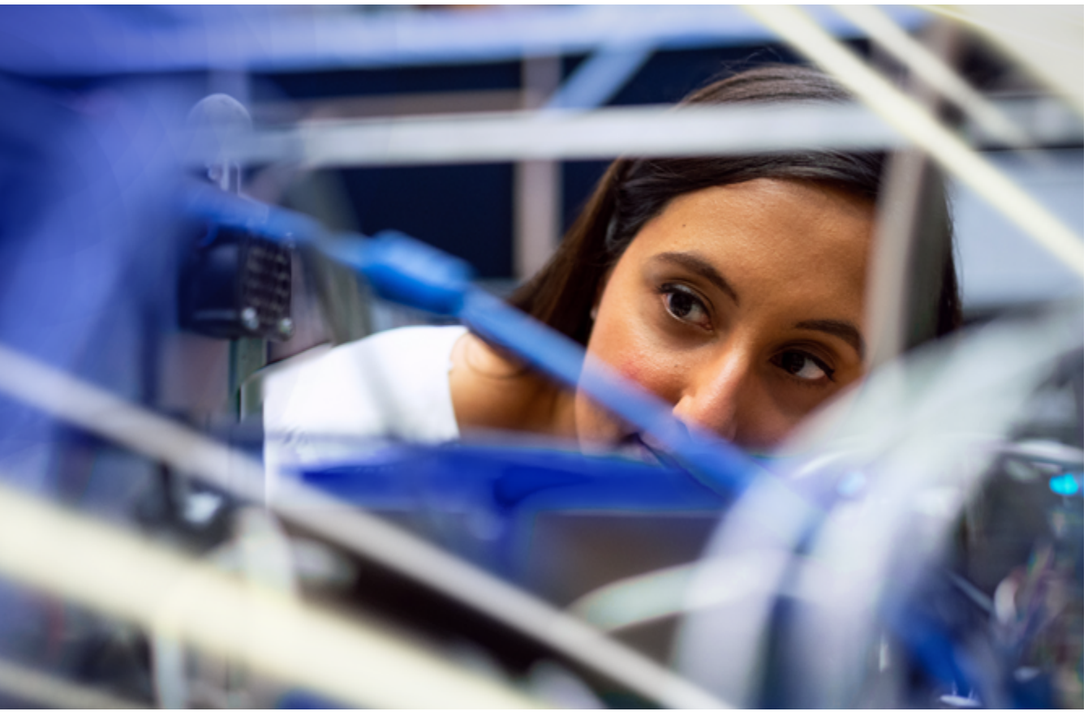
* 10 SEC-financed, 4 associated

We are happy to see that we have a trend towards a more gender equal centre where we are approaching the goal of a ratio of at least 40/60.

Looking at the number of females versus males, we could se that the stage IV projects during 2022 had a ratio of 31/69, while the ratio of the new stage V projects is 38/62. The distribution of funding between females and males has gone from a ratio of 36/64 in stage IV to 44/56 in stage V.



Based on the number of females and males in the projects



The theme groups are the core of SEC where researchers and experts from all partners collaborate.

The theme areas

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 the activity groups where researchers from all partner universities collaborate.

Each area is led by two theme leaders, from different universities. On the following pages their reports on what happened within the areas during 2022 is presented.

Theme 1

Intelligent Vehicles & Systems

Theme 1, Intelligent vehicles and systems, addresses total cost optimisation of the vehicle system, with a focus on energy efficiency and ownership experience. To address this requires knowledge of the customer, the vehicle, its subsystems, and its surroundings.

This is done by utilising tools, like mathematical modeling, dynamic simulation, performance analysis, control design, and optimisation 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 2022

The projects have revolved around understanding and characterising the customers, the vehicle, its subsystems, and its surroundings to address the core question. During 2022 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 SEC funded PhD student Olov Holmer successfully defended his thesis in February 2022. 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 thematic workshop and will be used in an international benchmark contest in control design at the IFAC World Congress 2023.

During 2022, the theme area also got the theme researchers focusing on electric range estimation for battery electric vehicles and modeling electro-chemical powertrain systems. Other achievements have been in the characterisation of external factors, like wind and road

resistance, as well as the analysis of electric all-wheel drive concepts and control design for optimised 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.

Challenges and possibilities

Complete vehicle energy management is the main challenge in the area. It is not limited to just energy used for the propulsion of the vehicle, it also includes energy usage in vehicle subsystems, like cooling of batteries or electric machines, like HVAC systems, but it also includes charging and route planning. This means that the complete experience of driving and owning is in focus. It also 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 utilises dynamic models, computational methods and simulation techniques to study system properties and optimise 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 trafficsituation ahead of the vehicle is. This 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, etcetera.

Business intelligence

Electrification, automation, and digitalisation are the mega trends in the area. Research is done in basic research on development of methods and tools for addressing the design of system of systems, like numerical optimisation, 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.

Theme 1 Project spotlight

Shorter range with harder winds

There is a need for optimising range and improving the estimation, says Mikael Askerdal.

One key obstacle for electromobility to overcome is the range of the vehicle. In this SEC project Volvo's industrial PhD student Mikael Askerdal brings knowledge to how to add weather information to the range estimation.

Weather is an important factor when estimating how far an electric vehicle can get before it needs to recharge. Parameters such as wind resistance, the state of the road, and the temperatures of the tires have a significant influence on how well the vehicle perform range-wise.

"The core issue is to be able to predict the weather's impact on the vehicle. The wind is one of the most important parameters, and what we have focused on in this project. One remarkable thing is that the side wind is about as largely an energy thief as head-wind, on heavy vehicles", says Mikael Askerdal.

Since range hasn't really been a barrier for combustion engines, the weather-aspect hasn't been an issue large enough to investigate much. Now when range and charging infrastructure are limitations within electromobility, there is a clearer need for optimising the range estimation. The results aren't necessarily focused on energy efficiency, but rather to get to where you want to go.

"The energy consumption may also be movable. Trucks have other energy consuming parts than propulsion. These activities are sometimes possible to wait with until the vehicle is connected to a charger and knowing how weather impact the range support this planning," says Mikael Askerdal.

What comes out of the project is that when you know your route and the wind conditions on that road, you can do an assessment of how much energy that will be used. With the weather parameter you will get a much more exact calculation.

"The knowledge that we have developed will hopefully contribute to optimising algorithms in Volvo's range estimation tools in one way or another," says Mikael Askerdal.

The project ended in May 2022 but the plan is to continue the research in a project where the state of the road, related to weather, will be the focus.

Theme 2

Electric Drives & Charging

Theme 2, Electric Drives & Charging, covers the electric energy transfer and conversion technologies necessary for electrified transportation on roads, water, and air. It includes the design, control, operation, and diagnostics of the propulsion system, the charging equipment, and the auxiliary systems onboard the vehicles.

The research activities in the theme span over a broad area and use various methodological tools. Theoretical/numerical modeling and simulation of components is based on analytical equations, dynamic models, finite-element numerical analysis, computational fluid dynamics, and more. The component integration into a dynamic system model exploits Matlab/Simulink or similar software platforms. Prototyping and laboratory testing are essential for the activities, using real-life conditions testing when relevant.

Research advancements within 2022

Within the associated project Evolution Road, Professor Mats Alaküla delivered a presentation at the Almedalen political event entitled "The role of Electric Roads in the energy transition" (original title "Elvägens roll i energiomställningen") in July 2022.

National and international attention

On the international side, one of our project leaders in Theme 2, Professor Sandra Eriksson from Uppsala University is actively participating in an EU consortium working on improving ferrite magnets, which is in line with two current projects in our theme.

On the national side, on the initiative of the Swedish Government and the Swedish Armed Forces, SEC and Theme 2 have been contacted to discuss critical challenges that the Armed Forces see in the electrification of the transportation sector, most notably the increase of conducted and radiated electromagnetic noise. A round table discussion took place in October 2022. As a result, during the following year, 2023, SEC and Theme 2, together with the Swedish Armed Forces, will organise two workshops on the topics of "Charging infrastructure and EMC" and "Electromobility and charging".

Transportation electrification is going ahead rapidly, solving issues posed by the manufacturing and operation of the electric vehicle fleet. However, this growth is highlighting two societal challenges that need to be taken care of:

The fast-charging infrastructure is built with switching power electronics and is thus a source of high-frequency noise that can be conducted and radiated. When a charging site with many fast chargers is made, the site area and the number of chargers contribute to aggregated levels of disturbance and a widened radiated spectrum. Similar reasoning also applies to various forms of electric roads.

Challenges and possibilities

The defence forces of Sweden have identified a need to discuss solutions to secure that these disturbances, both from individual chargers and large charging sites, 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 ongoing energy crisis is a testament to the fragile energy supply network. The increasing integration of the electric vehicle fleet and its need for a charging infrastructure integrated into the existing grid system requires significant actions towards 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 to prioritise the energy supply and secure a certain level of continued transport?

The e-mobility trend has no slowdown. Manufacturing electric vehicles is a "make or die" decision in the road transport sector. Every manufacturer is involved in e-mobility because the other alternative is to leave the market in a few years. For this reason, all the topics listed in Theme 2 roadmap are still very relevant both for industry and academia, and huge efforts are still devoted to drivetrain design for maximised efficiency, reliability, and recyclability.

Business intelligence

The situation is slightly different in the marine and aerospace sectors. The marine sector is pushing toward the electrification of large and small (leisure) boats, but there is still a significant energy density issue. Batteries are not energy-dense enough for the requirements posed by the water, while fuel-cell-based solutions are in the pilot stage. An interesting development for leisure boats, both in academia and in the industry, is the resurgence of the hydrofoil concept, where the energy storage requirements are significantly lower than those of a conventional electric boat.

The aerospace sector has been heavily involved in electrification force for a while, with power and energy density requirements that are even worse than marine applications and includes re-designing electric machines and power electronics with more extensive power and smaller size. The industrial scenario is, however, vibrant, with several start-up and well-established companies working on the electrification of aircraft and boats.

Professor Sandra Eriksson at Uppsala University, leads an SEC funded project to replace the metals in electrical vehicles. She and her PhD student are now investigating how to design electrical motors for electromobility that are rare earth metal-free.

Theme 2 Project spotlight

Replacing rare earth metals in EV motors

Rare earth metals are main components in the EV motors of today. But to be dependent of the metals can be problematic both from a security political point of view as well as sustainability wise. Professor Sandra Eriksson, at Uppsala University, leads a SEC-funded project to replace the metals in EVs.

The rare earth metals are basic elements with unique magnetic characteristics that are very suitable to use in motors of electric vehicles and other electronic devices, such as cell phones. But the metals are also problematic since there can easily become a shortage. This is a large risk for the manufacturers, since above 90 percent of new electric cars are relying on them. Another issue is that there are often problems related to the mining, such as radioactive material getting released in the process and that ground water gets polluted.

Sandra Eriksson and her PhD student are therefore investigating in how to design electrical motors for electromobility that are rare earth metal-free.

Mechanical integrity

“The rare earth metals are considered critical by the EU, but in this project, we want to show that they can be replaced by other materials”, says Sandra Eriksson.

One of the rare earth metal-free motors the researchers look into is one using ferrite magnets, which there is a great surplus of, as a replacement to the rare earth metals. They are much cheaper and more available, as they are made from iron oxide with some additional chemical elements. The downside is that they are much heavier and with a weaker magnetic field. “We need to change the design of the motor and compress the magnetic field. When doing this we also need to change the mechanics of the motor. These heavier magnets will raise issues concerning the mechanical integrity of the fast-spinning electrical motor. Our main results this far concern the integration of the mechanical and the electromagnetic design to keep as much magnetic flux as possible, while at the same time have a robust motor that can withstand fast rotation”, says Eriksson.

The researchers have a close collaboration with Scania in the project. Later in the project, they will build a prototype together for further research. There is a long way to go before the rare earth metals are replaced, but Sandra Eriksson thinks many will move away from the metals due to all the risks in it. For instance, in the summer of 2011, the price of neodymium increased tenfold when China, who is the main exporter of the metals, placed an export embargo on the metal.

“In the last ten years it has become very clear that there is a great win in replacing the rare earth metals since the price has increased very much. There is a danger in being too dependent of rare earth metals and if there is a way forward with ferrite magnets, many will be interested in it”, she says.

Theme 3

Energy Storage

Within Theme 3, Energy storage, the focus is to understand the energy storage units of different batteries and fuel cells when used in electric vehicles: what guides the choice of storage unit, and how its performance can be optimised. This range from materials and components 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, which warrants long driving range and optimal charging/fuelling conditions.

Research advancement within 2022

The SEC projects running and initiated during 2022 have revolved around testing procedures and protocols, different forms of modelling, system safety and diagnostics, and novel battery and fuel cells types targeting vehicles. Three PhD student projects started within Phase IV within the thematic area are now up to speed: on fuel cell performance prediction, on gas evolution in Li-ion battery cells, and control systems for temperature behaviour. PhD students and post-doc are also involved in other Theme 3 projects. Moreover, two thematic researcher projects were launched during 2021 and progressed significantly during 2022: on solid-state batteries and on intermediate temperature fuel cells. A range of new projects were also granted in 2022, and are now in an early start-up phase. Several of these included collaboration with industrial PhD students at different SEC partners.

Theme 3 has also organised a number of online events during 2022, to highlight research within the area and stimulate research interactions. A workshop was held in March focusing on energy storage for non-road vehicles: i.e., aviation, marine transport, construction and mining equipment. One workshop focused on fuel cell research, while yet one workshop compared batteries and fuel cells as energy storage solutions for different types of vehicles. Theme 3 also contributed to the PhD autumn school and to the Electromobility Days.

National and international attention

Batteries as energy storage solutions for electric vehicles continue to draw considerable media attention, and is now very high on the political agenda, not least within the context of the current European energy crisis. 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 scaling up in Sweden, and now comprise several actors in the Swedish landscape. “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. 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.

Considering the amount of financial resources and human capital being chanelled 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 has raw materials for batteries been highlighted as a fundamental critical issue, not least form the background of Russia’s war in Ukraine (Russia has been a major exporter of some Li-ion battery materials), which has sparked further media attention. 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 has also ramped up. In the hydrogen strategy for a climate-neutral Europe communicated by the European Commission, hydrogen has been identified as a key contributor in the mitigation of climate change. The need for Europe for a more robust energy system based on renewable resources has become even more apparent through the war in Ukraine, which has resulted in an even greater focus on hydrogen. The strategy is to make green hydrogen along with electricity the main energy vectors that enables a zero-emission Europe. It then becomes important to

obtain synergetic intersectoral effects by integration of hydrogen into the existing systems for energy and transport. Thus, it is quite evident that hydrogen based on renewable electricity will be available at a competitive cost also for transportation purposes and a natural consequence of this is that the interest in electrification of the transport sector with the help of hydrogen-powered fuel cells still is of large interest. For road-bound vehicles, the focus is primarily on trucks, but interest in ships, aviation and rail-bound transport is growing steadily.

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. 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 life-time, diagnosis and predictions still remain, and depend intrinsically on the battery cell chemistry. Moreover, sustainability, lack of raw materials and increasing costs are emerging as issues for the Li-ion technology, which motivates the interest in alterative battery and fuel cell technology.

Fuel cell-powered vehicles are in an earlier phase of commercialisation than battery-powered vehicles, and important issues revolve around system integration, costs and the design of auxiliary systems. As with batteries, life-time and predictability are important, and linked to the continued development of improved catalysts and membranes. It is also important to remember that most fuel cell vehicles also use batteries, and that the balance between the two ways of storing energy is part of the optimisation of the propulsion system.

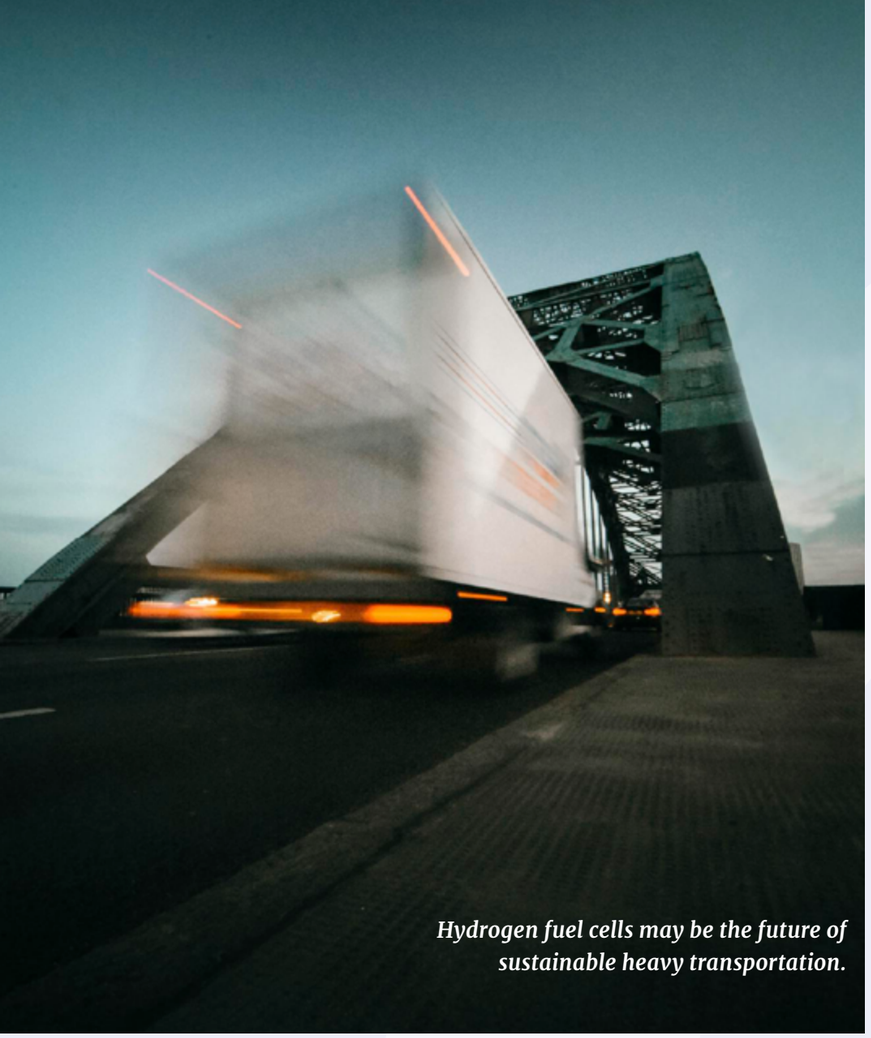
Business intelligence

With the Li-ion battery truly pushing the production limits, there are novel aspects which become critical in terms of

Energy losses can be kept at a minimum, safety assured, and health maintained, with long driving range and optimal charging/fuelling conditions.

supply chains and closed-loop systems. Novel Li-ion battery cell chemistries are targeting both higher electrochemical performance and more sustainable materials (Silicon/Carbon composite anodes, Nickel-rich and/or Cobalt-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.

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.



Hydrogen fuel cells may be the future of sustainable heavy transportation.

Theme 3 Project spotlight

Hotter fuel cells for higher effect in trucks

Fuel cells for vehicles could be more powerful, yet demand less space, if only they could be run on a higher temperature. Björn Eriksson, postdoc at KTH, leading an SEC-funded project, is looking at what happens in a fuel cell at higher temperatures.

Hydrogen fuel cells may be the future of sustainable heavy transportation, but to reach a breakthrough, they need to be able to deliver at a higher effect than today. One way of getting closer in the case of the proton exchange membrane fuel cell, the PEMFC, may be through increasing the heat in it. The temperature is one of the limitations of what effect can be delivered and the regular PEMFC has a maximum temperature of around 80 degrees Celsius.

"If we manage to get the PEMFC working in temperatures up to 120 degrees Celsius, that would enable a much higher maximum effect, which may be needed in trucks in steep and hilly environments. We know that the cell performs worse when the temperature increases, but until now we didn't know why", says Björn Eriksson, postdoc at KTH, and leader of the project Evaluation and optimisation of materials for IT-PEMFC.

It is all about the balance

Partners in the project are KTH, Linköping University, Volvo Group, ABB, PowerCell, and Scania. The project started in 2021 and the researchers have already some interesting results. They discovered that it is not the cell in itself that loses functionality when the temperature is increased. It is rather what happens with the gases in the cell.

A fuel cell runs on a combination of hydrogen as fuel and air as reactant. Together they produce electricity and water. But with a higher temperature in the cell, there will be more water, which reduces the concentration of available oxygen.

"It is all about finding the right balance between oxygen and water. At 80 degrees it is easy to control this balance, but with a higher temperature we need to find ways to maintain it. Pressure is on way, keeping the cell drier is another. We are working on the perfect combination", says Björn Eriksson.

Testing aeging mechanisms

Another temperature-caused limitation is the cooling system that is required to keep this temperature. The lower temperature the larger cooling system.

Björn Eriksson, postdoc at KTH is searching for the right balance.

"The trucks have limitations in how large systems they can have and manufacturers are very interested in ways to reduce size of the cooling system", says Björn Eriksson.

The industrial partners of the project also need to know more about how a higher temperature influences the lifetime of the fuel cell. Later in the project ageing mechanisms will be tested.

"It is good to know that what we are working on is really something that the industry wants. We are using commercial materials today, but we hope to learn about their limitations and then develop new materials. That is the next step within the project", says Björn Eriksson.

Theme 4

Environment & Society

Theme 4, Environment and society, investigates electromobility from a societal and environmental perspective. The aim of all activities is to guide development and policy work towards sustainable electromobility. During 2022, the theme conducted work around three strategic research areas.

The first, understanding user adoption and transport services, focus on the interplay between technology and the different actors. Both in the passenger as well as freight transportation system and also the mechanisms that govern the interaction that influence the development of electromobility.

The second research area, Measures for resource availability and circular economy, investigates strategies for circular material flows and securing important secondary raw materials.

Finally, Assessment of environmental impact and resource use, involves development of tools and models for assessing the sustainability aspects of technologies for electromobility.

Research advancements within 2022

In total thirteen projects, four funded by the centre and nine associated, ran within the theme area during this year. Another seven projects are linked to the theme but are coordinated within another theme area – two funded PhD projects (in theme areas 2 and 5) and five other associated projects. Theme 4 is the main thematic area for two SEC funded Ph.D. projects. There are also two theme researcher projects ongoing.

Within the environmental assessment strategic research area, one of the Ph.D. projects set its focus on lithium extraction from various types of ores, for processing and use in lithium-ion battery production leading to a publication in the high ranked journal Resources, Conservation and Recycling (impact factor 13.7) entitled Life cycle environmental impacts of current and future battery-grade lithium supply from brine and spodumene. In addition, the theme research project in the same strategic research area investigated the need for rare metals both in the infrastructure for charging and refuelling, and in the vehicle fleet, for a set of different technology scenarios for electrification compared to the current state.

Within the first research area, the other PhD project explored the relationship between charging infrastructure and vehicle development departing from the user perspective, and in the second theme researcher project, the work has continued to evolve around the electrification of freight transport system. Associated projects include environmental assessments, innovation system studies, circular economy studies and transport system analysis.

As every year, other activities have also been ongoing with one cross-thematic workshop, a set of open online seminars, two full day meetings for theme core group and the yearly “Thesis presentation bonanza”.

National and international attention

In January, theme leader Magnus Blinge was interviewed in national TV “TV4 Nyhetsmorgon” about latest progress on electrification in the heavy freight transport sector, in aviation and in the maritime sector.

In February, theme leader Anders Nordelöf was in a live interview on local Swedish radio P4 Göteborg about the emissions from large scale lithium-ion battery manufacturing. In April, Magnus Blinge presented SEC and Swedish ”best practices on cooperation to achieve electrification of

the transport sector" at the Swedish embassy in Budapest, Hungary, at a seminar organised by Swedish chamber of commerce.

In April, theme leader Anders Nordelöf was interviewed about how sustainable an EV is, from manufacturing to use, in Expressen, Kvällsposten and GT. He was also interviewed in Dagens Nyheter about Polestar 0 Project, and the ambition to create an emission-free EV.

Challenges and possibilities

The EV technology and adoption is evolving more rapidly every year. This implies new challenges for the society and the challenge is tackled within theme 4 through research that helps steering the development of electromobility towards long term sustainability hand in hand with meeting societal needs for transport, now and in the future. The gaps still exist in identifying environmental and socio-technical barriers of electrification technologies and support measures to overcome, work around or avoid these barriers, to enable a rapid large-scale transition of the transportation sector.

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, will be important to enable the introduction of the new technology in a sustainable way. 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.

The rapid implementation of electromobility in society is complex, involving technical, behavioural, commercial and governmental challenges.

Business intelligence

The rapid implementation of electromobility in society involves a complex combination of new challenges with technical, behavioural, commercial, and governmental aspects, requiring that a systems perspective is added to the state-of-the-art knowledge. Electrification, increasing levels of vehicle automation, Circular economy, Second-life of EV-batteries, 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 optimisation, and blockchains are promoted for providing traceability upstream in the life cycles of components, linking to responsible sourcing of key raw materials. A big challenge is to keep a high pace in all necessary areas, e.g., vehicles, batteries, production of renewable energy, infrastructure, and societal acceptance.

Electrification of transportation will have great impact on logistics.

Theme 4 Project spotlight

Electrification of logistics – where do we start?

Electrification will potentially reshape logistics companies' rout planning and relation to both customers, grid owners, and vehicle manufacturers. Henrik Gillström, Assistant professor at Linköping University, leads an SEC funded project where he explains the coming new reality of logistics.

With a focus on trucks with electric batteries, Henrik Gillström investigates what is needed for electrification of the logistics industry.

"I want to map up how the logistics sector can look like going fully electric. Which are the paths forward and where do we have the main barriers? It is an exciting field and there is a lot of interest in the topic from SEC's partners and others too", says Henrik Gillström.

SEC partners in this project are Scania, Volvo Cars, Volvo Group, Titan X, Vattenfall and Cevt, contributing with knowledge from their perspectives of the electrification of transportation and logistics.

"All logistics systems are different, and I try to describe what is needed in the different cases and different phases of the electrification of the logistics sector. A main question is "when is electrification suitable?", says Henrik Gillström.

One main difference is between closed and open systems. Closed being the routs that go between two set points, such as dairy logistics between farm and factory. Here charging stations can easily be planned because you know from the start what capacity will be needed at what point. The open systems are the harder ones.

"For example, when you do long-distance transports, or transportation with multiple delivery stops, it may be hard to know beforehand where you will be when you need to charge. Is it for instance possible to charge at your customers location? We need to understand more than just the transportation part of it. Customers can become providers and the whole logistics chain may be involving new stakeholders and services. Perhaps logistics companies have to start collaborating and share data with their customers, energy companies and grid owners in a new way", says Henrik Gillström.

SEC – a good arena

One main part of getting the full picture of electrification of the logistics industry is to map the barriers that prevent the transition to happen. Here is Henrik's list of main barriers to overcome to succeed. Henrik Gillström is now eager to collaborate with SEC's partners and will reach out through workshops and presentations throughout the rest of the project.

"SEC is a very good arena to be able to reach the companies. We can have workshops and discuss with the companies. Logistic companies are not yet engaged in SEC but it would be interesting to hear their thoughts too", he says.

Henrik Gillström, Assistant professor.

Practical and technological barriers

- Miss-match of characteristics of transport systems (conventional and electric)
- Limited range
- Risk of loss of freight capacity

Financial barriers

- Large investment cost for electric vehicles
- Logistics sector is a low-margin business
- Structure of logistics sector, logistics service providers vs. hauliers, who should pay?

Institutional barriers

- How can the inherent risk be shared between companies
- A need to collaborate to a larger degree with different actors

Cultural and social barriers

- Patriotic sector with strong connection to the vehicles
- Many small hauliers, lack of resources can affect the ability to transition

Theme 5

Vehicle-Grid Interaction

The number of electric vehicles is rapidly increasing in society and so does the present and future need for electric energy and power. This will have a significant impact on the operation of the electrical power system, considering that the electrification of other sectors - such as the industry and the built environment - is also expected.

The main task of Theme 5, Vehicle-Grid Integration, is to conduct research in key areas related to this topic, in order to promote collaborations and knowledge sharing. The research within theme 5 is divided into four strategic research areas: charging at lower power levels, charging at higher power levels, charging infrastructure from a system perspective and, finally, need and use of energy storage in the power system.

During the year, the theme group have arranged and participated to several different activities for Theme members but also to a broader audience. There have been workshops/seminars covering topics such as integration of transportation and energy systems, electric aircrafts, micro grid solutions and local energy storage solutions. In addition to these events, the thematic group meets regularly to discuss ongoing or potential research projects as well as other activities related to the theme.

Research advancements within 2022

During 2022, three new research projects were initiated within the Theme: Two PhD project focusing on smart charging strategies and characteristics of charging as well as one Theme researcher project focusing on vehicle grid interaction from a policy perspective. There are also several projects associated to SEC and Theme 5. Two examples of such associated projects are REEL and E-charge. Both projects focus on the electrification of heavy-duty trucks and researchers as well as industrial partners from Theme 5 participate in both of them.

National and international attention

During 2022, Theme 5 presented SEC and its research to different Swedish and international stakeholders, from grid utility companies to automotive industry companies. The Theme organised workshops and meetings where speakers with different interest in the vehicle-grid interaction research area were invited. We have involved among other start-ups, publicly owned companies, and research groups. Finally, the researchers of the theme group presented their findings at international conferences and events.

Challenges and possibilities

The activities within this field have increased drastically during the recent years and there is a lot of ongoing research and development in different sectors at the same time. This continuous evolution is compelling as well as challenging when doing research in the field since so many factors can change. Another challenge is that the development is going fast - within five year we expect to have a large proportion of EVs on our roads – and new solutions are required in the near future. At the same time as the electric vehicle fleet is growing, other sectors such as the industry sector is also expected to increase the demand of electricity. Thus, the power system needs to be upgraded and expanded to handle the need for more electric energy. Normally, it takes time to make substantial reinforcements of the grid. For many projects, the time frame is several years. Therefore, it will be important to look at charging solutions that the power system can handle in a short as well as medium time window, and also to investigate if any additional infrastructure will be needed. The electrification of the transportation sector also brings a lot of opportunities. First of all, it contributes to a more sustainable transportation system, but it may also enable a more sustainable power system. Our power generation will be more and more dependent on non-dispatchable power sources with the consequence that we also need to consider how we consume our electricity. If we have flexible loads, as EV charging, and we can plan when to turn them on and off, we can meet the power generation in a better way. Further on, if we can use the energy stored in the EV batteries for supporting the grid and other systems, e.g., V2G, the EVs can be an even more important part for the energy transition.

Business intelligence

Nowadays, there is a lot going on within the field of Interaction between vehicles and grid and there are a lot of innovative solutions on how to meet a future power demand for EVs. The public and private sectors are engaged to carry on research and invest in this area. The capacity of the power grid is getting more attention than ever before. As electrification of the transport system - as well as society as a whole – takes off, big cities face considerable problems with the capacity of the electric grid. At the same time more and more distribution grid owners realise that they must create flexibility in the system in order to avoid huge investments in the present grid. They also realise that the transport sector might not only be a burden on the grid but actually also an asset.

A model for best planning to meet the ever growing demand for charging stations is developed.

Theme 5 Project spotlight

Planning for charging points

To meet the ever-growing demand for charging points for EVs, power grid owners need to know where to place them for best efficiency. In an SEC funded project, PhD student Alice Jansson, Lund University, together with her supervisors, develops a model for best planning where to put the charging points.

In the project the researchers are looking into planning of charging infrastructure from a grid perspective. Including 100 percent electromobility in the calculation, the goal is to provide knowledge on how to know where to put the charging points in an optimised way. SEC partners involved in the project are Lund University, KTH, Vattenfall, E.ON, CEVT, Volvo Construction Equipment, and Scania.

Optimise grid infrastructure

"It is exiting and useful to have a collaborative project where both grid owners and vehicle manufacturers are participating", says Alice Jansson.

Together with her supervisors Francisco Márquez-Fernández and Olof Samuelsson she is looking at how to optimise the grid infrastructure in Skåne to see where charging points should be located, and whether the grid should be expanded or if the need for expansion can be reduced using flexibility services.

The results from the project will mainly be models that grid owners can use to predict where extra grid capacity will be needed and where the greatest risks for grid over load are situated.

For this they use the Monte Carlo simulation, which is a tool that does probabilistic modelling, in this case of the development of electrification and need for charging versus capacity of the grid at different points.

Model gives wider idea

"Today grid owners look at certain peak hours and parts of the grid to see what capacity they have. Our model gives a wider idea on a statistical basis of what capacity will be needed for the whole grid in a longer time period. Similar models have been used internationally, and I believe it can also be of great help for Swedish grid owners", says Alice Jansson.

The complex situation regarding energy in Sweden and the world has made the fields of EVs and electrical capacity in the grid grow closer much faster than expected. From being estimated as critical within about ten years' time it has now grown to be on everyone's lips due to fast growing societal electrification whilst in the middle of an energy crisis.

Alice Jansson, PhD Student.

"When I started in this field with a master's thesis a few years ago supervisors said "soon this will be extremely relevant". I thought "yeah right, they always say that", but they were right. It is exciting to be in a project this relevant for society", says Alice Jansson.

Four new partners joined SEC during the year

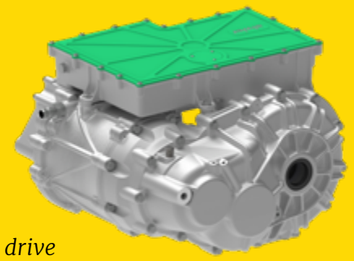
As the national research centre for electrification and transport, the aim of the Swedish Electromobility Centre is to gather leading competence, skills, and recourses within electromobility. Founded and sponsored by the Swedish Energy Agency, the industry and the academia, SEC historically has attracted various member partners among the vehicle and energy industry.

During the past year two institutes also have become full academic partners. That is The Swedish National Road and Transport Research Institute, VTI, who has levelled up to full member and the new member Research Institutes of Sweden, RISE, that has come onboard. This further strengthens the competence and capabilites in SEC:s important work, to reach the vision.

Alvier Mechatronics

Alvier Mechatronics, specialised in engineering services and electric drivelines, joins SEC as network partner. "SEC focus on electromobility and sustainable solutions is a perfect match for us; state of the art research, networking with the key people, and hopefully a possibility to get to know new talents on their way in," says Kristoffer Nilsson at Alvier Mechatronics.

The Höganäs owned company is specialised in engineering services such as system optimisation and design of electric motors and machines.



Electric drive unit developed by Alvier Mecatronics.

They provide prototypes for high-precision electronic high-frequency drive systems with a focus on the development and simulation of both electric and hybrid drive systems, creating models that simulate the entire functioning of electric machines and motors and their electronics.

"We are specifically good at system optimisation. If you want to develop a new driveline, we can, on a high level, design the way to develop this driveline in the best possible way, from parameters like cost, sustainability, performance and more", says Kristoffer Nilsson.

Alvier Mechatronics also have a connection to materials since we are owned by the material producer Höganäs and have great knowledge of how different materials will impact the electric motors and machies from a carbon footprint and a performance perspective for instance.

Their business lies close to SEC's theme 2, Electric drives and charging, and even if it is a small company, Kristoffer Nilsson hopes the company will be able to become active in SEC's projects in the future.

"We are participating on the networking level at least the first year to see how it fits. But participating with a smaller roll in a project would be interesting. First, we want to show the other partners and the students active in the project that we exist and what we do", he says.

Polestar

Polestar joined SEC in 2022 and got started quickly by a collaboration in one of the centre's projects. Arlena Amiri is Head of Advanced Engineering at Polestar.

"We participate in a project about modelling and ageing of Li-ion cells together with Volvo Cars, CEVT, Volvo Group, Chalmers and Uppsala University. Our role is mainly within modelling, but also method development and experiments", says Arlena Amiri.

Participating in SEC means increased possibilities for research studies, that may contribute to the company's initiative Polestar 0 Project, where they aim at manufacturing a fully climate neutral car by 2030. One large area of interest for

the company is battery technology and the sustainability aspects of batteries.

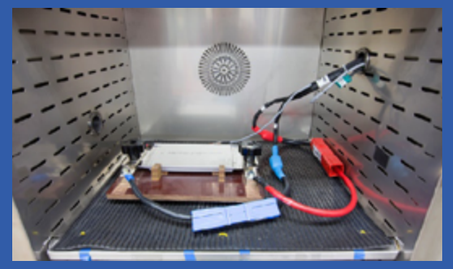
“To reach zero greenhouse gases and footprint, we need to find alternative production methods and materials for batteries, with higher energy density”, says Arlena Amiri.

She says that it was a natural step for Polestar to join the Swedish Electromobility Centre as Polestar’s vision is to improve the world and to accelerate the transition to sustainable electric mobility. Polestar sees the electric car as a scalable climate solution that already today has the potential to be completely emission-free during the use phase. They are also working actively to eliminate emissions from the supply chain and the manufacturing process.

Polestar towards zero emissions.

Participating in the centre is a way forward for both long-term and academic research, and shorter and more applied studies. “A positive thing with SEC is the speed forward, decision-making paths are shorter which leads to shorter time between project idea and start, complementing other national and European research frameworks”, says Arlena Amiri.

More specifically is Polestar looking for collaborating in SEC projects linked to sustainable materials and technical solutions for the automotive industry, and projects linked to the changes and conditions in society that are needed to accelerate into sustainable mobility more quickly.
“Powertrains and batteries are of course important functions, but so are bodywork, chassis and recycling. How far are we from being able to manufacture our products with raw materials that are available above ground?”, says Arlena Amiri.



Battery testing at RISE.

RISE

RISE, Reseach Institutes of Sweden, joined SES as full partners in 2022. “RISE has both deep research and a wide surface facing industry”, says Stefan Pettersson, director for Electro mobility at RISE and also focus area leader for energy and environment for mobility.

SEC and RISE have collaborated for a long time before they joined as partners at SEC and there have been close collaborations.

“RISE and SEC have been syncing and done knowledge sharing two times a year. But Sweden needs to gather our strength and we at RISE think this is a good time to join forces, to get a clearer collaboration and avoid risking double work”, says Stefan Pettersson.

One of RISE’s strengths is that the organisation

“We facilitate collaboration, catalyse innovation, and accelerate the energy transition. We engage in both fundamental issues and applied issues”, says Stefan Pettersson.

RISE owns more than 50 percent of Sweden’s test beds. One example is SEEL, Swedish Electric Transport Laboratory, where batteries and drivelines are tested.

“We want to connect our operations between SEEL and SEC”, says Stefan Pettersson.

RISE is engaged in realising the goals of the projects they are active in. When academia tends to lean towards education of students as a main goal, RISE is more focused on impact.

“We can put senior researchers on shorter projects to solve specific issues and faster give industry what they need. I think our partnership will make SEC more dynamic in that sense”, says Stefan Pettersson.

X Shore

X Shore is a young start-up company within the recreational boats industry. In 2022 they became partners of SEC to learn and get inspiration from scientists and the industrial network.

X Shore make fully electric high-end recreational boats. The Swedish company launched the first prototype in 2018 with an office in Stockholm and a factory in Linköping with around 100 employes in

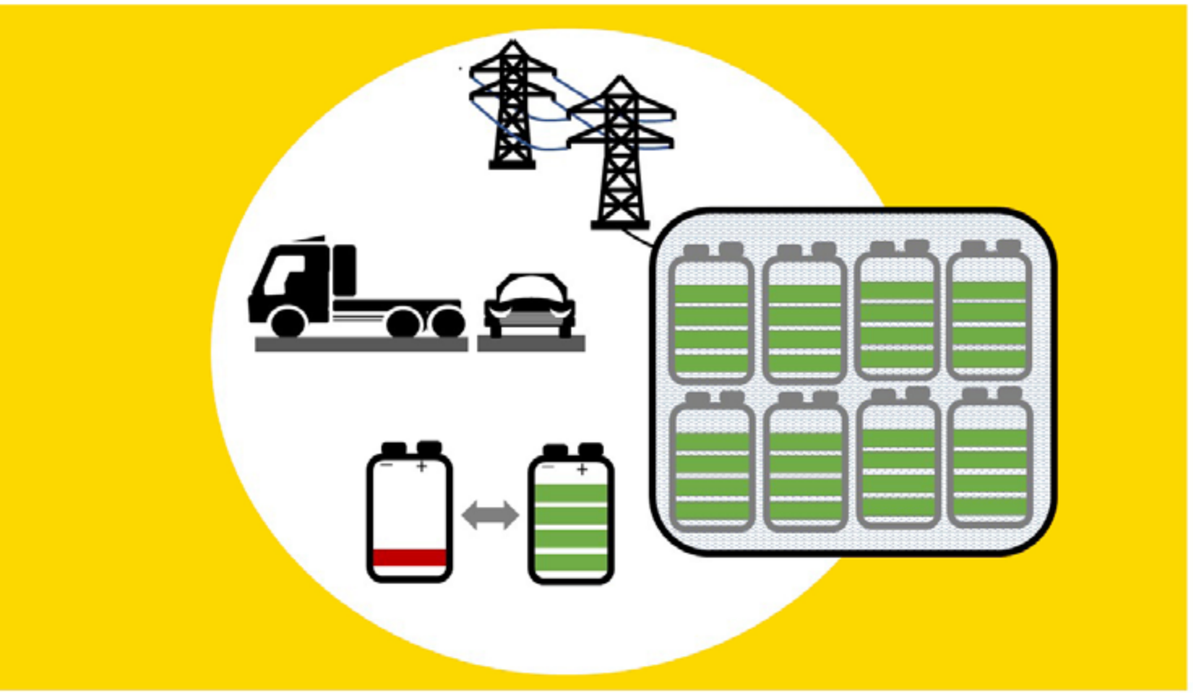
X Shore’s fully electric recreation boats.

total. “Our factory has the capacity of manufacturing about 400 boats per year mainly to support the sales in Europe, USA and the Middle East. Our ambition is to make electric boats affordable also to more average consumers. Recreational boating accounts for 1/3 of total CO2 emission from domestic flights in Sweden today, so electrification of boats can really make a difference”, says Kelin Jia, Electric drive train expert at X Shore.

The company has two boat models at the moment. One 8 metre long and one 6,5 meters. The electric boat also makes less impact on the local environment since leakages are rare compared to fossil-fuel engines.

A main challenge for the boat manufacturer is the drive train. A regular car motor wouldn’t work. When car motors don’t demand so much power after reaching wanted speed, a boat needs to keep the power high all the time to keep up the speed.

“We are pioneers in the electric boat industry. Many EV components are not suitable for us. What we need is more similar to truck engines, but those engines are much too big for having on a recreational boat, so this is relly a challenge”, says Kelin Jia.



Battery swapping is a complementary form of vehicle charging that may also play a role in energy storage that strengthens the energy grid.

SEC's first focus group started

The Swedish Electromobility Centre approved the formation of a focus group on Battery Swapping. This is the first focus group of the Centre and is coordinated by VTI, The Swedish National Road and Transport Research Institute.

Battery swapping is a complementary form of vehicle charging that may also play a role in energy storage that strengthens the energy grid. While yet lacking a strong role in Sweden, battery swapping solutions have increased considerably internationally.

The focus group has a cross-thematic relevance with the objective to explore and evaluate the technique from a Swedish perspective, including identifying research gaps and specific questions to address in future projects. The collaboration started in October, with the SEC partners from the industry, academy and institutes that were the first to confirm their interest, but the group is open for all SEC partners to join.

Collaborations 2022

SEC is constantly welcoming new partners that contribute to the centre's unique collaboration environment. Apart from this, the centre is also an attractive partner for other research centres and other organisations. Below are a few examples of external collaborations that have been ongoing in 2022.

BASE

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

BATTERY 2030+

BATTERY 2030+ is a large scale, long-term European research initiative with the vision of inventin the sustainable batteries of the future. SEC is a supporting organisation to Battery2030+. 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.

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.

IFP Energies nouvelles

This is a centre based at Linköping SEC collaborates through having theme leader Lars Eriksson as a teacher in the French institute's courses and he institute also contribute with researchers to SEC's grading committee.

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

PUSH (Production, use and storage of hydrogen) is an Agenda 2030 Research Centres 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.

REEL2

REEL2 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, and monitors how the cooperation in this field can be increased between the centres.

SPGA

Swedish Proving Ground Association (SPGA) facilitates vehicle testing in winter conditions. SEC has regular contact with SPGA and co-arranged a workshop on what research is relevant in winter conditions.

SEEL

SEEL Swedish Electric Transport Laboratory is a test center for research and development in the field of electromobility, and is owned and run by Chalmers and RISE as a joint venture. SEEL will establish 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 and have ongoing discussions on research and collaborations.

The two days were moderated by SEC's communciator Mats Tiborn.

The future was in focus at the Kick off.

A rewarding Kick off and E-mobility Day

The Swedish Electromobility Centre gathered for two days in AF-borgen, Lund 24-25 August. There were around a hundred participants from all partner organisations. First day was the Kick off for the 5th stage of the centre, focusing on business intelligence, looking into the future, and getting contributions to future road maps from both old and new partners.

There were inspiration lectures from Magnus Karlström, omEV, Robert Eriksson, Volvo Cars, Morris Packer, E.ON, and Klaas Burgdorf, the Swedish Energy Agency. Then all participants collaborated in the workshop called Next step in electro mobility – How do we get there? providing valuable input to SEC's coming road map work.

The Kick off for stage V and the annual E-mobility Day at the AF-borgen in Lund.

At the Kick off the groups showed great commitment in the discussions about SEC's role in realising the sustainable transport system of the future.

The second day with a visit to a demo site of an Electric road just outside of Lund was arranged.

Doctoral network

The Swedish Electromobility Centre's Doctoral student network is open for all PhD students in Sweden who study aspects of electrification of vehicles. The network is an arena for collaboration and networking between PhD students and stimulates their interaction with the Swedish automotive industry.

The Doctoral student network offers access to SEC's activities and network, knowledge building through seminars and PhD courses, contact and networking activities with other PhD students from different fields within electromobility, and preparation for future work and research challenges.

The PhD students in the network comes from both partner and other universities, and includes both academic and industrial PhD students. The network was led by Therése Eriksson at SEC partner Uppsala University during 2022.

PhD courses during 2022

Writing boot camp in May/June 2022
The Bootcamp focused on methods for efficient and productive writing. It consisted of a mix of instruction, discussion and actual writing.

Hybrid electric powertrains – Modeling, control, and optimization
The course was aimed for both engineers and researchers working on some aspect of electromobility. It was open for PhD students within the field and employees of the partner companies in the Swedish Electromobility Centre.

Autumn School
The annual Autumn School was held in Alingsås on 7–11 November. 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 location. Some students asked for a follow up course so they could join next year again.

There were 17 participants, 4 employees from SEC partner companies and 13 PhD students (both academic and industrial). There were quite a large group from Lund University, but also from KTH, Chalmers, Uppsala, Linköping and industrial PhD students from CEVT, RISE and Volvo.

Study visit at VCE

Volvo Construction Equipment welcomed the SEC PhD students to their facilities in Eskilstuna. The Ph.D. students got to practice pitching a poster, saw a machine show with VCE's electric machines among others, and had a nice dinner with networking opportunities. Most importantly, they had in-depth discussions with the employees at VCE, with a valuable exchange of knowledge from both sides. To once again make study visits were highly appreciated by the PhD students. Look out for more Doctoral Network study visits ahead.

Lunch Webinars 2022

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 2022 there were 8 lunch webinars.

Above: At the Autumn School in Alingsås students and engineers from SEC partners enjoyed lectures and practical exercises.

Left: Volvo Construction Equipment welcomed PhD students from all over Sweden to their facilities in Eskilstuna.

Outreach and communication

The most important communicators of the centre are the project participants from all the partners. They represent the centre by the results and the development that is being conducted all year around and by bringing the new knowledge into their organisations.

To support them in their work and to reach out digitally SEC's communicators deliver news to the partners and other relevant actors with regular news updates about the centre. Every month the SEC. Newsletter is being sent out to 3700 subscribers, mostly people working 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.

Events

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 E-mobility day and kick-off for the fifth stage in Lund in August. This event gathered 130 attendees from all partners, with presentations from SEC-funded projects, business intelligence and a workshop to support SEC's work on the roadmap.

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. OmEV 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.

External events

SEC's representatives have participated at multiple external events in 2022. SEC's representatives have participated at mulitple external events in 2022. To give an overview of the kinds of events, below are a few examples of how SEC contributes with knowledge for other organisations and society in general.

February: Linda Olofsson spoke at the Chalmers Energy network day
April: Magnus Blinge presented SEC and Swedish "best practices on cooperation to achieve electrification of the transport sector" at the Swedish embassy in Budapest, Hungary, at a seminar organised by Swedish chamber of commerce.
April: Linda Olofsson presented at eCommEXPO220503 Power Electrification Summit
May: SEC representatives presented at Chalmers Energy Area of Advance & IVL Seminar: Hur kan godstransporter bli utsläppsfria?
May: SEC were present at the rededication of the Ångström laboratory
June: Daniel Brandell represented SEC at the Business Sweden Summit in his presentation "Research along the battery value chain".
June: Linda Olofsson represented SEC at the Electrification Commission's spring conference
July: Within the associated project Evolution Road, Mats Alaküla delivered a presentation at the Almedalen political event entitled "The role of Electric Roads in the energy transition"
August: Linda Olofsson presented at Frihamnsdagarna: Klimatomställningen - hur redo är vi?
November: Linda Olofssom presented SEC at the celebrating of Electro at Chalmers turning 120 years.
December: Linda Olofsson presented good examples of cross-idnustrial collaborations at the CommEXPO Summit.

Throughout the year representatives from Theme 5 have presented SEC and its research to Swedish grid utility companies to automotive industry companies such as Gävle Energi and Ellevio, Volvo Construction Equipment, and We Drive Solar.

Media highlights

"Megabränder" – interview in SVT's Vetenskapens värld, with theme 3's leader Göran Lindbergh, 2022-03-06.

"Tekniken som kan ge tre gånger räckvidden" – interview in Elbilen i Sverige with theme 3's leader Daniel Brandell, 2022-05-31.

"Skifte kräver batteriexpertis" – interview in TT with theme 3's leader Daniel Brandell, 2022-05-04.

"Ett av de största teknikskiftena sedan industrialiseringen - Övergången till elbilar" – interview in Nerikes Allehanda with theme 3's leader Daniel Brandell, 2022-05-13.

"Här ska Northvolt utbilda experterna" – interview in Borlänge tidning with theme 3's leader Daniel Brandell, 2022-04-11.

SVT Nyheter Uppsala – interview with theme 3's leader Daniel Brandell, 2022-01-31.

"Här är jättarna som också kan bli aktuella" – interview in Örnsköldsviks Allehanda, sundsvalls Tidning and Tidningen Ångermanland, with theme 3's leader Daniel Brandell, 2022-01-22.

"Elflyg kan ersätta regionalflyg" – interview in TV4 with theme 4's leader Magnus Blinge 2022-01-17.

Nyheter P4 Göteborg – interview with theme 4's leader Anders Nordelöf 2022-02-10.

"Vägs ände för elvägar?" – interview in Dagens ETC with theme 4's leader Anders Nordelöf 2022-03-14.

"Så klimatsmart är elbilen – från tillverkning till användning" –interview in Expressen, GTband Kvällsposten with theme 4's leader Anders Nordelöf 2022-04-05.

"Polestars mål till 2030: En elbil helt utan utsläpp" – interview in Dagens Nyheter with theme 4's leader Anders Nordelöf 2022-10-08.

"Tips on battery expertise from Chalmers University of Technology" – theme 4's leader Anders Nordelöf mentioned in Telematics Wire, Car news and Acrofan 2022-02-09.

"Hög tid att elektrifiera transportsektorn" – Linda Olofsson mentioned in Transport och logistik 2022-03-08

The omEV newsletter

The electromobility year of 2022

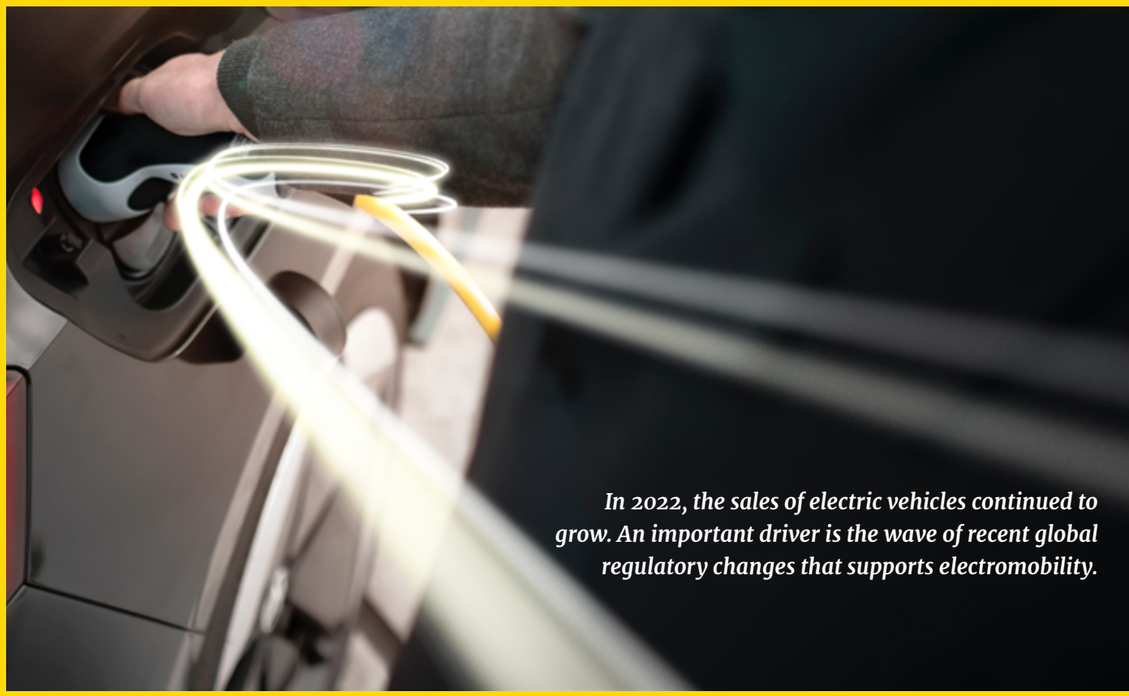
In 2022, the sales of electric vehicles continued to grow. Global electric car sales reached about 10.6 million units. Electric heavy-duty truck sales in the United States and Europe have also risen rapidly in the past few years.

An important driver is the wave of recent global regulatory changes that supports electromobility. For example, in Europe, the Fit for 55 package was proposed in July 2021 by the European Commission as part of the European Green Deal. The package is designed to reduce the European Union's greenhouse gas emissions by 55% by 2030. One part of the package is the revised regulation of CO^2 emission performance standards for cars and vans. The result of the revision is that The European Union has decided, in practice, to ban the sale of new petrol and diesel cars from 2035. This measure would mean that all new cars and vans sold in the EU as of 2035 should be zero-emission.

Magnus Karlström, editor in chief.

Another example of a new supporting policy is The Inflation Reduction Act (IRA) of 2022, a piece of legislation passed by the US Congress to reduce inflation and increase economic growth, but also to investments in domestic energy production, clean energy infrastructure and electromobility. One consequence of the IRA is more investment in battery production and mining battery materials in the USA.

IRA will therefore have consequences for one of the most important issue in electromobility. The challenge is to ramp up battery production, mineral mining and refining capacity quickly enough for the clean energy transition needed. There are also geopolitical dimensions since China is dominating both battery production and several of the supply chains for battery materials. Both the USA and the European Union want to increase their own capacity to supply batteries for the transition.



In 2022, the sales of electric vehicles continued to grow. An important driver is the wave of recent global regulatory changes that supports electromobility.

Moving on now to consider that the world is in the middle of a global energy crisis of unprecedented depth and complexity, according to the International Energy Agency. The global policy discussion about energy has changed because of the crisis. For example, the importance of energy security as a policy goal has increased, but also the importance of increasing the resilience of our energy and transport systems. Energy resilience could be defined as the ability to avoid, prepare for, minimise, adapt to, and recover from unanticipated disruptions in order to ensure the continuity of the energy supply. Both the resilience and energy security focus can influence the future of electromobility.

Challenges and possibilities

Finally, another finding in the field of electromobility is the gap in sales between developed markets and emerging markets. Countries such as China, Western Europe, and the USA have seen rapid growth in electric vehicle sales in recent years. However, in countries such as Indonesia, India and Brazil, the sales are far behind. The research conducted by Bloomberg New Energy Finance argues that the gap is caused by a lack of infrastructure, low consumer awareness, and limited access to finance.

Looking ahead to 2023, some newsworthy trends could be the development of hydrogen, the implementation of vehicle-to-grid technology, the potential success of Chinese export of electric vehicle and the kick-start of sales of heavy duty electric trucks, but also even more policy decisions such as European battery regulation, AFIR (Regulation on the Deployment of Alternative Fuel Infrastructure), the revision of Energy performance of buildings directive (EPBD) and the Emissions Trading System (ETS) for transport.

Magnus Karlström
Editor in chief of omEV

SEC Program Council

Meetings: 1 Feb, 25 Feb, 8 March, 8 June, 22 June, 14 Sept, 9 Nov

Permanent members

Nils-Gunnar Vågstedt	Chairman
Johan Hellsing	CEVT
Robert Eriksson	Volvo Cars
Elna Holmberg	Volvo Group
Fernanda Marzano	Scania
Maria Abrahamsson, replaced by Maria Grahn, March	Chalmers
Lina Bertling Tjernberg	KTH
Öivind Andersson	LU
Peter Värbrand	LiU
Eva Pålsgård, replaced by Cecilia Boström, March	UU

New permanent members, Stage V from 1 March

Arne Nåbo	VTI
Boel Wadman	RISE
Maria Rosqvist stakeholders' representative	(E.ON)
Ganesh Chandramouli, stakeholders' representative	(Alstom Group)

Co-opted Members

Linda Olofsson Director	SEC
Secretaries Linnéa Qvirist, Anna Aspgren, Anna Abelius	SEC
Jonas Fredriksson	Chalmers
Lars Eriksson	LiU
Fran Márquez-Fernández	LU
Luca Peretti	KTH
Daniel Brandell	UU
Göran Lindbergh	KTH
Magnus Blinge	LiU
Anders Nordelöf	Chalmers
Mikael Lantz	LU
Valeria Castellucci	UU
Magnus Karlström	Chalmers
Erik Svahn, replaced by Klaas Burgdorf, October	Energimynd.*
Magnus Lindgren	Trafikverket
Dmitry Svechkarenko	ABB
Arnaud Contet	TitanX
Thomas Tingelöf	PowerCell
Katarina Öquist	Epiroc
Christian Gruffman	Vattenfall
Gabriel Domingues	BorgWarner
Boel Ekergård	Högskolan Väst
Jan Westlund, replaced by Hans Kling, September	SAAB Group
Magnus Forsén	Alstom Group
Elin Eriksson	IVL
Pär-Ola Andersson	E.ON
Peter Öhman	LSP

New co-opted members, Stage V

Kelin Jia, from 1 March	X Shore
Rickard Arvidsson, from 1 July	Polestar
Alexandra Nafari, from 1 Nov	Alvier Mechatronics

* Energimyndigheten was a permanent member in Stage IV, and is co-opted Stage V.

SEC Partner Council

Meetings: 2 March, 20 June (per capsulam), 12 October

Partner Council

Anders Palmqvist,	Chariman
Annika Stensson Trigell	KTH
Charlotte P Björkman	UU
Per Dannetun	LiU
Heiner Linke	LU
Magnus Berg	Vattenfall
David Hellstedt	Volvo Group
Jan Palmér	Scania
Stefan Christiernin	Volvo Cars
Gabriel Domingues	BorgWarner
Leif Axelsson	CEVT
Dmitry Svechkarenko	ABB
Katarina Öqvist	Epiroc
Thomas Tingelöf	PowerCell
Jonas Jansson	VTI
Arnaud Contet	TitanX
Boel Ekergård	Högskolan Väst
Jan Westlund, replaced by Hans Kling in September	SAAB Group
Magnus Forsén	Alstom Group
Elin Eriksson	IVL
Peter Thelin	E.ON
Peter Öhman	LSP

New partners, Stage V

Stefan Pettersson	RISE
Kelin Jia, from 1 March	X Shore
Arlena Armiri, from 1 July	Polestar
Alexandra Nafari, from 1 November	Alvier Mechatronics

Co-opted members

Linda Olofsson	SEC
Linnéa Qvirist/Anna Abelius, secretaries	SEC
Erik Svahn, replaced by Klaas Burgdorf in October	Energimyndigheten

International scientific advisory board 2022

Anna Teyssot, Verkor, France

Giorgio Rizzoni, Ohio State University, US

Keith Hardy, National Laboratory, US

Management group and staff

Linda Olofsson
Director

Ellen Olausson
Deputy Director

Jonas Fredriksson
Theme 1

Lars Eriksson
Theme 1

Luca Peretti
Theme 2

Fran Márquez-Fernández, Theme 2

Mats Alaküla
Theme 2

Daniel Brandell
Theme 3

Göran Lindbergh
Theme 3

Anders Nordelöf
Theme 4

Magnus Blinge
Theme 4

Mikael Lantz
Theme 5

Valeria Castelluccci
Theme 5

Stefan Pettersson
RISE

Arne Nåbo
VTI

Also in service during 2022:
Linnéa Qvirist
Project Coordinator

Anna Aspgren Project Coordinator

Héléne Johansson
Project Manager of Communication

Frida Barrett Project Coordinator

Anna Abelius
Administrator

Mats Tiborn
Communications Officer

Therese Eriksson
Coordinator Doctoral Student Network

Magnus Karlström
Editor in chef omEV

Organisation

Full partners

Chalmers University of Technology
KTH Royal Institute of Technology
Linköping University
Lund University
Uppsala University
Scania
CEVT
Volvo Cars
Volvo Group
RISE Research Institutes of Sweden
VTI, the Swedish National Road and Transport Research Institute

Program partners

BorgWarner
Epiroc
Alstom Group
TitanX
PowerCell Sweden
E.ON
Polestar

Network partners

ABB
Högskolan Väst
IVL
Lindholmen Science Park
X Shore
Vattenfall
Alvier Mechatronics

Management group

Linda Olofsson, Director
Ellen Olausson, Deputy Director
Stefan Pettersson, RISE
Arne Nåbo, VTI
Jonas Fredriksson, Chalmers, Theme 1
Lars Eriksson, Linköping University, Theme 1
Luca Peretti, KTH, Theme 2
Fran Márquez-Fernández, Lund University, Theme 2
Mats Alaküla, Lund University, Theme 2
Daniel Brandell, Uppsala University, Theme 3
Göran Lindbergh, KTH, Theme 3
Anders Nordelöf, Chalmers, Theme 4
Magnus Blinge, Linköping University, Theme 4
Mikael Lantz, Lund University, Theme 5
Valeria Castellucci, Uppsala University, Theme 5

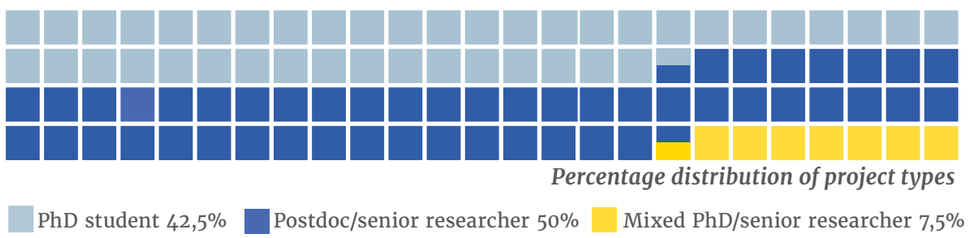
Staff

Anna Abelius, Administrator
Mats Tiborn, Communications Officer
Therese Eriksson, Coordinator Doctoral Student Network
Magnus Karlström, Editor i Chief omEV

Centre finance

Project types

One of the centre's objectives is that half of the SEC funded research projects that last for two years or more must be PhD student projects. Of the projects that were in progress in 2022, 42,5 percent were PhD student projects, 50 percent Postdoc/senior researcher projects, and 7,5 percent mixed PhD/senior researcher.



Percentage distribution of project types

PhD student 42,5% Postdoc/senior researcher 50% Mixed PhD/senior researcher 7,5%

SEC project funding in each theme

In 2022, the project portfolio included a total of 71 projects, of which 40 were SEC financed projects and 30 projects associated with SEC.

The projects across our theme areas have become more evenly distributed, where the newest theme areas dedicated to electromobility research on system level, Environment and Society (Theme 4) and Vehicle-Grid Interaction (Theme 5), have become stronger with 10 percent each of the ongoing projects. This can be compared with 20 percent in Intelligent Vehicles and Systems (Theme 1), 25 percent in Electric Drives and Charging (Theme 2), and 35 percent in Energy Storage (Theme 3).

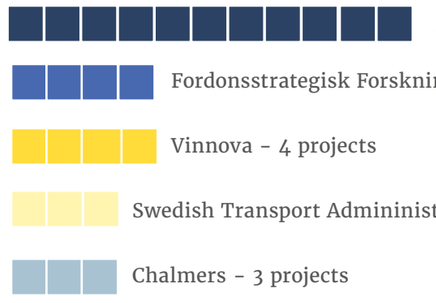
Perentage distribution of funding between the themes

1 Intelligent Vehicle and systems 22% 2 Electric Drives and Charging 24%
3 Energy Storage 30% 4 Environment and Society 12% 5 Vehicles Grid Interaction 12%

Cash funders in SEC associated projects

30 of the projects that were in progress in 2022, were associated projects, funded by various programs/centres.

The associated projects are funded by one or several funders. The main funders are:



Swedish Energy Agency - 11 projects

Fordonsstrategisk Forskning och Innovation, FFI - 4 project

Vinnova - 4 projects

Swedish Transport Admininistration - 3 projects

Chalmers - 3 projects

Other funders, with two or less projects, are: Batterifonden, CEVT, EU, KTH, Mistra, SSF, Statens vegvesen, Triple F, UPAB, Uppsala University, Volvo Group.

Events

Event name	Theme (1-5)	Stage	Date	Event type
Winter test region and SEC research collaboration - different aspects of charging	4, 5	IV	2022-01-18	Cross-theme workshop
Status update and future goals	5	IV	2022-01-31	Theme workshop
Fuel cell research at KTH	3	IV	2022-02-09	University workshop
Energibärare för hållbara transporter	Linköping University	IV	2022-02-09	University workshop
Introduction to Swedish Electromobility Centre @ LU	Lund University	IV	2022-02-14	University workshop
Electrification of Heavy Duty Vehicles – A Lunch Webinar at Uppsala University	Uppsala University	IV	2022-02-16	University workshop
Energy Storage for aviation, maritime, construction work and mining applications	3	V	2022-03-10	Theme workshop
Strategiska forskningsområden för elflyg	1-5	V	2022-03-21	Cross-theme workshop
Group activity and project proposal day at Scania	4	V	2022-03-28	Theme worskhop
Swedish Electromobility Centre (SEC) and the Road Freight Hydrogen Forum (FGV)	3	V	2022-04-01	Theme workshop
Workshop on Upcoming Applications Directed to Call for Projects	3	V	2022-04-05	Theme workshop
Integration of Transportation and Energy Systems	5	V	2022-04-05	Theme workshop
Seminars on modelling and diagnosis of demagnetization faults in synchronous machines, by Dr. Vasilios Ilioudis	2	V	2022-05-11 - 2022-05-12	Theme workshop
Electrification from a logistics perspective & Environmental aspects of current and future battery-grade lithium supply	4	V	2022-05-20	Theme workshop
MSc Thesis Bonanza	1	V	2022-06-07	Theme workshop
Manufacturing of electrical machines	2	V	2022-06-09	Theme workshop
Master Thesis Bonanza	4	V	2022-06-17	Theme workshop
Swedish Agencies' View on and Their Role in the Electrification of the Transport Sector	4	V	2022-10-13	Theme workshop
Innovations and barriers in electrification – at battery cell level and in the logistics system	4	V	2022-11-07	Theme workshop
ICEM conference summary	2	V	2022-11-15	Theme workshop
Roadmap update	5	V	2022-11-28	Theme workshop
Fuel Cells or batteries as energy storage for vehicles? What guides the decisions?	3	V	2022-12-05	Theme workshop
Policy research and roadmap update day	4	V	2022-12-05	Theme workshop
Workshop on Modeling and simulation of electrochemical vehicles	1	V	2022-12-21	Theme workshop

Projects

Project	Project manager	Main theme area	Main university partner	Other university partners	Company partners in SEC	Gender Equality Participants (f/m)	Gender Equality Funding (%f/%m)	International Collaborations yes/no	Stage
Charging behaviour and infrastructure need for plug-in electric vehicles , Stage IV ACTUAL grid and road simulation for e-mobility	Frances Spray	4	Chalmers	KTH	Volvo Cars	1/1	0/100	Germany, California, nternational EV policy council, Delaware	IV
E-machine design for enhanced recyclability and minimised environmental impact	Torbjörn Thiringer	2	Chalmers		ABB, CEVT, Volvo Cars	3/2	95/5	No	IV
Cost-benefit Optimised Charging Infrastructure	Gyözö Gidofalvi	5	KTH	LTH	Vattenfall	1/2	2/80	Massachusetts	IV
Thermal modelling and fault prognosis for Li-ion battery systems	Mattias Krysander	3	Chalmers		Scania Volvo Group	1/3	0/100	No	IV
Testing, Analysis and Design of Axial Flux Motors for Vehicle Applications	Sonja Tidblad Lundmark	2	KTH		ABB Volvo Group Volvo Cars	4/6	93/7	No	IV
Real-time observation of side-reactions: Understanding and predicting the lifetime characteristics of Li-ion cells	Erik Berg	3	KTH		ABB Volvo Group Volvo Cars	0/1	0/100	Germany	IV
Life Cycle Assessment of Large-Scale Lithium-Ion Battery Production and Recycling	Anders Nordelöf	4	Chalmers		CEVT, Scania, Volvo Group, Volvo Cars	0/3	0/100	No	IV
Design of rare earth element free motors for electromobility	Sandra Eriksson	2	UU		Scania	2/1	0/100	No	IV
Fuel Cell Performance Prediction	Rakel Wreland Lindström	3	KTH		ABB, Powercell, Volvo Group	2/4	1/100	No	IV
On-line health diagnostics of inverters for commercial vehicle drive systems	Staffan Norrga	2	KTH		Scania	0/1	0/100	Netherlands, France	IV
Modeling, System Analysis, and Control of Hybrid Electric Vehicles with Aftertreatment Systems	Lars Eriksson	1	LiU	Chalmers	Scania, Volvo Group	0/3	0/100	No	IV

Project	Project manager	Main theme area	Main university partner	Other university partners	Company partners in SEC	Gender Equality Participants (f/m)	Gender Equality Funding (%f/%m)	Internatio-nal Collabora-tions yes/no	Stage
Electric vehicle charging strategies and grid manage-ment – interaction with the electric grid	Maria Taljegård	2	Chalmers		ABB, RISE Volvo Group	2/2	75/25	Germany, California, International EV policy council, Delaware	IV
Prerequisites for electrification of freight transports	Henrik Gillström	4	LiU		Borg-Warner, CEVT, Scania, Titan X, Vatten-fall, Volvo Cars	0/1	0/100	No	IV
ACTUAL grid and road simulation for e-mobility	Francisco Márquez-Fernández	5	LTH	KTH	CEVT, E.ON, Scania, Vattenfall, Volvo Group, Volvo Cars	1/2	100/0	Massac-husetts	IV
Measurements and modelling of thermal and electrical behavior of labscale/industry prototype Li-Ion cells	Torbjörn Thiringer	3	Chalmers		CEVT, Powercell, Scania, Volvo Group, Volvo Cars	5/6	40/60	No	IV
Diagnostics and supervision of dynamically configurable battery systems (DiConBatt)	Mattias Krysander	1	LiU		Scania	1/2	75/25	No	IV
High Power Charging: when, where and how?	Karin Thomas	5	UU		CEVT, Scania, Vattenfall, Volvo Group	0/1	0/100	No	IV
Modelling and con-trol of complex AWD BEV architectures. Changfe of Projekt Manager during March 2022	Nikolce Murgovski	1	Chalmers		BorgWarner, CEVT, Volvo Group, Volvo Cars	1/3	30/100	Netherlands, China	IV
Data exchange between vehi-cle and power system for optimal charging	Jennifer Leijon	5	UU		CEVT, Vattenfall, Volvo Group, Volvo Cars	1/0	100/0	No	IV
Investigation of winding configu-ration and leakage indutance on electrical ma-chhine performance in terms of torque ability and ripple as well as iron loss	Sonja Tidblad Lundmark	2	Chalmers		ABB, Scania, Volvo Group, Volvo Cars	2/4	1/100	No	IV
XRD tomography of electrodes from Ni-rich Li-batteries – aging fingerprints in the 3D structure of the electrodes	Anti Liivat	3	LTH		Scania	1/3	0/100	No	IV

Project	Project manager	Main theme area	Main university partner	Other university partners	Company partners in SEC	Gender Equality Participants (f/m)	Gender Equality Funding (%f/%m)	Internatio-nal Colla-borations yes/no	Stage
Environmental Assessment of Electromobility Charging systems	Anders Nordelöf	4	Chalmers		CEVT, Scania, Volvo Group, Volvo	1/2	0/100	No	IV
NVH Analysis and Mitigation in Electrical machineS - NAMES	Francisco Márquez-Fernández	2	Chalmers	LTH	ABB, CEVT, Volvo Cars	0/2	100/1	No	IV
Chemical quenchers for inhibition of battery fires	Elna Heimdal Nilsson	3	LTH	UU	Volvo Cars	2/2	100/0	No	IV
Fuel cell durability prestudy	Anneli Jedenmalm	3	KTH	LTH/LiU	ABB, PowerCell, Volvo Group	5/7	43/57	No	IV
A Model and Simulation Platform for Electric Vehicle Systems with Motors, Power Electronics, Batteries and Fuel Cells and their Heating and Cooling Needs	Lars Eriksson	1	LiU	LTH	SAAB, Scania, TitanX, Volvo Group, Volvo Cars	0/10	0/100	No	IV
Charging behaviour and infrastructure need for plug-in electric vehicles , Stage IV	MIkael Askerdal	1	Chalmers		CEVT, Volvo Group, Volvo Cars	0/2	0/100	No	IV
PETECI: Predictive Energy and Thermal management of Electric vehicles with Connectivity to Infrastructure	Nikolce Murgovski	1	Chalmers		Volvo Cars	0/3	0/100	No	IV
Combining physical and data-based modelling to understand material failures in rechargeable lithium ion batteries	Peter Broqvist	3	UU		Scania, Volvo Cars	2/3	100/0	Nether-lands, Switzer-land, China	IV
Switchable pole phase drive systems for electromobility	Luca Peretti	2	KTH		ABB, Scania	0/2	0/100	No	IV
Performance and ageing of Li-based solidstate batteries	Mario Valvo	3	UU		Scania, Volvo Cars	0/1	0/100	No	IV
Evaluation and optimisation of materials for IT-PEMFC	Björn Eriksson	3	KTH		ABB, PowerCell, Scania, Volvo Group	0/1	0/100	No	IV

Project	Project manager	Main theme area	Main university partner	Other university partners	Company partners in SEC	Gender Equality Participants (f/m)	Gender Equality Funding (%f/%m)	Internatio-nal Collabora-tions yes/no	Stage
Planning Support for Electric Vehicles based on Optimal Control,	Lars Eriksson	1	LiU		Saab, Scania, Volvo Group	0/2	0/100	No	IV
DFN-model of Hard Carbon for Na-ion Batteries	Evelina Wikner	3	UU		CEVT, Volvo Group, Volvo Cars	3/5	80/20	No	V
PMaSynRM for Heavy Duty Application	Francicso Marquez-ernandez	5	LTH	KTH	CEVT, E.ON, Scania, Vattenfall, Volvo Group, Volvo Cars	1/2	100/0	Massac-husetts	V
Arcing as the Ignition Source in Malfunctioning Batteriess	Elna Heimdal Nilsson	3	LTH		CEVT, Volvo Cars	1/1	0/100	Nether-lands, Switzer-land, China	V
Heterogenic Ageing in Large Intercalation Batteries (HALIBatt-UU) – Uppsala	Fredrik Björefors	3	UU		CEVT, Volvo Group, Volvo Cars	0/1	0/100	No	V
Heterogenic Ageing in Large Intercalation Batteries (HALIBatt-KTH) – KTH	Rakel Wreland Lindström	3	Chalmers, UU, VTI		Scania, Volvo Cars	2/3	100/0	EU	V
Additive Manufacturing of Stator Windings	Mats Alakülai	2	KTH	RISE	ABB, Volvo Group	0/2	0/100	Nether-lands, China	V
Energy Management Strategies for Electrified Vehicles Under Traffic Uncertainties	Jonas	1	Chalmers		CEVT, Scania, Volvo Group, Volvo Cars	2/0	100/0	No	V

Associated projects

Project	Funder	Project manager	Main theme area	Main university partner
Ageing of Lithium-ion Batteries with Nickel-Rich Cathodes for Electromobility (ALINE)	The Swedish Transport Administration	Ida Kristoffersson	4	VTI
Battvolt	Mistra	Lars Eriksson	1	Linköping University
Blood Batteries, Social Life Cycle Impacts of	Batterifonden, Swedish Energy Agency	Rickard Arvidsson	4	Chalmers
Compact, modular, integrated electric machines	Swedish Energy Agency, KTH	Sjoerd Bosga	2	KTH
Diagnostics and Open Loop Lifetime Estimation	Swedish Energy Agency, FFI	Rasmus Andersson	2	Lund University
E-charge System demonstration of electrified lo	Vinnova	Gunnar Ohlin	4	Linköping University
Electromobility in smart cities	Uppsala University, Vattenfall	Rafael Waters	5	Uppsala University
Energy efficient propulsion system	Swedish Energy Agency, CEVT	Leon Lowered	2	Chalmers
Energy efficient thermal management	Swedish Energy Agency, CEVT	Nikolce Murgovski	1	Chalmers
EPOS - Electric Powertrain OptimiSation for	Swedish Energy Agency, FFI	Mats Alaküla	2	Lund University
Evolution Road	The Swedish Transport Administration	Per Löfberg	2	Lund University
FROST – Fuel Reduction Optimal Strategies	FFI	Lars Eriksson	1	Linköping University
High performing circular battery flows	Swedish Energy Agency	Patricia van Loon	4	Chalmers
Integrated electric Generator and motor (InGe)	Vinnova	Mats Alaküla	2	Lund University
Life Cycle Assessment of All-Electric Aircrafts	Chalmers	Rickard Arvidsson	4	Chalmers
LINK-SIC	Vinnova	Lars Eriksson	1	Linköping University
Low carbon transport solutions	Statens Vegvesen	Maria Taljegård	5	Chalmers
Multi-Scale Modelling the Interfacial Chemistry	Swedish Energy Agency	Daniel Brandell	3	Uppsala University
Operational Network Energy managementT for elect	Swedish Energy Agency	Balázs Adam Kulcsár	1	Chalmers
Optimering av elektriska maskiner baserat på	Swedish Energy Agency	Sandra Eriksson	2	Uppsala University

Project	Funder	Project manager	Main theme area	Main university partner
REEL2	FFI	Andreas Josefsson	5	Lund University
STORM - Smart freight TranspOrt and logistics Research Methodologies	European Commission	Yancho Todorov	4	Chalmers
Sustainability transitions in urban goods distribution: local arenas as enablers of technology diffusion	Swedish Energy Agency	Thomas Magnusson	4	Halmstad University
System Effects of Automation, Electrification and Digitalisation on Freight Transport	The Swedish Transport Administration	Anna Pernestål	4	KTH
The mobility house of tomorrow	Vinnova, Uppsala University and UPAB	Valeria Castellucci	5	Uppsala University
The role of stationary batteries and electric	Chalmers	Maria Taljegård	5	Chalmers
Ti3C2Tx MXene in Li- and Na-ion batteries	SSF	Kristina Edström	3	Uppsala University
TRACER	Triple F	Gyözö Gidofalvi	1	KTH
Transition to a fossil free European transport	Chalmers	Maria Taljegård	5	Chalmers
TVS Modelling	Volvo Group	Per Widek	2	Lund University

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Publication, Author, Date, Journal/conference, DOI, Project

100% privately owned electric cars- what are their potential impacts on the low-voltage grids?, Maria Taljegård, Aug-22, E-mobility days, N/A, Electric vehicle charging strategies and grid management – interaction with the electric grid

A large-scale high-resolution geographic analysis of impacts of electric vehicle charging on low-voltage grids, Elias Hartvigsson, Maria Taljegard, Mikael Odenberger, Peiyuan Chen, aug-22, Scientific Journal Energy, https://doi.org/10.1016/j.energy.2022.125180, Electric vehicle charging strategies and grid management – interaction with the electric grid

A model platform for life cycle assessment of lithium-ion battery production and use, Mudit Chordia, Evelina Wikner, Anders Nordelöf, Oct-22, NordBatt 2022, N/A, Life Cycle Assessment of Large-Scale Lithium-Ion Battery Production and Recycling

A model platform for solving lithium-ion battery cell data gaps in life cycle assessment, Mudit Chordia, Evelina Wikner, Anders Nordelöf, June-22, 35th International Electric Vehicle Symposium and Exhibition (EVS35), Life Cycle Assessment of Large-Scale Lithium-Ion Battery Production and Recycling

Airports with increased electrification – an ongoing project with case studies in Sweden, Jennifer Leijon, Jens Hagman, Hampus Alfredsson, Sara Ghaem Sigarchian, jun-22, 35th International Electric Vehicle Symposium and Exhibition (EVS35), High Power Charging: when, where and how?

Airports with increased electrification – an ongoing project with case studies in Sweden. Jennifer Leijon, Jens Hagman, Hampus Alfredsson, Sara Ghaem Sigarchian, jun-22, 35th International Electric Vehicle Symposium and Exhibition (EVS350), Data exchange between vehicle and power system for optimal charging

Centralised and decentralised electrolysis-based hydrogen supply systems for road transportation–A modeling study of current and future cost, Therese Lundblad, Maria Taljegård, Filip Johnsson, Nov-22, International Journal of Hydrogen Energy, https://doi.org/10.1016/j.ijhydene.2022.10.242, Electric vehicle charging strategies and grid management – interaction with the electric grid

Change in SiC MOSFET body-diode voltage drop in TO-247 packages during inverse-mode and forward-mode power cycling test, Bhanu Pratap Singh, Amin Farjah, Khaled Redwan Chaudhury, Staffan Norrga, Hans-Peter Nee, Mar-22, CIPS 2022 - 12th Int'l Conference on Integrated Power Electronics Systems, Online health diagnostics of inverters for commercial vehicle drive systems

Charging Electric Vehicles Today and in the Future, Jennifer Leijon, Cecilia Boström, Aug-22, World Electric Vehicle Journal, https://doi.org/10.3390/wevj13080139, Data exchange between vehicle and power system

Connection between transport and energy, Maria Taljegård, Dec-22, eComExpo Summit 2022, Electric vehicle charging strategies and grid management – interaction with the electric grid

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Designing temperature dependent free energy functionals for multi-scale modelling of cathode materials, Peter Broqvist, Oct-22, MMM10 The 10th International Conference on Multiscale Materials Modeling https://mmm10.jhu.edu/, Combining physical and data-based modelling to understand material failures in rechargeable lithium ion batteries

Designing Temperature Dependent Free Energy Functionals for Multi-Scale Modelling of Electrodes, Peter Broqvist, Aug-22, Euromech 2022 Colloquium, Multiscale Mehcanics, multiphysics modelling and simulations for energy storage, https://617.euromech.org/, Combining physical and data-based modelling to understand material failures in rechargeable lithium ion batteries

Designing Temperature Dependent Free Energy Functionals for Multi-Scale Modelling of Electrodes, Peter Broqvist, Oct-22, Swedish e-science Academy, Combining physical and data-based modelling to understand material failures in rechargeable lithium ion batteries

Diagnostics and supervision of dynamically configurable battery systems, Mattias Krysander, Aug-22, SEC E-mobility Day, Lund, Diagnostics and supervision of dynamically configurable battery systems (DiConBatt)

Does the grade and source of lithium used in batteries matter?, Mudit Chordia, Sanna Wickerts, Anders Nordelöf, Rickard Arvidsson, maj-22 SETAC, Europe 2022, Copenhagen, Denmark, Life Cycle Assessment of Large-Scale Lithium-Ion Battery Production and Recycling

Electrification of Vehicle Miles Traveled and Fuel Consumption within the Household Context: A Case Study from California, U.S.A, Mandev A., Sprei F., & Tal G., okt-22, World Electric Vehicle Journal, https://doi.org/10.3390/wevj13110213, Charging behavior and infrastructure need for plug-in electric vehicles , Stage IV

Electrification of vehicle miles travelled and fuel consumption within the household context: a case study from California, USA, Frances Sprei, dec-22, Transportation Research Board, Charging behavior and infrastructure need for plug-in electric vehicles , Stage IV

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Empirical charging behavior of plug-in hybrid electric vehicles, Mandev A., Plötz P., Sprei F., & Tal G., maj-22, Applied Energy, https://doi.org/10.1016/j.apenergy.2022.119293, Charging behavior and infrastructure need for plug-in electric vehicles, Stage IV

Experimental Characterisation of Anisotropic Mechanical and Thermal Properties of Gas Diffusion Layers, Rakel Wreland Lindström, May-22, 241st ECS meeting, Vancouver, Canada, Fuel Cell Performance Prediction

Fault Detection in Variable Phase-Pole Machines based on Harmonic Plane Decomposition, Yixuan Wu, Gustaf Falk Olson, Luca Peretti, Oct-22, 48th Annual Conference of the IEEE Industrial Electronics Society (IECON 2022), 10.1109/IECON49645.2022.9968826, Switchable pole phase drive systems for electromobility

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Hierarchical Diagnosis Algorithm for Component-Based Multi-Mode Systems, Mattias Krysander, July-22, IFAC World Congress, Diagnostics and supervision of dynamically configurable battery systems (DiConBatt)

Hur kan vi tillhandahålla vätgas åt framtidens hållbara transporter?, Maria Taljegård, June-22, Transportforum, Electric vehicle charging strategies and grid management – interaction with the electric grid

Improved Parametric Representation of IM from FEM for More Accurate Torque Predictions, Meng-Ju Hsieh, Torbjörn Thiringer, Emma Arfa Grunditz, Sep-22, International conference of electrical machines ICEM 2022, 10.1109/ICEM51905.2022.9910617, E-machine design for enhanced recyclability and minimised environmental impact

Indirect electrification of transport – a study of hydrogen supply for heavy road transportation, Maria Taljegård, June-22, 35th International Electric Vehicle Symposium and Exhibition (EVS35), Electric vehicle charging strategies and grid management – interaction with the electric grid

Innovation and collaboration in electric vehicles, energy systems, and charging infrastructure, Jennifer Leijon, Dec-23, 14th SANORD conference, Data exchange between vehicle and power system for optimal charging

Life cycle environmental impacts of current and future battery-grade lithium supply from brine and spodumene, Mudit Chordia, Sanna Wickerts, Anders Nordelöf, Rickard Arvidsson, Dec-22, Resources, Conservation & Recycling, https://doi.org/10.1016/j.resconrec.2022.106634, Environmental Assessment of Electromobility Charging systems

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Metal requirements for road-based electromobility transitions in Sweden, Seshadri Srinivasa Raghavan, Anders Nordelöf, Maria Ljunggren, Rickard Arvidsson, Journal article, peer-reviewed 2022, Resources, Conservation & Recycling, https://doi.org/10.1016/j.resconrec.2022.106777, Environmental Assessment of Electromobility Charging systems

Multi-sectoral transformation and organisational capabilities: a pathway model illustrated by the transition to electrified goods transport in Sweden, Henrik Gillström, June-22, IEEE International Conference on Imaging Systems and Techniques (IST 2022), Prerequisites for electrification of freight transports.

On the Mitigation of Leakage Flux in Spoke Type Permanent Magnet Synchronous Machines, M. D. Silva, S. Eriksson, Sep-22, International conference of electrical machines ICEM 2022, 10.1109/ICEM51905.2022.9910669, Design of rare earth element free motors for electromobility

Online electrochemical mass spectrometry on large-format Li-ion cells, Casimir Misiewicz, Robin Lundström, Istaq Ahmed, Matthew J. Lacey, William R. Brant, Erik J. Berg, Oct-22, Journal of Power Sources, https://doi.org/10.1016/j.jpowsour.2022.232318, Real-time observation of side-reactions: Understanding and predicting the lifetime characteristics of Li-ion cells

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Plug-in hybrid electric vehicle usage in the world: analysing the differences in the share of electrification between countries, Frances Sprei, Oct-22, Swedish Transportation Research Conference 2022, Charging behaviour and infrastructure need for plug-in electric vehicles , Stage IV

Prognostics And Health Management for Batteries, Changfu Zou, June-22, European Conference of The Prognostics And Health Management, Thermal modelling and fault prognosis for Li-ion battery systems

Resolving high potential structural deterioration in Ni-rich layered cathode materials for lithium-ion batteries operando, Anastasiia Mikheenkova, Olof Gustafsson, Casimir Misiewicz, William, R. Brant, Maria Hahlin, Matthew J. Lacey, Nov-22, Journal of Energy Storage, https://doi.org/10.1016/j.est.2022.106211, Real-time observation of side-reactions: Understanding and predicting the lifetime characteristics of Li-ion cells

The potential impact of a mobility house on a congested distribution grid – a case study in Uppsala, Sweden, C. Flygare, A. Wallberg, J. Hjalmarsson, C. Fjellstedt, C. Aalhuizen, V. Castellucci, July-22, CIRED workshop on E-mobility and power distribution systems, 02-03 June 2022, Hybrid Conference, Porto, Portugal, 10.1049/icp.2022.0880, High Power Charging: when, where and how?

Understanding how electrification affects the logistics system - A litterature review, Henrik Gillström, My Jobrant, Uni Sallnäs, June-22, NOFOMA Conference 2022, Prerequisites for electrification of freight transports.

Understanding the Capacity Fade in Polyacrylonitrile Binderbased LiNi0.5Mn1.5O4 Cells, Alma Mathew, Casimir Misiewicz, Dr. Matthew J. Lacey, Dr. Satu Kristiina Heiskanen, Dr. Jonas Mindemark, Prof. Erik Berg, Dr. Reza Younesi, Prof. Daniel Brandell, Sep-22, Batteries & Supercaps, https://doi.org/10.1002/batt.202200279, Real-time observation of side-reactions: Understanding and predicting the lifetime characteristics of Li-ion cells

List of abbreviations

AI:	Artificial Intelligence
CO2:	Carbon dioxide
E-mobility:	Electromobility
EMC:	Electromagnetic Compatibility
EV:	Electric vehicle
FFI:	Fordonsstrategisk forskning och innovation
Fit for 55:	EU Commissions Fit for 55' proposals" is ment to make climate, energy, land use transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels.
Gigafactories:	Facilities that produce batteries for electric vehicles on a large scale
HVAC:	Heating,ventilation and air conditioning
IFAC:	The International Federation of Automatic Control
Li-ion:	Lithium-ion
LiU:	Linköping University
LSP:	Lindholmen Science Park
LU:	Lund University
Matlab:	A programming and numeric computing platform
Na-ion:	Sodium-ion
PEMC:	Proton exchange membrane fuel cell
PhD:	Doctor of Philosophy
SHC:	Swedish Electric & Hybrid Vehicle Centre
Simulink:	MATLAB-based graphical programming environment for modeling, simulating and analyzing multidomain dynamical systems.
SSF:	Swedish Foundation for Strategic Resarch
UPAB:	Uppsala Parkerings AB
UU:	Uppsala University
V2G:	Vehicle to grid
VCE:	Volvo Construction Equipment


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