STAGE IV

SWEDISH ELECTROMOBILITY CENTRE

ANNUAL REPORT 2020

Swedish Electromobility Centre

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Swedish Electromobility Centre, 2021 03 31

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THIS YEAR WITH THE SWEDISH ELECTROMOBILITY CENTRE

2020 - what a year, so different it became. We started at full speed and then the corona pandemic struck in early March. We met the challenge, grew and became masters of online technology. Thank you all for your efforts!

At the start of the year the fourth stage was up and running with the first call for projects that attracted a record number of applications. The Centre had grown to almost the double in size.

We had identified the need to further expand our work on a system perspective. During the fall of 2019 the work had continued with the system perspective, after the kick-off, with a cross-thematic workshop that resulted in several project applications in our call. However, we want to go even further. A program-wide feasibility study on Electromobility scenarios was launched and during the year a larger group worked to identify driving forces, trends and rough scenarios to start working from.

The corona pandemic struck in March. As with all major historical challenges, we had to face the challenge and grow, and learn new habits and ways to meet for continued progress and successful work. We had to go online and use the tools available to continue activities and meetings. To fully master the online tools available became a new goal in order continue our important research and network.

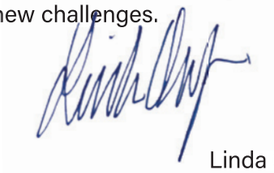
We used the situation to become masters of online work; workshops and conferences were successfully managed online with the number of participants almost touching one thousand. In the Scenario project break-out rooms and various digital tools were explored to get as close as possible to a real interactive workshop. We also launched the SEC lectures in response to the need for building of competence within electromobility – we would not let the pandemic slow us down or let us lose momentum. SEC Lectures had 979 registered participants and taught us the need for code of conduct in order to take interactive online events to the full-scale.

During the year we closed two calls for projects and launched a third call. The result during 2020 was 27 new projects. To say corona did not affect the projects is not true, many recruitments were delayed and hence starts of projects delayed as well and we were forced to postpone the deadline of the second call, delaying also these new coming projects.

Our conference E-mobility Days became Emobility Day online with close to 200 persons registered. Very interesting topics were discussed and a social program involving an E-mobility quiz and the presentation of the updated website for the center was also enjoyed.

In the end of the year the government launched the Electrification Commission, where SEC is represented through the Director, and the Electrification strategy. It shows how important our work is and how important it is to find solutions through collaboration. A road map for the full-scale electrification would be a very important delivery form these initiatives. At SEC we are ready to contribute!

Looking forward to 2021, the light in the tunnel and new challenges.



Linda Olofsson,
Director, Swedish Electromobility Centre

SEC COVERING THE FULL RANGE OF ELECTROMOBILITY

SEC gathers Sweden's leading organisations in electric transportation. Our deep knowledge of components and technology as well as understanding of the system perspective is applied in all applications for electromobility; we have expanded from road to also include off-road, air and water. Together we constitute the main Swedish platform for collaboration within electromobility.

The centre has seen a tremendous expansion over the last couple of years. 2020 was no exception. In December 2019 University West, Bombardier and SAAB became partners and developed the collaboration in the beginning of 2020, adding both rail and air to the centre's competence areas. In fall 2020 the Swedish Environmental Institute, IVL, and EON joined in and deepened the centre's knowledge within a variety of areas within sustainable mobility and the electric grid. It is the combination of width and depth of knowledge in our partner organisations that gives the centre its strength and provides a foundation for the development of Swedish electrification of transportation.

PARTNERS

PowerCell
Bombardier
University West
Chalmers
e.on
Swedish Energy Agency
Epiroc
Scania
Volvo
CEVT
Linköping University
vti
ABB
SAAB
KTH Vetenskap och Konst
Lund University
Titanx
Volvo
ivl Swedish Environmental Research Institute
Uppsala Universitet
BorgWarner
Vattenfall

OUR VISION

The Swedish Electromobility Centre's ambition is to lead the development towards society's future transportation systems, which will be electrified and fossil-free.

It is today not a bold statement to say that the world is moving towards a large-scale electrification of both society and industry. The question is if we are doing it fast enough and if we are doing it the most efficient and sustainable way.

Our vision is to become a world-class research centre, carrying out research and development in electric propulsion and energy supply for road and industrial hybrid and electrical vehicles, as well as aircraft and maritime vessels.

By gathering leading e-mobility actors that are all operating for electrification, to collaborate and exchange knowledge, together we increase the speed towards the fossil-free society.

Funded by the Swedish Energy Agency, we also have the governmental support to push for transport electrification and putting Swedish research, innovation and implementation of e-mobility in a world-leading position, contributing to sustainable mobility in the transportation business all over the world.

OUR MISSION

We gather leading academia and industry within e-mobility and, together with society's authorities, pave the way to the future of electric transportation. Our mission is to set and deploy the roadmap to this future and by funding research, collaboration and networking we support and partner with Swedish manufacturers of electrical vehicles to support and promote a sustainable development of the transport system.

We generate knowledge within the field of electromobility that builds the foundation for a sustainable society, where it is possible to stay mobile and at the same time make environmentally conscious choices. By investing in high quality research today, we gain the knowledge needed to enable a systematic change for the good of society tomorrow.

SEC's general task is to conduct research, development and training in electric vehicles, the vehicle as a whole and its charging infrastructure, as well as linking and finding synergies between the research efforts at each university. The roadmaps of the different thematic areas and the work that is done within the themes is the backbone of the centre and is used for generating a system perspective and scenario building.

We have set our course, because we truly believe that working together and doing it right from the start provide for the best conditions to achieve success. Together we create a sustainable transportation system. Together we create the electromobility of the future.

SEC´S TASK TOWARDS INDUSTRY IS TO:

- Be the hub in Sweden for applied research in electrification of road transport and work vehicles.
- Contribute to coordination gains across academia and industry, but also across SEC and with other centre formation in adjacent areas.
- Be a competent support for carrying out the research needed for industry's future products.
- Contribute to increased quality and relevance of the research by providing the industry with real issues, experience, data, test objects, test rigs and measuring equipment.
- Be a recruitment base at the licentiate/doctoral level, and at senior research level.
- Promote mobility between industrial and academic researchers.
- Create an inspiring research environment for the benefit of academia and industry.
- Be the catalyst that accelerates the electrification of vehicles.

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.

SEC CONTRIBUTES TO THE DEVELOPMENT OF A SUSTAINABLE SOCIETY

SEC is aware that rather than choosing to focus to on just some of the goals, it is important to look at how all the activities carried out by SEC is affecting each one of the goals.

For example, SEC is aware that batteries use minerals that at least in the past have affected both humans and the environment in a bad way. Therefore, SEC has also funded projects that have looked at these issues in order to minimize these bad side effects, which will help reduce both inequalities, maintain good health among people and make sure the water is kept clean.

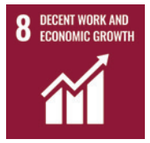
At the same time as the centre is active in reducing the negative effect some activities might have on the goals and try to do something about that, the whole centre rests on the idea of contributing to a more sustainable world through developing knowledge and technology.

SEC's main contribution in achieving some of the goals are connected to five goals.

NO.7 - AFFORDABLE AND CLEAN ENERGY

Electromobility is a sustainable way of transportation given that the energy comes from renewable sources. SEC contributes by speeding up the transition to sustainable transportation and in making electromobility available to everyone. Theme 5 how the vehicle and the grid collaborate is essential here.

NO. 8 - DECENT WORK AND ECONOMIC GROWTH



SEC funds projects that study the material in the batteries with the aim of sustainability, including working conditions. SEC also contributes to the goal by engaging companies and providing business opportunities also strengthen economic growth.

NO. 9 - INDUSTRY, INNOVATION AND INFRASTRUCTURE

Infrastructure is something SEC is working a lot with. For instance, the centre studies electric transition and electric roads. Innovation lies at the core of the centre and is connected to all research and all the projects involving industry.

NO. 11 - SUSTAINABLE CITIES AND COMMUNITIES

By being an active driver for the transition to fossil-free mobility, one of the main products of SEC is the reduction of fossil-based engines. SEC-funded projects also study how people relate to emobility and how communities and emobility correlate. Through electrification we have a much better opportunity to become fossil-free.

NO. 13 - CLIMATE ACTION

We have to reduce the carbon dioxide emissions. By developing highly efficient electric vehicles SEC contributes to that target by diminishing the reasons for using fossil fuel in the transportation sector.

SEC has the ambition to have a positive effect on as many of the 17 goals as possible.

Although it is hard to reach total gender equality at our SEC-activities, we are especially encouraging women to become active within SEC and in the process of granting funding, SEC looks at the number of women involved in the project and has set a goal for this.

International collaborations as well as working with people from different cultures are very important factors in order to maintain peace and to prevent future conflicts. SEC is not just encouraging international cooperation, but also have PhD students from all over the world working in the projects.

A SCENARIOS PILOT-STUDY ABOUT ELECTRIFICATION OF TRANSPORTATION

During the year, Chalmers Docent Anders Grauers has been leading the work of a SEC financed pilot-study which asks the question: "What does electrified road transport look like, in Sweden 2030, and how extensive is it?" with the aim to begin a large scenario project in 2021.

"There is a great deal of uncertainty about what the electrified road transport system will look like in the future. For a long time, focus has been on getting the technology ready. We have now reached far enough to say that technology isn't the issue anymore. When we outline scenarios for the future transport system, it is obvious that there are other main challenges ahead. For example, there are many decisions to be made regarding charging infrastructure and vehicle manufacturing. Since there are so many stakeholders no one can really make decisions about the whole electromobility system by themselves.

HANDLE THE UNCERTAIN

There is also an uncertainty about which is the right way forward and this is the reason why we work with scenarios. We want to understand what mechanisms will affect future development. The scenarios are tools to handle uncertainties, so that despite the uncertainties, reasonable decisions can be made. Once the project is over, there will be insights that will point out if, for example, there is a system solution that needs to be developed or if there is a need for new technology.

Companies, universities and authorities will be able to test their strategies and see if they work in all scenarios. Some will realize that they may have developed the wrong product or must change business model, others will get their strategies confirmed and get indicators of when a scenario is starting to become reality. Companies will be able to see that there are investors willing to invest in their type of product and power companies will get confirmation whether electric vehicles will have a huge breakthrough very soon or not, giving them heads up that it might be time to start investing in the charging infrastructure.

CLEAR ANSWERS

Some of the uncertainty we have about what will happen in the future is genuine uncertainty, but much is due to the fact that we have not investigated it systematically and well enough. Scenario analysis often show that many questions that appear to be difficult in fact may have clear answers once you dig into it. We can of course not be 100 percent certain, but with the project results we can at least be three to four times more certain than before.

The goal for the feasibility study has been to test a methodology and doing it with a wide participation. There have been many stakeholders and experts and we have started working with the issues. Many steps in the feasibility study have been made in high-speed only giving us an overall picture of where the focus should lie when rigging a large scenario project, rather than giving complete scenarios.

SCENARIOS

We have prepared and looked into four scenarios. One is when electric vehicles have become more cost beneficial than combustion engine vehicles. When that happens, the market will create the breakthrough automatically. But before we reach that point, we imagine three scenarios.

THREE SCENARIOS

One where the transition is policy-driven, which to some extent is already happening, one where there is a customer demand for electric vehicles, regardless the price, and one where there is neither policies for change nor customers demanding the vehicles. It is important to have all these scenarios in mind when creating a strategy. Both economy and technology seem to speak for a breakthrough for electric vehicles. However, we need to find if there are hidden obstacles, which is why it so important to involve many different perspectives in the coming large scenario project.

Digging deeper in these scenarios we want to know both what the system looks like but also how fast the transition goes.

SEC SHAPES THE FUTURE

Since SEC has large mobility actors active in the center, it is not only relevant to make an analysis of what we think will happen. We also can discuss what we want to happen, because our members actually have a great opportunity to be involved and influence the future.

SEC's five thematic areas all represent important parts needed in order to produce scenarios, but that is not enough. The SEC focuses on some of the problems, but when we get into a large scenario project, it will not be a pure SEC project. SEC can already answer what is possible to do from a technology perspective. Now we also want to answer what would be good overall system solutions", says Anders Grauers.

CONTRIBUTION TO SEC´S OBJECTIVES AND KPIs

SEC has been operating in its Stage IV throughout 2020. Six objectives, with the purpose to measure how well SEC's projects contribute to the centre's overall objectives, are used. To monitor performance, a number of KPIs (key performance indicators) are used. 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% 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 have the opportunity to participate in SEC's planned PhD courses.

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.

OBJECTIVES 4
Dissemination of knowledge and research findings

The thematic areas must convene thematic group meetings three times a year, and SEC must arrange an activity that involves all thematic areas every year.

OBJECTIVES 5
Collaboration

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

OBJECTIVES 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.

TOWARDS FULLFILLMENT OF SEC KPIS

During 2020 SEC has laid the foundation for the stage IV by granting some 30 new projects. The project portfolio, including for example 16 new PhD projects, is well composed for SEC to deliver the expected KPIs by the end of stage IV, see projects in Appendix A. Unfortunately, the project starts have been affected by the corona pandemic and some projects have not be able to start in the end of the year or early 2021. Nevertheless, we expect the projects to deliver results before the end of 2023.

Already, though very early in stage IV, we have delivered during 2020:

27 journal and conference papers

14 Master thesis

3 PhD and licenciate

12 Thematic workshops

6 International collaborations

1 center conference (E-mobility Day)

Altogether for stage IV (including half 2019):

1 patent application

47 journal and conference papers

17 Master thesis

8 PhD and licenciate

15 Thematic workshops

11 International collaborations

2 center conferences (E-mobility Day 2020 and Stage IV kick-off 2019)

WORKSHOPS

	Events	Participants
MARCH	2	12
APRIL	5	517
MAY	7	1518
JUNE	7	439
SEPTEMBER	3	30
OCTOBER	6	97
NOVEMBER	2	22
DECEMBER	8	188

Overview of events in 2020. 12 events did not have a list of participants.

See Appendix C - Events for details.

INTERNATIONAL COLLABORATIONS

SEC is the national Swedish research centre, but international collaboration is important for the centre. During 2020 seven projects have been done in international collaboration.

A few of the projects that were on-going during stage III have continued into stage IV. These projects are listed below.

THEME 3

Thermal modelling and fault prognosis for Li-ion battery systems

Project leader: Changfu Zou

Through a Vinnova-funded research project (led by Prof Torsten Wik), we collaborate with Beijing Institute of Technology and Geely Automobile in China.

THEME 4

Charging behaviour and infrastructure need for plug-in electric vehicles

Project leader: Frances Sprei

Fraunhofer ISI, UC Davis, International EV Policy Council

THEME 4

Life Cycle Assessment of Large-Scale Lithium-Ion Battery Production and Recycling

Project leader: Anders Nordelöf

The project incorporates an international research collaboration with Dr. Linda Ellingsen (previously at the Norwegian University of Science and Technology). She is a leading researcher in the specific LCA of LIB research field.

THEME 2

Online health diagnostics of inverters for commercial vehicle drive systems

Project leader: Staffan Norrga

A collaboration with the University of Bremen in Germany in the files of power semiconductor reliability is currently under discussion. We are also part of the European centre for power electronics, ECPE.

THEME 5

Cost-benefit Optimized ChArging INfrastructurE

Project leader: Gyözö Gidofalavi

The 15 years of research into movement knowledge discovery, management, and utilization are being commercialized via the DeepTech startup Gordian.

Gordian currently participates in the TUM Global DeepTech Venture Accelerator program lead by unternehmerTUM with the aim to enter the German market, engage the stakeholders, and develop MVPs for multi-actor multi-criteria transport-energy planning tools.

Gordian has also applied and has been selected as one of the top 12 from 300 startups to pitch for joining batch #2 of the EIT Urban Mobility Accelerator program (decision pending), where one potential use case involves charging infrastructure planning in the urban context.

THEME 1

Modeling, System Analysis, and Control of Hybrid Electric Vehicles with Aftertreatment Systems

Project leader: Lars Eriksson

Collaborations with IFPEN in France and with TNO Automotive in The Netherlands.

Power Conversion Challenges with an All-Electric Land, stage III

Project leader: Francisco Márquez Fernández

The project led to a collaboration with the Technical University in Berlin, which resulted in the project IDEAS.

Additionally, a collaboration was established with Honda Motor Company in Japan. Honda has developed their own ERS and are very interested in the work done within this project regarding electric safety. While this collaboration has not yet materialised in a new project, there is an open communication channel with Honda, which hopefully will lead to further cooperation

GENDER EQUALITY

SEC is operating in a male dominated area. The ambition is to have a gender balance of 40/60, which is a very high ambition that we are working hard on both in terms of representation and of funding.

Project Leader	Female	Male	Funding Females/ Males
Changfu Zou	1	3	0/100
David Sedarsky	0	4	0/100
Anders Grauers	1	2	23/77
Frances Sprei	1	1	0/100
Rakel Wreland Lindström	2	5	0/100
Joachim Lindström	0	8	0/100
Henrik Johansson	0	1	0/100
Torbjörn Thiringer	5	4	95/5
Anders Nordelöf	0	3	0/100
Staffan Norrga	0	1	0/100
Gyözö Gidofalvi	1	2	50/50
Sonja Lundmark	5	6	93.3/6.7
Erik Berg	0	1	0/100
Torbjörn Thiringer	0	3	0/100
Öivind Andersson	0	6	0/100
Lars Eriksson	0	3	0/100
Maria Taljegård	1	2	50/50
Mats Alaküla	0	1	0/100
Francisco Marquez	0	1	0/100
Sebastien Gros	0	4	0/100
	= 17	= 61	

SEC CHAIRMAN NILS-GUNNAR VÅGSTEDT

> It has been a year full of challenges for the centre, as for the rest of the world. 2020 was the year of adapting to the Corona-pandemic and at the same time managing to accomplish our goals. We have participants that partly have had their production shut off throughout the year and the large vehicle companies have had staff laid off up to 80 percent during long periods of time. It has been tough. Still, we are in the middle of the centre's fourth stage in which we aim at increasing the revenue with 100 percent and we are definitely making this goal.

With the pandemic in mind you may also argue that it is a proof of strength that we have been able to keep up with all the work that we have done. We became much better than we were before the pandemic using digital tools. E-mobility days, in September, might be the best example of that, where we stayed online for a full day and had many researchers presenting their work to much more participants than normally come to a physical E-mobility Days event. Before that, during spring, we started the SEC lectures with approximately 979 participants in total. Before the digitalization we would not have been able to gather that many people and given them the lectures we now gave them, so in a way we actually contributed to sustainable electrified transports more than in earlier years.

Considering the situation, we really have been lucky. SEC is a Swedish virtual centre with partners in academia and industry. Our chances to collaborate become better the more digital we get. We are only starting, but just the acceptance of collaborating using online tools is something we bring with us from this period. The climate footprint we make is also smaller when we reduce our traveling.

We are more and more becoming an entity for referrals, which I find very positive. One good example of that is the Swedish government's Electrification commission where our Director, Linda Olofsson, participate and have the possibility to contribute with knowledge from all partners into the commission. It is a strong evidence showing that our competence is asked for.

The trend analysis and intelligence that Magnus Karlström and colleagues contribute with in the omEV newsletter is still highly appreciated. They are widening the perspective and covers not only electric vehicles but also everything that influence the electrification of transport.

The most important delivery from the centre, from the industry's perspective, is competence. Every part of electromobility will be super expansive the coming ten years, so being a PhD student within SEC offers an amazing pallet of possible connections. All partners need competent people. Just find out what you are interested in!", says Nils-Gunnar Vågstedt.

SEC IN SWEDEN'S ELECTRIFICATION COMMISSION

Linda Olofsson, director of SEC, has been appointed to participate in the Swedish government's commission for electrification.

"The goal is completely in line with what we at the SEC work with and it is a great opportunity for us to contribute to the energy transition", says Linda Olofsson.

The commission's purpose is to accelerate the electrification of the transport sector. The commission will contribute to the government as a counseling body to ensure exchange between the government and industry, reseach, and society.

"The commission will be an engine for the wanted electrification, because this is something the government can't do alone", says Tomas Eneroth, Minister for Infrastructure in a press event where he presented the commission and its work.

"I look forward to this assignment. The work of increasing the pace of electrification is very important and much needed. Collaboration is the way forward to enable large-scale electrification and sustainable transport", says Linda Olofsson.

The commission's mission will be to investigate the need and possibilities for electrification through hydrogen, urgently develop an activity plan for electrification of the roads with the heaviest traffic, map how the electrification of the shipping industry and flight can be accelerated and investigate the needs and possibilities for finance.

The commission will also have a special focus on heavy transportation in a near future.

OUR THEMATIC AREAS

The Swedish Electromobility Centre brings together the Swedish automotive industry and technical universities with a range of different research disciplines. All are connected through their relevance for electric and hybrid vehicle technology. SEC promotes both deep, narrow technical studies as well as cross-discipline and cross-institution research.

Our thematic leaders of the Swedish Electromobility Centre during 2020,

THEME 1
SYSTEM STUDIES AND METHODS

System studies and methods develops methods and algorithms for model-based systems engineering, which are adopted and utilized in electrified vehicles. The core question for our thematic area is how to manage the vehicle's onboard energy in an optimal manner, so that it satisfies the customer's need. To address this requires knowledge of the customer, the vehicle, its subsystems and its surroundings. This is done by utilizing tools, like mathematical modelling, dynamic simulation, performance analysis, control design and optimization on vehicle system level or fleet level, i.e., design and control of system of systems. The focus for these methods and techniques is to reduce development time and effort, while striving for system optimality.

RESEARCH ADVANCEMENTS WITHIN 2020

SEC projects have revolved around understanding and characterization of the costumers, the vehicle, its subsystems and its surrounding in order to address the core question. During 2020 the theme researchers have addressed the topics of modelling and control of hybrid vehicles including exhaust gas aftertreatment systems for complete powertrain performance improvement. Other achievements have been on electric range optimization for battery electric vehicles and characterization of external factors, like wind and road resistance, as well as total cost of ownership estimation for the most viable vehicle configuration for specific driving missions. During 2020, our thematic area together with thematic area electrical machines, drive systems and charging, have arranged a seminar together with the company Vector to see the possibilities with communication between the vehicle and its surrounding.

As the year has been special, due to the corona pandemic, a lot of activities have also been held online, where researchers from the theme have been active to provide material for students and active engineers supporting life-long learning. The main topics cover the area of model-based systems engineering and electromobility and are published through online channels.

NATIONAL AND INTERNATIONAL ATTENTION

Project members have attended different conferences spreading information and presenting interesting research results. Among these conferences are the IFAC World Congress, Germany, SAE WCX™, US, and IEEE Intelligent Transportation System Conference, Greece, and also published results in several international journals. The theme leader Lars Eriksson was awarded Control Engineering Practice's Paper Price at the conference IFAC World Congress in Berlin.

CHALLENGES AND POSSIBILITIES

"Zero emissions" is the challenge most vehicle manufacturers are addressing. And as electrification is a possibility to achieve "zero-emissions", onboard complete vehicle energy management is the main challenge in the area. It is not limited to just energy used for propulsion of the vehicle it also includes energy use in vehicle subsystems, like cooling of batteries or electric machines, and driver and passenger comfort, like HVAC systems. This means that methods and tools needed to address the main challenge cannot be by studying the individual sub-systems in the vehicle, but needs to address the system as a whole, i.e., system of systems. A central part of the research utilizes dynamic models, computational methods and simulation techniques to study system properties and optimize the vehicle designs in system and mission settings, so we get energy efficient electromobility solutions.

Connected vehicles, where information about the vehicle and the outside world, provide system knowledge of how the vehicle is used, where it will go and how the traffic situation is ahead of the vehicle gives new opportunities, and a lot of functions that are using this knowledge are being developed right now. Vehicle manufacturers have already information sharing systems in the vehicles on the market. This gives an excellent platform for developing new system functionality, such as route management planning, range estimation, traffic flow control etc. This area is sometimes called Vehicle-to-X (V2X) and is an enabling technology on which our thematic area is building functionality.

BUSINESS INTELLIGENCE

Electrification, automation and digitalization 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 optimization, deep learning from data, dynamic 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 thematic area relies on.

Projects	Fuel Cells in Vehicle Systems	Modeling, System Analysis, and Control of...	*Road resistance estimation for improved...	*Diagnostics and supervision of dynamically...
Manager	Öivind Andersson	Lars Eriksson	Mikael Askerdal	Mattias Krysander
University Partner	LTH	LiU	Chalmers	LiU
SEC Industry Partner	ABB, CEVT, Scania, Volvo AB	Scania, Volvo AB	CEVT, Volvo AB, Volvo Cars	Scania

SEC Projects started or continued during 2020. Projects marked with an * have been inactive during the year.

THEME 2
ELECTRICAL MACHINES, DRIVE SYSTEMS AND CHARGING

Electrical machines, Drives, and Charging covers the technologies related to electric energy transfer and conversion that arise from the electrification of transport. This includes the propulsion system, charging equipment and auxiliary systems on board the vehicles.

The research activities conducted in the theme span over a broad area, including theoretical and numerical modelling and simulation of individual components (through analytical equations, Finite Element Analysis, Computational Fluid Dynamics, etc.), integration of the component models into a complete drive unit dynamic model (through Matlab/Simulink or similar software platforms), development and laboratory testing of prototypes for validation purposes, and real-life conditions testing when relevant.

RESEARCH ADVANCEMENTS WITHIN 2020

2020 has been a successful year for Theme Electrical Machines and Drives in terms of new projects. In the first project call by SEC in January we were granted 37 percent of all funding, comprising four PhD projects, three of them related to electrical machines (design for recyclability, axial flux topologies, and rear-earth free machines) and one on reliability of silicon carbide devices. We also conducted three pre-studies very successfully: a pre-study focusing on manufacturing effects in electrical machines, which has resulted in a large project with 2 PhDs (one in Chalmers and one in Lund) funded by Energimyndigheten, a pre-study in Fuel Cell systems (cross thematic with themes 1 and 3), that is currently also developing into a larger project, and last, a pre-study on integration of EV charging in an all-dc micro grid (cross-thematic with theme 5).

In the second call we received 38 percent of the available funding, corresponding to two PhD projects, one focusing on open-source design tools for electrical machines, and one aiming to define the requirements of future charging infrastructure by combining transport and power system simulations (cross-thematic with theme 5). Additionally, we were also granted a senior research project focusing on measuring and testing battery cells (cross-disciplinary with theme 3), and our first theme researcher project, focusing on NVH aspects of electrical machines, which will start in the beginning of the next year.

NATIONAL AND INTERNATIONAL ATTENTION

2020 has been a challenging year due to the limited opportunities for social gathering and interaction. However, for the same reasons, we have actively participated in several online events in order to cover for the lack of social spaces.

Our lecture on "Electrical Machines, Drives and Charging" on May 8th, as part of the series "Introduction to Electromobility", was attended by over 700 people. We also participated on the Electromobility Day, with a presentation on requirement-driven design of PMSM drives and different advanced eMachine cooling techniques.

During August 23rd-26th, the International Conference on Electrical Machines (ICEM'20) was held with Professor Yujing Liu from Chalmers taking the role as General Co-Chair. Due to the Corona situation, the conference activities were executed on-line. Most of the research groups being members involved in SEC-Theme 2 presented research results and, in summary, 23 research papers from Sweden were presented.

Unfortunately, the International Conference on Electric Road Systems (May 2020, Lund) was turned into a single day webinar with just a few selected presentation and discussion panels, so we did not get the visibility we could have gotten otherwise. However, the conference is intended to be in Lund again in 2021, giving a new opportunity to present our research.

Projects	A Pre-Study for Manufacturing Effects in...	* NVH Analysis and Mitigation in Electrical...	Testing, Analysis and Design of Axial Flux Motors	Online health diagnostics of inverters for...
Manager	Joachim Lindström	Francisco Marquez	Sonja Lundmark	Staffan Norrga
University Partner	Chalmers	LTH	Chalmers	KTH
SEC Industry Partner	BorgWarner, Vattenfall	ABB, CEVT, Volvo AB, Volvo Cars	ABB, Volvo AB, Volvo Cars	Scania

Projects	*Design of rare earth element free motors...	E-machine design for enhanced...	*Open-source framework for Electrical...
Manager	Sandra Eriksson	Torbjörn Thiringer	David Sedarsky
University Partner	UU	Chalmers	Chalmers
SEC Industry Partner	Scania	ABB, CEVT	Volvo Cars

SEC Projects started or continued during 2020. Projects marked with an * have been inactive during the year.

CHALLENGES AND POSSIBILITIES

The corona virus has significantly affected society during this year, and the research community has not been foreign to this. Among the most impacting effects are the temporary lay-offs that have affected most of our industrial partners, making it difficult or even preventing industrial collaboration. This posed a challenge when formulating new projects due to the requirement for co-financing. Moreover, the pandemic has also decreased the personal mobility which, at universities, can be seen in the reduction in international students. In the near future, this can also render recruitment processes for SEC projects.

On the bright side, social distancing restrictions have made us improve our digital skills. Thematic meetings, workshops and lectures had to be moved to digital platforms, and this made it possible for more people to participate in these activities.

BUSINESS INTELLIGENCE

Transport electrification is a relevant topic, evolving at a very fast pace in the last years. Among the most significant trends in our area are:

- Several vehicle manufacturers have started investing in in-house production of electric machinery and other electric drive components.
- Si-based power electronic devices are being replaced with counterparts based on SiC- or GaN-based semiconductors.
- The power electronic inverter and the corresponding electric machine become ever more integrated, in order to reduce both size and costs.
- The widespread of the internet and the development of artificial intelligence, together with increased communication speed and miniaturization of sensors and electronics have promoted cloud-based mass data logging. Several vehicle manufacturers currently log immense amounts of data from their fleets, which could later be used for improving design, modelling, control, diagnostics, etc.
- Aircraft electrification requires even higher power densities for electric drives than those already achieved for road vehicles. This may be achieved through a combination of motor and inverter integration, new machine topologies enabled by novel manufacturing techniques (such as additive manufacturing) and advanced cooling solutions.

THEME 3
ENERGY STORAGE

The primary function of theme Energy storage is to deepen the understanding of energy storage units, electrochemical cells, materials, and performance limiting processes, to exploit this knowledge for better performing electric vehicles. The focus lies on optimizing key factors behind ageing and health of the energy storage devices, focusing both on present and next-generation lithium-ion battery technologies and on fuel cell systems. The objective is to maximize the driving range, facilitate fast and flexible charging, improve storage diagnostics and minimize cost, safety hazards and environmental impact.

RESEARCH ADVANCEMENT WITHIN 2020

The SEC projects running and initiated during 2020 have revolved around the thematic focus areas testing procedures and protocols, electrochemical modelling, system safety and diagnostics, and fuel cells. Two PhD student projects have started within the area: one focused on fuel cell performance prediction, and one on gas evolution as a means to follow side-reactions and ageing of Li-ion battery cells. Research projects have comprised fuel cell in vehicle systems and thermal modelling and fault prognosis in Li-ion batteries, while research work on quenchers for battery fires and bridging the gap between lab scale cells and commercial cells are starting up.

Theme 3 has also organized a number of events during 2020, to highlight research within the area and stimulate research interactions. A battery modelling workshop was held with Comsol in March, while a workshop on solid-state batteries co-organized with Batteries Sweden was held in December. Theme 3 also organized seminar series during the pandemic and contributed to the seminar activities of SEC.

NATIONAL AND INTERNATIONAL ATTENTION

Building on the vast media attention generated by the Nobel prize in Chemistry late 2019, awarded to key discoveries leading to the Li-ion battery, the energy storage area has continued to be in the focal point

during 2020. The launch of the European mission Battery2030+ and the national center Batteries Sweden also sparked plenty of interest, with thematic leaders and profiled researchers associated with SEC appearing both nationally (SVT, SR, DN, SvD, Ny Teknik, etc.) and internationally in media. The emerging cell production of Li-ion batteries in Sweden and in Europe has also been highlighted, thereby creating a growing interest among the general public for batteries. It is clear that EVs are driving this development, which has made SEC a natural platform to turn to. The growing interest in fuel cells and hydrogen has also received significant media coverage, involving researchers associated with SEC. That Swedish researchers have been at the forefront of the battery area both in terms of scientific efforts and in coordinating research and development activities, both in academia and industry, have generated a strong position and plenty of exposure. Kristina Edström at Uppsala University, which has a long-term background within SEC, was awarded IVA's gold medal in 2020.

CHALLENGES AND POSSIBILITIES

Batteries and fuel cells today have reached different levels of maturity for implementation in the energy systems, which makes the challenges somewhat different. It should be acknowledged that these techniques are largely complimentary, and there is a strong future need for more implementation of both. For batteries, the volumetric expansion of production pose challenges on cost, safety, raw materials, charging infrastructure and recyclability, together with a strong demand for better battery performance. There are clear possibilities to meet these challenges, for example by improved methods for recycling, employment of improved materials and use of less critical raw materials (e.g., cobalt), and possible mining in areas closer to battery production sites. For fuel cells, hydrogen infrastructure and costs are even more critical to address, but the employment of hydrogen-based techniques in other sectors than electromobility will likely contribute beneficial in this development.

Furthermore, the corona pandemic has surely constituted a specific challenge for activities within SEC during 2020, but have been met through online and hybrid events.

BUSINESS INTELLIGENCE

Both battery and fuel cell research – fundamental and applied – are growing exponentially since several years back. Battery research is entering a consolidation phase and reorganization on the international level, truly pushing the production limits. Novel battery cell chemistries are being considered in both near (Si/C composite anodes, Ni-rich cathodes) and intermediate (solid-state) future. Fuel cells, on the other hand, have passed critical levels in terms of implementation in vehicles and can foresee a rapid expansion when a larger number of manufacturers provide serial production. Generally, the electrification increases the demand for energy storage, both in the transport sector and elsewhere, which opens up for several kinds of electrochemical systems: different batteries, different fuel cells, and also alternative and complementary technologies.

Projects	*Measurements and modelling of thermal and...	Fuel Cell Performance Prediction	Real-time observation of side-reactions...	Thermal modelling and fault prognosis for...	*Chemical quenchers for inhibition of...
Manager	Torbjörn Thiringer	Rakel Wreland	Erik Berg	Changfu Zou	Elna Heimdal
University Partner	Chalmers	KTH	UU	Chalmers	LTH
SEC Industry Partner	CEVT, Powercell, Scania, Volvo AB, Volvo Cars	ABB, Powercell, Volvo AB	ABB, Volvo AB, Volvo Cars	Scania, Volvo AB	Volvo Cars

SEC Projects started or continued during 2020. Projects marked with an * have been inactive during the year.

THEME 4
ELECTROMOBILITY IN SOCIETY

Electromobility in Society investigates electromobility from a societal and environmental perspective and focus on understanding the socio-technical systems and how they interact. The aim of all activities is to identify requirements on vehicles, infrastructure and societal processes, and to guide development and policy work towards sustainable electromobility. Understand user adoption and transport services is a strategic area that studies the interplay between technology and the different actors in the transportation system. This includes the mechanisms that govern how they interact and influence the development of electromobility. The second area is Measures for resource availability and

circular economy that investigates vehicle and societal system design strategies for securing important raw materials by promoting circular material flows. The third area is focused on developing tools and models for the Assessment of environmental impact and resource use of the technology.

RESEARCH ADVANCEMENTS WITHIN 2020

Eleven projects, associated to or funded by the center, have been running during this year. Theme 4 is the main thematic area for two SEC funded PhD projects. One project assesses lithium-ion battery production and its role in the overall life cycle of lithium-ion batteries, and the other explores plug-in hybrid electric car adoption and real household consumer behavior in terms of drive patterns and preferences for the charging infrastructure. Three PhD projects are coordinated within other themes of the centre (theme areas 2, 3 and 5), but also linked to theme 4. Two projects are associated, focusing on sustainable vehicle use and the innovation system for electric distribution trucks.

Although struggling with consequences from the corona pandemic, two theme researcher projects have been formulated and accepted and will start in 2021. One focusing on electrification of freight transport system from an actor's perspective and the other on environmental assessment of electromobility charging systems.

Other activities have been on-line lectures, SEC lecture series, seminars and workshops, including master thesis presentation Life cycle assessment of a PEM fuel cell stack operating in a panel van, seminars on Critical and scarce metals for electromobility? and Circular Business Models for Extended EV Battery Life and a presentation at a joint seminar with SEC and f3 (Swedish knowledge centre for renewable fuels) How does electrification and renewable fuels contribute to climate neutrality for the transport sector?

The thematic group has had reoccurring meetings during 2020 to discuss e.g. updates of the road map, the content of the theme researchers' projects and preparations for the new application for SEC to be submitted in the spring of 2021. Two meetings focused solely on knowledge sharing.

NATIONAL AND INTERNATIONAL ATTENTION

The Swedish weekly journal Ny Teknik wrote about one of the theme's ongoing PhD projects in January 2020, bringing forward that the climate mitigation potential of plug-in hybrid cars is dependent a sufficient all-electric range. In addition, Frances Sprei, the project leader of the PhD project, was interviewed about her research twice on Swedish national radio during 2020: on the need to change tax policies for vehicles due to electrification in January; and on the climate impacts of newly sold vehicles in the EU, in July.

Theme leader Anders Nordelöf's LCA research of vehicle electrification received international recognition by being frequently cited and used as an important data source by the DG Climate Action study, conducted by Ricardo Energy & Environment on behalf of the European Commission. This was brought to attention in Sweden in September by an article in Ny Teknik.

CHALLENGES AND POSSIBILITIES

The technology for the electrification of the transport sector has evolved rapidly the past few years. While the technology in fact has existed for decades, its widespread application and adoption in the society as a viable alternative in the transport sector is occurring only now. Consequently, industry and academia now regard electromobility as a vital enabler of future sustainable transportation rather than with caution. Even though there are already several cars and trucks available on the market, the technology is continually evolving in fast phase and the different technology innovations affects how e.g., charging infrastructure and the need for electricity supply and storage can be designed. There is an increasing trust that electrification of the transport sector is the way forward for the society to tackle a large-scale transition from the use of liquid fossil fuels and to achieve significant climate change mitigation. This shift to electrification is also motivated at a local level from issues concerning public health and air quality, and at a national level from considerations such as energy security and energy independence. But there are challenges in terms of how the societal acceptance and business models for transport companies will evolve and develop in line with infrastructure deployment. Even more crucial from a sustainability perspective is the challenge concerning resource extraction and resource availability, as well as a risk for societal rebound effects in the case of ill-considered implementation.

BUSINESS INTELLIGENCE

Electrification is taking off. We see a combination of legislation, subsidies and climate action from governments and an increasing ambition from industry to tackle the global warming. Sharing resources and new business models to comply to sustainability is emerging fast, such as circular economy. Mobility and Logistics as a service is growing, i.e. integration of rental cars, taxis or ride sharing with the existing public transport service, "crowd-shipping" of last mile deliveries and combining logistics platforms for higher utilisation. Technology driven development of connectivity and eventually autonomous vehicles will affect the possibilities to improve system efficiency.

Projects	Electromobility Scenarios	Towards electrification of freight...	*Environmental Assessment of Electromobility ...
Manager	Anders Grauers	Henrik Johansson	Anders Nordelöf
University Partner	LTH	LiU	Chalmers
SEC Industry Partner	-	Scania, TitanX	CEVT, Scania, Volvo AB, Volvo Cars

Projects	*Prerequisites for electrification of freight...	Charging behaviour and infrastructure, Stage IV	Life Cycle Assessment of Large-Scale Lithium...
Manager	Henrik Johanssons	Frances Sprei	Anders Nordelöf
University Partner	LiU	Chalmers	Chalmers
SEC Industry Partner	BorgWarner, CEVT, Scania, TitanX, Vattenfall, Volvo Cars	Volvo Cars	CEVT, Scania, Volvo AB, Volvo Cars

SEC Projects started or continued during 2020. Projects marked with an * have been inactive during the year.

THEME 5

INTERACTION BETWEEN VEHICLES AND GRID

With a significantly increased proportion of electric vehicles in society, the vehicle fleet will require an increased need for electric energy and power. This will have a significant impact on the operation of the electricity power system, in particular since an electrification of other sectors such as industry and the built environment is also expected. The main task of Theme 5 -interaction between vehicle and grid, is to conduct research in various areas that are related to this. The research within Theme 5 is divided into four strategic research areas; Charging at lower power levels; Charging at higher power levels; Charging infrastructure- a system perspective; and Need and use of energy storage in the power system.

During the year, the group has participated and arranged different activities. There have been two workshops/seminars. One of the workshops was arranged during the spring with the purpose to do a SWOT analysis about the theme and work on the roadmap. During the autumn, we organized a seminar about the parking house Dansmästaren. Apart from the common events, the thematic group meets approximately twice a month.

RESEARCH ADVANCEMENTS WITHIN 2020

During 2020, five projects were approved for funding from SEC, two research projects before summer and three PhD student projects after the summer. The projects are covering three of four strategic research areas defined for the theme (Charging at lower power levels, Charging at higher power levels and Charging infrastructure; a system perspective).

We are looking forward to seeing the first results from these projects during next year.

NATIONAL AND INTERNATIONAL ATTENTION

We have had initial discussion with Energiforsk on how we can collaborate and synchronize our activities within the field and in the future, if we can arrange common workshops.

CHALLENGES AND POSSIBILITIES

The activities within this field has increased drastically during the recent years and there is a lot of ongoing development/activities in different sectors at the same time. This makes it also challenging when doing research since so many factors/parameters 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. At the same time, other sectors such as the industry is also expected to increase the use of electricity. Thus, the power system needs to be upgraded and expanded to handle the increased electric energy need. The expansion will take time and some of the most important expansions will not be ready until 2030. Therefore, it will be important to look at charging solutions that the power system can handle in a short as well as medium time perspective and also to investigate if any additional infrastructure will be needed for the suggested charging.

The electrification of vehicles also brings a lot of opportunities. First, to have a more sustainable transportation, but also to 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 loads (in this case charging of EVs) that can be flexible, and we can plan when to turn it on and off, we can meet the power generation in a better way. Further on, if we can use the energy stored in the EVs batteries for supporting the grid and other systems, like Vehicle-2- Grid and, Vehicle-2-X, the EVs can be an even more important part for the energy transition.

BUSINESS INTELLIGENCE

As mentioned before, there is a lot going on within this theme and there is a lot of innovative solutions on how to meet a future power demand for EVs.

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, big cities face huge problems with the capacity of the electric grid. At the same time more and more distribution grid owners realize that they must create flexibility in the system in order to avoid huge investments in in the present grid. They also realize that the transport sector might not only be a burden on the grid but actually also an asset.

Projects	*Power systems integration of electric vehicles ...	Cost-benefit Optimized ChArging...	* Electric vehicle charging strategies and grid...	* High Power Charging when, where and how	* ACTUAL grid and road simulation for...
Manager	Massimo Bongiorno	Gyözö Gidofalvi	Maria Taljegård	Karin Thomas	Francisco Marquez
University Partner	Chalmers	KTH	Chalmers	UU	LTH
SEC Industry Partner	Volvo Cars	Vattenfall	CEVT	CEVT, Scania, Vattenfall, Volvo AB	CEVT, Scania, Vattenfall, Volvo Cars

SEC Projects started or continued during 2020. Projects marked with an * have been inactive during the year.

A PRE-STUDY FOR MANUFACTURING EFFECTS IN ELECTRICAL MACHINES

Joachim Lindström is a Volvo Cars representative in Theme 2, Electric Machines, Drive Systems and Charging. During 2020 he has been the project leader of a SEC funded feasibility study, which has led to a large FFI-funded project that started December 2020.

"In 2020, when SEC entered the financial phase 4, we had a workshop around project ideas for the coming phase. I had an idea about better correlating the characteristics of ferro magnetic material with the calculations we make when developing electric machines.

NEW NEED FOR BETTER CALCULATIONS

Up until now it hasn't been necessary really to have the exact calculations on magnetism in the material in a vehicle since we could rely on course empirical corrections, and most of the vehicles have had combustion engines, but in electric vehicles the magnetism of the engine components plays a much bigger part and now when the vehicle industry is investing massively in electrification and electrical propulsion, the need for better methods to describe ferro magnetic materials has grown.

SEC has been crucial to build a consortium and conduct this feasibility study. The centre provides a perfect forum for this type of discussion and it turned out I wasn't the only one thinking this was needed. Many of my theme colleagues had the same need and we decided that a feasibility study was what we would manage to apply for given the time limits that we had, studying a relatively unexplored field, and with multiple participants.

EXTERNAL FUNDING

We got SEK 200 000 from SEC for a feasibility study during 2020 and engaged Volvo Cars, Volvo Group, CEVT, BorgWarner, Surahammars bruk and senior researchers from Chalmers University of Technology and Lund University. The study has now led to a SEK 21,4 million project funded by FFI, the Swedish strategic vehicle research and innovation programme that started spring 2021.

What made this topic so suitable to make a feasibility study from is that it is so uncharted. It needed some oversight before we could start researching. If you know exactly where you want to go, perhaps a feasibility study isn't what you need, but if you need to probe an area and map a terrain, then a feasibility study is a very efficient tool. We have a lot of awareness regarding the phenomenon of changes in materials' magnetism in production, but the correlation with the scientific side is still underdeveloped, and the vehicle industry is really interested in getting more knowledge in this field.

SEC'S QUALITY STAMP

I think this is a very efficient way to work for SEC. The centre is a hub for Swedish researchers and helps the Swedish Energy Agency guarantee high quality in the projects they fund. We don't have all the resources that are needed to fund all Swedish electromobility research, so by delivering feasibility projects with the SEC quality stamp on we make external funders comfortable when choosing to fund our projects.

We now hope to improve the calculation methodology and that the results will lead to increased production efficiency. I can promise that if we gain good results in the coming project, the results will definitely be put to use. As a plus we get very needed new competence in the young people that will work in the project and hopefully will improve our organizations also after the project.

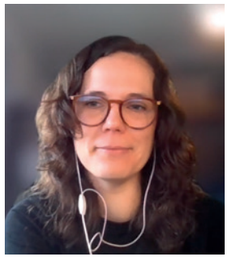
PROJECT SPOTLIGHT: POWERCELL DEEPENS THE SEC COLLABORATION IN NEW PROJECT

Even though fuel cells have reached a level of high efficiency, there are still components to optimize. In the SEC funded project "Fuel cell performance prediction" KTH and Powercell look to optimize hydrogen's journey through the stack.

Rakel Wreland Lindström, professor at the division of Applied Chemistry, KTH

"There is a lack of knowledge on how the stack design and usage affect the long-term performance and specifically transport of gases and humidity in a fuel cell stack. The GDL, the gas diffusion layer, that distributes the gas over the catalyst layer in the cell, is the focus in this project. A PhD student will combine experimental and modelling work both at KTH and at Powercell in Gothenburg. One critical issue is what characteristics the GDL should have to prevent liquid water to get stuck in the cell. Water may lead to congestions in the pores and will impair the performance and may alternate the porosity and electric conductivity of the carbon-based material in the long run. These processes are also influenced by the cell compression and the heat generated from the electrochemical processes in the cell. The goal with the project is to make a model that predicts the performance based on the GDL materials properties. We hope to contribute both to Powercells product development, but the research will also give valuable understanding on the effect of operation conditions on fuel cell performance and lifetime of value also for the integration of the fuel cell in the vehicle."

Lisa Kylhammar division manager Fuel cell design at Powercell Sweden AB



"We want to tie closer connections between us and academia and this project is a good chance for us to do that. Until now our partners have mainly been found outside the Swedish borders, but we see that Swedish research on fuel cells is gaining speed and we want to contribute to that.

It is also an important project for us technically, and we are eager to get results. The project will help us to choose the right material for our future products and I think we will have use for the projects results already within a year!

We have gone from being a small company that had to trust and depend on our suppliers' and partner's knowledge, and this is a part of a bigger investment where we develop our own knowledge. We are in an early stage of the project, but I still think we have had a good start and have a good plan for collaboration.

We are also looking forward to getting engaged in a Swedish Electromobility Centre project and it's going to be interesting and valuable to have the Centre's network to collaborate with."

PHD NETWORK

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

- Access to Swedish Electromobility Centre's activities and network.
- Contact with PhD students from different fields.
- Knowledge building through PhD courses, seminars and workshops.
- Equipment for future work and research challenges. All PhD students in Sweden working with different approaches, methods and focus in the area of e-mobility are welcome.

The network consists of students from all partner universities. It is run by SEC project manager Frida Barrett together with Rebecka Andersson, administrative officer.

SEC SUMMER SCHOOL

SEC arranges a yearly Summer School, a course for PhD students who want to deepen their knowledge and discuss their ideas concerning electromobility. Unfortunately, this year's Summer School was canceled due to the corona pandemic. The aim is now set on making the summer school of 2021 more extensive than in earlier years.

PHD COURSE

As an alternative to the summer school the centre developed and started the PhD course Electromobility Systems – Design Project, beginning in December 2020 continuing in the beginning of 2021.

LUNCH PRESENTATIONS

New this year are the Digital lunch seminars for doctoral students, which became an appreciated event. SEC hosted seven digital lunch seminars in 2020 with participants from all member Universities.

INTERVIEW WITH SEC PHD-STUDENTS

Anastasiia Mikheenkova is a PhD student at Uppsala University since October 2019. She studies agent mechanisms in Li-ion batteries in collaboration with Scania, Volvo, KTH and Chalmers. Her work is mostly related to theme 3.

"I really like the online seminars and the network activities provided by SEC in 2020. I think they were really interesting. I also had an opportunity to participate in some outside of event discussions with people from the network, which was really useful.

It was unfortunate that the summer school had to be canceled. That was something I was really looking forward for and hopefully I will be able to participate in the future. Of course, I also felt the lack of personal meetings which would have helped with the networking and discussions. However, I still think it was good that we had these networking events where we could meet and get connected to others. I think the kickoff event in the autumn was very positive. We had representatives from industry giving a good overview of their work and how it can be related to me as a PhD student. There was also a good part where we got to know each other within the network, which I think is important", says Anastasiia Mikheenkova.

Arvind Balachandran is a PhD student at Linköping University since August 2020. He studies power converters for electric drive trains, and his work is mostly related to theme 2.

"I started my PhD studies in August and my first impression of the doctoral network is that it is really nice with regular seminars and discussions. The regular lunch seminars give you a good knowledge about what is happening in the world of electromobility. I also like the PhD courses. In fact, I'm taking one right now: Electromobility Systems - design project, led by Anders Grauers', Chalmers. It gives an overall perspective with an electromobility cost benefit analysis perspective. It is a very nice platform for collaboration with industrial partners as well as PhD students from other universities. It is pretty exciting.

I started my PhD studies during the pandemic, so I don't really have anything to compare with, but I do miss socializing in physical meetings. It is a downfall that we can't meet and socialize. I'm looking forward for the summer course which I really hope will be possible in 2021, and something I missed in 2020. It would be a really good opportunity to get to know the industry and the e-mobility society. At the same time, the situation has led to more online classes. It is a real benefit to be able to take online classes with any university", says Arvind Balachandran.

COLLABORATION

SEC is a major host for collaboration within electromobility research in Sweden. Collaboration lies at the core of the centre, providing a link between major universities together with each other and industry involved in electromobility in the country. Together, this covers a large part of all research activities within hybrid and electric vehicles in Sweden. The centre mainly focuses on collaboration with organizations that complement its knowledge, and strengthen its role in Sweden. But the collaboration doesn't stop there. SEC is growing in many ways, in members, in project funding, but also in collaboration with other centres and with associated projects. Here are some of the organisations and projects the centre collaborated with in 2020.

COLLABORATIONS 2020

F3

f3 Swedish Knowledge Centre for Renewable Transportation Fuels is a nationwide centre for collaboration between industry, academia, research institutes and authorities engaged in contributing to a sustainable transport sector. In November 2020 SEC and f3 held a workshop with the name "Bio fuels and electrification play different roles, but both are needed". The reason for the workshop was the coming results from the so called phase-out inquiry that analyzes the preconditions for a national ban on new sales of petrol and diesel cars. The workshop included panel discussions with representatives from SEC and Chalmers and presentations from Sven Hunhammar, the Government's special investigator for the inquiry, Julia Hansson, IVL and Anders Nordelöf, SEC theme leader and Chalmers researcher.

SICEC

SEC has collaborated with SICEC during 2020. SICEC is a research cooperation between three Swedish Internal Combustion Engine competence centres: KCFP at Lund University, CERC at Chalmers University of Technology, and CCGEx at the Royal Institute of Technology. All of these centres have been involved in a dedicated SEC effort to identify research needs in the area of fuel cells in vehicle applications.

Vehicles are characterized by transient speeds and loads, often in unpredictable duty cycles and under extremely varying environmental conditions. This makes it challenging to engineer systems that deliver robust vehicle performance under all conditions. Due to the wide range of technologies involved in vehicles, the systems research area opens up opportunities for truly interdisciplinary research collaborations. The fuel cell area in particular offers a promising intersection between the electromobility and combustion engine areas.

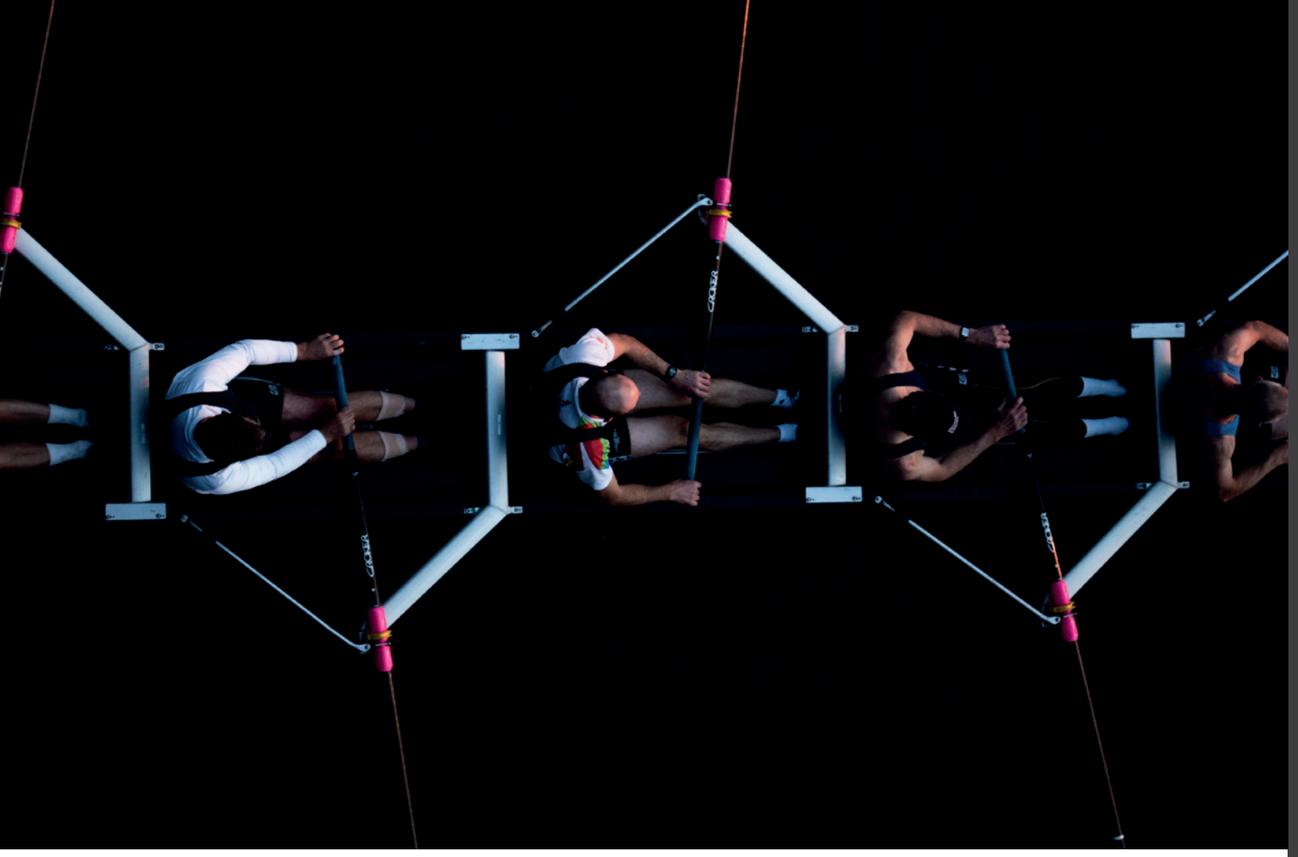
Swedish fuel cell research is traditionally strong in fundamentals associated with materials and processes within the fuel cell itself. These are studied within SEC. In vehicle applications, the fuel cell must also interact with a range of external systems for air and fuel supply, cooling, humidity control and so forth. These systems are often based on technology that is used in combustion engine systems. For this reason, fuel cell systems is an area where it is especially valuable for SEC to interact with SICEC.

BASE

In 2020, a new competence center on batteries – Batteries Sweden (BASE) – was founded, financed by Vinnova. There are immediate links between this new center and Theme 3 within SEC, both in terms of the participating universities (Uppsala, KTH, Chalmers), industries, and key people. While BASE cover the value chain of batteries and has a focus on the materials within the cell and has battery industry as partners, SEC in turn focus in this respect on battery application within electromobility. Nevertheless, there are interesting interfaces between these scientific and technological areas, and many of the issues regarding battery behavior in vehicles have a clear background in the applied cell chemistry. Joint activities between the centra have therefore taking place, such as a workshop on solid-state batteries in December 2020. More interactions of this sort can be foreseen, and the battery knowledge and competences developed within BASE can clearly be useful for the advancement of SEC.

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. The large importance of hydrogen in the transition towards sustainable and decarbonised energy and transport systems has been outlined by leading European politicians. The centre is still in an early phase, but future collaborations between PUSH and SEC in the field of hydrogen storage, distribution and use for transport applications are expected.

SAFER

The directors of SEC and Safer (the 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 group working with safety of electrical vehicles and invited SEC to collaborate. SEC participates with one representative in the group and monitors how the cooperation in this field can be increased between the centres.

SEEL

Work on the new large test centre for electric mobility took great steps forward in 2020 and the SEC community actively participated in several workshops with the work of identifying the need for research in all parts of the area and what equipment would be needed to perform this research.

SEEL will open the lab facilities in 2023 but is already involved in European battery research and intends to expand involvement in research already now in collaboration with the SEC.

OMEV

The interest for electric transportation is on an all-time high and the SEC Global Watch newsletter omEV has made a journey from almost twenty years ago with a just a few enthusiasts following the newsletter to being an important source of information of global events for many of the researchers and engineers that lead the development of Swedish e-mobility and practically all Swedish motor journalists. The omEV editorial staff also produce the omEV podcast. Both are funded though SEC by the Swedish Energy Agency and are available at omev.se.

MAGNUS KARLSTRÖM
Editor-in-chief of omEV

"Up to three times a week we give our subscribers a quick overview of what is happening in the world. We gather, analyze and package information about what is happening in the world of e-mobility and that may influence Swedish mobility development and hopefully save time for our readers and give them new insights.

The omEV team consists of me, Magnus Karlström, Jens Hagman, doctoral student at KTH and project manager at Sustainable Innovation and Helena Berg, battery expert with over 25 years in academy and industry. With our backgrounds combined we can proudly say that we possess extensive experience and scientific knowledge of e-mobility.

We gather the information through newsletters, scientific journals and branch magazines about e-vehicles. We get tips from readers using Twitter and subscribe to press releases from research institutes. If mainstream media reports about it, we don't. We stay relevant by offering a unique analysis and news that only professionals normally get.

OmEV started as a channel for reporting about the latest news, but in recent years we have turned it more into business intelligence. We spot trends, gather reports and write syntheses.

New this year is our round table talks where we let experts discuss controversial issues. We then use the discussion as a base for our analysis on the issue. This is an initiative following the Swedish Energy Agency's whish that we should produce more own knowledge, not only reporting about other news. We can now really dig deep into issues that we believe hasn't gotten the attention that it deserves. Vertical integration is one of these issues that we have put a lot of effort into", says Magnus Karlström.

OUTREACH AND COMMUNICATION

SEC functions like a network for researchers all over Sweden and industrial partners that are in the business of emobility and sees the advantage of collaborating with academia. At the same time the world around is getting more and more interested in what the centre does. Funded by the Swedish Energy Agency researchers also have a responsibility to inform the public of its accomplishments. Thus, communication and outreach are important tasks for the centre. The work that is being done in communication has a purpose of strengthening the centre as well as the nation in this fast- growing field of research and development.

NEWSLETTER

The SEC Newsletter gives a monthly update on what is going on within the centre. Here is also room for friends of the centre in e-mobility Sweden to show coming events that are of great interest of SEC partners. The newsletter has nearly doubled its subscribers during 2020 from around 1300 to 2500, with a significant increase during spring, simultaneously with when the very appreciated SEC lectures were held.

WEBSITE

By the end of 2020 SEC's new website was launched. The former had become outdated and the Centre has now gotten a more responsive, compelling and modern looking entrance at the web. The new website is based on a safer technical platform, with better support. It is also designed in a way that gives more flexibility, while at the same time follows the Centre's visual identity and brand. The new website also provides a better platform to attract a wider audience.

WORKSHOPS

SEC arranged and/or took part in 40 events in 2020. The most significant were the SEC lectures, the Emobility day, and a workshop held by Bombardier in their new test lab in Västerås. The new situation with traveling restrictions has created a wider acceptance for non-physical events. There are obviously many advantages in physical meetings, but there are also advantages in web events. The centre has been able to reach out to a much wider audience than ever before due to the pandemic and also to a much lower price, both in terms of finance and of carbondioxide.

GLOBAL WATCH

The omEV newsletter is a global watch service run through SEC. Magnus Karlström is the editor-in-chief and up to three times a week they give the subscribers a quick overview of what is happening in the world. They gather, analyze and package information about what is happening in the world of e-mobility and that may influence Swedish mobility development. New in 2020 was the round table talks where omEV gathers experts to discuss controversial issues. The discussion is then used in an analysis in the newsletter. The initiative is a response to the Swedish Energy Agency's whish that the editors should produce more own knowledge and not only report news.

CHANGES IN THE TEAM

In the second half of 2020 the SEC communication staff was changed, from Astrid Hedenström and Elinor Hedar from Chalmers Industriteknik, to Åsa Bertsch from the same organization and Mats Tiborn from IMCG International. Åsa is now responsible for newsletter, web and graphics and Mats for the centre's content production.

Mats Tiborn and Åsa Bertsch

MEDIA COVERAGE

2020 was a good year for SEC, figuring in media on twenty-two occasions. The centre was represented in both the largest newspapers and a variety of trade press. For instance, in March, Director Linda Olofsson was quoted in the journal Focus about the future of electric cars. Anders Grauers, Chalmers, was interviewed in Svenska Dagbladet in July on reasons for electric cars, and when Powercell became a SEC partner that was also covered in Svenska Dagbladet.

Emobility Day was held digitally in 2020 due to the pandemic.

SEC LECTURES

As a quick response to the sudden corona crisis, SEC offered a unique online course for its members: the SEC lectures.

During spring the centre arranged five lectures, one for each Theme. The course provided an overview of electromobility starting from storage of charging, powertrain and on-board systems all the way to social aspects, interaction with the electric grid and infrastructure, giving an introduction to the areas as wells as to different tools for modelling.

The SEC lectures were a success with an average of 450 participants. The most well attended had 549 participants.

The SEC Lectures consisted of five parts:

Part 1: Energy storage, batteries and fuel cells

Part 2: Electrical machines, drives and charging

Part 3: Vehicles systems

Part 4: Electromobility in society

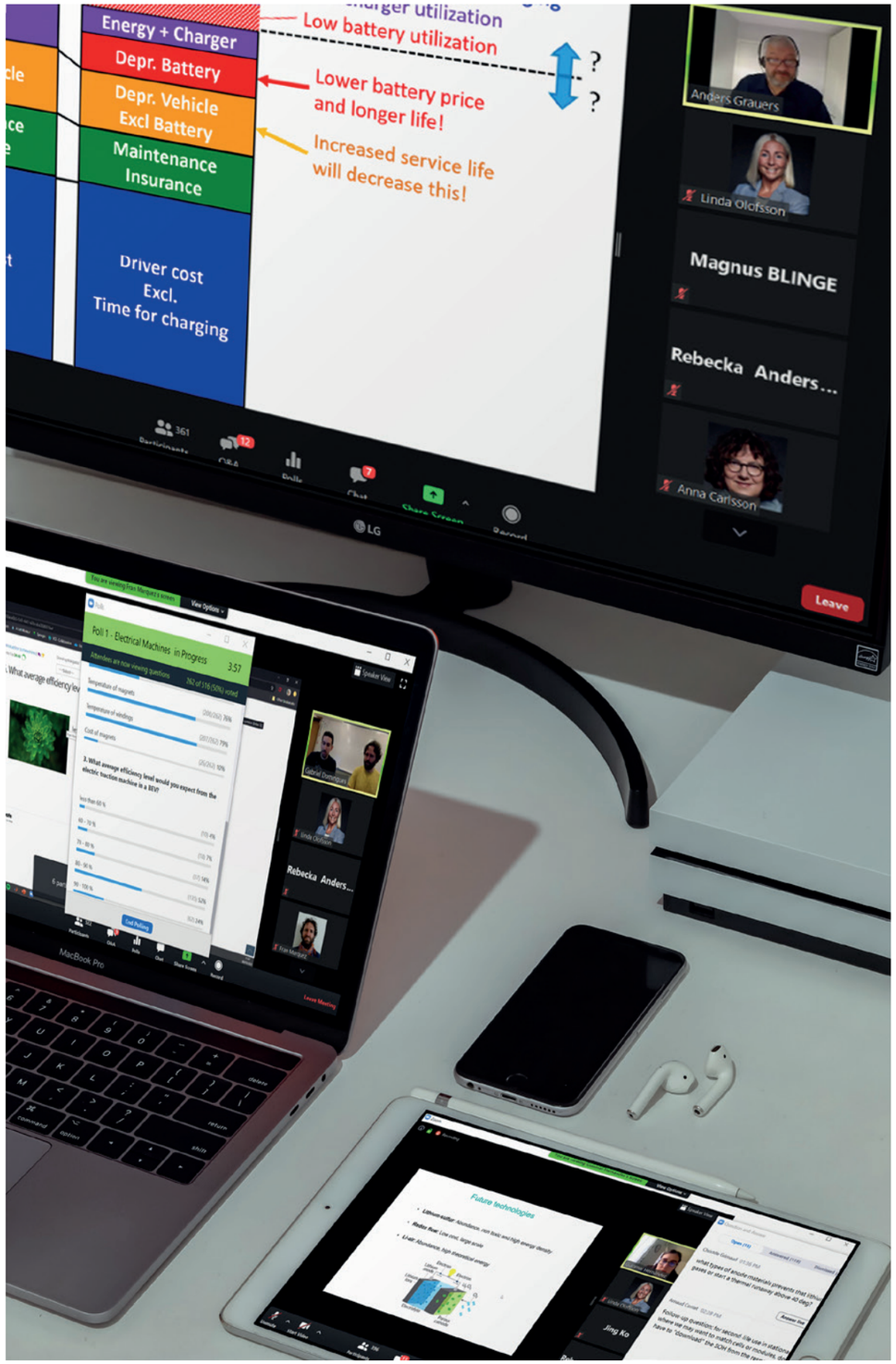
Part 5: Electrical grid and electromobility

"I think these lectures had a perfect timing.

There were many engineers having to stay at home and work or being put on furlough and these lectures offered them the opportunity to learn the basics of something new and interesting that is also trendy in our industry at the moment.

The good timing and interesting topics are the main reasons behind the incredibly high attendance to these lectures", says Gabriel Domingues of BorgWarner.

Gabriel Domingues was on of the lecturers at the second lecture, Electrical machines, drives and charging, which he co-hosted together with Theme leader of theme 2, Francisco Márquez Fernández.

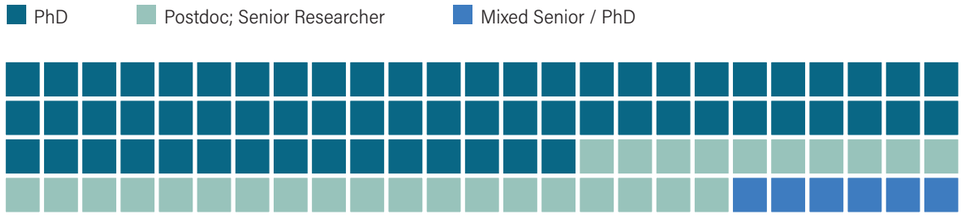


Screenshots from SEC Lectures

CENTRE FINANCE

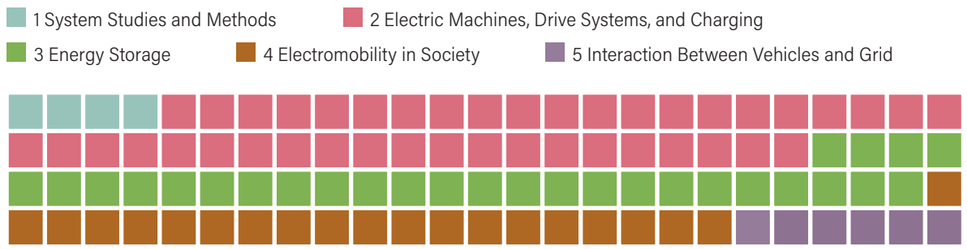
PROJECT TYPES

One of the centre's objectives is that half of SEC-funded research projects that last for two years or more must be PhD student projects. Of the projects approved and started during 2020 59 percent are PhD student projects.



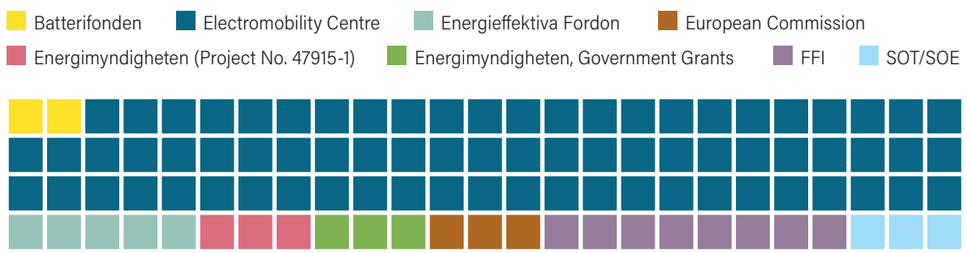
FUNDING IN EACH THEME (PROJECTS FINANCED BY SEC)

The three most active thematic areas were Theme 2: Electric machines, drive systems and charging, Theme 3: Energy storage, and Theme 4: Electromobility in society. These three themes dominated the project portfolio during 2020.



CASH FUNDING

73 percent of the projects connected to Swedish Electromobility are SEC-funded projects. In addition, 27 percent are associated projects from various programs/centres. Most of the associated projects come from Theme 1: Systems studies and methods.



COUNCILS AND MANAGEMENT

The board had eight Program Council meetings during 2020. The tables below illustrate the constellation of the Program Council and the General Assembly during 2020.

PERMANENT MEMBERS

Johan Hellsing	CEVT
Robert Eriksson	Volvo Cars
Elna Holmberg	Volvo AB
Nils-Gunnar Vågstedt (ordförande)	Scania
Fernanda Marzano	Scania
Erik Svahn	Energimynd.
Maria Abrahamsson	Chalmers
Lina Bertling Tjernberg	KTH
Öivind Andersson	LTH
Peter Värbrand	LiU
Eva Pålsgård	UU

DATES

Program Council 2020

2020-01-28	2020-09-14
2020-02-18	2020-09-24
2020-02-21	2020-11-20
2020-03-26	*2020-12-10
2020-05-04	

*extension of the meeting from 2020-11-20

CO-OPTED MEMBERS

Jonas Fredriksson (temaledare 1)	Chalmers
Lars Eriksson (temaledare 1)	LiU
Francisco M-Fernández (Temaledare 2)	LU
Luca Peretti/oskar Wallmark (Temaledare 2)	KTH
Daniel Brandell (Temaledare 3)	UU
Göran Lindbergh (Temaledare 3)	KTH
Magnus Blinge (Temaledare 4)	LiU
Anders Nordelöf (Temaledare 4)	Chalmers
Mikael Lantz (Temaledare 5)	LU
Cecilia Boström (Temaledare 5)	UU
Magnus Karlström	SEC
Anders Grauers	Chalmers
Frida Barrett (Protokollförare)	SEC
Linda Olofsson (Föreståndare)	SEC
Gabriel Domingues	BorgWarner
Arne Nåbo	VTI
Dmitry Svechkarenko	ABB
Arnaud Contet	TitanX
Christian Guffman	Vattenfall
Thomas Tingelöf	PowerCell
Katarina Öquist	Epiroc
Magnus Lindgren	Trafikverket
Boel Ekergård	Högskolan Väst
Magnus Forsén	Bombardier
Magnus Eek	SAAB
Elin Eriksson	IVL

DATES

General Assembly 2020

2020-09-01	2020-10-22	2020-11-30

PERMANENT MEMBERS

Anders Plamqvist (ordf.)	Chalmers	Thomas Tingelöf	PowerCell
Annika Stensson Trigell	KTH	Arne Nåbo	VTI
Charlotte Platzer Björkman	UU	Arnaud Contet	TitanX
Per Dannetun	LiU	Boel Ekergård	Högskolan Väst
Erik Swietlicki	LU	Magnus Eek	SAAB
Magnus Berg	Vattenfall	Magnus forsén	Bombardier
David Hellstedt	Volvo AB	Elin Eriksson	IVL
Jonas Hofstedt	Scania	Peter Thelin	E.ON
Stefan Christiernin	Volvo Cars		
Gabriel Domingues	BorgWarner		
Didier Schreiber	CEVT		
Dmitry Svechkarenko	ABB		
Katarina Öquist	Epiroc		

CO-OPTED MEMBERS

Erik Svahn	Energimynd.
Frida Barrett	SEC
Linda Olofsson	SEC

APPENDIX A - PROJECTS

Projects	Manager	Theme	University partner	Company partners
Electromobility Scenarios	Anders Grauers	4	LTH	-
Power systems integration of electric vehicles for	Massimo Bongiorno	5	Chalmers	Volvo Cars
Fuel Cells in Vehicle Systems	Öivind Andersson	1	LTH	ABB, CEVT, Scania, Volvo AB
A Pre-Study for Manufacturing Effects in Electrica	Joachim Lindström	2	Chalmers	BorgWarner, Vattenfall
Cost-benefit Optimized ChArging INfrastructurE	Gyözö Gidofalvi	5	KTH	Vattenfall
Towards electrification of freight transports	Henrik Johansson	4	LiU	Scania, TitanX
* Environmental Assessment of Electromobility Chargi	Anders Nordelöf	4	Chalmers	CEVT, Scania, Volvo AB, Volvo Cars
Modeling, System Analysis, and Control of Hybrid..	Lars Eriksson	1	LiU	Scania, Volvo AB
* Road resistance estimation for improved range...	Mikael Askerdal	1	Chalmers	CEVT, Volvo AB, Volvo Cars
* Measurements and modelling of thermal and...	Torbjörn Thiringer	3	Chalmers	CEVT, Powercell, Scania, Volvo AB, Volvo Cars
* NVH Analysis and Mitigation in Electrical...	Francisco Marquez-Fernandez	2	LTH	ABB, CEVT, Volvo AB, Volvo Cars
* Prerequisites for electrification of freight trans	Henrik Johansson	4	LiU	BorgWarner, CEVT, Scania, TitanX, Vattenfall, Volvo Cars
Charging behaviour and infrastructure, Stage IV	Frances Sprei	4	Chalmers	Volvo Cars
Fuel Cell Performance Prediction	Rakel Wreland Lindström	3	KTH	ABB, Powercell, Volvo AB
Real-time observation of side-reactions Unde...	Erik Berg	3	UU	ABB, Volvo AB, Volvo Cars
Testing, Analysis and Design of Axial Flux Motors	Sonja Lundmark	2	Chalmers	ABB, Volvo AB, Volvo Cars
Life Cycle Assessment of Large-Scale Lithium...	Anders Nordelöf	4	Chalmers	CEVT, Scania, Volvo AB, Volvo Cars
Online health diagnostics of inverters for commer	Staffan Norrga	2	KTH	Scania
* Design of rare earth element free motors for elect	Sandra Eriksson	2	UU	Scania
E-machine design for enhanced recyclability and mi	Torbjörn Thiringer	2	Chalmers	ABB, CEVT
Thermal modelling and fault prognosis for Li-ion b	Changfu Zou	3	Chalmers	Scania, Volvo AB
* Diagnostics and supervision of dynamically...	Mattias Krysander	1	LiU	Scania
* Open-source framework for Electrical-Thermal...	David Sedarsky	2	Chalmers	Volvo Cars
* Electric vehicle charging strategies and grid...	Maria Taljegård	5	Chalmers	CEVT
* High Power Charging when, where and how	Karin Thomas	5	UU	CEVT, Scania, Vattenfall, Volvo AB
* ACTUAL grid and road simulation for e-mobility	Francisco Marquez-Fernandez	5	LTH	CEVT, Scania, Vattenfall, Volvo Cars
* Chemical quenchers for inhibition of battery fires	Elna Heimdal Nilsson	3	LTH	Volvo Cars

SEC Projects started or continued during 2020. Projects marked with an * have been inactive during the year.

APPENDIX B - ASSOCIATED PROJECTS

Associated Projects	Manager	Theme	University partner	Company partners
XX ORCA - Optimized real-world cost-competitive	Olof Lindgärde			Volvo AB
XX Distributed propulsion in between vehicle units	Toheed Gandriz	1	Chalmers	Volvo AB
XX Emission Aware Energy Management of Hybrid Vehi	Jonathan Lock	1	Chalmers	Scania, Volvo AB, Volvo Cars
XX OPerational Network Energy managemenT for elect	Balázs Adam Kulcsár	1		
XX FROST – Fuel Reduction Optimal Strategies and T	Victor Leek	1	LiU	Scania
XX Towards a sustainable use of electric vehicles	Gyözö Gidofalvi	4	LiU	
XX Innovation system for electric distribution tru	Ksenia Onufrey	4	KTH	Energimyndiheten
ZZ Life cycle assessment of a fuel cell electr...	(Ex-jobb)	4	Chalmers	Powercell
ZZ Three-Mode Hybrid Powertrain Optimal Control...	(Ex-jobb)	1	Chalmers	CEVT
XX Anticipating Metal Scarcity challenge...	Björn Sandén	4	Chalmers	
XX Life Cycle Assessment of All-Electric Aircrafts		4	Chalmers	
XX Life cycle assessment of future battery chemist		4	Chalmers	
XX Blood Batteries, Social Life Cycle Impacts of			Chalmers	
XX Battvolt		1	LiU	Scania
XX Optimal energy management of construction equip		3	LiU	Volvo Cars
XX LINK SIC		1	LiU	
XX B FROST		1	LiU	
XX Multifysiksimulering av kylsystemet och...	Torbjörn Thiringer	2	Chalmers	
XX Robust, multi-level control for complete...	Nikolce Murgovski	1	Chalmers	
XX Evolution Road	Per Löfberg	2	LTH	
XX EPOS - Electric Powertrain OptimiSation for		2	LTH	BorgWarner
XX Diagnostics and Open Loop Lifetime Estimation		2	LTH	Volvo AB
XX Integrated electric Generator and motor (InGe)		2	LTH	
XX Transition to a fossil free European transport	Maria Taljegård	5	Chalmers	
* XX The role of stationary batteries and electric	Maria Taljegård	5	Chalmers	
XX Low carbon transport solutions	Maria Taljegård	5	Chalmers	
XX Electromobility in smart cities	Rafael Waters	5	UU	Vattenfall
XX Compact, modular, integrated electric machines	Oskar Wallmark	2		ABB, Scania
XX Sustainability transitions in urban goods di...	Thomas Magnusson	4	LiU	
XX Integrated Electric Long-Haul Truck & Charger	Gunnar Ohlin	4	LiU	Scania
* XX Optimering av elektriska maskiner baserat på ny				

SEC Projects started or continued during 2020. Projects marked with an * have been inactive during the year.

APPENDIX C - EVENTS

Date	Event namn	Theme	Participants
03-Mar	Comsol day:batteries	-	no participant list
01-Apr	Digital lunch seminar	PhD	38 participants
09-Mar	Theme meeting Scania	2	12 registered
20-Apr	Webinar	4	11 participants
21-Apr	Electromobility scenarios workshop	4	20st registered
22-Apr	PhD kickoff meeting	PhD	13 participants (20 registered)
26-Apr	SEC Lecture part 1	3	465 participants (435 active)
06-May	Digital lunch seminar	PhD	29 participants
08-May	SEC Lectures part 2	2	549 participants (521 active)
11-May	Webinar on fuel cells	3	98 registered
12-May	Thematic activity	5	no participant list
15-May	SEC Lectures part 3	1	502 participants (441 active)
18-May	Webinar on battery testing and diagnostic	3	61 registered
29-May	SEC Lectures part 4	4	383 participants (368 active)
03-Jun	Digital lunch seminar	PhD	21 participants
04-Jun	Electromobility scenarios workshop	4	24 registered
04-Jun	Mid-term presentation: Evaluation of Fuel Cell/Supercapacitor Hybrid Powertrain for Automotive Applications	2	no participant list
05-Jun	SEC Lectures part 5	5	356 participants (344 active)
08-Jun	Summer course "batteries for electromobility"	UU	no participant list
08-Jun	Master thesis presentation: Life cycle assessment for a fuel cells electric vehicle...	4	no participant list
10-Jun	Webinar on critical and scarce metals for electromobility?	4	50 registered
02-Sep	Digital lunch seminar	PhD	10 participants
09-Sep	Electromobility scenarios workshop	4	20 registered
23-Sep	Electromobility days 2020	SEC	no participant list
01-Oct	Thesis defense: The role of plug.in hybrid electric vehicles in electrifying personal transport - analysis of...	4	no participant list
07-Oct	Digital lunch seminar	PhD	31 participant (36 registered)
09-Oct	Real-time observation of side-reactions: Understanding and predicting the lifetime characteristics of li-ion cells	3	no participant list
21-Oct	Circular business models for extended EV battery Life	4	33 registered
28-Oct	Kickoff meeting	PhD	17 participants (20 registered)
04-Nov	VECTOR seminar: eMobilkity Use Cases and Solutions	1	no participant list
04-Nov	Digital lunch seminar	PhD	22 participants (20 registered)
28-Oct	Digital patent seminar	SEC	16 participants (24 registered)
01-Dec	Electromobility Systems - design project	PhD	19 registered
01-Dec	Electromobility research at LiU	LiU	20 registered
02-Dec	Digital lunch seminar	PhD	19 participants (18 registered)
07-Dec	Kickoff meeting: "Design of rare erath element free motors for electromobility"	2	no participant list
09-Dec	Collaboration seminar - bombarder test lab	Bombardier	48 participants (27 registered + bombardier rep.)
10-Dec	Theme 3 solid-state workshop	3	no participant list
15-Dec	Lunch seminar about electric flights	UU	82 participants (143 registered)
17-Dec	Thesis defense: Transportation Mission-Based Optimization of Heavy Combination Road Vehicles..	1	no participant list

TOGETHER WE CREATE THE ELECTROMOBILITY OF THE FUTURE

Swedish Electromobility Centre