Sweden-China Bridge

# CREATING A COLLABORATIVE ACADEMIC PLATFORM FOR THE ELECTRIFICATION OF TRANSPORTATION SYSTEMS

# CONTACT

**Mike Danilovic, Ph.D.**
Professor of Industrial Management Innovation
and Technology Management

Halmstad University
P O Box 823
SE-301 18 HALMSTAD, SWEDEN

Phone:
46708157588+ (Sweden)
8613761129945+ (China)

mike.danilovic@hh.se
www.hh.se/ciel

Visiting professor:

Distinguished Overseas Professor at Shanghai Dianji University
Shanghai, China

Affiliated researcher at Lund University, Sweden

## LIST OF PUBLICATIONS (2021)

1. Exploring Battery Swapping for Electric Vehicles in China 1.0
2. Exploring Battery Swapping for Heavy Trucks in China 1.0
3. Battery Technology in China 1.0
4. Hydrogen technology in China 1.0
5. Inductive Charging Technology in China 1.0

## SWEDEN-CHINA BRIDGE PROJECT HOME PAGE

**In Swedish**
https://www.hh.se/forskning/forskningsmiljoer/centrum-for-innovations--entreprenorskaps--och-larandeforskning-ciel/forskning-sprojekt-inom-ciel/sweden-china-bridge.html

**In English**
https://www.hh.se/english/research/research-environments/center-for-innovation-entrepreneurship-and-learning-research-ciel/research-projects-at-ciel/sweden-china-bridge.html

## TABLE OF CONTENT

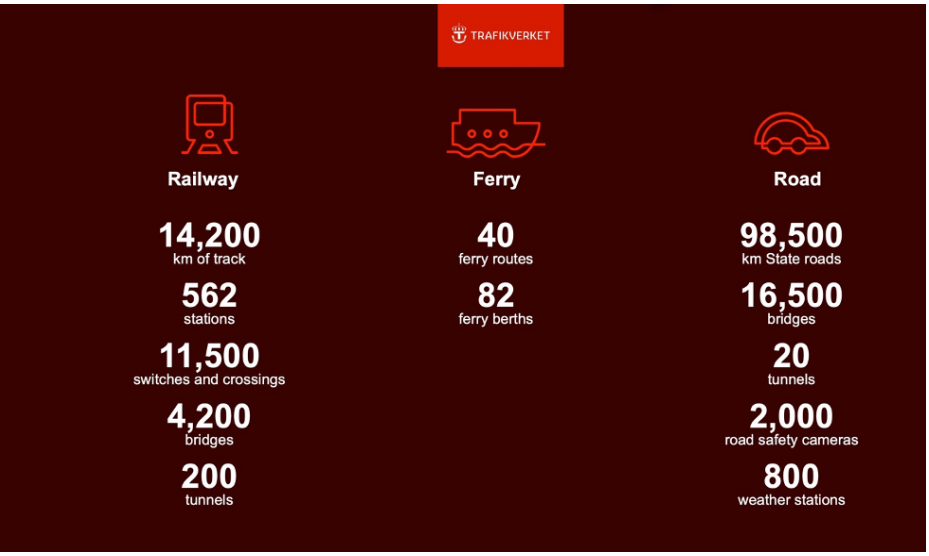
# SHORT DESCRIPTION OF SWEDISH TRANSPORT ADMINISTRATION (TRV)

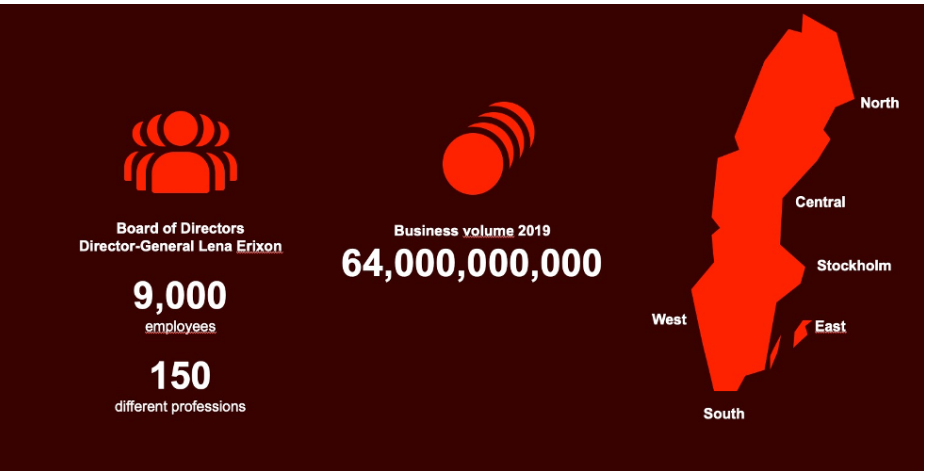
The Swedish government, through the Swedish Transport Administration, is responsible for long-term planning of the transport system for all types of traffic, as well as for building, operating and maintaining public roads and railways. Sweden is a rather large country compared with the size of population. The population in Sweden amount to approximately 10 million residents divided over 450 000 km$^2$.

A well working transport system is essential for moving peoples and goods over the country. In total the Swedish Transport Administration maintain about 100 000 km of state-owned roads, 75 500 km of private roads, along with 42,500 km of municipal roads, and 14 000 km state owned railroads.

TRV Business volume is about SEK 64 billion, of which the largest proportion is used on road and railway investments and on maintenance of roads and railways.

The road network support about 5 million light duty vehicle and 700 000 heavy duty vehicles. Road transport are responsible for emitting 17 million ton of $CO_2$ annually, 40 percent of the national emission of nitrogen oxides and 20 percent of small particles. In order to reduce the negative health effects and the emissions of greenhouse gasses the Swedish Government has decided on a climate law which will involve a compulsion to reduce carbon dioxide emissions from domestic transport, excluding aviation, by at least 70% by 2030 compared with 2010, before reaching a zero level in 2045.




**For further information on TRV please contact:**

**Mr. Jan Pettersson**
Program manager

jan.pettersson@trafikverket.se
+46 70304 2099

Swedish Transport Administration
SE 781 89 Borlänge
Sweden

# ORGANIZATION AND PROJECT MANAGEMENT

**Mike Danilovic**
Project leader, professor, Halmstad University, Sweden

Distinguished Overseas Professor at Shanghai Dianji University Shanghai, China

Affiliated researcher at Lund University, Sweden

**Jasmine Lihua Liu**, Ph.D.
Senior researcher at CIRCLE, Lund University, Shanghai Dianji University, China

Affiliated researcher at MMTC, Jönköping University, International Business School, Sweden

**Tomas Mülllern**
Professor, Jönköping University, Jönköping International Business School, Sweden

**Arne Nåbo**, Tech. Lic.
Research director, Swedish National Road and Transport Research Institute (VTI), Sweden

**Philip Almestrand Linné**, Ph.D., Researcher, Swedish National Road and Transport Research Institute (VTI), Sweden.

## Project funding agency

Swedish Transport Administration (Trafikverket, TRV), Sweden.

---

# KEY CHINESE PARTNERS

## Academia

**Wang Junhua**, professor, Tongji University, Shanghai, China.

**Liu Shuo**, assistant professor, Tongji University, Shanghai, China.

**Qiu Xiaoping**, professor, Southwest Jiatong University, Chengdu, China.

**Susan Lijiang Sun**, professor, Shanghai Dianji University, Shanghai, China.

**Ma Hongwei**, associate professor, Shanghai Dianji University, China.

## Industry

**Shanghai Powerkeeper**, Shanghai, China.

**Shanghai Jiulong Power**, Shanghai, China.

**Guoxun Yang**, CEO, Zhejiang VIE-Evatran Electronic Technologies Co., Ltd., Shanghai, China.

**Liu Zhen**, Senior Engineer, Shanghai, Urban and Rural Construction and Transportation Development Research Institute, China.

## BACKGROUND AND MOTIVATION FOR THE PROJECT

The idea of establishing an academic platform for knowledge sharing and transfer between Sweden and China emerged from this team's research on electric road systems (ERS) in relation to development of ERS in the Chinese context, but it has a broader scope than just ERS.

In this project we take a more extensive approach to ERS by integrating electrical vehicles and electrification of transportation systems with social and societal development of integrated intelligent technology and its implications for transportation systems. We are putting ERS-related technology and applications at the societal level, including global digitalization, integrated smart and intelligent city development, applied solutions, and integrated electrification of cities and society. ERS is integrated as one part of this hub of high-impact technological and social developments.

The establishment of the Sweden-China Bridge focuses on the following main subjects for exploration and thus extends beyond an interest in ERS:

- Energy sourcing: exploring the current status of development and integration of fuel cells, electric roads (conductive, inductive static, and inductive dynamic), solar roads, etc.) into a coherent electric transportation system.

- Development of vehicle technology and design using single energy sources such as batteries or hybrid solutions, static and dynamic inductive charging systems, conductive charging systems, and electric road infrastructure as an integrated societal system geared toward smart and intelligent society development.

- Socially integrated ecosystem development, in which electrification of transportation systems is one key element.

- Business models for commercialization and diffusion of technologies, electrified vehicles, transportation systems, and of transportation electrification infrastructure that is coherently integrated into urban and social systems.

- Technological and societal development are intertwined. This project will have a system perspective based on understanding that the future of electric vehicle transportation systems is connected to the development of entire urban ecosystems and designs and integrated transportation systems. All of these aspects are interrelated through the technology and functionality of different systems. We will explore the move towards intelligent society, smart cities, and high-tech transportation systems. In this transformation, technology is the basis for societal and business development through a network of actors that need to be coordinated and through technological solutions that need to be standardized.

The background of ERS is important in order to understand how and why the idea of a Sweden - China Bridge has emerged and why it might play an important role in the future development of electrical transportation systems.

## ELECTRIC ROAD TECHNOLOGY IN CHINA

In 2018, the World Road Association (PIARC) presented a comprehensive global study of electric road development mapping the current global state of electric road technology. China was a “blank spot” with unknown status, although PIARC had tried to explore and understand the status of development in China and the Chinese context. Thus, in 2018, Trafikverket (TRV) conducted a pilot study on the development of electric roads in China and made a week-long study trip, This was the start of an extensive dialogue with Chinese actors, such as the Ministry of Transport, national and provincial research institutes, universities, and even commercial manufacturers of inductive charging technology. The pilot study was led by Professor Mike Danilovic at Halmstad University and researchers from Shanghai Dianji University and TRV.

This pilot study found that China has chosen to adopt the large-scale implementation of inductive technologies (static and dynamic) for road electrification and the creation of smart & intelligent cities and society. In this vein, their advanced technology in inductive charging enables smart transportation structure for integrated development of smart cities and society. This was motivated by the belief that combinations of static and dynamic wireless charging systems were most suitable for the development of integrated smart and intelligent transportation systems, cities and society nationwide. In the Chinese approach, ERS is a core part of the large-scale development of smart cities and society and is designed to contribute to that broader goal.
By 2018, Chinese conductive technologies were ready for use in limited inter-city electrified transport.

The pilot study team from Halmstad University and Shanghai Dianji University showed that China is leading the way in the development and implementation of static and dynamic inductive electric road technology and has a strong commitment to implementing electric road technology at a larger scale.

By 2018 a 2 km long test range was in operation, and in 2021 they expect to have 19 km. At the 2022 Winter Olympic Games they expect to demonstrate a 45 km long test range based on inductive technology.

China is rapidly developing and implementing this technology, and its decision-makers are determined to quickly achieve a high level of technological development and social diffusion of large-scale system-based solutions. Chinese actors are making a large technology jump from electro-mechanical technology (conductive ERS) to electro-magnetic technology (inductive ERS). Due to communication and collaboration barriers, we know and understand very little of what is happening in China and how their technology is developed and implemented in large-scale systems applications. Also, we know very little about the commercial aspects of such integrated of technology and society, large-scale system development and implementation.

Sweden, on the other hand, has become a pioneering country in developing and implementing experimental conductive technology and creating demo tracks for ERS conductive technologies.

Sweden has made a firm decision to reduce $CO^2$ emissions, and electrification of roads might be one path to that goal. A number of test ranges are currently evaluating different technologies. The Swedish heavy vehicle manufacturers Volvo and Scania are pioneers in the electrification of heavy-duty vehicles.

Considering that China is both the largest producer of and largest market for electric vehicles, both personal cars and buses, it is important to explore deeper and understand what is being developed and implemented in that society which might be of interest for the rest of the world. It is important to mention that China is not limiting electrification to electric vehicles, electrified roads, and transportation systems.

Efforts are also being made to develop charging infrastructure for battery-powered vehicles, and investments are being made in energy production systems for electrical vehicles, such as fuel cell technology, and other related technologies such as artificial technology, autonomous driving systems, and so on. In addition, China has taken a broader approach to electrified transportation systems, including digitalization and the development of integrated intelligent cities.

Thus, the whole-system approach that China has taken is important to explore and understand. Its consequences on the entire evolution of the ecosystem, and on business model innovation for related industries and society are expected to be large.

Considering the fast development of Belt & Road Initiative (BRI) projects that seek to link China and most of the Asian countries with Europe, it is even more vital to explore and understand how rapid development of technology, infrastructure, and transportation systems in and through Asia might impact Europe's transportation system development, in order to synchronize and coordinate the standardization of large-scale system solution development and implementation in Europe and Asia.

Thus, this project intends to create a win-win scenario based on knowledge creation and a knowledge-sharing platform bridging Sweden and China. In the long run this bridge can bring Sweden and China into collaboration through joint research and development of technology and products that suit the need of many countries, operators and users.

## EXPLORATORY APPROACH

This project is exploratory in nature and includes a step-by-step approach to knowledge development. The project spans different areas of knowledge in which we will highlight what technologies and systems are prioritized, what drivers and motives exists for them, what actors are involved in the transition to electrified, intelligent and integrated transport systems, and what conditions and business models look like to achieve this conversion to electrified and integrated transport systems in an intelligent and smart society.

## THE PURPOSE OF THE PROJECT

The project has 3 main purposes:

1. The project aims to establish and develop an academic knowledge-sharing and -transfer platform between Sweden and China for collaboration between universities and research institutes in the two countries, in order to contribute to increased understanding and information and knowledge sharing on the technical and commercial development of electrified vehicle systems, integrated transport system solutions, and energy supply infrastructure as a fully integrated system of intelligent and smart cities.

2. From this perspective, the project will explore the development and implementation of relevant technology for the electrification of vehicles, such as fuel cells, bioenergy, battery storage, combinations of energy systems for hybrid vehicles, energy supply for integrated electrified vehicles, integrated electric road technology, associated charging infrastructure, and static and dynamic technology.

3. We also intend to explore the management of renewable energy supply systems, from the production of renewable electricity to its distribution to consumers of electrified transport systems, which is needed to ensure that electrified vehicles and transport systems can be supplied with the necessary electricity.

## RESEARCH QUESTIONS

Based on these three overall purposes, the project will address the following six specific research questions:

1. How is technological development organized within and between Chinese universities, research institutes and industry to ensure that both technical development and commercialization of the technology take place in a synchronized way?

2. How does academia collaborate with (a) integrated technology development and (b) urban and social development to ensure that technological development for electrification of vehicle systems is synchronized with the development of intelligent and smart cities?

3. What is the basis for deciding (decision-making criteria) on the choice of different electric vehicle propulsion technologies, from personal cars to heavy vehicles, such as fuel cells, hybrid technology, battery drive, and various electric road solutions?

4. How are future technology choices for the progress of the various electric vehicle systems viewed?

5. How is the supply of electricity needed for the rapid development of electric vehicle systems ensured?

6. How will business models be designed to enable the introduction of large-scale electric vehicle systems across China?

## PROJECT TARGETS

The scope of the following work is in electrification of vehicle systems, integrated transport system solutions, and energy supply infrastructure as a fully integrated system of intelligent and smart cities and society fields.

1. Establish and develop an academic knowledge-sharing and transfer platform between Swedish and Chinese universities and research institutes.

2. Describe the updated development of electrified transport system solutions integrated with ecosystem solutions for smart and intelligent cities in China, including both technology and business model development.

3. Create a data-driven knowledge base for mutual learning between Sweden and China. Perform 2–3 case studies, 1–2 of which will be studied in depth to understand the development and implementation status of technical systems in China.

4. Disseminate information on current cooperation and experience gained to relevant actors in Sweden, as well as create an infrastructure for future contacts, projects and other joint activities such as mutual workshops, seminars and international conferences.

5. Make the Sweden-China platform known in both Sweden, China and in the western ERS community. Share knowledge & assess the potential for future research, collaborative projects and other joint activities between the Swedish and Chinese academies.

6. Final report and finalizing the project.

## PROJECT RESEARCH METHODS

- Literature reviews of national Chinese journals (both English and Chinese articles), university databases etc. to learn what the research can show regarding the central areas of the project that are in.
- Observational studies with the universities and research institutes involved in R&D in the above areas.
- Conduct in-depth interviews with key personnel from academia and companies to create an understanding of identified technologies and technical solutions for the electrification of vehicle systems.
- Conduct collaborative workshops with representatives of different organizations, functions and organizational levels to explore and better understand topics of interest for this project.
- Identify key development projects and conduct 2–3 case studies to understand in more depth the “what, why, who and how” of technical and business solutions that are being developed and their interaction with intelligent and smart cities. These case studies will be identified in dialogue with the reference group for the project.
- Identify particularly interesting development projects and carry out in-depth studies that enable a deeper knowledge of technological and business development to electrify vehicle systems. These will be identified in dialogue with the reference group in the project.
- Conduct workshops with key researchers and leading companies to map prerequisites for technology and business development.

## PROJECT DELIVERABLES

- A knowledge platform for cooperation between key Swedish and Chinese academic and research institutes involved in the development of electric vehicle systems and their connections to the development of intelligent cities.
- Literature summaries with reflections and analyses of the state of knowledge in China regarding technological, business and societal development for electric vehicle systems.

- Report on state-of-the art knowledge regarding the technological development of electric vehicle and transportation systems and the interaction between technological development and commercialization of electric vehicle systems from a societal development perspective.

- Article analyses intended to be published in international journals.

- Descriptive and problematize articles presented at national and international conferences.

- 2-3 case studies of interesting development projects concerning electrification of vehicle systems in China. The focus of the different case studies may vary. Some may focus on energy supply systems, such as fuel cells, hybrid technology, batteries, etc. Others may focus on the interaction between electric vehicle systems and smart cities. And some may focus on the development of new technical systems such as solvägar.

- 1-2 in-depth studies in selected special areas. The focus may be on heavy vehicle development, including buses and their technical design. In-depth studies provide insight and knowledge about the interaction between academia and industry in particularly interesting areas, such as various technical solutions for the electrification of both heavy and light vehicles, including the design of business models.

- Descriptions and analyses of business models – exploring and in-depth understanding the content of the development of business models for the electrification of vehicle systems and their integration into society.

- Summary and analytical final report.

## EXPECTED VALUE CREATION

This project is expected to bring the following general value to key stakeholders and actors involved in the electrification of transport systems:

- To create a collaborative and learning platform between Sweden and China where the opportunities are shaped to conduct mutual knowledge dissemination and learning for Swedish players in the electrification of transport systems, system development and implementation in China and in Sweden.
- To create insights into the current and future status of electrification of transport systems in China from technical, social, societal and economic perspectives.

- To learn and mutually develop insights into how new knowledge, technology, system-based solutions, logistics and transportation systems can be developed, commercialized and operated in the lifecycle perspective.

- To create a long-term learning context in which Swedish and Chinese experiences can be exchanged for the benefit of both countries and their industries.

- To develop deeper understanding of how China is managing the large-scale electrification of the road network using different technologies, including electric charging, energy production (fuel cells, hybrid vehicles, battery storage and electric roads): What does the short- and long-term potential look like? How are they using long-term industry policy instruments to develop technology and implement it in society? How are they outlining business models for large scale ERS roll-out?


## TIME PLAN

| | ESTABLISH AND DEVELOP | DESCRIBE AND ANALYSE THE DEVELOPMENT | CREATE A DATA-DRIVEN KNOWLEDGE |
|---|---|---|---|
| PROJECT ACTIVITY/PHASES | 1 | 2 | 3 |
| | Establish and develop an academic knowledge-sharing and transfer platform between Swedish and Chinese universities and research institutes. | Describe and analyse the development of the electrified transport system solutions integrated with ecosystem solutions for smart and intelligent cities in China, including both technology and business model development. | Create a data-driven knowledge base for mutual learning between Sweden and China. Perform 2–3 case studies, 1–2 of which will be studied in depth to understand the development and implementation status of technical systems in China. |
| | 2020 SEPT. - DEC. | 2021 JAN. - JULY | 2021 MAY - NOV. |
| CONTENT DESCRIPTION | Develop relations between Swedish and Chinese counterparts, including academic, institutions, and business /industry actors in China that can be the bridge towards their Swedish partners. | Exploration of knowledge bases in China.<br>Literature review and summary of the state of the art in China. | Exploratory case studies in China.<br>Explore 2-3 case studies of key projects in China.<br>Explore 1-2 cases in depth. Deep case analysis of city-community-electrical vehicle system integration in the Chinese context. |


## DISSEMINATE INFORMATION

4

Disseminate information on current cooperation and experience gained to relevant actors in Sweden, as well as create an infrastructure for future contacts, projects and other joint activities such as mutual workshops, seminars and international conferences.

**2021 SEPT. - NOV.**

With Chinese partners, design and set up one workshop in China at the end of 2021 with Swedish and Chinese actors and selected Chinese partners.

## MAKE THE SWEDEN-CHINA PLATFORM

5

Make the Sweden-China platform known in Sweden, China and in the western ERS* community. Knowledge sharing.

Assess the potential for future research, collaborative projects and other joint activities between Swedish and Chinese academic and research institutes.

**2020 OCT. - 2022 NOV.**

Establish web page and regular information update from the start.

Annual participation at International ERS* conferences.

Participation in special TRV conferences/seminars in Sweden.

One international workshop in mid-2022 in China, with selected Chinese and international partners. Invited partners pay their own cost.

## WRITING

6

Write the final report and finalize the project.

**2022 NOV. - DEC.**

Presentation of the final results to Chinese partners.

Formal project closure.

Presentation of final PM to TRV.

* ERS = Electifiaction of the transport system.

HALMSTAD UNIVERSITY

LUND UNIVERSITY

TRAFIKVERKET

vti

JÖNKÖPING UNIVERSITY