

*EVS30 Symposium*  
*Stuttgart, Germany, October 9 - 11, 2017*

## **e-Mobility tour Gothenburg Sweden**

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### **Abstract**

The lecture will be composed of nationally highly appreciated examples of initiatives within electromobility field from Göteborg, Sweden's industrial hub, aiming for sustainability and low climate impact. The initiatives cover public transport as well as goods distribution solutions. Considerations for city development and the integration of different transport modes into new city planning will be discussed, as well as a view on socioeconomically values with different technologies. Competence and business landscape within Swedish electromobility will be presented and ground breaking private public partnership projects exemplified, followed by a deeper dissemination of learnings from them. Special attention will be given to the ElectriCity project, the latest findings from this private-public cross-collaboration project. The lecture on the topic "e-Mobility tour Gothenburg Sweden" is aimed for the Section 7.2 Urban mobility Concept at the EVS30 conference.

*Keywords: e-Mobility, City development, Competence, Business, ElectriCity*

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## **1 City of Gothenburg**

Gothenburg is a port city with a strategic location between Oslo and Copenhagen. It is also Sweden's second largest city, awarded as the environmental city of Sweden (2015) and famous for its continuous work with sustainability issues.

With roots stretching back to the days of heavy industry, our region has made the successful transition from an industrial heartland, to a greener, cleaner waterfront metropolis. It is this journey that has created a world leading greentech cluster in the Nordic region and with a special focusing on Waste, Transport, Energy and Urban Development.



Figure 1: City of Gothenburg

Today, Gothenburg, figure 1, is seen as a forerunner in environmental and urban development and one of the world's most progressive cities when it comes to addressing climate and environmental problems and within the field of sustainable mobility solutions.

We use the Swedish co-operation model, based on our capability to conceptualizing cross-sector collaboration and social innovation processes. In Gothenburg, we speed up the City's Innovation Strategy's time to impact by covering the entire "Penta Helix". Gothenburg has the resources to quickly mobilize the right skills, both internally within companies but also through consulting and services, often through PPPs.

Business Region Göteborg AB, (author) is a fully owned company within the City of Gothenburg, working in the field of cluster development and innovation and manage the Green Gothenburg platform, [1]. The author Per Österström, Head of Transport & Automotive at Business Region Göteborg, has been in charge of coordinating the city activities in the ElectricCity project.

## 1.1 Lecture composition

A brief introduction to Sweden's environmental transport goals, objectives, regulations and funding tools will be presented, see Section 2.2.

In the City of Gothenburg, several initiatives are effective within the electromobility field, aiming for sustainability and low climate impact. The initiatives cover everything from public transport, private people transport and goods distribution solutions, see Section 2.3.

Views on city development, the objectives and challenges and the integration of different transport modes into new city planning will be touched upon in Section 2.4.

Finally a deeper view on ground breaking private public partnership projects Electricity will be given, see Section 2.5.

## 2 e-Mobility tour Gothenburg Sweden

### 2.2 Support for e-Mobility: Sweden environmental goals & objectives

The transport sector is responsible for one third of emissions in Sweden. Given the existing lifetime of 17 years for a new car set in traffic in Sweden, firm actions has to be taken where new technology and new mobility sharing solutions are introduced together with much more use of and more attractive public transport solutions, to deal with the environmental problems. The Government has recently submitted a proposal to the Riksdag to reduce transport emissions by 70 per cent by 2030, compared with 2010.

According to Swedish transport administration analysis, to be able to reach the national objective of 70 % reduction till 2030 and the intermediate objective of 95g CO<sub>2</sub> by 2021, the emission cut has to be at least 6g/km CO<sub>2</sub> every year from now until 2021, compared with the decrease of 4g CO<sub>2</sub>/km and year (2015). From 2021-2025 the emissions has to reach a level of 70g CO<sub>2</sub>/km and further 50g CO<sub>2</sub>/km in 2030.

To reach the goal, ambitious measures are required and as a response to this the Swedish Government is further gearing up climate efforts. New green vehicles with low emissions of carbon dioxide will qualify for a bonus at purchase, while new vehicles with high emissions of carbon dioxide will be taxed at a higher rate for the first three years.

The aim of the bonus–malus system is to increase the proportion of green vehicles and help achieve the objective of a fossil-free vehicle fleet. The vehicles that will be affected by the new system are cars, vans and light buses.

Below follows a summary on the proposal:

- Vehicles that emit zero carbon dioxide will qualify for the maximum bonus of SEK 45 000. Vehicles that emit a maximum of 60 grams of carbon dioxide will qualify for the minimum bonus of SEK 7 500. Vehicles that run on gas will qualify for a minimum bonus of SEK 7 500.
- An increase in vehicle tax (malus) is proposed during the first three years for light vehicles that run on petrol or diesel. There will be no increase in vehicle tax for vehicles that can run on ethanol or gases other than liquefied petroleum gas.
- For vehicles not covered by the bonus–malus system, the limit for when the carbon dioxide component of vehicle tax is charged is reduced to what a vehicle emits in carbon dioxide per kilometre in mixed driving above 95 grams, which means a vehicle tax increase for the vast majority.
- It is proposed that the environmental supplement for vehicles that run on diesel and meet the Euro 6 emission requirements be retained and the five-year vehicle tax exemption abolished.
- Vehicle tax for motorcycles will increase from SEK 180 to SEK 360 per tax year.
- Vehicle tax for cars, vans and light buses in the weight-based system is to be adjusted as a consequence of vehicle tax being raised in the carbon dioxide based system.

The bonus-malus proposal will further be decided upon and submitted during 2018.

From a car manufacturers perspective, the challenges is both to lower the CO<sub>2</sub> emission levels and at the same time deal with the new CO<sub>2</sub> emission test cycles, moving away from the NEDC (new European driving cycle) latest updated 1997, and adapting to WLTP (world harmonized vehicle test procedure) in the period 2017-2020. This transition will happen through

- “light hybridization” with the introduction of extra batteries and electrical engines together with conventional technology,
- with the introduction of electrical hybrids and a battery capacity for the reach of approximately 50 km distance and
- through full electrification

Because of the still too high battery prices (>200 \$/kwh) which in turn sets the price level of the car, the pace of roll out and buy of full electric cars in volumes world wide is still low in comparison to conventional cars. An estimated price levels of 150\$/kwh (2020) and with an improved battery cycle efficiency, will further help to push more vendors to introduce new electrical cars (with a penalty on the revenue figures). When battery price levels reaches around 120\$/kwh the production cost of electrified cars approaches the price level of conventional cars.

Already today the electrical hybrids and full electric cars on the Swedish market meets the requirements of the Swedish set levels in the proposed bonus – malus system and shows CO<sub>2</sub> levels below 50g/km.

Given the Swedish car fleet consists of about 6,6 million cars in traffic (2016), which is about 75% of all vehicles in Sweden, and that about 80% of those cars move less than 40 km/day, an approximately 80% of the Swedish car CO<sub>2</sub> emissions could be cut by a heavy introduction of electrical hybrids. The total CO<sub>2</sub> emissions from cars in Sweden (2016) indicated a level of 10,61 million ton/year, which means a substantial cut of about 8 million tons CO<sub>2</sub> yearly.

Still, given that full electrified vehicles are estimated to be about 4 times more energy efficient and that energy in general is a scarce resource, a system with higher subsidies and a tax also adapted for electrified vehicles could benefit both the introduction of more full electrical cars and balance the lowering of the tax income on conventional cars. This way, as they are phased out new tax income from electrified vehicles could be generated

In Sweden there are also questions raised about balancing national subsidies and align them not to increase second sale rate to other countries, i.e. risk of subsidising other countries with Swedish taxpayers money. Latest figures shows that the increase in un-registration of electrified cars are forth fold the last years, with an increased flow of environmental cars mainly re-sold in Norway.

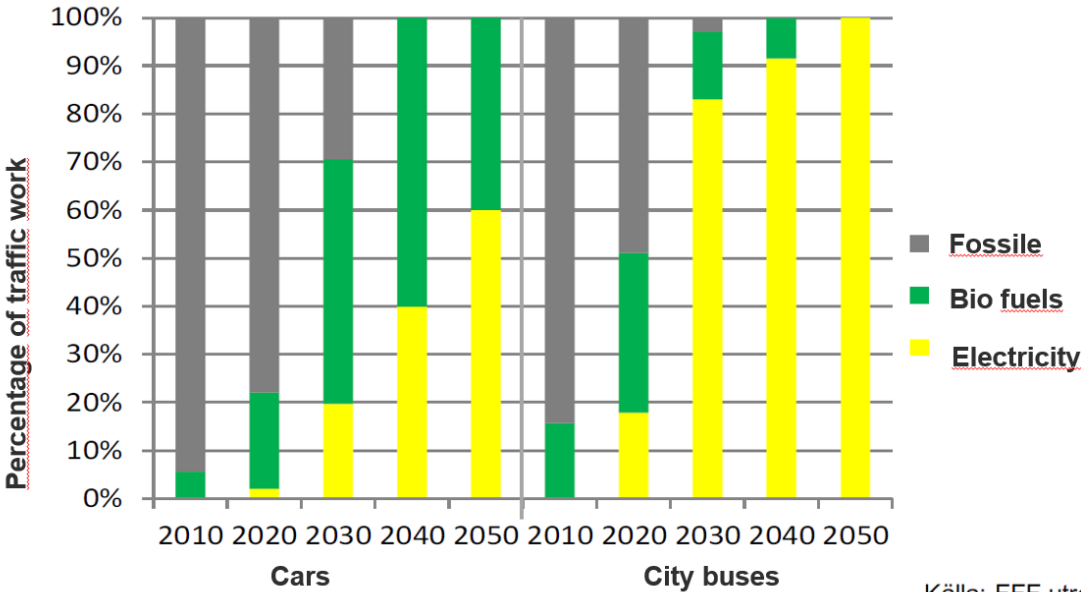


Figure 2: Swedish government fossile free fuel investigation (2013)

In 2013, the fossile free fuel investigation, done by the Swedish government, pointed out that the city bus segment would be the fastest to pick up the electrification trend. This introduction now foresees to take-off, figure 2.

The Swedish Transport agency has recently investigated and put forward a proposal to the Swedish government on environmental zones. The proposal suggest that two new zones are being introduced:

- Environmental Zone class 2 Involves cars, vans and light buses. Diesel Vehicles fulfilling Euro 6 requirement and vehicles run on petrol, ethanol or gas fulfil Euro 5 requirements

- Environmental zone class 3. Involves cars, motor bikes, mopeds class 1 and light and heavy trucks and buses. Light vehicles are required to run on electricity or hydrogen and heavy vehicles on electricity, hydrogen or is of the type of electrical hybrids that fulfil Euro 6 requirements.

The municipalities are still to be regulating and decide on the environmental zones. The proposal is that the police surveil and make sure that the regulations are followed. Also new road signs will be made for those environmental zones.



Figure 3: Environmental zone Gothenburg



Figure 4: Before implementing environmental zone.

More about the Gothenburg environmental zone defined in the central area of Gothenburg, can be seen in figure 3. In last 10 years we have made huge improvements to deal with congestion, emission, noise and safety problems within this zone, see figure 4 and today created a much more liveable and attractive city area, figure 5.



Figure 5: Gothenburg liveable city today.

## 2.3 Electric vehicles: mapping the value chain

Business Region Göteborg has a national mission to coordinate regional actors and companies within the field of sustainable transport for export. A mapping has been conducted covering 60 Swedish companies in the value chain from vehicles, battery technology and energy storage to infrastructure. Swedish e-Mobility business and research will be presented, see aggregated data in figures 6&7.



Figure 6: Swedish e-Mobility Centre, a research collaboration platform

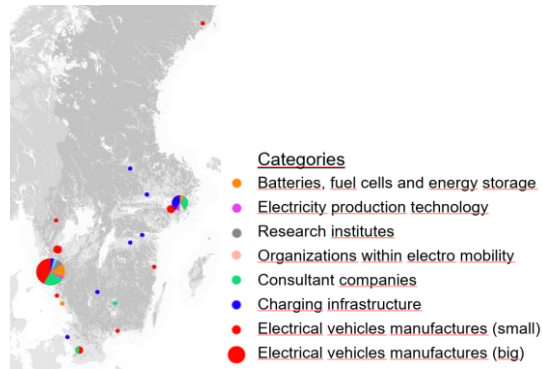


Figure 7: The Swedish Business landscape within e-Mobility

## 2.4 e-Mobility initiatives: city planning and social values

The coming years, the public and private sector of Gothenburg region will spend estimated 100 billion Euros on buildings and infrastructure, in order to comprise 1,8 million people in 2030, see figure 8.



Figure 8: The Rivercity project, northern Europe's targets urban development program in central areas of the city of Gothenburg.

The city development process involves driving sustainability questions and with the objectives to address societal challenges as social inclusiveness, economical growth and environmental aspects, where different ways to make the city much more attractive and liveable through the integration of public transport solutions with city planning are part of our means.

Examples of societal cost will be given, as for example related to road noise, where health problems, lower real estate values, and the cost of noise prevention are considered.

We will present measurements from buses with different technology, electric, gas and diesel buses and how they affect the noise levels and sound maps in the city, se figure 9

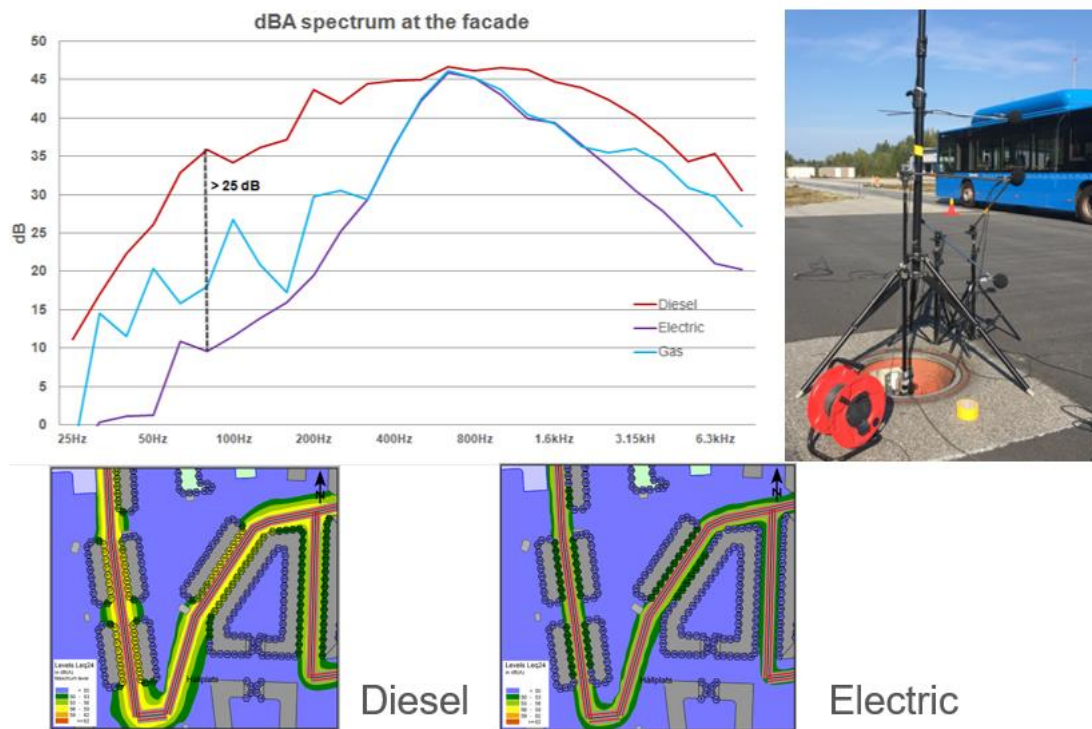


Figure 9: Sound map and frequency spectrum

We will also touch upon the traffic safety aspects and our work with Vision Zero - no fatalities or severe injuries in Gothenburg traffic, and the way we use hospital data to take decisions on speed reduction. The geofencing technology aspects will be further investigated and discussed both from a zero emission zone and environmental goals approach, but also considering safety aspects, being able to control the vehicle speed in sensitive areas, see figure 10

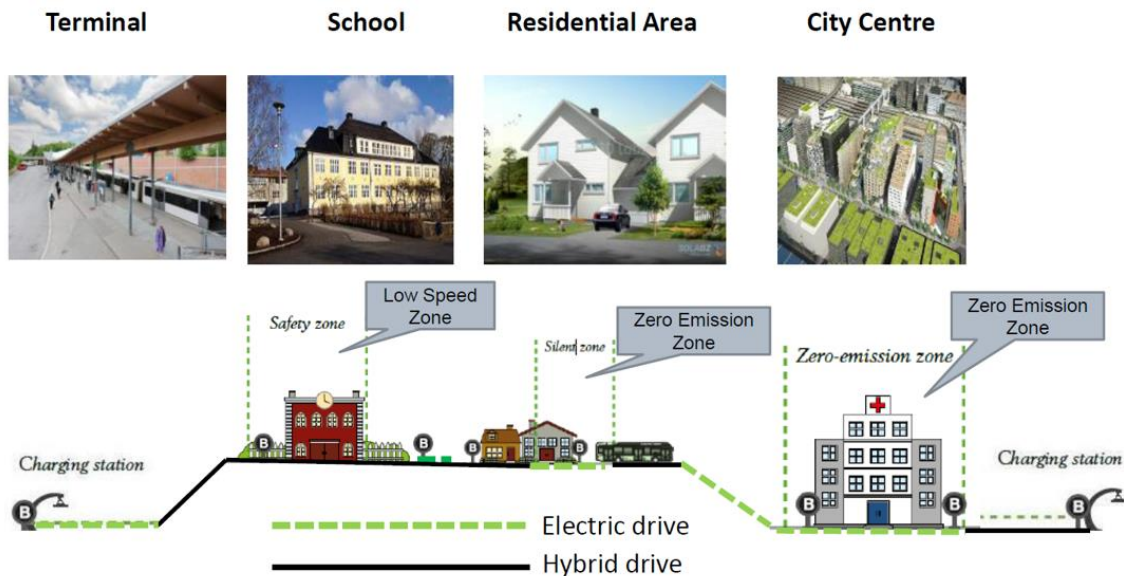


Figure 10: Geofencing technology (source Volvo)

The geofencing technology provides opportunities for a city to test and run traffic in areas previously prohibited because of noise or safety reasons.

One way to drive social inclusiveness is to provide more of and much more attractive public transport solutions.

The lecture will compose of examples how to make public transport much more attractive and examples will be given, both to new technology in buses, the bus stops and city development in general, see figure 11&12.



Figure 11: The ElectriCity project, indoor bus stop library.



Figure 12: The ElectriCity project, Christmas bus.

We will also show a rock video of one of the campaigns we run in the beginning of the ElectriCity project, where Zara Larsson the famous artist launched her new song inside the quiet electrified bus, see figure 13



Figure 13: Zara Larsson singer

E-Mobility and the integration of different transport modes with the city planning is part of the City of Gothenburg solutions, see figure 14, and which follows the city strategies and mode shift, figure 15.



Figure 14: Examples of e-Mobility initiatives in Gothenburg

Some other examples from figure 14 will be presented, as example “Stadsleveransen” – a last mile delivery solution, figure 16, with a common goods reception for business in the inner city. The concept is build on consolidating last mile delivery with electric powered vehicles.

### Our transport strategy

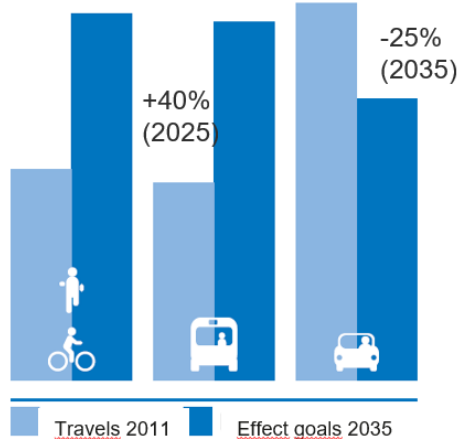


Figure 15: City Transport strategy



Figure 16: Stadsleveransen

## 2.5 The ElectriCity project: electrified silent bus

“Gothenburg set a new definition for accessibility of public transport”, states a CIVITAS award from 2016. In a new report by the United Nations Secretary-General’s High-Level Advisory Group on Sustainable Transport, our cooperative venture ElectriCity, a full scale implementation of an electric bus system, is highlighted as an innovative collaboration in the field of new, clean public transport. What happens when noise and exhaust fumes disappear? In our lecture, we will present a deeper view on ground breaking private public partnership project ElectriCity.

ElectriCity is a cooperative venture in Gothenburg bringing together industry, research and society to develop and test new solutions for next-generation sustainable public transport. The project started year 2013 and comprises 15 partners, such as the City of Gothenburg, AB Volvo, Ericsson, Västra Götalandsregion, Chalmers Institute of Technology. ElectriCity involves developing, testing, demonstrating and evaluating solutions which will contribute to the establishment of new, sustainable, attractive public transport systems and open up new opportunities for travel at urban planning in the future. The result is the innovative electrified bus route 55, see reference [2] and [3] which has experienced high international attraction from city planners, UN and C40 network.

The ElectriCity project is based on the principle of co-creation where the partners involved have common questions that they work together to find answers to. The lecture will discuss about how to create good preconditions to solve the societal challenges and create public welfare through co-creation and cross-collaboration. Ways to explore and exploit will be highlighted. The lecture will describe the different phases from establishment to operation of the ElectriCity project and success factors involved with it.



Figure 17: Bus Rapid Transit System

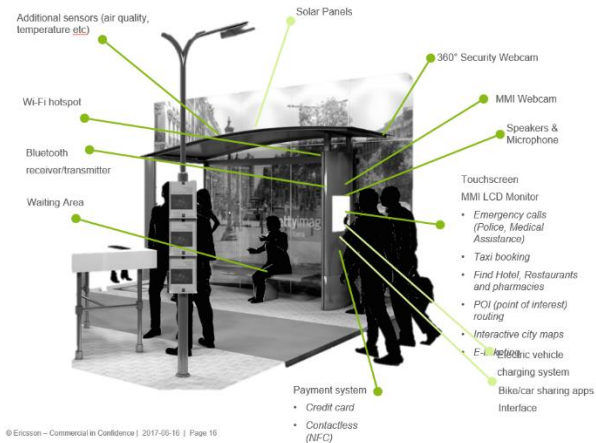


Figure 18: Connected bus stops (source Ericsson)

At present, the project main focus areas are; sustainable city development and the integration of transport with new buildings and city growth plans, high capacity electric public transport, figure 17, automation – and safety solutions, connectivity solutions figure 18, 19 & 20, services and business models. The lecture will present latest updates.



Figure 19: Sensor data (source Ericsson)

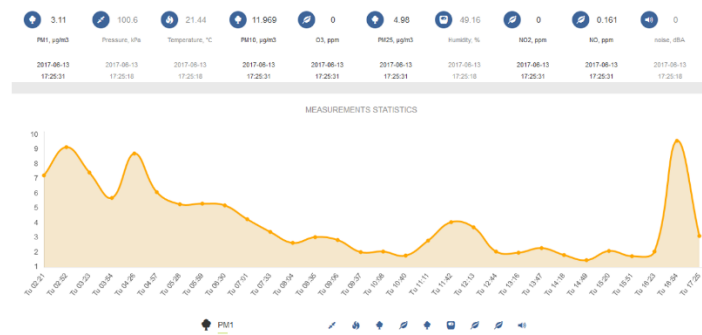


Figure 20: Sensors on the bus and the bus stops (source Ericsson)

Already today the project has translated to other areas in Europe that are setting up and runs electrified bus lines based on the concept of ElectricCity. The project has given high attention internationally and outside Europe with thousands of delegates from other cities, companies and researchers visiting Gothenburg to learn and see what we have achieved and to bring back home. The city of Gothenburg has a well established organization that helps to setup programs for delegations, in Green Gothenburg that offers expertise, inspiration and useful business contacts through unique visiting programs, based on the needs of the delegations, see figure 21

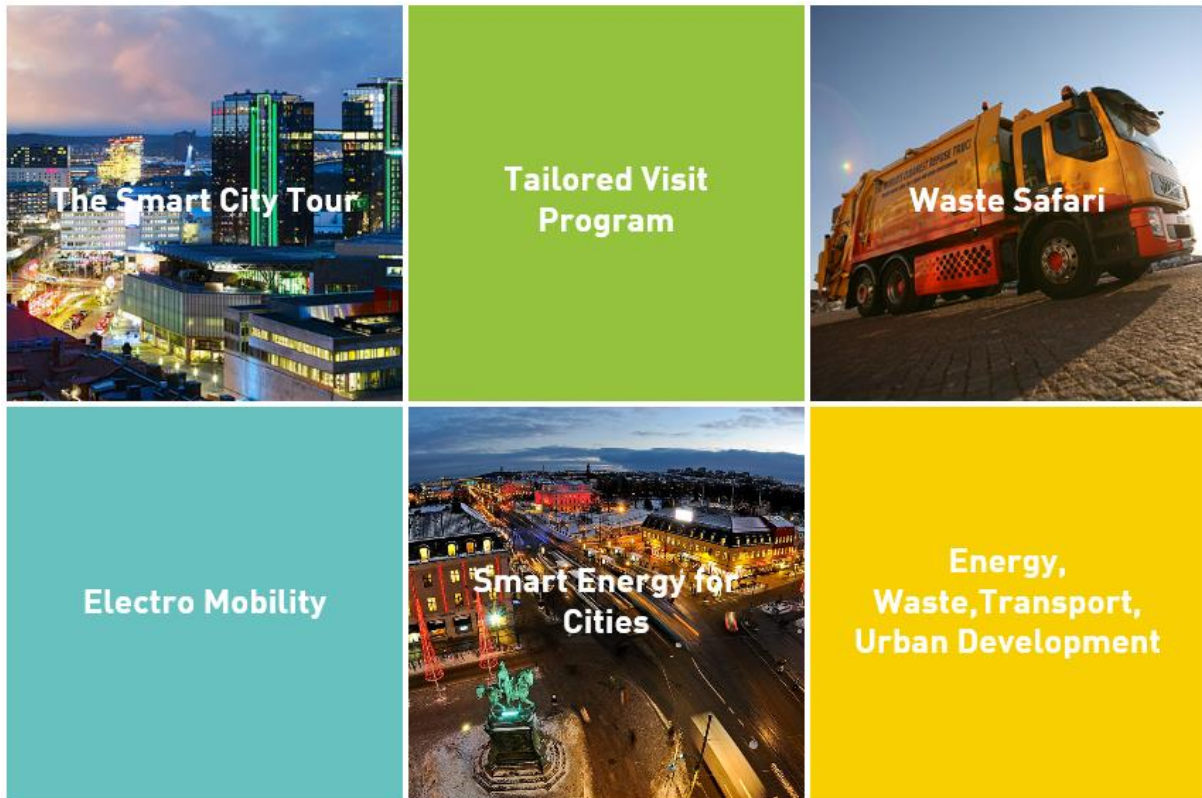


Figure 21: Green Gothenburg visiting programs.

## References

[1] Green Gothenburg Platform: <http://www.greengothenburg.se/>

[2] ElectriCity, highlighted in the UN report: <http://www.goteborgelectricity.se/en/news/electricity-and-route-55-highlighted-un-report>, Nov 2016

[3] ElectriCity, Status report: <http://www.goteborgelectricity.se/en/news/status-report-electricity>, June 2016

## Author

Per Österström has many years of experience in the Automotive, Telecom and IT sector as a manager for development teams. Holds a degree as Master of Science in Applied Physics and Electrical Engineering. Head of Transport and Automotive at Business Region Göteborg. Extensive experience from the EV sector through collaboration with the industry, the research and the public sector. Since 2015 coordinator of the private-public partnership project ElectriCity in Gothenburg.

