

32<sup>nd</sup> IASP World Conference on  
Science Parks and Areas of Innovation 2015

Beijing, China

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**Silent, emission free electric buses and tranquil urban  
oases - good prospects for tomorrow's cities**

*Plenary Session 1 :*

The impact of technology

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## **Silent, emission free electric buses and tranquil urban oases - good prospects for tomorrow's cities**

### **Executive Summary**

This paper deals with two projects that address both the issue of e-mobility and sound pollution, two interrelated themes. Johanneberg Science Park is part of both projects with responsibility for city planning and urban development aspects.

ElectriCity and Controllable Urban Soundscapes have been developed as separate projects addressing noise and emissions, paving way for integrated traffic and building solutions for dense, quiet and healthy cities. Now, the science park aims to combine results and knowledge from the two projects in a coordinated approach to achieve even greater impact.

There is no shortage of projects that aim to explore new ideas and avenues to improve sustainability of urban life. However, true effectiveness and impact of such innovations often require that they be integrated as parts of larger schemes, on city or district level. In Gothenburg, Johanneberg Science Park assumes the role of coordinating urban sustainability initiatives in order to bring about just this.

## Introduction

Cities are becoming increasingly bigger and are attracting ever more dwellers. Today, more than 50 % of the world's population is estimated to live in cities, and the proportion is expected to continue to increase rapidly in the foreseeable future. This makes it tremendously important to work to achieve an increased sustainability of urban life. Not only do we need to develop and put new technologies and solutions to use, we must also endeavor to influence human behavior in order to increase the likelihood of people acting in a sustainable fashion, and provide the motivation and awareness needed to embrace a lifestyle that can be supported by the world's limited resources.

There is no shortage of projects that aim to find and explore new ideas and avenues to improve the sustainability of urban life. However, true effectiveness and impact of such innovative projects often require that they are integrated as parts of larger schemes, on a city- or district level. In Gothenburg, Johanneberg Science Park has assumed a coordinating role for urban sustainability initiatives in order to effectively realize the vitally important goal of creating a sustainable city.

ElectriCity and Controllable Urban Soundscapes have developed as two separate projects which both, but from different angles, approach and address the same challenge; noise pollution, and which provide opportunities to establish integrated solutions for carbon-free traffic integrated with buildings in order to create dense, silent and healthy cities.

## Challenge: Decrease the carbon dioxide emissions and reach climate goals

The world is faced with making a crucial decision when it comes to energy. In order to curb the climate changes, protect valuable environments, and secure access to energy in the future, we need to choose to radically decrease our dependence on finite and environmentally hazardous fossil fuels. For this to become a reality, we need alternatives that are economically and socially viable and sustainable.

Chalmers University of Technology conducts extensive research on amongst other things, sustainable production of energy, increasing energy efficiency, smart electricity networks, environmentally friendly vehicle technology, and carbon sequestration. Developing electrically powered vehicles and alternative means of transportation are important parts of the work done by both Chalmers and Johanneberg Science Park. With a new fleet of vehicles where more vehicles are powered by electricity, there are now great possibilities to create more sustainability in cities around the world with less emissions, less noise pollution, and which are both denser and greener. [Känns påklustrat på slutet av meningen]

## Challenge: Noise pollution in cities

According to the WHO, noise pollution from traffic is the second largest environmental issue in the EU. Second to air pollution, noise pollution is the factor which influences people's health the most. The problem is significant and relevant in many growing cities outside of Europe as well.

Noise pollution is a massive health-issue. At the moment, our cities are growing rapidly and it is very important that there is a plan for how the soundscape in cities will be developed. There are many things that can be done in order to decrease the amount of noise pollution in cities, but there have to be solid plans for how to design and create a sustainable soundscape from the beginning when planning new neighborhoods.

A constant roar from the freeway, thumping sounds from trams passing by, airplanes taking off, and a bus decelerating right before again accelerating. Most noise pollution in an urban environment is produced by different kinds of vehicles, and when it reaches our ears it can make us lose our concentration and feel depressed. It can lower our ability to learn, disturb our sleep, create stress, raise our blood pressure, or even give us diabetes and heart disease.

Unlike most other environmental risks, noise pollution keeps increasing and get worse. The main reasons for this are the increases both in urbanization and in the amount of traffic. There is a substantial demand for housing in the cities, and much of the land available for building new houses is in close proximity to thoroughfares and traffic arteries. And except for the fact that the current recommendations in many cases are not respected and adhered to, there is also great pressure being placed on legislators to raise the recommended sound levels, hence making it easier to build in noise polluted environments.

A few years ago, a study conducted by the UN's world health organisation, WHO and the EU-countries' common center for research, was published which showed how noise pollution deprives Europe's citizens of a total of one million years of healthy life – every year. In Sweden alone, calculations have been done suggesting that over 1,7 million people are exposed to noise pollution exceeding the current benchmark of 55dBA immediately outside of their homes, and that between 300 and 800 people annually die sooner than they should as a result of being exposed to noise pollution. The number of people who died in traffic related accidents was 263 last year. Disturbing loud noises constitute an underestimated and growing health issue in Europe, and it has been estimated that every fifth inhabitant in Europe are constantly being exposed to sound levels high enough to significantly negatively influence their health.

We might not always be consciously aware of it, but the sound environment can be what determines if we choose use our balcony, choose to go to a particular café and sit in the outdoor seating area, and if we perceive a town square as pleasant and a park as natural.

In 2014 the report Quieter Cities of the Future was published by The CAETS Noise Control Technology Committee and the International Institute of Noise Control Engineering. The report was produced by the professors Tor Kihlman, Wolfgang Kropp, and William Lan, and it emphasizes the need for new solutions when it comes to noise pollution in the cities, and the negative effects caused by noise pollution.

The industry's various actors also need to take responsibility and assume active roles in transitioning into more sustainable cities with decreased emissions and noise. Commercialized solutions are being developed in Gothenburg and a central actor partaking in these developments is Volvo. Collaborative projects have been initiated in Gothenburg aimed at developing holistic solutions for a fully electrified transport-grid with the intention to decrease emissions substantially, and which also address the challenge of noise pollution.

"It is a well-known fact that noise pollution is a danger to our health, and it is our full conviction that electrically powered transportation in cities is the right way forward when striving for sustainable transport solutions. We consider this study to be a confirmation what the electrically powered buses we soon will be launching in Gothenburg will contribute to a better and more welcoming city by being free from both noise and emissions", says Niklas Gustavsson, Chief Sustainability Officer at Volvo Group.

In June 2015, the bus line ElectricCity will begin to run in Gothenburg. The route between Chalmers Johanneberg and Chalmers Lindholmen will be operated by silent and emission-free electrical buses which pick up passengers indoors and are powered by renewable electricity from wind and hydropower. The project was initiated by Volvo in collaboration with Chalmers, the Swedish Energy Agency, Region Västra Götaland,

the City of Gothenburg, Göteborg Energi, Västtrafik, Lindholmen Science Park and Johanneberg Science Park.

### **Johanneberg Science Park's role as a catalyst**

Evidently the two projects described above share many common aspects and promise a wealth of synergies can they be fit into an integrated plan and approach for sustainable urban development. Since Johanneberg Science Park is part of both projects, the science park has seized the opportunity of bringing them together in a larger concept. The currently initiated pre-study will use the accumulated knowledge from these and other ongoing projects dealing with transportation, mobility and terminals/bus stops to bring the new solutions from the prototype stage to district level usage with the aim to achieve national and international breakthrough. The pre-study will explore the feasibility of such up-scaling connected to city planning and provision of innovative services concerning mobility and transportation. This serves as a prime example of how a Science Park can use its position between and connections to academia, business and public governance to promote new technology and new solutions, and speed up acceptance and wide spread implementation of new ideas that will increase quality of life and lead the way towards a more sustainable future.

Johanneberg Science Park's focus on urban development and sustainable development constitute the third essential piece of the puzzle. If Volvo is to become world leading in sustainable transportation, it is no longer only about getting as close to zero emissions as possible, but to take the next step and contribute actively to the development of the society as a whole. The challenge is no longer limited to developing clean buses, but is now rather about incorporating all parts into a holistic solution and make them function smoothly together. It is a transition from improving the pre-requisites for public transportation, to developing safe and healthy urban environments.

Volvo's vision is to be world leading in providing sustainable solutions for transportation, and ElectriCity is an important step in realizing this ambition. The collaborative project has made it possible to actualize and implement the idea by using the buses in the environment they are intended for.

### **ElectriCity**

During the summer of 2015, Gothenburg will see a new bus route operated by vehicles which are completely silent, free from pollution and emissions, and powered by renewable electricity (Figure 1).

The buses will run between Johanneberg and Lindholmen, and are part of the project ElectriCity – a collaboration in which industry, research and society conjointly develop and test new solutions for the future's sustainable public transportation system. ElectriCity is a collaborative project which functions both as a platform for research and a demo-area, and as an actively part of Gothenburg's public



Figure 1 ElectriCity Electric Bus with charging fixture

transportation system. New techniques for supplying and storing energy are tested, and different solutions and ideas for bus stops, as well as traffic management systems are being developed. The ambition is to eventually up-scale the project outside of the demonstration arena.

The Volvo Group initiated ElectriCity and are responsible for developing the vehicles used in the collaborative project. The technology needed has been available for some time but the challenge has been to develop batteries that are economically viable and sustainable. Volvo made the strategic decision a few years ago to not construct city buses with diesel engines, but rather invest their efforts into developing electrically powered vehicles. It was an educated guess and gamble at the time since the technology then needed to be developed further, but in order to become world leading, you need to take risks, says Niklas Gustavsson, Chief Sustainability Officer at AB Volvo.

### An opportunity for open research

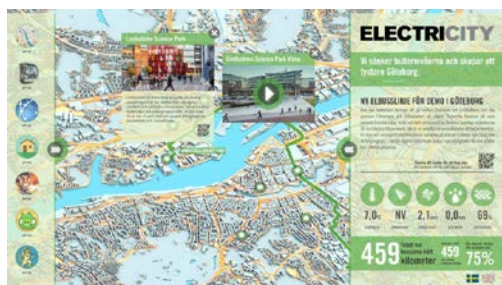


Figure 2 Interactive screen for ElectriCity bus stops

The collaborative project is run by AB Volvo, Chalmers, Johanneberg Science Park, Lindholmen Science Park, The Swedish Energy Agency, the City of Gothenburg's Traffic Administration Office, Göteborg Energi, Region Västra Götaland and Västtrafik. Out of the 18 million SEK Region Västra Götaland is putting into the project, 10 million SEK are reserved for open innovation. This provides companies and research institutes with the opportunity to develop and test new solutions which could possibly contribute to attractive and sustainable traveling. Research will be conducted in a number of

areas; both partly in areas concerned with technological development, but also in behavioral research, such as studying how to make public transportation into a more attractive option. Figure 2 shows the design of an interactive screen for passenger information proposed for the bus stops.

Volvo are partners in both Johanneberg Science Park and Lindholmen Science Park. Volvo's office for Public & Sustainability Affairs is located at Lindholmen, which is both a strategic and natural location considering that Lindholmen Science Park has transport as one of its focus areas. Through the bus line, which will be assigned number 55, the two parks will be tied together both physically and in terms of content and activities.

### The electric bus

- Silent and completely free of emissions.
- Drives the entire route (approximately 8 km) on electric power.
- Charges its battery completely in six minutes (Figure 3)
- Uses 80% less energy than a conventional diesel bus.
- 0% carbon emissions when using renewable electricity.
- The bus is equipped with WIFI and USB-sockets for charging phones and tablet devices.



Figure 3 Detail of charging fixture and pantograph

## Demo arena for new products and services

Within ElectriCity we are creating a platform for developing and testing products and services which can contribute to making public transport more attractive. Examples of the solutions explored in the project are ideas for new bus stops, traffic management systems, concepts for safety, and systems for supplying and storing energy. New business models for sustainably mobility will be tested as well, and the idea is for these to eventually be up-scaled outside of the demonstration arena.

## A platform for research

When an electrically powered bus moves through an urban environment, and for instance stops and charges its batteries indoors, new situations which might be interesting to researchers occur. These could for instance be how pedestrians and other vulnerable road-users are impacted by buses which are almost completely silent, or how travelers perceive and use the new solutions which the bus line will be equipped with. How do you manage the indoor climate in an environment where there are buses continuously coming and going? How should the electrical systems be designed? And last but not least – how can cities be planned in new and better ways(Figure 4)? New research could address and answer such questions.



Figure 4 Silent, emission-free buses allow new solutions in urban planning

## Controllable Urban Soundscapes

There are vast and wondrous possibilities in a city with access to almost anything. But having all kinds of human activity gathered in a small space also results in a substantial amount of noise. Constantly being exposed to loud noises can cause stress, difficulties to sleep, and eventually induce cardiovascular diseases,

which are all typical problems related to major cities.

A playground or a tram passing might not in itself be a major danger to our health by producing high sound levels, but it is the combined total of all the sounds of the city which constitutes noise pollution. The noise a city produces can be compared to the noise made by the Niagara Falls, with the difference being that as our senses perceive the natural context with the sound of the waterfall, this sound is not as damaging as the noises produced in a city.

Poor acoustic environments constitute a major problem and one of the environmental hazards that on a daily basis affects the greatest amount of residents in Gothenburg. But this need not be the case. There are solutions available which create healthy sound environments.

Controllable Urban Soundscapes is a collaborative project intended to create harmonic oases which are free from disturbing noises made by for instance traffic. Using advanced technology, disturbing sounds from roads nearby are muted. Sound can also be added to or altered in an environment in order to create a pleasant soundscape. Birds singing, music or trickling water are a few examples of sounds which can be added to a space or an environment.

There are currently many passive solutions to counteract noise pollution, such as noise screens and barriers, but few active systems. The systems being developed at the moment are made in modules, which makes them easy to adapt and place in a variety of different environments and contexts.

The technology is being tested and demonstrated in Gothenburg as well as in London where there is extensive experience in working with green environments. Prototypes will there be tested in small "Pocket Parks" in the city centre. The first environment selected for testing in Gothenburg will be one of the terminal stops in the ElectriCity project.

There has been a need to create silent environments for a long time. This project is the testing of a simple and movable system which might make it possible to build denser cities. The next step will be to test the system in parks, in walkways and on bicycle paths. As the modules develop, they might become applicable to for instance a town square, a larger public park or a school yard.

Controllable Urban Soundscapes is a collaboration between Johanneberg Science Park and the innovation company IMCG who run the project and the innovative process, as well as SP Technical Research Institute of Sweden. The University of Gothenburg and KSE Gruppen AB contribute with research expertise and experience relative to the subjects of acoustics, technology and test labs.

Johanneberg Science Park's role is to manage the project and coordinate the city's actors. A total of 20 million SEK is invested in the project, out of which 10 million come from Sweden's innovation agency, Vinnova. By using advanced technology, the project group will reduce disturbing noise from adjacent roads. They will also add sounds such as birds chirping and rippling water in order for the environment to be perceived as more harmonious. There are currently mainly passive solutions to reduce noise in place, such as noise barriers, but very few active systems and solutions are available.

It is also important to complement the added sounds with a visual aspect that enhances the effect of the auditory modifications. How you are influenced by sounds and noise depends on how you perceive it. The sound of water can be very noisy, but in one context it can be perceived negatively and in another positively. If you are provided with an image of a fountain as you are hearing the sound of water, it is more clearly



associated with water.

There is unquestionably a significant need to be addressed. We will work with module-based systems in order to facilitate for third parties involved. This is an important aspect and part of the project, and the project has already received requests from researchers who are working with the development of glass.

The work of developing a technical infrastructure which makes all the parts function smoothly is commencing. The technique will be demonstrated in Gothenburg and London throughout 2015, and the goal is to create commercialized solutions and technical prototypes which can be presented to and launched on the market.

## Reducing noise

There are currently three available tools for managing sounds and noise pollution in cities.

When for instance a park lies too close to a major road, the first step is usually to isolate the park from the noise. This is done by putting up a barrier or screen of some kind. You thereby stop the noise from reaching the park, but the noise will not disappear completely, only be removed a little further away.

One way to counteract this incomplete elimination of the noise would be to attach something that absorbed the noise as it travelled upwards along the noise barrier, such as a roof. By using absorption, the sound is encapsulated in the material which makes the noise disappear rather than only transfer from one location to another.

The third common tool used is diffusion, which means spreading the sound in different directions. In order to steer away noise occurring by a wall, it is crucial that you work with several walls which are not placed opposing one another, but rather for instance shaped as a hexagon.

Using all three tools simultaneously is of course the most efficient way to reduce noise pollution. Figures 5 and 6 show a prototype bus shelter developed for the ElectriCity electric bus service that employs a combination of different silencing techniques.



Figure 5 Sound-proofed bus shelter for ElectriCity



Figure 6 Detail (ceiling) of sound-proofed bus shelter

The solutions developed in the project Controllable Urban Soundscapes intended to create breathing-space in urban environments, are applicable to all major cities. The utility in terms of improved health and increased sense of enjoying the urban environment that can be generated by the project could impact millions of urban dwellers across Europe.

In the project Controllable Urban Soundscapes solutions are being developed for a wide range of applications:

- Noise barriers / with integrated bicycle paths or sidewalks
- Noise barriers with the option of having a silent spot behind the sound barrier
- Living plant walls which contribute to positive perception
- Rooms in the space – Small telephone-booths
- The possibility to encapsulate a place that produce a lot of noise, such as a construction site or similar contexts/situations
- Open landscapes with designated places for privacy and recreation. Modules connected to larger rooms with elements of living plant walls and walls made of glass in order to create different kinds of meeting-places and isolated spaces

The concept is based on shutting out as much noise as possible with soundproofing glass and to fill the construction with silencing materials. Three basic principles that are employed in the technology development are: Absorption, isolation and diffusion. A unique feature of this project is the crossdisciplinary collaboration, where both human and technology are in focus. Another novelty is the lateral thinking, where the soundscape is integrated in urban development and design. The application area, the combination of different technologies and the flexible design (delivered in flat packages – IKEA style) further set this project apart as innovative.

The collaborative projects ElectriCity and Controllable Urban Soundscapes make it possible for actors and SMEs to find new markets, and to develop their concepts and products. Johanneberg Science Park constitutes a central arena for these actors.

## Conclusion

When developing Johanneberg Science Park we aim to create a meeting-spot that is welcoming to all. The goal is to have a vibrant environment that accommodates researchers, students, city-dwellers, creative businesses and technologists, offering an attractive physical milieu as well as easy access to the latest research findings.

Future challenges will be complex and will require an holistic view and system-oriented thinking. In the Science Park, different actors meet in a boundary-crossing, innovative environment. The collaboration between stakeholders with different perspectives provides a strong foundation for the tests and demonstrations that are carried out in the Park.

We call our concept for collaboration Open Arena. In a neutral environment, business, academia and government jointly drive the development within our three focus areas – Energy, Urban development and Materials/Nanotechnology.

With focus on sustainable urban development, we are engaged in several projects demonstrated on the Johanneberg Campus and that contribute to the attractiveness of the area. Since noise pollution and greenhouse gas emissions are big challenges for growing cities, it is important for the Science Park to

participate in or lead projects such as TOR and ElectricCity, projects that will develop solutions to reduce noise and emissions and improve quality of life for city-dwellers. Initially tested in the Science Park area, they are also very much applicable for cities and partners everywhere.

These projects provide us with new knowledge in a realistic demonstration context and open up new possibilities and lines of thought. They are a means to attract new partners and also to foster collaboration between partners hitherto unknown to each other.