KTH – Energy and Climate Studies Unit

– Research themes and education –

Bioenergy systems

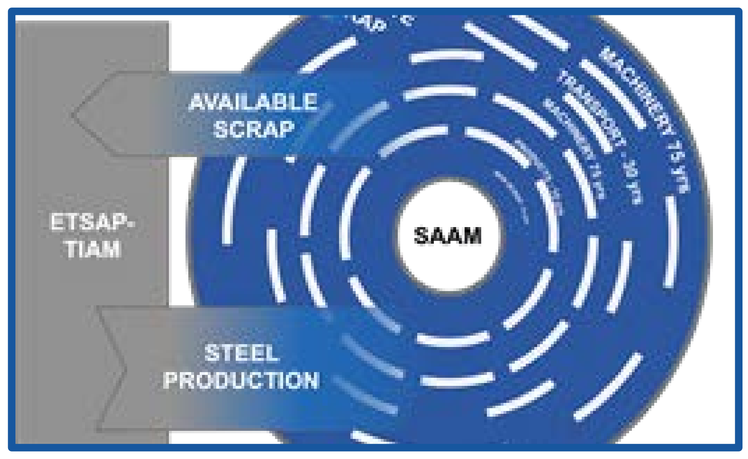
We look into ways through which the bioenergy potential can be realized in countries at different levels of development. We look into policies, technologies, industrial synergies, and creative ways to foster collaboration among countries towards the implementation of global and local social and environmental agendas.

Energy for sustainable development

We are exploring ways to promote electrification in developing countries particularly looking into policies, institutional organization and investment options. We analyze the development of markets for renewable options in developing country contexts and develop indicators to monitor policy implementation.

Energy systems efficiency

We are particularly interested in how different industrial sectors are evolving, and what the implications are in terms of energy demand and greenhouse gas emissions. In this context, we analyze energy efficiency improvement potentials and related requirements in terms of technological change and incentives to make it all happen.



Urban Sustainability

We focus on the development of livable and attractive cities with better integration of energy services into urban functions and industrial production. In this context, it is important to deliver energy services with high standards of safety, reliability and convenience, while also improving efficiency and reducing negative environmental and health impacts.

Master's study profile – Transformation of Energy Systems

A study profile for the MSc. Program Sustainable Energy Engineering (SEE) is offered in cooperation with other institutions at KTH focusing on energy policy and planning, modelling and management. Brazilian exchange students can choose to follow this profile.

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www.ecs.kth.se

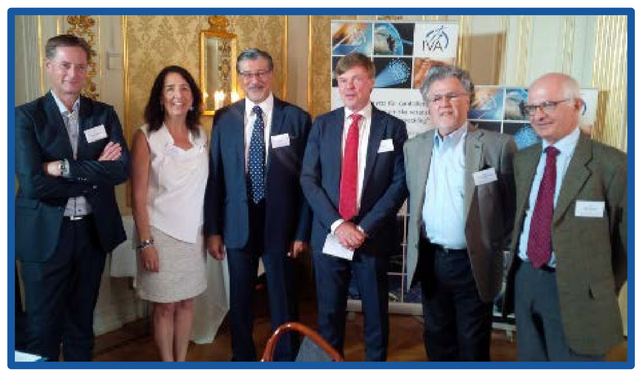
Smart City Concepts in Curitiba

– innovation for sustainable mobility and energy efficiency –

Transport and IT-based technologies open opportunities to rethink the development of cities. A consortium between Swedish and Brazilian stakeholders is exploring the deployment of these technologies together with new concepts for urban planning in Curitiba, Brazil. The project aims at sustainable technological solutions for the improvement of urban infrastructure.

About the project Smart City Concepts in Curitiba

In 2013, KTH, the City of Curitiba and institutions including local universities and the Federation of Industries of the State of Paraná signed a Memorandum of Understanding to develop projects in the areas of mobility, urban planning and environment. The MoU was signed in the presence of His Majesty King Carl XVI Gustaf of Sweden, the Mayor of Curitiba Mr. Gustavo Fruet, and a distinguished delegation composed of Swedish universities and industries. Since then, a consortium has been formed including KTH Royal Institute of Technology, VOLVO, SAAB Combitech, UTFPR (Federal University of Technology – Paraná), URBS (Urbanization of Curitiba S/A) and IPPUC (Urban Planning and Research Institute of Curitiba) to explore the deployment of technologies for improved mobility and energy efficiency in Curitiba, Brazil.



Project team

Prof. Semida Silveira, Project leader, KTH-ECS

Prof. Keiko Fonseca, Co-project leader, UTFPR

Dennis Dreier, KTH-ECS

Prof. Lena Wosinska, KTH-ONLab

Prof. Paolo Monti, KTH-ONLab

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Prof. Tatiana Gadda, UTFPR

Ingemar Johansson, COMBITECH

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Angelo Souza, CISB

Rafael Nieweglowski, VOLVO BUSES

Jessica Sandström, VOLVO BUSES

Renan Schepanski, VOLVO BUSES

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Elcio Karas, URBS

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Luisiana Paganelli Silva, IPPUC

Energy use and CO_2 emissions of city buses in Curitiba, Brazil

Dennis Dreier [a,*], Semida Silveira [a], Dilip Khatiwada [a],
Keiko V.O. Fonseca [b], Rafael Nieweglowski [c], Renan Schepanski [c]

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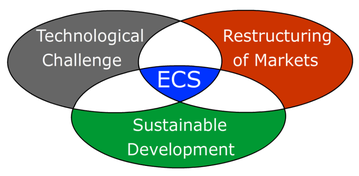
** Corresponding author (dennis.dreier@energy.kth.se)*

Energy and Climate Studies Unit
Department of Energy Technology
School of Industrial Engineering and Management (ITM)

The division of Energy and Climate Studies (ECS) has an interdisciplinary character with a strong systems approach, linking issues related to energy technology and policy, climate change and sustainable development.



At present, ECS works with five defined research themes:

- Bioenergy systems
- Energy access
- Energy systems efficiency
- Urban sustainability
- Energy and climate policy

www.ecs.kth.se

This research is part of a project aimed at sustainable technological solutions for the improvement of urban critical infrastructure in Curitiba, involving Swedish and Brazilian stakeholders.

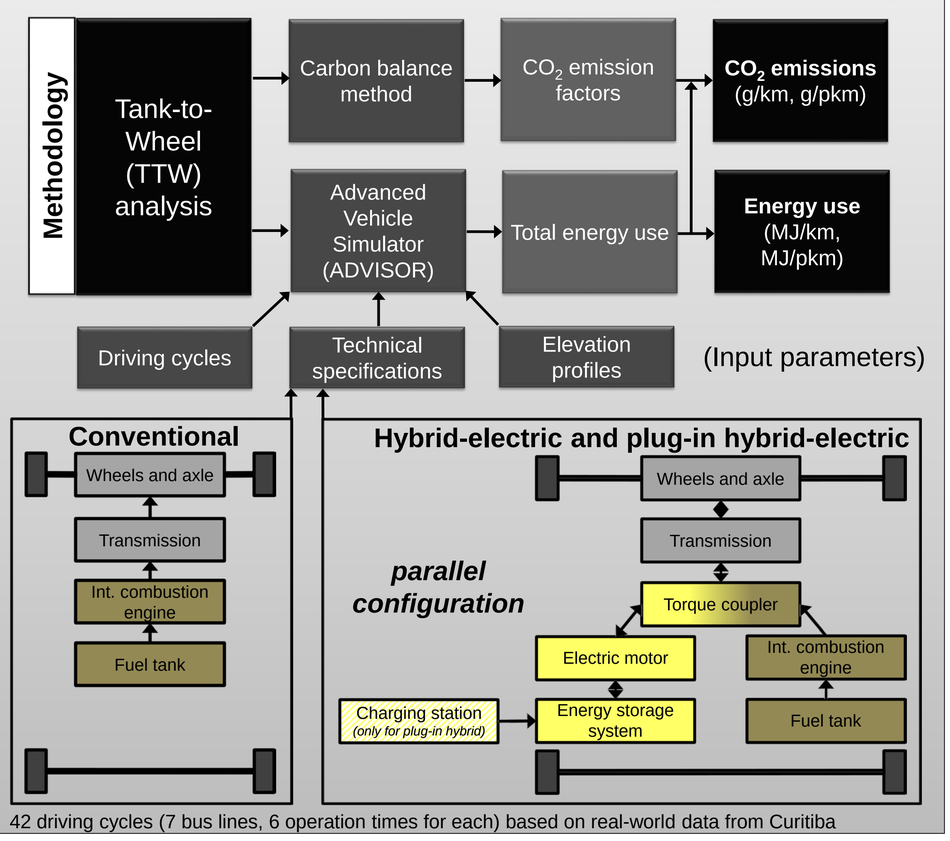
IN COOPERATION WITH:

VOLVO
COMBITECH
UTFPR – UNIVERSIDADE TECNOLÓGICA FEDERAL DO PARANÁ
CURITIBA
URBS
IPPUC
CISB – CENTRO DE PESQUISA E INOVAÇÃO SUECO-BRASILEIRO
VINNOVA

Curitiba's commitments

- Curitiba is member of the network C40 Cities Climate Leadership Group, committed to **reduce both greenhouse gas emissions and climate risks**
- C40 Clean Bus Declaration of Intent: Curitiba has committed to **reduce emissions from the transport sector** and to **improve air quality** through the **introduction of low or zero emission buses**, e.g. **city buses with advanced powertrains**

Modelling and simulation



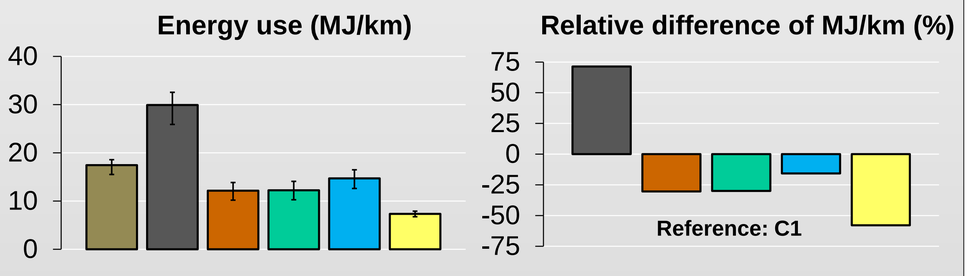
- 42 driving cycles (7 bus lines, 6 operation times for each) based on real-world data from Curitiba

City buses

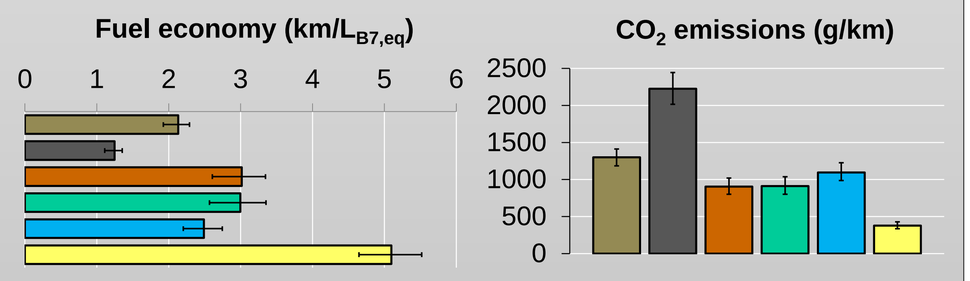
	City bus models		Powertrains	Chassis type	Passenger carrying Capacity	
Conventional powertrains		C1	Conventional	Two-axle	85	Operating today in Curitiba
		C2	Conventional	Bi-articu-lated	250	
Advanced powertrains		H1	Hybrid-electric (parallel)	Two-axle	79	
		H2	Hybrid-electric (parallel)	Two-axle	95	Potential alternatives for Curitiba
		H3	Hybrid-electric (parallel)	Articu-lated	154	
		P1	Plug-in hybrid-electric (parallel)	Two-axle	95	

- Picture sources of city buses: Urbanization Company of Curitiba (URBS) (http://www.urbs.curitiba.pr.gov.br/), Volvo Bus Corporation (volvobuses.com).

How do advanced powertrains in city buses affect energy use and CO_2 emissions during operation in Curitiba?



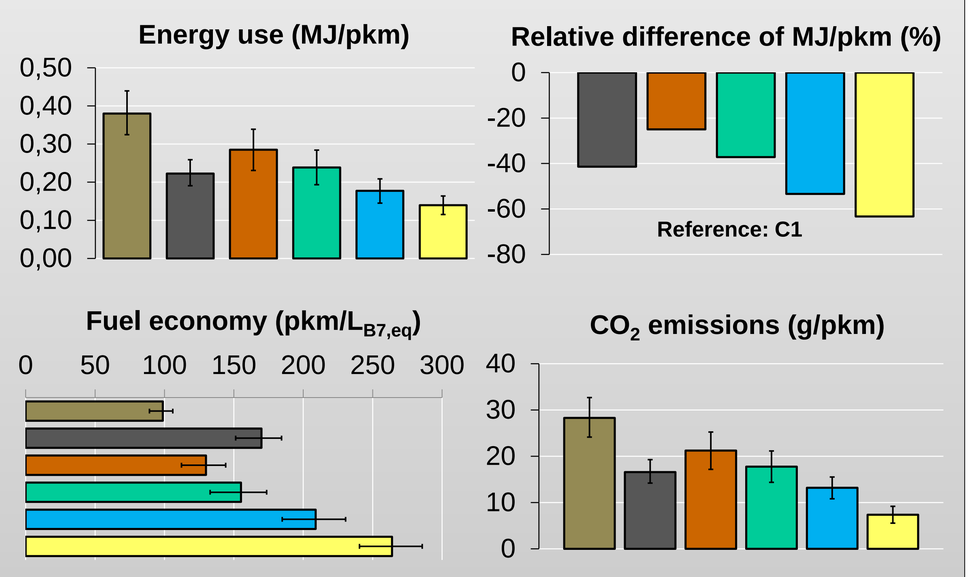
- **Advanced powertrains** (hybrid-electric, plug-in hybrid-electric) **can contribute to significant reduction of energy use[a] and CO_2 emissions of city buses**
- H1, H2 and P1 consume **30%, 30% and 58% less energy (MJ/km)** respectively, compared to C1 → **enormous energy saving potentials**



- H1, H2 and P1 **drive 42%, 42% and 139% longer distances** with the **same amount of fuel**[b] respectively, compared to C1 → **high fuel efficiency**
- **CO_2 emissions** (only from the tailpipe) are **linearly proportional** to energy use trends following from the applied **carbon balance method**
- **Future work:** Scaling up the analysis to city-wide public bus systems

[a] Ranges represent maximum and minimum estimations averaged over seven bus lines.
[b] Fuel properties of biodiesel blend (B7): Density: 0.856 kg/L; Lower heating value (LHV): 42.272 MJ/kg.

How do passenger carrying capacities affect energy use and CO_2 emissions of city bus operation in Curitiba?



- **Large passenger carrying capacities** (articulated, bi-articulated chassis) **can reduce energy use** and **CO_2 emissions per passenger-kilometre,** however **high occupancy rates** are **required** during operation
- Large bus **C2 uses less energy (MJ/pkm)**[c] than H1 and H2
- **Future work:** Logistics and economic analysis related to introduction of hybrid-electric and plug-in hybrid-electric city buses in Curitiba

[c] Passenger-kilometre (pkm): Total travelled distance by all passengers when carried one kilometre.

References:

Wipke, K., Cuddy, M., Burch, S., 1999. ADVISOR 2.1: a user friendly advanced powertrain simulation using a combined backward/forward approach. IEEE Transactions on Vehicular Technology, pp.1751–1761.

Markel, T., Brooker, A., Hendricks, T., Johnson, V., Kelly, K., Kramer, B., O'Keefe, M., Sprik, S., Wipke, K., ADVISOR: a System Analysis Tool for Advanced Vehicle Modeling. J. Power Sources, 110 (2002), pp. 255–266.

Intergovernmental Panel on Climate Change (IPCC), 1996. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories: Workbook (Volume 2).

This poster was presented to the president of Brazil, Dilma Rouseff, on the 19 Oct 2015 at KTH, Stockholm

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Smart City Concepts in Curitiba

– Research highlights –

Demonstration of new technology for mass transport corridors

System innovation, combining new bus-technologies and information technology to develop electro-mobility, and energy efficient and low-carbon transport services are needed when making urban sustainability a reality. Data collection and analysis of real-world bus operations are carried out to evaluate particular benefits of new bus technologies introduced in Curitiba.

- One hybrid articulated bus operating since the 18 March 2016.
- One plug-in hybrid-electric bus will be launched on 29 June 2016.

Planning of plug-in hybrid-electric bus operation

Evaluation of different scenarios for bus rapid transit operation with plug-in hybrid-electric buses for public transport using computer simulation models. Based on the simulation, charging stations will be added to the terminal and the effect on the traffic flow as well as strategies for mitigating these will be identified.

- A model of the Pinheirinho Terminal is being developed for simulations.

Providing high-capacity wireless broadband along Curitiba transportation corridors

Investigation of deployment strategies using fiber-based aggregation network for ubiquitous urban wireless broadband connectivity.

- Tonini et al. (2016). *Minimum Cost Deployment of Radio and Transport Resources in Centralized Radio Architectures*. (Published in: Proc. of IEEE International Conference on Computing, Networking and Communications)
- Raffaelli et al. (2016). *Optimization of centralized radio access networks in indoor areas*. (Published in: Proc. of IEEE International Conference on Transparent Optical Networks).

Energy and climate scenarios with improved environment and mobility

Analysis of energy efficiency and greenhouse gas emissions reduction in different scenarios for the bus rapid transit system in Curitiba, with focus on alternative fuels and electrification.

- Dreier (2015). *Assessing the potential of fuel saving and emissions reduction of the bus rapid transit system in Curitiba, Brazil.*
- Dreier et al. (2015). *Energy use and CO2 emissions of city buses in Curitiba, Brazil.* Presented at: Systems Analysis 2015, IIASA, Laxenburg, Austria, 11–13 Nov 2015.

ICT infrastructure for Open Data integration and interactive information sharing

Green and resilient design for optical cloud and wireless network services.

- Wang et al. (2015). *Restoration with Service Degradation and Relocation in Optical Cloud Networks*. (Published in: Proc. of IEEE/OSA/SPIE Asia Communications and Photonics Conference).
- Silva et al. (2016). *Restoration in Optical Cloud Networks With Relocation and Services Differentiation.* (Published in: Journal of Optical Communication and Networking).

Planning of electro-mobility in Curitiba

Analysis and mapping of road safety, noise, bus routes, bus stops, roads, commercial activities, noise sensitive activities, slopes, and air emissions to identify suitable places for investing in electro-mobility.

- Kozievitch et al. (2015). *Analyzing the Acoustic Urban Environment - A Geofencing-Centered Approach in the Curitiba Metropolitan Region, Brazil*. (Presented at: 5th International Conference on Smart Cities and Green ICT Systems, Rome, Italy).

ICT Infrastructure for Smart Cities: Curitiba, Brazil

Lena Wosinska [a], Paolo Monti [a], Matteo Fiorani [a],
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Optical Networks Laboratory
ONLab
Dept. of Communication Systems
School of Information and Communication Technology (ICT)

http://www.kth.se/ict/forskning/cos/research/onlab

At present, ONLab works on the following research areas:

- Optical Core and Access Networks Design Control and Provisioning
- 5G Transport Networks
- Optical Datacenter Networks and Interconnects
- Smart Cities
- Network Energy and Cost Efficiency

This research is part of a project aimed at sustainable technological solutions for the improvement of urban critical infrastructure in Curitiba, involving Swedish and Brazilian stakeholders.

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The importance of connectivity in cities

- Once high capacity broadband infrastructure is in place, it will be possible to develop a number of applications to improve the quality of life of the citizens.

High capacity infrastructure → **Development of applications** → **Improvement of life quality**

Application in Sweden and Brazil

- Access to broadband connectivity is considered as a commodity nowadays
- End users are expecting to be able to have access to high bandwidth services regardless of their locations and mobility conditions
- Need for very high capacity wireless broadband connectivity
- In Sweden the ubiquitous wireless broadband connectivity is quite advanced
- Brazil can follow closely if the right steps are taken
- In the Smart City Concepts in Curitiba project: ICT focus on efficient ways to deploy and manage an ICT infrastructure able to answer this need

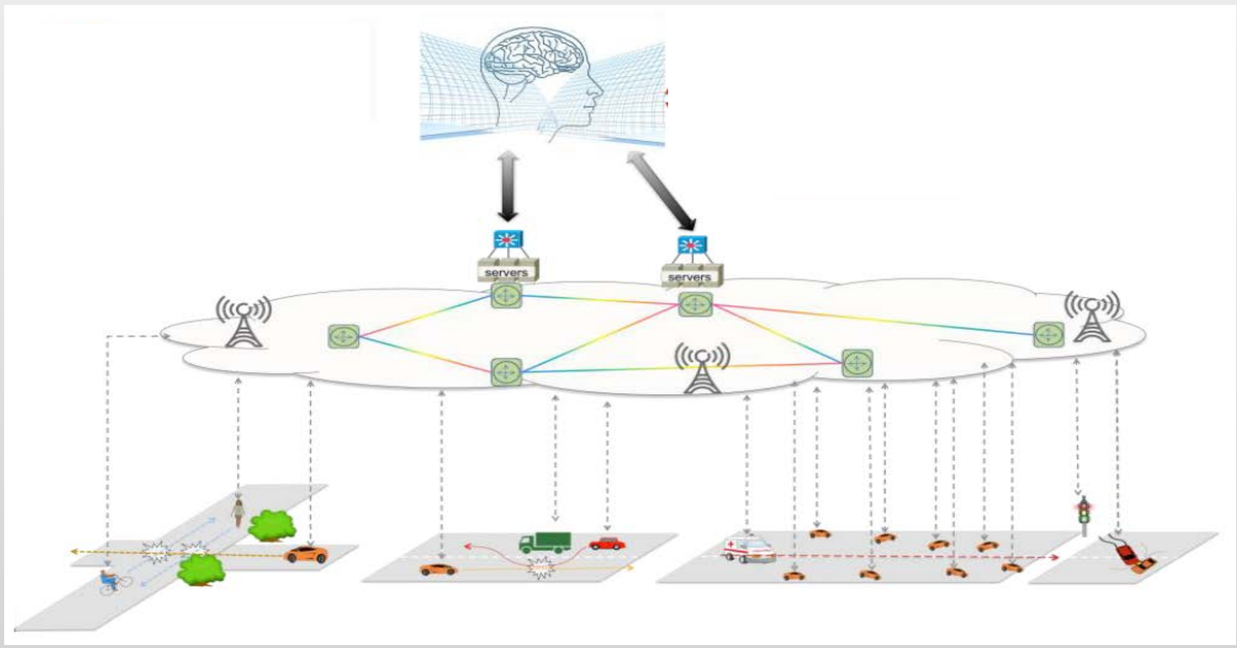
Future scenarios for Curitiba

- Example: Smart networked systems for road traffic:
  - Optimized and cognitive decision-making system
  - Runs virtually everywhere to detect and prevent accidents
  - Build on ICT infrastructure
  - Support of the most stringent requirements: Reaction time and robustness
- The involved systems consist of:
  - Networked road users (vehicles and pedestrians)
  - Smart decision making systems controlling the situation on the road

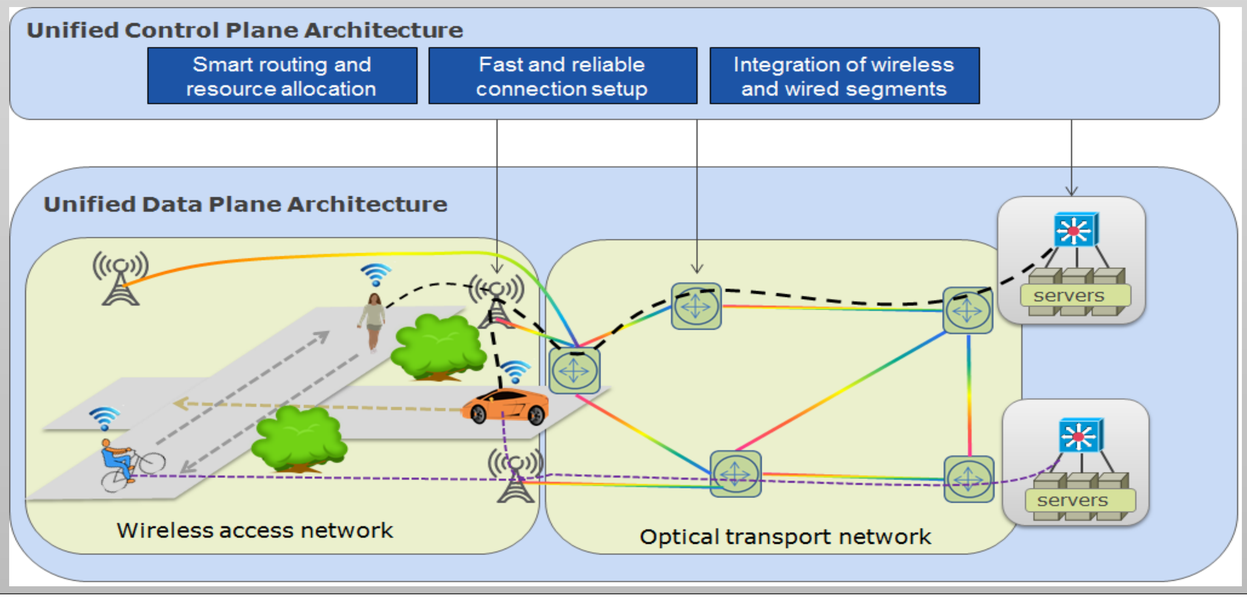
Functional principle of ICT system for road traffic

General framework

- Providing powerful computing and communication resources on the fly
- Designing fast, intelligent and robust decision-making methods
- Building a common artificial intelligence-based information and communication system platform



Unified control plane and data plane architecture design



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Electric hybrid buses in Curitiba: an arena for testing new products and services in public transport

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[c] *Urbanization of Curitiba S/A, Curitiba, Brazil – URBS*

VOLVO + SIEMENS + ERICSSON

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IN COOPERATION WITH:

VOLVO, COMBITECH, UTFPR – UNIVERSIDADE TECNOLÓGICA FEDERAL DO PARANÁ, CURITIBA, URBS, IPPUC, CISB – CENTRO DE PESQUISA E INOVAÇÃO SUECO-BRASILEIRO, VINNOVA

Air conditioner

Wifi connectivity

Zone management (speed limit)

Less emissions

Less noise

+

Zero emission zone

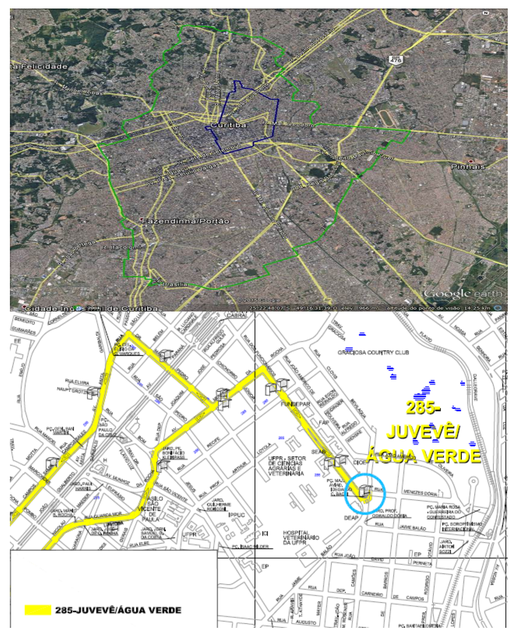
Conntected bus stop

Traffic studio
(monitoring with cameras and GPS)

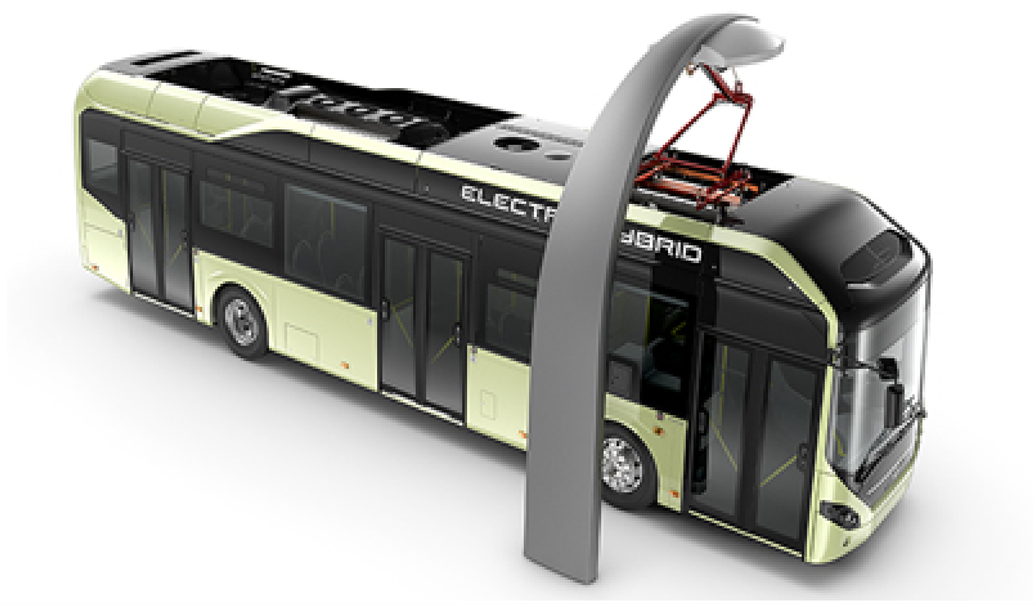
Passenger information
(at stops, on board, via web-mobile)

INTERBAIRROS II

This line has two directions: (020) clockwise and (021) anticlockwise. Its route passes through over 25 districts of Curitiba, on a path that takes about two hours to be covered completely. It represents a massive transportation with high capacity buses.



A NEW EXPERIENCE OF PUBLIC TRANSPORT



NEW SPECIAL LINE ELECTRICITY

Quiet and emission-free electric hybrid buses that contribute to a more pleasant urban environment.
Includes future bus stop solutions, ITS solutions, safety concepts, green depot and energy solutions