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

Model on charging infrastructure planning and its integration in the electric grid

Anne-Sophie Fulda[1], Rémi Jaboeuf, Monika Heyder, Pierre Imbert

EIFER, Germany, fulda@eifer.org

Abstract:

In order to support the diffusion of electric vehicles, charging infrastructure are being implemented almost everywhere. A competency of simulating infrastructure, taking into account all the possible developers at different scales, has been developed at EFER through a model called EVITA. It was applied in Flanders in 2016. Discussions of EANDIS and INFRAX with local stakeholders, together with EIFER mobility experts, permitted to decide on a scenario focusing on residential needs and identifying some points of interest in commerce and at parking places. The impact of this infrastructure on energy demand is particularly high around 18:00 in the evening, due to the important number of users charging their vehicle when coming back home. A shift of charging could be organized through an automatic signal, at home and in fleets, to postpone this demand in the late evening.

Keywords: energy consumption, EV (electric vehicle), charging infrastructure, mobility system, policy.

1 Introduction

In order to support the diffusion of electric vehicles, charging infrastructure are being developed almost everywhere. For 10 Years, local authorities and energy providers are concerned with the development of this infrastructure, facing the difficult issue of investing in charging stations. In France, the " loi de transition énergétique" (regulation on energy transition) obliges all local authorities to develop electrical charging infrastructure. Planning a charging infrastructure for electric vehicles represents a new challenge for local actors, because it is a slightly different way of planning than for a conventional transport infrastructure. Nevertheless, more and more private actors are becoming active; for example, hotels, restaurants and shops install charging stations in their parking lots in order to offer a new service to their clients. Energy providers face issues in implementations phases of infrastructure planning: once the location of stations is decided, the provision of energy, as well as the electric grid, have to be adapted to the new demand. Energy providers aim to anticipate more the deployment of charging infrastructures. A real need came out to coordinate the process between those different actors. How to find out the infrastructure shape, which assure that all actors are answering to their own issues?

The competency of simulating infrastructures, taking into account all the possible developers at different scales, was developed at EFER through a model called EVITA. Since 2009, the tool has already been applied to different cities and regions: Karlsruhe (Germany), Stuttgart (Germany), Strasbourg (France), Nice (France), Maubeuge (France), Steiermark (Austria), Province of Liège and Province of Limburg (Belgium). For all these applications, the model aimed to help local actors face the new challenge of integrating charging infrastructure to their transport system in particular finding the good balance between different uses of public space, parking policy, promotion of multimodality etc. The last application was carried out for the region Flandres in Belgium, in the framework of regional planning for electric vehicle. With about 1% of the total sales in 2015, electric vehicles still represent a limited share of the automobile market in Belgium. But only in 2016, more than 5.000 electric cars were sold (tesla model S 35%, Nissan Leaf 30% and Renault Zoe 12%...). In January 2016, the Flemish government adopted a purchase subsidy for new electric vehicles: for the smallest vehicles (<31000 €), buyers receive a 5000 € subsidy, while for the most expensive cars (> 61000 €), the subsidy is of 2500 €. This subsidy concerns only private households (i.e. not enterprises) and runs until 2020. The application of the tool EVITA in Flandres was driven through a partnership between local actors, local industrial and energy providers: *Eandis and Infrax in 2016*.

2017, the scope of the model was extended with an energy model which allows to evaluate the impact on energy demand at different scales. Independently of the partnership, EIFER applied this extension in the scenario in Flanders.

The article presents first the method of the model. Then, the different theoretical scenarios are describes. At last, the results are explained regarding the localization of the infrastructure and its impact on the local energy demand.

2 Architecture of the model

The method was developed as a planning method in a GIS, and was completed with an energy tool. The model uses geolocated data; it allows a calculation at two levels of detail: the zone and the point of interest (addresses of POI):

- Surface data: the result is the number of stations to be implemented for each zone with the proportion of stations to be distributed among different categories for residential, working, shopping and other purposes.
- Data at the addresses scale permit to determine the number of stations to implement at remarkable points of interest (POI). They correspond for example to administrative buildings, big shops, or parking spots…

The architecture of tool can be described in 3 steps (cf. figure1):

1. The calculation of the weighting parameters is based upon the user input. The method is a parameter weighting. The model allows to distribute all of the charging points in three contexts of use: Charging at home (zonal distribution), Charging at work (zonal distribution), Charging close to public infrastructures (distribution on POI), charging at main road rest area (cf. figure 4).

2. Charging stations are distributed in the zones according to the parameterized indexes. The method is an iteration identifying the maximum index. As a result, for a given category, each urban unit receives, depending on its relative importance, a number of charging points.

3. Finally, the last step is the evaluation of the infrastructure concerning energy consumption. Some hypotheses on charging behaviour are fixed regarding scientific output from pilot projects.

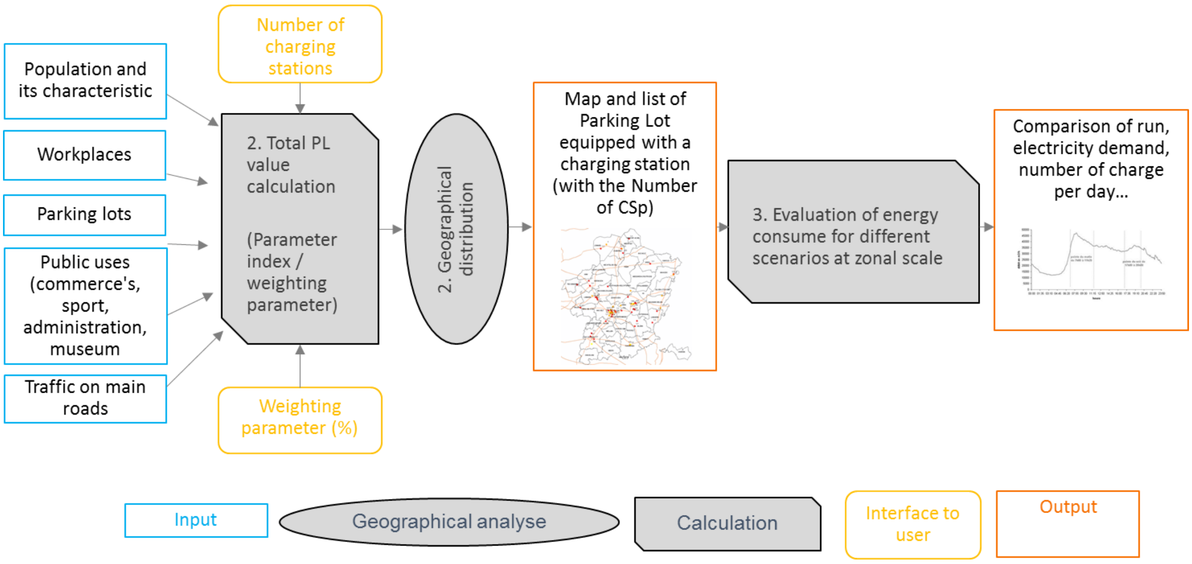

Figure1: Architecture of the model

The model calculates the following KPIs for each scenarios:

- Number of charging stations needed per commune and POI regarding parking habits for different purposes and activities
- Number of uses per day at a communal scale;
- Load curve at a communal scale (kWh during one typical working day);

From the point of view of the method, this model is a simple tool. Nevertheless, it has a high added value on the governance. It brings together all major stakeholders, and thus organises the coordination of actors and their confrontation with developing infrastructure.

3 A tool for governance

The tool is implemented in 6 step (figure 2):

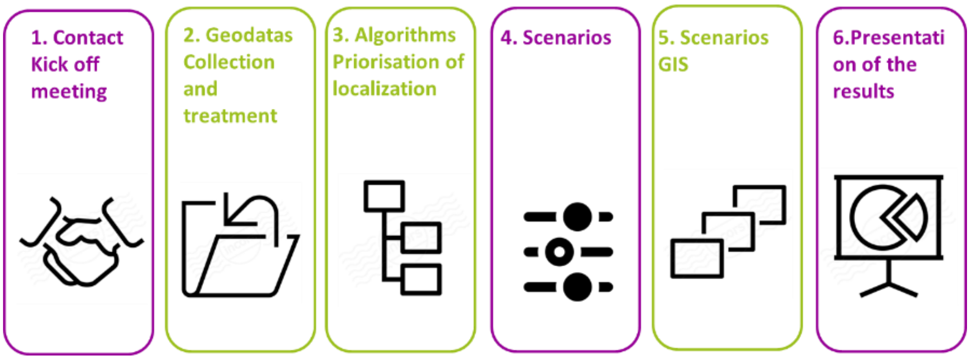

Figure2: Application step of the tool

1. First, a kick-off meeting takes place including the tool presentation. It is the moment to introduce next steps, such as data collection, and identify further participants needed for the process (like administrative actors with the competence of mobility systems, energy consultants, etc.).

2. Second, the collect and treatment of local data occurs. The work of the partners is significant and enables adequate treatment of the data. In Flanders, zonal data come from official sources such as the Federal Overheidsdienst Economy K.M.O, or the General Statistics Directorate (http://statbel.fgov.be/fr/statistiques/chiffres/). POI data are more difficult to get because not only lists of various POI addresses have to be found but also an indicator should be available in order to weight the POI, ones with the others. The geographical area of Flanders is a regional large perimeter containing over 9000 statistical zones and more than 1000 POI.

3. The third step correspond to the adaptation of the algorithm, if necessary. Indeed, some local specificities require new categories for the location of the infrastructure; for example, the application in Liège considered some parking places dedicated to car polling; the application in Nice integrated a category for tourism. At the demand of the energy providers Infrax and Eandis, the tool was adapted in Flanders to differentiate the zones managed by each actor.

4. The forth step consist in a workshop with all partners. This important day is divided in 2 phases.

a. First an important input is given on major topics:

- Prospective researches on EV-diffusion in the static fleet are presented: how many vehicles may be sold in the future? Most of the time, the best way is to define a range of possibilities with a tendency but also a high and low development.
- Return of experimentations (REX) are presented, especially on charging behaviours: how many charging points are needed considering the diffusion of EV in the fleet, as decided at step 1 ? A balance between need and wiliness to invest has to be found.
- At last, a meaningful input consist in a synthesis of researches analysing the location of charging stations. They permit to answer the question: *where should the charging points be distributed?* This part comprises a synthesis of declarative inquiries (questionnaires from pilot projects and analysis of actual distribution of charging stations). It is presented to the participant results on if charging stations should be near to a parking place used for shopping, for living, for working… from the point of view of the different users (private, firms, administrative).

All those inputs are discussed in order to understand how the various case studies, together with the knowledge of the REX, could define an orientation for the concerned territory.

b. The second phase of the workshop corresponds to the definition of scenarios. All participant should fill in a questionnaire aiming to help them decide the orientations for the infrastructure (figure 3).

2.3 How many CP from the public space infrastructure should be positioned surrounding *"commerce"?* Considering that:

- The willingness to charge while shopping is expressed by users.
- It makes commerce more attractive for car drivers.
- Commerce can promote an ecological and innovative image.
- CP represent an additional service for commerce.
- Public private partnerships can be targeted to fund the infrastructure.
- …

Not at all (0%)	Only few	Some	In balance with other uses	A lot	Almost all	All 100%

Figure 3: Example of question the participant have to fill out

Depending on their major interest, they have to express how important locations are from their point of view. For example, the local transport authority may either develop the infrastructure at on-road parking spots for more visibility, or in big parking lots in order to free public space for other uses. Energy provider may, in some situations, want to promote the development of fast charging stations, indenting an increase in energy consumption, or in other situations want to encourage slow charging systems in order to manage better the local energy demand and production. Then distinguished priorities of local actors are discussed, and diverse scenarios are defined. For example, it is possible to define, at first, extreme scenarios in order to make visible the shape of the infrastructure, and the energy impact of this contrasted infrastructure. The aim of the workshop is to achieve a scenario accepted by all participants.

4. Depending on the project, participants sometimes wish for new simulations. The main results are compiled in a report.

5. Results can be presented to an extended audience.

4 Flanders application

4.1 Scenario description

The “EU clean fuel strategy” (2013) sets the goal of 21,000 public charging points by 2020 in Belgium. The Region of Flanders includes 60% (3.35 million) of the total Belgian vehicle fleet (5.6 million). By applying this ratio, the number of charging points, that should be set up in the Region of Flanders is 12580. Nevertheless, participant decided to support the still emerging electro-mobility in Flanders, it was decided to install 5000 charging points by 2020.

In order to give a better understanding of the electric mobility issue in Flanders, the results of 9 contrasted scenarii were provided. The chosen scenario is the one that integrates at best the interests of all local authorities for the development of e-mobility. Only this final scenario is presented in this article.

The selected scenario (figure 4) is designed to ensure a balanced distribution of the stations, by implementing an important part of the stations in the residential sector (70%), in particular, where people have higher revenues and where they have limited private parking places. This scenario aims to provide with charging infrastructure the households the most keen on using EV.

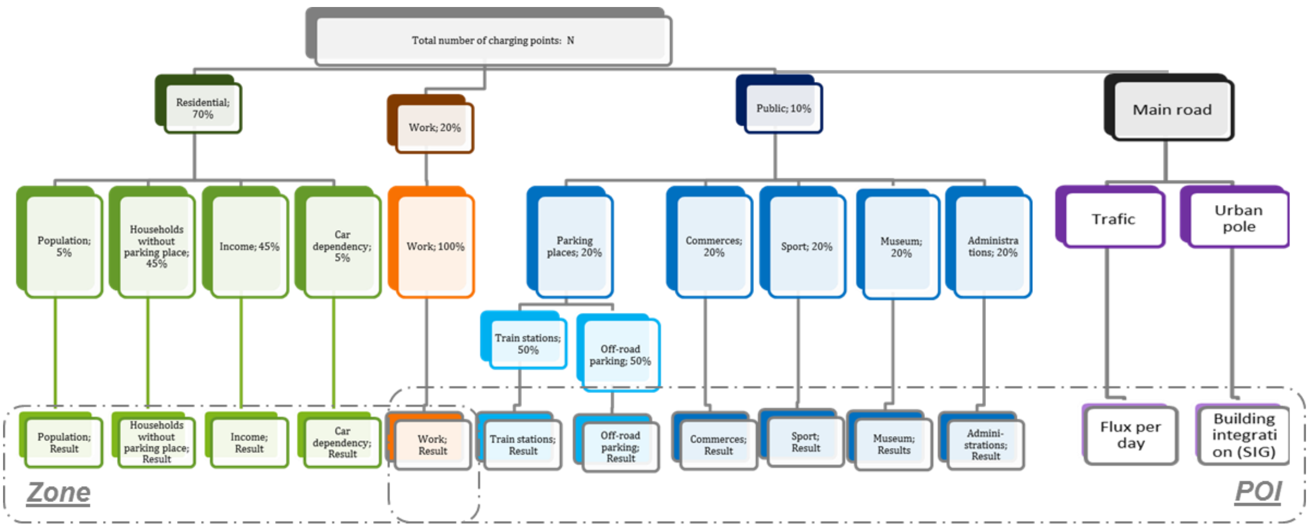

Figure 4: Final scenario in Flandres

Charging while working represent as well a big part of the infrastructure (20%). Public space for big parking and commercial purpose, as well as for visiting an administration is less important (10%). The infrastructure at main road stops was not taken into account in this scenario.

4.2 Results

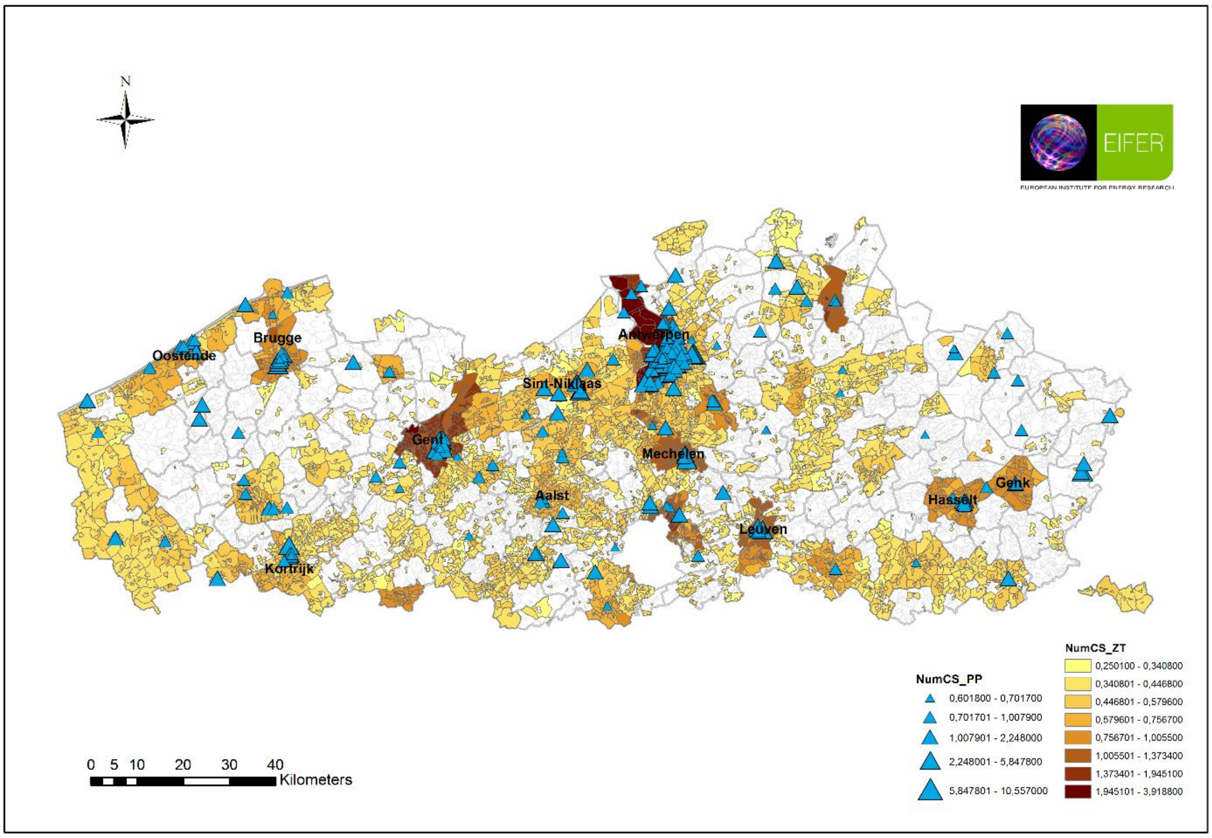

Figure 5: Map of Flanders showing the indicators of importance for both the zones and the points of interest.

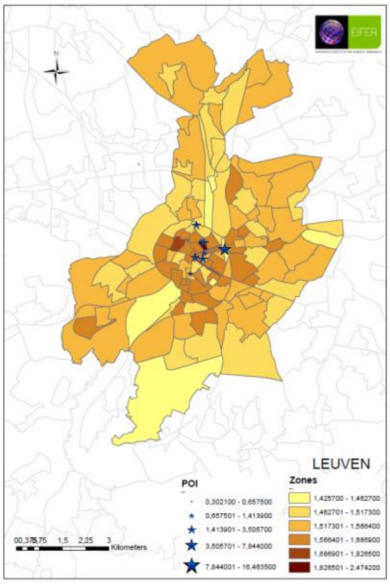

Figure 6: distribution of the charging infrastructure in Leuven

Figure 5 reveals an important need for public charging points in urban areas, where, due to higher densities of population, the possibilities to charge at home are reduced. Incomes are generally higher also in central areas of city centres. These two aspects contribute to the higher number of charging spot in urban areas. Antwerp, Gent and other big cities like Leuven concentrate an important part of zones with the highest number of charging station as well as POI (Figure 6).

The concentration of services (especially parking and commerce) in, or close to urban areas largely participate in explaining the positions of remarkable points of interest. In Antwerp and Gent, some points of interest with important indicators correspond to large commercial areas, these later being either remarkable shopping malls or more generally important concentrations of commerce.

Charging points assigned to the specific parking context represent 20% of the total number of points in public context, as for the other public sub-categories. Half of those are distributed among the train stations (SNCB/NMBS) on the basis of their frequentation. Thus, the stations of Antwerp and Gent have the highest indicator for this category. But other stations, located in less dense areas also receive significant indicators, so that areas with lower density and moderate median incomes can also receive charging infrastructure to support the development of e-mobility.

The energetic evaluation of the scenario was made at EIFER in 2017 outside of the partnership (figure 7). The energy consumption linked with this infrastructure corresponds to an average of 40km per day for all EV cars (about 15.000km a year).

For this scenario with a high majority of charging at home and at work, it can be seen that the pic of energy consumption will occur on the evening, especially at 18:00. That is the time when people come back home and charge their cars, but also the time for fleet managers to charge the vehicles of their enterprise. Accelerated and fast charging (at the firm premises or at some public space) are much more spread out during the day. To avoid the evening pic, developing charging shifts, at home and at work, later during the night could be valuable solutions.

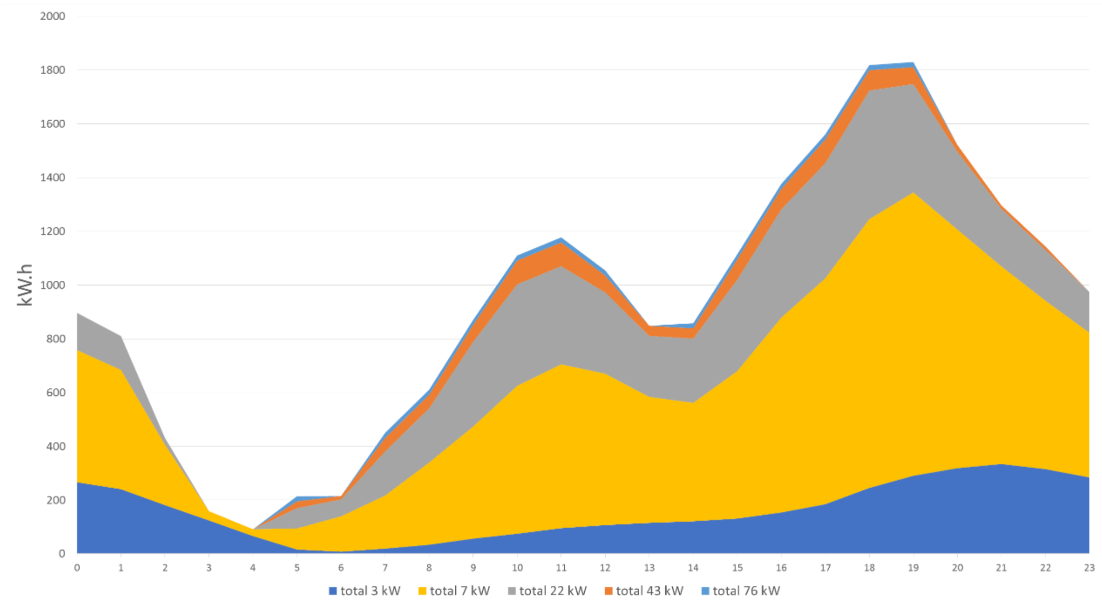

Figure 7: Energy needed for electric vehicle charge per day for all Flanders (kW.h)

A balance of energy demand can also be realised at an agglomeration (or even zonal) scale, so that energy providers could check the demand / offer balance. This could permit to identify the need for further energy production, eventually with local energy sources.

5 Conclusion

The implementation of the tool EVITA for the Flemish region both reveals and answers to the need for further promotion of EV through the development of public charging stations by different local actors. Discussions of EANDIS and INFRAX with local stakeholders, together with EIFER mobility experts, permitted to decide on the best scenario of infrastructure development to support the emergence of e-mobility in Flanders.

By implementing an important part of the charging stations in the residential sector, and in particular where people have higher revenues, and where they have limited private parking possibilities, the chosen scenario aims to provide with charging infrastructure the households the most keen on using e-vehicles. Despite a major concentration of charging points in denser areas, the result map reveals a rather balanced distribution of the CP all over the Flemish territory, which permits to create a continuous charging infrastructure.

The impact of this infrastructure on energy demand is particularly high around 18:00 on the evening due to the important number of users charging at home when coming back home. A shift of the charge could be organised via the implementation of an automatic signal, at home and in fleets, to postpone this demand in the late evening.

6 Out look

The presented model is being implemented at a micro level (each Parking place and each line of the grid) in an integrated planning tool. The project "Modélisation Urbaine Gerland" (MUG), launched in 2014 in Lyon, represents an answer to the need for inter-sectorial planning. The project is part of EcoCité 1 (French public funded project). It aims to develop an interactive planning platform to support Metropole of Lyon (France) in making strategic decisions on future urban developments. The main objectives of the project Modélisation Urbaine Gerland are :

- To reflect on the construction of the city of the future in an joined effort with two industrial partners and two local start-ups by merging visionary urban planning and computerized modelling
- To reflect on new ways of governance, by linking different domains in urban planning in a holistic and integrated way;
- To prepare for tomorrow's urban planning challenges, by developing a decision-support tool for long-term planning of the district Gerland; and,
- To support the development of new tools by accompanying the process of urban and social transition in the urban district Gerland.

Tackling these topics, as well as developing the simulation engine and integrating models into the interactive planning platform, shall be achieved in a partnership combining the competencies of the different partners. These skills and partners are : (1) urban planning Métropole de Lyon; (2) industrial research and infrastructure planning (energy planning and platform development EDF R&D, Veolia Research and Innovation); (3) complex systems (The CoSMo Company); (4) platform development as well as land use and transport dynamics (ForCity, consortium leader)[1]. EIFER is subcontractor of EDF. The case study is Gerland, which is part of the 7th Arrondissement of Lyon, France.

The presented e-Mobility infrastructure model is being integrated into the overall assessment of the district energy demand-and-supply, and compared with the local electricity production from PV installations. The input and output data are used in several other models. In the case of MUG, the model will be linked to a transport and public space model (developed by ForCity), as well as to an environmental model (developed by Veolia).

---

[1] The roles and competences of the consortium in the project Modélisation Urbaine Gerland in detail:

(1) Métropole de Lyon is project leader, main site stakeholder and future principle user

(2) The CoSMo Company is expert on complex systems working on the industrialization of CoSMo software-based urban modelling toolkit

(3) EDF supports the project by its expertise in energy and quality of life, through consulting and computational models

(4) ForCity is the consortium leader, leading the development of the decision-support tool, the land use and transport interaction model, the urban models and the platform hosting the technological components designed by the project partners.

(5) Veolia supports the project by expertise in air and waste management through consulting and computational models

References

Caperello, N.D. & Kurani, K.S., (2012) “Households’ Stories of Their Encounters with a Plug-In Hybrid Electric Vehicle”, Environment and Behaviour 44, p.493–508.

Cross Border Mobility for Electric Vehicles (CROME)” (2012) Proceedings of the 11ème séminaire francophone est-ouest de socio-économie des transports, Karlsruhe.

Deporter, S. and P.-M. Assimon (2011) Les vehicules electriques en perspectives, analyse coûts-avantages et demande potentielle, Commissariat général au développement durable.

Ensslen A., Paetz AG., Babrowski S., Jochem P. and Fichtner W. (2013) “On the road to an electric mobility mass market – How can early adopters be characterised?”, Workshop Future Mobility, Oldenburg.

European Alternative Fuels Observatory, (2016) [cited 2016 15/09]; Available from: http://www.eafo.eu/content/belgium.

European Parliament and Council of the European Union, Regulation (EC) (2009) No 443/2009 and of the council of 23 April 2009 setting emission performance standards for new passenger cars as part of the Community's integrated approach to reduce CO2 emissions from light-duty vehicles, E. Parliament.

charge map. charge map (2016) [cited 2016 16/09]; Available from: https://fr.chargemap.com/.

Franke T. and Krems F. (2013) “Understanding charging behaviour of electric vehicle users”, Transportation Research Part F, 21, p.75-89. References 135

Fulda, A.S. and J. Wirges (2010) MEREGIOMOBIL : standortplanung von Ladestationen für elektrische Fahrzeuge. Karlsruhe, p. 99.

Fulda A., Pierre, M., (2015) Using electric vehicles and the charging infrastructure: outcomes from a long term fied study among two groups of EV motorists. KIT book CROME, p. 23.

Fulda AS. and Nimal E. (2016) Quantitative analysis of public charging station use KIT: Karlsruhe. p. 15.

Glachant, M., Thibault, M_L., Faucheux, L. (2011) Le déploiement des infrastructures de charge de véhicules électriques et hybrides rechargeables : une approche économique, Mines ParisTech, Armines, p.80.

Graham-Rowe, E., et al. (2012) “Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations”, Transportation Research Part A: Policy and Practice 46, p.140–153.

Jarrigeon, A., Massot, MH., Pierre, M. & Pradel, B. (2015) “Les routines du quotidien à l'épreuve de la mobilité électrique”, Espace-Population-Société journal, following AISLF’s 13th “MSFS” conferences.

Kaschub, T., P. Jochem, and W. Fichtner, (2011) Integration von Elektrofahrzeuge und Erneuerbaren Energien ins Elektrizitätsnetzt - ein modellbasierte regional Systemanalyse. KIT IIP: Kalrsruhe p. 13.

King M., N., Harris M. and Lewis E., (2013) “Electric vehicle drivers’ reported interactions with the public: Driving stereotype change?”, Transportation Research Part F 17, p.33-44 .

Ministère de l'écologie du développement durable et de l'énergie (2014) Guide technique pour la conception et l’aménagement des infrastructures de recharge pour véhicules électriques et hybrides rechargeables. Mise à jour du volet technique du Livre vert sur les infrastructures de recharge ouvertes au public pour les véhicules décarbonés, p.36.

Setec its (2013). Déploiement des infrastructures de charge pour les véhicules électriques et hybrides rechargeable, p.35.

Pierre, M., (2014) “Quand préoccupations environnementales et enjeux professionnels s’entrecroisent: le cas des entreprises participant aux essais de voitures électriques”, in P. Lejoux et N. Ortar (Eds.), SHS Web of Conferences, Vol. 9.

Pierre M. and Huguet (2015), “Le véhicule hybride rechargeable : un nouveau système sociotechnique ?”, Revue Artefacts, dossier sur les électromobilités, éditions du CNRS (forthcoming).

Pierre, M., C. Jemelin, and N. Louvet (2009), Les Bornes de Recharge dans les Espaces Publiques: Quels Usages pour les Conducteurs de Véhicules Électriques? Quels enjeux pour la filière? EDF R&D. p. 110.

Wirges, J. and S. Linder, (2010), Location planning of charging stations for electric vehicles: A case study for Nice, p. 57.

Authors

Anne-Sophie Fulda has a master degree in geography at Rouen and an engineer diploma in urban planning at Hamburg (dipl.Ing.). Since 2007 at EIFER, she is responsible for the sustainable mobility project, in particular for the development of electric mobility in cities. The team of EIFER mobility was a scientific support of cross-border pilot project “CROME” assessing the acceptance of driving an electric vehicle and using public charging infrastructures. By analyzing e-mobility, Anne-Sophie Fulda uses the multitude of scientific methods (social, economic, simulation, local planning) to develop an analysis of the potential of new transport technologies and apply the results in practical projects.

Rémi JABOEUF is a Civil Engineer, graduated from the INSA Strasbourg; he also holds a Master’s degree in Sustainable Development and the responsibilities of the organizations of the Paris-Dauphine University. After several experiments in technical consultancies and environmental consulting firms, he decided to invest more specifically in favor of sustainable mobility. Since 2014, he works at EIFER on the analysis of mobility practices. He has been actively involved in analyzing the relevance of electrical technology in car-sharing services, studying the success conditions of business travel plans and regularly assisting communities in the early stages of implementation charging infrastructure for electric vehicles.