Integrating MATSim into a Comprehensive Multi-Model Platform for Analysis and Planning of Sustainable Electromobility Scenarios

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Abstract

Addressing the escalating crisis of climate change necessitates the broad application of low or zero-emission technologies throughout every economic sector. Amongst these, one solution that stands out in the realm of transportation is the widespread electrification of vehicles. This is particularly pertinent for Chile, a country whose urban areas bear the brunt of pollution, coupled with significant health risks that arise from vehicle emissions. Consequently, the shift towards electric vehicles (EVs) becomes not just desirable, but crucial in order to abate pollution levels and lay the foundation for a sustainable transportation infrastructure.

The Metropolitan Region of Santiago, the bustling home to more than 8 million inhabitants, has been grappling with significant pollution levels brought about by the pervasive use of internal combustion engines. This has resulted in the region being amongst the most affected areas. Simultaneously, southern Chilean cities such as Temuco, Valdivia, and Coyhaique are confronted with an added layer of environmental challenges. These cities struggle with pollutants from biomass-burning stoves, a problem that becomes particularly acute during the winter months.

In response to these environmental and health challenges, Chile has taken a proactive approach by establishing ambitious goals for transport electrification, as laid out in the National Strategy of Electromobility. This comprehensive strategy envisions a future where electric vehicles dominate the transport sector, with a goal of achieving 100% sales of electric light and medium-duty vehicles by 2035. Moreover, it aims for a complete transition of all public transportation to electric power by the year 2040.

The large-scale integration of electric vehicles (EVs) will not just transform the automobile industry, but also exert a substantial influence on various other dimensions. Indeed, the shift towards EVs is likely to be gradual, evolving user experiences and altering driving behaviors in the process. Correspondingly, urban infrastructures and electrical distribution grids will need timely and thoughtful adaptations to circumvent substantial implementation costs. Moreover, EVs will coexist with other complementary zero-emission technologies like photovoltaic panels, battery storage devices, and new electric heat/cooking appliances, adding another layer of complexity. Typically, the examination of these dimensions involves specialized simulation tools that utilize aggregation models to simplify the EV-user behavior.

Our objective is to combine multiple simulation tools to scrutinize sustainable electromobility scenarios in urban landscapes and across the nation. One such tool is the multi-agent transport simulator MATSim, which assists in evaluating the impacts of varying electromobility scenarios on urban transport and electric systems.

The factors considered include sustainability aspects, transportation system performance, the requirement for new charging and electrical infrastructure, and nationwide power grid planning.

The simulation suite under development considers the viewpoints of potential users, spanning both private and public sectors. To accomplish this, we have conducted several workshops to glean insights into the prerequisites for sustainable electromobility and pinpoint the primary challenges that are likely to surface in the upcoming years. We have initiated our exploration by applying our methodology to the cities of Temuco and Santiago. Mobility surveys serve as our primary data source in these cases, assisting in determining current transportation demand and agent activities. Furthermore, road networks are extrapolated from OpenStreetMap, while GTFS data is employed to secure public transport scheduling and routing information.

City transportation patterns of the future are intricately linked to the future location of households and land uses. Recognizing this, we're building forward-looking models of urban scenarios. These models incorporate the estimation of the future population segmented by household types, distribution of housing and apartment supplies across different city areas, and allocation of households within this real estate context. We use a wide array of data sources to calibrate these models, such as historical census information, household locations by type, and zoning conditions. At present, these models have been applied to the urban region of Temuco as a case study, yielding initial projections. These insights will be integrated into MATSim to generate more realistic electromobility scenario simulations.

With the incorporation of electromobility technologies and charging infrastructure into MATSim, our aim is to determine the usage of electric vehicle charging infrastructure and produce spatio-temporal charging profiles. These profiles will serve as inputs for a distribution network model, enabling an assessment of service quality impact and the necessity for network reinforcement. This methodology aids in the smooth integration of a significant number of electric vehicles, ensuring operational efficiency and optimal performance.

We are currently extending our analysis to encompass the impacts on both local and national electricity infrastructure and markets. This wider view allows us to assess the net reduction of CO_2 emissions due to electric vehicles (EVs), considering both emissions avoided by not burning fuels directly in traditional vehicles and emissions arising from additional electricity demand. To achieve this, we're developing an energy market model that optimizes the expansion and operation of the national electricity system.

Ultimately, our goal is to establish a valuable platform that provides policy insights for the public sector and serves as a predictive tool for the private sector. This platform is expected to play a vital role in advancing the development of sustainable electromobility in the coming years.