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EVI-PRO FOR BOGOTÁ COLOMBIA

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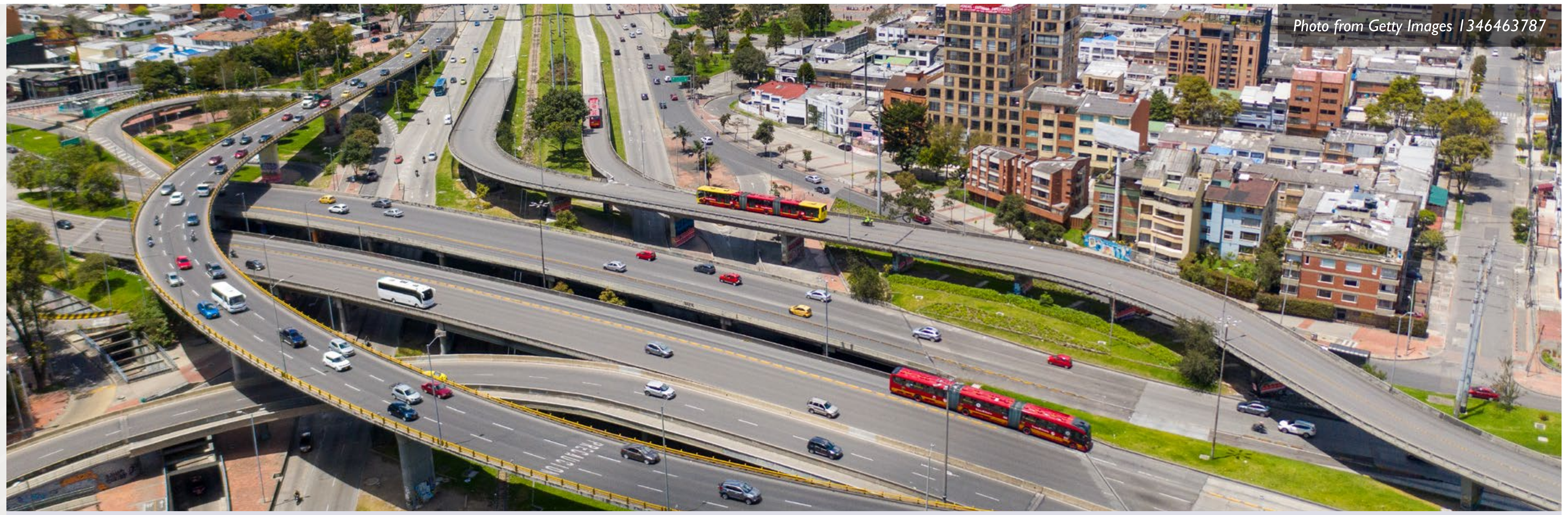
MODELING AND PLANNING OF ELECTROMOBILITY CHARGING INFRASTRUCTURE TO SUPPORT EV TRANSITIONS

The transportation sector is one of the largest producers of greenhouse gas emissions globally, with 37% of global CO_2 emissions in 2021 according to the International Energy Agency[1]. Transitioning from internal combustion engine vehicles powered by fossil fuels to electrified transportation is a critical component in reducing those emissions significantly over the coming decades and avoiding the worst consequences of climate change. With governments and automakers increasingly announcing electrification targets and a progression away from the production and sale of internal combustion engine vehicles, a robust network of charging infrastructure must be built to enable the widespread use of electric vehicles (EVs). Some of the greatest hurdles to EV deployment are linked to the buildout of the required charging infrastructure including where it should be built, what types and how much charging would be optimal given high costs of installation, and the impact on the electrical grid. To this end, the National Renewable Energy Laboratory (NREL) conducts extensive research on EV deployment, including the development of the Electric Vehicle Infrastructure Projection (EVI-Pro) model used to plan the future buildout of charging infrastructure given the travel patterns in a region. This document summarizes work done by NREL in Bogotá, Colombia, to help Colombia plan for its EV deployment goals.

EVI-PRO MODEL OVERVIEW

The EVI-Pro modeling tool is used for estimating the EV charging infrastructure needed to support the future charging demand of private light-duty vehicles in a geographic area. The model uses travel data and a range of assumptions about vehicle characteristics and future EV adoption to estimate how many times vehicles would need to charge at home, work, or at public stations. Then, based on where these trips are taking place, EVI-Pro calculates the required number of charging stations in each area to meet that demand. More information on the tool, including reports summarizing previously completed studies, can be found here: www.nrel.gov/transportation/evi-pro.html.

[1] https://www.iea.org/topics/transport



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TRAVEL DATA			SIMULATED CHARGE EVENTS		
DEPARTURE	ARRIVAL	DESTINATION	DRIVER A	DRIVER B	DRIVER C
7:00 AM	7:00 AM	Public	None	None	Public DCFC
9:30 AM	10:30 AM	Public	None	Public L2	None
12:45 PM	12:45 PM	Public	None	None	None
4:00 PM	5:00 PM	Home	Home L2	Home L2	None

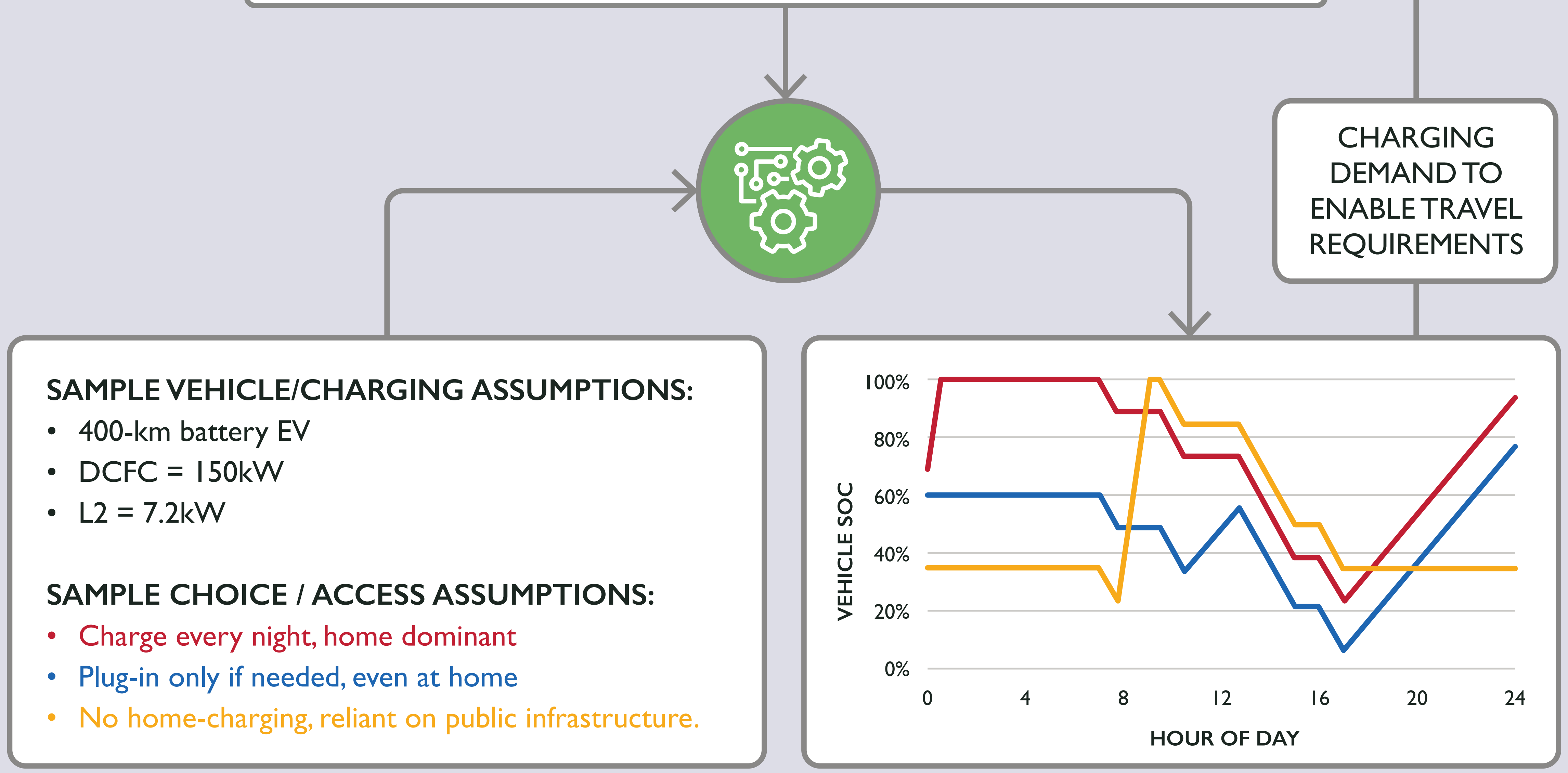

Figure 1. Visualization of basic inputs and outputs for the EVI-Pro model—vehicle and charging station assumptions combine with travel data to generate simulated charge events and electricity demand for a modeled day of travel.


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APPLICATION OF EVI-PRO IN BOGOTÁ, COLOMBIA

The EVI-Pro tool has previously only been applied to areas in the United States, but, with the help of government stakeholders in Colombia, NREL has developed a customized version by incorporating data specific to Bogotá. The Government of Colombia aims to have 600,000 EVs on the road by 2030, with 300,000 of these in Bogotá. Therefore, early planning of EV infrastructure is key in developing efficient energy planning and accelerating end-user adoption. The tool has been adapted to the specific conditions in Bogotá using data from an extensive travel survey conducted in 2019 by the Secretaría Distrital de Movilidad to help model and optimize the future charging demand for the area. More information about the travel survey can be found here: https://www.movilidadbogota.gov.co/web/encuesta_de_movilidad_2019.

Each trip from the 2019 travel survey is connected to an anonymized individual vehicle for a particular day, recording all trips for that day. Connecting trips to an individual vehicle allows the model to estimate changes in battery state of charge over time if that vehicle were assumed to be an EV and whether that EV requires midday charging to complete its travel. Additional information for each trip includes the purpose, origin, destination, start time, and end time. Using this data, EVI-Pro can then estimate when and where each EV will need to charge throughout a "modeled day."

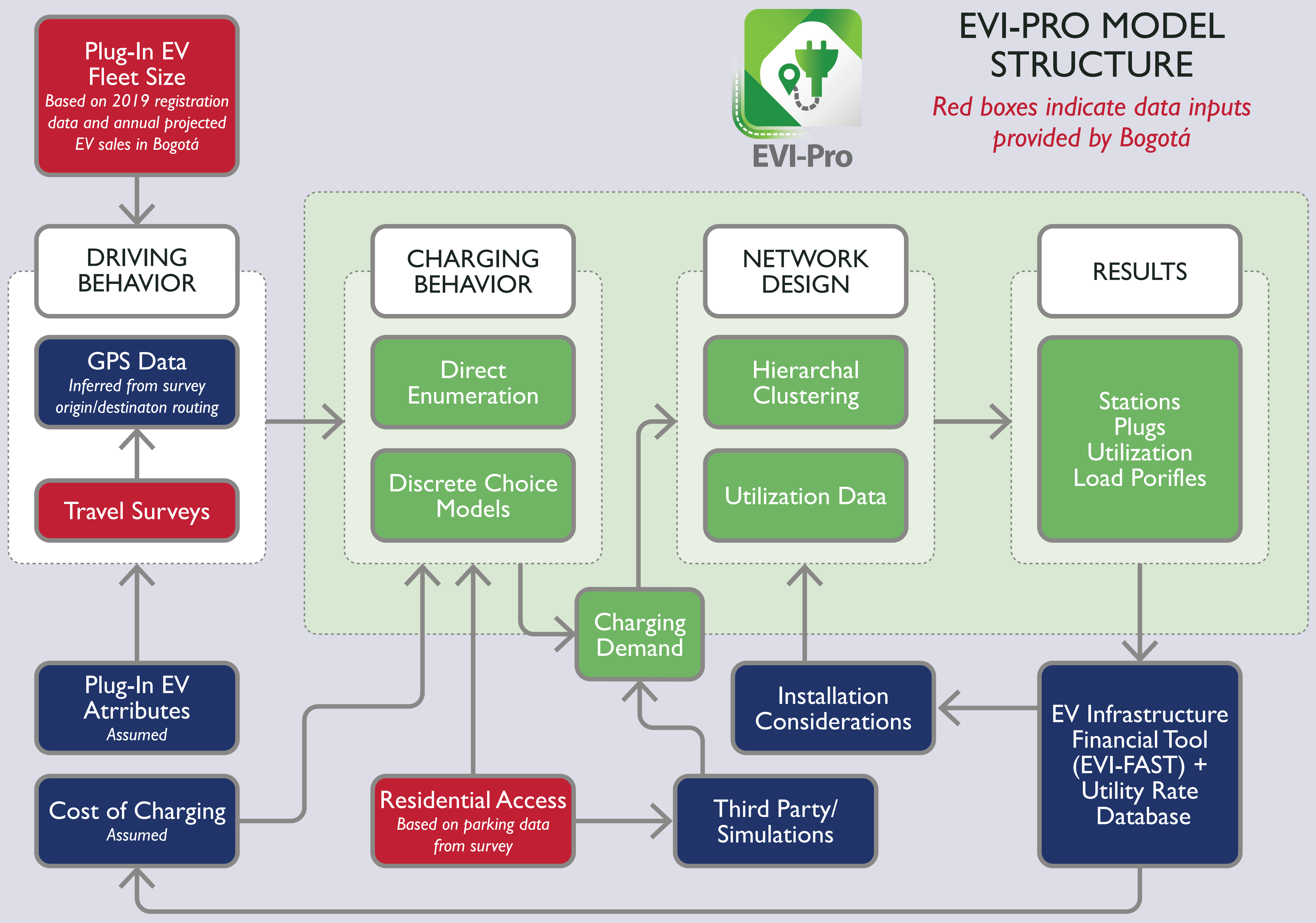

Figure 2. A visualization of the flow of data and logic driving the EVI-Pro model for Bogotá.

Applying EVI-Pro to the Bogotá context was made possible by an extensive **2019 travel survey**, conducted by Secretaría Distrital de Movilidad, which includes several key inputs for the model.

Urban socioeconomic data: Household, person, and vehicle tables:
- Household income, house ownership
- Vehicle registration
- Nightly parking by vehicle and household.

Travel data: 17,000 trips split by vehicle type and purpose:
- Origins and destinations (at the transportation analysis zone level)
- Trip start and end times
- Expansion factor estimated per trip to expand data to 16 million trips.

EVI-PRO PRELIMINARY OUTPUTS AND RESULTS FOR BOGOTÁ

Preliminary analysis for Bogotá, using the newly adapted version of EVI-Pro, yielded outputs that include a table of charge events required for the modeled vehicles to complete the travel day. These outputs are then used to estimate the power level, location, and location type (home, public, or workplace) of the required charging station. These outputs can be useful for both system planning—answering how many charging stations will need to be built—and for individual charging station owners—calculating how many charge events there might be at their station in a day. Additionally, the charge event data is used to estimate the additional power load on the grid from private light-duty EVs charging throughout the day. The contributions to the grid load from different chargers can be viewed by charger ownership and power level.

Figure 3 shows charging over the course of a modeled weekday with the same travel demand for 2025. These numbers are calculated based on EV deployment targets for the region of approximately 19,000 vehicles, assuming 50% of those are full battery EVs and 50% are plug-in hybrid vehicles. This ratio is an example of a parameter that can be reconfigured and varied to evaluate different future EV adoption scenarios. The figure on the right (3b) was run with an assumption of 75% of the home charging availability compared to the case on the left (3a). This difference in assumptions results in more charging at public (red) and work (purple) chargers, especially midday during working hours. In contrast, the charging demand overnight is lower in 3b with less home charging as there are fewer EVs parked at public chargers at those times.

Comparing the results above to the outcomes from weekend travel (**Figure 4,** 4a and 4b) shows the impact of changes in travel behavior. The travel survey shows significantly less vehicle travel overall on weekend days, resulting in much lower charging demand. Additionally, many of those who require charging outside the home are making trips to work, resulting in a large spike in Level 2 charging demand at the start of the workday. Depending on the region modeled and local travel behavior, weekend travel could also be characterized by longer trips than a typical weekday, resulting in more high-power (DCFC) charging to meet the greater daily travel need. However, the survey from Bogotá did not have longer travel days on the weekend, and the demand for public Level 2 or DCFC charging is low.

EVI-Pro can also make varied assumptions about the modeled year for the purposes of scaling up the assumed size of the EV fleet on the road. The weekday grid load with 75% home charging availability from 2025 is shown in **Figure 5** side by side with the same assumptions scaled up to the needs of the 2030 vehicle fleet. The Colombian government is estimating that approximately 120,000 EVs could be on the road by 2030, based on its goals of 300,000 EVs by 2035, which would result in a much greater electricity demand from charging (compare a peak of ~2MW in 5a versus ~14MW 5b).

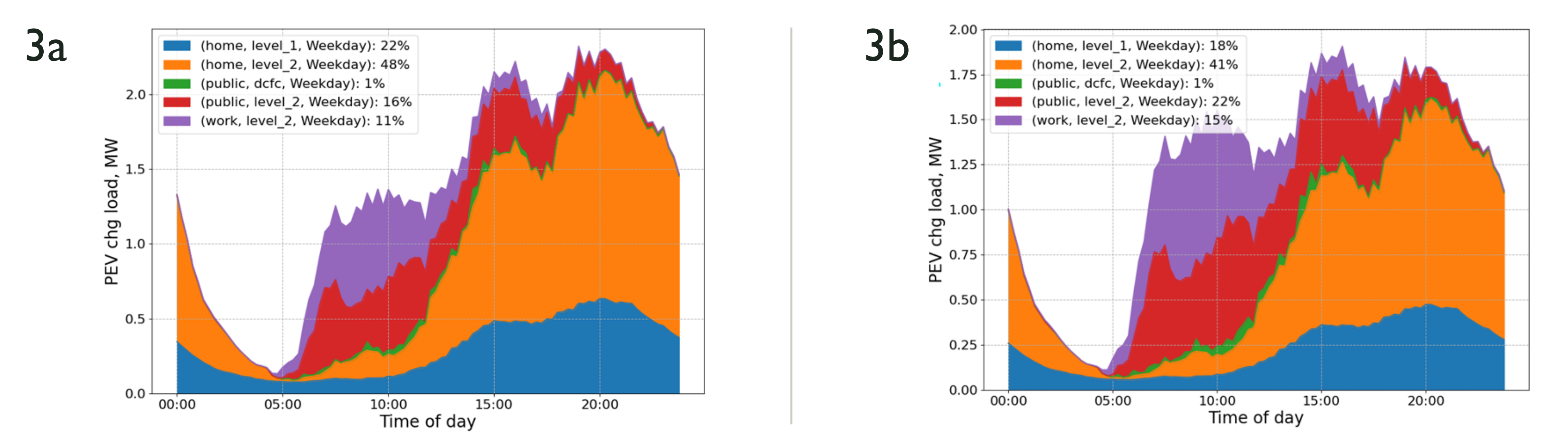

Figure 3. 2025 weekday charging demand with **(3a)** 25% less home charging availability vs. **(3b)** base home charging

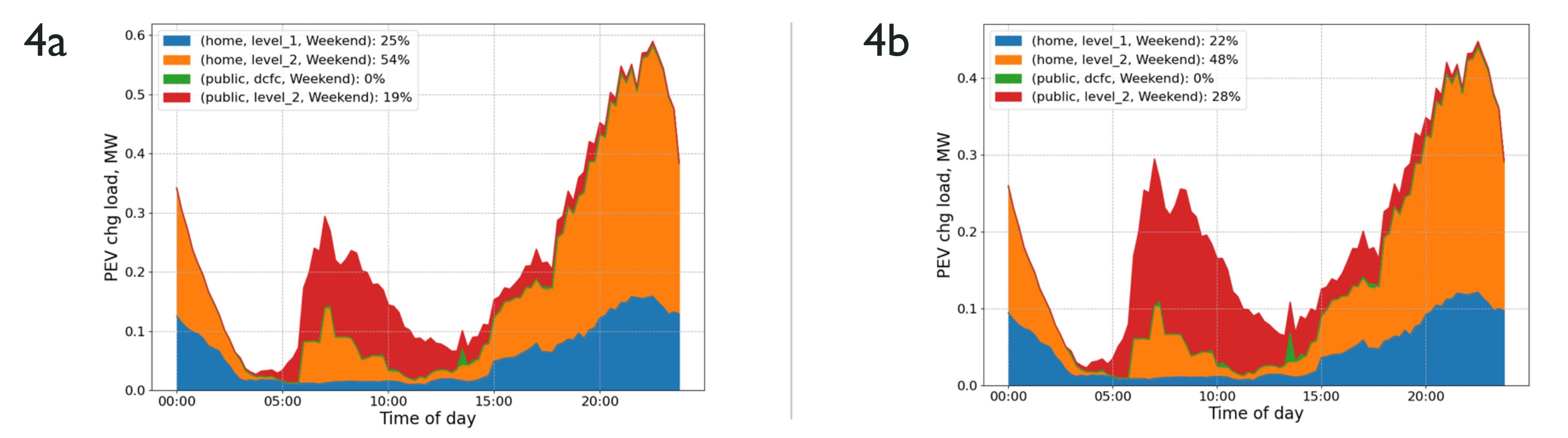

Figure 4. 2025 weekend charging demand with **(4a)** 25% less home charging availability vs. **(4b)** base home charging

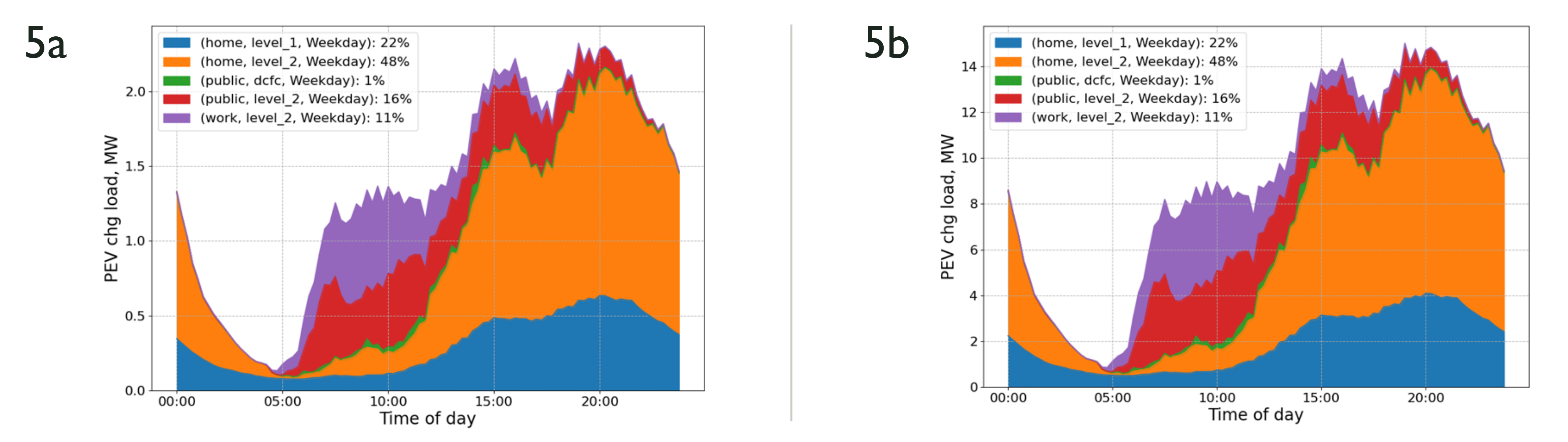

Figure 5. Weekday charging demand with 25% less home charging availability for the **(5a)** 2025 EV fleet or **(5b)** 2030 fleet

As part of this technical assistance project with Colombia, the NREL team created an interface that can be used to set some assumptions for the model run and then run EVI-Pro. This interface can be customized in the future based on specific analysis needs and interests. NREL also provided additional instruction and training in the use of the EVI-Pro model, including extensive documentation for Colombian stakeholders to operate and modify some of the more advanced inputs themselves. The model interface window is shown in **Figure 6**.

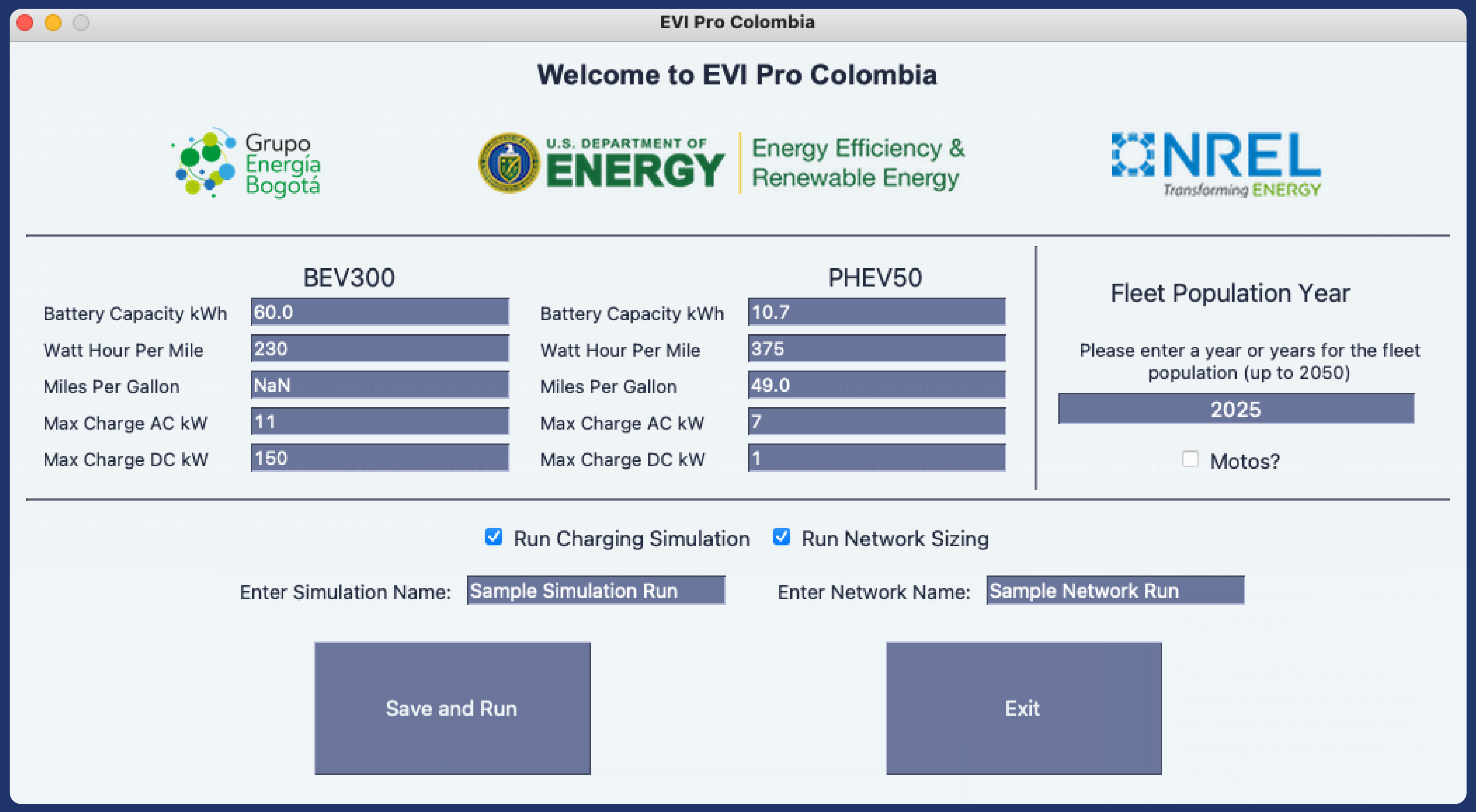

Figure 6. The user-friendly interface created for the customized Colombian version of EVI-Pro

IMPLICATIONS FOR CHARGING STATION BUILDOUT

With output from the EVI-Pro model, stakeholders in Bogotá can plan for future charging station demand and facilitate a smooth transition to electric mobility. Convenient access to public charging is one of the largest hurdles to EV adoption. However, by using location-specific travel data, stakeholders can help guide development in a way that increases access to charging at the destinations they will be most needed and useful to future EV owners. Estimates of how the EV fleet might grow in the future in different areas of the city can also help the evolution of the charging network over time.

Figure 7 shows this evolution in action with the estimated need for Level 2 charging stations by transportation analysis zone (TAZ) for 2025 and then the subsequent growth in stations to meet the demands of the expanded EV fleet by 2030 (Maps 1 and 2). More precise locations for these chargers within each TAZ are not identified using the EVI-Pro model, but NREL can work with stakeholders to identify locations of interest with easier installation enabled by public streetlights or other accessible high-power wiring. Recommended locations for Level 3 DCFC are shown in Map 3, corresponding to the locations that need high-powered charging due to heavy demand and/or shorter time spent parked. Finally, Map 4 shows the relative density of trip destinations by TAZ with a clear correlation to the shaded regions of Maps 1, 2, and 3.

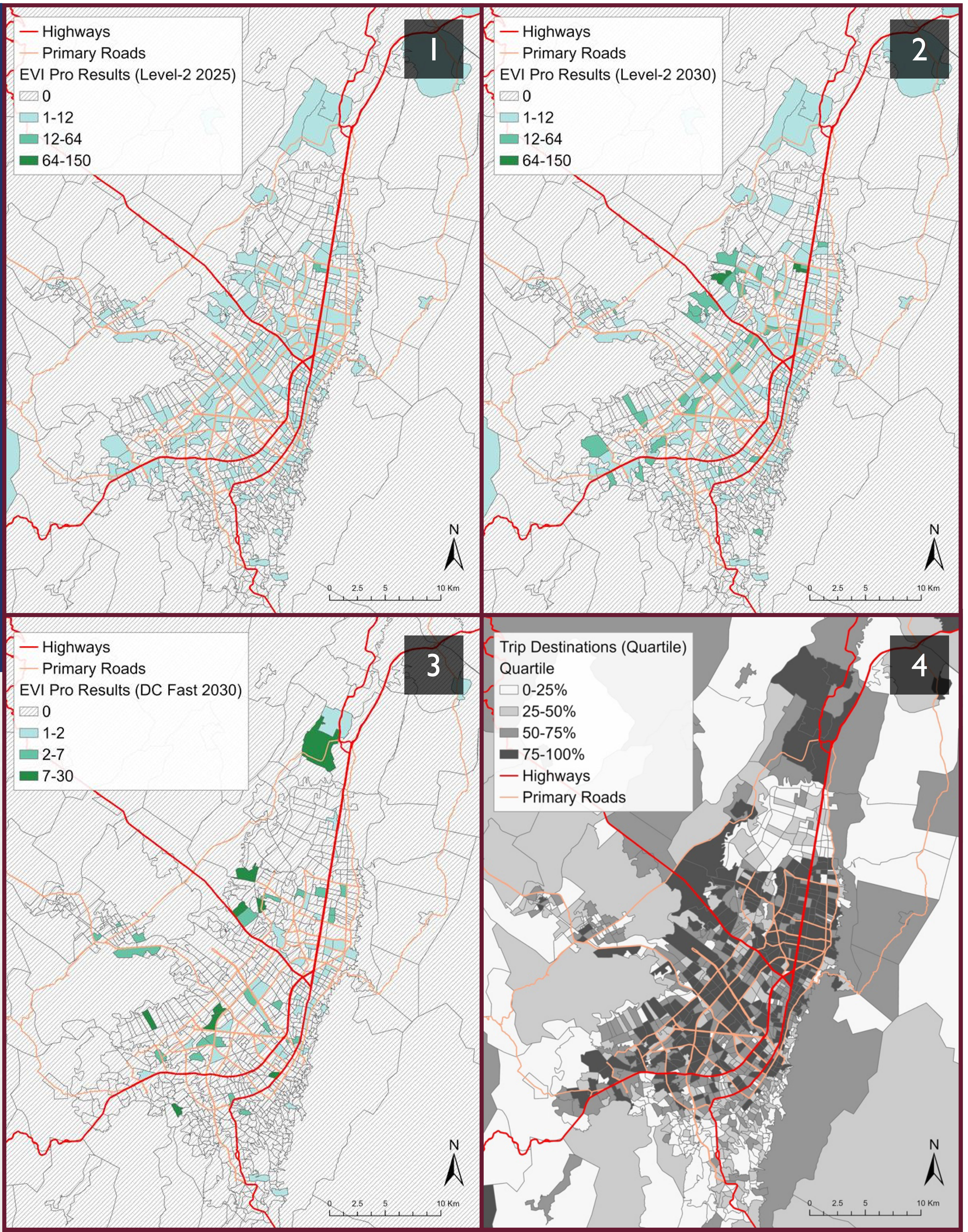

Figure 7. Maps of the Transportation Analysis Zones in Bogotá for projected buildout of **(1)** Level 2 charging stations in 2025; **(2)** Level 2 charging stations in 2030; **(3)** Level 3 (DCFC) stations in 2030; and **(4)** the counts of trip destinations from the 2019 travel survey that is driving the model's selection of charging locations

KEY TAKEAWAY AND NEXT STEPS

The work presented in this document helps enable data-driven long-term planning of electric vehicle charging capacity in the greater Bogotá region. **Key takeaways include:**

- NREL can work with stakeholders to customize the EVI-Pro model and provide guidance on its use and the synthesis and analysis of model results.
- The EVI-Pro model uses travel data as a primary input to estimate future charging station requirements and grid load impacts for the projected future adoption of private light-duty EVs. This travel data can be updated to account for changes in travel behavior and vehicle ownership.
- The impact on the grid from EV charging can vary significantly depending on the time of day, the day of the week, and the type of charging stations that are available for use.
- The distribution of charging stations may not be intuitive—spreading charging stations around the city evenly is less important than providing charging in the specific locations that are likely to have higher demand for EV charging.
- The density of modeled public charging infrastructure buildout is directly related to where vehicles end their trips and have time to plug in.
- Many different factors can impact charging demand, the grid load profile, and the distribution of chargers—a range of assumptions for these factors can be tested by designing and running different scenarios.
- EVI-Pro Lite, an online, publicly available version of the model, is built for the United States but can offer insight into how the recommended charging network size is impacted by changes in inputs: https://afdc.energy.gov/evi-pro-lite.

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Building on this work, stakeholders in Bogotá can develop different scenarios to study how changes in factors such as EV adoption, pricing of public charging, or home charging availability (among others) can impact the estimated future needs for EV charging infrastructure. NREL will continue working with Colombia to build on this analysis and ensure the team feels comfortable working with the provided model and data inputs. Experimenting with various scenarios can then be used to inform policy decisions and drive a more rapid transition to low-emission electrified transportation.

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CONTACT INFORMATION

The USAID-NREL Partnership

usaid.nrel@nrel.gov

To learn more, visit:

www.nrel.gov/usaid-partnership/project-colombia.html.

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