Determining Emissions from Electric Vehicle Adoption in Colorado

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Introduction

In the last few decades, there has been a push to discover and develop new transportation technologies that are both more efficient and less harmful for our environment. These advances have been made with the goal that the operation of the vehicle must release less pollution. Now the question is if the full life cycle of these vehicles are truly less harmful to the environment than the life cycle of internal combustion engine vehicles. Studies have been conducted throughout different regions of the United States to determine the emissions of various types of alternative vehicles. Elgowainy et al. (2010) found that regional electricity generation for battery recharging significantly impacts the energy use and green house gas (GHG) emissions.

Our research is part of a larger project called Project FEVER (Fostering Electric Vehicle Expansion in the Rockies). Project FEVER's main objective is to create a plan to increase the adoption of electric vehicles and electric vehicle equipment across Colorado. Through research and analysis, the project will identify barriers to EV penetration and develop strategies to overcome these barriers in the five issue areas of regulation, permitting, planning, policy, and outreach.

Approach

Our research is focused on the air quality impacts of electric vehicle (EV) penetration in Colorado. It demonstrates emissions released in a simulated 2020 Colorado for 16 different electricity generation scenarios, including our most aggressive scenario of replacing light duty gasoline vehicles with a 10% penetration of EVs. This projection will include assumptions about Colorado's future development of electricity generation and light duty vehicles. The year 2020 was chosen for this projection to allow a reasonable timeframe for the integration of EVs. EVs were chosen because they have the potential to reduce transportation-related air pollution. They release no air pollutant emissions during operation, but emissions do occur from the electricity generation needed to charge the EV. The air pollutant emissions our research focuses on include nitrogen oxides, sulfur oxides, ozone, particulate matter, and volatile organic compounds.

This study uses well-to-wheels life cycle assessment to compare the energy use and emissions of light duty gasoline vehicles with those of EVs that could be in use in Colorado in the year 2020. The well-to-wheels analysis considers energy use and emissions from the stages of production or extraction of the feedstock for vehicle fuel, fuel processing, fuel transport and distribution, and vehicle operation. For gasoline vehicles, this means accounting for impacts of crude oil extraction and refining, delivery of gasoline to the gas station, vehicle refueling, and gasoline consumption in the vehicle. For EVs, the well to-wheels assessment accounts for extraction and transport of natural gas, coal or other fuels used to generate electricity, electricity production, and transmission and distribution of electricity to the vehicle charging station. For plug-in hybrid electric vehicles, both gasoline and electricity pathways are considered. The well-to-wheels life cycle assessment was conducted using Argonne National Laboratory's Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) model, with key inputs tailored for Colorado in the year 2020.

Methods

As noted above, previous studies have found that the mix of generating plants used to provide electricity for EV charging is a critical factor in determining how net EV emissions compare to those from gasoline vehicles. To address that factor, detailed unit commitment and dispatch modeling was performed for the projected electric power sector in Colorado in 2020. Dispatch modeling uses a least-cost approach to determine which generating units will be used to meet electricity demand on an hour-by-hour basis. We used the PLEXOS dispatch model with projections from the Western Electricity Coordinating Council (WECC) for the composition and characteristics of the generating fleet available to serve Colorado customers in 2020 and their forecast hourly demand for electricity. The WECC projection of the power plant fleet was altered to reflect current plans for power plant fuel switching and shutdowns and Colorado's renewable portfolio standards.

Results

Results of this study projecting emissions changes for GHG and air pollutants will be released to local governments and other parties of interest. It should be noted that the actual electricity generation used for recharging EVs could be significantly different depending on actual penetration of EVs over time, impact of policy development, impact of future fuel prices, and impact on number of chargers per day.