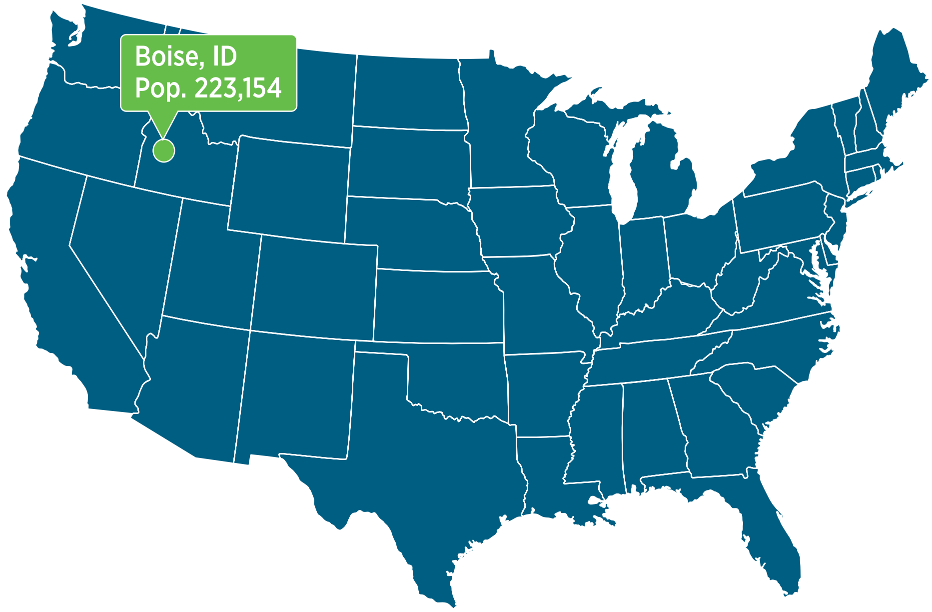
U.S. DEPARTMENT OF ENERGY

Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

CITY ENERGY: FROM DATA TO DECISIONS



Boise, Idaho: Improving Air Quality through Alternative Fuels & Reduced Vehicular Travel

The City of Boise partnered with the Energy Department and the National Renewable Energy Laboratory (NREL) to demonstrate how data and analysis can inform more strategic energy decisions. NREL based its analysis in-part on the City Energy Profiles on the State and Local Energy Data (SLED) website (*eere.energy.gov/sled*). The profiles contain data compiled by SLED and the Cities Leading through Energy Analysis and Planning (Cities-LEAP) program. Cities across the country can follow the same approach and use data-driven analysis in their own energy planning.

> "Boise recently developed a Transportation Action Plan, which provides a roadmap to mobility choices for all city residents. The data and analysis provided by NREL helps to quantify how mobility choices can provide additional benefits for air quality and reduced carbon emissions and supports city decision making processes."
>
> – *Haley Falconer, Environmental Division Manager, City of Boise*

City Energy Questions

The City of Boise is exploring approaches to improve local air quality by reducing personal vehicular travel and increasing alternative fuel use, and is specifically interested in data and analysis to address the following questions:

1. What is the emissions reduction potential of city policies and actions aimed at reducing personal vehicular travel through urban planning practices that facilitate alternative modes of transit (e.g., walking and biking)?

2. How would various levels of alternative fuel vehicle (AFV) adoption impact local fuel consumption and greenhouse gas (GHG) emissions?

Data and Analysis

To conduct the analysis for Boise, NREL evaluated estimated city energy data from SLED and supplemental data obtained directly from the City of Boise.

NREL combined SLED data with city-provided data to chart emissions by sector to understand Boise's vehicle greenhouse gas emissions. On-road vehicles accounted for an estimated 39% of Boise's total emissions from energy consumption in 2013 (see Figure 1).

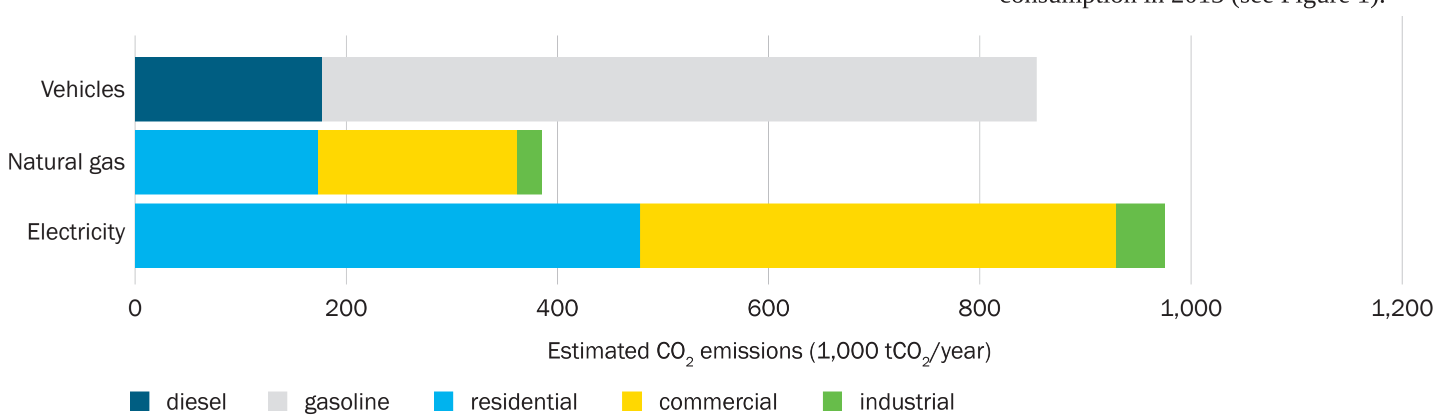


Figure 1. Annual energy GHG emissions (2013) for Boise, Idaho (Source: SLED and residential electricity data from the City of Boise)

Table 1. Light-Duty Vehicle Registrations by Type for Boise, Idaho (2013, 2016)

Vehicle Fuel	2013	2016
Electric	0.02%	0.08%
Hybrid (electric and gas)	1.41%	1.73%
Plug-in hybrid electric*	N/A†	0.08%

Data from R.L. Polk & Company.

* Plug-in hybrid electric vehicles have electric and gas engines with electric charging ability.

† Not applicable; R.L. Polk & Company 2013 data does not include a plug-in hybrid electric vehicle category.

Boise's percentages of hybrid and electric vehicles are small, but increasing (see Table 1). In 2013, Boise's percentage of hybrid electric vehicles ranked in the top 11% out of the more than 22,000 cities that Cities-LEAP analyzed that had more than 100 registered light-duty vehicles. In addition, light-duty vehicles registered in Boise as of 2013 had an average fuel economy of 22.4 miles per gallon (mpg), placing the city in the top third of the cities analyzed by Cities-LEAP, but below the average adjusted fuel economy for 2015 vehicles of 24.8 mpg.[1] Flex-fuel vehicles, which are optimized to use either E85 (a blend of up to 85% ethanol and 15% gasoline) or regular gasoline, were the most common AFVs in Boise in 2016 at 6% of all registered light-duty vehicles (see Figure 2).

Of the approximately 4,600 registered heavy- and medium-duty vehicles in Boise in 2013, 1.8% were compressed natural gas (CNG) vehicles. Using CNG can reduce life-cycle greenhouse gas emissions compared to conventional fuels. However, increasingly stringent vehicle tailpipe emissions regulations have decreased the difference between CNG vehicle emissions and conventional vehicles with modern emissions controls.[2]

Considerations for Reducing Fuel Consumption

Using a Cities-LEAP study on the carbon abatement potential of city-level energy actions,[3] along with City of Boise staff inputs and adjustments, NREL developed a calculator for emissions reductions potential from five common city-level actions (see Figure 3). City-provided factors include efficiency program participation rates, new construction and major renovation rates, growth rate, share of new growth anticipated to be infill and transit-oriented, public transit service and ridership expansion, city fleet hybridization percentage, and the percent of municipal operations procured from renewable sources within the next 15 years.

Expanding public transit service and ridership has the highest GHG emissions reduction potential for Boise relative to other common city energy actions.[4] Boise may consider working in partnership with their regional transportation district or other third parties to capitalize on opportunities to expand public transit ridership and service.

The Victoria Transport Policy Institute found the following ranges for private vehicle travel reduction from various transportation policy strategies: Special lanes for buses and high-occupancy vehicles, traffic signal preemption, faster loading systems: 4%–30%; parking management (e.g., parking pricing and incentives for reduced parking space requirements): 10%–30%; commute trip reduction programs (e.g., commuter financial incentives, rideshare matching, and guaranteed rides home): 20%–40%; improved user information (e.g., schedules, maps, and wayfinding): 5%–15%.[5]

City policies and actions aimed at reducing personal vehicular travel through urban planning practices that facilitate alternative modes of transit (e.g., walking and biking), also known as smart growth, have low carbon abatement

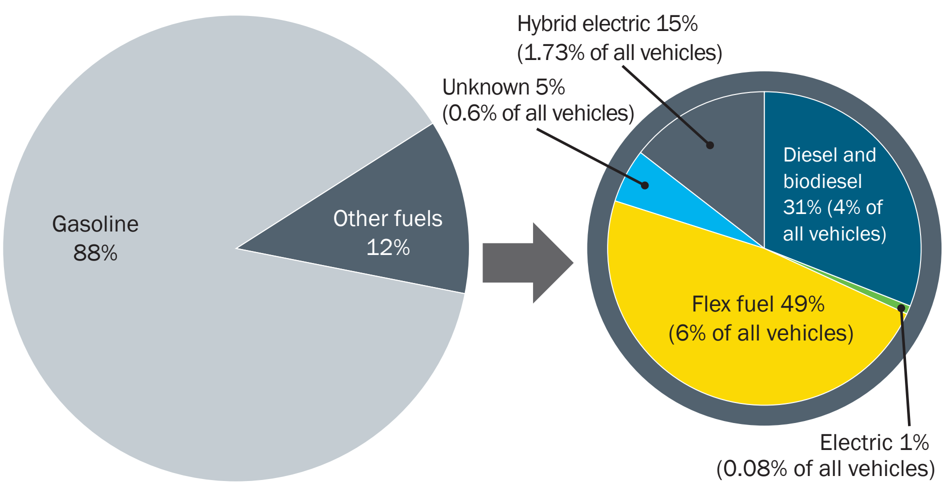


Figure 2. Light-duty conventional and alternative fuel vehicles by type (2016) registered in Boise, Idaho (Source: SLED)

[1] U.S. Environmental Protection Agency, "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends Report Overview," https://www.epa.gov/fueleconomy/trends-report.

[2] "Natural Gas Vehicle Emissions," Alternative Fuels Data Center, https://www.afdc.energy.gov/vehicles/natural_gas_emissions.html.

[3] E. O'Shaughnessy et al., *Estimating the National Carbon Abatement Potential of City Policies: A Data-Driven Approach*, National Renewable Energy Laboratory (2016), NREL-67101, http://www.nrel.gov/docs/fy17osti/67101.pdf and http://energy.gov/node/2104835.

[4] Note that the model and outputs depicted in Figure 1 represent a first-cut estimate to quantify the tCO_2 emissions reduction potential of various actions. The numerical values quantify emissions reduction potential to an order of magnitude.

[5] T. Litman, *Evaluating Public Transit as an Energy Conservation and Emission Reduction Strategy*, Victoria Transport Policy Institute (2015).

potential compared to other city policy approaches analyzed for Boise. The Cities-LEAP analysis of carbon abatement potential[6] showed that the estimated CO_2 abatement potential from smart growth policies is about twice as high in eastern coastal cities with large urban areas and higher vehicle miles of travel than in other U.S. cities.

Smart growth policies are among the most common types of city-level actions.[7] They achieve a variety of objectives, such as improved walkability, connectivity, and quality of life. Strategies for smart growth include the following:

- Affordable urban housing
- Bike and pedestrian infrastructure
- Location-based development impact fees that incentivize in-fill and redevelopment
- Location-efficient development—focusing development in areas with available public infrastructure
- Open space preservation and urban growth boundaries
- Targeted investments in city centers
- Transit-oriented development
- Zoning code reform to enable mixed land uses and higher population densities.

Urban planning practices that facilitate alternative modes of transit or reduce trip lengths use development incentives and regulations as a travel reduction strategy. Short-term emissions reduction potential is limited by the turnover of residential and commercial zones into new development. Therefore, smart growth policies may have much more significant impacts in the long term than in the short term.

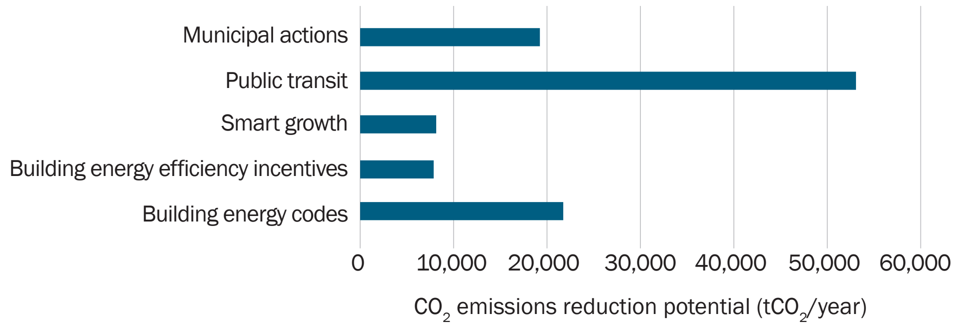


Figure 3. Annual GHG reduction potential of city energy actions for Boise, Idaho

Alternative Fuel Vehicle Adoption

Based on the Cities-LEAP estimate of vehicle miles traveled for Boise (available for all cities on SLED) and vehicle fuel economy data from registered vehicles in Boise, NREL estimated air pollutant emissions per vehicle (Table 2).[8]

To quantify the potential for reducing air pollution by switching to alternative fuels, NREL estimated criteria pollutant savings per 50 vehicles, based on registered vehicle fuel types and vehicle miles traveled in Boise (see Table 3). Electric vehicles provide the greatest air pollutant emissions reductions of the AFVs analyzed.

Vehicle Emissions

Nitrogen oxides (NO_x) and volatile organic compounds (VOCs) are criteria pollutants that may be of particular concern for air quality in Boise. NO_x and VOCs react in sunlight to form ozone, which irritates and damages lungs, worsens heart disease, and damages plants, rubber, fabrics, and paints. NO_x also contributes to acid rain. Carbon monoxide (CO) at low levels can exacerbate cardiovascular disease by reducing oxygen delivery and at high levels can be poisonous. Particulate matter (PM_{10} and $PM_{2.5}$) are generated primarily from tire and break wear (TBW) and can cause serious health impacts affecting the lungs and heart. Fine particles ($PM_{2.5}$) cause more damage than course particles (PM_{10}).

The following are actions that may help reduce fuel consumption through increased AFV adoption:

- Integrating AFVs into Boise's municipal fleet and installing alternative fueling stations at municipal properties
- Streamlining permitting and inspection of AFV charging installations to reduce costs and development time[9]
- Requiring EV charging station installation in commercial building codes and development and parking regulations to integrate EV charging into multifamily buildings and larger workplaces
- Providing incentives such as density bonuses and reduced parking requirements for installing EV charging infrastructure in new development[10]
- Adopting zoning ordinance amendments to enable installation of EV charging stations and encourage their appropriate placement.

[6] O'Shaugnessy et al. (pp. 59–60) and Figure 3 of "Study Shows Carbon Emission Reductions from City Energy Actions," https://energy.gov/eere/study-shows-carbon-emission-reductions-city-energy-actions.

[7] A. Aznar, M. Day, E. Doris, S. Mathur, P. Donohoo-Vallett, *City-Level Energy Decision Making: Data Use in Energy Planning, Implementation, and Evaluation in U.S. Cities*, National Renewable Energy Laboratory (2015), NREL/TP-7A40-64128, http://www.nrel.gov/docs/fy15osti/64128.pdf, p. 22.

[8] NREL used the AFLEET model to calculate criteria emissions on a per-mile basis for each fuel type. The light-duty vehicle miles traveled (VMT) for each fuel type was calculated based on the total gasoline use, the number of heavy-duty and ligh-duty vehicles that are operated on gasoline, the average fuel economy of light-duty and heavy-duty vehicles, and the total VMT for all vehicles. The fuel economy for heavy-duty vehicles was derived from AFLEET assumptions, and all other values come from SLED. This analysis uses an assumed average fleet model year of 2007, an average light-duty VMT of 6,151 miles/vehicle/year calculated from Cities-LEAP data on SLED and 2016 AFLEET data from Argonne National Laboratory.

[9] For more information, see the California Plug-In Electric Vehicle Collaborative, *Streamlining the Permitting and Inspection Process for Plug-In Electric Vehicle Home Charger Installations*: http://www.pevcollaborative.org/sites/all/themes/pev/files/PEV_Permitting_120827.pdf.

[10] See Alternative Fuels Data Center Local Laws and Incentives: https://www.afdc.energy.gov/laws/local_examples.

Table 2. Estimated Annual Criteria Emissions per Vehicle for Light-Duty Vehicles (2013) in Boise, Idaho

Vehicle fuel (passenger car)	Vehicle operation air pollutant emissions (lbs.)							
	CO	NO_x	PM_{10}	PM_{10} (TBW)†	$PM_{2.5}$	$PM_{2.5}$ (TBW)†	VOC	VOC (Evap)‡
Gasoline	45	4.2	0.08	0.38	0.07	0.05	2.6	0.92
Gasoline hybrid electric	45	3.5	0.08	0.38	0.07	0.05	1.4	0.92
E85*	45	4.2	0.08	0.38	0.07	0.05	2.6	0.78
Diesel	45	3.0	0.07	0.38	0.07	0.05	1.9	0.08
Gasoline plug-in hybrid electric vehicle	45	3.5	0.08	0.38	0.07	0.05	1.4	0.92
Electric	0	0.0	0	0.38	0	0.05	0	0

Table 3. Annual Air Pollutant Emission Savings from Converting 50 Gasoline Vehicles to Alternative Fuels (2013) for Boise

Vehicle Fuel (passenger car)	Vehicle operation air pollutant emissions savings (lbs.) in comparison to gasoline							
	CO	NO_x	PM_{10}	PM_{10} (TBW)†	$PM_{2.5}$	$PM_{2.5}$ (TBW)†	VOC	VOC (Evap)‡
Gasoline hybrid electric	0	34	0	0	0	0	59	0
Gasoline plug-in hybrid electric vehicle	0	34	0	0	0	0	59	0
EV	2,250	210	4	0	3	0	128	46
E85*	0	0	0	0	0	0	0	7
Diesel	-32	62	1	0	0	0	32	42

Source: NREL analysis using the AFLEET model (*greet.es.anl.gov/afleet*) and SLED data.

*Assumes that E85 fuel is used 100% of the time in flex-fuel vehicles. †TBW = tire and break wear ‡Evaporative VOC emissions are caused by the evaporation and venting of gasoline and diesel fuel from a vehicle.

Resources

The following resources may be useful to guide further research and action steps to reduce local air pollutants and fuel use:

DOE Clean Cities

The Clean Cities program supports local actions to cut petroleum use in transportation: *https://cleancities.energy.gov*. Treasure Valley Clean Cities is the coalition for Boise, Idaho: *https://cleancities.energy.gov/coalitions/treasure-valley*.

VMT and Alternative Fuels

- Alternative Fuels Data Center: *http://www.afdc.energy.gov*
- Transportation Data Book: *http://cta.ornl.gov/data/index.shtml*
- U.S. Energy Information Administration – Alternative Fuel Vehicle Data: *https://www.eia.gov/renewable/afv/index.php*
- ADOPT: A Historically Validated Light Duty Vehicle Consumer Choice Model: *http://www.nrel.gov/docs/fy15osti/63608.pdf*

Electric Vehicles

- Plugged In: How Americans Charge Their Electric Vehicles: *https://avt.inl.gov/sites/default/files/pdf/arra/SummaryReport.pdf*
- Electric Power Research Institute (EPRI) Guidelines for Infrastructure Planning: An Explanation of the EPRI Red Line/Blue Line Model (analysis of charging infrastructure planning): *http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000003002004096*
- Alternative Fuels Data Center: Charging Plug-In Electric Vehicles in Public: *http://www.afdc.energy.gov/fuels/electricity_charging_public.html*. Includes handbooks on workplace charging, integrating EVs into fleets, and zoning and parking ordinances.

The SLED Local Energy Action Toolbox provides examples and guides on incentivizing the adoption of AFVs, anti-idling measures, VMT reduction, and fuel switching for municipal fleets: *http://apps1.eere.energy.gov/sled/cleap.html*.

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