UrbanFootprint Technical Documentation
Household Cost Analysis

Overview

The UrbanFootprint Household Cost module estimates annual household costs associated with passenger vehicle transportation, residential energy use, and residential water use. Together, these represent dimensions of housing affordability as it relates to location efficiency, which impacts travel behavior and vehicle miles traveled (VMT); and housing type, which impacts energy and water use.

Comparative results among scenarios demonstrate the effects of land use and housing mix on affordability for individual households, and project-wide. Household costs are also subject to technical assumptions for vehicle and building performance, as well as cost assumptions for utilities, auto fuel, and auto ownership and maintenance. The VMT, building energy, and water use calculations upon which household cost estimates are based are described in the documentation for the Transportation, Energy Use, and Water Use modules.

The module comes loaded with default inputs for vehicle fuel economy; costs for auto fuel, ownership, and maintenance; residential electricity and natural gas costs; and residential water cost. These defaults represent current baselines, with national averages used for vehicle performance and ownership and maintenance costs, and state averages used for auto fuel, electricity, and natural gas. Users can change the baseline inputs if more local data are available, and use inputs for future-year scenarios to estimate the effects of better vehicle performance or changing costs.

Analysis is run at the scale of the project canvas (generally parcels or census blocks), yielding a mapped spatial output layer and corresponding data table; both can be used within UrbanFootprint for mapping and data exploration, and exported. The module also reports individual and comparative scenario results via summary charts, and generates a spreadsheet summary in Excel format.

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Methodology

The module estimates household costs based on the VMT, energy use, and water use outputs generated by the Transportation, Energy Use, and Water Use modules. Please refer to the documentation of these modules for details about how these outputs are derived.

Estimated household costs are also determined by input assumptions for vehicle performance, per-mile transportation cost, and utility prices. The following sections describe the default assumptions and calculations used.

Transportation Cost Calculations

On the basis of typical vehicle use, the Household Cost module applies an on-road average fuel economy for all cars, an average cost per gallon for gasoline, and an average cost per mile for ownership and maintenance.

The Transportation module estimates annual VMT per household. Household costs related to passenger vehicle transportation are then calculated with fleet-wide average assumptions for on-road vehicle fuel economy, fuel price, and per-mile ownership and maintenance cost, which can be set for the baseline and future years. Fuel economy in miles per gallon is applied to VMT for the fuel consumption calculation (in gallons). The fuel price (in constant dollars, that is, value in terms of today's dollars) is applied to fuel consumption for the fuel cost calculation. In addition, transportation costs related to vehicle ownership and maintenance are estimated by applying an average per-mile cost to VMT. The following equation summarizes the calculation:

$$HHCost_{transportation} = (VMT\ (miles)\ /\ FuelEconomy\ (miles/gallon))\ *\ FuelPrice\ (dollar/gallon)\ +\ VMT\ (miles)\ *\ O\&MPrice\ (dollar/mile)$$

Figure 1. Household Cost Analysis Flow

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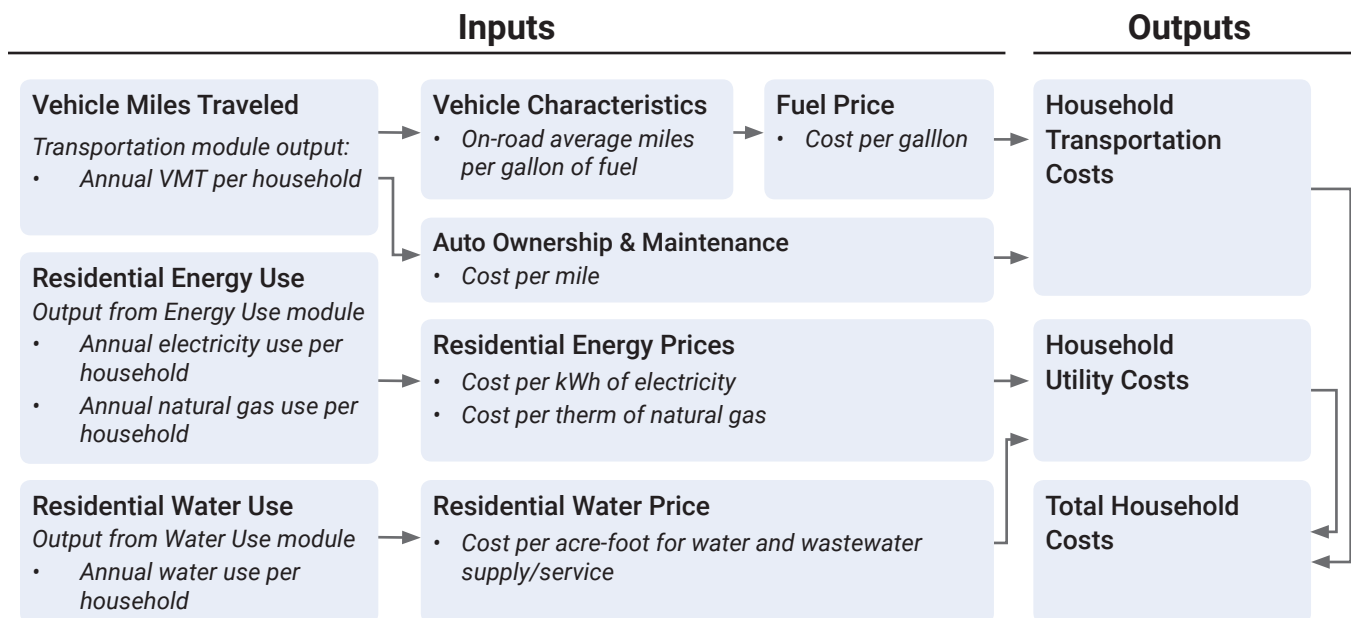
Energy Cost Calculations

The Energy Use module estimates electricity and natural gas use for residential and commercial buildings. Utility costs associated with electricity and natural gas use are calculated, in turn, on the basis of cost assumptions that can be set for the baseline and future years. The equation for household electricity and natural gas use costs is summarized below:

$$HHCost_{energy} = ElectricityUse\ (kwh)\ *\ ElectricityPrice\ (dollar/kwh)\ + \\ NaturalGasUse\ (therm)\ *\ NaturalGasPrice\ (dollars\ /\ therm)$$

Water Cost Calculations

The Water Use module estimates household water use. Water costs are calculated by applying water prices (in dollars per gallon) that can be set for the baseline and future years. The equation for estimating water costs is as follows:

$$HHCost_{water-use} = (IndoorWaterUse\ (gallons)\ + OutdoorWaterUse\ (gallons))\ *\ WaterPrice\ (dollars\ /\ gallon)$$

Input Parameters

UrbanFootprint comes loaded with a set of default costs for transportation fuel, auto ownership and maintenance, and residential electricity, natural gas, and water. This section describes the development of the default inputs using national data sources.

The default inputs can be replaced with localized baseline inputs, if available, via the Analysis Assumptions editor. Different cost inputs can be set for each scenario, and can be used to test the impact of changing prices into the future.
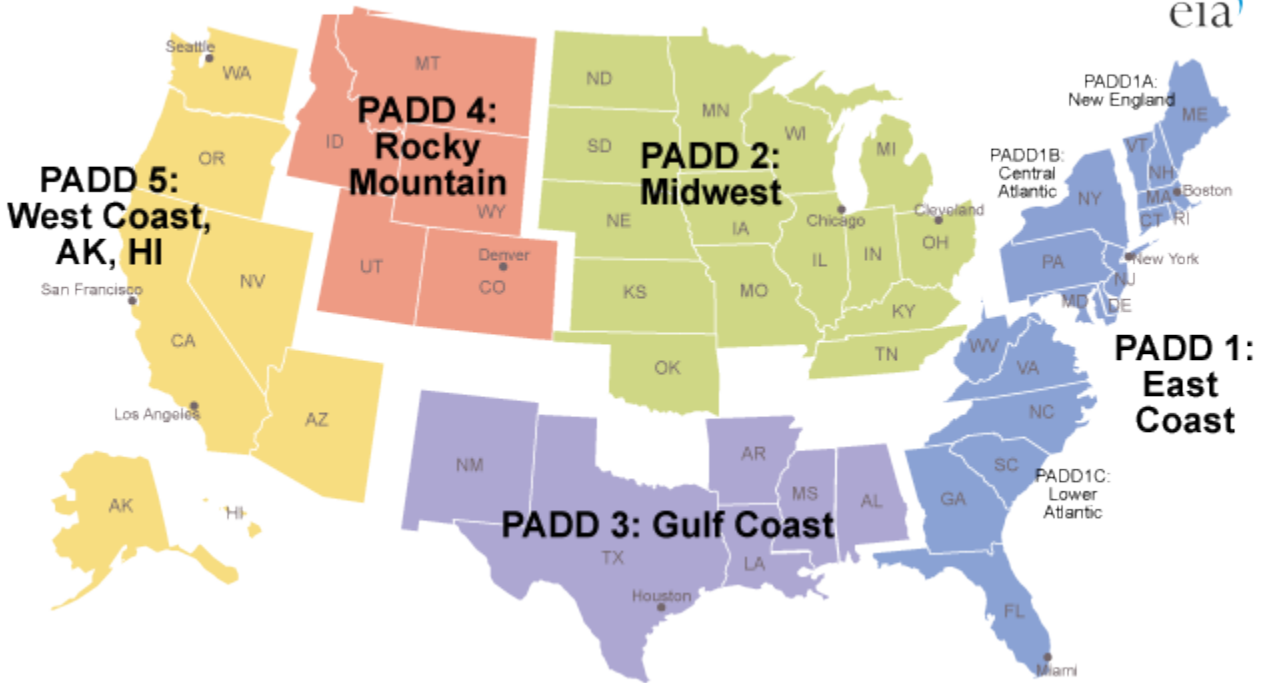
Default Transportation Costs

UrbanFootprint comes loaded with a set of default parameters related to transportation costs. Automobile fuel prices are generated from the Energy Information Administration (EIA) Weekly Retail Gasoline and Diesel Prices dataset[1]. The dataset includes average prices for all finished motor gasoline grades (regular, midgrade, premium) and formulations (conventional, reformulated). In general, prices are averaged over each Petroleum Administration for Defense District (PADD) (see Figure 1). PADDs are geographic divisions of the 50 states and the District of Columbia into five districts. The EIA also provides gasoline prices for several specific states, including California, Colorado, Florida, Massachusetts, Minnesota, New York, Ohio, Texas, and Washington. For these states, UrbanFootprint uses the state-specific gasoline price in place of the PADD average. Default values for each project are set using the annual average gasoline price for the PADD or state that the project falls within.

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1 https://www.eia.gov/dnav/pet/pet_pri_gnd_a_epm0_pte_dpgal_a.htm

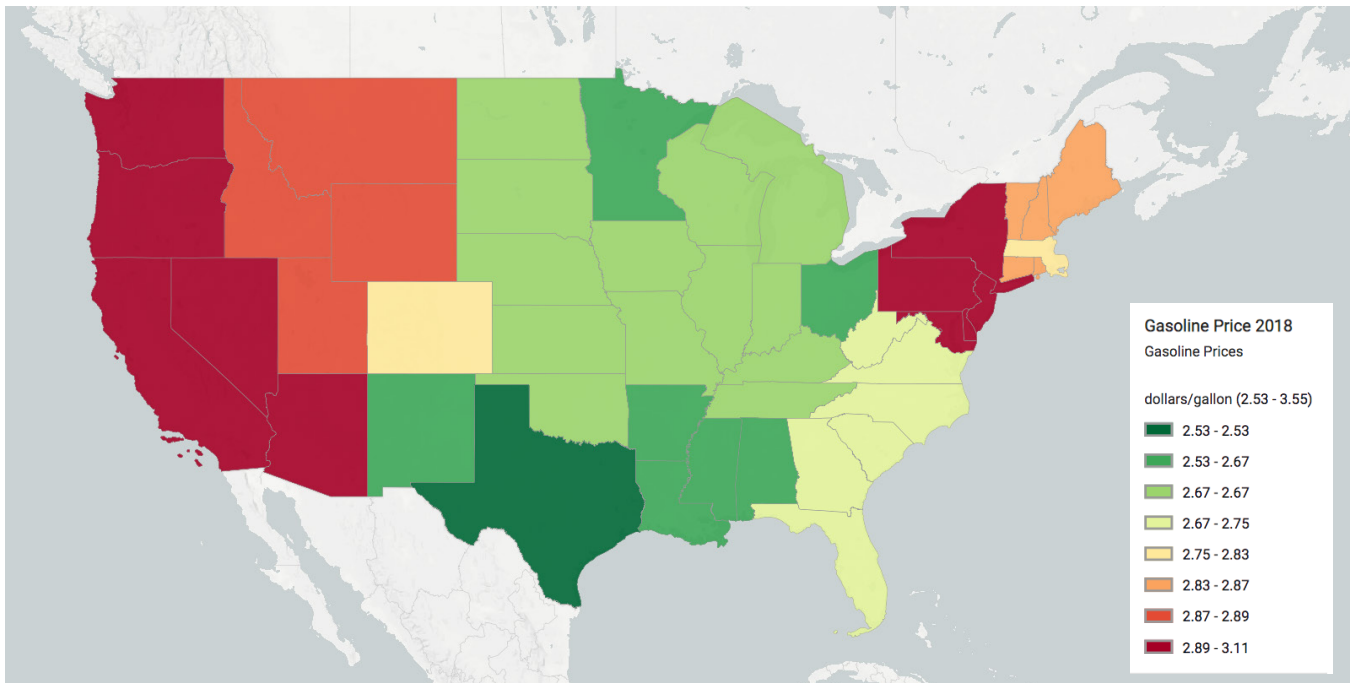Figure 1. Petroleum Administration for Defense Districts (PADDs). Source: EIA

Other transportation cost parameters are stored as single values that are used as nationwide defaults. The default fuel efficiency rate for passenger vehicles comes from the 2016 USDOT National Transportation Statistics Average Fuel Efficiency of U.S. Light Duty Vehicles dataset[2]. The default auto ownership and maintenance cost are AAA estimates for the average cost of a new vehicle manufactured and purchased in 2017 and driven 10,000 miles per year, excluding fuel costs. Table 1 summarizes the input parameters used to calculate transportation cost and the default baseline values used by UrbanFootprint. If available, users can input localized baselines and projected future-year values for more accurate and/or policy-oriented analysis.

Table 1. Default Input Parameters for Transportation Costs

Parameter	Default Baseline Value
Average on-road passenger vehicle fuel economy	22.96 miles/gallon
Auto fuel price	Values vary by PADD or state
Auto ownership and maintenance	0.63 dollars/mile

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2 https://www.bts.gov/content/average-fuel-efficiency-us-light-duty-vehicles

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Figure 2. Average Gasoline Prices by PADD and by State - 2018
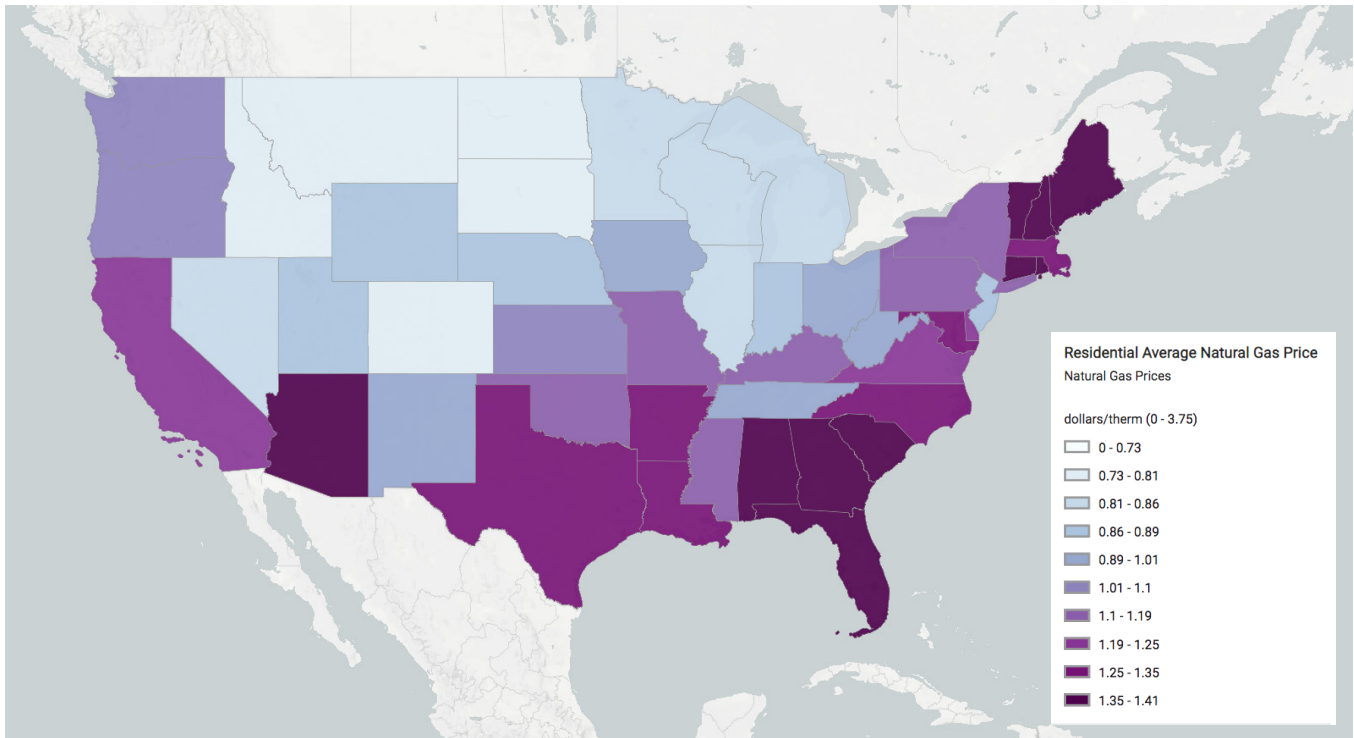

Default Residential Energy Costs

UrbanFootprint comes loaded with a set of default electricity and natural gas prices that vary by state. Electricity prices by state are generated from the U.S. Energy Information Administration (EIA) Monthly Electric Power Industry Report for the year 2017. The dataset contains revenue from electric power sold to ultimate consumers and the corresponding sale of electricity. Average prices are then calculated (in dollars per kilowatt-hour) by dividing the revenue by the amount of electricity sold. Note that because the derived average prices represent weighted averages for all consumers, they are not directly equal to the per kilowatt-hour rate the electric power industry participant charges individual consumers, though often the values are similar.

Figure 2. Default Residential Electricity Prices - 2017
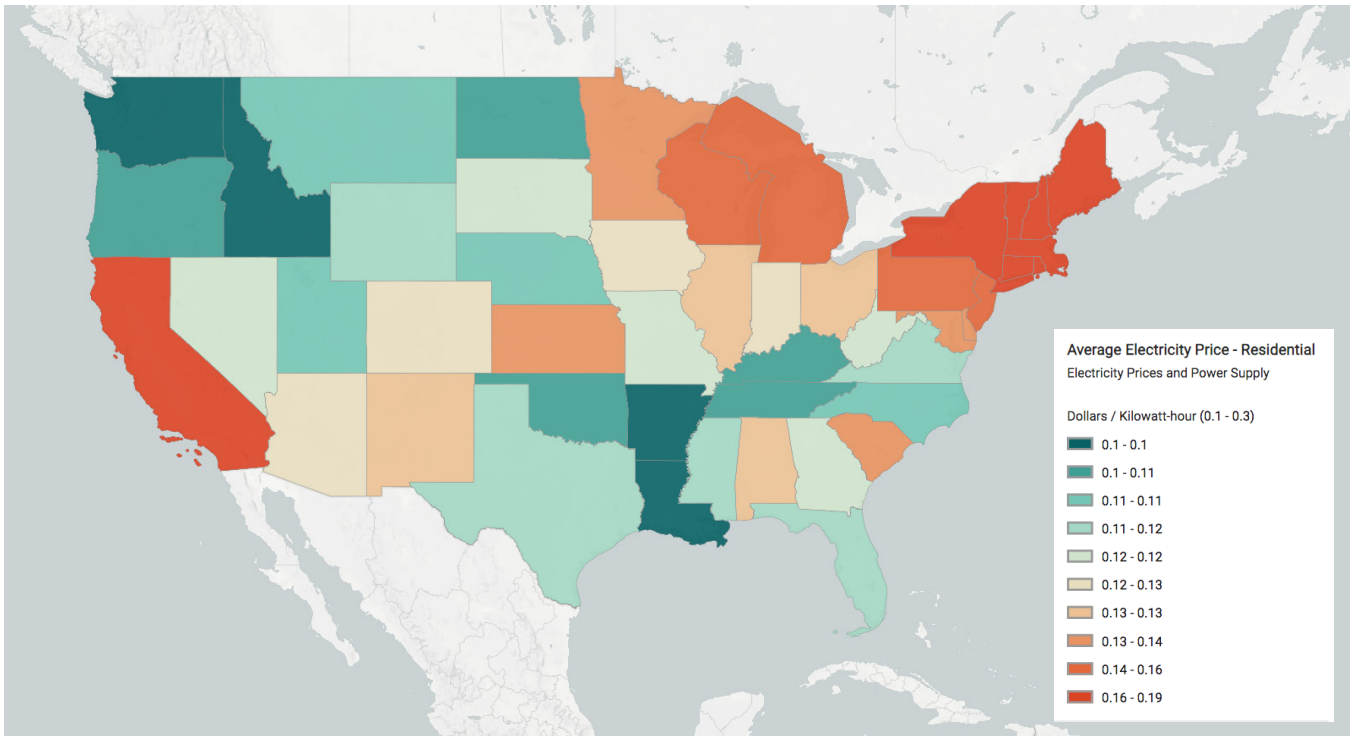
State natural gas prices are generated from the 2017 EIA Natural Gas Annual Report. The dataset contains average annual natural gas prices for residential, commercial, and industrial sectors.

Figure 2. Default Natural Gas Prices - 2017

Residential Average Natural Gas Price
Natural Gas Prices

dollars/therm (0 - 3.75)

	0 - 0.73
	0.73 - 0.81
	0.81 - 0.86
	0.86 - 0.89
	0.89 - 1.01
	1.01 - 1.1
	1.1 - 1.19
	1.19 - 1.25
	1.25 - 1.35
	1.35 - 1.41

Default Residential Water Costs

Table 2 shows the input parameter used to calculate household water cost and the default baseline UrbanFootprint uses. Users can input localized baselines and projected future-year values for more accurate and/or policy-oriented analysis. Water prices may include charges for both water supply and wastewater treatment.

Table 2: Default Input Parameters for Residential Water Costs

Parameter	Default Baseline Value
Residential water price	$7.74 per thousand gallons

Output Metrics

The Household Cost module generates a mapped spatial output layer and corresponding data table; both can be used within UrbanFootprint for mapping and data exploration, and exported. The module also reports individual and comparative scenario results via summary charts, and generates a spreadsheet summary in Excel format. The attributes of the spatial output/data table are summarized in Table 3.

Table 3: Household Cost Module Outputs

Attribute(s)	Description
Total Household Cost	Annual costs for fuel, auto ownership and maintenance, residential energy, and residential water, total for all households
Total Household Cost per Household	Annual costs for fuel, auto ownership and maintenance, residential energy, and residential water, per household
Transportation Cost	Annual fuel and auto ownership and maintenance costs, total for all households
Fuel Cost	Annual fuel costs, total for all households
Auto Ownership and Maintenance Cost	Annual auto ownership and maintenance costs, total for all households
Transportation Cost per Household	Annual transportation costs including fuel and auto ownership and maintenance, per household
Residential Utility Cost	Annual utility costs, including residential energy and water, total for all households
Residential Energy Cost	Annual residential electricity and natural gas costs, total for all households
Residential Water Cost	Annual residential water costs, total for all households
Total Residential Utility Cost per Household	Annual utility costs, including residential energy and water, per household
Residential Energy Cost per Household	Annual residential electricity and natural gas costs, per household
Residential Water Cost per Household	Annual residential water cost, per household

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