# Water Footprinting Data Documentation

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## *I. Water Consumption and Withdrawals from Energy Use (Household and Transportation)*

a) *Water Intensity of Electricity*

All current energy production systems depend on water in some form in the product's life-cycle. We used the following methods to calculate how much water from energy use is directly and indirectly consumed in indoor appliance activity and transportation. When calculating water use in electricity consumption, we took into account what the specific regional electricity mix is composed of. California and the US have a diverse electricity mixes, meaning many methods of electricity production contribute to the grid. The California Energy Commission (CEC) and US Energy Information Administration (US EIA) both provide data regarding their respective electricity mixes. For example, in 2012 43% of California's electricity was produced by natural gas.

Equation 1 was used to calculate the water use comprised with each electricity generation method. It involves average per capita consumption (CEC or US EIA and US 2012 Census), energy source's percentage of total mix (CEC or US EIA) and data regarding water use for each fuel source per unit of energy (respective data sources, see Table 1.1). This is applied to a region $\beta$ and comprises all generation methods $\alpha_1, \ldots \alpha_n$ for that region.

**Equation 1**: Total annual water consumption/withdrawal due to electricity

$$\frac{liter\ H_2O}{mmbtu} = \sum \%\ of\ mix_{source\ \alpha} * \frac{liters\ H2O_\alpha}{mmbtu}$$

**Table 1.1** Electricity Mix Sources

| Energy Source | Total Fuel Use in Electricity Production | Water Use |
|---|---|---|
| Coal | 1,2 | 3 |
| Hydropower | 1,2 | 3 |
| Natural Gas | 1,2 | 4 |
| Biomass | 1,2 | 5 |
| Nuclear | 1,2 | 3 |
| Geothermal | 1,2 | 3 |
| Solar (PV/Thermal) | 1,2 | 3 |
| Wind | 1,2 | 3 |
| Unspecified | 1,2 | Weighted average |

(1) California: CA Energy Commission, Energy Almanac: 2012 Total Electricity Power Mix
(2) USA: U.S. Energy Information Administration, 2013 Domestic Electricity Generation by Energy Source
(3) River Network, 2012 "Water Footprint of Electricity"
(4) Chesapeake Energy, 2010 "Deep Shale Natural Gas and Water Use"
(5) C. Scown, A. Horvath, T. McKone, 2011 "Water Footprint of U.S. Transportation Fuels"

b) *Water Intensity of Transportation*

Transportation was broken up into three phases: 1) Fuel Use, 2) Manufacturing and 3) Maintenance.

1) Fuel Use

Equation 2 calculated the water used in Fuel Use. It involves energy content of fuel and data regarding water uses for each fuel type (respective data sources, see Table 1.2). This was applied to a region $\beta$ and comprises all fuel types $\alpha_1, \ldots \alpha_n$ for that region.

**Equation 2**: Total annual water consumption/withdrawal due to transportation fuels

$$\frac{liters\ H_2O}{person} = \sum \frac{consumption\ of\ fuel_\alpha\ mmbtu}{region_\beta} * \frac{region_\beta}{population_\beta} * \frac{gallon\ of\ fuel_\alpha}{energy\ content\ mmbtu} * \frac{liters\ H_2O}{gallon\ of\ fuel_\alpha}$$

**Table 1.2** Transportation Fuels by Type Sources

| Fuel Type | Fuel Consumption | Water Use |
|---|---|---|
| Natural Gas | 1,2,3 | 4 |
| Diesel (from liquid petroleum) | 1,2,3 | 4 |
| Gasoline (from liquid petroleum) | 1,2,3 | 4 |
| Kerosene | 1,2,3 | 5 |
| Liquefied Petroleum Gases | 1,2,3 | 5 |
| Lubricants | 1,2,3 | 5 |
| Aviation Gasoline | 1,2,3 | 5 |
| Residual Fuel Oil | 1,2,3 | 5 |
| Electricity | 1,2,3 | Calculated |

(1) US Department of Energy Information Administration State Profiles and Energy Estimates, 2012
(2) Census Bureau: 2012 US Population Estimates (Midyear)
(3) CA Department of Finances, Population Estimates 2013 (Beginning of year)
(4) C. King, M. Webber, 2008 "The Water Intensity of Transportation"
(5) EPA, 2006 "Water and Energy Efficiency by Sector"

2) Manufacturing and Maintenance of Vehicles

Maintenance only included car washing. In the future, oil changes and other necessary maintenance procedures should be accounted for. Equation 3 involves average per capita car ownership (Office of Highway Police Information) and average water use per washing (Gasbuddy.com). This was applied to a region $\beta$ and comprises all maintenance activities $\alpha_1, \ldots \alpha_n$.

**Equation 3**: Total annual water consumption due to maintenance

$$\frac{liters\ H_2O}{person} = \frac{Vehicles_{region\ \beta}}{person} * \frac{liters\ H_2O_{activity\ \alpha}}{vehicle}$$

**Table 1.3** Maintenance Inputs Sources

| Activity | Average times activity performed | Water Use |
|---|---|---|
| Car Washing | 1 | 2 |

(1) Gasbuddy.com
(2) MSSP, IRS, Professional Carwashing and Detailing, US Census Bureau

Equation 4 involves average per capita car ownership (Office of Highway Police Information) and average water use per vehicle produced (Toyota and General Motors average). This was applied to a region $\beta$.

**Equation 4**: Total annual water consumption due to manufacturing

$$\frac{liters\ H_2O}{person} = \frac{Vehicles_{region\ \beta}}{person} * \frac{liters\ H_2O}{vehicle}$$

**Table 1.3** Manufacturing Inputs Sources

| Vehicle | Average Vehicle Ownership | Water Use |
|---|---|---|
| Average vehicle produced (GM/Toyota) | 1 | 2,3 |

(1) Office of Highway Police Information, 2010 Public Data "Vehicles per person"
(2) General Motors 2013 Sustainability Report
(3) Toyota 2013 Sustainability Report

c) *Household Energy Use*

We calculated the average per capita water consumption due to domestic activities. Equation 5 involves aggregate energy use per activity (US EIA), average household size (2009 Census), each energy source's percentage of use within each activity (US EIA) and data regarding water use for each energy source per unit of energy (respective data sources, see Table 1.5). This was applied to a region $\beta$ and all domestic activities $\alpha_1, \ldots\ \alpha_n$ for that region and comprises all energy sources $\gamma_1, \ldots \gamma_n$.

**Equation 5**: Total annual water use for a household, energy-consuming activity

$$\frac{liters\ H_2O_{activity\ \alpha}}{person} = \frac{total\ energy\ use_{activity\ \alpha}}{household_{region\ \beta}} * \frac{household_{region\ \beta}}{persons} * \sum \%_{fuel\ \gamma} * \frac{liters\ H_2O}{mmbtu}$$

**Table 1.5** Household Indirect Water Use by End Use

| Activity | Energy Use | Water Use |
|---|---|---|
| Space Heating | 1,2,3 | Electricity (Calculated)<br>Propane and Natural Gas (4)<br>Fuel Oil (6) |
| Water Heating | 1,2,3 | Electricity (Calculated)<br>Propane and Natural Gas (4)<br>Fuel Oil (6) |
| Air Conditioning | 1,2,3 | Electricity (Calculated) |
| Refrigeration | 1,2,3 | Electricity (Calculated) |
| Other (lighting, cooking appliances, clothes washers, dryers, dishwashers, televisions, computers, small electronic devices, pools and hot tubs) | 1,2,3 | Electricity (Calculated)<br>Propane and Natural Gas (4)<br>Fuel Oil (6)<br>Kerosene (5) |

(1) US Energy Information Administration: 2009 Residential Energy Consumption Survey
(2) Census Bureau: 2009 Average Household Size
(3) U.S. Census Bureau, Selected Housing Characteristics: 2009 California & United States
(4) Chesapeake Energy, "Deep Shale Natural Gas
(5) M. Staples et al, "Water Consumption Footprint and Land Requirements of Large-Scale Alternative Diesel and Jet Fuel Production"
(6) Environmental Protection Agency, Water and Energy Efficiencies by Sector

### *II. Direct Water Use*

The Water Conservation Bill of 2009 as issued by the California Department of Water Resources requires large water suppliers to report a variety of information regarding their water distribution and future plans. According to their website:

> Every urban water supplier that either provides over 3,000 acre-feet of water annually, or serves more than 3,000 urban connections is required to assess the reliability of its water sources over a 20-year planning horizon, and report its progress on 20% reduction in per-capita urban water consumption by the year 2020, as required in the Water Conservation Bill of 2009 SBX7-7. (http://www.water.ca.gov/urbanwatermanagement/)

The assessment, known as the Urban Water Management Plan, reports detailed domestic and public (commercial, industrial and institutional) water usages for all water utilities that meet the above requirement. We utilized data from four or five representative utility providers from each of California's hydrologic regions in order to calculate an accurate consumption value for the "average" Californian.

Both equations below calculate the regional/utility-serviced average water consumption for each member of their community. Withdrawals were not accounted for because the Urban Water Management Plans do not include data on the recycling rate of domestic water use. That being said, this can be seen as an upper estimate for total consumption for direct water usage.

**Equation 5**: Total annual water use from direct household water consumption

$$\frac{Direct\ Household\ Use}{Person} = \frac{(Single\ Family\ Residential + Multi\ Family\ Residential)\ Use}{Total\ Service\ Population}$$

**Equation 6**: Total annual water use from direct public water consumption

$$\frac{Direct\ Public\ Use}{Person} = \frac{(Commerical + Industrial + Institutional)\ Use}{Total\ Service\ Population}$$

### *III. Water Consumption and Withdrawals from Food Consumption*

Water consumption associated with food production is the largest component of the average person's water consumption. Equation 7 calculates the average per capita water consumption. It involves average food consumption per food item (US Census) and data regarding water use for each food item per unit mass (respective data sources, see Table 3.1). This was applied to food items $\alpha_1, \ldots\ \alpha_n$.

**Equation 7**: Total annual water consumption due to food consumption

$$\frac{liters\ H_2O}{person} = \sum \frac{food\ consumption_{category\ \alpha}\ kg}{year} * \frac{liters\ H_2O}{kg_{category\ \alpha}}$$

**Table 3.1** Food Consumption Sources

| Food Category | Average Consumption | Water Use |
|---|---|---|
| Meats | 1 | 3 |
| Dairy | 1 | 3 |
| Fats and Oils | 1 | 4, 5 |
| Flour and Cereal Products | 1 | 4, 5 |
| Sweeteners | 1 | 4, 5 |
| Fruits | 1 | 4, 5, 6 |
| Vegetables | 1 | 4, 5 |
| Beverages | 2 | 4, 7 |

(1) U.S. Census Bureau, 2009 "Per Capita Consumption of Major Food Commodities"
(2) U.S. Census Bureau, 2009 "Consumption of Selected Beverages by Type"
(3) Mekonnen, M.M and Hoekstra, A.Y., 2012 "A global assessment of the water footprint of farm animal products"
(4) Mekonnen, M.M and Hoekstra, A.Y., 2011 'The green, blue and grey water footprint of crops and derived crop products"
(5) Almeida, J et al. "Carbon and Water Footprints and Energy
(6) Almeida, J et al. "Carbon and Water Footprints and Energy Use of Greenhouse Tomato Production in
(7) Northern Italy Molson Coors Brewing Company Response, CDP Water Disclosure 2012 Information

### *IV. Water Consumption and Withdrawals from Goods and Services*

Water consumption associated with goods and services is the sector with the least amount of data and poorest data quality. Most often, the data available is generated by companies themselves, which go published with little documentation or outside review. Fortunately, company "sustainability reports" are becoming more popular in industry, which means data regarding water consumption involved in production/manufacturing may become more available.

For this sector we found data or estimated average consumption for a limited group of goods and services (respective data sources, see Table 4.2) and data regarding water use for each good or service (respective data sources, see Table 4.2).

**Table 4.2** Good and Service Sources

| Good or Service | Average Consumption | Water Use |
|---|---|---|
| **Apparel** | | |
| - Clothing | | 1, 2 |
| - Jeans | | 1, 2 |
| - Khakis | | 1, 2 |
| **Technology** | | |
| - Smart Phone | 3 | 4, 5, 6 |
| - Tablet | 3 | 4, 5, 6 |
| - Laptop | 3 | 4, 5, 6 |
| - Non-smart phone | 3 | |
| - Television | 3 | |
| **Hygiene Products** | | |
| - Toothpaste | | |
| - Other | | |
| **Entertainment** | | |
| - Sporting Events | 7 | 9 |
| - Music Events | 7 | 9 |
| - Movies | 8 | |

(1) Levi Strauss & Co "A Product Lifestyle Approach to Sustainability"
(2) Hanesbrand, 2013 CDP Water Disclosure Information Response
(3) PPIC Statewide Survey: 2013 Californians & Information Technology
(4) Apple 2014 Environmental Responsibility Report
(5) Apple 2014 Bill of Materials (various products)
(6) Various papers regarding most of items in Bill of Materials
(7) LiveAnalytics: Live Attendance Report 2012
(8) Motion Picture Association of America, Inc: Box Office and Admissions 2013 Data
(9) AEG 2012 Sustainability Report