



Humboldt County Energy Consumption Forecast

Calculation Methodology

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Striving to develop and implement sustainable energy initiatives that reduce energy demand, increase energy efficiency, and advance the use of clean, efficient and renewable resources available in the region.

This Methodology Report is written to accompany the County-Wide Energy Consumption forecasts found on the “Energy Consumption Facts” Tab in the “2005 County-Wide Community Inventory v1” spreadsheet (“Inventory”). It details the methodology used to estimate energy consumption for unincorporated county in support of the general planning process.

The County requested 2016, 2028, 2030 and 2040 energy consumption forecasts. The latest detailed County-specific energy consumption estimates available to RCEA are associated with the 2005 GHG inventories developed for both incorporated and unincorporated areas in Humboldt County (shown in Appendix A). Furthermore, the County provided growth metrics of households, population, employment, and vehicle miles traveled (VMT) for the years 2010, 2028, and 2040 (shown in Appendix A).

Energy consumption results from the 2005 County-Wide Community GHG Inventory were converted to MMBtu (Million British Thermal Units) to enable aggregating consumption across different fuel types. The MMBtu results were used from the following sectors: Residential, Commercial, Industrial, and Transportation, as shown in Appendix A and listed in the Inventory under the “Energy Consumption Facts” Tab. Using the MMBtu totals from the Inventory as a baseline, estimated energy consumption for the requested years was forecasted using Compound Annual Growth Rates (CAGR) developed using the provided growth metrics. Details of this approach are provided in the following sections.

1 Compound Annual Growth Rates

To forecast energy consumption for the requested years, sector-specific CAGRs were calculated for the periods of 2005-2010, 2010-2016, 2016-2028, 2028-2030, and 2030-2040. CAGRs were calculated using data provided by the County for 2010, 2028, and 2040, and then extrapolating/interpolating for 2005, 2016, and 2030. Because the County requested CAGRs that reflect projected growth for Unincorporated County, the following data was either provided by the County for Unincorporated County, or a calculation was applied to County-Wide data to estimate the fraction attributable to Unincorporated County. Sector-specific CAGRs were calculated based on the following data:

- Residential energy consumption growth – Unincorporated household estimates
- Commercial energy consumption growth – Unincorporated commercial and industrial square footage estimates calculated using employment data. Employment data by sector was provided for Unincorporated County. The number of jobs for each sector was then multiplied by the estimated square footage per employee, as provided by the County and shown in Appendix A. Estimated square footage for each employment sector was summed to produce a total square footage estimate each year.
- Industrial energy consumption growth – Identical to estimates used for Commercial energy consumption growth.
- Transportation energy consumption growth – Unincorporated vehicle miles traveled

2 Extrapolating/Interpolating

Because data provided by the County specified population, households, employment, and VMT forecasts for 2010, 2028, and 2040, equivalent values needed to be extrapolated to 2005 (to calculate the 2005-2010 CAGR), interpolated for 2016 (to calculate the 2010-2016 CAGR), and interpolated for 2030 (to calculate the 2028-2030 CAGR). The following equations were used to linearly extrapolate and interpolate values:

<p>Extrapolation (used for 2005)</p> $M_{y_0} = M_{y_1} + \left(\frac{y_0 - y_1}{y_2 - y_1} \right) (M_{y_2} - M_{y_1})$	<p>Interpolation (used for 2016 and 2030)</p> $M_{y_1} = M_{y_0} + \left(\frac{y_1 - y_0}{y_2 - y_0} \right) (M_{y_2} - M_{y_0})$
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where M_y is a metric for year y , and y is the actual year such as 2005 or 2010.

The specific equations used to extrapolate the 2005 values and interpolate the 2016 and 2030 values are included below:

- **2005**

- **Residential** (Unincorporated Households):

$$2005 \text{ households} = 56,031 + \left(\frac{2005 - 2010}{2028 - 2010} \right) (58,868 - 56,031)$$

- **Commercial** (Total Unincorporated SQF):

$$2005 \text{ SQF} = 17,761,500 + \left(\frac{2005 - 2010}{2028 - 2010} \right) (18,906,800 - 17,761,500)$$

- **Industrial** (Total Unincorporated SQF):

$$2005 \text{ SQF} = 17,761,500 + \left(\frac{2005 - 2010}{2028 - 2010} \right) (18,906,800 - 17,761,500)$$

- **Transportation** (Total Unincorporated VMT):

$$2005 \text{ VMT} = 3,541,683 + \left(\frac{2005 - 2010}{2028 - 2010} \right) (3,848,756 - 3,541,683)$$

- **2016**

- **Residential** (Unincorporated Households):

$$2016 \text{ households} = 56,031 + (2016 - 2010) \left(\frac{58,868 - 56,031}{2028 - 2010} \right)$$

- **Commercial** (Total Unincorporated SQF):

$$2016 \text{ SQF} = 17,761,500 + (2016 - 2010) \left(\frac{18,906,800 - 17,761,500}{2028 - 2010} \right)$$

- **Industrial** (Total Unincorporated SQF):

$$2016 \text{ SQF} = 17,761,500 + (2016 - 2010) \left(\frac{18,906,800 - 17,761,500}{2028 - 2010} \right)$$

- **Transportation** (Total Unincorporated VMT):

$$2016 \text{ VMT} = 3,541,683 + (2016 - 2010) \left(\frac{3,848,756 - 3,541,683}{2028 - 2010} \right)$$

- **2030**

- **Residential** (Unincorporated Households):

$$2030 \text{ households} = 58,868 + (2030 - 2028) \left(\frac{57,567 - 58,868}{2040 - 2028} \right)$$

- **Commercial** (Total Unincorporated SQF):

$$2030 \text{ SQF} = 18,906,800 + (2030 - 2028) \left(\frac{20,116,300 - 18,906,800}{2040 - 2028} \right)$$

- **Industrial** (Total Unincorporated SQF):

$$2030 \text{ SQF} = 18,906,800 + (2030 - 2028) \left(\frac{20,116,300 - 18,906,800}{2040 - 2028} \right)$$

- **Transportation** (Total Unincorporated VMT):

$$2030 \text{ VMT} = 3,541,683 + (2030 - 2028) \left(\frac{3,848,756 - 3,541,683}{2040 - 2028} \right)$$

The “UPDATED COUNTY FORECASTING” Tab in the Inventory contains all of the extrapolated/interpolated values, along with the CAGRs for each time period.

Using both the estimates provided by the County and the extrapolated/interpolated values, sector-specific CAGRs for each time period were calculated using the following equation:

$$CAGR_{y_0 \text{ to } y_1} = \left(\frac{M_{y_1}}{M_{y_0}} \right)^{\frac{1}{y_1 - y_0}} - 1,$$

where M and y are as defined above.

The equations used for the residential CAGRs are provided for example. These equations were used for all other sectors, with Households replaced by Total SQF for Commercial and Industrial, and VMT for Transportation.

2005-2010 Residential CAGR

$$CAGR_{2005 \text{ to } 2010} = \left(\frac{Households_{2010}}{Households_{2005}} \right)^{\frac{1}{5}} - 1$$

2010-2016 Residential CAGR

$$CAGR_{2010 \text{ to } 2016} = \left(\frac{Households_{2016}}{Households_{2010}} \right)^{\frac{1}{6}} - 1$$

2016-2028 Residential CAGR

$$CAGR_{2016 \text{ to } 2028} = \left(\frac{Households_{2028}}{Households_{2016}} \right)^{\frac{1}{12}} - 1$$

2028-2030 Residential CAGR

$$CAGR_{2028 \text{ to } 2030} = \left(\frac{Households_{2030}}{Households_{2028}} \right)^{\frac{1}{2}} - 1$$

2030-2040 Residential CAGR

$$CAGR_{2030 \text{ to } 2040} = \left(\frac{Households_{2040}}{Households_{2030}} \right)^{\frac{1}{10}} - 1$$

3 Total Energy Consumption Forecasts

The CAGRs for each time period were applied to 2005 Unincorporated County energy consumption estimates from the 2005 County-Wide Community Inventory. Using the following equations, energy consumption forecasts for 2010, 2016, 2028, 2030, and 2040 were calculated.

- **2010:** $MMBtu_{2005}(1 + CAGR_{2005\ to\ 2010})^5 = MMBtu_{2010}$
- **2016:** $MMBtu_{2010}(1 + CAGR_{2010\ to\ 2016})^6 = MMBtu_{2016}$
- **2028:** $MMBtu_{2016}(1 + CAGR_{2016\ to\ 2028})^{12} = MMBtu_{2028}$
- **2030:** $MMBtu_{2028}(1 + CAGR_{2028\ to\ 2030})^2 = MMBtu_{2030}$
- **2040:** $MMBtu_{2030}(1 + CAGR_{2030\ to\ 2040})^{10} = MMBtu_{2040}$

4 Results

The outputs from these equations are included in the “2005 County-Wide Community Inventory v1” spreadsheet, under the Energy Consumption Facts tab. Results are also shown below.

Table 1: Energy consumption projections for unincorporated Humboldt County.

		Unincorporated County Energy Consumption (MMBtu) ¹					
		2005	2010	2016	2028	2030	2040
Residential	Electricity	766,840	777,780	790,909	817,167	814,154	799,091
	Natural Gas	861,015	873,299	888,040	917,522	914,139	897,226
	Propane	180,753	183,332	186,426	192,616	191,905	188,355
	Wood	231,109	234,406	238,363	246,276	245,368	240,829
Commercial	Electricity	517,714	527,157	538,487	561,149	567,132	597,046
	Natural Gas	1,484,301	1,511,372	1,543,858	1,608,829	1,625,982	1,711,749
Industrial	Electricity	21,915	22,315	22,794	23,754	24,007	25,273
	Natural Gas	19,602	19,960	20,389	21,247	21,473	22,606
Transportation	Gasoline	3,648,759	3,738,804	3,846,859	4,062,968	4,054,859	4,014,315
	Diesel ²	1,472,529	1,508,868	1,552,476	1,639,691	1,636,419	1,620,056
Total		9,204,536	9,397,293	9,628,601	10,091,217	10,095,439	10,116,546

¹ Note that the number of significant figures reported do not indicate precision, but are provided for transparency in calculation results. A formal error analysis was not conducted for these projections.

² Projected diesel consumption for 2005 in the Inventory was roughly 18% less than tracked fuel sales provided by the North Coast Unified Air Quality Management District for the year 2005. The source of this discrepancy has not been addressed. The potential impact to total MMBtu values shown here is roughly 3%.

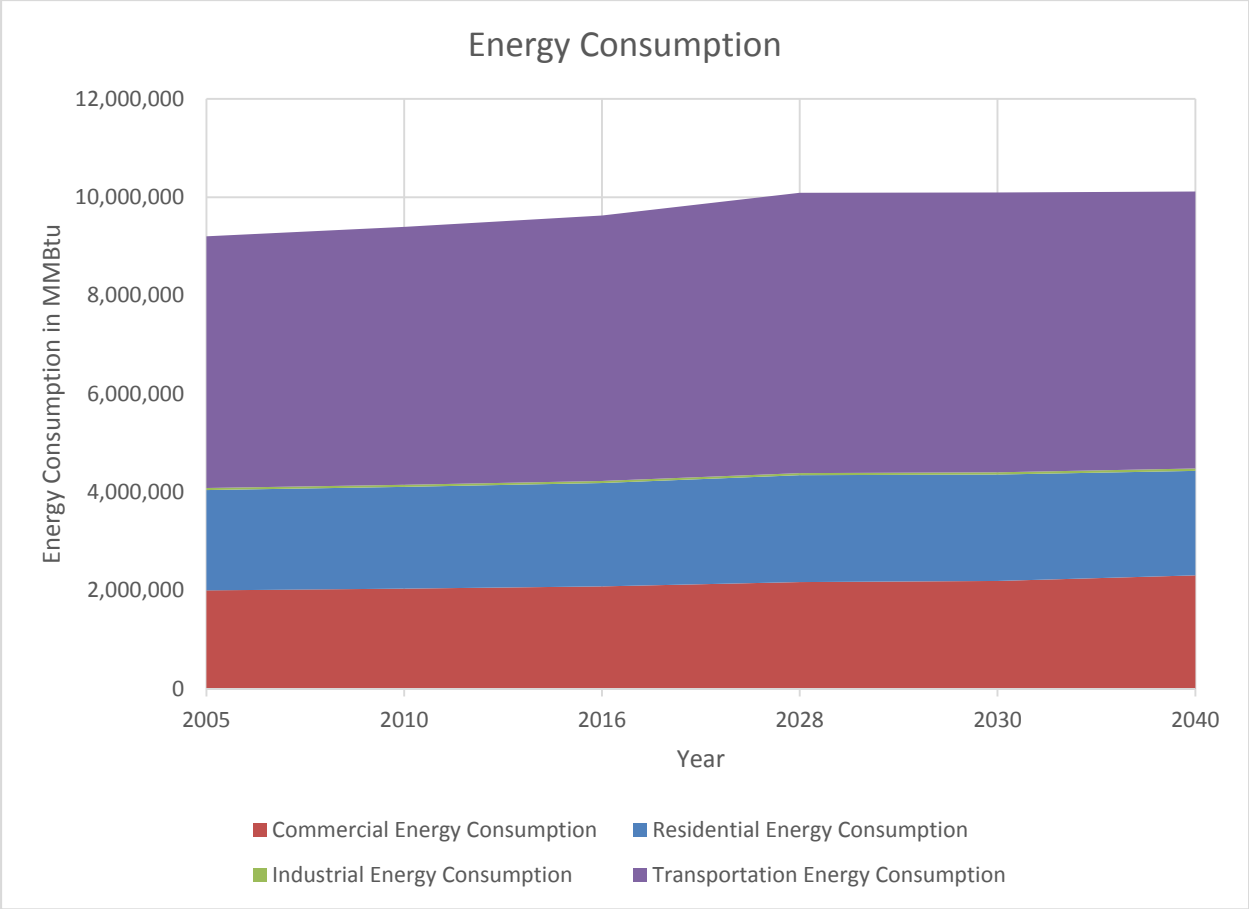


Figure 1: Energy consumption projections for unincorporated Humboldt County.

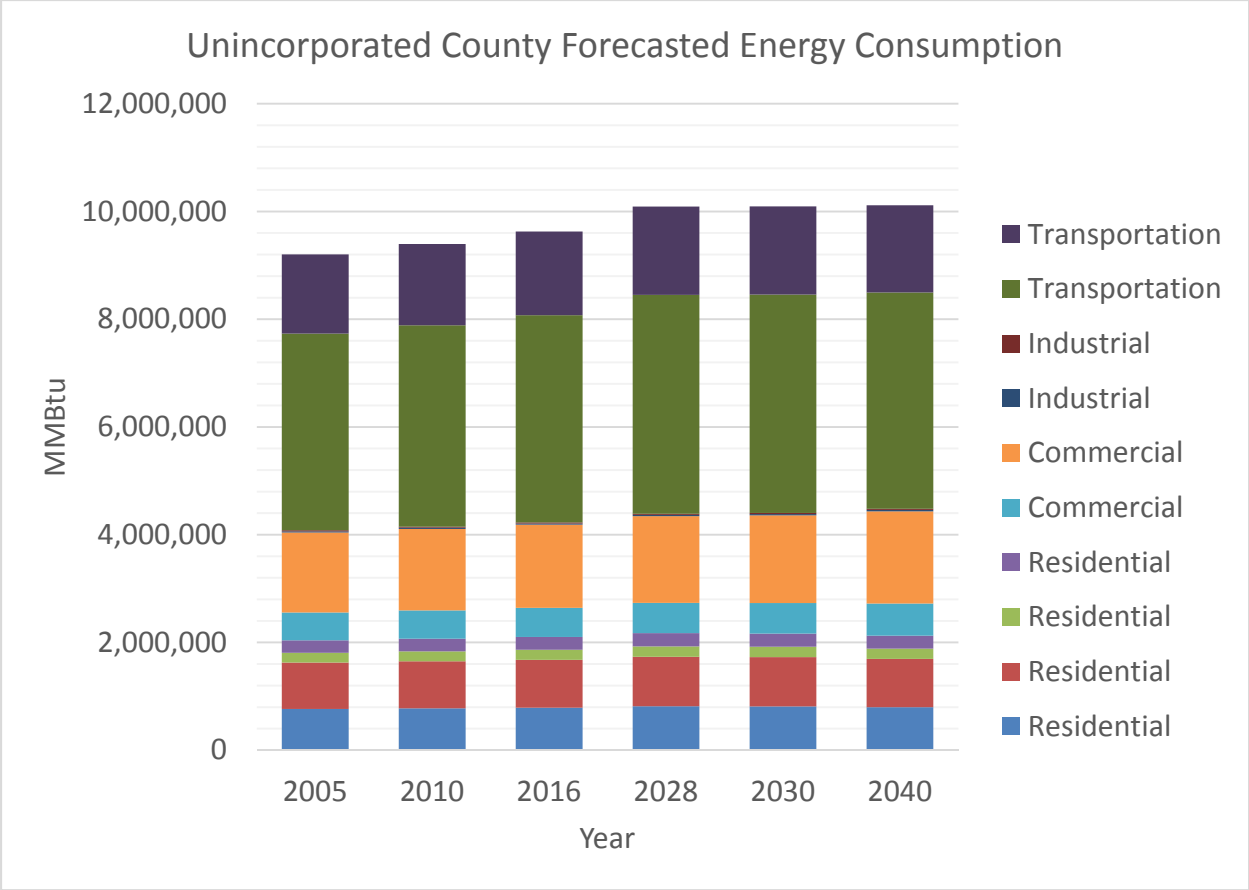


Figure 2: Energy consumption projections for unincorporated Humboldt County.

Appendix A Raw Data Utilized in this Analysis

The following tables show raw and calculated data used in this analysis. Table cells that are highlighted indicate values calculated using the methods outlined in this report. Table cells that are not highlighted indicate data provided by the County for this analysis.

Table 2: Energy consumption calculations for 2005 Unincorporated County. All energy units were converted to Million British Thermal Units (MMBtu).

2005 Unincorporated County Energy Consumption			
Category	2005 Unincorporated County Energy Consumption	MMBtu Conversion Factor	Energy Consumption in MMBtu
Residential Electricity (total kWh/year)	224,747,923	0.003412	766,840
Residential Natural Gas Consumption (total thm/year)	8,612,212	0.099976	861,015
Residential Propane (gal/year)	1,973,286	0.0916	180,753
Residential Firewood (cord/year)	10,749	21.5	216,060
Commercial Electricity Consumption (total kWh/year)	151,733,404	0.003412	517,714
Commercial Natural Gas Consumption (total thm/year)	14,846,575	0.099976	1,484,301
Industrial Electricity Consumption (total kWh/year)	6,422,902	0.003412	21,915
Industrial Natural Gas Consumption (total thm/year)	196,068	0.099976	19,602
Trans. Fuel Consumed: Light Duty, Gas (gal/year)	28,243,988	0.120405	3,400,717
Trans. Fuel Consumed: Light Duty, Diesel (gal/year)	1,209,539	0.137381	166,168
Trans. Fuel Consumed: Heavy Duty, Gas (gal/year)	1,098,595	0.120405	132,276
Trans. Fuel Consumed: Heavy Duty, Diesel (gal/year)	4,431,095	0.137381	608,748
Trans. Fuel Consumed: Off-Road, Gas (gal/year)	961,462	0.120405	115,765
Trans. Fuel Consumed: Off-Road, Diesel (gal/year)	5,077,942	0.137381	697,613

Table 3: Total projected households and employees. Highlighted values were calculated via interpolation or extrapolation.

Year	Households		Employees	
	Cities	Unincorporated	Cities	Unincorporated
2005	22,534	32,709	29,000	18,394
2010	22,855	33,176	29,478	18,724
2016	23,241	33,736	30,052	19,120
2028	24,012	34,856	31,199	19,911
2030	23,924	34,728	31,502	20,120
2040	23,482	34,085	33,018	21,164

Table 4: Total projected VMT within unincorporated Humboldt County. Highlighted values were calculated via interpolation or extrapolation.

Trip Origin	Trip Destination	2005	2010	2016	2028	2030	2040
Inside UC	Inside UC	1,057,118	1,070,071	1,085,614	1,116,701	1,113,424	1,097,038
Inside UC	Outside UC	828,054	851,484	879,600	935,833	934,774	929,479
Outside UC	Inside UC	864,744	888,993	918,092	976,290	975,088	969,080
Outside UC	Outside UC	706,469	731,135	760,734	819,932	817,788	807,070
	Total	3,456,385	3,541,683	3,644,041	3,848,756	3,841,075	3,802,668

Table 5: Total projected employees by job sector for the entire County. Highlighted values were calculated via interpolation or extrapolation.

Employees - County-wide									
Model Year	Retail	Service	Manufacturing	Government	Finance	Wholesale	Agricultural	Other	Health Care
2005	10,116	17,649	1,842	2,816	1,514	1,932	2,083	3,085	6,378
2010	10,286	17,950	1,870	2,865	1,537	1,970	2,119	3,143	6,463
2016	10,490	18,311	1,904	2,923	1,565	2,016	2,162	3,212	6,565
2028	10,899	19,034	1,972	3,040	1,620	2,108	2,249	3,351	6,769
2030	11,007	19,225	1,990	3,071	1,635	2,132	2,272	3,388	6,823
2040	11,547	20,179	2,080	3,226	1,708	2,253	2,386	3,571	7,093

Table 6: Projected employment by job sector for unincorporated Humboldt County. All values were calculated.

Employment - Unincorporated County									
Model Year	Retail	Service	Manufacturing	Government	Finance	Wholesale	Agricultural	Other	Health Care
2005	3,126	7,388	1,144	540	268	1,035	1,399	1,840	1,676
2010	3,181	7,520	1,161	551	270	1,058	1,424	1,877	1,683
2016	3,247	7,678	1,181	565	273	1,086	1,454	1,922	1,692
2028	3,380	7,995	1,222	592	279	1,142	1,513	2,011	1,710
2030	3,415	8,079	1,233	599	281	1,157	1,529	2,035	1,715
2040	3,589	8,496	1,286	634	288	1,231	1,607	2,153	1,739

Table 7: Projected infrastructure square footage by job sector using values from Table 5 and Table 7. All values were calculated.

Square Footage - Unincorporated County										
Model Year	Retail	Service	Manufacturing	Government	Finance	Wholesale	Agricultural	Other	Health Care	Total
2005	937,717	2,216,417	2,860,139	161,883	80,250	2,586,667	3,498,194	4,599,444	502,650	17,443,361
2010	954,300	2,256,000	2,902,500	165,300	81,000	2,645,000	3,560,000	4,692,500	504,900	17,761,500
2016	974,200	2,303,500	2,953,333	169,400	81,900	2,715,000	3,634,167	4,804,167	507,600	18,143,267
2028	1,014,000	2,398,500	3,055,000	177,600	83,700	2,855,000	3,782,500	5,027,500	513,000	18,906,800
2030	1,024,450	2,423,550	3,081,667	179,700	84,150	2,892,083	3,821,667	5,086,667	514,450	19,108,383
2040	1,076,700	2,548,800	3,215,000	190,200	86,400	3,077,500	4,017,500	5,382,500	521,700	20,116,300

Table 8: Average commercial square footage space per employee by job sector. Data provided by the County.

Building Square Feet	
SECTOR	SF/emp
Retail	300
Service	300
Manufacturing	2500
Government	300
Finance	300
Wholesale	2500
Agricultural	2500
Other	2500
Health Care	300