Pitkin County GHG Emissions
Utility Data Analysis and Buildout Study

Report prepared by:
Chris Pearson
August Hasz, P.E.
Resource Engineering Group, Inc.
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Section 1: Key Findings

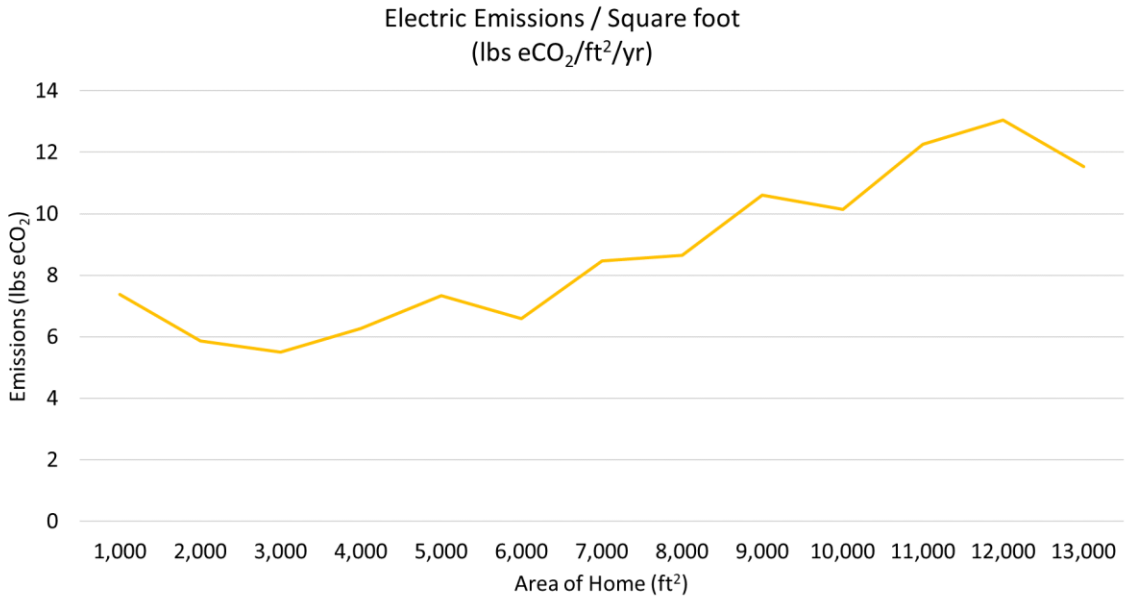
- **Home size and eCO_2 correlation:**
  - There is a strong correlation between home size and GHG emissions per area (expressed as lbs eCO_2/ ft^2 /yr). In general, larger homes use not just more energy, but also more energy **per square foot** (aka: sq ft, sqft, ft^2, etc.).
  - As home size increases from 1,000 ft^2 (the smallest homes studied) to 14,000 ft^2 (largest in the study), the total emissions **per ft^2** more than doubles, from an **average of 10.9 lbs eCO_2/ ft^2 /yr to 24.2 lbs eCO_2/ft^2/yr.**
- **Home size:** REG was asked to consider the impact of home sizes above 5,750 ft^2. Per the available data, limiting new development and redevelopment to 5,750 ft^2 maximum house size could result in over four times lower annual emissions from future construction. This is due to the combined effect of less area of home being built, and smaller homes having less impact per area. (Note, the impact of less area is fairly concrete. However, it is unknown how the energy use per area will scale if the "top end" of the market is restricted to a lower home area because the primary driver appears to be amenity loads.)
- **Amenity loads:** We speculate that the higher energy use per area with large homes is primarily driven by "amenity loads." Amenity loads are energy using amenities not seen in the average American household. Examples include: humidification, intensive AV + IT systems, oxygen systems, wine storage, very tight thermal control, use of infloor heating even during cooling season to provide "warm-toes", extensive air filtration systems, large cooking ranges requiring make-up air treatment, heat tape, extensive lighting systems, indoor and outdoor spas, indoor and outdoor pools, outdoor lighting, pumped and/or heated water

features, water treatment systems requiring pumping, snowmelt systems, indoor fireplaces, treated make-up air for indoor fireplaces, outdoor fireplaces, outdoor heaters, extensive air filtration systems, etc. (this is not an exhaustive list). Our analysis of exterior energy loads vs home size from Pitkin County REMP data supports this speculation as it shows that the use of snowmelt, spas, outdoor pools and heat tape increase dramatically as home size increases. If home size is limited and amenity loads are not addressed, the energy use per ft^2 of homes at the top end of the allowed size range may increase.

- **Data sets used:** Holy Cross Energy and Black Hills Energy provided data from nearly 900 homes spanning 4 years (2014 through 2017), for a total of 3,577 data records. This information was used in conjunction with Pitkin county data to identify home size, and then combine information in an anonymous fashion. All homes are located in Pitkin County. Pitkin County Community Development provided data from 120 REMP applications from the past 5 years (2018 through 2022).

Section 2: Graphs

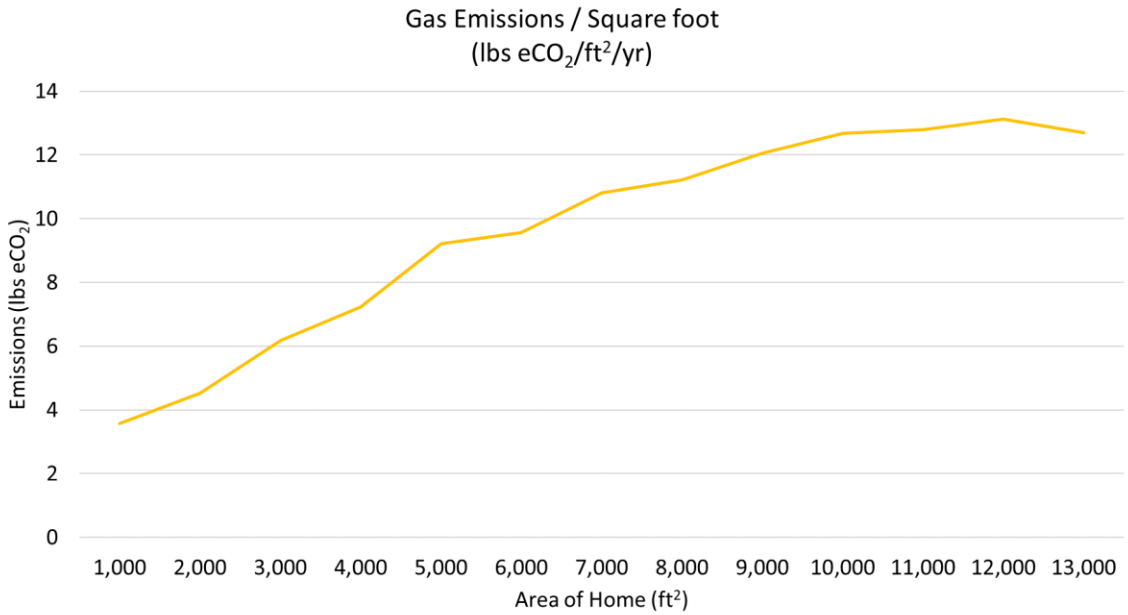
1. **Electric GHG emissions (eCO_2) per square foot of home, plotted against home size.**



Notes:

a. Emissions rate of 0.264 lbs eCO_2/kBtu based on 2022 Holy Cross Energy grid. (Note: Holy Cross has committed to "100% clean energy by 2030").
b. Many of the smaller homes included in this study are all electric so the EUI of electric is skewed higher for the smaller homes.

2. **Gas GHG emissions (eCO_2) per square foot of home, plotted against home size.**

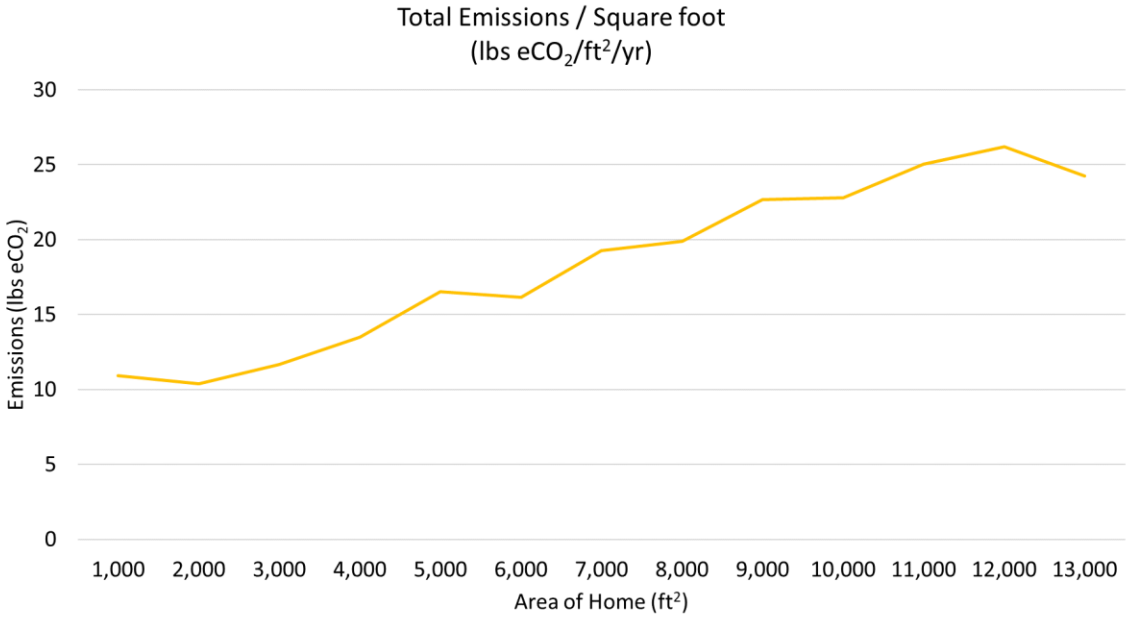


Notes:

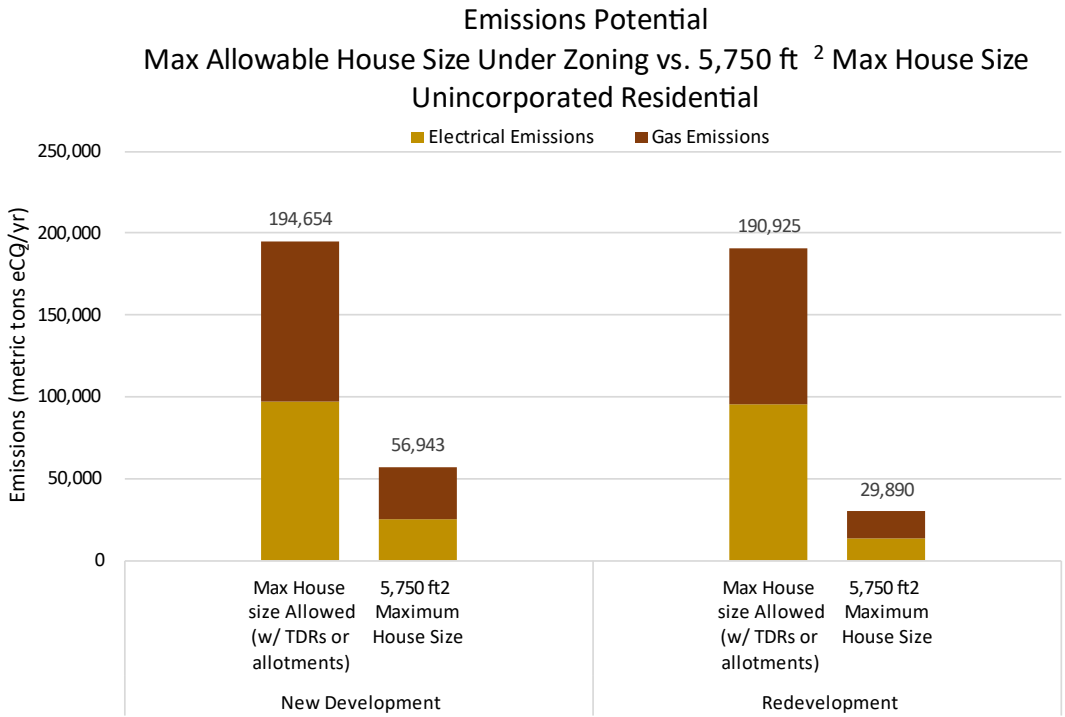
a. 0.137 lbs eCO_2/kBtu emission factor assumed based on:
   i. Methane heating factor of 29.8 (100yr GWP) assumed to align with previous studies provided to Pitkin County. (REG typically uses the 20yr GWP which has a methane heating factor of 80. That approach would result in emission factor of 0.171 lbs eCO_2/kBtu, an increase of 25%).
   ii. 1.4% system-wide leakage rate (EPA GHGI) assumed for leakage during extraction and transmission. This is the lowest published leakage rate, with studies publishing values as high as 12% in some locations. Approximately 4% is the average of published studies and we believe 4% may be a more accurate value to use. However, these values are debatable and we have therefore opted to use the 'best case' known value for this report. Using a 4% leakage rate results in an emission factor of 0.174 lbs eCO_2/kBtu (27% higher).
   iii. Assuming both the 20yr GWP methane heating factor of 80 and a 4% system-wide leakage rate, emission factor would be 0.271 lbs eCO_2/kBtu (nearly double the value used in these graphs).

b. Many of the smaller homes included in this study are all electric so the EUI of gas is skewed lower for the smaller homes.

3. **Total energy use GHG emissions (eCO_2) per square foot of home, plotted against home size.**



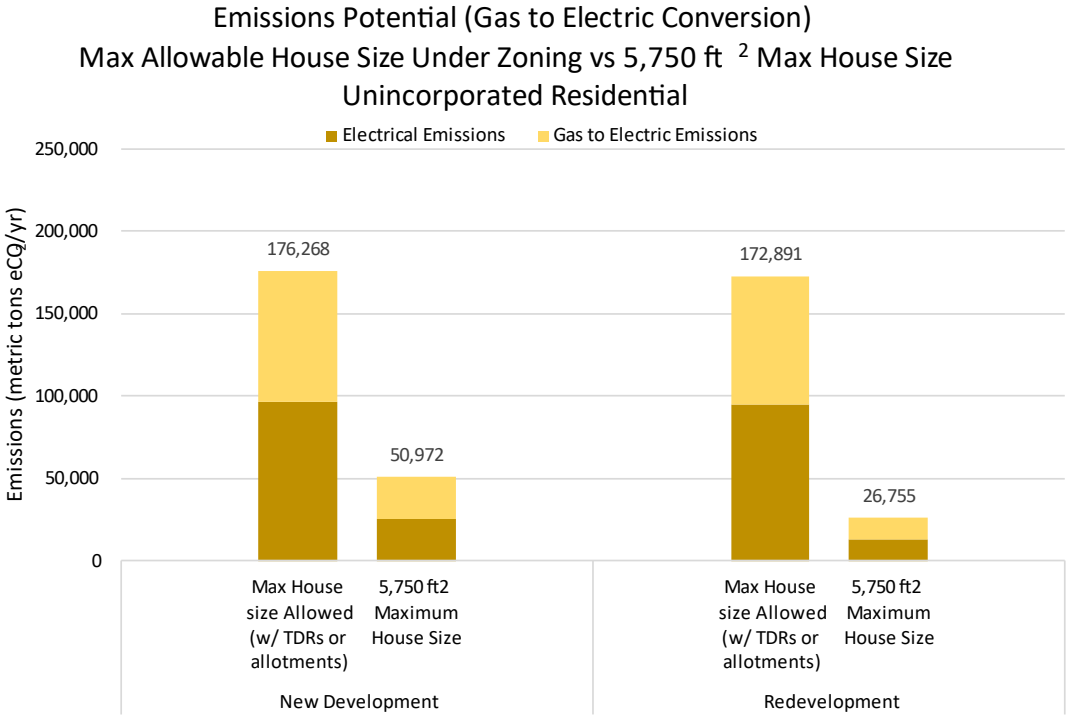
4. **Emissions potential of new development and redevelopment in Unincorporated Pitkin County.** Per the request of the BOCC, REG was tasked with estimating the eCO_2 for the current anticipated maximum allowable house size under current zoning vs. a 5,750 ft^2 maximum house size.



Notes:

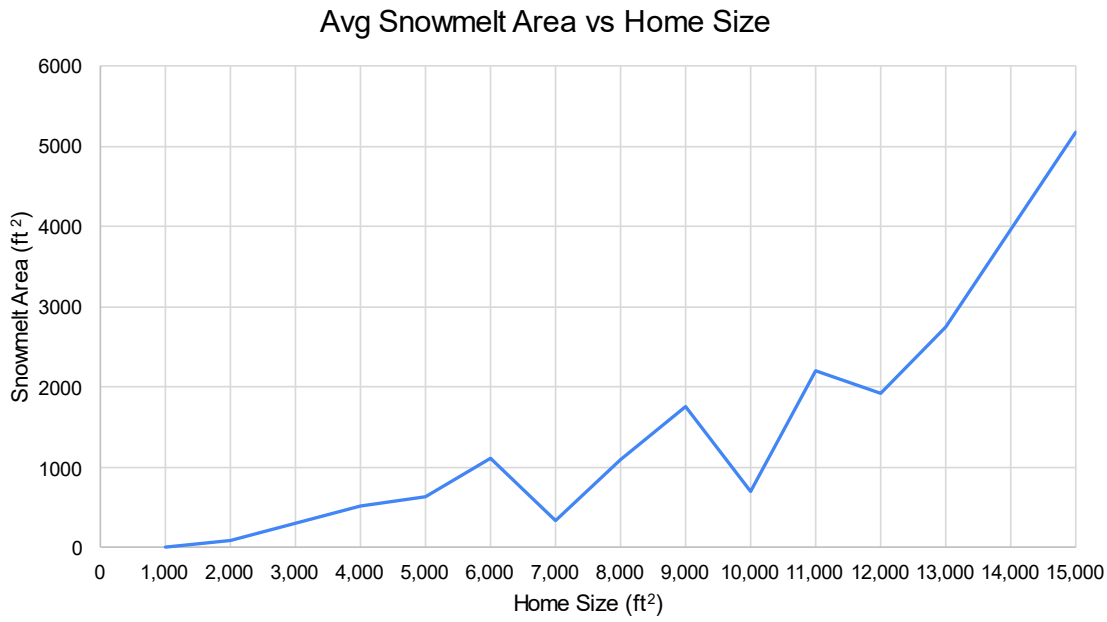
a. Estimated development areas taken from 2018 Pitkin County Buildout Study.
b. 5,750 ft^2 maximum house size (from 5,000-6,000 ft^2 bin): Average electric emissions rate of 7.3 lbs $eCO_2/yr/ft^2$ and average gas emissions rate of 9.2 lbs $eCO_2/yr/ft^2$.
c. Maximum allowable under current zoning (from 12,000-13,000 ft^2 bin): Average electric emissions rate of 13.0 lbs $eCO_2/yr/ft^2$ and average gas emissions rate of 13.1 lbs $eCO_2/yr/ft^2$.
d. Measured meter data from existing buildings is applied to future construction in this study. (While the impacts of building envelope and heating/cooling systems will in theory be significantly reduced with increasing home quality and building codes, the increasing use of amenity loads appears to be increasing the energy used per area of home with newer builds in this size range at a faster pace. Therefore, the existing numbers are not adjusted due to the unknown future trends of this data set.)
e. As Holy Cross Energy approaches 100% renewable energy the electrical emissions bars will approach zero. This will significantly reduce electrical use eCO_2 impacts. The impacts of future codes to limit gas use or amenity loads are not considered in this study.

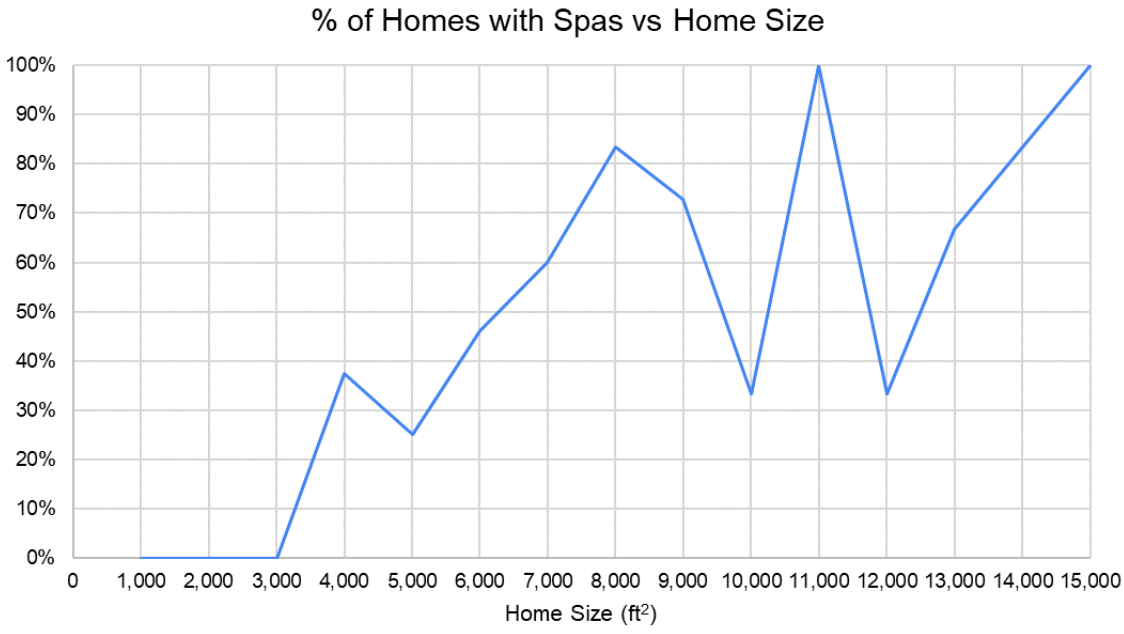
5. **Emissions potential of new development and redevelopment in Unincorporated Pitkin County – Gas to Electric Heat Pump Conversion.**

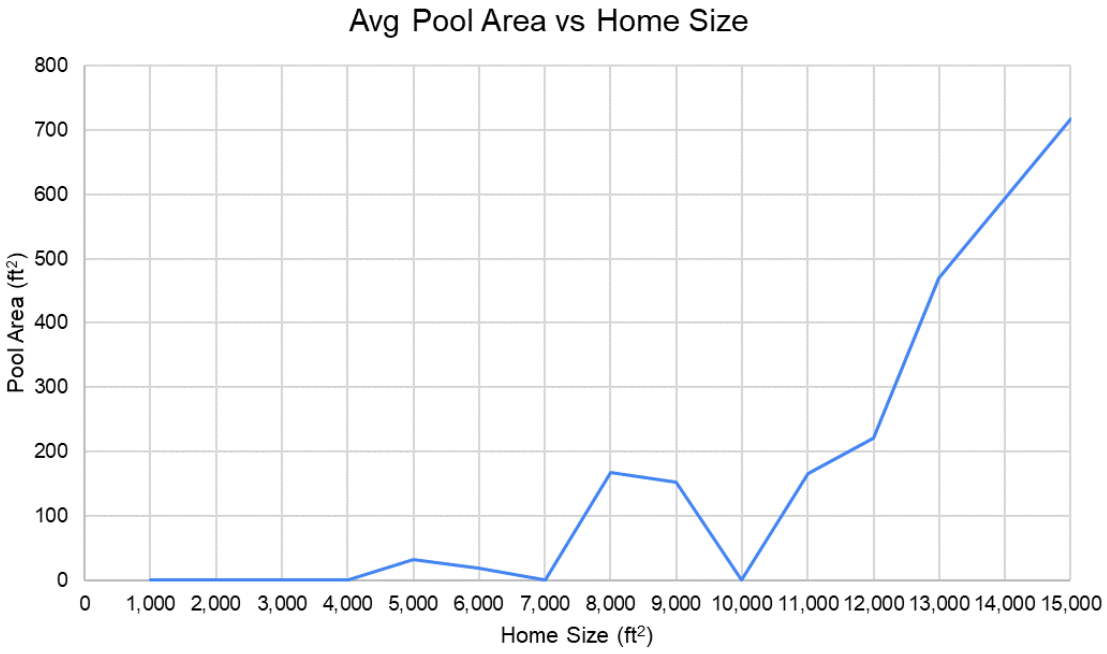


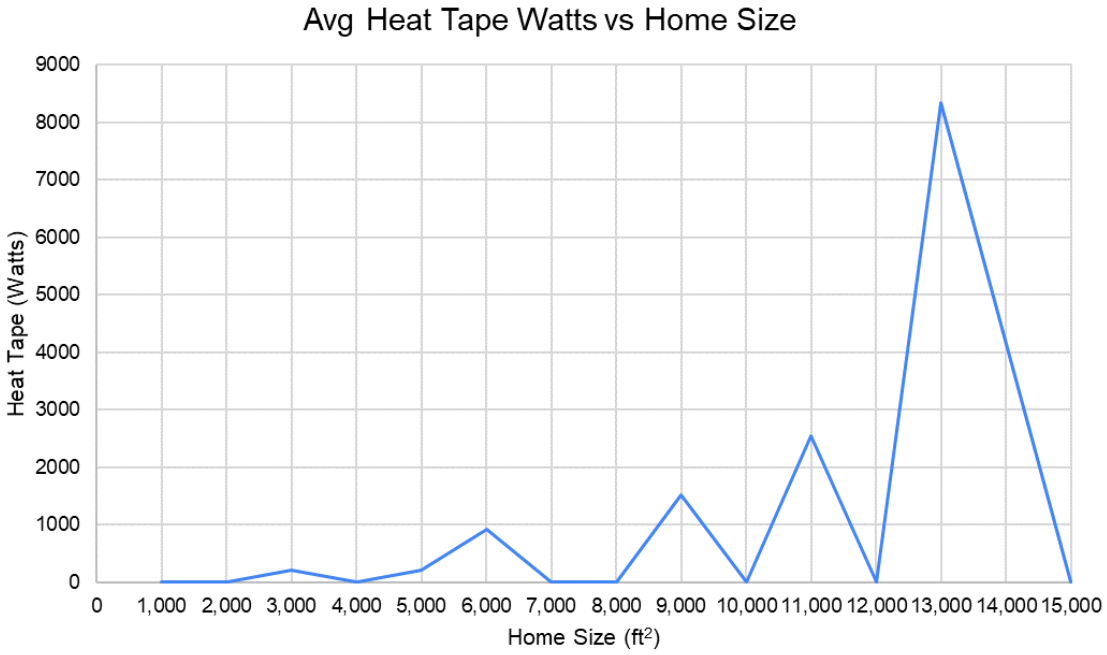
a. Gas to electric conversion of heating loads is done assuming 95% efficient gas boiler replaced with a heat pump system meeting an average annual COP of2.25 (a value consistent with air source heat pumps in cold climates). This is an optimistic assumption that all electric homes will utilize heat pumps. Providing heat for large exterior loads like snowmelt and pools/spas is difficult and not practical in most cases.

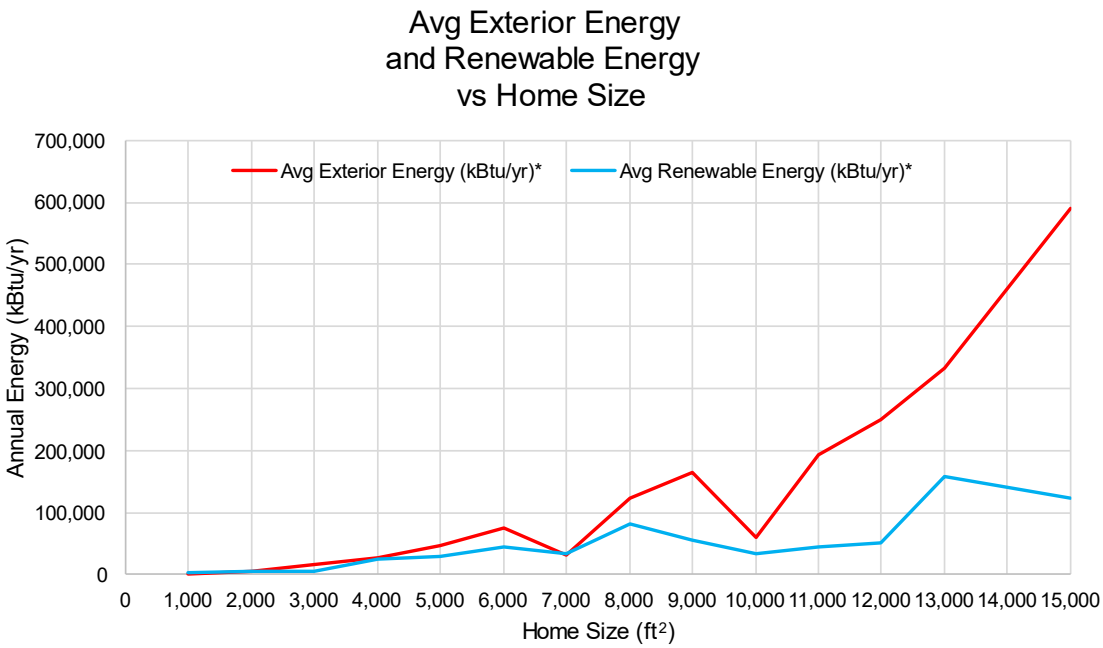
6. **The following graphs illustrate how various exterior energy load sources increase with the size of home.**






Avg Pool Area vs Home Size
Pool Area (ft²)
800
700
600
500
400
300
200
100
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
Home Size (ft²)


Avg Heat Tape Watts vs Home Size
Heat Tape (Watts)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
8,000
9,000
10,000
11,000
12,000
13,000
14,000
15,000
Home Size (ft²)



a. * $0.108 REMP cost $/kW of Array
b. This analysis is provided from 120 permit applications in the REMP program from 2018 through 2022. From these REMP applications, we see that not only does exterior energy increase for larger homes, but the exterior energy **per ft2 of residence increases sharply** across all categories of exterior energy.

Appendix: Data

1. GHG emissions from electric use per square foot of home.

	Electric lbs $eCO_2/ft^2/yr$				
Size (ft^2)	**2014**	**2015**	**2016**	**2017**	**AVG**
1,001 to 2,000	7.7	7.1	7.4	7.3	7.4
2,001 to 3,000	6.0	5.9	5.9	5.6	5.9
3,001 to 4,000	5.5	5.4	5.6	5.4	5.5
4,001 to 5,000	6.3	6.3	6.5	6.0	6.3
5,001 to 6,000	7.0	7.0	7.8	7.5	7.3
6,001 to 7,000	6.5	6.6	6.6	6.6	6.6
7,001 to 8,000	8.5	8.4	8.8	8.1	8.5
8,001 to 9,000	8.5	8.7	8.9	8.5	8.7
9,001 to 10,000	10.6	10.8	10.6	10.5	10.6
10,001 to 11,000	9.7	10.3	10.4	10.1	10.1
11,001 to 12,000	12.3	11.8	12.3	12.7	12.3
12,001 to 13,000	12.6	13.5	13.2	12.9	13.0
13,001 to 14,000	10.1	9.8	12.9	13.4	11.5

2. **GHG emissions from gas use per square foot of home.**

	Gas lbs $eCO_2/ft^2/yr$				
Size (ft^2)	2014	2015	2016	2017	AVG
1,001 to 2,000	3.3	3.1	4.8	3.1	3.6
2,001 to 3,000	4.7	4.5	4.6	4.4	4.5
3,001 to 4,000	6.4	6.0	6.1	6.3	6.2
4,001 to 5,000	7.7	7.0	7.1	7.1	7.2
5,001 to 6,000	9.5	9.0	9.0	9.4	9.2
6,001 to 7,000	10.1	9.0	9.8	9.5	9.6
7,001 to 8,000	12.2	11.1	8.2	11.8	10.8
8,001 to 9,000	10.8	11.3	11.9	10.9	11.2
9,001 to 10,000	12.4	11.8	11.6	12.4	12.1
10,001 to 11,000	13.7	12.6	12.4	12.0	12.7
11,001 to 12,000	13.4	11.4	12.9	13.5	12.8
12,001 to 13,000	13.5	12.4	12.1	14.4	13.1
13,001 to 14,000	12.3	11.4	11.3	15.8	12.7

3. **Total GHG emissions per square foot of home.**

	Total lbs $eCO_2/ft^2/yr$				
Size (ft^2)	2014	2015	2016	2017	AVG
1,001 to 2,000	11.0	10.3	12.1	10.4	10.9
2,001 to 3,000	10.7	10.4	10.5	10.0	10.4
3,001 to 4,000	11.9	11.4	11.7	11.7	11.7
4,001 to 5,000	14.0	13.3	13.6	13.1	13.5
5,001 to 6,000	16.5	16.0	16.7	16.9	16.5
6,001 to 7,000	16.6	15.7	16.3	16.1	16.2
7,001 to 8,000	20.7	19.5	17.0	19.9	19.3
8,001 to 9,000	19.3	20.0	20.8	19.4	19.9
9,001 to 10,000	23.0	22.5	22.2	22.9	22.7
10,001 to 11,000	23.5	22.9	22.8	22.1	22.8
11,001 to 12,000	25.7	23.1	25.1	26.3	25.1
12,001 to 13,000	26.1	26.0	25.3	27.3	26.2
13,001 to 14,000	22.4	21.1	24.2	29.3	24.2

4. Exterior Energy REMP data per square foot of home.

Heated Sqft															
Min	Max	Home Count	Snow Melt Count	% of Homes w/ Snow Melt	Avg Snow Melt Area (ft^2)	Exempt Spa Count	Spa Count	% of Homes w/ Spa	Pool Count	% of Homes w/ Pool	Avg Pool Area (ft^2)	Home Count 2020+ *	Heat Tape Count	% of Homes w/ Heat Tape	Avg Heat Tape Watts
-	1,000	11	0	0%	0	0	0	0%	0	0%	0	9	0	0%	0
1,000	2,000	21	2	10%	86	0	0	0%	0	0%	0	10	0	0%	0
2,000	3,000	7	1	14%	298	0	0	0%	0	0%	0	5	1	20%	200
3,000	4,000	8	2	25%	512	3	0	38%	0	0%	0	6	0	0%	0
4,000	5,000	16	6	38%	639	3	1	25%	1	6%	31	13	3	23%	212
5,000	6,000	13	9	69%	1115	6	0	46%	1	8%	18	5	2	40%	920
6,000	7,000	5	2	40%	333	1	2	60%	0	0%	0	3	0	0%	0
7,000	8,000	6	5	83%	1094	3	2	83%	2	33%	168	5	0	0%	0
8,000	9,000	11	9	82%	1749	3	5	73%	3	27%	152	5	2	40%	1521
9,000	10,000	3	1	33%	699	1	0	33%	0	0%	0	2	0	0%	0
10,000	11,000	3	2	67%	2195	2	1	100%	1	33%	166	2	2	100%	2550
11,000	12,000	3	1	33%	1925	0	1	33%	1	33%	221	1	0	0%	0
12,000	13,000	3	3	100%	2744	0	2	67%	2	67%	470	1	1	100%	8348
14,000	15,000	2	2	100%	5169	0	2	100%	2	100%	718	1	0	0%	0

* Heat tape was only included in REMP form from 2020 on.

5. Exterior Energy REMP payment and supplemental energy credit per square foot of home.

Heated Sqft						
Min	Max	Home Count	Avg Exterior Energy REMP Payment	Avg Supplemental Energy Credit	Avg Exterior Energy (kBtu/yr)*	Avg Renewable Energy (kBtu/yr)*
-	1,000	11	$ -	$ 2,372.12	-	3,747
1,000	2,000	21	$ 3,161.50	$ 3,437.33	4,994	5,430
2,000	3,000	7	$ 10,660.15	$ 2,621.58	16,839	4,141
3,000	4,000	8	$ 17,786.70	$ 15,748.28	28,096	24,876
4,000	5,000	16	$ 29,334.08	$ 18,194.16	46,337	28,740
5,000	6,000	13	$ 47,049.26	$ 27,551.82	74,320	43,522
6,000	7,000	5	$ 19,784.83	$ 21,636.20	31,253	34,177
7,000	8,000	6	$ 78,284.11	$ 51,396.91	123,660	81,188
8,000	9,000	11	$ 104,117.43	$ 34,674.54	164,467	54,773
9,000	10,000	3	$ 37,531.41	$ 20,587.01	59,286	32,520
10,000	11,000	3	$ 121,882.27	$ 27,956.07	192,529	44,160
11,000	12,000	3	$ 158,116.45	$ 32,465.62	249,765	51,284
12,000	13,000	3	$ 210,947.56	$ 99,743.46	333,219	157,558
14,000	15,000	2	$ 374,204.24	$ 77,413.53	591,104	122,285

* $0.108 REMP cost $/kW of Array