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Financial Incentives for the Installation of Ground-source Heat Pump Systems

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Table of Contents:

Tables and Figures:

Overview

Do financial incentives affect the number of ground source heat pump systems installed in a particular region and overall? Kevin McCray Consulting, LLC, was asked to research just that by the Oklahoma State University College of Engineering, Architecture, and Technology. In this paper, you will find information on types of financial incentives available, programs sorted by state, and the estimated number of ground source heat pumps installed by year. This paper will help identify the correlation between incentives and the installation of ground source heat pumps in areas with incentives and the potential impact of 3rd party financing.

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ABSTRACT

More than 500 financial incentives in 14 different forms have been made available to help to advance the number of installations of ground-source heat pump systems in residential and commercial structures in the United States. Due to inadequate market data availability, it is difficult to conclude about the national impact of financial incentives. An examination of a sampling of several state markets and a regional market within a state with known numbers of GSHP installations and available incentives may suggest incentives have not stimulated GSHP market growth or have had negligible impact, but theoretically could be the cause of all installations in a geographic market.

1. INTRODUCTION

Ground-source heat pump (GSHP, aka, "geothermal") system technology has been available for more than 50 years, but as recently as 2017, market share in the U.S. heating and cooling system marketplace is estimated at less than one (1) percent [McCray, 2017].

Financial incentives have long been believed to be drivers for the installation of these systems, which typically have higher overall installation costs than competing alternatives, but do enjoy longer lifetime energy usage cost benefits.

In 1981, it was reported only a few states offered any form of incentive largely for the technology, and there was no federal tax credit [McCray, 1981], although it was reported that credit claims were filed and honored.

Lienau [1995], et al reported in 1995 "utilities have designed a number of incentive packages to encourage the installation of GSHPs. In most cases, these incentives include cash rebates, special financing, [and] discounted energy rates, in a few cases free ground loop installations, or combinations of the above."

Rebates were associated with more than 47 percent of all utilities offering incentives, with the value of the rebates reported in ranges by rebate type.

Thirteen years after Lienau, Hughes [2008] shared "Since the early 1980s the utility industry has sponsored many modest but successful GHP [geothermal heat pump] programs in their service territories that clearly boosted the small industry in some localities."

2. NATIONAL DATABASE OF STATE INCENTIVES

The Database of State Incentives for Renewables & Efficiency®, or DSIRE, identifies itself as the most comprehensive source of information on incentives and policies supporting U.S. renewables and energy efficiency. DSIRE is operated by the North Carolina Clean Energy Technology Center at North Carolina State University and is funded by the U.S. Department of Energy and was established in 1995.

A 2017 examination of the DSIRE database found 595 financial incentives for GSHP installation across the United States offered by utilities, as well as local and state government, and five national incentives[1]. This was determined by using the database's filters. The filters used were several. The "technology" filter sorts to renewable energy, which sorts to geothermal technologies, which sorts to geothermal heat pumps. Applying additional filters to the 595 matches finds 343 utility GSHP incentive programs when the "implementing sector" filter is applied, 181 for state government, 60 for local government, six federal programs, and three from non-profit organizations.

Lineau had investigated only 57 utilities and had found 35 offered GSHP incentive programs.

Incentives found on DSIRE are sorted by 14 types.

Table 1.

Financial Incentive Type	Number of Programs
Bond Program	2
Corporate Depreciation	1
Corporate Tax Credit	8
Grant Program	17
Green Building Incentive	11
Industry Recruitment/Support	10
Leasing Program	1
Loan Program	72
PACE Financing	27
Personal Tax Credit	9
Personal Tax Deduction	1
Property Tax Incentive	29
Rebate Program	327
Sales Tax Incentive	6
Total	**521**

Lienau also identified additional options not found in Table 1, such as service agreements and annual maintenance, trenching costs or entire loop installation, discounted and controlled kilowatt hour rates, rebates for insulation standards, and rebates for desuperheaters or fully-integrated on demand units.

Some form of a financial incentive is offered in 48 states, with Minnesota hosting the most incentives with 79 (15.2 percent). In the DSIRE database Vermont and West Virginia do not show any available incentives.

Table 2.

Political Region	# of Incentive Programs
AK	1
AL	6

[1] The author experienced count variations in different data sorts when using DSIRE, but believes these numbers to be substantially representative of the conditions.

AR	2
AZ	3
CA	9
CO	20
CT	12
DE	5
FL	6
GA	8
HI	1
IA	26
ID	7
IL	15
IN	36
KS	1
KY	17
LA	1
MA	6
MD	26
ME	3
MI	13
MN	79
MO	14
MS	10
MT	6
NC	11
ND	6
NE	8
NH	8
NJ	6
NM	4
NV	3
NY	6
OH	13
OK	10
OR	13
PA	14
RI	6
SC	12
SD	11
TN	4
TX	12

US	5
UT	5
VA	9
WA	8
WI	10
WY	4
Grand Total	**521**

Two states, Vermont and West Virginia lack any DSIRE recorded financial incentives for GSHP installations.

The 50 states are sorted to four regions by the American Housing Survey of the U.S. Census Bureau:

- **Northeast:** Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, and Pennsylvania
- **Midwest:** Ohio, Michigan, Indiana, Illinois, Wisconsin, Minnesota, North Dakota, South Dakota, Iowa, Nebraska, Kansas, and Missouri
- **South:** Maryland, Delaware, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Texas, Oklahoma, Arkansas, Tennessee, Louisiana, West Virginia and Kentucky
- **West:** Alaska, Hawaii, Washington, Oregon, California, Idaho, Utah, Nevada, Arizona, New Mexico, Colorado, Wyoming, and Montana

When sorted by the housing regions of the American Housing Survey, the 12 states of the Midwest offer 232 incentives (45 percent); the 16 states of the South region offer 138 incentives (27 percent), the 13 states of the West region offer 84 (16 percent), and the 9 states of the Northeast offer 61 incentives (12 percent), for a total of 515.

The most popular incentive appears in the form of a rebate (62.7 percent of all incentives), which is trailed by loan programs (13.8 percent), property tax incentives (5.6 percent), and PACE financing (5.2 percent). Combined, these four incentive types represent 87.3 percent of all incentives nationwide.

- "Renewable energy **rebates**, also known as buy-down programs, provide a refund or discount off the cost of new renewable energy installations" [Lantz and Doris, 2009]. "Programs are often administered through local utilities or state agencies, and rebates are generally acquired through an application process. Rebate payments vary and are often based on the installed capacity of a system with the rebate value set at a given rate (i.e., dollars per watt). Rebate payments may be limited by size or dollar value, and/or include a one-time payment for renewable energy credits (RECs). They may also be coupled with production or expected production-based incentive (PBI) payments."

- **Loan programs** are typically short-term, low-cost loans to those installing renewable energy technology. These loans may serve to provide funding for costs associated with these projects.

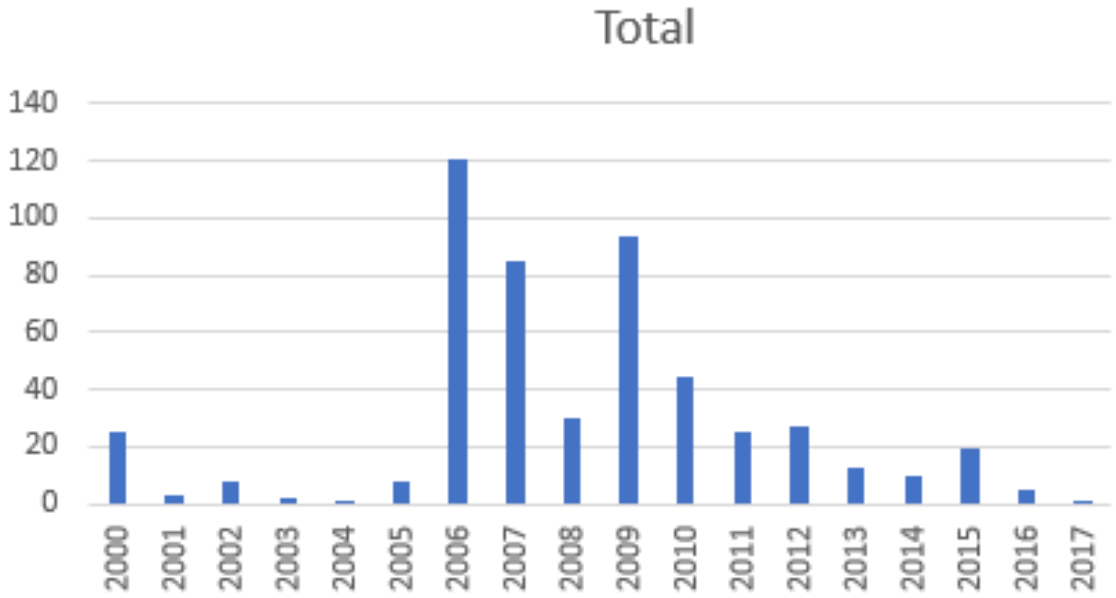
- **Property tax incentives** may include GSHP systems that are for the purpose of heating or otherwise supplying the energy needs of taxable property. These incentives make these properties exempt from local property tax for a defined number of years. Often these incentives apply only to the value added to a property by an eligible system. It does not constitute an exemption for the full amount of the property tax bill. Local governing authorities may interpret state property tax incentives differently.

- The PACE (**property-assessed clean energy)** model "allows local governments, state governments, or other inter-jurisdictional authorities, when authorized by state law, to fund the up-front cost of

energy improvements on commercial and residential properties, which are paid back over time by the property owners. PACE financing for clean energy projects is generally based on an existing structure known as a "land- secured financing district," often referred to as an assessment district, a local improvement district, or other similar phrase. In a typical assessment district, the local government issues bonds to fund projects with a public purpose such as streetlights, sewer systems, or underground utility lines." [PACE, 2017]

During the nine years of 2000 through 2008, 283 incentives (54.3 percent) were created, while 238 (45.7 percent) were created in the period of 2009 through 2017 (as of May 2017). Some 121 (23 percent) were created in 2006 alone.

Figure 1. Number of GSHP Incentives Created, by Year



Lienau cited "more than 18,800 GSHP systems (a system is a 3-ton equivalent) have resulted from these 35 [utility] programs," although no support was provided to conclusively establish that linkage.

3. INCENTIVES MARKET IMPACT

What impact have financial incentives had on a national market of GSHP installations? Given available data, it may not be feasible to establish a direct linkage between the two.

McCray [2017] notes at the 2017 IGSHPA conference it was reported by various speakers that since 1977, 5.9 million water source heat pumps and ground source heat pumps have been shipped by U.S. producers, and that 1.2 million ground-source heat pumps were installed in the U.S. by 2015. The speakers did not cite the sources of their data.

Donaldson [2014] contended the combination of climate change targets in the United Kingdom, as well policy support, should have boosted the British GSHP sector. However, total domestic installations remained relatively low, which was attributed to the economic recession that began in 2008, and the lack of consistent and qualified installation figures.

While a financial assistance program in Ontario seemingly stimulated GSHP installations, some 6,749 residential properties, in the early 1990s, Kantrowitz, et al [2011] found declining sales over time in the decade, reaching 442 units installed throughout Canada in 1998.

"No matter how we look at it, the massive financial assistance program did not generate sustained market activity and no industry infrastructure was built or maintained," the authors claim.

By 2011, the previous four years of Canadian financial assistance had not overcome barriers such as the perceived high first-cost of GSHPs, and had led to the financial assistance being "absorbed [as profit-taking] by stakeholders in the supply chain."

At present, there is no known publicly available source of annual GSHP shipment reports. It is not a service offered by either the International Ground Source Heat Pump Association, or the Geothermal Energy Organization, and neither organization tracks the annual number of installations. The Air-conditioning, Heating and Refrigeration Institute (AHRI) has tracked ground-source heat pump shipments, but the information is considered proprietary to its members.

For some years, two different federal sources reported on shipments of ground-source heat pumps manufactured by U.S. producers.

The U.S. Department of Energy's (DOE) Energy Information Agency provided data from 1994 to 2009 on three ARI "geothermal heat pump" model type shipments. The Agency stopped providing the data due to a lack of funding. The U.S. Census Bureau provided data on "ground and ground water source" heat pumps in the Bureau's Current Industrial Report MA533M, also from 1994 to 2009, again ending due to a lack of funding.

While the labels seemingly were describing the same equipment, the number of products reported shipped by U.S. producers never agreed between the two agencies. However, per GSHP industry veteran Dan Ellis in 2005, "the ARI [AHRI] industry shipment data is more reliable than this [sic] [federal] data." [McCray, 2005]

The following table looks at only the aggregate numbers for each year from 2000 to 2009:

Table 3.

Year	EIA	Census
2000	35,581	66,108
2001	Not reported	84,919
2002	37,139	70,835
2003	36,439	61,807
2004	43,806	75,519
2005	47,830	79,844
2006	63,682	91,045
2007	85,587	102,851
2008	121,243	90,577
2009	115,442	86,260

Hughes [2008], a DOE employee, reported different numbers than did EIA for earlier years, confusing the reliability of all datasets on GSHP shipments.

Additionally, some units were shipped outside of the United States and some GSHPs were imported, making U.S. manufacturer shipments an unreliable indicator for correlation to financial incentive impact.

The May 2017 study by Resources for the Future includes a table (Table 4 contains data abstracted from the RFF study) on the numbers of U.S. taxpayer adoptions of various renewable energy options, including geothermal (ground-source) heat pumps. The RFF researchers acknowledge only having data at the federal level, what they judged to be a major limitation of their investigation. RFF reported the number of "GeoTherm" (GSHP) adoptions from EIA for 2003 through 2006 and from U.S. Internal Revenue Service data for years 2006 – through 2013[2]. The number of adoptions vary from the EIA and Census product shipment data, which is understandable because not all product is installed in the same year as shipped by the manufacturer

Table 4.

Year	Number of GeoTherm (aka, GSHP) Adoptions
2003	18,908
2004	23,891
2005	26,146
2006	35,580
2007	50,147
2008	58,502
2009	77,238
2010	72,958
2011	70,673
2012	37,368
2013	65,760

Since 1980, the National Ground Water Association (NGWA), a membership organization that includes drilling firms, some of which may also drill for vertical closed loop GSHP installations, has collected drilling activity data by state. NGWA sorts these data into various categories, including one for GSHPs.

NGWA has found inconsistency with state GSHP data reporting. Some states record by installation or project, while others record the number of boreholes per project. Drilled boreholes could be for open loop, closed loop, standing column, or direct exchange configurations. Horizontal drilled borehole systems may also be counted by some states, but not counted are trenched systems, or those using surface water bodies, such as ponds.

Further, not every state agency tracking water well construction also tracks ground-source heat pump installations. There may be states where no agency records ground-source heat pump installations. Theoretically, the highest activity could be in states where there is no record of activity.

Vertically-drilled earth boreholes fitted with closed loop heat exchangers represent an estimated 46 percent of the ground-source market, with open loop/semi-open loops being about 10 percent [McCray 2017], with all other types composing the remaining 44 percent.

[2] RFF researcher Thor Jensen reports the dataset was IRS (Internal Revenue Service). 2015. "SOI Tax Stats—Individual Income Tax Returns, Line Item Estimates." Washington, DC: IRS. https://www.irs.gov/uac/SOI-Tax- Stats--Individual-Statistical-Tables- by-Size-of-Adjusted-Gross-Income.

The Nebraska Department of Natural Resources only records the installation site on their database, not the total number of boreholes. Tom Christopherson sorted the sites by those deemed "commercial" (10 boreholes or more) and those judged "residential" (10 boreholes or less).

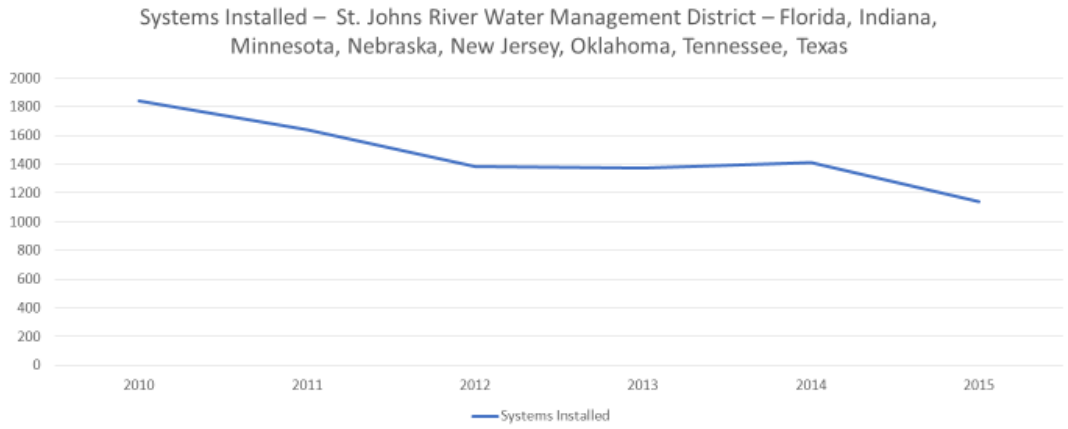
For Nebraska, 2,458 closed loop systems were installed from 2005 until 2016, with commercial installations accounting for 364, or 14.8 percent. According to Tom Christopherson [2017], program manager of the state's Department of Health and Human Services, Division of Public Health, Water Well Standards and Contractors' Licensing Program, more than 50 percent of the commercial installations were for public institutions, such as schools, jails, and administration buildings.
In Oklahoma, Angie Taylor [2017], the coordinator of the state's well driller program shares that in most cases, multiple borings were grouped together on the same well completion report, If they met the following criteria: (a) being located in the same 10 acre tract, (b) bored to basically the same depth and (c) having the same lithology.

Table 5. Number of GSHP Systems Installed, by Year

	2010	2011	2012	2013	2014	2015
St. Johns WMD, Florida	2	5	2	5	2	8
Indiana	78	97	86	73	134	65
Minnesota	442	322	202	174	201	168
Nebraska	263	212	239	265	309	258
New Jersey	167	150	112	105	98	71
Oklahoma	415	412	342	375	367	223
Tennessee	264	180	181	152	170	126
Texas	212	263	221	229	131	223

Figure 2.

GSHP System Installations, by Year



Source: Data provided by state agencies which record water well construction data. Compiled by the National Ground Water Association, May 2017.

A word of a caution about Table 5 and Figure 2 above. NGWA has been compiling counts of water well construction since 1980 and has learned from state government officials their data is only as good as the filing compliance by water well system professionals and the posting of the data by state officials. Experience indicates that reporting tends to lag by a year and even more. Thus, a fall off, as suggested for 2015, may simply be that the count is under reported for the year at this time.

Table 6 below shows the data for incentive creation, by year, and GSHP project installations, by year, by state/region of a state. These states (and one region of a state) were selected because the state agency was able to provide a number for GSHP projects for the consecutive years of 2010 through 2015. Some caveats to the table: (a) no federal incentive is included in any state or regional count; (b) these are counts derived only from the DSIRE database in May 2017 are counts for January each year, except for 2013, when the count was as of February; (c) in the instance of the St. John's Water Management District, the counts for incentives are those found throughout the state and may not have been specifically available within the Water Management District.

Table 6.

State or Region within a State	2010	2011	2012	2013	2014	2015
Florida – St. John's Water Management District						
# of GSHP Financial Incentives Available in this Year in this State[3]	5	6	6	6	n/a	n/a
# of Total GSHP Projects Reported in this Year	2	5	2	5	2	8
%[4] of increase in projects		150	-60	150	-60	300
Indiana						
# of GSHP Financial Incentives Available in this Year in this State	36	29	36	38	n/a	n/a
# of Total GSHP Projects Reported in this Year	78	97	86	73	1334	65
% of increase in projects		24	-11	-15	84	-52
Minnesota						
# of GSHP Financial Incentives Available in this Year in this State	47	46	47	71	n/a	n/a
# of Total GSHP Projects Reported in this Year	442	322	202	174	201	168
% of increase in projects		-27	-37	-14	16	-16
Nebraska						
# of GSHP Financial Incentives Available in this Year in this State	4	3	3	4	n/a	n/a
# of Total GSHP Projects Reported in this Year	236	212	239	265	309	258
% of increase in projects		-10	13	11	17	-17
New Jersey						
# of GSHP Financial Incentives Available in this Year in this State	8	7	6	7	n/a	n/a
# of Total GSHP Projects Reported in this Year	167	150	112	105	98	71
% of increase in projects						
Oklahoma						
# of GSHP Financial Incentives Available in this Year in this State	6	6	11	12	n/a	n/a
# of GSHP Projects Reported in this Year	415	412	342	375	367	223
% of increase in projects		-0.7	-17	10	-2	-39
Tennessee						
# of GSHP Financial Incentives Available in this Year in this State	6	5	5	5	n/a	n/a
# of GSHP Projects Reported in this Year	264	180	181	152	170	126
% of increase in projects		-32	0.6	-16	12	-26
Texas						
# of GSHP Financial Incentives Available in this Year in this State	16	15	20	21	n/a	n/a
# of GSHP Projects Reported in this Year	212	263	221	229	131	223
% of increase in projects		24	-16	4	-43	70

No attempt was made to correlate the numbers in Table 6 to the type of incentive utilized, if indeed any incentive was applied to GSHP installations.

[3] Inclusive of federal incentives.

[4] Percentages in Table 6 have been rounded to the nearest whole number.

4. RESIDENTIAL AND COMMERCIAL MARKETS

Financial incentives are available for both residential and commercial properties, but residential may be a more fertile ground, as it is responsible for 20 percent of the total global energy consumption. [Karytsas, 2017]

A 2017 analysis by Liu, et al [2017] indicated "retrofitting existing conventional HVAC systems in U.S. residential and commercial building can result in significant energy savings and carbon emission reductions. The residential sector has three times more energy savings potential than the commercial sector."

Liu concluded "financial incentives or third-party financing" could assist in overcoming the high initial cost barrier perceived to hobble the GSHP market.

Because the U.S. Census Bureau blends ground water and ground-source heat pumps with air-source heat pumps, data on new heat pump installations in both single-family housing, as well as multi-family housing are not good sources for insight to market share.

Commenting on heating and cooling policy options in New York state, Makhijani [2017] contends "incentives should therefore be geared to reducing first cost" and that a cash rebate would be better than a tax credit because tax credits force institutional customers to "share the benefits with third parties that are in it only for the financial gain. It lengthens the payback time and increases overall cost."

Households in the U.S. have received since 2006 more than $18 billion in federal income tax credits alone for so-called "clean energy" investments, although Borenstein and Davis [2016] judged these benefits have accrued "predominantly to higher-income Americans. The bottom three quintiles have received about 10 percent of all credits, while the top quintile has received about 60 percent."

Kantrowitz [2011] observed similar circumstances in the Canadian GSHP market. "For lower income individuals, assuming that energy bills represent a higher share of their disposable income, chances are that they will never be able to afford GSHP as a class. Considering this income effect, we deduce that financial assistance programs in recent years benefited a high proportion of free-riders from the population strata with the highest disposable income."

Free-ridership occurs when financial stimulus benefits those who would have made the investment without incentives, resulting in no increase in demand, but an increasing in a reduction in government tax resources.

Park, et al, [2010] in a simulation of payback periods for ground-source heat pumps in Korea reported that under the conditions of their simulation, "…payback periods of GSHP, when it replaces conventional system, are only 3.1 and 4.1 years, respectively. This implies that GSHP is still highly competitive without progressive tax exemption." Park assumed a 50 percent subsidy (a form of incentive) for the installation cost of the GSHP, and a fixed rate electricity cost of 0.07$/kWh.

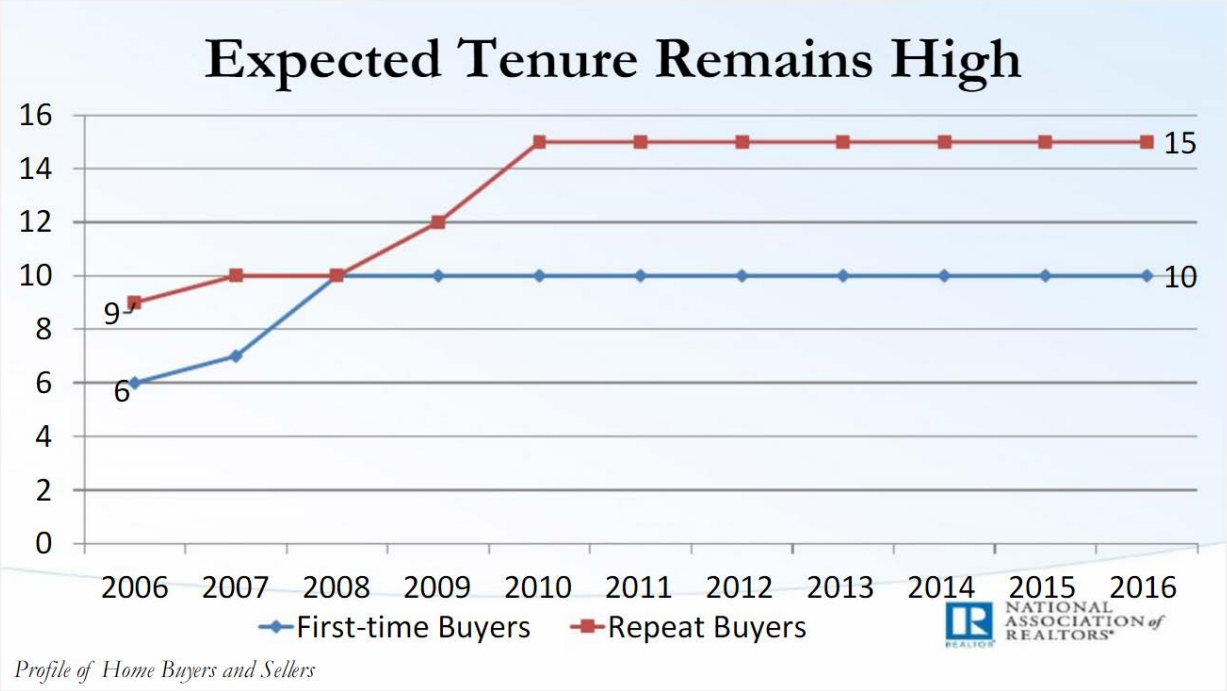
"For ground-source heat pump, the level of subsidy for the installation cost plays detrimental role in having realistic payback. Whereas, the impact of progressive tax in the electricity tariff on the payback is relatively small," Park concludes.

In a 2017 Resources for the Future report Jensen and Dowlatabadi find "despite their popularity, tax credits [for renewable energy] have been prone to free-ridership concerns since their inception."

In general, ground-source heat pumps are believed to have payback periods (the time to recover the costs of installation from energy expense savings) dependent upon several factors, such as: electric rates, savings from not purchasing alternative heating sources, such as oil or natural gas, and the value of available incentives.

According to Lautz [2016] the average occupancy of a single-family home in the United States, as of November 2016, is 15 years for repeat buyers, and 10 years for first-time purchasers. If payback periods for a GSHP are projected to exceed a home buyer's expected tenure in the property, the financial incentive may not be a factor in the selection of a GSHP system from a return on investment assessment. The estimated life for a properly designed and installed residential GSHP system is said to be 20 years. [Howard, 2011]

Figure 3.



Commercial construction has a different profile.

"Office buildings within the U.S. Commercial Real Estate (CRE) sector spend more than $32 billion annually on energy and contribute 18 percent of U.S. carbon dioxide emissions," according to Moya and Patton [2017]. "For building owners, energy costs directly impact net operating income , which is a key metric for their profitability. For tenants, who are often responsible for the cost of the energy consumption, efficiency improvements are tied to their bottom line."

The size, vintage, geographic region, and principal activity of a building are impactful to a building's energy use, and thus, are factors which could influence the selection of GSHPs, and the potential use of some form of financial incentive.

Moya and Patton included GSHPs in developing a tool to provide specific property recommendations for which energy technologies should be considered for further investigation by property owners. They determined in their case study of commercial properties in Michigan that despite the largest additional GSHP expense for a property owner would be the installation of loop wells, "geothermal heat pumps could be twice the cost of a conventional heating and cooling system, providing a payback period within 5 – 10 years in most cases."

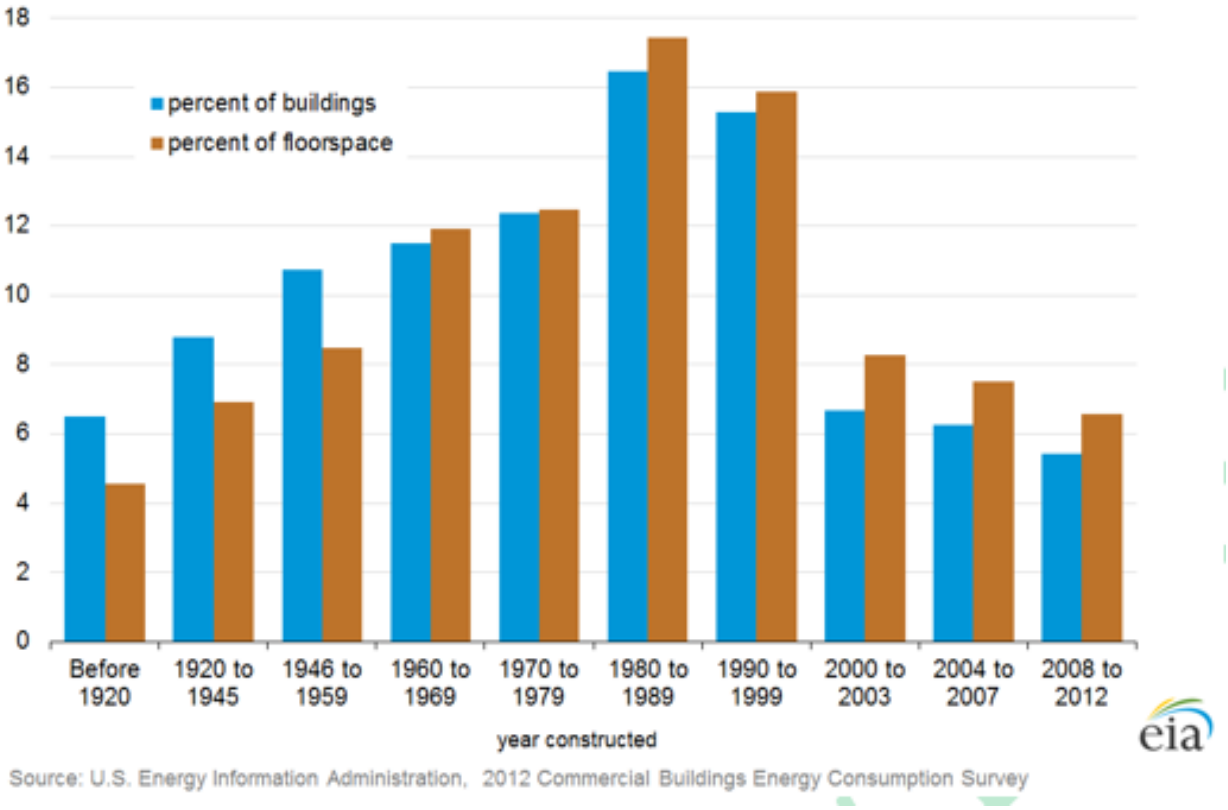
According to Richard Underman CPM, CCIM, LEED Green Associate, an executive vice president of Colliers International, a commercial real estate brokerage, there is no typical tenure. Occupancy can be short if the builder intends to quickly sell and move, or longer if the intention is to sell and lease back (10-20 years or more). Occupancy can be extended if the property remains cost-effective, although after 15 -20 years of occupancy major building systems may require replacement, such as HVAC, roof, pavement, and the building itself may become more or less functionally obsolete. These leave the property owner with potentially extensive capital requirements for replacement and remodeling to extend the owner's use of the building. Some commercial structures have economically sound lives well in excess of 50 years.

In general, reports George Ratiu, director of quantitative and commercial Research for NAR [2017], based on available data, most modern commercial buildings tend to have a lifespan of 40-60 years for the structure, with much shorter lifespans for exterior elements, equipment etc.

"Although about 12 percent of commercial buildings (comprising 14 percent of commercial floor space) were built since 2003, the commercial building stock is still fairly old, with about half of all buildings constructed before 1980; the median age of buildings in 2012 was 32 years. However, in the existing building stock, the newest buildings outnumber the oldest; there are more buildings built in the 2000s than buildings built prior to 1946." [https://www.eia.gov/consumption/commercial/reports/2012/buildstock/]

Due to the paucity of data available on the distribution of GSHP installations in general, and between residential and commercial installations, the perceived importance of GSHP financial incentives to commercial property developers/owners has not been determined.

Figure 4.



5. CONCLUSIONS

Although more than 500 financial incentives in 14 different forms have been made available in the 2000's to advance the number of installations of ground-source heat pump systems in residential and commercial structures in the United States, it does not appear incentives have had distinctive impact on GSHP market share in the overall US heating, ventilation, and air-conditioning product marketplace.

Publicly available market data is largely limited to a small set of data provided by the National Ground Water Association's annual tabulation of well construction activity, which also provides a look at the number of reported GSHP project installations, by state.

From these data it is difficult to conclude the national impact of financial incentives. Theoretically, incentives may be the cause of all GSHP installations in a geographic market.

Without surveying GSHP customers directly it is challenging to know the influence of incentives on the installation of a system. Real estate owner tenure, as well as rising utility costs, particularly to those using heating oil, or those looking to replace an aging conventional HVAC system, may consider switching to an energy efficient technology. Unmeasured factors, like the perception of the complexity of the incentive application process, could be off-putting to potential GSHP selection.

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