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Federal Tax Credits and Residential Investment in Renewable Energy

A Qualitative Summary

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Abstract

In this report we explore the impact of investment tax credits (ITC) aimed at renewable technologies at the residential scale. We use aggregate data from IRS filings spanning 2006–2013. During this period, the tax credit evolved both in level of support and range of technologies covered. The response of households to this natural experiment allows points to four conclusions: a) the savings due to tax credits are only passed on to homeowners when the technology is modular and suppliers are in competition (e.g., solar panels); b) net household outlay on modular systems stays the same regardless of the level of the tax incentive; c) in custom made systems (e.g., geothermal heat pumps) the tax credits are captured by the supplies; and d) signaling about the imminent end and then renewal of ITC led to an "early harvest" effect on sales of solar thermal and photovoltaic systems, causing prices to drop and annual adoptions to spike in 2008.

Key Words: tax credit, incentives, household budgets, renewable energy, modular systems, solar thermal, solar photovoltaic, geothermal

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1. Introduction

In the United States, federal and state governments have used investment tax credits (ITC) to shape investment patterns for conservation improvements and renewable technologies since the 1970s (Pitts and Wittenbach 1981). The Energy Policy Act of 2005 established the current Residential Energy Conservation Tax Credit for solar photovoltaic (PV), solar thermal (ST), and fuel cell technology. To receive the tax credit, households would file Form 5695 and receive an ITC worth 30 percent of the capital investment for eligible renewable energy technology, with a ceiling of $2,000. The ITC, as originally conceived, supported energy efficiency measures to the end of 2007 and renewable energy technologies until the end of 2008 (DOE 2014; DSIRE 2015).

The second half of 2008 witnessed the onset of a severe economic recession unprecedented since the Great Depression. As shown in Table 1, the ITC was extended and amended by the Emergency Economic Stabilization Act (EESA)[1] of 2008 and the Energy Improvement and Extension Act of 2008 (DOE 2014). When the economic crisis deepened the American Recovery and Reinvestment Act of 2009 was passed. Aiming to stimulate even greater investments it expanded the range of technologies to include small wind and geothermal heat pumps while removing the $2,000 ceiling on credits (DSIRE 2015).

Effectively, the Residential Renewable Energy Tax Credit straddles two economic regimes. In the first, ITC was used to leverage private investment toward improving energy security and addressing climate change. In the second regime, an even higher ITC was employed to leverage private investment in durable goods and stimulation of the economy (Aldy 2011).

Despite their popularity, tax credits have been prone to free-ridership concerns since their inception. Free-ridership occurs when financial stimulus is offered to households that would have made investments without the added incentive, thereby increasing government spending without a corresponding increase in aggregate demand. The first Residential Energy Conservation Tax Credit of 1977–1986, which was motivated by the energy crisis of the 1970s, included energy conservation improvements as well as renewable technology.[2] Surveyed households indicated they would have likely made the energy conservation investment without the ITC (Pitts and Wittenbach 1981; Carpenter and Theodore Chester 1984; Walsh 1989). Further, Walsh (1989) was unable to find any positive significant relationship between the federal and state tax credits and qualitative measures of energy conservation improvement. The ITC, therefore, appeared to be a largely ineffective policy tool for influencing investment in energy conservation at the residential scale. However, Hassett and Metcalf (1995) observed positive and statistically significant relationships for energy conservation improvements after accounting for heterogeneous preferences for conservation at the state level.

[1] The EESA was an omnibus bill with many components from the Troubled Assets Relief Program to the Energy Improvement and Extension Act.

[2] Eligible taxpayers could file Form 5695, and be eligible to deduct 15% initial costs for investing in energy conservation capital, and 40% for renewable energy technologies. The conservation improvements included insulation, storm window, weather stripping, and other efficiency improvements. The renewable technologies were solar photovoltaic, solar thermal, and geothermal. The tax credit also came with a ceiling on the deductible amount of $300 for energy conservation and $4,000 for renewable energy.

TABLE 1. BILLS AMENDING THE ITC FOR RENEWABLE ENERGY

Bill	*Amendments to renewable energy ITC*
EPA 2007	The ITC set at 30% of initial investment up to a $2,000 cap for solar photovoltaic, solar thermal, and fuel cells.
EESA 2008	The ITC was extended to 2016 and its scope was expanded to include small wind and ground source heat pumps. Caps were set at $2000 for solar thermal and geothermal heat-pumps, $4000 for small wind and eliminated for photovoltaic beginning in 2009.
ARRA 2009	The cap was removed for all renewable technologies, allowing the investor to claim 30% of all capital investments under the ITC.

Source: DSIRE 2015.

In contrast to energy conservation, tax credits were unambiguously important for shaping residential investment in renewable energy. Both initial and follow-up surveys found the importance of the tax credit to increase with more costly purchases, such as solar thermal collectors (Carpenter and Durham 1985; Carpenter and Theodore Chester 1984; Petersen 1985).

The current experiment with federal investment tax credits and renewable energy is well underway and much attention has been focused on the amount and partitioning of investment (Gold and Nadel 2011a; Gold and Nadel 2011b), and the efficacy of ITC incentives compared to other approaches (Metcalf 2008; Metcalf 2009). The evolution of the ITC, and its implications for the cost of adopting individual technologies for consumers has also been closely tracked (Bolinger 2014; Bolinger et al. 2008; Hughes 2008). Previous studies of the federal ITC have neglected how the ITC might affect supplier pricing and the type of investments being made, and the uneven impact of the ITC across different technologies.

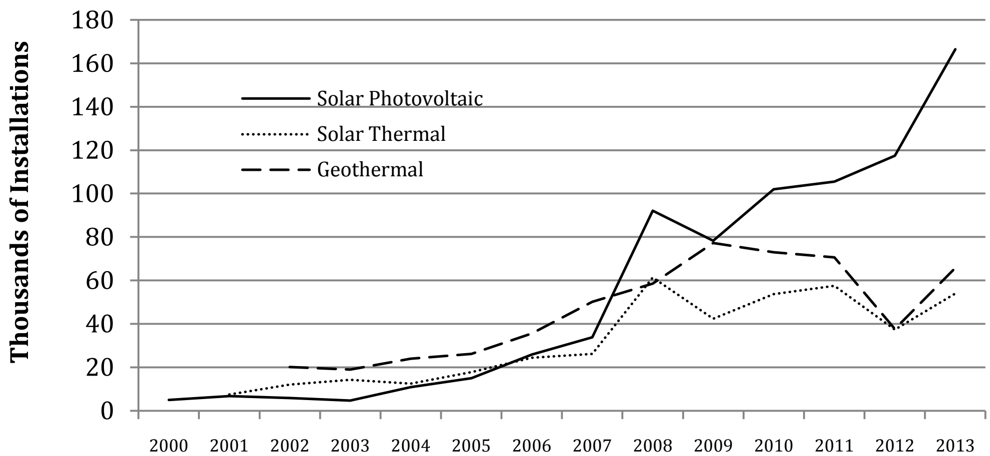
The changing terms of the ITC facilitate a natural experiment on residential investment in renewable technology. From 2006–2013, five technologies were eligible for the Residential Renewable Energy Tax Credit (ITC), three of which were adopted in sufficient numbers to allow comparison: solar photovoltaic (PV), solar thermal (ST), and geothermal (GT).[3] Taxpayers claiming the ITC must fill out Form 5695 recording the investment amount to claim the deductible. The Internal Revenue Service's (IRS's) website provides pooled estimates of the total number and investment for each technology from 2006–2013 (IRS 2015).

Figure 1 shows the number of annual installations for the three renewable technology types, indicating the year the ITC was introduced (2006), the year GT was added to the ITC (2008) and the year higher-level incentives were introduced (2009). Here we are primarily interested in how the changing level of incentives affected supplier pricing and consumer adoption patterns.

Our research uses panel data on IRS Form 5695 to analyze PV, ST, and geothermal (GT) investment, supplemented with information on the technology characteristics and price trends for a more nuanced analysis of adoption patterns of different renewable energy technologies by households.

[3] The low investment rates in fuel cells and small wind are noteworthy but difficult to analyze in the absence of supplementary surveys probing the conditions that have led to low adoption rates.

FIGURE 1. ANNUAL ADOPTIONS OF RENEWABLE TECHNOLOGIES BY RESIDENTIAL HOUSEHOLDS FROM EIA (2001-2006) AND FORM 5695 (2006-2013)



2. The Effect of Incentives on Supplier Pricing and Adoption Patterns

IRS Form 5695 provides only the total number and investment amount for each renewable technology. However, we can use price trends and each technology's characteristics to interpret the investment patterns in response to the changing terms of the ITC. In particular, we argue larger investments are only a desirable effect of higher-level incentives if the technology produces renewable electricity.

As shown in Table 2, solar PV stands apart from GT and ST by producing renewable electricity, which has implications for the scale of investment. Where net metering and/or feed-in-tariffs exist, electricity produced in surplus of the residential demand can be fed back into the distribution grid, and generate revenue or kudos to the investor.

In contrast, thermal energy cannot be transmitted far from its source. Consequently, its economic value to households lies in energy expenditure savings alone. This limits the size of thermal investments to peak domestic demand. Therefore, thermal systems should be more prevalent where demand (heating/cooling) is highest. This is supported by the available data on heat pump shipments showing the majority of systems being located in areas where loads would be higher and systems larger, such as in the US South (cooling) Midwest (heating) and Northeast (heating and cooling) (EIA 2012b).[4]

It follows that the marginal installation for renewable thermal systems following a decrease in net cost to the household (increase in ITC) would be where demand is lower, making the marginal installation smaller. In contrast, the ability to export electricity makes the marginal installation for renewable electricity larger. Unfortunately, there are no systematic data available on project sites, sizing, and costs. The available data only permits estimation of average household investments from Form 5695. Combined with independent price trends for the technologies supported through the ITC, we can calculate trends in average size of installation.

[4] Similar patterns are reported by the Department of Defense choosing to install GT in regions where climactic conditions lead to shorter payback periods (DOD 2007).

TABLE 2. RENEWABLE ENERGY TECHNOLOGY CHARACTERIZATION

	Solar Photovoltaic	Solar Thermal	Geothermal
Energy Form	*Electric*	*Thermal*	*Thermal*
Limit on scale on investment	Local regulations for distributed generation	Household demand	Household demand
Installation Type	Modular	Modular	Custom
Cost split	Mostly capital	Mostly Capital	Mostly Installation
Rate of technical change	High – falling module prices	Low – stable module prices	None – stable prices on hardware
Hardware competition	High	High	Low
Installer competition	High	High	Low*
Economies of scale	Moderate	Weak	Strong
Expected impact of ITC	Larger systems + Installations with lower insolation	Installations with lower demand/insolation	Smaller systems

Note: * May have some interaction with demand for drilling crews and equipment.

PV prices declined by half during the incentive period (Barbose et al. 2013). Policies, such as net metering and feed-in-tariffs, have further incentivized investment in certain states. Manufacturing, learning, and research and development have led to declining photovoltaic cell costs, while third party ownership, another service innovation reducing the initial outlay of capital, has grown to approximately 70 percent of solar PV installations in recent years (EIA 2012d; Margolis et al. 2013).[5] By contrast, ST prices have stabilized over the past decade and there are no recent technological or service innovations for GT offering meaningful cost reductions found by the authors (EIA 2012c; EIA 2012b; Groff 2014). Thus, given a fixed household budget, the price trend of PVs is expected to have led to larger installations.

There are two additional caveats when using prices to draw inferences. First, there is no way to test whether any trends are due to outliers. Second, the relationship between average investments and system sizes is more robust for modular systems (PV and ST) than for GT, which has high site-specific costs, discussed below.

Consider how the lion's share of installation costs for modular technologies are fixed (see Table 2), including capital equipment, allocated overhead, permit fees, financing, and profit. These costs are typically based either on unit costs (modules), or spread evenly over multiple installations (overhead, etc.). These characteristics are conducive to market transparency, and readily comparable pricing information facilitates competition among installers who can innovate in service delivery. By comparison, the prices for custom-built technologies are more heavily weighted toward installation compared to its component parts. GT is custom built by nature, and the ground-loop heat exchanger can be upwards of half of total installation costs. The price of the ground loop depends on the availability of space and drilling rigs,

[5] In this case the homeowner leases back the solar panel over time, and the installer loans back the value of the tax credit by reducing their lease payments.

heat reservoir type (sewer, water body, or ground), and, if ground, soil conditions. These characteristics increase the value of local knowledge, limit competition amongst installers, and, where pricing information is incompatible, increase the potential for local capture by installers.

With these caveats in mind, we can use average investment levels to study household responses to changing incentives. An increase in average outlay is likely indicative of a marginal investment in PV and inframarginal investment in ST and GT technologies. The custom-built nature of GT does, however, mean price movements could be the result of an increase in size or the price charged by installers.

3. Results

Table 3 displays the panel data from Form 5695 for each technology, including total number, aggregate investment, and the calculated average cost per installation, average ITC amount, and net household cost, among other explanatory factors.

The heterogeneous responses across technologies indicate that incentives are taken up in different ways by technology. For PV, the increase in average household gross investment (comparing 2006–2007 to 2009–2012) is approximately equal to the increase in deductible tax credit amount, meaning the homeowner cost net of taxes remained relatively flat at approximately $10,000 (excluding 2008). With declining PV prices and higher-powered incentives for homeowners, households were willing to invest the same amount, meaning it was the investment value and not the system size driving residential decision making for PV. In other words, homeowners treated PV as a fixed budget decision.

The average cost of an ST system reported on Form 5695 was less than $6,000, so the majority of homeowners were claiming the maximum ITC amount before the ceiling was lifted, and the average invested, ITC amount, and net household cost of ST remained flat. This stands in stark contrast to GT investment patterns that show a strong increasing trend from 2008 to 2013, with net cost to households more than doubling over the period of study.

It appears that for PV the higher-level incentives led to, on average, more marginal installations permitting homeowner to return more electricity to the grid. Given that both ST and GT technologies produce renewable thermal energy and are scaled based on need, we expected to observe similar investment trends in response to higher incentives. The price of ST systems was unaffected, however, the price of GT nearly doubled meaning either there was a shift toward larger systems (likely already profitable without the higher-level incentives), and/or the custom-built nature of the technology enabled installers to increase prices.

TABLE 3. NUMBER AND AGGREGATE INVESTMENT FOLLOWED BY AVERAGE COST, AVERAGE ITC AMOUNT, NET HOUSEHOLD INVESTMENT, AND OTHER CONTROL VARIABLES

SolarPV	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
No.	*4,678*	*10,786*	*15,008*	25,854	33,822	92,052	78,329	101,932	105,554	117,391	166,416
$1,000	-	-	-	285,077	379,031	497,185	1,095,004	1,471,535	1,488,515	1,855,168	2,085,619
Av. Cost	-	-	-	11.03	11.21	5.40	13.98	14.44	14.10	15.80	12.53
Av. ITC	-	-	-	2.00	2.00	2.00	4.19	4.33	4.23	4.74	3.76
NET HH INV	-	-	-	9.03	9.21	3.40	9.79	10.11	9.87	11.06	8.77
$/W[i]	9.9	9.3	8.9	9.0	9.1	8.7	8.3	7.1	6.3	5.3	4.7
State Incen[ii]	4.2	3.9	3.1	2.7	2.5	2.1	1.9	1.6	0.9	0.5	0.2
Elect ¢/kW[iii]	8.7	9.0	9.5	10.4	10.7	11.3	11.5	11.5	11.7	11.9	12.1
SolTherm	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
No.	*14,203*	*12,471*	*17,732*	24,357	26,211	61,339	42,380	53,637	57,467	37,340	54,010
$1,000	-	-	-	107,148	107,671	221,267	211,900	220,881	275,426	165,365	220,906
Av. Cost	-	-	-	4.40	4.11	3.61	5.00	4.12	4.79	4.43	4.09
Av. ITC	-	-	-	1.32	1.23	1.08	1.50	1.24	1.44	1.33	1.23
NET HH INV	-	-	-	3.08	2.88	2.53	3.50	2.88	3.35	3.10	2.86
ST $/ft^2 [iV]	2.1	1.8	2	2.0	2.0	1.9	*1.9*	*1.9*	*1.9*	*1.9*	*1.9*
Gas $/MBtu[v]	5.5	5.9	8.7	6.7	7.0	8.9	3.9	4.4	4.0	2.8	3.7
GeoTherm	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
No.	*18,908*	*23,891*	*26,146*	*35,580*	*50,147*	58,502	77,238	72,958	70,673	37,658	65,760
$1,000	-	-	-	-	-	484,154	1,097,334	920,180	1,215,451	695,317	928,587
Av. Cost	-	-	-	-	-	8.28	14.21	12.61	17.20	18.46	14.13
Av. ITC	-	-	-	-	-	2.0	4.26	3.78	5.16	5.54	4.24
NET HH INV	-	-	-	-	-	5.79	9.95	8.83	12.04	12.92	9.89
Housing[vi]	17,533	19,251	20,214	16,565	11,659	6,809	5,275	5,376	5,040	6,240	7,433
Reno. $M[vii]	100,344	115,399	143,767	138,991	134,703	129,058	113,652	114,780	120,907	115,113	134,639
Rig Count[viii]	48,987	56,930	67,060	81,076	88,151	94,316	55,417	78,746	96,009	97,306	88,675

Notes: Years 2001–2002 not shown. The number of adoptions from IRS for years 2006(8)–2013 and EIA from 2003–2006(8). i,ii)$/W from(Barbose et al. 2014); iii) US average residential electricity prices from (EIA 2015a); iv) Solar thermal $/f^2 is assumed constant from 2009 onwards (EIA 2012c); v) Henry Hub gas prices in $ per million Btu (EIA 2015b); vi) Seasonally adjusted single housing unit permits (000s) (US Census Bureau 2015b); vii) Home improvement activity in US millions (US Census Bureau 2015a); viii) US annual onshore rig counts (Baker Hughes 2015).

Finally, given the high capital outlay needed for GT, it is surprising to find a rising trend while gas prices were falling. However, the 2013 figures hint at a simple market-pricing model with suppliers taking advantage of their specialist local knowledge. Below are four other possible factors affecting the price of GT, of which the first two can be eliminated:

- A lack of awareness for GT prior to the introduction of the investment tax credit could mean the 2008 sample was not indicative of the average population, however, data on heat pump shipments from the EIA prior to the ITC shows steadily increasing numbers making a lack of awareness unlikely (EIA 2012b).
- Installation costs may have risen due to competition from the oil and gas industry for drilling rigs and riggers. This too can be dismissed as the economic downturn led to lower oil and gas prices and far lower drilling activity during the period of study (Baker Hughes 2015).
- It could be that only wealthy homeowners were able to sustain greater levels of investment during this period; if so, we might be observing the effects of income elasticity during the economic crisis. However, renewable technologies tend to be adopted by wealthier households to begin with (Long 1993; Walsh 1989).
- The tax credit may have enabled geothermal installations in more difficult to drill areas, such as homes situated on bedrock or where vertical installations were the only option. These costlier installations may have become affordable following an increase in the value of the tax credit.

The annual installations (Figure 1 and Table 3) display divergent and counterintuitive trends for PV, ST, and GT investments. PV and ST technology had a bumper year in 2008, followed by a decline in 2009. This break in trend is not reflected in GT investments.

The reason for this divergence is that investments in PVs and STs can be scaled back to match household budgets unlike a well-designed GT (a GT designed to meet 70 percent of household peak demand is custom built and very expensive). Initially, the Federal government had signaled that 2008 was the last year for residential ITC. Installers used this deadline to encourage homeowners to install PV and ST technology at whatever scale they could afford—benefiting from this last chance to realize the ITC. Thus, there were more households investing in PV and ST at scales not exceeding the $2000 ITC cap for the 2008 tax year. This had an “early harvesting effect” on 2009 installations for both PV and ST—even though the ITC was renewed at an even higher level. In contrast, there was no harvesting of GT and installations continued to rise and only levelled off after 2009, when gas prices reversed their rapid upward price trends that began in 2000. GT installations continue to diminish as the fear of “sky high” gas prices as a motivation for GT installations recedes.

Running counter to previous explanations for the decline of GT by Groff (2014), the number of GT installations was growing as housing starts fell and then falling during a housing recovery period (US Census Bureau 2015). This means either the share of GT among new construction increased during the ITC period, or the households adopting GT were “well-heeled” and relatively unaffected by the downturn in construction.

5. Conclusion and Policy Implications

The IRS tax return panel data facilitated a unique opportunity to study residential responses to changing incentives for residential renewable energy. Micro-data and a greater number of observations are ultimately required to confirm these inferences, however, this article demonstrates how technological characteristics can explain observed investment patterns in response to the ITC. The renewable technologies were differentiated based on whether they produced renewable thermal energy or electricity and whether they were module or custom built.

We find these characteristics were strong determinants for whether the higher-level incentives had a desirable impact on prices. Higher-level incentives that increase linearly with the investment amount are most likely to benefit renewable technologies producing electricity. By comparison, renewable thermal technologies are scaled based on need, and marginal investments are found in smaller installations. GT in particular saw a significant increase in prices due to either an increase in inframarginal installations or opportunistic behavior by installers made possible by its custom-built characteristics.

This study also revealed that consumers treated PV investments as a fixed-budget decision, with the net cost to homeowners remaining relatively flat during higher-level incentives and falling prices. Thus, PV is increasingly treated as an investment decision based on the benefits of producing electricity.

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