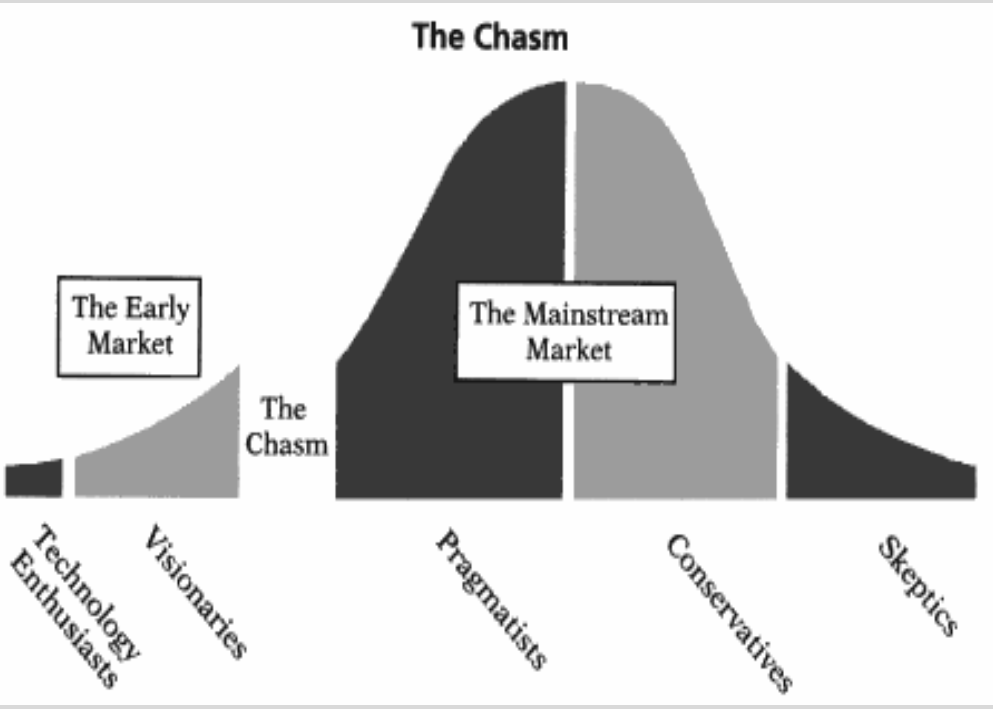
Energy Efficient Homes and Mortgage Risk: Crossing the Chasm At Last? A Role for Credit Modeling?



Drew Sanderford, George A. Overstreet, Peter Beling, and Kanshukan Rajaratnam

Credit Scoring and Credit Control XIII

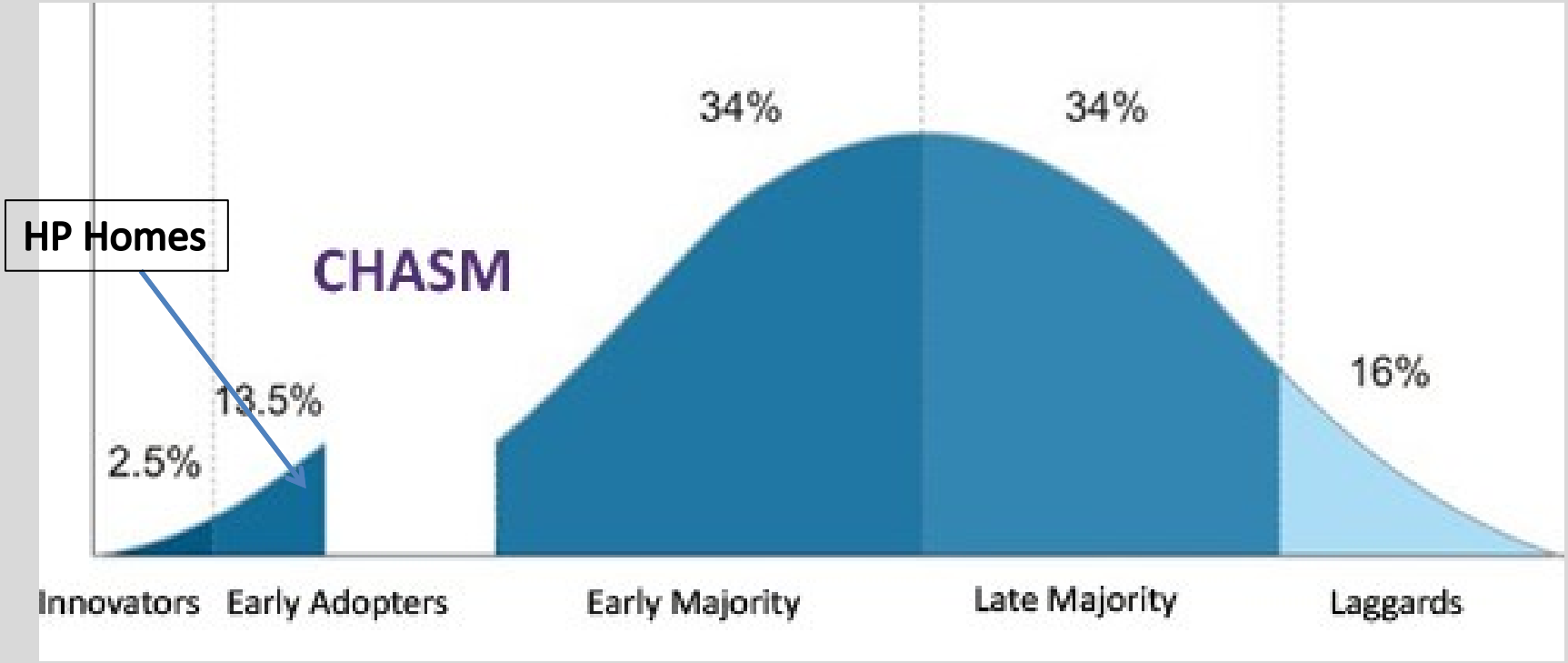
August 28-30, 2013

Agenda

- **Point of Departure**
- **Research Problem Framework**
- **Brief Synopsis of Literature and Key Papers**
- **Identification of Market Frictions in Relationship to Mortgage Origination Process**
- **Strategic Implications; Public Policy Implications**
- **Future Research Plans**

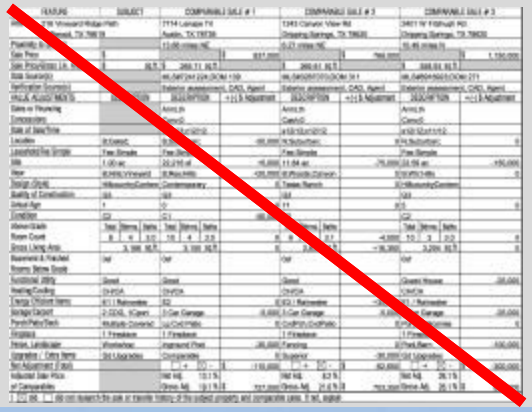
Point of Departure

High Performance Homes yet to cross Moore's (innovation adoption) chasm

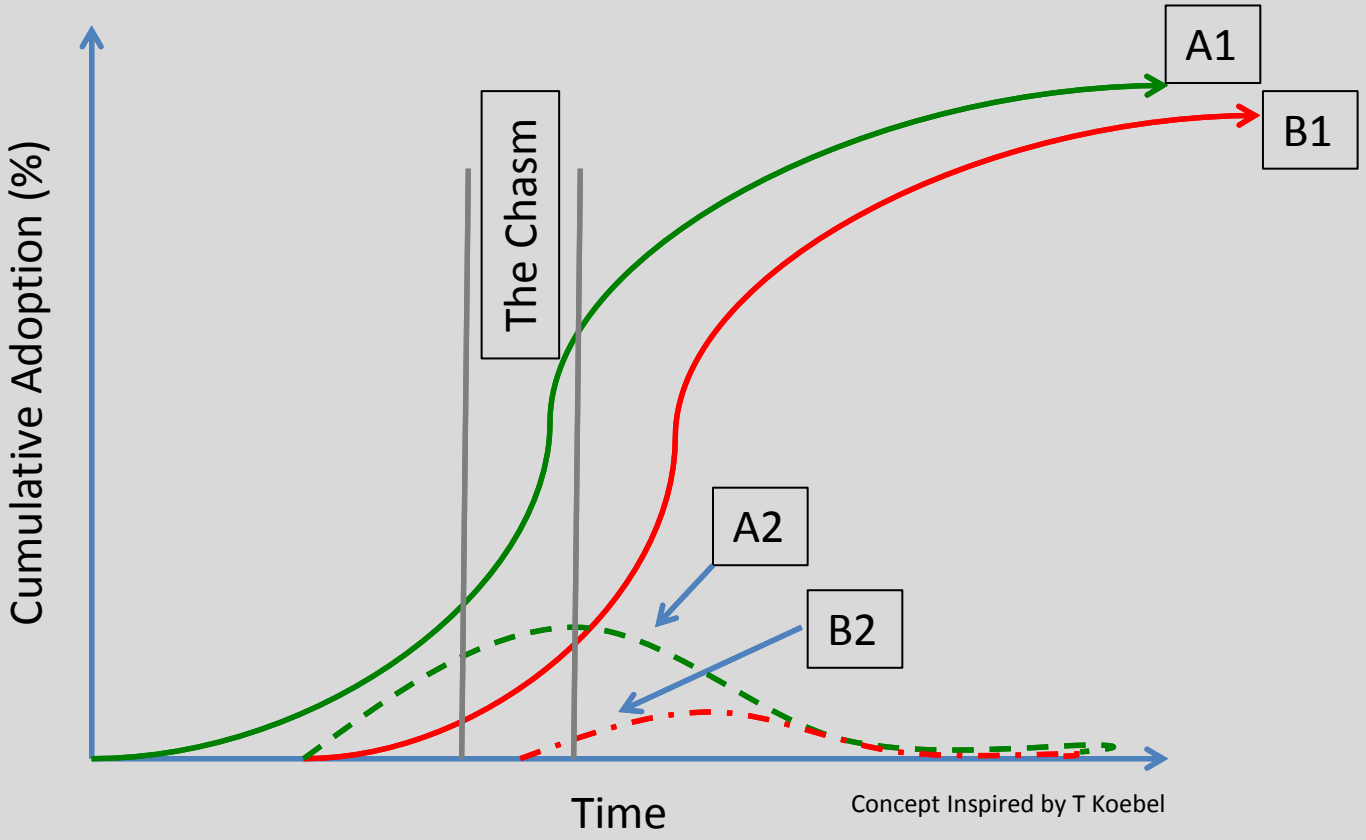


Hypothesis: Lender Most Significant Gatekeeper

Current Lending Process constrained by missing data & Research hamstrung by limited data



Expected Diffusion Trajectories



A1: Diffusion curve of the housing units with complete value proposition information
A2: Diffusion curve of same green homes without full green information
B1: Number of re-sales for green homes that can be used to establish the market value for green features including certifications
B2: Number of re-sales that can be used without green value information

"The Energy-Efficiency Gap," A.B. Jaffe and R.N. Stavins, *Energy Policy, 1994, Vol. 22, No. 10, p. 10.*

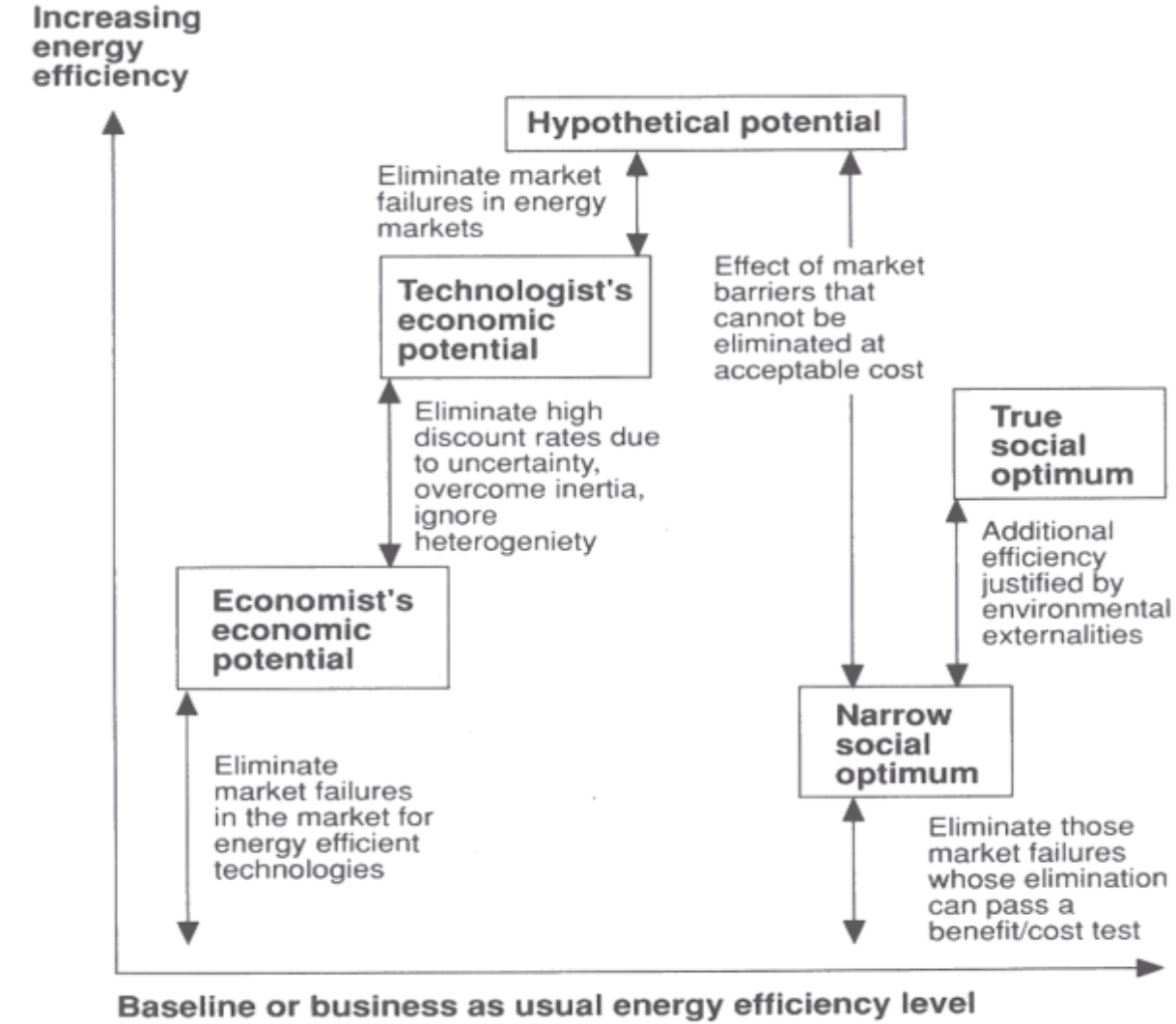


Figure 1. Energy-efficiency gaps.

Green Residential Real Estate Literature Summary Highlights

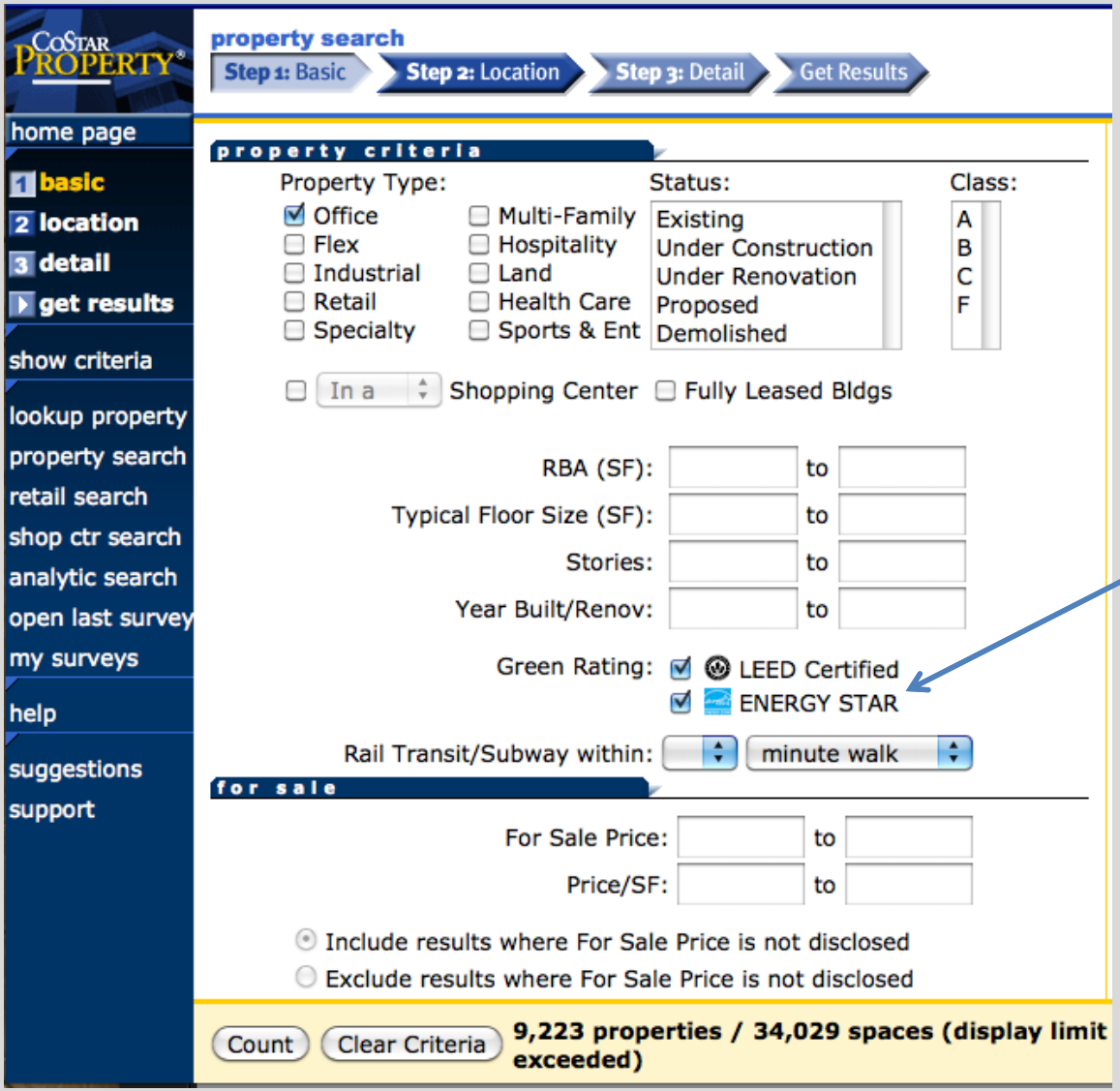
- **Sample of Hedonic Pricing Premium Models:**
  - **California: Green Point Certified = 9% (Kok & Khan, 2013)**
  - **Texas: Dual Paned Windows Texas = 3% (Aroul & Hanz, 2011)**
  - **Colorado: Energy Star Certification = $8.66/(SqFt) (Bloom et al, 2011)**
  - **California: Solar Panels = 3.5% (Dastrup et al, 2012)**

Green Commercial Real Estate Literature Highlights

- Hedonic Analyses: Premiums & Occupancy
  - Green certified commercial office commands rent premium or capitalized prices
    - (Eicholtz et al, 2011; Miller et al, 2008; Wiley et al, 2010; Pivo & Fisher, 2009 & 2010);
    - Rents are influenced by prevailing political ideology (Harrison & Seiler, 2011)
    - Green office investments made in softening markets (Wiley & Das, 2013)
  - Green certified office has less tenant churn
    - (Fuerst & McAllister, 2009)
- Fixed Effect Analyses:
  - Not all certifications influence churn, rent, occupancy equally
    - Dermisi, 2009/2012
  - Energy Star certification may be signal of superior professional management (Robinson, 2013)
- Data for most green commercial real estate papers drawn from CoStar or NCREIF databases
- Jaffee & Wallace (2009) pose serious question: Are mortgage defaults linked to volatility in commercial energy prices

Empire State Building Energy Efficiency Retrofit Investment Success

Principal Agent-Missing Information Less Severe In CRE



Energy Efficiency & Locational Efficiency Search-ability

Literature Summary: Energy Efficient (High Performing) Home Mortgage Market Frictions

Missing Information At All Stages of Underwriting

Inconsistent Appraisal Methods—which omit Energy Efficiency

Well Developed Automated Underwriting & Credit Scoring Innovations on the Financing Front

Principal-Agent Problems in Commercial Real Estate and Multi-family—Home Ownership ?

Only a few Key Mortgage Default Analyses Include Energy Efficiency Factors—Quercia, et al (2013) & Rauterkus, et al (2010)

Public Policy Landscape

Mortgage Default Modeling Has *Rarely* Included EE Variables: Key Papers

K Quercia, R., Sahadi, R. & Stellberg, S. (2013) "Home Energy Efficiency & Mortgage Risks"

Table 2: Summary of Findings

	BASELINE MODEL		HERS RATING SAMPLE	
	Default	Prepayment	Default	Prepayment
ENERGY STAR Certification	--	--	N/A	N/A
HERS Rating	N/A	N/A	++	++
FICO Score	--	++	--	++
Origination Loan-to-Value Ratio	++	--	+	--
Age of the House	--	--	-	--
Loan Type	++	++	++	++
Neighborhood Unemployment Rate	++	--	+	--
Neighborhood Income	++	++	++	+
House Value/ Area Median Sale Price	--	++	--	+

Note: ++, -- represent statistically significant results and +, - represent insignificant results.

Table 3. Quercia et al Energy Efficiency Hazard Model: Both EE and Non EE Homes included in this model

Table 3: Base Model (All Data)

	DEFAULT				PREPAY			
Variable	Estimate	Std. Err.	Sig	Odds Ratio	Estimate	Std. Err.	Sig	Odds Ratio
Intercept	8.91	0.37	***		1.94	0.26	***	
FICO Score	-0.01	0.00	***	0.99	0.00	0.00	***	1.00
Loan Origination After 2006	-2.92	0.05	***	0.05	-3.03	0.04	***	0.05
Original Loan to Value Ratio	0.79	0.17	***	2.20	-1.51	0.12	***	0.22
Loan Type	1.31	0.04	***	3.72	0.33	0.03	***	1.39
Zip Code Average Unemployment	0.03	0.01	***	1.03	-0.04	0.00	***	0.96
Zip Code Average Income	0.00	0.00	***	1.00	0.00	0.00	***	1.00
House Price Relative to Zip Code Sale Price	-0.13	0.03	***	0.87	0.16	0.02	***	1.18
Age of the House	-0.01	0.00	***	0.99	-0.01	0.00	***	0.99
ENERGY STAR Certification	-0.39	0.03	***	0.68	-0.32	0.02	***	0.73

n=71,062. Log likelihood=-52,007.6
*** p <= 0.001, ** p <= 0.01, * p <= 0.05, · p <= 0.1

Table 4. Quercia's Energy Efficiency Hazard Model: Energy Star Homes Only in this model

	DEFAULT				PREPAY			
Variable	Estimate	Std. Err.	Sig	Odds Ratio	Estimate	Std. Err.	Sig	Odds Ratio
Intercept	10.25	1.19	***		-0.49	0.74		
FICO Score	-0.02	0.00	***	0.98	0.00	0.00	***	1.00
Loan Origination After 2006	-3.76	0.18	***	0.02	-2.29	0.15	***	0.10
Original Loan-to-Value Ratio	0.30	0.44		1.35	-1.19	0.25	***	0.30
Loan Type	0.58	0.09	***	1.78	0.22	0.06	***	1.24
Zip Code Average Unemployment	0.02	0.01		1.02	-0.05	0.01	***	0.95
Zip Code Average Income	0.00	0.00	***	1.00	0.00	0.00	.	1.00
House Price Relative to Zip Code Sale Price	-0.18	0.08	*	0.83	0.10	0.04	*	1.11
Cooling Degree Days	0.00	0.02		1.00	-0.07	0.01	***	0.93
Heating Degree Days	-0.04	0.02	*	0.96	0.00	0.01		1.00
Electricity Price	0.01	0.01		1.01	-0.02	0.01	***	0.98
Area of the House	0.01	0.00	*	1.01	0.02	0.00	***	1.02
Age of the House	-0.01	0.02		0.99	-0.07	0.01	***	0.94
HERS Score	0.04	0.01	***	1.04	0.02	0.00	***	1.02

n=21,094, Log likelihood=-12,822.26
*** p <= 0.001, ** p <= 0.01, * p <= 0.05, · p <= 0.1

Quercia et al (2013) General Assessment

- Quercia et al (2013) is clearly an important and timely study having gotten a lot of press (Bloomberg, etc.) with Energy Star homes (EE) shown as 32 percent less likely to be subject to default risk than non-Energy Star--with other loan determinants controlled
- Lower risk is embedded in energy efficiency rating but their analysis was admittedly plagued by endogeneity due to missing variables and use of demographic versus personal data
- Still, study's findings are provocative and based on a large sample marred by reliance on macro level variables such as zip code average income, etc.

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Key Paper B: Rauterkus, S., Thrall, G., & Hangen, E., (2010), "Location Efficiency and Mortgage Default," *JOSRE* 2 (1)

Exhibit 4 | Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min.	Max.
Panel A: Chicago, IL					
DTI_orig (%)	11,834	36.97	10.79	1.00	99.00
FICO_orig	16,542	695.74	65.74	387.00	844.00
LTV_ratio (%)	18,607	79.36	11.58	4.72	107.50
Mort_age (days)	18,735	995.30	43.98	930.00	1,080.00
Orig_amt ($)	18,735	222,036.40	119,196.70	15,000.00	1,900,000.00
PCI ($)	18,735	33,731.98	21,626.74	0.00	154,098.00
Popgwth00CY (%)	18,735	0.45	4.72	−3.90	96.40
PNonwhite (%)	18,735	43.43	30.19	0.00	100.00
VehperHH	18,735	1.47	0.44	0.05	4.00
Vehper000HHinc	18,735	0.03	0.01	0.00	0.76
Walk_Score	18,735	64.53	19.53	0.00	100.00

Rauterkus, Thrall, Hangen (2010): Location Efficiency and Mortgage Default

Exhibit 5 | Probability of Default and Vehicles per Household

Variable	Model 1	Model 2	Model 3	Model 4
Panel A: Chicago, IL				
Lnvehper000inc	0.6761 (16.23)***	0.3069 (4.83)***	0.2969 (4.66)***	0.2574 (3.97)***
lnDTI _orig		0.4021 (7.16)***	0.4036 (7.19)***	0.3966 (7.06)***
lnFICO_orig		−3.1686 (−16.37)***	−3.1624 (−16.32)***	−3.1961 (−15.68)***
lnLTV_orig		0.5138 (3.87)***	0.5160 (3.87)***	0.33753 (3.09)***
lnMort_age			0.5106 (1.29)	0.6575 (1.64)
Popgwth00CY			−0.0114 (−1.02)	−0.0133 (−1.22)
Minblkgrp				0.1213 (2.57)**
Ownocc				−0.0119 (−0.16)
Refi				−0.2584 (−6.71)***
Whiteblkgrp				−0.1364 (−3.08)***
Constant	1.1946 (8.15)***	16.7104 (11.30)***	13.0952 (4.21)***	12.9345 (4.13)***
Pseudo R^2	0.0218	0.0834	0.0839	0.0954
N	18,632	10,372	10,372	10,372

Rauterkus, Thrall, Hangen (2010): Location Efficiency and Mortgage Default

- Sample size 40,000 (Chicago, Jacksonville, San Francisco case analyses plus whole) modeling probability of default
- Two proxy variables for location efficiency—1. *vehicles per household scaled by income*; 2. Walk Score (flawed)
- Default probability increases with number of vehicles controlled for income—different models per city
- Findings suggesting mortgage underwriting flexibility for households in such situations
- Public policy around "smart growth" has serious implications for mortgage default rates
- Suggests to Mortgage Underwriting Modelers: "findings suggest increases in *vehper000 inc could compensate for DTI and LTV" Do we agree?*

- **“The specific hypothesis is after holding traditional underwriting factors constant, mortgages on location-efficient homes will have superior performance to non-location efficient homes.” p. 118 Naturally, authors then call for setting a higher debt (payment) to income ratio for loans to location-efficient homes.**
- **“*Implication of EFFICIENT MKTS***

Rauterkus, Thrall, Hangen (2010): Location Efficiency and Mortgage Default Walk Score Results

Potential New Variables To Include In Underwriting Decision

New Variable	Source	Describes	Variable Type	Alt Type
Walkscore	Walkscore--API for Professionals	Locational Efficiency	Continuous	Ordered Classification
Distance from CBD	GIS Software Packages-Census	Locational Efficiency	Continuous	Ordered Classification
HERS	Independent 3rd Party Rater	Relative Energy Efficiency	Continuous	Ordered Classification
Eco-Label	Any national or regional Green Bu	Presence of Green Building Certification	Dummy	N/A
Utility Bills	Local or Regional Utility	Behavior of previous occupant	Continuous	Ordered Classification

- **Walkscore's flaws of a mile radius and lack of information on street safety and barriers including hills, water, and freeways require alteration—still if used conservatively has merit**
- **Not shown here but certainly of much interest is number of vehicles per household/income**
- **Crucial to Initiate Holistic Studies that Include Energy Efficiency and Locational Efficiency Factors (see Burt et al, 2010 favoring huge HUD led research effort)**
- **We favor creative handling of these twin factors by the market!**

Conclusions

- **Missing energy related information relating to housing (EE & LE) creates an inefficient market or sub-optimal analytical situation hindering diffusion of EE housing;**
- **Information transparency is critical to the mortgage underwriting process with minimal but increasing levels of local government impact thus far:**
- **Transportation related expenses (LE) roughly 3 to 4 times ($8000 per annum the (EE) home energy costs ($2000) so should be more significant;**
- **Implementing policies that brings this information into the market place will drive more transparent outcomes for housing innovations beneficial to the environment and economy—and cross Moore's chasm;**
- **Information relating to EE and LE transparency as relating to mortgage underwriter's gatekeeper role has potential asymmetric informational value for lenders and security holders;**
- **As housing markets become more efficient—with lender involvement--opportunities for asymmetric gain will decrease! First movers on the modeling front should create value for their firms!**

Conclusions Cont.

- **Would be wise to include the middle to lower end of the housing** market **given that benefits of energy efficiency are more significant portions of cash flow for the bottom two quartiles and, hence, more likely to factor into surviving a mortgage default trigger event (note—this is also true for rental properties plagued by "split incentives");**
- **U.S. behind the Europeans in availability of EE information, but could catch up with appropriate pubic policy and/or market driven information allowing incorporation of EE variables in mortgage default models with potential for enhanced predictability.**
- **Models could include several potentially relevant cash flow oriented variables with relative analytical ease and moderate incremental cost given public policy support;**
- **Industry should lobby for inclusion of energy related information at key points in time (prior to closing, etc)—to include operating level (historic energy bills) as well as at the asset rating level.**
- **Informational transparency in this key area will assure that market forces work at some close point to potential.**

Help us create an international research effort using private data bases that include both EE and LE variables—through the Credit Scoring Conference Network!

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Peter Beling

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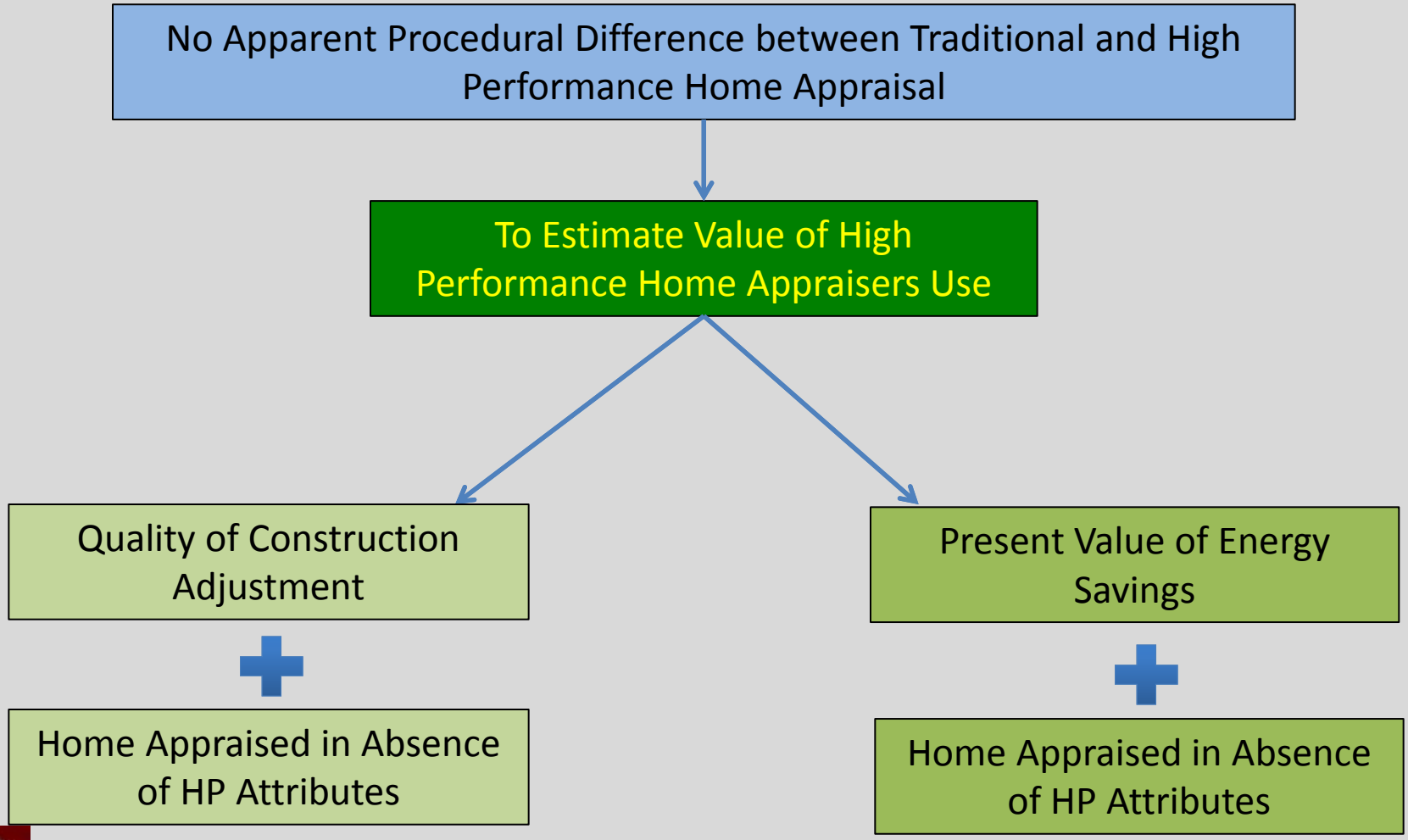
Inconsistent Appraisal Methods



Public Policy Landscape

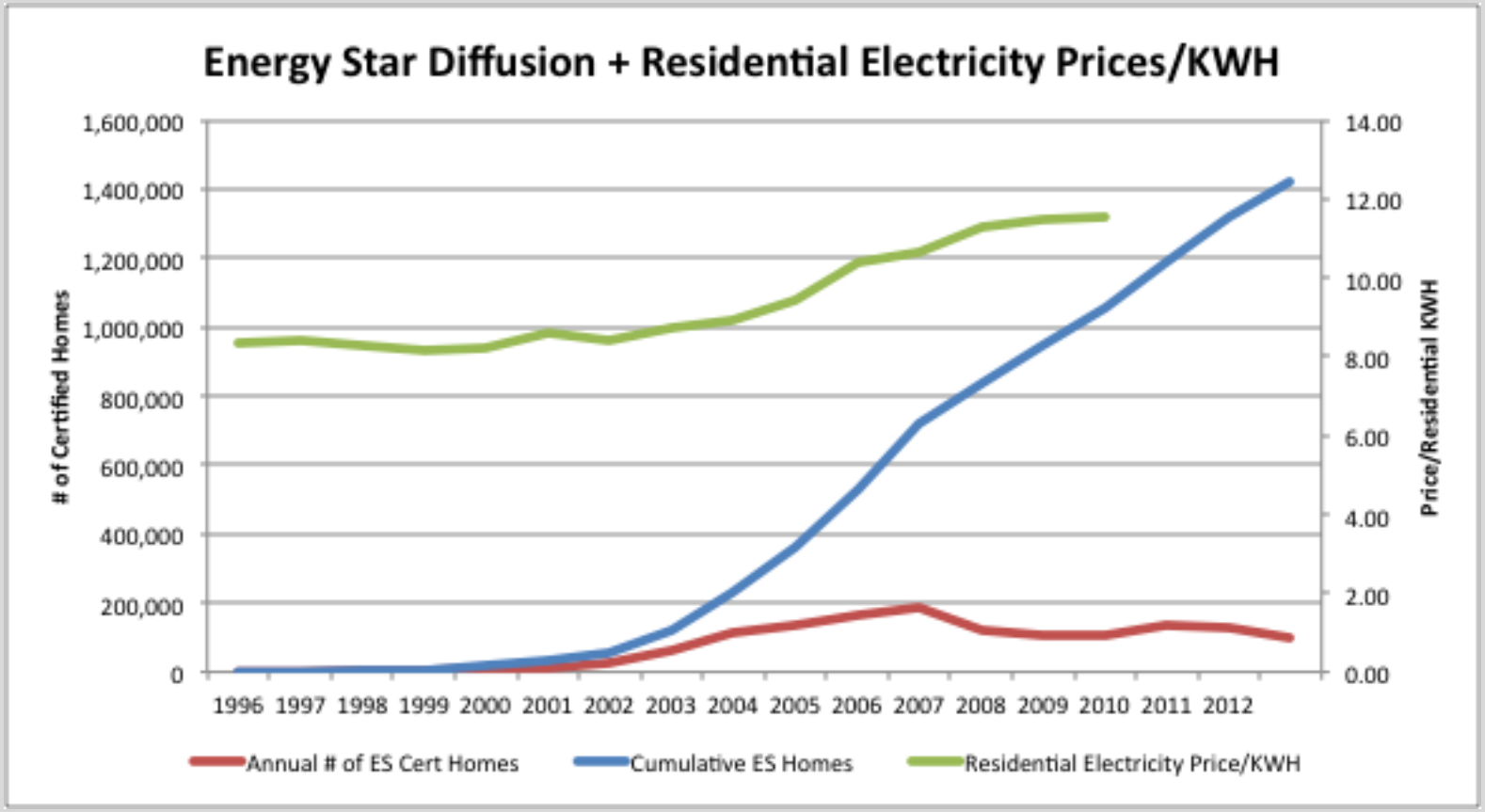
- **EPA's Database of State Incentives for Renewable Energy (DSIRE):**
  - **Each US State offers energy efficiency incentives**
    - **Grants, loans, utility rebates, etc**
    - **AVG of 21 programs/State**
    - **See evidence of increased use of HP Housing technologies in states with higher numbers of incentives (McCoy, Koebel, and Sanderford, 2013)**

- **US Green Building Council:**
  - **Integration of Green Building Into Zoning Codes**
    - **427 Commercial Pub Policies**
    - **228 Residential Pub Policies**
    - **Policy Growth from 2003 to 2011 (Kontokosta, 2011)**
    - **Administrative incentives are most effective policy tool in growing green office (Choi, 2010)**

- **Market Reactions:**
  - **See increased diffusion of green commercial after inclusion in zoning policy (Simons & Choi, 2009)**
  - **Markets with residential Policy see increased green home construction (Bond & Devine, 2013)**
  - **See increased numbers of green certified office buildings in markets where governments have green purchasing requirements (Simcoe & Toffel, 2011)**
  - **See increased numbers of green certified office buildings in markets where there are green public policy incentives or mandates (Kok et al, 2011)**
  - **Prevailing political ideology in market interacts with public policy incentives and influences rental prices (Harrison & Seiler, 2011)**

Overcoming Frictions

- Pascal's Wager?
  - Locationally efficient & HP Homeowners are less likely to default;
  - Locationally efficient & HP homes often sell at premium prices;
  - In an energy uncertain environment and one where environmental externalities matter, shouldn't we hedge towards green homes?
  - Findings suggest collateral is superior and borrowers are superior;

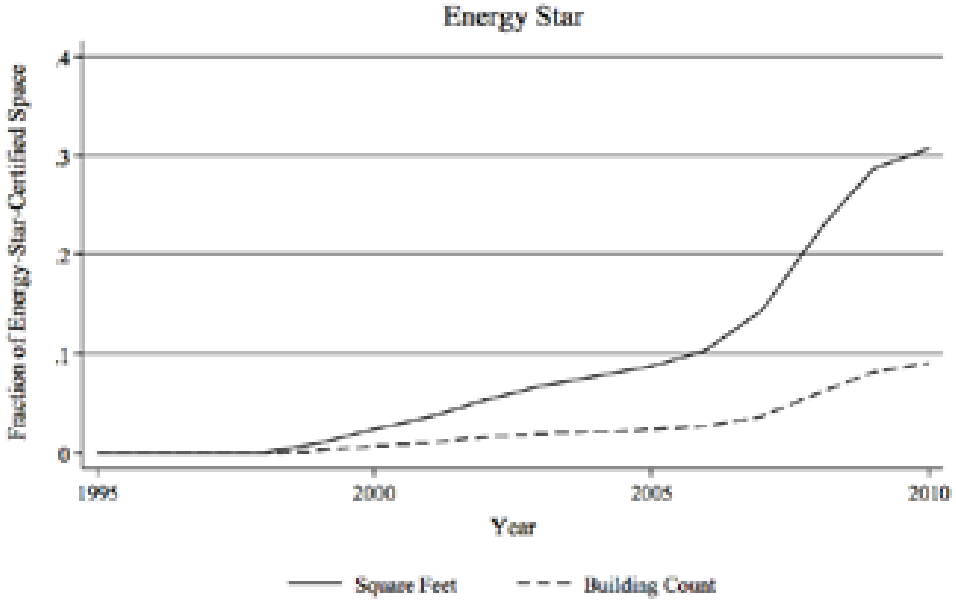


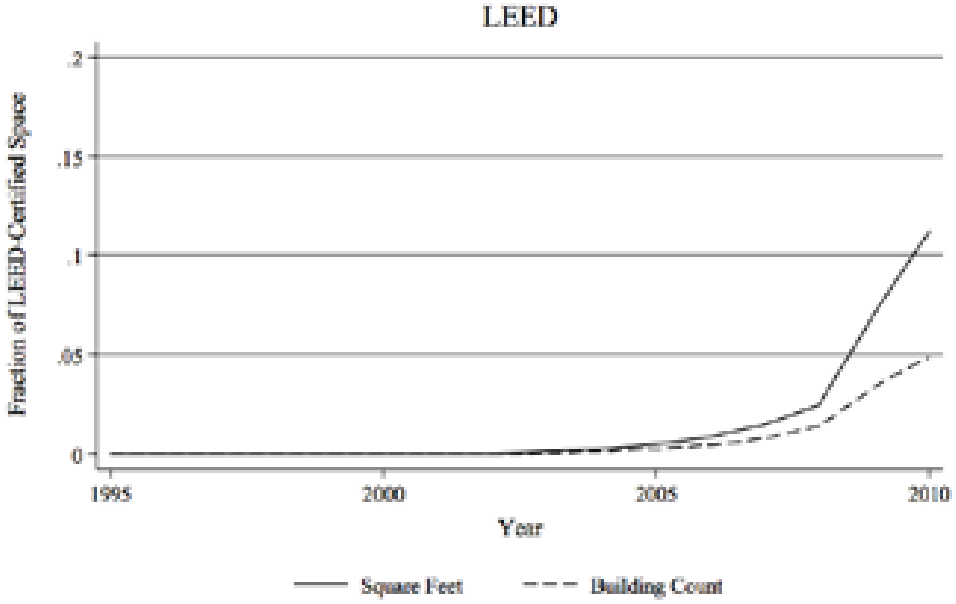
Calendar Year	# of EE Mortgages
2004	1,129
2005	441
2006	944
2007	1,071
2008	1,733
2009	3,089
2010	2,192
2011	780
2012	701
2013	264
Total	12,344

Title II: New Endorsements FY 2012 - 2011

	FY 2012	Percent of Total	FY 2011	Percent of Total
Energy Efficient Mortgage	659	< 0.01%	1,067	< 0.01%
203(k) Rehabilitation	22,477	0.018%	21,266	0.017%
Total Title II Endorsement	1,239,417	100.00%	1,270,906	100.00%

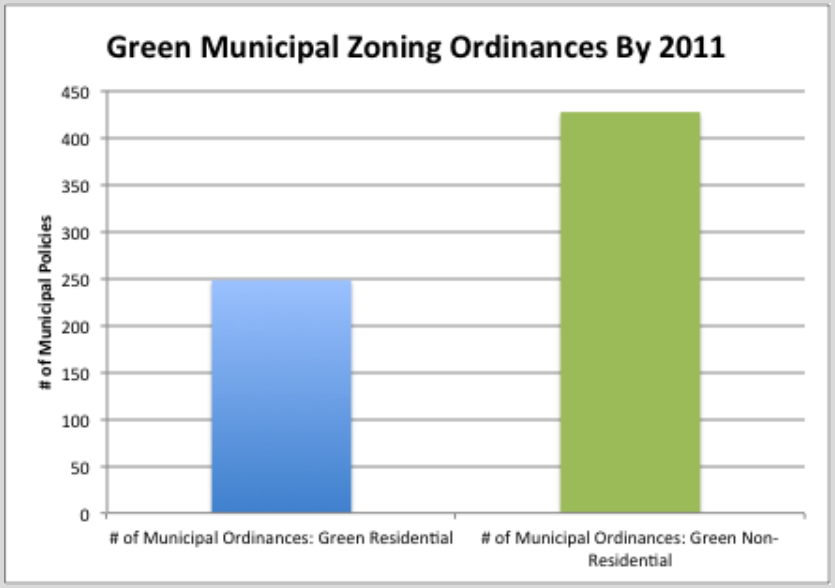
Note: Data is not available for Weatherization and Solar transactions.

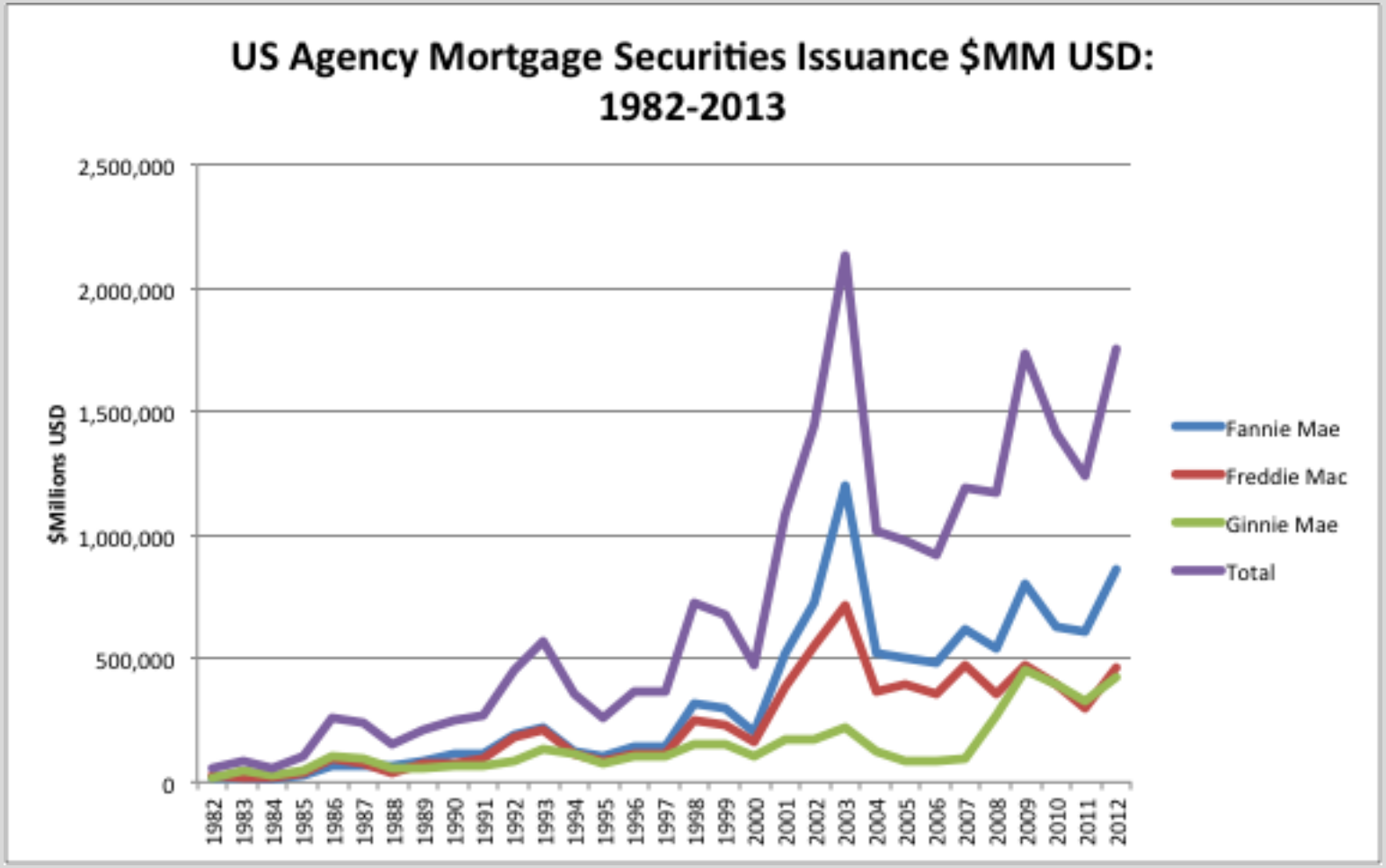




LEED Program	# of Projects Certified by 2013
Core & Shell	4,567
Existing Buildings	5,905
New Construction	20,934
Retail	1,353
Commercial Projects Total	32,759

LEED Program	# of Projects Certified by 2013
Homes	1,125
Mid-Rise Multifamily	3
Residential Projects Total	1,128




US Agency Mortgage Securities Issuance $MM USD: 1982-2013
$Millions USD
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
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1998
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2002
2003
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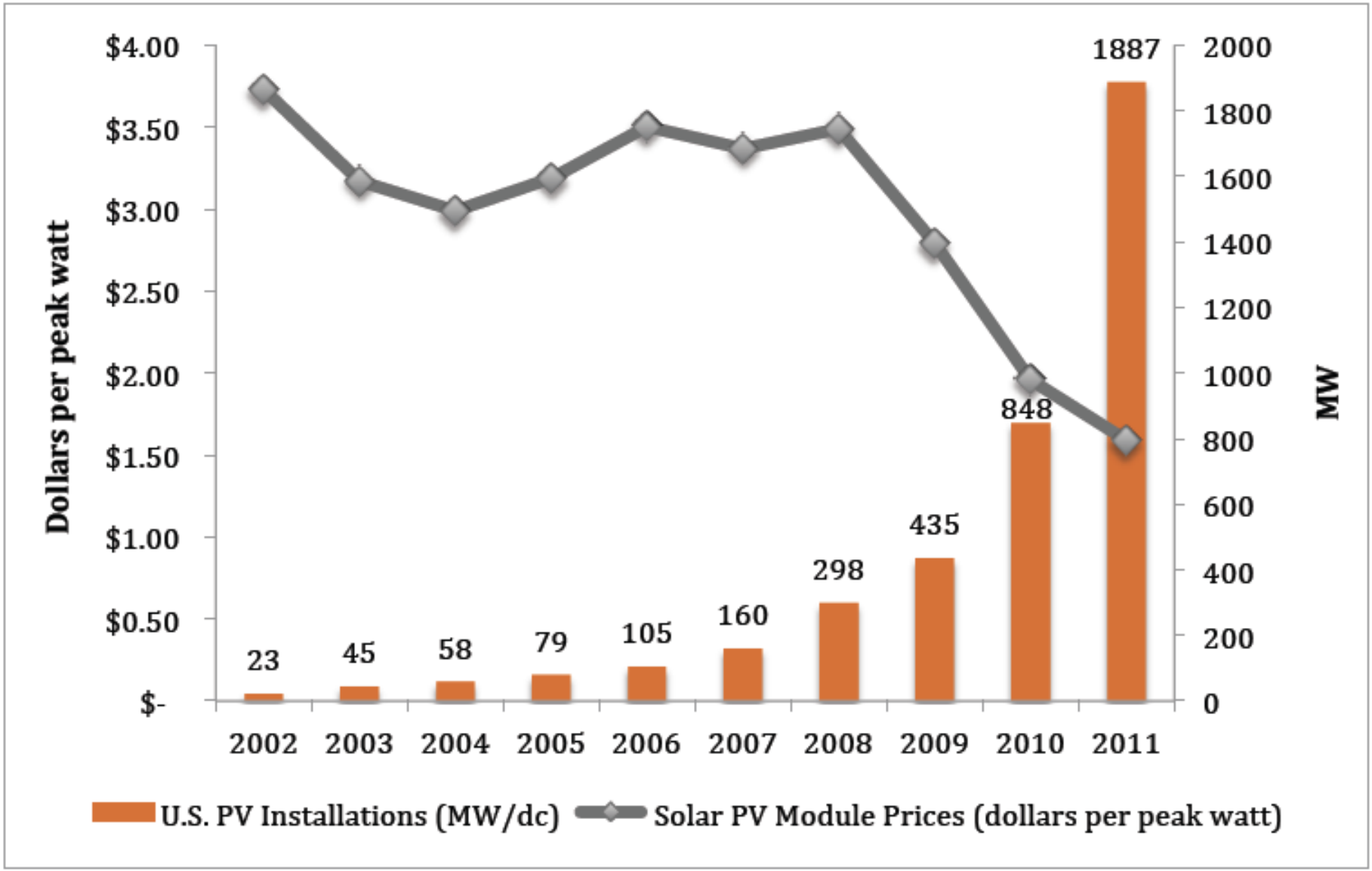
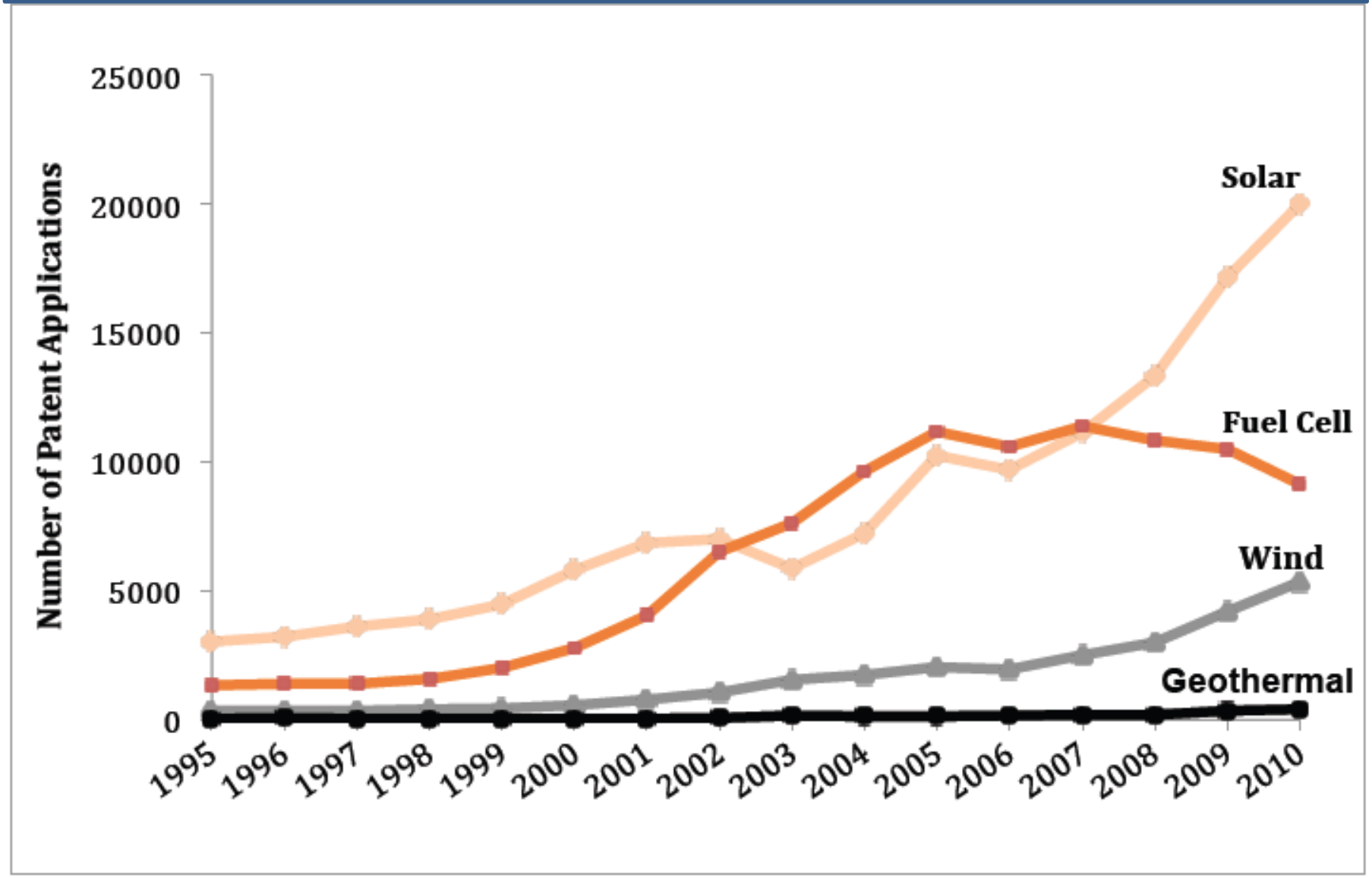
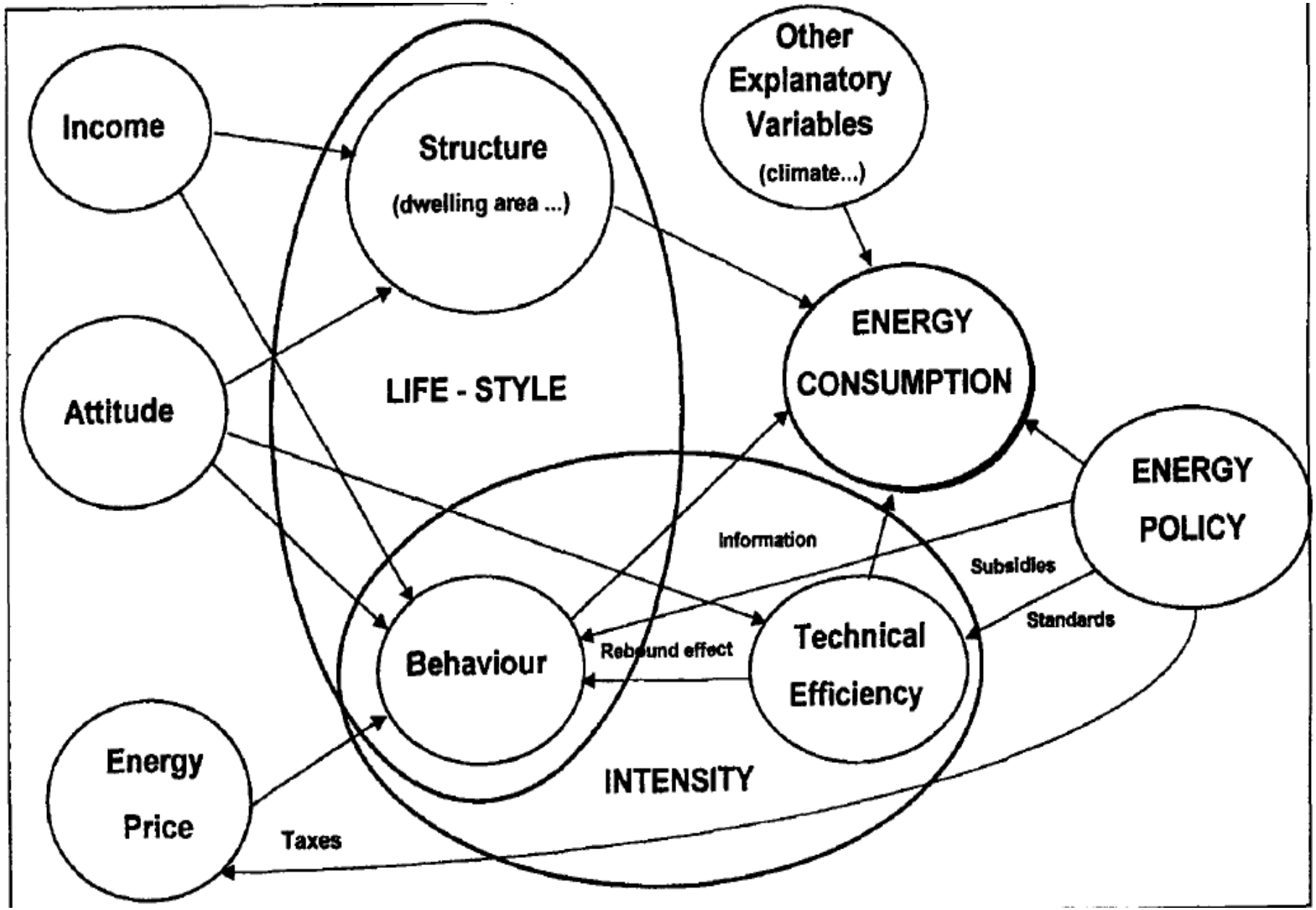
2007
2008
2009
2010
2011
2012
Fannie Mae
Freddie Mac
Ginnie Mae
Total


$4.00
$3.50
$3.00
$2.50
$2.00
$1.50
$1.00
$0.50
$-
Dollars per peak watt
2000
1800
1600
1400
1200
1000
800
600
400
200
0
MW
23
45
58
79
105
160
298
435
848
1887
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
U.S. PV Installations (MW/dc)
Solar PV Module Prices (dollars per peak watt)

Number of Patent Applications, 1995 - 2010



Hass, R. (1997), A basic scheme of definitions & interactions in residential sector, Fig. 4. p. 793.



Annual Consumer Expenditure Survey	2006	2007	2008	2009	2010	2011	Math Check
Average annual expenditures	$48,398	$49,638	$50,486	$49,067	$48,109	$49,705	$49,706
I. Food & Drink	$6,111	$6,133	$6,443	$6,372	$6,129	$6,458	12.99%
Food at home	$3,417	$3,465	$3,744	$3,753	$3,624	$3,838	7.72%
Food away from home	$2,694	$2,668	$2,698	$2,619	$2,505	$2,620	5.27%
II. Alcoholic beverages	$497	$457	$444	$435	$412	$456	0.92%
III. Housing Related	$16,366	$16,920	$17,109	$16,895	$16,557	$16,803	33.81%
A. Shelter	$9,673	$10,023	$10,183	$10,075	$9,812	$9,825	19.77%
Owned dwellings	$6,516	$6,730	$6,760	$6,543	$6,277	$6,148	12.37%
Mortgage interest and charges	$3,753	$3,890	$3,826	$3,594	$3,351	$3,184	6.41%
Property taxes	$1,649	$1,709	$1,758	$1,811	$1,814	$1,845	3.71%
Maint., repairs, insur., other exp.	$1,115	$1,131	$1,176	$1,138	$1,112	$1,120	2.25%
Rented dwellings	$2,590	$2,602	$2,724	$2,860	$2,900	$3,029	6.09%
Other lodging	$567	$691	$698	$672	$635	$648	1.30%
B. Utilities, fuels, and public services	$3,397	$3,477	$3,649	$3,645	$3,660	$3,727	7.50%
a. Total Gas, Electricity, and Other Fuels	$1,913	$1,934	$2,076	$2,001	$1,993	$2,000	4.02%
Natural gas	$509	$480	$531	$483	$440	$420	0.84%
Electricity	$1,266	$1,303	$1,353	$1,377	$1,413	$1,423	2.86%
Fuel oil and other fuels	$138	$151	$192	$141	$140	$157	0.32%
b. Water and other public services	$397	$434	$446	$481	$489	$501	1.01%
c. Telephone services	$1,087	$1,110	$1,127	$1,162	$1,178	$1,226	2.47%

C. Household operations	$948	$984	$998	$1,011	$1,007	$1,122	2.26%
Personal services	$393	$415	$383	$389	$340	$398	0.80%
Other household expenses	$555	$569	$614	$622	$667	$724	1.46%
D. Housekeeping supplies	$640	$639	$654	$659	$612	$615	1.24%
E. Household furnishings and equipment	$1,708	$1,797	$1,624	$1,506	$1,467	$1,514	3.05%
F. Apparel and services	$1,874	$1,881	$1,801	$1,725	$1,700	$1,740	3.50%
G. Transportation	$8,508	$8,758	$8,604	$7,658	$7,677	$8,293	16.68%
Vehicle purchases (net outlay)	$3,421	$3,244	$2,755	$2,657	$2,588	$2,669	5.37%
Cars and trucks, new	$1,798	$1,572	$1,305	$1,297	$1,219	$1,265	2.55%
Cars and trucks, used	$1,568	$1,567	$1,315	$1,304	$1,318	$1,339	2.69%
Other vehicles	$54	$105	$134	$55	$51	$64	0.13%
Gasoline and motor oil	$2,227	$2,384	$2,715	$1,986	$2,132	$2,655	5.34%
Other vehicle expenses	$2,355	$2,592	$2,621	$2,536	$2,464	$2,454	4.94%
Vehicle finance charges	$298	$305	$312	$281	$243	$233	0.47%
Maintenance and repairs	$688	$738	$731	$733	$787	$805	1.62%
Vehicle insurance	$886	$1,071	$1,113	$1,075	$1,010	$983	1.98%
Vehicle rental, leases, licenses, and other charges	$482	$478	$465	$447	$423	$433	0.87%
Public and other transportation	$505	$538	$513	$479	$493	$516	1.04%

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H. Health care	$2,766	$2,853	$2,976	$3,126	$3,157	$3,313	6.67%
I. Entertainment	$2,376	$2,698	$2,835	$2,693	$2,504	$2,572	5.17%
J. Personal care products and services	$585	$588	$616	$596	$582	$634	1.28%
K. Reading	$117	$118	$116	$110	$100	$115	0.23%
L. Education	$888	$945	$1,046	$1,068	$1,074	$1,051	2.11%
M. Tobacco products and smoking supplies	$327	$323	$317	$380	$362	$351	0.71%
N. Miscellaneous	$846	$808	$840	$816	$849	$775	1.56%
O. Cash Contributions	$1,869	$1,821	$1,737	$1,723	$1,633	$1,721	3.46%
P. Personal insurance and pensions	$5,270	$5,336	$5,605	$5,471	$5,373	$5,424	10.91%