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A preliminary evaluation of the case for tariff financing in California

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Executive Summary

Consumers regularly forgo purchases of high efficiency appliances that appear to be cost effective at a reasonable rate of return. While some argue that this is a true revelation of preferences for appliance features, this "efficiency gap" can be largely explained by a combination of market and behavioral failures that reduce consumers' ability to evaluate the relative value of appliances and skew preferences toward initial cost savings, undervaluing future reductions in operating costs. These failures and barriers include externalities of energy use, imperfect competition between manufacturers, asymmetric information, bounded rationality, split incentives, and transaction costs (Golove 1996).

Recognizing the social benefit of energy conservation, several major methods are used by policymakers to ensure that efficient appliances are purchased: minimum efficiency standards, Energy Star labeling, and rebates and tax credits. There is no single market for energy services; there are hundreds of uses, thousands of intermediaries, and millions of users, and likewise, no single appropriate government intervention (Golove 1996). Complementary approaches must be implemented, considering policy and institutional limitations.

In this paper, I first lay out the rationale for government intervention by addressing the market and behavioral failures and barriers that arise in the context of residential energy efficiency. I then consider the ways in which some of these failures and barriers are addressed through major federal programs and state and utility level programs that leverage them, as well as identifying barriers that are not addressed by currently implemented programs. Heterogeneity of consumers, lack of financing options, and split incentives of landlords and tenants contribute significantly to the under-adoption of efficient appliances.

To quantify the size of the market most affected by these barriers, I estimate the number of appliances, and in particular the number of outdated appliances, in California rental housing. Appliances in rental housing are on average older than those in owner occupied housing. More importantly, a substantial proportion of very old appliances are in rental housing.

Having established that a very old stock of appliances exists in California rental housing, I discuss tariff financing as a policy option to reduce the impact of the remaining market and behavioral barriers. In a tariff financing program, the utility pays the initial cost of an appliance, and is repaid through subsequent utility bills. By eliminating upfront costs, tying repayment to the gas or electric meter, requiring a detailed energy audit, and relying upon utility bill payment history rather than credit score in determining participant eligibility, tariff financing largely overcomes many barriers to energy efficiency. Using California as a case study, I evaluate the feasibility of implementing tariff financing. For water heaters in particular, this appears to be a cost-effective strategy. Tariff financing from utilities is particularly valuable because it improves the ability of low-income renters to lower their utility bills, without burdening landlords with unrecoverable capital costs.

To implement tariff financing country-wide, regulations in many states defining private loan-making institutions or the allowable use of public benefit funds may need to be modified. Tariff financing is relatively new and in most locations is only available as a pilot program or has only recently exited pilot phase. This preliminary evaluation suggests that tariff financing is a valuable future addition to the toolkit of policymakers who aim to increase the diffusion of efficient appliances. While regulatory approval is necessary in states that wish to pursue tariff financing, at this point, the major barrier to further implementation appears to be the newness of the financing mechanism.

PART 1: REVIEW OF BARRIERS TO EFFICIENCY AND CURRENT POLICIES

I. Market failures reduce efficient appliance adoption

A substantial number of market failures and barriers impact the availability of efficient appliances, as well as the consumer purchase decision. Key among these failures is the externality of energy use and asymmetry of information. Other failures may include concentrated market power among manufacturers and positive information externalities of appliance adoption (Gillingham 2009). Each market failure contributes to a lower average efficiency of the appliance stock than would be socially optimal.

Due to externalities of its use, particularly multiple environmental pollutants including particulates and greenhouse gases, residential energy consumption is inefficiently high (Weil 2003). Manufacturers make products and consumers buy and use them without consideration of the social impact of these actions. While internalizing the environmental and human health impacts of energy use into the price of energy would go a long way toward achieving an optimal level of energy use, such a price is both technically and politically difficult to develop. Additionally, other market and behavioral barriers limit the affect of energy prices on appliance production and purchase decisions, suggesting the need for other forms of policy intervention.

Even if energy were priced to reflect the social cost of its use, asymmetric information would lead to lower than optimal adoption of efficient appliances. Today's appliances are complex devices with many features that affect a consumer's purchase decision, such as size, color, noisiness, brand, and efficiency. Of these major factors, efficiency is the most difficult to understand. Appliance energy use and efficiency ratings are expressed in different terms for each product type. These terms, such as seasonal energy efficiency ratio (SEER) and annual fuel utilization efficiency (AFUE), often convey little information to the consumer. Even consumers who have recently purchased a central air conditioner do not on average have a good understanding of SEER, the term used to describe an air conditioner's efficiency; many are unsure whether a higher or lower value of SEER corresponds to higher energy efficiency (AHCS 2008).

If energy efficiency is known to be a desirable characteristic, but also one that is difficult for a consumer to verify, manufacturers and sellers have an incentive to suggest that all of their products are very efficient. This leaves sellers of truly efficient appliances with no way to communicate that their products' higher purchase prices reflect a higher value, rather than an attempt to gain additional profit, so the incentive for manufacturers to develop and produce higher efficiency appliances decreases. If buyers cannot confirm the true efficiency level of products, they soon learn to ignore energy efficiency as a purchase criterion and high-cost efficient appliances will be overlooked, even if they are cost effective (Gillingham 2009).

II. Behavioral failures and barriers also reduce efficient appliance adoption

Neoclassical economic theory assumes that consumers and firms not only act on perfect information, but also that they are able to accurately optimize among all relevant options and make rational, utility-maximizing choices. Consumers generally do not act in this way in reality. Many behavioral failures, departures from neoclassical assumptions, lead consumers to forgo purchases of efficient appliances that would in fact provide them with a net monetary gain. Even with all of the necessary data, the average consumer is not capable of performing the lifecycle cost analysis necessary to accurately compare the differences of two appliances. These behavioral failures include the boundedly rational decision making processes of heuristics, high implicit discount rates, and first cost aversion.

The theory of bounded rationality suggests “consumers are rational, but face cognitive constraints in processing information that lead to deviations from rationality in certain circumstances” (Gillingham 2009). Instead of maximizing utility, consumers rely on decision heuristics to choose between options; in some circumstances, the choices made with heuristics may appear to closely follow theoretical maximization, but in other circumstances may diverge significantly. Studies demonstrate that in general, people have difficulty understanding low probabilities, large amounts, and value streams over time, all factors that would feed into a rational calculation of an optimal appliance purchase (Camerer 2003). These decision heuristics may take many forms, such as “always buy Energy Star products” or “pick the middle option, not the cheapest or most expensive” or “pick stainless steel appliances.” Implicit in these heuristics is a tendency to give a higher weight to easily observable features of a product. As described above, energy efficiency is not an inherently easy concept to understand and is expected to be given a low weight under a decision heuristic if no effort is expended to improve consumer awareness.

The impact of bounded rationality affects energy consumption decisions, which are interconnected with incentives for efficient appliance adoption. Friedman (2002) demonstrates that under an increasing block structure, an electricity consumption model based on bounded rationality has more predictive power than one based on utility maximization, leading to over-consumption of electricity. A logical extension of this research finding suggests that bounded rationality will lead consumers to undervalue energy efficiency.

One of the ways in which bounded rationality manifests is in the form of irrationally high implicit discount rates. These are observed when consumer purchase decisions suggest that people require a rate of return on energy savings much higher than they will accept for other forms of investment. These observed implicit discount rates are a combination of several unobserved factors: the individual's true time value of money, lack of information and information processing ability, and quantifiable uncertainty due to a distribution of possible outcomes (e.g. future energy prices, future intensity of appliance use). Additionally, there are many common tendencies, such as smoking or under-saving for retirement, that demonstrate a human tendency to neglect long-term self-interest. As Sabini (1982) states, "one of the ways of being irrational… is to act on rational calculations for intervals that are irrationally short."

Discounting of future energy cost savings is closely tied to the concepts of loss aversion and first cost aversion. Loss adverse people will not take a gamble with even odds of a loss or gain of equal size (i.e. an expected payoff of zero) and will prefer a certain payment to a gamble with the same expected payoff. Loss and first cost aversion are manifested in a reduced willingness to pay now for a somewhat uncertain future benefit. Because an efficient appliance generally has a higher upfront cost than a similar lower efficiency model that is eventually recovered over its operating life through lower energy costs, a high implicit discount rate and associated loss and first cost aversion will lead consumers to undervalue future energy cost savings and choose lower efficiency appliances.

III. Reinforcing tendencies between market and behavioral failures

The above mentioned market and behavioral failures all tend toward over-consumption of energy and under-consumption of higher efficiency products, suggesting the value of interventions to increase the diffusion of high efficiency products. While pricing energy at the social marginal cost of it use would reduce the impact of many market failures, some behavioral failures are likely to remain. Higher energy prices may in fact reduce the tendency to undervalue future energy cost savings, as the magnitudes of these values will greatly increase, bringing choices closer in line with the neoclassical equilibrium.

To increase the adoption of efficient appliances, policy solutions must consider boundedly rational rather than purely rational responses to incentives (Shogren 2008). Due to first cost aversion, larger rebates may be necessary to achieve desired adoption rates and expected energy savings should be carefully evaluated to determine the largest feasible rebate. Estimates of the impact of a tax credit should account for the fact that consumers may discount at a high rate a credit received nearly a year after the time of purchase. Information, in the form of labeling and otherwise, must be carefully implemented so as the reduce information asymmetry, but not induce confusion in boundedly rational consumers.

IV. Current programs to address underinvestment in efficient appliances

The federal government employs several methods to overcome market and behavioral failures and induce adoption of efficient appliances. Appliance efficiency standards and Energy Star and Energy Guide labeling are the largest efficiency programs. These are in turn leveraged by state and utility level programs to further provide incentives for adoption of efficient appliances.

Appliance efficiency standards

Appliance efficiency standards change the distribution of new appliance efficiency by removing the least efficient options from the market. Standards circumvent some behavioral failures by requiring a change in the actions and choices of a small number of manufacturers, rather than all consumers (Weil 2003). Standards reduce the risk for manufacturers to invest in improving efficiency, as they will now know that all other manufacturers will have to make similar investments and will be held to the same standard. Knowing that standards will be updated over time, this creates an incentive for manufacturers to continuously work toward higher energy efficiency and to attempt to meet and exceed the efficiency levels offered by their competitors in order to set the bar for the next round of standards.

Removing the least efficient options partially mitigates the split incentive problem of the landlord – tenant and builder – buyer relationships. It is often in the interest of the landlord and builder to install inexpensive, low-efficiency appliances (unless they think they will be able to recoup the additional cost of efficient appliances through higher rent or sales value), so minimum efficiency standards likely cause improvement in appliance efficiency for tenants and buyers. The greatest gains here accrue to buyers of new homes because standards only impact sales of new appliances. Rentals and previously built owner-occupied housing units are likely to have older appliances, and the occupants will only benefit from efficiency standards when these appliances are replaced.

Standards are an example of asymmetrical paternalism: they improve the decisions of those most likely to make the poor choice of purchasing a very inefficient appliance, while not imposing on the choices of those who would more rationally choose a higher efficiency appliance anyway (Camerer 2003). Of course, there may be some people who are made worse off, because they have only minimal use for an appliance and do not use it enough to make its higher efficiency worthwhile. But due to the behavioral biases reviewed above, they are likely to be only a small portion of consumers. Additionally, by forcing manufacturers to scale up production of higher efficiency appliances more quickly than they naturally would, the economies of scale and manufacturer experience ("learning curve") may lead to a faster and sharper drop in the price of efficient appliances.

Information provision through labeling

Appliance efficiency standards rulemakings produce an additional benefit by establishing test procedures that are then used for information provision through Energy Guide labels. These test procedures provide a systematic way to compare the performance of appliances and estimate their energy consumption. Energy Guide labels present the consumer with the average annual operating cost of an appliance as well as a scale indicating how that particular model compares to the range of operating costs of similar appliances. These labels provide consumers with a manageable amount of information, which should aid in overcoming information asymmetry without requiring any complex computations on the part of the consumer. This does not mean that they are ideal, as the operating costs described are sometimes based on energy prices that have shifted substantially. For a consumer who lives in a region with very low energy prices, Energy Guide labels may overestimate their potential savings.

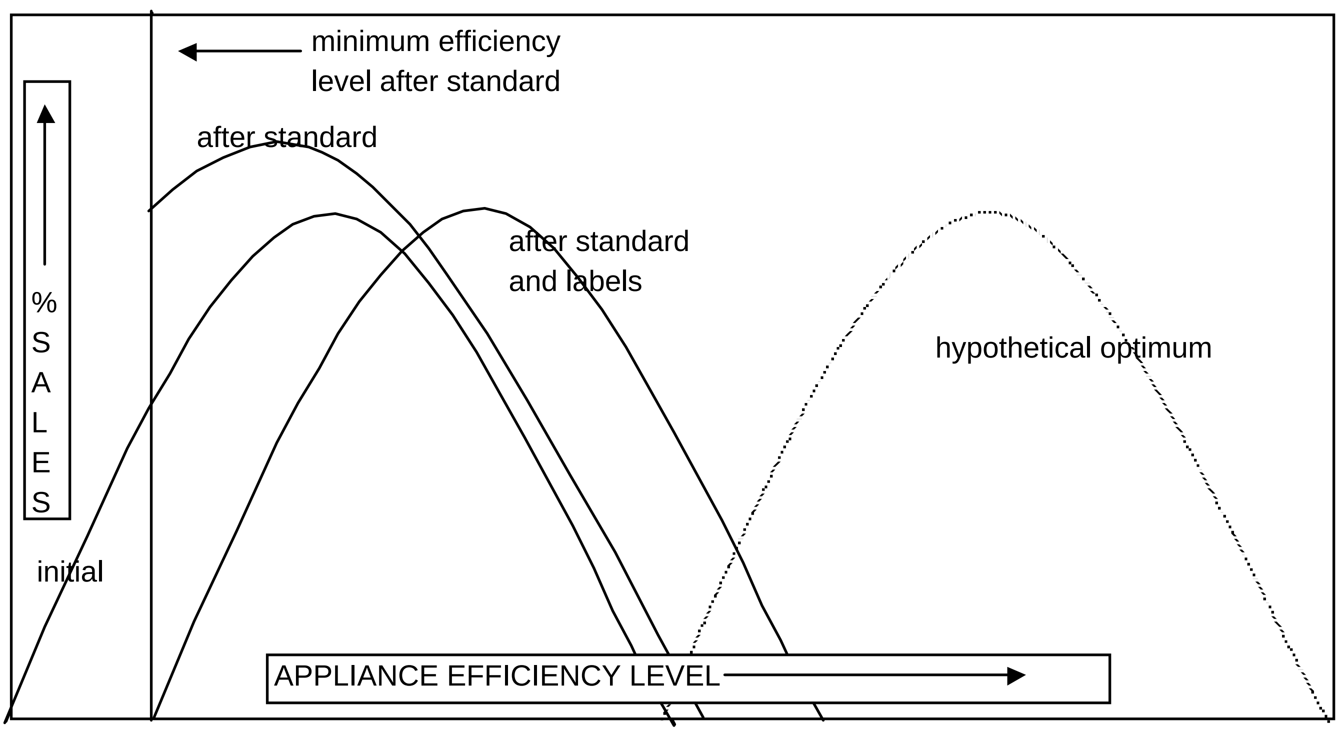
Energy Star labeling changes the efficiency distribution of new appliances by increasing the proportion of high efficiency appliance sales through increased awareness of efficiency differences between models. The Energy Star label is an endorsement label that is only given to models with very high efficiency for their product class. In conjunction with Energy Guide labeling, it provides consumers with a fairly complete and clear signal of the desirability of efficient appliances. By providing a credible endorsement from the Environmental Protection Agency, Energy Star labeling reduces consumer transaction costs by providing what is viewed as objective information.

Labeling overcomes poor consumer understanding of energy efficiency terminology. For example, in a survey of recent central air conditioner and heat pump purchasers only 44% say that they have heard of SEER (the common efficiency measure for these products); similarly only 45% know or guess that a higher SEER value corresponds to a more efficient appliance (AHCS 2008). In this same survey approximately 90% of respondents recognize the Energy Star label, 87% state that having an Energy Star certified heating or cooling system is important, 73% state that their purchase decisions are frequently influenced by the presence of the Energy Star label, and 68% state that any major appliance they purchase must have the Energy Star label (AHCS 2008). This suggests that Energy Star currently has a significant impact on the adoption of higher efficiency appliances.

Leveraging by other programs increases the combined impact of standards and labeling

By providing a common benchmark for energy efficiency, Energy Star labeling not only improves consumer awareness, but also creates a lever that can be easily used by state governments and utilities to offer incentives that encourage consumers to buy efficient appliances. These programs help to overcome first cost bias by giving a portion of the purchase price of a high efficiency appliance back to the consumer. Consumers who are debating whether or not it is worthwhile to choose an Energy Star product may be induced to purchase one if a rebate or credit is available. These policies can affect a large number of purchase decisions; of appliances purchases in California in 2008, 18% received a utility rebate and 12% received a tax credit (AHCS 2008). However, some efficient appliances would have been purchased without an incentive, so this by no means implies that labeling *caused* all of these efficient appliance purchases.

Figure 1. Impact of federal programs on efficiency level of new appliances



While current federal energy efficiency programs and state and utility programs that leverage them have done much to overcome market and behavioral failures and to induce increased adoption of efficient appliances, limitations still exist. The wide variety of market and behavioral failures suggests that many different types of programs may be needed to effectively alter the efficiency level of the stock of appliances in use (Weil 2003)

V. Remaining barriers to energy efficiency

While current policies have increased the efficiency level of appliances in the market today, remaining barriers to energy efficiency still exist; these barriers include the heterogeneity of consumers, insufficient access to financing, and split incentives.

Heterogeneity of consumers

Because efficiency standards focus primarily on aggregate and average savings, variation in appliance use intensity across consumers will create winners and losers. Similarly, Energy Star status may or may not indicate a good investment for a particular individual depending on their appliance use intensity. Knowing that differences in climate, household size, and energy use patterns affect the cost-effectiveness of an appliance choice, but not knowing where they stand on the spectrum of end use intensity, consumers may remain reluctant to invest in energy efficiency. The development of easy-to-use and easy-to-understand tools to accurately match consumers to the most efficient and cost-effective appliance for their particular situation could dramatically reduce the forgone energy savings created by the uncertainty due to consumer heterogeneity.

Insufficient access to financing

Even when consumers recognize that investing in a more efficient appliance would lead to net savings in the long run, many do not have sufficient savings to purchase the appliance outright and either cannot qualify for a loan at all or would face such a high interest rate that the benefits of energy cost savings are largely offset. While minimum efficiency standards remove the least cost-effective models from the market and rebates help to offset first cost, boundedly rational consumers may still choose suboptimally efficient appliances in many cases. Rebates must be applied for and may take weeks to be refunded. Along with these transaction costs, rebates are not useful for consumers who simply do not have savings or credit to cover the first cost of an appliance. The scenario is very similar for tax credits.

Split incentives

Split incentives exist between landlords and tenants, and also between builders and buyers of new homes. Because the energy efficiency ratings of appliances like central air conditioners, furnaces, and water heaters are generally not well-understood, and these appliances are largely invisible once installed in a home, a builder will choose a suboptimal efficiency level if they are concerned that they will not be able to convey the benefit to potential buyers. This incentive is amplified by builder knowledge of first cost aversion of buyers.

Most tenants pay for their utility use, but appliances, particularly those like air conditioners, furnaces, and water heaters that must be permanently installed, are usually chosen by the landlord. Because it is unlikely that the landlord will be able to charge higher rent to make up for the cost of installing efficient appliances and the landlord does not have to pay energy costs, they have incentive to choose the cheapest (and generally least efficient) appliances for a rental unit. Murtishaw and Sathaye (2006) find that in California, builder – buyer and landlord – tenant split incentives affect 33% of refrigerators, 78% of water heaters, and 53% of space heating in the residential sector.

Even with perfect information and a clear understanding of the potential for energy savings, a tenant has little ability to influence their landlord's appliance installation decisions (Murtishaw 2006). In the case of an old appliance failing, a tenant may be able to offer to pay the additional cost of a higher efficiency replacement. In the case of very old, but still functional appliances, tenants face the choice of living with the high utility bills or offering the full cost of replacement, even if they are unlikely to remain in the rental for a significant portion of the appliance's operational lifetime. While it is the current tenant's or landlord's willingness to pay for efficiency that will determine whether or not an inefficient appliance is replaced, the appropriate value to consider is the willingness to pay of the stream of tenants that will occupy a housing unit over the course of the lifetime of an efficiency investment.

PART 2: EVALUATION OF TARIFF FINANCING IN CALIFORNIA

VI. Establishing the potential role for utilities

Federal, state, and local governments and utilities have many methods at their disposal to address market and behavioral failures and improve the efficiency of the stock of appliances in use. The existence of split incentives is a strong basis for supporting programs that are complementary to price policy (Murtishaw 2006). As mentioned above, standards only impact the distribution of efficiencies of current sales, and price incentives in the form of rebates or high energy costs are unlikely to motivate a landlord or tenant to purchase an efficient appliance to replace an inefficient yet functional one.

Gas and electric utilities are ideally situated to mitigate the remaining barriers to the adoption of efficient appliances. Utilities serve a relatively small population compared to federal or state governments. They will have better knowledge of local climate, wealth, energy cost, social norms, and other factors that may influence energy use and efficient appliance adoption, allowing the utility to address some aspects of consumer heterogeneity. A utility's familiarity with its service area likely includes the ability to identify and target lower income communities or neighborhoods that were either built or underwent significant renovation about 30 years ago and may have many remaining appliances from that era. In the tariff financing program described in the following section, utility expertise is employed to reveal consumer heterogeneity and to target funds to cost-effective appliance replacements.

The current stock of California appliances

This analysis follows the work of Murtishaw and Sathaye (2006) to estimate the scale of the problem of split incentives in California rental housing using two sets of survey data, the 2008 American Home Comfort Survey (AHCS) and the 2009 update to the Residential Energy Consumption Survey (RECS). Examining the distribution of appliance ages across California rental and owner-occupied housing, two clear trends appear. The appliances in rental housing are on average older and a substantially greater share of rental appliances are more than 20 years old as compared to the appliances in owner-occupied housing (RECS 2009). These differences suggest that the landlord – split incentive remains a significant barrier to efficient appliance adoption.

Table 1. Appliance differences by housing type

	Mean age (rent)	**Mean age (own)**	**% 20+ yrs (rent)**	**% 20+ yrs (own)**
Furnace	13.5*	11.6	47**	25
Water heater	8.8*	7.5	17**	5
CAC	11.2	10.5	35**	15

** rent age > own age or rent % > own %, significant at 99% level
* rent age > own age or rent % > own %, significant at 95% level

Because appliances in rental housing are unlikely to be replaced until they fail, appliance longevity plays a substantial role in the persistence of the landlord – tenant split incentive problem. Furnaces can be very long lived, and furnaces 10 years of age or older are much less efficient than current Energy Star qualified models. The average lifetime of a furnace is generally assumed to be between 15-20 years (with a maximum lifetime of 20-30 years) depending on the exact type of furnace (DOE 2008). Water heaters are assumed to last approximately 12-15 years, with a maximum lifetime of 15-20 years (DOE 2010). Central air conditioners are assumed to last 18.4 years on average (DOE 2001). These are the assumptions that have been used in past Department of Energy rulemakings and influence the efficiency level of standards and the generosity of incentives offered for appliance replacement, including utility rebates.

Analysis of the AHCS furnace age data reveals that a large percent of furnaces in operation are very old: 26% furnaces older than 20 years, 10% furnaces older than 30 years. The situation is similar for water heaters; AHCS shows 14% of water heaters in use in 2008 were older than 15 years. A substantial number of very old appliances persist in use in spite of programs to disseminate efficiency information and encourage replacement. This data set provides age values only for owner occupied housing, but appliances in rentals would be expected to be of similar age or older on average, based on analysis of RECS data.

Table 2. Appliances in CA rental housing units

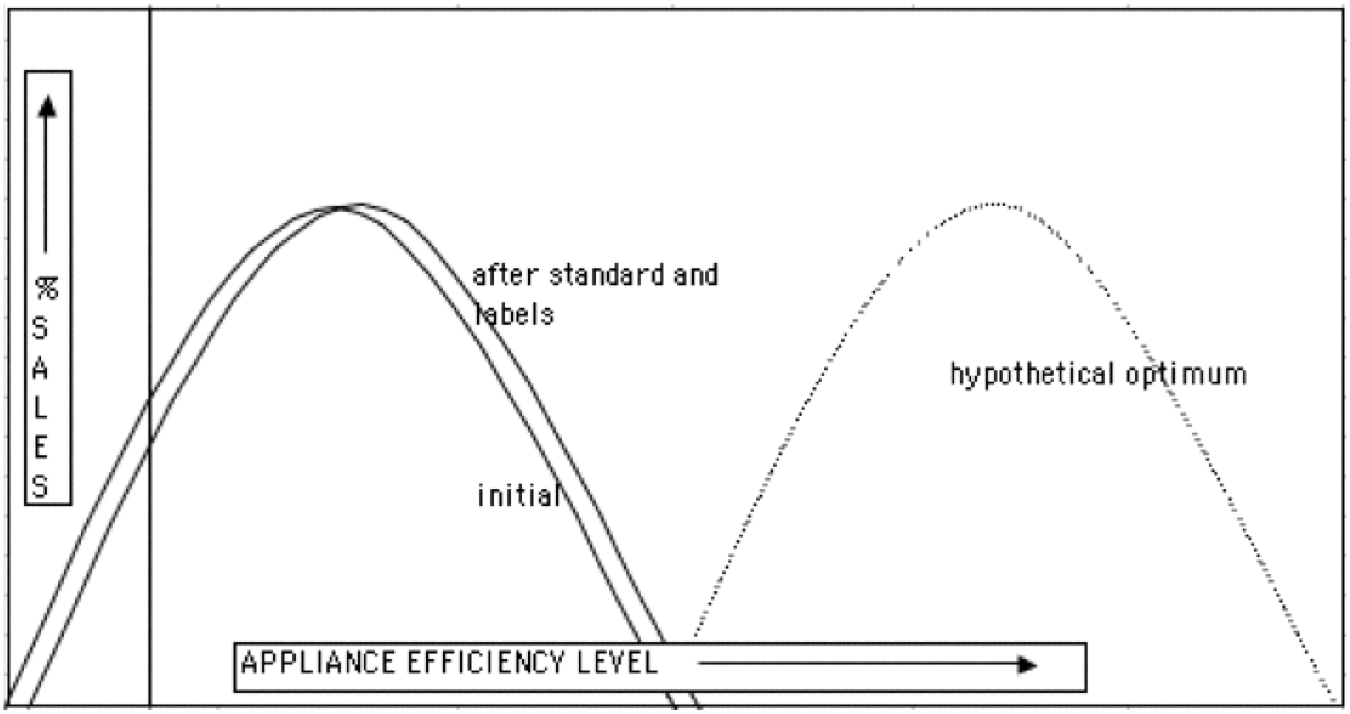
	% of rentals*	# of appliances	% 20 yrs +	# of appl. 20 yrs +	% 30 yrs +	# of appl. 30 yrs +
CAC	27%	1,471,841	35%	515,144	5%	25,757
Furnace	47%	2,562,093	41%	1,050,458	10%	105,046
WH	84%	4,579,060	17%	778,440	7%	54,491

(Based on an estimated 5,451,262 rental housing units in CA in 2009, see Appendix 1 for sources and calculations)

* Percent of total CA rental units that have unit-specific CAC, furnace, or water heater (rather than shared HVAC and water heating across multiple units in a building)

The average replacement rate for furnaces and CAC is about 1 – 2% per year (ODC 2000), even with current incentive programs in place. It is reasonable to suppose that water heaters have a similarly low replacement rate. Additionally, a portion of this 1 – 2% includes replacement of appliances younger than 20 years, so this understates the persistence of 20-year-old or older appliances in the stock. These replacement rates imply that very old appliances are likely to remain a major portion of the stock of appliances in the future, given no substantial changes to markets and policy. This situation is represented in Figure 2.

Figure 2. Impact of federal programs on appliance stock efficiency level



VII. Tariff financing addresses consumer heterogeneity, access to financing, and landlord – tenant split incentives

The tariff financing program described in this section reveals consumers heterogeneity, targets the greatest achievable savings, covers the full first cost of appliances, temporally coordinates the streams of first cost repayment with energy cost savings, and overcomes the split incentive problem between renters and landlords. The key feature of this program is that it not only ties the timing of repayment to the time of savings, but also ties the obligation of repayment to the person who benefits from the reduced energy costs. Tariff financing also addresses individually rational reasons not to adopt efficient appliances, which keep the stock of appliances less efficient than socially optimal.

Features of a tariff financing program

A tariff financing program has the following key features:

- Utility pays the upfront cost for installation of efficient furnace, CAC, or water heater
- Repayment obligation is tied to the gas/electric meter, not to the current tenant/owner
- Repayment occurs automatically through the utility bill
- An energy audit conducted by a utility expert is required to determine eligibility
- Qualifying appliance replacements must meet cost-effectiveness criteria

- Qualifying appliances are permanently installed in the residence and cannot be removed upon the current occupant's departure

Ideally, the expected payback period should be significantly less than the appliance lifetime, in order to guarantee that even considering repayment costs, the customer will see a lower utility bill after the appliance replacement. Pilot tariff financing programs to date have only offered financing if the installed cost of an appliance is less than 3/4 of the energy savings it is estimated to achieve over the first 3/4 of its expected lifetime (the "3/4 – 3/4 rule"). The 3/4 – 3/4 rule provides a simple rule of thumb that serves a comparable role to an analysis of the net present value of an appliance replacement, allowing for uncertainty in savings. This is a very conservative requirement, which virtually guarantees the cost-effectiveness of qualifying appliance replacements. Unless the uncertainty of savings is high, it may be worthwhile to relax this constraint so that more measures that are in fact cost-effective will qualify for financing, but retaining a minimum threshold of cost-effectiveness is essential for a successful tariff financing program. Including requirements like this helps to minimize the possibility of funding non-cost-effective replacements, which would be harmful to both the utility and the customer.

Since repayment is tied to the meter rather than a specific individual, tariff financing can be used for replacement of appliances in rental housing, so long as the landlord agrees to allow the renovation (Ho). The current and future tenants will then benefit from lower energy costs while repaying the utility through the housing unit's utility bill until the installation cost has been recovered. In order to tie repayment to the meter, the types of appliances must be limited to those that are permanently installed in the unit, such as central air conditioners, furnaces, or water heaters. Easily movable appliances, such as refrigerators, should not be financed in this way because the current occupant could easily take the appliance when they move out, leaving the next occupant with the obligation of repayment on their utility bill, but removing the benefit of the efficient appliance.

Because this financing mechanism relies on repayment through a special tariff, tariff financing can only be implemented if the state regulatory body, in this case, the California Public Utilities Commission, approves the tariff structure used for repayment. The approved tariff should include provisions for the handling of defaults (generally disconnection for non-payment, as is usually the case for utility bills) and sources of program funding (Brown).

There are several options available to fund a tariff financing program: public benefits funds, a partnership with an accredited lending institution, or a combination of the two (Brown). Public benefits funds are collected through public benefits charges that appear on the utility bills of all customers and are pooled to be put toward socially beneficial uses, such as appliance rebate programs. Tariff financing is a similar beneficial use that would be an appropriate use for these funds. Partnering with an accredited lending institution has the benefit of including a recognized lender, which should reduce the chance that the legality of the program will be challenged[1]. Because efficiency investments lead to lower utility bills and the repayment mechanism relies on the largely successful billing systems that are already in place, there is very little risk of default, and accordingly, the lender should be willing to offer a low interest rate. Combining a partnership with a lending institution with the use of public benefit funds to cover interest charges, an effective interest rate of 0% could be offered to qualified customers, ensuring that a greater number of cost-effective projects will be undertaken and that interest charges will not dissuade customers from participating (Jewell 2009).

A tariff financing program, once in place, is largely self-sustaining. As participants pay their utility bills, the repaid funds can be used to finance further appliance replacements. This cycle can be internally sustained, as opposed to programs like rebates, which are simply an outflow of funds.

Tariff financing reduces the impact of remaining barriers to energy efficiency

The screening and auditing processes required to determine qualification for the program ensure that energy savings will be sufficiently large that the new appliance is cost effective, making the customer comfortable with the investment, and taking advantage of consumer heterogeneity to identify the greatest opportunities for energy savings. Utility-provided energy audits address consumer bounded rationality by performing analyses and calculations for the customer and perhaps showing them how such calculations should be performed so that their future energy efficiency decisions are improved as well.

Because the customer faces no upfront cost, first cost aversion should have a much more limited impact on appliance adoption. The lack of upfront cost also eliminates the need for substantial amounts of savings or access to credit (Brown). Eligibility for the tariff financing program is based on the history of utility bill payment, rather than credit history, so those with low or no credit rating could still participate as long as they have been consistently paying their utility bill. The rate of default for utility bill payment is generally very low because non-payment results in disconnection from services.

The primary benefit of the tariff financing structure is that it can overcome landlord – tenant split incentives (Ho). There is no cost to the landlord, unless a housing unit goes unrented for a long period of time and the utility bill reverts to the landlord's responsibility. Tenant payment is proportional to the

[1] Property assessed clean energy (PACE) financing has been challenged by the Federal Housing Finance Agency on the grounds that the program lacks "appropriate underwriting guidelines and consumer protection standards" (FHFA 2010). Partnering with an accredited lender reduces the chance that tariff financing will face similar obstacles. PACE financing and

benefit they receive through the use of the higher efficiency appliance, and because repayment is linked to the utility meter, the repayment period can extend beyond the current tenant's period of residence (Jewell 2009). Tariff financing has the benefit of creating a direct link between the efficiency investment and the reduced energy cost because in spite of the repayment obligation, customers see the impact of the retrofit in the form of a lower utility bill.

Pilot tariff financing programs have demonstrated effectiveness

In recent years, tariff financing pilot programs have been implemented by several utilities across the country, including Midwest Energy, Hawaiian Electric Company and Hawaiian Electric Light Company, Public Service of New Hampshire (tariff financing for businesses), and New Hampshire Electric Cooperative. Results thus far are mixed, but encouraging.

There was initial Consumer Advocate opposition to Midwest Energy's How$mart program due to concerns about customer disconnection for nonpayment of the financing tariff, but the program has been implemented and operating successfully since 2007 (Fuller 2009). Midwest Energy's How$mart program had completed 84 projects as of the end of 2008, with more than 100 replacements and thermal shell improvements pending, and was averaging repayment rates that were approximately 80% of estimated monthly savings (Midwest Energy).

The New Hampshire Electric Cooperative (NHEC) originally implemented a residential tariff financing program for replacement of light bulbs with CFLs and weatherization improvements. This program was cancelled because of low participation, due largely to a flawed program design. The price of CFLs dropped shortly after the program began, making it unnecessary, and weatherization improvements decreased the need for *natural gas*, but NHEC's bill was for *electricity*, so customers were seeing an electric bill increase. Additionally, NHEC was only able to offer the high interest rate of 7% (Fuller 2009). The commercial tariff financing program continues to operate. A survey of participants of the NHEC commercial SmartSTART program suggests that over 90% of participants would not have installed new energy efficiency measures in the absence of utility rebates and the tariff financing program, implying that free-riding has not been a significant issue in these pilot programs (Brown).

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another option, on-bill financing, are further discussed in Appendix 2.

VIII. Application of tariff financing to California

Based on efficiency differences between new and 20- to 30-year-old appliances, appliance prices, and California energy costs, I estimate whether tariff financing of central air conditioners, furnaces, and water heaters appears to be a cost-effective strategy to pursue in this state. Other factors, such as heating or cooling intensity, energy price variation, and high efficiency rebates are also considered where applicable.

Both the simple payback period and an indication of whether or not the appliance passes the 3/4 – 3/4 rule are reported. As discussed above, the 3/4 – 3/4 rule is an estimation heuristic that largely guarantees that the customer will achieve net energy cost savings.

Central Air Conditioners

Because of the mild climate in much of California, central air conditioners (CAC) on average do not appear to be a viable product for tariff financing. The analysis suggests several ways in which a tariff financing program would need to be tailored to specific populations in order to find cost-effective replacement options. First, the oldest CAC should be targeted, rather than the aggregate group 20 years or older. 30-year-old CAC have significantly higher energy costs than those 20 years old, and under average cooling use, replacing a 30-year-old CAC with one that just meets the current Energy Star criteria has a simple payback period of approximately 22 years. However, one factor that must be taken into account when considering Energy Star appliances is that utilities currently offer sizable rebates on many of these products. After accounting for an average rebate of $428 per unit, the simple payback period is closer to 20 years.

Climate variation across California is also relevant. By concentrating on regions of the state with more intensive use of cooling, replacements appear more cost-effective. Considering a region that uses on average 1.6 times the state average cooling, the simple payback period for replacing a 30-year-old CAC is 14 years for a baseline efficiency unit and 12 years for an Energy Star unit, taking rebates into account (14 years excluding rebate). Assuming a conservative lifetime of 20 years for a new CAC unit, these would be cost-effective replacements even at a non-zero rate of interest.

Another factor is the cost of electricity. Electricity costs and prices vary substantially across the state, with average residential retail prices among the three largest utilities ranging from $0.155 to $0.181 per kilowatt-hour. Considering average cooling use and a high price of electricity, the simple payback period for replacing a 30-year-old CAC is 19 years for a current baseline unit and 16 years for an Energy Star unit, accounting for rebates.

Under ideal circumstances, regions could be identified with both hot climates and high electricity cost. Parts of the San Diego Gas and Electric service area and parts of the Central Valley may fall into this category. In this situation, it appears that the simple payback period for replacing a 30-year-old CAC is 12 years for a current baseline unit and 10 years for an Energy Star unit after rebate. In this situation, CAC replacement just about meets the 3/4 – 3/4 rule that has been used to select qualifying products in the pilot tariff financing programs to date, while no other combination of CAC age, climate, and electricity price comes close to meeting the rule.

Central air conditioners do not appear to be appropriate for tariff financing across California, and more detailed research should be performed on promising target regions with high electricity cost and high cooling use to determine if localized implementation of tariff financing would be cost effective. Simple payback periods and an indicator of 3/4 – 3/4 rule qualification are presented below in Table 3, and more extensive data tables for the central air conditioner, furnace, and water heater analyses are included in Appendix 1.

Table 3. Simple payback period and 3/4 – 3/4 rule for central air conditioner replacements

Efficiency level	Average Scenario		High Energy Use Scenario		High Energy Cost Scenario		High Energy Use and Cost Scenario	
	Years	3/4 – 3/4	Years	3/4 – 3/4	Years	3/4 – 3/4	Years	3/4 – 3/4
20 yr old to Baseline	64	No	40	No	53	No	33	No
20 yr old to Energy Star	45	No	28	No	37	No	23	No
30 yr old to Baseline	23	No	14	No	19	No	12	No
30 yr old to Energy Star	20	No	12	No	16	No	**10**	**Yes**

"Years" columns indicate the simple payback period in years; "3/4 – 3/4" columns indicate whether or not this appliance replacement would meet the 3/4 – 3/4 rule to qualify for tariff financing

Furnaces

California's mild climate also limits the cost-effectiveness of furnace replacement. As with CAC, four scenarios are considered: average energy use and energy cost, high energy use and average energy cost, average energy use and high energy cost, and high energy use and high energy cost. Due to data constraints, all furnaces 20 years of age and older are considered as a single group, rather than differentiating between 20- and 30-year-old units. The analysis suggests that only replacements of old furnaces with Energy Star efficiency units in regions with high energy use and high energy costs may be cost-effective, after accounting for an Energy Star rebate of $233 per unit. Table 4 provides the analysis results for furnaces.

Table 4. Simple payback period and 3/4 – 3/4 rule for furnace replacements

Efficiency level	Average Scenario		High Energy Use Scenario		High Energy Cost Scenario		High Energy Use and Cost Scenario	
	Years	3/4 – 3/4	Years	3/4 – 3/4	Years	3/4 – 3/4	Years	3/4 – 3/4
Baseline efficiency	25	No	16	No	19	No	12	No
Energy Star efficiency	22	No	14	No	17	No	**11**	**Nearly***

"Years" columns indicate the simple payback period in years; "3/4 – 3/4" columns indicate whether or not this appliance replacement would meet the 3/4 – 3/4 rule to qualify for tariff financing
* Installed cost to 3/4 lifetime savings ratio is 0.77 with these assumptions (and would need to be 0.75 to meet the 3/4 – 3/4 rule).

Water heaters

Unlike furnaces and central air conditioners, water heaters are used throughout the state and throughout the year. While only 17% of water heaters in rental housing are 20 or more years old, water heaters are in the majority of rental housing units, so there are still a large number of very old water heaters in use. Because water heater replacement appears cost-effective at average energy prices and energy use levels, special cases of high energy cost or high energy use are not included, but would also be cost-effective.

The old water heaters fall into two categories, natural gas storage and electric storage. There are also many types of new water heaters available: baseline electric storage, baseline natural gas storage, Energy Star natural gas storage, natural gas tankless, and condensing natural gas tankless. The replacement options that are cost effective differ depending on which type of water heater is being replaced.

Electric water heaters 20 years or older consume an incredible amount of energy, and replacing them with any of the options listed above would be cost effective. However, as the primary goal of a tariff financing program is to improve the efficiency of the stock of appliances, it appears that the program should recommend replacing old water heaters with condensing natural gas tankless water heaters, which are both highly cost-effective and consume very little natural gas and electricity.

Natural gas water heaters 20 years or older consume significantly more natural gas than new water heaters. However, the expected energy savings from replacing an old natural gas water heater with a new storage water heater are not great enough to meet the 3/4 – 3/4 rule, due to the relatively short average lifetime of water heaters. Replacement with a baseline efficiency or condensing natural gas tankless water heater has an expected payback period of 6 or 8 years, respectively, and both options meet the 3/4 – 3/4 rule. Table 5 summarizes the results of the water heater analysis.

Table 5. Simple payback period and 3/4 – 3/4 for water heater replacements

	Replacing old gas WH		**Replacing old electric WH**	
	Years	3/4 – 3/4	Years	3/4 – 3/4
Baseline efficiency electric storage	-12*	No	**1**	**Yes**
Baseline efficiency natural gas storage	9	No	**2**	**Yes**
Energy Star natural gas storage	12	No	**3**	**Yes**
Baseline efficiency natural gas tankless	**8**	**Yes**	**2**	**Yes**
Condensing natural gas tankless	**6**	**Yes**	**1**	**Yes**

"Years" columns indicate the simple payback period in years; "3/4 – 3/4" columns indicate whether or not this appliance replacement would meet the 3/4 – 3/4 rule to qualify for tariff financing
* the "-12" year payback period indicates that replacing an old gas water heater with a baseline efficiency electric water heater would *increase* energy costs
** estimates are based on a 15 year water heater life; with a 12 year water heater life, the old gas to baseline efficiency gas tankless no longer meets the 3/4 – 3/4

Potential savings from rental housing unit water heater replacements

Based on the per water heater savings potential estimated in the previous section, a substantial amount of electricity and natural gas could be saved if all old units in rental housing were replaced. Assuming an approximate split of 8% electric and 92% natural gas among old water heaters (AHCS), an estimate of the total potential for savings in rental housing water heaters is presented in Table 6 below.

Table 6. Water heater replacement impact

	Electric water heater replacement	Gas water heater replacement
Appliances impacted	62,275 units	716,165 units
Reduction in electricity use	286 million kWh/yr	--
Reduction in natural gas use	--	133 million therms/yr

It is unlikely that tariff financing will in actuality come close to removing all inefficient water heaters from California rental housing. Not all inefficient water heaters will be identified, and some landlords and tenants may be uninterested in participating in such a program. However, the results in Table 6 demonstrate the scale of the problem of split incentives. If tariff financing can effect replacement of even one tenth of these inefficient appliances, California energy use will be significantly reduced.

IX. Conclusions and recommendations

The broad range of market and behavioral failures present in the market for efficient appliances suggests that multiple policy instruments will be needed to reach an acceptable rate of adoption. This is in fact the way that appliance energy efficiency policy is addressed in the United States, with minimum efficiency standards and labeling, as well as procurement requirements, rebates, and tax credits that leverage Energy Star labeling. However, these programs still address only a portion of the barriers to efficient appliance adoption, and consumer heterogeneity, split incentives, and access to capital remain major impediments to efficiency improvements.

There is great potential for tariff financing to increase the average level of appliance efficiency in California rental housing, particularly through water heater replacement. In some regions of the state, replacement of outdated central air conditioners or furnaces may also be cost effective, but statewide, these appliances are generally not a good fit for tariff financing. While this paper has primarily focused on the rental housing sector, tariff financing can be extended to homeowners as well, which could greatly increase the scale of the program and its impact on California energy use. However, because greater barriers to efficiency exist in rental housing that cannot be addressed through any other existing energy efficiency policies, tariff financing must be mindfully implemented to ensure that renters are provided access to funds.

Target renting and low income populations to reduce the impact of free-ridership

To improve the effectiveness of the program and reduce free-ridership, the renting and low-income populations should be actively targeted. Including a flier with all bills that qualify for the lifeline rate could raise program awareness among low-income customers. Similarly, information could be selectively sent with bills for meters where the responsible payer has changed several times in the last ten years, which would likely indicate a rental unit. Another option is selectively calling these customers to inform them of the program and suggest scheduling an energy audit for those whose appliances appear to be very outdated. It is in the utility's interest to consider not simply the rate that the individual is paying when estimating cost-effectiveness. Though the cost savings to an individual paying the artificially low lifeline rate may be less than the necessary monthly repayment amount, this is not the appropriate value to consider. Lifeline rates are generally far below utility cost and must be subsidized by charges to other utility customers.

Maintaining the utility incentive to participate

Tariff financing requires substantial effort on the behalf of participating utilities: establishing criteria for qualification, determining a set of target appliances, and applying to their regulatory body for approval of the repayment tariff structure. This can be a time consuming process; receiving approval for tariff financing took about six months for Midwest Energy (Fuller 2009). In some cases, utilities may also need to modify their billing system or train and hire more energy auditors before implementing a tariff financing program.

Regulation of utilities influences the incentive for utilities to provide rebates, offer a tariff financing program, or otherwise actively engage in promoting the adoption of efficient appliances (Brown). Tariff financing and other efficiency incentives will not be voluntarily offered by a utility whose profits increase as their sales increase. Decoupling of utility profits from sales is a prerequisite to a tariff financing program.

The profit that California regulated utilities are allowed to make is decoupled from their sales, so the necessary utility incentives for tariff financing already exist. To ensure that tariff financing is implemented, the California Public Utilities Commission should further investigate the feasibility of tariff financing using more detailed data and regional analyses, and if feasibility is confirmed, collaborate with the state's four major gas and electric utilities to arrange the appropriate terms of a repayment tariff.

Mindful implementation can overcome difficulties found in failed pilot programs

Tariff financing is relatively new and in most locations is only available as a pilot program or has only recently exited pilot phase. Review of pilot programs reveals that the major impediment to tariff financing programs was the inability of some utilities to attract enough participants to cover the administrative costs of the program. The ability to offer a low interest rate is a key factor to encouraging participation. Also, pilot programs allowed renter and landlord participation, but did not actively seek out these individuals. Actively targeting the rental population should reveal more cost-effective replacements that would otherwise not be undertaken. These are as of yet no legal challenges to this form of financing, so it appears to be a valuable future addition to the toolkit of policymakers who aim to increase the diffusion of efficient appliances.

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Appendix 1: Assumptions and data for payback period analyses

Energy prices (2009$)
Average electricity price = $0.1492 per kWh (Energy Information Administration: http://www.eia.doe.gov/electricity/epm/table5_6_b.html)
High electricity price = $0.181 per kWh (rate for San Diego Gas and Electric: http://www.cpuc.ca.gov/PUC/energy/electric+rates/)
Average natural gas price = $0.8976 per therm (Energy Information Administration: http://www.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_SCA_a.html)
High natural gas price = $1.19058 per therm (Pacific Gas & Electric: pge.com/tariffs/Res_Current.xls)

Average energy use

Central Air Conditioners	SEER	Avg annual kWh
30+ year old	7.45	3717
20+ year old	9.23	2719
Current baseline efficiency	13	2,176
Current Energy Star	14.5	1,960

http://www.eia.doe.gov/emeu/consumptionbriefs/recs/actrends/recs_ac_trends.html
http://www.energystar.gov/index.cfm?c=airsrc_heat.pr_crit_as_heat_pumps
* the "high energy use" scenario assumes 1.6 times the rental – scaled average energy use

Furnaces	AFUE	Avg annual therms
20 - 30+ year old	65%	686
Current baseline efficiency	80%	552
Current Energy Star	92%	485

http://www.energystar.gov/index.cfm?c=furnaces.pr_crit_furnaces
http://www.cwlp.com/energy_services/efficiency_ratings/appliance_efficiency_ratings.htm
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/fb_fr_tsd/chapter_7.pdf

Water Heaters	Energy Factor	Avg annual kWh	Avg annual therms
20-30 yr old natural gas	--	0	360
20-30 yr old electric	--	6600	0
Current electric baseline	0.9	2604	0
Current gas storage baseline	0.59	0	165
Current gas storage Energy Star	0.67	66	137
Current gas tankless baseline	0.62	0	167
Current gas tankless condensing	0.94	28	94

Eric Hirst and Robert Hoskins. "Residential Water Heaters: Energy and Cost Analysis." Oak Ridge National Laboratory. 1979.
http://www.energystar.gov/index.cfm?c=water_heat.pr_crit_water_heaters
http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/htgp_finalrule_ch7.pdf

Rental energy scaling factor

	Avg # rooms in owner occupied	Avg # rooms in rental
National	6.4	4.3
Census Region 9 (Pacific)	6.2	4.0
California	6.1	4.0

2005 Residential Energy Consumption Survey (http://www.eia.doe.gov/emeu/recs/)

Average appliance prices

Central Air Conditioners	Avg installed price (2009$)
Current baseline efficiency	$3,641
Current Energy Star	$4,033

http://www1.eere.energy.gov/buildings/appliance_standards/residential/pdfs/chap7_nes.pdf

Furnaces	Avg installed price (2009$)
Current baseline efficiency	$2,175
Current Energy Star	$3,304

Furnace and Boiler Notice of Proposed Rulemaking Technical Support Document draft 2007-05-15

Water Heaters	Avg installed price (2009$)
Current electric baseline	$ 569
Current gas storage baseline	$ 1,079
Current gas storage Energy Star	$ 1,656
Current gas tankless baseline	$ 1,045
Current gas tankless condensing	$ 960

http://www1.eere.energy.gov/buildings/appliance_standards/residential/heating_products_fr_tsd.html

Rebate values

Central air conditioners

Energy Star central air conditioner: $428 (database compiled from California utilities for Department of Energy Regulatory Impact Analyses)

Furnace

Energy Star natural gas furnace: $233

Water heaters

Tank to tankless conversion: $50 (Pacific Gas & Electric: http://www.pge.com/myhome/saveenergymoney/rebates/appliance/waterheater/)
Baseline or Energy Star efficiency new water heater: average value $33 (database compiled from California utilities for Department of Energy Regulatory Impact Analyses)
Electric to gas: $100 (http://www.cityoflompoc.com/utilities/conservation/)

California housing units

	Total housing units	Rental housing units
2000	12,214,549	4,956,536
2009	13,433,718	5,451,262*

*estimated, assuming 2000 proportion of rental to total housing units
http://www.census.gov/popest/housing/HU-EST2009.html
http://www.census.gov/census2000/states/us.html

Appendix 2: A brief discussion of two similar financing methods

The on-bill loan financing mechanism shares many traits with tariff financing. The utility pays the upfront cost of a cost-effective appliance replacement and the customer repays through their utility bill. However, unlike tariff financing, the repayment obligation is tied to the customer, not the meter. If the customer moves, the remaining balance of the loan must be repaid. Because it is not tied to the meter, this financing method is less attractive for customers who may not remain in a residence for the entire expected lifetime or payback period of an appliance. Due to consumer finance laws, on-bill loan is generally only offered to businesses, not individual residential customers. If state consumer finance laws allow, this may be a valuable method to employ to increase the adoption of high efficiency portable, less expensive appliances, such as refrigerators.

Property assessed clean energy (PACE) financing, like tariff financing, ties the repayment obligation to the housing unit rather than to a particular person. However, in this financing method, a municipality or other form of community facilities district pays the initial cost of a permanently installed appliance, and repayment occurs through an increase in property taxes. Because of this repayment method, PACE financing is limited to property owners and cannot address the landlord – tenant split incentive.

Tariff, on-bill, and PACE financing are by no means perfect substitutes, and if feasible, should be offered as complementary programs in order to provide incentives for tenants and homeowners of all levels of wealth to invest in cost-effective efficient appliances.