Dual Baselines for Industrial Retrofits that Trigger Energy Codes

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ABSTRACT

Recent codes and standard updates at the state and federal level have increasingly added energy efficiency requirements for industrial motors and other industrial process loads such as refrigeration, industrial boilers and compressed air systems. Traditionally, the Public Utilities Commission (PUC) has only allowed utility energy efficiency programs to take credit for the amount of energy efficiency incented above a code baseline – the savings associated with bringing a facility or existing equipment up to code cannot be claimed nor incentivized – unless certain conditions are met. This policy results in missed savings opportunities—primarily because programs can provide information and incentives that motivate equipment and controls upgrades that would not occur otherwise. Absent the support offered by these programs, many industrial customers will continue to repair and refurbish equipment well after its normal lifetime, to avoid replacing it with a new code standard unit or high efficiency unit. We highlight in detail an example with industrial motors, where the customer may rewind the motor instead of upgrading to a more efficient motor. This paper proposes a new simplified rule set for retrofits that removes this policy barrier to significant industrial energy savings. Retrofit programs would be able to claim savings relative to existing conditions but, to prevent double counting the savings, a portion of the project savings would be subtracted from the codes and standards program. This approach would increase utility portfolio savings and optimize industrial and other energy efficiency opportunities by coordinating energy code development with industrial efficiency incentive programs.

Introduction

The California Title 24 Building Code, one of the most progressive building energy efficiency codes in the nation, has incorporated process efficiency measures over the last two code cycles. The expansion of scope to process measures, has allowed California to tap into large energy savings and demand reduction potential associated with efficiency measures required by code upon new construction or retrofit of industrial facilities. Additionally, state and federal appliance efficiency standards have achieved significant savings.

In many cases, the utility efficiency program evaluation policies of California Public Utilities Commission instructs the California Investor Owned Utilities (CA IOUs) to estimate the energy savings efficiency programs relative to a code baseline. For programs that are providing design and product incentives for the construction of new buildings, this makes sense as what would have happened without the incentive program is the building would have been minimally compliant with the building code. However, the code baseline is also being used for retrofit programs when retrofits trigger the application of the building efficiency standards or an appliance standard applies to the product being retrofitted. However for retrofit programs the code baseline may be a "convenience baseline" that does not reflect what would have happened without the presence of the utility efficiency incentive program.

Given the rapid expansion of the scope of building codes and appliance standards into the process efficiency arena, the code baseline can be fairly efficient and for some products close to the efficiency of the highest efficiency equipment on the market. As a result, high efficiency equipment retrofits that save a lot of energy relative to installed equipment may be deemed to save relatively little energy compared to a stringent code baseline. The energy savings estimate is often used to determine the magnitude of the incentive offered and how much reward the utilities are given to operate the program.

If the savings estimate from a given measure is low, the utility programs may not be able to offer a large enough incentive to motivate their customers to upgrade equipment. Also if the estimated energy savings is too low, the return to the utilities for operating the program may be so small or negative that the utilities drop the measure from their portfolio of measures. If the actual savings from a given measure is so small as to render an incentive program for the measure not cost-effective, then perhaps it makes more sense to allocate resources towards other measures where the savings outweigh the operation of the program. However there are a number of examples where the assumed code baseline is not a good representation of what would have occurred without the program and for these cases the current California incentive program policies may be inhibiting faster adoption of these measures due to misguided program policy.[1]

The Public Utilities Commission (PUC) has traditionally used two methodologies for calculating savings and incentives associated with retrofit projects (i.e., early retirement and replace on burn-out). Early retirement allows for calculations to be based on the difference between what is being installed (beyond code-baseline) and existing equipment, but is only applicable to a select group of programs and early retirement is often difficult to prove as the age of equipment is often not frequently listed on the equipment. In addition, as will be demonstrated for large motors, equipment can be repaired to last long past their "effective useful life." In addition, this early retirement protocol requires that the program must increase equipment efficiencies to beyond code levels, even if the code standard equipment is much more efficient than the existing unit. The primary reason this approach is not used more frequently, is the risk associated with ex post (after the program has run) verification findings that might attribute a small fraction of the savings to the program.

The replace on burn-out methodology allows programs to take credit only for the amount of energy efficiency incented above a code[2] baseline—the savings associated with bringing a facility up to code cannot be claimed nor incentivized. This approach is most applicable for rebate programs if: total failure of equipment is common, lifetimes are short, equipment repair instead of replace is infrequent or there is a clear gap between code compliant equipment and high efficiency units. However the replace on burn-out methodology is the default approach for evaluating retrofit programs and thus the majority of retrofit incentive programs are designed with this approach in mind.

The over-use of the replace on burn-out approach creates a lost opportunity for savings, particularly in the case where the efficiency difference in the code standard equipment and an energy efficient unit is relatively very small compared to efficiency spread between the installed unit and the energy efficient unit. Under these conditions, the incentives utilities can offer are

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[1] Other states have the same or similar issues as demand-side management programs often cite or use the California Energy Efficiency Policy Manual.

[2] For the purposes of this paper, we use "code" broadly to indicate building codes and/or appliance and equipment standards.

not sufficient to overcome the economic barriers of replacing older equipment and/or utilities cannot justify running those programs. When the incentive is substantially smaller, facility operators are much more likely to wait until complete equipment failure, as opposed to upgrading sooner. Worse yet, some customers, who may have been motivated with a higher incentive to replace their old motors with a new efficient motor, may instead choose to continually refurbish older equipment.

In California, the IOU Codes & Standards program advocates raising the minimum efficiencies allowed by state building and appliance codes and claims savings if this advocacy is successful. This program dedicates resources to accelerating the adoption of advanced energy efficiency codes. While energy efficiency code programs are the least cost method of increasing energy efficiency, the current program rules result in advanced energy codes negatively impacting retrofit programs.

We hypothesize that if the California IOUs could calculate savings and incentives based on the actual efficiency of specific equipment being replaced, instead of the code baseline, facility operators would be much more likely to upgrade older equipment sooner, allowing California to realize savings more quickly. Under this approach, utilities would claim savings for their code advocacy but only for those new and retrofitted facilities that were not influenced by incentive programs. In return for the reduced energy savings that could be claimed by the Codes & Standards program, the incentive programs would be allowed to expand the range of measures that encourage the retrofit of old inefficient equipment. Such an approach would increase the total energy savings that could be delivered by the portfolio of energy efficiency incentive and code programs. We provide a detailed analysis of how this updated policy could accelerate the early retirement and replacement of the older less-efficient industrial motor stock with high efficiency motors.

Replacement Motor Example

Electric motors are one example of equipment that could benefit from offering incentives based on the existing unit's efficiency instead of the code baseline. Electric motors have long lifetimes that range from 15-30 years based on unit size. Given that the first federal standard became effective in 1997 with the adoption of NEMA "Energy Efficient" efficiency levels, installed units that are over 16 years or older have not been subject to any efficiency standards and have large potential energy savings when updating to current federal code, or to a newer high efficiency unit. In 2010, EISA (Energy Independence and Security Act) revised motor efficiency requirements and adopted NEMA Premium levels. Thus what used to be considered high efficiency and eligible for incentives is now the code baseline. Although there are still motors with even higher efficiencies than NEMA Premium, these motors do not always have large energy savings over the new code, and therefore only minimal incentives can be provided.

Much like incandescent lamps, the majority of the lifecycle cost of the electric motor is in the energy usage. Purchasers are driven to rewind motors because of high capital costs of new motors, even though buying a new code baseline or high efficiency unit with just slightly higher efficiencies can produce large savings and have small payback periods. The average motor purchaser does not often perform a lifecycle cost analysis, which leads to high levels of motors being rewound or refurbished instead of replaced each year. By claiming energy savings from the actual baseline, the CA IOUs could provide impactful incentives to help change the electric motor market in California.

Motors Electricity Usage: Worldwide and in the US

Electric motors are used in everything from HVAC units to manufacturing. Table 1 provides an estimate of global electricity demand by sector and end-use. Electric motor-driven systems account for approximately 46 percent of all electricity used worldwide and 68 percent of all electricity used in the industrial sector (Waide and Brunner 2011). In the United States, Waide and Brunner (2011) estimate the electric motor-driven systems consumes 38 percent of the nation's electricity.

Table 1. Estimate of Global Electricity Demand (TWh) by Sector and End-Use (2006)

Sector	All	Light	Electronics	Electrolysis	Heat	Standby	Motors	Motors (% of sector)
Industry	6,500	500	200	500	800	100	4,400	68%
Transport	300	100	-	-	-	-	200	67%
Residential	4,300	900	700	-	1,600	200	900	21%
Commercial	3,700	1,300	500	-	300	200	1,500	41%
Agriculture	400	-	100	-	200	-	100	25%
Others	500	100	100	-	200	-	200	40%
Total	**15,700**	**2,900**	**1,600**	**500**	**2,900**	**500**	**7,200**	**46%**
Share of total (%)		**19%**	**10%**	**3%**	**19%**	**3%**	**46%**	

Note: the colored "Data Bars" provide visual representation of the relative amounts for each end-use category.
Source: Waide and Brunner (2011)

Federal Standards for Motors

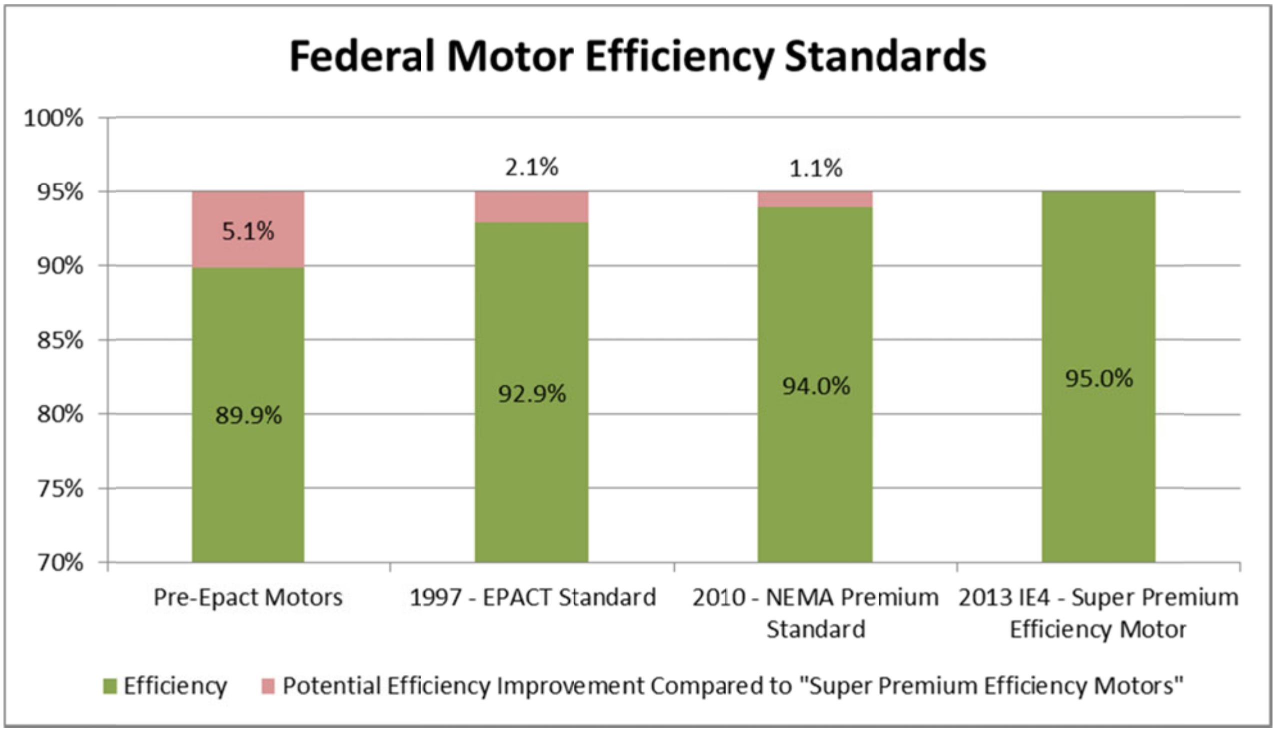
Motor efficiency is expressed as the ratio of useful power to total power input. The Energy Policy Act (EPACT) of 1992 established the first federal efficiency standard for electric motors. This standard became effective in 1997 and was the minimum efficiency standard until 2010 when the federal standard was raised to the NEMA Premium Standard. This latest update represents about a 1 percent increase in efficiency across all motor sizes. Table 2 provides a timeline for federal standards. In addition to NEMA, the International Electrotechnical Commission (IEC) produces global motors energy efficiency standards. Motor Standards have moved from IE1 classification to the current IE3 classification which is similar to NEMA Premium. The future IE4 standard (IEC 60034) is still in draft form, but is the current target for future "Super Premium" efficiency motors (Doppelbauer 2012). Figure 1 graphically represents the NEMA Premium standard levels compared to the future estimated IE4 standards.

Table 2. Federal Standards for Motors Timeline

Date	Federal Standard Key Event
1992	1st Federal Standard Adopted (via Congress through EPACT 1992)
1997	1st Federal Standard Effective
2007	2nd Federal Standard Adopted (via Congress through EISA 2007)
2010	2nd Federal Standard Effective
2012	3rd Federal Standard Final Rule Due*
2014	3rd Federal Standard Final Rule Expected*
2017	3rd Federal Standard Effective – Tentative

*Note: DOE missed the 2012 Final rule deadline for the 3rd standard update

Figure 1. Efficiency and Potential Efficiency Improvement for Federal Motor Standards



Tables A1 and A2 in the Appendix list the efficiencies, estimated energy usage, and estimated price for current and past code standard motors.

Incentive Programs and Motor Rewind Background

The California IOUs ran motor efficiency programs until 2011; a year after the new federal standard took effect. The current savings calculations for super premium efficiency motors relative to the code baseline produce very little savings, which discourages the development of future efficiency programs. The tables in this section show the potential savings impacts of changing the baseline for electric motor upgrades from the code standard to the actual existing unit. The energy code updates, advocated by the IOUs and other market actors, have resulted in significant savings but with the new code baseline have made it challenging to run incentive programs for installed motors. Some building owners with old inefficient equipment are not willing to upgrade due to high capital costs of a code-compliant product. Instead older, generally less efficient equipment is refurbished and maintained beyond its useful life.

Current energy efficiency policy governing the California IOUs does not allow energy efficiency incentives to be offered for units to upgrade to the code baseline unless it can be proven that the unit is being retired a year or earlier than expected. The savings claimed for incentives are currently calculated using the difference in the energy efficiency measure and the most recently effective code baseline.

The current program evaluation rules unnecessarily create a zero sum approach towards energy efficiency. The replace at burn-out approach towards retrofits can create a conflict between codes & standards programs and incentive programs because advocacy for more stringent codes can also limit the ability run effective efficiency incentive programs. The IOUs are able to claim significant savings for code standards for which they advocate. However, these code savings are reduced by code non-compliance rates, program attribution (an allocation that indicates how important the Codes & Standards program effort was to the code being adopted) and normally occurring market adoption (NOMAD) – a rising baseline over time relative to the rising efficiency increase in buildings and appliances absent the code change. Similarly the energy savings from incentive programs are derated by a Net to Gross Ratio (NTGR) that accounts for efficiency increases that would have naturally occurred in the market without incentives. Receiving an incentive for a naturally occurring retrofit that would have retrofitted with or without an incentive program is called free-ridership. According to the California Database of Energy Efficiency Resources this ratio can range from 0.19 to 0.89 depending on the program and can change after the programs final evaluation, measurement, and verification that may occur years after the incentives were paid out. A reduction in the NTGR can significantly reduce cost effectiveness of any efficiency program without warning and is therefore a large risk when running programs. The risk of a low NTGR under the early retirement model for evaluating a retrofit program has resulted in retrofit programs sticking to the replace upon burn-out model which estimates lower energy savings and results in smaller incentives and fewer retrofit opportunities but which also has less risk of a low NTGR later on.

When a motor fails, the primary options are full replacement of the motor or refurbishment in the form of rewinding the motor's coils and replacing the bearings to restore the unit close to its original operating capabilities. To make a proper decision, one must consider the cost to repair, the energy savings and reliability associated with a newer, more efficient motor, availability of a replacement, and the urgency of returning the failed motor to service (Sajovic 2007). Cost and the duration of placing the driven equipment back into service are often the largest considerations. The rewind and refurbish option can be 40-70 percent less expensive than the replacement option, but often degrades the efficiency of the motor. Many sources show that motor rewind and refurbishment often result in a decrease in efficiency between 1 to 5 percent, and could be worse for motors that are rewound multiple times. For the calculations below, a conservative figure of 1.1 percent is used (Ruddell 2004). In addition, a refurbished and rewound motor will not last as long as a new motor. Although sources on the lifetime of rewound motors are scarce, the windings of the motor are not the only part which can break. Failures in the motor casing, bearings, and other parts can lead to earlier failures in rewound and refurbished motors. Of course additional repairs can be made to fix these problems, increasing total costs, but also allowing units to be repaired indefinitely. Although motors will break down eventually the "repair indefinitely" proposed evaluation methodology for retrofits can be applied to electric motors. An earlier ACEEE Paper, "A New Class of Retrofits: "Repair Indefinitely," discusses in more detail this methodology which is applicable products which are significantly less expensive to repair rather than replace such as large motors. (McHugh et al 2010)

Incentive Programs vs. Motor Rewind Analysis

Table 3 below shows the average efficiency, energy usage and price, for: (1) a Base Case existing motor (assumed 50 percent are Pre-EPACT 1992 and 50 percent Post-EPACT 1992); (2) a motor rewind; (3) current Code Standard Motor (NEMA Premium); and (4) a Super Premium Efficiency Motor. Calculations were performed for motors ranging between 21 and 200 horsepower (HP) because motors under 20 HP are less likely to rewind, and motors over 200 HP only make up a small percent of the market, and have very high price barriers.

Table 3. Key Assumptions for Motor Scenarios

Motor Description	Example Motor	Metric	Base Case Installed Motor	Motor Rewind Option	Code Compliant Motor	Super Premium Efficiency Motor
21-50 HP	40 HP	Efficiency	0.914	0.904	0.940	0.950
		Annual Energy Usage (kWh)[1]	86,337	87,297	83,963	83,035
		Coincident Peak Energy Usage (kW)[2]	20.9	21.1	20.3	20.1
		Cost to run Equipment[3]	$ 8,806	$ 8,904	$ 8,564	$ 8,470
		Price[4]	N/A	$880	$1,950	$2,438
51-100 HP	75 HP	Efficiency	0.928	0.918	0.950	0.957
		Annual Energy Usage (kWh)[1]	208,924	211,248	204,110	202,510
		Coincident Peak Energy Usage (kW)[2]	38.6	39.0	37.7	37.4
		Cost to run Equipment[3]	$ 21,310	$ 21,547	$ 20,819	$ 20,656
		Price[4]	N/A	$1,320	$4,500	$5,625
101-200 HP	125 HP	Efficiency	0.932	0.922	0.953	0.961
		Annual Energy Usage (kWh)[1]	338,116	341,877	330,903	327,976
		Coincident Peak Energy Usage (kW)[2]	64.0	64.7	62.7	62.1
		Cost to run Equipment[3]	$ 34,488	$ 34,871	$ 33,752	$ 33,454
		Price[4]	N/A	$2,640	$9,000	$11,250

[1]Annual energy usage assumed 65% load factor and annual operating hours from U.S. DOE (DOE 2002) – 4067 for 21-50 HP, 5329 for 51-100 HP and 5200 for 101-200 HP motors.

[2]Assumes 64% Coincident Diversity Factor

[3]Assumes $0.102/kWh cost of electricity, the average cost of industrial electricity in California. This is 55% higher than the national average of $0.066/kWh (EIA 2013)

[4]Rewind price from (Penrose). NEMA Premium price from (Hasanuzzaman, Rahim & Saidur 2010). Assumed 25% additional cost for Super Premium Efficiency Motor. Motor prices vary depending on region and manufacturer, listed prices are only approximations. Additional pricing info can be found in Chapter 8 of the DOE's Preliminary TSD for the Energy Conservation Standard for Electric Motors (DOE 2012) or at Vaughens On-Line Price Guide

Table 4 summarizes the energy savings and financial differences between replacing a motor instead of rewinding a motor. If an old inefficient motor is being upgraded to a new Super Premium motor, the CA IOUs can only claim savings for the savings generated above a code compliant baseline (column 3) even though the realized savings are the entire savings from the soon to be rewound motor to new super-premium unit (column 2).

Table 5 compares the incentives and simple paybacks if an incentive was offered on the realized savings (column 2) instead of the savings over the code baseline (column 1). Incentives can serve to help lower payback and incremental costs, which will encourage users to replace their motors with super premium efficiency motors instead of rewinding them.

Table 4. Energy Savings and Potential Payback for Motor Replacement Options

Motor Description	Example Motor	Metric	(1) Replace Motor with Code-Compliant Motor instead of Rewind **(Baseline = Rewound Motor)**	(2) Replace Motor with Super Premium Efficiency Motor instead of Rewind **(Baseline = Rewound Motor)**	(3) Replace Motor with Super Premium Efficiency Motor instead of Rewind **(Baseline = Code-Compliant Motor)**
21-50 HP	40 HP	Energy Savings (kWh)	3,334	4,262	928
		Peak Demand Reduction (kW)	0.81	1.03	0.22
		Annual Cost Savings	$ 340	$ 435	$ 95
		Inc Cost vs. Baseline	$ 1,070	$ 1,558	$ 488
		Simple Payback (yrs)	3.1	3.6	
51-100 HP	75 HP	Energy Savings (kWh)	7,138	8,738	1,600
		Peak Demand Reduction (kW)	1.32	1.61	0.30
		Annual Cost Savings	$ 728	$ 891	$ 163
		Incremental Cost	$ 3,180	$ 4,305	$ 1,125
		Simple Payback (yrs)	4.4	4.8	
101-200 HP	125 HP	Energy Savings (kWh)	10,974	13,901	2,927
		Peak Demand Reduction (kW)	2.08	2.63	0.55
		Annual Cost Savings	$ 1,119	$ 1,418	$ 299
		Incremental Cost	$ 6,360	$ 8,610	$ 2,250
		Simple Payback (yrs)	5.7	6.1	

Table 5. Baseline Section Impacts on Efficiency Improvement Simple Payback

Motor Description	Example Motor	Motor Rewind	Metric	(1) Upgrade to Super Premium Efficiency motor **(Baseline = Code-Compliant Motor)**	(2) Upgrade to Super Premium Efficiency motor **(Baseline = Rewound Motor)**
21-50 HP	40 HP	$ 880	Costs after Rebate	$ 2,332	$ 1,951
			Rebate	$ 106	$ 487
			Simple payback with rebate	3.3	2.5
51-100 HP	75 HP	$ 1,320	Costs after Rewind or Rebate	$ 5,451	$ 4,677
			Rebate	$ 174	$ 948
			Simple payback with rebate	4.6	3.8
101-200 HP	125 HP	$ 2,640	Costs after Rewind or Rebate	$ 10,931	$ 9,736
			Rebate	$ 319	$ 1,514
			Simple payback with rebate	5.8	5.0

Rebates are based on the standardized incentive of $0.09 per kWh/yr and $100 per kW.

Allowing rebates to reflect the annual energy savings experienced by the customer allows for rebate amounts up to 6 times those seen by the current rebate process. The current rebate policy, based on the code-baseline, does very little to encourage an upgrade. An incentive between $100 and $300 per motor is hardly worth the time required to fill out the incentive paperwork. The current rebate policy provides an incentive that is 3% to 5% of the cost of the new motor – not a very compelling incentive to upgrade early. A rebate based on existing efficiency is 13% to 20% of the cost of the new motor. If we consider the incremental cost between rewinding and replacing the motor with a super-premium efficiency motor the current incentives provide approximately 5% to 10% of the incremental cost whereas incentives based on the existing conditions baseline would be defraying 18% to 31% of the incremental cost.

Inherent in the current incentive formulation is a message that the incentive is equivalent to one year's energy savings. Besides the direct financial incentive, the 6 times higher estimate of savings provides to the customer a well reinforced message on the inherent value of the upgrade. Not only does the incentive reduce the payback period for the motors by approximately one year, it also allows the customer to seriously consider the benefits of replacing a working motor with a new motor. Once the there is a serious consideration of the costs and savings of replacing the motor, the inherent cost-effectiveness of the measure helps sell the rest of the decision. A key assumption in this program design is that customers are not be aware of the relatively short payback periods—even with the current policy scenario that results in a much smaller rebate. Thus, targeted marketing and education should be a key component of the incentive program.

Depending on the size of the motor, motors are rewound or refurbished instead of replaced up to 95 percent of the time (Hasanuzzaman, Rahim & Saidur 2010). The prime target for encouraging the replacement of motors is the 21-200 HP size category. There are over 1.7 million motors between 21-200 HP in service in the U.S. today (DOE 2002). From the US market size, it is estimated that at least 13,000 of these motors need either to be replaced or rewound (refurbished) in California each year, accounting for approximately 2,000 GWh of energy. Since no current rebate program is being offered to increase sales to super premium efficiency or discourage rewinds, it is assumed that California has the same distribution of motors rewinds and replacements as others in the country. The left half of Table 6 contains estimates of the current distribution of motor rewinds and replacements. The right side of Table 6 estimates what distribution of rewinds versus replacements would be if a dual baseline evaluation method allowed increased incentives to support a successful retrofit program.

Table 6. Current and Future Distribution Scenarios for Motor Rewinds and Replacements

	Current Scenario Distribution				Future Scenario Distribution		
Motor Size (HP)	Motor Rewind[1]	Motor Replaced with NEMA Premium Motor	**Motor Replaced with Super Premium Efficiency Motor**		Motor Rewind	Motor Replaced with NEMA Premium Motor	**Motor Replaced with Super Premium Efficiency Motor**
21-50	81%	17%	**2%**		54%	17%	**29%**
51-100	90%	9%	**1%**		60%	9%	**31%**
101-200	91%	8%	**1%**		61%	8%	**31%**

[1]Current Motor Rewind % from (Hasanuzzaman, Rahim & Saidur 2010)

A program that could impact the repair/replace decisions as much as shown in Table 6 is estimated to save each year approximately 25 GWh/yr and reduce peak electrical demand by 5 MW. Assuming California could change the policy by 2015 to make a program like this more viable, the 5 year savings before 2020 (key date for AB 32 and other statewide goals), could be as large as 128 GWh/yr and 26 MW. Table 7 shows the annual and 5-year cumulative energy savings potential for this incentive. Further research should be conducted to find actual motors sales and rewinds in California, however these calculations are illustrative of the order of magnitude of the total savings potential based on a successful energy efficiency program and current available data on the size of the CA motor market

Table 7. Savings Potential for Decreasing Motor Rewinds and Increasing Super Premium Efficiency Replacement Motors

Motor Size (HP)	Annual Savings Potential (GWh)	Annual Peak Reduction Potential (MW)	Annual Untility Incentive Costs ($M)	5 Year Cumulative Savings Potential (GWh)	Annual Peak Reduction Potential (MW) after 5 years	5-year Incentive Costs to Utility ($M)
21-50	10	2.5	$1.2	52	12.7	$6.0
51-100	8	1.4	$0.8	38	7.1	$4.2
101-200	7	1.4	$0.8	37	7.1	$4.1
21-200 HP Motors	**26**	**5.4**	**$2.8**	**128**	**26.8**	**$14.2**

Operating an effective motor replacement programs is more than just being able to provide larger incentives. It should be noted that the incremental cost of a code compliant motor relative to a rewinding without any incentive is comparable to the incremental cost of a super-premium efficiency motor to rewinding after the larger incentive (based on savings relative to rewinding) is applied. Thus an upstream program to incentivize super-premium efficiency motors might shift sales from minimally code compliant motors (NEMA premium) to super premium efficiency but might not have much impact on the repair versus replace decision. Since the majority of savings potential is from convincing plant managers to purchase super-premium motors instead of rewinding their failing motors, an effective motor replacement program strategy would likely involve some form of downstream market intervention.

Policy Options and Discussion

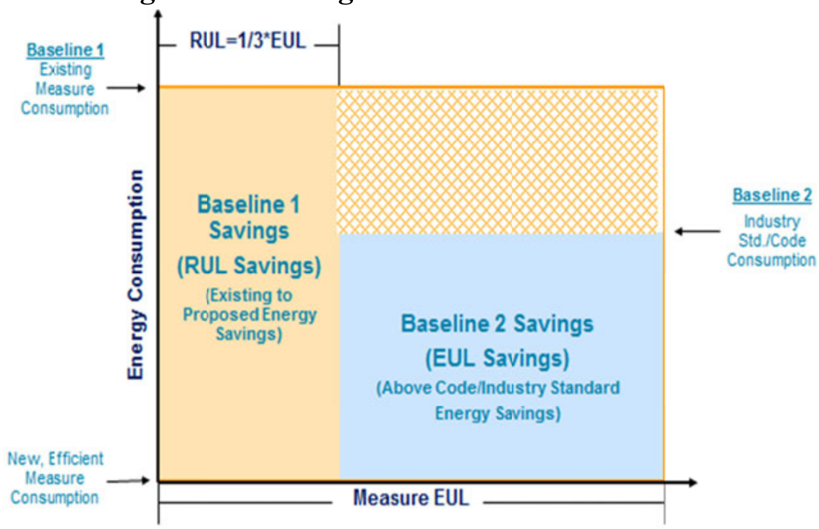
The motor example above identified two types of opportunities for savings that are greater than the savings from exceeding code baseline equipment.

1. Motivating the plant owner to replace motors rather than rewind. According to Hasanuzzaman et al. (2010) the vast majority of motors are rewound rather than replaced.
2. Convincing the owner to replace their old motor earlier and accelerate the savings that codes would generate over the long term.

In the 2013-2014 program cycle, this second type of savings can be acknowledged when, "Dual Baseline" calculations are used to calculate savings for Early Retirement measures. The current dual baseline calculation requires two savings calculation periods. The first baseline is the difference in the measure equipment and the existing equipment. This baseline is calculated for 1/3 of the units' Effective Useful Life (EUL). This portion is referred to as the Remaining

Useful Life (RUL). The second baseline, the savings between the measure equipment and the code baseline, is then used for the other 2/3 of the EUL. The hatched area in Figure 2 shows the difference in the first and second baseline calculation.

Figure 2. Existing Dual Baseline Calculation



The current "Early Retirement" savings methodology can only be applied if the replacement unit is more efficient than current code and compelling evidence demonstrates that the replacement was before the completion of the expected useful life. Additionally, units must be replaced through an energy efficiency program which accepts and encourages early retirement, and can provide enough documentation (and accept the risk) to prove early retirement. These restrictions limit overpaying for high efficiency motors to customers who would have replaced their motor anyway (free-riders), but this conservative approach can result in the loss an entire class of incentive programs when aggressive code baselines significantly reduce incentives for high efficiency installations.

As mentioned earlier the repair/replace baseline for large motors really can be characterized for most as "Repair Indefinitely." Current program evaluation rules have not caught up with this important energy savings mechanism and rationale for retrofit efficiency programs. Even the early retirement rule set underestimates the energy savings from programs that break the cycle of extended repair of obsolete equipment. The argument could be made that the existing efficiency baseline could be extended indefinitely and not one third of the expected useful life.

Other reasons for setting the efficiency baseline as the existing pre-retrofit efficiency include:

1. The retrofit would not have occurred without the program. An example is a program that promotes adding skylights to existing buildings. If skylights are added to an existing building, the code requires the addition of photocontrols. But without the program the building would not have either the skylights or the lighting controls and thus the baseline should be pre-retrofit.

2. The retrofit program requires that the code is scrupulously adhered to even if the local building department does not require it. This gets local contractors used to compliance and filling out the paperwork and also creates an example for the building departments what properly filled out code documentation is supposed to look like. Average retrofit compliance is less than 70%, thus a program that enforces 100% code compliance should get some credit relative to the adjusted code baseline.

What should be apparent from this discussion is that the appropriate baseline should be specific to the program theory of how the program saves energy. According to the CPUC (2006): *"A program theory is a presentation of the goals of a program, incorporated with a detailed presentation of the activities that the program will use to accomplish those goals and the identification of the causal relationships between the activities and the program's effects. ... A program theory may also indicate (from the developers perspective) what program progress and goal attainment metrics should be tracked in order to assess program effects."*

The code baseline is a convenience baseline which is useful as a baseline for new construction programs but which is more likely than not to be inappropriate for retrofit programs that are structured to motivate a change in behavior. When the existing efficiency is used as a baseline instead of the code baseline it is important to make sure that these projects are not double counted by a codes and standards program and an incentive program. If the incentive program is motivating a retrofit that would not have happened otherwise, this project is not really taking away savings from the Codes & Standards program because without the incentive program the retrofit would not have occurred at all or would have occurred sometime off into the future. In other words the incentive program is creating real energy savings that would not have occurred otherwise even when accounting for the revised energy code.

As California building codes move toward Zero Net Energy the need for promoting upgrades to code compliant and even higher efficiency equipment will continue to grow. The ability to propose even more aggressive energy codes is dependent upon robust emerging technology and energy efficiency programs to characterize, commercialize and commoditize the next generation of efficiency measures. Addressing these policy decisions sooner will allow for greater time to study the impacts and results of programs encouraging retrofits of equipment covered by advanced energy codes. Like most incentive programs, implementers must include program design considerations that minimize free-ridership, but policies need to be created to protect these specific programs from the risk associated with drastic changes in NTGR. Furthermore, there are likely technologies or program sectors where this new dual baseline approach is not necessary or advisable. Given policy directives to achieve increasing energy savings goals, appropriate program baselines for an integrated energy efficiency portfolio are a key policy issue needing close attention and resolution in the near future.

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Appendix Table A1. Efficiency, Energy Savings and Price of Sample Motors in Motor Size Categories

Measure Description	Example HP	Metric	Pre-Epact (Code prior to 1997) (ODP)	Pre-Epact (Code prior to 1997) (TEFC)	Epact (Code from 1997-2012) (ODP)	Epact (Code from 1997-2012) (TEFC)	Rewound Pre-Epact Motor (ODP)	Rewound Pre-Epact Motor (TEFC)	Rewound Epact Motor (ODP)	Rewound Epact Motor (TEFC)
Motor 21-50 HP	40	Efficiency	0.898	0.900	0.930	0.929	0.888	0.890	0.919	0.919
		Annual Energy Usage (kWh)	87,890	87,659	84,863	84,934	88,868	88,634	85,807	85,879
		Coincident Peak Energy Usage (kW)	21.3	21.2	20.5	20.6	21.5	21.5	20.8	20.8
		Cost to run Equipment	$ 8,965	$ 8,941	$ 8,656	$ 8,663	$ 9,064	$ 9,041	$ 8,752	$ 8,760
		Price	N/A	N/A	N/A	N/A	$ 880	$ 880	$ 880	$ 880
Motor 51-100 HP	75	Efficiency	0.917	0.916	0.939	0.939	0.907	0.906	0.929	0.929
		Annual Energy Usage (kWh)	211,310	211,624	206,401	206,362	213,660	213,978	208,696	208,658
		Coincident Peak Energy Usage (kW)	39.0	39.1	38.1	38.1	39.5	39.5	38.6	38.6
		Cost to run Equipment	$ 21,554	$ 21,586	$ 21,053	$ 21,049	$ 21,793	$ 21,826	$ 21,287	$ 21,283
		Price	N/A	N/A	N/A	N/A	$ 1,320	$ 1,320	$ 1,320	$ 1,320
Motor 101-200 HP	125	Efficiency	0.921	0.921	0.943	0.944	0.911	0.910	0.933	0.934
		Annual Energy Usage (kWh)	342,226	342,371	334,108	333,759	346,032	346,179	337,824	337,471
		Coincident Peak Energy Usage (kW)	64.8	64.8	63.3	63.2	65.5	65.5	64.0	63.9
		Cost to run Equipment	$ 34,907	$ 34,922	$ 34,079	$ 34,043	$ 35,295	$ 35,310	$ 34,458	$ 34,422
		Price	N/A	N/A	N/A	N/A	$ 2,640	$ 2,640	$ 2,640	$ 2,640

Appendix Table A2. Efficiency, Energy Savings and Price of Sample Motors in Motor Size Categories

Measure Description	Example HP	Metric	NEMA Premium - (Code 2012 - Present) (ODP)	NEMA Premium - (Code 2012 - Present) (TEFC)	Super Premium Efficiency Motor (NEMA Premium + 1 NEMA Band Efficiency) (ODP)	Super Premium Efficiency Motor (NEMA Premium + 1 NEMA Band Efficiency) (TEFC)
Motor 21-50 HP	40	Efficiency	0.940	0.939	0.950	0.950
		Annual Energy Usage (kWh)	83,919	84,008	83,035	83,035
		Coincident Peak Energy Usage (kW)	20.3	20.3	20.1	20.1
		Cost to run Equipment	$ 8,560	$ 8,569	$ 8,470	$ 8,470
		Price	$ 1,950	$ 1,950	$ 2,438	$ 2,438
Motor 51-100 HP	75	Efficiency	0.948	0.951	0.957	0.957
		Annual Energy Usage (kWh)	204,433	203,788	202,510	202,510
		Coincident Peak Energy Usage (kW)	37.8	37.7	37.4	37.4
		Cost to run Equipment	$ 20,852	$ 20,786	$ 20,656	$ 20,656
		Price	$ 4,500	$ 4,500	$ 5,625	$ 5,625
Motor 101-200 HP	125	Efficiency	0.952	0.953	0.961	0.961
		Annual Energy Usage (kWh)	331,077	330,729	327,976	327,976
		Coincident Peak Energy Usage (kW)	62.7	62.6	62.1	62.1
		Cost to run Equipment	$ 33,770	$ 33,734	$ 33,454	$ 33,454
		Price	$ 9,000	$ 9,000	$ 11,250	$ 11,250