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Early Replacement of Inefficient Residential Central Air Conditioners

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REPORT SUMMARY

Replacing inefficient residential central air conditioners before the end of their useful lives (early replacement) reduces electricity use as more-efficient units can produce the same cooling output with less input energy. This reduces the cost of providing that cooling output.

But, this action simultaneously increases other costs—by definition, early replacement moves forward in time the cost of replacing the equipment. In a present value sense, this increases the cost of serving the cooling load.

To be considered cost-effective, the increased equipment cost must be offset by sufficient amounts of avoided utility energy and capacity costs. In practice, because Wisconsin residential central air conditioning units operate for so few hours annually, and since new central air conditioning units are relatively expensive, the increased equipment cost becomes a prohibitive barrier. The present value of the energy and capacity savings pale in comparison to the increased present value of the equipment cost, yielding negative net present values for early air conditioner replacement. Therefore, based on this analysis, we conclude that residential central air conditioners are not prime candidates for the early-replacement concept.

We tested this finding by conducting sensitivity analysis on several key variables. No scenario result changed our general conclusion. It appears that other appliances, those that run much more often than residential central air conditioners, such as commercial refrigeration units or industrial motors, might be better choices for an early replacement program. Even in those cases, however, one must be careful to consider the actual operation of the equipment and the cost of the more-efficient units to ensure that there are sufficient amounts of net savings.

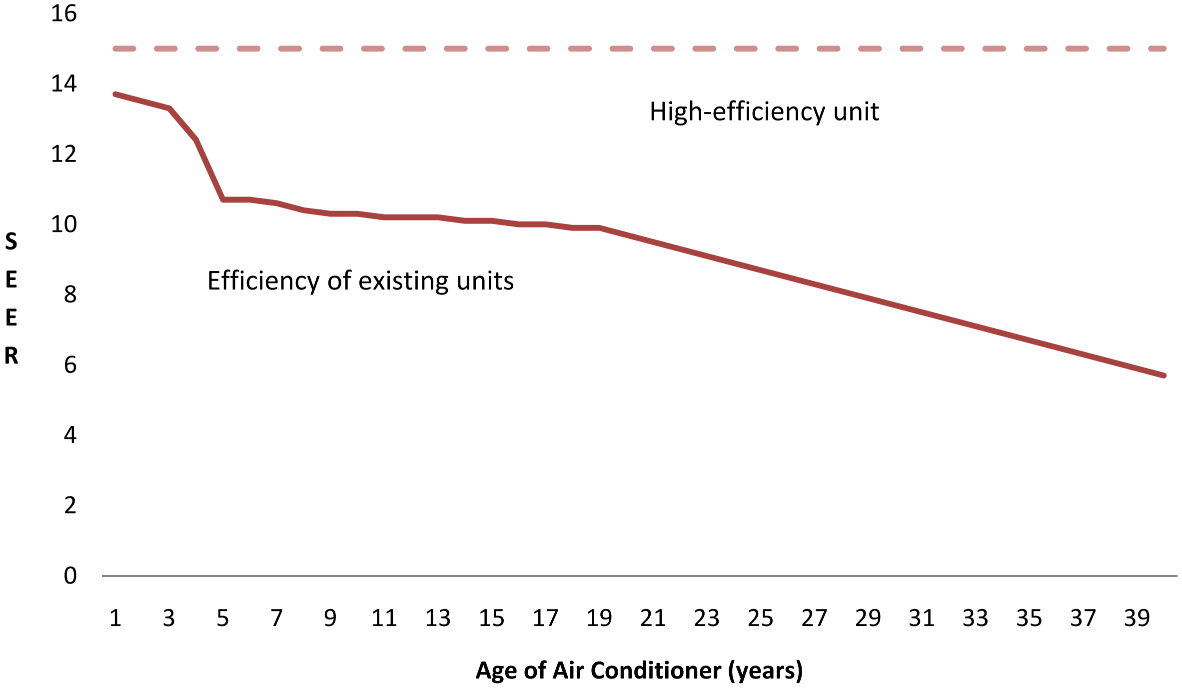
Although we did not explore program design issues in this study, it is important to note that the cost-effectiveness of an early replacement program would also depend on the number of free riders (i.e., those customers who would replace their air conditioners at a given point regardless of whether an early replacement program is in place). Since many air conditioners are replaced before they fail, it would be difficult for program managers to determine which customers were true participants and which were free riders. The program could therefore have to pay incentive payments to all replacers for a selected air conditioner vintage range, even though the actions of the free riders would produce no incremental electric system savings. This casts further doubt on the likelihood that an early replacement program for residential central air conditioners would produce benefits in excess of the associated costs.

BACKGROUND: ENGINEERING ECONOMICS OF RESIDENTIAL CENTRAL AIR CONDITIONERS

Many residential central air conditioners in operation today are noticeably less efficient than new high-efficiency units. It is conceivable then that replacing existing units before they fail (early replacement) might make economic sense.

Air conditioner efficiency is typically reported as a Seasonal Energy Efficiency Rating (SEER). New, high-efficiency units have SEERs in the neighborhood of 15.0. Analysis conducted by the Energy Center of Wisconsin shows that the SEERs for existing units tends to lie below that level, and that the older units have lower SEERs.[1]

Figure 1: Wisconsin Residential Central Air Conditioners SEER by Age of Unit



The annual energy use for an air conditioning unit can be calculated from the following equation. (Air conditioner capacity is expressed in tons, which is a convention that reflects the fact that in the distant past such units displaced technologies that used tons of ice to cool buildings.)

$$kWh = tons \times \frac{12{,}000\ \frac{Btu}{hr}}{ton} \times \frac{1\ watt}{SEER\ \frac{Btu}{hr}} \times \frac{1\ kW}{1{,}000\ watts} \times hours\ used$$

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[1] Sources: Energy Center of Wisconsin, Furnace and Air Conditioner Tracking Study project and http://www.cee1.org/cee/mtg/09-06_ppt/pham.pdf.

A typical air residential central air conditioner unit in Wisconsin has 2.5 tons of cooling capacity. Such a unit operates, on average, 310 hours per year.[2] Combining this information allows us to calculate the annual energy usage (kWh) for an efficient (SEER = 15.0) central air conditioner:

$$kW = 2.5\ tons \times \frac{12{,}000\ \frac{Btu}{hr}}{ton} \times \frac{1\ watt}{15.0\,\frac{Btu}{hr}} \times \frac{1\ kW}{1{,}000\ watts} \times 310\ hours = 620\ kWh$$

Per our data, a 10-year old unit would have a SEER of about 10.3. That unit would use the following amount of electrical energy:

$$kW = 2.5\ tons \times \frac{12{,}000\ \frac{Btu}{hr}}{ton} \times \frac{1\ watt}{10.3\,\frac{Btu}{hr}} \times \frac{1\ kW}{1{,}000\ watts} \times 310\ hours = 903\ kWh$$

Switching from the current 10-year old unit to the new high-efficiency unit would therefore save a bit less than 300 kWh per year:

$$903\ kWh - 620\ kWh = 283\ kWh$$

Per recent Focus on Energy program evaluations, the avoided cost of energy is $0.056 per kWh. This suggests annual energy savings of about $16 from replacing the 10-year old unit with a new, high-efficiency unit:

$$283\ kWh\ saved\ per\ year\ \times \$0.056\ per\ kWh\ saved = \$15.85\ per\ year$$

This result might give the reader pause. Even though replacing an inefficient 10-year old unit with an efficient new unit would reduce energy use by about one-third, the dollar energy savings are worth less than $20 per year. The energy savings are so small because the unit operates only 310 hours per year. That amounts to only about 3.5 percent of the total number of hours in a year.

The real savings from replacing a central air conditioner come in the form of peak demand reduction. Such units operate heavily on the hottest days of the year—the days on which the utility system reaches its peak demand. If the utility can trim residential central air conditioning usage via an efficiency improvement, it may be able to avoid or defer the construction of an expensive new peaking power plant.

We can calculate the peak demand contribution of a central air conditioner by modifying slightly the formula we used to calculate the annual energy use. Instead of considering the hours the unit runs per year, to calculate contribution to peak demand (measured in kW, not kWh) we need to know whether the unit is likely to be operating at the time of utility system peak. Since air conditioners cycle on and off on even the hottest days, this is referred to as the cycling factor. The contribution to peak demand is calculated as follows:

$$kW = tons \times \frac{12{,}000\ \frac{Btu}{hr}}{ton} \times \frac{1\ watt}{SEER\,\frac{Btu}{hr}} \times \frac{1\ kW}{1{,}000\ watts} \times cycling\ factor$$

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[2] Energy Center of Wisconsin, *Central Air Conditioning in Wisconsin: A Compilation of Recent Field Research*, 2008, ECW Report 241-1.

The typical cycling factor for a residential air conditioner on the hottest days is about 50 percent, meaning that at the time of utility system peak about half of the units are on and half are off. Using this information allows us to determine that a high-efficiency unit would therefore contribute about 1 kW to system peak:

$$kW = tons \times \frac{12{,}000\ \frac{Btu}{hr}}{ton} \times \frac{1\,watt}{15.0\,\frac{Btu}{hr}} \times \frac{1\,kW}{1{,}000\,watts} \times 50\% = 1.00\,kW$$

The inefficient 10-year old unit would contribute:

$$kW = tons \times \frac{12{,}000\ \frac{Btu}{hr}}{ton} \times \frac{1\,watt}{10.3\,\frac{Btu}{hr}} \times \frac{1\,kW}{1{,}000\,watts} \times 50\% = 1.46\,kW$$

Switching from the current 10-year old unit to the new, high-efficiency unit would therefore save a bit less than 0.5 kW at time of system peak:

$$1.46\,kW - 1.00\,kW = 0.46\,kW$$

Per recent Focus on Energy program evaluations, the avoided cost of peak capacity is $104 per kWyr. This suggests annual energy savings of about $48 from replacing the 10-year old unit with a new, high-efficiency unit:

$$0.46\,kW\ saved\ per\ year\ \times \$104\,per\ kWyr = \$47.84\,per\ year$$

Notice that in dollar terms the capacity savings is about three times greater than the energy savings, which were about $16 per year.

Combining the avoided energy and capacity savings produces annual savings from replacing the inefficient 10-year old unit with a new, high-efficiency unit of a little more than $60 per year:

$$total\ annual\ savings = \$15.84 + \$47.84 = \$63.68\,per\ year$$

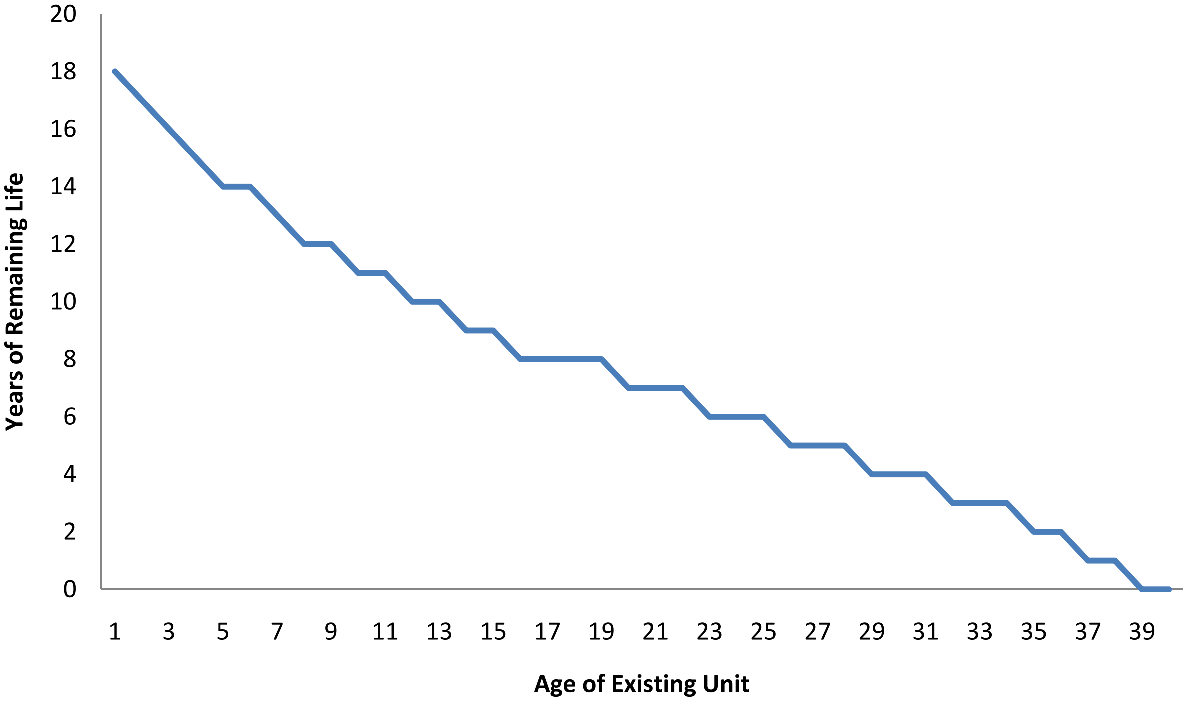
Our analysis suggests that a 10-year old unit typically would have about 11 more years of useful life. We assume that at the end of the useful life, the existing unit will be replaced with a high-efficiency unit as the market transforms. We can assume then that we will achieve savings of $63.68 per year for each of the next 11 years. We are working in real terms in this analysis, so the savings do not increase due to inflation. If we use a 5 percent real discount rate, which has historically been used in efficiency program evaluations, the present value of the savings stream is worth a bit more than $500:

Year	Annual Savings	Discount Factor	Present Value
1	$ 63.68	1.050	$ 60.65
2	$ 63.68	1.103	$ 57.76
3	$ 63.68	1.158	$ 55.01
4	$ 63.68	1.216	$ 52.39
5	$ 63.68	1.276	$ 49.89
6	$ 63.68	1.340	$ 47.52
7	$ 63.68	1.407	$ 45.26
8	$ 63.68	1.477	$ 43.10
9	$ 63.68	1.551	$ 41.05
10	$ 63.68	1.629	$ 39.09
11	$ 63.68	1.710	$ 37.23
Total			**$ 528.95**

We conducted this analysis for existing units with ages from 1 to 40 years old. A key consideration is the number of years that the existing unit will run before it will be replaced on its natural course. This is the period over which the savings from early replacement will accrue. This period will vary with the life of the unit.

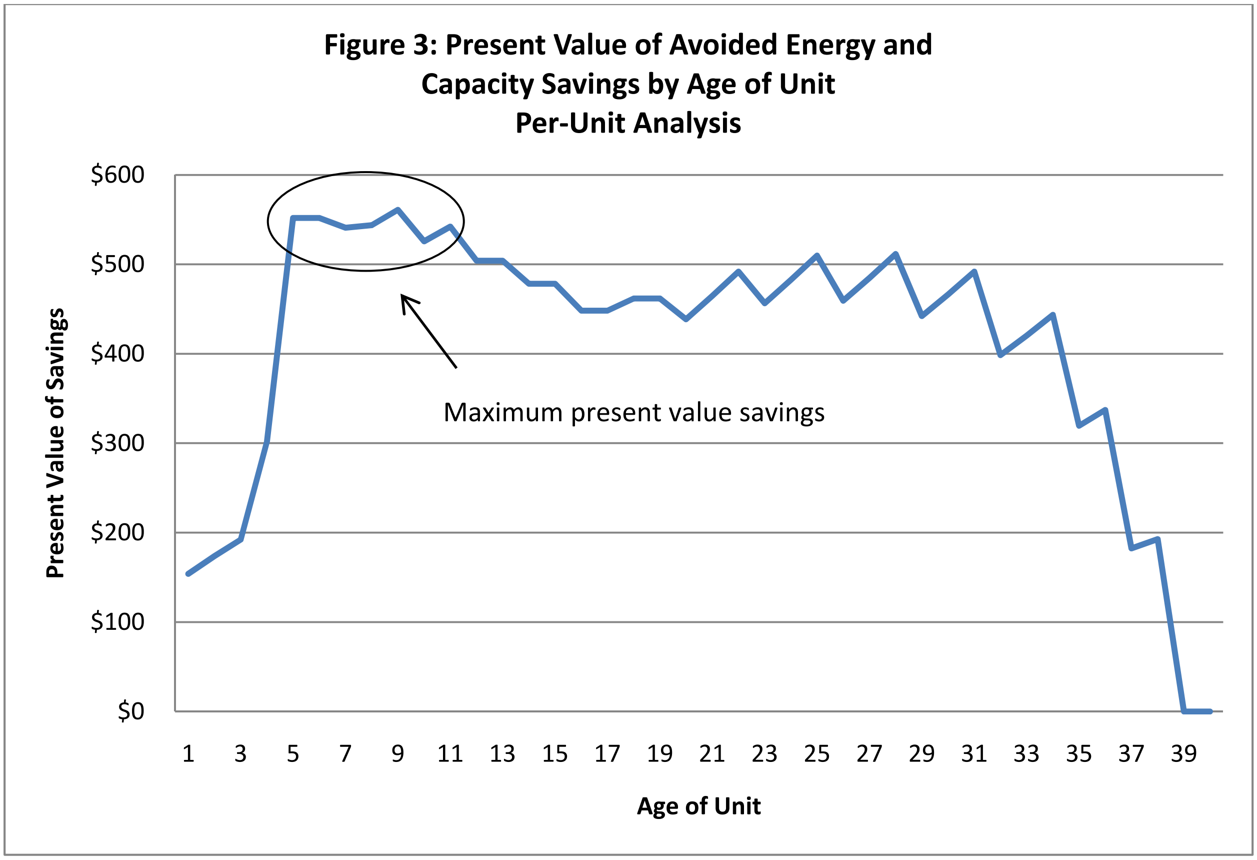
The older the unit, the fewer number of remaining years of expected life. The following chart shows our provisional estimates of remaining years of life based on the age of the existing unit (these are estimates based on conditional expected lives of appliances, and not on actual data).

Figure 2:
Remaining Life by Age ofUnit



This leads to a trade off in terms of targeting air conditioners for early replacement. Younger units are likely to be fairly efficient, and therefore do not offer much in the way of annual efficiency-related savings. Those savings, however, accrue over many years. Conversely, older units are likely much less efficient than new units, thereby suggesting that annual efficiency-related savings will be high. Since the age of the unit is advanced, however, the number of years over which those savings can accrue is diminished.

This suggests intuitively that the greatest per-unit energy savings are likely to be associated with middle-aged units, perhaps in the 8 to 12 year range. Initial analysis of the energy and capacity savings potential confirms this hypothesis. The following chart presents the present value of avoided energy and capacity costs by life of the existing air conditioner unit.



We see maximum per-unit savings potential for air conditioners in the 5 to 12 year range, although the savings are only slightly lower for units that are a bit older.

This analysis, though, is incomplete in several ways. First, since it is a per-unit analysis, it fails to consider the number of units of each vintage. The following chart shows the histogram of residential central air conditioner age for Wisconsin.[3]

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[3] Energy Center of Wisconsin, *Energy and Housing in Wisconsin: A Study of Single-Family Owner-Occupied Homes* (Volume 1: Report and Appendices), 2000, ECW Report 199-1.

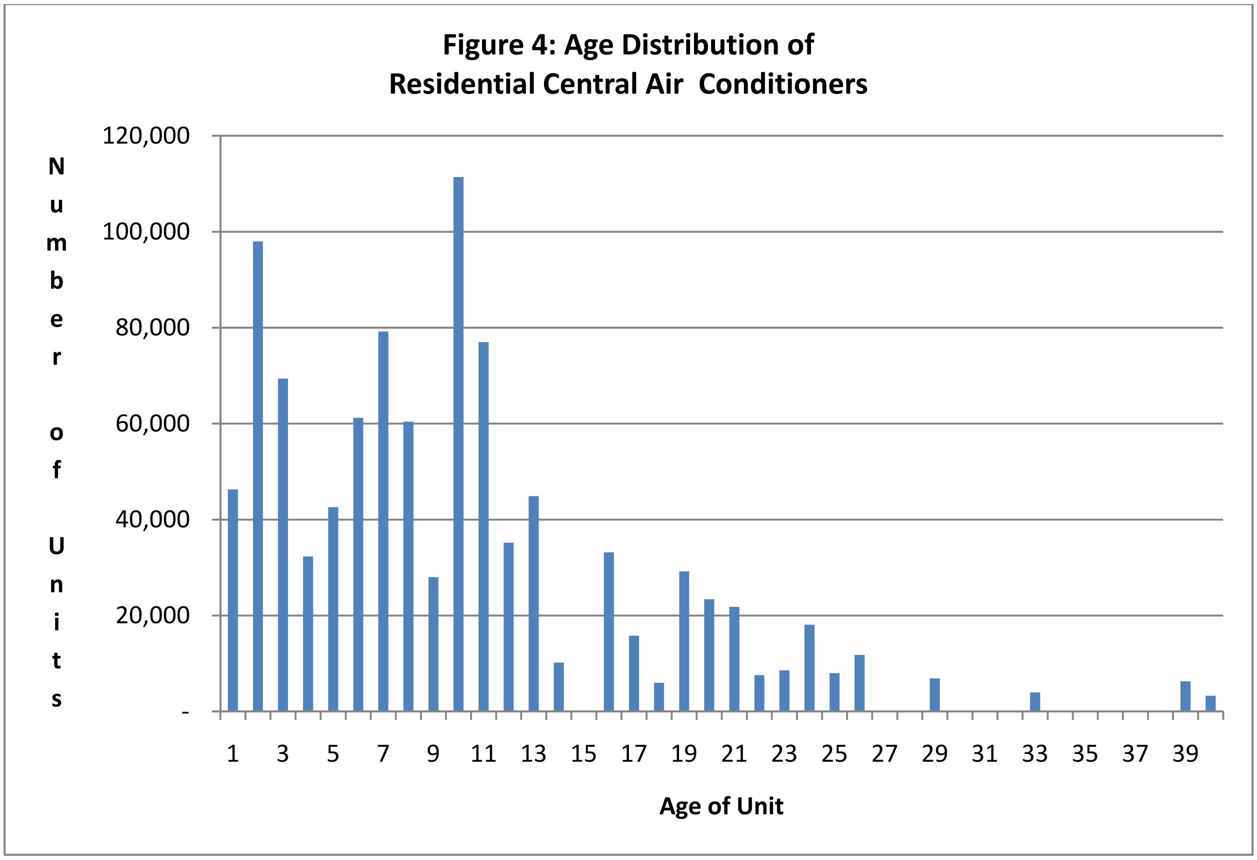


Figure 4: Age Distribution of Residential Central Air Conditioners

To estimate aggregate savings from early replacement, we would need to combine this information with the per-unit savings estimate discussed earlier.

But this chart, too, reflects incomplete information. Some of these units, especially the older ones, are near the end of their lives. We need to know how many units at each age would continue to operate, and thus be candidates for early replacement, rather than being replaced as scheduled. This is shown in the following chart.

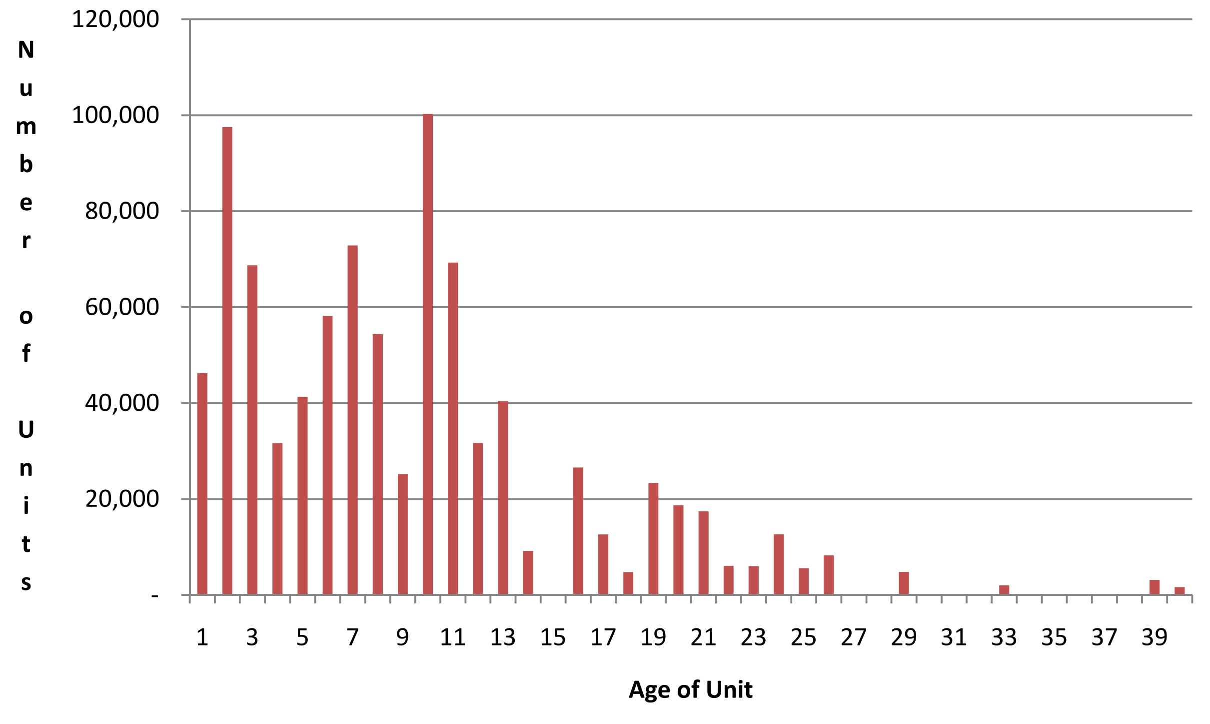
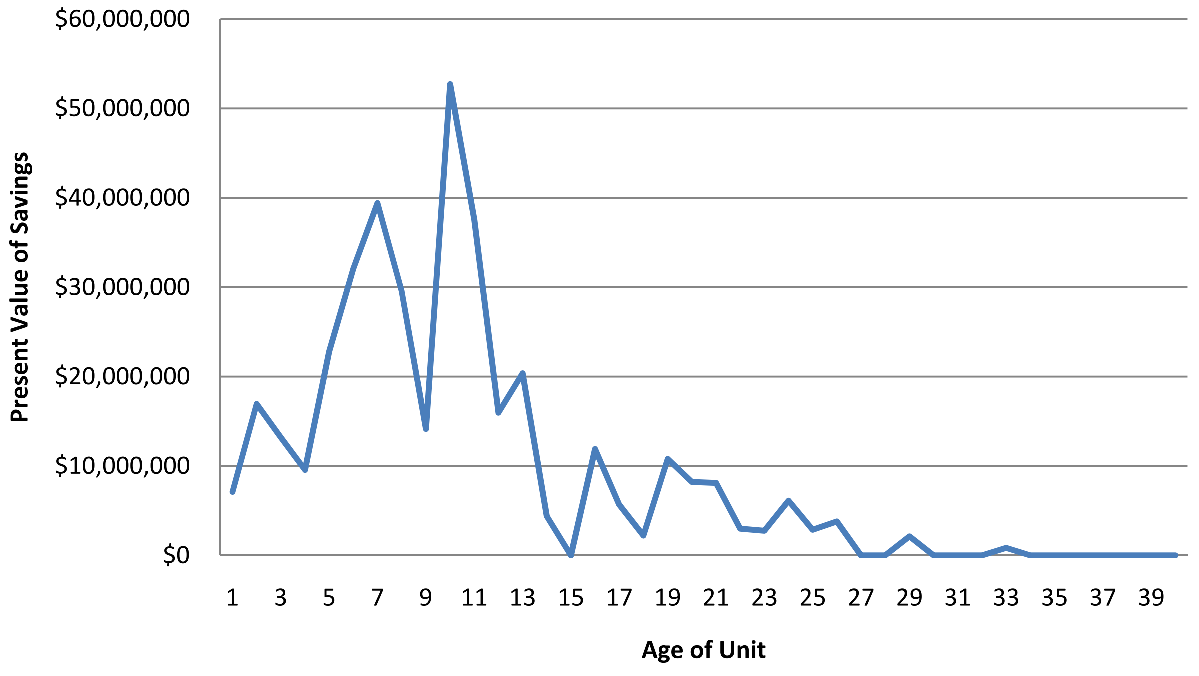


Figure 5: Age Distribution of Residential Central Air Conditioners Not Being Replaced

The remaining life of the units that continue to operate is the period over which the savings from early replacement can accrue. This life span is estimated by mortality analysis based on typical lives of air conditioner units.

We can combine this information with the per-unit present value of energy savings to estimate the aggregate potential gross savings from early replacement. This is shown in the following chart.

Figure 6: Present Value of Avoided Energy and Capacity Savings by Age of Unit Aggregate Analysis



This confirms our suspicion that the greatest potential for savings from early replacement of central air conditioners likely lies among units in the 8 to 12 year age range.

So far we have discussed only the savings estimates. There are costs associated with an early replacement program. Let us begin with the program administrator perspective. Assume that the administrator incurs costs of $400 per unit for customers who participate in the early replacement program. This includes rebates and program administration.

Note, however, that it might be difficult for the administrator to distinguish between true early replacers and those who were going to replace their units regardless of whether the early replacement program was in place. Many people replace units not at the time of absolute failure, but based on a fixed schedule (i.e., they might replace their unit every 12 years), or based on degraded performance. To be conservative, we assume that the early replacement program incurs a $400 cost for all air conditioner replacements (both early and scheduled) because the administrator cannot distinguish between early replacements and as-scheduled replacements.

This assumption does not have much effect on the analysis in the early years, as few people would schedule replacement of a 3-year old unit, for example, but it does have a noticeable effect as the age of the unit increases. The net aggregate effect of the $400 per-unit replacement cost is shown in the following chart:

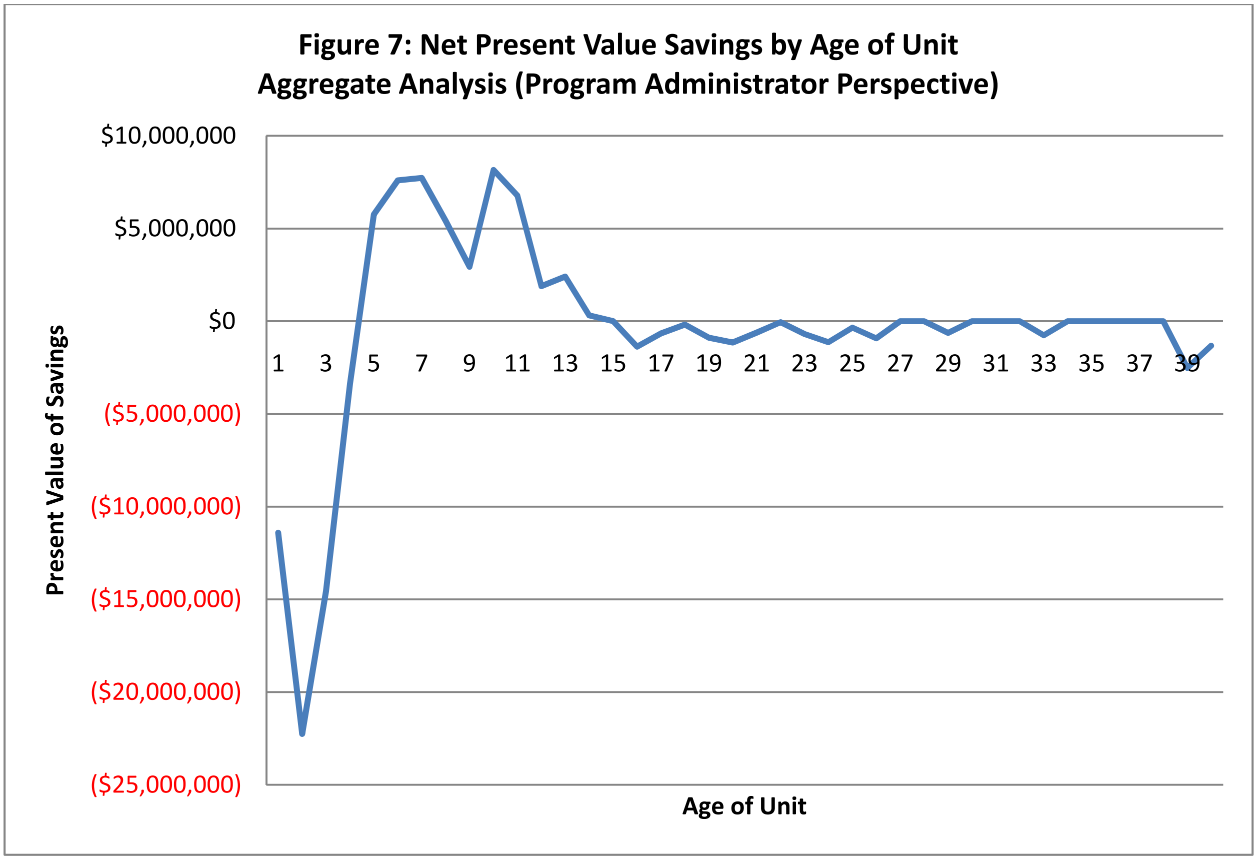


Figure 7: Net Present Value Savings by Age of Unit
Aggregate Analysis (Program Administrator Perspective)

This clearly reveals the sweet spot of the age of residential central air conditioners for which an early replacement program might make sense. Again, it appears as though air conditioners in the 8 to 12 year range are the candidates.

This analysis, though, contains a flaw, at least one that applies if we are using the Total Resource Cost test. This analysis presented so far counts as costs only the amounts spent by the program administrator. That is an incomplete assessment from this perspective.

When we replace a unit early, we bring forward in time the cost of the equipment. From the Total Resource Cost perspective, it is the full cost of this measure, and not only the portion that the program administrator pays, that matters.

In terms of customer equipment costs, an early replacement program is in some ways the antithesis of what happens to utility equipment costs. Whenever we save energy and capacity, we defer utility equipment costs to a later date. An early replacement program does this, however, by bringing forward in time the equipment cost of the efficient air conditioner. This increases the costs incurred by the consumer (and society) in a real economic sense. This increased cost looms large in an early replacement program, and, as we shall see dominates the analysis, making it difficult to justify replacing early air conditioners of any age.

To demonstrate this point, let us return to the analysis of the homeowner who has a 10-year old unit with a SEER of 10.3, one that is expected to last another 11 years. Assume the homeowner will move to the high-efficiency unit when the existing unit burns out. The cost of the new unit is $3,500. If the replacement will occur in year 11, the present value of that cost is:

$$PV(equipment\ cost) = \frac{\$3{,}500}{1.05^{11}} = \$2{,}046$$

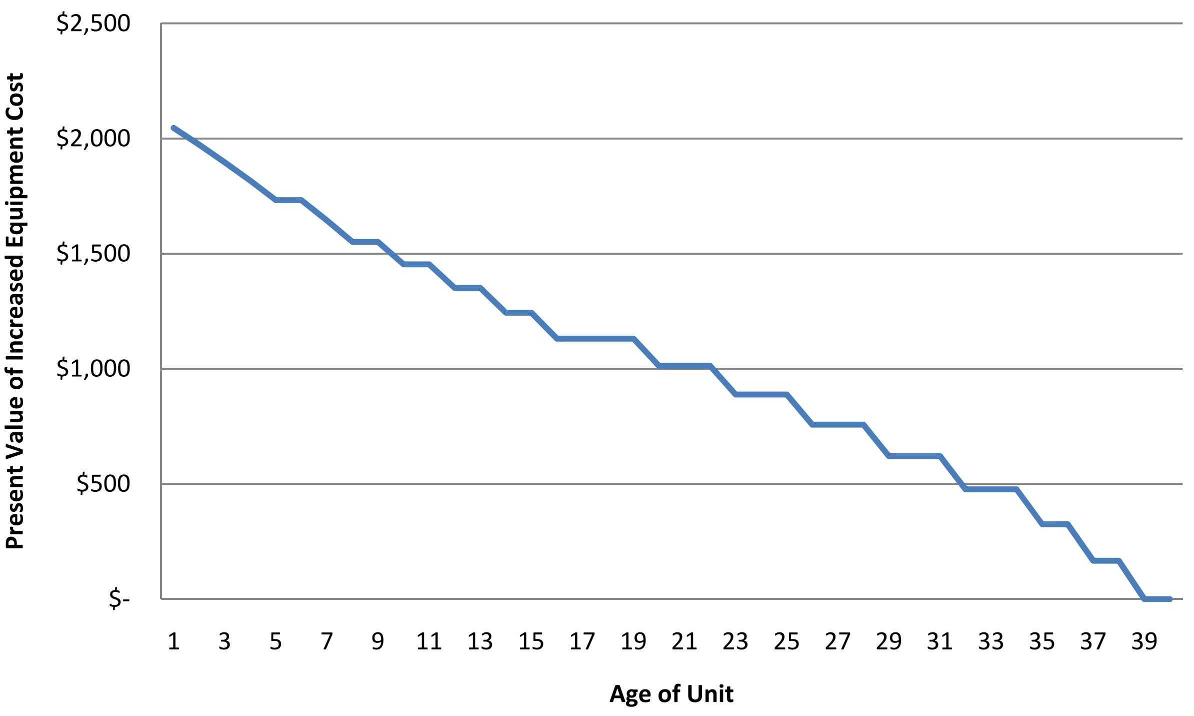
If the customer instead replaces the unit today, we move the $3,500 equipment cost to the present. Thus, the increase in present value of the equipment cost is:

$$increase\ in\ PV(equipment\ cost) = \$3{,}500 - \$2{,}046 = \$1{,}454$$

So instead of the $400 of costs we assumed when viewing this from the program administrator perspective, from the Total Resource Cost perspective we should be using $1,454 as the cost.

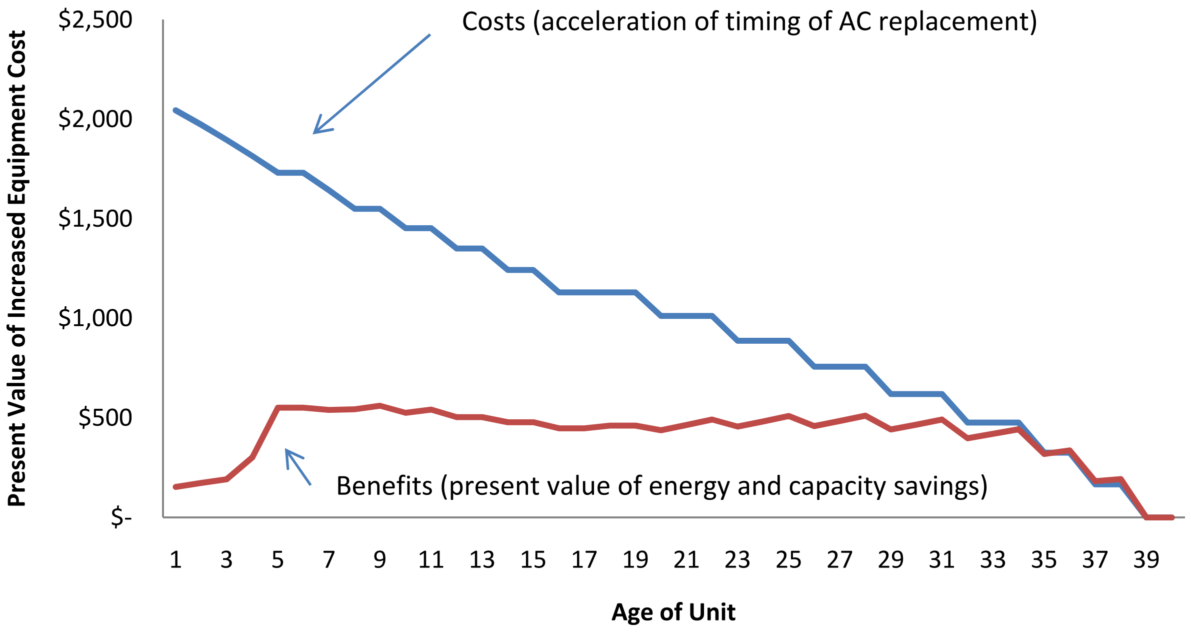
Since the present value of the cost depends on when the unit would naturally be replaced, and the replacement cost varies with the age of the unit, so does the increase in present value of equipment cost vary by the age of the unit. This is shown in the following chart.

Figure 8: Early Replacement Program Increased Equipment Cost by Age of Unit



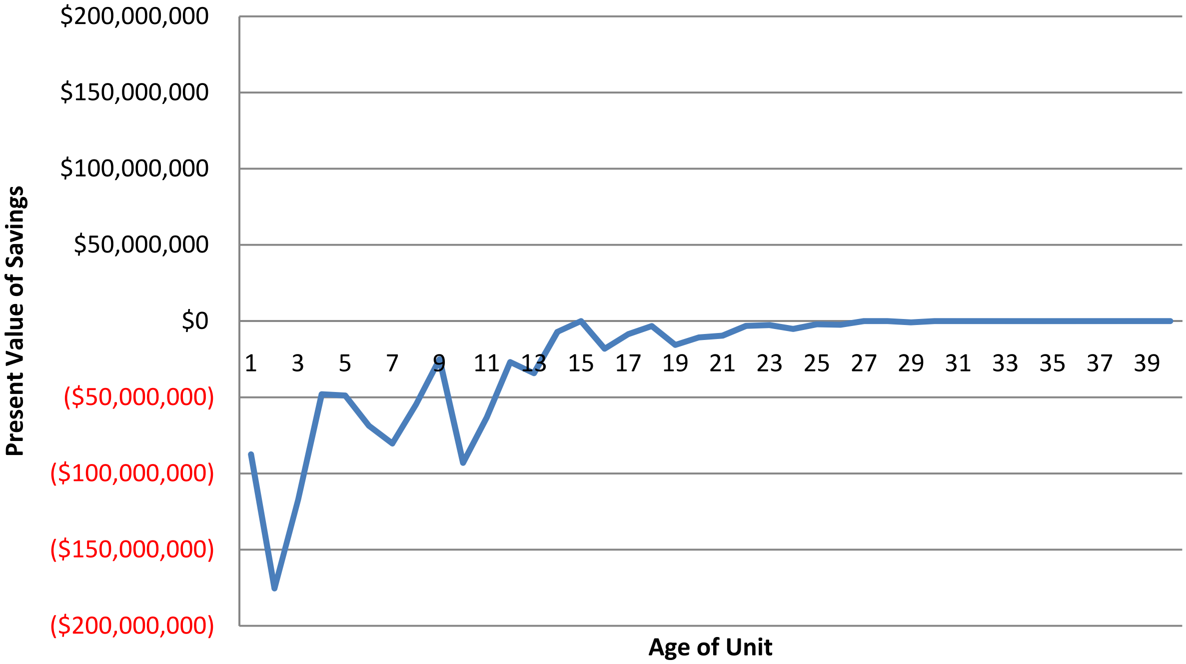
When we combine these per-unit costs with the per-unit benefits discussed earlier, we see that an early replacement program for residential central air conditioners faces an overwhelming hurdle.

Figure 9: Early Replacement Program Comparison of Present Value of Costs and Benefits by Age of Unit (Total Resource Cost Perspective)



When we net these two streams, and put the data on an aggregate basis, we find that there are no units of any age that provide net benefits when we replace air conditioners earlier than scheduled. This is shown in the following chart.

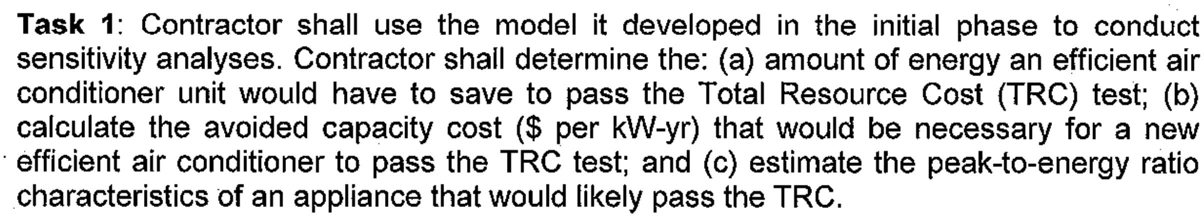
Figure 10: Present Value of Avoided Energy and Capacity Savings by Age of Unit Aggregate Analysis (Total Resource Cost Perspective)



For air conditioners in the age 8 to 12 year group, our target group for early replacement, the average present value per-unit energy and capacity savings is about $500. The average increase in equipment cost is about $1,500. Thus, the benefit-cost ratio for our target group is only about 0.33. Absent some fundamental changes in market conditions, this casts serious doubt on the likelihood that an early replacement program for residential central air conditioners would be cost-effective.

REQUESTED SENSITIVITY ANALYSES

Wisconsin Energy Conservation Corporation asked the Energy Center to analyze the sensitivity of our conclusion about the early replacement program along the following lines:



> **Task 1**: Contractor shall use the model it developed in the initial phase to conduct sensitivity analyses. Contractor shall determine the: (a) amount of energy an efficient air conditioner unit would have to save to pass the Total Resource Cost (TRC) test; (b) calculate the avoided capacity cost ($ per kW-yr) that would be necessary for a new efficient air conditioner to pass the TRC test; and (c) estimate the peak-to-energy ratio characteristics of an appliance that would likely pass the TRC.

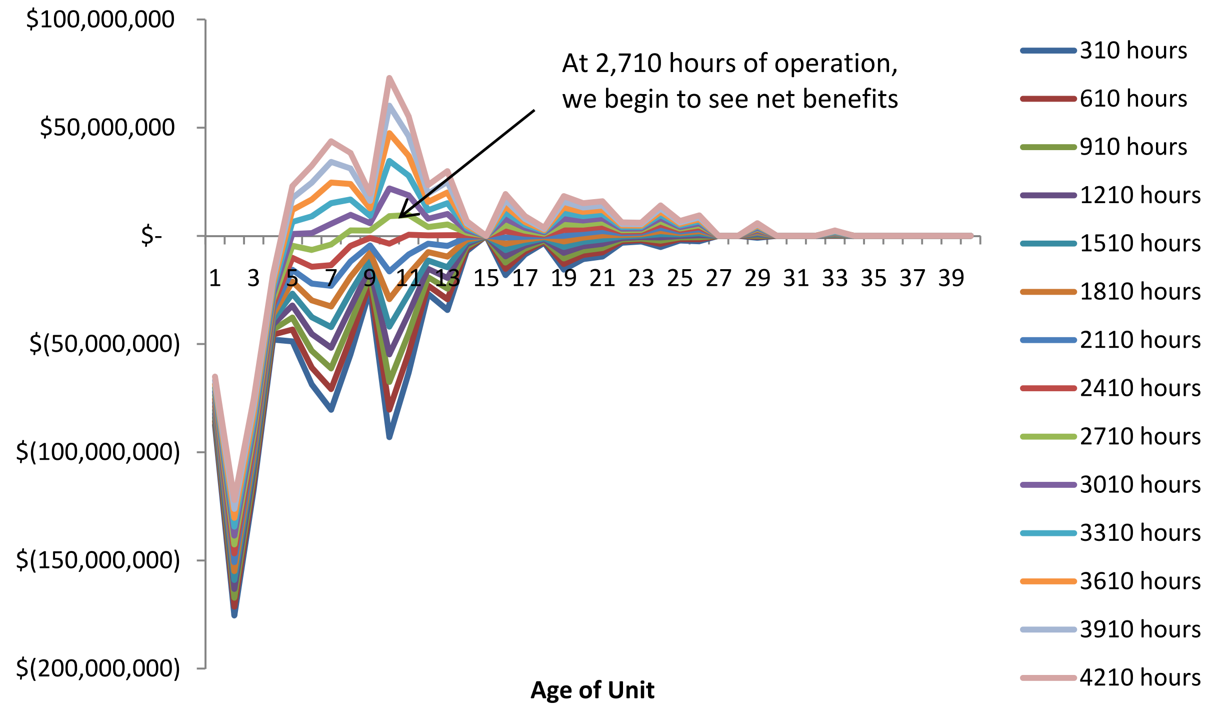
We present the results for each of these items below.

REQUIRED ENERGY SAVINGS

We showed earlier that most of the savings from a program that replaced residential central air conditioners comes in the form of peak demand reduction, not energy savings. Therefore, it seems likely that to change the cost-effectiveness based on energy savings, we would have to increase the level of those savings dramatically to move the program into the cost-effective range. That turns out to be true.

We estimated net savings by varying usage at intervals of 300 kWh per year. That is, for the base case we assumed 310 hours, for the first sensitivity we assumed 610 hours of use, then 910 hours, etc. The results are shown in the following chart.

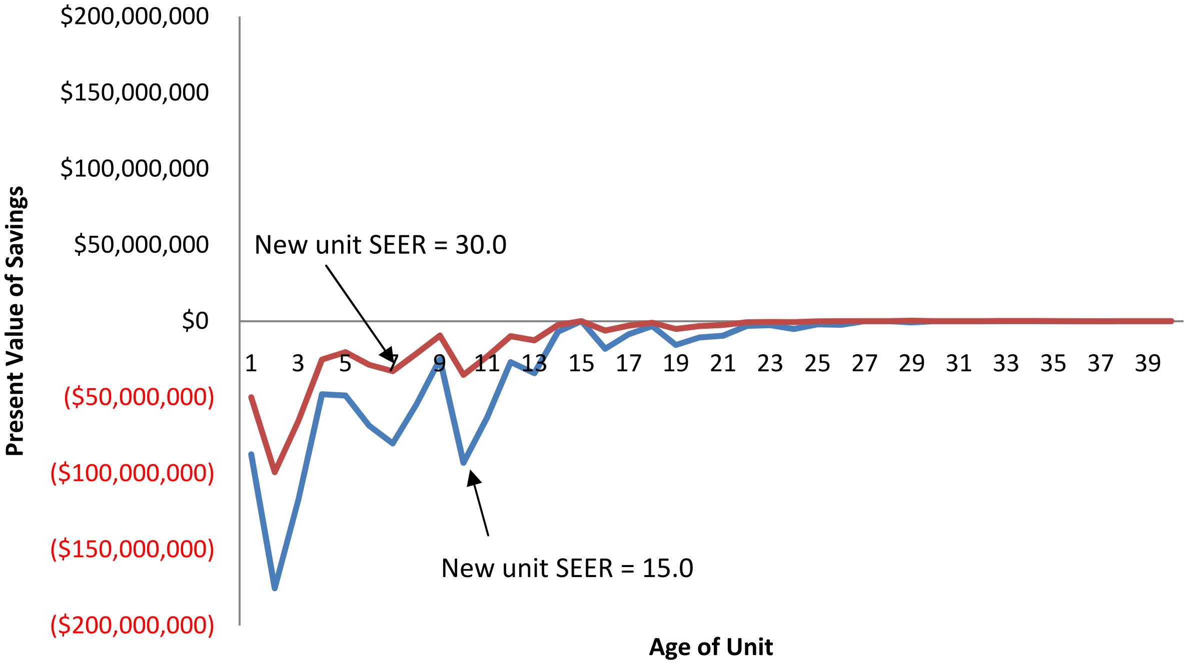
Figure 11: Aggregate Net Benefits by Hours of Operation by Age of Unit (Total Resource Cost Perspective)



We see that it is not until the unit runs for 2,710 hours, or almost 9 times longer than a typical residential central air conditioner unit runs, that we begin to see noticeable benefits in the target age range. Of course there is no way for us to create a need for a typical Wisconsin residential central air conditioner to run that often. The result suggests that it will be essentially impossible to find a level of energy savings that will create net benefits from early replacement.

Another way to look at this would be to determine how efficient the new unit would have to be to create net benefits. We can analyze this by varying the SEER for the efficient unit. We find that if we double the SEER of the efficient unit from 15.0 to the incredible level of 30.0, the program still fails to create net benefits. This is shown in the following chart.

Figure 12: Present Value of Avoided Energy and Capacity Savings by Age of Unit Aggregate Analysis (Total Resource Cost Perspective)



It turns out that even an infinite SEER would not save the program in economic terms. The existing unit simply does not use much energy, thereby limiting potential energy savings to a small amount.

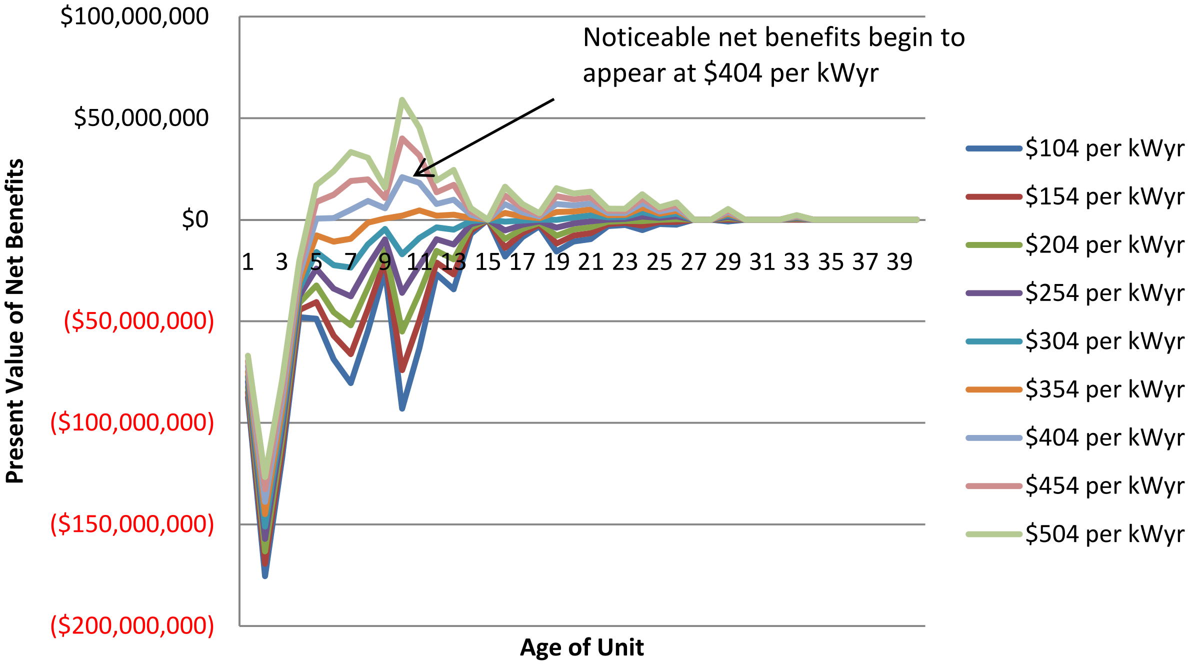
The answer to the first sensitivity query is therefore that even if the early replacement program could eliminate all energy use by the air conditioning unit, i.e., if the unit had an infinite SEER rating, the program would still not be cost effective. Again, that result makes sense because existing residential central air conditioners, the units that we would replace under such a program, do not use much energy. If we could change the operating characteristics, we would have to increase run time to about 2,700 hours per year. That, though, is also not possible as run time is driven largely by the weather. Therefore, we conclude that there is no level of energy savings that would make an early replacement program cost effective under the Total Resource Cost test.

AVOIDED CAPACITY COST

A potentially more promising avenue of exploration focuses on avoided capacity costs. As noted earlier, the primary benefit of improving residential air conditioner efficiency is the reduction in peak demand. Such reductions allow the utility to avoid or defer capacity costs.

The avoided capacity cost used in the initial analysis is $104 per kWyr. We analyzed the present value of net benefits at $50 per kWyr increments to the base avoided cost. The results are shown in the figure below.

Figure 13: Early Replacement Analysis
Aggregate Net Benefits by Age at Various Avoided Capacity Cost
(Total Resource Cost Perspective)



Noticeable net benefits begin to appear at $404 per kWyr

As the figure notes, we see net benefits from early replacement starting around the $400 per kWyr level. While that is quite a high avoided capacity cost when compared to that associated with conventional generating stations, it is not outside the range of the annual capacity cost for wind generators. The table below shows our estimate of the annual capacity cost of 15 upper Midwest wind projects.[4]

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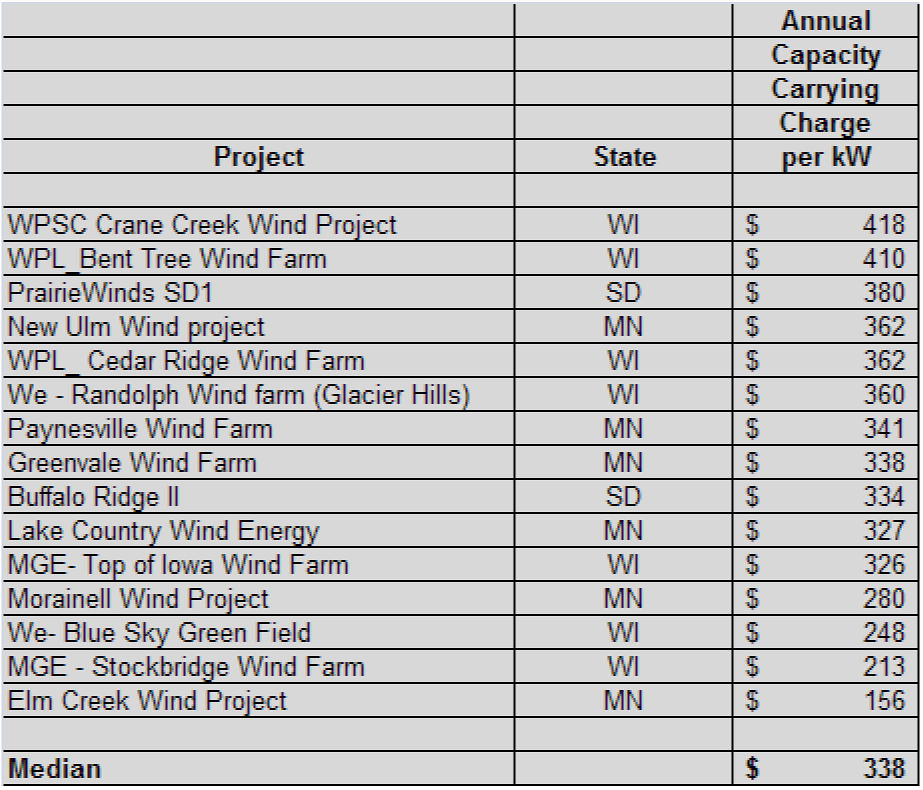
[4] We estimated these costs using the carrying charge approach. This method calculates the annual dollar return on the capital necessary to construct the project, including taxes on the equity returns. This dollar figure is then added to the annual depreciation expense. The sum of these annual revenues is then divided by the capacity of the unit (kW) to calculate the carrying charge.



Project	State	Annual Capacity Carrying Charge per kW
WPSC Crane Creek Wind Project	WI	$ 418
WPL_Bent Tree Wind Farm	WI	$ 410
PrairieWinds SD1	SD	$ 380
New Ulm Wind project	MN	$ 362
WPL_ Cedar Ridge Wind Farm	WI	$ 362
We - Randolph Wind farm (Glacier Hills)	WI	$ 360
Paynesville Wind Farm	MN	$ 341
Greenvale Wind Farm	MN	$ 338
Buffalo Ridge II	SD	$ 334
Lake Country Wind Energy	MN	$ 327
MGE- Top of Iowa Wind Farm	WI	$ 326
Morainell Wind Project	MN	$ 280
We- Blue Sky Green Field	WI	$ 248
MGE - Stockbridge Wind Farm	WI	$ 213
Elm Creek Wind Project	MN	$ 156
Median		**$ 338**

At first blush, this suggests that if an air conditioner replacement program produces capacity savings that displace an expensive wind turbine, ones with carrying costs at or above $400 per kWyr, such a program might be cost-effective.

Before we settle in on this conclusion, a point of caution is in order here. In analyzing avoided capacity costs, we held all other factors, including avoided energy costs, constant in the analysis. A wind turbine might have capacity costs near $400 per kWyr, but it would not have energy costs anywhere near $0.056 per kWh. The variable operating costs for a wind turbine are much lower (perhaps $0.01 per kWh). Therefore, in this analysis, one that isolates only the avoided capacity costs, we overstate the savings associated with the early replacement program. We discuss this point further later in the report when we substitute a wind turbine for a natural gas plant in a more complete economic analysis.

PEAK-TO-ENERGY ANALYSIS

The analysis presented so far suggests that, if we hold avoided capacity costs at the base level of $104 per kWyr, residential central air conditioners don't run often enough to create the savings necessary to overcome the increased equipment cost associated with the program. In other words, the peak-to-energy ratio for residential central air conditioners is too high. When the peak-to-energy ratio is high, there are fewer units of energy over which efficiency savings can accumulate. Therefore, from an energy efficiency perspective, a high peak-to-energy ratio is undesirable.

Per the base case analysis, the inefficient 10-year old unit with a SEER of 10.3 contributes 1.46 kW to peak demand and uses 903 kWh per year. Its peak-to-energy ratio is therefore:

$$\frac{peak}{energy} = \frac{1.46\ kW}{903\ kWh} = 0.0016\ kW/kWh$$

Recall that our sensitivity analysis showed that a unit would have to run about 2,710 hours to make the early replacement program cost effective. Recalculating energy use based on 2,710 hours (as opposed to the 310 hours used in the initial analysis), produces the following estimate of annual energy consumption:

$$kW = 2.5\ tons \times \frac{12{,}000\ \frac{Btu}{hr}}{ton} \times \frac{1\ watt}{15.0\frac{Btu}{hr}} \times \frac{1\ kW}{1{,}000\ watts} \times 2{,}710\ hours = 7{,}893\ kWh$$

Substituting this estimate into the peak-to-energy calculation yields the following result:

$$\frac{peak}{energy} = \frac{1.46\ kW}{7{,}893\ kWh} = 0.00018\ kW/kWh$$

The peak-to-energy ratio necessary to justify the program under the Total Resource Cost test is about an order of magnitude lower than the initial estimate.

MORE PROMISING OPPORTUNITIES WITH OTHER APPLIANCES

The message from the preceding analysis sends a clear message—early replacement is more likely to be cost effective for appliances that run frequently, a characteristic that is not applicable to residential central air conditioners. We have developed a list of appliances that have relatively high energy use relative to their peak demand contribution (i.e., they have a low peak-to-energy ratio). While further analysis would be required, these appliances appear to be better candidates for an early replacement program:

- Supermarket refrigeration
- Commercial air conditioners (such units run much more often that residential units)
- Chillers
- Motel packaged terminal heat pumps
- Motors
- Lighting

Supermarket refrigeration provides a good case in point. Such equipment runs year-round. Any efficiency savings for such units would accumulate over most hours of the year, which could help to generate the dollar savings necessary to overcome equipment costs.

According to the energy efficiency potential study that we prepared for the Wisconsin Public Service Commission, refrigeration equipment has a relatively low peak-to-energy ratio (0.00015).[5] The peak-to-energy ratio for residential central air conditioners is about 10 times higher than it is for supermarket refrigeration. In the industrial sectors, motors offer attractive peak-to-energy characteristics (0.000128).

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[5] Energy Center of Wisconsin, *Energy Efficiency and Customer-Sited Renewable Resource Potential in Wisconsin for the years 2012 and 2018*, August 2009, Appendix B.

Efficient commercial lighting has a peak-to-energy ratio of 0.00014, which makes it similar to refrigeration in this respect. Another example is commercial chillers. In health care applications, such as hospitals, such equipment has a peak-to-energy ratio of 0.00051.

This simple analysis ignores, however, the equipment cost factor, as well as the remaining years of expected life. Ideally, an appliance that is ripe for early replacement would have the following characteristics:

- Low peak-to-energy ratio
- Low level of efficiency relative to new units
- Long expected remaining life
- Low equipment replacement costs

USING RENEWABLE RESOURCES AS THE AVOIDED COST PROXY

The base case analysis used avoided energy and capacity costs that reflect the characteristics of a natural gas peaker unit:

Natural Gas Peaker

- Avoided energy cost = $0.056 per kWh
- Avoided capacity cost = $104 per kWyr

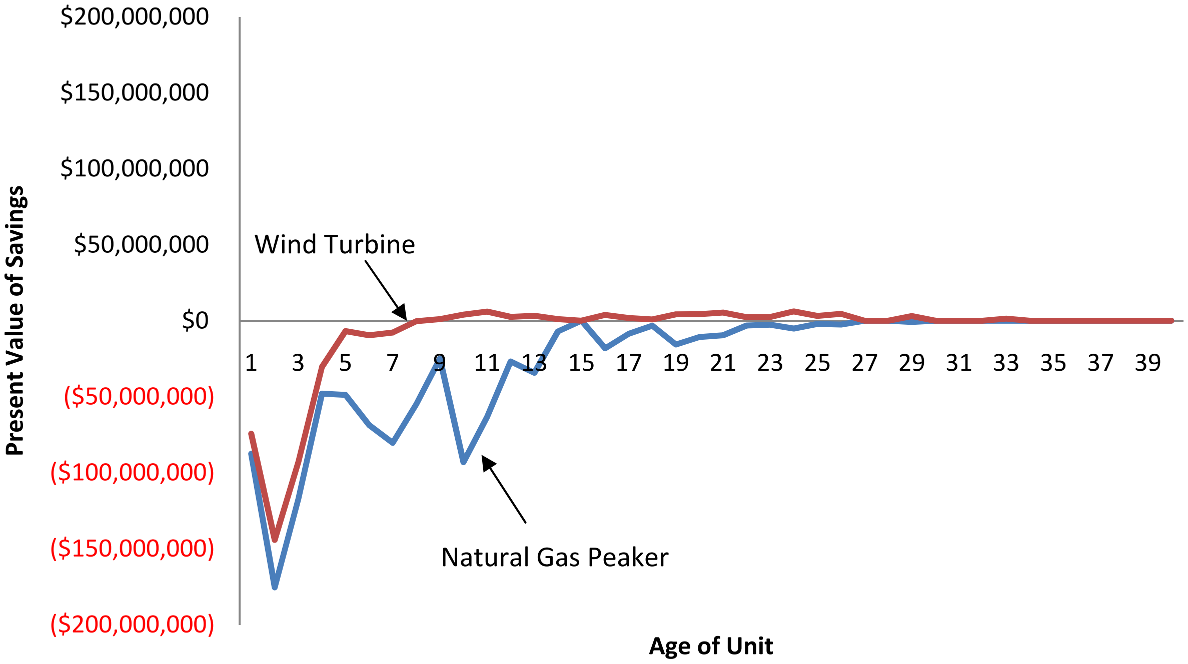
If we move to a wind turbine as the avoided cost proxy, the avoided capacity costs increase and the avoided energy costs drop:

Wind Turbine

- Avoided energy cost = $0.010 per kWh (this is variable operation & maintenance expense)
- Avoided capacity cost = $338 per kWyr (median of results presented earlier)

When we switch to the wind turbine, we see better results than those associated with the natural gas peaker proxy, but the savings are not substantial enough to justify an early replacement program, at least not under the Total Resource Cost perspective. This is shown in the following chart.

Figure 14: Net Benefits by Age of Unit Using Different Avoided Cost Proxies Aggregate Analysis (Total Resource Cost Perspective)



THE TOTAL RESOURCE COST TEST AS A SCREENING TOOL

Our analysis reveals that the early replacement concept for residential central air conditioners fails the cost-effectiveness test if we apply the Total Resource Cost perspective. The failure is due in part to the fact that this test considers all resource costs, including those borne by either the program or the homeowner. If we consider only the cost incurred by the program (Program Administrator’s test), then the program produces some net benefits. This is shown in the following figure.

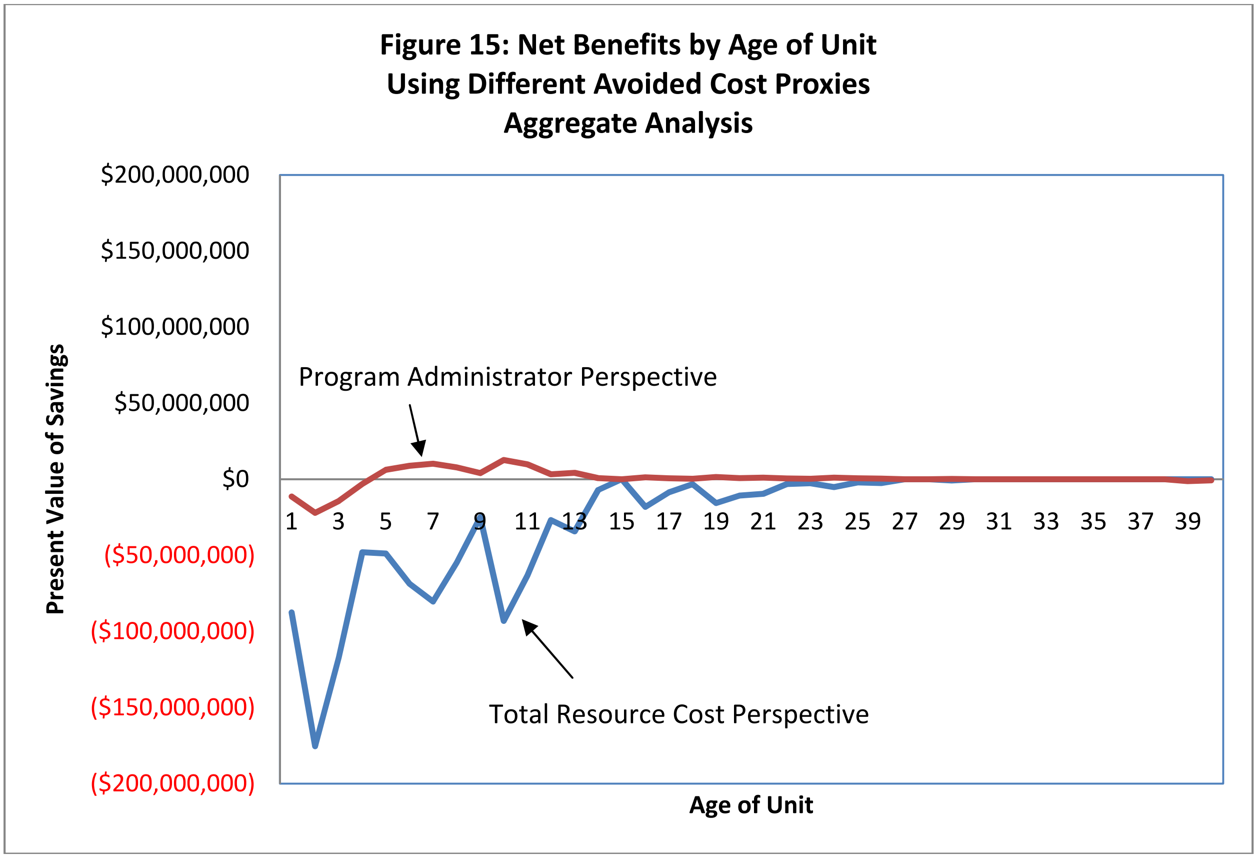


Figure 15: Net Benefits by Age of Unit Using Different Avoided Cost Proxies Aggregate Analysis

While it is unclear whether there are enough benefits from the Program Administrator perspective to justify a program, the important aspect to notice is the wide gap between the net benefits under the two approaches.

The Total Resource Cost test serves as an economic judge on society’s actions, one that determines whether efficiency investments are or are not appropriate. In this respect, the Total Resource Cost test may go too far. People make energy efficiency decisions for a variety of reasons, some of which are not captured by the test.

For example, say that a homeowner wants to reduce his or her carbon footprint. The benefits of reduced carbon emissions are not captured in the test. Other customers may make energy efficiency decisions based on something other than net present value analysis. Others may use net present value analysis, but may apply different discount rates.

Still others may have different forecasts of long-run avoided capacity and energy costs. For example, some people believe that the cost of providing electricity will rise dramatically in the near future. Improving the efficiency of appliances today will insulate consumers to some extent from the impacts of such price increases.

The point is that the Total Resource Cost test provides one way of analyzing the desirability of making efficiency improvements. It is not, however, the only way to analyze concepts such as early replacement of residential central air conditioners.