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Additional submitted attachment is included below.

Mitsubishi Electric Comments on How Policy Regarding ASHPs and Retrofit Electrification Can Maximize “Beneficial Electrification”.

Submitted by Bruce Severance, Regulatory Compliance Engineer, Mitsubishi Electric US, June 18, 2020
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Introduction

Mitsubishi Electric appreciates the Commission’s efforts to mitigate the impacts of buildings on climate change and recognizes the importance of rapid mobilization strategies that produce measurable reductions in GHGs over the next thirty years as well as a broader transform California’s economy to carbon free and carbon negative alternatives. On issues of climate mitigation strategies Mitsubishi Electric is an outspoken advocate. In June 2019, Mitsubishi Electric published “Environmental Sustainability Vision 2050” to clarify the company’s stance on addressing long-term environmental issues. This corporate vision asserts that “The Mitsubishi Electric Group shall utilize diverse technological assets throughout wide-ranging business areas to solve various environmental issues, including climate change…” Mitsubishi Electric regards climate mitigation a primary mission and service to our customers, and in furtherance of the goals of the Paris Accords, we believe the climate science and desire to be reliable and consistent partners in the global climate mitigation efforts.

Defining “Beneficial Electrification”

“Beneficial Electrification” is term generally used to address the common objectives of maximizing consumer energy savings and minimizing impacts on grid integration and grid capacity. Although it is generally understood that it is most cost effective to perform envelope energy upgrades prior to “electrifying everything”, there is often little discussion about the most cost effective means to minimize or eliminate the potential negative impacts of electrification. Obviously, removing an old 100kBTU furnace with a 5-ton AC system and replacing it with a more efficient 5-ton heat pump system is not the best strategy. There is a great deal of IOU data from the LIWP and EUC Programs to substantiate the value of basic envelope improvements in terms of energy savings to the resident and high ROI. So it is clear, the basic prescription of weatherization, sealing the floor of the attic, adding attic insulation, and adding attic ventilation in high cooling load climates is effective.

However, a range of potential site conditions and possible upgrades may represent “best practices” that reduce ROI for the resident, because they add substantial cost relative to incremental improvements in ROI and energy savings. When it comes to a whole-house approach to energy efficiency (EE) and electrification (EE+E) Rick Chitwood’s work with the CEC and as an energy consultant has set the standard, and has redefined the field of building science. With mindful consideration of ACCA and ASHRAE standards, Rick developed his own tricks of the trade for a “whole-house approach” to HVAC installation that reduce can reduce installation costs on new construction, and create cash-positive scenarios on retrofit (furnace replacement) projects with few exceptions.

So if it saves developers money, and lowers energy costs for residents, why aren’t all HVAC contractors doing this? The answer is education. The vast majority of system designers, integrators and HVAC contractors are not aware of Chitwood’s defining work, and they are entrenched in their old-school methods – so much so that “old-school” installers will argue that the “new-school” methods are “wrong” even if you show them scientific evidence to the contrary. Furthermore, embracing “new-school” principles would change how they do business and there is great resistance to changing their business models. This is a critical, and often, unrecognized barrier to implementation of the most beneficial electrification.

The Chitwood Method of HVAC Optimization

Implementation of most of Rick Chitwood’s “new-school” approach to ducted HVAC system optimization should become a defining standard for creating the most beneficial electrification scenarios. In general, Chitwood’s Method is simple: a) Shorten duct runs by “throwing” air from the center of the structure toward outside walls; b) Drop ducts to the floor of the attic so they can be deeply buried; c) Make all ducts “home runs” from the supply plenum to the register locations which eliminates trunk and branch design, increases fan efficiency, and allows all supply ducts to be less than 8” in diameter (increases effective R-value); d) install dampers at the starting collars at the supply plenum to perfectly balance room temperatures; e) oversize return grills and use 2” deep filter grills to reduce static pressure and increase filter performance. All of these measures taken together, combined with deeply buried ducts in blown attic insulation can significantly lower HVAC loads by significantly reducing both duct system and envelope losses. Chitwood has demonstrated 70% savings on retrofits, so even adoption of 80% of these measures on retrofits would allow HVAC system capacity to be cut in half, and would more than double system efficiencies. Why is this so important to beneficial electrification?

Chitwood Method Optimizes "Beneficial Electrification"

Imagine if we replaced every residential furnace and AC with a similar capacity heat pump (5-ton system replaces a 5-ton). Because the heat pump is now also meeting all heating loads, the resulting additional loads on the grid may double previous HVAC loads, doubling grid capacity requirements and infrastructure costs (which eventually are passed down to residents). That may seem bad enough, but other costs also increase: Because residential HVAC systems drive peak demand as everyone gets home at 5:30pm just as solar on the grid is going offline, the "business as usual" HVAC installation also has critical grid harmonization impacts. It maximizes demand at precisely the point in the day when we want to minimize demand to flatten the so-called "duck curve" which has immortalized for California policy makers just how challenging balancing large solar output on the grid can be. The consequence: utility scale or residential battery storage capacity would need to be roughly double what it otherwise needs to be in order to meet this ballooning peak demand period.

Lost Opportunities

When flattening the duck curve is the very definition of beneficial electrification, failure to implement Chitwood's HVAC optimization methods are entirely a lost policy opportunity. So many may ask, why is Mitsubishi Electric, a heat pump manufacturer, advocating for Chitwood's Method when it cuts the capacity of the heat pump in half and reduces the profit for the manufacturer on each project? As stated in the intro above, we are committed to climate mitigation, and we think this method maximizes the energy savings and carbon reduction on every new and retrofit project, but all altruism aside, this policy objective makes long term profit sense to every heat pump manufacturer.

When the goal is to electrify the residential gas infrastructure to reserve fossil fuel-RNG-hydrogen blends for industrial applications and heavy transport, the economics of market transformation must work for residents as well as manufacturers. Residents and regulators will not tolerate an attempt at market transformation that results in increased combined utility rates, particularly for LMI residents, and principle would dictate that the economics should be favorable for all parties. Chitwood's optimization method is precisely the prescription required to minimize installation and upgrade costs while also maximizing the ROI and energy savings for residents and program managers. In the event that an Inclusive Finance Model is implemented to reach the LMI rental market with a no-money-down EE+E value proposition based on projected energy savings, such risk management is critical to expanding the heat pump market. In short, manufacturers should embrace this methodology because it makes the economics of rapid market transformation much more viable.

The Relative Costs of Chitwood Optimization

How does the cost of a "new-school" Chitwood install compare to today's common HVAC installation practices? There are pluses and minuses to consider which apply to both new and retrofit jobs, but in the case of new construction, easier access and elimination of demo costs (duct removal, boot relocation, etc.) make new construction jobs lower cost than retrofit projects:

Retrofit Project Cost Reductions:

1) The HVAC system capacity can be cut in half, reducing system cost by 20%-25% minimum. ($5k ducted heat pump system can save $1,000 to $1300)
2) The system ducting is all smaller diameter with shorter duct runs and every grill having a home run to the supply plenum, which cuts duct material cost by about $250-$400, and reduces assembly labor compared to trunk and branch design by $250 (fewer joints to assemble and shorter ducts).
3) Strapping the ducting to the floor takes less time than hanging it from the ceiling in the attic and shorter runs saves time (Saves $80).

Retrofit Project Cost Increases:

1) Moving grill/boot locations from outside walls toward center of structure adds about $60 per "cut-in" (new boot). A home with 5 boots adds $300.
2) Patching holes in drywall at old locations and texturing: $40 per location. A home with 5 grills adds $200.
3) Oversized supply plenums are sometimes needed if there are more than 5 or 6 "home runs" and starting collars at the supply plenum (can cost $300-$400)
4) Oversized filter grills or additional filter grills may need to be added to improve efficiency, airflow and filter performance. ($400)
5) Bar-type supply grills without dampers and addition of dampers at the supply starting collars adds $6 per grill (special order) and $14 per damper at the starting collar.

So far these costs are about a wash, except for the additional cost of circuit upgrades if required to convert to a heat pump. However, if we are talking about the difference between a "standard" electrification, replacing a 5-ton furnace plus AC with a 5-ton heat pump and an optimized "beneficial electrification" scenario, the circuit upgrade cost may be significantly reduced or avoided if the replacement system is a 2-ton heat pump.

So far these comparative costs have not factored the basic EE measures that make this whole-house approach possible, and which must be done simultaneously in order to allow equipment downsizing: attic air-sealing, attic ventilation and insulation. We can only downsize the equipment if we are simultaneously downsizing the building loads – otherwise we have comfort issues and very unhappy customers.

The cost of adding attic insulation varies relative to site conditions and there are a few potential wild cards:

1) If you are adding R-38 over the top of R-19 batts and you are only partially air sealing without removing existing insulation, you are looking at about $.85/sf to $110/sf (varies with regional economies) to add to existing R-19 batts. So cost for a 1600 sf home is about $1500. If air-sealing is not being performed, cellulose insulation should be used which is denser and reduces leakage, but doesn't bury ducts as deeply.
2) However, if there are existing R-38 ducts, the ducts interfere with your ability lower ducts to the top of the truss (bottom chord), and either portions of the insulation have to be "split" to an R-19 thickness or removed to allow ducts to be buried. This adds to project costs, and illustrate another example wherein retrofitting the most inefficient homes first maximizes ROI and societal benefits.
3) Wild card: If rodents have contaminated the insulation (true for at least 40% of the houses I have seen and there are stats on this), you can't add insulation to such a mess and the attic insulation should be removed and replaced. Removal is about $.65/sf and detox spray can be $200. Filling holes with wire and rodent-proof foam can cost another $200. These are wild cards, but issues that address HUGE biotoxin-health issues. The most recent peer-reviewed science on biotoxin points to 24% of the population carrying the gene that predisposes people to CIRS (chronic inflammatory response syndrome) which is responsible for heart, lung, and brain disorders and many other related illnesses.
4) Homes without accessible attics or vaulted ceilings usually can't be reinsulated without re-roofing and adding rigid foam to the roof deck at considerable cost with a

much lower ROI. Similarly, the cost of re-ducting using Chitwood optimization is not cost effective if ducts are in wall and ceiling assemblies, and duct repairs require significant drywall repairs.

5) Adding attic ventilation is a cost effective measure in high cooling load climates because it can easily drop attic temperatures from 140 F. to 110 F and radically change the BTU losses. A solar attic fan costs $190 and takes about 20 to 30 minutes to install ($250 total). However, performing this upgrade on a home with a raised foundation without first completing floor sealing, raises concerns about increasing depressurization and biotoxin infiltration from the crawl space.

The Barriers Inherent in the Current HVAC Business Model

Data from DNGVL's study on HVAC contractor and consumer attitudes make specific market barriers perfectly clear: The fact that 96% of HVAC system buyers refuse to buy a new system until the old system fails imposes emergency conditions and short timelines on system replacement. Most homeowners are most concerned with getting a replacement system "fast and cheap" and do not understand the indoor air quality implications of not replacing the ducts at the same time that they replace the air-handler. Because system replacement costs are significant, residents are often pressing contractors to save everywhere they can, and permits and HERS testing often are eliminated from the job scope due to cost concerns. It is common for HVAC crews to make assurances of a "quality install", and homeowners tend to believe that the contractor that is installing the 96% efficient furnace is delivering a 96% efficient system. They do not know the statistics from NIST, NCI and ACEEE that show installed efficiency is on average only 56% of rated efficiency, primarily due to duct system leakage, so they imagine they are getting a "good deal".

It is hard to say if the average HVAC crew is fully aware of what is compromised when duct leakage is not addressed and duct testing is not performed on every job. In California, *average duct leakage is 30%* and many systems with pre-UL181 tapes have 50% or higher leakage. Swapping the furnace in the hall closet to meet the client's demand for cheap and fast, has dire consequences and numerous impacts: 1) 30% of the fan watt draw is consumed actively pushing BTUs out of the building envelope – a double efficiency hit which sends energy savings out the window; 2) Severe duct leakage which is most often encountered on the supply side (over 20%) causes building depressurization, which can back-draft flues and lead to CO poisoning dangers at all gas appliances within the conditioned space; 3) Depressurization leads to particulate and biotoxin infiltration with significant health impacts, as noted above there is new science on the impacts of biotoxin infiltration on vulnerable populations, roughly 24% of Californians).

Fixing the Rate of HVAC QI Compliance is Critical to Consumer Safety and Climate Mitigation

For all of these installation quality and indoor air quality reasons, moving the needle from the current 10% compliance rate with HERS requirements on residential installs to 90% is more critical to consumer safety, the success of our energy standards and climate mitigation than perhaps any other single issue. Although SB1414 required the CSLB and the CEC to collaborate on policy to remedy the low levels of compliance on retrofit projects, and numerous workshops and working groups have met on this subject for over a decade, nothing to date has been implemented that would significantly move the needle.

Until it was disbanded last year due to budget shortfalls, the Western HVAC Performance Alliance had working group discussions and lively debate about moving toward a single statewide permitting portal in through which HVAC contractors could both pull permits and business licenses in minutes online without going to building department offices. This would remove a significant barrier and reduce admin costs associated with permits and HERS compliance. But if in addition to this, business license applications included basic stats on the HVAC contractor company size, number of installers and type of work generally performed, a software algorithm could readily project the number of permits a company of such size should pull on a monthly basis to meet its overheads, and the portal would KNOW who was likely not pulling enough permits to justify their business. It could then send automated notices advising contractors to catch up on their permit applications or face escalating penalties. The cost of enforcement, if fully automated, would be close to zero, and minimal burden would fall on building departments while permit fee revenue would increase their operating budgets – a win-win for all concerned.

A New HVAC Contractor Business Model

Perhaps the biggest barrier to Chitwood's whole-house approach to beneficial electrification actually reaching scale in the marketplace is the constraints placed on HVAC contractor licenses.

Although an electrician is allowed to do drywall work if it is "incidental" to an electrical repair, an HVAC contractor is not allowed to perform attic upgrades (or hire subs to do them) even if such upgrades are "incidental" to their ability to deliver double the HVAC efficiency by downsizing the equipment at time of install. Because 96% of the furnace replacements are under "emergency" circumstances, HVAC contractors are usually only thinking about air-handler replacement so they can get to the next emergency on their schedule. There are some serious ironies: CSLB Board Members have said there is "no way" they would reverse 100 years of precedent to allow HVAC contractors to act as primary contractors for upgrades in the attic and crawl space, but HVAC contractors attempting to optimize beneficial electrification would be asked to lose money by downsizing the HVAC system while they turn most of the profit to a third-party general contractor who also takes control of their schedule – a triple loss and a completely unworkable business model. As Tony Seba, the Stanford scholar on market transformation says, "it's all about the business models". Market transformation, scalable electrification of the residential market, cannot happen until the CSLB and the CEC work together to remove market barriers as SB1414 requires.

The EE Measures That 'Win' Every Time

But certain prescriptions have proven over time to be cost effective:

1) Attic floor sealing, including top plate penetrations as well as the drywall to top plate joints cost about $400 to $600 on the average single family home and the reduced leakage is both cost effective for HVAC load reduction as well as better for indoor air quality (more on this later).
2) Repairing duct leakage to below 10% is possible on most retrofits, and it is cost-effective to do so, particularly on jobs wherein ducts need to be replaced. The code should move aggressively toward lower leakage standards on retrofit projects with accessible ducts, with exceptions made for ducts in floor and wall assemblies.
3) All first generation flex ducts should be entirely replaced. These ducts are light gray in color, and the outer sheathing does not hold up in high attic temperatures, so most are disintegrating with R-4 insulation falling off and higher leakage than should be tolerated. Under the EUC program, duct replacement has been found to be so cost effective that there is a very high incentive value for this measure. Duct replacement and repairs should be similarly incentivized in the future.
4) All ducting with pre-UL181 tapes should be replaced or joints resealed. There are numerous studies on this, mostly by LBNL, such as "Anything But Duct Tape", and it

is clear that this should be a part of any energy upgrade and it always increases ROI to the resident provided ducts are accessible.

No Cookie Cutter for "Beneficial" Energy Plus Electrification Upgrades

Because site conditions vary so substantially, it is not always easy to predict which envelope measures will be most cost effective to clients and program managers. For example, under-floor insulation seems like a good idea, but it adds substantially to cost and it may not produce substantial energy savings in a mild climate, while floor air sealing can substantially improve efficiency and air quality provided the crawl space is accessible. In general, homes with crawl spaces are more expensive to upgrade and they have lower ROI than slab-on-grade homes.

1) Homes with raised foundations are also inherently less healthy. Pre-1970's homes with raised foundations typically get up to 40% of their "make-up" air from the crawl space, and over 37% of residents report seeing rodents on an annual basis, meaning this is not a source of "fresh air", and infiltration from this space can pose significant health risks. Twenty-four percent of the population has a genetic predisposition to CIRS, and recent medical research has linked this to a range of inflammatory responses, including asthma, bronchitis, heart and neurological illnesses. Crawl space air sealing is not always feasible due to access issues, but reducing duct leakage and air-sealing the attic can substantially reduce infiltration from the crawl space.
2) All of these wild-card health and efficiency site variables point to the need for a whole-house approach to energy efficiency and electrification upgrades. If we are going to define "beneficial electrification" to include non-energy benefits such as health impacts, all HVAC contractors need to be aware of the indoor air quality impacts of duct leakage as well as combustion safety issues related to building depressurization and back-drafting of combustion flues – problems which are all too common.

All such health and safety concerns point to the need to train all HVAC contractors on basic whole house principles. Perhaps they don't all need to have BPI-level certification, but mandatory advanced training is warranted given the significance of these IAQ issues as well as the imminent introduction of low-GWP refrigerants that are slightly flammable and require training on system design and material handling. A new round of mandatory advanced training for all HVAC contractors is warranted, and may be the only way we are going to be able to meet decarbonization requirements in a manner that maximizes "beneficial electrification" by 2050.

Conclusions

In summary, in high cooling load climates, with single family residences with accessible attics and most ducts in attic, the additional cost of full or partial "Chitwood" install (not best practice, but 80% to 90% there) may be only zero to $3k depending upon site conditions. If high cooling loads create a potential $400-$500 in annual energy savings, the worst case cost has a 4-5 year payback for the resident, but avoids foreseeable grid infrastructure costs that will otherwise be passed on to ratepayers. Energy savings are going to be more moderate, and in some cases non-existent in mild climates where many homes have a gas furnace only with no AC. There are clear compliance and licensing barriers that prevent HVAC contractors from adopting the Chitwood method into their business model which must be addressed if we are to maximize societal benefits and set the stage for broader market transformation.

It is important to note that the Inclusive Finance Model (Tariff on Bill) for EE+E projects which will be reviewed by the CPUC in upcoming finance proceeding, would require a risk assessment tool that would accurately project the energy savings given site conditions and proposed EE plus E (electrification measures). It would also require a whole house approach to HVAC optimization in order to be most cost-effective and maximize paybacks and to reduce risk for both homeowners and investors. The potential for a fifty-fold increase in EE projects with partial or full electrification fully or mostly financed with private capital based on the security and certainty of projected energy savings may be a game changer, and it is far more important to shoot for optimizing paybacks, ROI and minimizing risk rather than "best practices". A balanced approach is needed to make broader market transformation a reality. Attempting to go zero energy on retrofits is not cost effective on many projects, because some measures involve increasing costs with diminishing returns on investment. We will have the greatest GHG reduction if we are able to target a much larger segment of the housing market including rental properties that usually have deferred maintenance, while also targeting the low-income families that need the most economic relief. Pragmatism is called for in order to find the balanced solutions that make the economics of market transformation work.