October 31, 2011

Ingersoll Rand Residential Solutions comments on California Energy Commission Staff Proposed Amendments to Title-24, Part 6, Subchapters 2 and 7

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1. 150.0(m)(15) Restrictions on HVAC Air Flow.

The staff draft proposed language of 150.0(m)(15) says:

> **"Zonally Controlled Central Forced Air System.** Central forced air systems shall simultaneously demonstrate, in every zonal control mode, an airflow from the residence and through the circulation blower greater than 350 CFM per ton of nominal cooling capacity and a blower Watt draw of less than 0.58 W/CFM as determined utilizing the methods specified in Reference Residential Appendix RA3.3."

It is not really appropriate to require that the "airflow from the residence and through the circulation blower [be] greater than 350 CFM per ton of nominal cooling capacity". The concern of IRCO is not the application of this limit to zoned systems, but the fact that it will be applied to all cooling systems.

This requirement does not take into account contemporary practices employed in the design of modern high efficiency equipment. It is quite common today to employ air flow though systems at 350 CFM/Ton or lower. In fact, IRCO has approximately 14,500 AHRI ratings of Trane and American Standard air conditioners rated at less than 350 CFM/Ton. That reflects the reality of the psychrometric principles applied in HVAC design.

To explain this point, it is first necessary to realize that virtually all places in the continental U.S. require dehumidification at least occasionally. We tend to think of places as having a dry climate if they have little rain. Imperial, California, might be a good example, with about 3 inches of rain per year according to NOAA/NCDC. However, in terms of design dew-point, Imperial lies between Chicago and Atlanta, neither of which would be considered to have a dry climate. [The ASHRAE 2% design dew-points and the annual rain fall for several cities are shown in the chart below.]

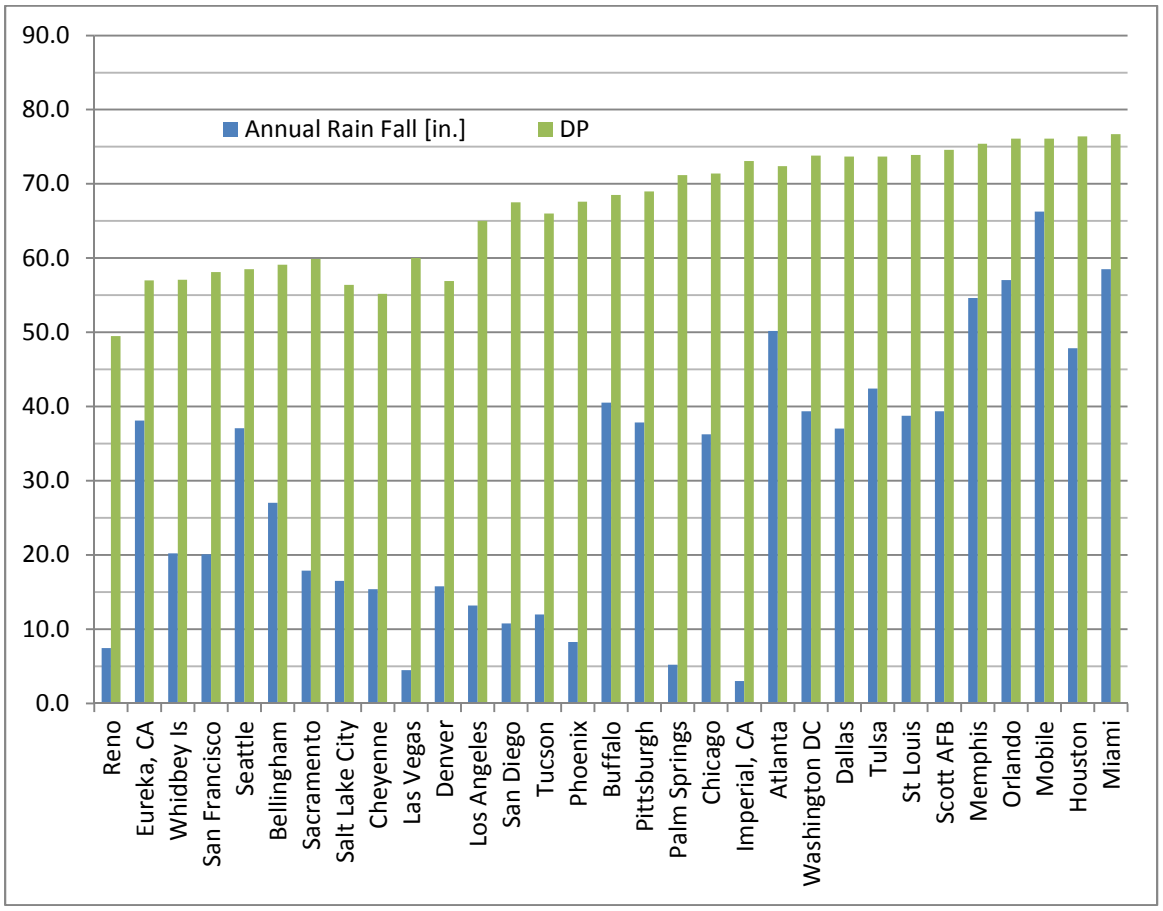
The apparent dilemma is explained, at least in part, by the fact that very warm air can contain more moisture than very cool air. So, cool places like Eureka, CA, San Francisco, and Seattle have lower design dew-points than do some desert locations like Tucson, Phoenix, and Palm Springs.

Given that the air in buildings comes from outdoors, and that, above the condensation temperature, dew-point is not affected by dry-bulb temperature, the dew-point in buildings will be the same as it is outdoors unless humidity is added to the air by cooking and bathing, etc., or is removed by an air conditioner.

Whether dehumidification occurs in an air conditioner at any particular time is determined in large measure by the indoor wet-bulb and dry-bulb temperatures, or alternately by the dew-point

and dry-bulb temperature. Cooling performance of a representative split system with a coil and furnace is shown in the Table-1. At 80°F or even 78°F indoor dry-bulb temperature and 59°F wet-bulb, the sensible cooling capacity is the same as the total capacity. This is the so-called dry-coil condition under which no dehumidification occurs. --- At the other extreme, with 71°F wet-bulb and 72°F dry-bulb, almost at 100% relative humidity, over two-thirds of the capacity is latent cooling [dehumidification]. Of course, a properly designed and operated system should never let this situation occur.

As the industry strives for more efficiency, and to make efficient systems more cost-effective for the consumer, there is a tendency to decrease indoor air flow under rating and operating conditions. The motivation lies in the physics of airflow and heat transfer. The power consumption of the blower increases by about the cube of the airflow [the cube in theory, but somewhat less due to non-ideal components]. This means that the blower power could increase by almost 50% when the air flow is increased from somewhat below 350 CFM/Ton to 400 CFM/Ton. The corresponding increase in capacity would be on the order of 10% or less.



Conclusion IRCO urges the California Energy Commission to avoid placing air-flow minima in HVAC specifications in Title 24, or elsewhere. As illustrated here, these can reduce the utility of the air conditioner and decrease its efficiency [or conversely, increase the cost to achieve a given efficiency level].

TABLE 1. -- COOLING PERFORMANCE AT INDOOR DRY BULB TEMPERATURES

OD AMB	ID WB	TOT CAP	72	75	78	80	KW
85	59	33.7	27.0	30.2	33.4	33.7	2.68
	63	35.3	22.1	25.4	28.6	30.7	2.70
	67	37.7	17.5	20.8	24.0	26.1	2.73
	71	40.9	13.1	16.4	19.6	21.7	2.76
95	59	31.7	26.1	29.3	31.7	31.7	2.97
	63	33.3	21.3	24.6	27.7	29.9	3.00
	67	35.6	16.7	20.0	23.2	25.3	3.03
	71	38.6	12.3	15.6	18.8	20.9	3.06
105	59	29.8	25.2	28.5	29.8	29.8	3.26
	63	31.3	20.5	23.7	26.9	29.1	3.30
	67	33.4	15.9	19.2	22.4	24.5	3.33
	71	36.2	11.5	14.8	17.9	20.1	3.36
115	59	27.9	24.4	27.2	27.9	27.9	3.55
	63	29.2	19.7	22.9	26.1	28.2	3.59
	67	31.3	15.2	18.4	21.6	23.7	3.63
	71	33.9	10.7	14.0	17.2	19.3	3.66

2. <u>Requirement for [Upgradeable Setback] Thermostats</u>

110.2 (c) **<u>Thermostats</u>**

> *In addition to the comments below, which are in direct response to the staff-proposed revisions to Title 24, Part 6, there is attached hereto a set of comments provided to the US EPA on their "Residential Climate Control" Partner Commitments, Version 1.0, Draft 2 by IRCO on April 30, 2010. These are provided in anticipation that CEC will try to coordinate the Title-24 requirements for thermostats with those of other agencies.*

In expanding the coverage by roughly an order of magnitude over the length of the coverage in the 2008 standards, it is evident that the CEC is striving for specificity. However, the specificity added is a combination of rather ambiguous generalizations and specificity that tends to lead the user to proprietary designs or features.

1. Setback capabilities: This is essentially a repeat of the wording in the 2008 standard and no comment is needed.

2. Upgradeable Capabilities: It is not clear why it is stipulated that "USTs shall not include onboard communication devices" other than as a reflection that no communication protocols and interfaces have been standardized to the satisfaction of the CEC; or alternatively, that it is anticipated that the UST' will have to communicate via one of a variety of standards not yet selected for each utility of other controlling entity. As a consequence, it is impossible to assure

that the UST's will be fully compatible with the evolving utility interface of choice for any given application.

Provision of an "expansion port" to accommodate a communication module, necessitates that the particulars of that port be defined.

Whether or not the UST can receive and respond to DR signals is a mixed requirement. Receipt of the signals is dependent on the communication protocol defined and the ability of the UST to accommodate this module through an as-yet-undefined port.

Response in this specification is interpreted as taking an action within the UST "in response to" the command, as contrasted to "responding to" the entity that issued the DR signal. That is, the communication called for in interpreted as being unilateral [simplex] as contrasted to bilateral [duplex].

A. Event Response.

The CEC is urged to coordinate this function set and, the specifications, therefore, with the U.S. EPA so that they may be common.

The reasoning behind the stated response to pricing signals is not clear. It is generally assumed that the pricing signals are intended to enable the occupant to make informed decisions on the settings of the UST. In that context, one would assume that these decision would be adaptive, adjusted depending on the particulars of the price signal including its very nature, such as whether the signal provides particulars on tomorrows peak rates, or something along the lines of "the price in increasing" without telling by how much or for how long.

B. Override Function: --- Agreed.

3. Other Required Capabilities:

A. Expansion Capabilities

Designing to provide the ability for the occupant to be able to insert or remove the communications module without the need to use tools or hardware, makes it very clear that the manufacturer of the UST must know, a priori, the size and shape [and tolerances] and interface characteristics of the module so that appropriate accommodations can be made.

B. Display

In an apparent attempt to avoid over-specifying, the proposal is ambiguous.

The mention of a stand-alone indicator using light-emitting diodes is confusing in at least two regards. First, it suggests that this is a service diagnostic tool, not an occupant-informing device. Items i, and iii in the list reinforce this impression.

If more than rudimentary communication with the user [occupant or technician?] is intended, something more than LEDs is going to be required.

It is inappropriate to cite an LCD when other technologies such as plasma, etc., might work as well or better.

The enumerated applications of the display are very ambiguous:

i) What is sought in terms of status? Anything beyond “communicating” or “not communicating” OR “sending” or “receiving” will likely require essentially continuous duplex communication just for status monitoring.

ii) It would be hoped that a display to the rate-payer would be more informative than suggested here. In the event of a DR event, the rate-payer might reasonably expect some indication of the duration of the event. In the event of a pricing event, the price and expected duration of the event should be communicated. In both cases, “duration” should communicate the start and end times.

iii) Other maintenance-related information needs to be expanded so that the UST manufacturer has some idea of what display capability is sought.

C. “Mapping of terminal numbers 1-6” is unclear.

First, it is important to distinguish between the terminals that connect the UST to an external power source and the controlled equipment, those envisioned for the “standalone indicator”, those for the interface between the UST and the to-be-defined communication module, and possibly those between the UST with communication module and a phone line, cable, or internet connection.

Second, the standard thermostat terminals are identified by an alphabetical code, as illustrated in NEMA DC-3. They are not numbered.

D.

The notion of randomizing requires further elaboration. First, how many “time slices” are sought within the prescribed 30 minute period? Second, what provisions are to be made to assure that the return-to-normal times are not only randomized but also unsynchronized? If all USTs had the same random algorithm, they might all return to normal at the same, but random, time.

E.

The staff proposal makes reference to “Reference Joint Appendix JA5”, but the CEC website shows the following.

2008 Joint Appendices (2011 Update in Progress) JA5-1

Joint Appendix JA5

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F.

This provision states that the UST is to “Reference default program as specified in Energy Star XXX”. While it is understood that CEC staff cannot be more explicit on the document ID while it is still in flux, it is not clear what is meant by “Reference the default program”.

Please contact me with any questions that you may have.

Thank you,

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Attachment

April 30, 2010

Ingersoll Rand Residential Solutions comments on: Energy Star Program Requirements for Residential Climate Controls, Version 1.0, Partner Commitments, Draft 1 [undated]

GENERAL COMMENTS

Nature and descriptive title of the product The product covered by the ***Program Requirements for Residential Climate Controls*** is first and foremost a ***thermostat***. This is an important distinction because the consumer who is expected to purchase this product knows what a thermostat is, but not what a "climate control" is. Climate is a very long term pattern of weather. The communicating aspect is what distinguishes the product under discussion from the current programmable thermostat offerings, and the intended external monitoring and control to be effected through the communications is short term, essentially instantaneous. It would be more accurate to call it an indoor weather control, which might be universally recognized as a poor choice.

Lack of a consensus standard For most, if not all other Energy Star products, there exists either an actual or de facto standard for the product or the Energy Star requirements constitute a relatively minor addition to the features of the covered products. High efficiency furnaces would be an example where Energy Star qualifying products were widely available before the program standard was set, and the standard was presumably targeted at the top 25% of those products in terms of efficiency. The Energy Star requirements for entertainment electronics would be an example where the added features specified were a relatively small part of the total feature set of the covered products.

In the case of the "Residential Climate Controls", EPA is specifying a feature set which is a very substantial increase in the feature set of programmable thermostats that are currently widely available in the market.

Coordination with Smart Grid It is not clear how the controls described in the Program Requirements are intended to interface with the Smart Grid. On the face of it, it appears as though the controls are intended to interface with the Smart Grid, but the Smart Grid requirements are very much in a state of flux and various utility programs are progressing along different lines on aspects of the Smart Grid. This raises the question of how the subject control can be designed to be compatible with all of these.

Ramp-up of the installed base for significant penetration will take many years. The current market is reported [private communication] to be on the order of 10 million units per year. With some 130 million dwelling units in the U.S., it would take something on the order of 13 years to have the subject controls in substantially all dwelling units. It is anticipated that during that time, program requirements may well change to such an extent that controls purchased early will be obsolete within a few years.

Cost of the controls During the webinar on April 19th, the EPA representative estimated that the subject controls will cost several hundred dollars. A cost in that range raises the question of why the consumer would opt to purchase the control, especially if he had a system that was working to his satisfaction. Many consumers may not have the discretionary finances to make such a purchase. This means that, if time-of-use rates are imposed, either some accommodation must be made for the less affluent consumers or they will suffer disproportionately.

Effective Date Because of the lack of an actual or de facto consensus standard for the products under discussion, the time table defined by EPA in the April 19, 2010 is unrealistic and unreasonable. The product is, by intention, a major departure from the overwhelming majority of the products in the market, and, by implication, from the overwhelming majority of the product designs available in the supplying industry. In EPA's April 19th webinar, the following time table was presented:

- 3-31-2010 Draft 1 Version 1.0 Residential Climate Controls specification
- 4-19-2010 Stakeholder webinar
- 4-30-2010 Stakeholder comments due
- May 2010 Draft 2 specification
- June 2010 Stakeholder webinar
- July 2010 Draft usability metric
- August 2010 Stakeholder webinar
- September 2010 Final draft specification
- October 2010 Final Version 1.0 Residential Climate Controls specification

Section 5) of the Program Requirements document indicates that the specification "shall go into effect on October 1, 2010" and that "[a]ll products must meet the requirements … [of the specification] … to qualify for Energy Star.".

Thus, there is zero lead time between the release of the final specification and requiring compliance with that specification. A reasonable lead time would be 6 to 12 months, and even that could be challenging.

Cycle rate [definitions page 5] is an important aspect of the proper function of thermostats applied to most furnaces, air conditioners and heat pumps, the overwhelming majority of which are neither staged nor modulated. In fact, even with staged appliances, cycle rate is important although it can take on the additional meaning of the frequency of cycling between stages. It is only with continuously modulated appliances that the concept of cycle rate may be inapplicable. It may have relevance even there since few if any appliances modulate down to 0% output.

Automatic Switchover and Safeguard Settings The Program Requirements should include automatic switchover and define the requirements such that it provides the feature without an efficiency penalty. This would require some form of "smart" switchover. --- If there is a significant need for or benefit from modes like "Away" and "Long-Term Hold", then the automatic switchover should be associated with safeguard settings. The most obvious of these would be intended to protect plumbing fixtures against freezing. Although overheating effects might not be as dramatic, the control should protect against these also.

Vulnerability to Hacking With an open protocol for communications, the subject controls would appear to be especially vulnerable to hacking once the installed base reaches a size that

interests hackers. This could take the form of passive hacking, such as monitoring energy use patterns to identify promising burglary prospects, or active hacking to turn systems on or off at inappropriate times of to adjust setpoints to temperatures that are too high or too low.

COMMENTS BY SECTION

1. Section 1: Although it appears that this standard requires some form of external communications for all Residential Climate Controls, the wording is not consistent throughout. For instance, Section 2 states “Any Residential Climate Control that complies with either the “Climate Control” or “Communicating Climate Control” definition in Section 1.1 is eligible for Energy Star qualification.”

The standard should allow non-communicating Climate Controls to be eligible for two reasons: (1) User-programmable, non-communicating controls can save significant energy according to the standard, and (2) open protocols for the required communications are not yet developed and available. Even though the standard does allow an exception for “field upgradeable” communication capability, manufacturers should not expend time and effort developing a feature or option that may become obsolete or more expensive when future open protocols are agreed upon.

2. Section 1: There needs to be a definition for “Away” mode. This term is used throughout with no consistent meaning.

3. Recovery, Heat Pump with Auxiliary Heat: The definition of this in Section 1.A.15 calls it an “algorithm that minimizes the use of auxiliary heat to maximize energy savings.” Prior research shows that minimizing the use of auxiliary heat does not always maximize energy savings. Under some colder outdoor conditions, the use of auxiliary heat to assist recovery can increase energy savings by allowing for a longer setback period. This requirement is also incomplete in that it does not specify how one determines if their algorithm truly “maximizes energy savings”.

4. Section 2.C: Residential HVAC systems and controls are routinely installed in small commercial businesses. Does EPA have data to support the statement that residential controls in non-residential applications “are likely to waste energy and not comply with applicable building codes”? More to the point, the controls should have adequate flexibility to accomplish the energy-saving goals for these small commercial applications. The schedules defined on page 9 of the Program Requirements should have sufficient flexibility to meet the needs of the small commercial application.

5. Section 3.5: The allowable “Away” setpoint values should not be limited. That may discourage people from using the "Away" feature if they do not wish to have that large a setback. That would reduce the amount of energy savings that can be achieved. Limiting the "Away" setpoint values will promote the use of one of the Hold options. Users will ultimately revert to Hold if they don’t like default settings

5.a Section 3.7 : Is the standard low-cost off-the-shelf Climate Control model, intended to act as the baseline for comparisons in qualifying controls as mentioned in the Note at the bottom of page 11 currently on the market, and if so, what is the make and model number? Unless that control is defined in the near term, control manufacturers will have no idea of the product against which the usability of their products will be measured. The usability test is essentially a

human-factors test, and the human-factors interface affects the physical design of the product as well as functional design, with ripple effects on circuit boards, tooling, test equipment, etc.

6. Section 3.13: Why do all Climate Controls need access to outdoor temperature even if they do not use that information? If an EMS needs outdoor temperature, it should have its own capability. This rather simple-sounding requirement could lead to costly wiring changes for existing heat/cool installations. The tens of millions of housing units which have central heat but not central air conditioning might well benefit from a programmable setback comfort control, but have no need for any signal wiring to the outdoors.

7. Section 3.14: Why is humidity measurement required? We question whether there is data to support the claim that reducing humidity levels and raising temperatures will save energy while providing equivalent comfort? This is certainly not true in heating, and it is questionable whether it is true in a well-designed and well-applied air conditioner. ---- Humidity control and its benefits are quite system-dependent, and no specific systems are specified for this feature. --- Explicit humidity control, as contrasted to that coincidental to heating or cooling, will increase energy consumption. For example, narrow-range humidity control is sometimes achieved by cooling and dehumidifying with re-heat to maintain thermal comfort.

7.a Section 3.15: Adaptive recovery routines to reduce use of supplementary heat for heat pumps will result in the system starting recovery from setback earlier and decrease the setback time by as much as four hours. As noted in 3. above, this may result in increased energy consumption through shortened set-back periods.

8. Section 3.16: Maximum power consumption of 0.5 W is too low for practical devices and probably not economically justified. This requirement should be higher (8 -10 W), and should include the operational power required by the communication hardware. --- There should perhaps be a distinction drawn between peak power and average power consumption. --- There are a few mentions of batteries in the Program Requirements document. It is questionable whether a battery-powered device could have sufficient capacity to actuate control hardware in the HVAC system for 12 months without replacement unless the controlled hardware "made up the deficit". That would not reduce the energy consumption; it would simply move it elsewhere in the system. If batteries are considered for normal operation [as contrasted to back-up for power outages] then the full environmental impact of their use should be considered. ---- Do line-powered controls also have to meet the 0.5 watt power restriction?

8.a Section 3.18: Reducing the Night setpoint to 78 degrees is a step in the right direction but the occupant will most likely set it lower in the southern states due to the hot humid conditions.

9. Section 3.19: This section indicates that the Software Development Kit must give “access to the product’s full range of communication and remote control capabilities.” It is important that this be limited to the parameters described in Sections 3.22 and 3.23. Otherwise, it constitutes an open-ended requirement to which a manufacturer cannot design with any confidence.

10. Section 3.20: This section states that “Where suitable open communication standards exist, they must be used.”

- Does this mean it must be compatible with all open communication standards?
- Who determines which standards are “suitable”?
- Will EPA provide a list of such open standards which the controls are intended to accommodate?

- Is it expected that a given control will be compatible with multiple open protocols?

11. Some existing thermostats allow auxiliary heat to be used during heat pump operation, even when not needed to meet the load. This feature is used by some people to provide higher supply air temperatures even though it significantly reduces the overall heating efficiency of the system. This should not be allowed in controls meeting Energy Star Program Requirements.

12. Control algorithms for newer, higher-efficiency systems are becoming increasingly more complex and equipment-specific. These proprietary algorithms are partially or completely located in the "Climate Controls" and control characteristics such as the current speeds of fans, blowers and compressors, or the current operating stage of multi-stage equipment. This raises several considerations:

- While it is appropriate that communication with these controls be via open protocols, the control algorithms themselves cannot be open without compromising Intellectual Property.
- Use of third-party controls with these systems would require either tailoring the controls [under a confidentiality agreement], or partitioning the control algorithms into a separate physical unit.
- If a third-party supplier intends that his control be used with a given HVAC system, the third-party supplier must be held accountable to verify compatibility to the satisfaction of the consumer and the manufacturer of the equipment under control.
- In general, modulated equipment should not be shut off during utility high load conditions. It should perhaps be set to a lower heating or cooling capacity [stage, speed, etc.].
- Remote control of modulated equipment may require additional parameters to be added to the lists of 3.22 and 3.223.

13. The actual room temperature (rounded to the nearest one degree) should be displayed at all times. Changing the setpoint should not alter the actual room temperature being displayed on the control. If the set point is to be continuously displayed, it should be in a distinctly smaller font than that used for the room temperature display and should be clearly labeled to avoid confusion.

EXPLICIT QUESTIONS FROM THE WEBINAR OF APRIL OF April 19, 2010.

Q 1: EPA welcomes input on definitions. Are relevant definitions missed? Can wording be improved?.

A 1: Comments and recommendations are provided above

Q 2: EPA requests comment on requirements for 3rd party access and use of open standards for communications. Are there alternate paths to achieve these goals?

A 2: The requirements for open protocols for external communication and control presuppose the existence of an as-yet undefined environment in which utilities or other entities exercise

monitoring and control functions and provide informational communications with the unit in the home. The developments in this direction are moving along divergent paths broadly characterized as Smart Grid and Home Area Network. This has not reached a point which would provide confidence that the EPA Program Requirements will be compatible with the eventual outcome. An attempt to generalize the requirements to accommodate any and all outcomes is unrealistic and will result in undue product cost.

There is no reason why the communications between various elements of the HVAC system should employ open protocols or should be open to monitoring or external intervention.

Q 3: EPA welcomes input on data frequency, data transmission and remote control response. Are requirements reasonable? What system level throughput is being achieved in utility implementations?

A 3: Very few "normal" events happen rapidly or frequently in HVAC systems or on the power grid which serves them. In terms of HVAC hardware events, there may be a basis for recording when events occur [perhaps with a resolution of one minute], but transmission of that information more often that twice an hour might not serve any useful purpose.

The data and communication rates and implied external command rates imply that a strong underlying motive at work in these requirements is provision of data strictly for research purposes. Thus, in effect, the consumer is being asked to pay a premium for a product so that a third party can monitor his management of his own HVAC system.

In thinking about bi-directional event reporting, it is important to consider what the receiver of the information is able to do with the information and how long it takes to do so. For example, there is no reason that a change in time-of use rates should not be announced far enough in advance to permit the controls in the residence to respond to avoid or reduce exposure to peak rates. This is clearly true for the "tariffs" but it is equally true of the impending entry into a peak rate period.

Development of definitive answers to questions about the appropriate sampling rates and report frequencies requires that the full intended function sets be defined, that each function be evaluated, and that consensus be reached between representatives of the "sender" and "receiver" communities.

Q 4: EPA welcomes advice on all aspects of test design, such as test concept, number of users, selection criteria for user panel, etc.

A 4: As noted above, the most evident gap at the moment is lack of identification of the baseline unit against which products will be measured. This is coupled with the fact that the intended test concept is totally subjective and arbitrary.

The pass/fail criteria should be defined <u>now</u> in absolute terms such as number of steps to achieve each function and the number of buttons or other input devices involved. This requires that each intended programming function for the minimal acceptable function set be defined.

There should be expected to be significant generational differences in the "comfort level" level of the user with the programming process. EPA needs to identify how these differences will be accommodated.

Is it EPA's intention that the controls will have an "erase" button for use in programming, and how many of the preceding key strokes would be affected?

Q 5: Are these tasks reasonable [for the usability test]? Are there others we should use in addition or instead? How many tasks?

Proposed Tasks:

- Initial setup
- Establish constant temperature
- Establish a day/night schedule
- Establish a 5/2 schedule
- Activate Away mode
- Cancel Away mode & restore program control
- Recognize active modes and parameters

A 5: Until the function set is better defined, it is impossible to tell whether this is an adequate test outline. But, as a simple example of the need for expanded definition consider the followinbg:

- An "Away" mode would presumably be at constant temperature so "Activate Away mode" would seem to be indistinguishable from "Establish constant temperature".
- Likewise, "Establish a day/night schedule" would seem to be a subset of "Establish a 5/2 schedule".

Q 6: EPA welcomes recommendations for an appropriate readability test or standard to replace the font size requirement.

A 6: The key here would seem to be to define and then accommodate the variations within an overwhelming majority of the population. This should involve definition of character size, font, line thickness, color, and contrast as a minimum [e.g., consideration of the use of different colors for different system states must take into consideration the number of color-blind people.]. Likewise a reasonable range of departures from normal vision must be taken into consideration.

Q 7: Are these [usability secondary requirements] appropriate requirements? Are there others?

- Single operation to activate “Away” mode
- Green –Yellow –Red LEDs, or equivalent, capable of providing at a glance TOU price tier indication
- Single operation temperature adjustment
- Font size

A 7: A 6 addresses the color issue and font size. --- The question on the "Away" mode cannot be answered with certainty until "Away" is better defined. For example, the user may wish to define how many hours, days, or weeks he will be Away, or he may prefer a simple indefinite

Hold until he returns and adjusts the control to its normal schedule. --- For temperature setting, there should be one "button" for "Up" and one for "Down". A "button" might be any form of contact sensor.

Q 8: EPA welcomes input on the default recovery requirement. Will adaptive recovery enhance user comfort, reduce overrides and auxiliary heat use, or will it confuse users?

A 8: This has been addressed in the General Comments section above.

Q 9: EPA welcomes input on humidity control and accuracy. Are requirements reasonable? Should independent temperature & humidity control be considered?

A 9: The numerical requirements are covered in the comments above. --- If temperature and humidity are controlled independently, the energy consumption will necessarily increase. The trivial example is humidification during the heating season. This requires vaporization of water which requires on the order of 1000 Btu per pint of water evaporated. --- Separate control of cooling and dehumidification would also require a significant increase in energy consumption, possibly a large increase if precise control were sought.

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