INTERPRETATION IC 90.1-2010-15 OF
ANSI/ASHRAE/IES STANDARD 90.1-2010
Energy Standard for Buildings Except Low-Rise Residential Buildings

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Reference: This request for interpretation refers to the requirements presented in ANSI/ASHRAE/IES Standard 90.1-2010, Section 6.5.1.4, relating to Economizer Heating System Impact.

Background:

Section 6.5.1.4 of Standard 90.1 states:

Section 6.5.1.4 Economizer Heating System Impact.
HVAC system design and economizer *controls* shall be such that economizer operation does not increase the building heating *energy* use during normal operation.

90.1-2010 User's Manual Page 6-69 (my emphasis) states:
Economizer Heating System Impact (6.5.1.4)
The Standard requires that the HVAC system and economizer design and controls be such that operation of the economizer does not increase building heating energy **costs** during normal operation.

Interpretation No.1: The requirement in Section 6.5.1.4 is based on building heating energy use, not building energy cost.

Question No.1: Is this interpretation correct?

Answer No.1: Yes

Background: In a water-source heat pump system:

- A heat pump operating in the heating mode uses a combination of heat absorbed from the condenser loop and heat of compression (compressor input energy) as heat delivered to the building space.
- If there is little or no heat added to the condenser loop by other water-source heat pumps operating in the cooling mode, a boiler adds energy to keep the loop water temperature from falling below its lower setpoint.
- The sum of the heat pump compressor energy and boiler energy used to add heat to the loop is required to maintain the space at its desired heating setpoint.
- The boiler energy use is the heat energy added to the loop water divided by the boiler efficiency.

- Therefore, at such a condition, the building heating energy use is the sum of compressor energy use (in the heating mode) and boiler energy use.

Interpretation No.2: For a building with a water-source heat pump system, a boiler and no other heat source, the building heating energy use includes both compressor energy use (for those heat pumps operating in the heating mode) and any boiler energy use.

Question No.2: Is this interpretation correct?

Answer No.2: Yes

Background: 90.1-2010 User's Manual, Page 6-66, states:

Example 6-LL. Waterside Economizer, Water-Source Pump System
Corresponding section: Water Economizers (6.5.1.2)

Question:
Because of the difficulty of providing air economizers with water-source heat pumps mounted above ceiling, a precooling coil type of water economizer, shown in Figure 6-O, is proposed instead for each heat pump serving both interior and exterior zones of an office building. Does this design comply with the Standard?

Answer:
No. This design can meet the requirements of Section 6.5.1.2 and 6.5.1.3, but it will not meet the requirements of Section 6.5.1.4 which requires that economizers be designed in a manner that will not increase the heating energy usage of the system…
With the proposed design, in cold weather the economizer will require that condenser water temperatures be cold enough to provide free-cooling in interior zones. This cold temperature, however, will increase the compressor energy required by those heat pumps serving exterior zones operating in the heating mode (the colder the water temperature, the more compressor energy required)…"

If interpretation 2 is correct, the building heating energy use includes both WSHP compressor energy use and boiler energy use. Example 6-LL only considers compressor energy use, not the overall *building* heating energy use (which must include boiler energy use also).
When an interior (or any other) zone is cooled by this type of pre-cooling waterside economizer, the heat from the space is rejected to the condenser loop. This heat rejection to the water reduces the amount of heat that the boiler must add to the condenser loop. So, to properly examine the impact on the overall building heating energy use, the reduction in boiler energy use must be accounted for in this example.
So the question is, if the loop water temperature is lowered to enable the use of a pre-cooling waterside economizer coil, how does the impact of increasing the WSHP compressor kW (for those heat pumps operating in the heating mode) compare to the reduction of boiler energy required (because of the heat added to the loop by the waterside economizer for those heating pumps serving zones that require cooling).

Attached is a spreadsheet with calculations at the 90.1-2010 utility rates of $.0939/kWh and $1.22/therm; here is an example at one set of heating and cooling requirements:

- Heating load = 61 MBh
- Cooling load = 5 MBh
- Boiler efficiency = **100%**

sample 5-ton WSHP	Entering Water Temperature from Loop		
	45°F	55°F	68°F
WSHP Heating COP	3.70	4.04	4.4
If an airside economizer is used:			
WSHP compressor energy (heating mode), kW	4.83	4.43	4.06
Boiler energy input, MBh	44.51	45.90	47.14
Overall building heating energy, MBh	61.0	61.0	61.0
Overall building heating energy, $	1.00	0.98	0.96
If a pre-cooling waterside economizer is used:			
WSHP compressor energy (heating mode), kW	4.83	4.43	4.06
Boiler energy input, MBh	39.51	40.90	42.14
Overall building heating energy, MBh	56.0	56.0	56.0
Overall building heating energy, $	0.94	0.91	0.90

For this example, a proper comparison is between a system with an airside economizer with a loop control temperature of 55 degrees (61 MBh), and a system with a pre-cooling waterside economizer with a loop control temperature of 45 degrees (56 MBh). Clearly, the system with the pre-cooling waterside economizer has lower building heating energy use.

In all cases examined, when the energy from the waterside economizer is rejected to the condenser loop, the overall building heating energy use is reduced. Note that with a 100% efficient boiler (e.g. electric heat with no losses), the additional heating compressor kW is exactly offset by the boiler input energy. That is why building heating energy use is the same at all temperatures.

If the boiler is fossil fuel-fired, and therefore less than 100% efficient, the overall building heating energy use is less when a waterside economizer is used. Here is the same example with an 80% efficient boiler:

- Heating load = 61 MBh
- Cooling load = 5 MBh
- Boiler efficiency = **80%**

sample 5-ton WSHP	Entering Water Temperature from Loop		
	45°F	55°F	68°F
WSHP Heating COP	3.70	4.04	4.4
If an airside economizer is used:			
WSHP compressor energy (heating mode), kW	4.83	4.43	4.06
Boiler energy input, MBh	55.64	57.38	58.92
Overall building heating energy, MBh	72.13	72.48	72.78

Overall building heating energy, $	**1.13**	**1.12**	**1.10**
If a pre-cooling waterside economizer is used:			
WSHP compressor energy (heating mode), kW	**4.83**	**4.43**	**4.06**
Boiler energy input, MBh	**49.39**	**51.13**	**52.67**
Overall building heating energy, MBh	**65.88**	**66.23**	**66.53**
Overall building heating energy, $	**1.06**	**1.04**	**1.02**

Again, the system with the waterside economizer uses less total building heating energy (65.88 MBh) than the system with the airside economizer (72.48 MBh).

Since Section 6.5.1.4 is based on overall *building* heating energy use, and building heating energy use includes both compressor energy use (in the heating mode) and boiler energy use, Example 6-LL is not correct.

If Interpretation 3 is correct, an erratum should be issued deleting Example 6-LL – **or, preferably,** replacing 6-LL with an example showing that waterside economizers on water-source heat pump systems meet the requirement of Sections 6.5.1.2, 6.5.1.3, and 6.5.1.4.

The committee could state that the User's Manual is not part of the standard, however, examples in the User's Manual are commonly used by design teams and code officials to interpret the standard. Leaving Example 6-LL as is, is not a tenable position since the example does not address boiler energy consumption, only heating WSHP compressor energy consumption, and therefore the example is incorrect

Interpretation No.3: Section 6.5.1.4 is based on overall *building* heating energy use, and building heating energy use includes both compressor energy use (in the heating mode) and boiler energy use, Example 6-LL is not correct.

Question No.3: Is this interpretation correct?

Answer No.3: Yes

Comments: The MSC agrees this example be eliminated from the User's Manual and has put it on the 2013 User's Manual tracking list.