Evaluation of Low-E Storm and R-5 Windows for inclusion in Pennsylvania's Weatherization Priority List – Report by Energetics in Collaboration with LBNL

May 11, 2010

Analysis Methodology for Low-e Storm Windows

The Weatherization Assistant energy audit software (version 8.6) was used to evaluate the impact of low-e storm windows in each of the same 37 reference homes employed in development of the most recent Pennsylvania weatherization measure prioritization list. [Dalhoff, Jan 2010] Only site-built homes were evaluated using NEAT, as the MHEA algorithms used for mobile homes do not yet include the capability to model low-e storm windows.

These 37 homes were evaluated with natural gas heating systems in Scranton, Harrisburg, and Pittsburgh, and Philadelphia (representing the North Central, South East, South West, and Philadelphia regions, respectively).

Low-e storm windows were modeled with the following parameters:

- same pricing as the LBNL analysis (average $7.85 per ft2, plus $15 per window for other installation costs)
- glass emissivity = 0.22
- center-of-glass solar heat gain coefficient = 0.74
- 15 year lifetime
- Both Furnace efficiencies of 94.7% and 80%
- Natural Gas Heating

It is believed that low-e storm windows will last as long, if not longer, than modern replacement windows because there is no IG seal to fail, are simpler in design, and are made of durable materials. The low-e glass uses a durable "hard coat" ceramic coating that is actually harder than the glass itself, and should not be confused with "soft coat" low-e coatings common in replacement windows which must be protected in a sealed IG unit. As such, it is believed the actual performance of low-e storm windows should be at least 20 years. However, to ensure a conservative assessment, this evaluation was performed with a more conservative 15 year lifetime.

All other measures, measure costs, and fuel costs remained the same as in the most recent prioritization list development. However, replacement of the heating system was not included in this analysis, as the purpose of this study was to evaluate low-e storm windows in conjunction with other envelope measures.

This analysis considered reference homes where the existing windows are single pane wood frame, as well as metal framed clear dual pane windows.

Results for Low-E Storm Windows over Single Pane Wood Frame Windows

For all cases (37 homes, 4 cities and both 94.7% and 80% furnace efficiency with natural gas heating), low-e storm windows were selected as a qualified measure, with SIR values substantially higher than 1.

- **SIR values with a furnace at 94.7% efficiency using the more conservative 15 year lifetime ranged from 1.2 to 2.2, with an average of 1.4.**
- **SIR values with a furnace at 80% efficiency using the more conservative 15 year lifetime ranged from 1.4 to 2.2, with an average of 1.66.**

- **Amongst the measures considered, measure priority rank ranged from 4th to 10th with an average placement of 6th;**
- **The remaining per home project funds available after installation of both low-e storm windows and higher priority measures averaged $2277 available out of the $6500 per home limit (numbers produced from a home with a furnace efficiency of 94.7%);**
- **The max cost of Low-e storm windows to maintain an SIR above 1 is $11.15/ft^2 + $15/window or ~ $12.50 / ft^2 total installed cost (overall average on an aggregate basis; numbers produced from a home with furnace efficiency of 94.7%)**

- A few test cases with electrical resistance heating indicate similarly high SIR's in the range of 3.1 to 4.0.

Detailed results are shown in Tables 1-2, and recommendations are made at the end of this document.

Results for Low-E Storms over Metal Frame Clear Double Pane Windows

A similar analysis was performed where the existing windows in the base case homes are metal framed, clear glass dual pane windows. The most conservative cases with natural gas heating and 15 year storm window lifetime with furnace efficiencies of 94.7% and 80% were analyzed.

For all cases (37 homes, 4 cities), low-e storm windows were selected as a qualified measure, with SIR values substantially higher than 1.

- **SIR values with a furnace at 94.7% ranged from 1.2 to 2.1, with an average value of 1.4.** The SIR values are approximately 0.1 lower than for low-e storm windows over single pane wood frame windows.
- **SIR values with a furnace at 80% ranged from 1.3 to 2.1, with an average value of 1.59.** The SIR values are approximately 0.1 lower than for low-e storm windows over single pane wood frame windows.
- **Measure priority rank ranged from 4th to 10th with an average placement of 6th**
- **The max cost of Low-e storm windows to maintain an SIR above 1 is $10.40/ft^2 + $15/window, or $11.80 / ft^2 total installed cost (overall average on an aggregate basis; numbers produced from a home with furnace efficiency of 94.7%)).**

Detailed results are shown in Tables 3-4, and recommendations are made at the end of this document.

Table 1: SIR results for Low-E Storm Windows over Single Pane Wood Frame Windows
Reference Homes with **Natural Gas Heating, 15 year lifetime, 94.7% Furnace Efficiency**

	SIR for addition of Low-E Storm Windows			
	Scranton (North Central)	Harrisburg (South East)	Pittsburgh (South West)	Philadelphia
AVERAGE	**1.5**	**1.3**	**1.5**	**1.4**
Reference Home				
Exposed Floor 1	1.5	1.2	1.4	1.4
Wood Frame Cape Cod 1 KW 1	1.4	1.3	1.4	1.4
Wood Frame Cape Cod 2 KW 2	1.4	1.3	1.4	1.4
Wood Frame Cape Cod 3 KW 3	1.4	1.3	1.4	1.4
Wood Frame Cape Cod 4 KW 4	1.4	1.3	1.4	1.4
Wood Frame Cape Cod 1 KW 5	1.5	1.2	1.4	1.4
Masonry 1	1.5	1.2	1.5	1.4
Masonry 2	1.5	1.2	1.5	1.4
Masonry 3	1.5	1.3	1.5	1.4
Masonry 4	1.5	1.3	1.5	1.4
Masonry 5	1.5	1.3	1.5	1.4
Row House Masonry 1	1.5	1.3	1.5	1.5
Row House Masonry 2	1.6	1.3	1.5	1.5
Row House Wood Frame 1	1.5	1.2	1.5	1.5
Row House Wood Frame 2	1.6	1.2	1.5	1.5
Semi Detached Masonry 1	1.6	1.3	1.5	1.5
Semi Detached Masonry 2	1.6	1.3	1.5	1.5
Semi Detached Wood Frame 1	1.5	1.2	1.5	1.4
Semi Detached Wood Frame 2	1.5	1.3	1.5	1.5
Wood Frame Cond Bsmt 1	1.5	1.3	1.5	1.4
Wood Frame Cond Bsmt 2	1.5	1.3	1.5	1.4
Wood Frame Cond Bsmt 3	1.5	1.3	1.5	1.4
Wood Frame Cond Bsmt 4	1.5	1.3	1.5	1.4
Wood Frame Slab 1	1.5	1.3	1.5	1.5
Wood Frame Slab 2	1.5	1.3	1.5	1.5
Wood Frame Slab 3	1.5	1.3	1.5	1.5
Wood Frame Slab 4	1.5	1.3	1.5	1.5
Wood Frame Uncond Bsmt 1	1.4	1.3	1.4	1.4
Wood Frame Uncond Bsmt 2	1.4	1.2	1.4	1.4
Wood Frame Uncond Bsmt 3	1.5	1.2	1.4	1.4
Wood Frame Uncond Bsmt 4	1.5	1.2	1.4	1.4
Wood Frame Uncond Bsmt 5	2.2	1.8	2.1	2.0
Wood Frm Vented Crawl Space 1	1.5	1.2	1.4	1.4
Wood Frm Vented Crawl Space 2	1.5	1.2	1.4	1.4
Wood Frm Vented Crawl Space 3	1.5	1.2	1.4	1.4
Wood Frm Vented Crawl Space 4	1.5	1.2	1.4	1.4
Wood Frm Vented Crawl Space 5	1.5	1.2	1.4	1.4

Table 2: SIR and Rank results for Low-E Storm Windows over Single Pane Wood Frame Windows
Reference Homes with **Natural Gas Heating, 15 year lifetime, 80% Furnace Efficiency**

	SIR for addition of Low-E Storm Windows			
	Scranton (North Central)	Harrisburg (South East)	Pittsburgh (South West)	Philadelphia
AVERAGE	**1.8**	**1.5**	**1.7**	**1.7**
Reference Home				
Exposed Floor 1	1.7	1.4	1.7	1.6
Wood Frame Cape Cod 1 KW 1	1.7	1.4	1.6	1.6
Wood Frame Cape Cod 2 KW 2	1.7	1.4	1.6	1.6
Wood Frame Cape Cod 3 KW 3	1.7	1.4	1.6	1.6
Wood Frame Cape Cod 4 KW 4	1.7	1.4	1.6	1.6
Wood Frame Cape Cod 1 KW 5	1.7	1.4	1.7	1.6
Masonry 1	1.8	1.5	1.7	1.7
Masonry 2	1.8	1.5	1.7	1.7
Masonry 3	1.8	1.5	1.7	1.7
Masonry 4	1.8	1.5	1.7	1.7
Masonry 5	1.8	1.5	1.7	1.7
Row House Masonry 1	1.8	1.5	1.8	1.8
Row House Masonry 2	1.8	1.5	1.8	1.8
Row House Wood Frame 1	1.8	1.4	1.7	1.7
Row House Wood Frame 2	1.8	1.5	1.8	1.8
Semi Detached Masonry 1	1.8	1.5	1.8	1.7
Semi Detached Masonry 2	1.9	1.5	1.8	1.8
Semi Detached Wood Frame 1	1.8	1.4	1.7	1.7
Semi Detached Wood Frame 2	1.8	1.5	1.8	1.7
Wood Frame Cond Bsmt 1	1.8	1.5	1.7	1.7
Wood Frame Cond Bsmt 2	1.8	1.5	1.7	1.7
Wood Frame Cond Bsmt 3	1.8	1.5	1.7	1.7
Wood Frame Cond Bsmt 4	1.8	1.5	1.7	1.7
Wood Frame Slab 1	1.8	1.5	1.7	1.7
Wood Frame Slab 2	1.8	1.5	1.7	1.7
Wood Frame Slab 3	1.8	1.5	1.7	1.7
Wood Frame Slab 4	1.8	1.5	1.7	1.7
Wood Frame Uncond Bsmt 1	1.7	1.4	1.6	1.6
Wood Frame Uncond Bsmt 2	1.7	1.4	1.7	1.6
Wood Frame Uncond Bsmt 3	1.7	1.4	1.7	1.6
Wood Frame Uncond Bsmt 4	1.7	1.4	1.7	1.6
Wood Frame Uncond Bsmt 5	2.2	1.8	2.1	2.0
Wood Frm Vented Crawl Space 1	1.7	1.4	1.7	1.6
Wood Frm Vented Crawl Space 2	1.7	1.4	1.7	1.6
Wood Frm Vented Crawl Space 3	1.7	1.4	1.7	1.6
Wood Frm Vented Crawl Space 4	1.7	1.4	1.7	1.6
Wood Frm Vented Crawl Space 5	1.8	1.5	1.7	1.6

Table 3: SIR results for Low-E Storm Windows over Metal Frame Clear Double Pane Windows Reference Homes with **Natural Gas Heating, 15 year lifetime, 94.7% Furnace Efficiency**

	SIR for addition of Low-E Storm Windows			
	Scranton (North Central)	Harrisburg (South East)	Pittsburgh (South West)	Philadelphia
AVERAGE	**1.4**	**1.3**	**1.4**	**1.4**
Reference Home				
Exposed Floor 1	1.4	1.3	1.4	1.3
Wood Frame Cape Cod 1 KW 1	1.4	1.2	1.3	1.3
Wood Frame Cape Cod 2 KW 2	1.4	1.2	1.3	1.3
Wood Frame Cape Cod 3 KW 3	1.4	1.2	1.3	1.3
Wood Frame Cape Cod 4 KW 4	1.4	1.2	1.3	1.3
Wood Frame Cape Cod 1 KW 5	1.4	1.3	1.4	1.3
Masonry 1	1.4	1.3	1.4	1.4
Masonry 2	1.4	1.3	1.4	1.4
Masonry 3	1.4	1.3	1.4	1.4
Masonry 4	1.4	1.3	1.4	1.4
Masonry 5	1.5	1.3	1.4	1.4
Row House Masonry 1	1.5	1.4	1.5	1.5
Row House Masonry 2	1.5	1.4	1.5	1.5
Row House Wood Frame 1	1.4	1.3	1.4	1.4
Row House Wood Frame 2	1.5	1.4	1.5	1.5
Semi Detached Masonry 1	1.5	1.3	1.4	1.4
Semi Detached Masonry 2	1.5	1.2	1.5	1.5
Semi Detached Wood Frame 1	1.4	1.3	1.4	1.4
Semi Detached Wood Frame 2	1.5	1.3	1.4	1.4
Wood Frame Cond Bsmt 1	1.4	1.3	1.4	1.4
Wood Frame Cond Bsmt 2	1.4	1.3	1.4	1.4
Wood Frame Cond Bsmt 3	1.4	1.3	1.4	1.4
Wood Frame Cond Bsmt 4	1.4	1.3	1.4	1.4
Wood Frame Slab 1	1.5	1.3	1.4	1.4
Wood Frame Slab 2	1.5	1.3	1.4	1.4
Wood Frame Slab 3	1.5	1.3	1.4	1.4
Wood Frame Slab 4	1.5	1.3	1.4	1.4
Wood Frame Uncond Bsmt 1	1.4	1.2	1.3	1.3
Wood Frame Uncond Bsmt 2	1.4	1.3	1.4	1.3
Wood Frame Uncond Bsmt 3	1.4	1.3	1.4	1.3
Wood Frame Uncond Bsmt 4	1.4	1.3	1.4	1.3
Wood Frame Uncond Bsmt 5	2.1	1.7	2.0	1.9
Wood Frm Vented Crawl Space 1	1.4	1.3	1.4	1.3
Wood Frm Vented Crawl Space 2	1.4	1.3	1.4	1.3
Wood Frm Vented Crawl Space 3	1.4	1.3	1.4	1.3
Wood Frm Vented Crawl Space 4	1.4	1.3	1.4	1.3
Wood Frm Vented Crawl Space 5	1.4	1.3	1.4	1.3

Table 4: SIR and Rank results for Low-E Storm Windows over Metal Frame Clear Double Pane Windows Reference Homes with **Natural Gas Heating, 15 year lifetime, 80% Furnace Efficiency**

	SIR for addition of Low-E Storm Windows			
	Scranton (North Central)	Harrisburg (South East)	Pittsburgh (South West)	Philadelphia
AVERAGE	**1.7**	**1.4**	**1.7**	**1.6**
Reference Home				
Exposed Floor 1	1.7	1.4	1.6	1.6
Wood Frame Cape Cod 1 KW 1	1.6	1.3	1.6	1.5
Wood Frame Cape Cod 2 KW 2	1.6	1.3	1.6	1.5
Wood Frame Cape Cod 3 KW 3	1.6	1.3	1.6	1.5
Wood Frame Cape Cod 4 KW 4	1.6	1.3	1.6	1.5
Wood Frame Cape Cod 1 KW 5	1.6	1.4	1.6	1.6
Masonry 1	1.7	1.4	1.6	1.6
Masonry 2	1.7	1.4	1.6	1.6
Masonry 3	1.7	1.4	1.6	1.6
Masonry 4	1.7	1.4	1.7	1.6
Masonry 5	1.7	1.4	1.7	1.6
Row House Masonry 1	1.8	1.4	1.7	1.7
Row House Masonry 2	1.8	1.4	1.7	1.7
Row House Wood Frame 1	1.7	1.4	1.7	1.7
Row House Wood Frame 2	1.7	1.4	1.7	1.7
Semi Detached Masonry 1	1.8	1.4	1.7	1.7
Semi Detached Masonry 2	1.8	1.5	1.7	1.7
Semi Detached Wood Frame 1	1.7	1.4	1.7	1.6
Semi Detached Wood Frame 2	1.7	1.4	1.7	1.6
Wood Frame Cond Bsmt 1	1.7	1.4	1.6	1.6
Wood Frame Cond Bsmt 2	1.7	1.4	1.7	1.6
Wood Frame Cond Bsmt 3	1.7	1.4	1.6	1.6
Wood Frame Cond Bsmt 4	1.7	1.4	1.6	1.6
Wood Frame Slab 1	1.7	1.4	1.7	1.6
Wood Frame Slab 2	1.7	1.4	1.7	1.6
Wood Frame Slab 3	1.7	1.4	1.7	1.6
Wood Frame Slab 4	1.7	1.4	1.7	1.6
Wood Frame Uncond Bsmt 1	1.6	1.3	1.6	1.5
Wood Frame Uncond Bsmt 2	1.6	1.3	1.6	1.6
Wood Frame Uncond Bsmt 3	1.7	1.4	1.6	1.6
Wood Frame Uncond Bsmt 4	1.7	1.4	1.6	1.6
Wood Frame Uncond Bsmt 5	2.1	1.7	2.0	1.9
Wood Frm Vented Crawl Space 1	1.7	1.4	1.6	1.6
Wood Frm Vented Crawl Space 2	1.7	1.4	1.6	1.6
Wood Frm Vented Crawl Space 3	1.7	1.4	1.6	1.6
Wood Frm Vented Crawl Space 4	1.7	1.4	1.6	1.6
Wood Frm Vented Crawl Space 5	1.7	1.4	1.6	1.6

Analysis Methodology for R-5 Windows

The Weatherization Assistant energy audit software (version 8.6) was used to evaluate the impact of R-5 windows in each of the same 37 reference homes employed in development of the most recent Pennsylvania weatherization measure prioritization list. [Dalhoff, Jan 2010]

These 37 homes were evaluated with natural gas heating systems in Scranton, Harrisburg, and Pittsburgh, and Philadelphia (representing the North Central, South East, South West, and Philadelphia regions, respectively).

For the scenario of upgrading to an R-5 window when a window must be replaced for health and safety reasons, R-5 windows were modeled with the following parameters:

- $5 incremental cost over a basic code window
- U-factor = 0.22
- solar heat gain coefficient = 0.3
- 20 year lifetime
- 94.7% Furnace Efficiency
- Natural Gas Heating

All other measures, measure costs, and fuel costs remained the same as in the most recent prioritization list development. However, replacement of the heating system was not included in this analysis, as the purpose of this study was to evaluate R-5 windows in conjunction with other envelope measures. To be conservative, a very high furnace efficiency of 94.7% was used. Actual furnace efficiencies will be lower, so this will ensure the results of this analysis are conservative worst-case.

Results for Upgrading to an R-5 Window when Replacing a Degraded Window

For all audit runs (37 homes, 4 cities), R-5 windows were selected as a qualified measure, with SIR values substantially higher than 1 when needing to replace a degraded window.

- **SIR values using a 20 year lifetime ranged from 1.6 to 3.0.**
- **Measure priority rank ranged from 4^{th} to 10^{th}**
- **For worst case homes, as long as the incremental cost of R-5 windows remained below $\$8.90/ft^2$, the SIR value remains above 1. (overall average on an aggregate basis)**

Detailed results are shown in Table 5, and recommendations are made at the end of this document.

Table 5: SIR results for Upgrading to R-5 Windows when Replacing a Degraded Window Reference Homes with **Natural Gas Heating, 20 year lifetime, 94.7% Furnace Efficiency**

	SIR for Upgrade to R5 Windows (over code window)			
	Scranton (North Central)	Harrisburg (South East)	Pittsburgh (South West)	Philadelphia
AVERAGE	**2.1**	**1.7**	**2.1**	**2.1**
Reference Home				
Exposed Floor 1	2.0	1.7	2.0	2.0
Wood Frame Cape Cod 1 KW 1	1.9	1.6	1.9	1.9
Wood Frame Cape Cod 2 KW 2	1.9	1.6	1.9	1.9
Wood Frame Cape Cod 3 KW 3	1.9	1.6	1.9	1.9
Wood Frame Cape Cod 4 KW 4	1.9	1.6	1.9	1.9
Wood Frame Cape Cod 1 KW 5	1.9	1.6	1.9	1.9
Masonry 1	2.1	1.7	2.0	2.0
Masonry 2	2.1	1.7	2.0	2.0
Masonry 3	2.1	1.7	2.0	2.0
Masonry 4	2.1	1.7	2.0	2.0
Masonry 5	2.1	1.7	2.0	2.1
Row House Masonry 1	2.2	1.7	2.3	2.5
Row House Masonry 2	2.2	1.7	2.3	2.5
Row House Wood Frame 1	2.1	1.7	2.2	2.4
Row House Wood Frame 2	2.2	1.7	2.2	2.5
Semi Detached Masonry 1	2.2	1.8	2.2	2.2
Semi Detached Masonry 2	2.3	1.8	2.2	2.2
Semi Detached Wood Frame 1	2.2	1.7	2.1	2.1
Semi Detached Wood Frame 2	2.2	1.7	2.2	2.2
Wood Frame Cond Bsmt 1	2.1	1.7	2.0	2.0
Wood Frame Cond Bsmt 2	2.1	1.7	2.0	2.0
Wood Frame Cond Bsmt 3	2.1	1.7	2.0	2.0
Wood Frame Cond Bsmt 4	2.1	1.7	2.0	2.0
Wood Frame Slab 1	2.1	1.7	2.0	2.0
Wood Frame Slab 2	2.1	1.7	2.0	2.0
Wood Frame Slab 3	2.1	1.7	2.0	2.0
Wood Frame Slab 4	2.1	1.7	2.0	2.0
Wood Frame Uncond Bsmt 1	1.9	1.6	1.9	1.8
Wood Frame Uncond Bsmt 2	2.1	1.6	2.1	2.1
Wood Frame Uncond Bsmt 3	2.0	1.7	2.0	2.0
Wood Frame Uncond Bsmt 4	2.0	1.7	2.0	2.0
Wood Frame Uncond Bsmt 5	3.0	2.4	2.9	2.8
Wood Frm Vented Crawl Space 1	2.0	1.7	2.0	2.0
Wood Frm Vented Crawl Space 2	2.0	1.7	2.0	2.0
Wood Frm Vented Crawl Space 3	2.0	1.7	2.0	2.0
Wood Frm Vented Crawl Space 4	2.0	1.7	2.0	2.0
Wood Frm Vented Crawl Space 5	2.1	1.7	2.0	2.0

Analysis for Complete R-5 Window Replacement, and Cost to reach an SIR of 1

To start, an analysis for R-5 windows (including low-e storm windows as a possibility) was completed with the following fixed replacement costs:

- $\$7.85/ft^2$+$15/window for low-e storms
- $\$25/ft^2$ for R-5 (complete replacement)
- $\$15/ft^2$+$100/window for R-5 (complete replacement)

The following results were found:

- Low-e storms are still selected, with SIR from 1.3 – 1.4 when using Metal Frame Clear Double Pane Windows as the base case. The SIR is about 0.1 lower than the case for replacing single pane wood. This is with the 15 year lifetime.
- R-5 windows are not selected and have SIR < 1.

In order to independently determine the R-5 window cost in order to arrive at 1, neither storm windows nor replacement windows were considered in the following R-5 analysis. The 37 homes were evaluated with natural gas heating systems in Scranton, Harrisburg, and Pittsburgh, and Philadelphia (representing the North Central, South East, South West, and Philadelphia regions, respectively) with the following parameters:

- U-factor = 0.22
- solar heat gain coefficient = 0.3
- 20 year lifetime
- 80% Furnace Efficiency (not replacing furnace or boiler)
- Natural Gas Heating

All other measures, measure costs, and fuel costs remained the same as in the most recent prioritization list development. These costs would have to include lead safe installation.

Results

Table 6: Price Point for SIR of 1 and upgrade to R5 Windows over Single Pane Wood Frame Windows for worst case homes (overall average on an aggregate basis)

	Scranton (North Central)	Harrisburg (South East)	Pittsburgh (South West)	Philadelphia
Window Cost $/ft^2	**$26.45**	**$22.35**	**$25.55**	**$25.15**

Table 7: Price Point for SIR of 1 and upgrade to R5 Windows over Metal Frame Clear Double Pane Windows for worst case homes (overall average on an aggregate basis)

	Scranton (North Central)	Harrisburg (South East)	Pittsburgh (South West)	Philadelphia
Window Cost $/ft^2	**$25.45**	**$21.50**	**$24.55**	**$24.35**

Recommendations:

The NEAT results were consistent across all home types in all locations, demonstrating low-e storm windows and R-5 windows as a cost justified weatherization measure to significantly improve home energy efficiency in the situations outlined below.

As such, it is recommended that Pennsylvania's weatherization priority list for site-built homes be amended to include:

A) The addition of a low-e storm window to any existing single pane wood frame window or metal frame clear double pane window. This recommendation also applies to any single pane wood frame window with an existing deteriorated clear storm window.

B) The installation of an R-5 window where a window must be replaced due to health, safety or structural concerns. The maximum average incremental cost for this measure over a basic code window is $8.90 per ft2.

C) The replacement of an existing single pane wood frame window with an R-5 window as long as the total average installed cost (including any lead-safe practices) is less than costs within table 6.

D) If metal frame clear double pane windows are encountered often enough in Pennsylvania, then the replacement of an existing metal frame clear double pane window with a R-5 window is recommended as long as the total average installed cost (including any lead-safe practices) is less than costs within table 7.