Mr. Richard Karney
U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
1000 Independence Ave SW
Washington, D.C. 20585

August 15, 2008

Dear Rich,

On behalf of the Aluminum Extruders Council, I would like to express our gratitude for your open communication with stakeholders regarding revisions to the Energy Star® program for Windows, Doors, and Skylights. We will provide detailed comments on the proposed Energy Star criteria in a separate letter. However, the primary purpose of this letter is to present more information on our proposal for the Energy Star program to promote the use of recycled materials in fenestration framing. This expands upon the presentation I made at the stakeholder meeting.

We are proposing a new **recycled content credit**, in which a credit towards meeting the U-factor criteria could be earned by using a higher amount of recycled material in the framing of the product. The amount of the credit would vary depending on both the percentage of recycled content and the climate zone, as described in the attached analysis.

The justification for this new credit has two general foundations. First, promoting the use of recycled materials is consistent with the general **sustainability** goals of DOE and EPA. More efficient use of materials reduces the ecological impact of a building. This includes reduced landfill waste, as well as reduced energy and emissions associated with manufacturing, transportation, and disposal. Additionally, for certain materials, emissions associated with incineration and/or decomposition are of particular concern.

Second, promoting the use of recycled materials would result in specific **embodied energy savings** associated with the fenestration product. This is consistent with the guiding principles of Energy Star to promote significant and measurable energy savings, while recognizing equivalent functionality and performance of different product technologies. *As the analysis shows, the embodied energy savings from the use of recycled aluminum can be as significant as the energy savings from proposed reductions in U-factor!* This is particularly true in the south. Therefore, it makes absolute sense to include a credit towards U-factor for the use of recycled content based on equivalent energy savings.

The attached analysis includes a proposed recycled content credit for aluminum framed fenestration products. A similar credit could be developed for other materials, although perhaps with a bit more difficulty, due to the limited data and lack of recycling infrastructure for other common framing materials.

Thank you for your consideration, and please feel free to contact me at any time if you have any questions or would like further details.

Sincerely,

Thomas D. Culp, Ph.D.

Proposal for a Recycled Content Credit in the Energy Star® program for Windows, Doors, and Skylights

Concept

The basic premise is that the use of recycled content in fenestration materials can provide significant embodied energy savings, which can then be equated to home energy savings resulting from changes in the U-factor over the lifetime of the window. The guiding principles of Energy Star® include promotion of products which provide significant and measurable energy savings, while recognizing equivalent functionality and performance of different product technologies. Therefore, it is consistent with Energy Star guiding principles to provide a credit towards meeting the U-factor criteria based on the use of recycled materials.

The proposed amount of credit is based only on embodied energy savings equivalent to the home energy savings associated with the change in U-factor, as detailed in the analysis below. It should be noted that this approach is conservative, and even further credit could be justified based on other sustainability benefits not included in this analysis, such as reduction of landfill waste, and reduction of energy and emissions associated with disposal.

Applicability

The following proposed credit was developed for aluminum framed residential fenestration products. A similar credit could be developed for other materials, although perhaps with a bit more difficulty, due to the limited data and lack of recycling infrastructure for other common framing materials.

Proposed Credit

A credit towards meeting the U-factor criteria shall be allowed based on the percentage of recycled content used in the aluminum framing materials of the fenestration product, as shown in the following table:

Proposed Energy Star Recycled Content Credit

Energy Star Climate Zone	Percent Recycled Content of Framing Materials (by weight)	U-factor Credit (Btu/hr·ft^2·F)
Zone 1	≥ 20%	0.03
	≥ 30%	0.05
	≥ 40%	0.07
	≥ 50%	0.09
	≥ 60%	0.10
	≥ 70%	0.12
Zone 2	≥ 20%	0.02
	≥ 30%	0.03
	≥ 40%	0.03
	≥ 50%	0.04
	≥ 60%	0.05
	≥ 70%	0.06
Zone 3	≥ 20%	0.01
	≥ 30%	0.01
	≥ 40%	0.02
	≥ 50%	0.02
	≥ 60%	0.02
	≥ 70%	0.03
Zone 4	≥ 20%	0.01
	≥ 30%	0.01
	≥ 40%	0.01
	≥ 50%	0.01
	≥ 60%	0.02
	≥ 70%	0.02
Zone 5	≥ 20%	0.00
	≥ 30%	0.01
	≥ 40%	0.01
	≥ 50%	0.01
	≥ 60%	0.01
	≥ 70%	0.02

For this credit, recycled content is defined as material diverted from the waste stream and reused in place of raw or virgin material in manufacturing of a product. This includes post-industrial and scrap materials recovered from manufacturing and deconstruction processes, as well as post-consumer materials. The percentage of recycled content shall be determined by weight.

On an annual basis, the manufacturer shall submit documentation to DOE listing the material source and percentage of recycled content used in the framing, and a signed certification attesting that the credit requirements have been met. The manufacturer shall also be responsible for notifying DOE of any changes in recycled content.

Analysis Method

The amount of credit in each climate zone was established by determining the equivalent energy savings between:

(1) the home energy savings resulting from a change in U-factor over the lifetime of the window, and

(2) the embodied energy savings resulting from the incorporation of recycled content in aluminum framing.

Home Energy Savings from U-factor Changes

RESFEN 5.0 was used to analyze the effect of U-factor changes on annual energy use of homes. We understand that LBNL has refined the RESFEN assumptions for use with Energy Star. This analysis could be easily repeated with the revised parameters. However, it is unlikely to change the credit significantly, which depends more on the slope of the energy savings vs. U-factor rather than the absolute energy use.

House description:

- 2-story new frame construction
- 2000 ft^2 floor area
- 300 ft^2 window area, equally distributed
- RESFEN default foundation and insulation package by location
- Both heat pump and gas furnace analyzed in zones 1-2.
  Gas furnace only in zones 3-5.

Representative Cities:

Energy Star Zone 1	Energy Star Zone 2	
Daytona Beach, FL	Charleston, SC	
Jacksonville, FL	Atlanta, GA	
Houston, TX	Fort Worth, TX	
Phoenix, AZ	Los Angeles, CA	
Energy Star Zone 3	**Energy Star Zone 4**	**Energy Star Zone 5**
Richmond, VA	Boston, MA	Portland, ME
Kansas City, MO	Des Moines, IA	Minneapolis, MN

The source annual energy savings vs. U-factor were then determined for each city, while keeping SHGC, VT, and AL constant. Source multipliers of 3.16 and 1.1 were used for electricity and natural gas, respectively.

Finally, the net present value of source annual energy savings over a 35 year window lifetime was calculated with a conservative 4% discount rate, as well as the slope of the NPV energy savings vs. U-factor. This result was then used to determine equivalence with the embodied energy savings calculated below.

Embodied Energy Savings from Recycled Content

The embodied energy of aluminum framing was calculated using the following parameters:

- Embodied energy of virgin aluminum: 207 MJ/kg
- Embodied energy of recycled aluminum: 12 MJ/kg
- Frame weight per length: 0.4 kg/ft
- Frame length per window area: 1.27 ft/ft^2
- Total frame weight per home: 152 kg

Aluminum Window Frame Embodied Energy

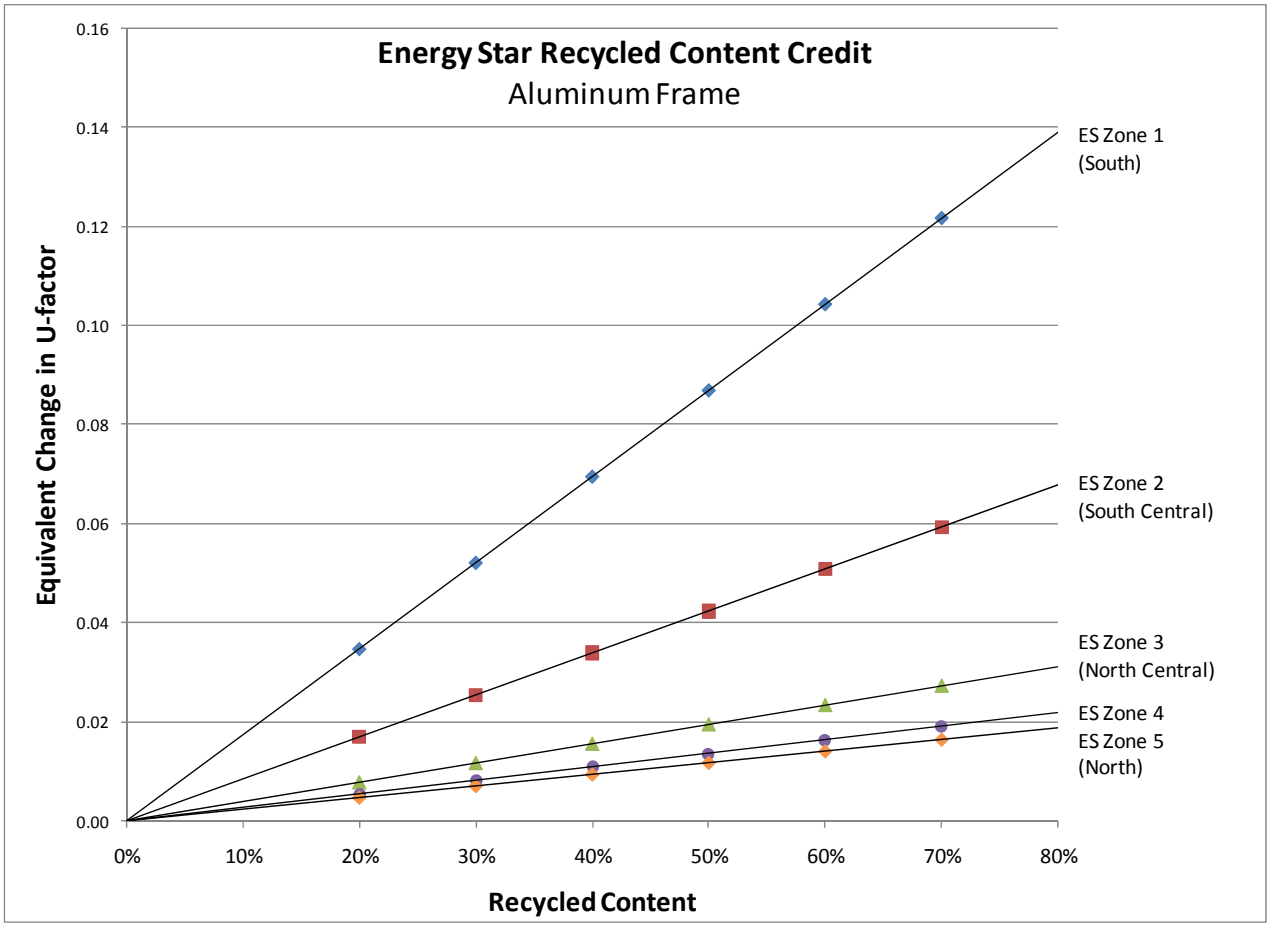
Recycled Content (%)	Embodied Energy (MJ)	Energy Savings (MJ)
0% (virgin)	31533	--
20%	25604	5929
30%	22639	8894
40%	19675	11859
50%	16710	14823
60%	13745	17788
70%	10781	20753

Recycled Content Credit

Using this data for each city, the change in U-factor was determined which would give the equivalent energy savings over a 35 year window lifetime as the embodied energy savings from including recycled content in the window framing. For zones 1-2, this U-factor credit was determined for homes with both heat pumps and gas furnaces, and then averaged. Finally, the average credit was determined for each climate zone by averaging the results for each representative city.

Results

The equivalent U-factor credit vs. recycled content is shown graphically below, for each climate zone. As expected, the credit is largest in the southern zones where the U-factor is less important to home energy savings, and embodied energy savings from using recycled content can be more important.

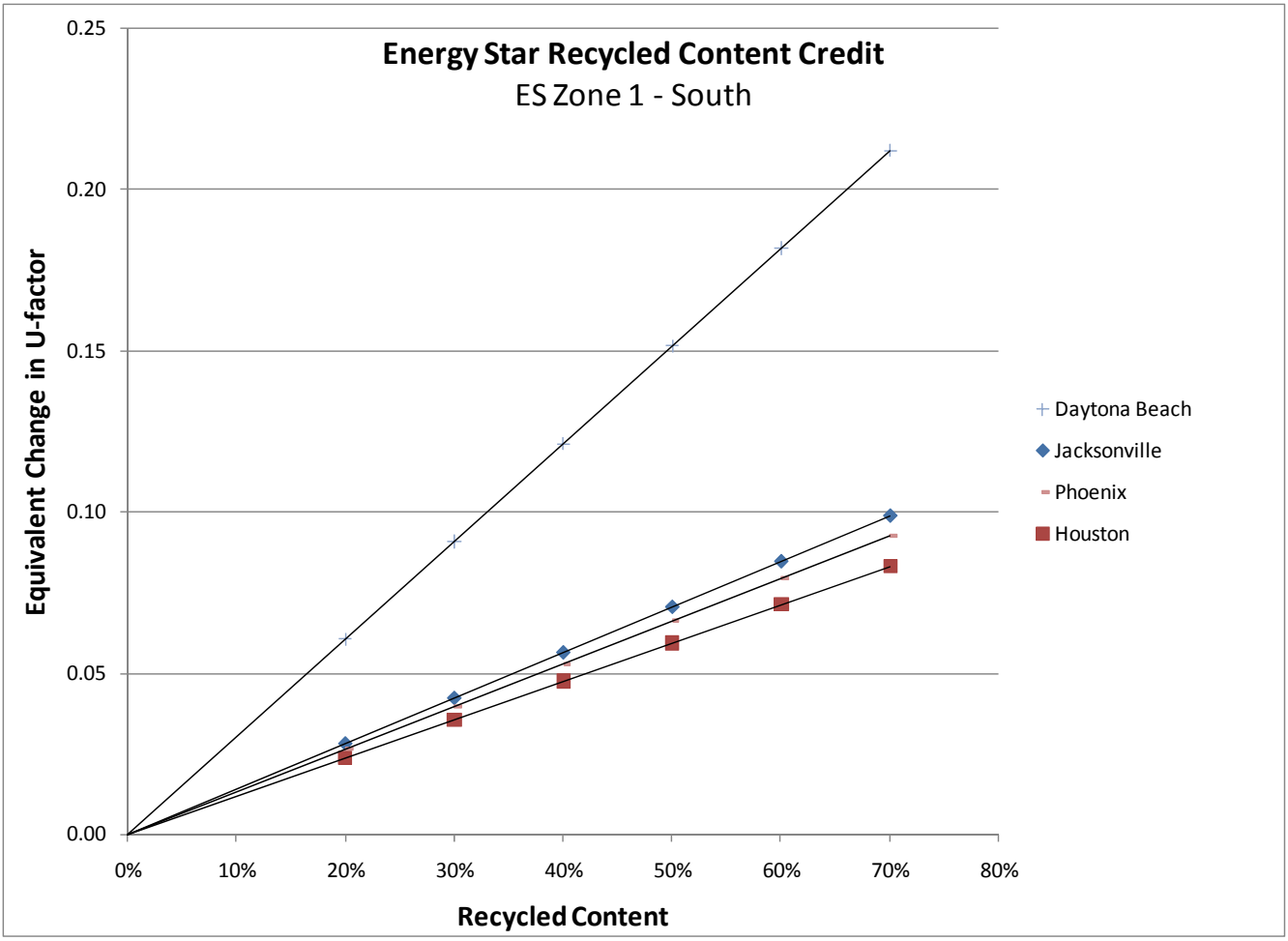


The detailed analysis for each climate zone is shown on the following pages.

ENERGY STAR ZONE 1

Combined Recycled Content Credit
based on equivalent U-factor vs. embodied energy savings

Recycled content	Equivalent ΔU
20%	0.03
30%	0.05
40%	0.07
50%	0.09
60%	0.10
70%	0.12



Note that the calculated credit in Daytona Beach is higher than the other selected cities (Jacksonville, Houston, and Phoenix). This is because of the lower importance of U-factor in southern Florida. Similarly, an even higher credit would be expected if other locations such as Orlando, Tampa, Miami, and Hawaii were included in the analysis.

JACKSONVILLE, FL

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30		1631	2962	4593	14515	0	0
0.55	0.30		1572	2974	4546	14366	535	288
0.50	0.30		1512	2988	4500	14219	1064	572
							Slope	-5724 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30	14.3	4191	2962	7153	13970	0	0
0.55	0.30	13.7	4015	2975	6990	13818	586	315
0.50	0.30	13.1	3839	2988	6827	13665	1172	631
							Slope	-6310 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.030	0.027	**0.028**
30%	8894	0.044	0.040	**0.042**
40%	11859	0.059	0.054	**0.056**
50%	14823	0.074	0.067	**0.071**
60%	17788	0.089	0.081	**0.085**
70%	20753	0.104	0.094	**0.099**

DAYTONA BEACH, FL

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30		721	3125	3846	12152	0	0
0.55	0.30		685	3141	3826	12089	229	123
0.50	0.30		648	3158	3806	12028	447	241
							Slope	-2406 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30	6.7	1964	3125	5089	12035	0	0
0.55	0.30	6.3	1846	3141	4987	11957	364	196
0.50	0.30	6	1758	3158	4916	11914	620	334
							Slope	-3335 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.070	0.051	**0.061**
30%	8894	0.106	0.076	**0.091**
40%	11859	0.141	0.102	**0.121**
50%	14823	0.176	0.127	**0.152**
60%	17788	0.211	0.152	**0.182**
70%	20753	0.246	0.178	**0.212**

HOUSTON, TX

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30		2068	3213	5281	16688	0	0
0.55	0.30		2002	3221	5223	16505	660	355
0.50	0.30		1934	3229	5163	16315	1342	722
							Slope	-7224 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30	16.7	4894	3213	8107	15537	0	0
0.55	0.30	16.1	4718	3221	7939	15369	604	325
0.50	0.30	15.4	4513	3229	7742	15168	1314	707
							Slope	-7071 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.023	0.024	**0.024**
30%	8894	0.035	0.036	**0.036**
40%	11859	0.047	0.048	**0.047**
50%	14823	0.059	0.060	**0.059**
60%	17788	0.070	0.072	**0.071**
70%	20753	0.082	0.084	**0.083**

PHOENIX, AZ

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30		1080	5210	6290	19875	0	0
0.55	0.30		1030	5188	6218	19650	813	438
0.50	0.30		979	5160	6139	19400	1712	921
							Slope	-9214 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.60	0.30	9.4	2755	5120	7875	19210	0	0
0.55	0.30	8.9	2608	5188	7796	19263	283	152
0.50	0.30	8.4	2462	5160	7622	19014	911	490
							Slope	-4903 (MJ/yr/ΔU)

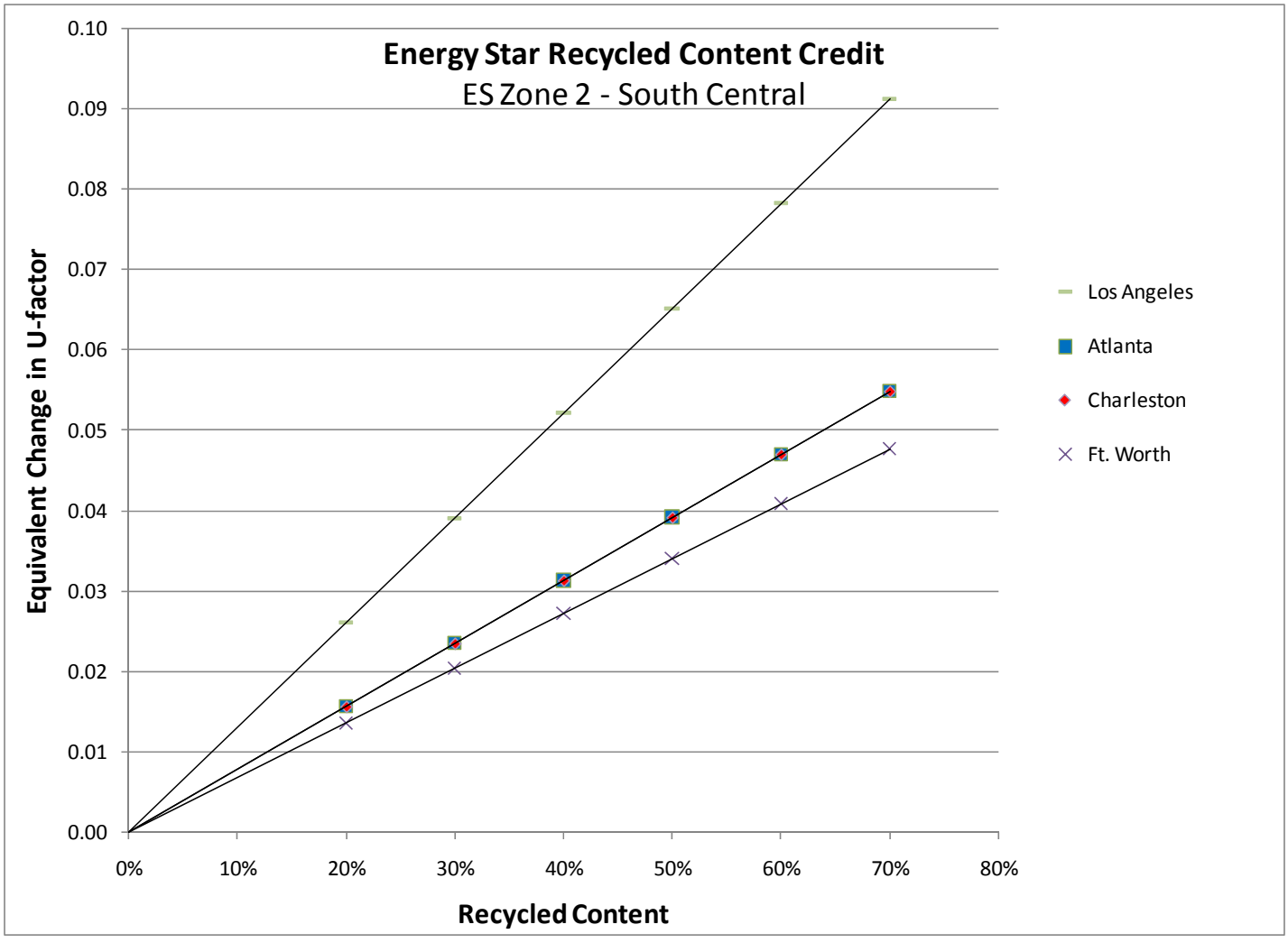
Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.018	0.035	**0.026**
30%	8894	0.028	0.052	**0.040**
40%	11859	0.037	0.069	**0.053**
50%	14823	0.046	0.086	**0.066**
60%	17788	0.055	0.104	**0.079**
70%	20753	0.064	0.121	**0.093**

ENERGY STAR ZONE 2

Combined Recycled Content Credit
based on equivalent U-factor vs. embodied energy savings

Recycled content	Equivalent ΔU
20%	0.02
30%	0.03
40%	0.03
50%	0.04
60%	0.05
70%	0.06



CHARLESTON, SC

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30		2285	2341	4626	14618	0	0
0.35	0.30		2177	2360	4537	14335	1016	547
0.30	0.30		2066	2387	4453	14072	1965	1057
							Slope	-10573 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30	18.8	5510	2341	7851	13458	0	0
0.35	0.30	17.7	5187	2360	7547	13164	1092	588
0.30	0.30	16.7	4894	2387	7281	12927	2050	1103
							Slope	-11032 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.016	0.015	**0.016**
30%	8894	0.024	0.023	**0.024**
40%	11859	0.032	0.031	**0.031**
50%	14823	0.040	0.038	**0.039**
60%	17788	0.048	0.046	**0.047**
70%	20753	0.056	0.054	**0.055**

ATLANTA, GA

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30		2741	1621	4362	13784	0	0
0.35	0.30		2612	1638	4250	13430	1274	686
0.30	0.30		2477	1661	4138	13076	2548	1371
							Slope	-13713 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30	21.9	6418	1621	8039	12182	0	0
0.35	0.30	20.7	6067	1638	7705	11849	1205	648
0.30	0.30	19.4	5686	1661	7347	11503	2494	1342
							Slope	-13419 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.012	0.013	**0.012**
30%	8894	0.019	0.019	**0.019**
40%	11859	0.025	0.025	**0.025**
50%	14823	0.031	0.032	**0.031**
60%	17788	0.037	0.038	**0.037**
70%	20753	0.043	0.044	**0.044**

FORT WORTH, TX

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30		2365	2786	5151	16277	0	0
0.35	0.30		2259	2790	5049	15955	1160	624
0.30	0.30		2145	2792	4937	15601	2434	1310
							Slope	-13101 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30	19.3	5656	2786	8442	15026	0	0
0.35	0.30	18.3	5363	2790	8153	14716	1041	560
0.30	0.30	17.2	5041	2792	7833	14368	2194	1181
							Slope	-11807 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.013	0.014	**0.014**
30%	8894	0.019	0.022	**0.020**
40%	11859	0.026	0.029	**0.027**
50%	14823	0.032	0.036	**0.034**
60%	17788	0.039	0.043	**0.041**
70%	20753	0.045	0.050	**0.048**

LOS ANGELES, CA

Heat pump

Window properties			Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC		(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30		696	139	835	2637	0	0
0.35	0.30		639	145	784	2477	576	310
0.30	0.30		581	155	736	2327	1118	602
							Slope	-6018 (MJ/yr/ΔU)

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.30	7.7	2257	139	2396	2922	0	0
0.35	0.30	7.1	2081	145	2226	2747	611	329
0.30	0.30	6.4	1876	155	2031	2553	1314	707
							Slope	-7071 (MJ/yr/ΔU)

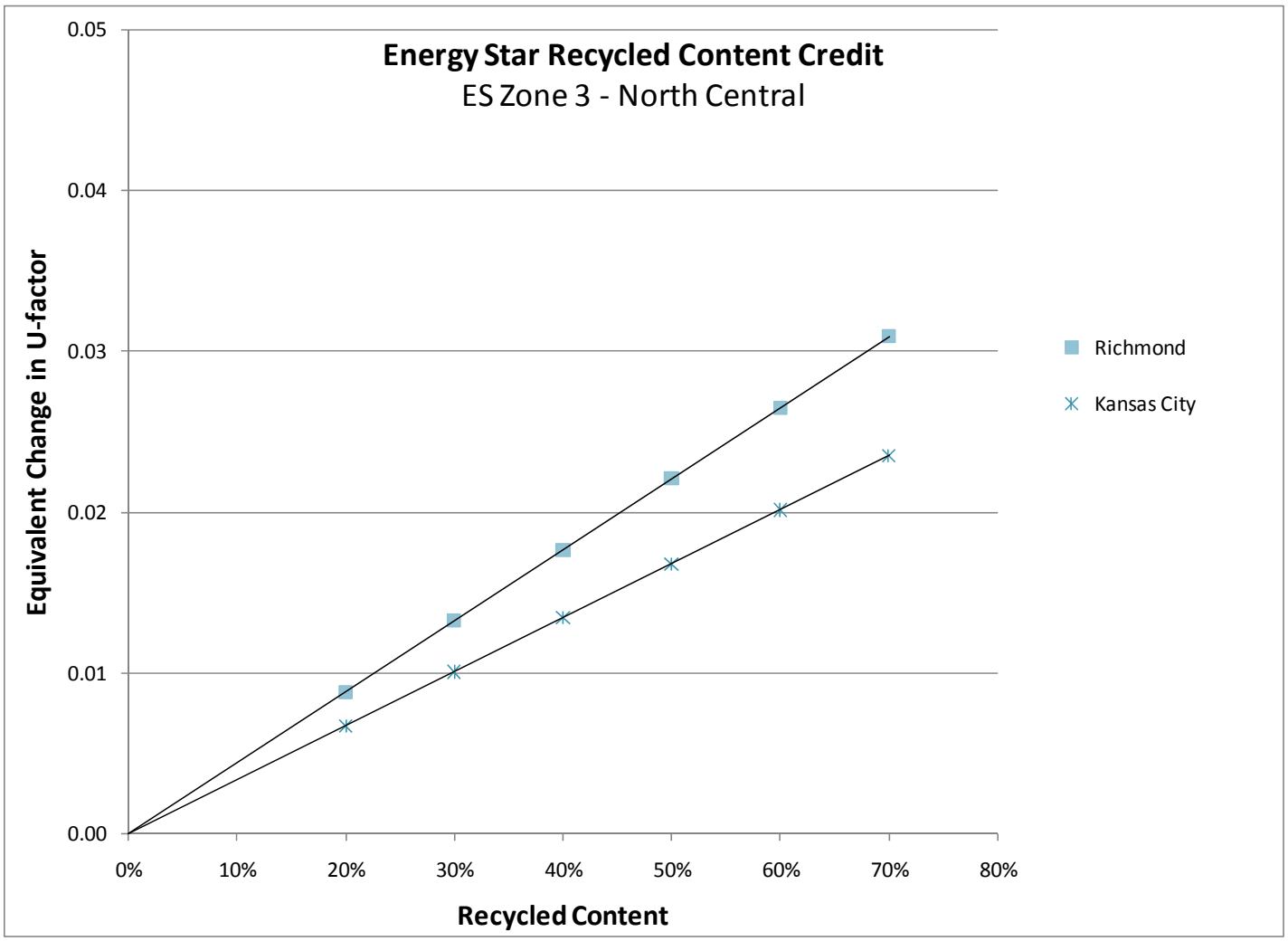
Equivalent U-factor vs. embodied energy savings:

		Heat Pump	Furnace	Average
Recycled content	Emb. Eng savings (MJ)	Equiv ΔU	Equiv ΔU	**Equiv ΔU**
20%	5929	0.028	0.024	**0.026**
30%	8894	0.042	0.036	**0.039**
40%	11859	0.056	0.048	**0.052**
50%	14823	0.070	0.060	**0.065**
60%	17788	0.084	0.072	**0.078**
70%	20753	0.099	0.084	**0.091**

ENERGY STAR ZONE 3

Combined Recycled Content Credit
based on equivalent U-factor vs. embodied energy savings

Recycled content	Equivalent ΔU
20%	0.01
30%	0.01
40%	0.02
50%	0.02
60%	0.02
70%	0.03



KANSAS CITY, MO

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.40	51.7	15152	1864	17016	22557	0	0
0.35	0.40	49.5	14507	1875	16382	21883	2282	1228
0.30	0.40	47.2	13833	1883	15716	21167	4679	2518
							Slope	-25182 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

Recycled content	Emb. Eng savings (MJ)	**Equiv ΔU**
20%	5929	**0.007**
30%	8894	**0.010**
40%	11859	**0.013**
50%	14823	**0.017**
60%	17788	**0.020**
70%	20753	**0.024**

RICHMOND, VA

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.40	33.7	9876	1488	11364	15566	0	0
0.35	0.40	32	9378	1506	10884	15075	1729	930
0.30	0.40	30.2	8851	1525	10376	14555	3559	1916
							Slope	-19155 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

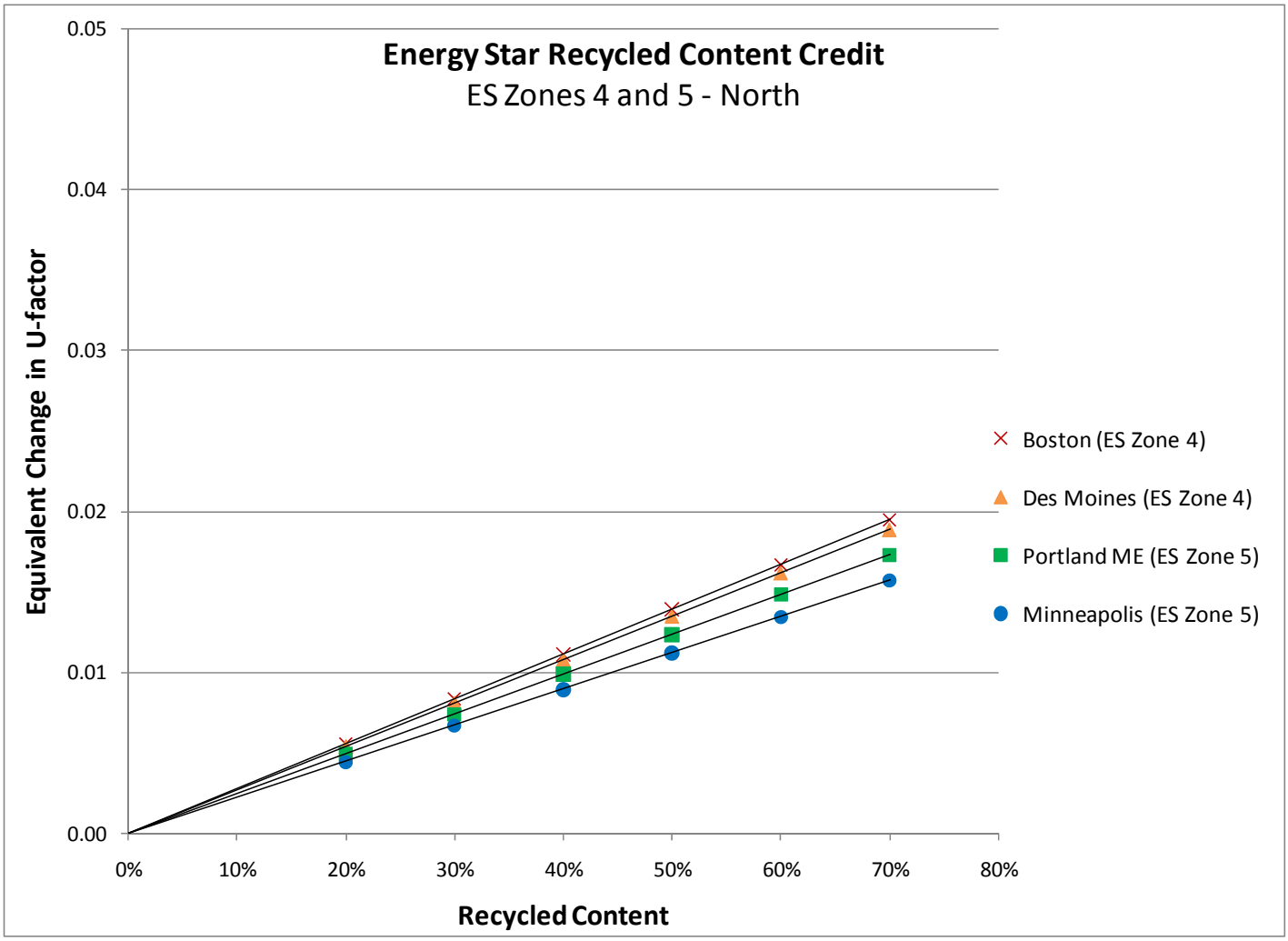
Recycled content	Emb. Eng savings (MJ)	**Equiv ΔU**
20%	5929	**0.009**
30%	8894	**0.013**
40%	11859	**0.018**
50%	14823	**0.022**
60%	17788	**0.027**
70%	20753	**0.031**

ENERGY STAR ZONES 4 AND 5

Combined Recycled Content Credit
based on equivalent U-factor vs. embodied energy savings

Zone 4	
Recycled content	Equivalent ΔU
20%	0.01
30%	0.01
40%	0.01
50%	0.01
60%	0.02
70%	0.02

Zone 5	
Recycled content	Equivalent ΔU
20%	0.00
30%	0.01
40%	0.01
50%	0.01
60%	0.01
70%	0.02



Zone 4:

DES MOINES, IA

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.40	70.1	20544	1162	21706	26271	0	0
0.35	0.40	67.3	19724	1172	20896	25400	2918	1570
0.30	0.40	64.5	18903	1183	20086	24532	5833	3139
							Slope	-31388 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

Recycled content	Emb. Eng savings (MJ)	**Equiv ΔU**
20%	5929	**0.005**
30%	8894	**0.008**
40%	11859	**0.011**
50%	14823	**0.013**
60%	17788	**0.016**
70%	20753	**0.019**

BOSTON, MA

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.40	65	19050	579	19629	22784	0	0
0.35	0.40	62.3	18258	582	18840	21923	2838	1527
0.30	0.40	59.6	17467	592	18059	21084	5651	3041
							Slope	-30408 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

Recycled content	Emb. Eng savings (MJ)	**Equiv ΔU**
20%	5929	**0.006**
30%	8894	**0.008**
40%	11859	**0.011**
50%	14823	**0.014**
60%	17788	**0.017**
70%	20753	**0.019**

Zone 5:

MINNEAPOLIS, MN

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.40	88.6	25966	771	26737	30999	0	0
0.35	0.40	85.3	24999	782	25781	29970	3442	1852
0.30	0.40	81.9	24003	792	24795	28905	6993	3763
							Slope	-37634 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

Recycled content	Emb. Eng savings (MJ)	**Equiv ΔU**
20%	5929	**0.005**
30%	8894	**0.007**
40%	11859	**0.009**
50%	14823	**0.011**
60%	17788	**0.014**
70%	20753	**0.016**

PORTLAND, ME

Furnace

Window properties		Heating	Heating	Cooling	Total Site Energy	Total Source Energy	Source energy savings	Savings - Net Present Value
U (IP)	SHGC	(MBtu)	(kWh)	(kWh)	(kWh)	(kWh)	(MJ/yr)	(MJ/yr)
0.40	0.40	72.2	21160	344	21504	24363	0	0
0.35	0.40	69.2	20281	355	20636	23430	3126	1682
0.30	0.40	66.1	19372	364	19736	22459	6364	3425
							Slope	-34247 (MJ/yr/ΔU)

Equivalent U-factor vs. embodied energy savings:

Recycled content	Emb. Eng savings (MJ)	**Equiv ΔU**
20%	5929	**0.005**
30%	8894	**0.007**
40%	11859	**0.010**
50%	14823	**0.012**
60%	17788	**0.015**
70%	20753	**0.017**