ENERGY STAR for Exterior and Interior Storm Windows

Analysis of Additional Low-e Glass Options

April 4, 2018

Introduction

- In response Draft 1 Specification and Criteria Analysis Report for ENERGY STAR storm windows, stakeholders raised a number of questions about the proposed criteria:
  - Is emissivity greater than 0.15 cost-effective?
  - Is ≤0.55 solar transmittance (Tsol) cost-effective in northern climates? Is >0.55 Tsol cost-effective in southern climates?
  - Is ≤0.55 Tsol cost-effective for interior storm windows in southern climates?
  - Is any Tsol cost-effective in the North-Central Zone?

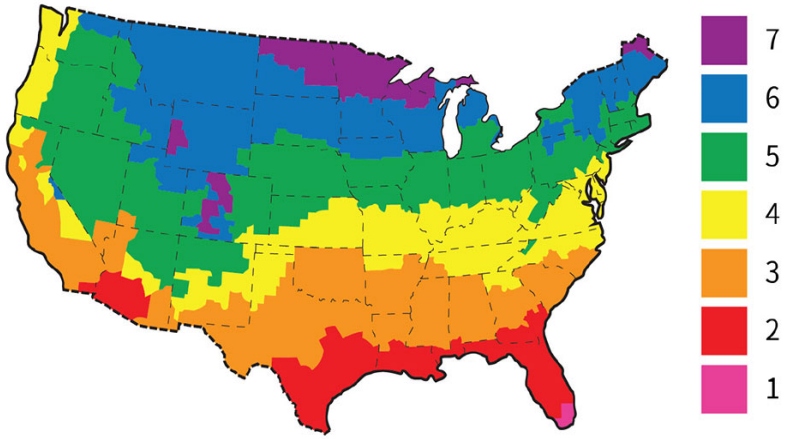
- To further evaluate the proposed criteria, EPA analyzed additional glass options with a wider range of emissivity and Tsol values. The following slides illustrate the results of RESFEN modeling of low-e and clear glass storm windows in IECC climate zones 1-8, and individual cities in climate zone 4:
  - Incremental household energy savings
  - Incremental energy cost savings
  - Incremental payback periods

Methodology

- EPA modeled energy savings in RESFEN with the following assumptions:
  - 24 US cities in IECC climate zones 1-8
  - One-story (1,700 sq ft) and two-story (2,800 sq ft) homes with 15% glazing area
  - U-factor and SHGC of the storm window assemblies calculated using WINDOW simulations over single-pane wood frame primary windows (see slides 4 and 8 for glass properties)
  - Standard assumptions used in *PNNL-24826* (Culp and Cort 2015), including household characteristics and climate

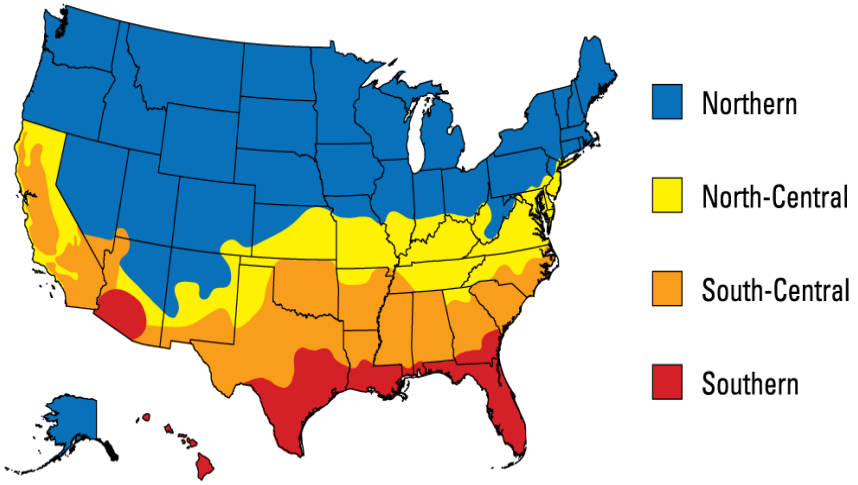
IECC and ENERGY STAR Climate Zones

IECC Climate Zone Map



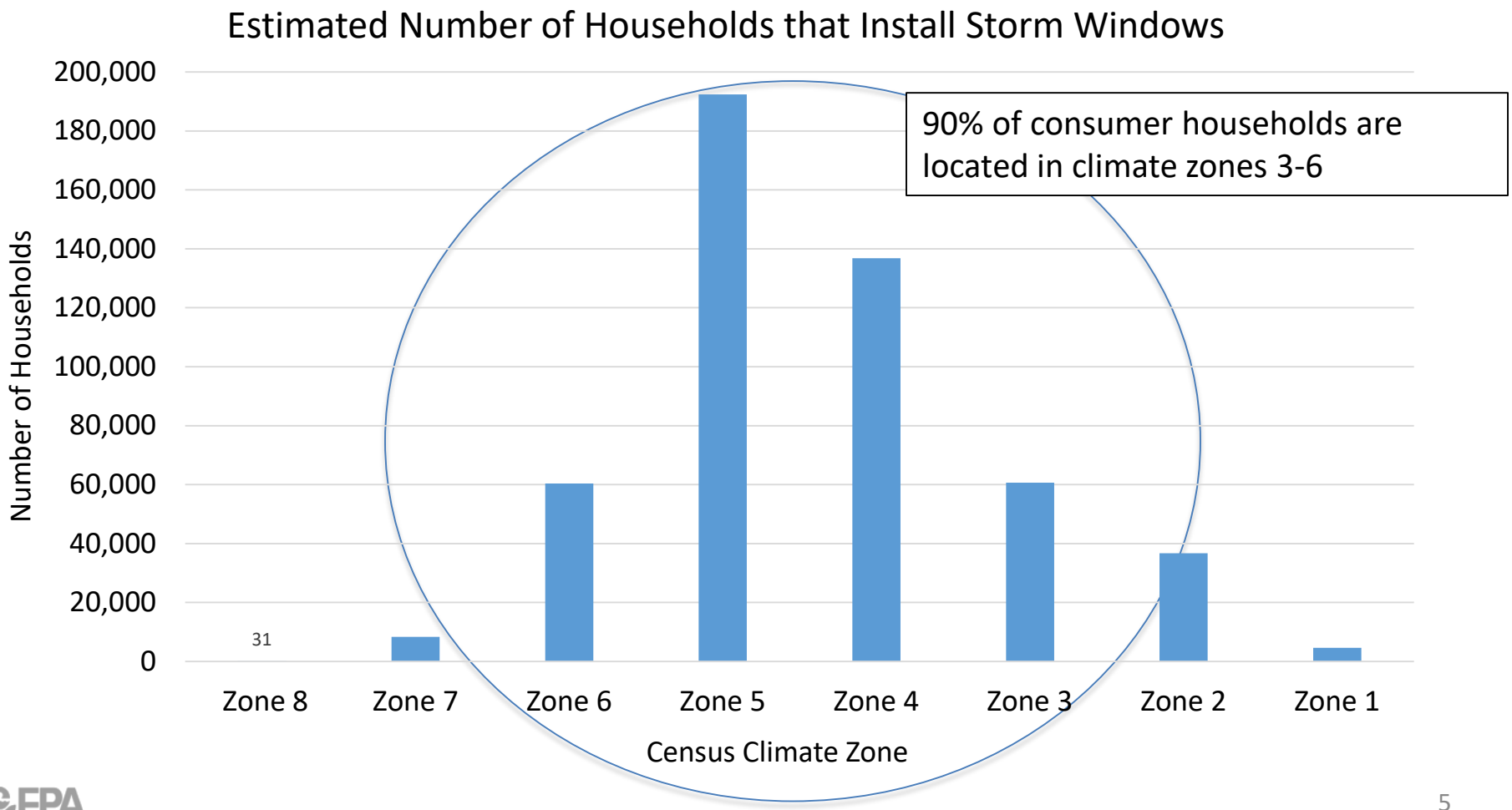
*Climate Zone 8 comprises of the Northern half of Alaska and Hawaii is in Climate Zone 1.

ENERGY STAR Climate Zone Map



- EPA averaged energy savings for one-story and two-story householders in all cities in each zone to calculate the average climate zone savings
- ENERGY STAR climate zones roughly map to IECC zones: Northern Zone (IECC zones 5-8), North-Central Zone (4), South-central Zone (3), Southern Zone (1-2)

Estimated Number of Households in each Climate Zone



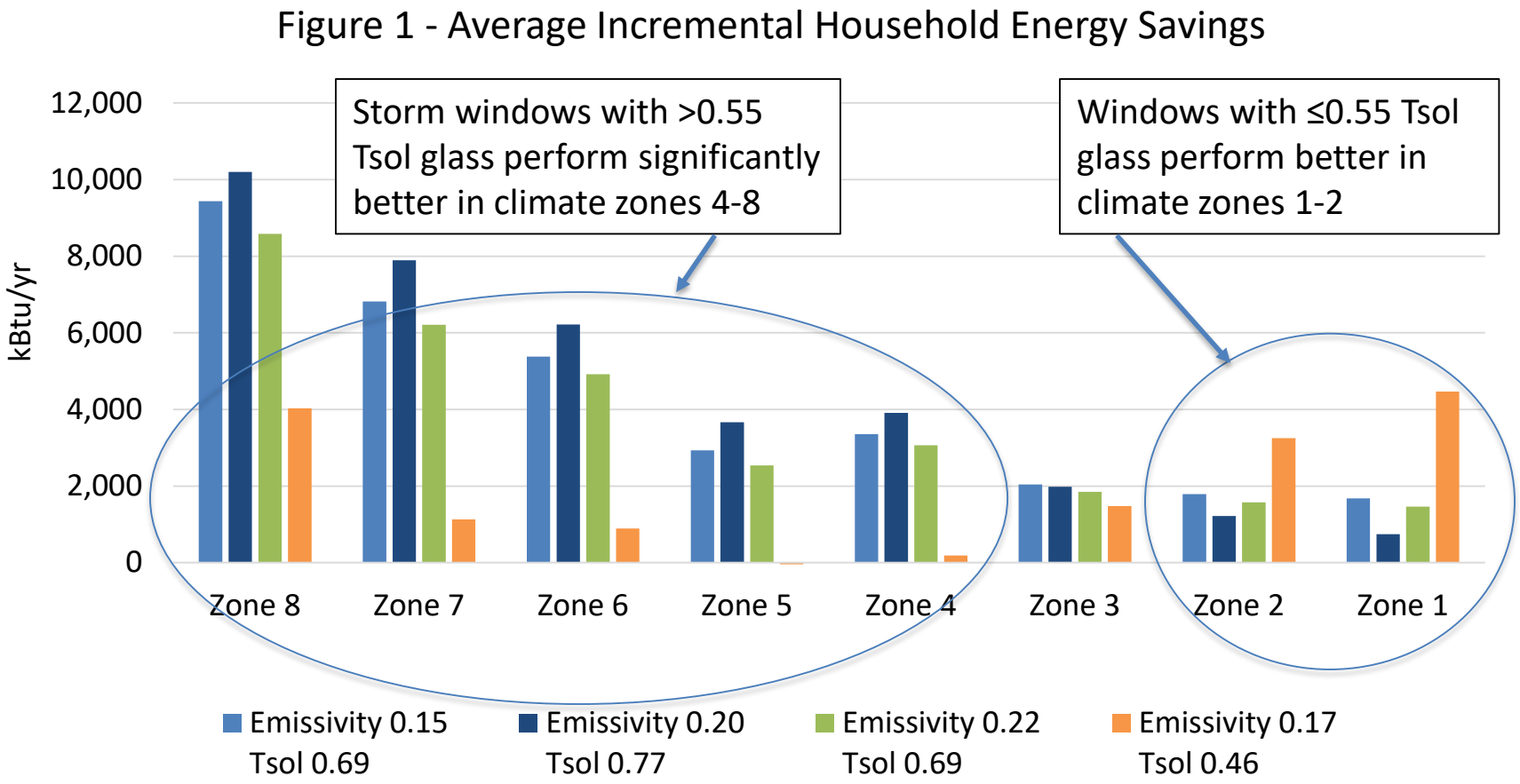
Exterior Storm Window Analysis

- EPA modeled exterior storm window performance for the following glass options:

Glass Option (3 mm)	Emissivity	Solar Transmission	U-factor	SHGC
Clear	0.84	0.86	0.466	0.537
AGC Comfort Select 73	0.15	0.69	0.356	0.458
Guardian IS20	0.20	0.77	0.364	0.502
PPG Sungate 500	0.22	0.69	0.367	0.468
Pilkington Solar-E	0.17	0.46	0.359	0.337

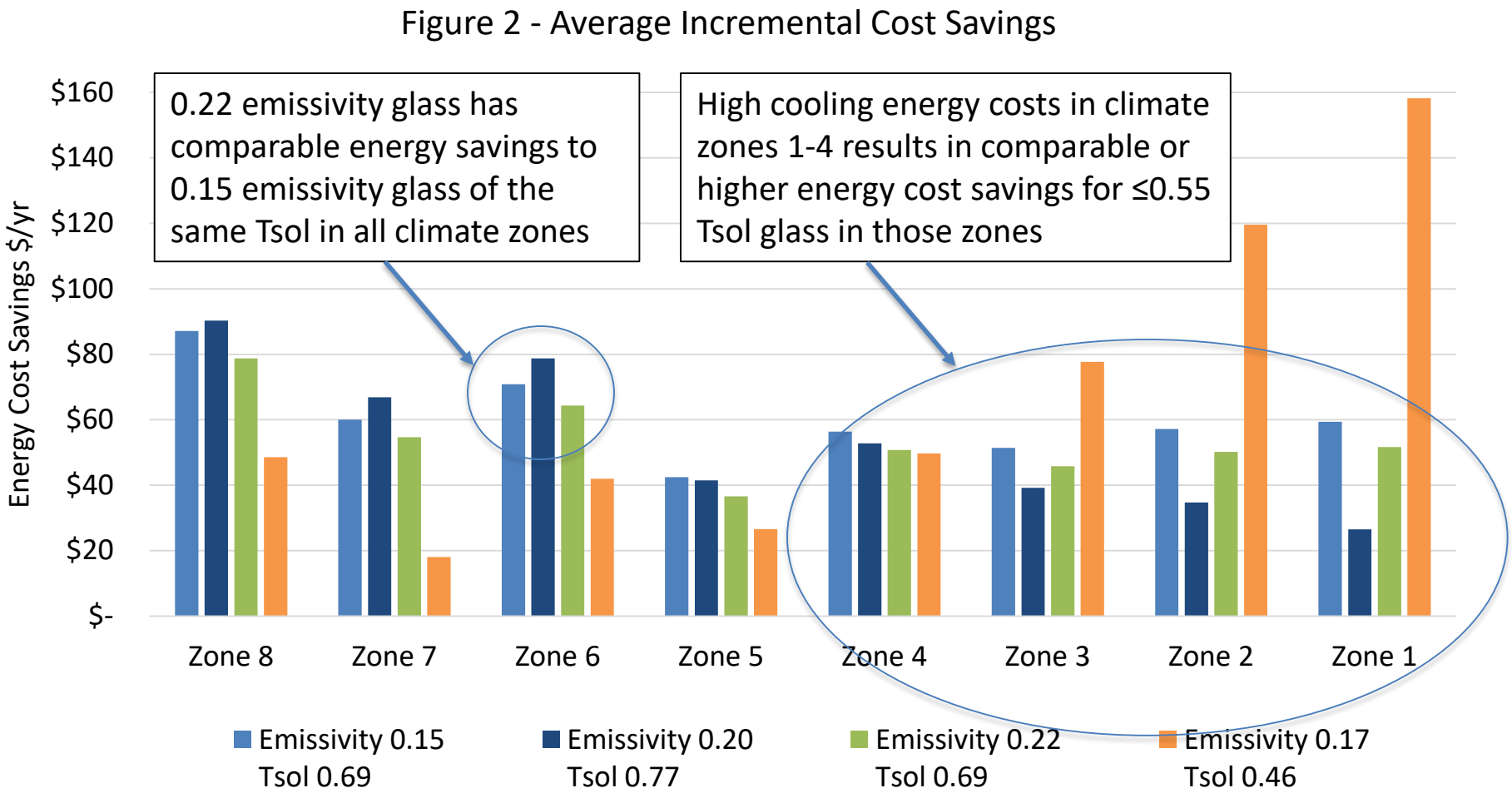
- These glass options are currently available on the market, and can be used by storm window manufacturers to meet the proposed criteria
- Glass options were selected to evaluate a range of energy performance. Other glass options that meet the proposed criteria may also be available on the market

Exterior Storm Windows



Average excludes savings for Seattle, WA In climate zone 4

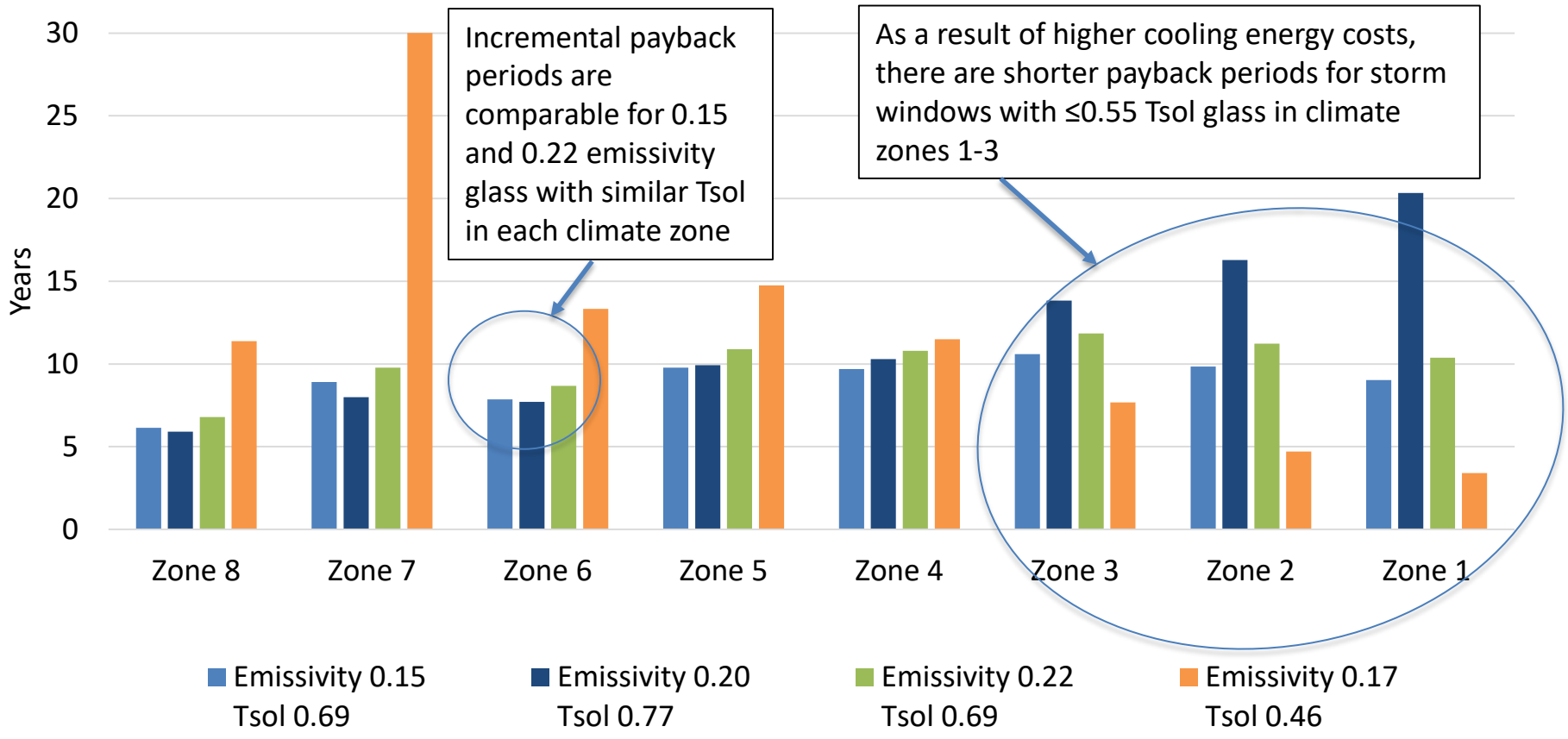
Exterior Storm Windows



Average excludes savings for Seattle, WA In climate zone 4

Exterior Storm Windows

Figure 3 - Average Incremental Payback Period



Average excludes payback for Seattle, WA In climate zone 4

Exterior Storm Windows – Summary

- The energy and cost savings for storm windows with 0.22 emissivity are slightly lower compared to 0.15 emissivity for similar Tsol values; however, the payback periods are very similar for those two options in each climate zone
- Higher energy and cost savings for storm windows with ≤0.55 Tsol in climate zones 1-3 results in shorter payback periods compared to >0.55 Tsol storm windows
- It is clear that >0.55 Tsol storm windows have shorter payback periods in climate zones 5-8 compared to ≤0.55 Tsol storm windows

Interior Storm Window Analysis

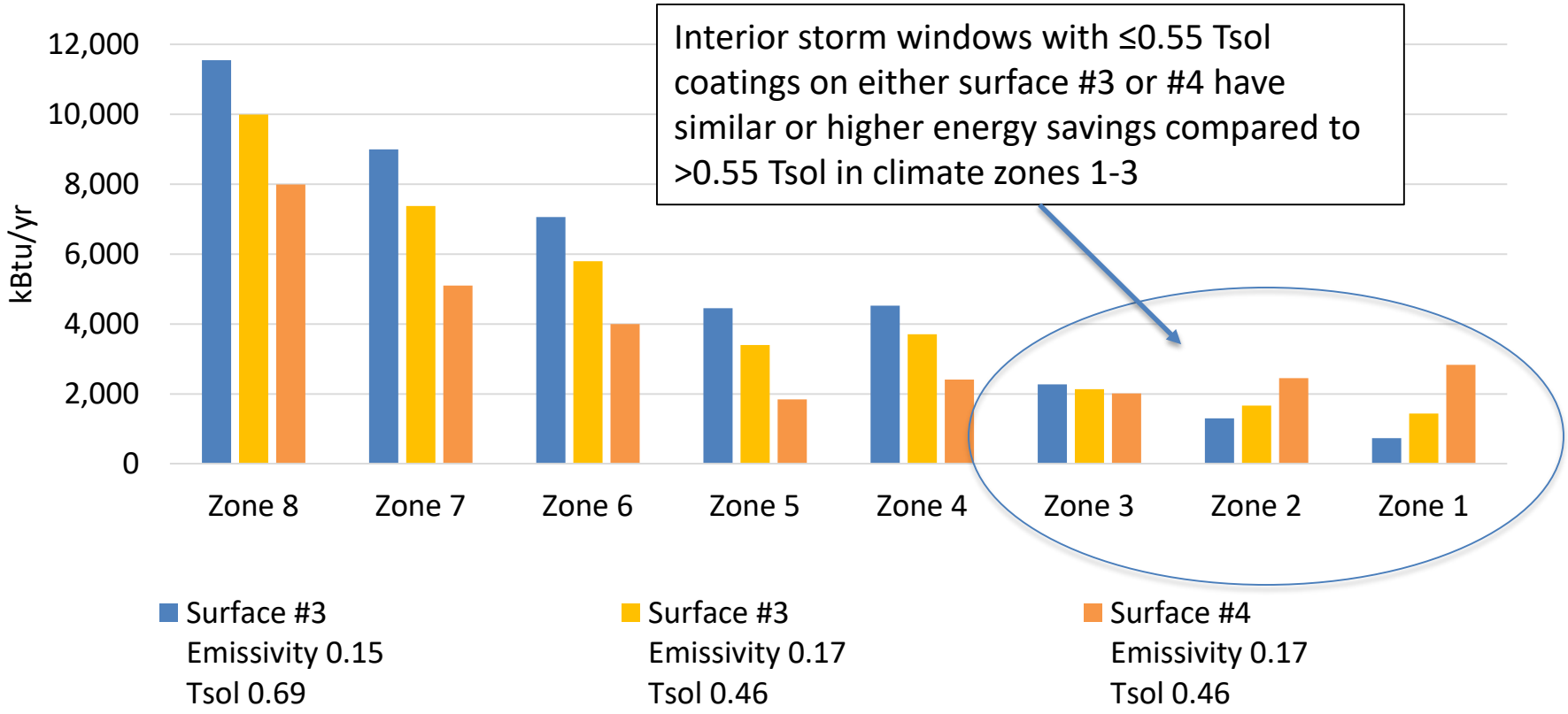
- EPA modeled interior storm window performance for the following glass options:

Glass Option (3 mm)	Emissivity	Solar Transmission	U-factor	SHGC
Clear	0.84	0.86	0.458	0.535
AGC Comfort Select 73 on Surface 3	0.15	0.69	0.344	0.497
PNA Solar-E on Surface 3	0.17	0.46	0.347	0.474
PNA Solar-E on Surface 4	0.17	0.46	0.343	0.412

- EPA compared the performance of >0.55 Tsol glass with ≤0.55 Tsol glass on surface #3 and #4 to further evaluate the Draft 1 proposal ≤0.55 Tsol glass not be eligible for ENERGY STAR certification for interior storm windows

Interior Storm Windows

Figure 4 - Average Incremental Household Energy Savings

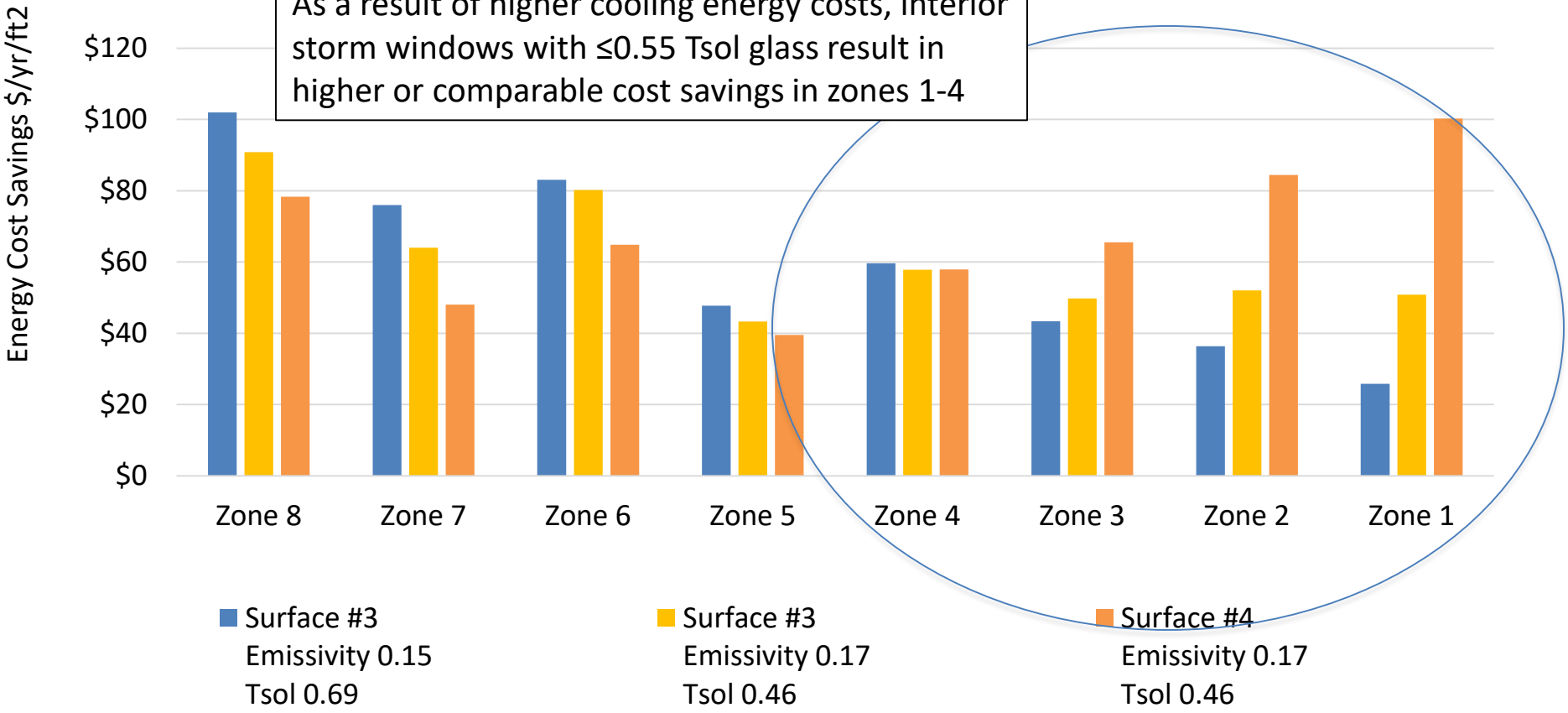


Average excludes savings for Seattle, WA In climate zone 4

Interior Storm Windows

Figure 5 - Average Incremental Cost Savings

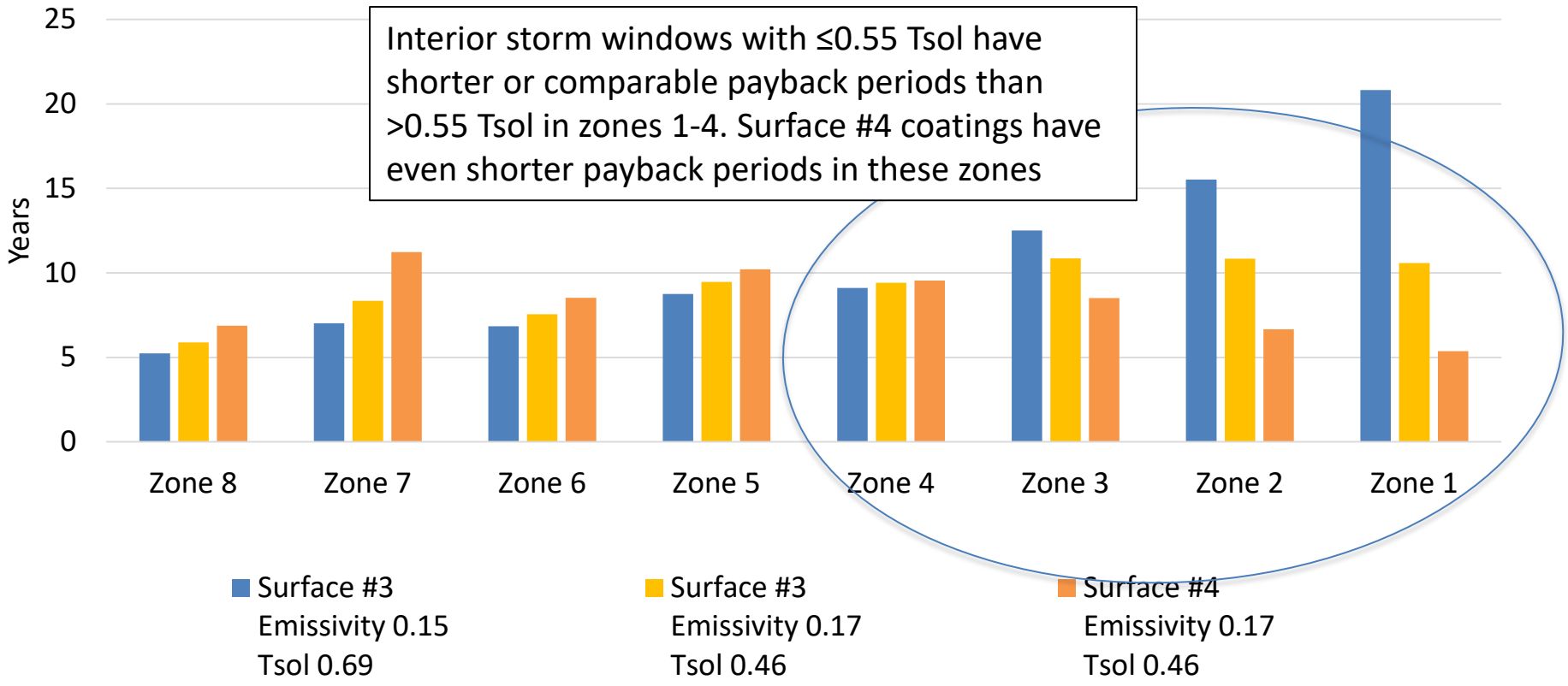
As a result of higher cooling energy costs, interior storm windows with ≤0.55 Tsol glass result in higher or comparable cost savings in zones 1-4



Average excludes savings for Seattle, WA In climate zone 4

Interior Storm Windows

Figure 6 - Average Incremental Payback Periods



Average excludes savings for Seattle, WA In climate zone 4

Interior Storm Windows – Summary

- Interior storm windows with >0.55 Tsol glass result in higher energy savings compared to ≤0.55 Tsol glass in climate zones 4-8
- Interior storm windows with ≤0.55 Tsol glass result in higher or comparable energy savings in zones 1-3, as well as higher or comparable cost savings in climate zones 1-4
- Interior storm windows with low-e coating on the interior face (surface 4) have shorter payback periods than surface 3 low-e coatings in zones 1-3. In Zone 4, the payback periods are comparable

Deeper Analysis of Climate Zone 4

- EPA modeled exterior storm window performance in climate zone 4 for the following glass options:

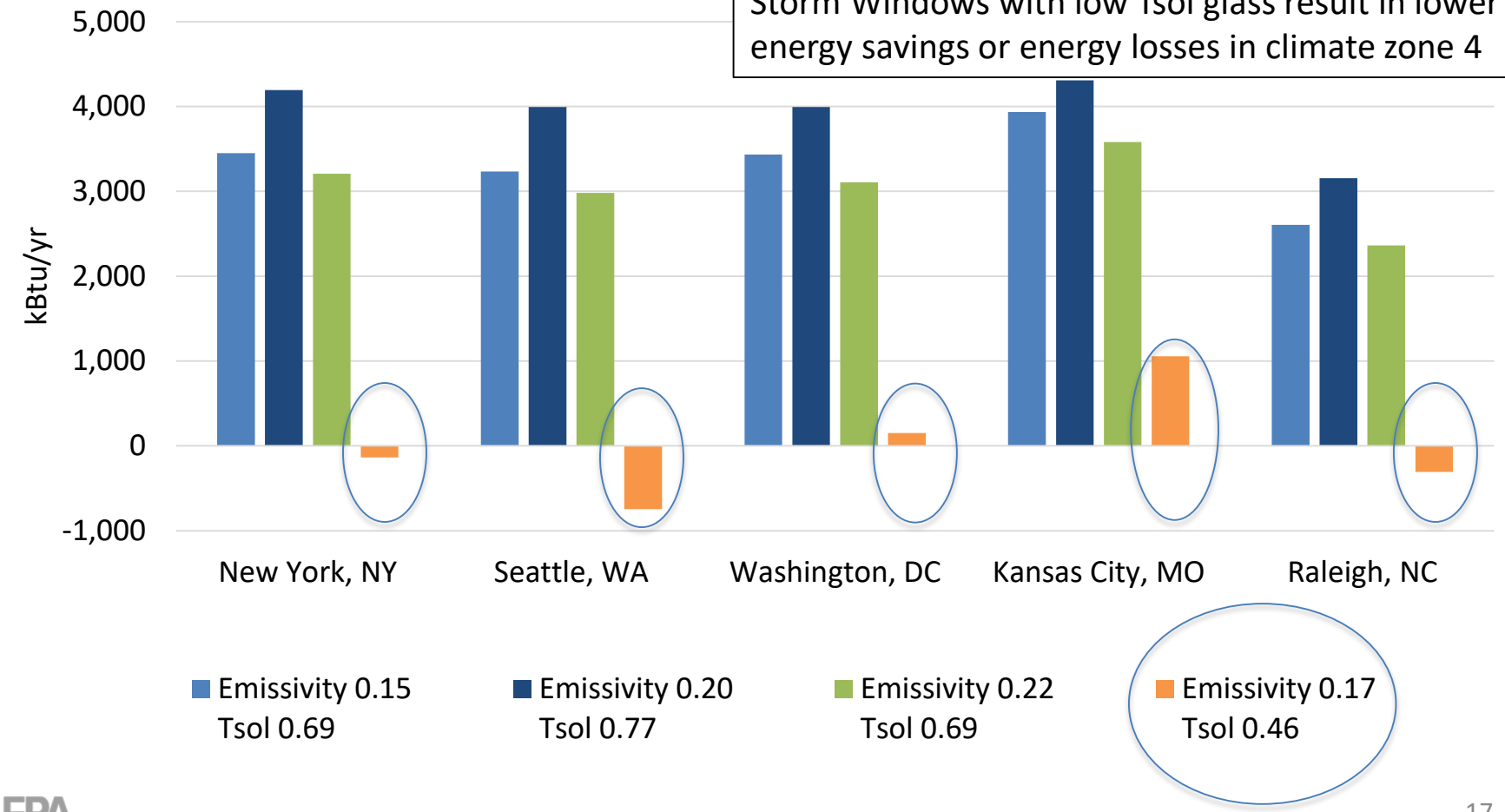
Glass Option (3 mm)	Emissivity	Solar Transmission	U-factor	SHGC
Clear	0.84	0.86	0.466	0.537
AGC Comfort Select 73	0.15	0.69	0.356	0.458
Guardian IS20	0.20	0.77	0.364	0.502
PPG Sungate 500	0.22	0.69	0.367	0.468
Pilkington Solar-E	0.17	0.46	0.359	0.337

- In the Draft 1 specification, EPA proposed allowing any solar transmittance value in climate zone 4
- EPA conducted additional analysis on heating and cooling savings in 5 cities in climate zone 4

Exterior Storm Windows in Climate Zone 4

Figure 7 - Average Incremental Household Energy Savings

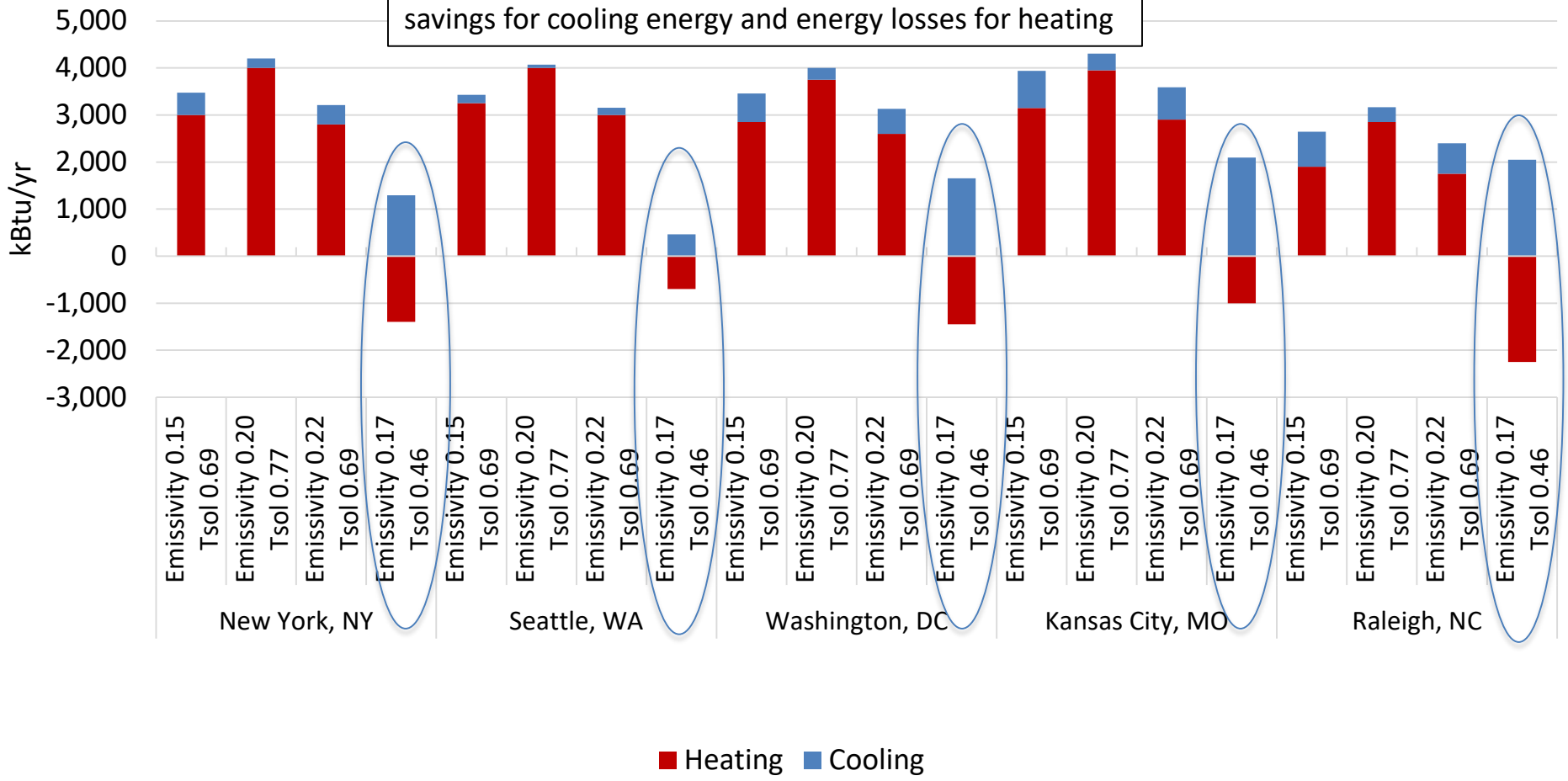
Storm Windows with low Tsol glass result in lower energy savings or energy losses in climate zone 4



Exterior Storm Windows in Climate Zone 4

Figure 8 - Incremental Heating and Cooling Energy Savings

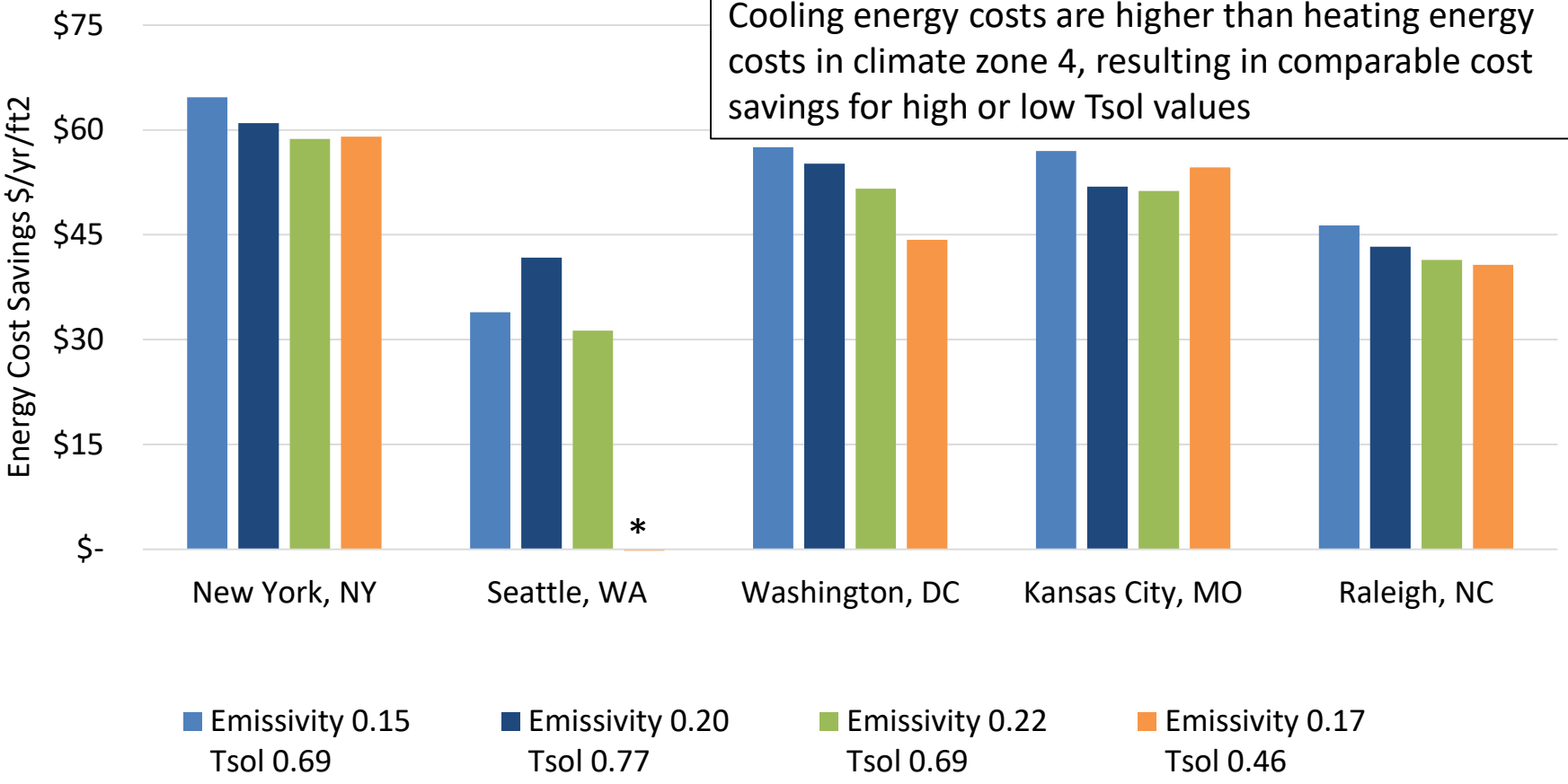
Storm Windows with low Tsol glass result in positive savings for cooling energy and energy losses for heating



Exterior Storm Windows in Climate Zone 4

Figure 9 - Incremental Cost Savings

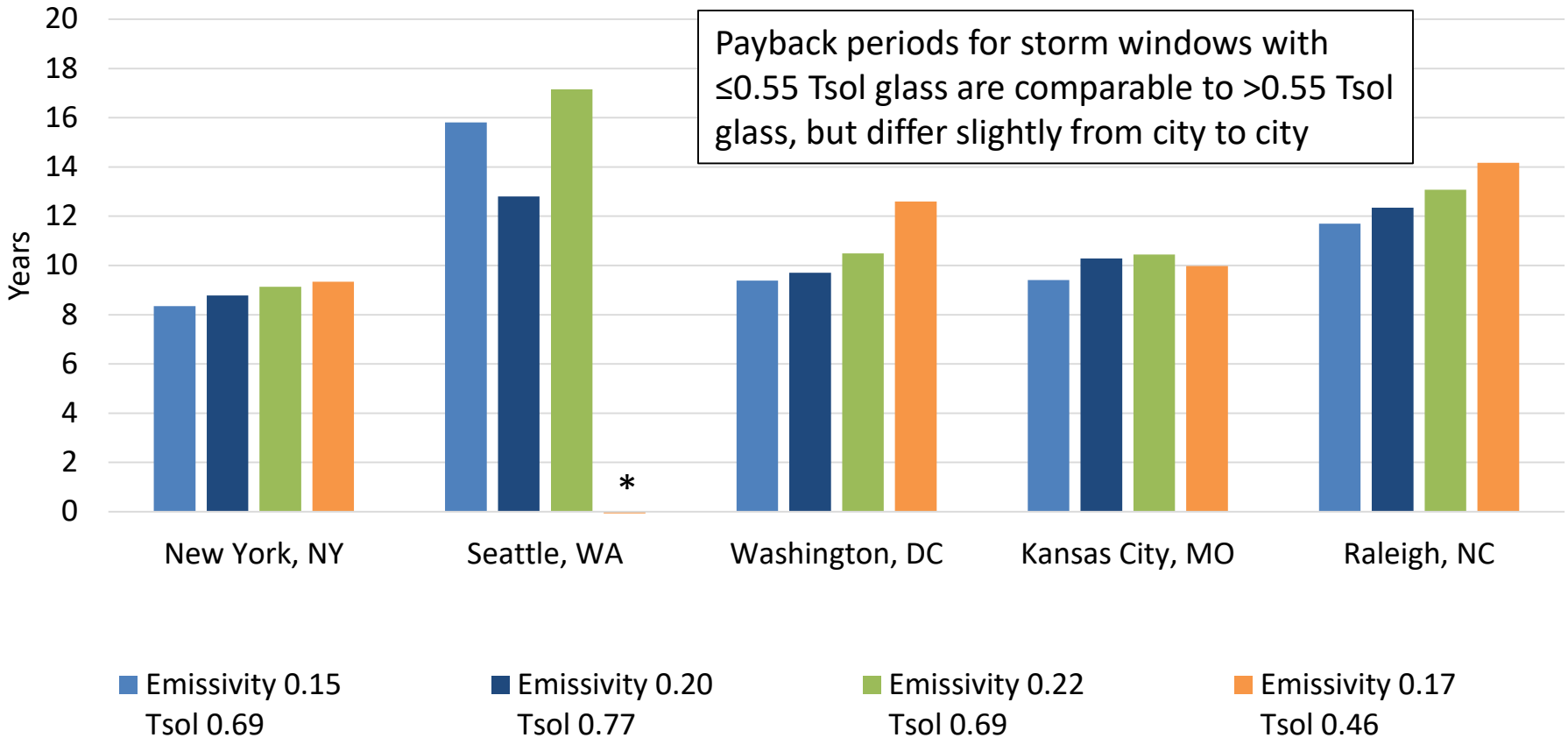
Cooling energy costs are higher than heating energy costs in climate zone 4, resulting in comparable cost savings for high or low Tsol values



*Cost savings for Low Solar Gain Low-E Emissivity 0.17 in Seattle, WA not shown due to negative cost savings

Exterior Storm Windows in Climate Zone 4

Figure 10 - Average Incremental Payback Periods



*Payback for Low Solar Gain Low-E glass (Emissivity 0.17) in Seattle, WA not shown due to negative cost savings

Exterior Storm Windows in Climate Zone 4 - Summary

- Average annual energy savings are lower for storm windows with ≤0.55 Tsol glass compared to >0.55 Tsol, with high cooling savings offset by increased heating energy use in 3 out of 5 cities
- High electricity costs increase the cost of cooling energy, resulting in comparable incremental payback results for the low and high Tsol glass options
- Seattle, WA was assumed to have fewer cooling degree days than other Zone 4 cities. As a result, ≤0.55 Tsol glass would not generate positive energy cost savings in Seattle

Conclusions

- After analyzing additional glass options with a variety emissivity and solar transmittance values, EPA has concluded that emissivity of 0.15 and 0.22 are both cost effective in all climate zones.
- ≤0.55 Tsol glass is not cost effective in the Northern Climate Zone (IECC Zones 5-8), and >0.55 Tsol glass is not cost effective in the Southern and South-Central Climate Zone (IECC Zones 1-3), confirming the proposed Draft 1 criteria for solar transmittance.
- High and low Tsol storm windows offer comparable cost savings and payback periods in the North-Central Climate Zone (IECC Zone 4), meaning glass options with any solar transmittance value are justified. Cost savings between cities can vary, so EPA recommends North-Central Zone consumers consider the design of their home and their heating and cooling preferences when choosing between low and high Tsol glass options.
- EPA concludes that ≤0.55 Tsol interior storm windows should be eligible for ENERGY STAR certification in these climate zones. Interior storm windows with ≤0.55 Tsol have higher energy cost savings compared to >0.55 Tsol in the Southern and South-Central Climate Zone (IECC Zones 1-3).

Supporting Data

- Modeling results and summary tables for this analysis are available on the specification development web page
- https://www.energystar.gov/products/spec/exterior_and_interior_storm_panels_version_1_0_pd

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