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Energy Star Program Savings Estimates

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LBL's role



- LBNL performed national analysis
- Analysis purely based on energy (Btu) not cost (\$)
- Show where savings are possible
- Used to evaluate scenario's
- Analysis also used to help DOE with program planning

General Approach



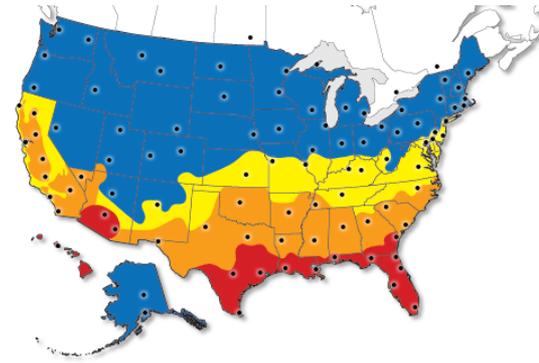
- This update uses the same basic framework and tools as the 2008 specification.
- Intent: keep the methodology as similar as possible to the previous analysis
- Computer Simulations of Window Performance in a Typical House used to assess energy savings potentials from Energy Star program (using DOE-2 annual energy simulation tool)

Energy Simulations



- DOE-2 energy simulations for homes
 - 98 Climates
 - 40+ window types per climate
 - Gas, Electric Resistance, and HP heating
 - Electric Air Conditioning
 - New and Existing, 1 and 2 story homes
 - RESFEN 6 available:

http://windows.lbl.gov/software/resfen/6/resfen_download.asp



- Converted simulation results to Equations
 - Heating/cooling data regressed for each climate as a function of U and SHGC
 - Regressions form the basis for National Energy Savings Model

Major Assumptions



House Type

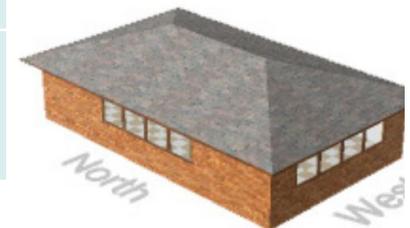
Construction is modeled as frame. Both 1- and 2-story houses are modeled in all climates. Energy impact based on the fractions of 1- and 2-story homes in each climate, for New and Existing.

Foundation:

Based on location, and National Association of Home Builders (NAHB) data. Basement, slab, and crawlspace foundation types are modeled

| Floor Area | New | Existing |
|----------------------|---|---|
| 1 Story Homes | 1700 sq. ft. | 1700 sq. ft. |
| 2 Story Homes | 2800 sq. ft. | 2600 sq. ft. |
| Insulation: | New is based on location using 2006 IECC requirements in Table 402.1.1 (except for fenestration). | Existing is modeled based on Ritschard et al. (1992). |
| Infiltration: | SLA = 0.00036 | SLA = 0.00054 |

SLA = Standard Leakage Area = Effective leakage area / conditioned floor area.



Rationale: National Model



- DOE-2 models tell only part of the story:
 - Four buildings for each of 98 cities in database:
 - New vs. existing homes, 1 vs. 2 story
 - Also need to account for regional variation:
 - Population density
 - window sales patterns
 - Heating fuels
 - equipment penetration
- National sales model weights these regional patterns.

National Savings Model



- Estimates national and regional energy consumption
 - Estimates window sales based on Ducker shipment data.
 - Disaggregated by new homes / remodel and replacement
- Savings from window programs calculated by comparing scenarios.
 - The DOE-2 database allows wide range of U/SHGC simulations.
- Model handles translation among the different geographic areas
 - Efficiency: ENERGY STAR, IECC zones
 - Population, housing characteristics: Census
 - Sales: States
- Calibrated using RECS data

Reference Windows



- Double-pane, clear glass, vinyl frame
 - Used to represent low-end products and older code options,
- IECC criteria were used as the basis for the next sets of reference criteria
 - 2009 and 2012
 - Modifications to SHGC in modeling
- Also current ENERGY STAR (v. 5.0)
- Set penetration rates for each type based on existing and projected building code adoption.

Modeled Reference Windows



| | Zone | Criteria Maxima | | Model Inputs | |
|--------------|---------------|-----------------|------|--------------|------|
| | | U-factor | SHGC | U-factor | SHGC |
| Double Clear | All | N/A | N/A | 0.45 | 0.55 |
| IECC 2009 | 8 | 0.35 | NR | 0.35 | 0.27 |
| | 7 | 0.35 | NR | 0.35 | 0.27 |
| | 6 | 0.35 | NR | 0.35 | 0.27 |
| | 5 | 0.35 | NR | 0.35 | 0.27 |
| | 4 | 0.35 | NR | 0.35 | 0.27 |
| | 3 | 0.5 | 0.3 | 0.5 | 0.27 |
| | 2 | 0.65 | 0.3 | 0.65 | 0.27 |
| | 1 | 1.2 | 0.3 | 1.2 | 0.27 |
| IECC 2012 | 8 | 0.32 | NR | 0.32 | 0.27 |
| | 7 | 0.32 | NR | 0.32 | 0.27 |
| | 6 | 0.32 | NR | 0.32 | 0.27 |
| | 5 | 0.32 | NR | 0.32 | 0.27 |
| | 4 | 0.35 | 0.4 | 0.35 | 0.27 |
| | 3 | 0.35 | 0.25 | 0.35 | 0.25 |
| | 2 | 0.4 | 0.25 | 0.4 | 0.25 |
| | 1 | NR | 0.25 | 1.2 | 0.25 |
| ENERGY | Northern | 0.30 | NR | 0.30 | 0.27 |
| STAR | North-Central | 0.32 | 0.4 | 0.32 | 0.27 |
| (2010) | South-Central | 0.35 | 0.3 | 0.35 | 0.27 |
| | Southern | 0.6 | 0.27 | 0.6 | 0.27 |

Modeled Criteria Scenarios



To evaluate potential Version 6.0 ENERGY STAR criteria, several sets of candidate window specifications were developed.

- Complete criteria sets to evaluate overall programmatic impact potential
- Individual U-factor and SHGC criteria across the zones
- Understand trends in heating and cooling loads at various levels.

| ENERGY STAR Climate Zone | U-Factor | SHGC |
|--------------------------|-----------|-----------|
| Northern | 0.18-0.27 | 0.25-0.27 |
| North-Central | 0.22-0.30 | 0.27 |
| South-Central | 0.25-0.32 | 0.23-0.25 |
| Southern | 0.30-0.40 | 0.17-0.25 |

Modeling Variations



- Several ENERGY STAR Market Penetration variants were modeled
 - 10%, 5% and no MP reduction after new specification
- Savings presented are “first year” program savings; further MP over time was not modeled.
- What we present are results for the default-MP with calibration

Savings Results



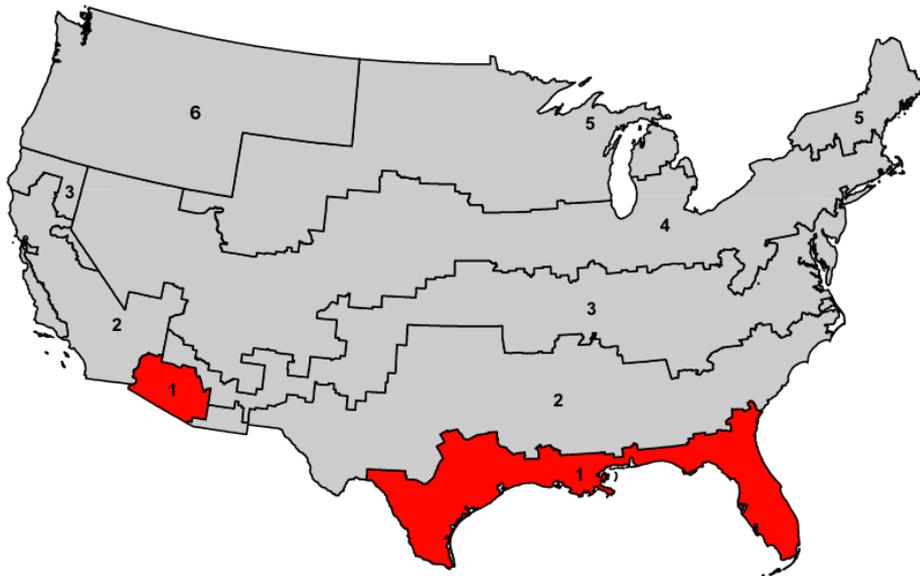
- Savings presented are “first year” program savings only.
 - Further market penetration over time not modeled
- Savings due to changed SHGC over existing Energy Star are small in most instances.
 - Higher than expected share of efficient windows
 - Very high market share of ENERGY STAR compliant products
- Zone savings $\approx 0.23 - 0.99$ trillion Btu per year

Zone 1 South



| Specification | V. 5 | V.6 |
|-------------------|------|------|
| U-value | 0.60 | 0.40 |
| SHGC (Criterion) | 0.27 | 0.25 |
| SHGC (as Modeled) | 0.27 | 0.25 |

| Trillion Btu Savings | |
|----------------------|------|
| Total | 0.99 |
| Heating | 0.93 |
| Cooling | 0.06 |



Remarks:

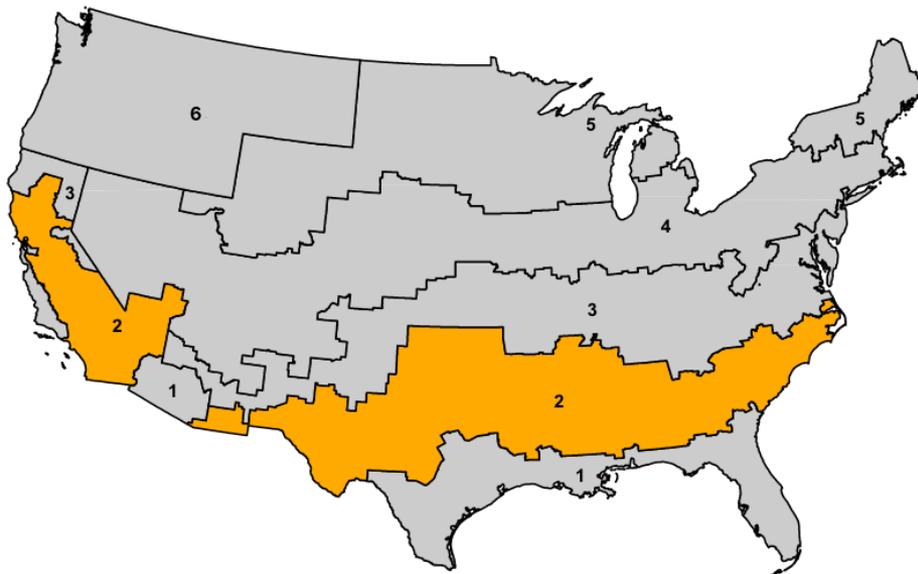
Heat savings quite substantial, partly due to relatively low existing penetration rate of high efficiency windows.

Zone 2 South Central



| Specification | V5 | V6 |
|-------------------|------|------|
| U-value | 0.35 | 0.31 |
| SHGC (Criterion) | 0.30 | 0.25 |
| SHGC (as Modeled) | 0.27 | 0.25 |

| Trillion Btu Savings | |
|----------------------|------|
| Total | 0.23 |
| Heating | 0.17 |
| Cooling | 0.06 |



Remarks:

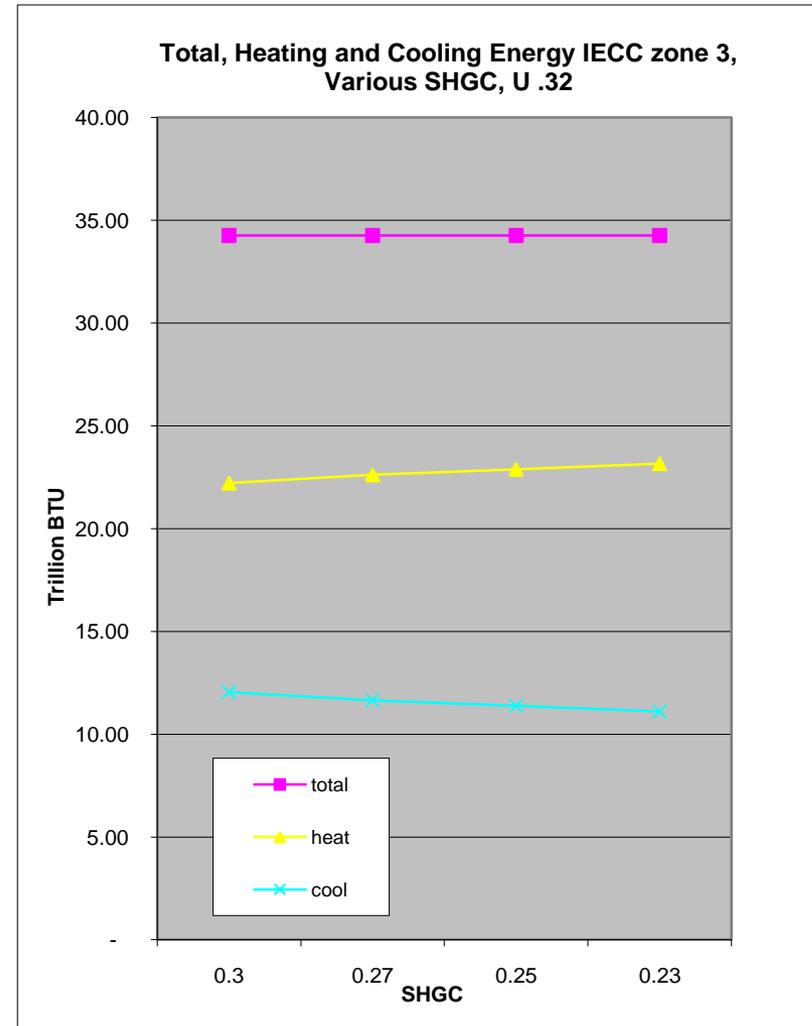
Proposal modestly improved in this zone, and savings correspond.

SHGC sensitivity in South Central zone



Changes in Heating and Cooling Energy due to changes in SHGC largely offset each other.

Same effect at U .32 and .35

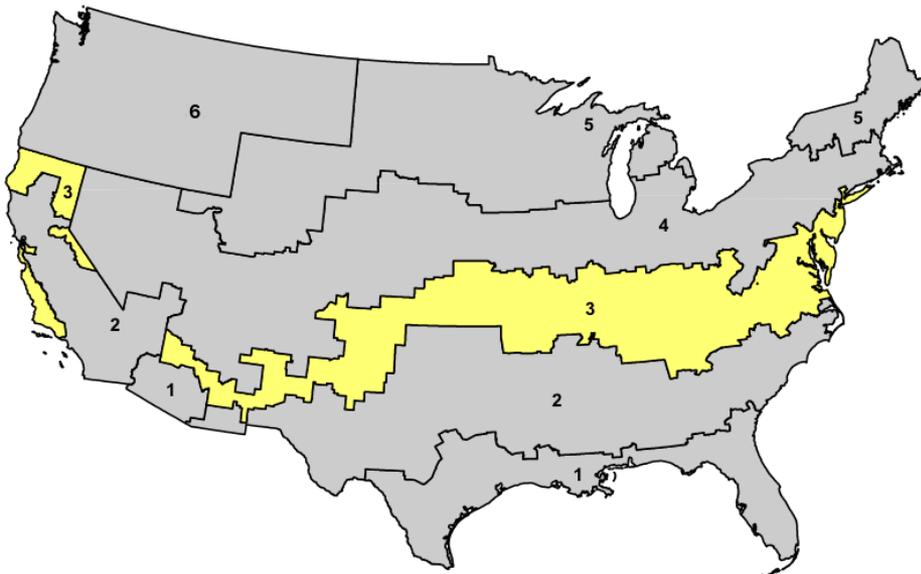


Zone 3 North Central



| Specification | V5 | V6 |
|-------------------|------|------|
| U-value | 0.32 | 0.29 |
| SHGC (Criterion) | 0.40 | 0.40 |
| SHGC (as Modeled) | 0.27 | 0.27 |

| Trillion Btu Savings | |
|----------------------|--------|
| Total | 0.47 |
| Heating | 0.54 |
| Cooling | (0.07) |



Remarks:

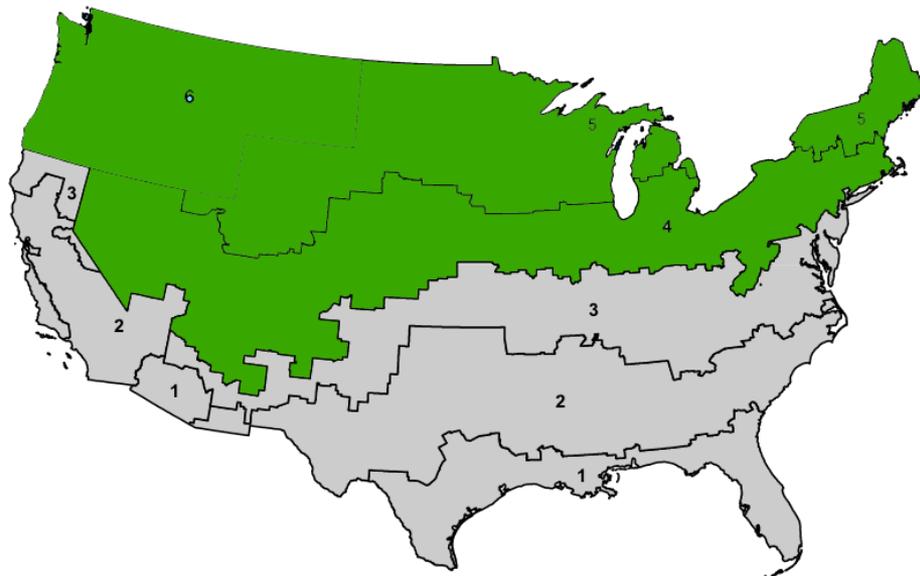
Heat savings dominate.
Improvement only in U-factor.
Modest cooling losses.

Zone 4 North



| Specification | V5 | V6 |
|-------------------|------|------|
| U-value | 0.30 | 0.27 |
| SHGC (Criterion) | Any | Any |
| SHGC (as Modeled) | 0.27 | 0.27 |

| Trillion Btu Savings | |
|----------------------|--------|
| Total | 0.51 |
| Heating | 0.67 |
| Cooling | (0.15) |



Remarks:

Energy savings in heating, due to significant U-factor improvement.

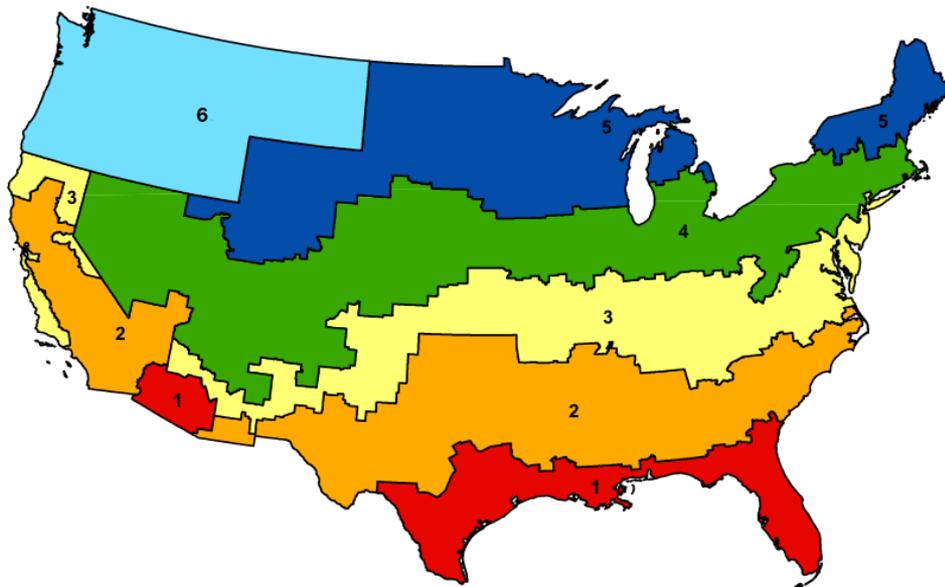
Most populous zone

National Savings



| Trillion Btu Savings | |
|----------------------|--------|
| Total | 2.21 |
| Heating | 2.31 |
| Cooling | (0.10) |

1 trillion Btu \approx \$18 million



Remarks:

Significant annual savings in heating energy, overall modest increase in cooling energy.

Even greater heating savings possible but might require shift to triples and minimum SHGC in the North.

Annual savings from program expected to increase in future years as penetration of ENERGY STAR products increases.

Trade-off analysis



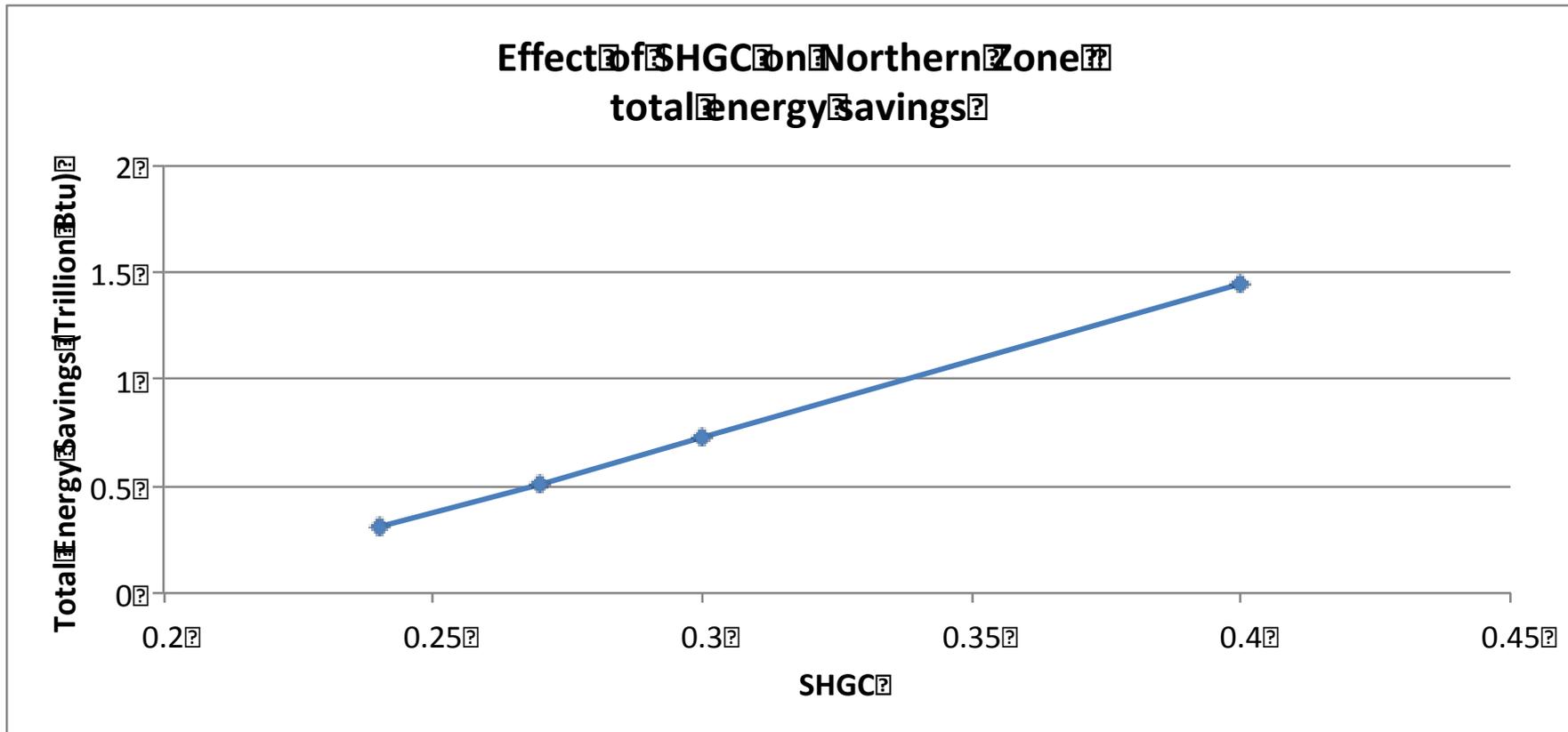
- In heating climates, equal annual energy performance can be achieved with different U/SHGC combinations.
 - Want to reduce overall energy consumption
 - Lower U – better thermal performance
 - Raise SHGC – increased “free” heat (but must be “useful” to offset net heating)
- How much do you have to raise SHGC to keep the same energy consumption with a higher U?
 - - 0.01 U = 0.xx SHGC
- Tradeoff analysis performed for Northern ENERGY STAR zone

Procedure



- Calculate overall energy consumption with spec U (0.27) and modeled SHGC (0.27)
- Then increase the U-factor by 0.01
- Calculate which SHGC will result in equivalent energy consumption
- Result: $U=0.28$, $SHGC=0.32$
- $0.01 U = 0.05 SHGC$

Effect of SHGC in the North



- SHGC=0.27 modeled in Northern Zone because of market availability of products
- Setting a minimum SHGC higher would result in significantly larger savings (e.g. double the savings for SHGC=0.35)

Sources



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