# Building Technologies Program

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

## DOE Research Initiatives for High Performance Windows

**Presented at the AEE Columbia River Chapter**

**Portland, OR**

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November 8, 2010

# DOE Building Envelope and Window R&D Budget

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| Year | Budget Request $Million | Final Budget Appropriations $Million |
|---|---|---|
| **FY04** | $5.1 | $8.2 |
| **FY05** | $5.0 Windows<br>$0 Envelope | $5.8 Windows<br>$2.8 Envelope } $8.6 |
| **FY06** | $5.0 Windows<br>$0 Envelope | $3.8 Windows<br>$2.9 Envelope } $6.7 |
| **FY07 & FY08** | $4.7 Windows<br>$2.4 Envelope | $4.7 Windows<br>$2.4 Envelope } $7.1 |
| **FY09** | $5.2 Windows<br>$3.4 Envelope | $5.5 Windows<br>$4.5 Envelope } $10.0 |
| **FY 10** | $10.5 Windows<br>$5.5 Envelope | $10.5 Windows<br>$ 5.5 Envelope } $16.0 |
| **FY 11** | $10.5 Windows<br>$8.5 Envelope | TBD (Continuing Resolution) |

ARRA ~ $25

# Integrated Programs to Reduce Prices of Highly Insulating Windows

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**Technical Support**

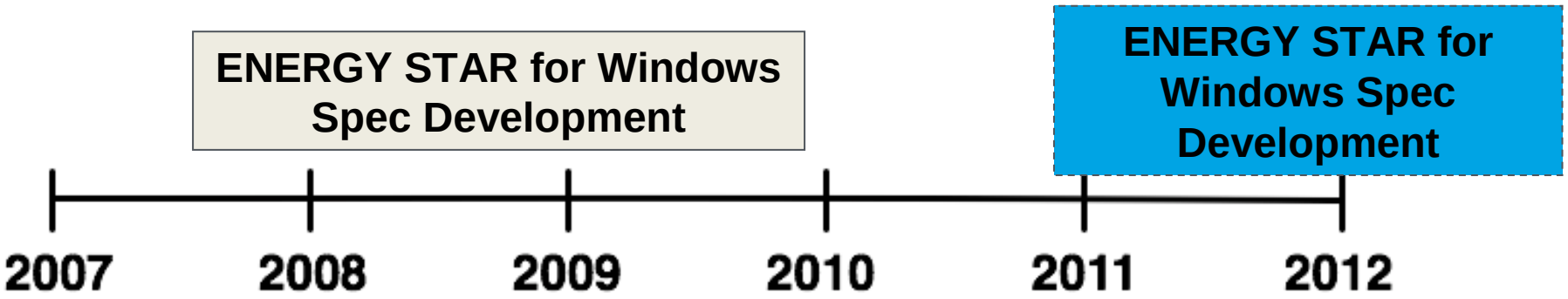
**Building America Demonstrations**

**High-Performance Specs in LEED for Homes & NGBS**

**Production Engineering RFP – 50% DOE Cost Share (ARRA funding)**

**Technology Procurement/Volume Purchases**

**Support Utility Programs for Advanced Window Promotion & Incentives**



# DOE Provides Technical & Financial Support

BERKELEY LAB

http://windows.lbl.gov/software

NFRC
National Fenestration Rating Council

www.nfrc.org

Efficient Windows Collaborative

www.efficientwindows.org

- Full range of software support tools, education materials and expansion to new product categories.
- Continued financial support to assist industry in rating, certifying and promoting efficient windows products.

# Whole Building Demonstrations



- Current: determine system affects – reduced ducting, HVAC capacity & improved comfort
- Next:
  - Highly insulating (>R5) and dynamic solar control, using products from production engineering project.
  - Manufactured housing R-5 windows demonstration in Pacific Northwest/PNNL (joint funded by BPA)

# Next Generation of Windows: Production Engineering

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- Highly Insulating
  - Goal is U-factor 0.10
  - Possible vacuum glazings
- Dynamic solar control
  - Passive heating and dramatic peak cooling reduction, SHGC 0.53 – 0.09
  - Now market ready, prices will drop with more investment in production
  - Many new projects underway in 2012 - 2014

Prototype – Concept Window
Highly Insulating and Dynamic
U-factor 0.18
SHGC 0.04 – 0.34
Low cost unsealed center lite

# Highly Insulating R5 Production Engineering Solicitation & Award

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- DOE Selected GED Integrated Solutions in partnership with PPG, and other major window companies.
- Goal – Affordable R5 (U-factor of 0.22 or less for operable window and 0.20 or less for fixed window) with price premium less than $4/ft$^2$ compared to conventional double pane low-e.
- Multiple paths to market, window companies and IGU sales.
- Product availability 12 – 24 months.
- Traco recently selected for high performance commercial product development.
- Small Business Innovation Research RFP for materials & envelope anticipated in FY11

# Dynamic Windows Field Trials

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## Project Results

-Cooling energy savings up to 20%
-Peak demand savings up to 26%

-Human factors evaluation underway

## Commercial

## Residential

# ENERGY STAR: DOE Criteria Now Led by EPA

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## ENERGY STAR for Windows – Effective January 2010

ENERGY STAR® Qualification Criteria for Residential Windows, Doors, and Skylights

**Windows**

| Climate Zone | U-Factor[1] | SHGC[2] | |
|---|---|---|---|
| Northern | ≤ 0.30 | Any | Prescriptive |
| | =0.31 | ≥ 0.35 | Equivalent Energy Performance |
| | =0.32 | ≥ 0.40 | |
| North-Central | ≤ 0.32 | ≤ 0.40 | |
| South-Central | ≤ 0.35 | ≤ 0.30 | |
| Southern | ≤ 0.60 | ≤ 0.27 | |

**Doors**

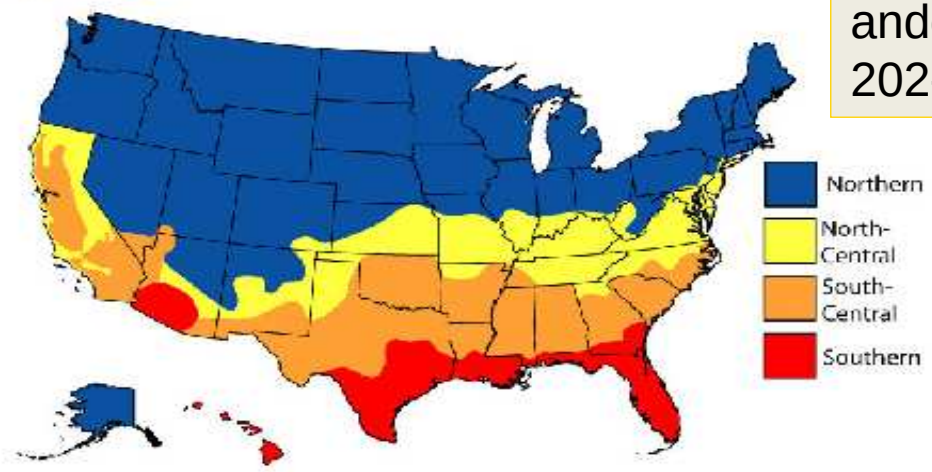
| Glazing Level | U-Factor[1] | SHGC[2] |
|---|---|---|
| Opaque | ≤ 0.21 | No Rating |
| ≤ ½-Lite | ≤ 0.27 | ≤ 0.30 |
| > ½-Lite | ≤ 0.32 | ≤ 0.30 |

**Skylights**

| Climate Zone | U-Factor[1] | SHGC[2] |
|---|---|---|
| Northern | ≤ 0.55 | Any |
| North-Central | ≤ 0.55 | ≤ 0.40 |
| South-Central | ≤ 0.57 | ≤ 0.30 |
| Southern | ≤ 0.70 | ≤ 0.30 |

[1] Btu/h.ft².°F

[2] Fraction of incident solar radiation

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# ENERGY STAR Phase II for Windows




- DOE will support EPA in moving ahead with Phase II ENERGY STAR criteria.
- Consideration by EPA given to a “Super Star” approach for all products, with advanced criteria sooner, combined with longer time in market for current ENERGY STAR.
- DOE originally proposed in 2008 a U-factor of 0.20-0.24 for Northern Climates with SHGC > 0.35 in the 2013 to 2014 timeframe.
- Comments from industry will be sought by EPA when draft criteria issued for windows, doors & skylights in August 2011.

# Heat Transfer in Windows

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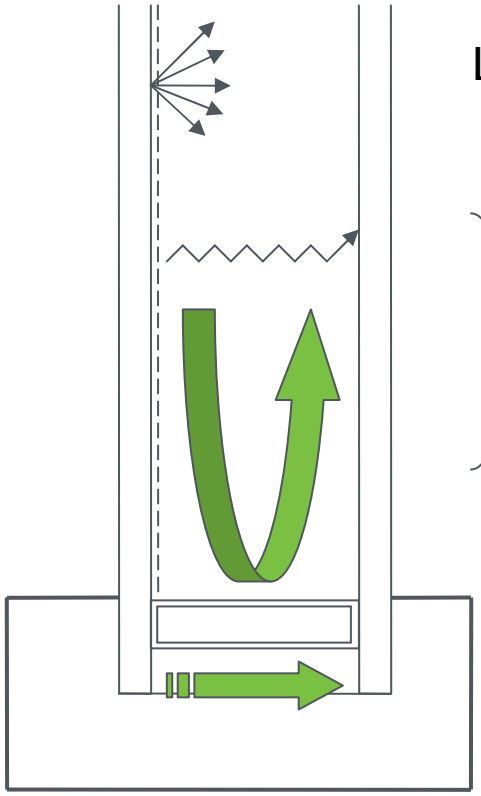
## Heat Transfer Mechanisms

Radiation

Conduction

Convection

Conduction



## Heat Transfer Reduction Mechanisms

Low-e (emissivity) coatings

Special gas fills (Ar/Kr)
Multiple cavities (panes)

Low conductance spacers
Better/more insulative frames

# Performance Indices

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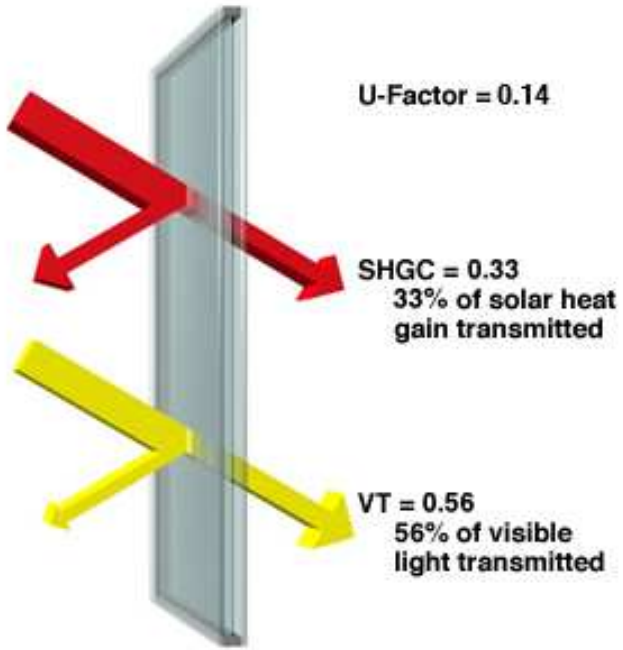
## Key windows performance indices

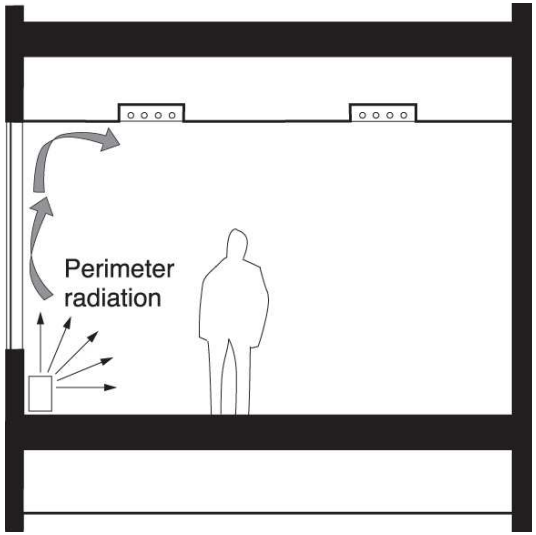
- ❑ U-factor
  - Measure of thermal resistance to non-solar heat flow
  - Units: Btu/hr-ft$^2$-$^o$F
  - R-value is reciprocal of U-factor: U=0.20, R=1/0.20 = 5 hr-ft$^2$-$^o$F/Btu
  - Lower U/higher R is better
  - Focus on whole window U-factor
- ❑ SHGC (Solar Heat Gain Coefficient)
  - Measure of solar gains in %
  - Ranges from 0-1, higher means more solar heat gains to interior
- ❑ VT (Visible Transmittance)
  - Measure visible light transmitted in %
  - Ranges from 0-1, higher means more daylight (and possibly glare) in interior

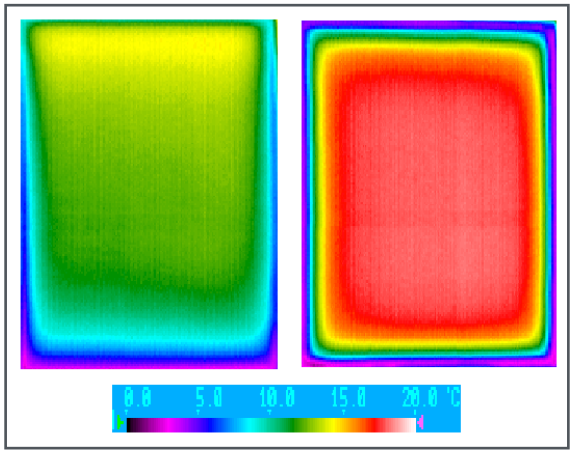


# Comfort Benefits of Highly Insulating Windows (Non-Quantitative)



- Areas near windows can be uncomfortable.
- Generally provide perimeter heating near or under windows to mitigate.
- Perimeter heating may not be necessary with highly insulating windows.



# Windows & Solar Heat Gain



The right solar heat gain coefficient depends strongly on climate and house design:

- Solar heat gain through windows helps offset heating loads (east and south facing windows)
- Can increase cooling requirements (primarily with west facing windows)

# Integrated Program to Reduce Price of Highly Insulating Windows

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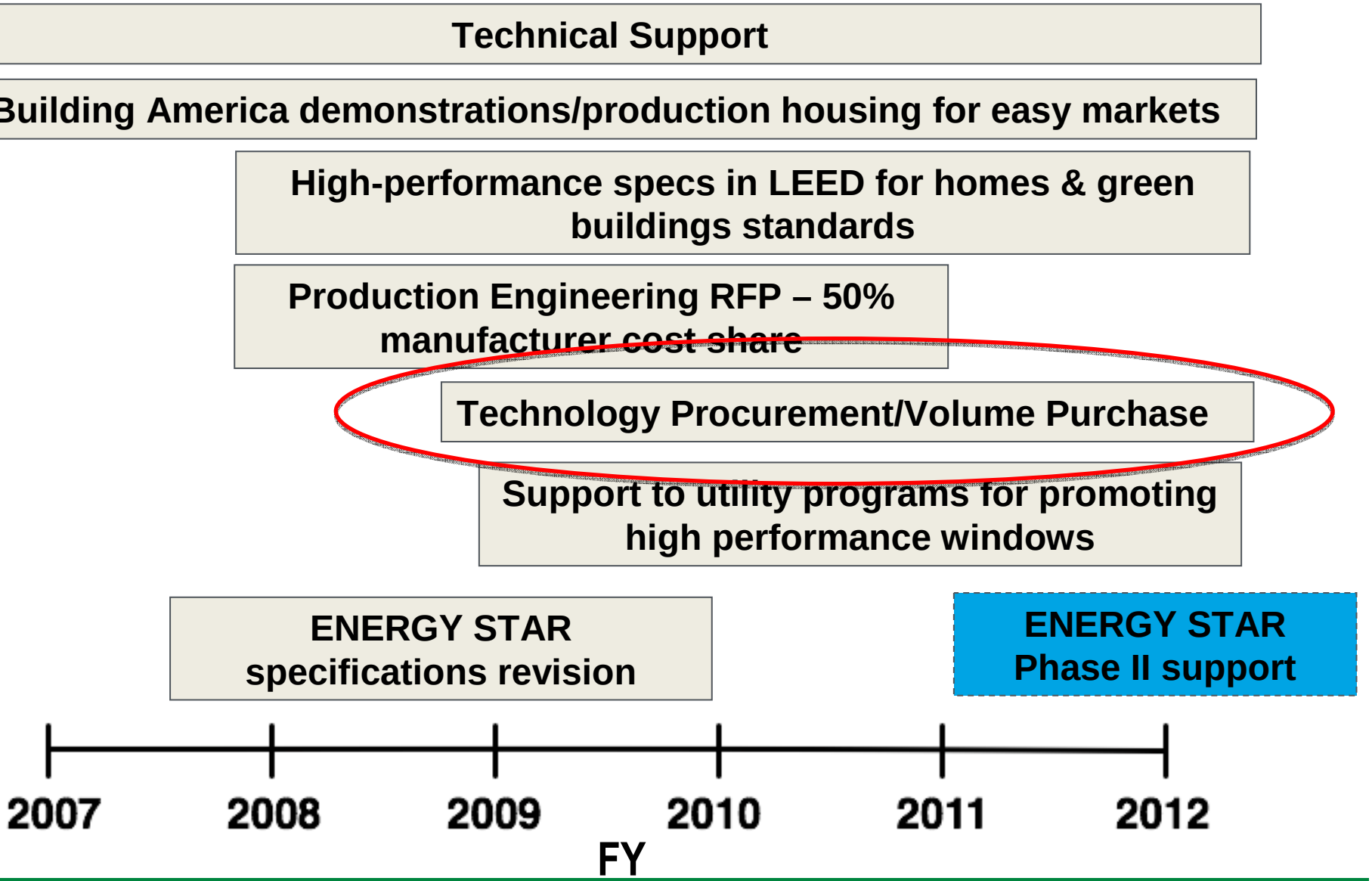

# R-5 (U=0.2-0.22) and Low-E Storm Windows Volume Purchase Phase I

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## Launched May 2009

### Specifications and Certifications

High Performance Windows

- U-factor: 0.20-0.22
- Air leakage: ≤ 0.30 cfm/ft$^2$
- Certifications: NFRC/NAFS
- Warranty (yr): 20 glass/10 non-glass
- NFRC label required
- NAFS 05: Performance Grade R25

Low-e Storm Windows

- Emissivity: <0.22
- Glass thickness: 3 mm minimum
- Structural test: ANSI/AAMA 1002.10-93
- Registry: IGDB (LBNL database)
- Warranty (yr): 10 glass/non-glass
- Registration in International Glazing Database (LBNL)

NFRC National Fenestration Rating Council

AAMA

WINDOW & DOOR MANUFACTURERS ASSOCIATION WDMA

NAMI

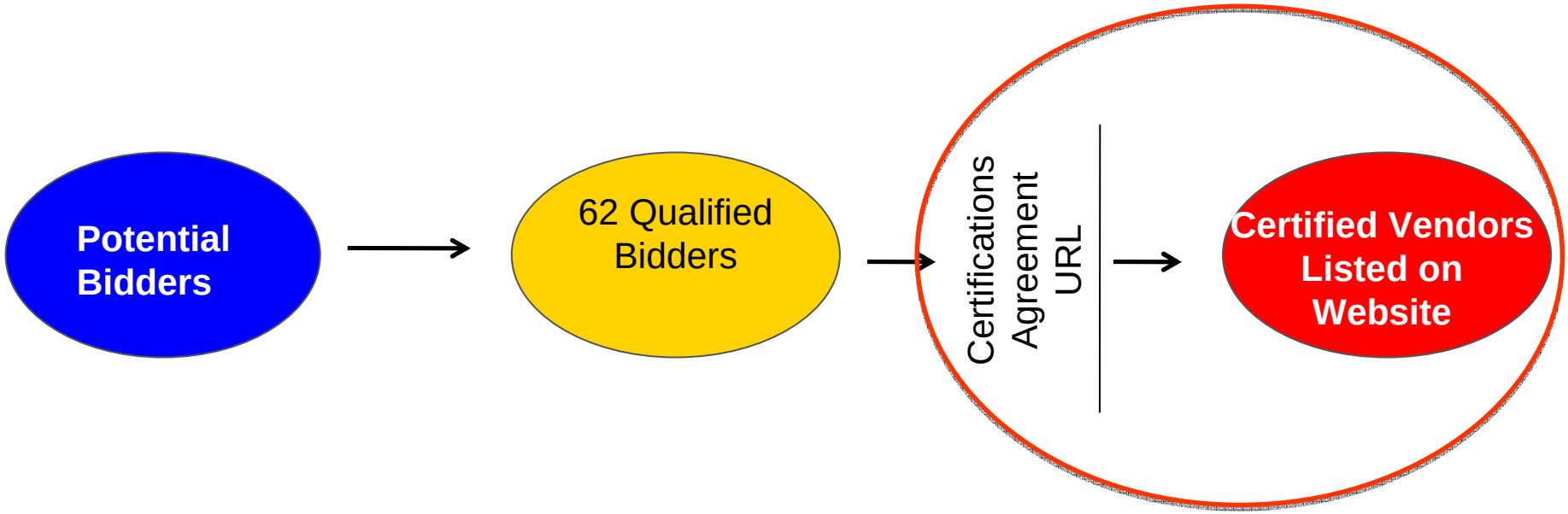
KEYSTONE CERTIFICATIONS, INC.

BERKELEY LAB LAWRENCE BERKELEY NATIONAL LABORATORY

# Phase I Results



- There are currently 40 certified windows vendors including 4 low-e storm windows vendors listed on the website.
- More certified vendor's products are added each month.



# Products and Pricing

- Minimum order of 15/20 for retrofit/new construction windows.
- No minimum order for sliding glass doors.
- Minimum order of 20 for low-e storm windows.
  - Vendors are expected to honor all requests which meet the minimum order requirement.
- Prices shown are 'base' prices and a ***maximum*** bid by each vendor for each united inches (UI) category.
- Prices shown are not by vendor and may not be increased over the period of the program—but may be decreased.
  - Price is for window frame type & color(s) listed.
  - Price does not include handing, shipping, taxes, installation or added features.
- List of vendors and window products they sell is posted on site.
- Delivery area in North America for each vendor is given.

# On-Line Savings Estimator

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## Highly Insulating or Low-E Storm Windows Energy Savings Estimator

Version 1.1

### 1) Basic Inputs

State and City: WA Spokane

New or Existing House?: Existing

Advanced Window/Storm Window Option: Low-E Storm Windows

Compare Advanced Option to: Existing Window

Assumed U-factor for comparison window (+ storm window if applicable): 0.86

If Comparing to Exising Windows, Select Here:
- Single pane, metal frame (eg aluminum)
- Single pane, non-metal frame (eg wood or vinyl)
- Single pane, metal frame + storm window
- Single pane, non-metal frame + storm window
- Double pane, metal frame (eg aluminum)
- Double pane, non-metal frame (eg wood or vinyl)

### 2) Additional Whole House Inputs

Approximate Floor Area: 2,400

Amount of Windows: Average (0.15 WFA)

WFA = Window to Floor Area

OR

Actual Window Area*: sq ft

*If a value is entered in the 'Actual Window Area' section, that value is used instead of the floor area estimate.

### Savings Estimates

| | Savings Per 3' X 5' Low-E Storm Window | Savings for Whole House with Low-E Storm Windows |
|---|---|---|
| Compared to: | Single pane, non-metal frame (eg wood or vinyl) | Single pane, non-metal frame (eg wood or vinyl) |
| Annual Energy Cost Savings | $ 12 | $ 300 |
| Lifetime Energy Cost Savings (assumes 20 year window life) | $ 250 | $ 5,998 |
| Discounted* Lifetime Energy Savings (assumes 20 year window life) | $ 186 | $ 4,462 |
| Lifetime C02 Savings (lbs) | 139 | 3,329 |

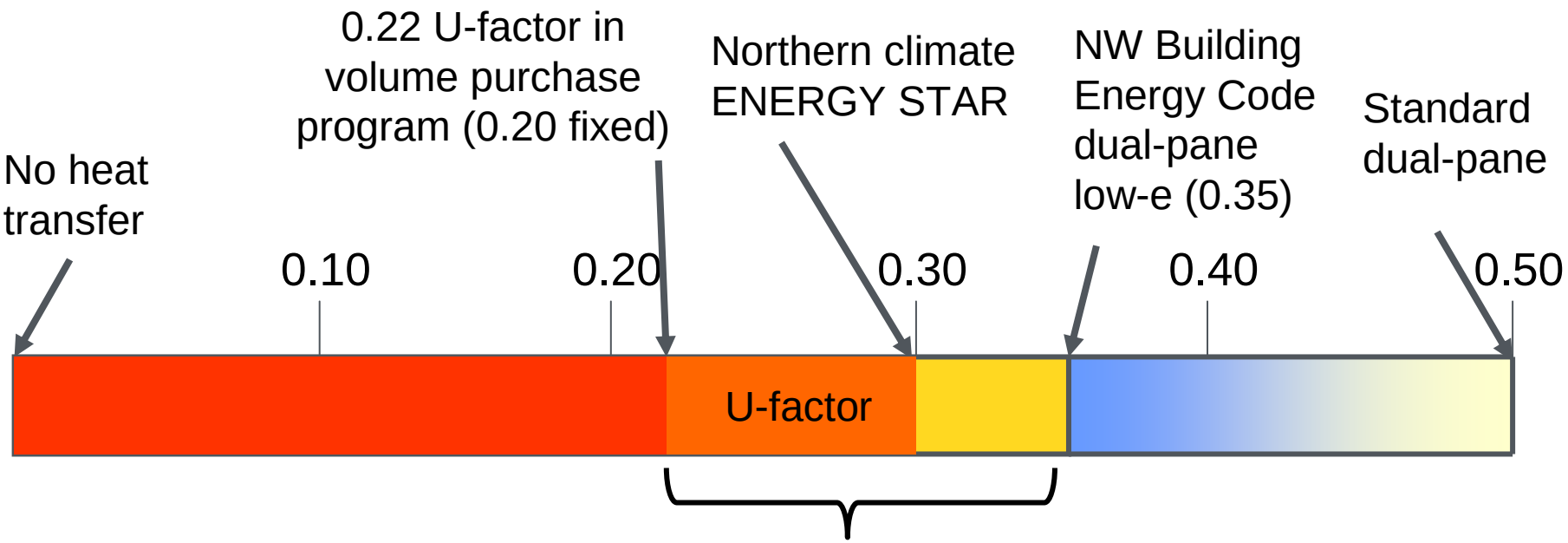
Assumed Electricity Price: $ 0.07 $/kWh

Assumed Natural Gas Price: $ 1.17 $/therm

Costs are the projected average of 2010-2020 prices in real 2009 dollars

# Whole Window U-factor Range






Energy cost savings (over code) in typical new 2,400 ft$^2$ home*

Portland: $65/year

Spokane: $83/year

*Energy cost savings estimator for download at: www.windowsvolumepurchase.org

# Low-E Storm Windows



- Pyrolytic Low-E coating (hard coat)
- Does not degrade in non-sealed cavity
- Can be installed inside or outside
- Identical installation cost to clear storm windows

# Retrofit with Low-E Storm Windows

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Start: Single glazed wood window

Add: Low-E storm window


| Storm Window Retrofit | Portland | Spokane |
|---|---|---|
| Energy Savings* | $151 | $186 |
| Installed Cost | $136 - $325** | |

*20 year discounted energy savings for 3 ft x 5 ft window in a 2,400 $ft^2$ home.
**Range of costs from the vendors participating in the volume purchase program

## Phase II Volume Purchase Program Solicitation

- Propose adding optional bid quantities for windows and low-e storm windows(1-19; 100-499; +500) to required bid (20-99)
- Propose adding awning windows.
- Propose adding bids for alternative frame types (e.g., wood, composite, fiberglass).
- Added a certification requirement for insulating glass (IG).
- Added a requirement for condensation resistance (CR) of >50.
- Propose adding commercial-style windows for punch-out applications across a range of performance grades and corresponding U-factors appropriate for 3+ story buildings.

**Launch Phase II Products in Spring 2012**

http://www1.eere.energy.gov/buildings/windowsvolumepurchase/

# Contacts

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