Title 24-2013 Nonresidential and High-rise Residential Fenestration Stakeholder Meeting

Eric Shadd, P.E.
Project Manager/Energy Analyst

Architectural Energy Corporation

June 9, 2011

Outline

- Methodology, Analysis & Results
- Code Language
- Remaining Work

Methodology, Analysis & Results

- Research
  - Literature
    - Existing Standards: Title 24, ASHRAE 90.1, etc.
    - Technical documents
    - Market studies
    - Online resources
  - Interviews
    - Codes & Standards developers
    - Fenestration industry
    - Technical experts
  - Goals
    - Gather product information and typical practices
    - Methodology
    - Gather stakeholder contacts

Methodology, Analysis & Results

- Products
  - Types
    - As close to all possibilities as reasonable
    - Applicability to a prescriptive standard
  - Cost from manufacturer surveys
- Life-cycle cost
  - Representative fenestration in an energy model
  - Curve fit developed to match energy model results
  - Curve fit used on all fenestration alternatives
  - Minimum life-cycle cost from curve fit as basis for Standard
- Stakeholder list developed and contacts made

Methodology, Analysis & Results

- Differences from previous update (2001)
  - Updated product costs
  - More products
  - SHGC as a function of angle of incidence
  - Updated energy costs and weather files

Methodology, Analysis & Results

- Fenestration cost
  - Fenestration cost premium over a baseline used
  - Raw cost premium of products from California window manufacturer surveys
  - Adjustments made for non-CA or if cost not from window manufacturer
  - Fenestration cost = sum of product cost that make up the fenestration (Glass cost + frame cost + spacer cost, etc.)

Methodology, Analysis & Results

- Fenestration
  - Selection rules
    - For overall analysis
      - Applicability to a prescriptive standard (e.g. market availability, reliability, verifiable performance data)
      - Viable configurations of fenestration alternatives (e.g. no soft coatings on room-side surface)
    - For representative fenestration in energy model
      - 10 even intervals for each NFRC performance rating (i.e. U-factor, SHGC and VT)

Methodology, Analysis & Results

- Fenestration cont'd
  - Indexing algorithm generated all viable fenestration using above selection rules
    - 1,393 windows
    - 588 glass skylights
    - 55 plastic skylights
  - Performance properties of fenestration calculated by CMAST (new NFRC tool)

Methodology, Analysis & Results

- Energy model
  - Guided by
    - Predicted use of EnergyPlus for future Title 24 compliance
    - Use of actual NFRC fenestration performance (CMAST)
    - Forecasted California construction by building type, developed outside this analysis
    - The U.S. Department of Energy Commercial Reference Building Models of the National Building Stock
    - Title 24-2008
    - Engineering judgment

Methodology, Analysis & Results

- Energy model cont'd
  - Environment
    - Updated weather and TDV for all climate zones
  - Envelope
    - 130' X 130', single-story, Title 24-2008 prescriptive minimums
    - Orientation: directly facing the cardinal directions.
    - 4' X 5' windows at 10%, 20%, 30% and 40% WWR
    - 4' X 4' skylights at 2% and 5% SRR.
    - Representative fenestration modeled per above rules

Methodology, Analysis & Results

- Energy model cont'd
  - Zones: 4, 15' deep perimeter and a 100' X 100' core
  - Loads
    - Title 24-2008 ACM loads
    - Automatic bi-level daylighting controls in the primary sidelit, secondary sidelit and skylit zones.
  - Systems: Title 24-2008 ACM System 1 (PSZ)

Methodology, Analysis & Results

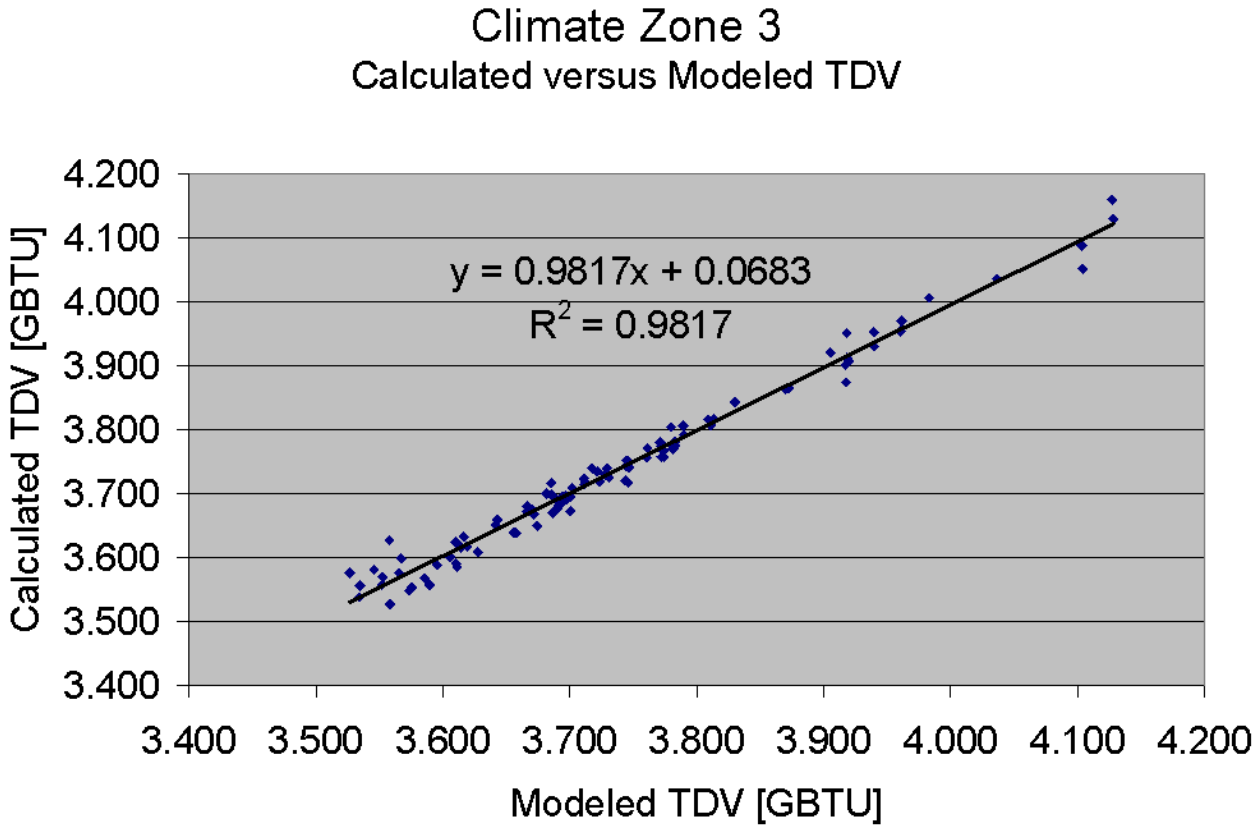
- Curve fit structure
  - Previous code update
  - Data inspection
  - Physical analogies

$$TDV_i = C_u FR^{pfU}\,\text{U-factor}^{pU} + C_s FR^{pfS}\,\text{SHGC}^{pS} + C_V FR^{pfV} VT^{pV} + TDV_{Base}$$

  - Where:
    - TDV_i = The TDV energy use of the ith fenestration alternative
    - C_x, pfx and px are constants that vary by climate zone.
    - x is a subscript that references U: U-factor, S: SHGC and V: VT
    - FR = the fenestration ratio
    - TDV_{Base} = A baseline TDV that is very roughly analogous to a non-windowed prototype building.

Methodology, Analysis & Results

- Good fits, Example CZ 3



Methodology, Analysis & Results

- After curve fit developed, then all fenestration put into equation to determine their annual TDV use.
- From the annual TDV use, the 30-yr PV of annual energy cost was determined from a CEC multiplier
- The final life-cycle cost:
  - Fenestration cost premium + 30-yr PV of annual energy

Methodology, Analysis & Results

- Minimum life-cycle cost (LCC)
  - Fenestration that had the lowest LCC
  - Specific to each climate zone at each WWR and SRR
  - This fenestration became the basis for the Standard but certain adjustments were made
- Adjustments from minimum LCC
  - Code simplification: single U-factor, SHGC and VT
  - Code bounding (setting maximums and minimums)
  - Stakeholder comments

Methodology, Analysis & Results

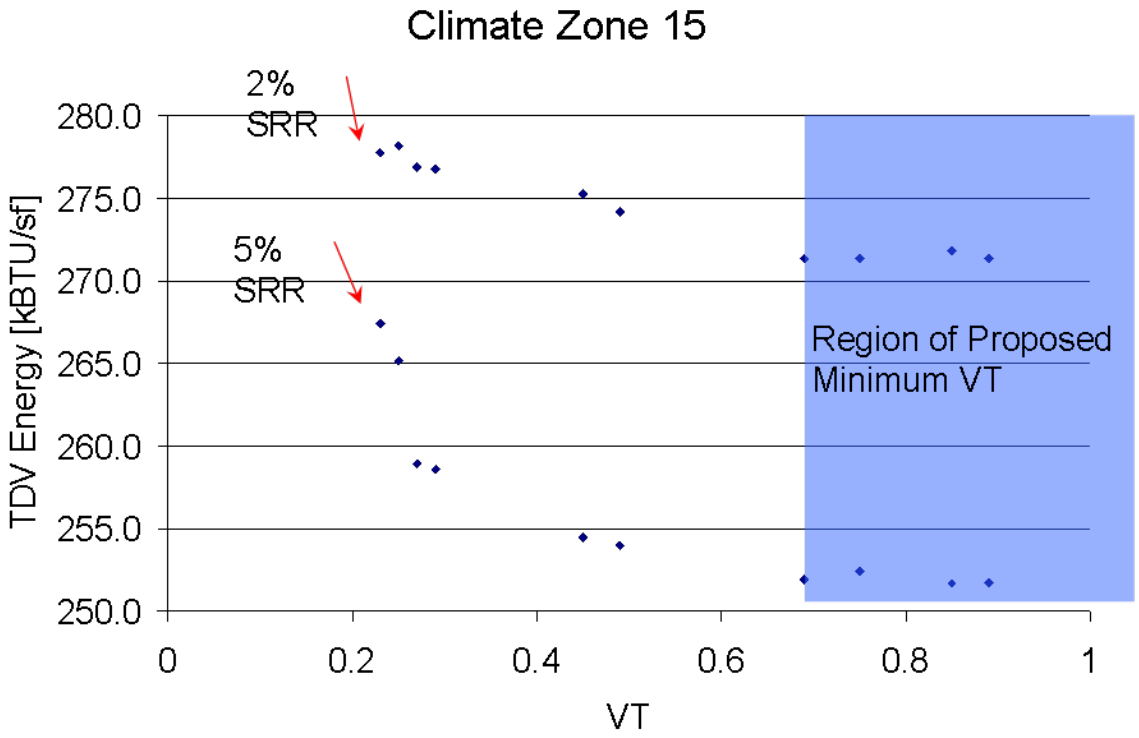
- Code simplification
  - CEC move to simplify code
  - Explored single U-factor, SHGC and VT for all climate zones and all WWRs & SRRs
  - Method to find optimum
    - The lowest statewide LCC of a single U-factor SHGC and VT
    - All fenestration from original minimum LCC were put into statewide LCC formula
    - The statewide LCC was calculated as
      - LCC of each fenestration at all WWRs in all CZs
      - Forecasted construction by building type and climate zone
      - DOE reference building and CEUS database characteristics

Methodology, Analysis & Results

- Code bounding
  - By inspection of the physical phenomenon a maximum U-factor, maximum SHGC and minimum VT sufficiently optimizes the Standard
  - For plastic skylights, pigment
    - Determines SHGC and VT
    - A maximum SHGC sets a maximum VT in effect
    - Analysis showed that increasing VT above the minimum always increased savings or had neutral impact regardless of the corresponding SHGC increase for nonresidential occupancies

Methodology, Analysis & Results

- Code bounding, plastic skylights example climate zone 15 (highest cooling load)
- Flat because of saturated daylight, will decrease for higher lighting levels



Methodology, Analysis & Results

- Stakeholder comments
  - Proposed performance ratings cannot be achieved by all window types (e.g. operable windows)
  - The basis was revised again
    - Same COG assembly into different window types
      - Fixed, Operable, Curtainwall/Storefront and Glazed Doors
    - Several configurations within a type were calculated (e.g. operable: casement, awning, horizontal slider)
    - The maximum U-factor, maximum SHGC and minimum VT over all configurations within a window type became the final basis for the Standards

Methodology, Analysis & Results

- Stakeholder comments cont'd
  - Several mainly geared towards leaving lower VTs as an option
  - Glare from a VT standard
    - Nonresidential VT lowered since preliminary analysis (from 0.52 to 0.44). High-rise residential not a concern.
    - Prescriptive Overall Envelope TDV Energy Approach or Performance Approach can be used if a lower VT or clerestory arrangement is desired
    - The RSHG formula allows overhangs to reduce SHGC without affecting VT. This feature mitigates glare and provides a means for higher SHGC/VT.

Methodology, Analysis & Results

- Stakeholder comments cont'd
  - Glare from a VT standard cont'd
    - Lower VT glazing does not mitigate direct sunlight contrast.
    - Reflective glare on computer screens can be mitigated by low-reflectance computer accessories (computer anti-glare technology expected to advance much faster than the life-cycle of a building's fenestration)
    - Occupant orientation can always significantly mitigate glare
    - 100% of the current nonresidential standards is susceptible to VTs higher than the proposed VT (0.44)

Methodology, Analysis & Results

- Stakeholder comments cont'd
  - Exterior shading and interior blinds should be considered in the analysis
    - Exterior shading would tend to drive the VT higher
    - Interior blinds
      - Actively controlled to maximize daylight. (Heschong Mahone Group, 2011, Daylight Metrics, California Energy Commission Public Interest Energy Research)
      - Given that, it is best to have a high VT when those blinds/shades are closed so as to permit the maximum light through

Methodology, Analysis & Results

- Stakeholder comments cont'd
  - The technology proposed in the Standard (triple-silver low-e coating) is proprietary to only two companies
    - Proprietary to two but available from four of six major manufacturers
    - Title 24 only has cost-effectiveness, market availability, etc. constraints, not proprietary constraint.
    - Other glazings can meet the Standard via the Prescriptive Overall Envelope TDV Energy Approach or Performance Approach

Methodology, Analysis & Results

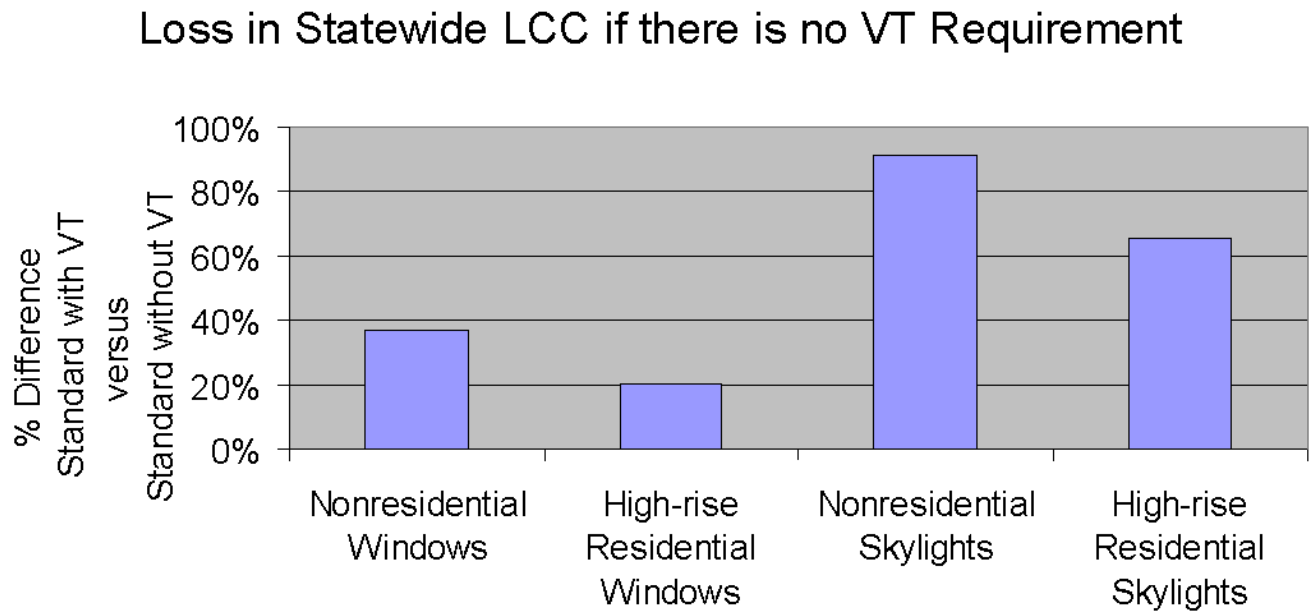
- Stakeholder comments cont'd
  - Effective aperture and LSG (VT/SHGC) should be considered in lieu of VT
    - Effective aperture is being eliminated from all parts of the Standard because of code simplification
    - LSG would not guarantee the daylight energy savings because even dark glazing could meet this requirement.

Methodology, Analysis & Results

- Stakeholder comments cont'd
  - Daylighting controls do not have a significant effect on savings
    - Our analysis shows a significant savings from daylighting.
    - Almost all sidelit and skylit spaces will require daylighting in the new Standard.

Methodology, Analysis & Results

- If there is no requirement on VT the losses are significant



Methodology, Analysis & Results

- Proposed T24-2013 Savings over Title 24-2008

	Electricity [GWh/yr]	Demand [MW/yr]	Natural Gas [kTherms/yr]	TDV [GBTU/yr]	30-yr LCC PV [M$]
Nonresidential Windows					
Minimum LCC	27.59	6.46	-2.23	702.6	86.5
T24-2013 (Proposed)	27.93	6.38	-3.01	704.8	83.0
T24-2013 (No VT)	16.46	3.17	-1.47	390.2	52.0
High-rise Residential Windows					
Minimum LCC	1.22	0.35	-30.66	27.4	3.5
T24-2013 (Proposed)	1.34	0.40	-43.78	28.8	3.5
T24-2013 (No VT)	0.94	0.33	-45.18	18.8	2.9

Methodology, Analysis & Results

- Savings over Title 24-2008 cont'd

	Electricity [GWh/yr]	Demand [MW/yr]	Natural Gas [kTherms/yr]	TDV [GBTU/yr]	30-yr LCC PV [M$]
Nonresidential Glass Skylights					
Minimum LCC	1.22	0.49	-0.72	37.6	4.9
T24-2013 (Proposed)	1.23	0.49	-0.76	37.7	4.9
T24-2013 (No VT)	0.16	0.14	0.08	7.5	0.4
High-rise Residential Glass Skylights					
Minimum LCC	0.02	0.01	-0.27	0.7	0.1
T24-2013 (Proposed)	0.02	0.01	-0.30	0.7	0.1
T24-2013 (No VT)	0.02	0.01	-0.31	0.4	0.0

Methodology, Analysis & Results

- Savings over Title 24-2008 cont'd

	Electricity [GWh/yr]	Demand [MW/yr]	Natural Gas [kTherms/yr]	TDV [GBTU/yr]	30-yr LCC PV [M$]
Nonresidential Plastic Skylights					
Minimum LCC	7.02	0.00	-0.02	2.7	32.2
T24-2013 (Proposed)	6.85	0.00	0.00	-1.0	28.5
High-rise Plastic Glass Skylights					
Minimum LCC	TBD	TBD	TBD	TBD	TBD
T24-2013 (Proposed)	TBD	TBD	TBD	TBD	TBD

Code Language

- Table 143-A

All Climate Zones					
Windows		Fixed	Operable	Curtainwall/ Storefront	Glazed Doors
	Max U-factor	0.36	0.47	0.41	0.45
	Max RSHG	0.22	0.17	0.24	0.20
	Min VT	0.44	0.33	0.48	0.18
	Overall Max WWR	40%			
Skylights		Glass, Curb-mounted	Glass, Deck-mounted	Plastic, Curb-mounted	
	Max U-factor	0.58	0.46	1.11	
	Max RSHG	0.25	0.25	NR	
	Min VT	0.52	0.52	0.69	
	Overall Max SRR	5%			

Code Language

- Table 143-B

All Climate Zones					
Windows		Fixed	Operable	Curtainwall/ Storefront	Glazed Doors
	Max U-factor	0.36	0.45	0.40	0.45
	Max SHGC	0.25	0.22	0.26	0.23
	Min VT	0.52	0.46	0.56	0.20
	Overall Max WWR	40%			
Skylights		Glass, Curb-mounted	Glass, Deck-mounted	Plastic, Curb-mounted	
	Max U-factor	0.58	0.46	1.11	
	Max SHGC	0.25	0.25	0.34	
	Min VT	0.52	0.52	0.29	
	Overall Max WWR	5%			

Remaining Work

- Definitions of Window Types (Operable, etc.)
- Default VT
  - Table
  - Formula
- Miscellaneous documentation and minor calculations

Questions?