

US DOE Envelope and Windows Roadmap Workshop



U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

Marc LaFrance
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Buildings Largest End-use Sector for Energy Consumption



Residential & Commercial



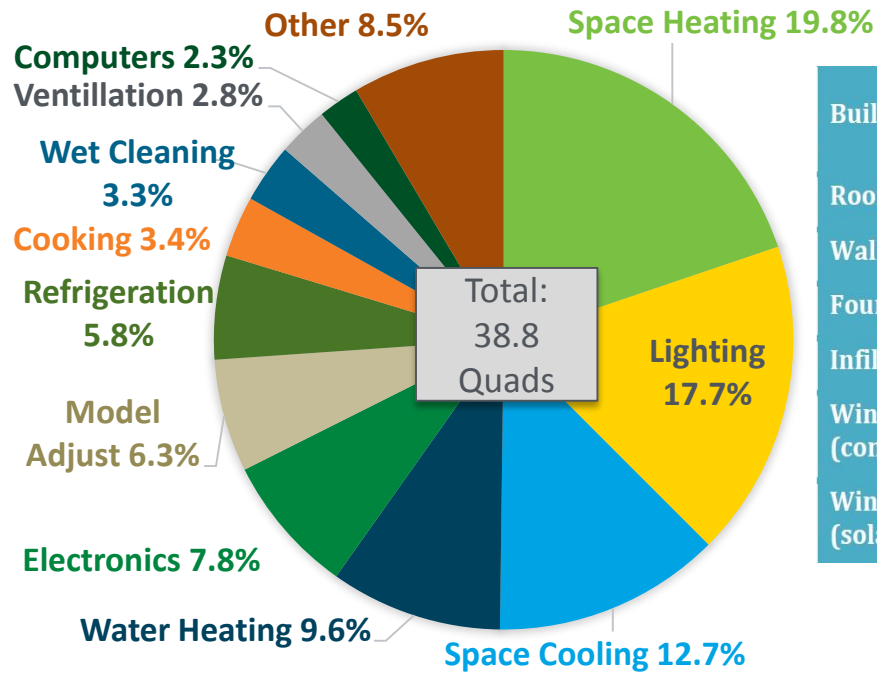
Industrial



Transportation

U.S. Building's Energy Consumption and Expenditures

Building Energy Use



Envelope & Windows Impact Over 50% of Loads

Building Component	Residential (quads)		Commercial (quads)	
	Heating	Cooling	Heating	Cooling
Roofs	1.00	0.49	0.88	0.05
Walls	1.54	0.34	1.48	-0.03
Foundation	1.17	-0.22	0.79	-0.21
Infiltration	2.26	0.59	1.29	-0.15
Window (conduction)	2.06	0.03	1.60	-0.30
Window (solar heat gain)	-0.66	1.14	-0.97	1.38

Buildings Natural Gas Use: **60%** of U.S. total

Buildings Electricity Use: **75%** of U.S. total

U.S. Building Energy Bill: **\$380 billion** per year

BTO 2016-2020 Multi-Year Program Plan



BTO Goal:

- **2030 goal:** Reduce average energy use per square foot of U.S. buildings by **30%** below 2010 levels
- **Long-term goal:** reduce average EUI of U.S. buildings by **50%**



National Goals:

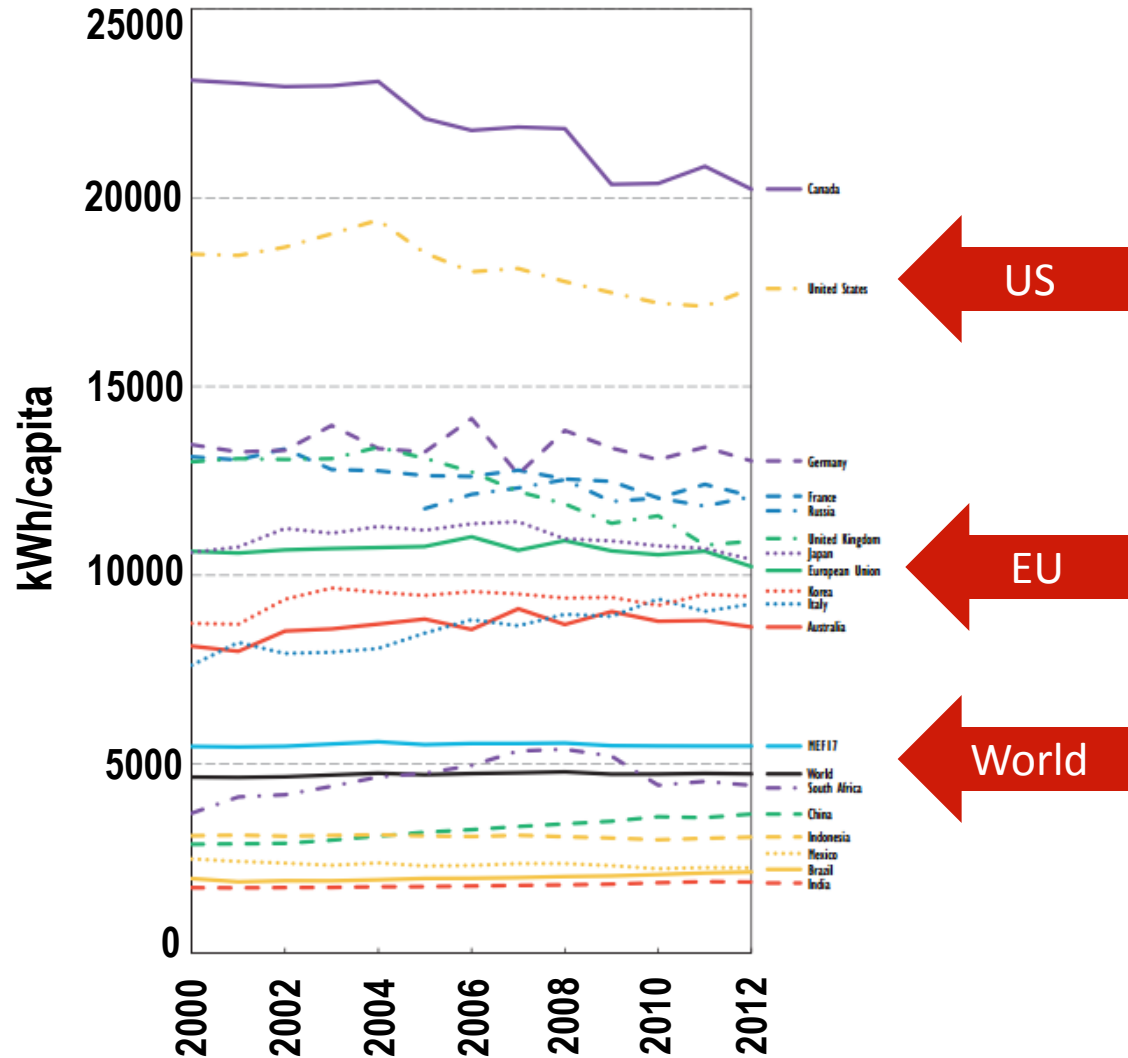
- By 2030, double energy productivity relative to 2010
- Reduce greenhouse gas emissions 26%–28% below 2005 levels by 2025

Building Energy Consumption per Capita

- US has one of the highest building energy use per capita of the world
- UK has had one of the fastest declines
- Energy efficient materials and products, building codes and overall energy policy drive reductions

Source: IEA, Building Energy Performance Metrics Report, 2015

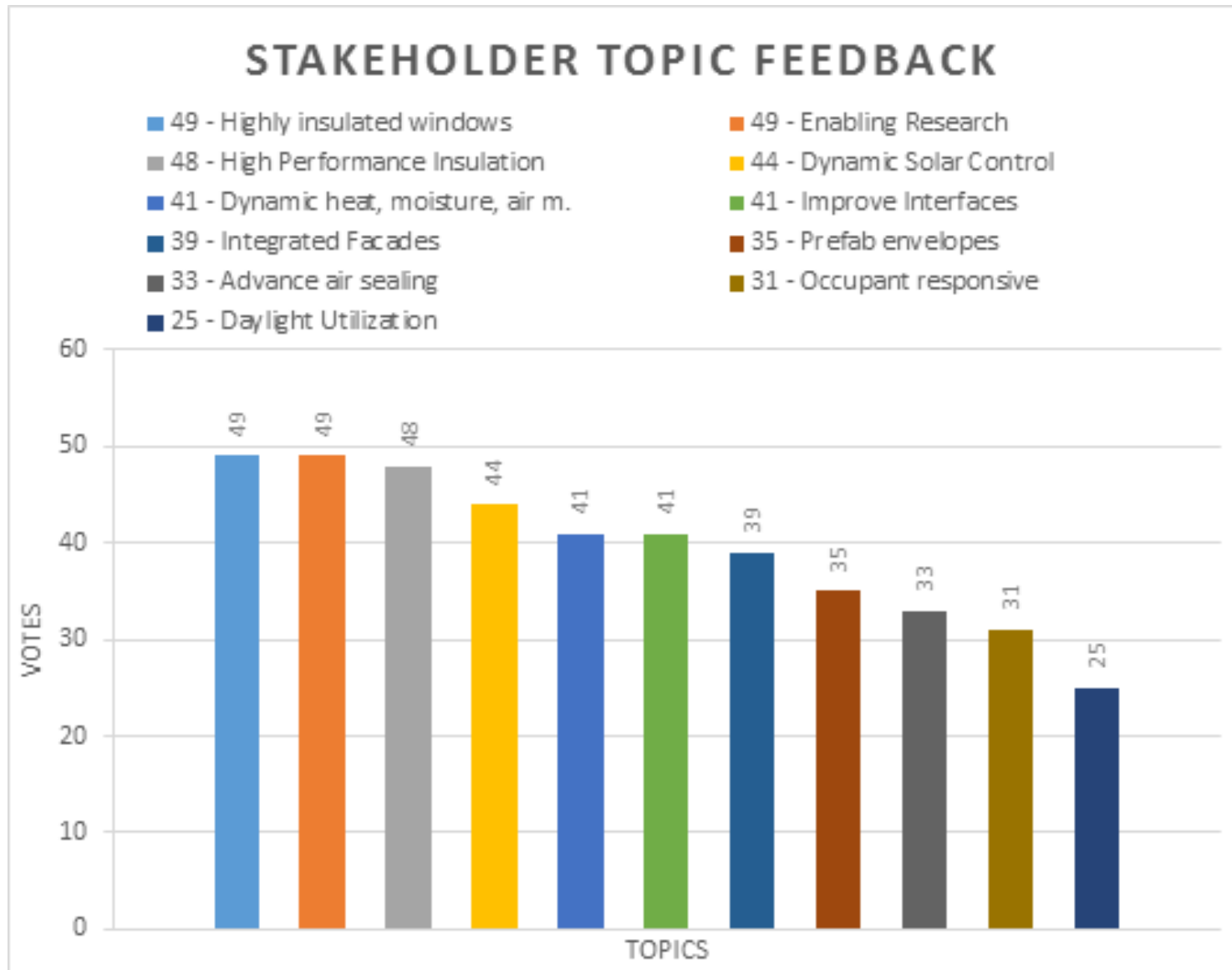
Figure 9 • Building energy use per capita in MEF economies, 2000-12



Objectives for Workshop

- Confirm critical role that Building Envelope and Windows play in achieving BTO Goals
- Seek stakeholder input that will contribute to an update to the building envelope and windows technology roadmap
- Identify goals and actions to achieve technological progress that will result in less energy consumption in the buildings sector while supporting associated benefits (e.g. peak load reduction, job creation, productivity, etc)
- Identify opportunities for DOE R&D investment, dependent upon funding and priorities
- Identify high risk scientific challenges and material development opportunities for national laboratory and academia investigations
- Identify actions with partners for implementation including approaches to overcome barriers to adoption

Participant Responses from Registration Page



Reference Materials

- DOE Envelope and Windows Roadmap
 - Highly insulated windows, dynamic windows, and daylighting
 - Thin high performance insulation, advanced air sealing, and highly insulated roofs
- Building America Research to Market Plan
 - High performance moisture managed envelopes; optimal comfort for low-load homes; optimal ventilation and IAQ
- IEA Building Energy Efficiency Envelope Roadmap
 - Global regional assessments on high priority technology adoption and performance metrics
 - Identification of high priority technologies and actions associated by entity
 - Policy assessments
- Competitive Financial Opportunities
 - FY17 BENEFIT: Innovative, HVAC, Sensors & Control, Scale – up > up to 20M
 - FY 17 SBIR – Windows focus on highly insulating, dynamic, fundamental supporting science

Current Roadmap Goals/Targets – Review & Update Needed

Technology	2025 Installed Cost Premium Target	2025 Performance Target
<i>Highest Priority R&D Area</i>		
R-10 Windows	Residential: $\leq \$6/\text{ft}^2$ Commercial: $\leq \$3/\text{ft}^2$ over typical 2010 windows	<ul style="list-style-type: none"> Residential: R-10, $V_T > 0.6$ Commercial: R-7, $V_T > 0.4$ Comparable weight and thickness to currently installed base
<i>High Priority R&D Areas</i>		
Dynamic Windows	Windows: $\leq \$8/\text{ft}^2$ Window Films: $\leq \\$2/\text{ft}^2$ over a standard IGU	<ul style="list-style-type: none"> $\Delta\text{SHGC} > 0.4$ V_T bleached state > 0.6 (residential) and > 0.4 (commercial)
Visible light redirection (commercial)	$\leq \$5/\text{ft}^2$ over standard window or shade including lighting and controls costs	50% reduction in lighting energy use over a 50-ft floor plate

Vision: Convert Windows to Net Zero Energy: +5Q

Strategy: Energy Losers -> Neutral -> Supply Net Energy

Performance Gaps: Defined by Climate/Energy Function

- **Heating climates**

- Reduce heat losses so solar energy balances and exceeds loss
- Gap: technologies with lower heat loss, $U \sim .1$

- **Cooling climates**

- Reduce cooling loads but allow daylight/view
- Gap: Shift from Static properties -> dynamic control of SHGC, T_v

- **All climates – Lighting, Ventilation**

- Replace electric lighting with daylight
- Gap: extend daylight use to 30' depth
- Utilize natural ventilation w/ operable windows

- **Electricity supply options**

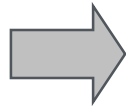
- Photovoltaics-building skin as power source

Glazing and Façade R&D Landscape

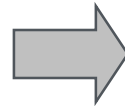
Multiple “Scales” for R&D and Innovation

Nano → *Micro* → *Macro*

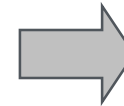
“1 μ ”
coating



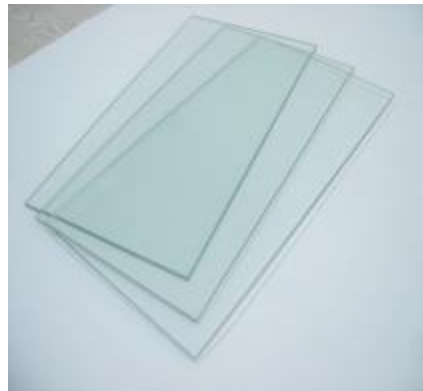
“1mm”
glass



“1m”
Window,
shading



“100m”
Building

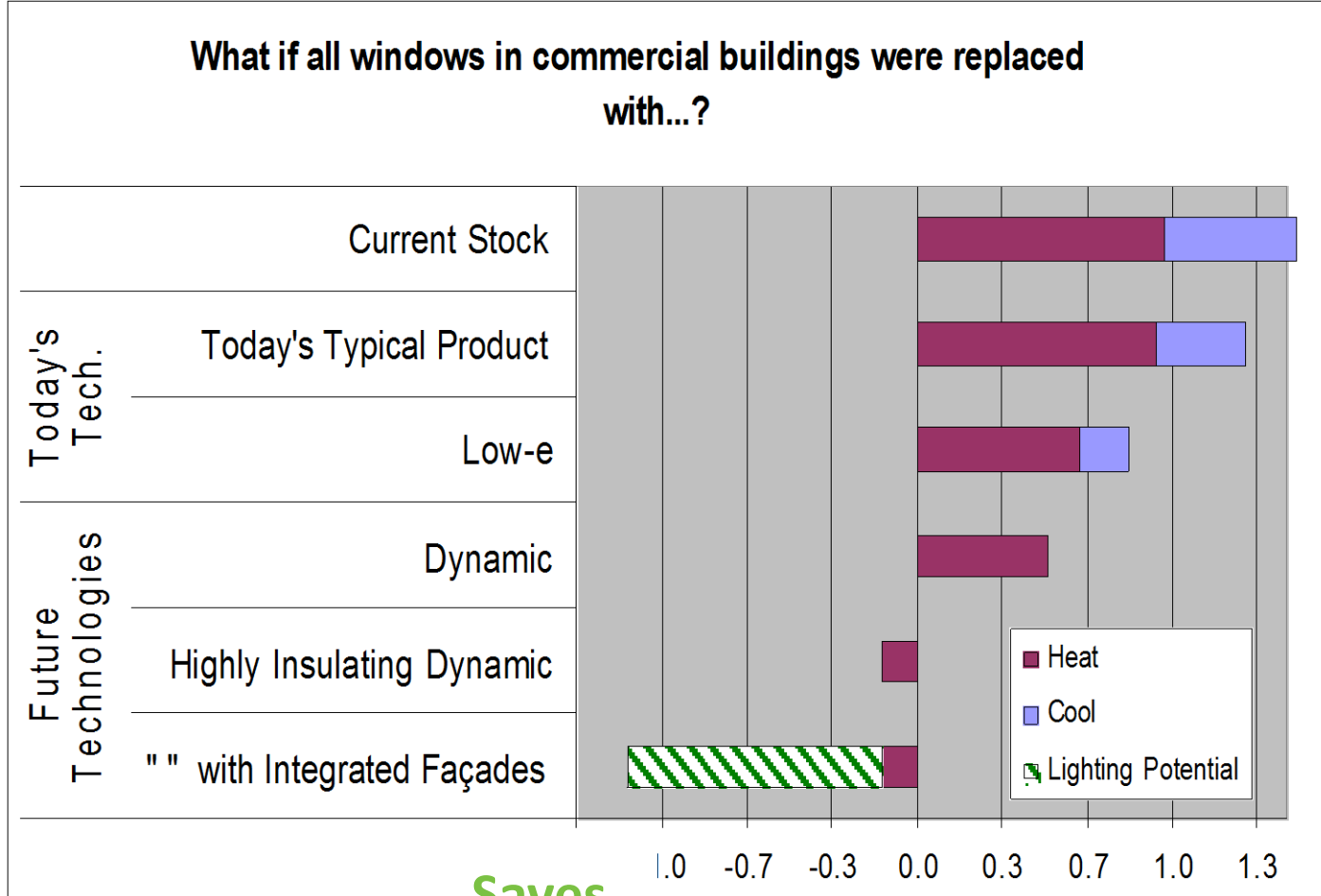


Next Generation of Windows

- Highly insulated, dynamic solar control, daylighting
 - Commercially available products in both areas but very low market penetration, and low likelihood of rapid change
 - What technology or market innovation could change that?
- Value to low energy buildings
 - Improved thermal and visual comfort, reduced noise, smaller HVAC, reduced peak loads
 - Residential: eliminate branch duct work and allow for more window area
 - Commercial: perimeter zone conditioning eliminated, lower utility rates linked to peak demand
- How to build consumer demand, industry feedback?
 - R&D innovation: more features at lower cost
 - Voluntary programs to grow market demand
 - Mandatory codes and standards, as proposed in Canada for Hi-R
 - Improve value proposition on conventional window replacements, etc

“Zero Net Energy” facades: National Impacts

Converting a \$20B/yr cost to a \$15B/yr Net Surplus!



Cost = \$20B

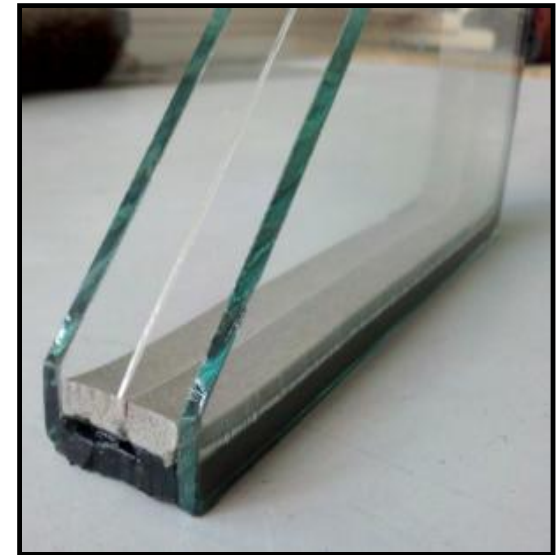
Saves \$15B

Current Windows Activity

- Competitive Financial Awards
 - **WCMA:** Attachments Energy Rating Council (AERC)
 - **Arconic:** Novel Thermal Break with Simplified Manufacturing for R-7 Commercial Windows
 - **LBNL and Pella:** Highly Insulating Residential Windows Using Smart Automated Shading
- Annual Operating Plan Projects
 - **LBNL:** window suite of software tools development and maintenance, technology development, and Energy Star Most Efficient support, and five specialized laboratory facilities for development and validation
 - **NREL:** durability testing, and installed cost analysis - difficult to find an easy reduced, better consumer education needed, customer acquisition
- International Collaboration India (CBERD) and China (CERC 2), small level of effort on window activity

Stepping Stone to Next-Gen Windows: “R8 Thin Triples”

- Market “stuck” at Energy Star window, double, low-E, R3
 - No Market Pull so manufacturers won’t invest in triples: now <2% sales
 - Transition to Much Lower U = ~.1 - .15 would save 1+ Quad
- **Challenge:** Drop-in “R8 IGU Glazing” to replace current R4 IGU
 - No change in IGU weight, width -> no need for expensive sash redesign
- New R8 IGU added to existing frame will improve Window R3 -> R6
- **Technology approach**
 - Add thin (.7mm) glass layer, extra low-E, improved spacer, Krypton gas fill
 - Optimized thermal package can achieve R10
 - Other package benefits: e.g comfort, smaller HVAC
- **Benefits**
 - Improved Comfort, Larger window size w/codes, lower HVAC, big energy savings
 - Primes housing market for more extensive future change, vacuum windows, smart windows, etc
- **Status: LBNL has validated concept with proof prototypes**
 - Assembled 6 industry partners to advance to pilot line



Key Challenges and Opportunities for Windows

- Window replacement not usually cost effective based on energy benefits unless replacing window anyway
 - reduce installed cost (new and retrofit)
- Ensuring quality, consistent installation, and transparency on what customers buy
 - replacement window vs new window
- Integrated wall/window upgrade as a system should reduce cost and add “market value” to homes
 - Is it possible to get early window replacement based on home value improvements?
- Value proposition to consumers can be increased by reducing cost and fully assessing benefits
 - all energy impacts: infiltration, comfort, thermostat settings; and non-energy benefits: reduced noise, aesthetics, resale and market value, etc

Workshop Strategy

- Gaps and Opportunities
 - What is broken, how can things be improved, what barriers are holding back greater investment into building envelopes and windows
- Technical Solutions
 - Refine and re-confirm, as appropriate, DOE existing technology strategies
 - Explore fundamental new approaches that could offer greater value proposition with significant R&D over a longer timeframe
 - Define near term solutions that can be pursued by stakeholders with specialized technical support from national laboratories
- Innovative Technology Pathways and Implementation
 - Define actions by entities on how to develop and implement technology solutions
 - Identify suggested priorities, metrics and goals

Contact Information – Residential and Emerging Technologies Teams

P Marc LaFrance, CEM

Advanced Technology and Energy Policy Manager

US Department of Energy

1000 Independence Ave, SW

Washington, DC 20585-0121

marc.lafrance@ee.doe.gov

202-586-4972

Cell 240-474-2177