Advanced Fenestration Controls for Resilient and Decarbonized Buildings
Community Engagement for Market Impact and Justice

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WBS 3.1.3.20, 3.5.5.30, 3.5.5.31, 3.5.3.15, 3.2.1.13

Project Summary

Objective and outcome

Driving greater adoption of advanced fenestration controls

Addressing window-related needs in disadvantaged communities

Maintaining the window innovation pipeline

Increasing uptake of efficient windows in commercial buildings

Team and Partners

LBNL: Luis Fernandes, Christoph Gehbauer, Peter Grant, Taoning Wang, Tammie Yu, Anothai Thanachareonkit, Brendon Smith, Robert Hart, Charlie Curcija, Howdy Goudey, Jacob Jonsson

Partners: NREL, PNNL, National Fenestration Rating Council, automated façade manufacturers, and others

Stats

Performance Period: 10/01/2019-09/30/2023

DOE budget: $1,300K, Cost Share: $0

Milestone 1: Façade and Lighting Integration Report

Milestone 2: Advanced Fenestration Controller released

Milestone 3: Educational videos and factsheets released

LBNL Windows Group

Innovative Window and Retrofit Solutions

- Hi-R (Thin-Triple, VIG)
- Attachments
- Decarb
- Field Demonstrations
- Codes and Standards

Foundational, Industry Enabling Support for Windows Energy Performance

- Software (WINDOW, THERM, AERCalc, IGDB/CGDB)
- Optical Facilities
- Thermal Facilities

Advanced Fenestration Controls for Resilient and Decarbonized Buildings Community Engagement for Market Impact and Justice

- Dynamic Facades
- Disadvantaged Communities
- Maintaining an Innovation Pipeline
- Increasing Uptake in Commercial Buildings

Alignment and Impact

Increase building energy efficiency

Dynamic windows can reduce primary energy use associated with windows by 20-40% in commercial buildings with high perimeter to floor area ratios by 2050

Accelerate building electrification

Energy efficient windows can enhance electrification effort with up to 50% reduced HVAC system sizing, 30% reduced back-up sizing, enhanced comfort, and building resilience

Transform the grid edge at buildings

Dynamic windows can enhance grid flexibility and reduce peak electricity use by up to 25%

Prioritize equity, affordability, and resilience

- Affordable, easy to install, open-source controls technology
- Expanded opportunities for job creation in installing and commissioning façade systems
- Solutions focused on the specific needs of disadvantaged communities

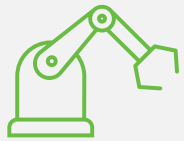
Harris, Chioke. *Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption*. United States. https://doi.org/10.2172/1866581

Alignment and Impact - Dynamic Facades

Building Sector	Performance [SHGC Range]	Installed Premium [$/ft^2 window area]	Primary Energy Savings [Quads]	
			2030	2050
Residential	0.05 - 0.65	6.50	1.29	1.23
Commercial		29.20	0.35	0.37

Success

Technology advancement



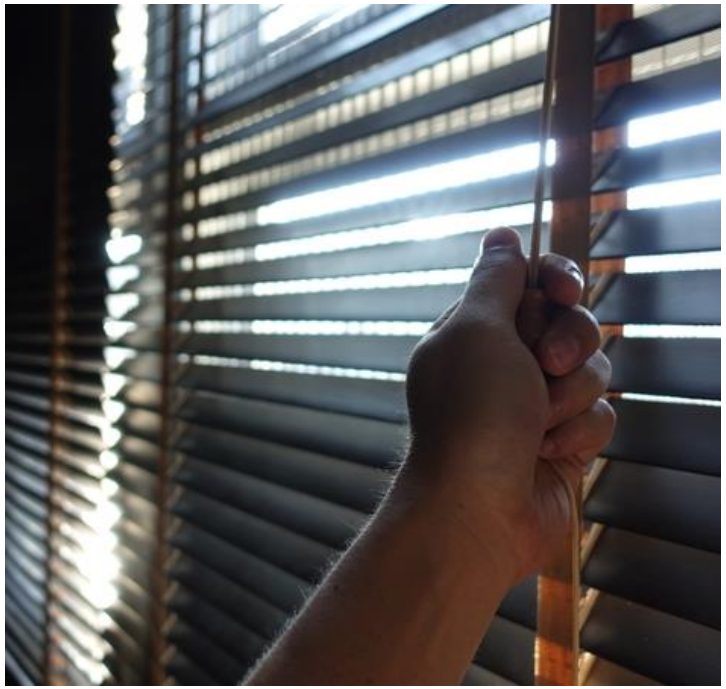
Manufacturing at scale

Market adoption

Harris, Chioke. *Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption*. United States. https://doi.org/10.2172/1866581

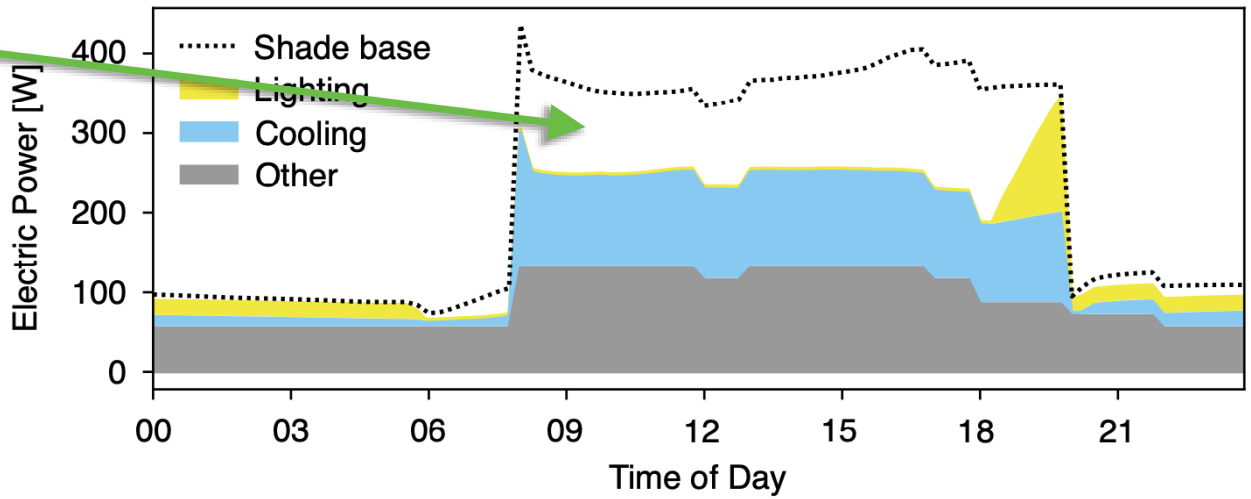
Problem 1 – Dynamic Facades

- Most dynamic façade elements are manually operated
- Automated facades operate independently from energy end-uses
- This is inefficient
  - Higher energy use
  - Reduced potential for decarbonization
  - Reduced grid services opportunities

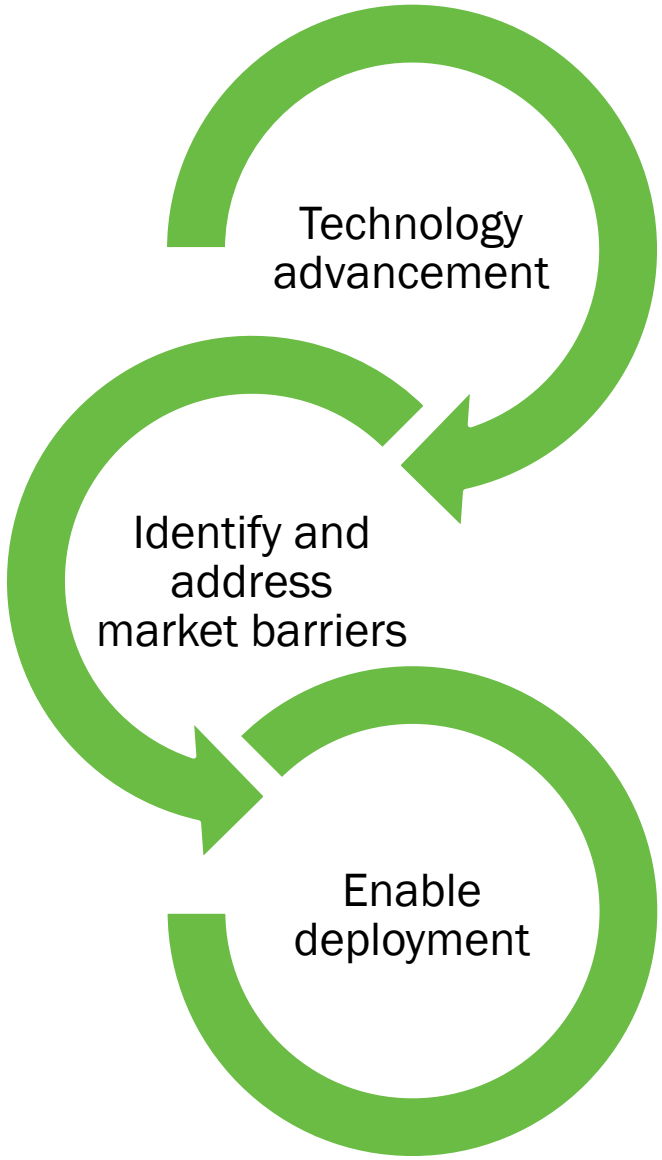


Problem 1 – Dynamic Facades

- **In “real world” buildings**
  - Façade integration is rare
  - Where it happens it requires custom wiring (dry contact relays)
  - ”Integrated” operation sometimes done manually (e.g., demand response)
- **Meanwhile, in research environments**
  - 30% energy savings and 35% peak demand reduction vs. manual operation
  - 63% reduction in electricity bills vs. heuristic controls when integrated with renewables and storage



Approach 1 – Dynamic Facades



Develop, test, and demonstrate advanced control algorithms

Develop, test, demonstrate, and share methods and tools for evaluating and implementing integrated façade controls

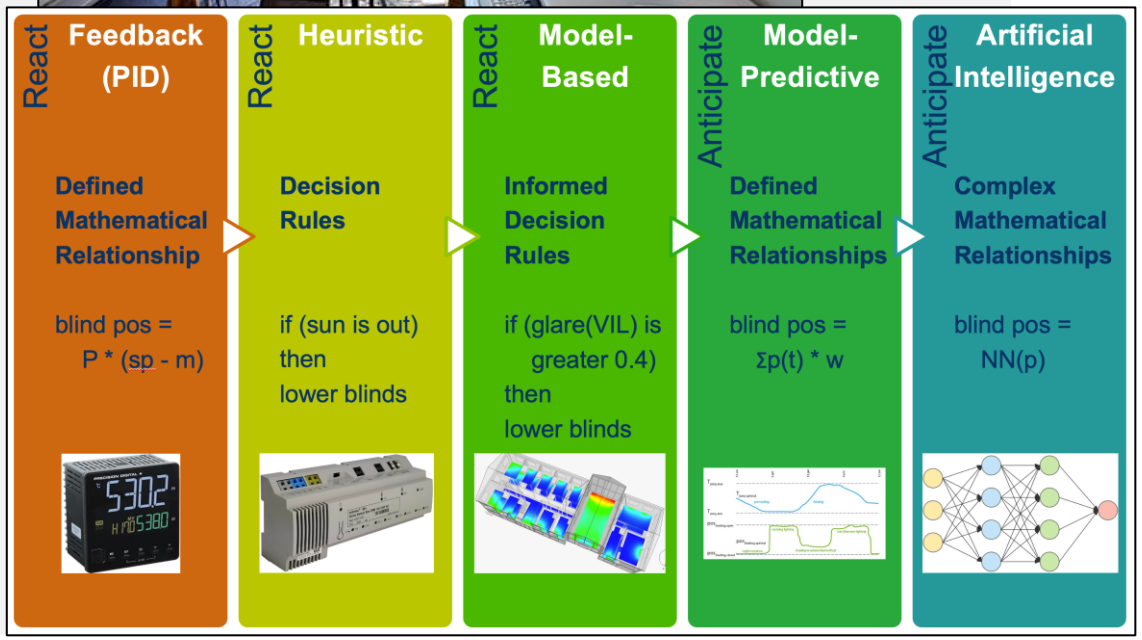
Supporting workforce development in automated facades and façade integration

Progress and Future Work: Dynamic Facades

Develop advanced control algorithms

- Model predictive control (MPC)
- Reinforcement learning
- Controls integrate façade, lighting, HVAC
- Open-source Advanced Façade Controller available on GitHub

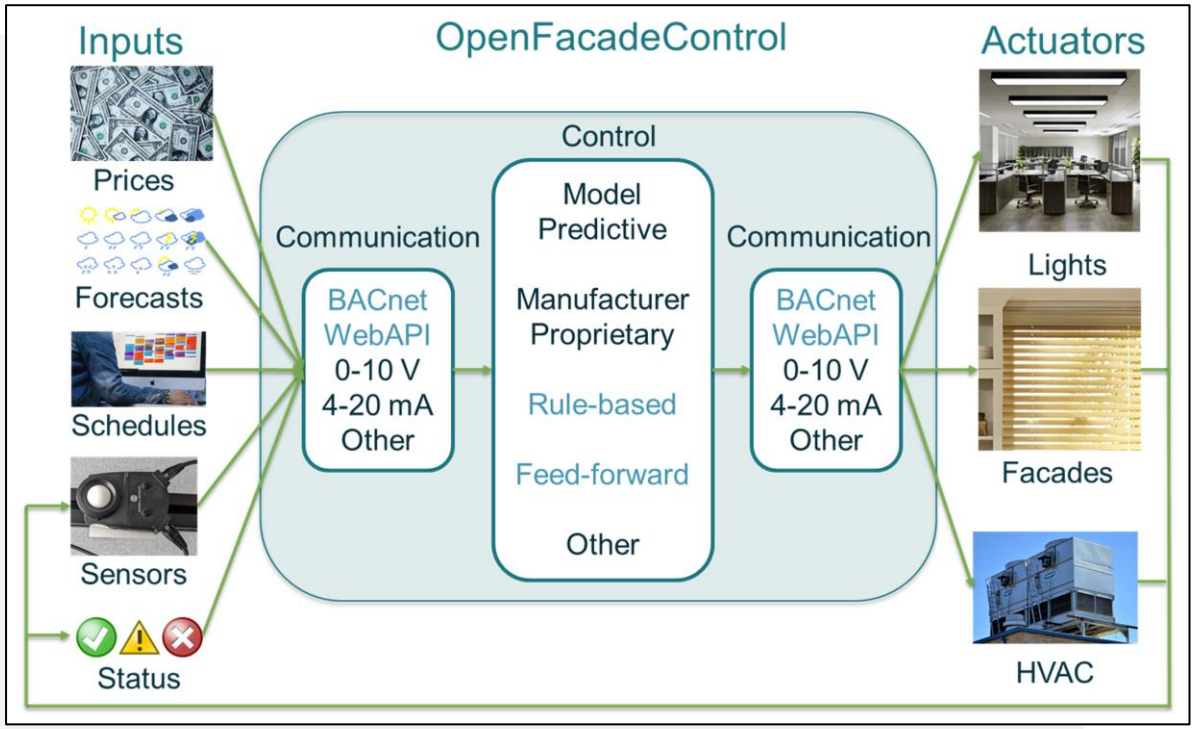
- FY23+
  - Expanding capabilities to enable
    - Grid integration
    - Carbon emission minimization
    - Circadian rhythm optimization



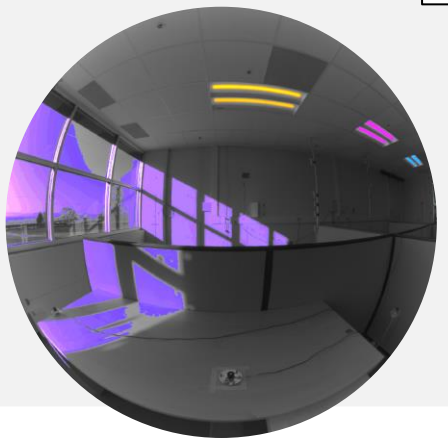
Progress and Future Work: Dynamic Facades

Enabling integration

- Scoping study (collaboration with PNNL)
- OpenFacadeControl (OFC) – an open-source framework for façade integration – under development
- Developing framework for quantifying performance of integrated systems
- Industry/stakeholder workshop



Glare sources (highlighted in color in the image) in a typical office scene often include both daylight and electric lighting systems but conventional glare metrics were not developed for this type of situation

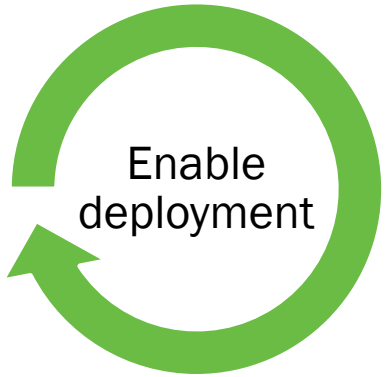


- FY23+
  - OFC: expand capability, full-scale testing and demonstration
  - In-person workshops with industry/users
  - Outreach

Progress and Future Work: Dynamic Facades

Gap Analysis

		Training Style		Material Covered			
	Name	Audio/Visual	Hands-On	Technologies	Products	Installation	Market
Lights	CALCTP	x	x	x	x	x	CA, US*
Facades	Halio	x				x	Their products
	View	x			x	x	Their products
	Legrand	x			x	x	Their products
	MechoShade	x				x	Their products



Support workforce development

- Survey of training landscape
- Educational material under development

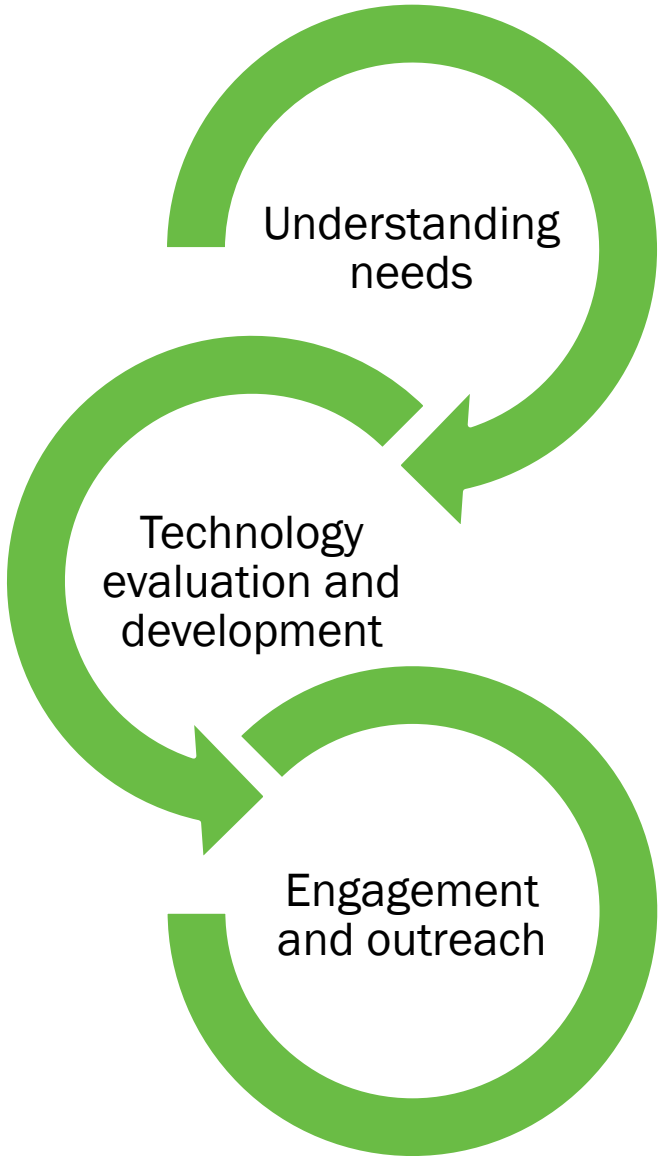
- FY23+
  - Develop/share informational materials
  - Outreach to current/potential training entities

Problem 2 – Disadvantaged Communities

Buildings in disadvantaged communities (DACs)

- **Perform worse** than average on energy use, resilience, and comfort
- Represent a large **opportunity for decarbonization**
- Unaddressed through **lack of**
  - Systematized **knowledge** about DAC needs
  - Market **incentives** targeting technology development to address needs
  - Specific technological **solutions**

Approach 2 – Disadvantaged Communities

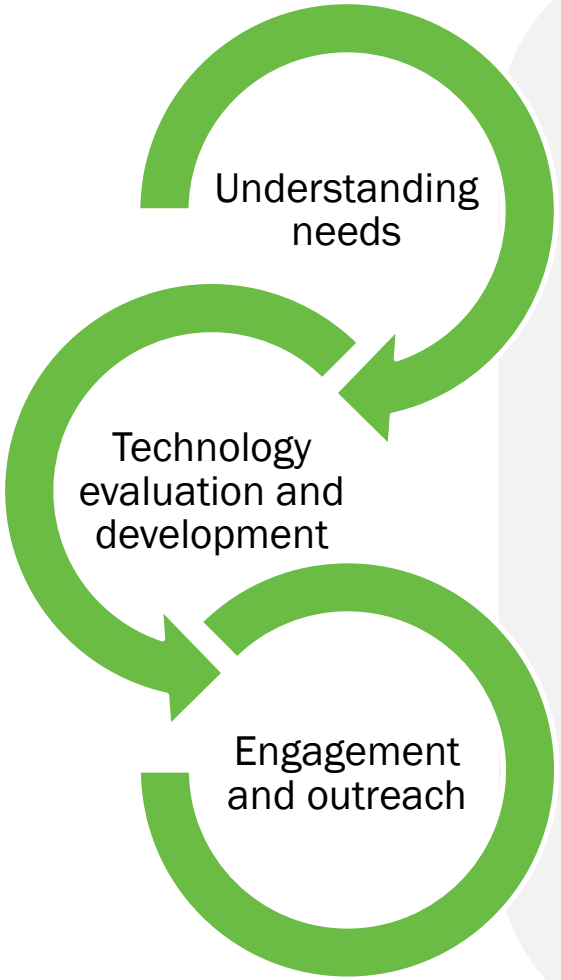


Gather and organize knowledge about windows in DACs

Evaluate technology options and perform/support development as needed

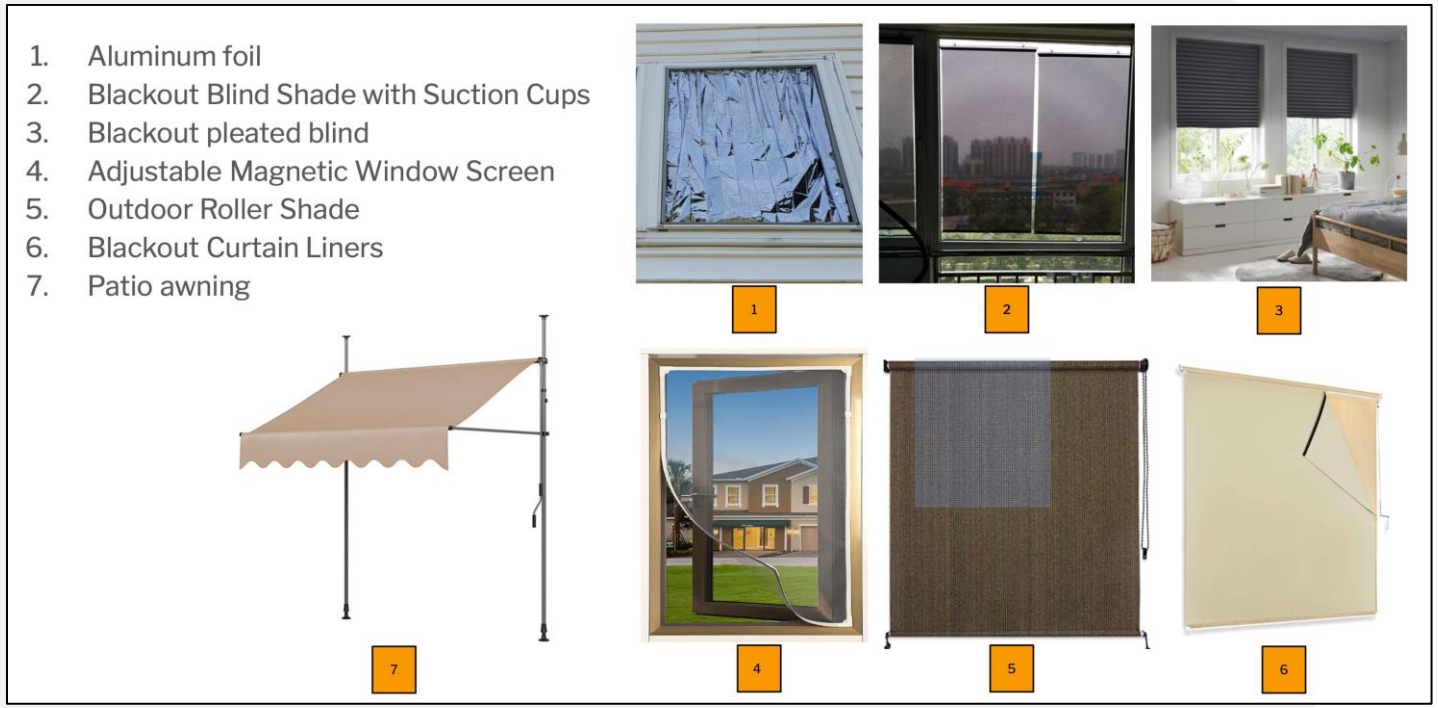
Drive market transformation and provide guidance to stakeholders and decisionmakers

Progress and Future Work: Disadvantaged Communities



Addressing DAC needs

- Survey of window-related needs - ongoing
- List of affordable DYI/self-install solar control products



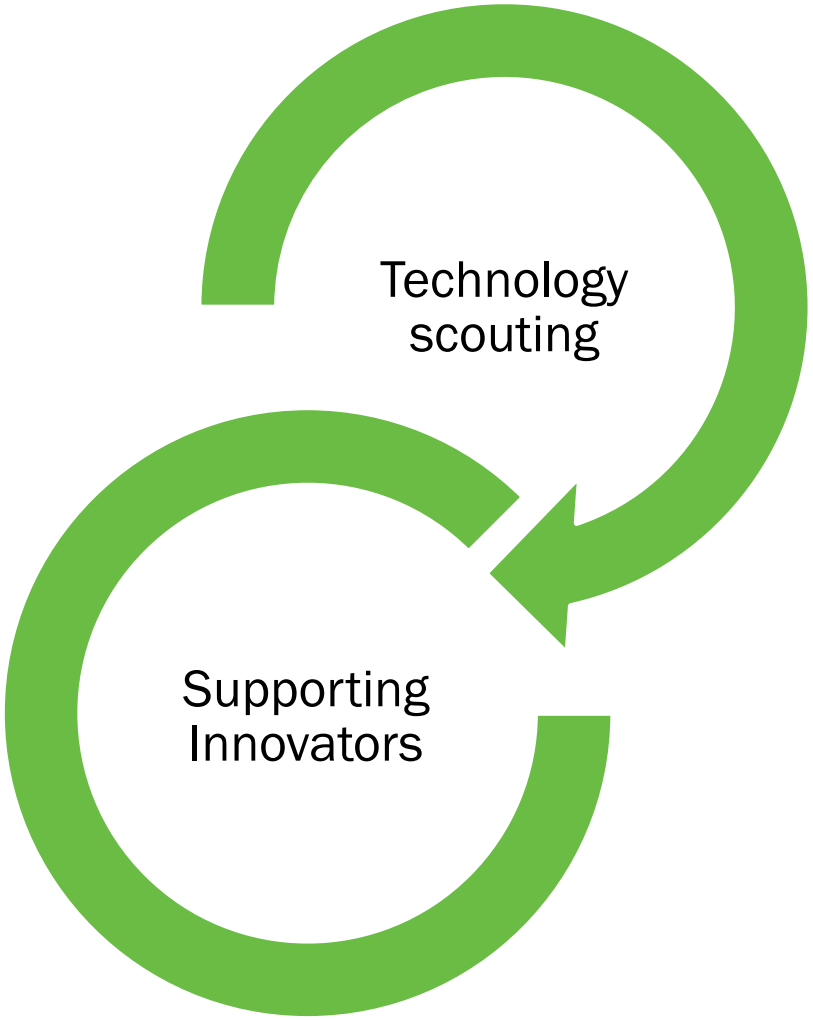
- FY23+
  - Complete survey
  - Test/share DYI/self-install products
  - Automated exterior solar control solution for renters
  - Identify/support/develop targeted solutions
  - Outreach to stakeholders and decision makers

Problem 3 – Maintaining the Innovation Pipeline

- Many current energy-efficient window technologies have roots in 1970s-1980s
- We need to start working now on the window technologies of 2050
- Lack of window science knowledge can hamper innovation

Thermochromic window in transition. Most of the area of the lower panes is unshaded and its temperature has risen above the switching temperature, due to incident solar radiation. The top two panes are shaded by an overhang. (Source: Lee et al., 2013, A Pilot Demonstration of Electrochromic and Thermochromic Windows in the Denver Federal Center, Building 41, Denver, Colorado, GSA Proving Ground report).

Approach 3 – Maintaining the Innovation Pipeline



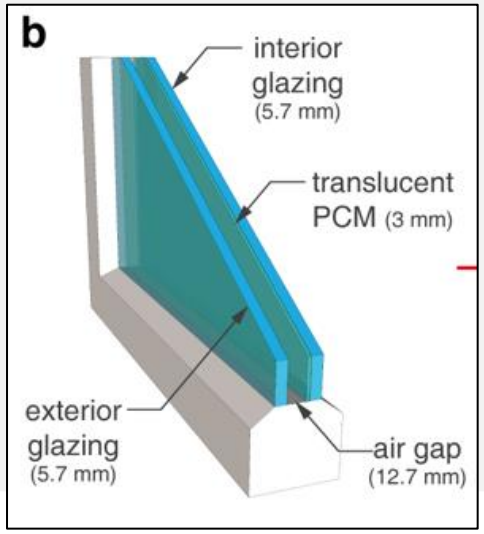
Identify, assess potential for, and develop new technologies

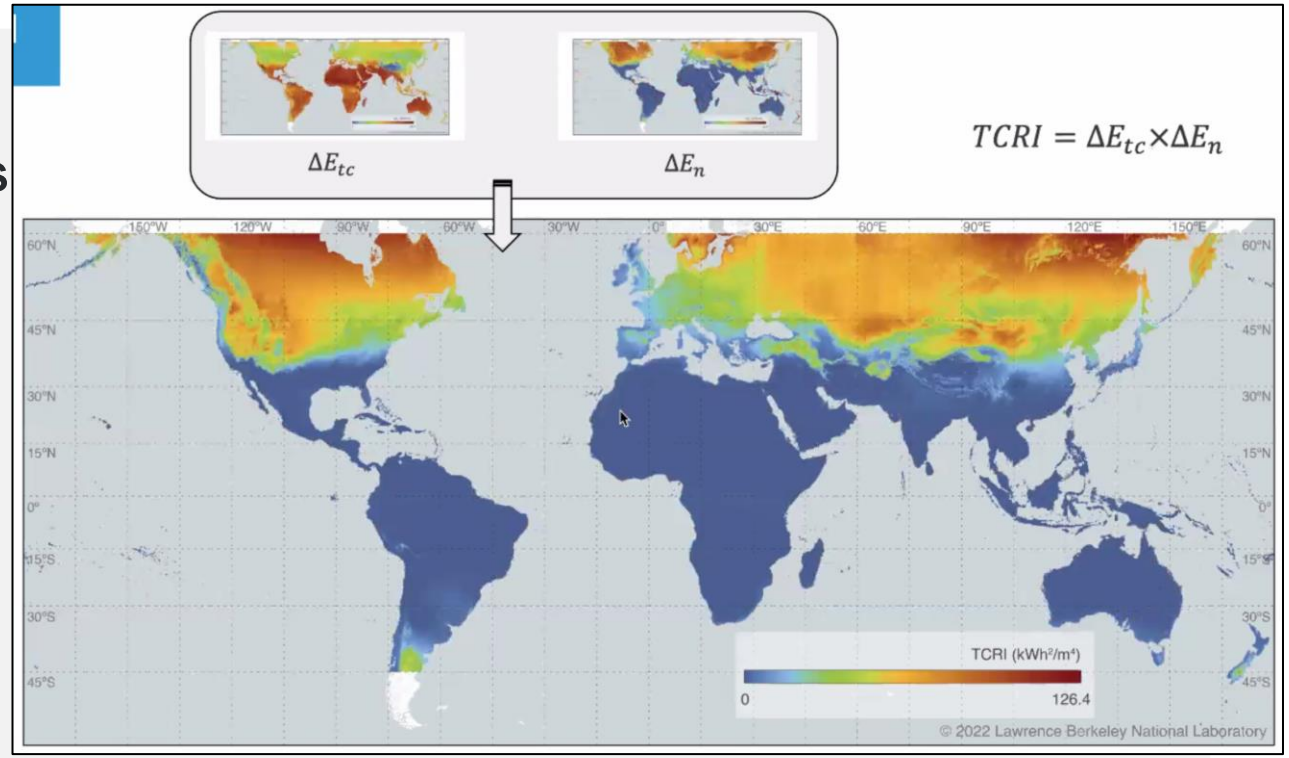
Provide informational resources and technical assistance for new technology development

Progress and Future Work: Maintaining the Innovation Pipeline

Identifying, assessing, developing new technologies

- Assessment of potential of
  - Translucent phase-change materials
  - Thermochromic glazing
- Maintaining living list of potential new technologies





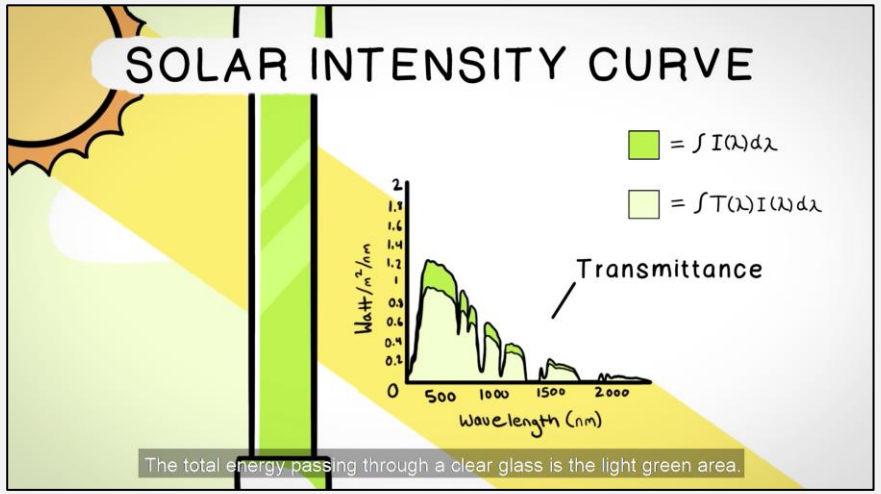
TCRI is an index of how suitable thermochromic windows are for providing energy savings in a particular climate, taking into account the possible range for thermochromic material properties

- FY23+
  - Assess potential of new technologies
  - Develop MEMS based microshutter technology

Progress and Future Work: Maintaining the Innovation Pipeline

Providing information and technical support

- Windows 101 for Scientists and Inventors videos and factsheets
- Windows R&D success stories
- Direct technical support

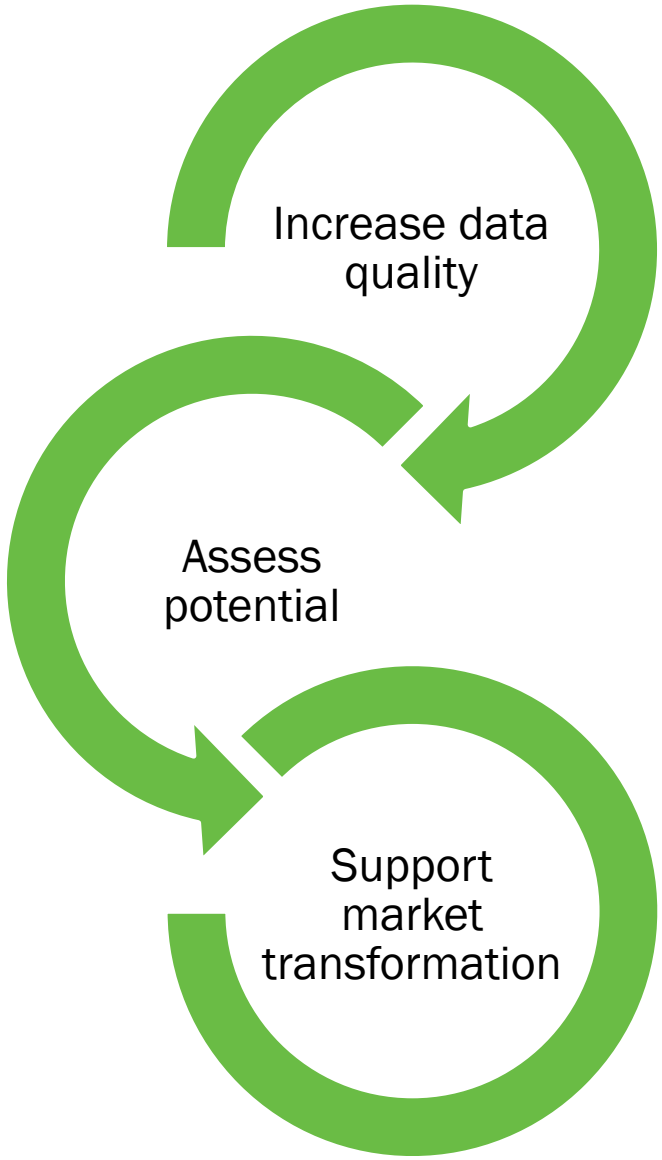


- FY23+
  - Informational materials media campaign
  - Individual technical support

Problem 4 – Increasing Uptake in Commercial Buildings

- **Commercial buildings have comparatively low uptake of efficient windows**
  - Commercial building windows are rarely NFRC rated
  - Energy codes have more relaxed minimum performance for commercial windows
  - EnergyStar for commercial windows does not yet exist
- **Value of upgrading commercial building windows not well understood**
  - Insufficient data

Approach 4 – Increasing Uptake in Commercial Buildings

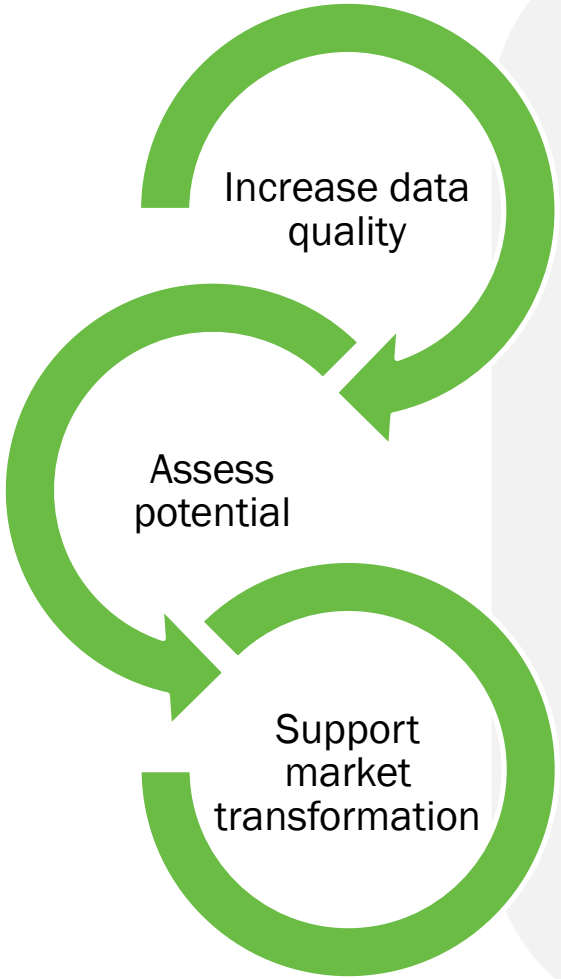


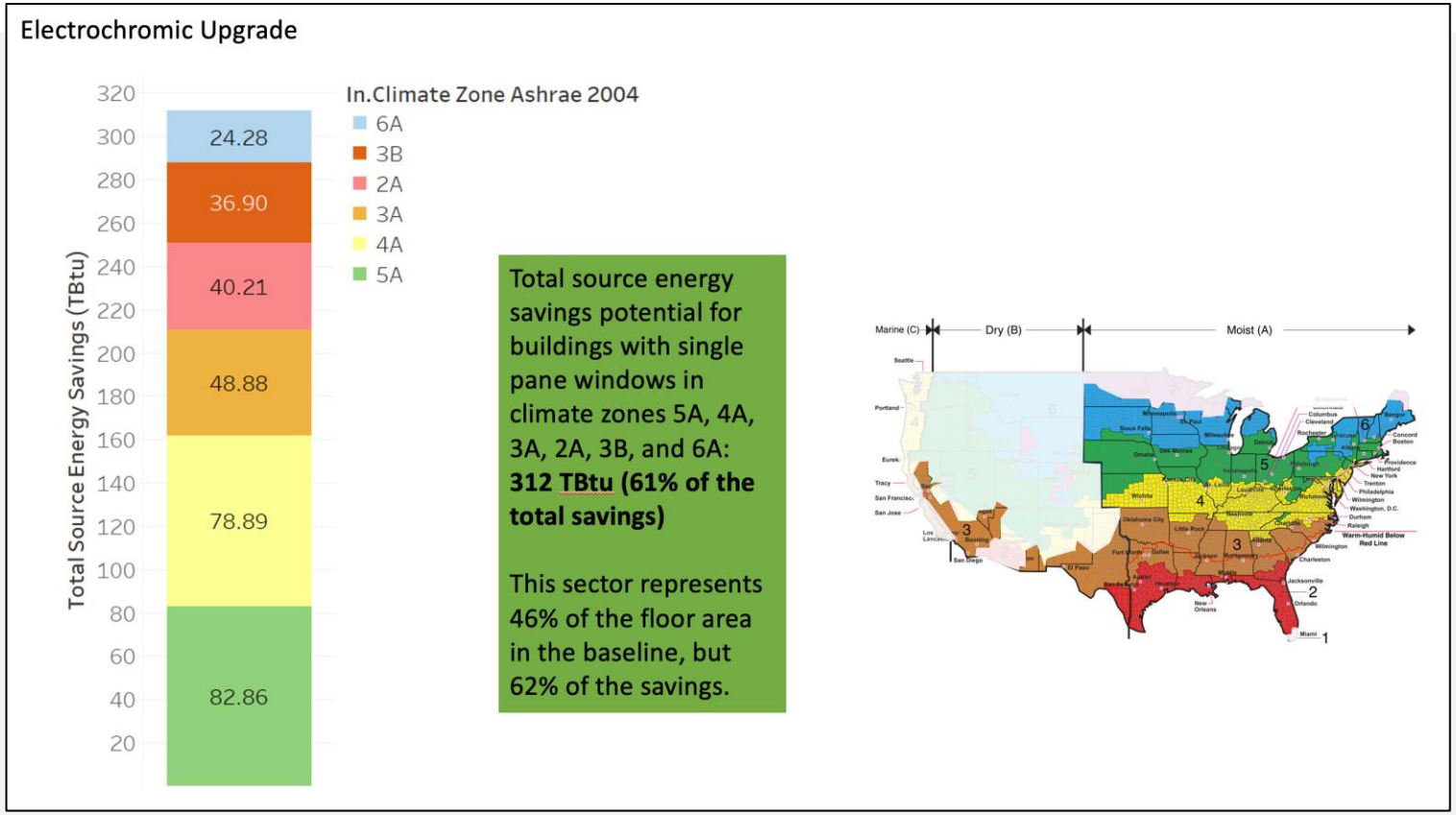
Guide and support gathering more granular data on windows in commercial buildings

Develop estimates of the nationwide potential of window upgrades in commercial buildings

Support market transformation initiatives

Progress and Future Work: Increasing Uptake in Commercial Buildings





- Data gathering, analysis
- Estimates of national impact (collaboration with NREL)

- FY23+
  - National impact of dynamic secondary glazing retrofits
  - Support DOE prize development and implementation

Recent testimonials

"LBNL's windows program provides **invaluable research, software, and lab support** for the rapidly emerging smart glass industry, and the broader glass industry as a whole."

"The **research and resources provided by LBNL are crucial** for the continued development and adoption of energy efficient and human-centric fenestration products."

Galen Burrell
Director of Lighting Design

"LBNL (...) have been an **invaluable resource** for MechoShade and the entire commercial shading marketplace especially for the past 2 decades that I have been in this industry."

"**As the complexity of solutions grows** to drive increases in performance, a **resource like LBNL becomes even more valuable to help guide tangible advances in building systems and standards** that help drive real value for customers at a variety of levels."

Steve Hebeisen
Director of Engineering

"LBNL's **publications on energy savings potential of EC technologies, technology assessments in the advanced window testbed, and field study demonstrations** are all **instrumental** in the development of Halio's EC project."

"In my view they are the **trusted scout leading the way** for a $150B industry."

Andy McNeil
Product Manager

Thank You

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REFERENCE SLIDES

Project Execution

	FY2020				FY2021				FY2022				FY2023			
Planned budget	1,015,596				873,121				736,187				649,360			
Spent budget	923,873				817,025				746,310				443,888			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Past Work																
Façade and Lighting Integration																
Educational Videos/Materials																
Identifying and Evaluating New Materials																
Increasing Uptake in Commercial Buildings																
Disadvataged Community Needs/Competition																

Team

Key team members and stakeholders with whom you are working and their roles