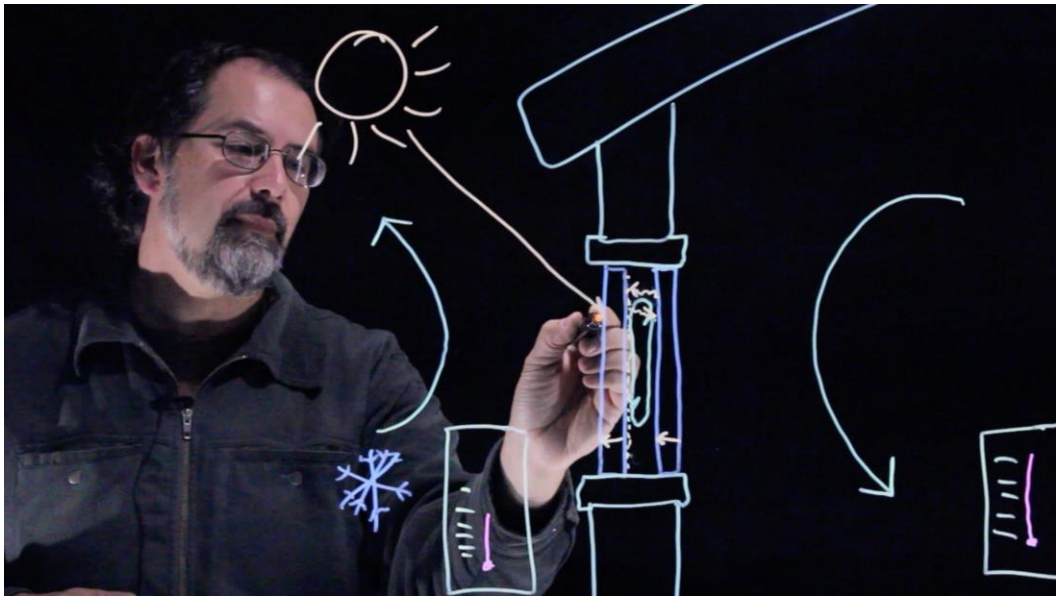
U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Foundational Design Research to Aid Innovators and Researchers



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Project Summary

Timeline:

Start date: 10/1/2018

Planned end date: 9/30/2021 (years 2 and 3 to be confirmed)

Key Milestones

1. Go/No-Go; 6/30/2019
2. Year 1 content released; 9/30/2019

Budget:

Total Project $ to Date:

- DOE: $400k
- Cost Share: $0

Total Project $:

- DOE: $400k (FY20, FY21 funding to be confirmed)
- Cost Share: $0

Key Partners:

- UC Berkeley/other academia
- ARPA-E

Project Outcome:

Providing non-window researchers with the background they need to develop innovative windows technologies through a series of foundational guidance materials

Inventors pursue development of energy-efficient window technologies; many lack guidance on how to target development to achieve zero net energy performance.

Project will develop and disseminate guidance needed by inventors to pursue value added, high impact development strategies for components technologies or integrated systems.

This work will also identify core work in characterization methods and modeling tools needed to support the development and commercialization of innovative fenestration.

Team

LBNL Windows R&D Team

- Christian Kohler, Eleanor Lee, Charlie Curcija, Luís Fernandes, Howdy Goudey, Robert Hart
- Decades of windows R&D experience
  - Theory + laboratory and field testing
  - Thermal, optical behavior of windows
  - Software tools
- Extensive connections to window industry





Roles:

- Develop guidance materials
- Reach out to non-window R&D community to assess effectiveness
- Coordinate with other team members

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Non-window R&D community

- UC Berkeley, other academia
- Non-window industry researchers
- ARPA-E
- Others as needed/recommended

- Role: provide feedback on usefulness of guidance materials
- Reached by
  - Asking for colleague recommendations
  - DOE staff recommendations

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Other National Laboratories

- Role: provide input for guidance materials on additional window topics: e.g., NREL on durability

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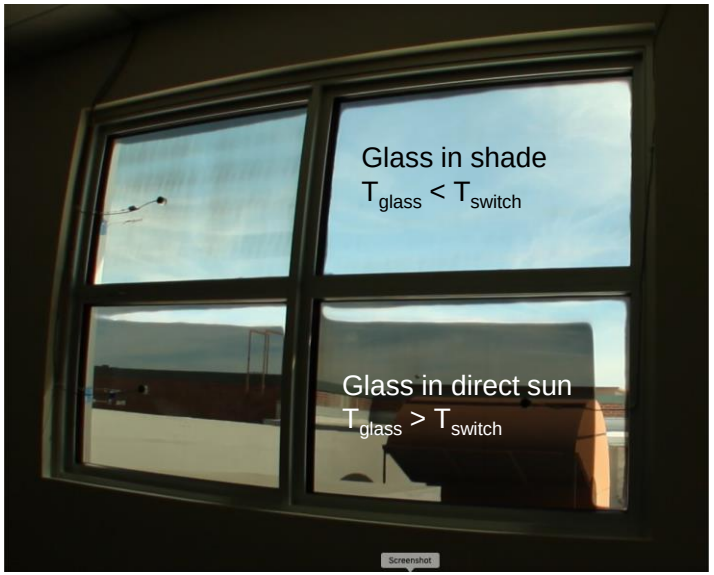
LBNL Communications Office

- Role: Communications support

Effective guidance for non-window inventors and researchers

Challenge

- Dynamic, highly-insulating windows could be net energy producer rather than consumer
- Some technical barriers due to **lack of building physics knowledge on the part of the inventors.**
  - Introductory guidance materials usually targeted at practitioners (e.g. application guides for building designers or operators) or consumers
  - Innovators familiar with science and engineering concepts but specialized on fields other than windows (e.g., material science, optics, thermodynamics, controls engineering, advanced manufacturing, human factors)
  - E.g., thermochromic glazing initially developed targeting switching temperature based on outdoor air temperature, not glass temperature
- **Objective: to develop and disseminate foundational guidance needed by inventors for value added, high impact window technology development**

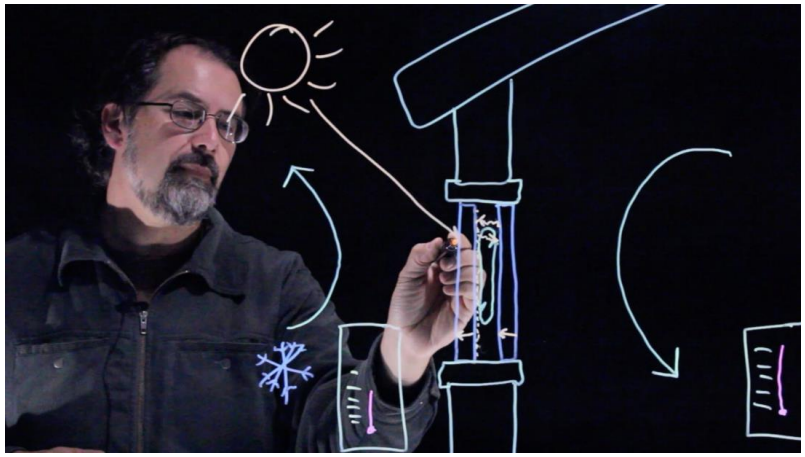


Thermochromic window in transition. Most of the area of the lower panes is unshaded and its temperature has risen above the switching temperature, due to incident solar radiation. The top two panes are shaded by an overhang. (Source: Lee et al., 2013, A Pilot Demonstration of Electrochromic and Thermochromic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

- Contribution to BTO goals:
  - Enabling accelerated technology development through specific, targeted information to R&D community (industry, government, academic) on achieving energy reduction goals through technological innovation
  - Supporting development and commercialization of innovative fenestration technologies through identifying necessary core work in characterization methods and modeling tools

Approach

- Develop effective guidance materials (e.g., videos, FAQs, factsheets) and disseminate them to non-window research community
- Current approach (developed in consultation with DOE Program Manager):
  - Series of short videos with supporting materials (e.g. a video primer on window components and nomenclature accompanied by a factsheet for reference purposes)
  - Informal, “colleague-to-colleague” style of communication; introductory to the field of windows but assuming viewer with an R&D background
  - Guidance materials point to existing resources that may be hard to identify by non-windows R&D community



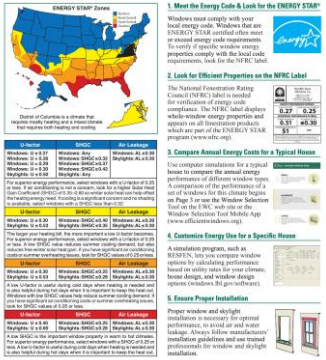
Still from video sample (Dec 2018): LBNL researcher Howdy Goudey explaining solar heat gain.

- Assess effectiveness via feedback from stakeholder network of non-windows researchers, e.g.:
  - UC Berkeley, other academia
  - ARPA-E
- 3-year plan
  - Year 1 (FY19): Develop list of topics for 3-year effort, guidance materials for 1-2 topics; gather stakeholder feedback
  - Year 2 (FY20): Develop guidance materials for additional 1-2 topics; adjust approach based on stakeholder feedback
  - Year 3 (FY21): Develop guidance materials for additional 1-2 topics; implement permanent resources (e.g., web, others) needed beyond project

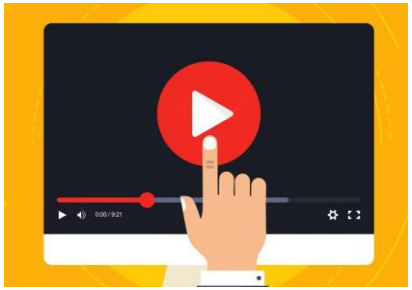
Impact

Outputs

- Guidance targeted at currently underserved non-windows R&D community



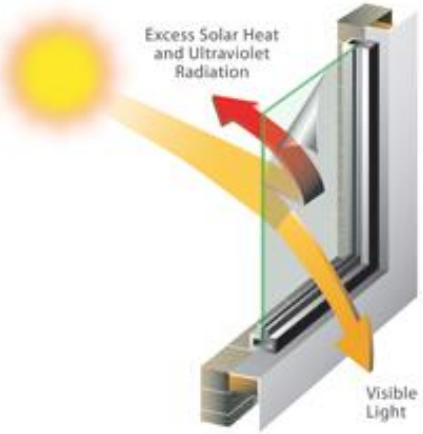
Factsheets



Videos

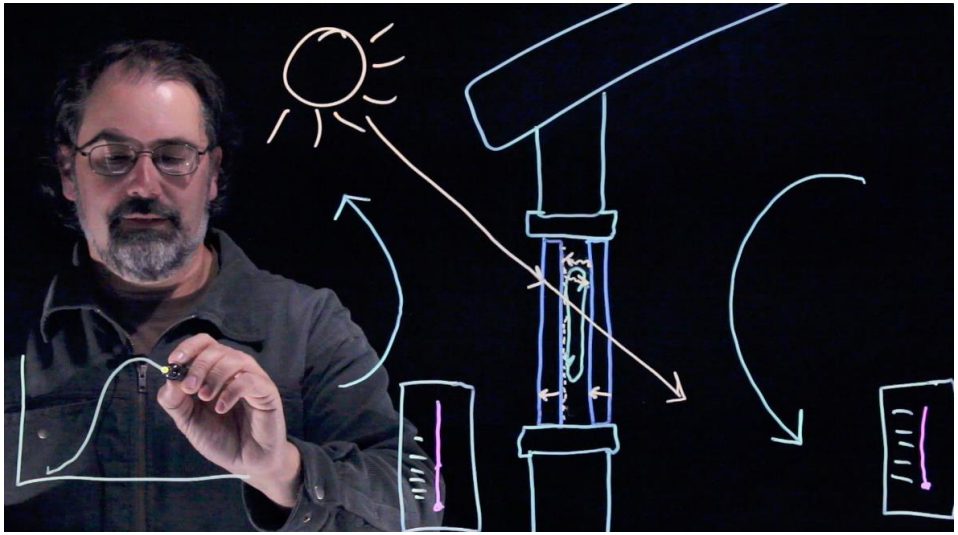
Outcomes

- Accelerated window technology development
- Identification of necessary core work in window characterization methods and modeling tools



Progress

- Project proceeding according to plan; at early-middle stage of FY19 plan
- Draft 3-yr plan and initial samples of guidance materials (video, factsheet/FAQ) delivered for 12/31/2019 milestone
- Video (+supporting materials as needed) agreed as main communications vehicle; SHOW VIDEO HERE
- 50% draft guidance materials (video scripts) delivered for 3/31/2019 milestone



Still from video sample (Dec 2018): LBNL researcher Howdy Goudey explaining solar spectrum implications for energy-efficient windows.

What is heard	What is seen on screen
Hi! I'm [NAME], a [JOB - e.g., a reasearcher at LBNL, where I work on energy efficient windows] and in this video I'm going to walk you through some of the basic terminology that we use to talk about windows and their components in a research and development context.	Person talking
Let's start with a basic window - this is the glass a single-pane window. As the name says, it only has one pane of glass. The glass itself can be clear or tinted.	Draws section pane of glass (blue); labels "glazing"; adds "clear", "tint"
It also has a frame, which can be made of materials like, for example, wood, vynil or aluminum.	Draws section of frame (pink) around the top and bottom edges of the glass; labels "frame"; add "wood, PVC, Al"
In newer buildings, multi-pane windows are more common; this configuration is usually called an insulated glazing unit, or IGU for short. An IGU with two glass panes is called a double IGU, with three glass panes a triple IGU, and so on.	Adds one pane next to the first one, modifies frame
The gap between the glass panes is usually called the "air gap"; despite the name, it can be filled with gas mixes other than air, most commonly a mixture of argon and air but there are krypton-filled gaps as well.	Labels "air gap"; writes "Ar, Kr" below "air"

Section of script draft (Mar 2019): section shown is part of a video introducing the basic nomenclature used in windows R&D.

Remaining FY19 work

- Develop series of “colleague-to-colleague” short videos introducing windows as R&D topic and some current R&D challenges
  - 1. Basic concepts and nomenclature
  - 2. Physical properties
    - Heat flow
    - Optical properites
  - 3. Challenges
    - 3.1 Making windows energy efficient and comfortable in winter conditions
      - Multiple-pane windows
      - Reducing thermal conductivity of gap between glass panes
      - Reducing thermal conductivity of window frame
      - Low-emissivity coatings
    - 3.2 Making windows energy efficient and comfortable in summer conditions
      - Spectrally-selective coatings
      - Chromogenic glazing
- Gather feedback from initial stakeholder network
  - Non-window colleagues at other LBNL divisions, UC Berkeley
  - ARPA-E personnel, e.g., who underwent windows R&D learning curve

Remaining Project Work

FY2019 work is proceeding according to original plan and on track to completion on schedule.

Milestone Name/Description	End Date	Type	Status
Task 2. Foundational guidance: 80% draft content for Year 1 completed and presented using the defined method(s) of dissemination	6/30/19	Go/No-go	In progress
Task 2. Foundational guidance: Public release of Year 1 content Task 3. Public release of success stories	9/30/19	Annual milestone	Not started

FY2020, FY2021 work planned, to be further defined after Go/No-go decision on 6/30/2019.

Thank You

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REFERENCE SLIDES

Project Budget

Project Budget: $400k for FY19
Variances: No variances
Cost to Date: $35k
Additional Funding: None

Budget History					
FY 2018 (past)		FY 2019 (current)		FY 2020 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$0	$0	$400k	$0	$400k	$0

Project Plan and Schedule