DOCKETED	
Docket Number:	23-ERDD-01
Project Title:	Electric Program Investment Charge (EPIC)
TN #:	254893
Document Title:	Lawrence Berkeley National Laboratory Comments - Berkeley Lab Comments - 23-ERDD-01 Retrofitting with Innovative Building Envelope Solutions Concept
Description:	N/A
Filer:	System
Organization:	Lawrence Berkeley National Laboratory
Submitter Role:	Public Agency
Submission Date:	3/6/2024 4:52:56 PM
Docketed Date:	3/6/2024

Comment Received From: Lawrence Berkeley National Laboratory
Submitted On: 3/6/2024
Docket Number: 23-ERDD-01

Berkeley Lab Comments - 23-ERDD-01 Retrofitting with Innovative Building Envelope Solutions Concept

Please see comments attached.

Additional submitted attachment is included below.

BERKELEY LAB
Bringing Science Solutions to the World

March 6th, 2024
Director Jonah Steinbuck
Director of the Energy Research and Development Division
California Energy Commission
715 P Street
Sacramento, California 95814

Re: Lawrence Berkeley National Laboratory Comments on CEC Draft Solicitation Concept for Retrofitting with Innovative Building Envelope Solutions

Director Steinbuck,
Berkeley Lab appreciates the opportunity to present our comments in response to the CEC's request for feedback on the Draft Solicitation Concept for Retrofitting with Innovative Building Envelope Solutions.

Below, we've summarized our comments by Group number corresponding to the draft solicitation. As a corollary to this, we would also like to highlight the body of existing work funded by the DOE, which may be of use in supporting short term solutions to achieve similar goals.

Significant R&D funded by DOE for envelopes for residential buildings highlights the cost and performance barriers as well as the state-of-the-art for various technologies and retrofitting strategies. It would be helpful for applicants to know of these relevant findings from referencing previous studies on these topics, to understand the nature of barriers that are being addressed and how the deficiencies in the state-of-the art are being met through the GFO.

While there are well-established, effective and (mostly) commoditized approaches in use right now, that can create impactful solutions for achieving goals of the solicitation in the near term, it will be helpful to know how this GFO intents to build upon the state of the art to help make advancements.

Comments Regarding Group 1 - Value Proposition Improvement- Residential Envelope Technology Retrofit Opportunity for Opaque Envelopes (VPI-RETRO- Opaque Envelopes):

Berkeley Lab suggests clarification on whether this is related to surface treatment or cavity insulation.

There are several well-understood challenges to adopting surface treatment technologies:

- Adding to the exterior of buildings without removing existing sheathing
- Addressing window and door connections

- Addressing exterior rain spouts, IT wiring, electric power conduit, electric panels, etc. if adding insulation to the building exterior
- Home exteriors are complex shapes and are often not suitable for panelized construction. It is difficult and expensive to custom make complex exterior insulation systems to clad a home.

It will be helpful to know if this solicitation expects that the proposed projects overcome these issues.

The existing compliance tool used to do the energy efficiency documentation would have limitations of usability for a novel technology given that the software would, by definition, not already include a novel technology. We suggest considering other calculation methods to assess the novel technologies.

We encourage the commission to include a 24-month monitoring period in this solicitation (12 months pre and 12 months post). Additionally, we suggest that the energy bills are obtained both pre and post monitoring.

We also suggest that the CEC consider adding ventilation strategies, including Energy Recovery Ventilators (ERV). Residents in most of California's climates would greatly benefit from ventilation.

Comment Regarding Group 2: Value Proposition Improvement - Residential Envelope Technology Retrofit Opportunity for Vacuum Insulated Glass (VPI-RETRO- Vacuum Insulated Glass)

- Regarding the following point, "projects in this group must be less costly, less invasive, and/or easier to install than traditional retrofit methods.", we suggest the solicitation tie this to value, cost vs benefit (energy, comfort, etc.) instead of just a cost basis. We cannot expect these high-performance products to be cheaper and higher performing than the existing market options, at least in the short term. Additionally, it can be challenging to justify energy savings alone as a reason for window replacement. We recommend that the solicitation consider the reasons for window replacement other than those related to financial or energy savings associated with load reduction, such as: comfort, broken or worn out existing windows etc. Particularly for the windows addressed in the solicitation it will be useful to quantify how much more additional energy savings can be achieved when compared with current practice (you can get between 5%-15% additional improvement by going to higher performance instead of code minimum. See: https://windows.lbl.gov/publications/thermal -performance-and-potential andhttps://www.pnnl.gov/news -media/how-triple-pane-windows-stop-energy-and-money-flying-out-window)

- Regarding the following point, “software modeling of high-performance windows (i.e., durability, stability)” Berkeley Lab requests further clarification on what the solicitation is looking for. Is this related to the development of a model or just running FEA? Is the focus on simulation of durability, or on condensation, thermal, etc?

- Regarding the following point, “under this method, the new VIG window combined with the existing frame must achieve a U-factor of no greater than 0.18.” We comment that this might be an unrealistic performance level in an existing frame. A fairly quick analysis to see how good the frame needs to be to hit this and/or how good the VIG needs to be with a typical wood or steel frame should be done to ensure the proposal isn’t asking for unrealistic performance numbers.

- Berkeley Lab comments that a complete product changeout U<0.08, is very ambitious/not currently possible even with VIG hybrid construction, especially at $8/sf incremental. It is difficult to get to the center of glazing at U<0.08, let alone with the frame. R8 (U=0.13) is very difficult, but potentially achievable, but not at $8/ft2 premium. Also, what is considered the baseline for the premium cost?

- Regarding the following points addressed in the draft solicitations (1) “Can the project team develop accelerated testing of VIG components to ensure that VIG windows will last at least 40 years?” and (2) “Projects must develop a standard testing process to evaluate the durability, stability, longevity, and mechanical strength of the VIG window.”, Berkeley Lab comments:
    - Durability of VIG is currently being studied through the National Laboratories in collaboration with the University of Sydney and working with multiple industry partners in support of on-going standard development efforts under ASTM and ISO. It would probably be most effective that teams leverage this effort to demonstrate their proposed products.
    - Can CEC clarify the reasoning behind “at least 40 years"? Standard IGUs are certified for a 10 year lifetime. Why would VIG be held to a higher standard? It would probably be a good idea to raise expected lifetime, but that should be done in conjunction with all glazing systems, so that each of them are held to the same standard.

The draft solicitation notes that the research project must address a specific set of barriers for VIG window installations. Below Berkeley Lab provides comments regarding a number of those barriers.

- 2. “Can VIGs work for windows larger than eight feet?”
  The vast majority of large commercial installations do not go over 8 ft, therefore, this seems like an introduction of additional barriers. Additionally, the impact of size on

durability of VIG is currently being studied through the National Laboratories in collaboration with the University of Sydney and working with multiple industry partners in support of on-going standard development efforts under ASTM and ISO. Information from this effort should be leveraged.

- "What is the optimum pillar spacing that maximizes energy performance while maintaining durability of the glass panes?"
  Berkeley Lab comments that this is a solved problem, it is in the literature and Berkeley Lab WINDOW software, and could be excluded from the solicitation. See references below:
  - Fischer-Cripps, A.C., et al.: Stresses and fracture probability in evacuated glazing. Build. Environ. 30(1), 41–59 (1995)
  - Collins, R. E., et al.: Vacuum glazing: design options and performance capability. In: Glass in Buildings Conference, Bath UK. vol. 221 (1999).
  - Collins, R.E., Fischer-Cripps, A.C.: Design of support pillar arrays in flat evacuated windows. Aust. J. Phys. 44(5), 545–564 (1991)
  - Turner, G. M., et al.: Limits to performance of evacuated glazing.In: Optical Materials Technology for Energy Efficiency and Solar Energy Conversion XIII, vol. 2255, SPIE (1994).
  - Fischer-Cripps, A.C., Collins, R.E.: Architectural glazings: Design standards and failure models. Build. Environ. 30(1), 29–40 (1995)
  - Fischer-Cripps, A.C., Collins, R.E.: The probability of Hertzian fracture. J. Mater. Sci. 29, 2216–2230 (1994)

- "What are the project team's plan for addressing the lack of certification procedures, such as NFRC rating, for VIG windows? Without an NFRC rating, VIG windows cannot get full performance compliance credit."
  NFRC can certify VIG through multiple methods currently. This includes both through physical testing as well as modeling approaches. Durability is presently assessed through the ASTM E2188/E2190 methods while further, potentially more appropriate methods are being developed under ASTM, ISO and within the National Laboratories.

We believe this project will be most valuable if the following is considered:

- A focus on developing design improvements to low TRL VIG designs OR demonstrating existing designs, both is too much for the given funding amount.
- Standard development is not needed as there is already funded efforts underway for that work.

For windows retrofit solutions, the value proposition is impacted by (i) installation cost and (ii) energy performance (addressed above).

Installation Costs:

- Regarding cost, where significant labor is associated with window installs, the CEC could consider setting an install target of a lower installation cost - say $250/window for a typical window size. Since it takes a fixed amount of time to remove and dispose of existing windows, or install scaffolding if not on the ground floor, CEC may want to consider technologies and ideas that address these installation issues. It would help to get clarification if the solicitation expects applicants to include inputs from window install companies on the largest costs and time sinks for window installs to propose projects under this solicitation?

- Obtaining a good air/water seal and dealing with associated framing is of significant importance (solutions for self-installing window systems might address this barrier in Group 4 and would benefit from a bit more integration.).

- Another key issue that should be considered is the like-for-like requirements in many building codes and we recommend the solicitation take this limitation into consideration on window performance.

- Installation costs and window type (that changes costs) solutions may depend on starting point:
    - metal frame single pane from the 50s, 60s and 70s
    - old double hung with weight pockets
    - like for like code requirements

Production costs:
Is the expectation that the production cost reduction through advanced manufacturing will largely be achieved from economies of scale by moving from prototype to normal production or would CEC expect to support novel manufacturing techniques?

Comments Regarding Group 3: Value Proposition Improvement - Residential Envelope Technology Retrofit Opportunity for with Multiple Measures (VPI-RETRO- MM)

Regarding the target performance metric of 1 ACH for air sealing requirement, Berkeley Lab considers that achieving this target might be unrealistic since it requires interventions that are incredibly time consuming and costly. An effective approach to achieve this goal would involve not just an improved leak sealing technology, but would also need to replace all the windows and doors with the very best windows and doors currently available. We highly recommend a more realistic target: either 3 ACH50 or a reduction of 50% over baseline. Both of these are currently difficult and costly to achieve in older homes (in California the 3 ACH50 is sometimes met in new construction).

We recommend the inclusion of duct sealing and insulating in Table 3. Typical savings of 20% of HVAC loads have been demonstrated in California homes (Jump, D.A., Walker, I.S. and Modera, M.P., (1996), “Field Measurements of Efficiency and Duct Retrofit Effectiveness in Residential Forced Air Distribution Systems.”, Proc. ACEEE 1996 Summer Study, Vol. 1 pp. 147-156. American Council for an Energy Efficient Economy, Washington, D.C. LBNL 38537.) for moderate costs of about $800 (Less, B.D., Walker, I.S., Casquero-Modrego, N. and Rainer, L. 2021. The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes. doi:10.20357/B7FP4D). This is usually, by far, the most cost-effective energy saving update for existing CA homes, which tend to have leaky and poorly insulated ducts. We recommend setting targets for very low duct leakage (e.g., set a target of 5 cfm at 25 Pa, or lower) and at least R-20 insulation (which means either buried ducts or requiring the ducts are all inside the envelope).

It would be valuable to consider targets for low global warming potential (GWP) refrigerants, or R&D on how to have refrigerants not leak, e.g., better refrigerant line connectors (no more flare fittings).

We need to get beyond SEER, EER, HPSF for heat pumps and start looking into ways to ensure that the controls operate as intended. Many heat pump controls are black boxes that installers and contractors cannot adjust - often resulting in poor performance compared to manufacturers ratings. For example, locking in control modes that force low efficiency operation when recovering from night time setbacks. There are plenty of conscientious contractors in the state who are really concerned about the controls issues. The CEC may want to consider consulting with these contractors as it relates to this topic.

We need new form factors and (lower) capacities more suitable for retrofit (and also deal with noise issues for HPWH) as these are key installation barriers in many homes. We suggest that this solicitation include these as design parameters and include them in revised Table 3.

Comments Regarding Group 4: Value Proposition Improvement- Improving the Thermal and Air Infiltration in Window Retrofits with Existing Frames

Regarding air infiltration performance, what is intended for the T24 infiltration criteria? Is this to define a test procedure or create a guideline on what infiltration reduction can typically be assumed for input into the software, or both? Additionally, of equal, if not greater importance for the majority of California climates is natural ventilation, so adding provision for the cost-effective natural ventilation in windows would be an integral part of this group.

The CEC posed General questions for stakeholders. We have addressed a few of those below:

- Addressing question 2: Several envelope retrofit technologies that aren’t addressed in this draft solicitation concept that should be considered include secondary glazing systems, automated shading, thermochromic glazing, and electrochromic glazing.

Secondary glazing systems provide a lower-cost option for window retrofits and, with high-performance technologies such as VIG, can achieve substantial improvements in performance. They can also be integrated with automated shades or electrochromic glazing to provide a solution that not only improves insulation but can also modulate solar heat gains according to the season and time of day, thus further improving energy performance. New materials that radiate heat to the deep sky for achieving sub-ambient surface temperature should be included as opaque envelope technologies of interest for field performance testing and quantification in life cycle payback.

- Addressing question 3 as it relates to Groups 2 and 4: Payback is not a big decision factor in residential window retrofits. Value is much more important and improvements to aesthetics, comfort, and resilience to extreme events are more typical selling points.
- Addressing question 4 as it relates to Group 2: Commercial buildings should also be addressed, but it makes sense to address separately. Most manufacturers of Vacuum Insulated Glass see the commercial retrofit sector as their first target, but there is still value in research on the residential retrofit side.

Lastly, we comment that the project should investigate the market size of this solution.

Berkeley Lab appreciates the opportunity to provide feedback on the draft solicitation concept for **Retrofitting with Innovative Building Envelope Solutions.**

The following individuals contributed comments: Iain Walker, Luis Fernandes, and Robert Hart.

Sincerely,
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