Aerogel Insulated Glazing Unit (A-IGU)

Team Members
Lawrence Berkeley National Laboratory
National Renewable Energy Laboratory
Research Triangle Institute

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PI: Wendell E. Rhine
wrhine@aerogel.com
Phone: 508 466 3130

PM: Shannon White
swhite@aerogel.com
Phone: 508 691 1175

EXPORT CONTROL WARNING
Approximately 40% of homes in the US still have single pane windows.

Problems with single pane windows
- Low energy efficiency
- Energy costs
- Condensation
- Drafts due to air infiltration
- Comfort level
- Soundproofing

Problems with replacement windows
- High cost
- Long payback period
- Gas-filled panes may leak
- Short lifetime
- Do not meet heritage or historic window aesthetic requirements

The Window Debate – Replace or Restore

Single pane windows can be restored using existing methods but currently restoration methods do not include improving their energy efficiency.

Solution to Problem
Develop cost-effective aerogel-insulated glazing units (A-IGU) that can be used to improve the energy efficiency of single pane windows.

The Market
>$150 billion retrofit market opportunity.
Aspen’s Solution
• A thin profile aerogel insulated glazing unit (1/4\textsuperscript{th} inch thick A-IGU) that can replace glass panes to improve energy efficiency of windows at a lower cost than purchasing replacement windows.

Intellectual Property
• Processes for making and supercritically drying aerogels to reduce manufacturing costs (<$10/sq.ft.).
**Aspen’s Product – An energy efficient aerogel insulated glazing unit (A-IGU)**

- Silica aerogels are one of the best transparent insulation materials known.

### Energy efficiency

- **Thickness dependent**

### U-values using low-e glass

<table>
<thead>
<tr>
<th>Thickness</th>
<th>U-value BTU/ft² h F</th>
<th>U-value W/m² K</th>
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<tbody>
<tr>
<td>2 mm</td>
<td>0.37</td>
<td>2.09</td>
</tr>
<tr>
<td>12 mm</td>
<td>0.13</td>
<td>0.76</td>
</tr>
</tbody>
</table>

- **R = 7.7**
- **R10 when gap is 18mm thick**

**1/4th inch thick pane replacement**

- **Retrofit solution**

**Triple pane performance in double pane format**

- **New replacement window**

**Meets ARPA-E requirement**

- **Triple pane performance**

**2 mm glass panes**

- **Warm edge spacer**
- **Existing single pane sash**

**>2 mm aerogel thermal barrier, TC <14 mW/m-K**

**12 mm aerogel**

- **2 mm glass panes**
- **Warm edge spacer**
- **Double pane sash**
Market for A-IGUs

- Our market survey indicated that currently there is a limited market for replacing panes in residential single pane windows to improve their energy efficiency.
- This business opportunity involves installing new energy efficient panes in the existing sash of single pane windows so that the window would retain the same aesthetic characteristics as the original window.

Market Road Map

- **Replacement panes for the panes in single pane windows**
- **Skylights**
- **Replacement windows**
- **New windows – double pane format - triple pane performance**

Entry product  
Future products
Entry Product

- Replacing the panes in single pane windows with energy efficient panes would be a lower cost option than purchasing replacement windows and decrease energy costs for the homeowner.

Advantages of A-IGUs

- The resulting window when combined with a storm window can be as energy efficient as or better than that of new replacement windows.
- Original window is not altered.
- Meets historic window requirements.
- Improves comfort levels.
- Avoids condensation issues.
- Not reliant on gas fill or vacuum.
- Lower cost option than replacement windows.
- Shorter payback period.
Properties

- Met ARPA-E goals for transparency (>80%), haze (~1%), and U-value (<0.4 BTU/ft² h F).
- Modeling studies show that replacing the panes in single pane windows with the A-IGU panes would improve the energy efficiency of the homes.

<table>
<thead>
<tr>
<th>City</th>
<th>Total site energy reduction (GJ)</th>
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<tbody>
<tr>
<td>Houston</td>
<td>11%</td>
</tr>
<tr>
<td>Minneapolis</td>
<td>19%</td>
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Status

- Designed, developed and tested a new process for production of transparent aerogels.
- Demonstrated production of aerogels using the new drying process.

Challenges

- Further development is required to refine and scale-up the new process for making A-IGUs that meet transparency, haze, and cost requirements.
ASPEN AEROGLELS, INC.

- Path Forward

- Proof of Concept Prototype 1
  - 4” x 4”
  - 2018

- Prototype 2
  - Prepare 5 panes simultaneously
  - 8” x 8”
  - 2019

- Scale-up Prototype 3-4
  - 8” x 8” to 24” x 24”
  - Develop process compatible with IGU production line
  - 2020

- Refine and optimize scale-up process
  - 2023

- Manufacturing
  - Demonstrate and begin production
  - 2030
  - >1 million sq ft/year

Follow on funding
- Partnership
- Joint venture
Market
- The new A-IGUs would be an opportunity to expand the windows industry by offering retrofit products for the huge number (40%) of residences and buildings in the U.S. that still have single pane windows.

Partners
- Aspen is seeking a partner or partners interested in collaborating or forming a joint venture to help develop and commercialize the technology.

Collaboration and partners
- Supplier of glass panes, sheets, IGUs (e.g., Cardinal, Pilkington, etc.).
- Windows restoration companies
- Traditional windows companies for marketing and distribution.
- Building materials supply companies.
- Joint venture possible after proving technology.

Path Forward
- Partnering with a materials, windows or IGU companies for distribution.
- Leveraging partner’s manufacturing and distribution channels.