HEAT LOAD AND SOLAR GAIN PREDICTION FOR SOLID WALL DWELLINGS RETROFITTED WITH TRIPLE VACUUM GLAZING FOR SELECTED WINDOW TO WALL AREA RATIOS

Saim Memon & Philip C. Eames

Centre for Renewable Energy Systems Technology (CREST)
School of Electronic, Electrical and Systems Engineering,
Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK

S.Memon@lboro.ac.uk
P.C.Eames@lboro.ac.uk
- Heat Loss
- Solar Gain
- Energy Cost Saving
- Window to Wall Area Ratio

How to make consumers happy

Photo Credit: Google 3D Warehouse
Dwelling with Conventional Glazings

Heat Loss

Paying more bills
Ultra Low Heat Loss

Saving money due to reduction of energy consumption
What is the Triple Vacuum Glazing

Support Pillars

Vacuum Gap

Vacuum Pressure $\leq 0.1\ Pa$

Glass Sheets

Edge Seal

Idea Credit: (Eames, 2008), (Manz et al, 2006), and (Fang et al, 2010)
Modelling & Simulation Approach

Location: London
Weather Database: ASHRAE

External Temperature Profile

BOUNDARY CONDITIONS

<table>
<thead>
<tr>
<th>U-Values</th>
<th>W/(m².K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof</td>
<td>0.24</td>
</tr>
<tr>
<td>Solid Wall</td>
<td>0.34</td>
</tr>
<tr>
<td>Floor</td>
<td>0.24</td>
</tr>
<tr>
<td>Door</td>
<td>2.19</td>
</tr>
</tbody>
</table>

Inside Set Point Temperature 21 °C

Window to Wall Area Ratio 13.19%
(1.2mx2m)

Heating System
Boiler= LTHW gas fired
Water radiator with supply Temp = 60°C
Efficiency = 80%

Cooling System
Natural Ventilation

Simulated Glazing Types & U-Values W/(m².K)

Single (5.7)  Double (2.9)  Triple (1.9)  Double Vacuum (0.85)  Triple Vacuum (0.45)
Winter Heat Load Analysis

- Single Glazed Window Room
- Double Glazed Window Room
- Triple Glazed Window Room
- Double Vacuum Glazed Window Room
- Triple Vacuum Glazed Window Room

Date: Sun 01/Dec to Fri 28/Feb
Maximum Heating Power 1.34kW at -5.6 to -6.1°C weather side temperature for the case of Single glazed window and 1.08kW for Triple Vacuum Glazed window.

Peak time Heat Load Reduction with Triple Vacuum Glazing 260 watts
Winter Solar Gain Analysis

Maximum Solar Gain received through Single glazing is 1.15kW and through triple vacuum glazing 0.785kW

Peak time Solar Gain Reduction with Triple Vacuum Glazing is 365W

Azimuth angle = 175°
Elevation angle = 26°
Winter Heat Energy used by Boiler in kWh

- Single Glazed
- Double Glazed
- Triple Glazed
- Double Vacuum Glazed
- Triple Vacuum Glazed

Heat Energy Used by Boiler KWh

- Dec
- Jan
- Feb
Total winter heat energy required when using a double air filled glazing is 1849kWh and for triple vacuum glazing is 1674.3kWh.

Winter Energy saving with Triple Vacuum Glazing
174.7kWh

Comparing energy saving of triple vacuum glazing with single=398.2kWh, Triple=109.1kWh, and double vacuum= 12.9kWh.
Winter Solar Heat Gain in kWh

<table>
<thead>
<tr>
<th></th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
</tr>
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<tbody>
<tr>
<td>Single Glazed</td>
<td>40</td>
<td>50</td>
<td>37</td>
</tr>
<tr>
<td>Double Glazed</td>
<td>35</td>
<td>45</td>
<td>32</td>
</tr>
<tr>
<td>Triple Glazed</td>
<td>30</td>
<td>40</td>
<td>27</td>
</tr>
<tr>
<td>Double Vacuum Glazed</td>
<td>25</td>
<td>35</td>
<td>23</td>
</tr>
<tr>
<td>Triple Vacuum Glazed</td>
<td>20</td>
<td>30</td>
<td>18</td>
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</table>
Total winter Solar Heat Gain of single glazing simulated as 126.5 kWh and for the triple vacuum glazing 86.7 kWh.

Winter solar energy loss with triple vacuum glazing 39.8 kWh.

Comparing solar energy loss of single glazing with Double= 24.7 kWh, Triple= 36.9 kWh, and double vacuum=21.4 kWh.
Winter Energy Cost and Savings

<table>
<thead>
<tr>
<th>Glazing Type</th>
<th>Winter Cost</th>
<th>Winter Savings</th>
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</thead>
<tbody>
<tr>
<td>Single Glazed</td>
<td>£117.05</td>
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<tr>
<td>Double Glazed</td>
<td>£117.9</td>
<td>£15.62</td>
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<tr>
<td>Triple Glazed</td>
<td>£124.7</td>
<td>£20.20</td>
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<tr>
<td>Double Vacuum Glazed</td>
<td>£129.3</td>
<td>£26.93</td>
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<tr>
<td>Triple Vacuum Glazed</td>
<td>£144.88</td>
<td>£27.83</td>
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</tbody>
</table>

Initial 2680 kWh units costs per year = 8.675 pence and subsequent consumption charged 3.955 pence.
standard gas tariff. Initial 2680 kWh units costs per year= 8.675 pence and subsequent consumption charged 3.955 pence.

Annual Energy Cost and Savings

<table>
<thead>
<tr>
<th>Glazing Type</th>
<th>Annual Savings</th>
<th>Annual Cost</th>
<th>kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triple Vacuum Glazed</td>
<td>£36.07</td>
<td>£276.33</td>
<td>3788.7</td>
</tr>
<tr>
<td>Double Vacuum Glazed</td>
<td>£35.11</td>
<td>£277.29</td>
<td>3812.9</td>
</tr>
<tr>
<td>Triple Glazed</td>
<td>£22.90</td>
<td>£289.5</td>
<td>4121.6</td>
</tr>
<tr>
<td>Double Glazed</td>
<td>£18.15</td>
<td>£294.25</td>
<td>4241.7</td>
</tr>
<tr>
<td>Single Glazed Baseline</td>
<td>£18.15</td>
<td>£312.40</td>
<td>4700.6</td>
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Annual Savings (compared to room with single glazed window)
Assuming a dwelling consists of 6 simulated rooms or a high rise building consists of 100 rooms, considerable energy and cost saving could be realised.
Heat Load Performance Analysis of Glazings at Different Window to Wall Area Ratios (WWR)

Modelling & Simulation Approach

- Single Glazed Window
- Double Air Filled Glazed Window
- Triple Air Filled Glazed Window
- Triple Vacuum Glazing
- Double Vacuum Glazing

South
Heat Load Performance Analysis of Glazings at Different Window to Wall Area Ratios (WWR)

![Graph showing heat load performance analysis of glazings at different window to wall area ratios (WWR). The graph includes data points for single glazed, double glazed, triple glazed, double vacuum glazed, and triple vacuum glazed materials. The x-axis represents window to wall area ratios ranging from 5.49% to 32.96%, and the y-axis represents heat load required from the boiler in watts.](image-url)
Winter & Annual heat loads and solar gains were analysed and it was predicted that the heat load can be reduced significantly by using either double or triple vacuum glazing.

Predictions of the costs of energy and potential financial savings resulting from replacing single glazing by more energy efficient glazing systems were made.

It was also shown that for low heat loss glazings it is possible to significantly increase window to wall area ratios with little increase in room heat load.

Glazed buildings can be redesigned to improve heat load performance since both the wall and the triple vacuum glazing have almost the same thermal transmittance.