

# INVESTIGATION OF THE EFFECTS OF FENESTRATION SYSTEMS ON THE ENERGY PERFORMANCE OF A TYPICAL COMMERCIAL BUILDING

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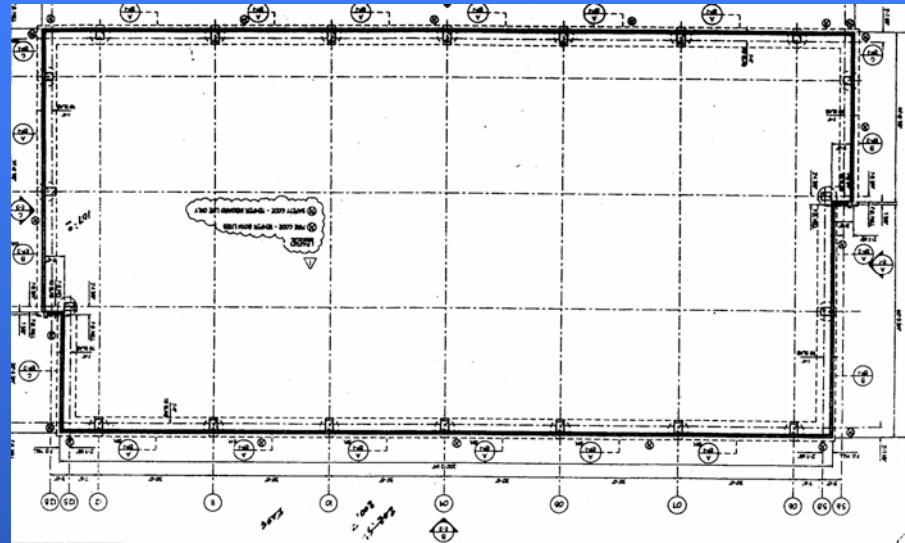
# INTRODUCTION

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- Issue of new rating system for Non residential products
  - Large number of different fenestration configurations
  - Process for rating the products becomes increasingly difficult
  - Can small percentage of fenestration products can be modeled using more generic performance indicators? How small can be the small percentage? What values should be considered for these small percentage of products?
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# BUILDING DESCRIPTION

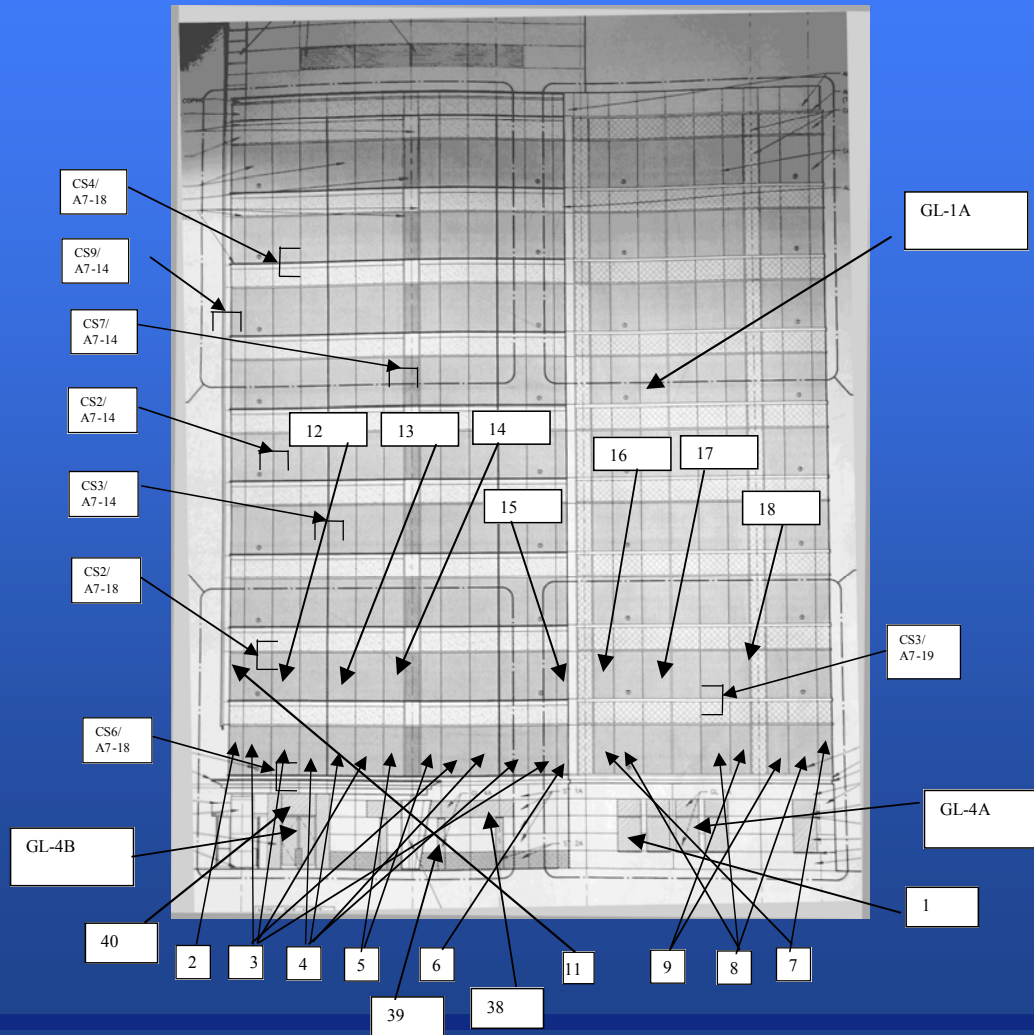
- Floor area:  $\sim 220,000$  sf
- Window area:  $\sim 50,000$ sf
- No of floors: 10
- Typical curtain wall Configuration
- Glazing systems:
  - N,S,W (U-factor= $0.43$  Btu/hr-sqft-F, SHGC= $.24$ , VT= $0.2$ )
  - E (U-factor= $0.29$  Btu/hr-sqft-F, SHGC= $.30$ , VT= $0.6$ )
  - First floor : (U-factor= $0.99$  Btu/hr-sqft-F, SHGC= $.81$ , VT= $0.88$ )
- Office Building
- Location: Dallas, TX



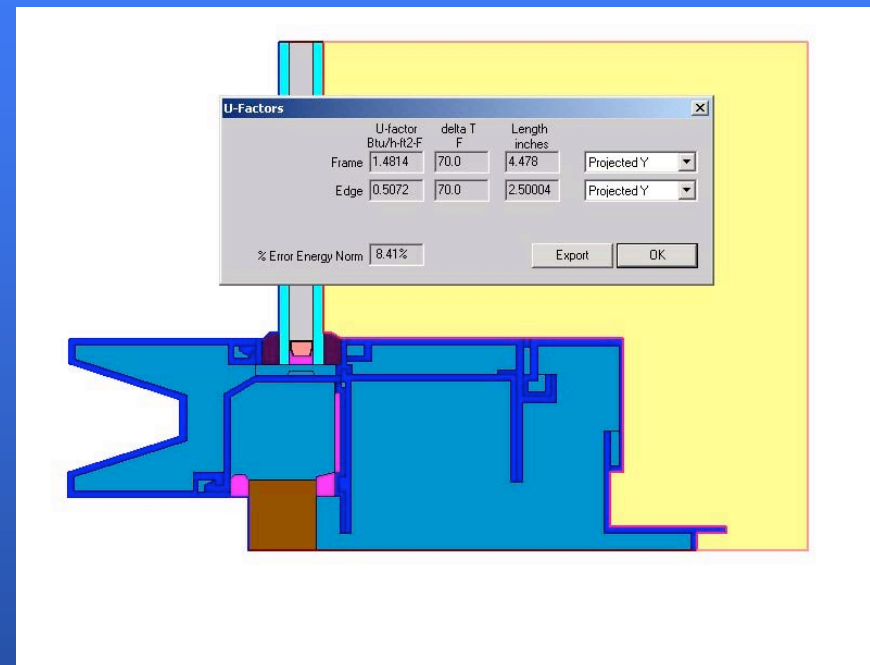
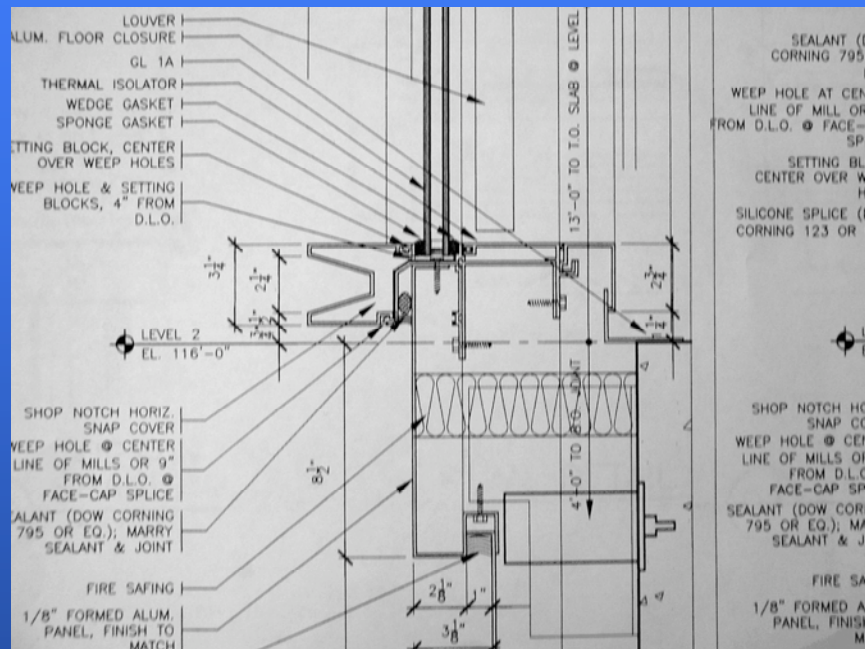
# BUILDING VIEW



# TYPICAL ELEVATION



# TYPICAL CURTAIN WALL CROSS SECTION



# DISTRIBUTION OF WINDOWS

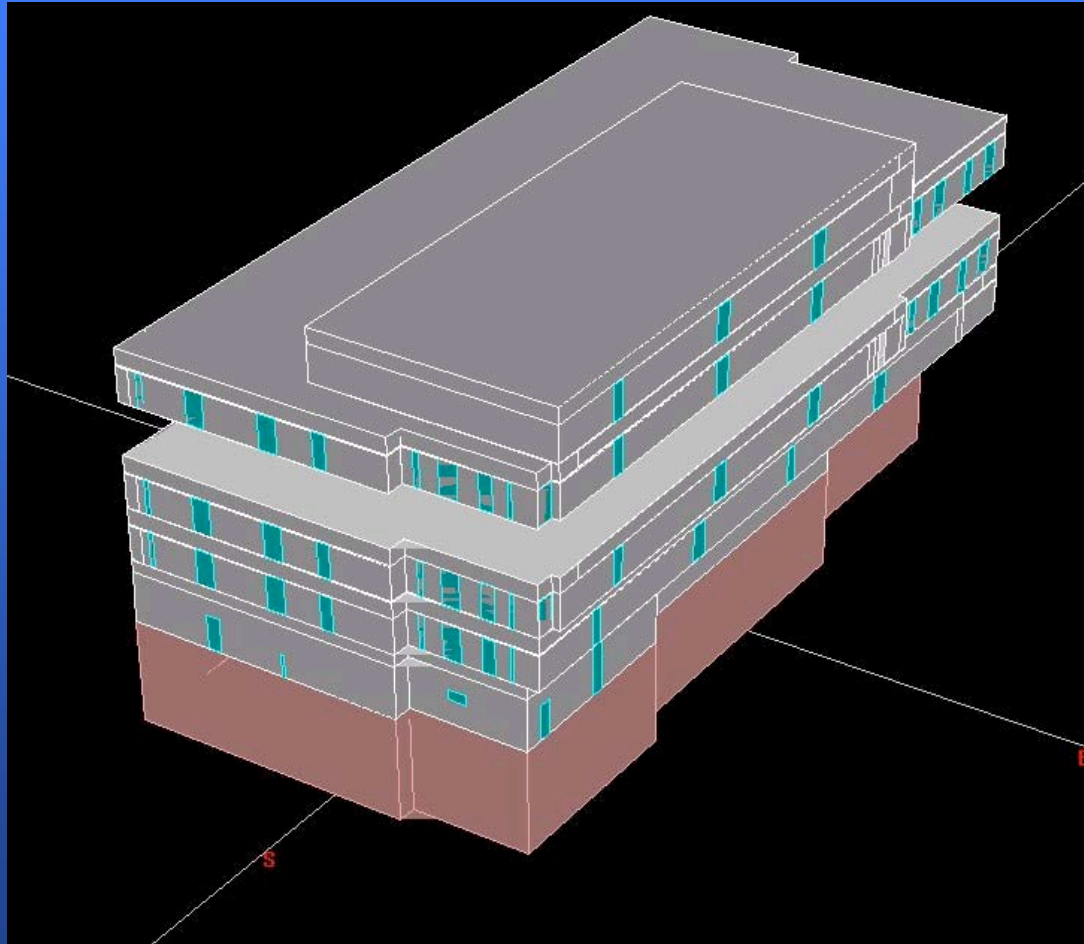
|                        | <1%    | <2%    | <3%     | <5%     | >5%     | Total   |
|------------------------|--------|--------|---------|---------|---------|---------|
| No of window types     | 20     | 23     | 32      | 36      | 6       | 42      |
| Area (sq ft)           | 3219.5 | 5640.5 | 16638.5 | 24063.5 | 25434.0 | 49497.5 |
| % of total window area | 6.50   | 11.40  | 33.61   | 48.62   | 51.38   | 100     |

# GLAZING SYSTEMS

| Glazing | Description   | U factor<br>(W/m <sup>2</sup> K) | SHGC | VT   |
|---------|---|----------------------------------|------|------|
| GL-1A   | Coated insulated vision glass VA - 1-22 with coating (e=0.528) at 2 <sup>nd</sup> surface | 2.44                             | 0.24 | 0.20 |
| GL-3A   | Coated insulated vision glass Viracon 2/M super LowE, coating (e=0.04) on surface 2       | 1.65                             | 0.30 | 0.60 |
| GL-4A   | Monolithic vision glasses, clear, 1/2" min thickness                                      | 5.62                             | 0.81 | 0.88 |
| GL-4B   | Tempered monolithic vision glass, clear, 1/2" min thickness                               | 5.62                             | 0.81 | 0.88 |

# BUILDING SIMULATION

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# LOAD AND ENERGY USE

| Components                            | Peak Load (actual building)<br>(kW) |             | Energy (actual building)<br>(MWh) |               |
|---------------------------------------|-------------------------------------|-------------|-----------------------------------|---------------|
|                                       | Cooling                             | Heating     | Cooling                           | Heating       |
| Window glass +<br>frame conductance   | 334.7                               | -313.1      | 506.6                             | -327.2        |
| Window solar                          | 139.9                               | 10.8        | 475.6                             | 56.1          |
| Walls+roof<br>conduction              | 14.2                                | -22.3       | 29.6                              | -20.8         |
| Occupant                              | 91.4                                | 5.0         | 241.1                             | 22.3          |
| Lighting                              | 125.4                               | 18.5        | 395.1                             | 56.3          |
| Equipment                             | 67.1                                | 11.2        | 214.0                             | 31.1          |
| Infiltration                          | 8.6                                 | -18.5       | 6.5                               | -19.5         |
| Misc.                                 | 9.9                                 | -22.1       | 0.2                               | -78.1         |
| Latent (occupant and<br>infiltration) | 57.3                                | 0.0         | 142.4                             | 0.0           |
| <b>Total</b>                          | <b>848.6</b>                        | <b>11.2</b> | <b>1868.6</b>                     | <b>-279.7</b> |

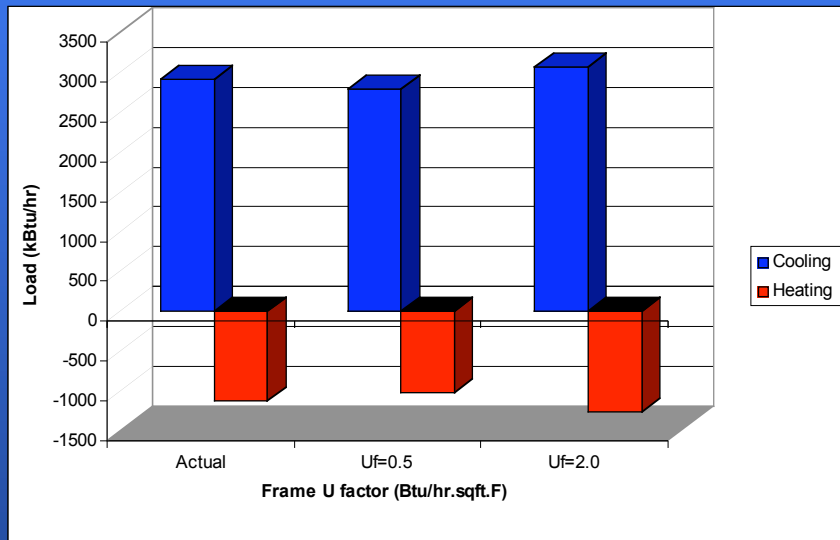
# EFFECT OF FRAME U VALUE

## ■ DALLAS, TX

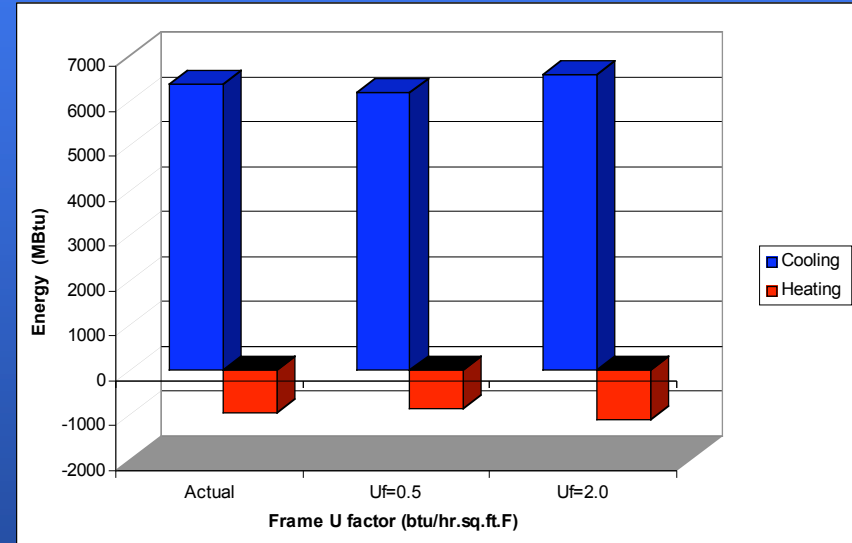
| U factor of<br>frame<br>(W/m <sup>2</sup> K) |        | Building Peak Load<br>(kW) |             |         |              | Building Energy<br>MWh |             |         |              |
|--|--------|----------------------------|-------------|---------|--------------|------------------------|-------------|---------|--------------|
|  |        | Cooling                    | % Diff      | Heating | % Diff       | Cooling                | % Diff      | Heating | % Diff       |
|  | Actual | 848.4                      |             | 330.3   |              | 1868.2                 |             | 279.7   |              |
| 2.84   | Total  | 813.6                      |             | 298.8   |              | 1810.8                 |             | 246.3   |              |
|  | Diff.  | -34.8                      | <b>-4.1</b> | -31.5   | <b>-9.5</b>  | -57.3                  | <b>-3.1</b> | -33.4   | <b>-11.9</b> |
| 11.36  | Total  | 894.3                      |             | 370.4   |              | 1933.7                 |             | 317.2   |              |
|  | Diff.  | 45.9                       | <b>5.4</b>  | 40.0    | <b>12.16</b> | 65.5                   | <b>3.5</b>  | 37.5    | <b>11.7</b>  |

# EFFECT OF FRAME U VALUE

## ■ DALLAS, TX



**Cooling and heating LOAD  
for actual building**



**Cooling and heating ENERGY  
for actual building**

# EFFECT OF MINOR WINDOWS

## ■ DALLAS, TX

| U factor of frame<br>(W/m <sup>2</sup> K) | Building Peak Load<br>kW |             |         |             | Building Energy<br>MWh |             |         |             |
|---|--------------------------|-------------|---------|-------------|------------------------|-------------|---------|-------------|
|   | Cooling                  | % Diff      | Heating | % Diff      | Cooling                | % Diff      | Heating | % Diff      |
| Actual                                    | 848.4                    |             | 330.3   |             | 1868.2                 |             | 279.7   |             |
| Minor windows<br>Total                    | 843.7                    |             | 325.2   |             | 1858.7                 |             | 273.6   |             |
| U= 2.84<br>Diff.                          | -4.7                     | <b>-0.5</b> | -5.2    | <b>-1.6</b> | -9.4                   | <b>-0.5</b> | -6.1    | <b>-2.2</b> |
| Minor windows<br>Total                    | 857.6                    |             | 335.2   |             | 1877.5                 |             | 285.7   |             |
| U=11.36<br>Diff.                          | 9.2                      | <b>1.1</b>  | 4.9     | <b>1.5</b>  | 9.4                    | <b>0.5</b>  | 6.0     | <b>2.1</b>  |

# EFFECT OF FRAME U VALUE

## ■ MINNEAPOLIS, MN

| U factor of<br>frame<br>(W/m <sup>2</sup> K) | Building Peak Load<br>(kW) |        |             |        | Building Energy<br>MWh |        |             |        |             |
|--|----------------------------|--------|-------------|--------|------------------------|--------|-------------|--------|-------------|
|  | Cooling                    | % Diff | Heating     | % Diff | Cooling                | % Diff | Heating     | % Diff |             |
| Actual                                       | 782.01                     |        | 742.99      |        | 1046.1                 |        | 1318.0      |        |             |
| 2.84   | Total                      |        | 681.71      |        | 1030.2                 |        | 1191.5      |        |             |
|  | Diff.                      | -32.68 | <b>4.2</b>  | -61.22 | <b>-8.23</b>           | -15.9  | <b>-1.5</b> | -126.5 | <b>-9.6</b> |
| 11.36  | Total                      | 816.26 |             | 809.41 |                        | 1067.6 |             | 1435.4 |             |
|  | Diff.                      | 34.25  | <b>-4.4</b> | 66.42  | <b>8.93</b>            | 21.5   | <b>2.0</b>  | 117.4  | <b>8.9</b>  |

# EFFECT OF MINOR WINDOWS

## ■ MINNEAPOLIS, MN

| U factor of frame<br>(W/m <sup>2</sup> K) | Building Peak Load<br>kW |            |                |             | Building Energy<br>MWh |             |                 |             |
|---|--------------------------|------------|----------------|-------------|------------------------|-------------|-----------------|-------------|
|   | Cooling                  | % Diff     | Heating        | % Diff      | Cooling                | % Diff      | Heating         | % Diff      |
| Actual                                    | 782.0                    |            | 743.0          |             | 1046.1                 |             | 1318.0          |             |
| Minor windows<br>U= 2.84                  | Total<br>773.1           |            | Total<br>723.7 |             | Total<br>1040.1        |             | Total<br>1276.3 |             |
|   | Diff.<br>-8.9            | <b>1.1</b> | Diff.<br>-19.3 | <b>-2.6</b> | Diff.<br>-6            | <b>-0.6</b> | Diff.<br>-41.7  | <b>-3.2</b> |
| Minor windows<br>U=11.36                  | Total<br>789.6           |            | Total<br>760.5 |             | Total<br>1052.1        |             | Total<br>1357.5 |             |
|   | Diff.<br>7.6             | <b>0.9</b> | Diff.<br>17.5  | <b>2.3</b>  | Diff.<br>6             | <b>0.6</b>  | Diff.<br>39.5   | <b>3.0</b>  |

# EFFECT OF FRAME U VALUE

## ■ WASHINGTON, DC

| U factor of<br>frame<br>(W/m <sup>2</sup> K) |        | Building Peak Load<br>(kW) |             |         |             | Building Energy<br>MWh |             |         |             |
|--|--------|----------------------------|-------------|---------|-------------|------------------------|-------------|---------|-------------|
|  |        | Cooling                    | % Diff      | Heating | % Diff      | Cooling                | % Diff      | Heating | % Diff      |
|  | Actual | 826.6                      |             | 493.9   |             | 1255.7                 |             | 671.5   |             |
| 2.84   | Total  | 791.4                      |             | 446.2   |             | 1234.3                 |             | 605.4   |             |
|  | Diff.  | -35.2                      | <b>-4.2</b> | -47.7   | <b>-9.6</b> | -21.4                  | <b>-1.7</b> | -66.1   | <b>-9.8</b> |
| 11.36  | Total  | 863.9                      |             | 550.32  |             | 1281.3                 |             | 744.3   |             |
|  | Diff.  | 37.3                       | <b>4.5</b>  | 56.42   | <b>11.4</b> | 25.6                   | <b>2.0</b>  | 72.8    | <b>10.8</b> |

# EFFECT OF MINOR WINDOWS

## ■ WASHINGTON, DC

| U factor of<br>frame<br>(W/m <sup>2</sup> K) | Building Peak Load<br>kW |             |             |             | Building Energy<br>MWh |             |             |              |             |
|--|--------------------------|-------------|-------------|-------------|------------------------|-------------|-------------|--------------|-------------|
|  | Cooling                  | % Diff      | Heating     | % Diff      | Cooling                | % Diff      | Heating     | % Diff       |             |
| Actual                                       | 826.6                    |             | 493.9       |             | 1255.7                 |             | 671.5       |              |             |
| Minor windows<br>U= 2.84                     | Total<br>821.7           |             | 486.1       |             | 1251.4                 |             | 659.6       |              |             |
|  | Diff.                    | <b>-4.9</b> | <b>-0.6</b> | <b>-7.8</b> | <b>-1.6</b>            | <b>-4.3</b> | <b>-0.3</b> | <b>-11.9</b> | <b>-1.7</b> |
| Minor windows<br>U=11.36                     | Total<br>831.4           |             | 502.1       |             | 1259.8                 |             | 683.0       |              |             |
|  | Diff.                    | <b>4.8</b>  | <b>0.6</b>  | <b>8.2</b>  | <b>1.7</b>             | <b>4.1</b>  | <b>0.3</b>  | <b>11.5</b>  | <b>1.7</b>  |

# CONCLUSIONS

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- Number of fenestration configurations in a commercial buildings could be quite large
  - The contribution of windows in cooling/heating energy is high
  - Frame represents relatively significant portion of the window load and energy consumption,
  - Variations in frame U-factor can represent significant difference in peak load and energy performance
  - Variations of frame U-factor for “minor” windows is relatively small and can be substituted with generic performance
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