NET ZERO HOUSING

A Machine with a Poetic Bias
1.2 - City Walk

“Two generations of luxury apartment houses confront each other diagonally across an intersection, and a comparison is telling. No. 740 is another of the buildings by Rosario Candela, architect of 834 Fifth Avenue, and it is in many ways his best - a solid, sumptuous mass that sits on a corner with absolute authority. The building is sheathed entirely in limestone, and a fluted base and entrance details suggest a hint of Art Deco.....

No such Roman affectations across the street. No. 733 Park was an attempt to construct an apartment house in the grand manner of buildings of a generation previous, such as No. 740, but it is nothing but a tower of red brick.”

*The City Observed : New York, Paul Goldberger*
1.2 - City Walk

1.2.1 Scenic Sketches - 740 Park Avenue
740 Park Avenue:
Scenic Sketches

Corner Detail

Street Base at Entry Door

View from Park Avenue and East 71 Street
1.2 - City Walk

1.2.2 Documentation - 733 Park Avenue
733 Park Avenue: General Information

Architects:

Ely Jacques Kahn and Robert Allen Jacobs

Builders:

Alexander Muss and Charles Rosenberg

Technical Data:

Height: 299 ft  
Floors: 30  
Apartment Units: 28, Co-op  
Construction Start - End: 1969 - 1971

Firm’s History:

The firm Khan and Jacobs was formed in 1940. Jacob was the son of architect Harry Allen Jacobs and graduated from Columbia University’s architecture school in 1934. Between 1934-35 he worked as a designer and draftsman for Le Corbusier in Paris. In 1935 he returned to New York and became a designer for Harrison and Fouilhoux Architects, and in 1938 he joined Jacobs Kahn’s firm and became a partner in 1940.

The firm worked on a wide range of project types, including commercial, industrial, institutional buildings, airports, and housing. Drawing from European influences, they were leaders among American architects. Kahn’s modernism before WW2 was of the Art Deco-Modern variety, while Jacob’s modernism was very much a product of his influence by Le Corbusier.

Building’s History:

733 Park Avenue represented a style of luxurious upscale urban living that has today disappeared from the city. The new 30-story tower replaced the red brick, English Regency-style mansion built in 1904 by Carrere & Hastings for senator Elihu Root. The Landmarks Preservation Commission had tried to save the house; however, without success, the 30-room mansion was put up for sale by Mrs. Carl Tucker, who had lived there since 1915.

The building is setback from the edge of the lot, interrupting Park Avenue’s continuous solid wall of buildings. 733 Park Avenue and 900 Park Avenue were the only two towers at the time that soared above the rest, which averaged about 15 stories. The architects decided to set back the tower to prevent the new building from disrupting the famous avenue’s look. This setback created a small landscape plaza, today designated as a Privately Owned Public Space (POPS).

733 Park Avenue has been described by many as a "bland” apartment building with a granite base and simple dark brown bricks above. In a 1979 article from The New York Times, "Top Postwar Apartment Buildings,” Paul Goldberger described 733 Park Avenue as having an "ordinary outside but a very distinguished inside” and while “not River House, it probably comes closer to recreating the grand apartment houses of an earlier era than anything else Park Avenue has seen in decades.” The 30-story building contained only 28 full-floor apartments. Each typical unit consisted of 9 rooms and 4.5 bathrooms. The duplex penthouse consistent of 9 rooms more generously spaced out. The 8ft 11in floor-to-ceiling heights were higher than average for its time but not impressive. Each apartment was served by both a passenger and servant elevator.
733 Park Avenue:
Original Typical Floor Plan
733 Park Avenue:
Photographic Documentation
733 Park Avenue:
Photographic Documentation
733 Park Avenue:
Photographic Documentation
1.2 - Living Room

“...the wall of a house has many of the same functions as a shutter - to keep out storm winds or excess heat - and yet we are unlikely to appreciate a wall for those particular functions because it does not go through any changes that would draw our attention to its performance.”

*Thermal Delight in Architecture, Lisa Heschong*
1.2 - Living Room

2.2.1 Interior Rendering
733 Park Avenue:
Living Room - Original Design
733 Park Avenue:
Living Room - New Design
1.2 - Living Room

2.2.2 Thermal Comfort Analysis
733 Park Avenue:
New York City - Psychrometric Chart

Summer

Winter
733 Park Avenue:
New York City - Psychrometric Chart

Summer

Winter
733 Park Avenue: CBE Thermal Comfort

**Summer**

- **PMV**: 0.05
- **PPD**: 9.4%
- **Sensation**: Neutral
- **SET**: 23.9 °C
- **Psychrometric (air temperature)**: 36.5 °C
- **Relative humidity**: 58.8%
- **W**: 29.7 g·kg⁻¹
- **h**: 31.8 °C
- **T**: 31.5 °C
- **V**: 11.9 m·s⁻¹

**Winter**

- **PMV**: -0.08
- **PPD**: 8.1%
- **Sensation**: Neutral
- **SET**: 24.1 °C
- **Psychrometric (air temperature)**: 33.5 °C
- **Relative humidity**: 74.1%
- **W**: 34.9 g·kg⁻¹
- **h**: 23.6 °C
- **T**: 23.5 °C
- **V**: 9.9 m·s⁻¹

**NOTE:** In this psychrometric chart the abscissa is the dry-bulb temperature, and the mean radiant temperature (MRT) is fixed, controlled by the operator. Each point on the chart has the same MRT, which defines the comfort zone boundary. In this way you can see the changes in MRT that affect thermal comfort. You can also still use the psychometric chart as before, and each point will have the same MRT.
733 Park Avenue:
CBE MRT Calculator

Summer
Jun 21 at 12pm

Winter
Dec 21 at 12pm

Original Design

New Design

Net Zero Houseing | Professor Benzing

Ana Paola Hernandez | December 13, 2021
4.2 - Model with Urban Context

The R-value is a measure of how well a two-dimensional barrier, such as a layer of insulation, a wall or ceiling, resists the conductive flow of heat. R-value is the temperature difference per unit of heat flux needed to sustain one unit of heat flux between the warmer surface and colder surface of a barrier under steady-state conditions.
733 Park Avenue:
Context Model
733 Park Avenue:
Floor, Wall and Ceiling Assemblies

Floor Assembly

Wall Assembly

Roof Assembly

---

ANA PAOLA HERNANDEZ | DECEMBER 13, 2021
Net Zero Housing | Professor Benzing
### Assemblies (default)

<table>
<thead>
<tr>
<th>Grp. no.</th>
<th>Area group</th>
<th>Assembly no.</th>
<th>Assembly name</th>
<th>Total thickness (m)</th>
<th>U-value (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>External Door</td>
<td>89ud</td>
<td>external_door</td>
<td>0.05</td>
<td>0.50</td>
</tr>
<tr>
<td>8</td>
<td>External Wall - Ambient</td>
<td>83ud</td>
<td>PH external wall</td>
<td>0.46</td>
<td>0.15</td>
</tr>
<tr>
<td>9</td>
<td>External Wall - Ground</td>
<td>86ud</td>
<td>PH basement wall</td>
<td>0.41</td>
<td>0.26</td>
</tr>
<tr>
<td>10</td>
<td>Roof/Ceiling - Ambient</td>
<td>84ud</td>
<td>PH roof</td>
<td>0.46</td>
<td>0.15</td>
</tr>
<tr>
<td>11</td>
<td>Floor slab / Basement ceiling</td>
<td>85ud</td>
<td>PH floor</td>
<td>0.41</td>
<td>0.25</td>
</tr>
<tr>
<td>14</td>
<td>Temperature zone X</td>
<td>88ud</td>
<td>Wall to zone X</td>
<td>0.46</td>
<td>0.15</td>
</tr>
<tr>
<td>18</td>
<td>Partition Wall to Neighbour</td>
<td>87ud</td>
<td>wall_neighbour</td>
<td>0.41</td>
<td>0.25</td>
</tr>
</tbody>
</table>

### Assemblies (user-defined)

<table>
<thead>
<tr>
<th>ID</th>
<th>Assembly name</th>
<th>Total thickness</th>
<th>U-value (W/m²K)</th>
<th>Internal insulation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>83ud</td>
<td>PH external wall</td>
<td>0.46</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>84ud</td>
<td>PH roof</td>
<td>0.46</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>85ud</td>
<td>PH floor</td>
<td>0.41</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>86ud</td>
<td>PH basement wall</td>
<td>0.41</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>87ud</td>
<td>wall_neighbour</td>
<td>0.41</td>
<td>0.25</td>
<td></td>
</tr>
<tr>
<td>88ud</td>
<td>Wall to zone X</td>
<td>0.46</td>
<td>0.15</td>
<td></td>
</tr>
<tr>
<td>89ud</td>
<td>external door</td>
<td>0.05</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>90ud</td>
<td>733_Exterior Wall</td>
<td>0.302</td>
<td>0.187</td>
<td></td>
</tr>
<tr>
<td>91ud</td>
<td>733_Roof</td>
<td>0.317</td>
<td>0.378</td>
<td></td>
</tr>
<tr>
<td>92ud</td>
<td>733_Floor</td>
<td>0.317</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>93ud</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>94ud</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>95ud</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>96ud</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>97ud</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>98ud</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>99ud</td>
<td></td>
<td>0.0</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
733 Park Avenue:
Design PH Context Model

Emission:

- Transmission heat loss (outdoor surfaces)
- Transmission heat loss (thermal bridges)
- Ventilation heat losses
- Transmission heat loss (windows)
- Non-useful heat gains
- Specifics own heat demand
- Interior heat gains
- Solar heat gains

Heat balance:

- Losses: 15,723
- Gains: 14,771
- Total: 5,636

Project overview:

- Climate: PHPP-Standard
- Building type: Dwelling
- Annual heat demand (Qo): 147,718 kWh/m²a
- TFA (Total Floor Area): 2,01 m² (Direct entry)
- Thermal envelope area: 64,13 m²
- Heat Loss Form Factor: 400.3
- Projected building footprint: 60 m²

Number of windows: 0
6.2 - Figure & Ground - Solar Analysis

Architectural relations are based on the common laws of physics, but ultimately become truly meaningful only through reference and analogy to the individual’s existence as a human being.”

_Karl Friedrich Schinkel, Das Architektonische Lehrbuch_
Figure Ground Elevations:
Original Design

South:
- Wall Area: 17,894 sf
- Window Area: 3,576 sf
- WWR: 20%

West:
- Wall Area: 17,321 sf
- Window Area: 4,062 sf
- WWR: 23.5%

North:
- Wall Area: 17,321 sf
- Window Area: 4,297 sf
- WWR: 24.8%

East:
- Wall Area: 15,035 sf
- Window Area: 80 sf
- WWR: 0.53%
Figure Ground Elevations:
New Design: Horizontal Windows

South:
- Wall Area: 17,894 sf
- Window Area: 6,058 sf
- WWR: 33.9%

West:
- Wall Area: 17,321 sf
- Window Area: 6,131 sf
- WWR: 35.4%

North:
- Wall Area: 17,321 sf
- Window Area: 6,296 sf
- WWR: 36.3%

East:
- Wall Area: 15,035 sf
- Window Area: 80 sf
- WWR: .53%
Figure Ground Elevations:
New Design: Floor to Ceiling Windows

South:
- Wall Area: 17,894 sf
- Window Area: 12,840 sf
- WWR: 71.8%

West:
- Wall Area: 17,321 sf
- Window Area: 12,767 sf
- WWR: 73.7%

North:
- Wall Area: 17,321 sf
- Window Area: 13,442 sf
- WWR: 77.6%

East:
- Wall Area: 15,035 sf
- Window Area: 80 sf
- WWR: 0.53%
Cut-out Models:
Window Comparison

Original Design

Horizontal Windows

Floor to Ceiling Windows
Adjusted Design PH Model:
New Design: Horizontal Windows
Design PH Analysis:
New Design: Horizontal Windows

![Heat balance diagram](image)

- **Transmission heat loss (opaque surfaces)**
  - Area groups: 2 - Exterior Wall, 3 - Exterior Wall - Ambient, 4 - Exterior Wall - Ground, 5 - Interior Wall, 6 - Interior Wall - Ambient, 7 - Roof, 8 - Roof - Ambient, 9 - Floor slab, 10 - Floor slab - Basement ceiling, 11 - Floor slab - Exterior wall, 12 - Floor slab - Ground, 13 - Window, 14 - Window - Ambient, 15 - Ceiling, 16 - Ceiling - Ambient, 17 - Non-useful gains, 18 - Internal heat gains, 19 - Solar heat gains

- **Transmission heat loss (windows)**
  - Area groups: 2 - North Windows, 3 - East Windows, 4 - South Windows, 5 - West Windows, 6 - Horizontal Windows

- **Transmission heat loss (thermal bridges)**
  - Area groups: 10 - Thermal Bridges - Ambient, 11 - Thermal Bridges - Internal, 12 - Thermal Bridges - Exterior wall, 13 - Thermal Bridges - Ground, 14 - Thermal Bridges - Exterior wall - Ambient, 15 - Thermal Bridges - Ground - Ambient

- **Ventilation heat losses**
  - Parameters:
    - Ventilation system:
      - Airflow: 0.0147 m³/s, 2180.65 m³/h, 2180.65 kW, 2180.65 kW
    - Efficiency: 0.0005

- **Solar heat gains**
  - Area groups: 2 - North Windows, 3 - East Windows, 4 - South Windows, 5 - West Windows, 6 - Horizontal Windows

- **Internal heat gains**
  - Parameters:
    - Treated Floor Area: 8000 m², 2435.55 m², 2180.65 m³/h, 2180.65 kW
    - Heating period (days): 2.28, 179.30, 4.20, 78.40
    - Internal heat gains (kWh): 8000.00, 2180.65, 2376.60, 78.40

- **Ventilation heat losses**
  - Select ventilation type:
    - 1. Air change with m³/h
    - 2. Air change with kW

- **Internal heat gains**
  - Building type: Dwelling, Commercial, None
  - Heat gains (kWh): 8000.00, 2180.65, 2376.60, 78.40

---

**Educational Licence, Not for Professional Use (expires in 235 days)**

- Climate: New York
- Building type: Dwelling
- Annual heat demand (Q0): 5.6 kWh/m²a
- Treated Floor Area (TFA): 8000 m²
- Thermal envelope area: 7136 m²
- Heat Loss Form Factor: 0.89
- Projected building footprint: 21.16 m²
- Number of windows: 244
- Number of thermal surfaces: 22
- Number of thermal bridges: None defined

**Render mode:** Render by Area Group
9.2 - Mass & Void - Tectonic Facade

“...his conviction increased that architectural manipulation, as a homely art or a fine art must be rendered completely plastic to the mind and the hand of the designer; that materials and forms must yield to the mastery of his imagination and his will...”

Perspective Street View:
9:00 am
Perspective Street View:
12:00 pm
Perspective Street View:
6:00 pm
Design PH Analysis: Overall Energy Balance

**Heat balance**

- **Heat flows (kWh/m²a)**
  - **Losses**
    - Transmission heat loss (opaque surfaces): 1.6
    - Transmission heat loss (thermal bridges): 11.1
    - Ventilation heat losses: 6.9
    - Non-useful heat gains: 0.2
    - Specific ann. heat demand: 8.6
    - Internal heat gains: 7.8
    - Solar heat gains: 11.1
  - **Gains**
    - 15.0

**Project overview**

<table>
<thead>
<tr>
<th>Climate</th>
<th>New York</th>
<th>change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building type</td>
<td>Dwelling</td>
<td></td>
</tr>
<tr>
<td>Annual heat demand ($Q_a$)</td>
<td>7.8 kWh/m²a</td>
<td>details</td>
</tr>
<tr>
<td>Treated Floor Area (TFA)</td>
<td>8000 m² (Direct entry)</td>
<td>details</td>
</tr>
<tr>
<td>Thermal envelope area</td>
<td>7136 m²</td>
<td>details</td>
</tr>
<tr>
<td>Heat Loss Form Factor</td>
<td>0.89</td>
<td>details</td>
</tr>
<tr>
<td>Projected building footprint</td>
<td>- - m²</td>
<td>details</td>
</tr>
<tr>
<td>Number of windows</td>
<td>344</td>
<td>details</td>
</tr>
<tr>
<td>Number of thermal surfaces</td>
<td>22</td>
<td>details</td>
</tr>
<tr>
<td>Number of thermal bridges</td>
<td>97</td>
<td>details</td>
</tr>
</tbody>
</table>

**Render mode**

Render by Area Group
Design PH Analysis:
Tectonic Facade Window Shade Analysis

- **Shading mask diagram (raster)**

- **Analyze single window**
  Select a single window to analyze using the button below or ‘Analyze window shading’ from the context menu. Hourly results can be inspected in the tables and charts below.

  **NOTE:** The settings below will be used for all windows the next time you run analysis. The energy balance will not be updated until you run analysis.

  - **Analyze selected window**: Select shading mask resolution (lo-res (30))
  - **Select number of analysis points**: Centre point
  - **Analysis Unshaded Radiation Shading Factor mp reduc**
    - Winter: 194.4, 157.5, 0.86
    - Summer: 268.5, 240.0, 0.89

- **Hourly radiation on slope, shaded**
- **Hourly radiation on slope, unshaded**

Net Zero Houseing | Professor Benzing

Ana Paola Hernandez | December 13, 2021
### Design PH Analysis:

**Detail Analysis**

#### Transmission heat loss (opaque surfaces)

<table>
<thead>
<tr>
<th>Area group</th>
<th>Total area (m²)</th>
<th>Area weighted U-value (W/m²K)</th>
<th>Av. temp. factor</th>
<th>Ann. hrg. degree hours (kWh/a)</th>
<th>Transmission heat losses (kWh/a)</th>
<th>Q₁ (kWh/m²a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 - External Door</td>
<td>6076.23</td>
<td>0.19</td>
<td>1.00</td>
<td>64.00</td>
<td>40670.37</td>
<td>7.59</td>
</tr>
<tr>
<td>8 - External Wall - Ambient</td>
<td>1128.29</td>
<td>0.51</td>
<td>1.00</td>
<td>64.00</td>
<td>7156.80</td>
<td>11.54</td>
</tr>
<tr>
<td>9 - External Wall - Ground</td>
<td>337.19</td>
<td>0.38</td>
<td>1.00</td>
<td>64.00</td>
<td>8156.26</td>
<td>1.62</td>
</tr>
<tr>
<td>10 - Roof/Ceiling - Ambient</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>11 - Floor slab / Basement ceiling</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>12 - 1st Floor</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>64.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>13 - 2nd Floor</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>64.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>14 - Temperature zone X</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>15 - Partition Wall to Neighbour</td>
<td>212.37</td>
<td>0.25</td>
<td>0.00</td>
<td>64.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Total: 5825.75

#### Transmission heat loss (windows)

<table>
<thead>
<tr>
<th>Area group</th>
<th>Total area (m²)</th>
<th>Area weighted U-value (W/m²K)</th>
<th>Av. temp. factor</th>
<th>Ann. hrg. degree hours (kWh/a)</th>
<th>Transmission heat losses (kWh/a)</th>
<th>Q₁ (kWh/m²a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - North Windows</td>
<td>565.02</td>
<td>0.94</td>
<td>1.00</td>
<td>64.00</td>
<td>35268.40</td>
<td>4.41</td>
</tr>
<tr>
<td>3 - East Windows</td>
<td>7.56</td>
<td>0.46</td>
<td>1.00</td>
<td>64.00</td>
<td>221.16</td>
<td>0.03</td>
</tr>
<tr>
<td>4 - South Windows</td>
<td>565.48</td>
<td>0.95</td>
<td>1.00</td>
<td>64.00</td>
<td>34922.55</td>
<td>4.28</td>
</tr>
<tr>
<td>5 - West Windows</td>
<td>565.95</td>
<td>0.53</td>
<td>1.00</td>
<td>64.00</td>
<td>19173.56</td>
<td>2.40</td>
</tr>
<tr>
<td>6 - Horizontal</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Edward Windows</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Total: 1723.01

#### Transmission heat loss (thermal bridges)

<table>
<thead>
<tr>
<th>Area group</th>
<th>Total length (m)</th>
<th>Average U-value (W/m²K)</th>
<th>Av. temp. factor</th>
<th>Ann. hrg. degree hours (kWh/a)</th>
<th>Transmission heat losses (kWh/a)</th>
<th>Q₁ (kWh/m²a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 - Thermal Bridges Ambient</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>16 - Perimeter Thermal Bridges</td>
<td>129.64</td>
<td>0.04</td>
<td>0.60</td>
<td>64.00</td>
<td>1990.86</td>
<td>0.25</td>
</tr>
<tr>
<td>17 - Thermal Bridges Floor Slab / Basement Ceiling</td>
<td>129.64</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Total: 1296.14

#### Ventilation heat losses

<table>
<thead>
<tr>
<th>Energy effective air change rate (changing)</th>
<th>Ventilation volume (m³/h)</th>
<th>Heat capacity of air (W/m³K)</th>
<th>Ann. hrg. degree hours (kWh/a)</th>
<th>Transmission heat losses (kWh/a)</th>
<th>Q₁ (kWh/m²a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation system</td>
<td>21600.00</td>
<td>0.33</td>
<td>64.00</td>
<td>342711.07</td>
<td>4.20</td>
</tr>
<tr>
<td>Infiltration</td>
<td>21600.00</td>
<td>0.33</td>
<td>64.00</td>
<td>21076.07</td>
<td>2.83</td>
</tr>
</tbody>
</table>

Total: 1212.3

#### Solar gains

<table>
<thead>
<tr>
<th>Area group</th>
<th>Win. area (m²)</th>
<th>Glazing area (m²)</th>
<th>g-value</th>
<th>Reduction factor</th>
<th>Radiation, Gₛ (MJ/m²)</th>
<th>Solar heat gains (kWh/a)</th>
<th>Q₁ (kWh/m²a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 - North Windows</td>
<td>565.02</td>
<td>420.35</td>
<td>0.50</td>
<td>0.31</td>
<td>136.34</td>
<td>12518.11</td>
<td>1.50</td>
</tr>
<tr>
<td>3 - East Windows</td>
<td>7.56</td>
<td>6.10</td>
<td>0.50</td>
<td>0.60</td>
<td>423.49</td>
<td>975.58</td>
<td>0.12</td>
</tr>
<tr>
<td>4 - South Windows</td>
<td>565.48</td>
<td>399.78</td>
<td>0.50</td>
<td>0.38</td>
<td>527.84</td>
<td>5980.87</td>
<td>7.08</td>
</tr>
<tr>
<td>5 - West Windows</td>
<td>565.95</td>
<td>423.32</td>
<td>0.50</td>
<td>0.35</td>
<td>189.33</td>
<td>16737.54</td>
<td>2.34</td>
</tr>
<tr>
<td>6 - Horizontal</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Total: 1723.01

#### Internal heat gains

<table>
<thead>
<tr>
<th>Treated Floor Area (m²)</th>
<th>Internal heat gain rate (W/m²)</th>
<th>Heating period (days)</th>
<th>Heating period (days)</th>
<th>Internal heat gains (kWh/a)</th>
<th>Q₁ (kWh/m²a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8000.00</td>
<td>2.28</td>
<td>175.00</td>
<td>4.20</td>
<td>76440.00</td>
<td>9.56</td>
</tr>
</tbody>
</table>

#### Ventilation heat losses

Select ventilation type: Balanced PH ventilation with HR

- 9760 - [95.0%] Default: PH minimum efficiency HR

<table>
<thead>
<tr>
<th>Room (m²)</th>
<th>Treated Floor Area</th>
<th>Ventilation volume (m³/h)</th>
<th>Net air volume for pressure test, Vₚₚ (m³)</th>
<th>Air change rate at pressure test, nₚₚ (1/h)</th>
<th>Wind protection coef. f</th>
<th>Wind protection coef. I</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.70</td>
<td>8000.00</td>
<td>21600.00</td>
<td>23760.00</td>
<td>0.60</td>
<td>0.07</td>
<td>15.00</td>
</tr>
</tbody>
</table>

#### Glazing (user-defined)

<table>
<thead>
<tr>
<th>ID</th>
<th>Description</th>
<th>g-value</th>
<th>U-value (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>PH Glazing</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>02</td>
<td>Natural Light Glazing</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>03</td>
<td>Natural Light Glazing</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>04</td>
<td>Natural Light Glazing</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>05</td>
<td>Natural Light Glazing</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>06</td>
<td>Natural Light Glazing</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td>07</td>
<td>Natural Light Glazing</td>
<td>0.5</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Net Zero Houseing | Professor Benzing

Ana Paola Hernandez | December 13, 2021
11.2 - Photovoltaic (PV) Energy Calculation

“Solar Power is not about fashion, it’s about survival”

Sir Norman Foster
Photovoltaic (PV) System:
Renewable Energy Laboratory (NREL) PV Watts Calculator

## RESULTS

51,375 kWh/Year*

System output may range from 48,317 to 53,096 kWh per year near this location.

<table>
<thead>
<tr>
<th>Month</th>
<th>Solar Radiation (kWh / m² / day)</th>
<th>AC Energy (kWh)</th>
<th>Value ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>2.05</td>
<td>2,216</td>
<td>1,138</td>
</tr>
<tr>
<td>February</td>
<td>2.86</td>
<td>2,949</td>
<td>1,474</td>
</tr>
<tr>
<td>March</td>
<td>4.18</td>
<td>4,605</td>
<td>2,343</td>
</tr>
<tr>
<td>April</td>
<td>5.03</td>
<td>5,309</td>
<td>2,655</td>
</tr>
<tr>
<td>May</td>
<td>5.48</td>
<td>5,625</td>
<td>2,912</td>
</tr>
<tr>
<td>June</td>
<td>6.27</td>
<td>6,287</td>
<td>3,143</td>
</tr>
<tr>
<td>July</td>
<td>6.20</td>
<td>6,387</td>
<td>3,193</td>
</tr>
<tr>
<td>August</td>
<td>5.43</td>
<td>5,535</td>
<td>2,768</td>
</tr>
<tr>
<td>September</td>
<td>4.53</td>
<td>4,516</td>
<td>2,258</td>
</tr>
<tr>
<td>October</td>
<td>3.15</td>
<td>3,351</td>
<td>1,676</td>
</tr>
<tr>
<td>November</td>
<td>2.25</td>
<td>2,398</td>
<td>1,199</td>
</tr>
<tr>
<td>December</td>
<td>1.67</td>
<td>1,858</td>
<td>929</td>
</tr>
<tr>
<td>Annual</td>
<td>4.09</td>
<td>51,376</td>
<td>25,688</td>
</tr>
</tbody>
</table>

### Location and Station Identification

- **Requested Location**: 712 Park Avenue New York
- **Weather Data Source**: Lat, Lon: 40.77, -73.98
- **Latitude**: 40.77° N
- **Longitude**: 73.98° W

### PV System Specifications (Residential)

- **DC System Size**: 45.2 kW
- **Module Type**: Standard
- **Array Type**: Fixed (open rack)
- **Array Tilt**: 0°
- **Array Azimuth**: 180°
- **System Losses**: 14.08%
- **Inverter Efficiency**: 96%
- **DC to AC Size Ratio**: 1.2
- **Average Retail Electricity Rate**: 0.500 $/kWh

### Performance Metrics

- **Capacity Factor**: 13.0%

---

**Annual Electric Energy:**
Overall Floor Area of Building:

\[
\text{Annual Electric Energy:} \quad 51,375 \text{ kWh/Year} + \quad 8,000 \text{ m}^2 = 6.4 \text{ kWh per year ft}^2
\]

**Design PH Annual Heat Demand:**

7.8 kWh/m²a

**PV systems delivery of the annual heating demand**

= 82%
Crown and Techtonic Facade:
Final Perspective Street View: