

### BUILDING INFORMATION

|   |   |   |
|---|---|---|
| <b>TSPR Example Building 1: Office - VAV with HW Reheat</b> | Building Type: <b>Office</b>  | Analysis Date: <b>07/10/2020</b>                                      |
| 123 Example Street<br>Seattle, WA 98101                     | Gross Floor Area: <b>65,000 ft<sup>2</sup></b><br>Year of Construction: <b>2016</b> | Building ID #: <b>20672</b><br>Software Release: <b>2020.2.0.1331</b> |

### Whole Building Total System Performance Ratio

|                         |      |
|-------------------------|------|
| Proposed Building TSPR: | 12.1 |
| Baseline Building TSPR: | 10.9 |

✓ The Total System Performance Ratio complies with the 2018 Washington State Energy Code.

Total System Performance Ratio (TSPR) is the ratio of the sum of a building's annual heating and cooling load in thousands of BTUs to the sum of the annual carbon emissions in pounds from energy consumption of the building HVAC systems.

### SUBMITTED BY

|              |                             |
|--------------|-----------------------------|
| Name         | A. Example Submitter        |
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### BUILDING ENVELOPE INFORMATION

|                                    |                         |
|------------------------------------|-------------------------|
| Total Gross Wall Area <sup>1</sup> | 40800.0 ft <sup>2</sup> |
| Total Window Area <sup>2</sup>     | 12240.0 ft <sup>2</sup> |
| Building Window to Wall Ratio      | 30%                     |

### Areas by Orientation

| NORTH           |                         | WEST            |                        |
|-----------------|-------------------------|-----------------|------------------------|
| Gross Wall Area | 10560.0 ft <sup>2</sup> | Gross Wall Area | 9840.0 ft <sup>2</sup> |
| Window Area     | 3168.0 ft <sup>2</sup>  | Window Area     | 2952.0 ft <sup>2</sup> |
| SOUTH           |                         |                 |                        |
| Gross Wall Area | 10560.0 ft <sup>2</sup> |                 |                        |
| Window Area     | 3168.0 ft <sup>2</sup>  |                 |                        |
| EAST            |                         |                 |                        |
| Gross Wall Area | 9840.0 ft <sup>2</sup>  |                 |                        |
| Window Area     | 2952.0 ft <sup>2</sup>  |                 |                        |

The Total System Performance Ratio Analysis has been performed in accordance with the 2018 Washington State Energy Code.

<sup>1</sup> 'Total Gross Wall Area' includes both opaque and glazed wall area.

<sup>2</sup> Window includes all vertical fenestration, including curtainwall and storefront.

Building ID #: 20672

Gross Floor Area - Building: 65,600 ft<sup>2</sup>

### Whole Building Annual HVAC Site Energy Use by End-Use

| End Use                                  | Proposed Building |             | Baseline Building |             |
|--|-------------------|-------------|-------------------|-------------|
|  | Electricity (kWh) | Gas (Therm) | Electricity (kWh) | Gas (Therm) |
| Heating                                  | 0                 | 902         | 1,730             | 84          |
| Cooling                                  | 28,659            |             | 59,400            |             |
| Fans                                     | 28,446            |             | 43,622            |             |
| Pumps                                    | 24,775            |             | 2,760             |             |
| Heat Rejection                           | 2,562             |             | 1,258             |             |
| Heat Recovery                            | 0                 |             | 0                 |             |
| <b>Total HVAC Energy Use</b>             | <b>84,442</b>     | <b>902</b>  | <b>108,771</b>    | <b>84</b>   |
| <b>Total HVAC Energy Use (kBtu)</b>      | <b>378,368</b>    |             | <b>379,532</b>    |             |
| <b>Total HVAC Carbon Emissions (lbs)</b> | <b>69,624</b>     |             | <b>77,066</b>     |             |

### Whole Building Annual HVAC Heating and Cooling Loads

| Proposed and Baseline System |                |
|------------------------------|----------------|
| End Use                      | (kBtu)         |
| Heating                      | 109,163        |
| Cooling                      | 734,391        |
| <b>Total</b>                 | <b>843,555</b> |

Building ID #: 20672

Gross Floor Area - Building: 65,600 ft<sup>2</sup>

## BUILDING CHARACTERISTICS SUMMARY

### Central Plants

#### Plant Loop 1

|                   |                    |
|-------------------|--------------------|
| Plant Loop Type   | Heating Loop       |
| Pump Power        | 16.0 W/gpm         |
| <b>Plant Name</b> | Plant Loop 1 Plant |
| Equipment Type    | Boiler             |
| Fuel Type         | Natural Gas        |

#### Plant Loop 2

|                      |                                      |
|----------------------|--------------------------------------|
| Plant Loop Type      | Cooling Loop                         |
| Chiller Pump Control | Constant Primary: Variable Secondary |
| Primary Pump Power   | 4.0 W/gpm                            |
| Secondary Pump Power | 12.0 W/gpm                           |
| <b>Plant Name</b>    | Plant Loop 2 Plant                   |
| Equipment Type       | Chiller                              |
| Chilled Water Reset  | Yes                                  |
| Compressor Type      | Reciprocating                        |
| Condenser Type       | Water                                |
| Condenser Loop       | Plant Loop 3 - Cooling Tower         |

#### Plant Loop 3

|                             |                    |
|-----------------------------|--------------------|
| Plant Loop Type             | Condenser Loop     |
| Condenser Pump Control      | Variable Speed     |
| Pump Power                  | 16.0 W/gpm         |
| <b>Plant Name</b>           | Plant Loop 3 Plant |
| Equipment Type              | Condenser          |
| Condenser Type              | Cooling Tower      |
| Cooling Tower Fan Control   | Variable Speed     |
| Design Range Temperature    | 7.0 Δ °F           |
| Design Approach Temperature | 10.0 Δ °F          |
| Cooling Tower Efficiency    |                    |

Building ID #: 20672

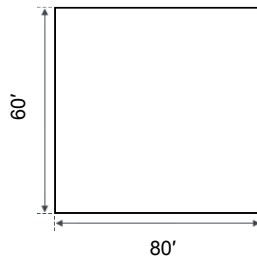
Gross Floor Area - Block 2: 43200 ft<sup>2</sup>

### BLOCK CHARACTERISTICS SUMMARY

#### Block 2

##### Block Details

Block Name: Block 2  
Floors Above Ground: 9  
Floors Below Ground: 0  
Floor-to-Floor Height: 12.00 ft  
Floor-to-Ceiling Height: 9.00 ft  
Use Type: Office



Current Building

##### Roof

Roof U-value 0.027 Btu/°F-ft<sup>2</sup>-h

##### Skylights

No Skylights

##### Floor

Floor Type Exterior Floor  
Floor U Value 0.04 Btu/°F-ft<sup>2</sup>-h

##### Walls and Windows

###### Surface 1

Gross Wall Area 6480.0 ft<sup>2</sup>  
Wall Type Above Grade Wall  
Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h  
Window Area 1944.0 ft<sup>2</sup>  
Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
Window SHGC 0.38  
Window-to-Wall Ratio 0.3

###### Surface 2

Gross Wall Area 8640.0 ft<sup>2</sup>  
Wall Type Above Grade Wall  
Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h

##### Current Building

Window Area 2592.0 ft<sup>2</sup>  
Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
Window SHGC 0.51  
Window-to-Wall Ratio 0.3

###### Surface 3

Gross Wall Area 6480.0 ft<sup>2</sup>  
Wall Type Above Grade Wall  
Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h  
Window Area 1944.0 ft<sup>2</sup>  
Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
Window SHGC 0.38  
Window-to-Wall Ratio 0.3

###### Surface 4

Gross Wall Area 8640.0 ft<sup>2</sup>  
Wall Type Above Grade Wall  
Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h  
Window Area 2592.0 ft<sup>2</sup>  
Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
Window SHGC 0.38  
Window-to-Wall Ratio 0.3

##### Lighting

Lighting Power Density 0.66 W/ft<sup>2</sup>

##### Block HVAC Information

Thermal Zone Layout Perimeter and core  
Perimeter Zone Depth 15.0 ft  
Primary Heating/Cooling System AHU1: VAV with HW Reheat

##### DCV

Percent Area for DCV Control 10.0%

Building ID #: 20672

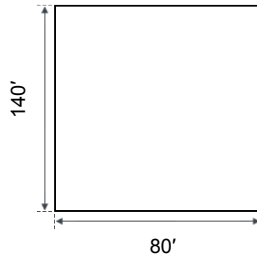
Gross Floor Area - Block 1: 22400 ft<sup>2</sup>

## BLOCK CHARACTERISTICS SUMMARY

### Block 1

#### Block Details

Block Name: Block 1  
 Floors Above Ground: 2  
 Floors Below Ground: 0  
 Floor-to-Floor Height: 12.00 ft  
 Floor-to-Ceiling Height: 9.00 ft  
 Use Type: Office



Current Building

#### Roof

Roof U-value 0.027 Btu/°F-ft<sup>2</sup>-h

#### Skylights

No Skylights

#### Floor

Floor Type Slab-on-Grade  
 Floor F-Factor 0.54 Btu/°F-h-ft

#### Walls and Windows

##### Surface 1

Gross Wall Area 3360.0 ft<sup>2</sup>  
 Wall Type Above Grade Wall  
 Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h  
 Window Area 1008.0 ft<sup>2</sup>  
 Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
 Window SHGC 0.38  
 Window-to-Wall Ratio 0.3

##### Surface 2

Gross Wall Area 1920.0 ft<sup>2</sup>  
 Wall Type Above Grade Wall  
 Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h

Window Area 576.0 ft<sup>2</sup>  
 Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
 Window SHGC 0.51  
 Window-to-Wall Ratio 0.3

##### Surface 3

Gross Wall Area 3360.0 ft<sup>2</sup>  
 Wall Type Above Grade Wall  
 Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h  
 Window Area 1008.0 ft<sup>2</sup>  
 Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
 Window SHGC 0.38  
 Window-to-Wall Ratio 0.3

##### Surface 4

Gross Wall Area 1920.0 ft<sup>2</sup>  
 Wall Type Above Grade Wall  
 Wall U Value 0.055 Btu/°F-ft<sup>2</sup>-h  
 Window Area 576.0 ft<sup>2</sup>  
 Window U Value 0.3 Btu/°F-ft<sup>2</sup>-h  
 Window SHGC 0.38  
 Window-to-Wall Ratio 0.3

#### Lighting

Lighting Power Density 0.66 W/ft<sup>2</sup>

#### Block HVAC Information

Thermal Zone Layout Perimeter and core  
 Perimeter Zone Depth 15.0 ft  
 Primary Heating/Cooling System AHU1: VAV with HW Reheat

#### DCV

Percent Area for DCV Control 10.0%

#### Current Building

Building ID #: 20672

Gross Floor Area - 2 Block(s): 65600 ft<sup>2</sup>

### HVAC System Total System Performance Ratio

|                      |      |
|----------------------|------|
| Proposed System TSPR | 12.1 |
| Baseline System TSPR | 10.9 |

### HVAC System Annual Site Energy Use by End-Use

| End Use                                  | Proposed System   |             | Baseline System   |             |
|--|-------------------|-------------|-------------------|-------------|
|  | Electricity (kWh) | Gas (Therm) | Electricity (kWh) | Gas (Therm) |
| Heating                                  | 0                 | 902         | 1,730             | 84          |
| Cooling                                  | 28,659            |             | 59,400            |             |
| Fans                                     | 28,446            |             | 43,622            |             |
| Pumps                                    | 24,775            |             | 2,760             |             |
| Heat Rejection                           | 2,562             |             | 1,258             |             |
| Heat Recovery                            | 0                 |             | 0                 |             |
| <b>Total HVAC Energy Use</b>             | <b>84,442</b>     | <b>902</b>  | <b>108,771</b>    | <b>84</b>   |
| <b>Total HVAC Energy Use (kBtu)</b>      | <b>378,368</b>    |             | <b>379,532</b>    |             |
| <b>Total HVAC Carbon Emissions (lbs)</b> | <b>69,624</b>     |             | <b>77,066</b>     |             |

### HVAC System Annual Heating and Cooling Loads

| End Use      | Proposed and Baseline System |  |
|--------------|------------------------------|--|
|              | (kBtu)                       |  |
| Heating      | 109,163                      |  |
| Cooling      | 734,391                      |  |
| <b>Total</b> | <b>843,555</b>               |  |

### HVAC System

**Primary Heating/Cooling System** AHU1: VAV with HW Reheat

**Block(s) Served** Block 2, Block 1

**Primary Heating/Cooling System** AHU1: VAV with HW Reheat

System Type VAV with HW Reheat

**Cooling Source** Plant Loop: Plant Loop 2

Linked Plant Efficiency 4.9 COP

**Heating Source** Plant Loop: Plant Loop 1

Linked Plant Efficiency 93.0% Et

#### Distribution Equipment

Distribution Type Multiple Zone

Terminal Unit Type Reheat

Reheat Source Hot Water Plant

Hot Water Plant Loop Plant Loop 1

Minimum Air Flow Fraction 0.200

Fan Control Variable Air Volume

#### System Controls

DCV Yes

Economizer Yes

Supply Air Temperature (SAT) Reset Warmest Zone

Fan Static Pressure Reset Yes

#### Energy Recovery Ventilation

ERV Yes

ERV Sensible Effectiveness: Heating 0.7

ERV Latent Effectiveness: Heating 0.0

ERV Sensible Effectiveness: Cooling 0.7

ERV Latent Effectiveness: Cooling 0.0

ERV Economizer Bypass Yes

ERV Supply Air Temperature Control Yes

System Fan Power Reduction when ERV Bypassed 0.0W/CFM

Building ID #: 20672

Gross Floor Area - Large Office: 65600 ft<sup>2</sup>

The following section documents the baseline HVAC system which is added by the TSPR tool for the baseline simulation run. The baseline system is as specified in the [2018 Washington State Energy Code](#)

### HVAC System

|                                       |                              |   |                              |
|---------------------------------------|------------------------------|---|------------------------------|
| <b>Block(s) Served</b>                | Block 1, Block 2             | <b>System Type</b>                                    | Dedicated Outdoor Air System |
| <b>Primary Heating/Cooling System</b> | Water-Loop Heat Pump         | <b>Cooling Source</b>                                 | No Cooling                   |
| <b>Ventilation System</b>             | Dedicated Outdoor Air System | <b>Heating Source</b>                                 | No Heating                   |
| <b>Primary Heating/Cooling System</b> |                              | <b>Distribution Equipment</b>                         |                              |
| System Type                           | Water-Loop Heat Pump         | Distribution Type                                     | Single Zone                  |
| Plant Loop Type                       | Condenser Loop               | Total System Fan Power                                | 0.819 W/CFM                  |
| Condenser Pump Control                | Variable Speed               | DOAS Bypass Air Temperature Setpoint                  | 60.0 F                       |
| Pump Power                            | 16.0 W/gpm                   | Fan Control   | Constant Air Volume          |
| <b>Plant 1</b>                        |                              | <b>System Controls</b>                                |                              |
| Equipment Type                        | Condenser                    | DCV   | No                           |
| Condenser Type                        | Cooling Tower                | <b>Energy Recovery Ventilation</b>                    |                              |
| Cooling Tower Fan Control             | Variable Speed               | ERV   | Yes                          |
| Design Range Temperature              | 10 Δ °F                      | ERV Sensible Effectiveness- Heating                   | 0.7                          |
| Design Approach Temperature           | 7 Δ °F                       | ERV Latent Effectiveness- Heating                     | 0.0                          |
| Cooling Tower Efficiency              | 40.2 gpm/hp                  | ERV Sensible Effectiveness- Cooling                   | 0.7                          |
| <b>Plant 2</b>                        |                              | ERV Latent Effectiveness- Cooling                     | 0.0                          |
| Equipment Type                        | Boiler                       | ERV Economizer Bypass                                 | Yes                          |
| Fuel Type                             | Natural Gas                  | ERV Supply Air Temperature Control                    | Yes                          |
| Thermal Efficiency                    | 80.00%                       | System Fan Power Reduction when ERV0.0 W/CFM Bypassed |                              |
| <b>Primary Heating/Cooling System</b> |                              |   |                              |
| <b>Cooling Source</b>                 | Terminal DX                  |   |                              |
| Cooling Efficiency                    | 4.46 COP                     |   |                              |
| <b>Heating Source</b>                 | Heat Pump                    |   |                              |
| Heating Efficiency                    | 4.61 COP                     |   |                              |
| Fuel Type                             | Electricity                  |   |                              |
| Condenser Type                        | Water                        |   |                              |
| Condenser Plant Loop                  | Condenser Loop               |   |                              |
| Fan Power (W/CFM)                     | 0.528 W/CFM                  |   |                              |
| <b>Ventilation System</b>             |                              |   |                              |

Building ID #: 20672

Gross Floor Area - Building: 65,600 ft<sup>2</sup>

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**Reported HVAC system parameters are based on the average of the equipment serving each block as follows:**

- For DX cooling systems, the cooling COP excludes the fan energy and is weighted by cooling capacity.
  - For heat pumps, the heating COP excludes the fan energy and is weighted by heating capacity.
  - Total System Fan Power is the input electric power for all fans in required to operate at fan system design conditions divided by the supply airflow rate. Where multiple fan systems serve a single block fan power is based on weighted average using on supply air cfm.
  - The minimum airflow ratio is the average minimum damper position for all systems serving the block, weighted by cfm.
-



# Washington State TSPR Analysis

## Mechanical Equipment Schedule - Plant Loops

Building ID #: 20672

Gross Floor Area - Building: 65,600 ft<sup>2</sup>

| Plant Schedule Entries |          |            |             |                |                  |                       |                    |
|------------------------|----------|------------|-------------|----------------|------------------|-----------------------|--------------------|
| Equipment ID           | Quantity | Plant Type | Fuel Type   | Rated Capacity | Rated Efficiency | Calculated Efficiency | Plant              |
| Boiler 1               | 2        | Boiler     | Natural Gas | 1000.0 MBH     | 93.0 Et          | 93.0 Et               | Plant Loop 1 Plant |
| Chiller 1              | 2        | Chiller    | NA          | 150.0 tons     | 4.89 COP         | 4.9 COP               | Plant Loop 2 Plant |
| Chiller 2              | 1        | Chiller    | NA          | 100.0 tons     | 4.89 COP         | 4.9 COP               | Plant Loop 2 Plant |

Building ID #: 20672

Gross Floor Area - Building: 65,600 ft<sup>2</sup>

### Cooling System Information

| Equipment ID | Quantity | System Type        | Cooling Source | Rated Capacity (Btu/h) | Rated Efficiency | Calculated Efficiency | Air Handler              |
|--------------|----------|--------------------|----------------|------------------------|------------------|-----------------------|--------------------------|
| AHU Eq1      | 3        | VAV with HW Reheat | Plant          | NA                     | NA               | NA                    | AHU1: VAV with HW Reheat |

### Heating System Information

| Equipment ID | Quantity | System Type        | Heating Source | Fuel Type | Rated Capacity (Btu/h) | Rated Efficiency | Calculated Efficiency | Air Handler              |
|--------------|----------|--------------------|----------------|-----------|------------------------|------------------|-----------------------|--------------------------|
| AHU Eq1      | 3        | VAV with HW Reheat | Plant          | NA        | NA                     | NA               | NA                    | AHU1: VAV with HW Reheat |

### Fan System Information

| Equipment ID | Quantity | System Type        | Design Supply Airflow (CFM) | System Fan Power (W/CFM) | Air Handler              |
|--------------|----------|--------------------|-----------------------------|--------------------------|--------------------------|
| AHU Eq1      | 3        | VAV with HW Reheat | 4000                        | 1.022                    | AHU1: VAV with HW Reheat |

# Washington State TSPR Analysis

## Mechanical Equipment Schedule - VAV Terminal Units

Building ID #: 20672

Gross Floor Area - Building: 65,600 ft<sup>2</sup>

Terminal Schedule Entries

| Equipment ID | Reheat | Reheat Source   | Design Supply Airflow | Minimum Supply Airflow | Minimum Airflow Fraction | Air Handler              |
|--------------|--------|-----------------|-----------------------|------------------------|--------------------------|--------------------------|
| Terminal Eq1 | Yes    | Hot Water Plant | 3000                  | 600.0                  | 0.2                      | AHU1: VAV with HW Reheat |
| Terminal Eq2 | Yes    | Hot Water Plant | 30000                 | 6000.0                 | 0.2                      | AHU1: VAV with HW Reheat |
| Terminal Eq3 | Yes    | Hot Water Plant | 40000                 | 8000.0                 | 0.2                      | AHU1: VAV with HW Reheat |