Hello!

Ciao! Grüezi!
Gruezi woh! Buongiorno!
Gruezi Sali! Sali zamme!
Guten Tag! Hoi! Bonjour!
Salü! Guetä Morgä!

Gruessach mittenand!
Hoi zame!
Gruetzì!
Grüezi zäme!
Bun di!
JARGON?
# Peak Loads in WUFI

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating demand</td>
<td>4.05 kBtu/ft² yr</td>
</tr>
<tr>
<td>Cooling demand</td>
<td>0.71 kBtu/ft² yr</td>
</tr>
<tr>
<td>Heating load</td>
<td>4.46 Btu/hr ft²</td>
</tr>
<tr>
<td>Cooling load</td>
<td>1.96 Btu/hr ft²</td>
</tr>
<tr>
<td>Source energy</td>
<td>6,199 kWh/Person yr</td>
</tr>
<tr>
<td>Site energy</td>
<td>14.24 kBtu/ft² yr</td>
</tr>
</tbody>
</table>

### Heating Load
- Specific: 4.46 Btu/hr ft²
- Target: 4.7 Btu/hr ft²
- Total: 6,473.82 Btu/hr

### Cooling Load
- Specific: 1.96 Btu/hr ft²
- Target: 3.8 Btu/hr ft²
- Total: 2,836.48 Btu/hr
## Design Information

Weather: Spokane Int'l AP, WA, US

### Winter Design Conditions

<table>
<thead>
<tr>
<th>Component</th>
<th>Winter Design Conditions</th>
<th>Summer Design Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outside db</td>
<td>11 °F</td>
<td>90 °F</td>
</tr>
<tr>
<td>Inside db</td>
<td>70 °F</td>
<td>75 °F</td>
</tr>
<tr>
<td>Design TD</td>
<td>59 °F</td>
<td>15 °F</td>
</tr>
</tbody>
</table>

### Heating Summary

<table>
<thead>
<tr>
<th>Element</th>
<th>Heating</th>
<th>Sensible Cooling Equipment Load Sizing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>15761 Btu</td>
<td>28842 Btu</td>
</tr>
<tr>
<td>Ducts</td>
<td>5346 Btu</td>
<td>3011 Btu</td>
</tr>
<tr>
<td>Central vent (150 cfm)</td>
<td>1786 Btu</td>
<td>442 Btu</td>
</tr>
<tr>
<td>Humidification</td>
<td>0 Btu</td>
<td>Use manufacturer's data</td>
</tr>
<tr>
<td>Piping</td>
<td>0 Btu</td>
<td>n</td>
</tr>
<tr>
<td>Equipment load</td>
<td>22893 Btu</td>
<td>Rate/swing multiplier</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment sensible load</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30551 Btu</td>
</tr>
</tbody>
</table>

### Infiltration

<table>
<thead>
<tr>
<th>Element</th>
<th>Heating</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method</td>
<td>Blower door</td>
<td>Blower door</td>
</tr>
<tr>
<td>Shielding / stories</td>
<td>3 (partial) / 1</td>
<td>3 (partial) / 1</td>
</tr>
<tr>
<td>Pressure / AVF</td>
<td>50 Pasc / 247 cfm</td>
<td>50 Pasc / 247 cfm</td>
</tr>
</tbody>
</table>

### Latent Cooling Equipment Load Sizing

<table>
<thead>
<tr>
<th>Component</th>
<th>Heating</th>
<th>Cooling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (ft²)</td>
<td>2469</td>
<td>2469</td>
</tr>
<tr>
<td>Volume (ft³)</td>
<td>24685</td>
<td>24685</td>
</tr>
<tr>
<td>Air changes/hour</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Equiv. AVF (cfm)</td>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

### Equipment Total Load (Sen+Lat)

- Equipment load: 346 Btu
- Equipment total load (Sen+Lat): 30897 Btu
- Req. total capacity at 0.70 SHR: 3.6 ton
PEAK HEAT LOAD CALCULATION

\[ P_H = P_T + P_V - (P_S + P_I) \]
INDOOR DESIGN TEMP

68F to 77F (PHIUS+)
70F to 75F (Manual J)
Heat Loss Equation:

\[ Q = UA \Delta T \]
SUMMER SHADING
INFLTRATION

Loads in Btuh

Simplified Method: “Tight” setting

Blower Door Method: 0.05 cfm50/sf env

(at 1450 sf iCFA)
ACHnat(Tight) x N factor = ACH50

### LBL “N” Factors

<table>
<thead>
<tr>
<th>Zone</th>
<th>N Factor</th>
<th>Number of Stories</th>
<th>Height Correction Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14-17</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>17-20</td>
<td>1.5</td>
<td>0.89</td>
</tr>
<tr>
<td>3</td>
<td>20-23</td>
<td>2</td>
<td>0.81</td>
</tr>
<tr>
<td>4</td>
<td>23-26</td>
<td>2.5</td>
<td>0.76</td>
</tr>
</tbody>
</table>

To determine the correct multiplier, identify the N-factor for your region and multiply the result by the appropriate height correction factor.

### Table 5A

#### Default Air Change Values for Three or Four Exposures

<table>
<thead>
<tr>
<th>Construction</th>
<th>Air Changes per Hour (Heating)</th>
<th>Infiltration CFM for One Fireplace*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Floor Area of Heated Space (SqFt)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>900 or Less</td>
<td>901 to 1500</td>
</tr>
<tr>
<td>Tight</td>
<td>0.21</td>
<td>0.16</td>
</tr>
<tr>
<td>Semi-Tight</td>
<td>0.41</td>
<td>0.31</td>
</tr>
<tr>
<td>Average</td>
<td>0.61</td>
<td>0.45</td>
</tr>
<tr>
<td>Semi-Loose</td>
<td>0.95</td>
<td>0.70</td>
</tr>
<tr>
<td>Loose</td>
<td>1.28</td>
<td>0.94</td>
</tr>
</tbody>
</table>

*For one additional fireplace, add 7 CFM to the above fireplace values. For two or more additional fireplaces, add 10 CFM (total) to the above.

#### Air Changes Per Hour (Cooling)

<table>
<thead>
<tr>
<th>Construction</th>
<th>Air Changes per Hour (Cooling)</th>
<th>Fireplaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Floor Area of Air Conditioned Space (SqFt)</td>
<td>Infiltration</td>
</tr>
<tr>
<td></td>
<td>900 or Less</td>
<td>901 to 1500</td>
</tr>
<tr>
<td>Tight</td>
<td>0.11</td>
<td>0.08</td>
</tr>
<tr>
<td>Semi-Tight</td>
<td>0.22</td>
<td>0.16</td>
</tr>
<tr>
<td>Average</td>
<td>0.32</td>
<td>0.23</td>
</tr>
<tr>
<td>Semi-Loose</td>
<td>0.50</td>
<td>0.36</td>
</tr>
<tr>
<td>Loose</td>
<td>0.67</td>
<td>0.49</td>
</tr>
</tbody>
</table>

### Notes
- Tight: All structural panels, corners, cracks, and penetrations are sealed by meticulous workmanship using a combination of air barrier (film), taping, packing and caulking. Window and door assemblies are rated at less than 0.25 CFM per running foot of crack at 25 mph (wind speed). Bath exhaust fans, kitchen exhaust fans, and dryer vents are equipped with backdraft dampers. The house does not have ceiling recessed light fixtures or, if so, there is a negligible amount of leakage around the fixture. No combustion equipment (furnaces, water heaters, dryers, etc.) contained within the conditioned space, or, if so, they are of the direct-vent variety. The house does not have powerful (i.e., 150 CFM or greater) range hoods (a high-power hood that has its own source of makeup air is acceptable). Fireplaces, if any, receive combustion air from the outdoors and have tight glass doors.
Maximum hourly glazing load exceeds average by 35.2%.

House does not have adequate exposure diversity (AED), based on AED limit of 30%.

AED excursion: 1228 Btuh (PFG - 1.3*AFG)
OFFICE STANDARDS

PASSIVE HOUSE CERTIFICATION

BUILDING ENVELOPE
1. FLOOR SLAB PERIMETER: 173 FT
2. ICF (INCLUDING INTERIOR PARTITIONS): 1980 SF
3. FLOOR AREA (EXCLUDING INTERIOR WALLS): 1875 SF
4. NET AIR VOLUME (DRYWALL TO DRYWALL): 17462 CF
5. BUILDING ENVELOPE AREA: 6704 SF
6. OCCUPANTS (BEDROOMS + 1): 4
7. AIR INFLTRATION (VERIFIED BY BLOWER DOOR TEST)
   ADC 0.99±15% BASED ON BUILDING VOLUME OF 17462 CF
   CFM0 PER ENVELOPE AREA = 0.04 CFM/FT² OR 268 CFM TOTAL

MECHANICAL SYSTEMS
1. HRV/ERV
   EFFICIENCY 89%
   HUMIDITY RECOVERY EFFICIENCY 94%
   ELECTRIC EFFICIENCY 0.33 W/H
   SUPPLY DUCT LENGTH 8'
   EXHAUST DUCT LENGTH 18'
   INSULATION THICKNESS 4'
2. HEATAC
   CCP: 3.9
3. HOT WATER
   PERFORMANCE RATIO
   SOURCE ENERGY FACTOR 3.16 BTU/MBTU
   CO2 EMISSIONS FACTOR 0.1 gBTU
4. PLUMBING PIPE LENGTHS
   RECIRC SYSTEM PIPE LENGTH
   DISTANCE FROM WATER HEATER TO EACH TAP
   (WATER AND DISHWASHER EXCLUDED)
   EXTERIOR DIAMETER OF HOT WATER PIPES 0.325'
   (NORMAL, DIAMETER 0.18')

"MIN 15" SEPARATION BETWEEN VENTILATION SUPPLY AND EXHAUST DIFUSERS,
SUPPLY LOCATED X 4' ABOVE ROOF BUT NOT ABOVE ROOF, AND X 10' FROM KNOWN
CONTAMINATION SOURCES SUCH AS LAUNDRY, PLUMBING OR EXHAUST VENTS.

SUPPORTIVE DEVICES
1. DWV CIRCULATING PUMP ENERGY DEMAND 29.1 W
2. RANGE HOOD

INSULATION SCHEDULE

RESIDENCE ROOF/ CEILING CONSTRUCTION
1. METAL ROOF
2. VENTILATION MAT
3. ROOFING MEMBRANE
4. 5/8" PLYWOOD SHEATHING
R=R8
5. TRUSS FRAMING w/ 22" BLOWN IN FIBERGLASS INSULATION
6. 2 X 8 DROP CEILING
7. 5/8" GYPSUM
TOTAL R-VALUE = R8 + R-39 MIN. PER IECC 2012 SECTION 402.1.1

RESIDENCE EXTERIOR WALL CONSTRUCTION - WOOD FRAME (NOT INCLUDING RAINSCREEN)
R=R8
1. 2" THICK I EPS INSULATION
2. 2" THICK I EPS INSULATION
3. 1/2" PLYWOOD SHEATHING
R=R21
4. 2X6 STRUCTURAL WALL w/ BLOWN IN FIBERGLASS INSUL
5. 5/8" GYPSUM WALL BOARD
TOTAL R-VALUE = R21
R=20 MIN. PER IECC 2012 SECTION 402.1.1

RESIDENCE SLAB ON GRADE CONSTRUCTION
1. 4" CONCRETE SLAB ON GRADE WITH REINFORCEMENT
2. VAPOR BARRIER
R=R24
3. 6" THICK I EPS INSULATION
4. 6" 3/4 MINUS GRAVEL
TOTAL R-VALUE = R24
R=10 MIN. TO 2 DEEP PER IECC 2012 SECTION 402.1.1

FOUNDATION WALL CONSTRUCTION
R=R8
1. 2" THICK I EPS INSULATION
R=R10
2. 2 1/2" THICK I EPS INSULATION
3. CONCRETE FOUNDATION WALL, RE: STR
R=R6
4. 5" THICK I EPS INSULATION
R=R6
5. 1/2" THICK I EPS w/ FLAT STUD FRAMING
6. 7/8" GYPSUM ADJACENT TO HABITABLE AREAS
TOTAL R-VALUE = R32
R=10 MIN. TO 2 DEEP PER IECC 2012 SECTION 402.1.1

NOTE: TOTAL ASSEMBLY R VALUES ARE HIGHER THAN GIVEN TOTALS, AND ARE AVAILABLE ON REQUEST

VENTILATION SCHEDULE

ROOMS

SUPPLY: 1
BEDROOM 1 24
BATH 1 24
BEDROOM 2 20
BATH 2 20
BEDROOM 3 20
BATH 3 20
LIVING ROOM 40
KITCHEN 36
CLOSET 8
LAUNDRY 12
TOTAL 112

UTILIZATION

SUPPLY AIR DUE TO PERSONS 72
TOTAL EXTRACT AIR DEMAND 112
VOLUMETRIC REQUIREMENT 114
DESIGN AIR FLOW RATE 114
AVERAGE AIR FLOW RATE 86
AVERAGE AIR CHANGE RATE MIN 0.3 [1HR]
Environmental control systems tend to be treated rather like the Cinderella of architecture; given only the plainest clothes to wear, they are relegated to a back room to do the drudgery that maintains the elegant lifestyle of the other sisters: light, form, structure, and so forth.

Thermal Delight in Architecture by Lisa Heschong
MECHANICAL ROOMS
BRONZE AGE ROUND HOUSE

Image: Soluis Heritage
EQUIPMENT SELECTION

Mini-split, ductless heat pump, split system

Multi-zone or multi-split system

Outdoor unit, ODU, compressor

Indoor unit, IDU, air handler, fan coil, cassette,
wall mount unit, floor mount, ceiling cassette,
short-run ducted or concealed fan coil unit

Line set

Branch box

Inverter technology
MANUAL J,S,T,D

- Calculate Loads
- Size Equipment
- Calculate Air Flow
- Design Ducts

Diagram:
- Design Criteria
  - Construction Details
  - HVAC Equipment Selection
  - Type of Duct System
- Manual J
  - Entire House Loads
  - Room Loads
- Manual S
  - Size HVAC Equipment
  - Blower Performance
- Manual D, T
  - Total External Static Pressure
  - Duct Sizing Procedure
  - Register Performance
  - Geometry and Fitting Data
- Strategy Guidelines:
  - Accurate Heating and Cooling Load Calculations
  - HVAC Equipment Sizing
  - Air Distribution Basics and Duct Design
SYSTEM DESIGN
COMFORT
EXPECTATIONS
ACRONYMS

Efficiency = ratio of system output to system input.

Coefficient of performance (COP) = ratio of the rate of heat delivery or removal to the rate of energy input.

Energy efficiency ratio (EER) = ratio of cooling capacity in Btu/h to the rate of electric input in watts.

Seasonal energy efficiency ratio (SEER) = ratio of total cooling output during the cooling period to the total electric input.

Heating seasonal performance factor (HSPF) = ratio of total heating output of a heat pump during the heating season to total electric input.

(HSPF for heating, SEER for cooling)
SPECIFICATIONS: MXZ-8C48NAHZ,

<table>
<thead>
<tr>
<th></th>
<th>Outdoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling</td>
<td>D.B. 23 to 115°F [D.B. −5 to 46°C] *1</td>
</tr>
<tr>
<td>Heating</td>
<td>W.B. −13 to 59°F [W.B. −25 to 15°C]</td>
</tr>
</tbody>
</table>

*1. D.B. 5 to 115°F [D.B. −15 to 46°C]. When an optional Air Outlet Guide is installed.
# COLD CLIMATE HEAT PUMPS

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Brand Name</th>
<th>Model Name/Product Line (if applicable)</th>
<th>Cooling Capacity (Btu/h)</th>
<th>Capacity (btu/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fujitsu General America, Inc</td>
<td>Fujitsu</td>
<td>Halcyon Single-Phase</td>
<td>12,000</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Minimum Capacity 47°F</th>
<th>Rated Capacity 47°F</th>
<th>Maximum Capacity 47°F</th>
<th>Minimum Capacity 17°F</th>
<th>Rated Capacity 17°F</th>
<th>Maximum Capacity 17°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,100</td>
<td>16,000</td>
<td>19,400</td>
<td>2,793</td>
<td>10,200</td>
<td>17,600</td>
</tr>
</tbody>
</table>

- Outdoor Dry Bulb (°F): -5
- Minimum Capacity X°F: 2,377
- Maximum Capacity X°F: 15,000
## Installed Efficiency

### Indoor Units:
- 2 / 2 to 5

### Capacity:
- 42 / 21 to 42

* Connectable capacity is not actual capacity.

### Total Pipe Length:
- 60.0 / 492.0 feet

### Furthest Actual:
- 50.0 / 262.0 feet

### Furthest Equiv.:
- 50.0 / 262.0 feet

### Correction Factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outdoor Unit Capacity</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Temperature</td>
<td>0.81</td>
<td>0.84</td>
</tr>
<tr>
<td>Piping Length</td>
<td>0.99</td>
<td>0.99</td>
</tr>
<tr>
<td>Defrosting</td>
<td>-</td>
<td>0.95</td>
</tr>
<tr>
<td>User Derate</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Total Derate</td>
<td>0.80</td>
<td>0.79</td>
</tr>
<tr>
<td>Additional Refrigerant</td>
<td>7.4 lb</td>
<td></td>
</tr>
<tr>
<td>Total Refrigerant Amount</td>
<td>17.9 lb</td>
<td></td>
</tr>
</tbody>
</table>

### Conditions (°F)

#### Cooling
- Indoor DB: 76.0
- Humidity: 50.0%
- Indoor WB: 63.0
- Outdoor DB: 93.0

#### Heating
- Indoor DB: 70.0
- Outdoor DB: -6.0
- Humidity: 72.8%
- Outdoor WB: -6.6
PARTIAL LOADS
DUCT DESIGN AND AIR FLOW
PASSIVE HOUSE ZONING
CONTROLS
...and the Peak Cooling Load is only -16,000 BTUH!
SUGGESTED READING

Air Conditioning Contractors of America
www.acca.org

Building Science Corporation
www.buildingscience.com

Energy Vanguard
www.energyvanguard.com

Green Building Advisor
www.greenbuildingadvisor.com

PHIUS+ Certification Guidebook

Mechanical and Electrical Equipment for Buildings
Walter T. Grondzik and Alison G. Kwok

Thermal Delight in Architecture
Lisa Heschong