Hot & Humid Climate Challenges
for Multifamily Affordable Buildings
13th Annual North American Passive House Conference

Boston, MA
Sept. 21-22, 2018

www.consinfra.com        www.eplusbuildings.com
Interesting Facts - Colombia

Colombia has:
- The world’s most colorful river
- The tallest seaside mountain in the world

Sierra Nevada de Santa Marta

Caño Cristales
"The River of Five Colors"
Interesting Facts - Colombia

Colombia has:

- Per square meter the most biodiversity of any country
- The most species of birds in the world
- It is the habitat of more than 1754 species
Cartagena, a colonial walled city, is one of UNESCO world heritage sites.
Residential Condominium Puerto Madero, a 40 acre site located 4.5 miles from the heart of Cartagena’s colonial walled city.
Puerto Madero offers up to 2250 multifamily housing units
PHIUS Climate Specific Criteria

PASSIVE STANDARDS IN VARYING CLIMATES

Seattle
State: WA
Location: Tacoma Intl AP
Zone: 4C
Annual Heating Demand...: 5.4
Annual Cooling Demand...: 1
Peak Heating Load Btu/...: 3.3
Peak Cooling Load Btu/...: 3.4
Manual J Peak Heating ...: 5.6
Manual J Peak Cooling ...: 4.8
PHIUS Climate Specific Criteria

Very Hot
Hot
Warm
Pleasant
Some Cold
Cold
Very Cold
USA PHIUS+ 2015 Building Criteria

<table>
<thead>
<tr>
<th>Metric</th>
<th>Requirement</th>
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<tbody>
<tr>
<td>Heating Demand (Site):</td>
<td>1 - 12 kBTU/Ft2-YR</td>
</tr>
<tr>
<td>Cooling Demand (Site):</td>
<td>1 - 21.4 kBTU/Ft2-YR</td>
</tr>
<tr>
<td>Peak Heat Load:</td>
<td>0.8 - 5.4 BTU/Ft2-Hr</td>
</tr>
<tr>
<td>Peak Cooling Load:</td>
<td>1.8 - 8.9 BTU/Ft2-Hr</td>
</tr>
<tr>
<td>Total Energy Demand (Source):</td>
<td>Beds+1 / 6200 kWh/PERSON-YR (Temporary)</td>
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<tr>
<td></td>
<td>Beds+1 / 4200 kWh/PERSON-YR (Future)</td>
</tr>
<tr>
<td>Air Tightness:</td>
<td>0.05 cfm/gross sqft shell @ 50 pa</td>
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<tr>
<td></td>
<td>0.08 cfm/gross sqft shell @ 75 pa</td>
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</tbody>
</table>
And we found a difference between the ASHREA location’s climate data and the one generated by PHIUS based on the local airport meteorological data. A difference that has an impact in the sizing of the ventilation unit. So we went with the PHIUS one, that looks more accurate.
Climate Comparison

Cartagena – Colombia
Latitude 10.4

Warren – Vermont
Latitude 44.2
Cooling Demand Comparison

Cartagena – Colombia
Latitude 10.4

Warren – Vermont
Latitude 44.2
Our Greatest Challenge

The local building practice against which we have to compete and one that does not take in consideration:

- Envelope Insulation
- Energy Efficient Windows
- Sanitary Ventilation
Most Relevant Design Factors

- Orientation
- Shading
- Air Tightness
- Ventilation & Air Dehumidification
- Internal Latent Heat Gains
- Structural Design Limitations
- Laundry Rooms Exhaust
- PH Components’ Cost
ORIENTATION
SHADING

South – March – 10 AM
SHADING

North – July – 10 AM
Ventilation Air Dehumidification

The best option in this case is a DOAS consisting of an ERV with a dehumification coil to supply cooled and dehumidified air at 55 F DB / 54.6 F WB
DOAS Sizing

- The major contributors to energy loss are the ventilation air and air infiltration due to their latent heat.

- Therefore, we need to determine the minimum ventilation volume possible to prevent over ventilating with high humidity air.

- **PHIUS+** requirement calls for 18 CFM/person which at an occupancy rate of 144 (PHPP calculates 87.6) occupants (3 per unit) gives a total of **2592 CFM**.

- The Energy Star minimums are for 48 kitchens @ 25 cfm each = 1200 and 96 bathrooms @ 20 cfm each = 1920, totaling = 3120 CFM.

- The recommended PHIUS rates, which run lower than this most of the time are for 48 kitchens @ 36 cfm each = 1728 and 96 bathrooms @ 24 cfm each = 2304, totaling = 4032 CFM.

- The design airflow per **PHPP** with 48 kitchens and 96 bathrooms is 3955 CFM (6720 m3/h) which modulated to 12 h standard operation and 12 h minimum operation come down to **2313 CFM** (3929 m3/h).
DOAS Sizing

- A third approach was also analyzed, to have the DOAS treat the ventilation air and deal as well with the latent load of the infiltration air

- This calculation came to 1630 CFM (for 0.3 ACH) plus 982 CFM (for latent loads) = 2612 CFM delivered at 54.6 F WB and 55F DB

CONCLUSION

- PHIUS+ = 2592 CFM
- PHPP = 2313 CFM
- THERMODYNAMICS = 2612 CFM

Therefore the requirement is 2600 CFM which at 80% operation rate of the DOAS, the DOAS capacity should be 3250 CFM coupled with a 14 Ton Dehumidification coil
Ventilation Ducting
- Once the infiltration and ventilation air latent heats and internal latent heats are taken care of with the ventilation system, a small 9000 BTU single source A/C unit or smaller can take care of the sensible heat of the apartment, which added to the ventilation air cooling capacity totals 1 ton of cooling per apartment.

The local practice for an apartment like this is to have 40,000 BTU (3.3 ton) of cooling capacity installed.
Structural Challenges

- Double Concrete Wall with Sandwich XPS
- Requires a Transition Slab for Underground Garage
Required Structural Approach

The structural design presents a challenge of uninsulated areas along the floors’ slabs.
## Required Structural Approach

### Uninsulated floor sections

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<thead>
<tr>
<th>Parameter</th>
<th>Criteria</th>
<th>Alternative Criteria</th>
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<tbody>
<tr>
<td>Treated floor area m²</td>
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<td>Space heating</td>
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<tr>
<td>Heating demand kWh/(m²a)</td>
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<td>≤ 15</td>
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<td>Heating load W/m²</td>
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<tr>
<td>Frequency excessively high humidity (&gt; 12 g/kg) %</td>
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<td>≤ 10</td>
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<tr>
<td>Airtightness</td>
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<tr>
<td>Pressurization test result n₅₀ 1/h</td>
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### Fullfilled?

- yes
- yes
- yes

### 10 mm EPS insulated floor sections

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Laundry Room Challenge

Air Infiltration Heat Losses

Due to local custom, a centralized common laundry room is not feasible, therefore individual laundry rooms must be installed in each of the 48 apartments, with direct exhaust venting.

In cases of direct venting, the PHIUS Make Up Air calculator must be used to account for direct venting of the Exhaust Dryer.

This provides a new CFM average and a new efficiency of the ERV down from the one specified by the manufacturer, negatively affecting the cooling demand.
Components’ Cost Challenge

Windows
Double pane energy efficient windows come at 420% the cost of single pane conventional windows

DOAS System
Not required in conventional construction is an added direct cost to the Passive House proposal

Insulated Envelope
Not required in conventional construction is also an added direct cost to the Passive House proposal
Passive House Planning Package – PHPP modeling comparison

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Conventional Construction

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Estimated if Passive House – 97% reduction in Cooling Demand & Load
Market, Education, and Sales Challenge

- Economic Benefits
- Health Benefits
- Quality Benefits
- Technology Benefits
- Other benefits
Puerto Madero Passive House
How we are making it happen!

- Cost of land
- Team with proven track record. Three team members with over 30 each of expertise
- Over 50% of equity capital is our own
- Manage the whole value chain leveraging efficiency while keeping costs low (architecture, permitting, project management, sales)
- Integrated project delivery (IPD) / Lean Construction
- No traditional leverage (Crowdfunding has helped partially finance this project)
Financing Sustainable Development / Impact Investing

- The Grantham Foundation
- Calvert Foundation
- Global Environment Fund
- KFW DEG
- French Development Agency

- HBS Impact Investing Alumni Group
Thank you

Because we care about you saving money and living healthy, and care about the environment, our legacy and our future, we make energy efficient buildings.

Andrew Straus – astraus@consinfra.com
Enrique Bueno – ebueno@eplusbuildings.com