Energy Efficient Buildings

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

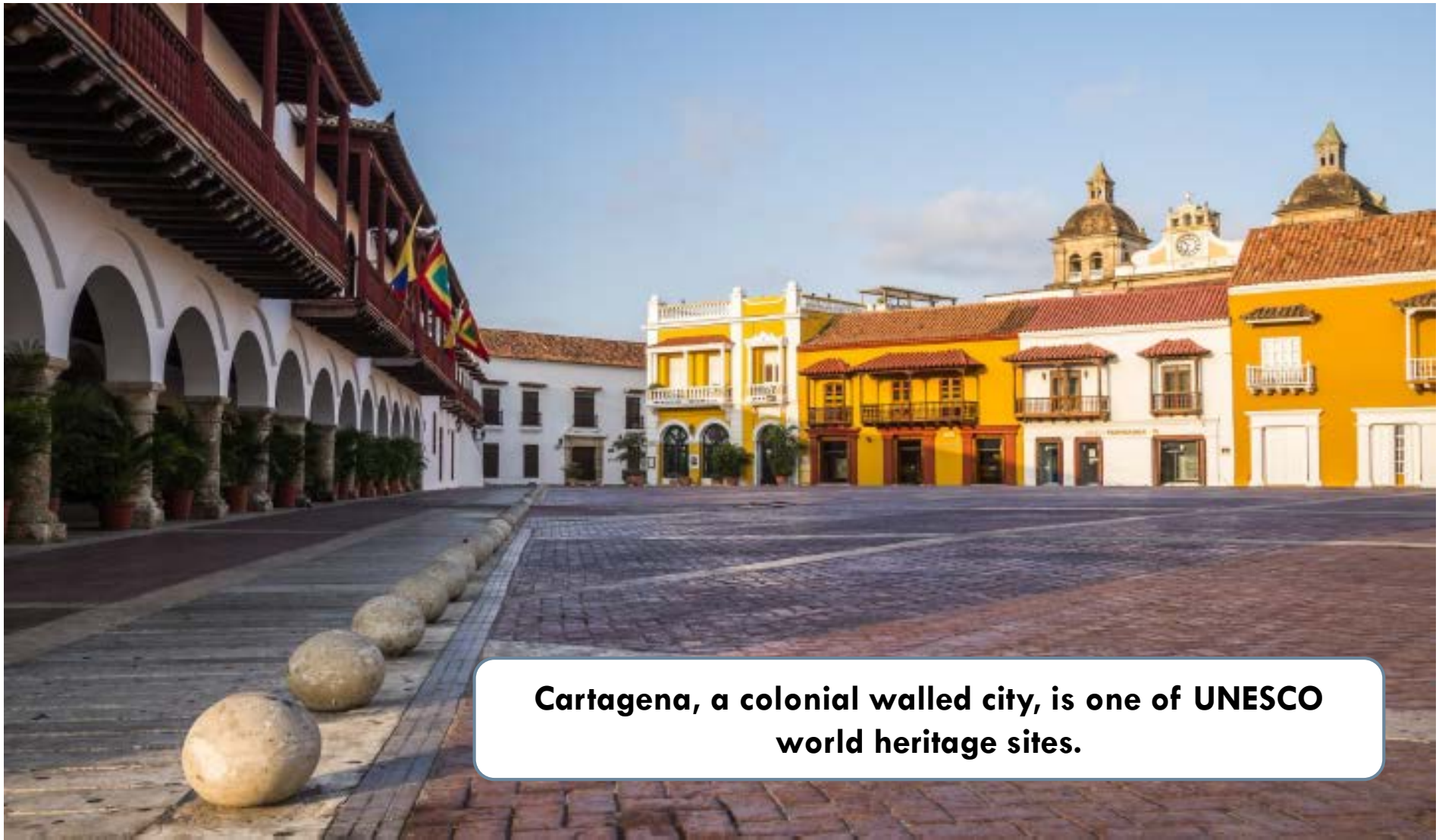
Caño Cristales
"The River of Five Colors"

Interesting Facts - Colombia

Colombia has:

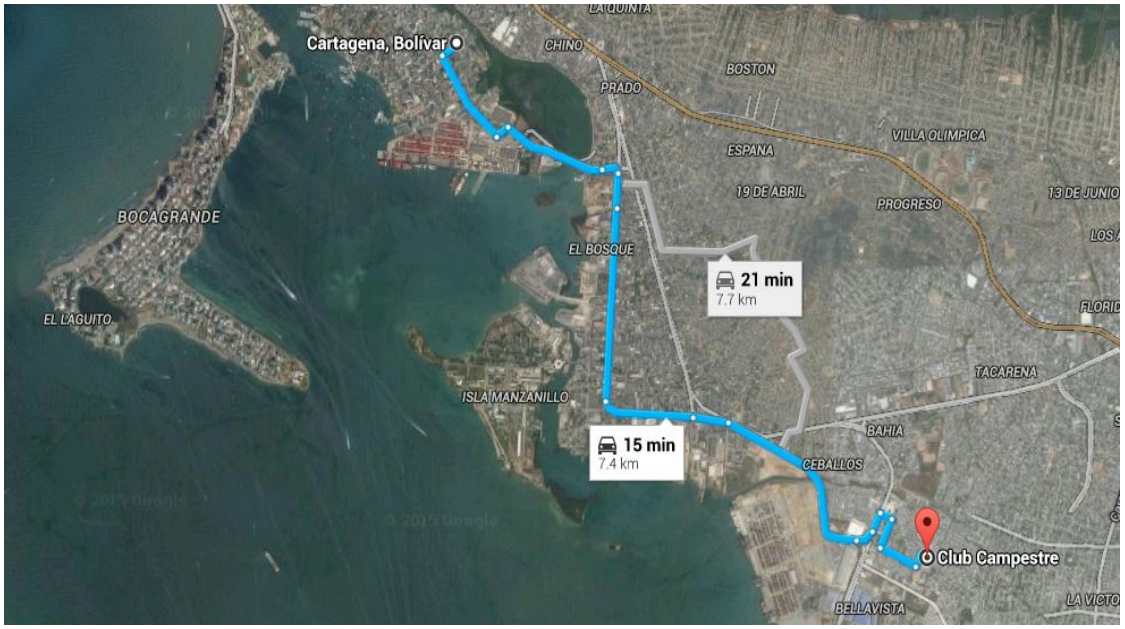
- Per square meter the most biodiversity of any country
- The most species of birds in the world
- It is the habitat of more than 1754 species

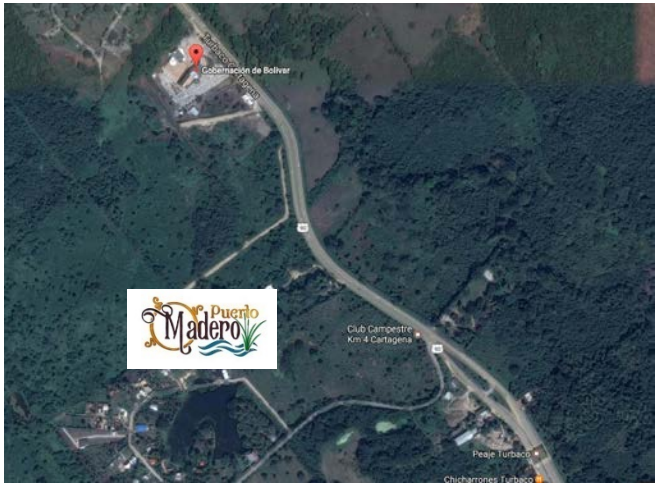
Project Location
Cartagena - Colombia



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

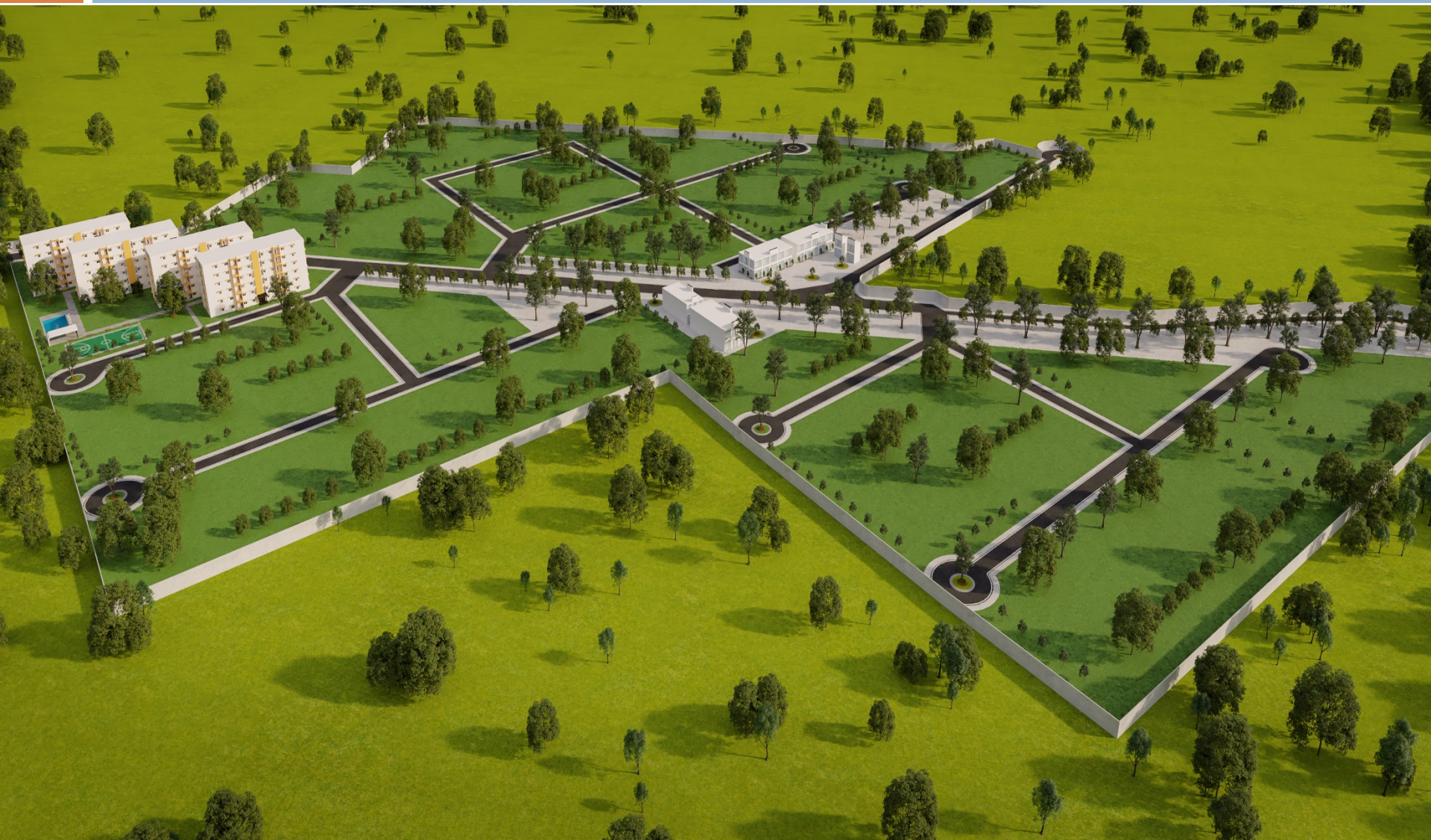




Puerto Madero

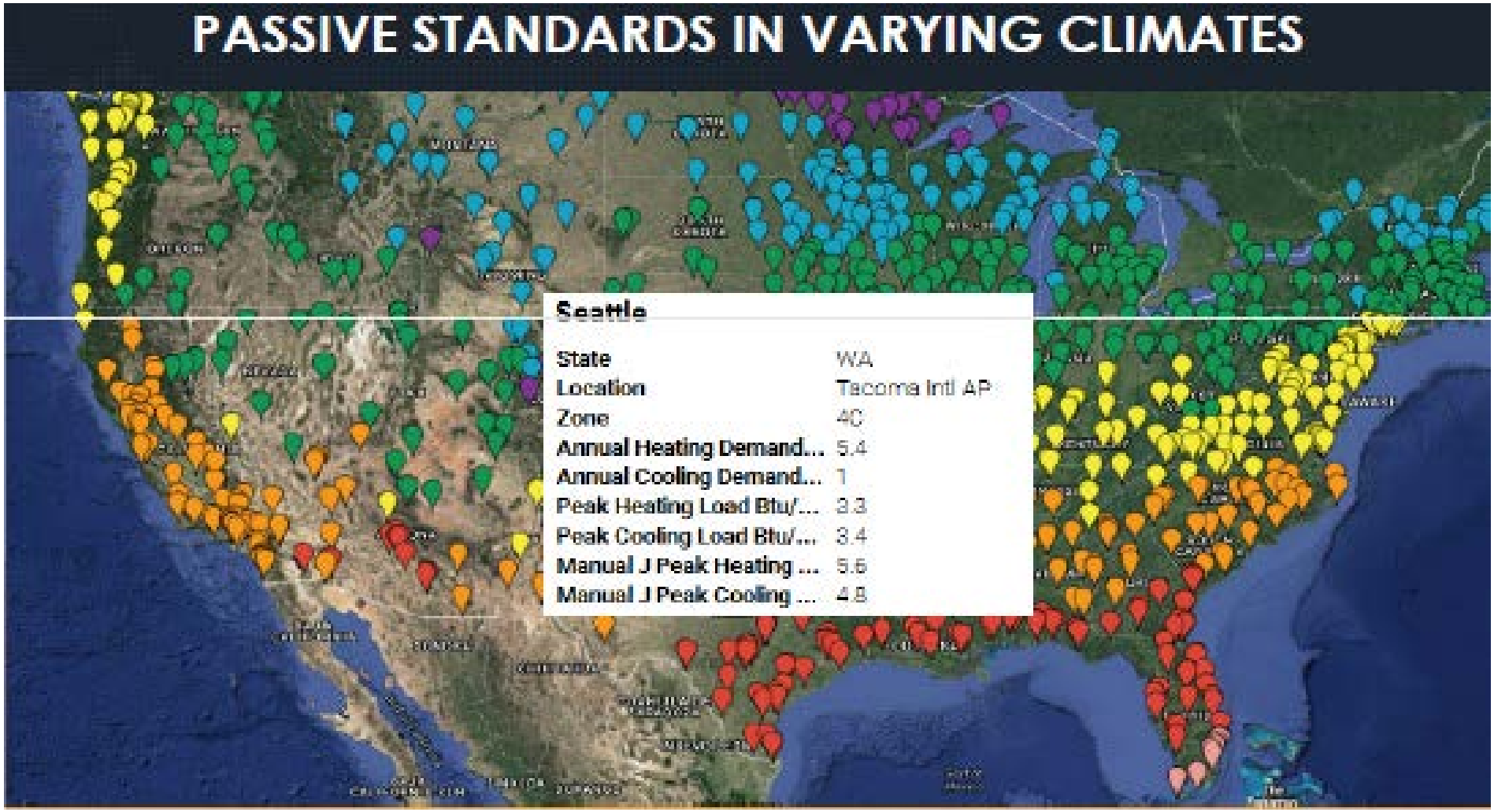
offers up to 2250 multifamily housing units

Puerto Madero
First Phase

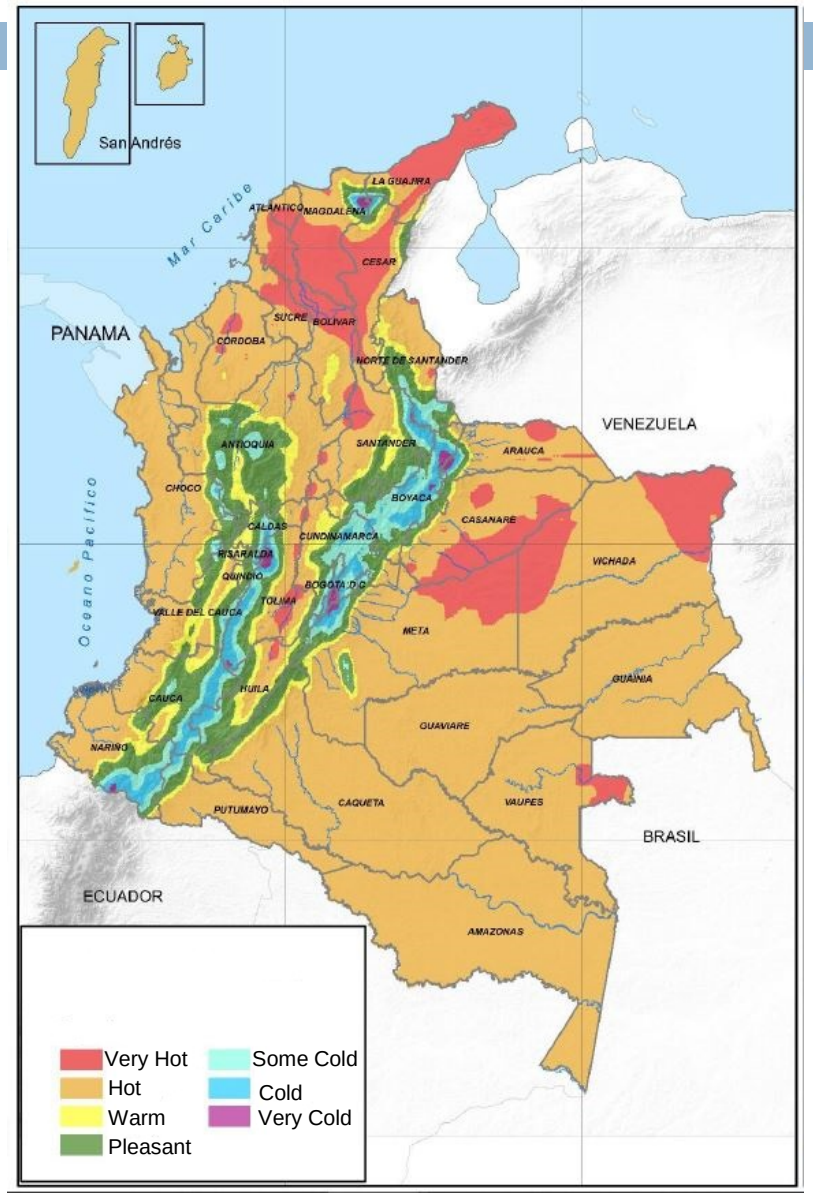


Puerto Madero
First Phase

PHIUS Climate Specific Criteria



PHIUS Climate Specific Criteria



USA PHIUS+ 2015 Building Criteria

Heating Demand (Site):	1 - 12 kBTU/Ft2-YR
Cooling Demand (Site):	1 - **21.4 kBTU/Ft2-YR**
Peak Heat Load :	0.8 - 5.4 BTU/Ft2-Hr
Peak Cooling Load:	1.8 - 8.9 BTU/Ft2-Hr
Total Energy Demand (Source):	Beds+1 / 6200 kWh/PERSON-YR (Temporary) Beds+1 / 4200 kWh/PERSON-YR (Future)
Air Tightness:	0.05 cfm/gross sqft shell @ 50 pa 0.08 cfm/gross sqft shell @ 75 pa

Site Specific Climate

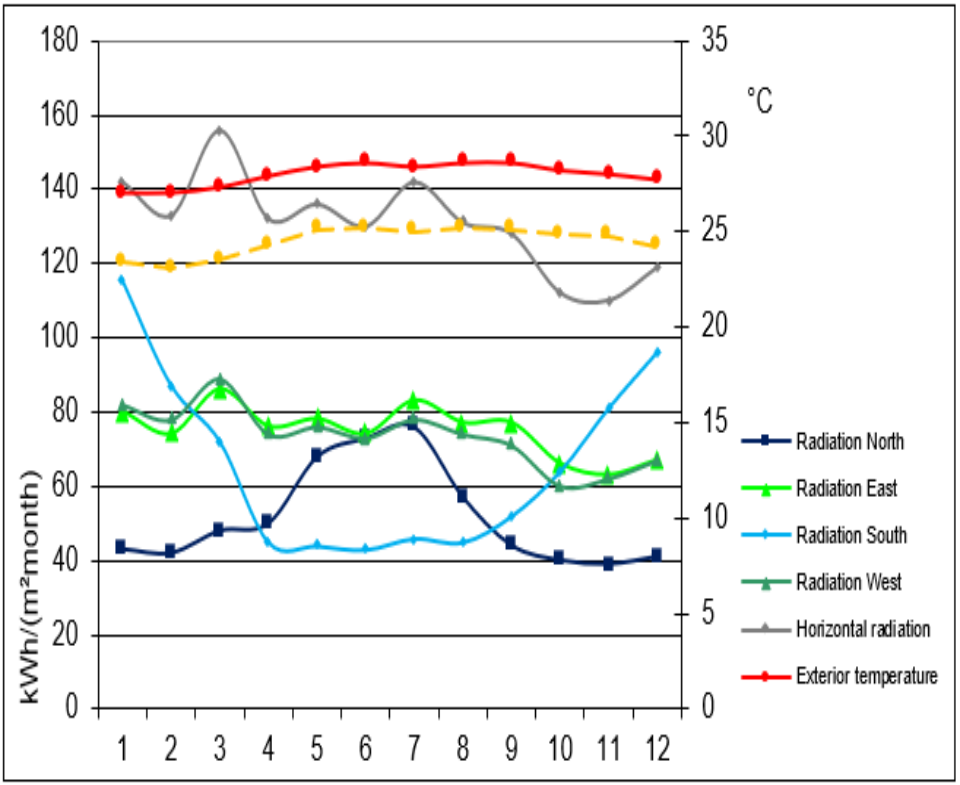
Deg. F	1	2	3	4	5	6	7	8	9	10	11	12
Ambient	80.6	80.6	81.1	82.2	83.1	83.5	83.1	83.5	83.5	82.8	82.4	81.9
Dewpoint	74.1	73.6	74.3	75.7	77.2	77.4	77.0	77.4	77.2	76.8	76.6	75.6

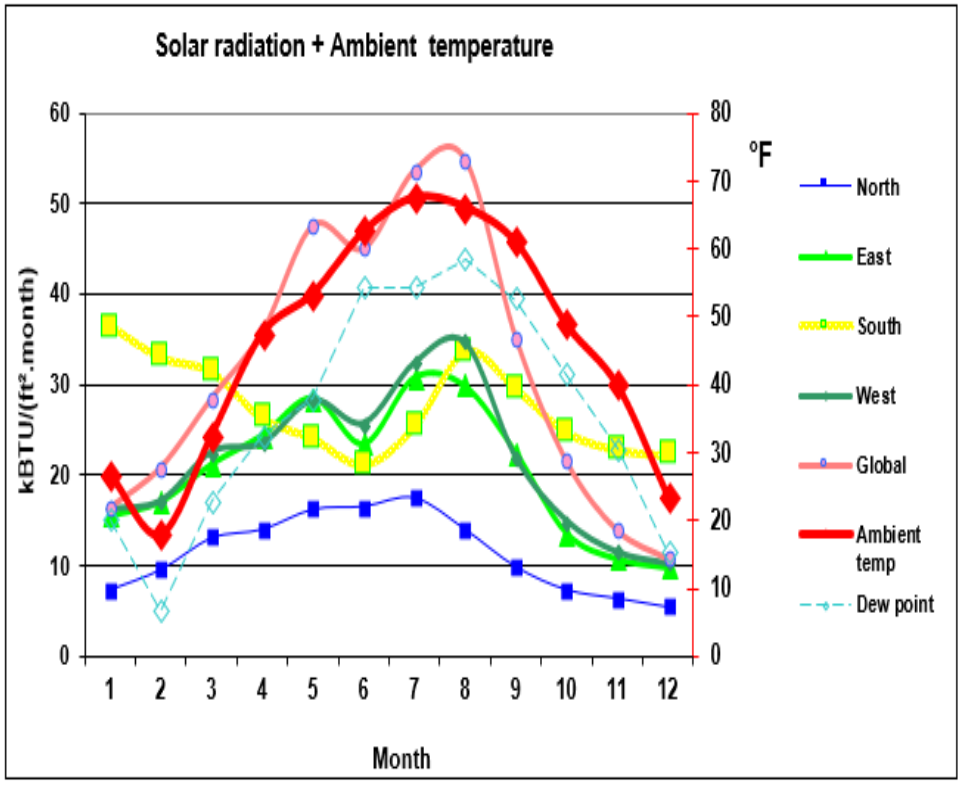
Daily temp. variation (F^o)	9.5

Very Hot and Humid

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

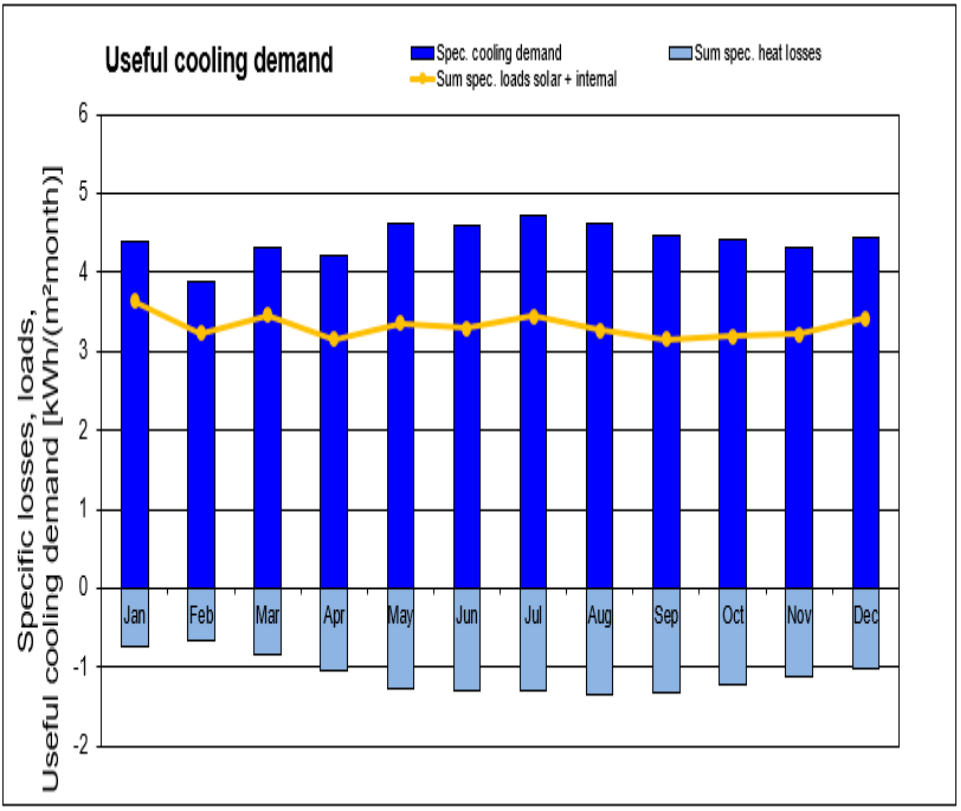


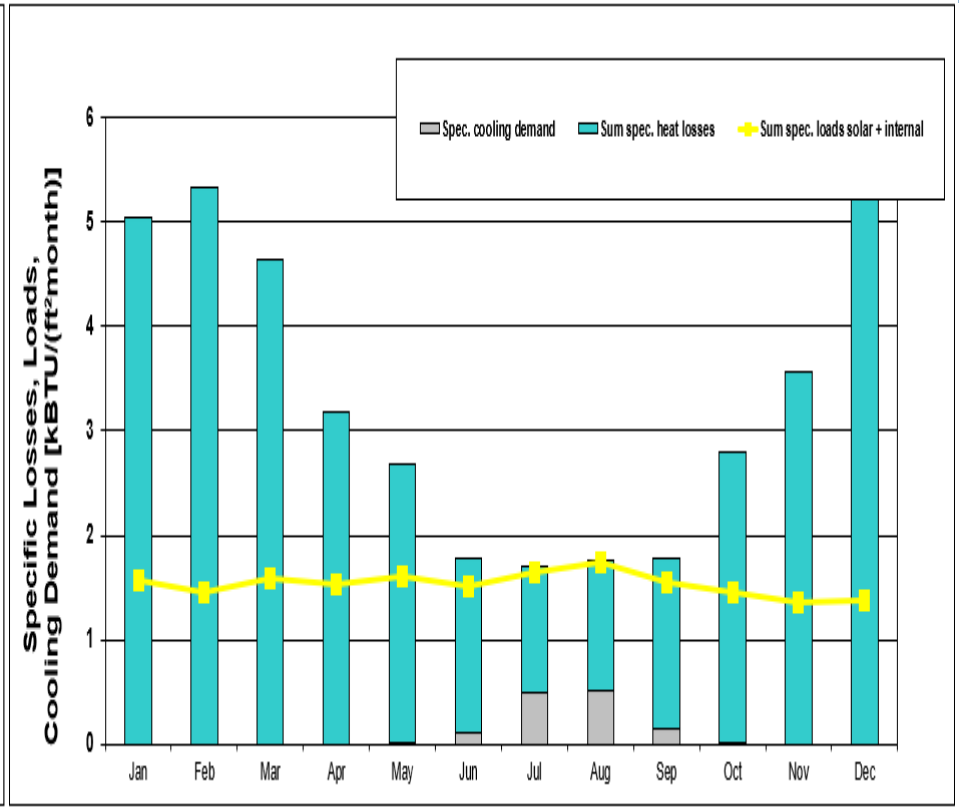


Cartagena – Colombia
Latitude 10.4

Warren – Vermont
Latitude 44.2

Cooling Demand Comparison





Cartagena – Colombia
Latitude 10.4

Warren – Vermont
Latitude 44.2

Our Greatest Challenge

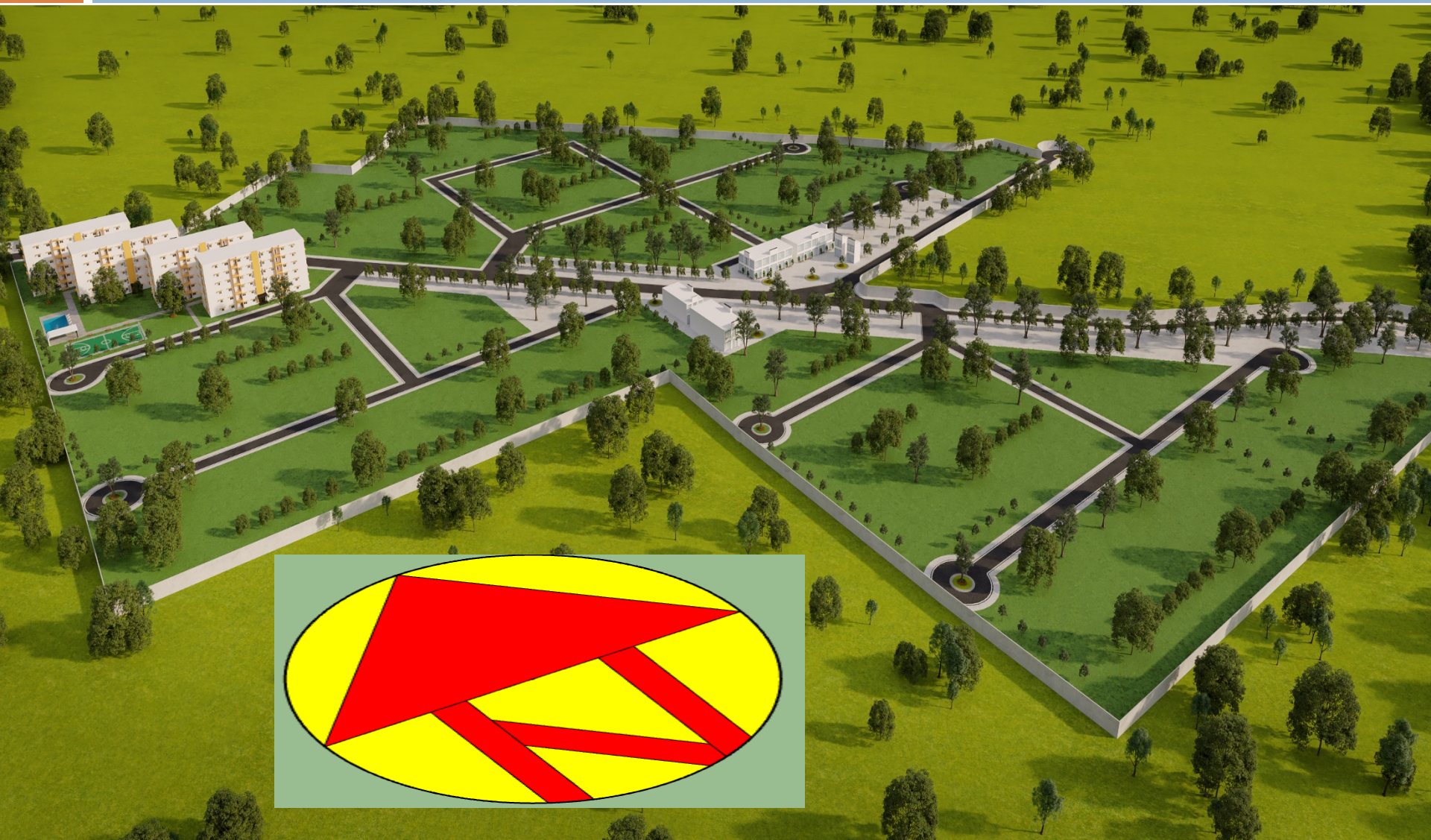
The local building practice against which we have to compete and one that does not take in consideration:

- 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



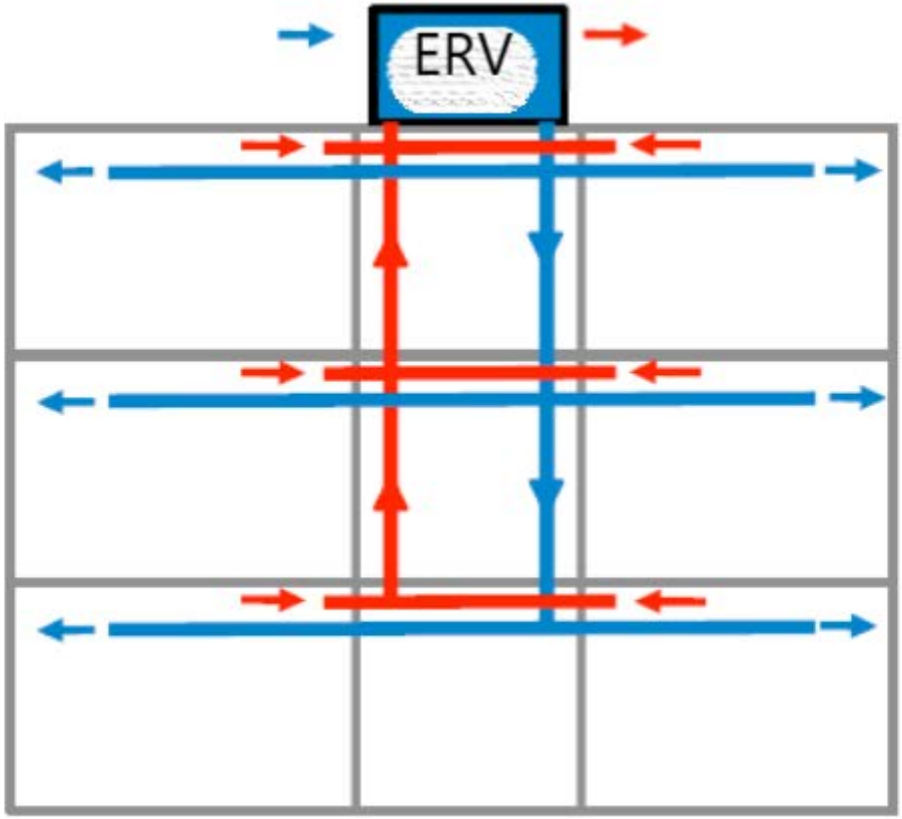
SHADING

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 mayor contributors to energy loss are the ventilation air and air infiltration due to their latent heat

- Therefor 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

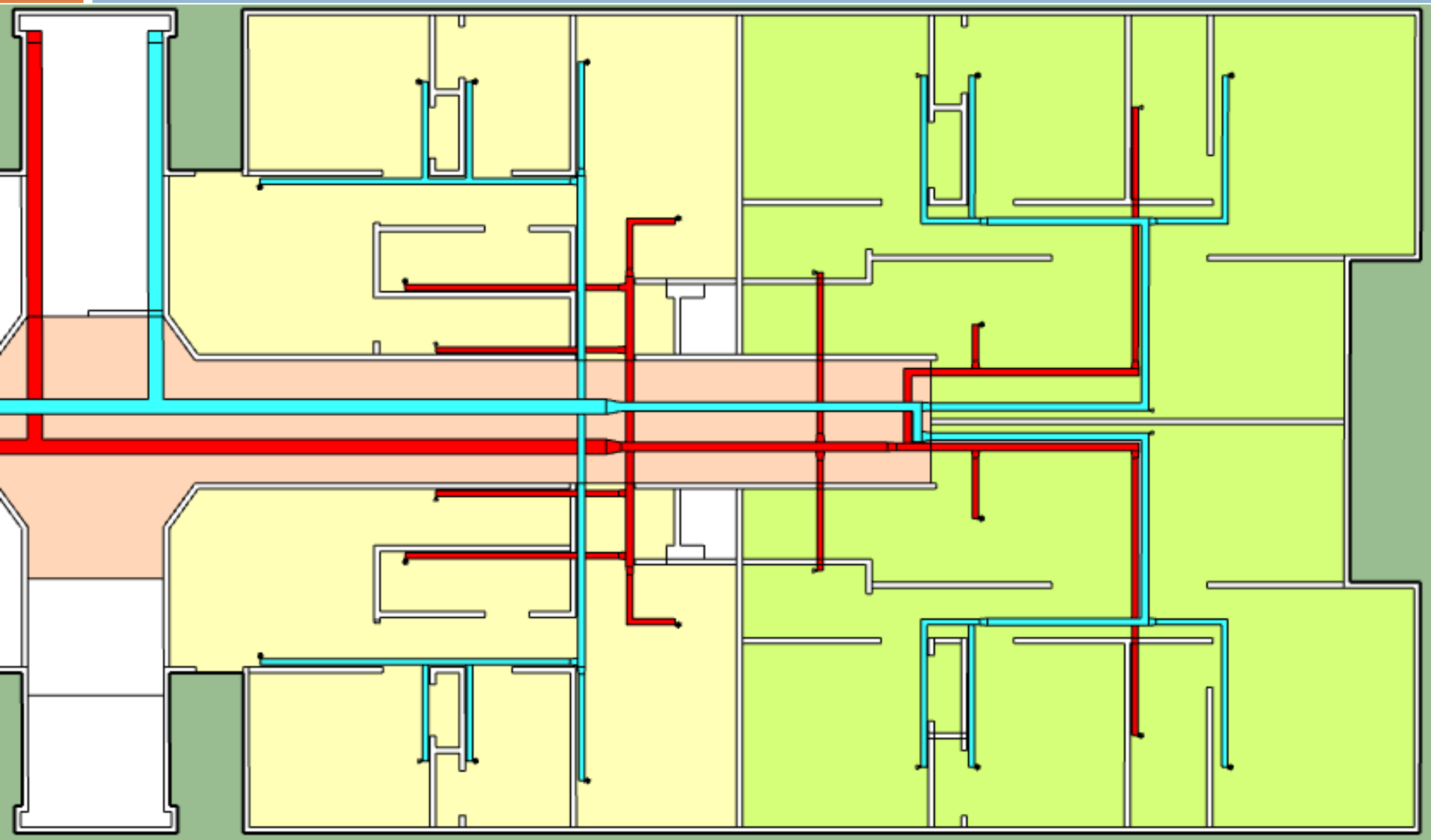
- **PHIUS+** = **2592 CFM**

- **PHPP** = **2313 CFM**

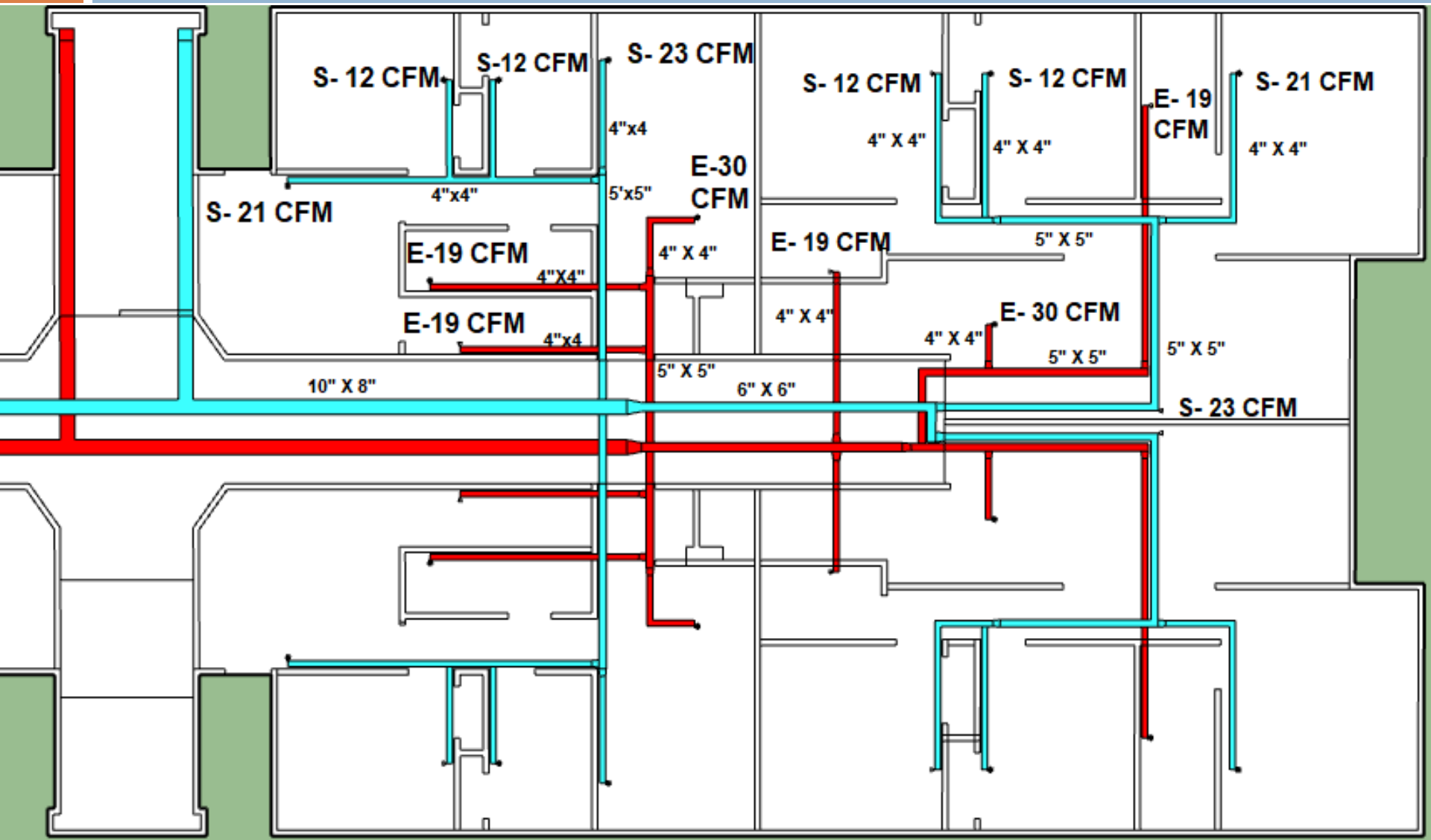
- **THERMODYNAMICS** = **2612 CFM**

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



Ventilation Ducting



Other Mechanicals

- 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 aprtment, which added to the ventilation air cooling capacity totals 1 ton of cooling per apartment

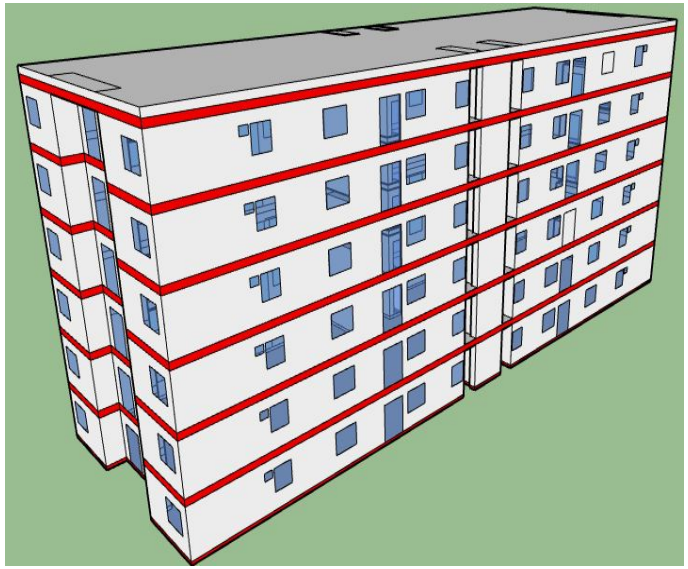
The local practice for an apartment like this is to have 40,000 BTU (3.3 ton) of cooling capacity installed.

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

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	3334.0				
Space heating	Heating demand	kWh/(m²a)	0	≤	15	-	yes
	Heating load	W/m²	-	≤	-	-	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	103	≤	48	93	no
	Cooling load	W/m²	8	≤	-	11	
	Frequency of overheating (> 25 °C)	%	-	≤	-		-
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/h	0.5	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	53	≤	120		yes

Uninsulated floor sections

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	3334.0				
Space heating	Heating demand	kWh/(m²a)	0	≤	15	-	yes
	Heating load	W/m²	-	≤	-	-	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	91	≤	48	93	yes
	Cooling load	W/m²	7	≤	-	11	
	Frequency of overheating (> 25 °C)	%	-	≤	-		-
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/h	0.5	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	45	≤	120		yes

10 mm EPS insulated floor sections

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 apartment, 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

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	3334.0				
Space heating	Heating demand	kWh/(m²a)	0	≤	15	-	yes
	Heating load	W/m²	-	≤	-	-	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	3329	≤	48	93	no
	Cooling load	W/m²	324	≤	-	11	
	Frequency of overheating (> 25 °C)	%	-	≤	-		-
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/h	0.5	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	438	≤	120		no

Conventional Construction

					Criteria	Alternative criteria	Fullfilled?[2]
	Treated floor area	m²	3334.0				
Space heating	Heating demand	kWh/(m²a)	0	≤	15	-	yes
	Heating load	W/m²	-	≤	-	-	
Space cooling	Cooling & dehum. demand	kWh/(m²a)	91	≤	48	93	yes
	Cooling load	W/m²	7	≤	-	11	
	Frequency of overheating (> 25 °C)	%	-	≤	-		-
	Frequency excessively high humidity (> 12 g/kg)	%	0	≤	10		yes
Airtightness	Pressurization test result n_{50}	1/h	0.5	≤	0.6		yes
Non-renewable Primary Energy (PE)	PE demand	kWh/(m²a)	45	≤	120		yes

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