REDUCING COOLING ENERGY DEMAND OF COASTAL HOTELS IN TROPICAL CLIMATE THROUGH

SUSTAINABLE FAÇADE RENOVATION STRATEGIES

P5 PRESENTATION

TU Delft

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PROBLEM STATEMENT

Climate Change

Tourism: Pillar of the Dominican Economy

Cooling Energy Consumption

Green Energy and Sustainability Investment

RESEARCH METHODOLOGY

Comparative Research

On-Site Experience and Documentation

Design and Cooling Energy Performance

Main Research Question:

Can the cooling energy demand of coastal hotels under tropical climate conditions be reduced by 50% by applying sustainable facade renovation strategies?

THESIS STRUCTURE

Cooling Energy Performance

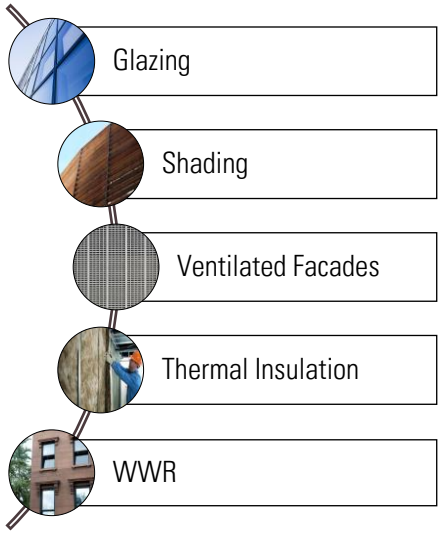
- Thermal Comfort
- Cooling Energy Demand
- Stationary and Dynamic Simulations

Coastal Hotels

- Façade Typology
- Construction Materials

Tropical Climate

- Temperature
- Humidity/Precipitation
- Solar Radiation
- Winds



Passive Design Strategies

Design Integrated Sustainable Façade Renovation Strategy

- Passive Design Strategies
- Sustainable Materials

TROPICAL CLIMATE

DOMINICAN REPUBLIC

High Solar Radiation

High Humidity

Virtual Absence of Seasons

10 most vulnerable countries to Climate Change

Risks: Earthquakes – Hurricanes – Flooding

Coastal Cities:

- Puerto Plata
- Samaná
- Punta Cana
- La Romana
- Santo Domingo

Coastal Hotels in the Dominican Republic

Construction Materials

Façade Typologies

Predominant categories:

- Structure: Frame Systems
- Material: Concrete
- Light-weight Structure: Wood
- Exterior Finishing: Concrete Mortar
- Opening Type: Single Glazing

PASSIVE DESIGN STRATEGIES

Glazing

Shading

Window-to-Wall ratio (WWR)

Ventilated Facades

Thermal Insulation

Material	Thickness (m)	Thermal Mass (J/kg*K)	Thermal Transmittance (W/m*K)	Embodied Energy (J/Kg)	CO2 Footprint Primary Production (Kg/Kg)	Recyclability (%)	Density (Kg/m^3)	Weight* (Kg)
OSB	0.0127	1552	0.13	1.84e7 – 2.03e7	0.84 - 0.93	1.34 – 1.48	650	8.3
Glulam	0.10	1200	0.38	$1.92e^7 – 2.12e^7$	0.805 – 0.888	1.34 – 1.48	550	11
BioFoam	0.05	480	0.034	$8.86e^6 – 1.01e^7$	2.55 – 3.48	100	660	26.4
Cork	0.10	1200	0.042	$3.81e^6 – 4.20e^7$	0.192 – 0.211	100	240	19.2
Hemp	0.05	1600	0.056	$1.00e^6 – 1.20e^6$	0.37 – 0.41	0.1	860	34.4
Steel	0.175	480	50	$7.71e^6 – 8.51e^6$	0.606 – 0.668	95	8050	56.4
Bamboo	0.10	1008	0.18	$1.43e^4 – 1.58e^4$	0.0019 – 0.0021	1.3 – 1.5	1160	9.3
Rockpanel	0.008	920	0.37	9.27E+07	1.43 – 2.10	100	1050	8.4

CASE STUDY
EMOTIONS BY HODELPA – PUERTO PLATA

Coastal Hotel Selection Criteria:

- Recently Renovated (2017)
- Common Concrete-Frame Structure
- Common Concrete-Block Facade

Building **Guest Block 16** Selection Criteria:

- Proximity to the beach (climate challenges)
- Least shaded (exterior vegetation)
- Highest Energy Consumption (at full capacity)

THERMAL COMFORT

Indoor temperature - humidity - heat stress

Cooling Energy Demand

- Split-Unit Inverter Technology
- Unit Sizes: 3.5 / 5.3 / 7.0 (kWh)
- Hotel Cooling Set-point temperature: 22 °C
- User Cooling Set-point temperature: 18 °C

Stationary and Dynamic Simulations

- Thermal Transmittances

$$Q_{transmission} = (A_{window} \times U_{window} + A_{wall} \times U_{wall}) \times (T_{out} - T_{in})$$

Q_{intern}: Amount of people x internal heat production

$$Q_{sun} = qSun \times A_{window} \times g\text{-}value_{window}$$

$$Q_{ventilation} = (p_{air} \times c_{air} \times n \times V_{air}) \times (T_{out} - T_{in})$$

$$W = Q_{intern} + Q_{sun}$$

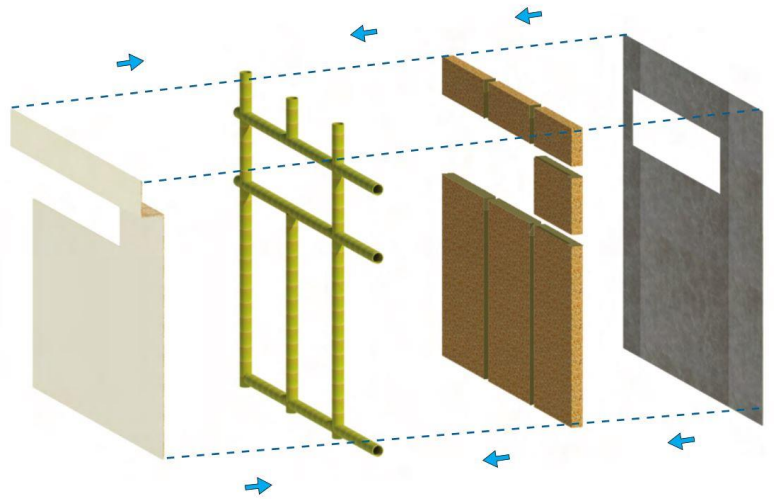
$$H = (A_{window} \times U_{window} + A_{wall} \times U_{wall}) + (p_{air} \times c_{air} \times n \times V_{air})$$

$$M = \text{floor area} \times \text{thickness} \times P_{material} \times C_{material} + P_{air} \times C_{air} \times V_{air}$$

$$T_{in} = T_{out} + W/H \left(1 - e^{-H/M \times t}\right)$$

Price of the m^2 selected Sandwich Panel (in Euros per Kg)					
Material	**Thickness (m)**	**Weight* (Kg)**	**Price (€ per Kg)**	**Total cost (per 1m^2 panel)**	**Layer Position**
OSB	0.0127	8.3	€ 0.94	$ 7.76	Interior
Cork (comercial size B)	0.10	24	€ 6.62	$ 158.88	Insulation
Bamboo	0.10	9.3	€ 1.50	$ 13.92	Structure
Rockpanel	0.008	8.4	€ 12.20	$ 102.48	Exterior
Total	**0.12**	**49.9**		**$ 283.04**	

* Weight is based on a 1m^2 model panel



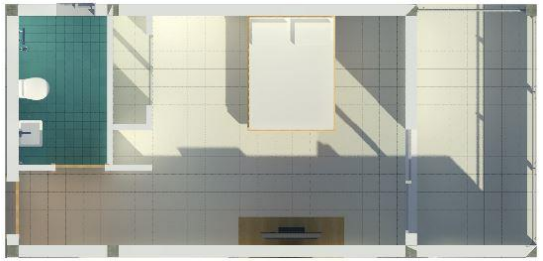
Level 4

Room 43

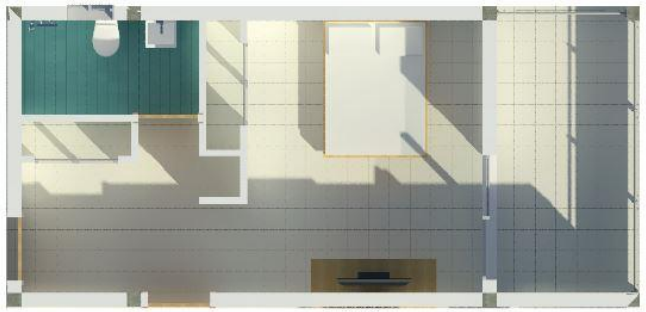
Room 44

Room 45

Room 46

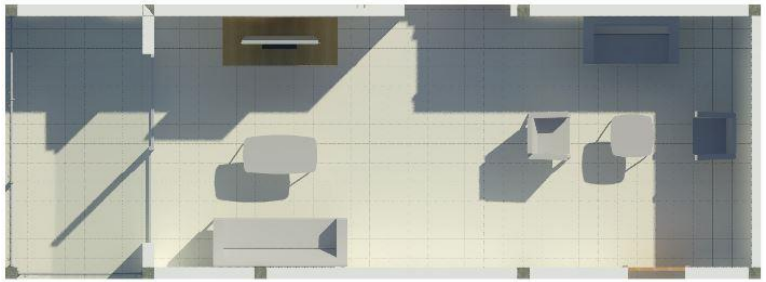


Junior Suite



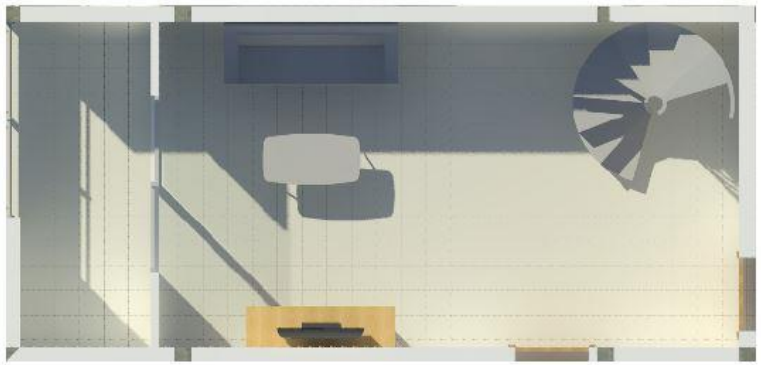
Deluxe Suite

Single Room

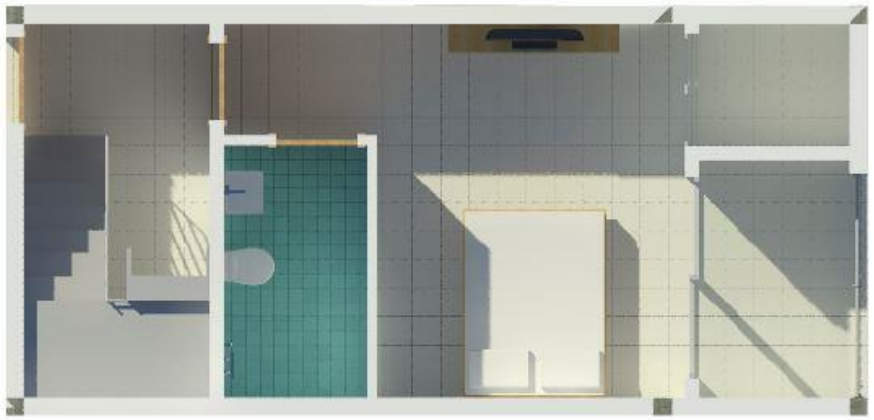


Living Room

Double Deluxe Suite



Pent-House Living Room



Pent-House First Room

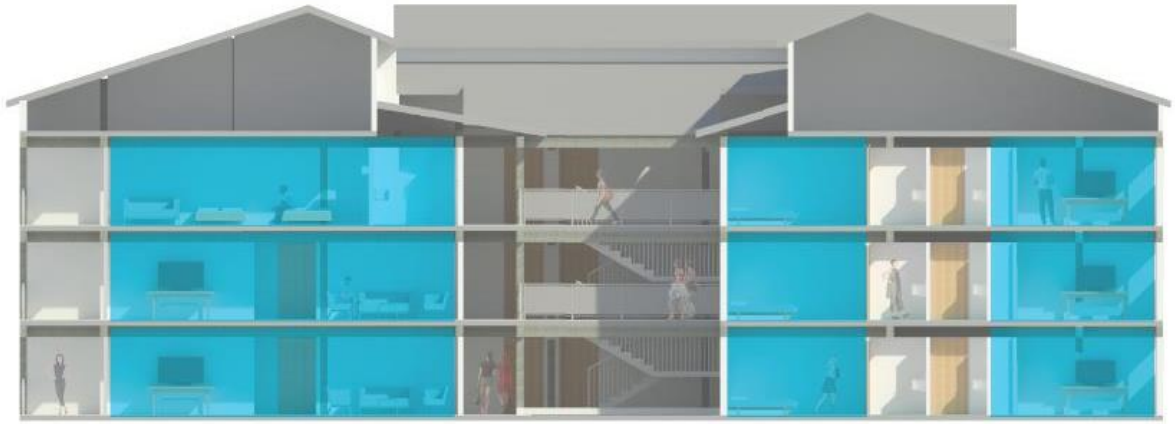
Pent-House Top Room

Activity of Guest Block 16	
Floor Areas and Volumes	
Ocuppied Floor Area (m^2)	1403.1
Ocuppied Volume (m^3)	3143.3
Occupancy	
Occupancy Density (people/m^2)	0.05
Schedule	On 24/7
Metabolic	
Activity	Bedroom (other, cell, etc)
Factor (men= 1.0, women= 0.85, children= 0.75)	0.90
Environmental Control	
Cooling Setpoint Temperatures	
Cooling (^{o}C)	18
Cooling setback (^{o}C)	22
Humidity Control	
RH Humidification Setpoint (%)	20
RH Dehumidification Setpoint (%)	80
Minimum Fresh Air	
Fresh air (l/s-person)	10.0

Construction of Guest Block 16			
Category	**Type**	**Thickness (cm)**	**U-Value**
Exterior Walls	Heavyweight concrete block plastered	20	U = 2.14
Interior Walls	Light-weight concrete block plastered	15	U = 1.92
Ceilings	Concrete slab	15	U = 0.41
Floors	Passive floor, no insulation, tile or vinyl	3	U = 2.95
Slabs	Concrete Slab	15	U = 0.41
Exterior Roof	Waterproof Covering, Polyurethane, Screed, Concrete and Plaster	20	U = 0.53

Openings of Guest Block 16			
Windows			
Glazing Type	**Dimensions (m)**	**Thickness (cm)**	**U-Value [W/(m²K)]**
Sliding Window Balcony A (Single Glazing)	2.10 x 1.80	0.127	U = 5.56
Sliding Window Balcony B (Single Glazing)	2.10 x 2.16	0.127	U = 5.56
Sliding Window Balcony C (Single Glazing)	2.10 x 3.00	0.127	U = 5.56
Sliding Window Room A (Single Glazing)	0.70 x 0.70	0.127	U = 5.56
Sliding Window Room B (Single Glazing)	1.00 x 1.80	0.127	U = 5.56
Sliding Window Room C (Single Glazing)	1.00 x 2.00	0.127	U = 5.56
Doors			
Door Type	**Dimensions (m)**	**Thickness (cm)**	**U-Value [W/(m²K)]**
Solid Core Oak	0.90 x 2.13	5.1	U = 2.61

HVAC System Data of Guest Block 16	
HVAC Template	
Template	Split + Mechanical Ventilation
Mechanical Ventilation	
Outside air definition method	Minimum fresh air (Sum per person + per area)
Operation	On 24/7
Cooling	
Cooling System	Individual Inverter Split Units
Fuel	Electricity from grid
Minimum supply air temperature (°C)	18
Cooling limit type	By capacity
Schedule	On 24/7



Cooling Energy Consumption of Guest Block 16 in the Month of August, 2019									
Room	Size (m^2)	Room Type	HVAC Capacity (Split Unit)	Facades with Mayor Exposure to Solar Radiation	Zone Air Sensible Cooling Energy (KWh)	Cooling Load per Area (Kwh/m^2)	Outside Humidity (%)	Cooling setpoint temperature	Cooling setback setpoint temperature
Level 1									
Room 1	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NW	549.9	20.1	80%	18 °C	22 °C
Room 2	29.5	Junior Suite	18000 BTU/hr (5.27 KWh)	N	403.2	13.7	80%	18 °C	22 °C
Room 3	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	N	499.7	17.0	80%	18 °C	22 °C
Room 4	57.8	Junior Suite	18000 BTU/hr (5.27 KWh)	NE	705.9	12.2	80%	18 °C	22 °C
Room 5	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	506.4	28.6	80%	18 °C	22 °C
Room 6	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	433.5	25.2	80%	18 °C	22 °C
Room 7	38.5	Living Room	24000 BTU/hr (7.03 KWh)	SW	799.2	20.8	80%	18 °C	22 °C
Room 8	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	831	21.7	80%	18 °C	22 °C
Room 9	**15.0**	**Single Room**	**12000 BTU/hr (3.51 KWh)**	**SE**	**558.8**	**37.3**	**80%**	**18 °C**	**22 °C**
Room 10	16.3	Single Room	12000 BTU/hr (3.51 KWh)	S	420.7	25.8	80%	18 °C	22 °C
Room 11	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SW	665.9	24.3	80%	18 °C	22 °C
Room 12	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	473.6	16.1	80%	18 °C	22 °C
Room 13	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	475	16.2	80%	18 °C	22 °C
Room 14	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SE	691.4	25.2	80%	18 °C	22 °C
Level 2									
Room 15	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NW	905.7	33.1	80%	18 °C	22 °C
Room 16	29.5	Junior Suite	18000 BTU/hr (5.27 KWh)	N	737	25.0	80%	18 °C	22 °C
Room 17	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	N	377.5	12.8	80%	18 °C	22 °C
Room 18	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	NE	902.8	32.9	80%	18 °C	22 °C
Room 19	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	555.5	31.4	80%	18 °C	22 °C
Room 20	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	474.9	27.6	80%	18 °C	22 °C
Room 21	38.5	Living Room	24000 BTU/hr (7.03 KWh)	SW	953.4	24.8	80%	18 °C	22 °C
Room 22	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	1010.4	26.4	80%	18 °C	22 °C
Room 23	**15.0**	**Single Room**	**12000 BTU/hr (3.51 KWh)**	**SE**	**658**	**43.9**	**80%**	**18 °C**	**22 °C**
Room 24	16.3	Single Room	12000 BTU/hr (3.51 KWh)	S	506	31.0	80%	18 °C	22 °C
Room 25	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SW	735	26.8	80%	18 °C	22 °C
Room 26	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	541	18.4	80%	18 °C	22 °C
Room 27	29.4	Junior Suite	18000 BTU/hr (5.27 KWh)	S	356.5	12.1	80%	18 °C	22 °C
Room 28	27.4	Junior Suite	18000 BTU/hr (5.27 KWh)	SE	833.5	30.4	80%	18 °C	22 °C
Level 3									
Room 29	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	NW	431.6	15.8	80%	18 °C	22 °C
Room 30	29.5	Pent- House Living Room	18000 BTU/hr (5.27 KWh)	N	398.3	13.5	80%	18 °C	22 °C
Room 31	29.5	Pent- House Living Room	18000 BTU/hr (5.27 KWh)	N	402.6	13.6	80%	18 °C	22 °C
Room 32	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	NE	449.1	16.4	80%	18 °C	22 °C
Room 33	17.7	Single Room	12000 BTU/hr (3.51 KWh)	NW	610.8	34.5	80%	18 °C	22 °C
Room 34	17.2	Single Room	12000 BTU/hr (3.51 KWh)	E	540.2	31.4	80%	18 °C	22 °C
Room 35	38.5	Deluxe Double Suite	24000 BTU/hr (7.03 KWh)	SW	578.5	15.0	80%	18 °C	22 °C
Room 36	38.3	Living Room	24000 BTU/hr (7.03 KWh)	E	1053.7	27.5	80%	18 °C	22 °C
Room 37	16.3	Single Room	12000 BTU/hr (3.51 KWh)	SE	528.4	32.4	80%	18 °C	22 °C
Room 38	**15.0**	**Single Room**	**12000 BTU/hr (3.51 KWh)**	**S**	**667.2**	**44.5**	**80%**	**18 °C**	**22 °C**
Room 39	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	SW	781.2	28.5	80%	18 °C	22 °C
Room 40	29.4	Pent- House First Room	18000 BTU/hr (5.27 KWh)	S	594.5	20.2	80%	18 °C	22 °C
Room 41	29.4	Pent- House First Room	18000 BTU/hr (5.27 KWh)	S	619.3	21.1	80%	18 °C	22 °C
Room 42	27.4	Deluxe Suite	18000 BTU/hr (5.27 KWh)	SE	832.4	30.4	80%	18 °C	22 °C
Level 4									
Room 43	37.4	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SW	1189.5	31.8	80%	18 °C	22 °C
Room 44	37.4	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SE	1256.9	33.6	80%	18 °C	22 °C
Room 45	36.1	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SW	1132.4	31.4	80%	18 °C	22 °C
Room 46	36.1	Pent- House Top Room	18000 BTU/hr (5.27 KWh)	SE	1068	29.6	80%	18 °C	22 °C
Totals	1288.4	-	-	-	30696	23.8	-	-	-

T_{in} considering only the window:

$T_{in} = T_{out} + W/H\ (1 - e^{-H/M \times t})$

$T_{in} = 31 + 867.2/\mathbf{22.96}\ (1 - e^{-22.96/4{,}768{,}200 \times 39{,}600})$

$T_{in} = 31 + 867.2/\mathbf{22.96}\ (1 - e^{-0.191})$

$T_{in} = 31 + 867.2/\mathbf{22.96}\ (0.17)$

$T_{in} = 31 + 6.42$

$\mathbf{T_{in} = 37.4\ °C}$

$\mathbf{T_{in} = 36.9\ °C}$

The thermal transmittance ($Q_{transmission}$) difference between the surface areas of the walls and the window are obtained from the following calculations:

A) For the window:

$Q_{transmission} = (A_{window} \times U_{window}) \times (T_{out} - T_{in})$

$Q_{transmission} = (2.00 \times 5.48) \times (31\ °C - 18\ °C)$

$\mathbf{Q_{transmission} = 142.5\ W}$

B) For the walls:

$Q_{transmission} = (A_{wall} \times U_{wall}) \times (T_{out} - T_{in})$

$Q_{transmission} = (18.30 \times 2.14) \times (31\ °C - 18\ °C)$

$\mathbf{Q_{transmission} = 509.1\ W}$

C) Difference:

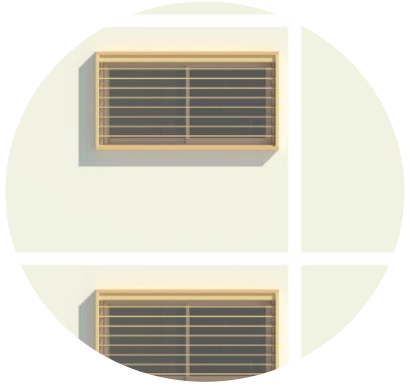
$Q_{transmission}$ = Wall $Q_{transmission}$ - Window $Q_{transmission}$

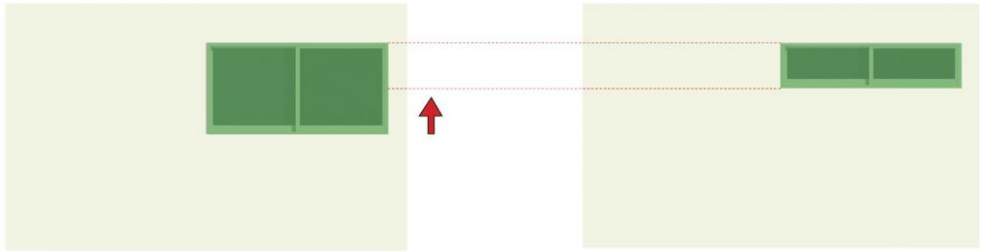
$Q_{transmission} = 509.1\ W - 142.5\ W$

$\mathbf{Q_{transmission} = 366.6\ W}$

PHASE 1

SUSTAINABLE FAÇADE RENOVATION STRATEGIES

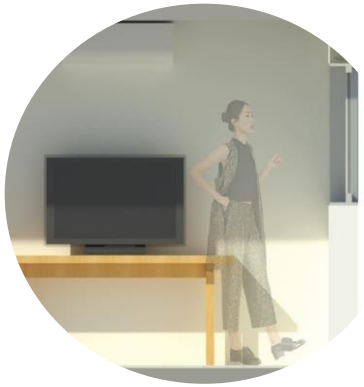




22%

19%

9%



Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 1: APPLICATION OF INDIVIDUAL PASSIVE DESIGN STRATEGIES									
Improvement from single glazed to more efficient double glazed windows									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	510.1	34.0	**8.7**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	605.8	40.4	**7.9**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	614.8	41.0	**7.9**
Addition of exterior shading on the windows									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	434.8	29.0	**22.2**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	512.7	34.2	**22.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	535.6	35.7	**19.7**
Reduction of the Window-to-Wall ratio % (WWR)									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	452.4	30.2	**19.0**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	588.0	39.2	**10.6**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	614.2	40.9	**7.9**

SUSTAINABLE FAÇADE RENOVATION STRATEGIES

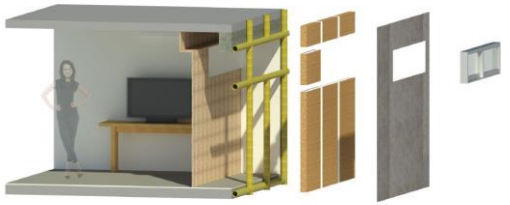
Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 2: APPLICATION OF EXTERNAL SHADING TO OPAQUE SURFACES									
Application of shading overhangs of 0.5 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	384.9	25.7	**31.1**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	457.6	30.5	**30.5**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	473.8	31.6	**29.0**
Application of shading overhangs of 1.0 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	384.7	25.6	**31.2**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	455.3	30.4	**30.8**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	472.4	31.5	**29.2**
Application of shading overhangs of 1.5 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	374.9	25.0	**32.9**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	439.9	29.3	**33.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	458.6	30.6	**31.3**
Application of shading overhangs of 2.0 m long									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	372.1	24.8	**33.4**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	446.5	29.8	**32.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	462.3	30.8	**30.7**

31%

33%

SUSTAINABLE FAÇADE RENOVATION STRATEGIES

Cooling Energy Consumption of Guest Block 16 after Sustainable Façade Renovation Strategies in the Month of August, 2019									
Room	**Size (m^2)**	**Room Type**	**HVAC Capacity (Split Unit)**	**Facades with Mayor Exposure to Solar Radiation**	**Zone Air Sensible Cooling Energy (KWh)**	**Cooling Load per Area (Kwh/m^2)**	**Zone Air Cooling After Strategy (KWh)**	**New Cooling Load per Area (Kwh/m^2)**	**Savings (%)**
PHASE 3: REPLACEMENT OF EXISTING EXTERIOR WALLS WITH SELECTED SUSTAINABLE SANDWICH PANEL WALL									
Replacement of existing exterior cement block-concrete plaster wall with previously evaluated Sandwich Panel Wall (SPW) assembled with Sustainable Materials									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	211.9	14.1	**62.1**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	262.4	17.5	**60.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	273.3	18.2	**59.0**
Addition of external Sustainable Wall Layers to existing exterior cement block-concrete plaster walls									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	192.9	12.9	**65.5**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	236.9	15.8	**64.0**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	240.2	16.0	**64.0**
Addition of Ventilated external Sustainable Wall Layers with Insulation to existing exterior cement block-concrete plaster walls									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	176.7	11.8	**68.4**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	215.5	14.4	**67.2**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	214.4	14.3	**67.9**
Replacement of existing exterior cement block-concrete plaster wall with previously evaluated Sandwich Panel Wall (SPW) assembled with Sustainable Materials									
Room 9	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	558.8	37.3	211.9	14.1	**62.1**
Room 23	15.0	Single Room	12000 BTU/hr (3.51 KWh)	SE	658	43.9	262.4	17.5	**60.1**
Room 38	15.0	Single Room	12000 BTU/hr (3.51 KWh)	S	667.2	44.5	273.3	18.2	**59.0**



62%

66%

68%

	Strategy	Cost unit	Price (EUR)
Phase 1	Double Glazing	m2	190
	Window Shading	m2	118.2
	Window –to-Wall Ratio Reduction to 50%	m2	144.9
Phase 2	Opaque Surface Shading (0.5m)	m1	88.3
	Opaque Surface Shading (1.0m)	m1	148.1
	Opaque Surface Shading (1.5m)	m1	223.9
	Opaque Surface Shading (2.0m)	m1	299.5
Phase 3	Replacement of Existing Wall with SFWP	m2	212
	Addition of Sustainable Wall Layers (SWL)	m2	201
	Addition of Ventilated SWL	m2	201
	Addition of Ventilated SWL without insulation	m2	121

POST-CALCULATIONS

Cooling Energy Demand (in Kwh)						
Room 38						
Strategies	18 °C	19 °C	20 °C	21 °C	22 °C	
Phase 1						
Double Glazing	615	615	501	445	389	34%
Savings Percentage	8%	8%	25%	33%	42%	
Shading	533	477	422	368	314	33%
Savings Percentage	20%	28%	37%	45%	53%	
WWR 50%	614	557	500	443	388	34%
Savings Percentage	8%	16%	25%	34%	42%	
Phase 2						
Overhang 0.5m	474	419	366	313	261	32%
Savings Percentage	29%	37%	45%	53%	61%	
Overhang 1.0m	472	418	365	312	260	32%
Savings Percentage	29%	37%	45%	53%	61%	
Overhang 1.5m	459	405	351	299	247	32%
Savings Percentage	31%	39%	47%	55%	63%	
Overhang 2.0m	462	408	355	302	250	32%
Savings Percentage	31%	39%	47%	55%	63%	
Phase 3						
Replacement of Walls with SFWP*	273	258	242	227	211	9%
Savings Percentage	59%	61%	64%	66%	68%	
Addition of SWL**	240	226	212	198	184	8%
Savings Percentage	64%	66%	68%	70%	72%	
Addition of Ventilated SWL with insulation	220	202	190	178	166	7%
Savings Percentage	68%	70%	72%	73%	75%	
Addition of Ventilated SWL without insulation	270	252	234	216	198	10%
Savings Percentage	60%	62%	65%	68%	70%	

*Sustainable Façade Wall Panel

**Sustainable Wall Layers

without interventions		
Kwh)		
20 °C	21 °C	22 °C
430	365	302
532	470	408
544	481	419
502	439	376
20%	30%	40%

10% Savings increase per 1 °C

FINAL CONCLUSIONS

Achieving cooling energy savings higher than 50% is possible only using passive design strategies and sustainable materials on renovations

Renovation of exterior opaque surfaces have a higher impact on the cooling energy demand than transparent surfaces in these conditions

The strategy of shading both opaque and transparent surfaces provide the best cooling energy savings previous to Phase 3 (Intervention on Wall)

Is possible to save up to 10% in cooling energy per degree Celsius above an operating temperature of 18 °C

The best cost-effective strategy to reduce cooling energy is the addition of ventilated sustainable façade layers without insulation

REFLECTION

The expectations about the results were exceeded

Perhaps using parametric design could've been another alternative to this research

The collection of local data in the Dominican Republic was difficult. Tourism sector is very private with their data

The application of ventilated facades on Tropical Climate are interesting to develop further

Renovation of exterior opaque surfaces have a higher impact on the cooling energy demand than transparent surfaces in these conditions

Quality in wall construction should be improved in the Dominican Republic

Combined Adjusted Cooling Set-point Temperature with Sustainable Renovation Strategies

Combined renovation strategy according to investor's budget

FUTURE DEVELOPMENT

Further evaluation on the other Guest Buildings

Other cooling energy lower-impact areas of Coastal Hotels could be evaluated (Lobby – Offices – Restaurants)

Other materials could be tested in the calculations and other type of wall panels assembly can be evaluated

Evaluation on operation of other models of AC can be calculated

Intervention on roof design

Venturing of local businesses in harvesting, manufacturing and installation of sustainable materials


THANK YOU