



FLORIDA SOLAR ENERGY CENTER

Creating Energy Independence Since 1975

Developing Exhaust Air Energy Recovery Credits for the Florida Energy Code

Final Report

Bereket Nigusse & Muthusamy Swami

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Contract Overview

- Start date: Nov 3, 2014
- End date: June 1, 2015
- Deliverables:
 - Interim Report: delivered
 - Final Report: delivered
 - Recommendation: delivered



Objective

Update Energy Recovery Ventilator (ERV) device Credits used for commercial code compliance calculation. Current code uses 6.0% for climate zone 1 and 4.0% for climate zone 2.



Energy Calculation Metrics

□ Annual Energy Use Intensity (EUI)

[kBtu/ft²/yr]

□ Annual HVAC Energy Use Savings

[kBtu/ft²/yr]

$$HVACEnergyUse_{Savings} = HVACEnergyUse_{withoutERV} - HVACEnergyUse_{withERV}$$

□ Annual HVAC Energy Use Percent Savings

$$HVACEnergySavings = 100 \left(\frac{HVACEnergyUse_{withoutERV} - HVACEnergyUse_{withERV}}{HVACEnergyUse_{withoutERV}} \right)$$



Task Summary

- Identify Major Florida Cities
- Identify Prototype Buildings
- Computer Simulation
- Energy Savings Calculation
- Update ERV Credit
- Sensitivity Analysis
- Recommendation



Identify Major Florida Cities

- ❑ Identified six cities in climate zone 1 and 2
- ❑ Miami for Climate Zone 1 and Five Cities for climate zone 2 (Tampa, Orlando, Jacksonville, Gainesville, and Tallahassee)
- ❑ Determined annual energy use for the climate zone 2 cities for each of the prototype buildings
- ❑ Jacksonville and Gainesville has annual energy use within 1.0% of each other
- ❑ Decided to keep the six cities for this study



Prototype Buildings

Fully Modeled Prototype Buildings

- Small Size Office
- Medium Size Office
- Large Size Office
- Standalone Retail
- Primary School
- Secondary School
- Hospital
- Large Size Hotel
- Small Size Hotel



Prototype Buildings

Modeled Buildings: without sensitivity analysis

- Outpatient Health Care**
- Retail Strip Mall**
- Warehouse**



Prototype Buildings

Not ERV Applicable Buildings:

- Restaurant Fast Food
- Restaurant Sit-Down

Not Modeled Buildings:

- Apartment Mid Rise
- Apartment High Rise



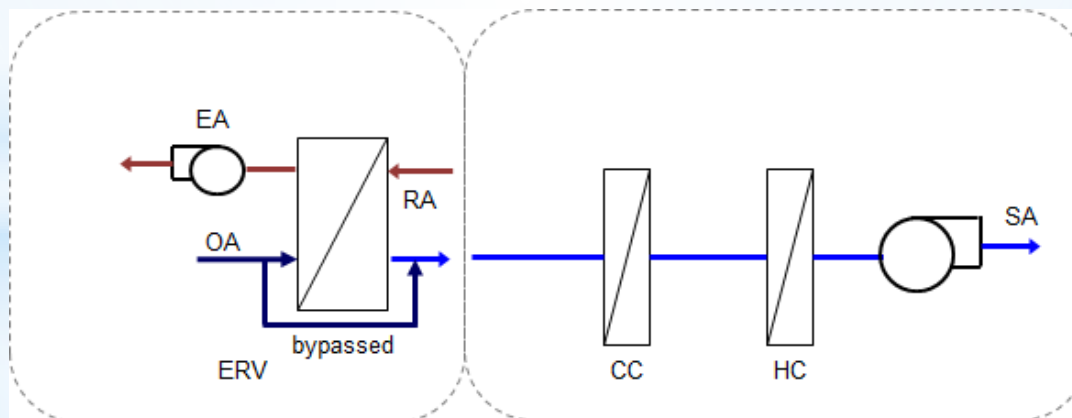
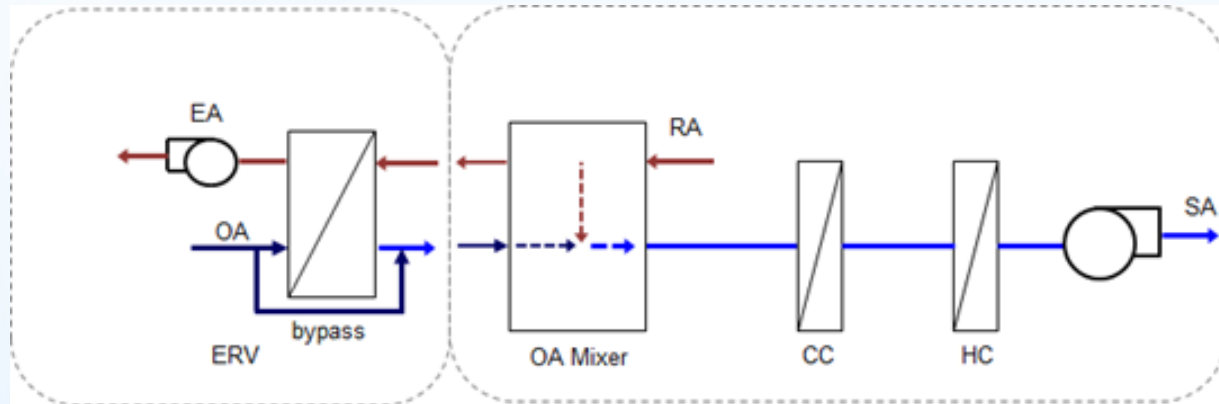
Computer Simulation

- ❑ Modified prototype buildings
- ❑ Created HVAC systems with and without ERV
- ❑ Performed sizing calculation
- ❑ Obtained effectiveness and pressure drop data (AHRI certified database)
- ❑ Created automated input file processor tool
- ❑ Simulation
- ❑ Analyzed results & reviewed assumptions
- ❑ Alternative Configurations



Computer Simulation

System Configurations



Computer Simulation

ERV Inputs Assumption: Medium Size Office Building

ERV Name	Nominal Supply Air Flow Rate [m3/s]	Nominal Supply Air Flow Rate [cfm]	ERV/HRV Device Type	ERV/HRV Auxiliary Power, W	ERV/HRV ΔP , Pa (AHRI 1060)	Fan Total Efficiency	Fan Motor Efficiency	Fan ΔP Adjustment, Pa (ASHRAE 90.1)
VAV_BOT OA HR	1.102	2,335	Wheel	256.5	212.5	0.55	0.820	271.0
VAV_MID OA HR	1.195	2,532	Wheel	256.5	212.5	0.55	0.820	271.0
VAV_TOP OA HR	1.195	2,532	Wheel	256.5	212.5	0.55	0.820	271.0

ERV Name	100% Heating ϵ_s	100% Heating ϵ_l	75% Heating ϵ_s	75% Heating ϵ_l	100% Cooling ϵ_s	100% Cooling ϵ_l	75% Cooling ϵ_s	75% Cooling ϵ_l
VAV_BOT OA HR	0.72	0.64	0.76	0.68	0.72	0.64	0.77	0.68
VAV_MID OA HR	0.72	0.64	0.76	0.68	0.72	0.64	0.77	0.68
VAV_TOP OA HR	0.72	0.64	0.76	0.68	0.72	0.64	0.77	0.68



Computer Simulation

Two sets of simulation were conducted

- ❑ With and without fan pressure adjustment
- ❑ Fan pressure adjustment was applied to reference building
- ❑ 2014 Florida Energy Code Section C403.2.10 allows fan pressure adjustment due to ERV
- ❑ Two sets of results were determined
- ❑ Results with fan pressure adjustment were used for ERV Credit calculation



Energy Savings Calculation

□ Annual HVAC Energy Use Savings

$$HVACEnergyUse_{Savings} = HVACEnergyUse_{withoutERV} - HVACEnergyUse_{withERV}$$

□ Annual HVAC Energy Use Percent Savings

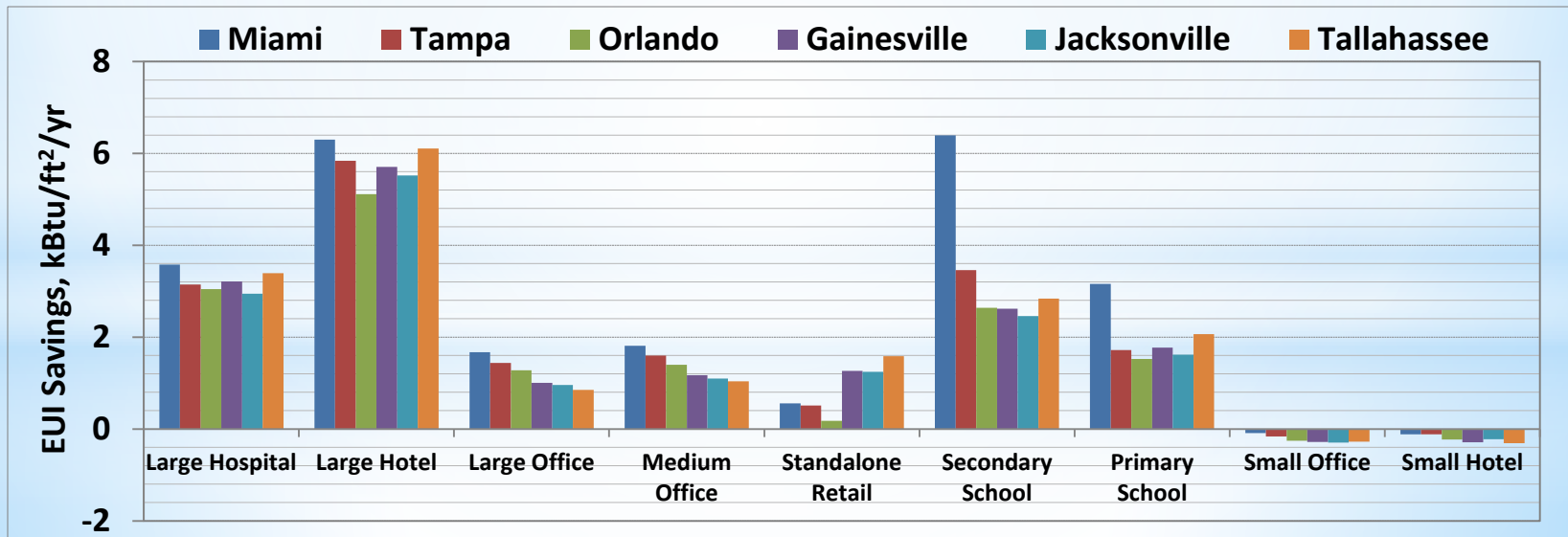
$$HVACEnergySavings = 100 \left(\frac{HVACEnergyUse_{withoutERV} - HVACEnergyUse_{withERV}}{HVACEnergyUse_{withoutERV}} \right)$$



Results: Energy Savings

Annual HVAC Energy savings without fan pressure adjustment (kBtu/ft²/Yr)

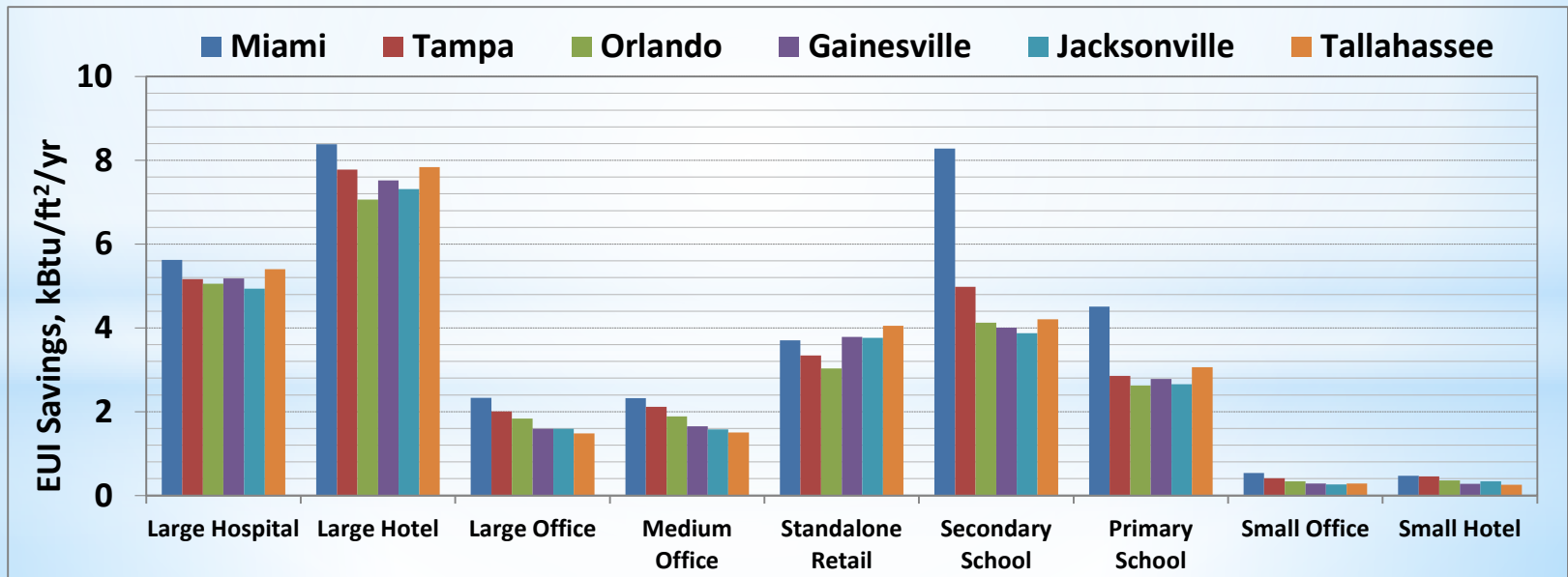
Cities	Large Hospital	Large Hotel	Large Office	Medium Office	Standalone Retail	Secondary School	Primary School	Small Office	Small Hotel
Miami	3.58	6.30	1.67	1.81	0.56	6.39	3.16	-0.09	-0.12
Tampa	3.15	5.84	1.44	1.60	0.52	3.46	1.72	-0.16	-0.11
Orlando	3.04	5.11	1.28	1.40	0.18	2.64	1.53	-0.26	-0.23
Gainesville	3.21	5.71	1.00	1.18	1.27	2.62	1.77	-0.28	-0.29
Jacksonville	2.94	5.52	0.96	1.10	1.25	2.46	1.62	-0.30	-0.22
Tallahassee	3.40	6.11	0.85	1.04	1.58	2.84	2.06	-0.27	-0.31



Results: Energy Savings

Annual HVAC Energy savings with fan pressure adjustment (kBtu/ft²/Yr)

Cities	Large Hospital	Large Hotel	Large Office	Medium Office	Standalone Retail	Secondary School	Primary School	Small Office	Small Hotel
Miami	5.63	8.39	2.33	2.32	3.70	8.28	4.51	0.53	0.47
Tampa	5.16	7.78	2.00	2.11	3.34	4.98	2.86	0.41	0.45
Orlando	5.05	7.06	1.84	1.89	3.03	4.13	2.62	0.33	0.36
Gainesville	5.18	7.52	1.59	1.65	3.79	4.01	2.78	0.28	0.28
Jacksonville	4.94	7.31	1.59	1.58	3.76	3.87	2.66	0.27	0.34
Tallahassee	5.40	7.84	1.48	1.51	4.05	4.20	3.06	0.29	0.26



Results: ERV Credits

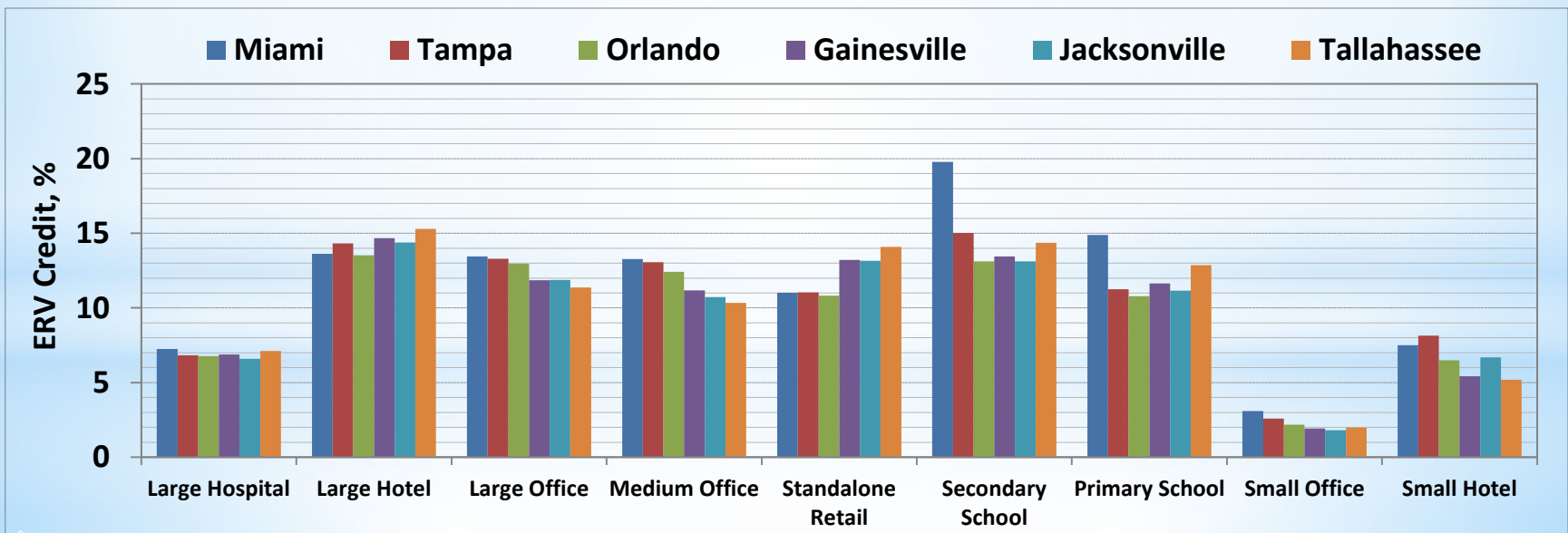
- ❑ ERV Credit Definition: annual cooling and heating energy savings in percent.
- ❑ Annual energy savings due to ERV device installation is estimated as the annual cooling and heating energy use of a building without ERV device times the ERV Credit.
- ❑ The annual cooling and heating energy is the electric and gas energy used to provide cooling and heating.



Results: ERV Credits

ERV Credit (%): by building types and climate zones

Cities	Large Hospital	Large Hotel	Large Office	Medium Office	Standalone Retail	Secondary School	Primary School	Small Office	Small Hotel
Miami	7.24	13.62	13.45	13.28	11.01	19.78	14.88	3.09	7.50
Tampa	6.82	14.32	13.30	13.05	11.03	15.02	11.25	2.59	8.13
Orlando	6.76	13.53	12.96	12.41	10.83	13.11	10.78	2.17	6.49
Gainesville	6.89	14.67	11.85	11.18	13.22	13.45	11.63	1.92	5.41
Jacksonville	6.59	14.38	11.88	10.72	13.16	13.12	11.16	1.81	6.70
Tallahassee	7.11	15.29	11.37	10.35	14.09	14.35	12.86	1.98	5.20



Sensitivity Analysis

Sensitivity of ERV Credit to uncertainty in the ERV inputs assumption:

❑ ERV effectiveness

- Changed the design value by 10.0%

❑ ERV pressure drop

- Changed pressure drop proportional to the effectiveness change

$$\Delta P = 2.2 \cdot \varepsilon - 0.5$$

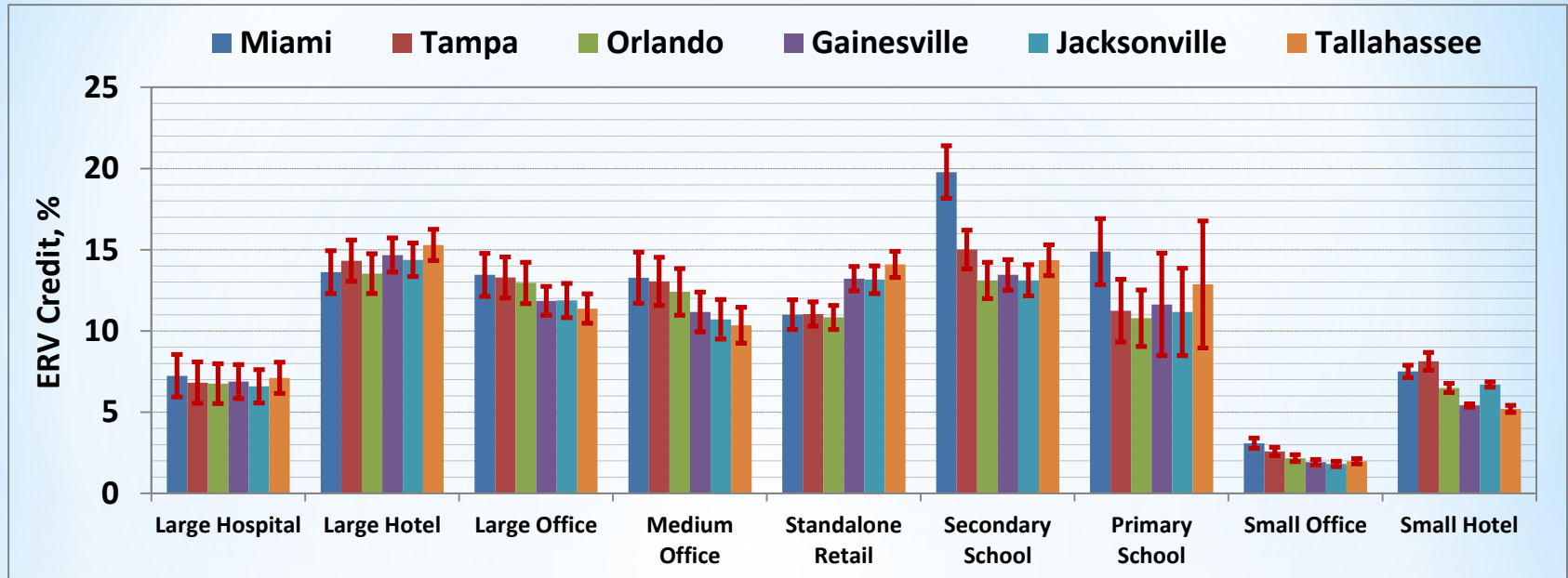
❑ Impacts of inputs uncertainties

- Combined impact of inputs uncertainty using error propagation formula



Results: Sensitivity Analysis

ERV Credit sensitivity to effectiveness uncertainty



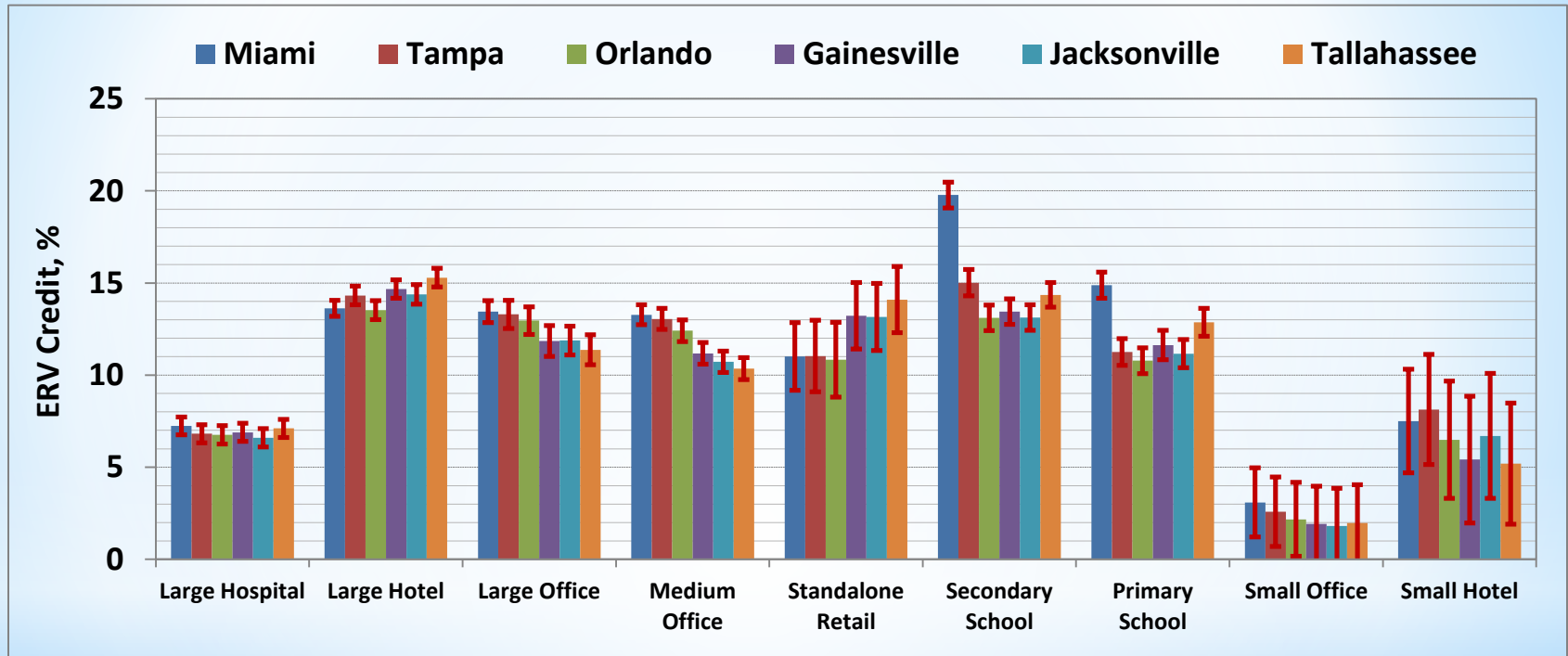
ERV Credit sensitivity by building type and climate zone

Climate Zones	Large Hospital	Large Hotel	Large Office	Medium Office	Standalone Retail	Secondary School	Primary School	Small Office	Small Hotel
1	1.32	1.32	1.33	1.57	0.92	1.62	2.03	0.31	0.39
2	1.11	1.11	1.08	1.29	0.78	1.03	2.69	0.19	0.16



Results: Sensitivity Analysis

ERV Credit sensitivity to pressure drop uncertainty



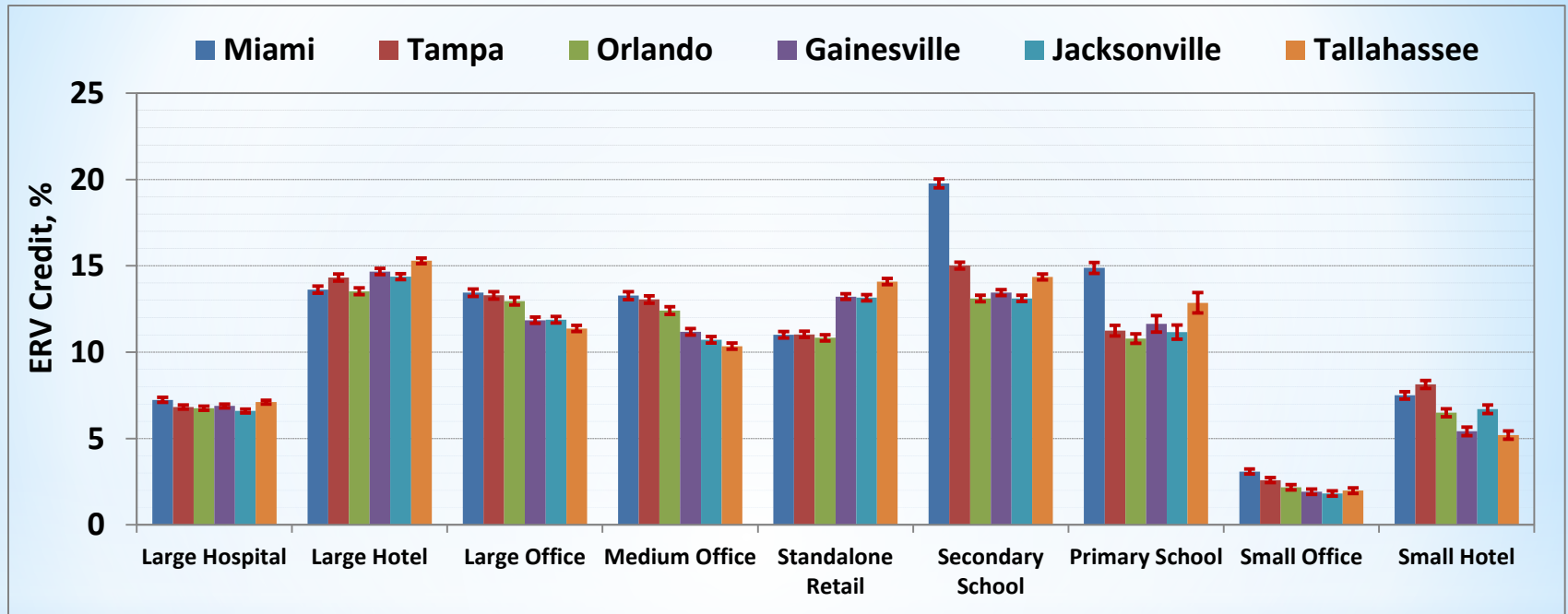
ERV Credit sensitivity by building type and climate zone

Climate Zones	Large Hospital	Large Hotel	Large Office	Medium Office	Standalone Retail	Secondary School	Primary School	Small Office	Small Hotel
1	0.49	0.44	0.60	0.54	1.83	0.70	0.71	1.88	2.81
2	0.50	0.51	0.79	0.58	1.88	0.69	0.75	2.01	3.26



Recommendation

ERV Credit sensitivity for 1.0% effectiveness change



ERV Credit sensitivity for 1.0% change in design cooling effectiveness

Climate Zones	Large Hospital	Large Hotel	Large Office	Medium Office	Standalone Retail	Secondary School	Primary School	Small Office	Small Hotel
1	0.14	0.21	0.21	0.23	0.19	0.26	0.32	0.15	0.21
2	0.11	0.18	0.20	0.20	0.17	0.18	0.41	0.15	0.24



Recommendation

ERV Credit by Building Types and Climate Zones

Building Types	Floor Area Limits, ft ²	ERV Design Cooling Effectiveness ϵ , %	ERV Credit Climate Zone 1, %	ERV Credit Correction per 1.0% effectiveness, Climate Zone 1	ERV Credit Climate Zone 2, %	ERV Credit Correction per 1.0% effectiveness, Climate Zone 2
Hospital	-	67.0	7.24	0.14	6.83	0.11
Large Hotel	≥100,000	67.0	13.62	0.21	14.44	0.18
Small Hotel	<100,000	69.0	7.50	0.21	6.39	0.24
Large Office	≥100,000	68.0	13.45	0.21	12.27	0.20
Medium Office	≥50,000	72.0	13.28	0.23	11.54	0.20
Small Office	<50,000	67.0	3.09	0.15	2.09	0.15
Standalone Retail	-	70.0	11.01	0.19	12.47	0.17
Primary School	-	68.0	14.88	0.26	11.54	0.18
Secondary School	-	68.0	19.78	0.32	13.81	0.41
Warehouse	-	65.0	6.19	0.15	7.40	0.15
Retail Strip Mall	-	65.0	8.11	0.19	10.76	0.17
Outpatient Health Care	-	65.0	7.75	0.14	5.62	0.11
Others	-	-	6.0	-	4.0	-



ERV Credit Application

Modify the ERV Credits for design cooling effectiveness different from the reference values in the Table Provided by Building Types and Climate Zones. The ERV Credit correction are provided for every 1.0% design cooling effectiveness deviation from the reference values in the Table.

- **ERV Credit Adjustment:**

$$ERV_{Credit}^{Adjusted} = ERV_{Credit}^{Table} + \left(\varepsilon_{CoolingProposed} - \varepsilon_{CoolingTable} \right) \cdot ERV_{Credit}^{Correction}$$

- **Annual Energy Savings due to ERV device:**

$$HVAC_{EnergyUse}^{Savings} = \left(\frac{ERV_{Credit}^{Adjusted}}{100} \right) \cdot HVAC_{EnergyUse}^{withoutERV}$$



Thank you
Questions?

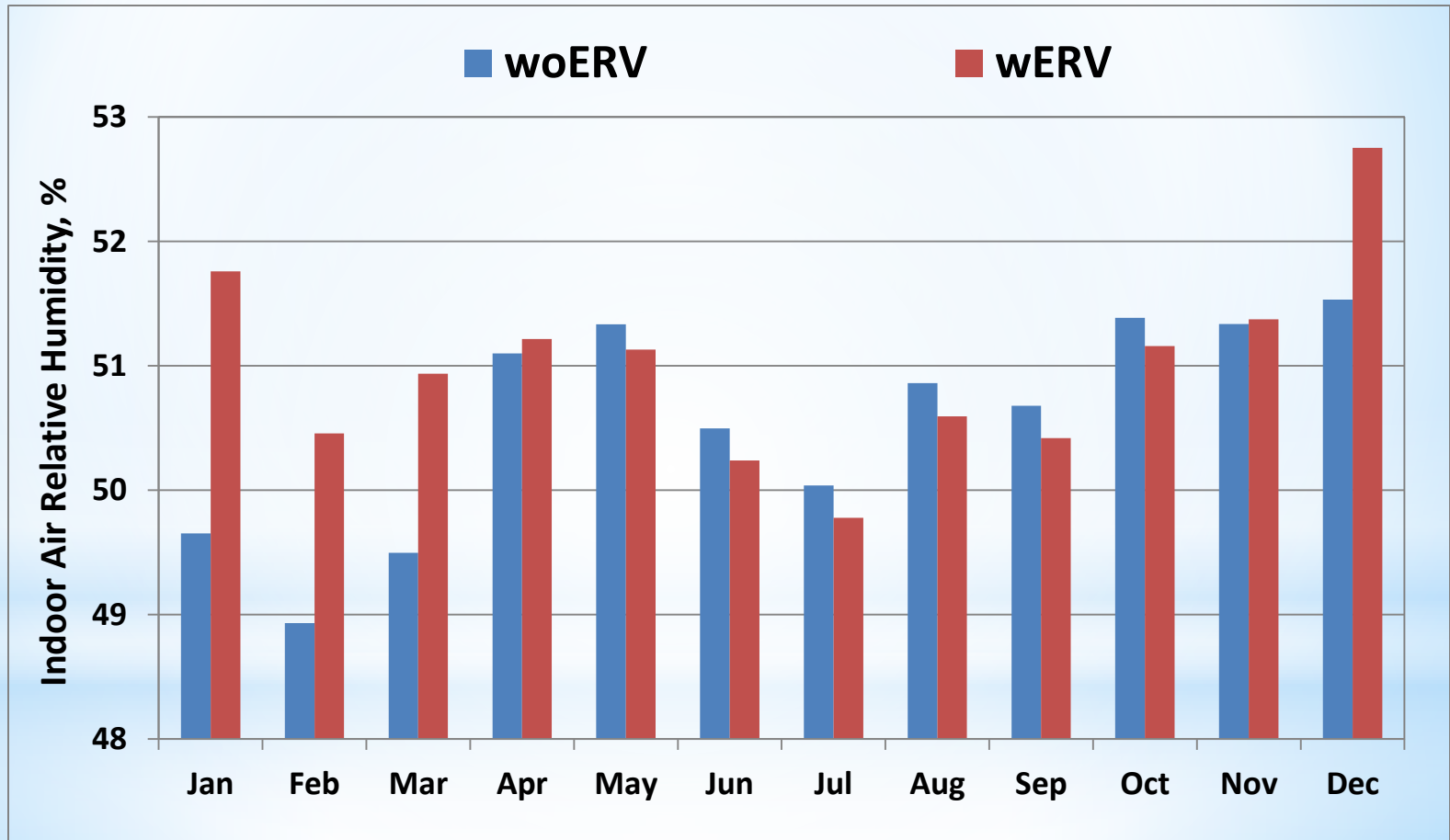


Additional Supporting Slides



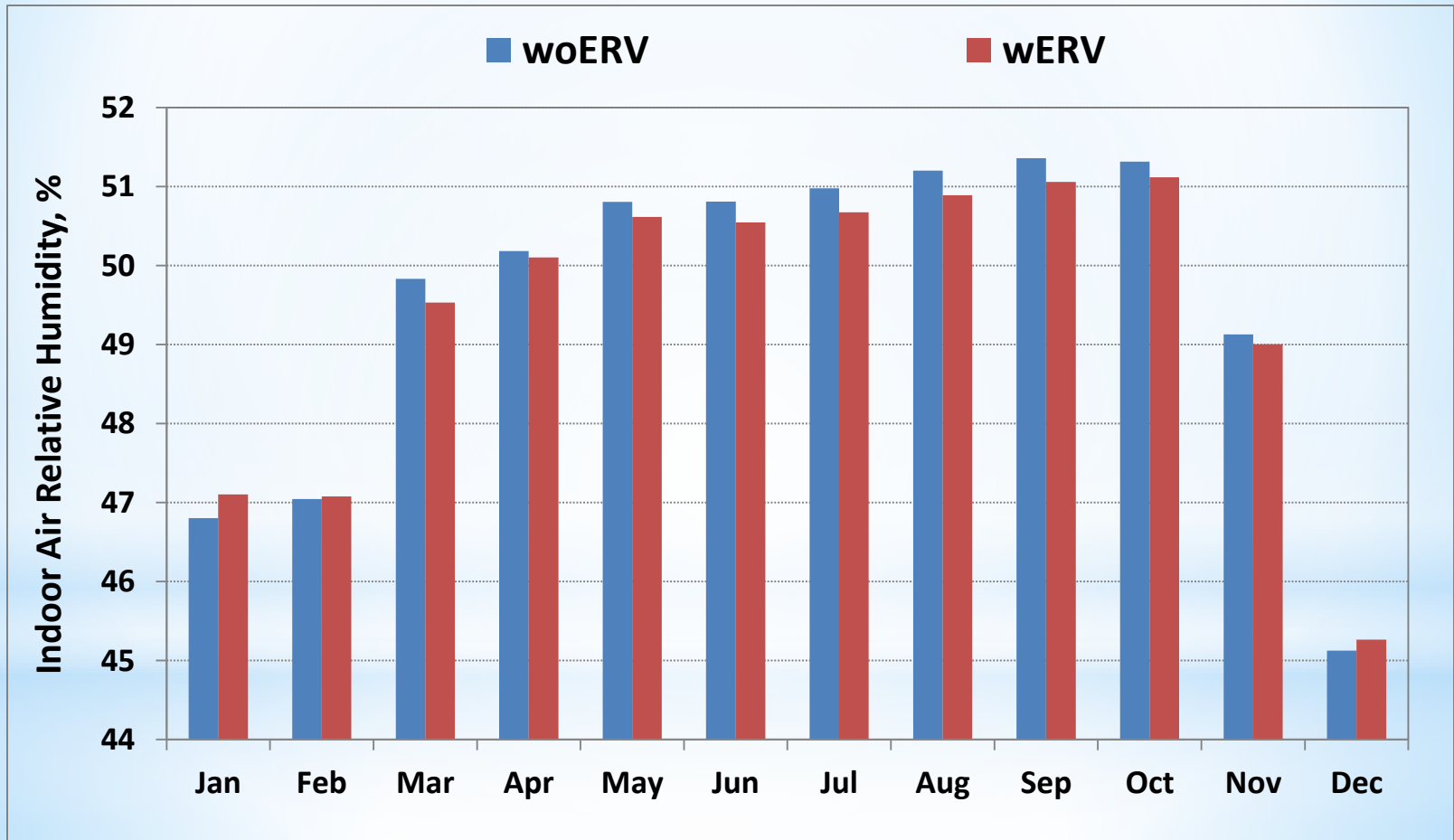
Indoor Relative Humidity

Large Office Building Average Indoor Relative Humidity-Miami



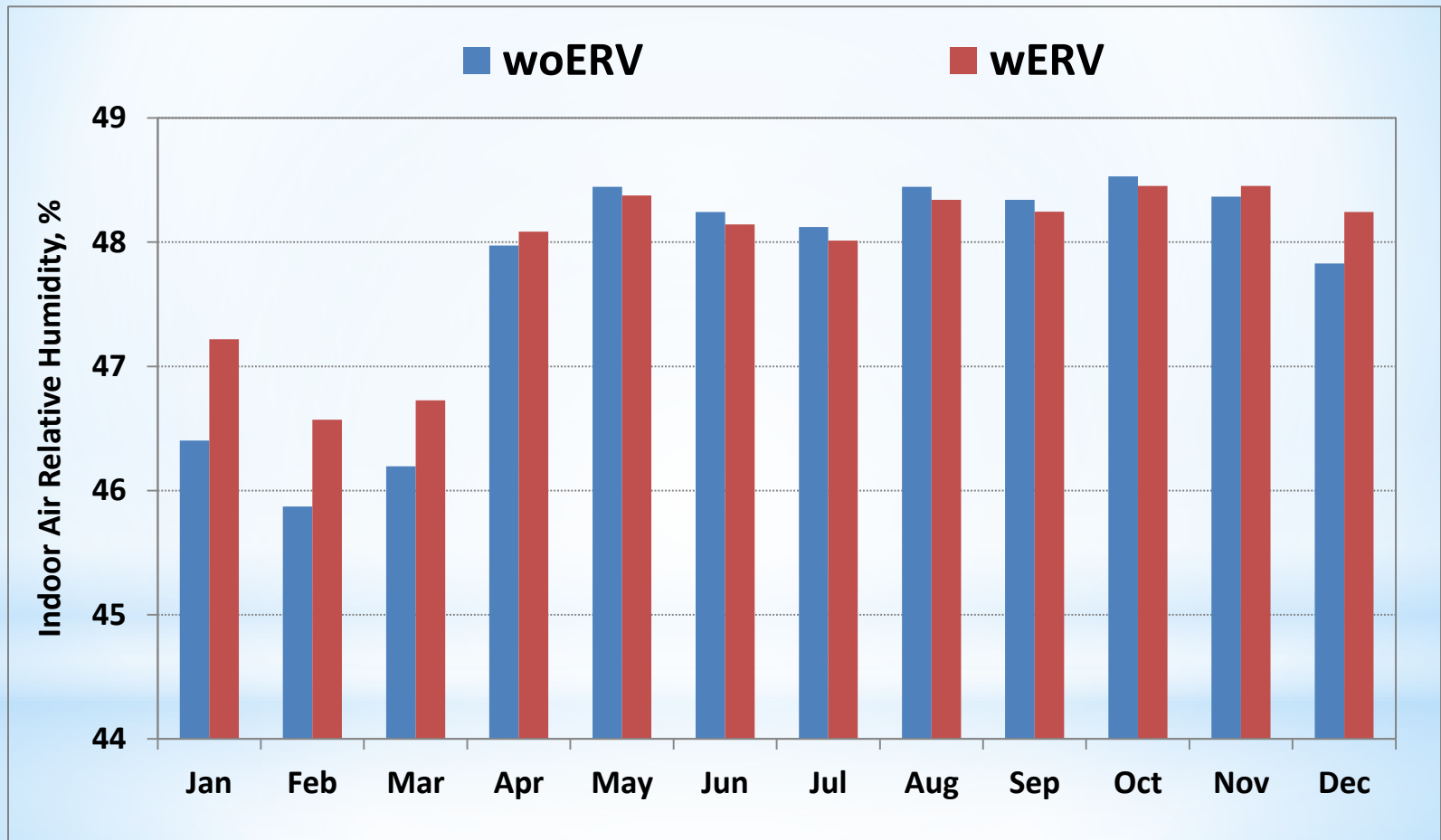
Indoor Relative Humidity

Large Office Building Average Indoor Relative Humidity-Tampa



Indoor Relative Humidity

Hospital Building Average Indoor Relative Humidity-Miami



Indoor Relative Humidity

Hospital Building Average Indoor Relative Humidity-Tampa

