Energy Consumption Simulation and Construction Cost Analysis for Wood and Steel Framing System in Florida Residential Housing – Case Study

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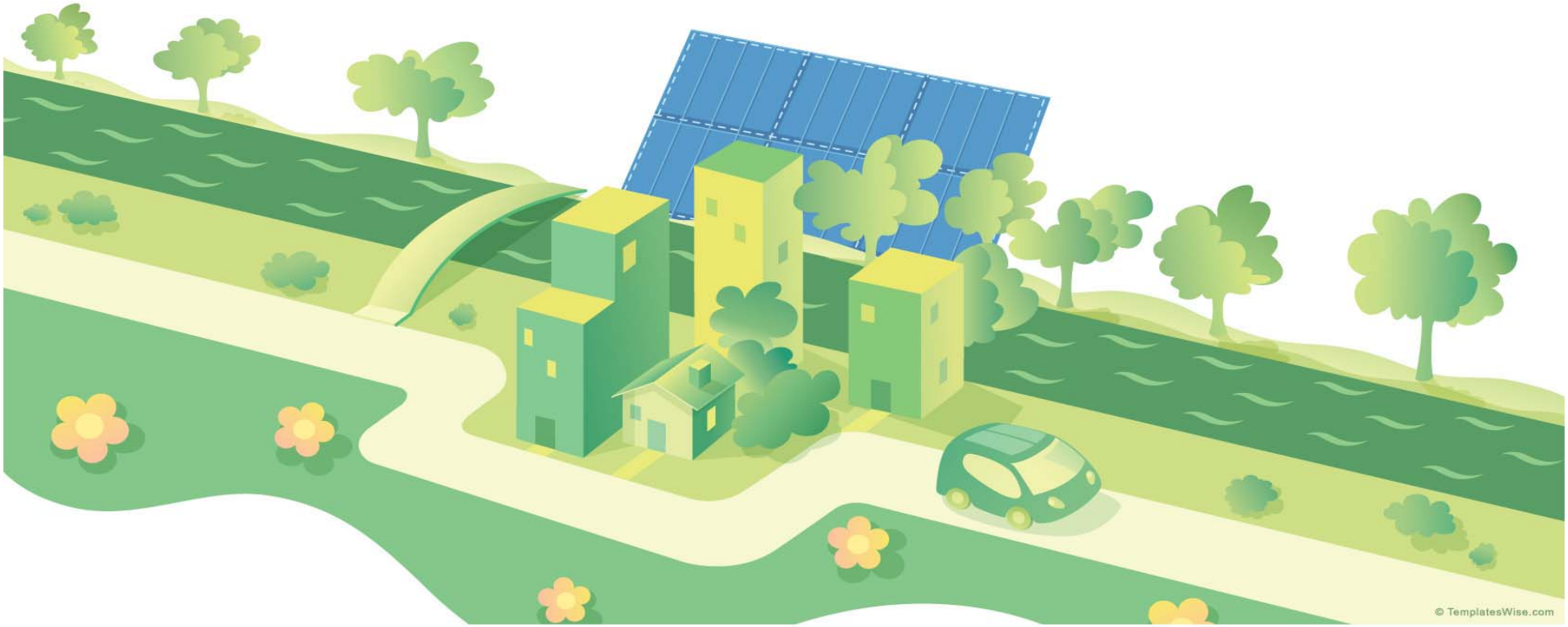
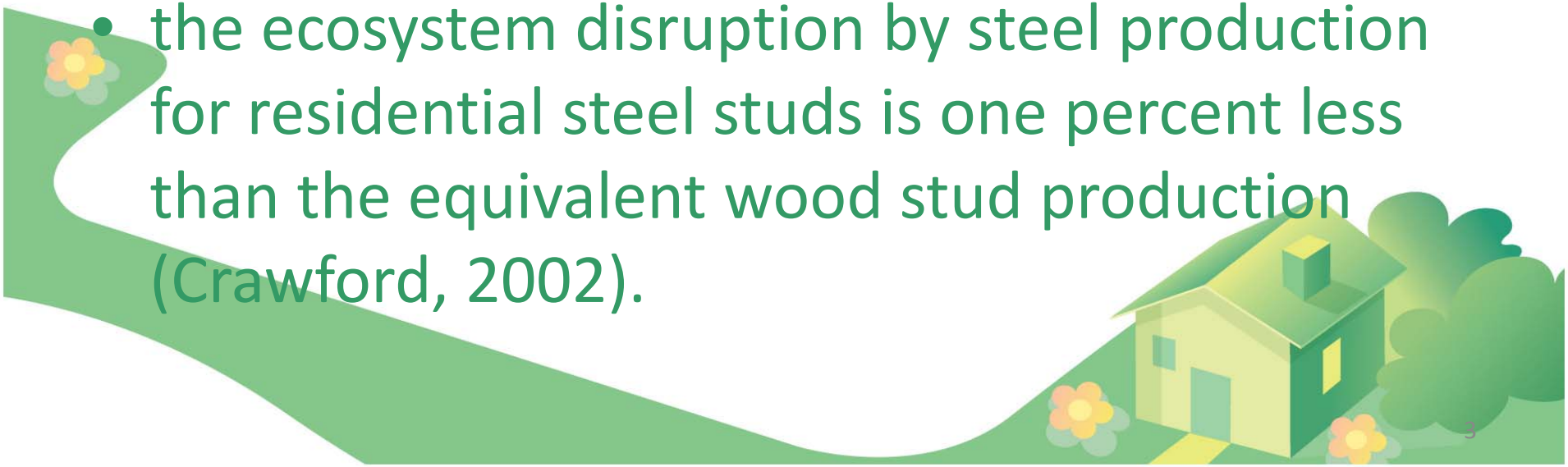


Agenda

- Background
- Introduction to the base case
- Methodology
- Energy consumption and construction cost analysis
- Conclusion

Background

- steel stud framing offers some advantages for its fundamental characteristics
- the ecosystem disruption by steel production for residential steel studs is one percent less than the equivalent wood stud production (Crawford, 2002).



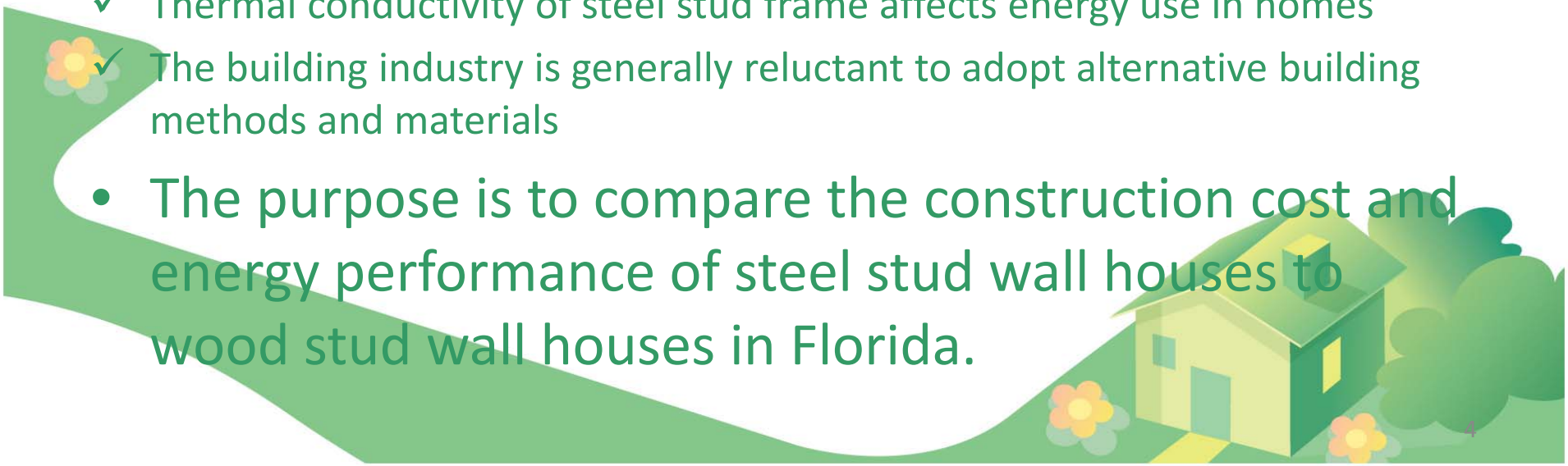
Background

- barriers that impede its adoption in the residential market

✓ Thermal conductivity of steel stud frame affects energy use in homes

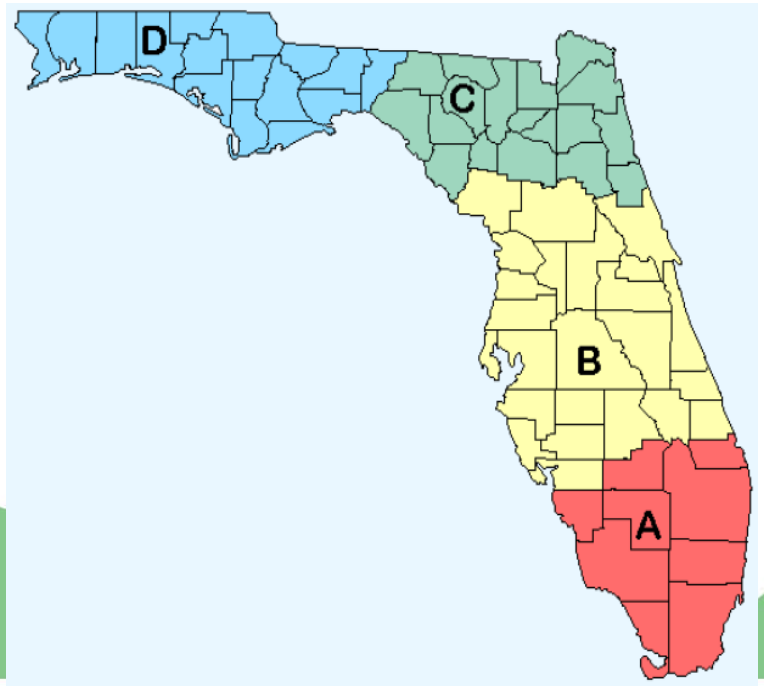
✓ The building industry is generally reluctant to adopt alternative building methods and materials

- The purpose is to compare the construction cost and energy performance of steel stud wall houses to wood stud wall houses in Florida.

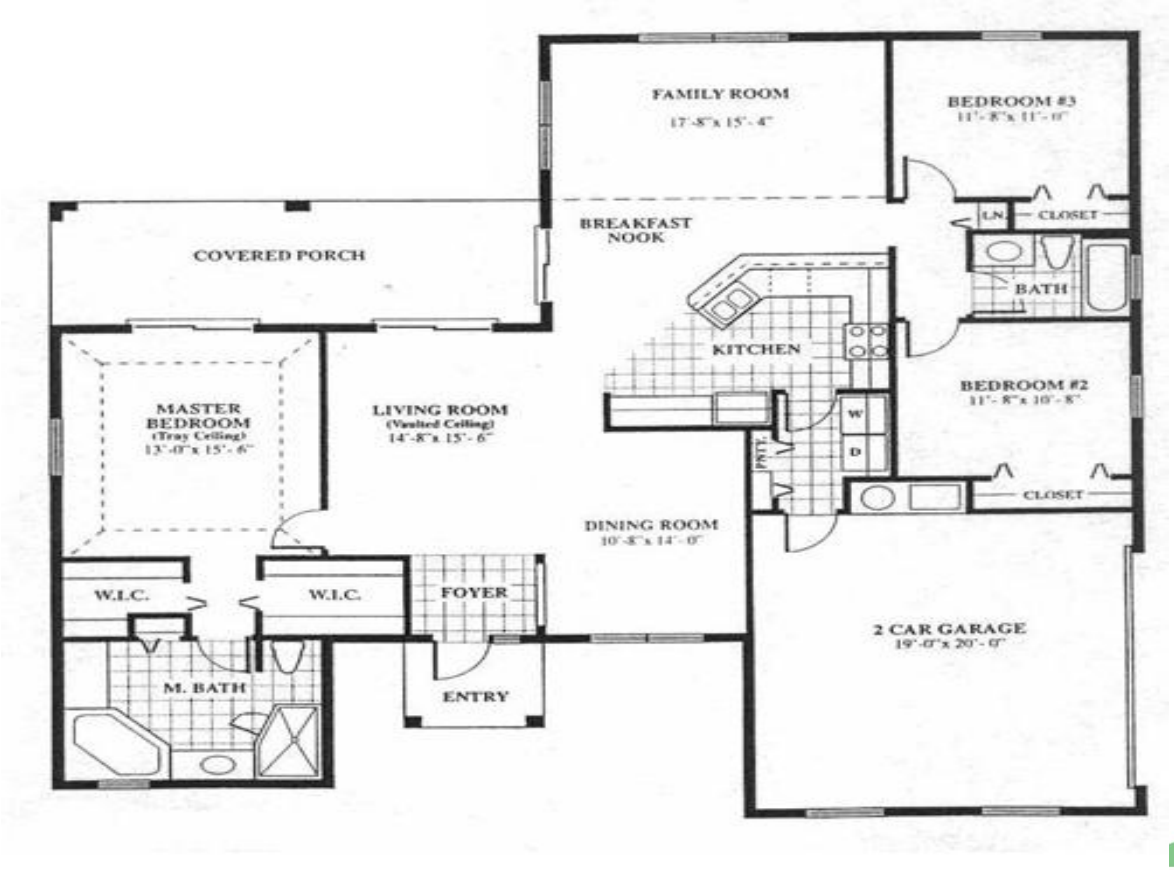


Background

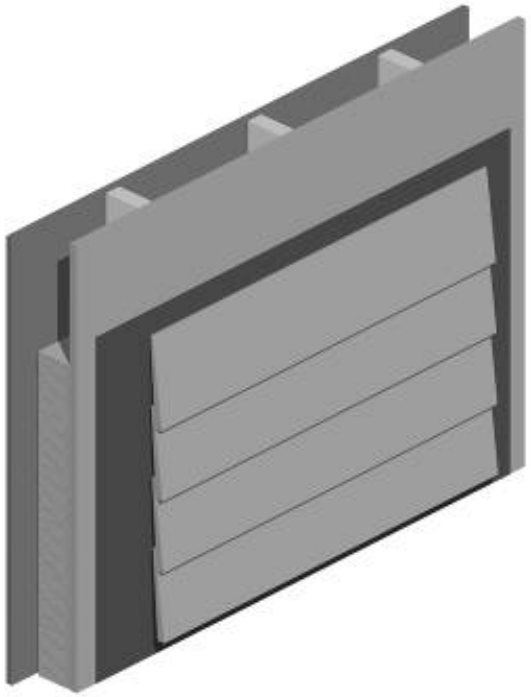
- weather and environmental variations



Introduction to the base case



Introduction to the base case



Building Envelope Details of Wood and Steel Wall Frame House

Wood Frame Wall	Steel Frame Wall	Attic and Roof	Slab on grade
Wood stud @ 16”	Steel stud @ 24”	Asphalt fiberglass roofing shingle	8” Concrete slab
Cavity Insulation R-13	Cavity Insulation R-13	1” wood decking	¼” Underlay cushion
Interior Drywall-1/2" Gypsum	Interior Drywall-1/2" Gypsum	Roof insulation	3/8” Carpet
Exterior Sheathing: 7/16" OSB	Exterior Sheathing: 7/16" OSB	Ceiling 1/2" Gypsum	
Siding Materials: Wood Siding	Siding Materials: Wood Siding		

Methodology-Cost Data

- NAHB (National Association of Home Builders) Research Center (2002) conducted construction cost comparison between wood frame house and steel frame house.

Structural Wall Framing Productivity and Cost				
House	**Hours per Foot of Wall Length (hours/ft)**	**Material Cost per Foot of Wall Length ($/ft)**	**Labor Cost per Foot of Wall Length ($/ft)**	**Total Cost per Foot of Wall Length ($/ft)**
Steel stud	0.49	$13.36	$20.34	$33.70
Wood stud	0.38	$8.21	$11.82	$20.03
Non-structural Wall Framing Productivity and Cost				
House	**Hours per Foot of Wall Length (hours/ft)**	**Material Cost per Foot of Wall Length ($/ft)**	**Labor Cost per Foot of Wall Length ($/ft)**	**Total Cost per Foot of Wall Length ($/ft)**
Steel stud	0.21	$3.46	$8.88	$12.36
Wood stud	0.30	$3.09	$9.40	$12.49

Methodology-Cost Data

- $C_i = LF_i / LF_B \times C_B$ (Equation 1)

Where:

C_B : the cost of Beaufort, South Carolina

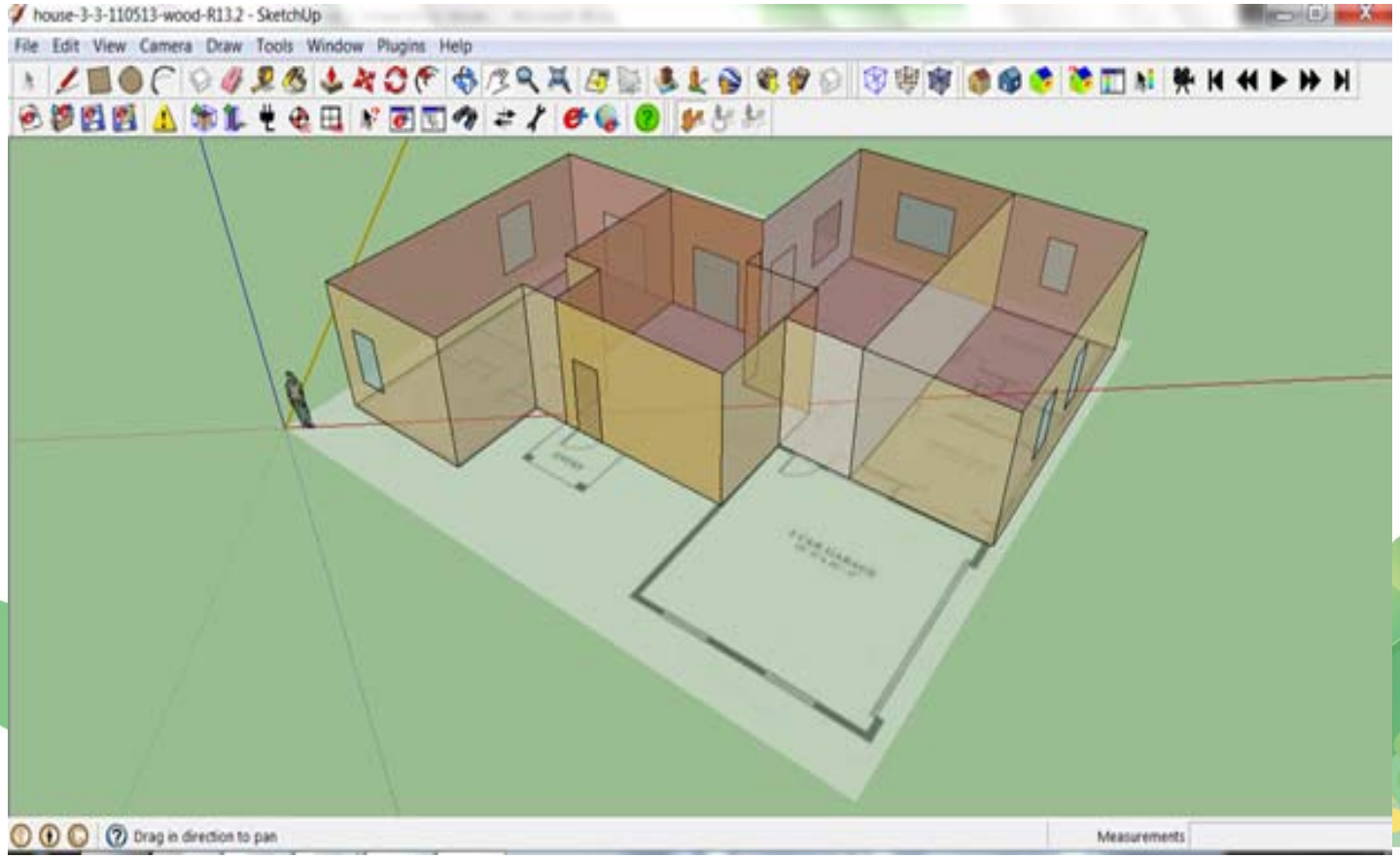
C_i : the cost of the studied city (Jacksonville, Miami, Orlando, and Tallahassee)

LF_B : the location factor of Beaufort, South Carolina

LF_i : the location factor of the studied city

City	Beaufort, South Carolina	Jacksonville, Florida	Miami, Florida	Orlando, Florida	Tallahassee, Florida
Material	96.6	98.5	98.0	100.3	98.8
Installation	39.6	64.2	70.6	65.8	52.3
Total	68.7	81.7	84.5	83.4	76.0

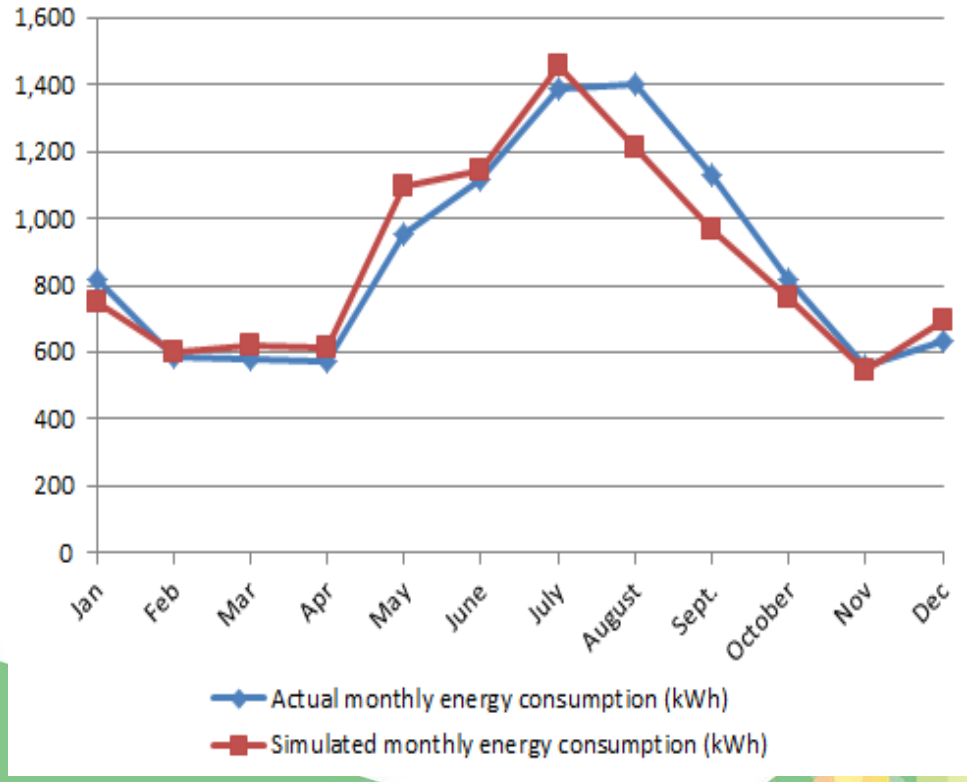
Methodology-Geometric Modeling



Methodology-Material and Thermal Features Modeling

Parameters	Thickness (in.)	Thermal Conductivity (BTU-in/h-s)	Thermal Resistance (R Value)	Total R Value
wood stud wall frame				
Wood stud @ 16” with cavity insulation R-13			10.189	13.215
Interior Drywall-1/2" Gypsum	0.5	1.11	0.451	
Exterior Sheathing: 7/16" OSB	0.438	0.212	2.059	
Siding Materials: Wood Siding	0.394	0.763	0.516	
steel stud wall frame				
Steel stud @ 24” with cavity insulation R-13			6.374	9.4
Interior Drywall-1/2" Gypsum	0.5	1.11	0.451	
Exterior Sheathing: 7/16" OSB	0.438	0.212	2.059	
Siding Materials: Wood Siding	0.394	0.763	0.516	

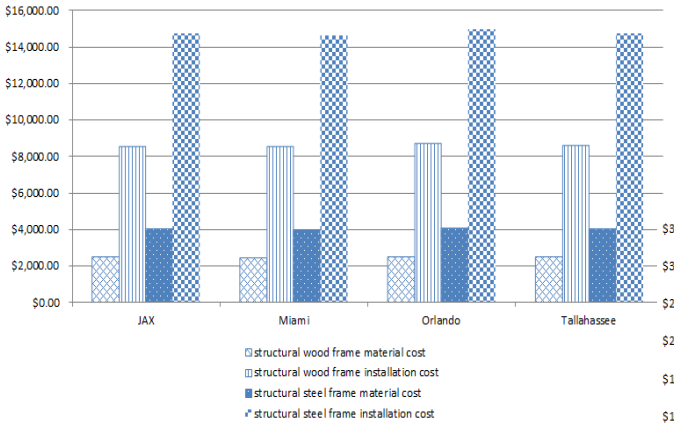
Methodology-Model Assessment

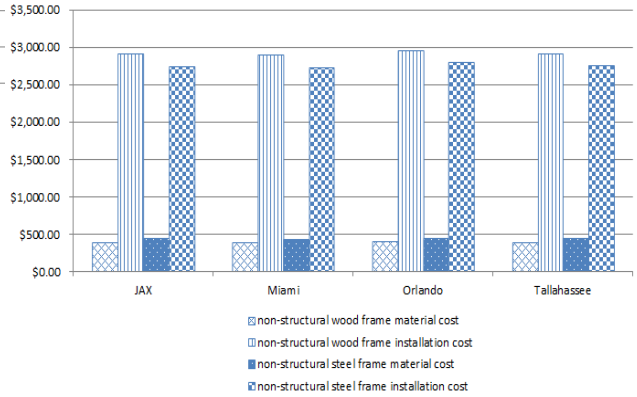


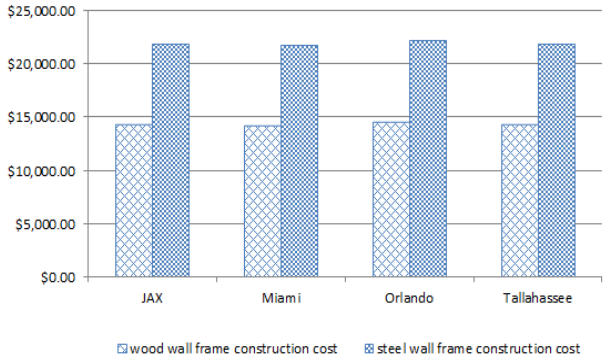
Methodology-Model Assessment

Month	Actual Energy Consumption (kWh)	Simulated Energy Consumption		Energy Consumption Difference (kWh)	Energy Consumption Difference in %
		GJ	kWh		
Jan	815	2.69	748.56	66.44	8.15%
Feb	586	2.16	598.77	-12.77	-2.18%
Mar	577	2.23	620.67	-43.67	-7.57%
Apr	573	2.21	613.27	-40.27	-7.03%
May	954	3.95	1,097.46	-143.46	-15.04%
June	1,120	4.11	1,142.98	-22.98	-2.05%
July	1,388	5.24	1,455.94	-67.94	-4.89%
Aug	1,401	4.37	1,212.59	188.41	13.45%
Sept	1,131	3.48	966.39	164.61	14.55%
Oct	820	2.74	760.56	59.44	7.25%
Nov	560	1.97	546.18	13.82	2.47%
Dec	637	2.50	693.64	-56.64	-8.89%
Total	10,533	37.65	10,457.01	75.73	0.72%

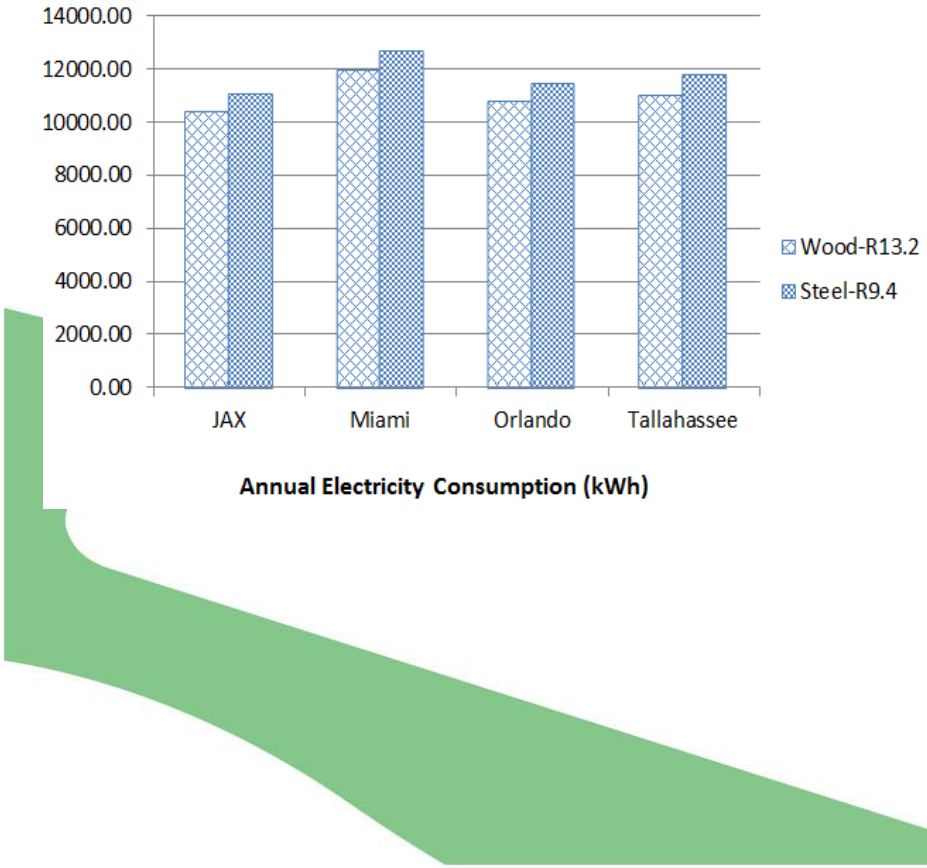
Construction Cost Analysis

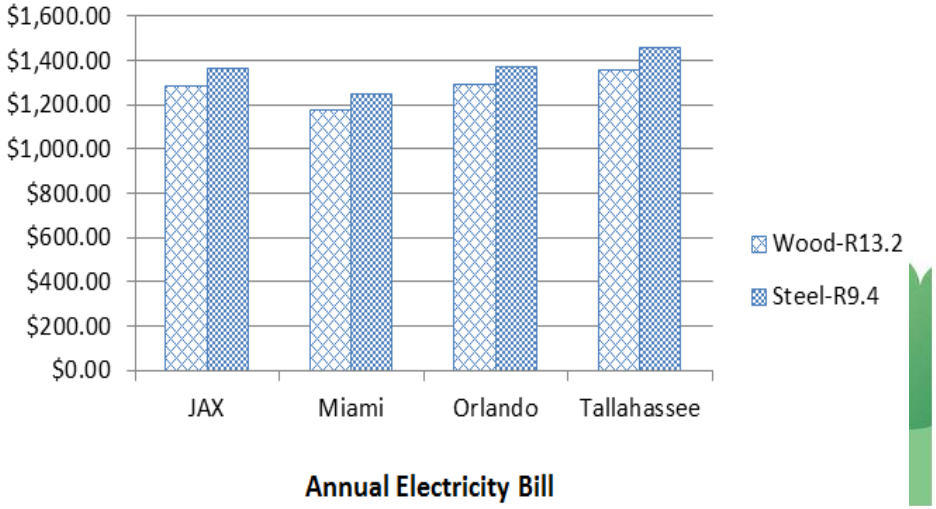






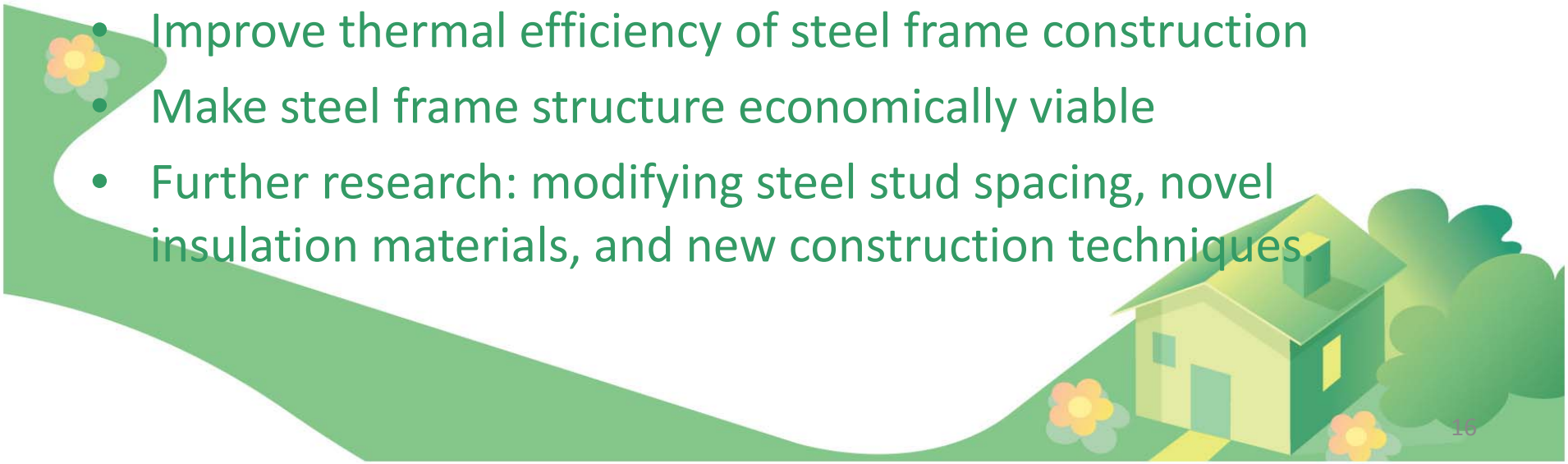
Energy Consumption Analysis





Conclusion

- a house built with steel wall frame has greater construction cost (53% more) and annual energy consumption (6%-7% more) than wood wall frame.
- Improve thermal efficiency of steel frame construction
- Make steel frame structure economically viable
- Further research: modifying steel stud spacing, novel insulation materials, and new construction techniques.



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