

# Modular Multi-family Construction:

## A Field Study of Energy Code Compliance and Performance through Offsite Prefabrication



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**Research Question:** Does prefabrication in a controlled factory setting improve *energy code compliance*, *energy performance* and *production efficiency*?

**Data:** CZ3b (LAX), CZ3c (SFO), CZ4a (PHL) and CZ4c (SEA)

Code compliance study (construction)

- 25 offsite multi-family buildings (12 full / 13 partial)
- 30 site-built multi-family buildings (8 full / 22 partial)

Energy performance study (post-occupancy)

- 23 offsite multi-family buildings (14 benchmark / 9 SIM)
- 128 site-built multi-family buildings

**Project Duration:** FY 2021-2023

**Budget:** \$ 500K

**Approach:** Field study; plan reviews, factory-site inspections

**Volumetric Modular**

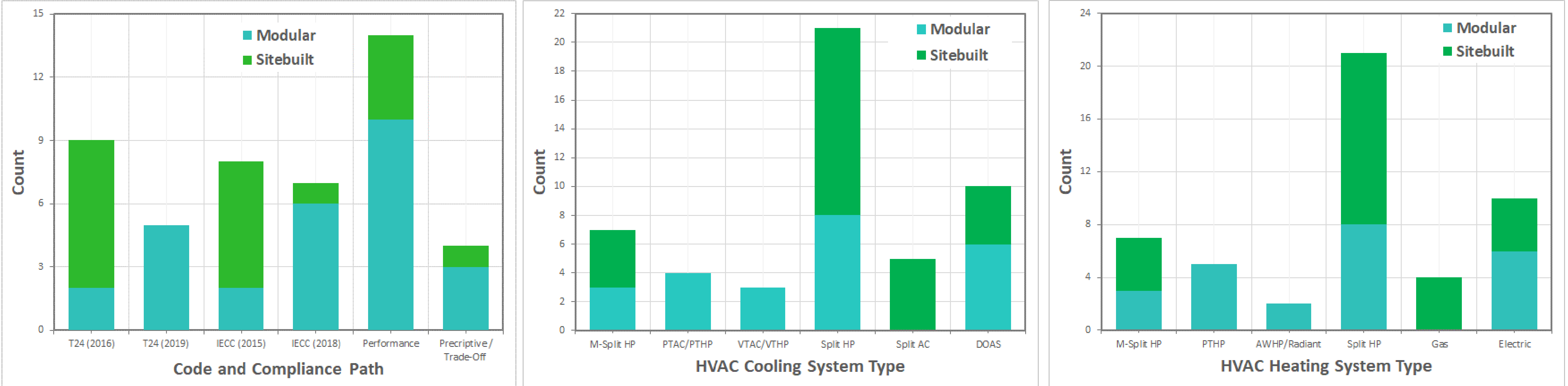
**Component-Based / Closed Panel**

### Findings

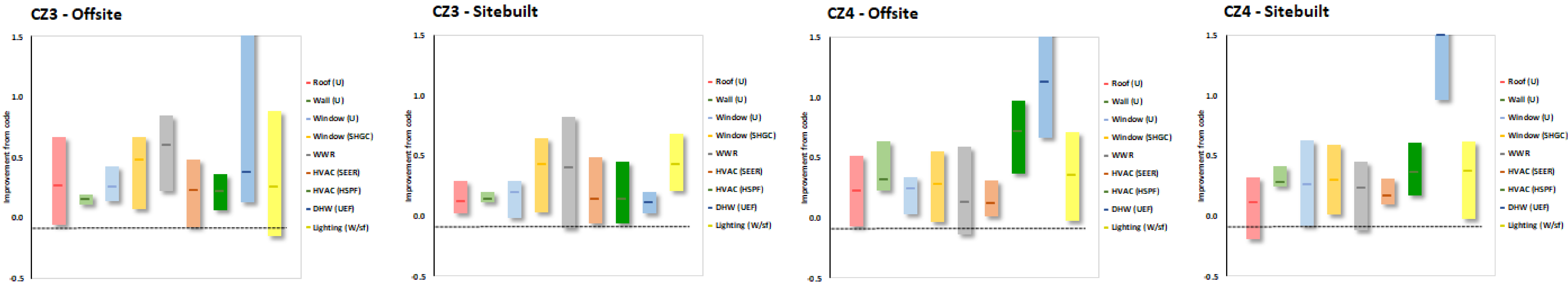
#### 1. Building Characteristics

	Offsite	Site-built
Gross Area*	132,100sf	157,700sf
Conditioned*	80%	76%
Residential*	72%	67%
Story Height*	6	6
Units*	120	117
Unit Area*	877sf	1,019sf
Market Rate*	40%	62%
Affordable*	60%	38%

\* Average



#### 2. Energy Code Compliance



#### 3. Energy Performance (EUI)

	Offsite			Site-built		
Climate Zone	Number of Buildings	EUI (kBtu/sf/yr)	Energy Star Score	Number of Buildings	EUI (kBtu/sf/yr)	Energy Star Score
3B	2	43.3	58	25	35.5	76
3C	7	42.0	91	64	33.0	86
4A	3	35.4	87	19	46.3	63
4C	2	28.0	98	20	32.0	93
Average		38.7	86		35.8	81

#### 4. Air Leakage

	Offsite	Site-built
Units	7	8
Type	Affordable	Market Rate
Floor Area	460	810
ACH (factory)	1.8	-
ACH (site)	6.0	4.7
CFM/sf	0.22	0.23

\* Average



#### 5. Production Efficiency and Other Factors

	Building Types	Construction Schedule	Construction Cost	Transportation Site Logistics	Facilities	Project Delivery	Business Model	Materials Waste	Permitting Inspections	Quality	Design Flexibility	Safety Productivity
Site-built	All sectors.	Unpredictable site conditions. Moderate risk of delays.	Low construction cost. Moderate risk of change orders and contingency.	Moderate site storage and staging area.	Minimal facility investment except MEP and specialty trades.	Decentralized. Risk shared among several sub-contractors and suppliers.	Low fixed costs. Production can be quickly scaled to meet demand.	Significant cut-off and packaging waste. Little or no recycling.	Standard permitting and inspection process.	Moderate QA/QC. Weather-related moisture problems common.	Flexible to design changes.	Decentralized production exposed to weather and onsite hazards.
Modular	Low-rise and mid-rise multifamily, hospitality, education, office, healthcare.	≥40% shorter construction schedule. Moderate risk of delays.	5% lower construction cost. Moderate risk of delay costs.	High transportation costs and distance limitations. High site-staging area storage.	Extensive facility investment.	Centralized. ≥40% of project risk allocated to manufacturer. 'Super sub' contractor in design-build delivery.	High fixed costs. Stable flow of production required. Modules cannot be manufactured and stored between project cycles.	Doubling of floor, wall and ceiling framing. Significant reuse of cut-off waste.	Permitting delays common. Require offsite inspections.	High factory QA/QC. Moderate transportation and placement damage. Rework.	Minimal flexibility to design changes. Must be incorporated early in design.	Centralized, climate-controlled production. Minimal onsite workers exposed to risk.
Panelized Component-based	Mid-rise and high-rise multifamily. Diversification to other markets likely.	≥40% shorter construction schedule. Low risk of delays.	High construction cost. Low ownership cost.	Moderate transportation costs and distance limitations. Minimal site storage.	Moderate facility investment.	Decentralized. Risk shared among several component manufacturers and vendors. Prime in design-build delivery.	Moderate fixed costs. Stable flow of production required. Standard panels manufactured and stored between project cycles.	Use of renewable, recycled and recyclable materials. Use of reversible material assemblies.	Require offsite inspections.	High factory QA/QC. Minimal transportation and placement damage.	Moderate flexibility to design changes.	Centralized, climate-controlled production. Minimal onsite workers exposed to risk.