Innovative Technology in Home Construction: Impact on Labor and Costs

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Breaking New Ground

DESIGNING AFFORDABLE HOUSING FOR THE COACHELLA VALLEY WORKFORCE

Breaking New Ground

DESIGNING AFFORDABLE HOUSING FOR THE COACHELLA VALLEY WORKFORCE

2016-2017 | PlaceWorks partnered with The California Endowment to identify design and policy solutions to bring affordable housing to more family households.

Geography: Eastern Coachella Valley with statewide and national implications.

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Terwilliger Center for Housing

Photo: La Quinta Resort & Spa
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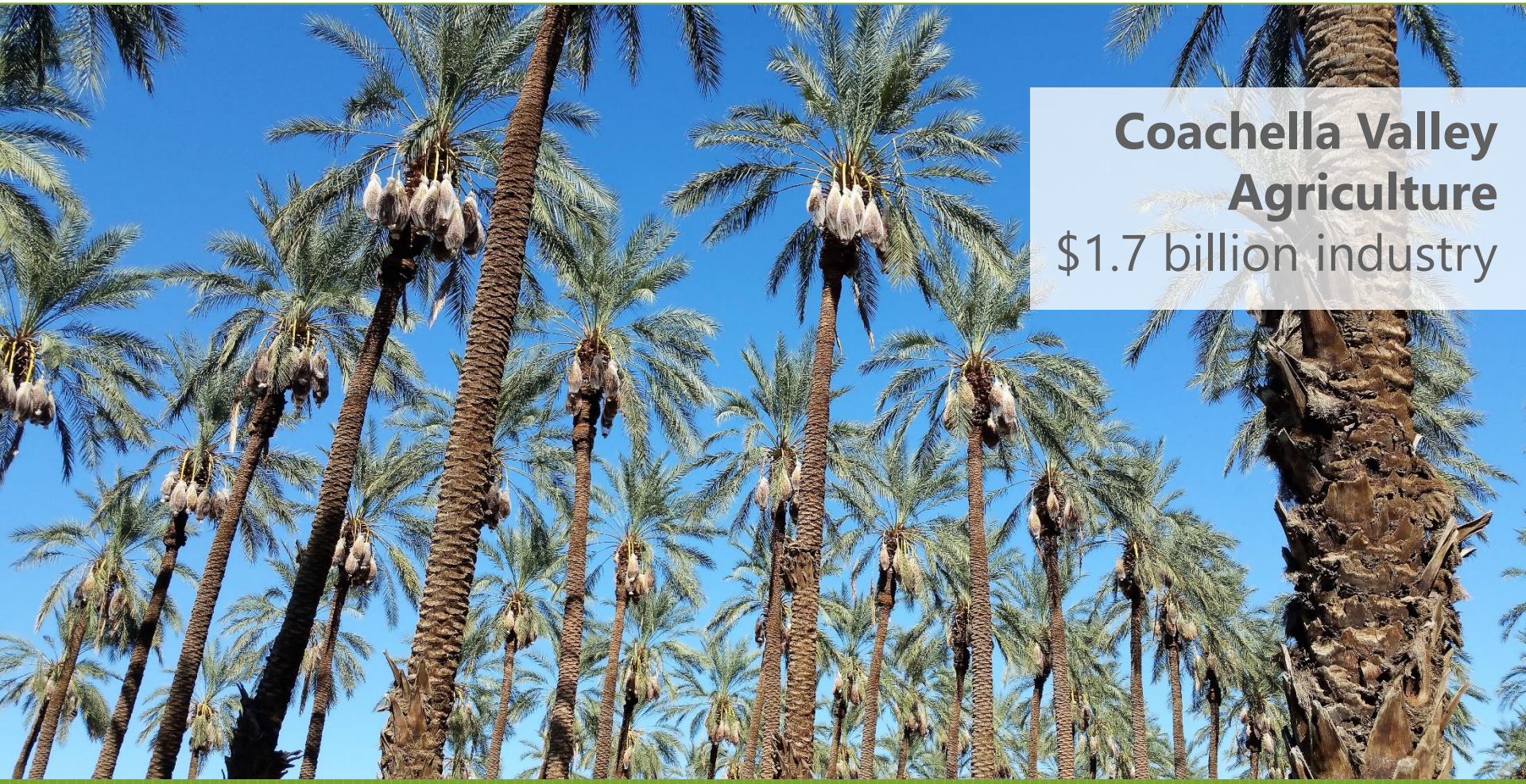
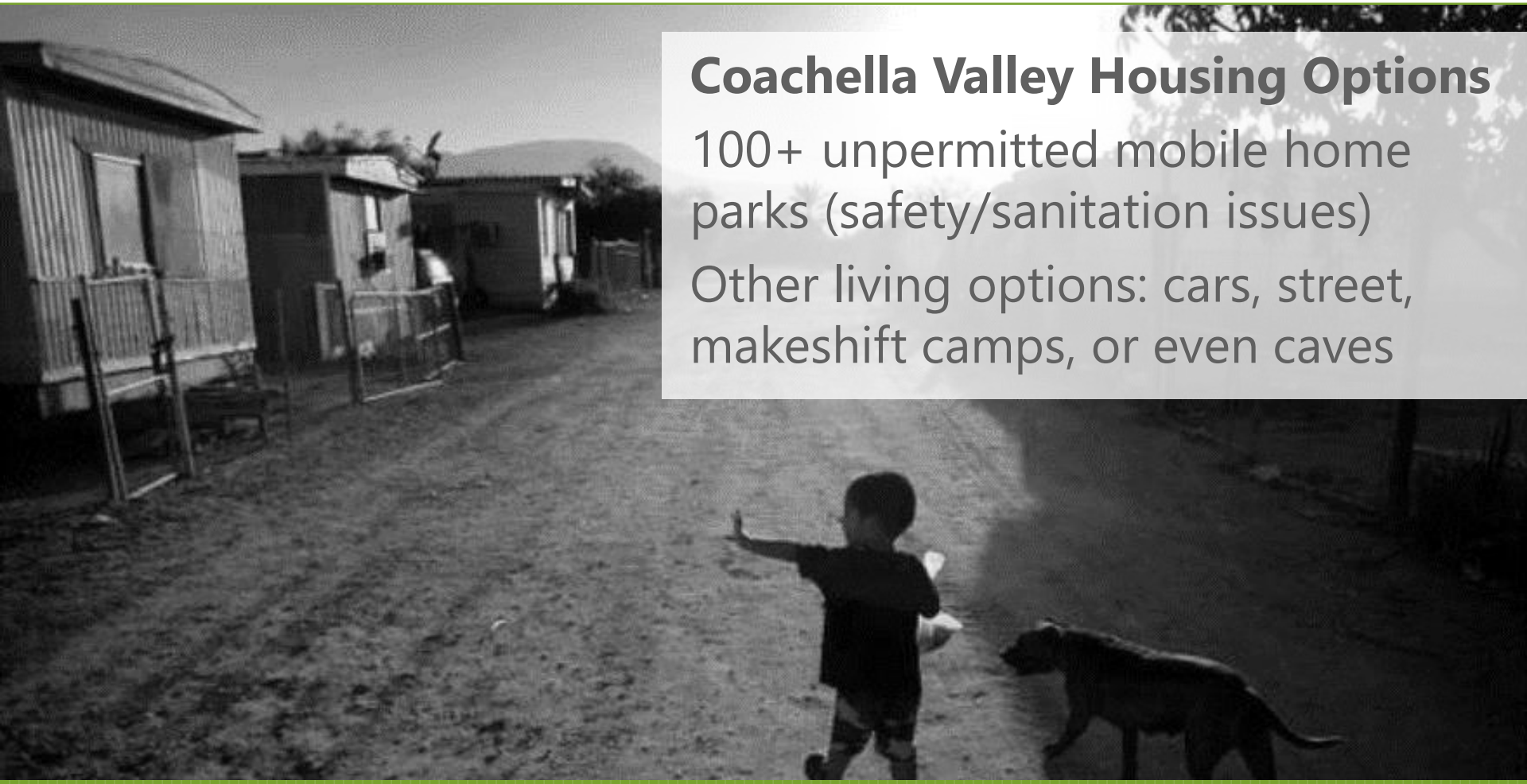


Coachella Valley Agriculture

$1.7 billion industry

Photo: Date palm farm in Coachella Valley
Photo source: UCANR



Coachella Valley Housing Options

100+ unpermitted mobile home parks (safety/sanitation issues)

Other living options: cars, street, makeshift camps, or even caves

Photo: Mobile home park in Coachella Valley
Photo source: The California Endowment

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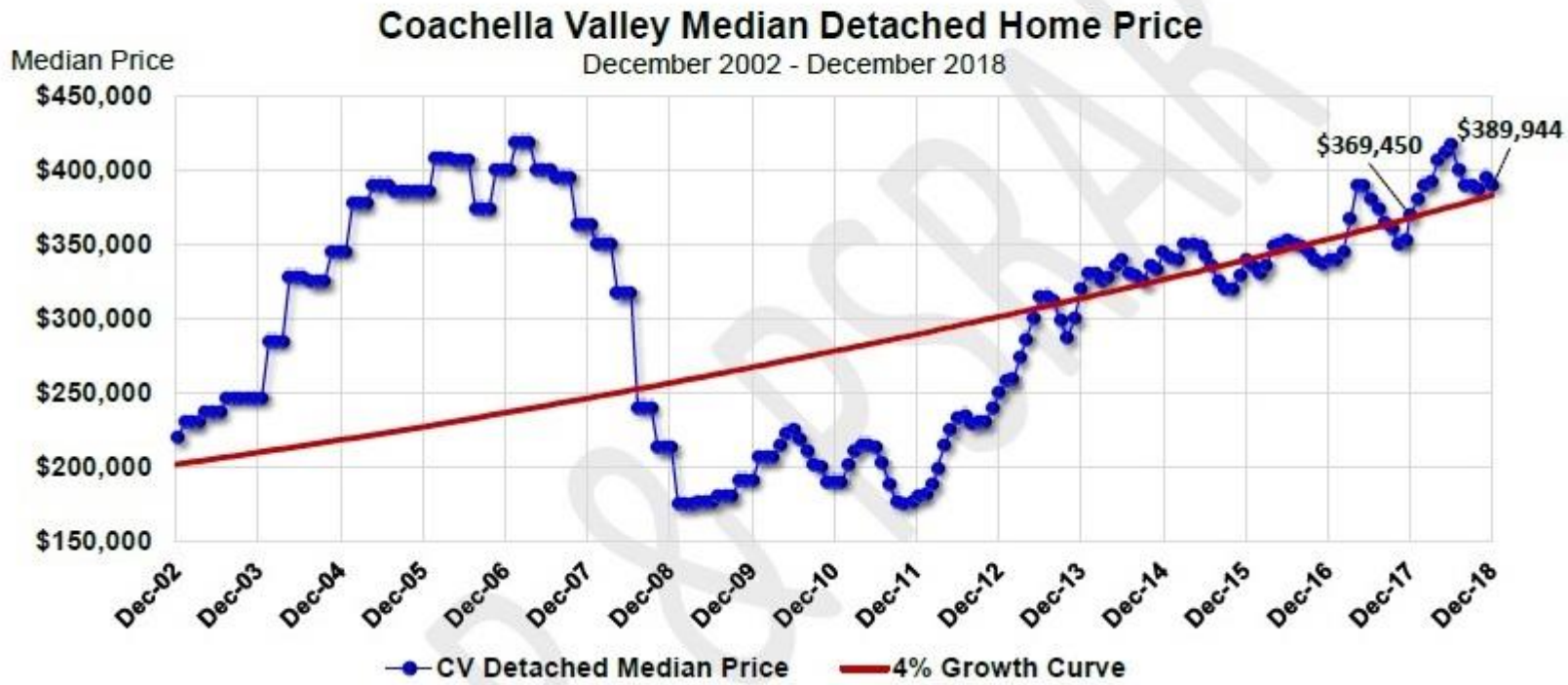
The Desert Housing Report

December 2018



Source: California Desert Association of Realtors
Desert Housing Report

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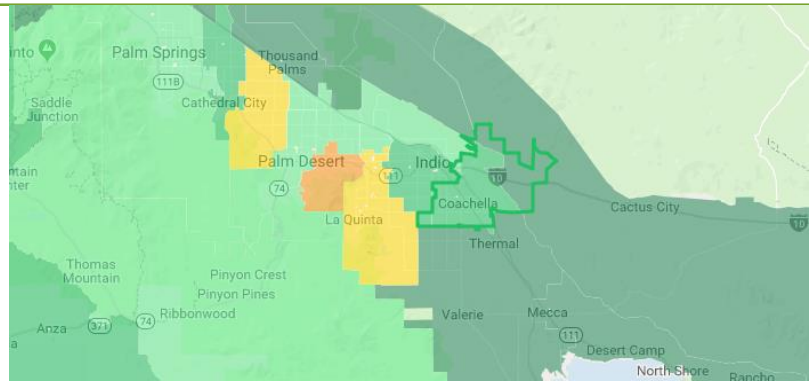
Coachella Real Estate Market Overview

$242,500	$152	$1,700
Median Sales Price	Price Per Sqft	Median Rent Per Month
View Homes for sale	View Homes for sale	View Homes for rent

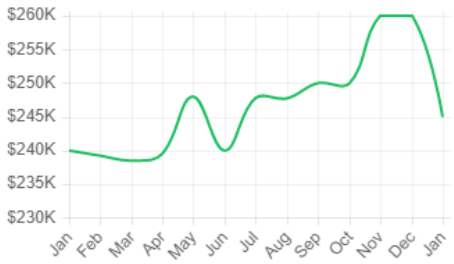


Housing Market Trends

Market trends help you understand the movement of key price indicators. Trends in Coachella show a 3% year-over-year rise in median sales price and a 19% rise in median rent per month.

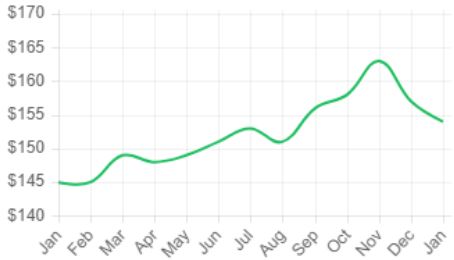
Median Sales Price

The median sales price for homes in Coachella for Oct 24 to Jan 23 was $242,500 based on 38 home sales.



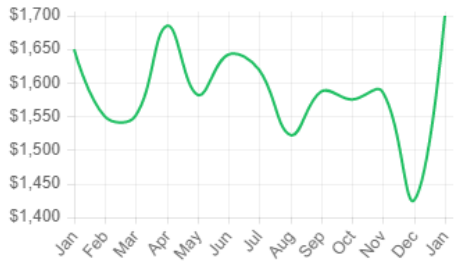
Price Per Square Ft.

Average price per square foot for Coachella was $152, an increase of 6% compared to the same period last year.



Median Rent Per Month

The median rent per month for apartments in Coachella for Dec 24 to Jan 24 was $1,700.



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Source: Trulia real estate market overview January 2019
www.trulia.com/real_estate_Coachella-California

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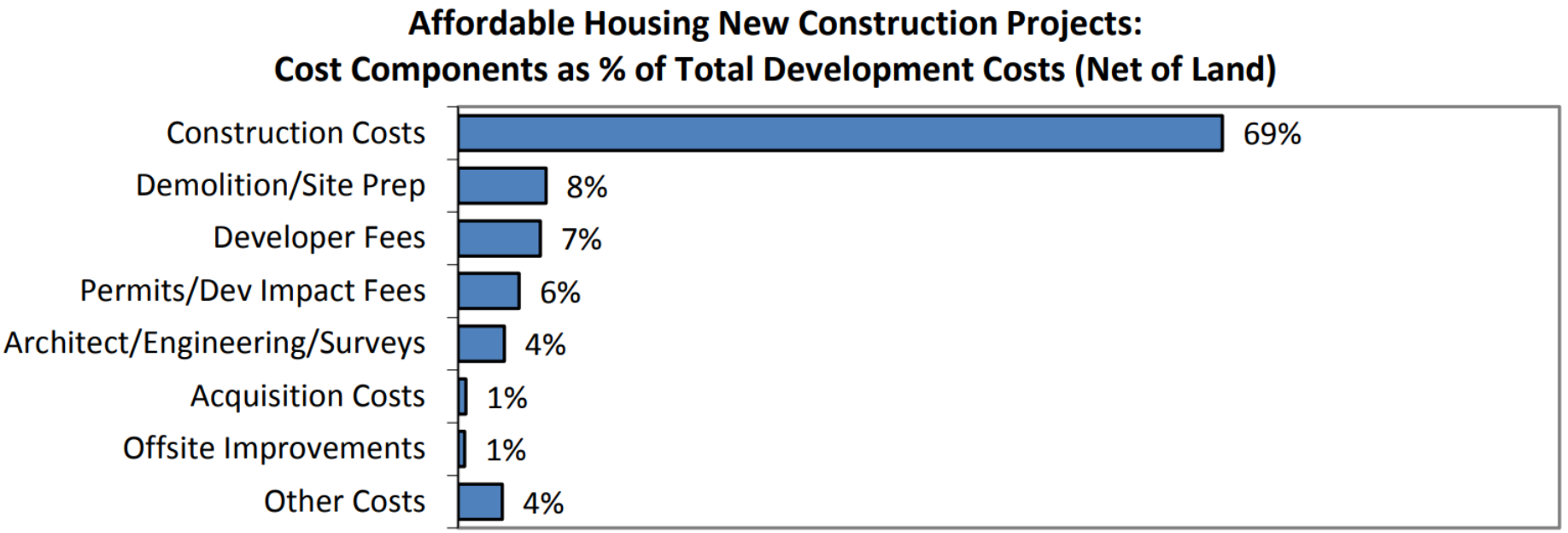

Average calculated by summing (real) cost measures across all 400 affordable projects and dividing by total project costs excluding land.

Source: 2014 California Affordable Housing Cost Study
Figure 1 Sources of Development Cost

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Can we decrease construction costs?

- Materials
- Technology
- Policy

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Photo: Structural Insulated Panels (SIP)
Photo source: XXX

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Technology & Material		Market Share
Site Built *(local code)*		**89%**
	Stick frame	55%
	Concrete masonry	14%
	Panelized	13%
	Insulated Concrete Form (ICF)	4%
	Steel frame	2%
	Structural Insulated Panel (SIP)	<1%
	Other	<1%
Modular Construction *(local code)*		**2%**
Manufactured Home *(federal code)*		**9%**

Construction Material & Technology

US Housing Market Share (2018)

Source: Mullens, Michael. "Innovation in the U.S. Industrialized Housing Industry: A Tale of Two Strategies." International Journal for Housing Science and Its Applications 32, no. 3 (2008): 163–78

Emerging Technologies

3D printing

Autonomous brick laying

Autonomous construction

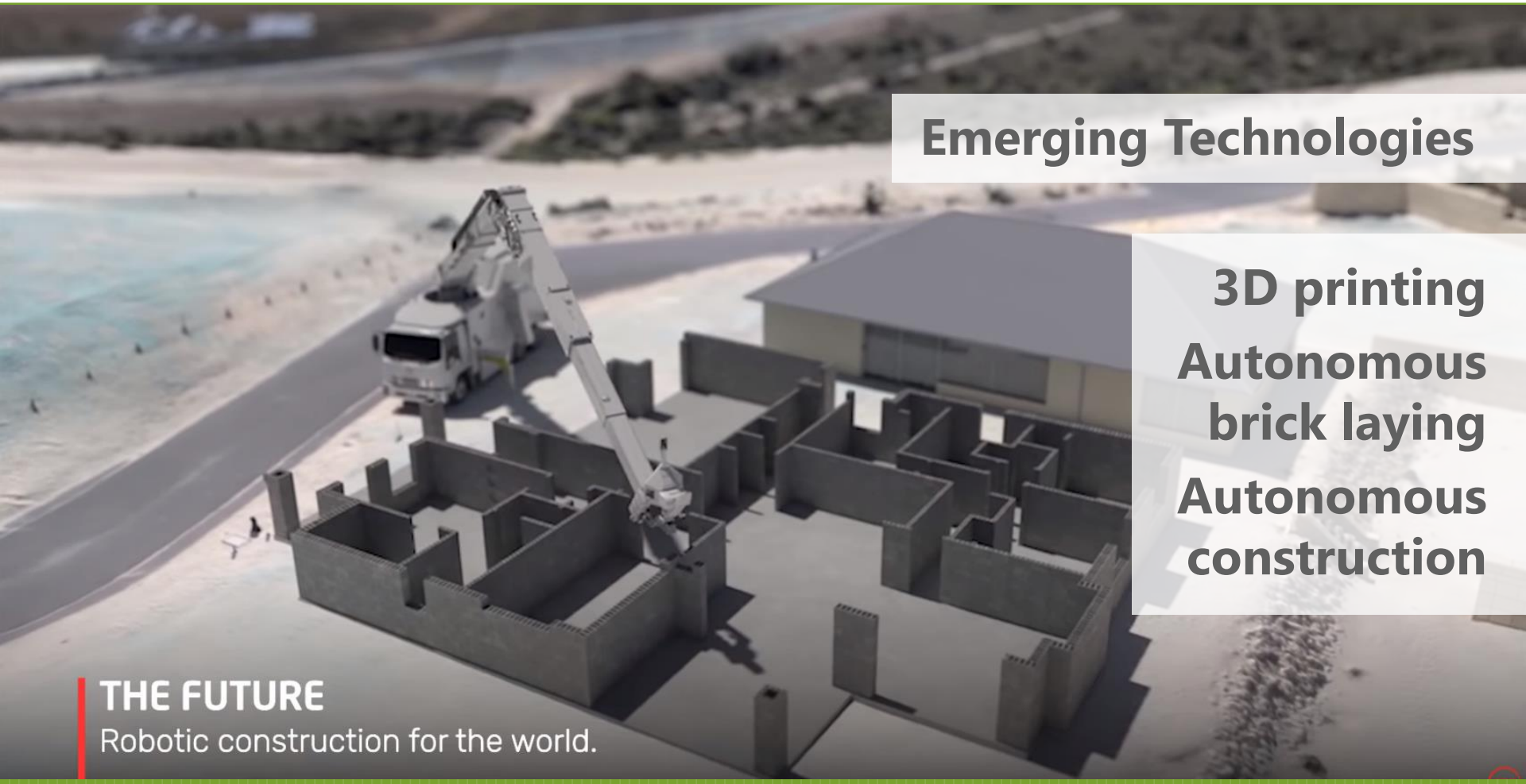
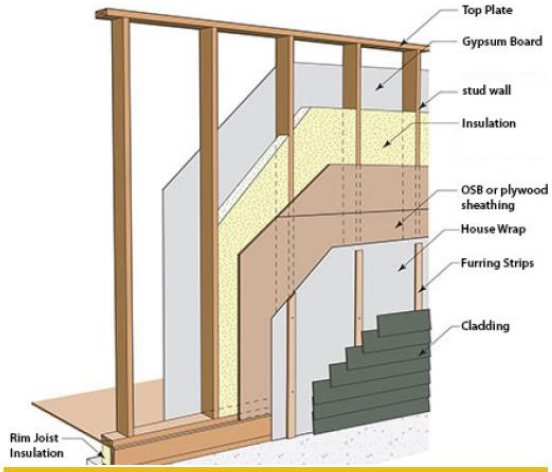


Image: Hadrian X, a fully-automated, end-to-end bricklaying robot by Fastbrick Robotics (FBR)
Image source: https://youtu.be/264r1Bowy-g | www.fbr.com.au

Construction Material: Traditional Stick Frame

2016 Baseline

Stick framing is the traditional method of home building in the United States. Typically, homes are assembled on site using lumber to form walls and roof trusses. These frames is then linked together and sheathed with plywood on the exterior and drywall on the interior. The exterior is finished with shingles, clapboard, vinyl siding, adobe or some kind of brick or brick veneer.



Material

Under Construction

Finished View

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Costs based on the low end of the cost per square foot estimate range to build an affordable single family home in Riverside County (per Valon Consulting 2016).

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Modular Construction

+21%

Modular construction involves factory built construction of rooms (boxes) that are shipped to the site and stitched together to create entire buildings on a permanent foundation. Modular construction can use a wide variety of materials while meeting the same building codes and architectural specifications as conventional construction.

Factory Construction

Site Installation

Finished View

Costs based on figures from Silvercreek, a factory-built housing manufacturer in Perris, California as of 2015.

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Manufactured Homes

-25%

A manufactured home is factory-built that is assembled on a permanent chassis and intended to be a single-family dwelling on a support chattel or a permanent foundation. Manufactured homes are built to comply with the federal uniform building standards (HUD Code). Manufactured homes are not the same as mobile homes. Mobile homes have not been constructed since June 15, 1976 at which time the federal preemptive HUD Code took effect.

Factory Construction

Site Installation

Finished View

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Costs based on 2015 Manufactured Housing Survey for a double-wide home.

Construction Material: Structural Insulated Panels (SIP) +3%

SIP is a composite building material consisting of an insulating layer of rigid core sandwiched between two layers of structural board. The board can be a sheet of metal, plywood, cement, magnesium oxide board (MgO) or oriented strand board (OSB) and the core of the panel can be either expanded polystyrene foam (EPS), extruded polystyrene foam (XPS), polyisocyanurate foam, polyurethane foam or composite honeycomb (HSC).

Material

Under Construction

Finished View

Costs assumes $14.9-$17.6 per sq. ft. installed wall, and $5.3-$7.3 per sq. ft. installed roof.

Construction Material: Super Adobe (Cal-Earth) +1%

Long or short sandbags are filled with on-site earth and arranged in layers or long coils (compression) with strands of barbed wire placed between them to act as both mortar and reinforcement (tension). Stabilizers such as cement, lime, or asphalt emulsion may be added.

Material

Under Construction

Finished View

Costs based on the costs of building the Earth One Prototype in an Bernardino County, CA. Estimate provided by CalEarth.

Construction Material: Rammed Earth

+32%

Rammed Earth is a building method used for constructing walls, foundations, and floors using raw materials such as earth, sand, chalk, lime, gravel or clay. The building process involves compressing a damp mixture of earth with various proportions of sand, gravel and clay into an externally supported frame /mould, thus creating a solid wall surface.

Material

Under Construction

Finished View

Costs based on the $230/sf estimate to build a Global Model "Earthship" by Earthship Biotecture. www.earthship.com

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Technology & Material	2016 Cost
Site Built	**varies**
Stick Frame	**Baseline**
Structural Insulated Panels	+3%
Ziegel Block	N/A
Structural Concrete Insulated Panels	+9%
Insulated Concrete Form	+9%
Super Adobe	+1%
Straw-Bale	+26%
Rammed Earth	+32%
Modular Construction	**+21%**
Manufactured Home	**-25%**

Construction Material & Cost

1,200 SF Single Family Home

Urban Land Institute
Terwilliger Center for Housing

Costs generated in coordination with the BIA and an affordable housing builder to generate baseline proforma. PlaceWorks obtained cost figures from manufacturers for building wall material and substituted new material costs into baseline project. Cost factors also assume the use of prevailing wage.

Observations on Current Technologies

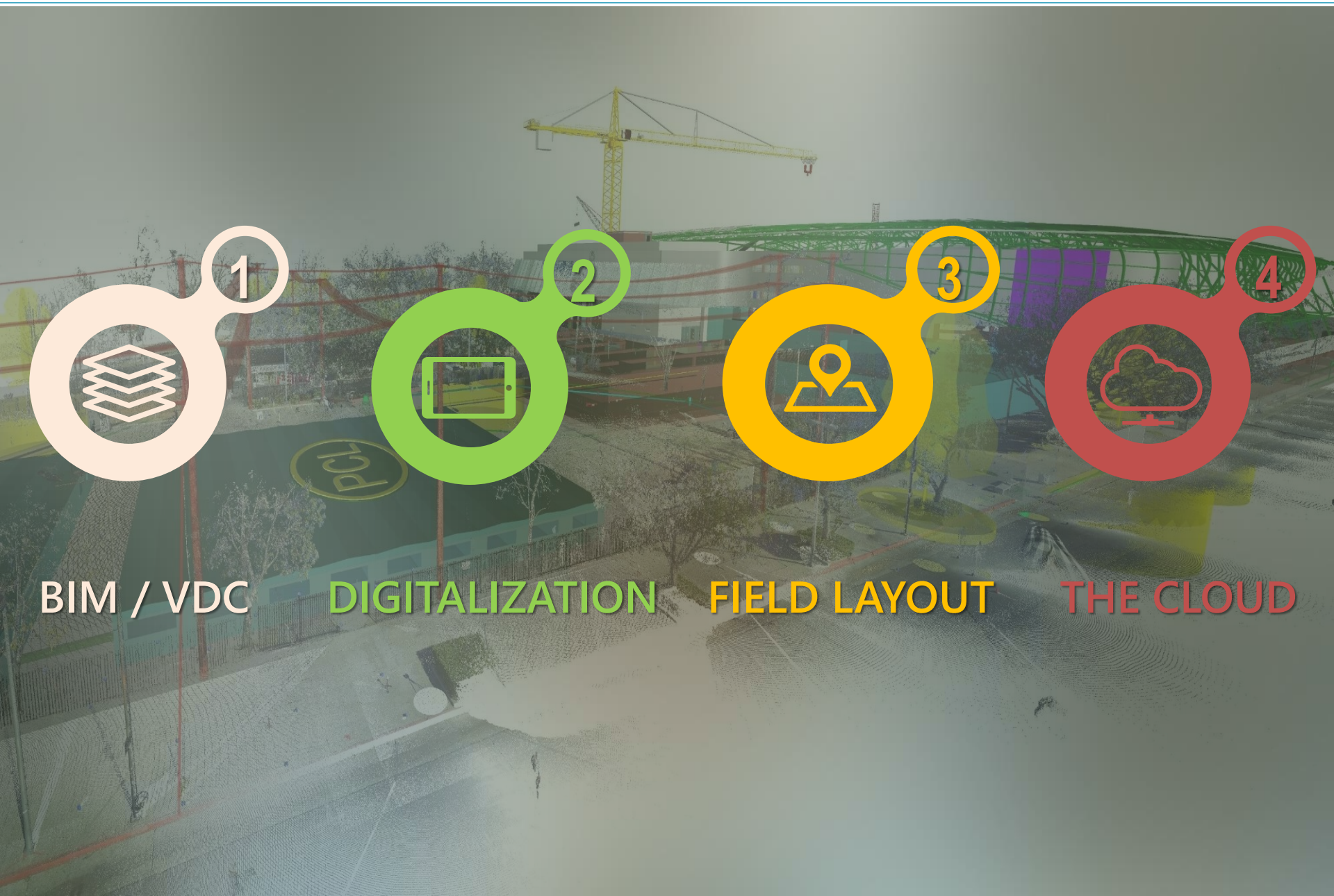
- As of 2018, stick built construction was still the least expense
- Other technologies may catch up or even become more cost effective in places like California (e.g., 2020 ZNE requirements)
- Select technology based on location and desired benefits
  - Construction cost
  - Life cycle value (owner's cost to maintain/heat/cool)
  - Regulatory compliance with new building codes
  - Allow owner participation in construction

Changes in Policy & Research

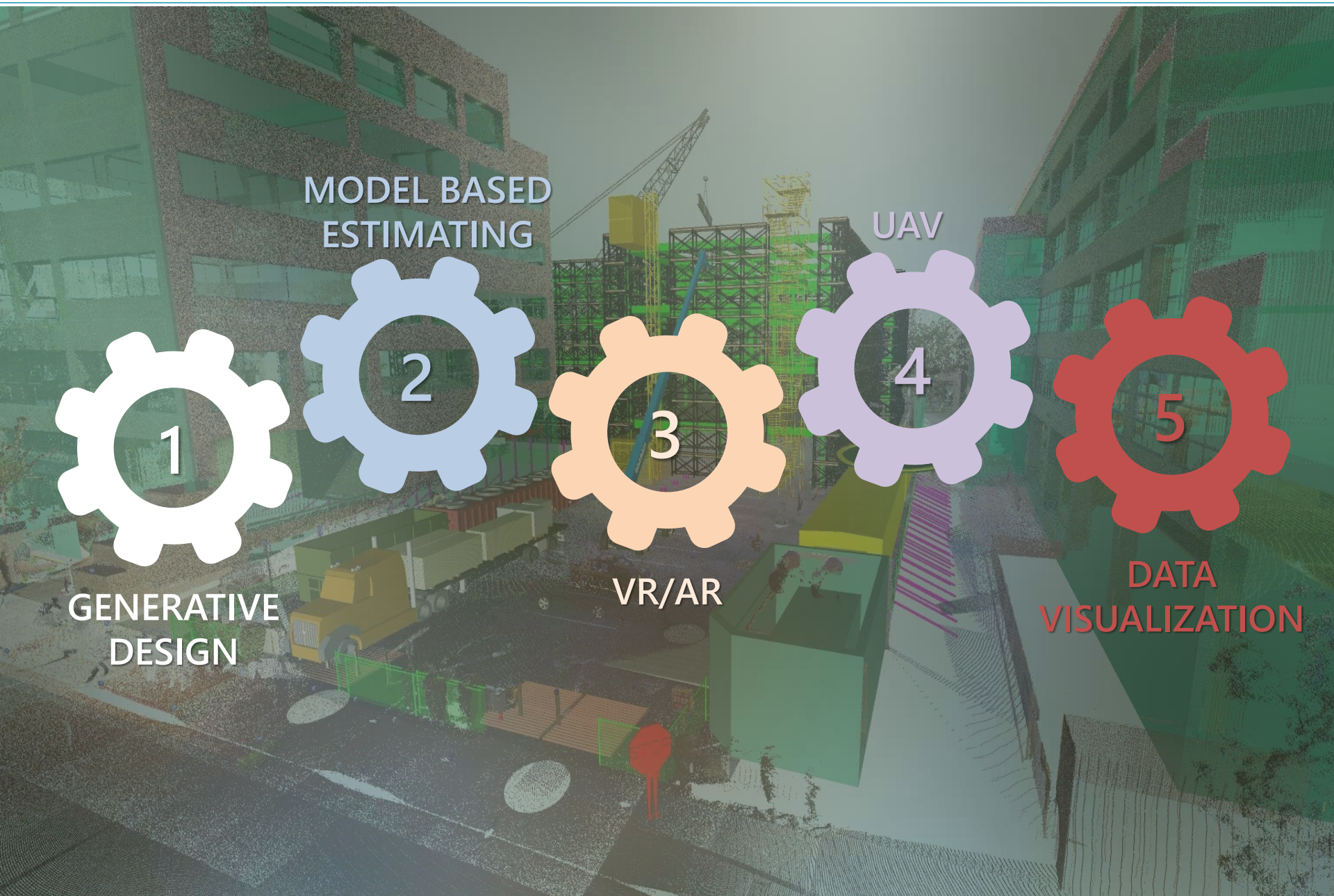
- **Reduce emphasis on energy efficiency**
  Energy efficiency gains lowered ongoing utility costs, but did not reduce construction costs or make it more affordable to buy or rent a home.
- **Protect affordable housing from delays and uncertainty**
  With such a dire need for affordable housing, consider foregoing environmental clearance requirements (e.g., CEQA) and avoid associated delays, NIMBYs, and lawsuits.
- **Tax incentives or public subsidies are increasingly inefficient**
  As housing costs rise faster than incomes, using taxpayer money to subsidize affordable housing becomes less and less efficient and does not fundamentally reduce housing costs.
- **Bring back focus on reducing construction costs**
  Make this a priority at the federal and state level; e.g., refund and refocus the public-private Partnership for Advancing Technology in Housing (PATH) program.

Technology in Construction

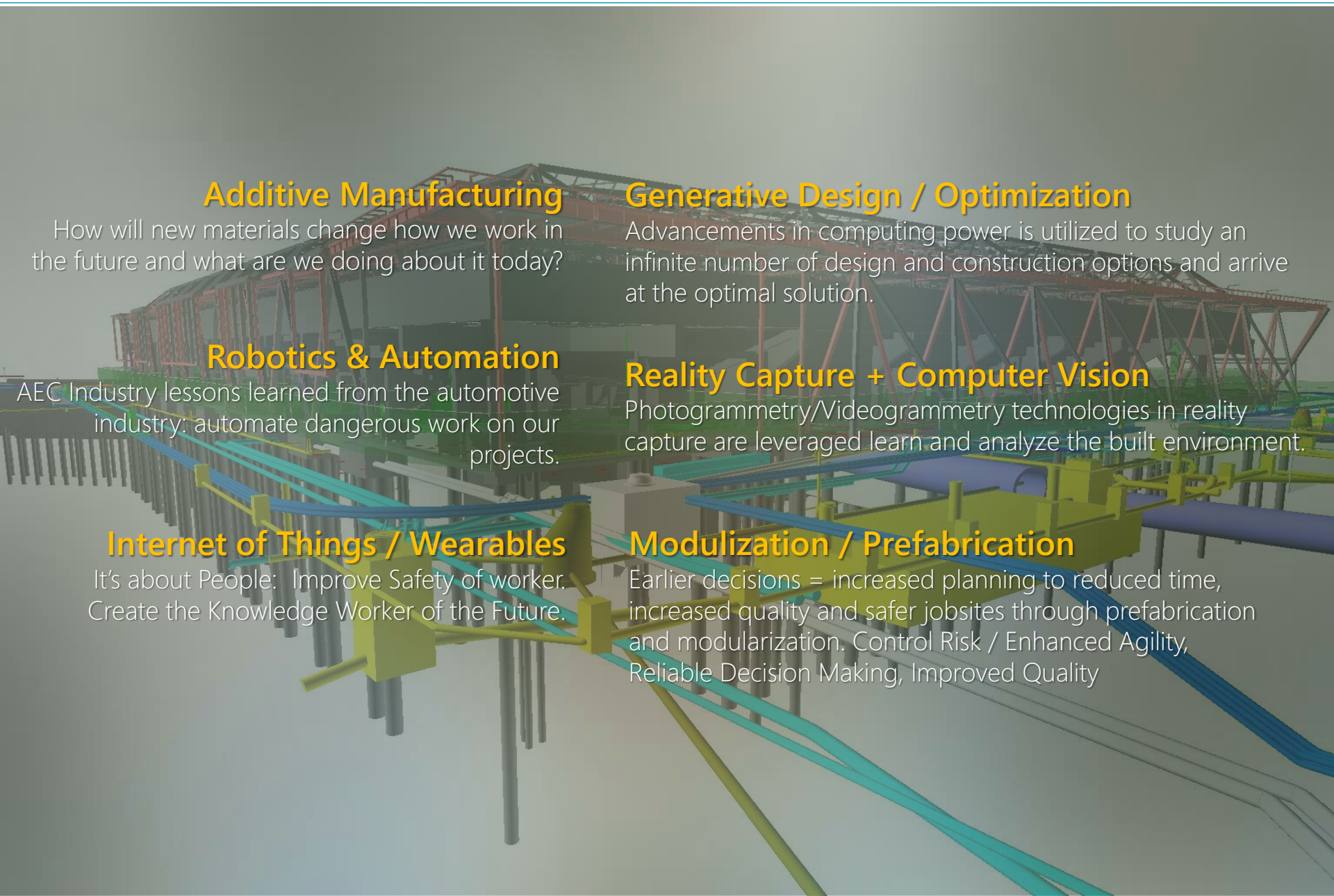
Standard Technology



Advanced Technology



Emerging Technology



Additive Manufacturing

How will new materials change how we work in the future and what are we doing about it today?

Generative Design / Optimization

Advancements in computing power is utilized to study an infinite number of design and construction options and arrive at the optimal solution.

Robotics & Automation

AEC Industry lessons learned from the automotive industry: automate dangerous work on our projects.

Reality Capture + Computer Vision

Photogrammetry/Videogrammetry technologies in reality capture are leveraged learn and analyze the built environment.

Internet of Things / Wearables

It's about People: Improve Safety of worker. Create the Knowledge Worker of the Future.

Modulization / Prefabrication

Earlier decisions = increased planning to reduced time, increased quality and safer jobsites through prefabrication and modularization. Control Risk / Enhanced Agility, Reliable Decision Making, Improved Quality

What is Modular?

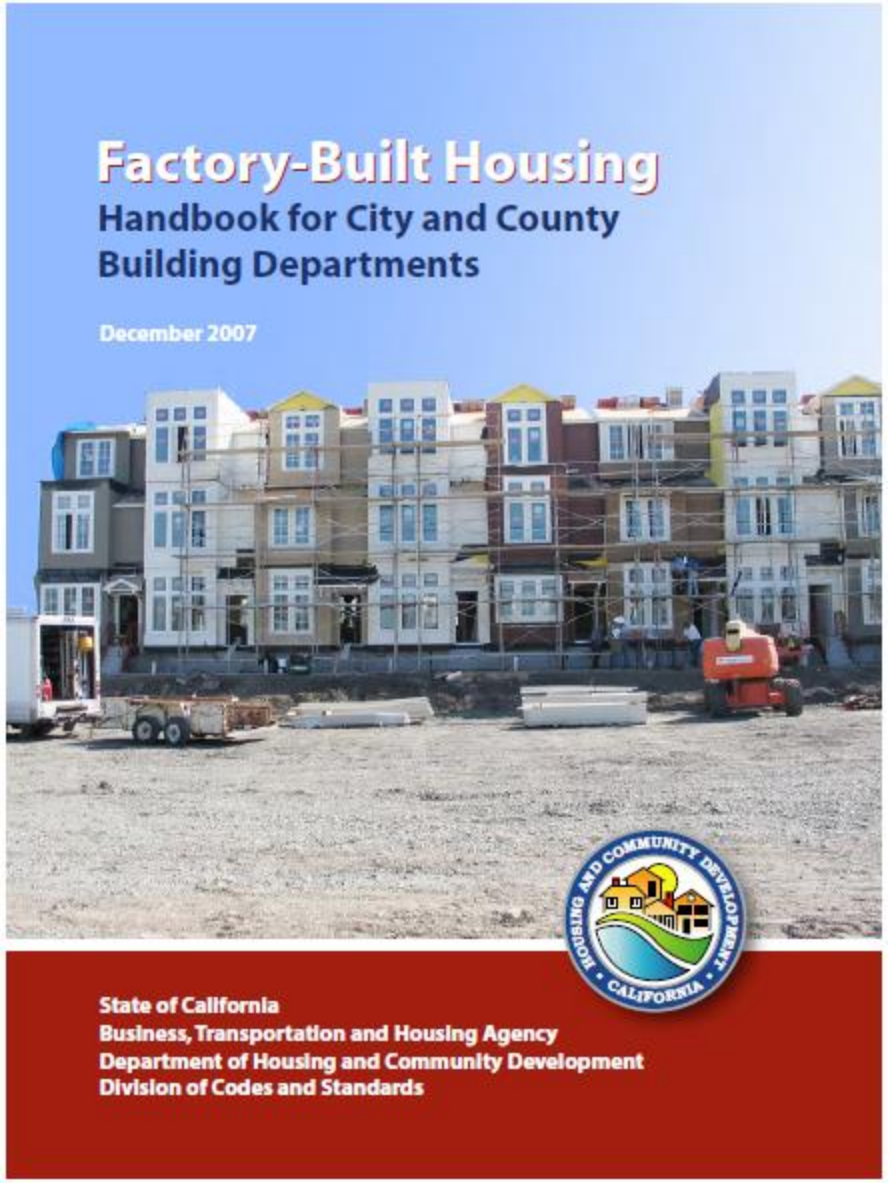
- Typically factory built construction of rooms (boxes) that are shipped to the site and stitched together to create entire buildings
- Meets same building codes and architectural specifications as conventional construction

Modular Codes

- HCD Released Guidelines
- Meets same building codes and architectural specifications as conventional construction

"Modular construction…is faster, less expensive, allows for high levels of quality control and significantly reduces waste and truck traffic. It's also safer for workers as construction is done inside in controlled environments,"

– Michael Bloomberg
Mayor
New York City



Differences from Panelized Construction

- Panelization: The use of interlocking wall, floor and roof assemblies fabricated on tables (on or off-site) and assembled on building pads.
- Greatest efficiencies come from repetitive component members used in highly repetitive plan solutions

Benefits of Modular

- Potential savings in high wage environment.
- Compressed project schedules
- Sustainability
- More controlled conditions
- Fewer job-site environmental impacts
- Fewer conflicts in work crew scheduling
- Reduced requirements for on-site materials storage
- Increased workers safety

Challenges of Modular

- Limited experience
- Unfamiliarity /Limited Interest/ Learning Curve, Scope Gaps
- Limited factory production capacity
- Risks associated with sole source supply from one factory
- More upfront design and preconstruction effort
- Approval Process / Code Challenges
- Transportation
- Market prejudice
- Major parts of development may need to be field-built
  - ie. Garages, Foundations, Common areas
- Labor Union Pressure
- Potential Height Impact

What does Modular look like?

Exterior designs can embrace modularity

Michael Maltzman Architect

Or can be more like a traditional building

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HOPE through HOUSING FOUNDATION

Together, we transform lives and communities.

Yucca Valley Senior Housing

Local Government Partners

- **Getting local government partner comfortable with modular**
  - **Get the city on board early**
  - **Overcoming preconceived notions: “It’s not a mobile home”**
  - **Loss of local control: *perception or reality*?**
  - **Balancing State law and Local Ordinances**
  - **Getting Political and Staff support**

Pre-Development and Design Management

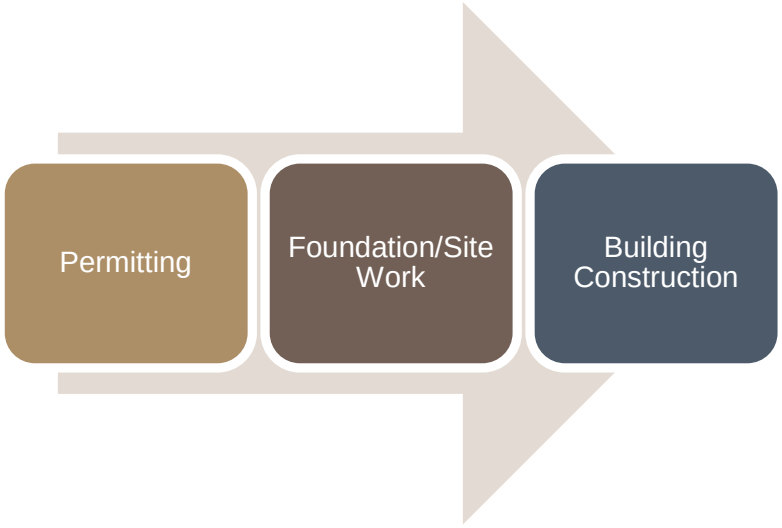
- Code issues are complicated by the difference between how the factory constructs vs. site built
  - Fire ratings
  - Seismic design
  - Utility routing
  - Mating of factory and site utility connections
  - As examples

Pre-Development and Design Management

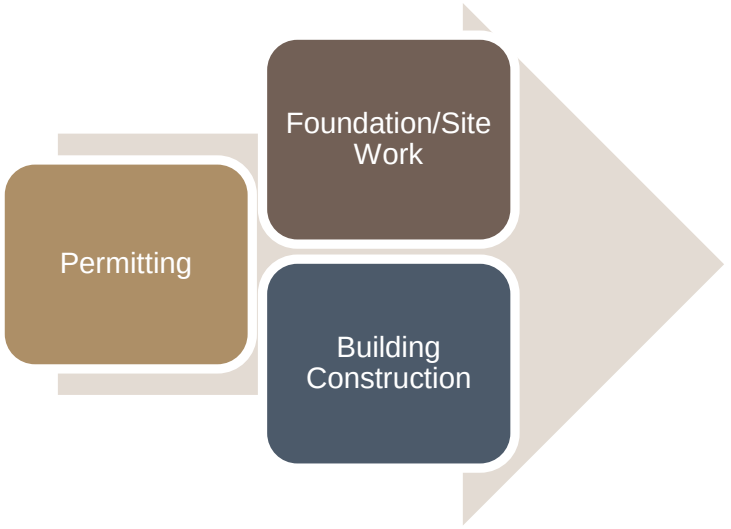
- The most cost effective money a developer spends is during design
  - Every dollar spent in design can save thousands once under construction

Compressed Project Schedule

Traditional Construction



Modular Construction



- **Compressed Project Schedules**
  - **Components Manufactured Off-Site while:**
    - **Foundation Poured**
    - **Site Work Completed**