Mainstreaming Modular High-Performance Homes:

Research, Collaboration, and Best Practices at the intersection of Advance Building Science and Advanced Building Construction

Stacey Rothgeb, Shanti Pless, Ankur Podder (NREL),
Trish Cozart (NREL, IN^2), David Schultz (Simple Homes)



Description

This 3-part session* will be moderated by National Renewable Energy Laboratory (NREL) and aims to focus on knowledge dissemination from ongoing research, collaboration opportunities, and best practices thriving at the intersection of advance building science and advanced building construction to deliver affordable high-performance homes.

Learn about strategies at the intersection of advance building science and advanced building construction to deliver affordable high-performance homes!

*Mainstreaming high performance homes and communities (including affordable housing, low-rise multi-family, sustainable development). Knowledge Level Required: Basic.

Part 1: NREL's Ongoing Research

NREL Industrialized Construction Innovation Team



Stacey Rothgeb
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Shanti Pless
Senior Energy Efficiency Research Engineer, NREL
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Ankur Podder
Building Advanced Manufacturing Research Engineer, NREL
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Learn about early wins from NREL's ongoing research with modular builders to enable and integrate cost-effective energy efficiency strategies for high-performance buildings, especially low-rise multifamily.

Part 2: NREL Innovation & Entrepreneurship Center



Trish Cozart
Group Manager, Innovation and Entrepreneurship Center
IN2 Program Manager
trish.cozart@nrel.gov

Learn about collaboration opportunities for High Performance Housing Professionals by Wells Fargo on housing affordability, construction innovation, and energy efficiency.

Part 3: Simple Homes



David Schultz
Co-founder & COO,
Simple Homes
david@simplehomes.com

Learn about best practices from the modular building industry on designing and building high performance homes from Simple Homes.

US Department of Energy Advanced Building Construction

Integrating energy efficiency solutions into highly productive U.S. construction practices for new buildings and retrofits







New Building Materials



Robotics



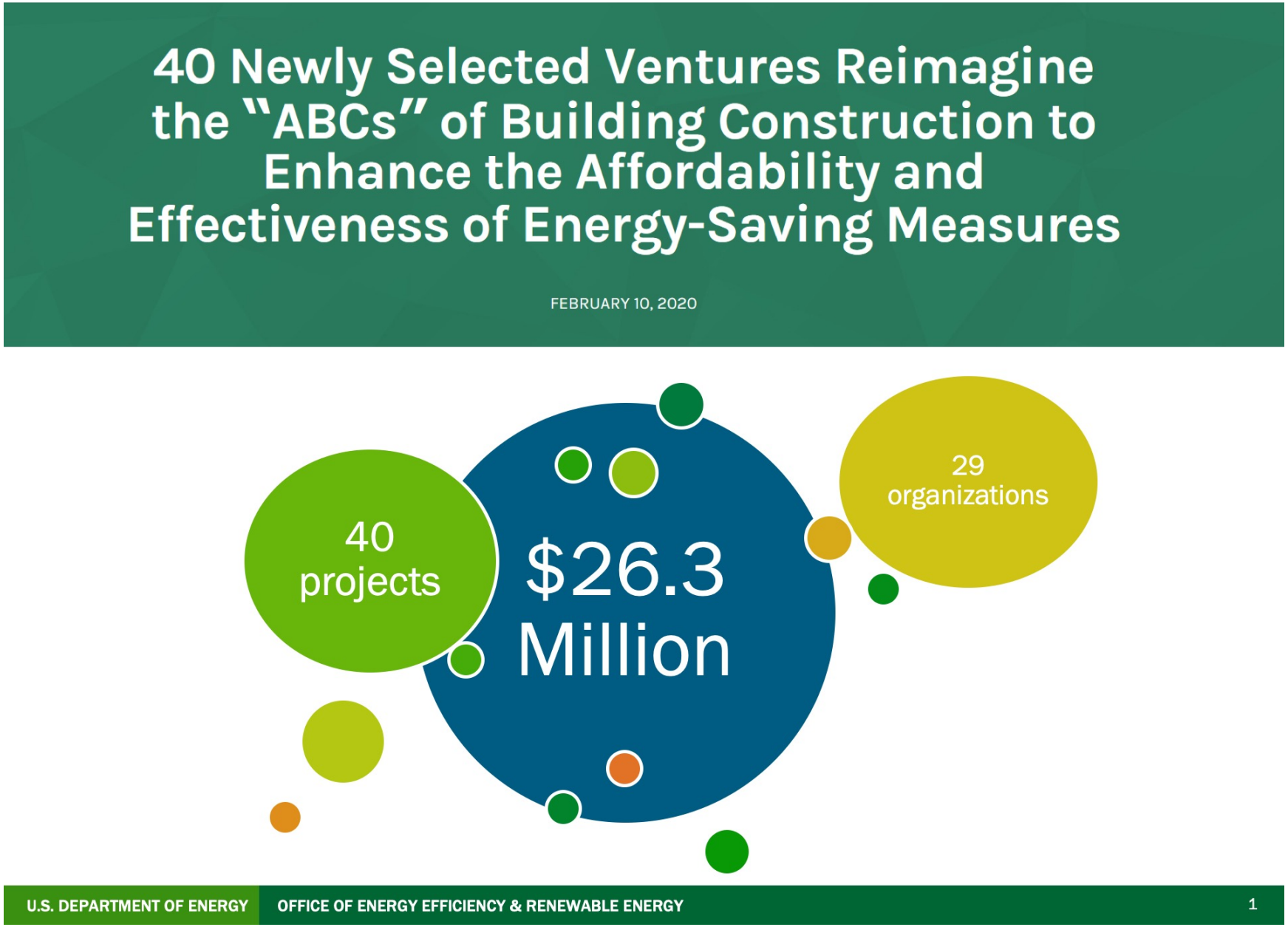
3D Printing & New Methods of Fabrication



Digitization

US Department of Energy Advanced Building Construction

https://www.energy.gov/eere/buildings/advanced-building-construction-initiative



Ongoing NREL Projects on Advanced Building Construction

Advanced Building Construction Projects with NREL role (in varying capacities)

Topic 1: *Integrated Building Retrofit (phase 1: 18 months):*

National Renewable Energy Laboratory (NREL) (Golden, Colorado) will undertake two projects to develop:

- A zonal heat pump for whole-home panelized retrofits
- Innovative Technologies to Overcome Interface Challenges for Wall Retrofit Systems : A computerized workflow for panelized retrofits including pre-retrofit data collection, panel design, off-site manufacturing, and on-site installation
- **Princeton University (Mercer, New Jersey)** will use dehumidifying membranes to create novel facade-integrated building screen retrofits to reduce a building's cooling and ventilation energy use.

Topic 2: *New Construction Technologies projects:*

- **Vermont Energy Investment Corp. (Burlington, Vermont)** will develop a state-of-the-art zero energy modular (ZEM) home construction system, including designs for a ZEM factory and a ZEM multifamily affordable housing unit.
- **Slipstream Group Inc. (Madison, Wisconsin)** will evaluate and field test new approaches for delivering space heating and cooling in manufactured homes to improve energy efficiency, durability, and indoor air quality without increasing costs.

Topic 3: *Advanced Technology Integration:*

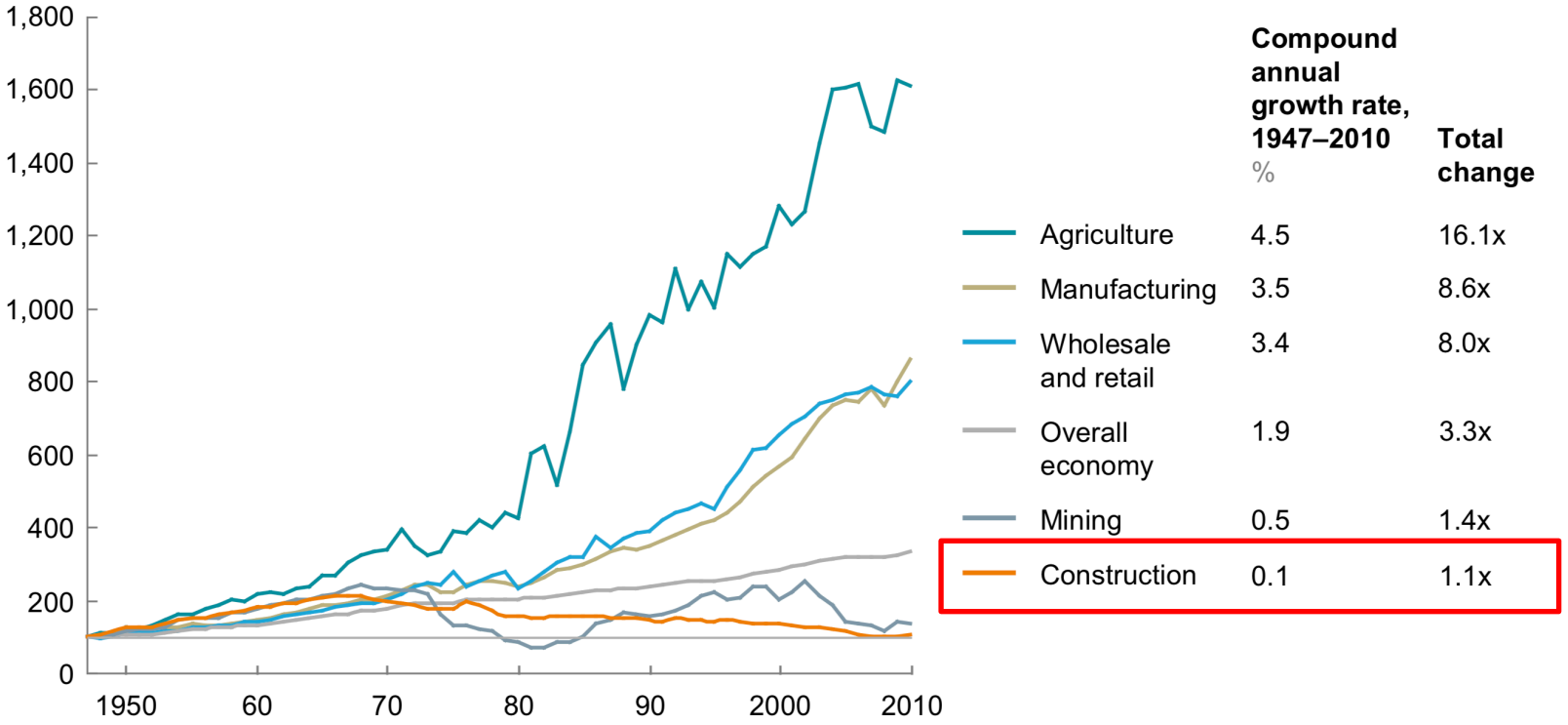
- **Rocky Mountain Institute (ADL) (Boulder, Colorado)** will establish a national collaborative of building and construction stakeholders to accelerate the development, demonstration and standardization of innovative high-performance construction technologies, with a focus on modular, off-site, and prefabricated technologies to improve energy affordability and performance.
- **University of Nebraska-Lincoln (Lincoln, Nebraska)** will conduct a field assessment of commercial and multifamily modular buildings compared to traditional construction methods. *NREL advising only.*
- **Elevate Energy (Chicago, Illinois)** will conduct a building stock analysis and validation of advanced energy technologies in Chicago single-family homes.

Need for Industrialized Construction in the United States for Affordable Housing Delivery

Lower Productivity in Construction

"America's construction industry productivity is lower today than it was in 1968."

Gross value added per hour worked, constant prices
Index: 100 = 1947



Many sectors have transformed and achieved quantum leaps in productivity; construction has changed little, limiting productivity gains
Key advances, 1947–2010

Need for Industrialized Construction in the United States for Affordable Housing Delivery

Need for Affordable Housing

- The country will need to build an average of 324,000 new apartments each year to keep up with demand
- At least 4.6 million new apartments by 2030
- 20.4 million existing apartments today
  - As many as 11.7 million will need to be renovated by 2030

63% of apartments in 2030 will be new or renovated



weareapartments.org/Vision2030.pdf

Need for Industrialized Construction in the United States for Affordable Housing Delivery

Off-Site Construction of Multifamily

TERNER CENTER FOR HOUSING INNOVATION
UC BERKELEY

SEARCH

BUILDING AFFORDABILITY BY BUILDING AFFORDABLY: THE CASE FOR OFF-SITE MULTIFAMILY CONSTRUCTION

"Off-site construction of housing, which leverages the efficiencies of factory production to achieve significant cost savings, represents a much-needed solution to this problem. It has the potential to revolutionize the way homes and apartments are built."

http://ternercenter.berkeley.edu/uploads/offsite_construction.pdf

"Inefficiencies in traditional construction have hampered productivity and driven costs up for decades, resulting in increasingly costly development. Today, in many regions in the United States, the production of housing - especially infill multifamily housing – has become so costly to produce it demands rents or sale prices that are unaffordable for most people."

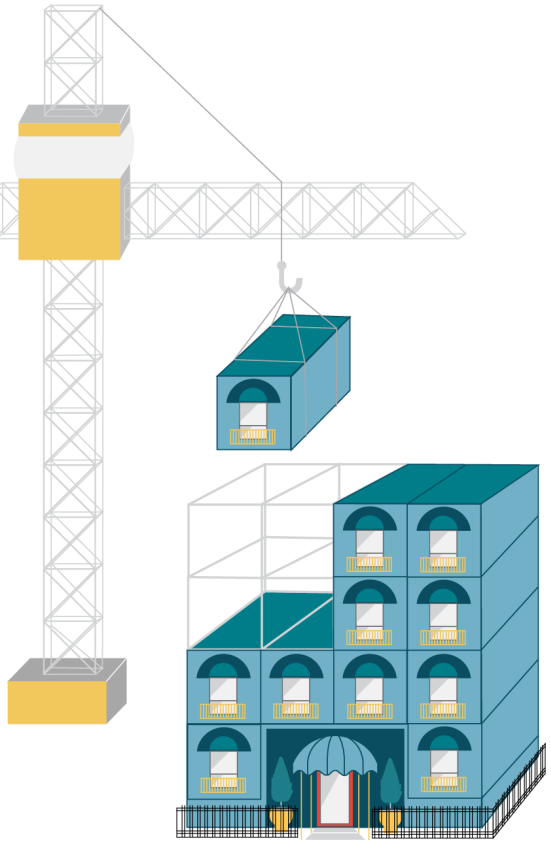
Review of Permanent Modular Construction in the US

Volumetric Modular Construction of Multifamily

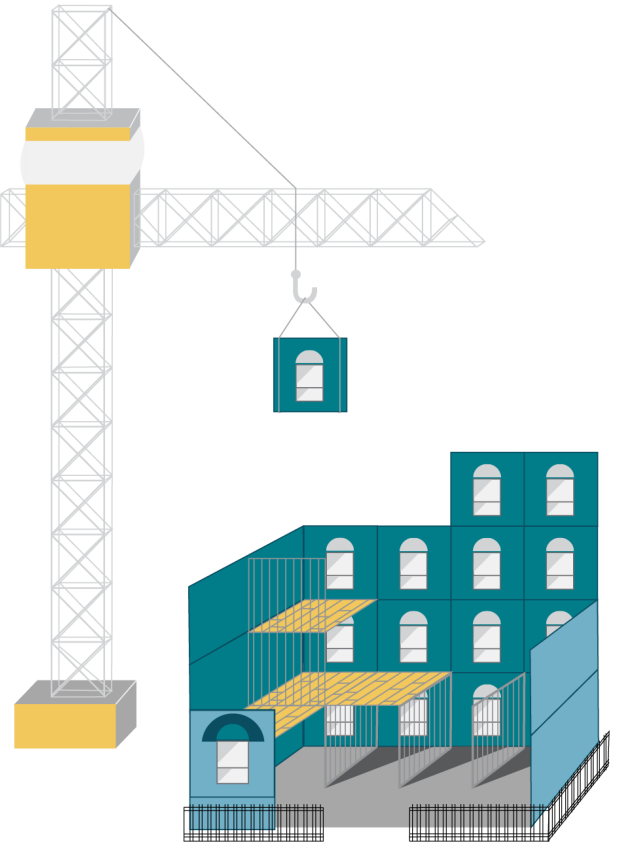
- Involves 75%–95% completion of modular apartment units in off-site factories
- Save up to **20%** on hard costs and reduce construction time up to **50%**

Many U.S. developers and builders see modular construction as an opportunity to remain competitive and create housing at a lower cost thereby passing the benefits downstream to the tenant or the owner

Volumetric Construction



Non-volumetric Construction

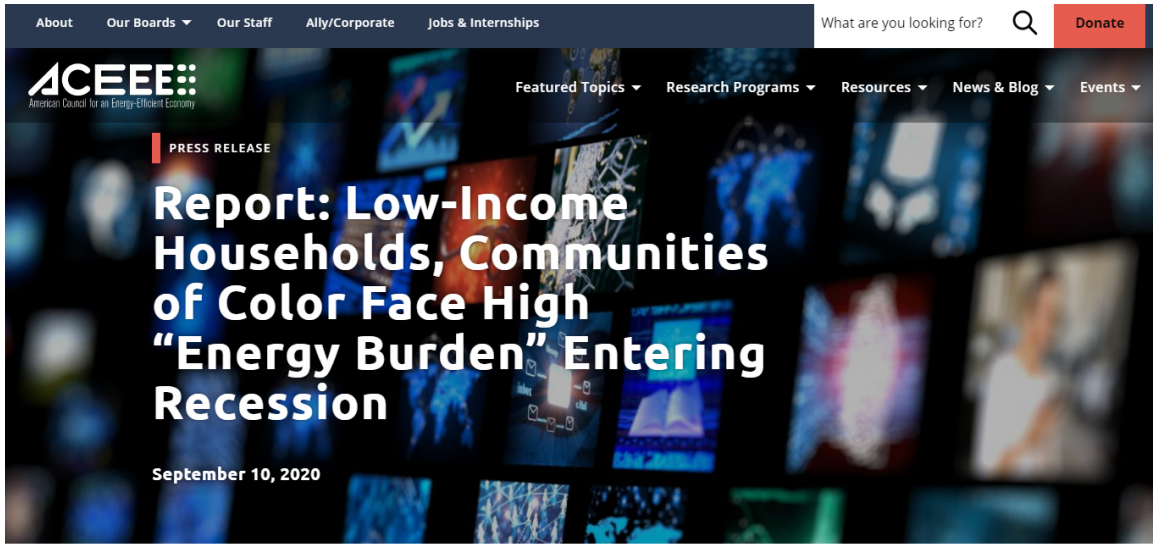


(BuildingGreen, Inc. 2018)

Integrating Energy Efficiency Strategies

Need to Solve the Energy Burden

"*Low-income households face disproportionally high energy burdens*. Low-income households spent 8.1% of their income on energy costs, on average, compared to 2.3% for non-low-income households."



Washington, DC—Low-income households, as well as Black, Hispanic, and Native American households, pay a much larger share of their income on energy bills, straining budgets and putting them at heightened risk of utility shutoffs during the COVID-19 pandemic and recession, according to a new analysis from the American Council for an Energy-Efficient Economy (ACEEE).

The report, arriving as some states end moratoriums on utility shutoffs instituted earlier this year, finds that one-fourth of all U.S. households and two-thirds of low-income ones have high energy burdens, meaning they spend more than 6% of their income on utility bills. Two of every five low-income households have severe burdens, spending more than 10% of their income on energy costs.

Register for the report webinar on Sept. 16

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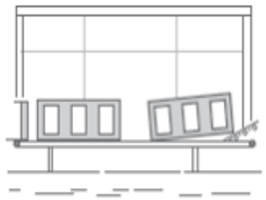
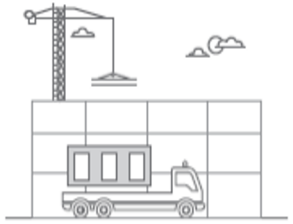
Integrating Energy Efficiency Strategies

Need to Solve for Energy Burden



Assembled in a factory



Transported to site



Assembled



Connect to grid









While there may be unintended or secondary Energy Efficiency benefits to Modular Construction, such as a tighter envelope due to higher construction quality in a controlled factory environment, **Modular Construction has not been leveraged specifically to enhance Energy Efficiency**

Integrating Energy Efficiency Strategies

From Zero Energy Buildings to Zero Energy Modular Buildings

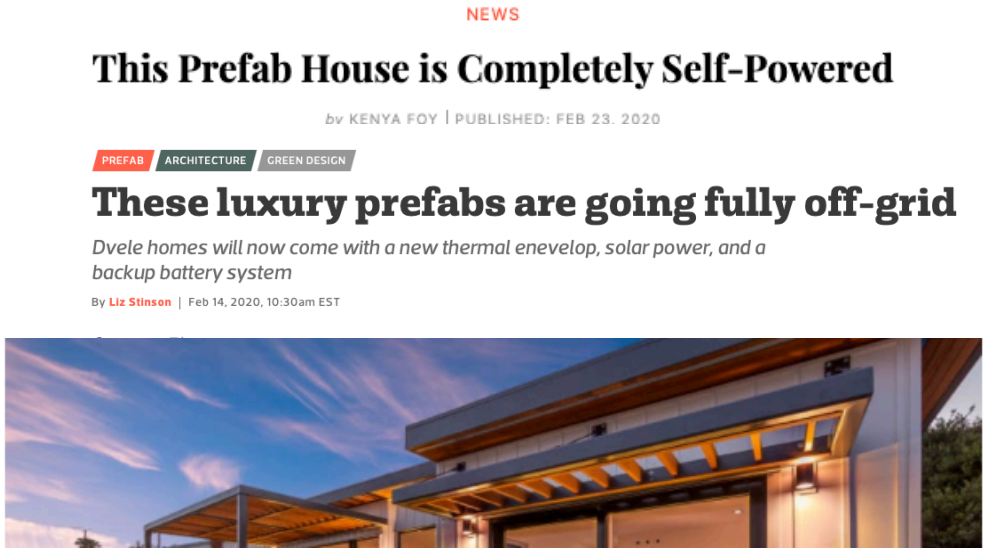


- Design guidance by building type and climate zone
  - Supported by case studies and energy modeling
- Developed by leading industry experts and national labs
- Looked to for beyond code recommendations

More information: https://www.ashrae.org/technical-resources/aedgs

Zero Energy Modular Trends

Single-Family/Residential Buildings, CA projects


NEWS

This Prefab House is Completely Self-Powered

by KENYA FOY | PUBLISHED: FEB 23, 2020

PREFAB ARCHITECTURE GREEN DESIGN

These luxury prefabs are going fully off-grid

Dvele homes will now come with a new thermal enevelop, solar power, and a backup battery system

By Liz Stinson | Feb 14, 2020, 10:30am EST

https://www.curbed.com/2020/2/14/21135428/prefab-homes-self-powered-dvele


LivingHomes Debuts Next-Generation Zero Energy C6 Prefab Home

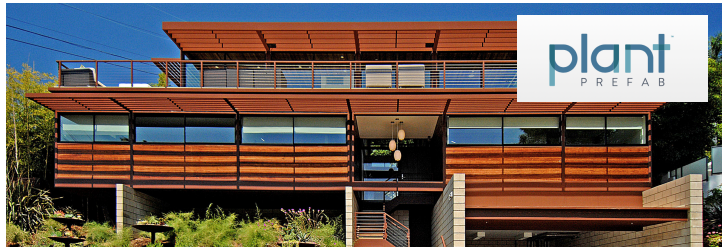
https://inhabitat.com/livinghomes-debuts-next-generation-zero-energy-c6-prefab-home/



Dvele https://www.dvele.com



S2A Modular https://www.s2amodular.com



Living Homes / Plant Prefab: https://www.plantprefab.com/about/

Methods

Research Question

NREL aims to claim this missed opportunity, prove how Industrialized Construction could address the cost and energy burden, and integrate Industrialized Construction benefits with Energy Efficiency, as well as advanced controls, distributed energy resources, and grid-friendly design strategies.

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

NREL
Transforming ENERGY

"How can optimal integration of Energy Efficiency strategies with Industrialized Construction be achieved with little or no additional cost, labor, or lead time?"

Permanent Modular Construction Partners in Multi-family

Primary Building Material: Wood



Volumetric Building Companies—Hamlet, North Carolina



Factory_OS—Vallejo, California

Primary Building Material: Steel



Skender—Chicago, Illinois



FullStack Modular—Brooklyn, New York

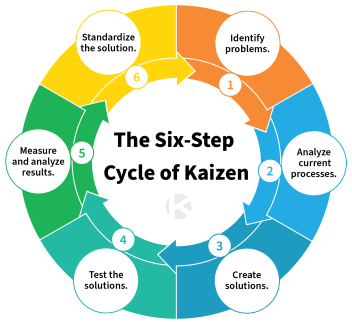
Partner with leading factories and showcase projects to achieve optimal integration of energy systems within the emerging advanced manufacturing industry for buildings

MOMENTUM INNOVATION GROUP

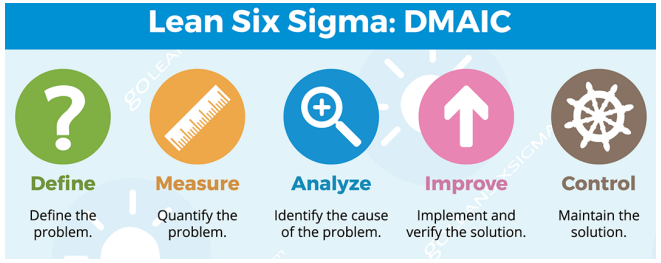
Oregon State University
Civil and Construction Engineering

Manufacturing Principles and Methods applied to Construction Industry

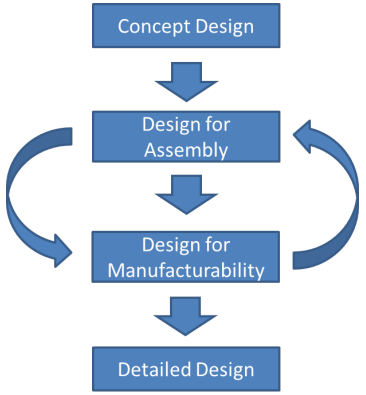
LEAN + DfMA + Automation









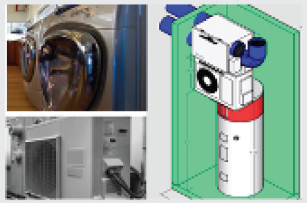




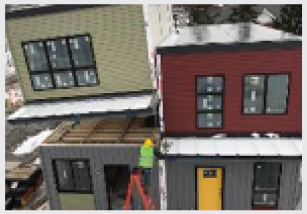


Design for Manufacturing and Assembly (DfMA) for Energy Efficiency Strategies

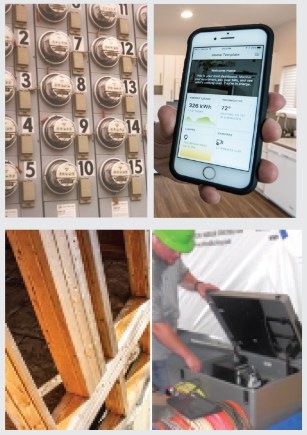
MECH POD

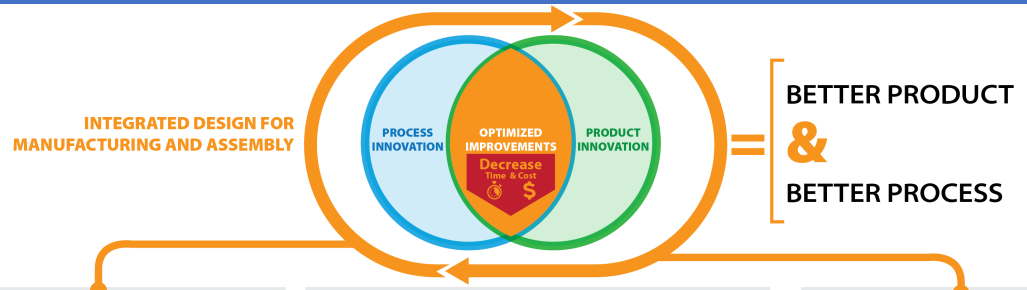


PV & STORAGE



OTHER IN-FACTORY STRATEGIES



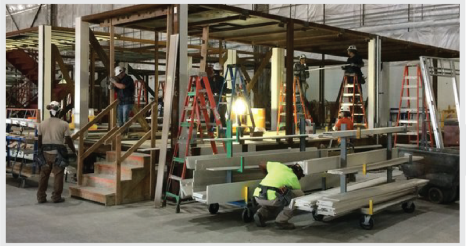


PROJECT PHASING



MAXIMIZE COMPONENTS OF ENERGY EFFICIENCY STRATEGIES with envelope, mechanical systems, and DERs through chunking into sub-assemblies that can be integrated offsite

DESIGN FOR MANUFACTURING (DfM)



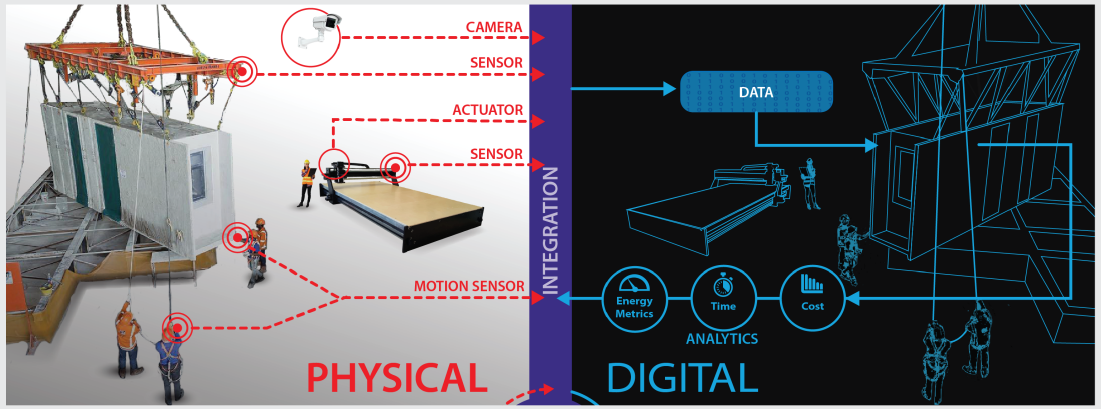
OPTIMIZE DESIGN OF ENVELOPE, MECHANICAL SYSTEMS, AND DERs as sub-assemblies with pre-run energy analytics to achieve off-site production efficiency

DESIGN FOR ASSEMBLY (DfA)



OPTIMIZE DESIGN FOR STREAMLINED CONNECTION OF BOTH ONSITE & OFFSITE COMPONENTS with continued focus on reducing site work by moving jobs into the controlled environment of off-site factory

FACTORY INFORMATION MODEL



LOD 400+ REVIT MODEL & SHOP DRAWINGS

High-Fidelity 3D Digital Twin model BIM-based product information and DES-based process information

Methods

Design for Manufacturing and Assembly (DfMA)

Summary of strategies and components for site-built to achieve ZEBs

Site-built strategies	Components
Building and site	Building design, site design, and orientation strategies
	Planning for renewable energy
	Use of open-source BEM platform
Building envelope strategies	Envelope construction strategies and factors
	Compartmentalization/airtight envelope
	Thermal mass and bridging, well-insulated envelope
Daylighting	Design- and space-specific strategies
	Solar heat gain coefficient multipliers for projections
Electric lighting	Luminaire recommendations, design strategies
	Advanced control strategies
Plug load	Plug load management
	Power distribution systems
Kitchen equipment	Equipment, design strategies, and performance
	Heat recovery
Service water heating	System types and design strategies
	Electric resistance and heat pump water heater
	Design strategies and equipment recommendations
	Chilled/hot-water system with single-zone air-handing unit
	Air-source variable refrigerant flow (VRF) multi-split
	Ground-source heat pump
	Dedicated outdoor air system
Renewables and storage systems	Photovoltaic (PV)-ready design strategies
	Energy storage system
	Building-integrated PV and building-attached PV
	Electric vehicle integration



Summary of strategies for off-site to achieve ZEM multifamily buildings

Off-site strategies	Components
Building envelope strategies	Insulation systems maximized for life-cycle cost savings
	Aerosol-based sealing for air-tightness improvements
	Pre-insulated thermally broken studs (such as TStuds[a])
	Advanced wall-framing technologies
	Building envelope compartmentalization
Mechanical equipment solutions	Integrated mechanical system pod solution for space conditioning and water heating (in-unit heating, ventilating, and air conditioning [HVAC] and heat pump water heater)
	Heat recovery options from wastewater
	Integrated exhaust and ventilation heat recovery with dehumidification/heating/cooling solutions
	Ventless dryers to eliminate exhaust vent maintenance
	Grid controllable, all-electric domestic water heater
	Induction cooking
Smart apartment controls	Occupant engagement platform
	Advanced controls integration
	Enable single utility meter with software submetering
	Grid-integrated HVAC and hot water controls, utility price signaling
	Grid-interactive efficient buildings (GEBs) controls, sub-metered module with hourly real-time pricing
Renewables and storage systems	Single meter to enable large-scale PV with unit submetering
	Modular electrical rooms with battery uninterruptible power supply (UPS) and demand management
	In-unit battery storage for demand management and backup UPS
	Factory-assembled building solar systems

Design for Manufacturing and Assembly (DfMA) for Energy Efficiency Strategies

Explore strategies that maximize factory assembly scope

- Factory installed EE strategies can simplify installation, better control scope and scheduling, enhance quality, standardize means and methods, increase construction productivity, and reduce overall construction timelines
- And eliminate/reduce on-site construction scope
  - Quantify trade-offs for strategies that increase cost of module but reduce construction cost/time/complexity and/or eliminate on-site scope

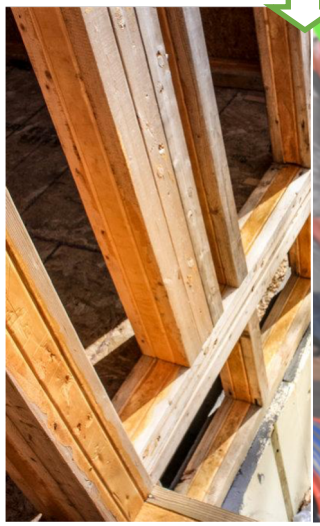
This allows modular solutions to maximize cost effectiveness of solutions and leverage industrial engineering and advanced manufacturing approaches to increase productivity and reduce first cost of construction

  - *DfMA, Digital twin optimization of processes, standardized part list, industrialized construction, etc*

Strategies and Components for Off-Site Integration

1- Advanced Envelope Strategies

- Off-Site Wall Framing *with Thermally Broken Studs for Low-Cost Thermally Efficient Envelopes*
- Aerosol-Based Sealing Technology *for improved Airtightness of modular units*





2- Smart Apartment Controls Platform

- *For Modular Grid-Interactive Efficient Buildings (modGEBs)*
- Occupant engagement platform



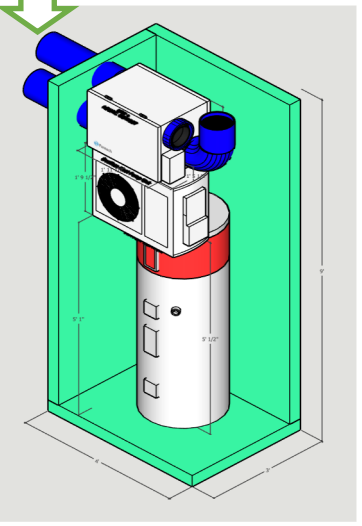


3- Integrated Mechanical Pod solution (Factory-Installed, In-Unit)

- *For Space Conditioning, Energy Recovery, and Water Heating*







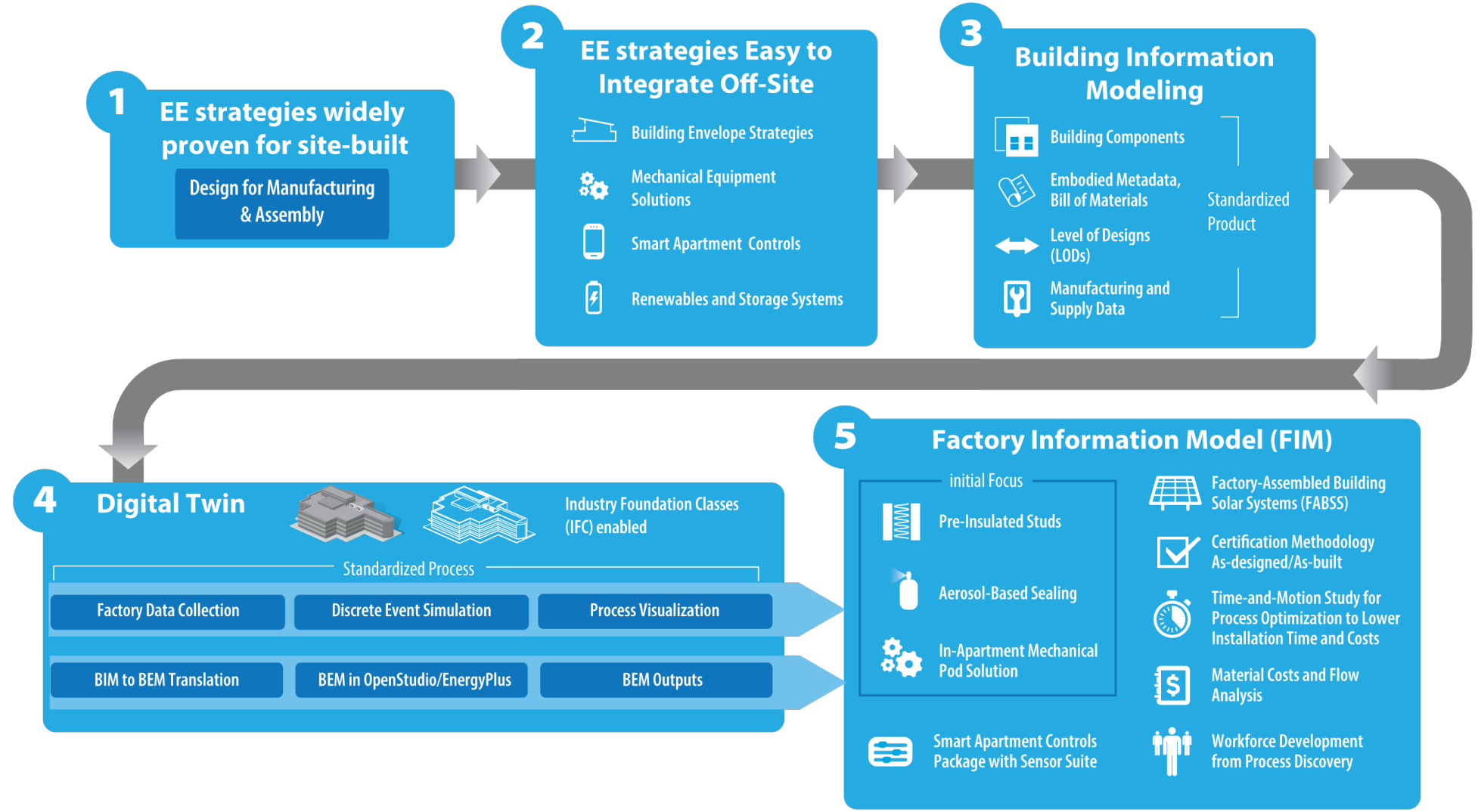
4- Factory-Assembled Building Solar Systems (FABSS)

- *For Solar PV, Building-integrated PV (BiPV), and In-Unit Battery Storage*

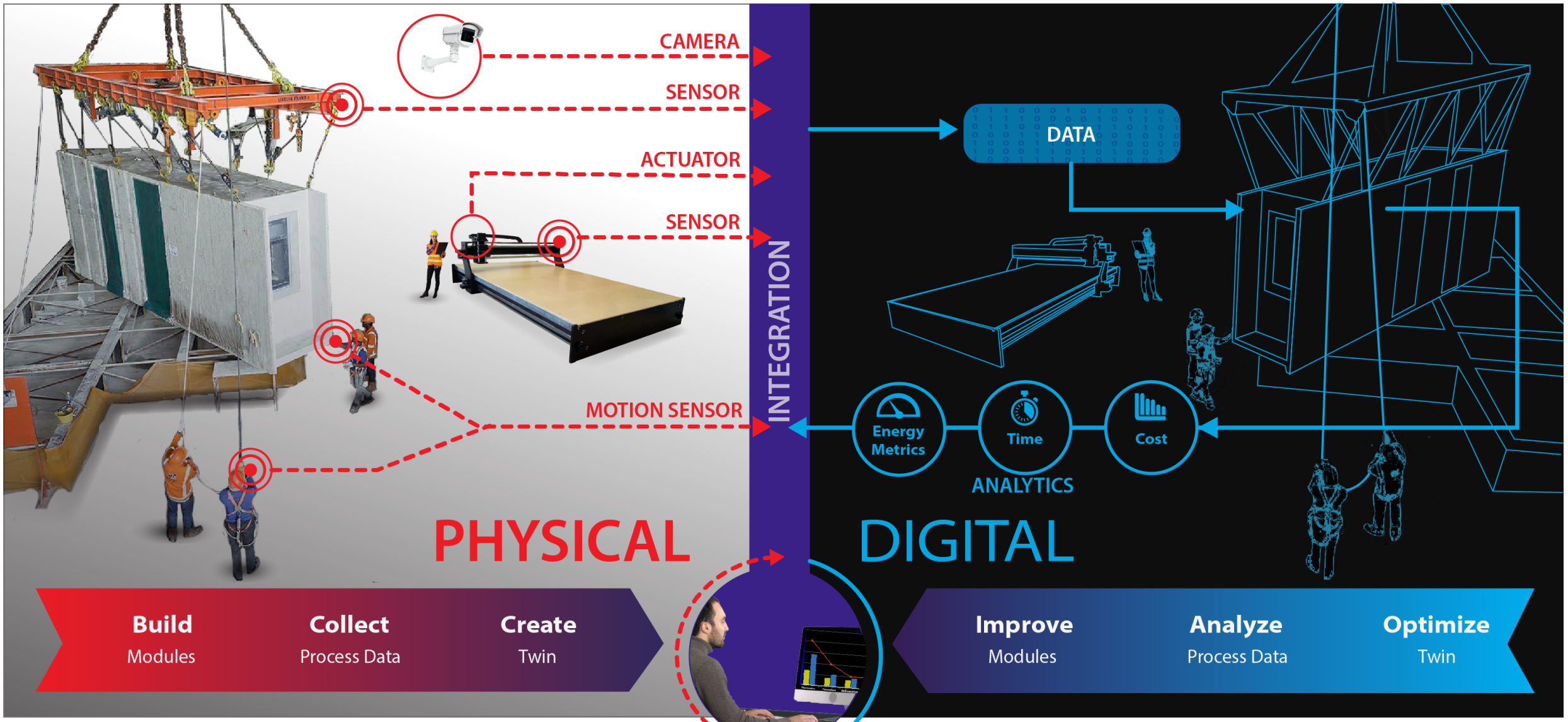


Methods

Industrialized Construction Assessment Framework



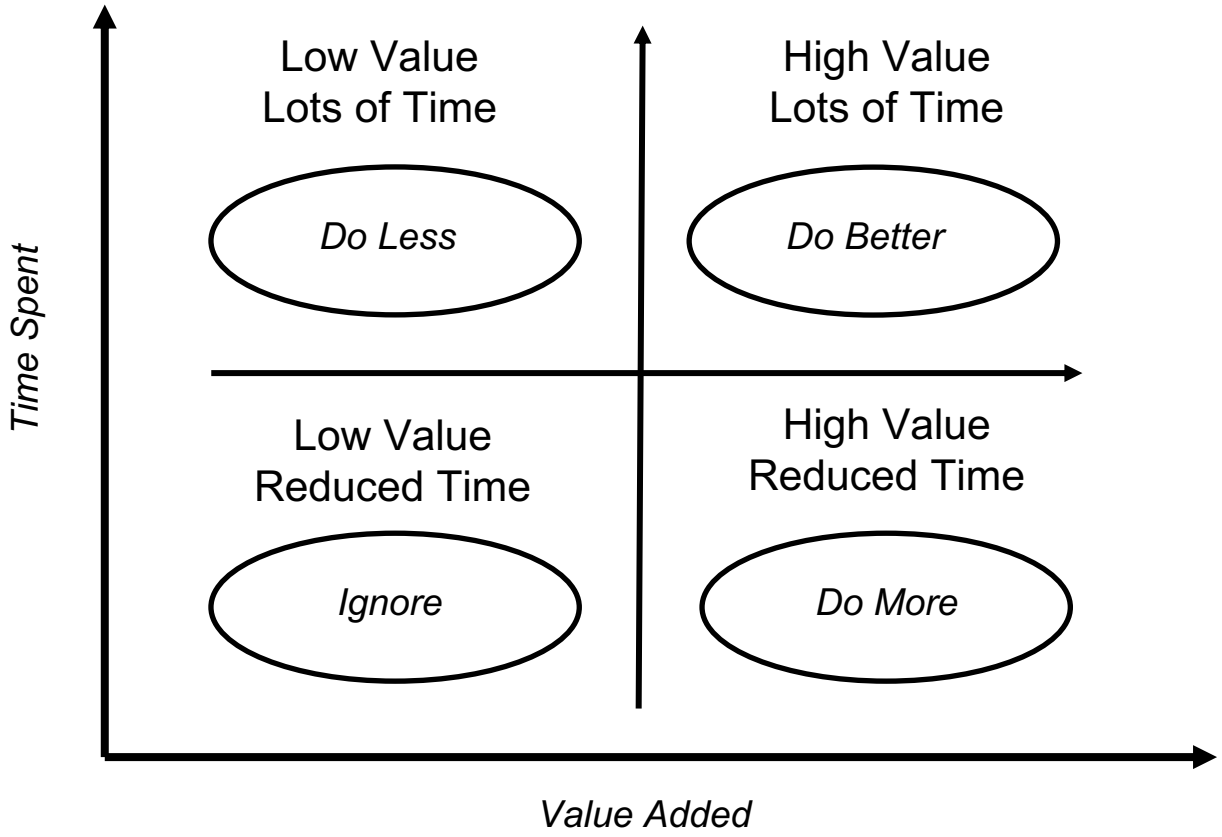
What is a *Digital Twin* for Modular Homebuilding?



Advancement in Time-and-Motion Study

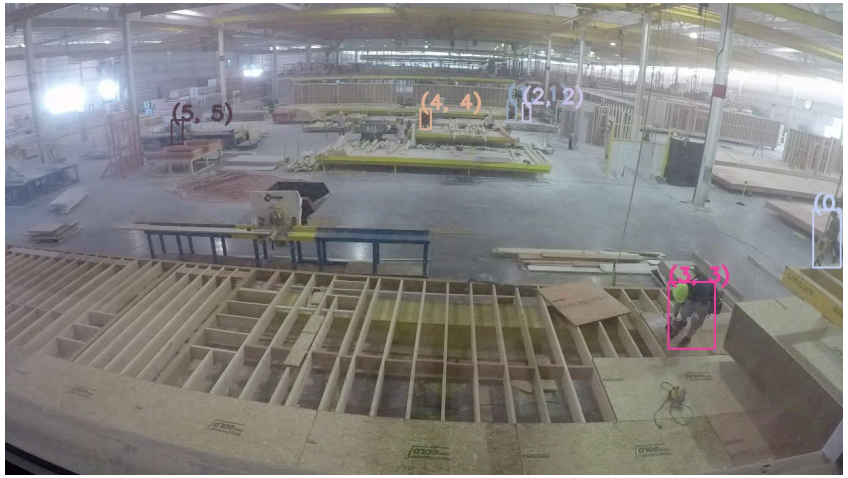
In Partnership with
Oregon State University
Civil and Construction Engineering

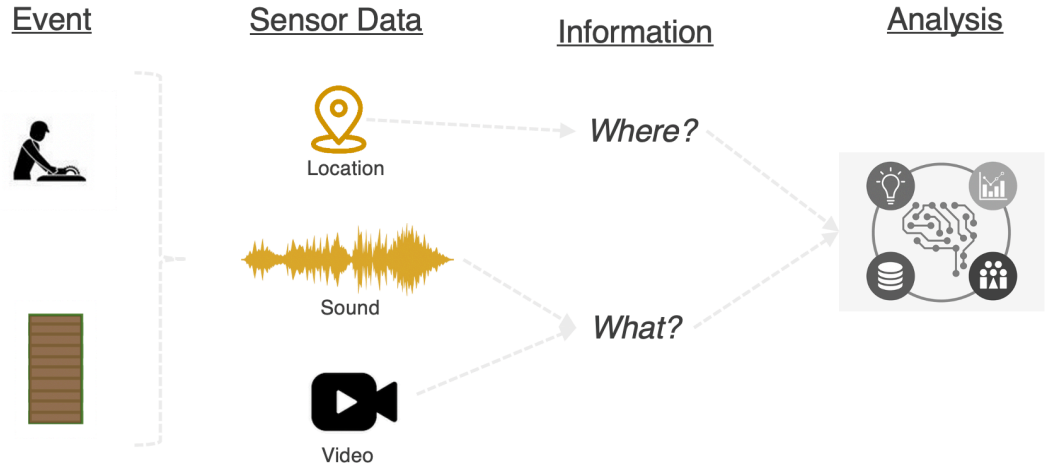
Time-and-Motion study is a technique for recording the times of performing a certain specific job which is carried out under specified conditions.



ML-enabled Time-and-Motion Data

Watch Full Video:
https://drive.google.com/file/d/1PNTWo8IThwOcvJTwRKIu3EQfA6zk7Xku/view?usp=sharing



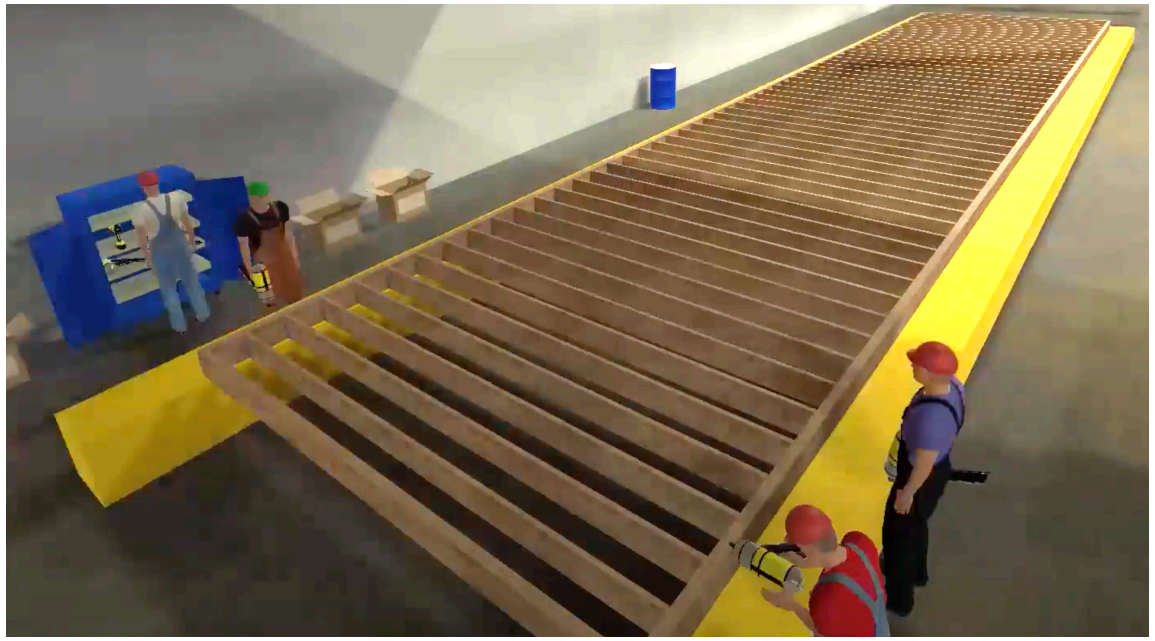


Industrialized Construction Factory Information Model

In Partnership with Oregon State University
Civil and Construction Engineering

"Process-Based Digital Twin"

Floor Build Station Digital Twin flythrough video: https://youtu.be/U8nZkwbAW28

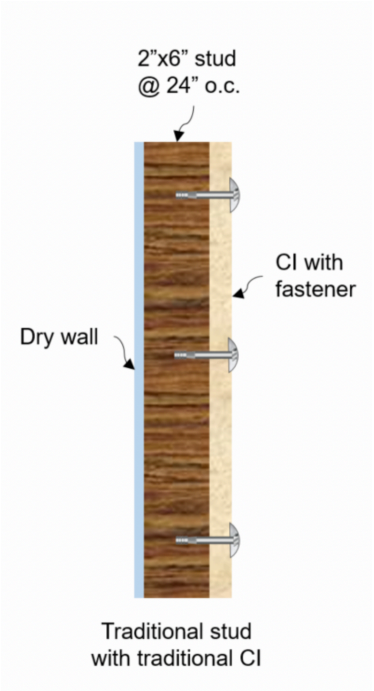


Wall Installation Station Digital Twin flythrough video: https://youtu.be/k9co4-WTWf0



Early Results from Comparative Process Analysis

1. Off-Site Wall Framing with Pre-Insulated Studs/TStuds



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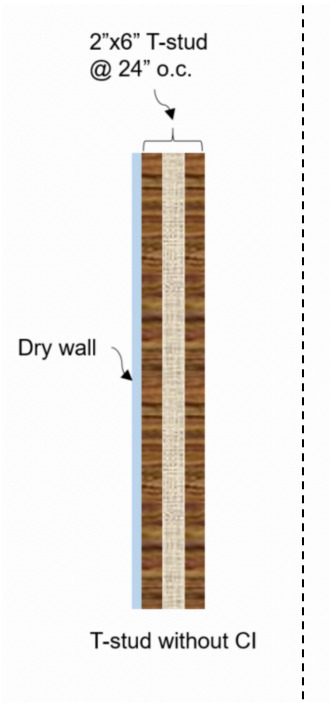
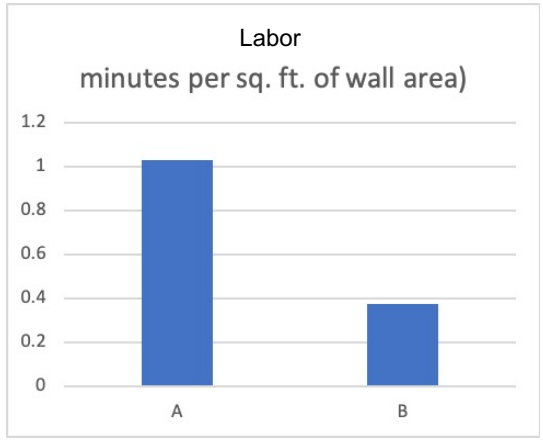
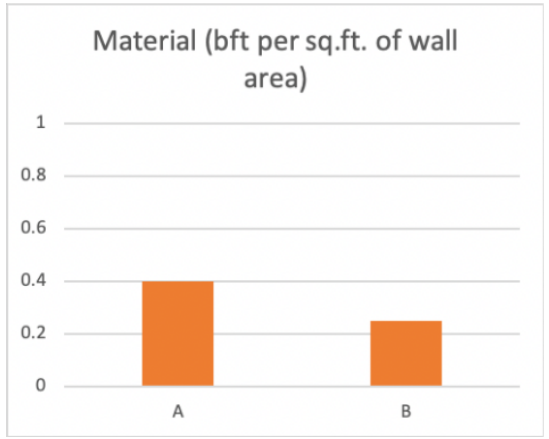
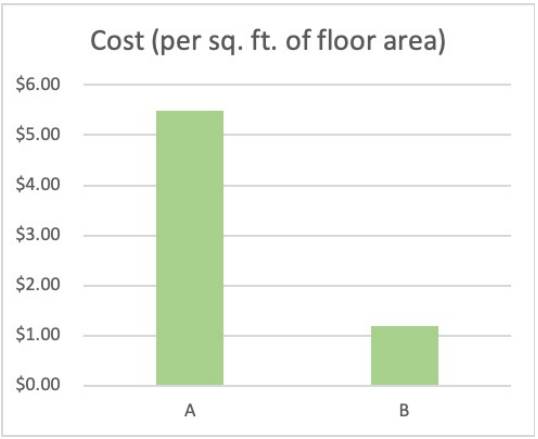


B







A- Off-Site Wall framing with standard 2x6 studs followed by on-site continuous insulation
B - Off-Site Wall framing with pre-insulated thermally broken studs and **no** on-site continuous insulation

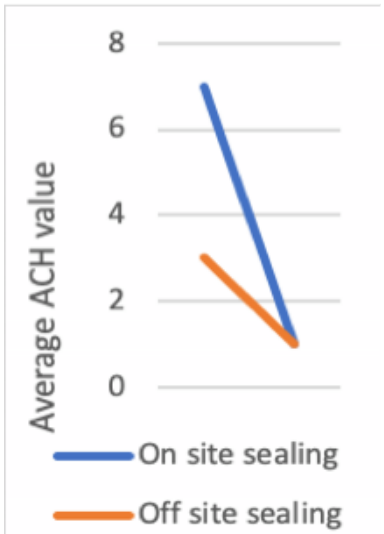
B has reduced labor-minutes by 63%, total material used by 38%, and cost (for material and labor) by 78% vs. A

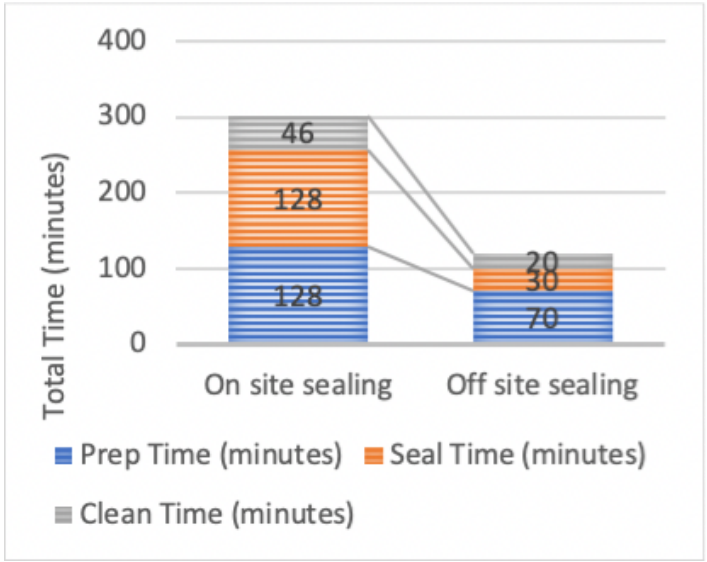
Early Results from Comparative Process Analysis

2. In-Factory Aerosol-Based Sealing of Modular Units

AEROBARRIER™
Breakthrough Envelope Sealing Technology By Aeroseal







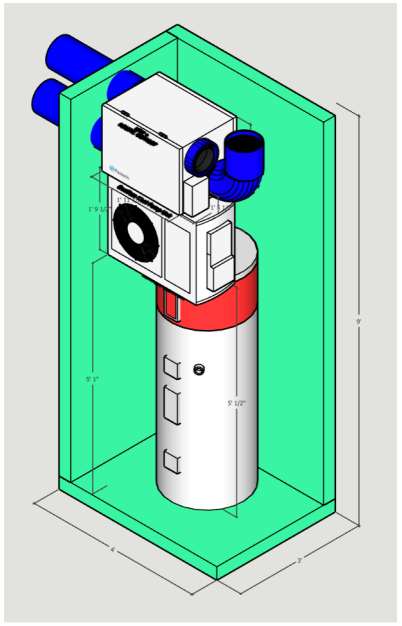


Aerosol-based sealing in factory of factory-built modular apartment units (off-site sealing) starts in modules that are 60% more airtight and takes 60% less total time to complete the three stages of preparation, sealing, and cleaning in comparison to aerosol-based sealing in site-built apartment units (off-site sealing).
Due to significantly faster sealing time, off-site sealing brings down costs by 40%.

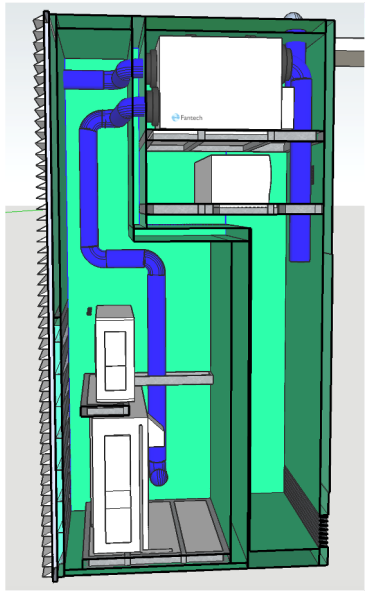
Towards a Shared Development Platform at NREL Campus

In-Apartment Mechanical Pod DfMA, Prototyping, Testing, and Validation

1. DfMA

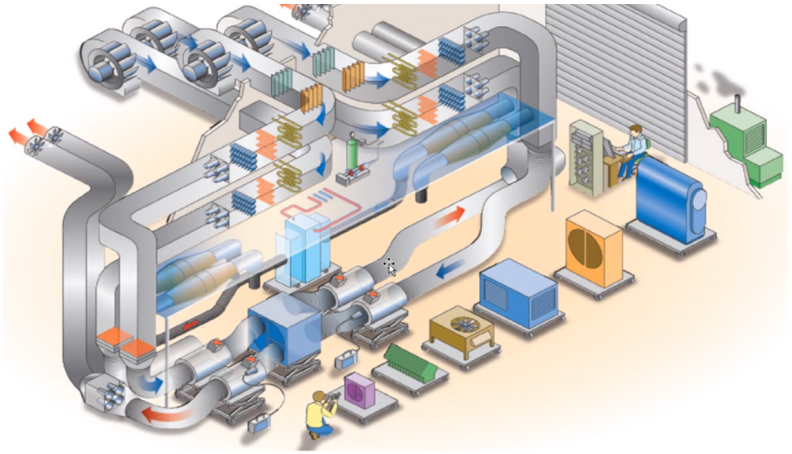


Basic Vertical Module (3'X3')
Components: Heat Pump water heater, HRV, Outdoor unit



Two-Module System
Components: CO2 based Sanden unit, ERV/HRV, Mini-split system, Dryer, Washer

2. Prototyping and Testing at NREL's HVAC Test Lab



3. Integration and Validation in real-scale modular apartment currently at NREL Campus

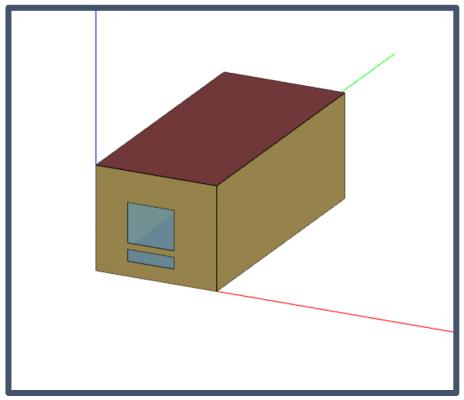


Novel Tools

Energy Modeling integration with Modular DfMA

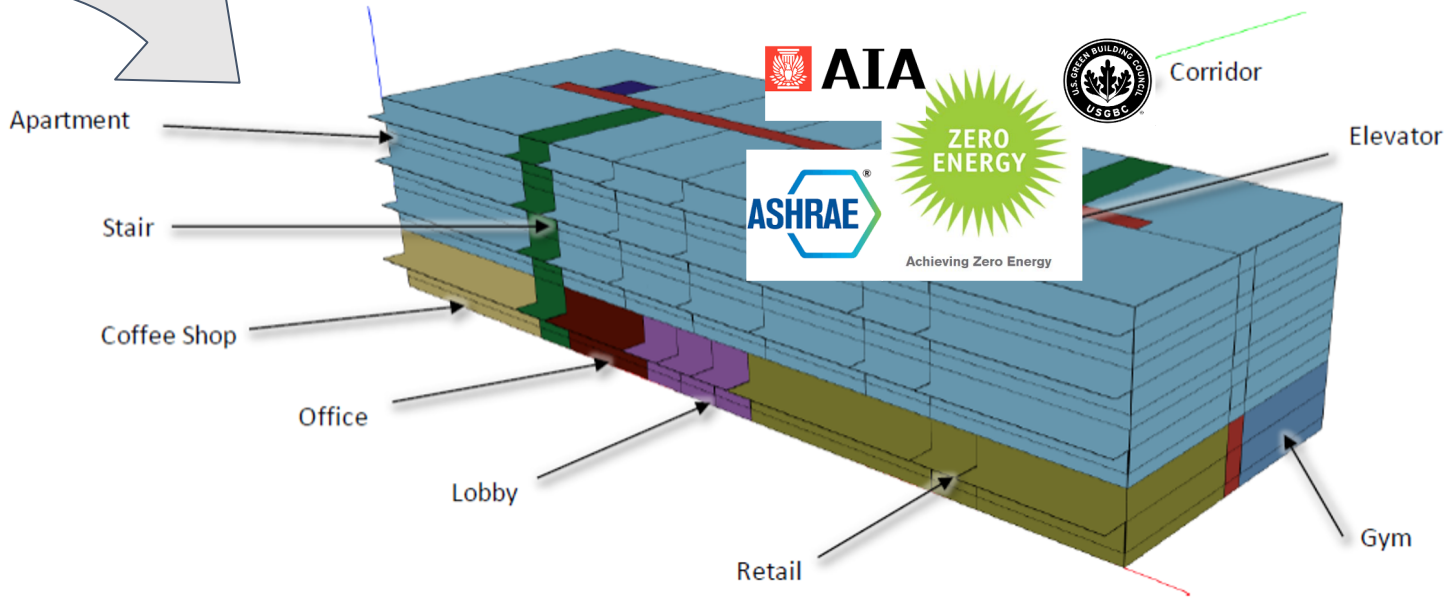
One Module scale → Whole-building scale

Seed model



One standard module input with energy pre-runs

(Standard Module) x Number of units

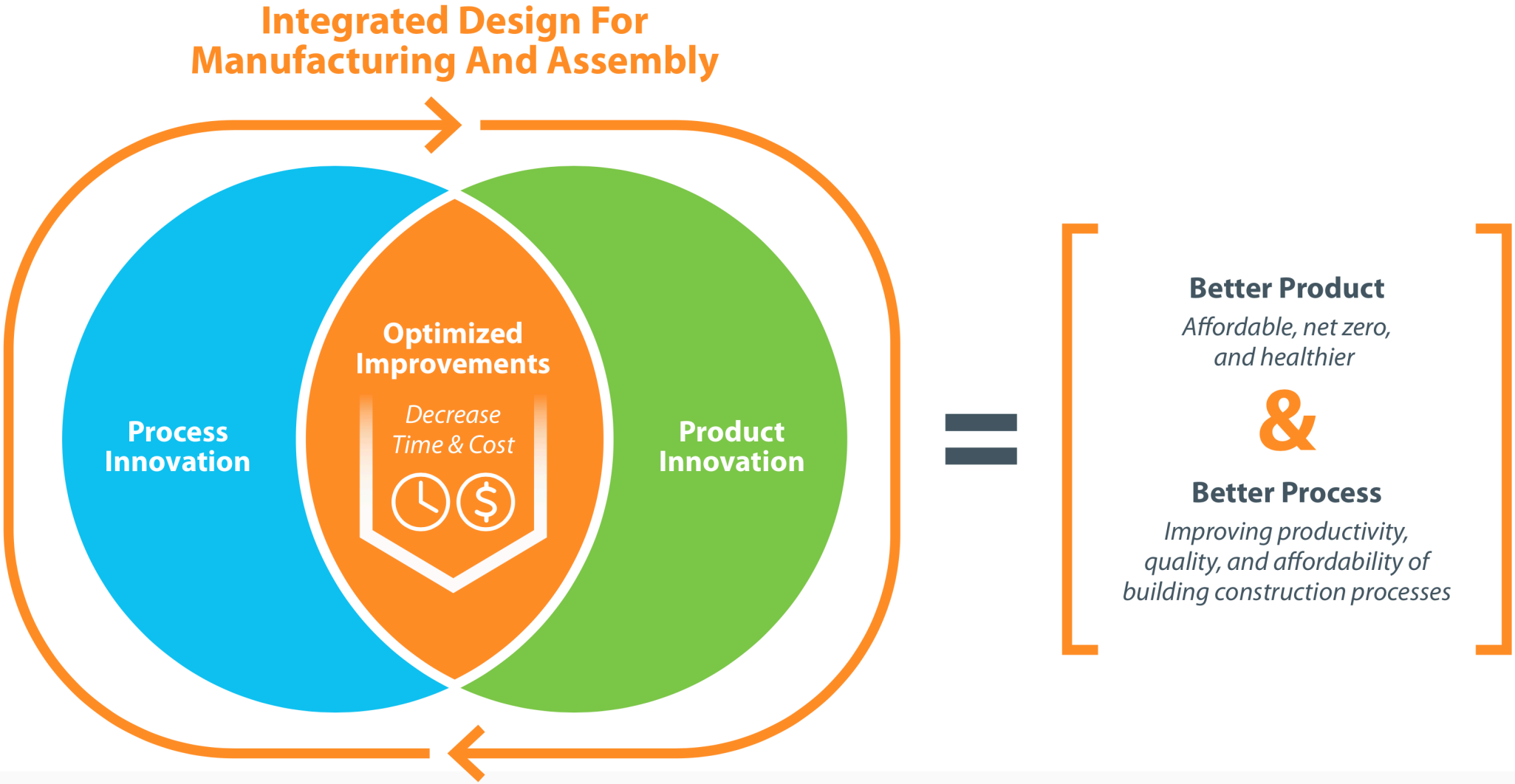


- Energy Pre-runs
- Load Calcs
- Least Cost Curve

- Mod-Mod Adiabatic Walls
- Exterior Wall
- Mod-Corridor Adiabatic Wall
- Floor

Next Steps

Process-Product Innovation



Find more about ongoing research efforts

Integrating Energy Efficiency Strategies and Distributed Energy Resources into Industrialized Construction

NREL is leveraging the benefits of industrialized construction—higher-quality buildings, faster construction timelines, improved productivity, increased technology integration, and labor cost savings—to enable cost-effective strategies for energy efficiency, integrated grid-interactive controls, and renewables.

Read more:
https://www.nrel.gov/buildings/industrialized-construction.html



NREL is partnering with startups like Blokable Inc. bring more affordable, energy-efficient housing to market by optimizing off-site industrialized construction techniques.

NREL Buildings Researchers



Shanti Pless
Senior Research Engineer



Stacey Rothgeb
Senior Research Engineer



Ankur Podder
Research Engineer



Noah Klammer
Graduate Researcher—CU



Zoe Kaufman
Research Engineer

Ongoing NREL Projects: *Advanced Building Construction + Building Science*



IN² Blokable



ABC Retrofit Panel HP



Ice Juneau



ABC Zero Energy Modular System – VEIC



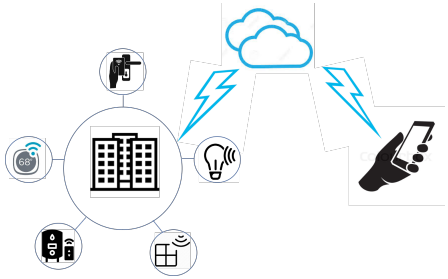
ABC New Iglu



BTO EE in PMC



CLT LCA



IN² StratisIOT



ABC Collaborative



IN² Pre-Framing



ABC Simple Install System

NREL Innovation and Entrepreneurship Center



Trish Cozart
Group Manager, Innovation and Entrepreneurship Center
IN2 Program Manager
trish.cozart@nrel.gov

Learn about collaboration opportunities for High Performance Housing Professionals by Wells Fargo on housing affordability, construction innovation, and energy efficiency.

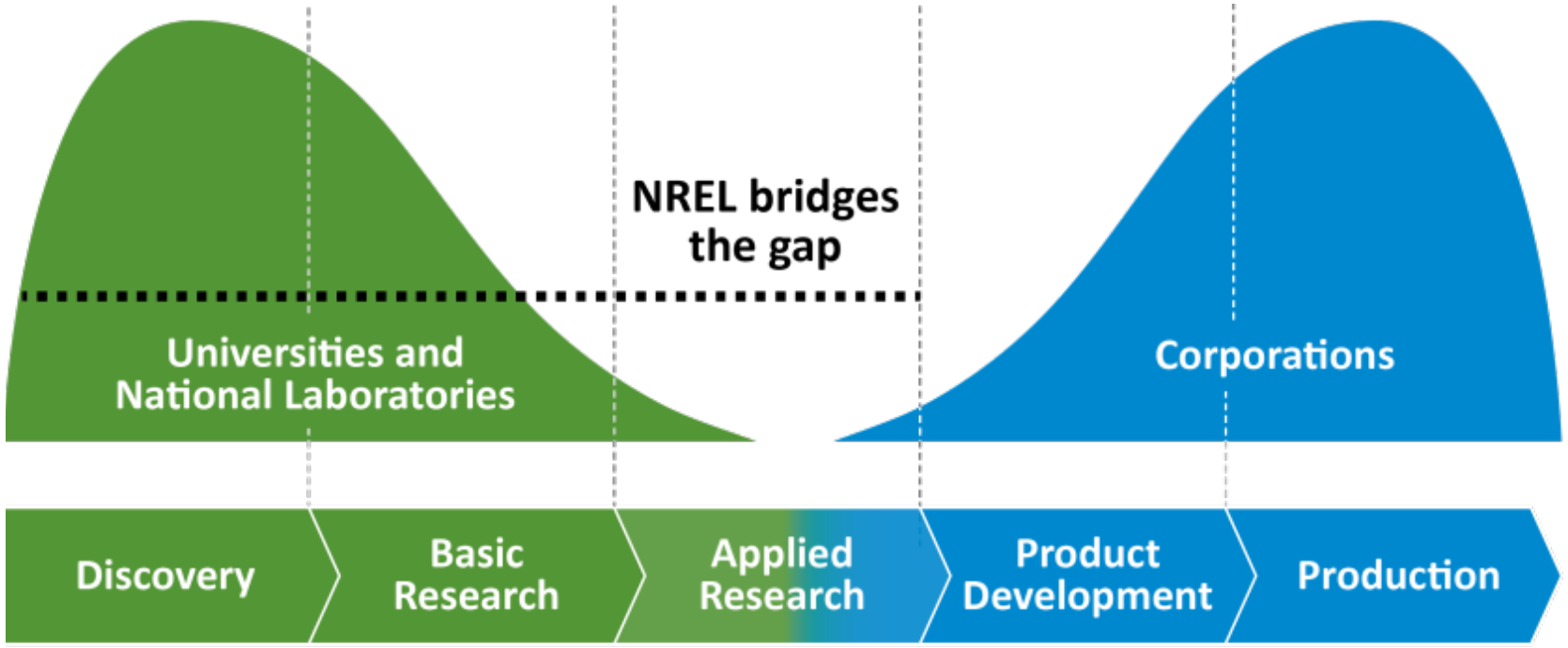
AGENDA

1. About the NREL Innovation & Entrepreneurship Center
2. About the Wells Fargo Foundation
3. Housing Affordability Breakthrough Challenge
4. Wells Fargo Innovation Incubator (IN^2)
    - Housing Tech Portfolio
    - Ways You Can Get Involved

NREL | Innovation & Entrepreneurship Center

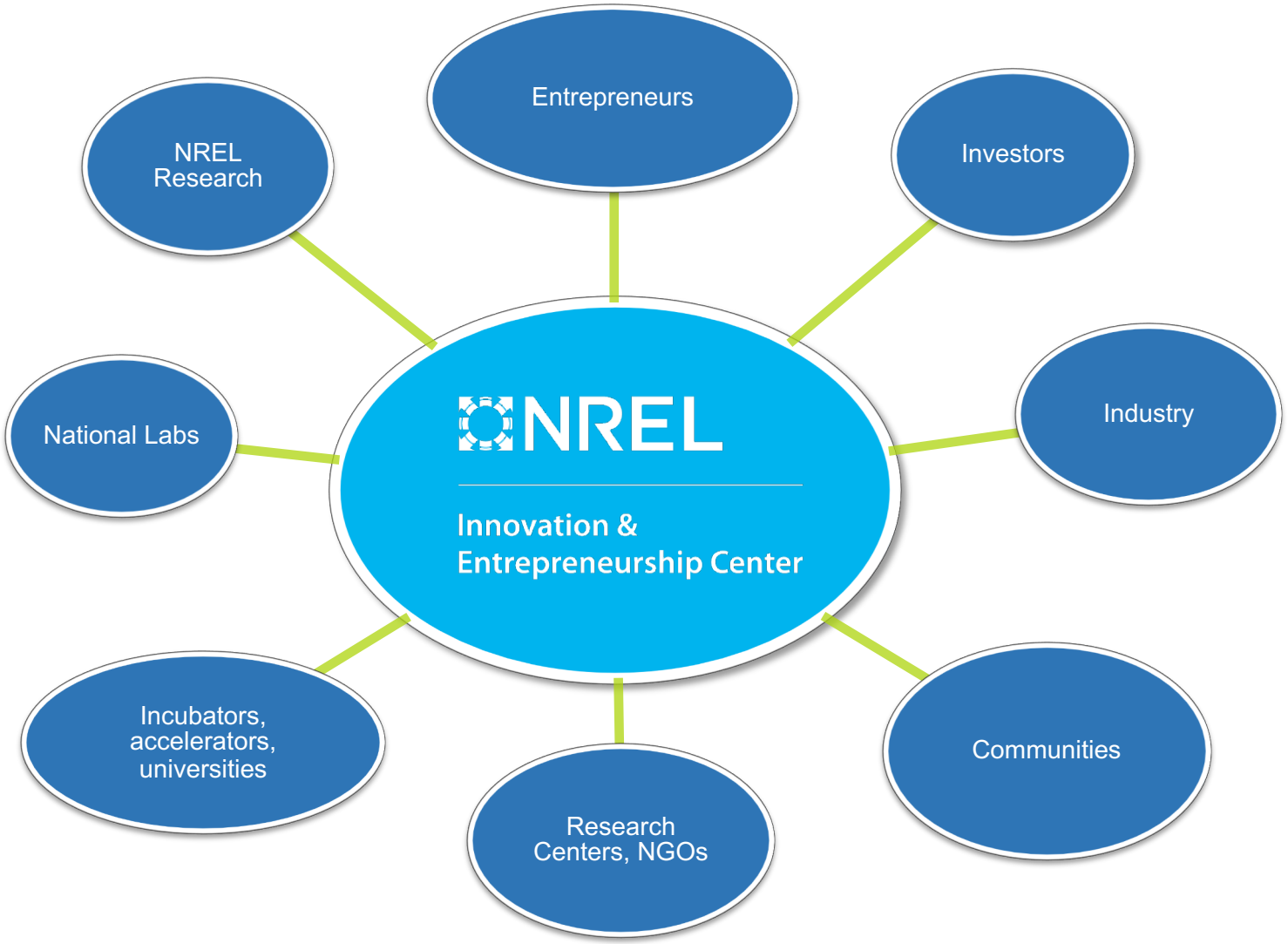
Building a **cleantech ecosystem** to **empower** market solutions that **transform** communities around the world

Bridging the Gap

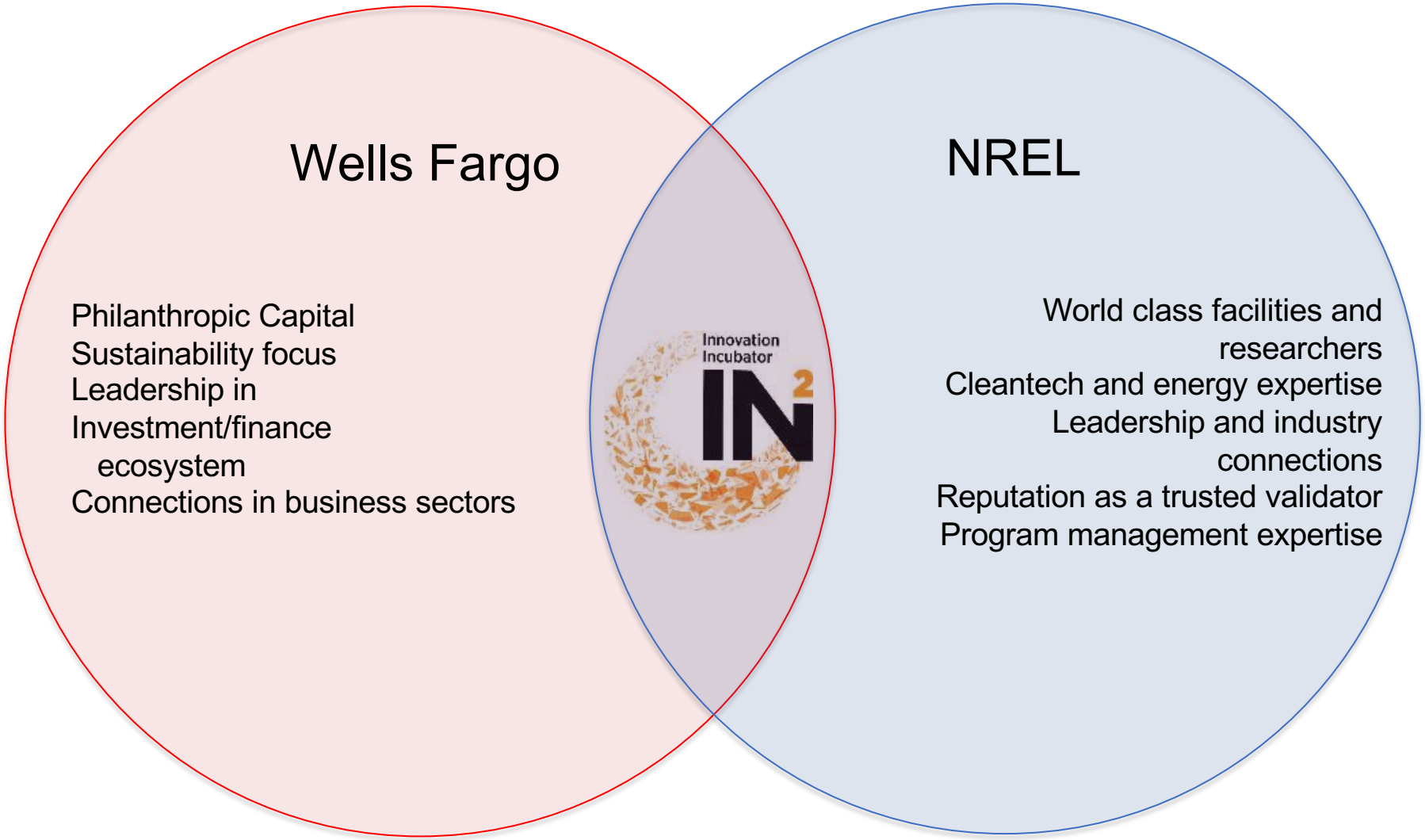


Center of Connections

Our ability to develop connections on behalf of other labs and the entire ecosystem makes **NREL a leader in technology commercialization**.



Public-Private Partnerships



Small Biz + Housing + Environment



The Wells Fargo Foundation is interested in supporting promising cleantech startups with the goal of **commercializing low-carbon solutions** in order to achieve the associated **social, economic, and climate benefits** that are so urgently required.

Major Wells Fargo Foundation Initiatives



Example Wells Fargo Funded Housing Programs

Enterprise

Housing Affordability Breakthrough Challenge

Innovation Incubator

IN²

WELLS FARGO | NREL

Six $2M Grants in 2020

Enterprise

Housing Affordability Breakthrough Challenge

- Housing Financing
- Resident Services & Support
- Housing Construction

Innovative, scalable and viable ideas to increase housing affordability solutions

Housing Construction Finalists

COLD CLIMATE HOUSING RESEARCH CENTER

FORT&RRA
FOR THE PEOPLE. FOR THE LAND. FOREVER.

FlyawayHomes

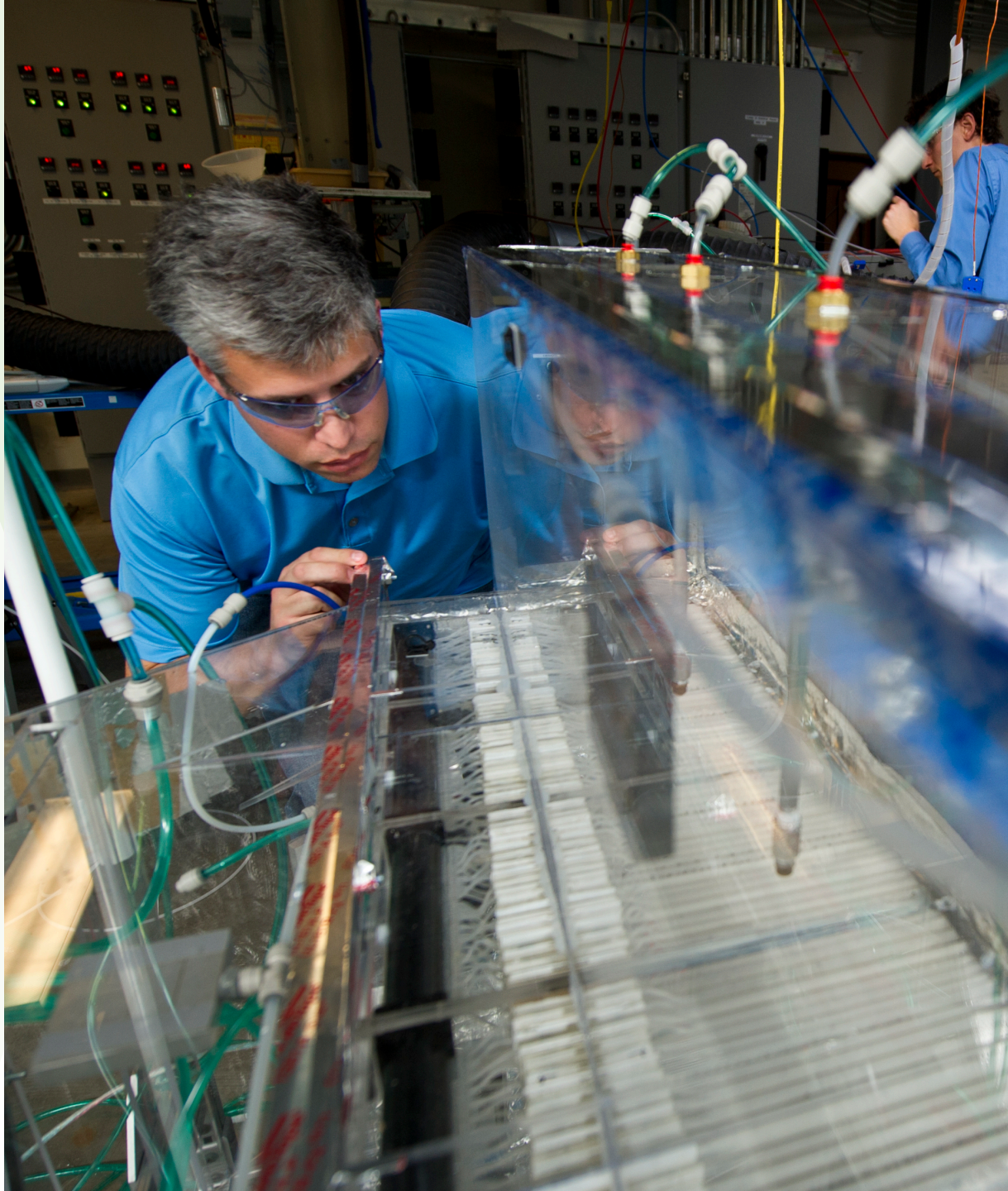
COMMUNITY DEVELOPMENT CORPORATION OF BROWNSVILLE

About the Wells Fargo Innovation Incubator (IN^2)

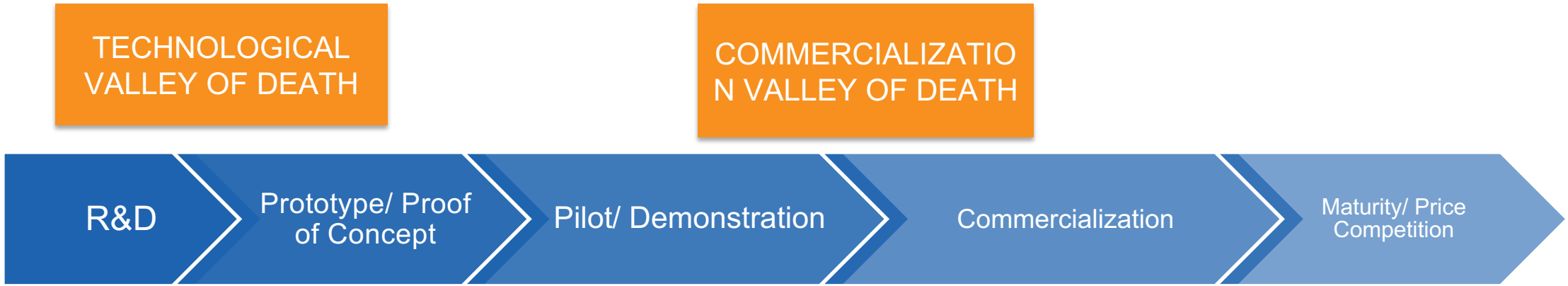
Innovation Incubator

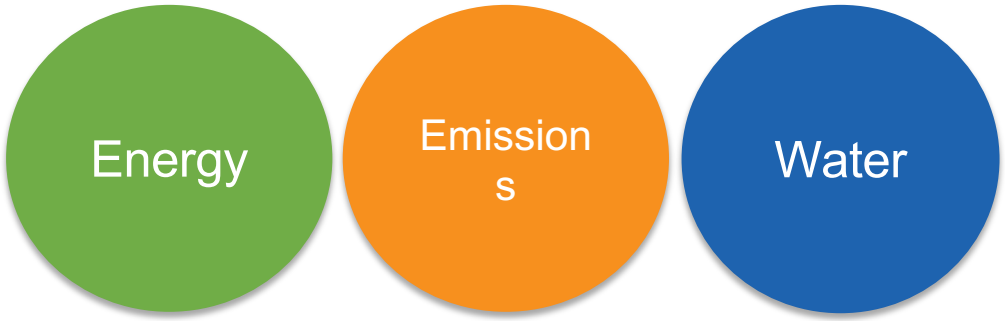
IN²

WELLS FARGO | NREL



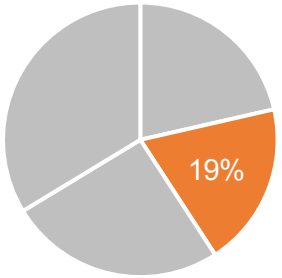
Under Invested, High Impact





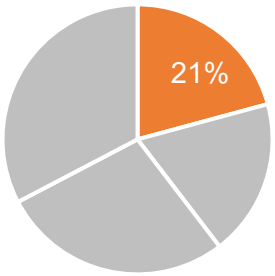
Current Focus Areas of the Incubator

COMMERCIAL BUILDINGS



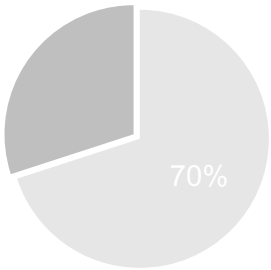
Consumes 19% of the U.S. energy

HOUSING



Consumes 21% of U.S. energy

AGRICULTURE



Consume 70% of world's water supply and 14% of energy

24% global GHG emissions

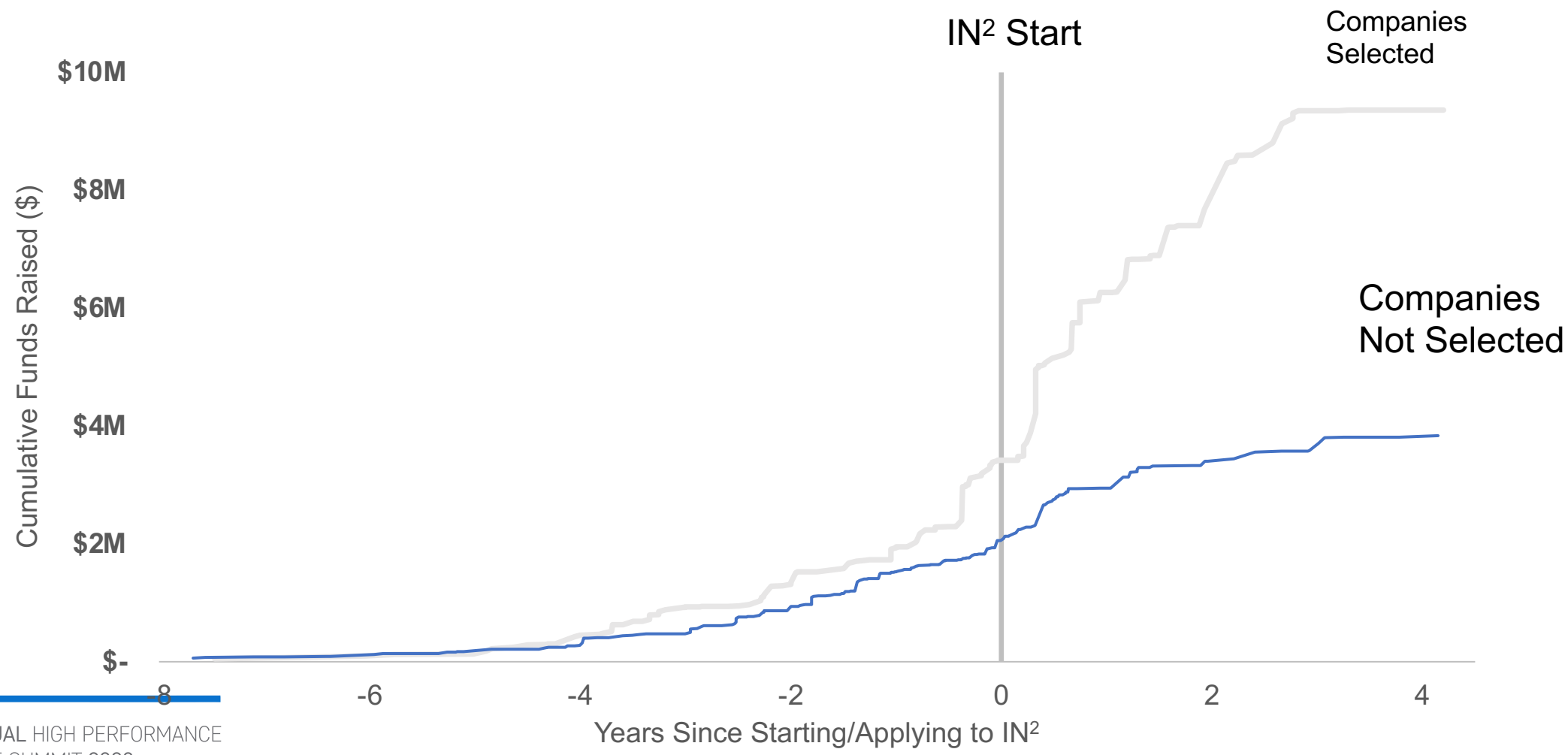
Buildings responsible for 40% global GHG emissions

- Data Infrastructure
- Energy Analysis
- Energy Management
- Energy Storage
- HVAC Systems
- Smart Glass
- Water

- Advanced manufacturing & construction process
- Materials
- Community and district-level technology and planning tools
- Energy-efficient technologies

- Crop Production
- Plant Science
- Precision Agriculture

Rate of Investment in IN² Companies vs Applicants



IN² By the Numbers



$313M

Investment
Since joined IN²

372

Jobs Created

1:28

Funding
Leverage Rate

6

Mergers &
Acquisitions

46

Portfolio Companies

60+

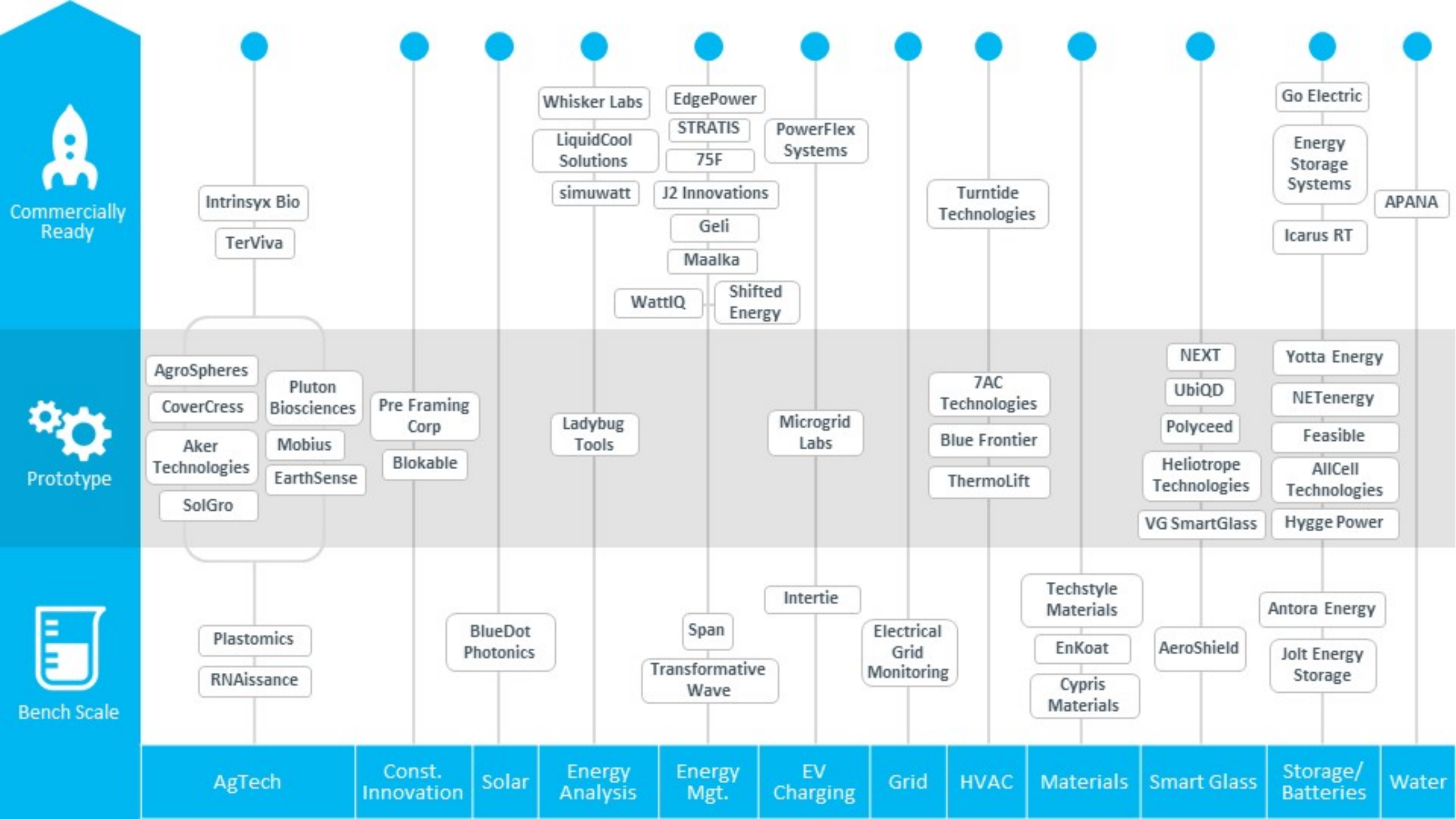
Channel Partners

How Our Incubator Works?

Early stage companies at any technology levels shown at the right are eligible to apply. Each company selected to be in the IN^2 program is given **$250,000 in non-dilutive capital**.

Most of the funds are used to provide **technical assistance** for a project at the lab run by an expert researcher and scoped and agreed upon by the company. Some of the funds are used for **project support** including any project supplies or travel needed by the company.

PROGRAM	TECHNOLOGY DEVELOPMENT	FUNDING
TIER 1 Bench Scale	▪ TRL 1-5 ▪ Conceptual stage with physical proof the concept may work ▪ Development plans for prototyping and testing ▪ 3-5 years to market	Up to $250,000 200K Technical Assistance 50K Project Support
TIER 2 Prototype	▪ TRL 6-7 ▪ Prototype available for testing and validation ▪ Plans available for development to final product ▪ Less than 2 years to market	
TIER 3 Commercially Ready	▪ TRL 8-9+ ▪ Production models available in limited quantity ▪ Less than 18 months to market	


Commercially Ready
Prototype
Bench Scale
Intrinsyx Bio
TerViva
Whisker Labs
LiquidCool Solutions
simuwatt
EdgePower
STRATIS
75F
J2 Innovations
Geli
Maalka
WattIQ
Shifted Energy
PowerFlex Systems
Turntide Technologies
Go Electric
Energy Storage Systems
Icarus RT
APANA
AgroSpheres
CoverCress
Aker Technologies
SolGro
Pluton Biosciences
Mobius
EarthSense
Pre Framing Corp
Blokable
Ladybug Tools
Microgrid Labs
7AC Technologies
Blue Frontier
ThermoLift
NEXT
UbiQD
Polyceed
Heliotrope Technologies
VG SmartGlass
Yotta Energy
NETenergy
Feasible
AllCell Technologies
Hygge Power
Plastomics
RNAissance
BlueDot Photonics
Span
Transformative Wave
Intertie
Electrical Grid Monitoring
Techstyle Materials
EnKoat
Cypris Materials
AeroShield
Antora Energy
Jolt Energy Storage
AgTech
Const. Innovation
Solar
Energy Analysis
Energy Mgt.
EV Charging
Grid
HVAC
Materials
Smart Glass
Storage/ Batteries
Water

Energy Management



SPAN.IO

Span is developing a device that replaces traditional electric panels to deliver a new level of energy automation in the home.



STRATIS

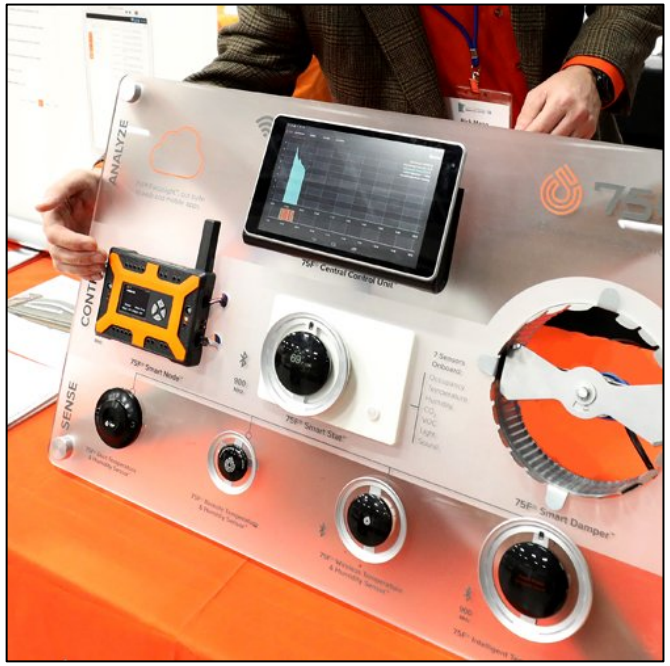
STRATIS is an IoT Platform that provides smart access, energy, water, and automation management for multifamily and student housing.

Energy Management



SHIFTED ENERGY

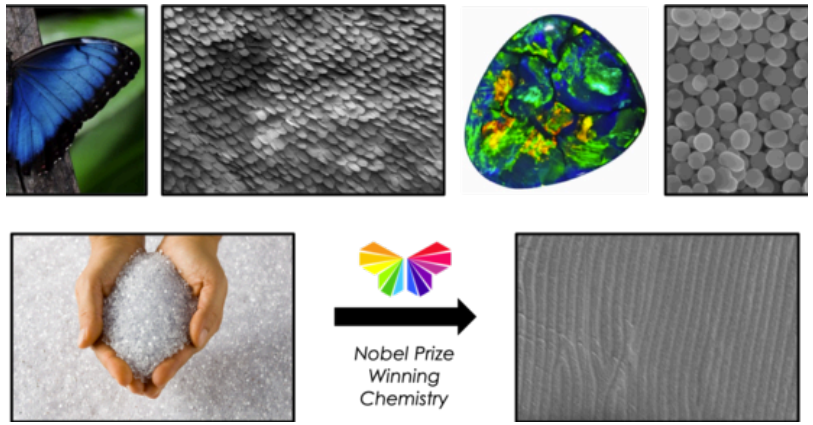
Shifted Energy developed a Power Controller and accompanying software that converts existing electric water heaters into intelligent, grid-interactive water heaters.



75F

75 offers an easy-to-setup HVAC controls system that increases operational efficiency and improves the building occupant experience.

Materials



CYPRIS

Cypris Materials creates paintable heat-reflective coatings as a roofing retrofit for both residential and commercial building to reduce cooling loads.



EnKoat

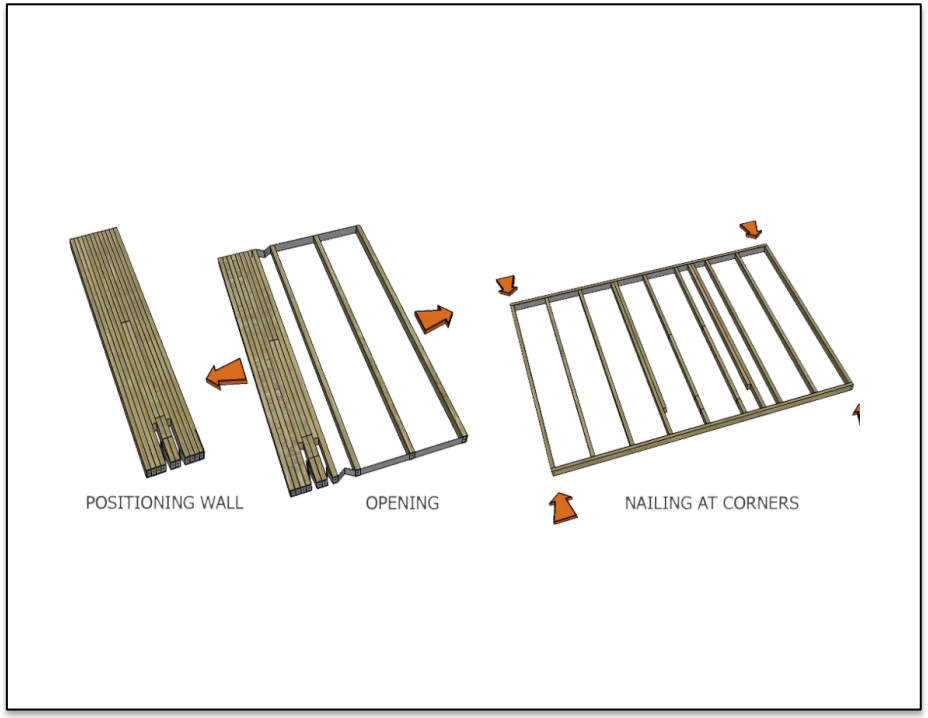
EnKoat has re-engineered traditional architectural coatings, like paint, plaster and stucco, into energy-saving coatings by incorporating phase change materials.



Techstyle MATERIALS

Techstyle Materials is developing multifunctional building material that automatically regulates the flows of heat and water vapor through surfaces.

Construction Management



PRE FRAMING CORP

Pre Framing is an innovative, partially-prefabricated solution which allows homebuilders, general contractors and framers to build standard and gable walls faster, with less waste and more precision than traditional methods.



blokable

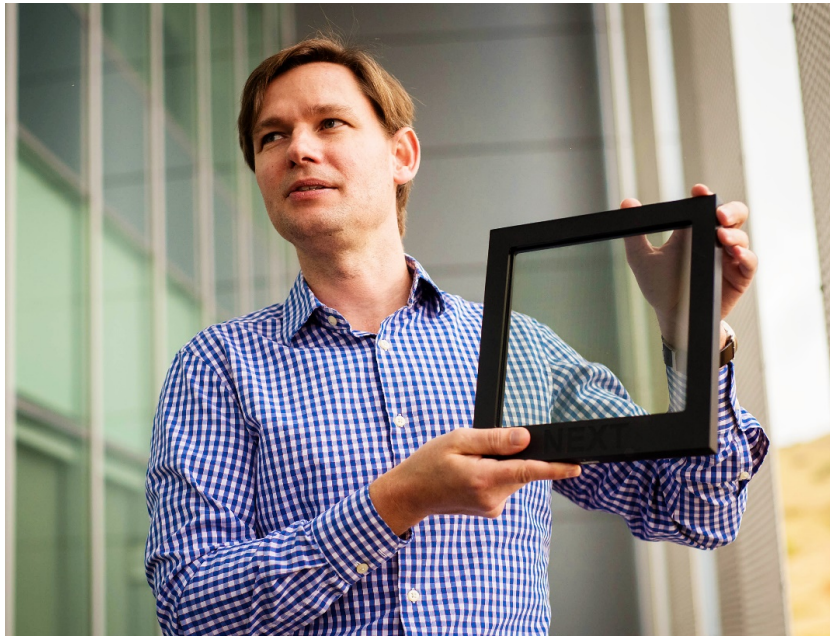
Blokable's Building System (BBS) is a comprehensive building system designed, engineered, and manufactured to consistently produce high-quality, low-cost, connected housing.

Smart Glass



AeroShield

AeroShield manufactures super-insulating, nanoporous form of glass for energy efficient windows: durability, modeling, TEA



NEXT
NEXT ENERGY TECHNOLOGIES, INC

NEXT offers low-cost, printable, transparent coatings that are seamlessly integrated into windows, allowing for the harvest of light energy for use as onsite renewable power: durability, modeling



UbiQD
UBIQUITOUS QUANTUM DOTS

UbiQD is producing nanomaterials for energy harvesting that provide a simple, scalable, low-cost, and aesthetically pleasing approach to solar windows: durability, modeling

How to Get Involved

- **Entrepreneurs**: If you know of or are a housing tech startup, contact us at IEC@nrel.gov and we can help direct you to opportunities related to your needs.

- **Construction/Housing Industry**: Subscribe to our newsletter to get information about the latest from our portfolio each quarter. Contact us to and we can introduce you to companies with emerging tech and/or talk to you about possible demonstration/pilot opportunities.

- **Corporates**: Contact us to learn how to fund your own cohort and leverage program built by NREL and funded by Wells Fargo.



WELLS FARGO | NREL

IN2ecosystem.com
IN2@nrel.gov

Part 3: Simple Homes



David Schultz
Co-founder & COO,
Simple Homes
david@simplehomes.com

Learn about best practices from the modular building industry on designing and building high performance homes from Simple Homes.



Simple Homes

Using technology to reduce waste in residential construction

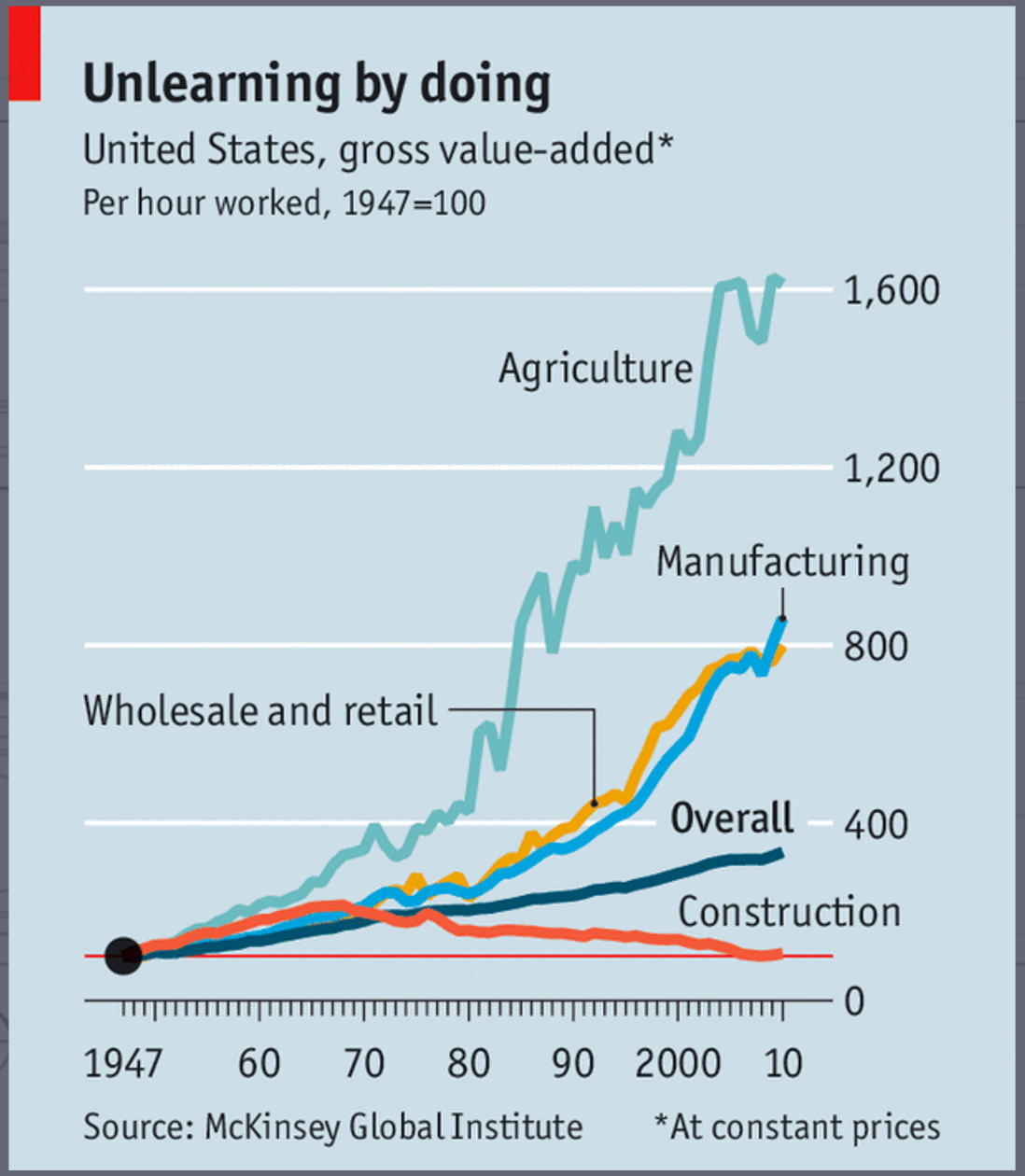
Our mission:
simply building better.

We help builders craft better homes through design, technology, and proven Swedish-inspired panelized off-site construction.

The problem

A $500b industry that has not fundamentally changed in 100 years

- According to a 2018 McKinsey study, whereas productivity in manufacturing has doubled since 1995, **construction productivity has declined – a difference of 1.7x**
- A Financial Times analysis found that homebuilders are **35% less efficient relative to the U.S. economy**
- The **industry is also one of the least digitized,** according to a different 2016 study by McKinsey



The impact

Increasing construction costs have contributed to a growing housing crisis…

- in 2016, nearly **50% of U.S. renters were considered cost burdened**
- We are not building enough houses: according to the National Low Income Housing Coalition, **the U.S. is 7.7M units short**
- In Denver, since 2011 **wages are up 11% - while rents are up 46% and housing prices are up 49%**

…while the environmental impacts of homebuilding remain staggering

- Constructing a **2,000sf home creates 8,000lbs of waste** on average
- Each year the U.S. generates about **160 million tons of building-related construction debris** – 2/3 of all solid waste generated
- Homes account for **39% of total energy consumption, 68% of electricity consumption, and 38% of CO2 emissions**

Digital design to physical construction



We build a digital fabrication model for every project. Our fabrication models are highly detailed and contain every stud and every piece of hardware required to build the home. This **data is then translated directly to the shop floor** in the form of machine files, laser files, and digital work orders.

Our building system

We design, manufacture, and assemble homes as components and assemble them rapidly on-site with our own crews.

Our system includes all structural elements of the building – wall panels, floor panels, and roof systems. We provide a variety of levels of finish depending on the needs of our customers.







Denver ADU



Offsite Construction Value



- Shorter cycle times
- Waste reduction
- Industrialized quality control process
- Safer working conditions
- Increased volume and productivity.

Offsite Challenges

- Factory overhead
  - Relatively large minimal viable scale.
- Transportation logistics
- Inertia in building industry
- Resistance from existing labor pool
- Regulatory
- Banking and finance















Example projects + key partners

McSTAIN NEIGHBORHOODS

ROG& WILCO

PARKWOOD HOMES

L&D CONSTRUCTION

elevation COMMUNITY LAND TRUST

Habitat for Humanity

TELLURIDE FOUNDATION
Make more possible... Here. Now. Tomorrow

Our team



Jeff Hopfenbeck
Co-founder & CEO

McKinsey & Company
University of Colorado



John Schwarz
Chief Design Officer

GE Johnson
Kansas State University



David Schultz
Co-founder & COO

L&D Construction
Colorado State University



Mac Little
Dir. Digital Fabrication

Prescient Co
University of Houston



Jeff Prager
CFO

The CFO Project
University of Colorado



Abner Casavant
Head of production

Whirlpool
Lee University

Simple Homes

W: www.simplehomes.com

E: David@simplehomes.com

Q&A

Please feel free to reach out to panelists:

- Shanti Pless, NREL Shanti.Pless@nrel.gov
- Stacey Rothgeb, NREL Stacey.Rothgeb@nrel.gov
- Ankur Podder, NREL Ankur.Podder@nrel.gov
- Trish Cozart, NREL Trish.Cozart@nrel.gov
- David Schultz, Simple Homes David@simplehomes.com

THANK YOU

Join the conversation:
#2020EEBAVirtualSummit #eeba #goeeba

Save the dates for next year!

SEPT 14 – 16 2021
Denver, CO

EEBA
VIRTUAL HIGH PERFORMANCE HOME SUMMIT 2020
SEPT 29 - OCT 9 | ONLINE VIA WHOVA