

REALIZE

Industrial Approaches to Net Zero Energy Retrofits

Mechanical System Manufacturers Webinar
November 13th, 2018



Transforming global energy use to create a clean, prosperous, and secure low-carbon future.

SPEAKERS



Amy Egerter | CPHC, LEED AP BD+C

Amy currently leads the REALIZE technical team while also supporting the RMI Buildings practice in designing and conducting various techno-economic studies. Prior to joining RMI, Amy worked as a sustainability consultant for architects, engineers, and contractors. She carried out whole building energy simulations, daylight analysis, and LEED certification for projects ranging from multifamily housing to university campuses. Amy has a BS and MS from Stanford University in civil and environmental engineering with a focus in architectural design.



Galen Staengl | P.E., LEED® AP BD + C, CPHC

Galen has 20 years of experience designing and modeling cutting-edge energy efficient mechanical systems for green building projects and industrial facilities. As President of Staengl Engineering, Galen has provided design and energy analysis for many buildings that have received various awards while achieving LEED Platinum and Gold levels, Passive House certification, Net Zero energy, Net Positive energy, and Living Building Challenge. Galen has a BS in chemical engineering from the University of Virginia and is licensed in various states. He has a variety of professional affiliations including ASHRAE and USGBC.





AGENDA

- **REALIZE OVERVIEW**
- **REALIZE REQUEST FOR PROPOSALS**
- **GLOBAL COOLING PRIZE**
- **Q&A**



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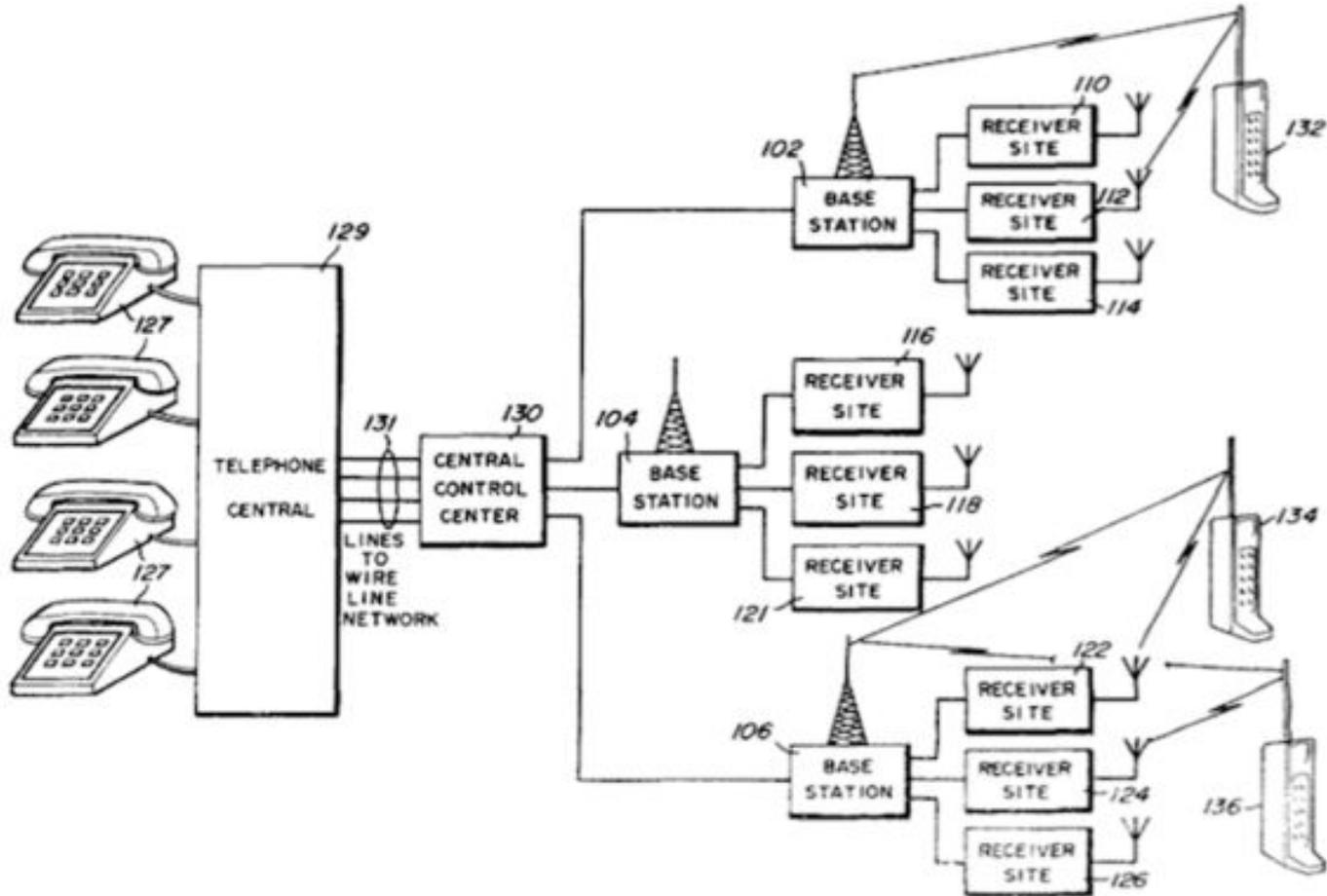


THE PROBLEM

A “MODERN” DAY RENOVATION



A SERVICE ANALOGY





THE SOLUTION

REALIZE: GOAL AND MISSION

REALIZE seeks to create a business model inspired by Energiesprong to catalyze industry to develop industrialized, deep energy retrofits for the US residential market.



ENERGIESPRONG: A MODEL OF INSPIRATION

Core offering: A net zero carbon retrofit bundle that is 1) affordable, 2) attractive, 3) ensures energy performance, and 4) can be delivered in less than two weeks



QUALITY

*Net-zero energy homes
with long performance
warranties*



NON-INTRUSIVE

*Refurbishment within a
week to 10 days*



AFFORDABLE

*Financeable through
energy cost savings*



LOOK & FEEL

*Attractive and
comfortable homes*

MARKET ENABLEMENT MODEL





ENERGIESPRONG EXAMPLES

ENERGIESPRONG



FACADE PANELS: A VARIETY OF SOLUTIONS

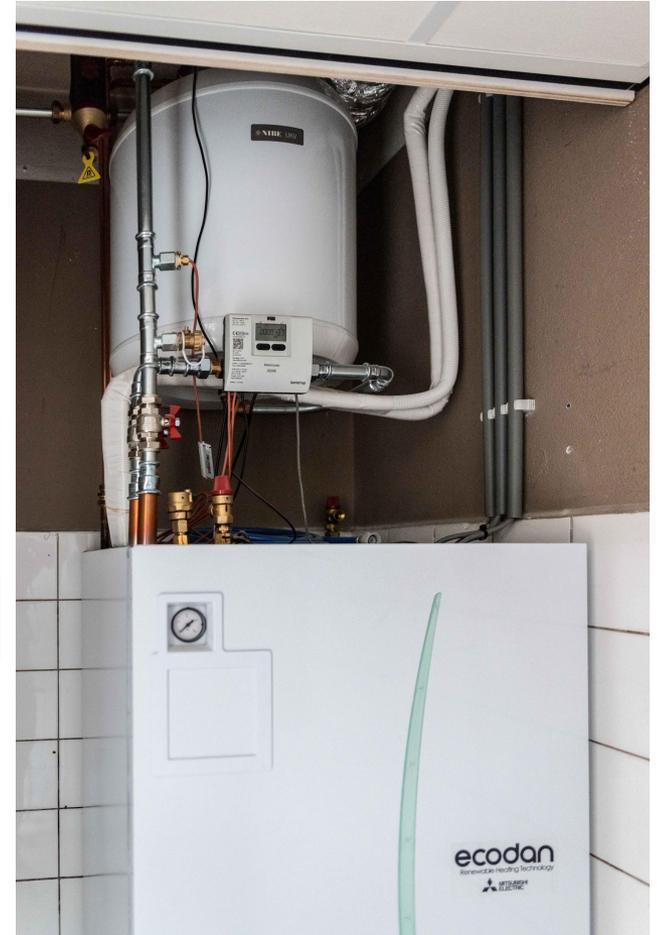


ENERGIESPRONG MECHANICAL SYSTEMS

- Energiesprong retrofits are always all-electric.
- The mechanical systems typically consists of a heat pump (space heating and DHW), ERV, hot water tank, solar panels, PV inverter, and printed circuit board controls.
- In some projects, the heat pump, HPWH, ERV, PV inverter, and control board were distributed, while in others they were packaged together into one unit or one mechanical closet.
 - later project iterations utilize a packaged mechanical system box, as developed by Factory Zero.
- The market was later to innovate on the mechanical side and more progress has been made on the facade systems.

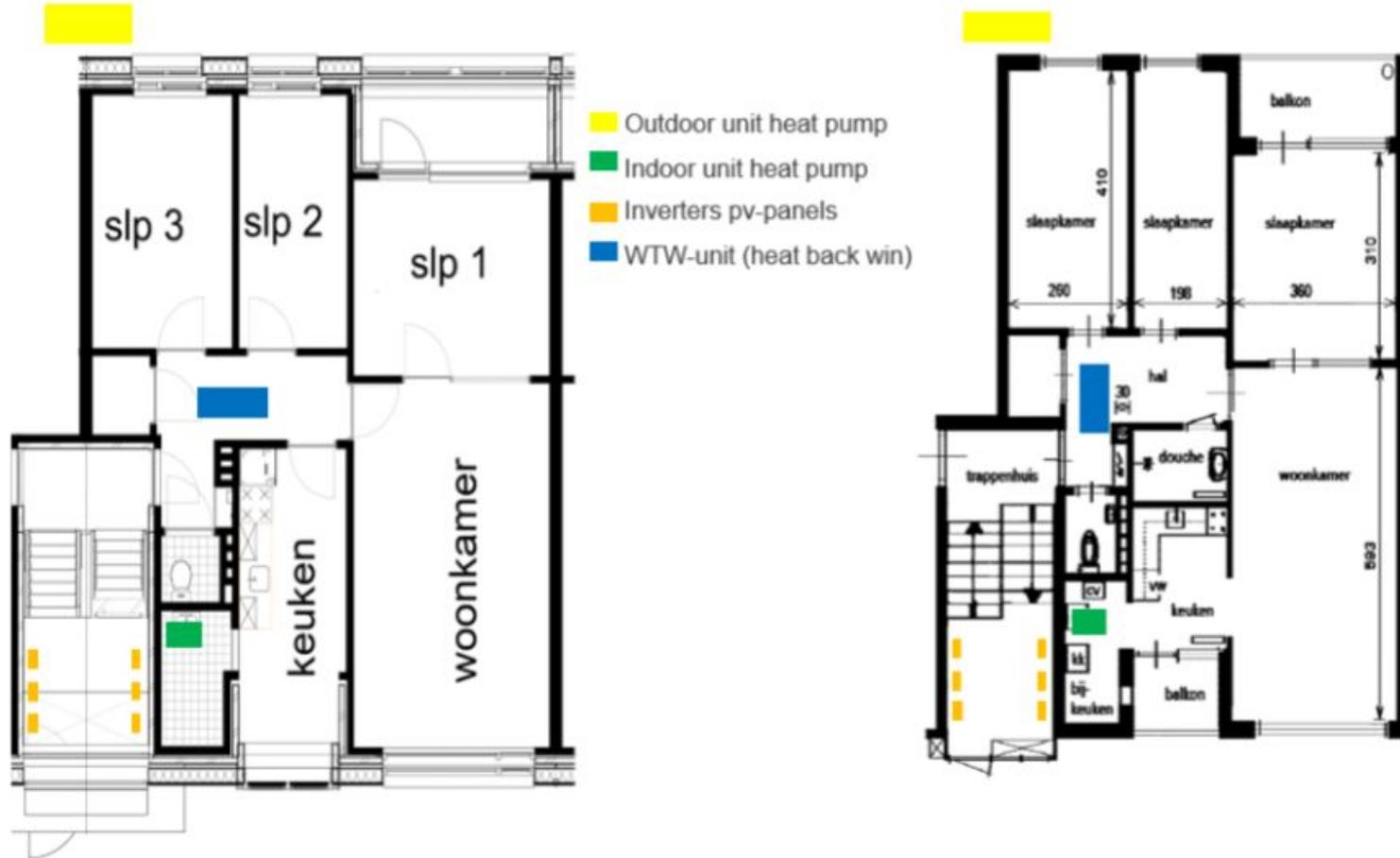
DISTRIBUTED MECHANICAL SYSTEM EXAMPLE

- Mitsubishi HP for space heating in exterior cabinet
- Interior HPWH and tank
- Zehnder ERV



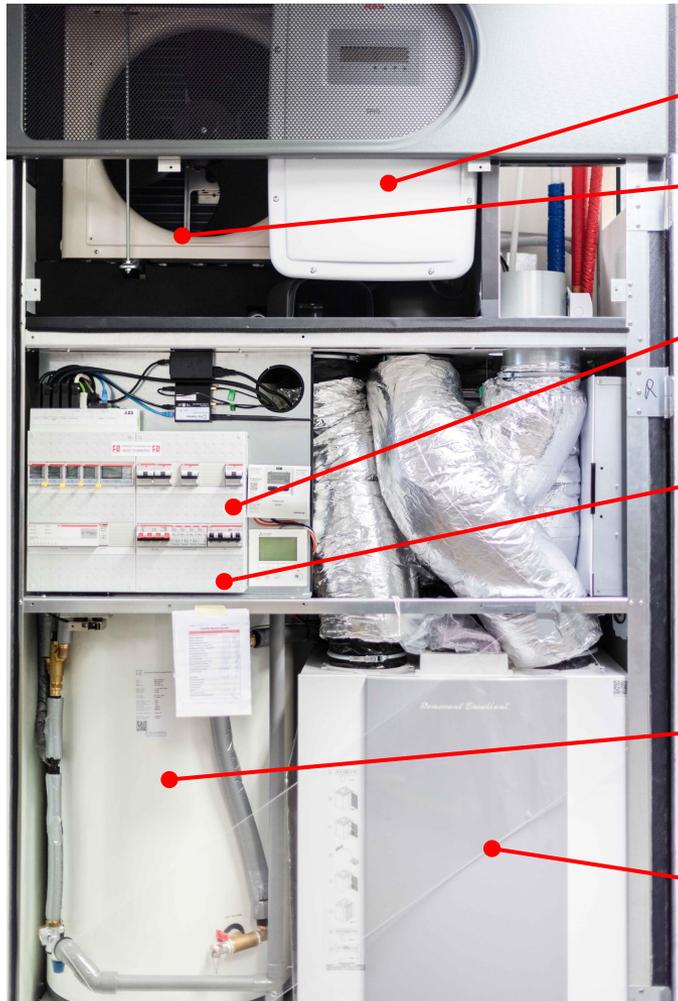
DISTRIBUTED MECHANICAL SYSTEM EXAMPLE

DISTRIBUTED SYSTEMS USING AIR TO WATER HP AND EXISTING RADIATORS



PACKAGED MECHANICAL SYSTEM EXAMPLE

FACTORY ZERO'S INTEGRATED CLIMATE ENERGY MODULE (iCEM) COMBINES ALL MECHANICAL COMPONENTS



PV Inverter

Heat Pump (for DHW and space heating)

Control Board and Thermostat

Plumbing (behind control board and ducting)

DHW Tank

ERV

- Parts sourced from various OEMs and assembled on site
- Working with one, large OEM to get standardized parts for next model

iCEM TECHNICAL DETAILS

 **Integrated Climate Energy Module**

Model : **iCEM 300Se-m**
Serial no. : **0067517417**
Year : **07.2018**
Weight E/F : **485/685 kg**

Rated voltage : **~/N, 400V, 50Hz**
Rated current : **15.5A**
Rated input : **6.2kW**

Refrigerant : **R410A, 1.4kg**
Max pressure : **4.15MPa**

Rated storage capacity : **200L**
Actual capacity : **191L**
Rate volume of coil : **7.3L**
Coil surface : **1.6m²**
Primary design pressure : **600kPa**
Sec. design pressure : **800kPa**

Ventilation airflow max : **300m³/h**

Max DC input voltage : **1000Vdc**
Max DC amperage : **2x15A**



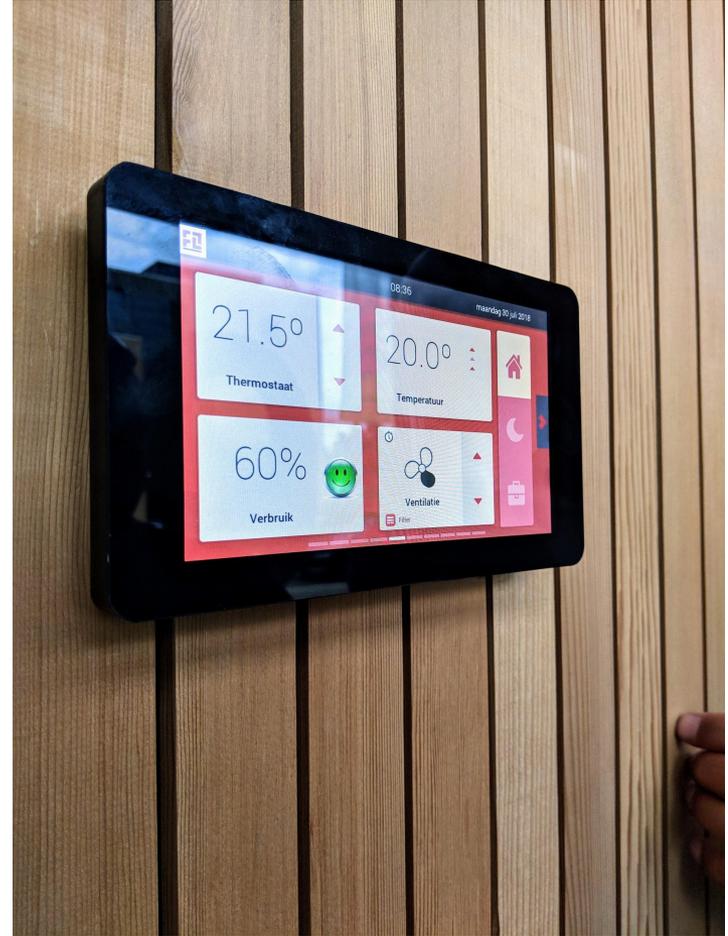
FACTORY ZERO WORKS BV
Stephensonstraat 9, 4004JA, Tiel
MADE IN THE NETHERLANDS

Full specifications can be found here: https://factoryzero.nl/icem_buitenoplossing/

FACTORY ZERO PROJECT EXAMPLES



INTERIOR DETAILS





MAKING THE BUSINESS CASE

INTEGRATED MECHANICAL SYSTEM MARKET STUDY



NEXT-GENERATION BUILDING MECHANICAL SYSTEMS HOW MANUFACTURERS CAN CAPTURE VALUE THROUGH INNOVATION IN MULTIFUNCTIONAL SYSTEMS

INSIGHT BRIEF

November 2018

||||||| HIGHLIGHTS

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- Rocky Mountain Institute's (RMI's) REALIZE initiative aims to catalyze zero carbon retrofits in the US affordable multifamily housing sector using an approach developed in the Netherlands by Energiesprong, a government-funded program that developed a standardized retrofit and funding approach for social housing.
- REALIZE calls for mechanical manufacturers to develop multifunctional, packaged, all-electric heating, ventilation, and air-conditioning (HVAC) and domestic hot water (DHW) equipment solutions to meet the growing demand in the multifamily housing sector for easy-to-install, retrofit-ready systems.
- REALIZE believes that consolidating the functions and operations of mechanical equipment will be essential as building control systems and grid-integrated design become more mainstream.
- The analysis found that there is potential to retrofit 16.1 million units of affordable and market rate multifamily housing in American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) climate zones 3, 4, and 5, with annual energy savings totaling as much as \$4.3 billion.
- REALIZE determined the performance requirements, estimated energy savings, and value-based price points for these integrated HVAC and DHW systems. This analysis did not look at electric system upgrade costs or installation costs, in order to isolate the economics of the equipment only.

https://www.rmi.org/wp-content/uploads/2018/11/RMI_REALIZE.Next_Gen_Building_Mechanical_Systems_2018.pdf



REALIZE
A Rocky Mountain Institute Initiative

HVAC INNOVATION IS NEEDED TO ADDRESS EXISTING MULTIFAMILY ENERGY USE

REALIZE calls for mechanical manufacturers to develop new systems that are:

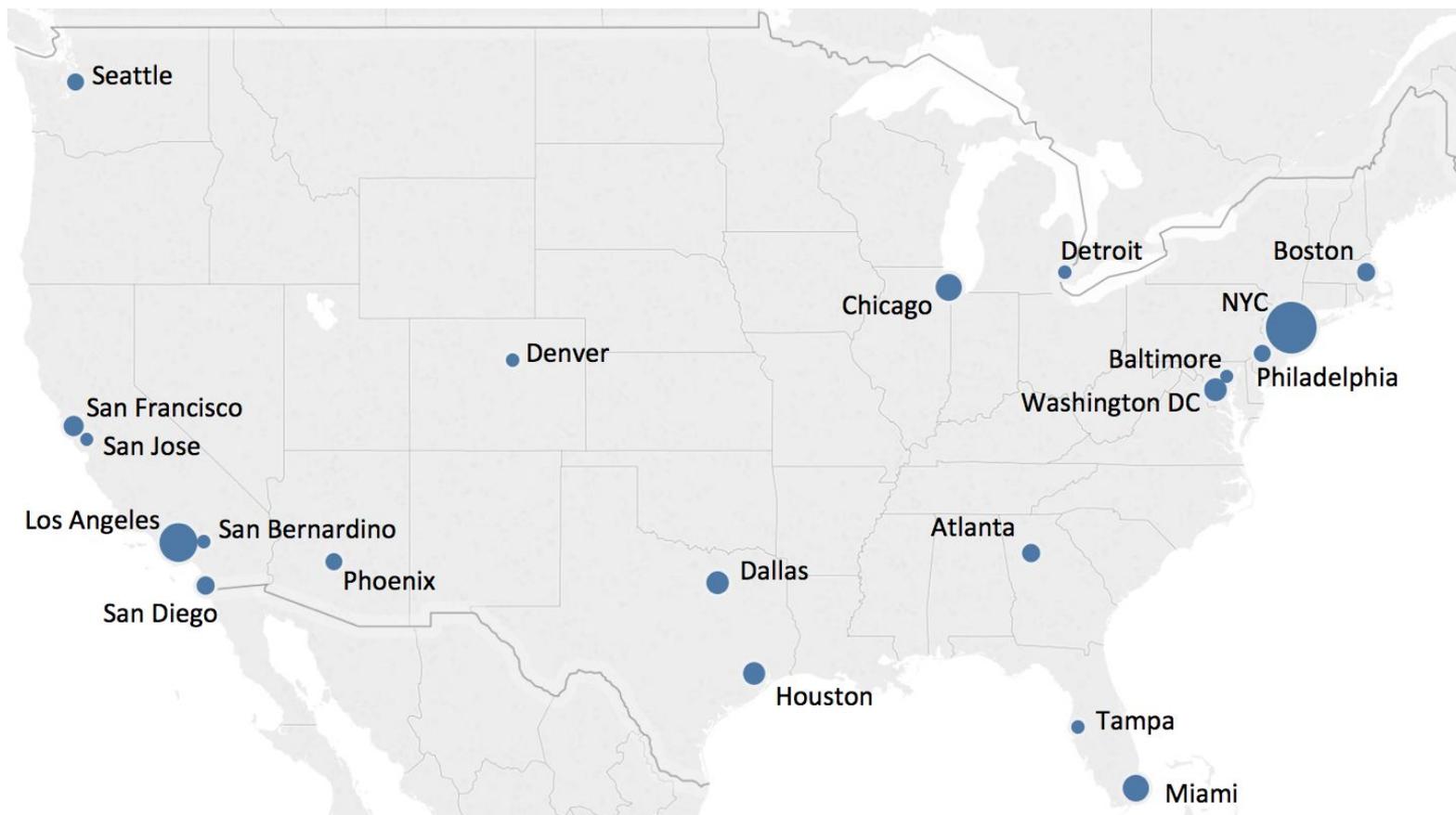
- **Multifunctional:** The mechanical system solution should provide heating, cooling, ventilation, dehumidification, and domestic hot water.
- **Packaged:** The equipment used to meet the functional needs of the mechanical unit should be packaged together into one integrated system. This will allow for simpler installation and scalability.
- **All-electric:** As the grid becomes cleaner and policies begin to demand the use of clean energy in all sectors, deploying all-electric solutions will be the most impactful strategy for building retrofits.

This next generation of mechanical systems will enable less disruptive retrofits and enable manufacturers to stay ahead of policy trends.



REALIZE SCALING POTENTIAL

Based on census and Residential Energy Consumption Survey data, the market size for REALIZE is estimated at 16.1 million units for ASHRAE climate zones 3, 4, and 5 (the most populous regions for multifamily housing).



Source: "Small and Medium Multifamily Housing Units: Affordability, Distribution, and Trends," Yeokwang An, Raphael W. Bostic, Andrew Jakobovics, Anthony W. Orlando, and Seva Rodnyansky, November 3, 2015.



VALUE BASED PRICE POINT ANALYSIS

ADDITIONAL ECONOMIC VALUE CAN BE CREATED FROM LEVERAGING ENERGY COST SAVINGS

- REALIZE added the increased energy savings that could be used in an energy performance contract style financing model to the business-as-usual mechanical equipment costs* to determine a cost threshold for the proposed system.
- Based on these additional savings, manufacturers can capture an additional \$2,300-\$3,800 depending on the climate conditions.

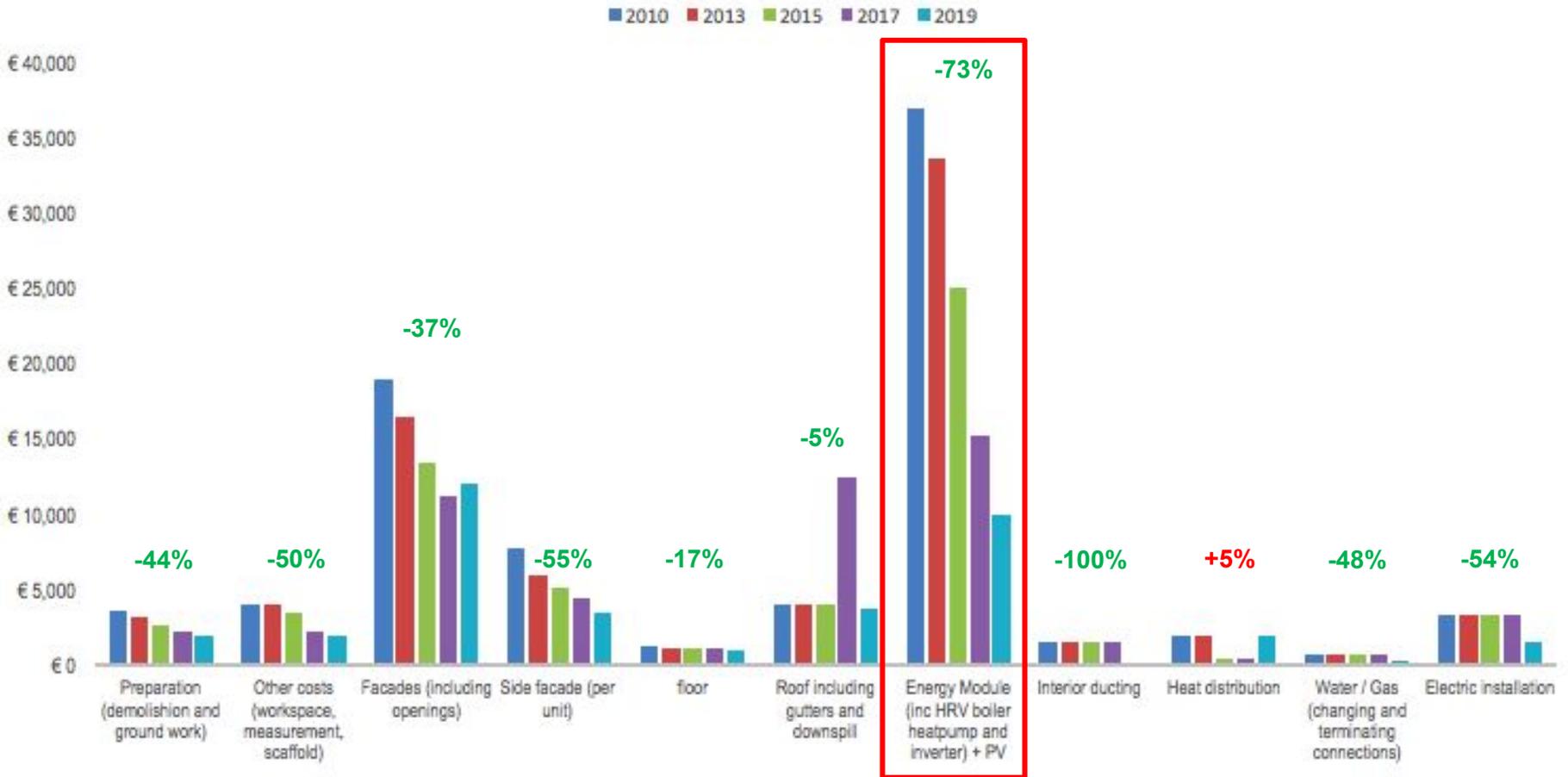
Item Description	Cost per Unit
ASHP SEER 18, 9.3 HSPF	\$2,900
HPWH, 50 gal	\$1,100
ERV	\$700
Dehumidifier	\$1,000
<u>Total BAU Cost</u>	<u>\$5,700</u>
<u>Incremental Potential Cost of Proposed System based on Economic Value</u>	<u>\$2,300-\$3,800</u>
<u>Cost Threshold for Proposed System based on Economic Value</u>	<u>\$8,000-\$9,500</u>

*Equipment costs only. Installation and potential electrical upgrade costs not included. REALIZE acknowledges that the excluded costs can, in some cases, be significant however they have been excluded as this analysis aims to isolate the actual equipment value-based price points for mechanical manufacturers.



DUTCH COST COMPRESSIONS ACHIEVED TO DATE

Cost Curve - Dutch Garden Style Retrofit



HOW TO ACHIEVE COST REDUCTIONS

LESSONS LEARNED FROM ENERGIESPRONG CAN HELP THE UNITED STATES MARKET ACHIEVE SIMILAR RESULTS

- **Standardized factory manufacturing:** Standardize and streamline the component parts to enable an assembly line–style manufacturing process.
- **Reduced installation costs:** Determine a standard existing condition to target to reduce site pre-work, foster contractor education to reduce installation confusion, and reduce size of equipment to minimize the likelihood of required electric panel upgrades.
- **Mass procurement through demand aggregation:** Work with large portfolio owners and other demand aggregators, such as REALIZE, to ensure that high demand for the product is secured.



MARKET INITIATIVES

SOME OF OUR PARTNERS



U.S. DEPARTMENT OF
ENERGY



CNCA
CARBON NEUTRAL CITIES ALLIANCE



Passive House Institute US



CALIFORNIA
ENERGY
COMMISSION



Net-Zero
ENERGY COALITION



Re:Vision
GREEN ARCHITECTURE
SUSTAINABILITY CONSULTING
COMMUNITY ENGAGEMENT

*Energie
Sprong*



SF Environment



STAENGL
ENGINEERING



COOLING & HEATING



Energy. Innovation. Solutions.



stone energy associates



THE **LEVY** PARTNERSHIP



Natural Resources
Canada



ASSOCIATION FOR **ENERGY**
AFFORDABILITY INC.



INTEGRAL
GROUP



PROSPECT
Silicon Valley



RenewAire
Energy Recovery Ventilation



Goodman
Air Conditioning & Heating



REALIZE
A Rocky Mountain Institute Initiative



RetrofitNY

ONGOING AND UPCOMING REALIZE PROJECTS

- **Department of Energy (DOE) Grant**
 - Tasked to design, engineer, manufacture, and monitor an integrated, prefabricated envelope and mechanical system on a pilot building.
 - Selecting a 30- to 50-unit multifamily building in a major metro area in the Northeast or Midwest for the first pilot.
- **California Energy Commission (CEC) Award**
 - 300,000 sq. ft of projects demonstrating integrated net zero energy retrofit packages for affordable multifamily housing across California.
 - Ongoing market facilitation mechanism to aggregate large volumes of demand to implement integrated retrofit projects at scale.
- **Ongoing Market Facilitation Across Active Geographies**
 - Special emphasis on demand aggregation across national multifamily portfolio holders.
 - Innovation focus on streamlined financing enabling easier adoption.





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RFP DESCRIPTION

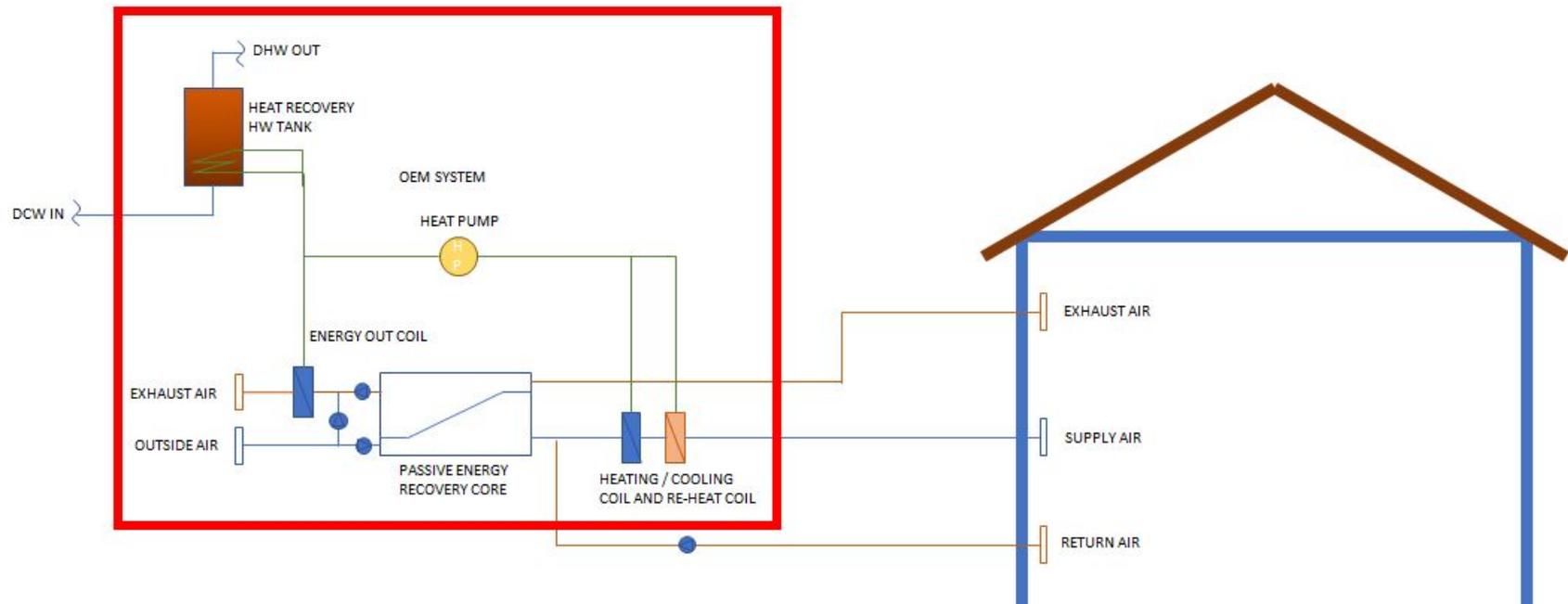
- REALIZE is seeking a mechanical manufacturer or team of manufacturers as a partner that will collaborate on designing, engineering, and manufacturing an integrated mechanical solution.
- The mechanical solution should be all electric and provide heating, cooling, ventilation, dehumidification, DHW, controls, a PV inverter, and potentially battery storage and other smart grid technologies.
- REALIZE understands that given the DOE project timeline, with construction set to begin in 2020, immediate new product development might not be feasible and encourages manufacturers to form collaborative teams when responding to the RFP.
- The pilot building will be located in ASHRAE climate zone 5 or 6 and will be at least 30 units.



DESIRED MECHANICAL SYSTEM DESCRIPTION

- **Option 1: Air-to-air heat pump**

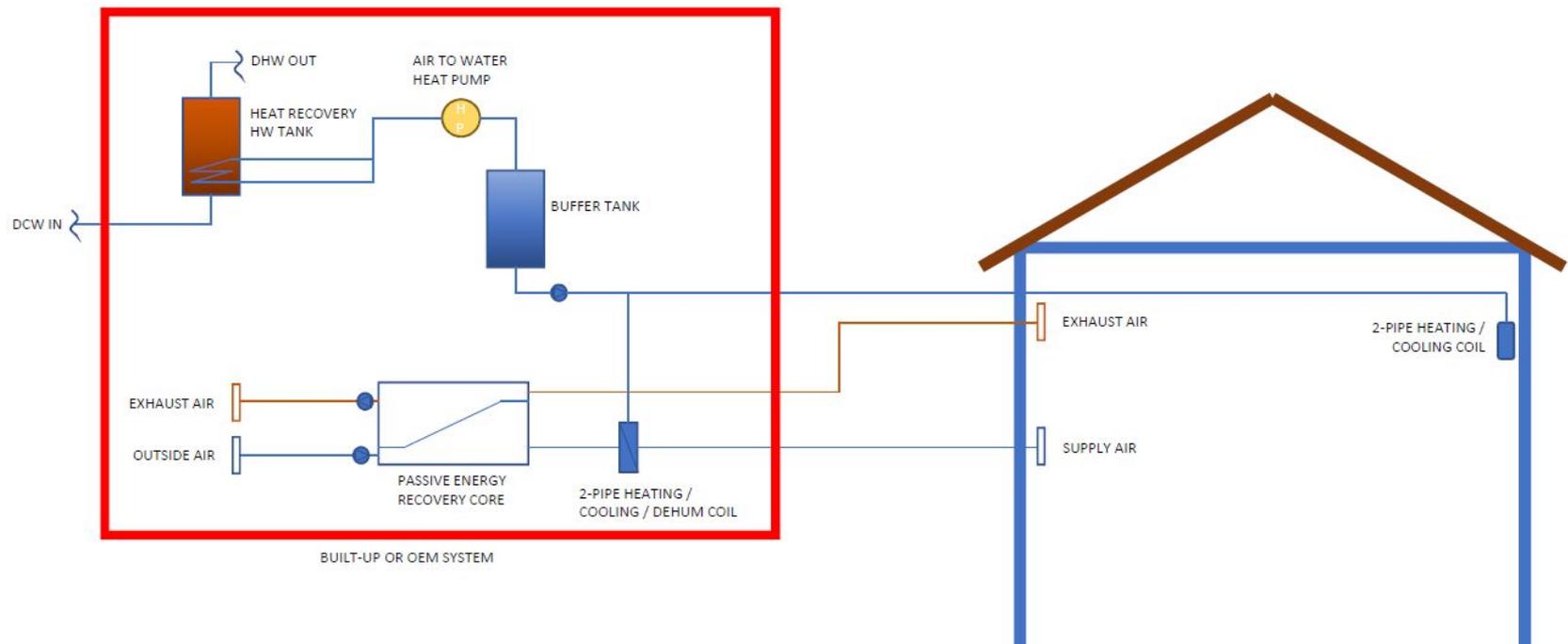
- Will condition air to be distributed through new duct work to the living and bedroom spaces
- Minimum SEER 19
- Ventilation air may be combined with heating and cooling
- Sized no larger than 125% of design cooling load



DESIRED MECHANICAL SYSTEM DESCRIPTION

- **Option 2: Air-to-water heat pump**

- Will condition water which will be distributed to rooms in the apartment
- 2-pipe, hydronic fan coils will be installed in the living and bedroom spaces
- Ventilation air through a standalone duct system with a coil provided to control humidity
- Sized no larger than 125% of design cooling load



OTHER MECHANICAL SYSTEM DESIGN CRITERIA

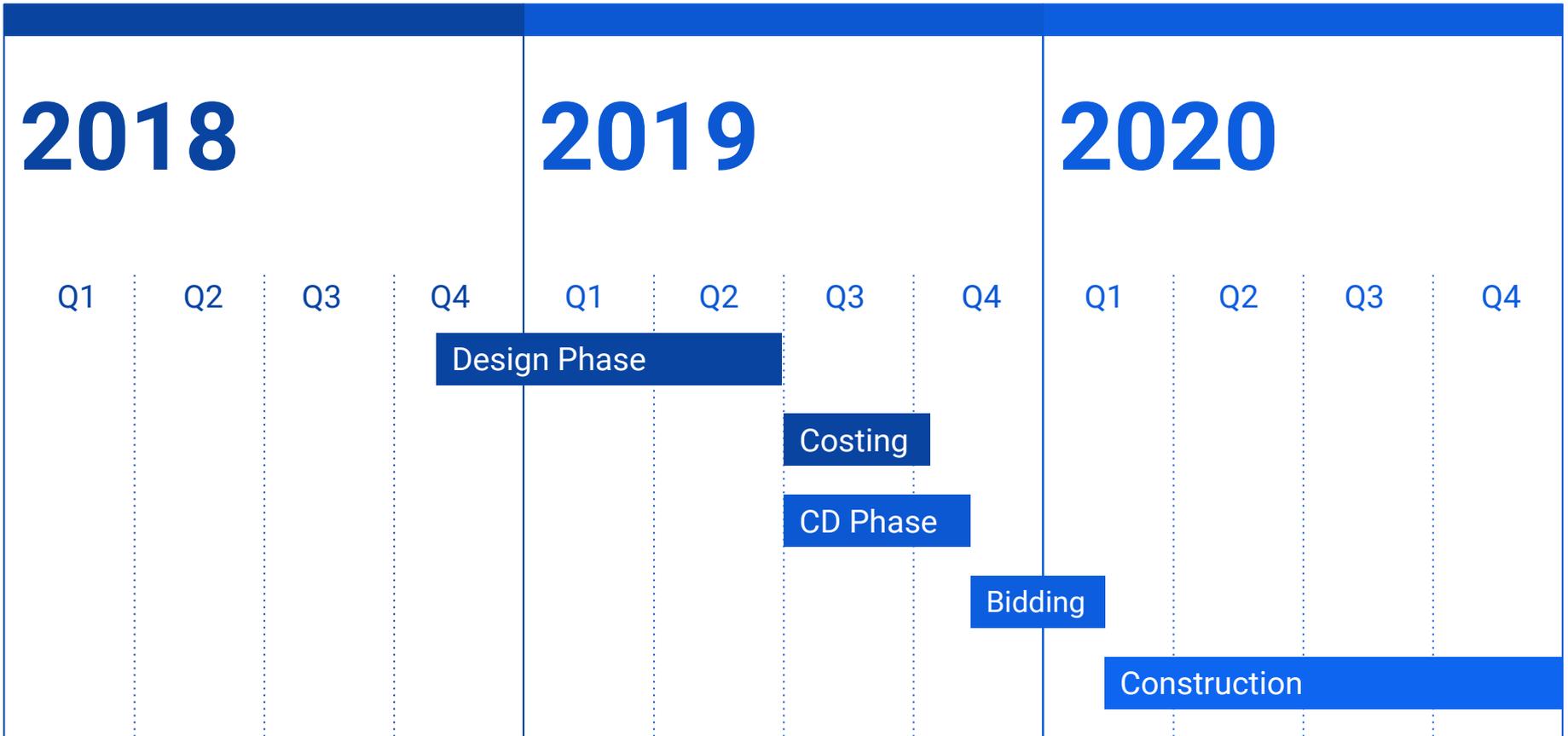
- Must recover at least 80% of sensible heat from the exhaust air stream.
- Auxiliary heating may be required for cold climates.
- Both outside air and recirculated air must be filtered to a minimum MERV 13 rating.
- Air shall be delivered to rooms by low-velocity ductwork.
- System controls will allow occupants to control temperature setpoints, fan speeds and system mode.
- System will include domestic hot water heat pumps, integrated with space conditioning heat pumps when possible to capture waste compressor heat during cooling.
- Refrigerant with low global warming potential is required, natural refrigerant such as CO₂ is preferred.
- A PV inverter for self-consumption must be able to be included in the mechanical package.

A full Mechanical Basis of Design document will be included with RFP and will list full system requirements.

PROPOSAL REQUIREMENTS

- Company background
- Company qualifications
- Specifications and response to functional needs
- Cost estimates for the generic pilot building
- Design, production, installation schedule and process
- Process and partnership approach (both with REALIZE and potential team members)

PROJECT SCHEDULE FOR DOE PILOT



RFP Timeline

- Submission requirements and format to be included with RFP release.

RFP Release	11/13/18
Q&A Period Ends	11/23/18
Intent to Apply Due	11/23/18
Proposal Deadline	12/14/18
Interviewees Notified	12/17/18
Interview Period Ends	1/11/19
Selection	1/16/19

- RFP to be emailed to webinar participants and posted on www.rmi.org/REALIZE





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Global trends are driving massive increases in demand for residential air conditioning (5x increase in non-OECD by 2050)

POPULATION

83 million people/year, with 97% of growth in developing countries



CLIMATE CHANGE

Global average temperatures expected to rise $>2^{\circ}\text{C}$ by 2100



INCOME

$>4.5\%$ GDP growth in non-OECD countries through 2025



URBANIZATION

99% of population growth is occurring in urban environments

Comfort cooling represents one of the largest end-use threats to our climate

There is little incentive for incumbent players to innovate, so the Global Cooling Prize is encouraging market disruption



The GCP is an international competition that will award **\$2M in interim prizes and \$1M final award** to a cooling solution that has at least 5x lower climate impact than today's standard AC units



Universal adoption of cooling technology with 5x less climate impact would bring global climate goals within reach

\$3M

total prize money

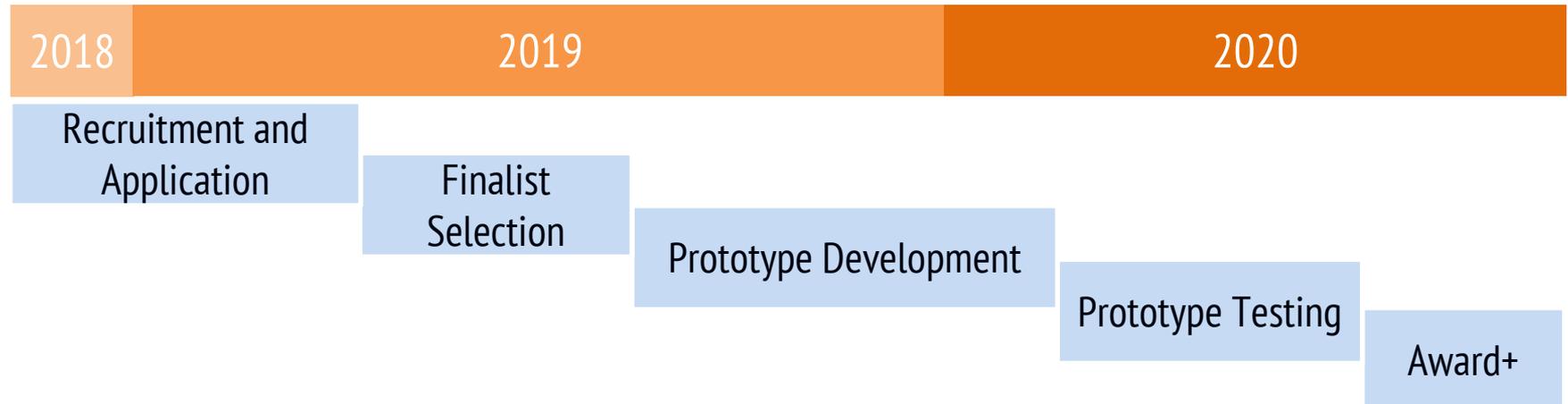
~100 GT

avoided CO2 emissions through 2050

~0.5°C

global warming mitigation by 2100

Project Timeline



Sources/Notes: CLASP, "AC Challenge Program for India", 2017; LBNL, "Benefits of Leapfrogging to Superefficiency and Low Global Warming Potential Refrigerants in Room Air Conditioning", 2015; global warming mitigation estimated at 0.2-0.3°C by 2050.

THANK YOU

FOR MORE INFORMATION VISIT
www.rmi.org/REALIZE OR EMAIL US AT
REALIZE@rmi.org

RFP AVAILABLE AT
<https://www.rmi.org/our-work/buildings/realize/rfps>

DOWNLOAD THE INSIGHT BRIEF AT
https://www.rmi.org/wp-content/uploads/2018/11/RMI_REALIZE.Next_Gen_Building_Mechanical_Systems_2018.pdf

FOR GLOBAL COOLING PRIZE INFORMATION VISIT
www.globalcoolingprize.org AND APPLY AT
www.globalcoolingprize.org/apply/