REALIZE Industrialized Retrofits

Mechanical Systems Partner Request for Proposals

1. Background and Proposal Summary

Buildings account for 70% of electricity use and 39% of emissions in the United States (US). Of these buildings, there are 125 million existing residential units (single family and multifamily). According to the Net Zero Energy Coalition (NZEC) 2017 Residential Zero Energy Inventory, only 13,906 homes across the US and Canada are currently operating at zero net energy. This presents a massive opportunity to drive down carbon emissions from existing homes. Currently, the construction and renovation sector has not created a mass-scale solution to addressing energy inefficiency in existing buildings.

REALIZE is an effort inspired by an innovative model from the Netherlands, known as Energiesprong, developed to catalyze mass-scale, zero-energy retrofits. Energiesprong, a public-private partnership in the Netherlands, has implemented thousands of zero-energy retrofits over the past three years, with another 100,000 planned across Europe. To get a sense of their innovative approach see the following video.

REALIZE is a collaborative effort led by Rocky Mountain Institute (RMI) and inclusive of funding partners such as the United State Department of Energy (DOE), California Energy Commission, and the Carbon Neutral Cities Alliance. This specific call for proposals supports a Department of Energy award which is inclusive of partners Passive House Institute US (PHIUS), Net Zero Energy Coalition (NZEC), The Levy Partnership, Re:Vision Architecture, Staengl Engineering, Energiesprong, and various manufacturers.

The DOE award supports the design, engineering, manufacture, and monitoring of an integrated, prefabricated envelope and mechanical system on a pilot building. The team is in the process of selecting a 30- to 50-unit multifamily building in a major metropolitan area in the Northeast or Midwest for this first pilot. The pilot will be strategically selected to represent a much larger building stock in order to allow for replicability of the solution at scale. Concurrently, the State of New York has launched the RetrofitNY program, with six demonstration projects of this model currently in incubation.

Supported by this request for proposals (RFP), REALIZE plans to develop and implement a holistic, all-electric retrofit solution. This retrofit solution will address the envelope (windows, walls, roof, foundation), mechanical, electrical, and plumbing (MEP) systems, heating, ventilation, and air conditioning (HVAC) systems, domestic hot water (DHW), controls, and, potentially, solar photovoltaic (PV) and storage systems.

The Dutch retrofit solution is designed to minimize tenant disruption and apply as much of the package as possible from the outside-in. Energiesprong developed a façade and mechanical solution which are integrated into a prefabricated unit that can be installed without excessive site pre-work. The schematic in Figure 1 shows a mechanical box developed by Factory Zero, a manufacturing startup built around the Energiesprong concept. While the REALIZE team hopes that respondents will draw inspiration from the Dutch approach, we also hope to develop a solution(s) unique to North American climate zones and markets. The DOE pilot will likely be located in American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) climate zone 5 or 6. We would like to encourage new and innovative thinking and the integration of various HVAC equipment suppliers to create a holistic mechanical design solution.

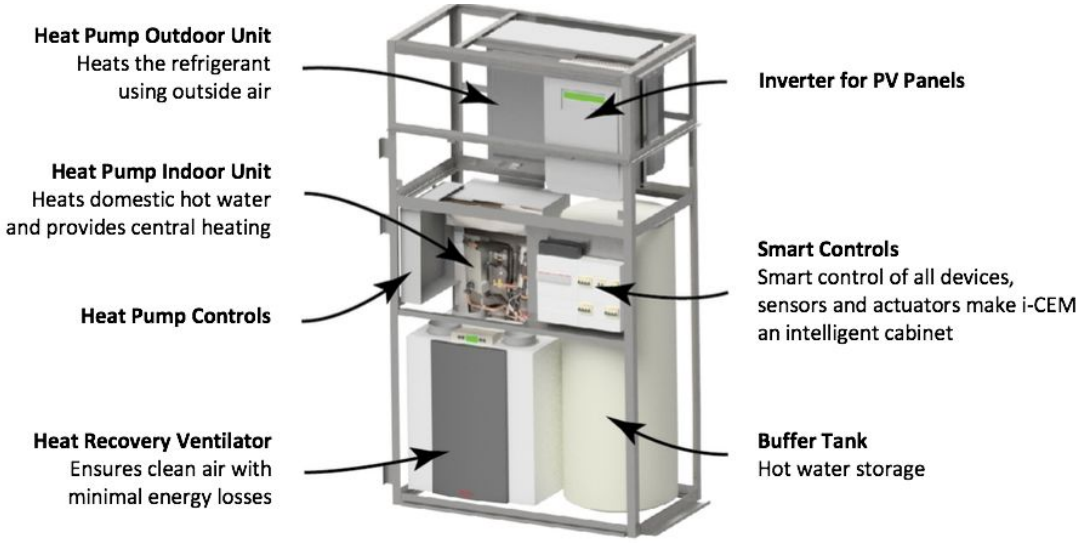

Figure 1: Factory Zero i-CEM Schematic, Source: https://factoryzero.nl/icem_buitenoplossing/

1.1. Fabricator Partnership

The team is seeking a partner or team of partners to collaborate on the design, engineering, and manufacture of a mechanical solution that will provide space heating and cooling, ventilation, domestic hot water, dehumidification, controls, and PV self-consumption. The team also encourages applicants to consider how battery storage could be incorporated into such a package to enable grid integration. The system should be capable of meeting all building loads and meeting local code requirements. The manufacturing team will also coordinate delivery and installation of the system to maintain a high level of quality assurance.

This pilot project presents an opportunity for all members of the team to test the solution and integration process, while demonstrating successful implementation in order to attract larger contracts and commitments across the US. We are seeking to engage a manufacturer who will work with the team to invest in designing and engineering this new solution, with the open and innovative spirit required to create something groundbreaking and impactful.

We encourage manufacturers to apply in teams with other manufacturers, duct fabricators, subcontractors, or any other partners who might be able to add value to the proposal. This is not a requirement, but anyone who can provide a more complete solution will gain an advantage and we anticipate that integration between various equipment types will be necessary to produce the solution.

1.2. Proposed Heating and Cooling Options

The heating and cooling solution provided can be one of two options: either an air-to-air heat pump or an air-to-water heat pump.

1.2.1. Option 1: Air-to-Air Heat Pump

Heating and cooling will be provided to each apartment by an air-to-air heat pump with a minimum Seasonal Energy Efficiency Ratio (SEER) rating of 19 (or equivalent). The heat pump will condition air that will be distributed through new ductwork to the rooms in the apartment. Ventilation air (outside air) may be combined with the heating and cooling air in a single network of supply ductwork, supplying air to the living and bedroom spaces.

1.2.2. Option 2: Air-to-Water Heat Pump

Heating and cooling will be provided to the apartments by water conditioned by air-to-water heat pumps. The heat pump will condition water that will be distributed to the rooms in the apartment. 2-pipe, hydronic fan coils will be installed in the living and bedroom spaces for space conditioning. Ventilation air will be through a standalone duct system.

1.3. Sample Unit: Building Loads and Parameters

Although the selected solution will be applied to a whole building, for the purposes of this RFP teams should submit a proposal for a single apartment unit, while keeping connections between adjacent units in mind. The sample unit to be considered should have the following characteristics:

- 815 ft^2 of interior floor area
- 1.5 occupants
- Peak Heating Load: 1,100-6,300 Btu/h
- Peak Cooling Load:
    - Sensible 4,300-9,000 Btu/h
    - Coincident Latent 350-400 Btu/h
    - Air Volume Flow 210-430 cfm @ 55.4 F
- Peak Dehumidification Load ~1,300 Btu/h with energy recovery ventilator (ERV), ~1,800 Btu/h without ERV.

Additionally, the unit should be designed to meet the criteria described in the Basis of Design (BOD) in Appendix A.

2. Mechanical Solution Desired Design

The purpose of the mechanical solution is to improve both the energy performance and thermal control of the building while delivering an elegant, cost-effective, scalable, and simplified retrofit solution. The specific requirements that the solution must fulfill are outlined in the REALIZE Mechanical BOD document included in Appendix A.

3. Project Schedule

Table 2 outlines key milestones for the pilot project:

Table 2. Pilot Project Schedule

Task	Description	Timing
Pilot Site Selection	Formal request for proposals for candidate buildings	Q2 and Q3 2018
Final Site Selection	Includes interviews and site visits to inform final pilot selection	Q4 2018
Final Design	Formal owner acceptance of the retrofit design	June 2019
Construction Documents	Development of construction documents	Q3 2019
Construction Commences		Q1 2020
Monitoring	Performance testing and monitoring	Period of one year after completion

4. Proposal Requirements

All applicants are requested to provide the following information in each proposal. Please do not exceed 15 pages, excluding exhibits and attachments (e.g., specifications).

4.1. Company Background - Information about company's focus, philosophy, products, and services as they pertain to this scope.

4.2. Company Qualifications - Description of most comparable projects completed by company.

4.3. Specifications & Response to Technical Requirements - As noted above, this is a new specification for a demonstration project, therefore inability to meet all of the design requirements outlined in the BOD may not necessarily be disqualifying, but do take care to respond to all points and submit all the requested documentation. Respondents must provide the following in response to the requirements outlined in the BOD.

4.3.1. Written response demonstrating how requirements will be met via any of the following: 1) an existing solution, 2) approach your team would take to making customizations or combinations of existing solutions, 3) examples of past projects that included this equipment. If the proposed solution does not address all requirements, please include a brief explanation as to why, and how those requirements could be met in future iterations.

4.3.2. Specifications of a standard product with potential customizations to meet requirements highlighted.

4.3.3. Conceptual designs, shop drawings, and specification sheets as-needed to demonstrate ability to meet requirements.

4.4. Cost Estimate - Present a budget for a solution which is appropriate for the Sample Unit described in Section 1.3 and the Basis of Design in Appendix A. Project budget to include:

4.4.1. High level estimate breakdown for fabrication (labor + materials) for the mechanical system.

4.4.2. Delivery and Installation - please indicate if this is done in-house or by another contractor.

4.4.3. Scaling - at what volumes are there expected cost reductions, and what is the typical percentage reduction.

4.4.4. Cost Share Comments - to be competitive for this high-profile pilot project, we anticipate that the successful vendor will be working at cost, potentially with some cost share.

4.5. Schedule and Process - Please include:

4.5.1. Estimated timeline for design (anticipate a collaborative design with the project partners and building owner), fabrication, delivery, and installation.

4.5.2. If additional manufacturers or subcontractors will be used for product sourcing, fabrication, or installation, please specify and describe their role and responsibilities.

4.5.3. Notes on any portions of manufacturer processes that are not explicitly covered in other portions of the proposal, but should be taken into consideration.

4.6. Process & Partnership - Given the pilot is underway with work being done to create relationships with large portfolio owners, cities, and states, we fully expect to support this disruptive solution to continue to break open this latent market opportunity for all involved. Please describe why your company is aligned with the mission and goals of this initiative beyond the scope of the pilot, what unique capabilities position you for a longer-term partnership, and what types of commitments you plan to make to invest in potential future business.

4.7. RFP Timeline

Table 4 below outlines the scheduled milestones for the RFP process.

Table 4. REALIZE Manufacturers' RFP Timeline

Milestone	Due Date	Notes
RFP Release	11/13/18	RFP issued and available online at: www.rmi.org/REALIZE.
Question and Answer Period Ends	11/23/18	During this period, submit any questions via email to realize@rmi.org. Questions and Answers related to missing or incorrect information in the RFP will be issued as addenda to all respondents, and will be available on the website referenced above. Strategy or approach questions will be answered directly and kept confidential.
Intent to Apply Due	11/23/18	Send an email indicating your intent to submit a proposal. Emails should be directed to the project team at realize@rmi.org.
Proposal Deadline	12/14/18	All final proposals are due by email and should be submitted to the project team at realize@rmi.org.
Interviewees Notified	12/17/18	All respondents will be notified of whether they qualify for the next level of consideration in the process. If so, phone interviews will be scheduled.
Interview Period Ends	1/11/19	All phone interviews complete.
Selection	1/16/19	All finalists will be notified of selection decision.

Thank you for your interest in the REALIZE project and we look forward to learning more about your organization.

Appendix A: Mechanical Basis of Design

Purpose:
The purpose of this document is to outline the design basis for mechanical systems to accompany a deep envelope retrofit as a part of the REALIZE program.

Premise:
The REALIZE program aims to develop pre-engineered building envelope and mechanical retrofit systems that will reduce residential building energy consumption by at least 50%. A secondary target is that the retrofitted buildings be "Net Zero Ready." Additionally, it is desired that these systems will be a part of a "retrofit-in-place." As such, a solution that is mounted and routed from the outside of the building is preferred.

Codes:
The MEP systems in the retrofit package must meet local building code requirements. Adopted codes will depend on project location and governing authority. Ventilation and local exhaust air will be provided based on rates required in ASHRAE 62.2 or local code, whichever is more stringent.

Fuel:
Mechanical systems will be run completely on electricity.

Design Parameters:
The occupied temperature set points shall be maintained during regular occupancy hours, while the unoccupied temperature set points shall be maintained during unoccupied periods. Design outdoor temperatures will be based on building climate and appropriate design criteria.

- Occupied Temperature: Winter: 68°F; Summer: 77°F
- Occupied Humidity Maximum (no minimum): 50% + 5% relative humidity (RH)
- Unoccupied Temperature: Winter: 66°F; Summer: 78°F
- Unoccupied Humidity Maximum (no min): 50% + 5% RH
- Passive House Institute US indoor surface comfort criteria

Heating and Cooling Option #1: Air-to-air heat pump
Heating and cooling will be provided to each apartment by an air-to-air heat pump with a SEER (or equivalent) rating of 19 or better, and a minimum Heating Seasonal Performance Factor (HSPF) of 10.0. The heat pump will be required to operate under cold climate conditions as required by region (likely ASHRAE climate zone 5 or 6). The heat pump will condition air that will be distributed through new ductwork to the rooms in the apartment. Ventilation air (outside air) may be combined with the heating and cooling air in a single network of supply ductwork, supplying air to the living and bedroom spaces.

Unit fans shall be variable speed, brushless direct current (DC) motors. Compressors shall be variable speed. Refrigerant with the lowest possible global warming potential (GWP) is desired, and natural refrigerant (such as CO_2) is preferred. The heat pump shall be sized for no larger than 125% of the design cooling load for the apartment, or shall have the ability to modulate down to design cooling loads and meet design cooling loads latent load component. Waste heat from cooling and dehumidification shall be used to heat domestic hot water for the apartment.

Maximum fan energy for the heat pump system will be 0.45 W/cfm. This will include the losses in the duct system.

Option 1: Summary Table

Function	Equipment	Minimum Efficiencies
Heating / Cooling / Dehumidification	Air-to-air heat pump	Minimum SEER: 19 kBTU/kWh Minimum HSPF: 10 kBTU/kWh Maximum fan energy: 0.45 W/cfm
Ventilation / Energy Recovery	ERV	Minimum sensible heat recovery efficiency (SRE): 80% Max fan energy: 0.7 W/cfm
Domestic Hot Water Heating	Waste cooling / dehumidification heat + heat pump or electric back-up	If Heat Pump: Minimum uniform energy factor (UEF): 3.5
Filtration	Conditioning and ventilation supply	Minimum efficiency reporting value (MERV): 13 Maximum initial pressure drop: 0.05 in H_2O Thickness: 2”

Heating and Cooling Option #2: Air-to-water heat pump

Heating and cooling will be provided to the apartments by water conditioned by air-to-water heat pumps. The heat pump will condition water that will be distributed to the rooms in the apartment. 2-pipe, hydronic fan coils will be installed in the living and bedroom spaces for space conditioning. Fan coils will be variable speed with brushless DC motors. Ventilation air will be through a standalone duct system. All hydronic piping will be insulated with minimum R-4 insulation and a continuous vapor barrier to avoid condensation. A coil will be provided in the ventilation air supply in order to control humidity in ventilation air. The air to water heat pump should meet the following minimum efficiency criteria (at AHRI standard conditions):

- Integrated Part Load Value (IPLV) Energy Efficiency Ratio (EER), (water temp 44 F, OSA temp 95 F): 23.0
- Coefficient of Performance (COP), (water temp 95 F, OSA temp 47 F): 3.9

Compressors shall be variable speed. Refrigerant with a low GWP is required, and natural refrigerant (such as CO_2) is preferred. The heat pump will be required to operate under cold climate conditions as required by region (likely ASHRAE climate zone 5 or 6). The heat pump shall be sized for no larger than 125% of the design cooling load for the apartment, or shall have the ability to modulate down to design cooling loads and meet design cooling loads latent load component. Waste heat from cooling and dehumidification shall be used to heat domestic hot water for the apartment.

Maximum fan energy for this system will be 0.45 W/cfm. Additionally, pump energy will be limited to 25 W/ton of cooling capacity.

Option 2: Summary Table

Function	Equipment	Minimum Efficiencies
Heating / Cooling / Dehumidification	Air-to-air water heat pump	Min IPLV EER: 23.0 kBTU/kWh Min COP: 3.9 kWh/kWh Max Fan Energy: 0.45 W/cfm Max Pump Energy: 25 W/ton
Ventilation / Energy Recovery	ERV	Min SRE: 80% Max Fan Energy: 0.7 W/cfm
Domestic Hot Water Heating	Waste cooling / dehumidification heat + heat pump or electric back-up	If Heat Pump: Min UEF: 3.5
Filtration	Conditioning and ventilation supply	MERV: 13 MAX Initial DP: 0.05 in H_2O Thickness: 2”

Dehumidification:
Provision for humidity control will be provided.

Ventilation:
Ventilation air will be supplied to the apartment on a continuous basis to meet the ventilation code criteria airflow. Ventilation air will be supplied to the bedrooms and living spaces while exhaust air will be extracted from the kitchens and bathrooms. Energy recovery will be applied to the ventilation air, to recover, at minimum, 80% of the sensible heat energy from the exhaust air stream. Ventilation equipment will be supplied with a “boost” mode, allowing the system to temporarily increase the ventilation and exhaust amounts by as much as 75 - 100%. ERV defrost, if required, will be provided by electric resistance heat, hydronic heat, or in some manner that prevents interruptions or imbalance in ventilation and exhaust air flow rate. An “economizer” bypass mode shall allow bypassing the heat recovery device when conditions outside are favorable for “free cooling.”

If a ducted range hood is included in the apartment, ducted, fan powered make-up air will be supplied to the apartment to maintain space pressurization. If a ducted range hood is utilized, the maximum exhaust flow will be assumed to be 200 cfm. This air will be heated, as necessary.

Filtration:
Both outside air and recirculated air shall be filtered to a minimum MERV 13 rating, with accommodation for a minimum 2” thick, low face velocity filter. Maximum initial filter pressure loss will be 0.05 inches of water column.

Duct Systems:
Air shall be delivered to rooms by low-velocity ductwork. Design friction loss shall not be more than 0.06 inches/100 feet where possible. Ductwork air velocity shall be limited to 600 fpm in noise-sensitive areas. All branch ducts shall be equipped with volume dampers for balancing at the branch connection. All ductwork shall be in the conditioned space. Where feasible, ductwork shall be round in cross section. Flexible ductwork shall be installed without pinching. Total ductwork leakage (measured by pressurization testing at 25 Pa) for ducts distributing conditioned air shall be limited to 5 percent of the total air handling system rated airflow at high speed.

The building air delivery system shall be designed to provide a balanced airflow to all conditioned spaces and zones (bedrooms, hallways, basements, etc.). Inter-zonal air pressure differences, when doors are closed, shall be limited to 3 Pa. The design will incorporate transfer grilles as necessary to balance return airflows. Ventilation air will be supplied directly to bedrooms and living areas. All supply and outside air ductwork shall be insulated with a minimum of R-6 and shall include a continuous vapor barrier to prevent condensation.

Occupant Controls:
System controls will allow apartment occupants to control space temperature setpoints, fan speeds, and system mode (heating, cooling, dehumidification).

Solar PV:
The retrofit will include the addition of a rooftop solar PV system with an inverter to enable self consumption where feasible.

Domestic Hot Water Heating:
Domestic hot water shall be heated by heat pumps. When possible, the heat pumps shall be integrated with the space conditioning heat pumps to capture waste compressor heat during cooling and to reduce system cost; they can also be standalone heat pump water heaters. Heat pump hot water heaters will have a minimum UEF of 3.5. Hot water storage will be provided in highly insulated storage tanks (minimum R-15 continuous insulation). Back-up heat will be electric resistance if required.

Battery Storage:
The retrofit will include on-site battery storage connected to the mechanical systems and PV array to enable the storage and self consumption of energy generated onsite.