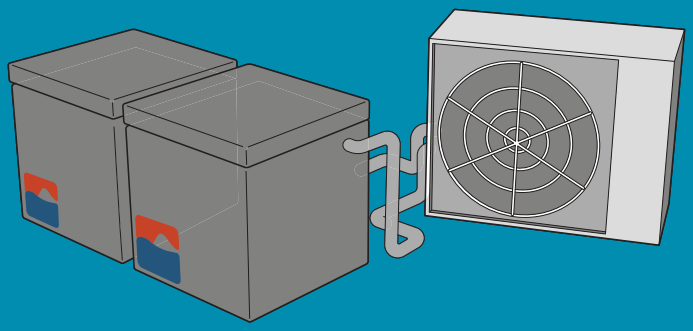
Technology Early Deployment

Stow Energy

Syncing Home HVAC and Renewables with

Intelligent, Low-Cost Energy Storage



Stow Energy pairs heat pumps with simple and modular water batteries to provide customer comfort and load shift capability for the typical American home. The integrated system provides improved heat pump efficiency with optimized runtimes, mitigates capacity drop during extreme temperature events, improves turndown capability for part load comfort, and offers load shift at a lifecycle cost of <$0.08/kWh$_e$.

Stow's complete HVAC system is a retrofit-ready solution poised to catalyze the energy transition and benefit households across America. The HVAC system design is straightforward for installers and homeowners. A monobloc heat pump eliminates time-consuming refrigerant handling and the potential carbon emissions from refrigerant leakage which, according to IPCC, accounts for 26% of current AC emissions. The productized plumbing panel uses push-to-connect fittings for rapid field installations. The homeowner continues to control heating and cooling via a smart thermostat.

TECHNOLOGY BENEFITS

PROVIDES ULTRA LOW-COST
thermal storage at $0.08/kWh$_e$.

OPTIMIZES EFFICIENCY
by operating heat pump during cooler hours.

PROMOTES ELECTRIFICATION
through simplified heat pump deployment.

ENABLES LOAD SHIFTING
and reduces peak demand of residential HVAC.

Disclaimer: Stow Energy was chosen for TED because it supports **California's clean energy goals** for energy efficiency, reduced GHG emissions and demand flexibility. This document does not constitute or imply endorsement, recommendation, or favoring by EPRI or SCE of the product or company described herein. This publication is funded and administered by Southern California Edison's Emerging Technologies Program.

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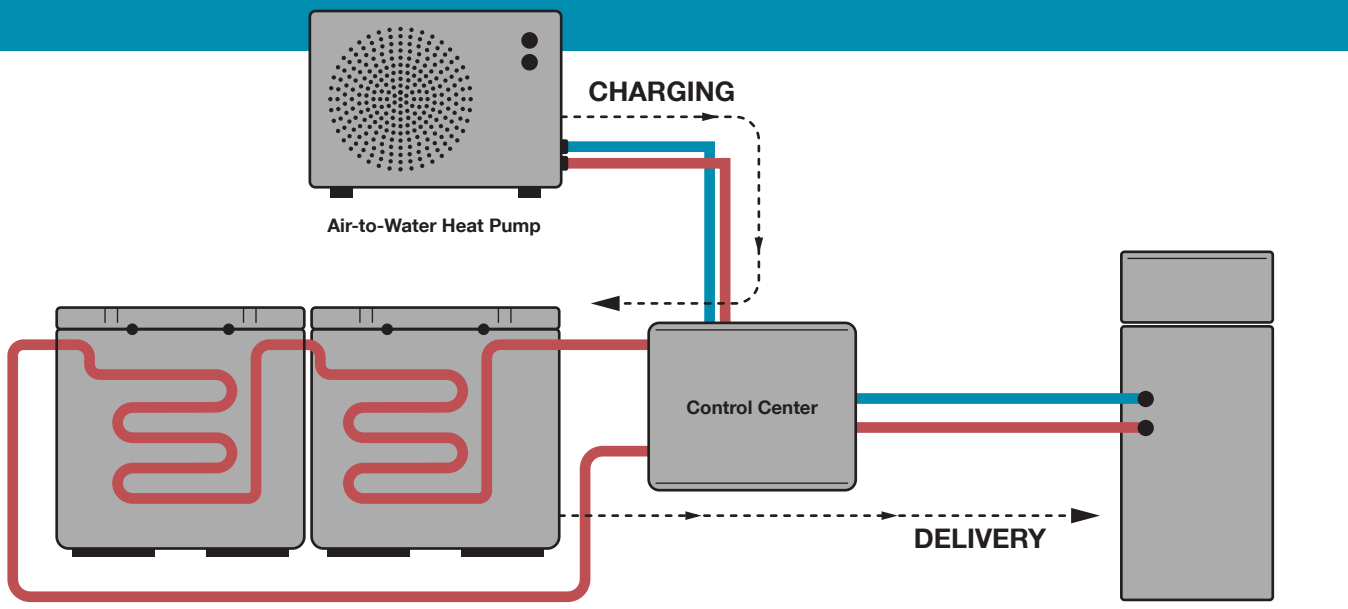
Stow Energy technology

Stow's thermal platform for homes enables a single heat pump to provide heating, cooling and hot water. The platform also incorporates a water battery to shift heat pump electricity use to low cost, low carbon time periods. The first product pairs an air-to-water heat pump with a proprietary thermal storage tank and control center with a hydronic air handling unit to deliver forced air heating and cooling. Utility-integrated software optimizes charge and discharge of heat from water in the storage tanks, enabling a 4-10kWh$_e$ load shift for a typical home while maintaining home comfort. A hydronic air handling unit transfers heat stored in the water to air and delivers space conditioning to the home. This initial configuration is compatible with central ducted HVAC systems, which serve 56%, or over 40 million, of existing US residential single family homes.

Stow's thermal storage tanks are unpressurized, so they can be manufactured as modular HDPE cubes instead of much more expensive steel cylinders. The rectangular form offers a 27% increase in storage volume versus a cylinder with the same diameter. Furthermore, the durable, double-wall construction offers highly effective continuous insulation and extended service life.

The control center is a manufactured assembly of pumps, valves, and meters paired with an onboard computer. The panel shifts skilled plumbing work off the jobsite and limits install labor to simple push-to-connect pipe connections and control wiring. The onboard software collects air temperatures, occupant behavior, utility price and event signals, and weather forecast data to optimize when the heat pump will generate and store thermal energy. The optimization can be tuned to adjust priorities among operational cost, utility event availability, self-consumption of solar, and carbon emission reduction subject to a commitment to maintain homeowner comfort.



CHARGING

The HP charges the thermal storage. Runtimes can be optimized for comfort, carbon emissions, and/or energy cost.

DELIVERY

When the home thermostat calls for heat or cooling, Stow Energy delivers stored energy to the hydronic AHU to distribute through the central ducts.

TARGET CUSTOMERS

The target market for Stow Energy's first product is suburban single-family homeowners with centralized HVAC. The beachhead market is California, where TOU tariffs, DER demand response programs, bans on natural gas, storage incentives, and prevalent rooftop solar all encourage heat pump and energy storage adoption. Most early adopters are looking to replace an existing furnace and add or replace cooling while minimizing carbon emissions. Many are also solar customers looking to increase consumption of low-cost daytime energy.

HARDWARE COMPATIBILITY

- ✓ **220V circuit** and a 120V service receptacle are required for air-source heat pump installation, these can be repurposed from an AC system.
- ✓ Thermal Storage cubes are compact, with a similar footprint to an AC condenser.
- ✓ Hydronic AHU is a straightforward furnace replacement and can **leverage existing ductwork** but requires installation of a condensate drain

SYSTEM FEATURES

ENERGY STORAGE
proposition for utility DR programs.

INTELLIGENT CONTROLLER
for optimized home energy use.

ROOFTOP SOLAR
compatible to charge storage with renewables.

THERMAL STORAGE
capacity of up to 5kWh$_e$ per module.

EFFICIENT THERMAL COMFORT
for up to 10 hours.

CA INCENTIVES
for low-income/disadvantaged communities.

INCREASED HEATING CAPACITY
shifts heating energy during peak hours.

California's decarbonization challenge

California's executive order B-55-18 mandates that the state achieve carbon neutrality by 2045. Additional legislation supports this goal through multiple strategies that include double energy savings by 2030 (SB 350), increased demand flexibility (19-OIR-01), advanced energy storage and 100 percent of all retail electricity from renewable energy (SB 100). Applying these strategies to new construction and upgrades to existing buildings provides a path to achieving carbon neutrality but also comes with a new set of challenges:

1.

New technologies for buildings

must support most or all of the desired outcomes for California.

2.

Testing, compliance & standards

including utility participation and enabled workforce.

3.

Establishing trust

that replacement of old systems will meet/exceed performance expectations.

STOW ENERGY SUPPORTS CALIFORNIA'S DECARBONIZATION GOALS

ENERGY, GHG, & DEMAND REDUCTION

SCALABLE RENEWABLE GENERATION FOR RESIDENTIAL HVAC

STORAGE CAPABILITIES
provides increased demand flexibility and promotes clean energy generation through OpenADR.

Addressing market barriers to decarbonization of HVAC systems

Challenges

CURRENT

- ✓ Mini-split systems are prone to leak refrigerant (drives 26% of current AC GHG emissions).
- ✓ Customers often perceive that heat pumps have weak low temperature performance.
- ✓ Lack of a low-cost mechanism to load shift will drive severe winter morning demand peaks.
- ✓ Lack of training for HVAC contractors increases risk and drives high installed costs.
- ✓ Space constraints due to water's limited heat capacity.
- ✓ Lack of approval for higher-efficiency refrigerants in outdoor, monobloc applications (R290, R32).
- ✓ Lack of incentives for homeowners to load shift using behind-the-meter storage during DR events.
- ✓ Lack of energy service wholesale pricing schema and resource adequacy policy to justify behind-the-meter storage as a monetizable asset.

CREATING A PATH TO COMMERCIALIZATION THROUGH THE FOLLOWING ACTIVITIES:

Opportunities

LEVERAGE POINTS

- ✓ Utilizing monobloc heat pumps to manage refrigerant at the factory level.
- ✓ Working with Watts to bring monobloc heat pump install cost near parity with mini-split systems.
- ✓ Collaborating with existing CEC funded contractor training programs.
- ✓ Increasing space efficiency with proprietary storage cubes.
- ✓ Using outdoor monobloc unit with low-GWP refrigerant (R-32). Demonstrates safe deployment of flammable refrigerants.
- ✓ Partnering with Exelon to shape utility tariffs, programs and incentives to support decarbonization.

FUTURE OPORTUNITIES

- ✓ Execute multiple pilot projects, quantify performance, and prove customer value.
- ✓ Persuade major heat pump manufacturers to certify and market monobloc, water-based residential heat pump systems and service parts in the US.
- ✓ Persuade IRS that Stow's system offers storage that can qualify for solar tax credits.
- ✓ Collaborate with EPRI through the Incubatenergy Labs Challenge.
- ✓ Develop standards for air-to-water heat pump systems in order to access incentive programs.

Market readiness

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TECHNOLOGY READINESS LEVEL SCORE

- All sub-components & materials are made with well-established practices, sub-assemblies of common parts, or market ready/ field tested.
- System engineering and controls need additional testing, validation and implementation.
- Limited field testing to date.

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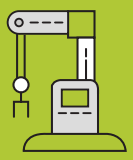
YEARS TO MARKET

- Product completion and certification will take 9-12 months.
- Launch for early adopter customers will begin in 2022, with broader scale up in 2023.



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MANUFACTURER READINESS LEVEL SCORE

- Leveraging heat pump and air handler equipment from large manufacturers.
- Rotomolded storage tanks use existing production lines and methods.
- Control center needs refinement for scaled manufacturing.

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KEY OUTCOMES

- Pilot M&V data quantifying customer value and DR/system value.
- Identification of and collaboration with aligned HVAC installers for future growth.
- Customer, utility, and contractor testimonials to catalyze expansion.

Supporting utility goals for decarbonization

1.

Energy savings

Stow can boost heat pump capacity under extreme conditions by charging the storage tank when ambient temperatures are most temperate.

2.

Decarbonization

Stow can electrify existing furnace systems and shift electricity use to align with renewable energy production. Next gen will be able to electrify NG water heaters.

3.

C&S alignment

Stow meets 2020 Load Management Rulemaking (19-OIR-01) for increased demand flexibility.

4.

Demand flexibility

Stow can shift morning heating and evening cooling load to cover curtailment periods.

TECHNOLOGY STATUS:

Stow Energy filed patent application 17/148,365 describing the system architecture and control algorithms. Stow has logged over 700 runtime hours in a lab setting and have two field pilots installed. The plumbing panel is on its third design iteration, and Stow has manufactured a custom control board. They have tested heat pumps and developed control interfaces with three different manufacturers.

PERFORMANCE DATA:

For a typical heat pump sized at 9kW (3 tons) for single family home (2-3k sqft):

- ✓ Monobloc heat pump efficiency COP over 5 in mild heating and cooling conditions.
- ✓ Storage tanks up to 0.04 kWh_e per gallon in heating and up to 0.02 kWh_e per gallon in cooling, with between 2% and 8% stored energy loss over a 24-hours at a 54°F temperature difference.
- ✓ Simulated performance data on heat pump performance suggests 20% annual energy cost savings from energy storage in Stockton, CA. Actual savings will be reduced in proportion to real-world forecast error and imperfect control execution.

PAYBACK PERIOD:

Stow Energy HVAC + Hot Water
(project premium v. typical ASHP and HPWH Systems*) **$3,200**

Incentives
SGIP Incentive Credit ($0.15/Wh)** $1,500

Annual Savings
TOU Savings (PG&E EV2A) $160
DR Participation Value $180
Total $340

5.0 YEAR AVERAGE PAYBACK

Northern California pricing when paired with solar and the EV-2A tariff.

**Stow with heating, cooling, and hot water (planned release) compared to typical air source heat pump and heat pump water heater solutions.*

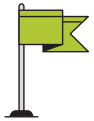
***assumes SGIP credits Stow's system for 10kWh of storage (cooling value).*

Stow Energy Utility Opportunity Assessment

TECHNOLOGY CATEGORY

HVAC

Stow Energy Heat Pump With Low-Cost Thermal Storage And Predictive Controls



ETP PRIORITIES

ENERGY SAVINGS

- Shifts HVAC load to off-peak hours.
- Storage boosts heat pump efficiency.

DECARBONIZATION

- Monobloc minimizes refridgerant leaks.
- Storage can shift operations to align with renewables.

C & S ALIGNMENT

COP ~4 over a range of operating conditions, comparable to available air-source or water-source heat pumps.

DEMAND FLEXIBILITY

Modular storage capacity in 2-5kWh$_e$ cubes.

KNOWLEDGE INDEXES

TECHNICAL PERFORMANCE

Medium

MARKET KNOWLEDGE

Medium

PROGRAM INTERVENTION

Low

UTILITY VALUE

- Provides attractive proposition for DR programs.
- Up to 100% reduction in gas usage if replacing fossil fuel fired furnace.

OPPORTUNITIES

CRITICAL ETP ACTIONS

- Socialize within SCE.
- Socialize with other IOUs.
- Field test in CA.

LEVERAGE POINTS

- EPRI Incubatenery Labs Challenge.
- Align with CA Priority Partnership Areas.
- Target markets with carbon reduction incentives and policies.

GAPS TO FILL

- CA field demo data.
- IAPMO* certification.

MARKET SIZE

- Single family homes with ducted HVAC, 41m households

* International Association of Plumbing and Mechanical Officials

BARRIERS

IN-PROGRESS

- Lack of real-world data from pilot sites.
- Lack of attractive TOU rates for some homeowners.
- Space constraints for storage.

UPCOMING

- Customer adoption.
- Development of distribution & service relationships.

SOLUTION

- Build brand awareness.
- Partner with solar installers to identify target homes.
- Network with 3rd party implementers and OEMs.

NEXT STEPS

COMPANY

1. Execute field pilots and produce M&V reporting.
2. Complete IAPMO certification.
3. Complete the software stack for DR market participation.

UTILITY

1. Field demo results.
2. Value proposition and business use case.

OTHER

1. EPRI M&V testing and/or grant collaborator.
2. Partnerships with developers, HVAC contractors, Building Energy Management Systems.

ted

TED is a process where innovative technologies are selected for assessment and review based on the technology application, team strength, and alignment with the Technology Priority Maps, to fulfill the California decarbonization challenge.

FOR MORE INFORMATION

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