



All-Electric New Construction System Options

Version September 2020

This document outlines known best practice system options for new construction buildings as they relate to electrification of major end uses. This document is intended to guide the building industry to available technology options and their applications. These recommendations are primarily for buildings in ASHRAE Climate Zones 1 through 5. While this document is primarily for new construction buildings, it discusses electrification retrofit applications at a high-level.

There is one table for a large set of distinct building segments and end-uses, each covering technology solutions, major manufacturers, and pros/cons to weigh. For more information please visit AllElectricDesign.org. This document is brought to you by Peninsula Clean Energy and Silicon Valley Clean Energy, with the help of TRC Companies, DNV-GL, Guttman and Blaevoet, Meyers+, Redwood Energy, and SmithGroup.

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SINGLE FAMILY NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Heat Pump - Central Ducted	For homes with crawlspace or attic to accommodate ducting	Daikin, Goodman, Lennox, Trane, Amana, Carrier, Bryant	Hidden unit Contractor familiarity Less refrigerant	Zoning is more difficult No central heat recovery but can be achieved with separate balanced ventilation systems with ERV/HRV systems
Heat Pump - Mini-split	For small homes or homes without crawlspace or attic to accommodate ducting. Can be paired with short ducting to serve adjacent zones.	Daikin, Mitsubishi, Electrolux, York, McQuay	Well-circulated air Easy zoning Heat-recovery capable	Requires multiple refrigerant lines Aesthetics Need parallel system for outside air delivery (unless indoor ducted fan coils are selected) Large condensing units
Packaged Terminal Heat Pump (PTHP) / Vertical Terminal Heat Pump (VTHP)	For inexpensive single-zone installation with similar performance to split systems. Recommended for affordable housing or small homes.	Friedrich, Island, Innova, Olimpia	Inexpensive Easy to install Easy zoning Integrated fresh air Great for ADUs, affordable housing, tiny homes	Aesthetics Sound control
Heat Pump - Central Air-to-Water Heat Pump (AWHP)	Hydronic distribution system that uses heat pumps to heat the water to circulate to in-unit terminal space heating units	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana, Chiltrix, SpacePak, Arctic, Aermec	Aesthetics (mostly hidden system in-unit) Relatively easy retrofit solution for existing central boiler plants Refrigerant system is in one single package (less complex for installation) Ideal for climates requiring minimal cooling DHW can also be produced in most climates Great for expensive homes	More expensive to install Zoning is more difficult Systems are not in wide use, so learning curve for designers and installers High heat pump conversion cost Lower equipment lifespan (15-20 years) in comparison to boiler
Domestic Hot Water (DHW)				
Heat Pump - Unitary DHW Storage Systems	One HPWH in a central location	Rheem, AO Smith, Bradford White, Stiebel Eltron	Easy retrofit	Vent to the outside Use a vented door as you would for an apartment
Heat Pump - Unitary DHW Storage Systems, low Global Warming Potential (GWP) refrigerant	One HPWH in a central location	Sanden	Extra low GHG emissions Larger than other systems High COP Split system provides flexibility	Bigger than most homes require Compressor and storage tanks are not integrated, requiring a bigger installation footprint Recirculation can be challenging
Cooking				
Induction	Induces current in cookware	Amana, GE, Jenn-Air, Kenmore, KitchenAid, LG, Samsung, Bosch, Café, Frigidaire	High heat control, increased safety Similar or faster cooking time compared to gas Reduction of smoke, grease and airborne particulates Twice as expensive as resistance	Requires magnetic stainless steel or cast iron cookware
Resistance	Conducts heat to cookware	Amana, GE, Jenn-Air, Kenmore, Samsung, Frigidaire	Works with any cookware	Low heat control, hot surface

SINGLE FAMILY NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
Laundry				
Heat Pump Dryer	Recirculates air within drum and condenses water to holding tank. Using active heat exchanger to recapture heat, making it more efficient than condensing.	Samsung, Kenmore, Miele, Blomberg, Beko, Whirlpool	Does not use a vent, reducing fire risk Highest efficiency dryer for sale	Longer drying time
Condensing - Combined washer/dryer	All-in-one clothes washer and dryer. Uses vapor compression cycle but with passive, room temperature condensing surface rather than actively chilling for heat recapture. Uses more energy than heat pump dryer.	Whirlpool, LG, Summit, Haier, Deco, Magic Chef	Does not use a vent, reducing fire risk Does not require moving clothes across two appliances. Lower electrical capacity needed. Make sure to fill 2/3rds tumbler capacity at max to attain drying	Most products offer smaller (e.g., 2.5 cubic foot) capacity LG offers 4.5 cf, considered mid-size in U.S. (large is 7 cf)
Resistance Dryer	Resistance dryer	Samsung, LG, GE, Maytag, Electrolux	Shorter drying time	Requires a vent, least efficient electric option, high temperature ages clothes

LOW-RISE MULTI-FAMILY (<= 20 dwelling units) NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Heat Pump - Central Air-to-Water Heat Pump (AWHP)	Hydronic distribution system that uses heat pumps to heat the water to circulate to in-unit terminal space heating units.	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana, Chiltrix, SpacePak, Arctic, Aermec	Aesthetics (mostly hidden system in-unit) Relatively easy retrofit solution for existing central boiler plants Refrigerant system is in one single package (less complex for installation) Ideal for climates requiring minimal cooling DHW can also be produced in most climates	More expensive to install Usage cannot readily be individually metered Zoning is more difficult Systems are not in wide use, so learning curve for designers and installers High heat pump conversion cost Lower equipment lifespan (15-20 years) in comparison to boiler
Heat Pump - Mini-split or ductless split systems	Each apartment has single outdoor unit serving indoor units in each room. Condenser unit can be installed outside each apartment with short piping to each room. Can provide heating and cooling to multiple zones.	Daikin, Mitsubishi, Electrolux, York, McQuay, Fujitsu, Gree, Carrier	Well-circulated air Optimized zoning (room load can be matched to each outdoor unit) Heat-recovery capable	Requires multiple refrigerant lines Aesthetics Fresh air can be challenging Large condensing units
Heat Pump - Ducted, Single Zone (ASHP)	A single-apartment heat pump ducted with outdoor condenser	Carrier Residential, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Minimal penetrations in roof or walls compared to other AC units Well-circulated air	Additional ductwork which can be challenging when space limited Domestic hot water production will need to be decoupled
Variable Refrigerant Flow (VRF) Systems	Central heat pump system with refrigerant distribution	Daikin, Fujitsu, LG, Mitsubishi and Panasonic	Easy zoning Highly efficient at part load Heat-recovery capable Domestic hot water can be produced Simultaneous heating and cooling available Minimal penetrations in roof or walls compared to other AC units	High cost Depending on application, separate ventilation system is required Little opportunity for a phased retrofit A lot of field connected piping prone to refrigerant leakage if not done by trained installer Maintenance contract
Packaged Terminal Heat Pump (PTHP) / Vertical Terminal Heat Pump (VTHP)	Reversible zonal packaged air conditioners that provide heating and cooling from the same unit. Can be paired with short ducting to serve adjacent zones.	Friedrich, Island, Innova, Olimpia, GE	Inexpensive Easy to install Easy zoning Integrated fresh air	Typically low performance compared to other options Limited cold-climate PTHP options available Aesthetics Sound control
Electric radiant floor heating with Passive House level of insulation	Underfloor radiant mats for space heating with high level of wall and roof insulation to minimize annual energy use	NuHeat, Sun Touch	Inexpensive Easy to install Comfortable Easy zoning Aesthetics No sound	Requires separate fresh air system Low efficiency No integrated cooling

LOW-RISE MULTI-FAMILY (<= 20 dwelling units) NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
Domestic Hot Water				
Central Air-to-Water- Heat Pump (AWHP) Hot Water System with central storage	One HPWH in a central location (for low-rise MF, SF size AWHPs can be manifolded together) Implement load-shift strategies to reduce utility bills while maintaining sufficient hot water supply	Aermac SPA, Colmac, Rheem, AO Smith, Bradford White, Stiebel Eltron, Nyle, SpacePak, Chilltrix.	Can be hydronically coupled with space heating system	Can be higher installation costs Performance at low temperature is poor (supplemental systems for cold climates required)
Heat Pump - Central Storage, low Global Warming Potential (GWP) refrigerant	One HPWH in a central location Implement load-shift strategies to reduce utility bills while maintaining sufficient hot water supply	Sanden	Extra low GHG emissions Larger than other systems High COP at low ambient temperature	High installation costs
Unitary Heat Pump - Distributed (individual tank. One per 1/2 apartment.)	Multiple HPWHs will reduce time-to-tap for larger homes with distant hot water fixtures.	Aermac SPA, Colmac, Rheem, AO Smith, Bradford White, Stiebel Eltron, Nyle, SpacePak, Chilltrix.	Maintenance relatively simple as there are individual units Can be individually metered at the unit More opportunities for phased retrofit	More systems to maintain Higher footprint
Cooking				
Induction	Induces current in cookware	Amana, GE, Jenn-Air, Kenmore, KitchenAid, LG, Samsung, Bosch, Café, Frigidaire	High heat control, increased safety Similar or faster cooking time compared to gas Reduction of smoke, grease and air borne particulates	Requires magnetic stainless steel or cast iron cookware
Resistance	Conducts heat to cookware	Amana, GE, Jenn-Air, Kenmore, Samsung, Frigidaire	Works with any cookware	Low heat control, hot surface
Laundry				
Heat Pump Dryer	Recirculates air within drum and condenses water to holding tank. Using active heat exchanger to recapture heat, making it more efficient than condensing.	Samsung, Kenmore, Miele, Blomberg, Beko, Whirlpool	Does not use a vent, reducing fire risk Highest efficiency dryer for sale	Longer drying time. Not yet available in coin-operated versions in U.S.
Condensing - Combined washer/dryer	All-in-one clothes washer and dryer. Uses vapor compression cycle but with passive, room temperature condensing surface rather than actively chilling for heat recapture. Uses more energy than heat pump dryer.	Whirlpool, LG, Summit, Haier, Deco, Magic Chef	Does not use a vent, reducing fire risk Does not require moving clothes across two appliances. Lower electrical capacity needed. Make sure to fill 2/3rds tumbler capacity at max to attain drying.	Most products offer smaller (e.g., 2.5 cubic foot) capacity. LG offers 4.5 cf, considered mid-size in U.S. (large is 7 cf)

HIGH-RISE MULTI-FAMILY (>20 dwelling units, 4+ stories) NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Heat Pump - Central Air-to-Water Heat Pump (AWHP)	Hydronic distribution system that uses heat pumps to heat the water to circulate to in-unit terminal space heating units. May be considered as a one-for-one replacement for a hot water boiler, where it performs a similar role in a central plant-based system.	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana, Chilltrix, Arctic, Aermec	Aesthetics (mostly hidden system in-unit) Refrigerant system is in one single package (less complex for installation) Ideal for climates requiring minimal cooling DHW can also be produced in most climates	More expensive to install Usage cannot readily be individually metered Zoning is more difficult Systems are not in wide use, so learning curve for designers and installers High heat pump conversion cost Lower equipment lifespan (15-20 years) in comparison to boiler
Heat Pump - Mini-split or ductless split systems	Each apartment has single outdoor unit serving indoor units in each room. Condenser unit can be installed outside each apartment with short piping to each room. Can provide heating and cooling to multiple zones.	Daikin, Mitsubishi, Electrolux, York, McQuay, Fujitsu, Gree, Carrier	Well-circulated air Optimized zoning (room load can be matched to each outdoor unit) Heat-recovery capable Can be individually metered at the unit	Requires multiple refrigerant lines Aesthetics Need a parallel system for outside air: delivery, conditioning and filtering Large condensing units
Heat Pump - Ducted, Single Zone (ASHP)	A single-apartment heat pump ducted with outdoor condenser	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana, Chilltrix, Arctic, Aermec	Aesthetics High efficiency May be able to accommodate an outside air connection and provide both MERV-13 filtration and temperature conditioning Well-circulated air	Additional ductwork which can be challenging when space limited Domestic hot water production will need to be decoupled Condensing units often placed on patio
Variable Refrigerant Flow (VRF) Systems	Central heat pump system with refrigerant distribution	Daikin, Fujitsu, LG, Mitsubishi and Panasonic	Easy zoning Highly efficient at part load Heat-recovery capable Domestic hot water can be produced Simultaneous heating and cooling available Minimal penetrations in roof or walls compared to other AC units	Depending on application, separate ventilation system is required Little opportunity for a phased retrofit A lot of field connected piping prone to refrigerant leakage if not done by trained installer Growing industry awareness of global warming potential of associated refrigerant leaks, and difficulty of locating and repairing leaks with long pipe runs concealed in construction
Packaged Terminal Heat Pump (PTHP) / Vertical Terminal Heat Pump (VTHP)	Reversible zonal packaged air conditioners that provide heating and cooling from the same unit. Can be paired with short ducting to serve adjacent zones.	Friedrich, Island, Innova, Olimpia. Innova, GE	Inexpensive Easy to install Easy zoning Integrated fresh air	Typically low performance compared to other options. Limited cold-climate PTHP options available Aesthetics Sound control
Water Source Heat Pump Systems	Discharges/extracts heat from water flowing in a closed hydronic loop serving four pipe indoor coil units (most likely).	Water furnace	Aesthetics High efficiency Operate at more constant, and cooler temperature than air-source systems Well-circulated air	High first costs (installation and first years of operation) High water consumption
Ground Source Heat Pump Systems	Discharges/extracts heat from ground or body of water through an open/closed hydronic loop serving four pipe indoor coil units (most likely).	Water furnace	Aesthetics High efficiency Operate at more constant and cooler temperature than air-source systems Reduces need for large mechanical rooms or equipment areas. Life cycle cost savings Can provide individual zone temperature control Excess heat from GSHP can be diverted to provide water heating for entire building	Large space on site is required for ground well (smaller for vertical wells) High first costs (installation and first years of operation) Systems are still not in wide use, so learning curve for designers and installers Can have high water consumption

HIGH-RISE MULTI-FAMILY (>20 dwelling units, 4+ stories) NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
Domestic Hot Water				
Central Air-to-Water- Heat Pump (AWHP) Hot Water System with central storage	One HPWH in a central location Implement load-shift strategies to reduce utility bills while maintaining sufficient hot water supply	Aermac Nyle, Colmac	Can be hydronically coupled with space heating system	High installation costs Performance at low temperature is poor (supplemental systems for cold climates required)
Heat Pump - Central Storage, low GWP refrigerant (R-744)	One HPWH in a central location. Implement load-shift strategies to reduce utility bills while maintaining sufficient hot water supply	Sanden, Maykawa	Extra low GHG emissions Can be hydronically coupled with space heating system High COP	High installation costs
Wastewater Heat Recovery Heat Pump	One HPWH in a central location which draws heat from the wastewater main.	Sharc, Piranha	Very high performance	200 apt units per unit Space requirements in basement.
Heat Pump - Distributed	Multiple HPWHs will reduce time-to-tap for larger homes with distant hot water fixtures. Implement load-shift strategies to reduce utility bills while maintaining sufficient hot water supply	Rheem	Maintenance relatively simple as there are individual units Can be individually metered at the unit More opportunities for phased retrofit	Double the cost of central HPHW Typically decoupled from space heating
Cooking				
Induction	Induces current in cookware	Amana, GE, Jenn-Air, Kenmore	High heat control, increased safety Similar or faster cooking time compared to gas Elimination of nitrogen dioxide	Requires magnetic stainless steel or cast-iron cookware
Resistance	Conducts heat to cookware	Amana, GE, Jenn-Air, Kenmore	Works with any cookware	Low heat control, hot surface
Laundry				
Heat Pump Dryer	Recirculates air within drum and condenses water to holding tank. Using active heat exchanger to recapture heat, making it more efficient than condensing.	Samsung, Kenmore, Miele, Blomberg, Beko, Whirlpool	Does not use a vent, reducing fire risk. Highest efficiency dryer for sale.	Longer drying time. Not yet available in coin-operated versions in U.S.
Condensing - Combined washer/dryer	All-in-one clothes washer and dryer. Uses vapor compression cycle but with passive, room temperature condensing surface rather than actively chilling for heat recapture. Uses more energy than Heat Pump dryer.	Whirlpool, LG, Summit, Haier, Deco, Magic Chef	Does not use a vent, reducing fire risk Does not require moving clothes across two appliances. Lower electrical capacity needed. Make sure to fill 2/3rds tumbler capacity at max to attain drying.	Most products offer smaller (e.g., 2.5 cubic foot) capacity. LG offers 4.5 cf, considered mid-size in U.S. (large is 7 cf)
Resistance Dryer	Resistance dryer	Samsung, LG, GE, Maytag, Electrolux	Shorter drying time	Requires a vent, least efficient electric option, high temperature ages clothes.

SMALL OFFICE NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Heat Pump - Central Air-to-Water Heat Pump (AWHP)	Hydronic distribution system that uses heat pumps to heat the water to circulate to in-unit terminal space heating units	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana	Aesthetics (mostly hidden system in-unit) Refrigerant system is in one single package (less complex for installation) Ideal for climates requiring minimal cooling DHW can also be produced in most climates	More expensive to install Usage cannot readily be individually metered Zoning is more difficult Systems are not in wide use, so learning curve for designers and installers High heat pump conversion cost Lower equipment lifespan (15-20 years) in comparison to boiler
Variable Refrigerant Flow (VRF) Systems	Central heat pump system with refrigerant distribution	Daikin, Fujitsu, LG, Mitsubishi and Panasonic	Easy zoning Highly efficient at part load Heat-recovery capable Domestic hot water can be produced Simultaneous heating and cooling available Minimal penetrations in roof or walls compared to other AC units	Depending on application, separate ventilation system is required A lot of field connected piping prone to refrigerant leakage if not done by trained installer
Packaged Heat Pump - Single Zone System	Packaged, all-in-one system including heating, cooling, ventilation air, and return air all in a single unit	Carrier, Daikin, Trane, Goodman, Lennox	Integrated outdoor air Easy retrofit solution Low cost All commercial installers have experience No refrigerant piping	Exterior aesthetics Limited efficiency performance Considered "low quality" system Not 100% outdoor air
Packaged Variable Air Volume (VAV) Heat Pump with Electric Resistance Reheat	Packaged rooftop system typical for small offices across the United States, except with a reversing valve enabling heat pump mode and electric reheat boxes (as opposed to hydronic reheat boxes)	Carrier, Daikin, Trane, Lennox, Price, Titus, Krueger	Contractor familiarity Multiple zones with one unit No refrigerant piping	Not 100% outside air Recirculated air is mixed between spaces High electricity demand on reheat boxes Increased ductwork requirements
Domestic Hot Water (DHW)				
Central Air-to-Water- Heat Pump (AWHP) Hot Water System with central storage	One HPWH in a central location	Aermec SPA, Colmac Water Heat, Rheem, AO Smith, Kenmore, Lochinvar, Bradford White, Stiebel Eltron	Can be hydronically coupled with space heating system	High installation costs Performance at low temperature is poor (supplemental systems for cold climates required)
Heat Pump - Central Storage, low Global Warming Potential (GWP) refrigerant	One HPWH in a central location	Sanden	Extra low GHG emissions Can be hydronically coupled with space heating system	High installation costs
Heat Pump - Distributed	Multiple HPWHs will reduce time-to-tap for larger homes with distant hot water fixtures.	(same)	Maintenance relatively simple as there are individual units Can be individually metered at each tenancy More opportunities for phased retrofit	Typically decoupled from space heating
Cooking				
Induction	Induces current in cookware	Amana, GE, Jenn-Air, Kenmore, Blomberg, Beko, Whirlpool	High heat control, increased safety Similar or faster cooking time compared to gas Reduction of smoke, grease and air borne particulates	Requires magnetic stainless steel or cast-iron cookware
Resistance	Conducts heat to cookware	Amana, GE, Jenn-Air, Kenmore, Haier, Deco, Magic Chef	Works with any cookware	Low heat control, hot surface

LARGE OFFICE NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Heat Pump - Central Air-to-Water Heat Pump (AWHP)	Hydronic distribution system that uses heat pumps to heat the water to circulate to in-unit terminal space fan-coil heating units	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana, Multi-stack	Aesthetics (mostly hidden system in-unit) Relatively easy retrofit solution for existing central boiler plants Refrigerant system is in one single package (less complex for installation) Ideal for climates requiring minimal cooling DHW can also be produced in most climates	More expensive to install Usage cannot readily be individually metered Zoning is more difficult Systems are not in wide use, so learning curve for designers and installers High heat pump conversion cost Lower equipment lifespan (15-20 years) in comparison to boiler
Variable Refrigerant Flow (VRF) Systems	Central heat pump system with refrigerant distribution	Daikin, Fujitsu, LG, Mitsubishi and Panasonic	Easy zoning Highly efficient at part load Heat-recovery capable Domestic hot water can be produced Simultaneous heating and cooling available Minimal penetrations in roof or walls compared to other AC units	High cost Depending on application, separate ventilation system is required Little opportunity for a phased retrofit A lot of field connected piping prone to refrigerant leakage if not done by trained installer
Water Source Heat Pump Systems	Discharges/extracts heat from water flowing in a closed hydronic loop serving four pipe indoor coil units (most likely)	Carrier, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Operate at more constant, and cooler temperature than air-source systems Well-circulated air	High first costs (installation and first years of operation) High water consumption
Ground Source Heat Pump Systems	Discharges/extracts heat from ground or body of water through an open/closed hydronic loop serving four pipe indoor coil units (most likely)	Carrier, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Operate at more constant, and cooler temperature than air-source systems Reduces need for large mechanical rooms or equipment areas. Life cycle cost savings Can provide individual zone temperature control Excess heat from GSHP can be diverted to provide water heating for entire building	Large space on site is required for ground well (smaller for vertical wells) High first costs (installation and first years of operation) Systems are still not in wide use, so learning curve for designers and installers Can have high water consumption Boring companies are hard-to-find and expensive.
Domestic Hot Water				
Central Air-to-Water- Heat Pump (AWHP) Hot Water System with central storage	One HPWH in a central location	Aermec SPA, Colmac Water Heat, Rheem, AO Smith, Kenmore, Lochinvar, Bradford White, Stiebel Eltron	Can be hydronically coupled with space heating system	High installation costs Performance at low temperature is poor (supplemental systems for cold climates required)
Heat Pump - Central Storage, low Global Warming Potential (GWP) refrigerant	One HPWH in a central location	Sanden	Extra low GHG emissions Can be hydronically coupled with space heating system	High installation costs
Heat Pump - Distributed	Multiple HPWHs will reduce time-to-tap for larger homes with distant hot water fixtures.	(same)	Maintenance relatively simple as there are individual units Can be individually metered at each tenancy More opportunities for phased retrofit Cooling can be rejected to help cool IT rooms for free	Double the cost of central HPHW Typically decoupled from space heating
Cooking				
Induction	Induces current in cookware	Amana, GE, Jenn-Air, Kenmore	High heat control, increased safety Similar or faster cooking time compared to gas Reduction of smoke, grease and air borne particulates	Requires magnetic stainless steel or cast-iron cookware
Resistance	Conducts heat to cookware	Amana, GE, Jenn-Air, Kenmore	Works with any cookware	Low heat control, hot surface

SMALL RETAIL NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Packaged Rooftop Heat Pump	Packaged, all-in-one system including heating, cooling, ventilation air, and return air all in a single unit.	Carrier, Daikin, Trane, Goodman, Lennox	Integrated outdoor air Easy retrofit solution Low cost All commercial installers have experience No refrigerant piping	Aesthetics Limited efficiency performance Considered "low quality" system. Not 100% outdoor air
Variable Refrigerant Flow (VRF) Systems	Central heat pump system with refrigerant distribution	Daikin, Fujitsu, LG, Mitsubishi and Panasonic	Easy zoning Highly efficient at part load Heat-recovery capable Domestic hot water can be produced Simultaneous heating and cooling available Minimal penetrations in roof or walls compared to other AC units	High cost Depending on application, separate ventilation system is required Little opportunity for a phased retrofit A lot of field connected piping prone to refrigerant leakage if not done by trained installer
Packaged Heat Pump - Single Zone System	Single zone packaged units each providing heating and cooling to one zone.	Carrier Residential, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Minimal penetrations in roof or walls compared to other AC units Well-circulated air	Additional ductwork which can be challenging when space limited Domestic hot water production will need to be decoupled
Domestic Hot Water				
Heat Pump - Central Storage, low Global Warming Potential (GWP) refrigerant	One HPWH in a central location	Sanden	Extra low GHG emissions Can be hydronically coupled with space heating system	
Heat Pump - Central Storage	One HPWH in a central location	Rheem, AO Smith, Bradford White, Stiebel Eltron	Easy retrofit	
Heat Pump - Distributed	Multiple HPWHs will reduce time-to-tap for larger homes with distant hot water fixtures.	(same)	Maintenance relatively simple as there are individual units Can be individually metered at each tenancy More opportunities for phased retrofit	Double the cost of central HPHW Typically decoupled from space heating
Cooking				
Induction	Induces current in cookware	Amana, GE, Jenn-Air, Kenmore	High heat control, increased safety Similar or faster cooking time compared to gas Reduction of smoke, grease and air borne particulates	Requires magnetic stainless steel or cast-iron cookware
Resistance	Conducts heat to cookware	Amana, GE, Jenn-Air, Kenmore	Works with any cookware	Low heat control, hot surface

LARGE RETAIL NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Heat Pump - Central Air-to-Water Heat Pump (AWHP)	Hydronic distribution system that uses heat pumps to heat the water to circulate to zonal space fan-coil heating units	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana	Aesthetics (mostly hidden system in-unit) Relatively easy retrofit solution for existing central boiler plants Refrigerant system is in one single package (less complex for installation) Ideal for climates requiring minimal cooling DHW can also be produced in most climates	More expensive to install Usage cannot readily be individually metered Zoning is more difficult Systems are not in wide use, so learning curve for designers and installers High heat pump conversion cost Lower equipment lifespan (15-20 years) in comparison to boiler
Packaged Rooftop Heat Pump	Packaged, all-in-one system including heating, cooling, ventilation air, and return air all in a single unit.	Carrier, Daikin, Trane, Goodman, Lennox	Integrated outdoor air Easy retrofit solution Low cost All commercial installers have experience No refrigerant piping	Aesthetics Limited efficiency performance Considered "low quality" system Not 100% outdoor air
Variable Refrigerant Flow (VRF) Systems	Central heat pump system with refrigerant distribution	Daikin, Fujitsu, LG, Mitsubishi and Panasonic	Easy zoning Highly efficient at part load Heat-recovery capable Domestic hot water can be produced Simultaneous heating and cooling available Minimal penetrations in roof or walls compared to other AC units	High cost Depending on application, separate ventilation system is required Little opportunity for a phased retrofit A lot of field connected piping prone to refrigerant leakage if not done by trained installer
Water Source Heat Pump Systems	Discharges/extracts heat from water flowing in a closed hydronic loop serving four pipe indoor coil units (most likely)	Carrier, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Operate at more constant, and cooler temperature than air-source systems Well-circulated air	High first costs (installation and first years of operation) High water consumption
Ground Source Heat Pump Systems	Discharges/extracts heat from ground or body of water through an open/closed hydronic loop serving four pipe indoor coil units (most likely)	Carrier, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Operate at more constant, and cooler temperature than air-source systems Reduces need for large mechanical rooms or equipment areas. Life cycle cost savings Can provide individual zone temperature control Excess heat from GSHP can be diverted to provide water heating for entire building	Large space on site is required for ground well (smaller for vertical wells) High first costs (installation and first years of operation) Systems are still not in wide use, so learning curve for designers and installers Can have high water consumption
Domestic Hot Water				
Central Air-to-Water- Heat Pump (AWHP) Hot Water System with central storage	One HPWH in a central location	Aermac SPA, Colmac Water Heat, Rheem, AO Smith, Kenmore, Lochinvar, Bradford White, Stiebel Eltron	Can be hydronically coupled with space heating system	High installation costs Performance at low temperature is poor (supplemental systems for cold climates required)
Heat Pump - Central Storage, low Global Warming Potential (GWP) refrigerant	One HPWH in a central location	Sanden	Extra low GHG emissions Can be hydronically coupled with space heating system	High installation costs
Heat Pump - Central Storage	One HPWH in a central location	Rheem, AO Smith, Bradford White, Stiebel Eltron	Easy retrofit	

LARGE HOTEL NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
HVAC				
Heat Pump - Central Air-to-Water Heat Pump (AWHP)	Hydronic distribution system that uses heat pumps to heat the water to circulate to in-unit terminal space heating units	Daikin, Colmac, Mitsubishi, Sanden, Goodman, Lennox, Trane, Amana	Aesthetics (mostly hidden system in-unit) Relatively easy retrofit solution for existing central boiler plants Refrigerant system is in one single package (less complex for installation) Ideal for climates requiring minimal cooling DHW can also be produced in most climates	More expensive to install Usage cannot readily be individually metered Zoning is more difficult Systems are not in wide use, so learning curve for designers and installers High heat pump conversion cost Lower equipment lifespan (15-20 years) in comparison to boiler
Heat Pump - Ducted, Single Zone (ASHP) (Guestrooms Only) Multizone ASHP (Non-Guestroom Spaces)	A single-guest suite heat pump ducted with outdoor condenser	Carrier Residential, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Minimal penetrations in roof or walls compared to other AC units Well-circulated air	Additional ductwork which can be challenging when space limited Domestic hot water production will need to be decoupled
Variable Refrigerant Flow (VRF) Systems	Central heat pump system with refrigerant distribution	Daikin, Fujitsu, LG, Mitsubishi and Panasonic	Easy zoning Highly efficient at part load Heat-recovery capable Domestic hot water can be produced Simultaneous heating and cooling available Minimal penetrations in roof or walls compared to other AC units	High cost Depending on application, separate ventilation system is required Little opportunity for a phased retrofit A lot of field connected piping prone to refrigerant leakage if not done by trained installer
Packaged Terminal Heat Pump (PTHP) (Guestrooms Only) Multizone ASHP (Non-Guestroom Spaces)	Reversible zonal packaged air conditioners that provide heating and cooling from the same unit	Amana, GE, Frigidaire, Magic-Pak	Well-circulated air Easy zoning Heat-recovery capable Maintenance relatively simple as there are individual units Can be individually metered at the unit Lower equipment costs More opportunities for phased retrofit	Requires multiple refrigerant lines Aesthetics Fresh Air can be challenging Limited cold-climate PTHP options available More appropriate for low-rise buildings that have 6 floors or less. Can be paired with short ducting to serve adjacent zones.
Water Source Heat Pump Systems	Discharges/extracts heat from water flowing in a closed hydronic loop serving four pipe indoor coil units (most likely)	Carrier, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Operate at more constant, and cooler temperature than air-source systems Well-circulated air	High first costs (installation and first years of operation) High water consumption
Ground Source Heat Pump Systems	Discharges/extracts heat from ground or body of water through an open/closed hydronic loop serving four pipe indoor coil units (most likely)	Carrier, Fujitsu, Mitsubishi, Panasonic, LG, Trane, Daikin	Aesthetics High efficiency Operate at more constant, and cooler temperature than air-source systems Reduces need for large mechanical rooms or equipment areas. Life cycle cost savings Can provide individual zone temperature control Excess heat from GSHP can be diverted to provide water heating for entire building	Large space on site is required for ground well (smaller for vertical wells) High first costs (installation and first years of operation) Systems are still not in wide use, so learning curve for designers and installers Can have high water consumption

LARGE HOTEL NEW CONSTRUCTION DESIGN PRINCIPLES FOR ALL-ELECTRIC BUILDINGS

System Type Options	Description	Manufacturers	Pros	Cons
Domestic Hot Water				
Central Air-to-Water- Heat Pump (AWHP) Hot Water System with central storage	One HPWH in a central location Implement load-shift strategies to reduce utility bills while maintaining sufficient hot water supply,	Aermac SPA, Colmac Water Heat, Rheem, AO Smith, Kenmore, Lochinvar, Bradford White, Stiebel Eltron	Can be hydronically coupled with space heating system	High installation costs Performance at low temperature is poor (supplemental systems for cold climates required)
Heat Pump - Central Storage, low GWP refrigerant (R-744)	One HPWH in a central location Implement load-shift strategies to reduce utility bills while maintaining sufficient hot water supply,	Sanden	Extra low GHG emissions Can be hydronically coupled with space heating system	High installation costs
Cooking				
Induction	Induces current in cookware	Amana, GE, Jenn-Air, Kenmore	High heat control, increased safety Similar or faster cooking time compared to gas Reduction of smoke, grease and air borne particulates, resulting in lower ventilation requirements Reduction in maintenance on hoods and filters	Requires magnetic stainless steel or cast iron cookware
Resistance	Conducts heat to cookware	Amana, GE, Jenn-Air, Kenmore	Works with any cookware	Low heat control, hot surface
Sous-vide	Hot water immersion cooker	PolyScience	Increased control of cooking temperature Ease of repeatability of the quality of food produced Ideal for commercial kitchens that have preplanned meal preparation and volume Improved food safety and health	Increased cooking time Usually requires combination of grill for 'finished' look
Laundry				
Heat Pump Dryer (Central Laundry Room)	Recirculates air within drum and condenses water to holding tank.	Samsung, Kenmore, Miele	Does not require a vent, efficiency	Longer drying time
Heat Pump - Combined washer/dryer (Central Laundry Room)	All-in-one clothes washer and dryer.	Whirlpool, LG, Summit	Does not require moving clothes across two appliances. Lower electrical capacity needed.	Smaller capacity
Resistance Dryer (Central Laundry Room)	Resistance dryer	Samsung, LG, GE, Maytag	Shorter drying time	Requires a vent, less efficient