Electrification of Military Facilities

SAME NoVA Post Resilience Webcast

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Discussion Topics

- EPRI Overview
- Technology Overview
  - Residential
  - Commercial
  - Industrial
  - Non-Road Transportation
- Summary
- Electrification 2024
- Questions

EPRI Overview

Introduction to EPRI

BORN IN A BLACKOUT

Founded in 1972 as an independent, nonprofit center for public interest energy and environmental research

New York City, The Great Northeast Blackout, 1965

EPRI'S VALUE

To provide value to the public, our members, and the electricity sector

THOUGHT LEADERSHIP

INDUSTRY EXPERTISE

COLLABORATIVE MODEL

OUR MEMBERS...

- 450+ participants in more than 30 countries
- EPRI members generate approximately 90% of the electricity in the United States
- International funding – nearly 25% of EPRI's research, development, and demonstrations
- $415M Annual Funding

Three Key Aspects of EPRI

Independent

Objective, scientifically based results address reliability, efficiency, affordability, health, safety, and the environment

Nonprofit

Chartered to serve the public benefit

Collaborative

Bring together scientists, engineers, academic researchers, and industry experts

Electrification Program (P199)

Focus Areas:

- ***Electrification and Decarbonization Road Mapping Studies***
- ***Program Development and On-Going Support***
- ***Technology Deep Dives***
- ***Vendor Engagement***
- ***Emerging Technologies Analyses***

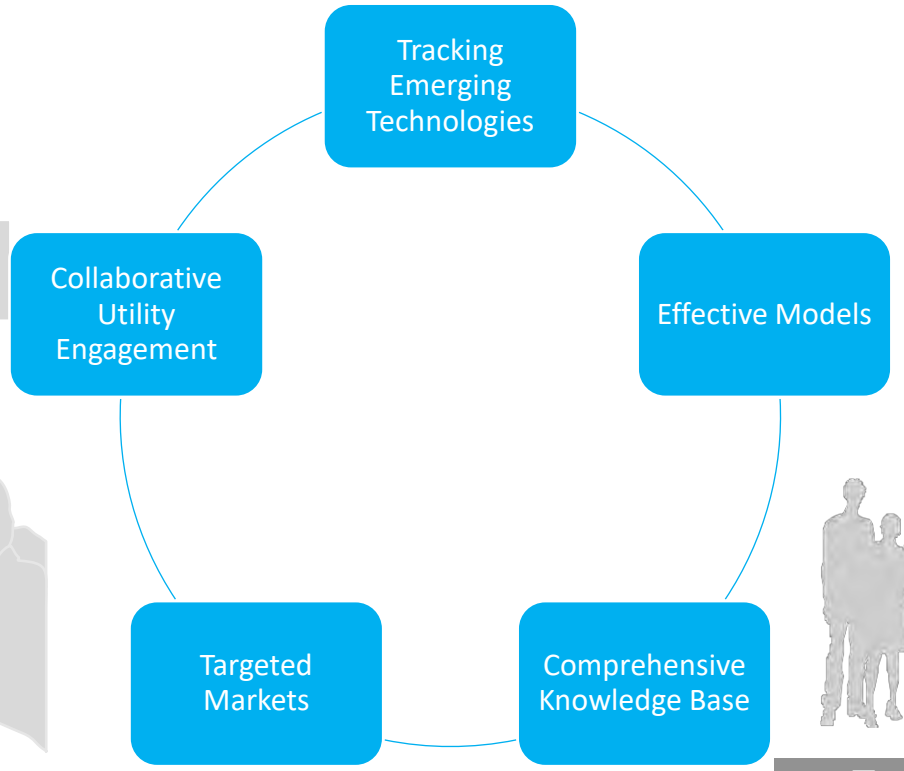
The core mission of Electrification is….

Financial Analysts

Key Account Managers

Facility Managers

Economic Development



….to benefit utility customers, which benefits utilities.

Military Electrification Overview

Electrification Program Focus

RESIDENTIAL

Space Heating:
- Air Source Heat Pumps
- Ductless Split Heat Pumps
- Cold Climate Heat Pumps

Water Heating:
- Heat Pump Water Heaters

Cooking:
- Induction Cooktops

COMMERCIAL

Space Heating:
- Rooftop Heat Pumps
- VRF Heat Pumps

Water Heating:
- Heat Pump Water Heaters

Cooking:
- Electric Fryers
- Griddles, Combi-Ovens

Others:
- Infra Red Comfort Heaters
- Pool Dehumidifiers

INDUSTRIAL

Electric Process Heating:
- Infrared heating
- Induction Melting
- Radiofrequency drying
- Ultraviolet Curing
- Electric Arc Furnace

Steam Generation:
- Electrode Boilers
- Industrial Heat Pumps

NON-ROAD TRANSPORTATION

- Forklifts
- Electric Terminal Trucks
- Airport Ground Support Equipment
- Truck Refrigeration Unit
- Landscaping Equipment
- Marine Equipment
- Agriculture Equipment
- Electric Golf Carts

Commercially available technologies in Res/Com/ Ind/ Non-road Trans. are researched with a focus on understanding key markets, customer cost-benefits, emissions impact and develop marketing materials

Residential Technologies

Technology Cut Sheets

Residential Air-Source Heat Pumps

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RESIDENTIAL AIR-SOURCE HEAT PUMPS

Residential heat pumps are electric appliances that can provide both central heating and cooling. They offer a level of home comfort comparable to that provided by traditional furnaces at a higher efficiency and potentially lower cost for customers. With heat pumps, electric utilities may also gain electric heating load in the winter.

DID YOU KNOW?

When a heat pump is paired with backup natural gas or propane fuel, the electric utility gains heating load in shoulder months, when temperatures range from 45°F to 65°F. On the coldest days, the fossil fuels provide heat, mitigating a utility's winter peak kW demand.

HOW IT WORKS

A heat pump is essentially an air conditioning (AC) unit that can operate in reverse. In cooling mode, the heat pump removes heat from a conditioned space and transfers it to the ambient space. In heating mode, the heat pump, which is equipped with a reversing valve, removes heat from the ambient space and transfers it to the conditioned space thus providing heat.

Air-source heat pumps are available in various configurations and classifications, including ducted or ductless, and with single-speed or variable-speed compressors. Although the term air-source heat pump applies to all heat pumps that extract heat from the air, it commonly refers to the ducted, single-speed configuration.

Most residential air-source heat pumps have both an outdoor unit and an indoor fan-coil section. Most also have backup heat capability provided by either electric resistance (a single-fuel system), or fossil fuel (a dual-fuel system).

APPLICATIONS

As is the case for homes with gas or propane furnaces and AC units, residential heat pumps are best suited for homes with existing forced air ductwork, including:

- New homes
- Existing homes
- Single-family and multi-family units

BENEFITS

Heating and cooling flexibility. With air-source heat pumps, the same equipment can be used to meet both space heating and cooling needs using electricity as the fuel source.

Potential cost savings. New homes can be designed with adequate electrical supply for an air-source heat pump with an electric backup heater. A single-fuel system may be less expensive than a dual-fuel system.

Energy savings. In existing homes, equipment older than 15 years is likely inefficient (not meeting the current minimum standard) and approaching end of life. In comparison, air-source heat pumps can provide higher energy savings.

Utility system stability. Fossil-fuel backup heating picks up peak heating load, reducing the impact on the utility grid during winter peak.

Emissions impacts. High-efficiency heat pumps can reduce the CO_2, NO_x, and SO_x footprints of the customers and the community due to lower fuel usage. This is especially true when the electricity generation mix is cleaner. The emissions impacts will become more favorable over time as the emissions intensity of generation sources decreases.

LIMITATIONS

Higher first cost. Air-source heat pumps may cost more to purchase than traditional gas or propane furnaces. If installers can make the case for savings over time by analyzing utility bills and comparing electricity, natural gas, and propane fuel costs, the chances of selling a heat pump increase dramatically.

Cold climate operation. A heat pump may not be an effective heating solution in colder regions. An air-source heat pump's operational efficiency and ability to deliver adequate heat degrade as outdoor air temperature falls.

Lack of incentive. Even though efficient air-source heat pumps deliver savings on monthly utility bills, they may not be big selling points for prospective new-home buyers.

Access to electrical service. Heat pump installation may require updated or expanded electrical service to accommodate the electrical load.

Customer and installer awareness. In regions where heat pumps are not typically used, customers may be unfamiliar with the technology and have reservations about switching from a traditional furnace. Installers, also, may be unaware of the benefits.

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Technology Cut Sheets

Residential Heat Pump Water Heaters

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RESIDENTIAL HEAT PUMP WATER HEATERS

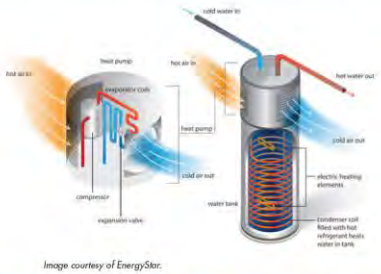

Image courtesy of EnergyStar.

Residential heat pump water heaters (HPWHs) offer a highly efficient alternative to traditional electric resistance or natural gas tank water heaters. The efficiency of HPWHs can be as much as two to three times that of traditional water heaters.

HOW IT WORKS

Just as a heat pump can be used to condition a living space by using electricity to transfer heat from one place to another, it can be used to heat water. A HPWH captures heat from ambient air and transfers it via refrigerant fluid and a compressor to water in an insulated storage tank.

A HPWH can be used alone or in conjunction with a space-conditioning heat pump. A HPWH with an integrated backup electric resistance heating element is known as a hybrid system.

HPWHs are most efficient when surrounded by warm or humid air, 40°F to 90°F, year-round. Because they rely on air transfer, HPWHs require at least 1,000 cubic feet of surrounding air volume, and because they exhaust cool air, installation in an attached garage in a mild climate or in a basement furnace room is ideal.

DID YOU KNOW?

EPRI researchers are investigating a HPWH that can superheat to a higher temperature, using CO_2 as the working fluid instead of typical refrigerant used in a conventional HPWH. In some applications this technology may offer faster recovery and even higher efficiency.

APPLICATIONS

Heat pump water heaters can be found in both residential and commercial markets. In residential applications, they may be used in the following settings:

- Single-family homes
- Multifamily homes
- Mobile homes

BENEFITS

Energy-saving performance. Although a HPWH typically costs more upfront, operating costs are much lower due to energy savings. An electric HPWH uses one-half to one-third the energy of a traditional electric resistance or natural gas water heater. Manufacturer rebates, tax credits, and local utility promotions may further offset the higher upfront cost.

Elimination of gas venting and piping. A HPWH requires no venting or piping. In new construction, this translates to savings of approximately $200 when compared with a gas water heater system.

Lower power HPWH in development. Although today's HPWHs require 240V service with sufficient ampacity on the electrical panel, new HPWH technologies may come with more modest ampacity requirements (15 amps at 208V or 240V). Work is underway on a low water-need HPWH that can run on 120V. These new units tend to be 30 gallons or smaller, and may be suitable for small households.

LIMITATIONS

Recovery time and first-hour rating. Recovery time and first-hour rating are different ways of measuring water heater response. HPWHs generally have a slower recovery (reheating) time than conventional resistance water systems. Recovery time varies somewhat with ambient air temperature; installed in a hot garage in the summer, for example, a HPWH will recover quickly. First-hour rating refers to the amount of hot water that can be delivered in the first hour of use. A larger tank, around 80 gallons, can compensate for slower recovery time and help on the first-hour rating. Good recovery time and storage capacity together help the first-hour rating.

Installation considerations. A HPWH requires 240V service with adequate ampacity on the electrical panel. It also requires a condensate drain, which may present an obstacle in some cases such as multifamily homes.

Operating sounds. Unlike resistance water heaters, HPWHs create some sound during operation due to their use of fans and compressors. Similar to the sound of a furnace fan, most homeowners do not notice it.

Limited market presence, availability, and user knowledge. Plumbers typically do not carry HPWHs in stock, and inventory is limited. Homeowners tend to purchase a new water heater only after their existing water heater fails. Under pressure to act fast, they are likely to choose the first unit that is readily available and meets their basic needs. For HPWHs to gain an increasing foothold in the market, homeowners need to be aware of their benefits and installers need to have them available.

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Technology Cut Sheets

Residential Induction Cooktops

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RESIDENTIAL INDUCTION COOKTOPS

Induction cooktops offer a highly efficient alternative to electric resistance and natural gas cooktops in home kitchens. They provide rapid heat-up and precise temperature control, and heat only the cookware containing food—not the area around them—so there is no heat loss or excessive energy use.

DID YOU KNOW?

The efficiency of residential induction cooktops is roughly 85%. That means, on average, 85% of the electrical energy is applied to the cookware rather than escaping into the kitchen. With a conventional open flame gas range, at best 32% of the energy is applied to the cookware.[1]

1 "Residential Cooktop Performance and Energy Comparison Study" Frontier Energy Report #501318071-R0, July 2019. https://www.sanjoseca.gov/DocumentCenter/View/86779

HOW IT WORKS

On conventional cooktops, heat is generated by an electric element or gas burner, then transferred by thermal conduction to the cookware, which heats the food. An induction cooktop eliminates the middle step of heating a burner. Instead, it heats the cookware directly through magnetic induction.

With induction cooking, a copper coil under the stovetop generates a high frequency oscillating magnetic field. This field produces electrical currents called eddy currents in magnetic cookware; ideal cookware is cast iron due to the magnetic nature of iron. The eddy currents encounter resistance in the cookware, causing it to heat directly, while the cooktop stays relatively cool. The base of the cookware (in closest proximity to the induction electromagnetic field) heats the most, but some inductive heating also occurs up the side of the cookware, diminishing with distance from the surface. Because the glass ceramic surface is a poor conductor of heat, the magnetic energy transfers directly to the cookware but does not heat the cooktop. In addition to serving as a heat insulator, the glass ceramic surface provides electrical and mechanical protection.

Induction cooktop options include small, portable, 120-volt induction units with only one or two elements; full-size, 240-volt, four- to six-element standalone cooktops; and full-size, 240-volt, four- to six-element ranges paired with a convection oven.

APPLICATIONS

Induction cooktops can be used in any home cooking application including:

- Single-family and multi-family residential kitchens
- Catering services, where electricity is available and where small, residential-scale induction units are a safer option than a propane tank
- Parties or places where food is held hot in pans that are heated by small fuel cans
- Kitchens where safety is even more paramount due to concern over open flames or gas being left on inadvertently

BENEFITS

No emissions on site. With electric induction cooktops, no byproducts of combustion are released to the kitchen.

Energy cost savings. Since the efficiency of induction cooktops is roughly double that of conventional open-flame gas ranges, the cost savings can add up since less fuel is used.

Cooler kitchen. Heat applied more efficiently to the cookware means less heat is released, making the kitchen more comfortable for the occupants. Because some heat still escapes through air convection, having adequate air flow is necessary to extend the life of the electronics in the induction equipment.

Faster cooking. Food cooks faster when energy is delivered more efficiently for comparable heat inputs. For example, induction cooktops may boil water faster than gas or traditional electric resistance coil cooktops. High-end induction cooktops can detect the base area of the cookware and optimize the electromagnetic field applied to heat the base.

Better heat control. Induction cooktops equipped with temperature settings—versus those that have only low, medium, or high power settings—provide more uniform temperatures than even a gas flame.

Safety. With induction cooktops there is no open flame and no risk of fire or escaped unburned gas. Once the induction coil is de-energized, heat dissipates quickly, so the surface is not hot to touch. Heating stops once the metal cookware is removed from the induction coil.

Easy cleaning. The smooth glass ceramic cooking surface is easy to clean.

LIMITATIONS

Magnetic cookware required for optimum efficiency. Induction cooking works much less efficiently with non-magnetic cookware, such as aluminum or copper, due to their lower resistive effect. Some induction cooktop manufacturers compensate for non-magnetic cookware by using a ferromagnetic plate design or complex power electronics. Conduction from the plate is a less ideal mechanism for infrequently used non-magnetic cookware.

Metal cutlery, jewelry impacts. Because metal jewelry or cutlery can conduct heat, it is safest not to leave them on the induction cooktop at any time, in the event the unit is inadvertently turned on. Most induction systems can detect small metal objects in proximity to the cooktop and will not heat them. Furthermore, distance from the induction coil matters, since the electromagnetic field diminishes with the square of the distance, so it is safe to wear jewelry, use metal cutlery, or even use a pacemaker while cooking because there is sufficient distance from the coil. Manufacturer specifications and the owner's manual typically provide additional details.

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Commercial Technologies

Technology Cut Sheets

Commercial Rooftop Unit Heat Pumps

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

COMMERCIAL SINGLE-SPEED ROOFTOP UNIT HEAT PUMPS

Commercial single-speed rooftop unit (RTU) heat pumps deliver air-conditioning (AC) and space heating comfort comparable to that provided by fossil-fuel forced-air systems at higher efficiency.

HOW IT WORKS

An RTU heat pump typically has the indoor and outdoor components of a heat pump packaged together in a single unit and is located outdoors on the roof of a building. It draws air from the interior space, conditions it, and returns it to the interior. Most commercial single-speed RTU heat pumps combine the heat pump with electric resistance or fossil-fuel backup heat. Because the term RTU can refer to heating, ventilation, and AC equipment that has either a heat pump or cooling and gas heating components packaged together, it is helpful to distinguish the heat pump versions by calling them RTU heat pumps.

APPLICATIONS

RTUs (either heat pump or non-heat pump based) are used in roughly 50% of commercial floorspaces. Best-fit applications for RTU heat pumps are determined by building size and configuration, and include:

- Retail (strip mall and standalone retail), restaurants, and office space
- Buildings with flat roofs without obstructions
- Situations in which indoor space is at a premium

DID YOU KNOW?

Federal minimum efficiency standards for commercial RTUs are based on unit capacity. Small commercial RTUs have capacities between 65,000 Btu/hr. (roughly 5 tons) and 135,000 Btu/hr. Large commercial RTUs have capacities between 135,000 Btu/hr. and 240,000 Btu/hr. Very large commercial RTUs have capacities between 240,000 Btu/hr. and 760,000 Btu/hr. Their minimum cooling efficiency standards range from 12.0 IEER (integrated energy efficiency ratio) for small capacity units to 10.4 IEER for large units, and their minimum heating efficiency standards range from 3.3 COP (coefficient of performance) to 3.2 COP, respectively.

BENEFITS

Increased efficiency. An RTU heat pump is far more efficient than a traditional fossil-fuel based forced-air system since the heat pump can deliver more heat relative to the amount of electricity it consumes, whereas a fossil-fuel furnace or boiler is limited to less than 100% efficiency. As a result, an RTU heat pump delivers energy savings in the heating mode.

Space savings. An RTU heat pump can be conveniently installed on the roof of a building and therefore not take up any floor space. Since this roof space does not compete with other uses, RTUs allow for maximum use of a building's interior space.

Heating and cooling flexibility. With RTU heat pumps, the same equipment can be used to meet both space heating and cooling needs using electricity as the fuel source. No additional installation work is needed to accomplish heating needs. Additionally, they offer a fossil fuel-free alternative when paired with electric resistance backup heat.

Emissions impacts. Although emissions associated with this technology depend on the electric utility's generation emissions, an electric heat pump can reduce the CO_2, NO_x and SO_x footprint of a customer and its community, especially when compared to a fossil-fuel furnace. The emissions impacts will become more favorable over time as the emissions intensity of generation sources decreases.

LIMITATIONS

Higher first cost. RTU heat pumps may cost more than non-electric heating equipment. However, they cost only slightly more than packaged RTUs that include a fossil-fuel furnace. The customer must also consider the relative operating costs of electricity and alternate fuel when deciding which system to purchase.

Customer and installer awareness. Customers and installers may be unfamiliar with RTU heat pumps, since the heat pump version of RTUs is still quite new. Typically, RTUs that provide heating capability do so through a furnace. Not knowing its benefits, customers may have reservations about switching from a traditional technology, and installers may not know how to propose it as a viable option.

Installation in tall buildings. RTUs (heat pump or non-heat pump versions) are generally not recommended for buildings higher than 10 stories because it becomes difficult to push air through the ducts and reach every conditioned zone.

Roof access for maintenance. In order to maintain RTU heat pumps over time, easy access to the building roof is necessary. If roof access is difficult, maintenance may be neglected and the lifetime of the RTU heat pump may be shortened.

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Technology Cut Sheets

Commercial and Industrial Heat Recovery Chillers

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COMMERCIAL AND INDUSTRIAL HEAT RECOVERY CHILLERS

A 105-ton heat recovery chiller for a pharmaceutical storage facility in Malaysia. Photo courtesy of ACMV Pte. Ltd., Singapore

A heat recovery chiller is a heat pump that is employed to recover building heat that would otherwise be rejected. It can simultaneously provide heating and cooling with excellent efficiency and economy of scale in large commercial and industrial facilities with central heating, ventilation, and air conditioning (HVAC) systems.

HOW IT WORKS

A standard chiller produces cold water and dissipates heat absorbed by the refrigerant into the atmosphere through the primary condenser. A heat recovery chiller has a second condenser or condenser circuit added on to a conventional chiller where the energy contained in the refrigerant is transferred to an incoming hot water loop. This hot water, which is typically around 105°F, can be used to heat the building's space or to preheat the return water from the building's water heating loop. The lower temperature lift that the boiler must create as a result of preheating the water means that it has to do less work and consequently the overall heating efficiency improves.

The presence of simultaneous heating and cooling loads year-round is a requirement for using the heat recovery feature in a chiller.

APPLICATIONS

Heat recovery chillers can be used for hot water production, space heating, process heating, boiler water preheating, and dehumidification in industrial and commercial buildings. Specific applications are listed below.

- Hospitals: laundry, boiler preheating
- Universities: dormitories, boiler preheating
- Manufacturing: process water heating, boiler preheating
  - Food processing
  - Chemical
  - Primary metals
  - Automotive
  - Wineries
- Large hotels, resorts and casinos: laundry, showers, swimming pools
- Office buildings: perimeter reheating, domestic hot water preheating
- Schools: cooking/dishwashing, hot water preheating
- Military bases: barracks, boiler preheating, domestic hot water preheating, laundry

DID YOU KNOW?

When multiple chillers are arranged in series to accomplish heating or cooling needs, it is a good engineering practice for the heat recovery chiller to be base-loaded, that is, be the first chiller in line to be used for producing chilled water. The more loaded the chiller is, the greater its energy efficiency.

BENEFITS

Energy efficiency. The process of recovering otherwise wasted heat energy from the chilled water loop results in improved overall thermal efficiency. Heating with electrical motor-driven refrigerant compression instead of a fossil fuel boiler makes the process even more energy efficient.

Humidity control. In institutional settings the recovered heat can be used to control humidity in sensitive areas like laboratories and operating rooms.

Peak demand savings. In cooler climates, heat rejected by the chiller cooling towers or air-cooled chillers can be recovered by the chiller and used for space heating in lieu of electric strip backup. This can help to eliminate peak demand for the utilities.

Efficient hot water preheating. In multiunit facilities like hotels, barracks and educational facilities, hot water preheating can reduce natural gas water heating for pools, hot tubs, showers, laundry, food services cleaning, dishwashing, and cooking.

Recovery of process heat. Manufacturing facilities can upgrade low-quality waste process heat and reinject it into various process applications thereby reducing fossil fuel demand through a heat recovery chiller that simultaneously serves a portion of the chilled water demand.

LIMITATIONS

High capital cost. Initial investment is a barrier for heat recovery chillers, however, the high capital cost can be largely offset by low operating costs. Typical payback can range from one to three years depending on fuel prices and usage.

Limited use of heat recovery feature in warm climates. In warm climates, where cooling needs predominate, the heat recovery feature doesn't yield significant benefits because the need for simultaneous cooling and heating is limited or doesn't exist.

More cooling energy requirement. Studies have shown that a heat recovery chiller consumes a greater amount of cooling energy than a standard chiller because it operates at a higher condensing pressure and temperature. As a rule, heat energy should be recovered at the lowest possible temperature that can practically meet the heating needs.

Changes to the heating system. The temperature of hot water obtained from the heat recovery chiller is generally around 105°F to 110°F. Manufacturing facilities that use water hotter than 105°F to 110°F for their current processes may need to modify the heating system design using customized solutions to obtain water with the right amount of heat.

Lack of awareness about the latest technology. Customers' limited understanding of energy recovery and its advantages prevent them from adopting the technology. Sometimes they have a general preconceived idea of a chiller but fail to note heat recovery possibilities.

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Technology Cut Sheets

Commercial Electric Fryer

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COMMERCIAL ELECTRIC FRYER

Large fryers are commonly found in commercial kitchens where food is fried. Natural gas fryers lead this market segment. Electric fryers are not new technologies; however, they can improve the cooking process, product throughput and quality, and workplace environment.

HOW IT WORKS

The three most common types of commercial fryers are open pot, flat bottom, and pressure fryers. Open pot is the most common; the user submerges a basket of food into a vat of hot oil. Typically, fryers are turned on when the kitchen opens and turned off when it closes. Although they may sit idle for hours, fryers are left on so the oil stays hot and ready to use when needed. Under these circumstances, electric fryers—with their heating elements submerged in oil—are safer and more energy efficient when compared to gas fryers, especially those that use open flame to heat the oil.

APPLICATIONS

Commercial electric fryers can be used anywhere food is cooked for commercial purposes:

- Restaurants
- Hotels
- Cafeteria
- Retail
- Stadium

DID YOU KNOW?

One size and type of fryer does not meet all cooking needs. Different foods, such as donuts, fish, funnel cakes, and french fries, may require different fryers.

BENEFITS

Faster pre-heating and recovery time. Electric fryers are more efficient and can provide faster throughput than their gas counterparts because of their design, with heating elements submerged in the oil.

Secondary energy savings. In addition to using energy more efficiently, commercial electric fryers can reduce the need for more air-conditioning in the kitchen because they don't have a combustion flue exhaust. Less energy used means money saved.

Oil savings. The oil degrades faster in a gas fryer than in an electric fryer. As a result, the electric fryer delivers oil savings for the same quantity of food.

More comfortable workplace. Gas fryers cook with open flames, adding waste heat to an already hot and confined space. Electric fryers remove gas combustion from the kitchen.

Reduced emissions. Electric fryers reduce the release of volatile organic compounds and carbon monoxide into the working environment, resulting in lower ventilation costs.

Lower maintenance. An electric fryer needs less maintenance while gas fryer burners may require more frequent attention due to issues such as burner clogging, which lead to higher maintenance expense.

Ease of cleaning. Electric elements on a fryer swing upwards making them easier to clean, while gas fryer require the cleaner to go around the tubes and heat exchangers.

LIMITATIONS

Lack of adequate electrical service. The biggest barrier to electric commercial fryers is a lack of adequate electricity in the kitchen to power the equipment. The cost of providing adequate power depends on outlet and wiring configuration, breaker box configuration, and proximity of power to the kitchen.

Higher capital cost. Commercial electric fryers may cost more upfront than gas fryers, but their throughput and workplace comfort benefits provide value for purchasing decision-makers.

Customer perception. Some customers prefer to cook with gas—or think they do. They may not have experience with electricity, so they shop for gas because it's what they know. They may also have brand loyalty, or be limited by corporate policy that dictates the type of equipment purchased for the kitchen.

More time to procure. Due to lower demand for electric fryers, dealers may not stock the equipment, therefore it may take longer to buy it, creating a cycle that further hinders adoption.

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Technology Cut Sheets

Commercial Induction Cooktops

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COMMERCIAL INDUCTION COOKTOPS

Image courtesy of Vollrath.

Induction cooktops offer a highly efficient alternative to electric resistance and natural gas cooktops in commercial kitchens.

HOW IT WORKS

On conventional cooktops, heat is generated by an electric element or gas burner, then transferred by thermal conduction to the cookware, which then heats the food. An induction cooktop eliminates the middle step of heating a burner. Instead, it heats the cookware directly through magnetic induction.

With induction cooking, a copper coil under the stovetop generates a high-frequency oscillating magnetic field. This field produces electrical currents called eddy currents in special magnetic cookware. The eddy currents encounter resistance in the cookware, causing it to heat directly, while the cooktop stays relatively cool. A glass ceramic cooktop surface protects the copper coil. Because the glass ceramic surface is a poor conductor of heat, it allows magnetic energy to transfer to the cookware without heating the surface.

An induction cooktop provides precise temperature control. The unit heats only the pots and pans containing food—not the area around them – so there is no heat loss or excessive energy use.

DID YOU KNOW?

Induction cooking technology maintains high efficiency regardless of cookware size, while conventional electric cooktop efficiency drops dramatically with smaller cookware.

APPLICATIONS

Induction cooktops can be used in any cooking application, but are most commonly found in commercial settings, including:

- Restaurants
- Commercial food preparation operations
- Hospitals
- Schools
- Nursing or residential care facilities

BENEFITS

Faster heating and cooking. Induction cooktops heat food much faster—several manufacturers claim 50% faster—than traditional cooktops, thereby speeding up the cooking process.

Precise temperature control. Induction cooktops respond more quickly when the temperature is either raised or reduced. They excel at simmering.

Highly efficient. Today's induction cooktops contain sensors to determine pot size. They transfer to the pot only the amount of energy needed, so there is no wasted energy. U.S. Department of Energy research indicates an induction cooktop has an average efficiency of 72.2%, somewhat higher than other electric cooktops. Because the efficiency of other technology depends so strongly on cookware size, the energy savings potential of induction cooktops is dependent on the prevalence of cooking with vessels smaller than the electric element diameter.

Easier to clean. With their clear glass top, induction cooktops are easier to clean than gas burners or electric heating elements. They do not heat the surface, so spills and splatters do not "cook" on the surface.

Safer to use. An induction cooktop surface does not get hot. Immediately after cooking, the surface may be warm to touch due to heat transfer from the pot, but it cools down quickly.

Cooler kitchen. There is no open flame or heating element, so the kitchen remains more comfortable for food preparation workers.

LIMITATIONS

Requires special pots and pans. Special magnetic pots and pans which can transfer the electromagnetic energy are required for induction cooking. However, nonmagnetic vessels can be used if placed on a ferromagnetic disk, which then acts as a conventional hotplate.

Cost. Induction cooktops are considered expensive cooking technology. Equipment costs vary, depending on size and features, from a few hundred dollars to several thousand dollars, depending on the size of the equipment.

Education and training is needed. Because induction cooking heats food so quickly, cooks and kitchen workers need training on both the use of the equipment and how to cook on an induction cooktop.

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Technology Cut Sheets

Infrared Comfort Heaters

EPRI

INFRARED COMFORT HEATERS

Infrared comfort heaters are compact heating devices that are capable of radiating heat to a space without ventilation or forced-air flow. These highly flexible heaters are suitable for a wide range of indoor and outdoor applications.

HOW IT WORKS

Every infrared comfort heater contains a heat source such as a quartz lamp, quartz tube, or metal rod that emits infrared radiation when electricity is supplied to it. Reflectors focus the infrared rays directly toward the objects and occupants in the space. Additionally, nearby surfaces such as floors and walls reradiate the heat for increased occupant comfort. These heaters are generally controlled by a simple on-off switch, but some devices allow the heat intensity to be adjusted using an input controller.

DID YOU KNOW?

Un-flued fossil fuel furnaces release water vapor, which can cause dampness and mold inside a building. In contrast, infrared heaters eliminate localized mold and dampness, and this is a major benefit for them.

APPLICATIONS

For outdoor use, infrared heaters work well for high, open spaces that have constant air exchange due to open doors. For indoor use they are available in several designs to function efficiently in different spaces. Typical applications are:

Outdoors

- Open truck loading bays
- Garages
- Outdoor seating at restaurants
- Tennis courts
- Construction sites

Indoors

- Warehouses
- Lobbies
- Churches
- Hospital recovery rooms
- Baggage rooms

BENEFITS

Efficient heating. Infrared heaters convert 100% of electricity to heat (primarily radiant but the remainder convection near the heater). They directly heat the objects and the occupants in the space; no energy is lost to heated air that may be inaccessible to occupants. Also, a building owner can heat selected portions of the space rather than heating the entire building. Lower energy use means lower energy bills for the customer.

Instant heating. Infrared heaters, primarily those with quartz lamps, turn on and radiate heat instantly. Restaurants, for instance, can start them several minutes before opening. In contrast, a forced-air system requires time for heat to build up in a space since hot air must travel long distances to reach the vents.

Portability. Most infrared heaters are portable to some extent, i.e., they can be moved from room to room. Certain infrared heater models are designed with portability as the prime distinguishing factor.

Low maintenance. Infrared heaters are like electric resistance heaters in that they have no moving parts such as motors or compressors. The primary required maintenance is periodic cleaning of the reflectors.

Flexible installation. Infrared heaters are available in a variety of sizes and shapes. They allow for creative installation on the ceiling, walls, or floor depending on the aesthetics of the heated space.

LIMITATIONS

Safety issues. High-intensity infrared lamps installed close to the floor can pose a hazard to the eyes. The glare of shortwave infrared rays can be irritating if one looks directly at the lamp. This challenge can be mitigated by installing the equipment sufficiently higher, on the walls or the ceiling.

Health issues. The direct heat rays that fall on human skin can cause a burning sensation, which can in turn reduce blood pressure and cause fainting. Because heat output decreases with distance, placement higher on walls or the ceiling can mitigate this challenge. Furthermore, occupants should not sit or stand too close to these lamps.

Quick loss of heat. A room loses heat the moment an infrared heater is turned off. The heater needs to stay on continuously to keep personnel comfortable.

Not meant for large areas. Infrared heaters are intended to be used as spot heaters, such as for a small portion of a space. To heat a large area would require a series of infrared comfort heaters strategically positioned, which may not be as cost-efficient as a traditional HVAC system.

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Industrial Technologies

Technology Cut Sheets

Electrode Boilers

EPRI

ELECTRODE BOILERS

1 Nozzle Header Assembly
2 Counter Electrode

Photos courtesy of Precision Boilers, USA.

Electrode boilers produce hot water or steam for a variety of industrial and commercial processes. Because they have relatively large capacities ranging from 2 MW to 65 MW, they are an attractive option for providing high heat output.

HOW IT WORKS

An electrode boiler is a pressure vessel inside which electrodes are suspended. The electrodes are connected to a medium voltage (4–25 kV) AC source. Electricity from the electrodes flows through multiple streams of water, vaporizing some of the water into steam. The steam accumulates in the upper part of the pressure vessel and is released through the main steam valve.

The production of steam can be controlled with a variable frequency drive (VFD) water pump using the conductivity of the water. The output of the boiler is proportional to the number of streams of water flowing to the electrodes.

DID YOU KNOW?

The capacity of electrode steam boilers manufactured in the United States ranges from 2,000 kW to 65,000 kW, with a steam output of 6,900 to 225,000 pounds per hour. **Note:** 1 kW = 3.45 lb/hr = 0.1 boiler hp = 3,350 Btu/hr.

APPLICATIONS

The primary applications for electrode boilers are as follows:

- Manufacturing chemicals, oils, dyes, paints, cosmetics, glues, resins, and paraffin
- Cleaning surfaces prior to painting, and phosphatizing with steam to prevent corrosion
- Producing steam for reaction and distillation vessels, and for pipe tracing to protect pipes and vessels against freezing
- Steel mill steam vacuum systems
- Heating rolls for paper coating, calendaring, laminating, corrugating, and embossing
- Auxiliary boilers for power plants for heating, startup, and off-peak steam production
- District heating for campuses or cities
- Primary or backup steam for hospitals and other critical services

BENEFITS

Efficient heating. Electrode boilers are nearly 100% thermally efficient, whereas fossil-fuel boilers are approximately 75%–85% efficient. Higher energy efficiency implies lower operating cost. Additionally, electrode boilers operate at near 100% efficiency over their full output range, while fossil-fuel boilers have a maximum efficiency over a very narrow range of loading.

Easy modulation of load. Electrode steam boilers easily modulate steam loads because steam production can be controlled by a VFD water pump.

Energy and time savings in standby mode. Electrode boilers consume up to ten times less energy than fossil-fuel boilers while on standby, i.e., during periods when hot water or steam is not required in the facility. Furthermore, they can be switched from hot standby to full production within a few minutes, thereby eliminating a long heat-up cycle.

No onsite emissions. No complex pollution or combustion-control equipment is needed with electrode boilers. Therefore, they are cleaner and easier to use and maintain than fossil-fuel boilers. Electrode boilers are particularly attractive where emissions need to be moved offsite.

Simple installation and maintenance, space saving. Inside an electrode boiler there are no combustion chambers, burners, exhaust systems, or heat-transfer surfaces. Nor are there moving parts to wear or bind. There is no economizer to capture wasted heat. Electrode boilers require no makeup air fans or exhaust vents for flues. In addition, they typically comprise about 25% of the footprint of a fossil-fuel boiler.

LIMITATIONS

Relatively large voltage range. Electrode steam boilers operate at a voltage range of 4–25 kV. Unless the utility directly supplies this amount of voltage to a facility, a dedicated transformer may be needed on site.

High first cost. The capital cost of an electrode boiler can be 30%–60% higher than a firetube fossil-fuel boiler. However, the overall installation can be more economical because electrode boilers require neither exhaust stacks, emission controls, nor the switches, valves, regulators, or other gas train components typically needed for natural gas burners.

Water quality considerations. To ensure maximum lifetime for an electrode boiler, the water quality should be well maintained. Softened water can prevent scale deposits on the electrodes. Similarly, the boiler water conductivity should be maintained at the level specified by the manufacturer to prevent electrode damage due to arc-overs.

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Technology Cut Sheets

Infrared Curing and Drying

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

INFRARED CURING AND DRYING

Many industrial processes require controlled heat for drying products and curing coatings. This drying or curing process is accomplished in large industrial ovens that traditionally have used convection heat fueled by natural gas. Electric infrared radiation (IR) ovens offer an efficient and cost-effective alternative to convection ovens.

DID YOU KNOW?

Infrared technology has attractive payback and increased productivity for a wide range of applications, owing to its reduced final energy consumption when compared to conventional heating as well as its non-energy benefits such as low floor space requirement and low maintenance to name a few.

HOW IT WORKS

Whereas convection ovens first heat the air in order to transmit heat to a product through forced convection, IR transmits heat through electromagnetic waves. Electric IR emitters can provide fine control of IR wavelength in order to match specific requirements of an application. For example, IR frequency can be tuned to heat only the substrate while passing unabsorbed through a coating.

An IR oven can be used as a standalone technology. It also can be used to supplement heating in a natural gas convection oven. This is called a hybrid IR application or a boost oven.

APPLICATIONS

IR can be used in a wide range of processes to dry or cure products, including but not limited to:

- Paint on car bodies and home appliances
- Paint and powder coatings on light fixtures
- Paints and varnishes on hardboard, particleboard, and chipboard
- Coatings on steel and aluminum coils and sheets
- Epoxy powder coatings on oil filters and irrigation pipes
- Polyvinyl chloride waterproofing on automobile rocker panels
- Pre-drying of ink and powder coating on paper
- Dyes and coatings on textiles, apparel, and fabric
- Glass and glass products manufacturing
- Machinery and computer products manufacturing

BENEFITS

Faster curing and drying. IR systems achieve full output in seconds and provide higher heat transfer rates and faster response times ranging from less than a second to five minutes, depending on wavelength. This compares to 20-40 minutes for conventional methods.

Energy efficient. With IR, there is no waiting for the oven to warm up and no need to keep it running, so less energy is consumed. IR is 90% more efficient in some applications. IR's energy usage profile can result in lower load factor for some facilities.

Improved productivity. Faster production results in curing and drying more products in less time. Some ovens can be zoned, providing maximum flexibility and better process control.

Less floorspace. IR ovens are compact and save space, with an up to 92% smaller footprint than convection ovens.

Low maintenance. Little is required beyond periodic cleaning of the reflectors and replacement of emitters.

Cleaner production. Reduced airflow during process minimizes dust and dirt contamination.

Cleaner environment. Electric IR produces zero on-site emissions due to the absence of fuel combustion; however localized emissions from process chemicals, such as paint or coatings, may still occur.

Enhanced worker safety. Reduced ambient air heating through the elimination of open flames, reduced on-site emissions and dust contribute to a safer work environment.

Higher-quality products. IR improves product appearance by ensuring more even coloring and coating. High-gloss coatings may appear even glossier. Well-controlled heating ensures that the product is not overheated. Pigment cross-contamination can be reduced due to the need for lesser airflow.

LIMITATIONS

Line-of-sight technology. Curing and drying is only effective where the IR radiation can reach the surface. For products with complex hidden surfaces, solutions to work around line-of-sight issues include use of a hybrid system with a convection oven and allowing adequate soak-time.

Product guarantee barriers. In the past, some manufacturers were not willing to change their coating process unless the change was approved by their coating vendor, and some vendors warranted their product only if it cured for an established period of time and temperature through a recipe that essentially requires curing with natural gas convection. More recently, many paint manufacturers are formulating paint for IR curing.

Cost. Capital cost may be higher for IR ovens than for convection ovens, and installation costs vary depending on infrastructure needs, material handling requirements, and safety equipment. A general rule of thumb is that electric IR emitters cost $100–$200 per kilowatt, depending on equipment rating.

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Technology Cut Sheets

Ultraviolet Disinfection of Wastewater

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ULTRAVIOLET DISINFECTION OF WASTEWATER

Ultraviolet (UV) disinfection of wastewater is both effective and increasingly cost effective. Concerns about chlorine compounds in wastewater discharge have led to more stringent regulations, spurring the increased use of UV technology in wastewater treatment operations. In addition, UV radiation can kill cryptosporidium, while chlorination cannot.

DID YOU KNOW?

UV lamps that use light-emitting diodes (LEDs) are evolving to compete with conventional mercury arc lamps, however they are not fully commercialized for use in largescale wastewater treatment applications. Although currently less efficient individually, UV-LED lamps can outperform mercury lamps on a systems level, chiefly because their output frequencies can be tuned to more effectively destroy specific pathogens. Other benefits of UV-LED lamps include their small footprint, instant-on and unlimited cycling capabilities, and low temperature.

HOW IT WORKS

A UV disinfection system transfers electromagnetic energy from UV lamps to a microorganism's genetic material. The UV radiation penetrates the organism's cell walls, disrupting its DNA and RNA, and destroying its ability to reproduce.

The effectiveness of a UV disinfection system is proportional to the amount of UV radiation delivered to the organisms. This amount depends on turbidity and other characteristics of the water being treated, the intensity of the UV radiation, and the duration of exposure. All of these factors are controlled by system design and operation. Chief design considerations are the power and efficiency of the UV lamps and the configuration of the reactor—the container in which water is exposed to UV radiation.

APPLICATIONS

UV radiation is used in a variety of water disinfecting applications, including drinking water, wastewater, process water, and surface disinfection. While only a fraction of drinking water treatment plants currently use UV disinfection exclusively, roughly one-third of U.S. and Canadian wastewater treatment plants use UV disinfection. The market for both applications is growing. Other applications include:

- Fruit and vegetable preserving and specialty food manufacturing
- Dairy product manufacturing
- Beverage manufacturing
- Medical device disinfection
- Ballast water disinfection
- Air treatment to control disease such as swine flu and Ebola

BENEFITS

Effective disinfectant. UV water treatment is effective at destroying most viruses, spores, and cysts, including cryptosporidium.

No toxic chemicals. UV water treatment is a photochemical process not a chemical process, so there is no need to generate, handle, transport, or store toxic materials. It produces no residual chemicals such as chlorine compounds that can harm human or aquatic life downstream.

Responsive to wastewater regulations. UV treatment does not produce chlorine compounds in wastewater discharge. For this reason, wastewater treatment operations are adopting UV treatment as an alternative to chlorine-based systems in response to more stringent wastewater regulations.

Responsive to community concerns. UV treatment's effectiveness as both a disinfectant and a way to reduce the downstream impact of wastewater discharge makes it an acceptable solution to community concerns about water quality, environment, and public health.

Fast acting. UV treatment requires shorter contact time (20 to 30 seconds) when compared with other technologies.

More compact. UV disinfection equipment requires less space than other technologies.

No onsite emissions. Although UV disinfection equipment produces no onsite emissions, its electricity source emissions depend on the electricity provider.

LIMITATIONS

Higher cost. When compared to chlorination, the initial capital, operating, and maintenance costs of UV wastewater treatment systems are higher; however, other factors, such as regulatory requirements, might offset this cost.

Capital intensive. When compared to chlorination, UV systems require significant maintenance, are more sensitive to the clarity of wastewater, and require careful control to ensure effectiveness.

Effectiveness depends on exposing microbes to UV radiation. Because UV treatment involves line-of-sight technology, water flow should be optimized so that the water "sees" the light. UV disinfection can be less effective in turbid water, or in water with a high amount of total suspended solids. For this reason, UV disinfection is usually the last step in the wastewater purification process, after turbidity has been minimized.

Potential for organism reactivation. If certain conditions exist, organisms can sometimes repair themselves, reversing the destructive effects of UV.

Careful control needed. Limitations of UV disinfection sometimes can be overcome by careful control of wastewater flow rates or combining UV with other technologies. For example, applying ultrasonic energy can aid in the distribution of surfactants, which can enhance the performance of UV disinfection.

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Non-Road Transportation

Technology Cut Sheets

Electric Forklifts

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ELECTRIC FORKLIFTS

Electric forklifts, or lift trucks, have been material-handling workhorses for years. Recent technology advances have boosted electric forklift performance and utility, enabling them to compete with internal combustion (IC) counterparts indoors and out, while delivering energy and emissions benefits and substantial cost savings over their lifetime.

DID YOU KNOW?

Class 1 electric forklifts compete directly with Class 4 IC units; the market has adopted and sees equivalency between the two power options. Increasingly, Class 1 electric forklifts are also competing with Class 5 IC trucks in outdoor applications that were once considered too heavy-duty for electrics. Today, industry experts believe Class 1 electric forklifts could replace 50% to 80% of existing Class 5 units. However, market adoption and equivalency in this sector is slower.

HOW IT WORKS

Electric forklifts operate just like conventional IC lift trucks but are powered by industrial batteries instead of propane, diesel, natural gas, or gasoline fuel and use power electronics-based motor controllers to control travel and hoist functions.

Forklifts are classified by vehicle design and power source, and by their use. Class 1, 2, and 3 trucks are electric. Class 1 forklifts are counterbalanced rider trucks with typical lift capacity of 3,000 to 20,000 lbs. Some models can lift up to 40,000 lbs. A Class 2 narrow-aisle forklift typically has 3,000 to 5,500 lbs. lift capacity, with high reach capacity. Class 3 forklifts are electric hand/rider or pallet trucks. Class 4 and 5 trucks are IC.

Outdoor forklifts, regardless of fuel, use pneumatic tires to improve handling on rough surfaces. They also have enclosed motors and electronic systems to ensure safe operation in wet, dusty, windy conditions. They sometimes have an enclosed cab for driver comfort.

APPLICATIONS

Electric forklifts are used indoors and outdoors in both large round-the-clock operations and small businesses, including the following sectors:

- Warehousing and storage
- Manufacturing
- Large retail
- Goods movement, shipping, and storage
- Construction
- Agriculture
- Commercial manufacturing, preparation, and storage of food
- Mining
- Health, technology, and research operations
- Waste management

BENEFITS

Lower total cost of ownership. Despite their higher upfront capital costs, when compared to IC units, electric forklifts are easier and less costly to maintain because they have fewer moving parts. Payback period is usually less than two years, depending on local energy prices and equipment usage. As a rule of thumb, an electric unit will be the more economic option when usage is greater than 1,000 hours a year.

Highly efficient. New 80VAC technology optimizes energy efficiency and performance, doubling the runtime between battery charges. New high-frequency chargers are roughly 90% efficient.

Multiple ways to charge. Today's charger technologies can charge multiple batteries at once, in the forklift. With opportunity charging and fast charging—newer regimes often chosen by multi-shift operations—users plug-in during breaks throughout the day. Opportunity charging requires lower electrical current than fast charging and generates less internal heat.

Zero emissions. Electric forklifts with their zero local emissions ensure cleaner, more healthful air, indoors and out. Operations may not need to ventilate a facility as much when using electric forklifts. This is good for the environment and may reduce ventilation costs.

Quiet, vibration-free operation. Electric forklifts are quiet; they do not contribute to workplace noise, and drivers and other workers around them do not have to shout to be heard. IC equipment vibrates, which contributes to worker fatigue; electric forklifts do not.

Safer, more comfortable workplace. Because of their zero emissions and quieter operation, electric forklifts contribute to a cleaner, safer, and more comfortable workplace.

LIMITATIONS

Higher capital cost. Although an electric forklift costs about the same as an IC forklift, the batteries and charging equipment add to the upfront cost. Lower operating costs can quickly make up the difference. In addition, many utilities and government agencies offer incentives for electric equipment. Education about total cost of ownership benefits is a must.

Charging infrastructure needed. Business operations should consider their daily needs before converting from IC to electric forklifts. Newer vehicle and charging technologies have eliminated the need for battery swapping and charging rooms; however, older electric forklift technologies still require separate rooms, equipment, and manpower to swap batteries and monitor charging regimes. In addition, batteries require weekly maintenance.

Can meet most, but not all lifting needs. While electric forklifts today are available with lift capacity of up to 40,000 pounds, some demanding tasks may require even higher lift capacity offered by IC equipment.

User misperceptions, and lack of product exposure. Many users still wrongly believe electric forklifts are underpowered, that batteries cannot last a full shift, and that electric lift trucks are unsafe in wet weather outdoors. Many users have no experience with outdoor electric forklifts, do not hear about the benefits from dealers, and never receive economic payback information. More dealer and user education is needed. Misperceptions change quickly after experience with high-powered, high-performance, AC electric forklifts.

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Technology Cut Sheets

Electric Transport Refrigeration Units

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ELECTRIC TRANSPORT REFRIGERATION UNITS

Photo courtesy of Carrier Transicold

Electric transport refrigeration units (eTRUs) are gaining market momentum in the goods movement industry as a cost-effective alternative to diesel-powered transport refrigeration units (TRUs). Customer demand for more efficient, lower-maintenance solutions together with engine idling laws that restrict diesel-mode operation at loading docks, staging areas, or rest stops, are driving eTRU adoption.

DID YOU KNOW?

In addition to fuel cost savings, eTRUs can deliver ongoing maintenance cost savings because an electric motor requires less maintenance than a diesel engine. A side benefit of electric standby operation is life extension of the refrigerated trailer or "reefer." The eTRU's electric motor runtime replaces diesel engine operating hours each year. With less wear-and-tear on the diesel engine a reefer can operate for a longer period before being taken out of service for engine repairs or complete replacement. In one food distribution example, the life of a reefer was extended from five years to as many as seven years.

HOW IT WORKS

Mobile refrigeration systems or TRUs provide temperature control for perishable goods during transport via truck, trailer, shipping container, or rail car. Historically, TRUs have relied on a diesel internal combustion engine (ICE) inside the unit's housing to power the refrigeration compressor.

Commercialized over the last decade, eTRUs have electric components that power the refrigeration compressor. There are two common configurations. Hybrid-electric eTRUs use an engine generator set, which couples an integral diesel ICE with an electric generator to power the compressor. Electric standby eTRUs have a separate electric motor in addition to the diesel ICE; they can operate on either the ICE or electricity, plugged into the grid during loading and staging.

New eTRU technology can be used in both long-haul and short-haul operations. The market potential for eTRUs is particularly favorable in short-haul operations that return to base the same day and comprise approximately 40% of total refrigerated transport. The economics for conversion from solely diesel operation to eTRU are favorable for trucks that typically idle for more than 1,000 hours per year.

APPLICATIONS

Today's eTRUs can replace traditional TRUs in most goods movement applications, including:

- Food manufacturing and distribution (produce, frozen food, meat, dairy, beverages, etc.)
- Food delivery services in small refrigerated trucks
- Pharmaceutical and cosmetics manufacturing and distribution
- Live products transport (plants, flowers, and animals)
- Cold storage
- Delicate furniture or equipment that requires temperature or humidity control during transport

BENEFITS

No emissions on site. At loading docks and staging areas where reefers may be parked for several hours or days, eTRUs plugged into the grid and operating solely on electricity emit zero local emissions. Diesel operation results in pollutant emissions that are more readily controlled where electricity is generated. State and local anti-idling laws further drive adoption of eTRUs.

Fuel cost savings. New eTRUs can deliver fuel cost savings of 40% to 70% compared to diesel operation, depending on fuel prices. This savings figure assumes at least 1,000 hours per year of operation, where idling on diesel is avoided.

Noise reduction. Diesel engines are noisy and may be problematic if they are operating during sleeping hours near residential neighborhoods. The electric motors and components that run refrigeration compressors in eTRUs are quieter.

Last-mile solution. The growing consumer demand for delivery of refrigerated foods ordered online increases the demand for both eTRUs and smaller refrigerated delivery vehicles for areas inaccessible to large trailers. Electric versions of both types of refrigerated transport can take advantage of investment in electric infrastructure to serve these needs.

LIMITATIONS

Higher capital cost. Although eTRUs generally cost more than traditional diesel TRUs, first cost is not as large a barrier as it once was, since hybrid-electric options are more commonplace today.

Infrastructure cost and integrity. The business case must be made for installation of robust electric infrastructure at the idling location to accommodate and facilitate the use of eTRUs with electric standby capability.

Behavior change. Drivers and all on-the-ground logistics personnel need education and reinforcement to ensure that eTRUs are plugged in whenever possible and unplugged when the truck and trailer depart.

Accurate economics and information outreach. Businesses operating TRUs underestimate the time spent idling and therefore the associated fuel and maintenance costs and environmental impacts. Often, they are unaware of alternatives.

On-road plug-in availability. Increased provision of plug-in infrastructure at rest stops and other locations would allow long-haul truck operators with eTRUs to take full advantage of their truck's electric capabilities.

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Technology Cut Sheets

Electric Ground Support and Gate Electrification Equipment for Airports

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ELECTRIC GROUND SUPPORT AND GATE ELECTRIFICATION EQUIPMENT FOR AIRPORTS

Every gate at an airport is typically equipped with mobile ground support equipment (GSE) such as baggage tractors, belt loaders, and pushback tractors, as well as stationary gate equipment such as ground power units (GPUs) and preconditioned air systems (PCAs). This equipment is integral to airport operations. Electrifying it yields immediate benefits such as eliminating on-site emissions and, in some cases, lowering operating costs.

HOW IT WORKS

Mobile Electric GSE. Baggage tractors are used to move carts loaded with passenger baggage or cargo. Electric baggage tractors typically operate at 72VAC to 80VAC with a 500-Ah lead-acid battery and 30-kW AC motor. One tractor can pull 3,500 to 5,000 pounds of load. Belt loaders load baggage and cargo into an aircraft cargo hold. Electric belt loaders are self-propelled and can operate on both AC and DC power. Electric belt loaders can service a range of aircraft sizes, with typical weight capacity of approximately 2,000 pounds. Pushback tractors push the aircraft backwards away from the airport gate. Electric pushbacks can move small- to mid-sized aircraft using either a tow bar or a cradle. Drawbar capacity is up to 28,000 pounds.

Stationary Gate Electrification Equipment. GPUs provide electricity for parked aircraft. An electric GPU replaces either a portable diesel generator or the aircraft's auxiliary power unit and eliminates jet fuel combustion. PCAs blow fresh air (cool or warm) into the aircraft while it is parked at the gate. Their heating and cooling capacity ranges from 30 to 100 tons. Historically, they have been powered by diesel. Like GPUs, electric PCAs can be wired directly into AC power at the gate.

APPLICATIONS

Electric GSE can be used in small, mid-size, and large airports. The number of each GSE type in use at an airport is typically a function of the number of gates at the airport. Small airports typically have one of each type per gate, while large airports may have an extra baggage tractor and belt loader.

DID YOU KNOW?

The short investment payback period required by many commercial and industrial operations can pose a barrier to electrification. In contrast, airports are near-permanent installations that can accept slightly longer payback periods. While the gate electrification equipment and the charging infrastructure are owned by the airport authority, the GSE is owned or leased by individual airlines.

BENEFITS

Fuel savings. The typical duty cycle of GSE is intermittent. However, because GSE may need to be moved quickly, operators often leave it running while they attend to other duties. For internal combustion GSE, the result is wasted fuel and increased emissions. In contrast, electric GSE draws power only when it is moving and can be left in an on state without penalty.

Energy cost savings. Converting to electric GSE from diesel can produce average savings of $8,000 to $10,000 per gate per year, depending on fuel costs, for a gate with two baggage tractors, two belt loaders, and one pushback tractor.

Emission-free with lower noise. Employees at airports like the quiet, emission- and vibration-free operation of electric pushback tractors and baggage tractors.

Payback. Converting GPUs and PCAs from diesel to electric offers almost immediate payback for airports. Converting to electric GSE may involve slightly longer payback periods determined by the available federal or state grants as well as other incentives.

Better control. Electric pushback tractors and baggage tractors are easy to handle. They have good torque, stop quickly, and turn on a dime. A baggage tractor can pull four full carts of bags with ease.

LIMITATIONS

Infrastructure requirements. Conversion to electric GSE requires installation of conventional or fast-charging ports. Additionally, power availability can depend on factors such as the age of the airport terminal buildings.

Familiarity issues. Sometimes it takes time for employees to get used to the new electric GSE, especially the mobile equipment. However, once they accept it, they tend to prefer it over the combustion equipment.

Perceived impact on availability of electricity. Airport officials may be concerned about the impact of electrifying GSE on the quality and reliability of an airport's electric power for other purposes. However, overloading is usually not an issue and is only a perceived limitation.

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Technology Cut Sheets

Electric Terminal Trucks

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ELECTRIC TERMINAL TRUCKS

Photo courtesy of Orange EV.

A terminal truck moves trailers in a cargo yard, warehouse, or intermodal facility much as a switcher locomotive positions railcars. Terminal trucks are known by a variety of names, including yard hostlers, spotters, yard trucks, yard dogs, shunt trucks, and tractors. Electric terminal trucks offer environmental benefits and better operator control than their diesel counterparts.

DID YOU KNOW?

Terminal trucks can be deployed in customer sites without a need for utility incentives in many states because of currently available federal and state incentives. For example, U.S. Environmental Protection Agency Diesel Emission Reduction Act (DERA) grants can be applied towards electric terminal truck replacements.

HOW IT WORKS

Electric terminal trucks, like their diesel counterparts, are heavy-duty trucks that can bear up to 80,000 pounds of gross weight (including the weight of the truck). These trucks come with 80-kWh to 160-kWh batteries which can be opportunity-charged during routine daytime breaks or fully charged overnight using onboard chargers. Typically, 80-kW chargers are used for opportunity charging and 10-kW to 20-kW chargers are used for standard charging. There are no standardized plugs for charging these vehicles. Typically, each vehicle manufacturer has proprietary charging equipment and connectors, much like other non-road industrial vehicles such as forklifts.

Electric terminal trucks can drive at a maximum speed of 25 mph. Due to their low speed, their usage is typically measured in hours of operation supporting the in-yard round-the-clock duty cycle rather than in miles traveled. They can be driven in both non-road and on-road applications.

APPLICATIONS

Electric terminal trucks can be used in many locations. Typical applications are:

- Distribution centers
- Intermodal stations
- Container/trailer facilities (railyards, manufacturing, distribution, etc.)
- Industrial sites
- Warehouses
- Ports
- Waste management sites

BENEFITS

Energy efficient. The final energy consumption of electric terminal trucks can be five to six times less than that of diesel trucks. Lower energy use results in fuel cost savings.

Operational benefits. Electric terminal trucks offer several non-energy benefits such as less truck vibration and lower noise and heat, which in turn reduce driver fatigue, health costs, safety incidents, and driver turnover.

Workplace and environmental safety. Electric terminal trucks eliminate the use of diesel fuel and motor oils and reduce the need for solvents, thereby diminishing the potential for worker injuries such as slips and falls. Removing these fuels and liquids from the workplace also cuts costs associated with spills, cleanup, and related environmental compliance.

Better truck control. Regenerative braking used in electric terminal trucks provides energy recovery and allows the driver to control the vehicle with a single pedal. By easing up on the accelerator pedal, the driver controls the truck's deceleration, resulting in a smooth, shorter stopping distance and faster stopping time.

LIMITATIONS

High upfront cost. The primary barrier to the deployment of electric terminal trucks is the high upfront cost. However, an electric terminal truck can save money on fuel, maintenance, and emission control equipment. These savings compensate for the upfront cost and result in a reasonable payback period. Moreover, state and federal grants offer assistance with the purchase of electric terminal trucks.

Dangers with high voltage. Many manufacturers produce terminal trucks which run on 350V DC to 450V DC power and can be potentially unsafe. However, some commercially available electric terminal trucks run on voltages lower than 120V (like residential voltages) and are safer to operate.

Infrastructure upgrade needs. At some sites, customers may not understand the infrastructure upgrades required to convert their existing fleet of terminal trucks to electric.

Legal and economic barriers. It is legal and usually more economical for truck owners to replace a failed diesel engine with a refurbished diesel engine instead of replacing the entire truck. This choice locks in diesel use for longer periods and can forestall conversion to an electric terminal truck.

Awareness. In many cases, customers are not aware of the availability and benefits of an electric option for terminal trucks.

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Summary

EPRI's Focus and Thoughts:

- ***Conduct Electrification and Decarbonization Road Mapping Studies, Including Economic and Environmental Analyses***
- ***Manage Clients' Moves From Road Mapping Studies to Implementation***
- ***Continually Investigate New Technologies and Market Adoption***
- ***Vendor Engagement***

Markets are changing at an ever increasing pace. Staying current on technologies and markets are critical for effective military engagements.

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Questions