# Appendix 3:
## Historical ITP Technology Successes

# Historical ITP Technology Successes

## IMPACTS

### Advanced Turbine System

As part of the Industrial Power Generation Program, an advanced metallic material, first-stage turbine vane was developed. This vane allows turbines to operate at higher compression ratios and/or temperatures than conventional gas turbines resulting in an efficiency improvement of 15%, less down-time, and less maintenance. The use of these vanes has resulted in an energy savings of 245 billion Btu.

### Aerocylinder Replacement for Single-Action Cylinders

(www.smedbergmachine.com)

The aerocylinder, a machinery shock absorber, replaces conventional, single-action compressed-air cylinders in industrial forging, stamping, and welding applications. The aerocylinder has been installed on over 400 stamping and welding presses, primarily in the automotive industry. Using this system reduces downtime, prolongs equipment life, improves final product quality, and has resulted in an energy savings of more than 340 billion Btu since 1988.

### Aluminum Roofing System

(www.transmet.com)

This technology uses aluminum chips to reflect about 70% of the solar radiation received on asphalt roofs, which reduces building cooling needs. This invention has saved over 635 billion Btu since its introduction in 1984 and is now used on more than 35 million square feet of roofing.

### Arc Furnace Post-Combustion Lance

(www.praxair.com)

A technology was developed that was applied in electric arc furnaces to increase productivity, reduce energy requirements, and improve control. The system consists of a water-cooled lance and controls to inject oxygen to combust the carbon monoxide in and above the furnace's foamy slag. The six installed systems have saved a total of 2.46 trillion Btu of energy.

### Auxiliary Air-Conditioning, Heating and Engine Warming System for Trucks

(www.ponypack.com)

An auxiliary power unit was developed to maintain cab power in heavy-duty, long-haul trucks when the main engine is not operating. This unit takes fuel from the truck's fuel tanks to heat and air-condition the cab and sleeper, to generate electricity to keep the battery charged, and to furnish hot water to keep the truck's engine warm. Since 1988, more than 3000 units have been installed on trucks and have saved an estimated 19.9 trillion Btu in the form of diesel fuel.

### Biomass Grain Dryer

Originally developed for grain-drying processes, this heat exchanger system later expanded into the furniture industry. By burning husklage, wood waste, or other biomass fuels, the process quickly disposed of combustible waste, provided an alternative energy source, and saved landfilling fees. Used within both the corn and furniture manufacturing industries, this system resulted in a cumulative 1.35 trillion Btu in energy savings and reduced landfill scrap by thousands of tons since being commercialized.

### Biphase Rotary Separator Turbine

A biphase turbine recovers waste energy from pressurized process streams that separate into liquid and gas when the streams are depressurized. Conventional turbines cannot be used efficiently with two-phase flows because they cannot withstand the forces released during the liquid's rapid evaporation to a vapor. This turbine is being used by 125 large (500-ton) chillers and is saving 15 kW per chiller, for a cumulative savings of 107 billion Btu.

### Brick Kiln Design Using Low Thermal Mass Technology

(www.swindelldressler.com)

An innovative brick kiln was developed that uses low thermal mass and low-$NO_x$ burner technologies. This brick kiln uses three technical innovations: ceramic-fiber insulation in lieu of traditional refractory brick, a lower profile stack design for brick kiln cars, and more but smaller low-$NO_x$ gas burners. These innovations result in a reduction in natural gas usage of 35% compared to a conventional kiln. The two brick kilns have cumulatively saved 280 billion Btu.

### Catalytic Distillation

(www.neochem.net)

Distillation is one of the most energy-intensive industrial processes, accounting for over 40% of the energy consumed by the chemicals industry each year. This single-stage catalytic reaction/distillation process has become a major commercial success and has improved the energy efficiency and productivity of certain chemical processes, including the production of methyltertiary- butyl-ether (MTBE) and tertiary-amyl-methyl-ether (TAME). Since its introduction in 1982, the 36 units installed in the United States have saved 43 trillion Btu.

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### Cement Particle-Size Classifier

A system was developed to control the size distribution of cement particles and to help reduce the current energy-intensive regrinding process. Cement products produced from the improved particle distribution consumed less energy and were of better quality. This system yielded a total of approximately 9.5 trillion Btu in energy savings since its commercialization in 1984.

### Chemical for Increasing Wood Pulping Yield

(www.chemstone.com)

Unevenly processed wood chips in the pulp industry result in poor-quality pulp, often requiring reprocessing. A cooking aid was developed that reduced the amount of virgin wood feedstock needed to process wood chips and increased pulp yield and quality. The cooking aid helps pulp-cooking liquors penetrate the chips, resulting in more uniform cooking, and enabling the production of more uniform fibers in less time and with less energy. Since 1995, 23 mills in the United States have used this chemical system to save over 8 trillion Btu.

### Chemical Separation by Fluid Extraction

This technology removes hazardous organic compounds from contaminated solid or liquid waste streams. The technology is more energy efficient than conventional technical hazardous waste treatment methods. The use of this technology has resulted in energy savings of 440 trillion Btu since 1990.

### Chemical Vapor Deposition Optimization of Ceramic Matrix Composites

Ceramic matrix composites comprise a technology that is practical for a wide range of industrial and aerospace applications. Ceramic matrix composites are extremely heat-tolerant and corrosion-resistant, making them ideal for applications requiring lightweight materials capable of withstanding high temperatures. Chemical vapor deposition (CVD) is used to enhance the physical characteristics of the ceramic matrix composites. A computer model was developed and used to increase the throughput of two CVD coating reactors that optimized the coating process used to make ceramic matrix composites.

### Cogeneration – Coal-Fired Steam Turbine

Using a coal-fired boiler and turbine exhaust steam system, a cogeneration process was developed for use primarily within the textile industry. The 16 systems installed saved more than 31 trillion Btu of energy/year and significantly reduced emissions due to lower demand for utility-generated electricity.

### Cogeneration – Slow-Speed Diesel Engine

This stationary internal combustion, slow-speed, two-stroke diesel engine was developed to accommodate limited space and/or varying load demands. The compact, slow-speed diesel engine has excellent efficiency, greater load flexibility, and lower fuel and maintenance costs than conventional cogeneration options. The three installed units have saved a total of approximately 17.7 trillion Btu of energy.

### Coil Coating Ovens

This system was developed to recover thermal energy previously lost in the solvent-based paint curing/incineration process. Heat, recovered from solvent vapor combustion in zone incinerators, was routed back into the curing oven to vaporize more solvent. The thermal incinerators normally used were replaced by afterburners and a waste heat boiler to produce process steam. A three-fourths reduction in natural gas requirements and a reduction in pollution control energy resulted in over 35 trillion Btu of cumulative energy savings since the system was commercialized. The savings were increased even further as a result of a technology upgrade that eliminated the zone-burning portion of the process.

### Combination Grain Drying

Designed to prevent spoilage during storage and reduce energy consumption, this system used a high-speed dryer and storage bin equipped with a drying fan. The grain was first dried by a high-speed, hot-air dryer, then transferred to a drying/storage bin that delivered ambient air to cool and further dry the grain to a moisture content of around 14%. This combination drying method improved grain quality, increased drying capacity, and reduced propane and natural gas consumption.

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### Component Cleaning

A chemical product for industrial cleaning was developed based on supercritical fluid technology. Equipment was developed that converted carbon dioxide ($CO_2$) into a fluid that was used to clean metal, plastics, printed wire boards, etc. This technology takes the place of chlorofluorocarbon (CFC) solvents in the cleaning process and has reduced the energy needed to evaporate the solvents during the drying process.

### Computer-Controlled Oven

To lower volatile organic compound (VOC) emissions, the computer-controlled oven technology was developed that permits operation at a higher percentage of lower explosive limits, reducing in dilution air requirements and the energy required to heat the high-temperature ovens. Optimizing airflows reduces VOC emissions that, in turn, reduces VOC incineration requirements. Fifteen installations saved a cumulative total of 27.75 trillion Btu of energy since being commercialized in 1982.

### Continuous Cascade Fermentation System for Chemical Precursors

(www.bio-process.com)

A cascade reactor for ethanol production from carbohydrate feedstocks was developed that eliminated the need to fill, empty, and wash a fermenter as part of a batch operation. Feed is introduced continuously into the first of three to five stirred reactors placed in series, with the outflow of one reactor flowing into the next reactor. This continuous operation allows quick and complete saccharification and fermentation of feedstocks and removal of ethanol into a gas phase as it is produced. Since its introduction in 1996, this reactor has saved over 800 billion Btu.

### Cupola Stack Air Injection

This process reduced the carbon monoxide (CO) content of the effluents from a cupola furnace and improved the efficiency of combustion in the furnace during production of gray iron. This process eliminated the need for afterburners and the large amounts of energy they used to reduce the CO content in the emissions. By injecting air into the exhaust gases below the furnace charging door, the CO was ignited at temperatures already existing in the stack, with the resulting final exhaust gas having a CO concentration of less than 1%. Cupola stack air injection saved a total of 80 billion Btu of energy before being superseded by more advanced technology.

### Delta T Dryer Control System

(www.moisturecontrols.com)

This dryer control system significantly improves control capability because it measures moisture content continuously in the dryer rather than only at the exit from the dryer. This more precise temperature control saves 10% to 20% more energy than conventional dryer control systems. Over 300 Delta T control systems have been installed and have saved more than 17 trillion Btu since 1985.

### Direct Source-to-Object Radiant Heating Panels

(www.radiantnow.com)

Radiant heating systems transfer heat directly to a person or object in a manner similar to sunlight, eliminating energy consumed by mechanical heat-delivery requirements. These systems can save up to 50% in heating costs compared with baseboard electric-resistance heating and up to 30% compared with heat pumps. Since 1981, more than 375,000 radiant heating panels have been sold, saving more than 1.45 trillion Btu.

### D'MAND® Hot Water Recirculating and Waste Prevention System

(www.gothotwater.com)

A system was developed for water heaters to conserve water and energy while providing hot water on demand. The system moves the tepid water back to the water heater rather then discarding it prior to hot water delivery. The primary energy savings are from the reduced amount of energy needed to heat the water returned to the water heater tank. More than 33,000 units have been installed in residential and commercial applications and have cumulatively saved 604 billion Btu.

### Dual-Cure Photocatalyst

Traditional volatile organic compound (VOC)-based coatings release undesirable organic chemical vapors into the atmosphere during the drying or curing phase of the coating application. A novel photocatalyst system was developed as part of a dual-cure process that allows light-activated, simultaneous polymerization of two monomers to produce a material consisting of two independent but interpenetrating polymer networks. The VOC emission levels from this process are substantially below those obtained using conventional coating technologies, and cure times are shorter. Since its introduction in 1995, this system has saved over 3.7 trillion Btu.

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### Dye Bath Reuse
To reduce the use of chemicals, water, and energy, two process modifications were developed for batch-dying textiles. These modified processes involved reconstituting and recycling the spent dye bath, eliminating the final rinse-water step. These modifications resulted in a cumulative energy savings of 2 trillion Btu prior to being replaced with advanced technologies.

### Electric Tundish
An enclosed and more efficient holding furnace or tundish was developed and demonstrated for the continuous casting of copper alloys. Switching to electricity to heat the tundish rather than gas or oil results in an energy efficiency increase from 20% to 98%. Four tundishes were installed in 1994 and operated until the manufacturing facility closed in 1996.

### Electronic Starter Device for Fluorescent Lamps
A quick and reliable electronic lamp starter was developed for small fluorescent applications. This technology was an important improvement for lower wattage fluorescent lamps which still use older preheat circuit designs. Use of the inexpensive and easily installed starter can double the life of a fluorescent lamp. More than 1.6 million units have cumulatively saved 3.1 trillion Btu.

### Energy-Efficient Canning
A thermal syphon recycle system using a recycling steam jet vacuum compressor and a recirculation pump and heat exchanger outside of the cooker were two methods developed to improve energy efficiency in the canning industry. From the installation of 100 new or retrofitted units, a cumulative energy savings of nearly 3 trillion Btu were realized.

### Energy-Efficient Fertilizer Production *(Pipe Cross Reactor)*
An ammonia granulation technology was developed to reduce moisture content and energy consumption in the production of pellet fertilizers. The process employed a pipe-cross configured reactor, mounted within a granulator, where liquid raw materials were mixed and then dried via heat from the chemical reaction. Seven reactors were constructed that produced a superior product with a 1% moisture content, reduced pollution, and contributed a cumulative energy savings of 2.6 trillion Btu.

### Energy-Efficient Process for Hot-Dip Batch Galvanizing
(www.ferrotech.com)
This process combines a thermally stable flux solution and a preheat furnace to reduce energy use and increase batch galvanizing productivity while reducing waste generation. Hot-dip galvanizing is widely used to protect steel from corrosion. The process was used at a Pennsylvania steel company and saved 4 billion Btu of energy.

### Fluidized-Bed Waste Heat Recovery System
A self-cleaning waste heat recovery system was developed to replace industrial furnace conventional recuperators. The system employed finned heat exchange tubes submerged in a bed of spherical alumina particles that absorbed heat from the hot gas and transferred it to the finned tubes. The water flowing through the tubes was converted to steam for use elsewhere in the plants while the alumina particle agitation kept the tubing clean and distributed the heat evenly.

### Foam Processing
To replace the very energy-intensive wet processing of textiles, a process was developed to substitute medium-density foam for some of the water processing. A 50% to 70% moisture retention reduction was realized along with a significant decrease in energy previously required for drying, water usage, and pollution control. This technology, and several similar techniques, achieved a cumulative energy savings of more than 11 trillion Btu.

### Glass Feedstock Purification
An optical sortation technology, which removes ceramic and other contaminants from glass cullet using optical sensors and computer-controlled jets of compressed air, was developed. This technology was used to recycle 50 tons/day of glass at one plant for two years thus resulting in a cumulative energy savings of 48 billion Btu.

### Guide for Window Routing Device
(www.bi-glass.com)
A tool guide to control the operation of a router was developed for converting single-glazed wooden-framed windows into double-glazed windows. Single-pane glass can thus be replaced with panes that are more energy-efficient without replacing the sash members or the entire window. This technology was used by licensees in the United States and England and has saved more than 520 billion Btu of energy.

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### Heat Exchanger Dryer
This modified multideck dryer that incorporated a heat recovery system, was developed for the wood board products industry. Air-to-air, air-to-water, and air-to-liquid heat exchangers enabled the previously lost heat from exhaust gases to be reused throughout the plant. Three installations yielded nearly 800 billion Btu in cumulative energy savings.

### High-Effectiveness Plate-Fin Recuperator
Materials and fabrication techniques were developed that made the previously cost prohibitive plate-fin recuperators more economically feasible for a larger number of industrial applications. The recuperators can recover 90% of the energy from exhaust as hot as 1550°F, are more compact than conventional techniques, and use a flexible flow pattern. Further, the technology provides more heat transfer surface per cubic foot of volume and is often used in nonfouling heat recovery applications. More than 100 units were installed with a cumulative energy savings of around 5 trillion Btu.

### High-Efficiency Dehumidifier
(www.heatpipe.com)
A system was developed to recover reheat energy and to control the humidity in all types of buildings. This system uses heat pipe technology to increase the humidifying capacity of air-conditioning equipment and operates without any mechanical or electrical inputs. More than 12,000 units have been sold and have cumulatively saved 1.38 trillion Btu.

### High-Efficiency Direct-Contact Water Heater
(www.kemcosystems.com)
This industrial/commercial water heating system uses a water-cooled burner sleeve and combustion zone to extract all possible energy from natural gas combustion by bringing water into direct contact with a submerged-flame jet-type burner. More than 3,000 units are in use throughout the United States, and have saved a cumulative total of more than 300 trillion Btu in natural gas.

### High-Efficiency Weld Unit
An inverter welding power source that included a multiprocess capability was developed for arc welding processes. Up to 75% smaller in size and weight than conventional units, this system's portability and improved weld quality also provided energy savings of up to 45% over conventional power sources. More than 75,000 units were sold, resulting in a cumulative energy savings of 21 trillion Btu before they were replaced by more advanced welding technology.

### High-Temperature Burner Duct Recuperators
Two ceramic tube recuperators, able to withstand 2000°F+ temperatures, were designed to recover heat from high-temperature industrial furnace exhausts. Used in iron forging and steel production, fuel consumption was reduced by approximately 50%.

### High-Temperature Radiant Burner
(www.alzeta.com)
The high-temperature radiant burner forms the core of a thermal processing unit that destroys up to 99.9% of one of the most potent classes of global warming gases known – the perfluorocarbons (PFCs) that are generated during semiconductor manufacturing. The burner operates reliably at high process temperatures and provides uniform, well controlled heat while increasing the efficiency of traditional burner systems. Since its introduction in 1995, over 5000 burners have saved more than 9.4 trillion Btu in the United States.

### Hot Blast Stove Process Model and Model-Based Controller
A central control system was developed and installed on a blast furnace to optimize the thermal efficiency of the hot-blast stove system. The controller is linked to process optimization algorithms that determine heating fuel rates, thus minimizing fuel requirements and reducing the number of disruptions in iron production. This invention has saved more than 220 billion Btu since its installation in 1998.

### Humidity Sensor *(Optical)*
An optical humidity sensor (hygrometer) that determines humidity by measuring the absorption of ultraviolet light was developed for the pulp and paper industry. Replacing less reliable humidity sensors, the hygrometer maximizes drying efficiency by optimizing the balance of exhausted and makeup air. Multiple installations realized a cumulative energy savings of 20 billion Btu.

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### Hydrochloric Acid Recovery System
(www.betacontrol.com)
An on-site, closed-loop HCl recovery system was developed for galvanizers and small- and medium-size steel manufacturers. Benefits of the recovery system included reduced demand for virgin HCl, the elimination of the use of chemicals for neutralizing waste acid, and energy and cost savings associated with processing, transporting and disposing of the waste acid The use of this system resulted in cumulative energy savings of 410 billion Btu.

### Hyperfiltration – Textiles
Hyperfiltration, a membrane-based separation technique, was adapted to treat textile industry wastewater. This process also found widespread use in the food-processing, biotechnology, pharmaceutical, pulp/paper, chemical, electronic, and nuclear industries. Allowing recovery of raw materials and minimizing waste, this process achieved a cumulative energy savings of nearly 1 trillion Btu.

### Hyperfiltration Process for Food
(www.niroinc.com)
A membrane hyperfiltration process is being used to separate juice into pulp and liquid fractions. This process replaces the energy-intensive thermal evaporation step in the concentration process. This process has been installed in 17 locations and has saved more than 13 trillion Btu since 1989.

### Improved Composite Tubes for Kraft Recovery Boilers
(www.sandvik.com)
Originally, carbon steel tubes were used for tube panels in black liquor recovery boilers, but severe corrosion thinning and occasional tube failures led the forest products industry and boiler manufacturers to search for materials that could better survive in the recovery boiler environment. As a result of this search, weld overlay and co-extruded tubing alloys were developed and are being used in over 18 U.S. kraft recovery boilers and numerous foreign installations. Boiler manufacturers used these improved tubes in new and rebuilt kraft recovery boilers to cumulatively save over 4.5 trillion Btu in the United States.

### Improved Poured Concrete Wall Forming System
(www.liteform.com)
A method for pouring concrete walls for building basements and crawlspaces was developed that uses lightweight, highly insulative extruded polystyrene forms. If left in place, these forms create walls that are both load-bearing and thermally insulating, up to R-22. Over 47 million square feet of walls have been installed that have cumulatively saved 978 billion Btu.

### Irrigation Systems
The design of efficient low-pressure impact sprinklers, low-pressure spray heads, and improved drop tubes upgraded center-pivot irrigation systems dramatically. Operating at lower pressures, these systems required 10% less water intake, reduced runoff, and yielded a cumulative energy savings of approximately 49 trillion Btu due to reduced pumping requirements.

### Lightweight Steel Containers
A process for manufacturing lightweight steel containers uses the container's internal pressure for rigidity rather than a thick wall. The resulting container wall is substantially thinner, which reduces the container's metal content by 40% but provides equivalent or better strength. The process saves energy by using less material in the container, less material processing, and less transportation weight. Two container production lines have cumulatively saved 3 billion Btu.

### Membrane Filtration Technology to Process Black Olives
A zero discharge wastewater purification and reclamation system was installed at an olive production plant. This system used a cyclone separation system followed by ultrafiltration and reverse osmosis to recycle wastewater back into the plant. Since its installation in 1997, it has saved 100 billion Btu.

### Membrane Separation of Sweeteners
A system to preconcentrate corn steep water was accomplished via a hollow-fiber membrane process. Resistant to fouling, this system extracted more than 50% of the water from the corn steep stream prior to evaporation, thus significantly reducing energy requirements. Additionally, a spinoff technology was commercialized for wastewater treatment.

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### Meta-Lax Stress Relief Process
(www.bonal.com)
A process applies subresonant vibrational energy to relieve stress in metal objects. The process replaces heat treating applications and reduces the energy and time needed to heat treat metal. The equipment is portable and treats a wide variety of work pieces in a pollution-free operation. More than 990 units have cumulatively saved 136 trillion Btu.

### Methanol Recovery from Hydrogen Peroxide Production
(www.fmc.com)
A process was developed to recover and clean contaminated methanol for reuse in producing hydrogen peroxide. This process recovers more than 90% of the methanol needed to produce hydrogen peroxide, thereby saving the energy needed to produce virgin methanol. The process also saves energy by reducing the transportation of virgin methanol. The two units using this process have cumulatively saved 244 billion Btu.

### Method of Constructing Insulated Foam Homes
(www.homecorpintl.com)
A method was developed for constructing buildings that are both energy efficient and structurally sound. The home consists of an exterior patented wall system made of expanded polystyrene (EPS) foam insulation panels with an internal steel-reinforced concrete post and beam design. This wall has an R-40 insulation panel with an internal steel-reinforced concrete post and beam design. The roof is insulated by EPS slabs sandwiched between the rafters and has an R-50 insulation value. The 326 homes constructed using this method saved a cumulative total of 38 billion Btu since 1996.

### Night Sky – A New Roofing Technology
A natural evaporating roofing/cooling system was developed for flat or slope-roofed commercial buildings to increase the roof's life expectancy and reduce building cooling loads by 50%. This system spray-cools water on the roof at night and then applies the cooled water to reduce subsequent cooling loads. Systems involving more than 95,000 square feet have been installed and have cumulatively saved 2 billion Btu.

### Nitrogen-Methanol Carburization
A system was developed for steel manufacturers that replaced the conventional endothermic atmosphere process with a nitrogen-methanol carburization process. In addition to improving the strength, hardness, and wear resistance of the steel parts, the system proved more reliable and easier to operate. Significant reductions in carbon dioxide and other pollutants were noted along with a cumulative energy savings of 12 trillion Btu.

### No-Clean Soldering Process
After soldering, electronic equipment used to be cleaned using CFC solvents. Changing the soldering technique eliminated the need to use CFC solvents for cleaning, resulting in energy savings and reduced CFC waste. This process has cumulatively saved 3.9 trillion Btu.

### Onsite Process for Recovering Waste Aluminum
In the production of aluminum automobile wheels approximately 30% of the aluminum content is machined away as chips during the cutting and grinding steps. A process for recycling the chips onsite rather than offsite improves the energy efficiency and productivity of chip recycling while simultaneously reducing airborne pollutants and other manufacturing wastes. This process has resulted in cumulative energy savings of 139 billion Btu.

### Organic Rankine-Cycle Bottoming Unit
This organic Rankine-cycle system was developed to replace less-efficient, conventional steam Rankine-cycle systems in generating electricity from lower temperature waste-heat sources. It was found to be adaptable to a variety of solar and geo-thermal energy applications as well as suitable for many types of industrial waste-heat streams. The system consists of a standard Rankine-cycle engine, toluene as the working fluid, a waste-heat boiler, a waste-gas flow-control valve, system controls, and an electric generator. The installation of several units cumulatively saved 500 billion Btu of energy.

### Oxy-Fuel Firing
(www.praxair.com)
This oxygen-enriched combustion system for glass-melting furnaces significantly reduces energy requirements. About one-fourth of all glass-melting capacity in the United States has been converted to oxy-fuel firing. In addition to energy savings, this technology reduces $NO_x$ emissions by up to 90% and particulates by up to 30%. Since its commercialization in 1990, oxy-fuel firing technology has saved more than 25 trillion Btu.

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### Paint Wastewater Recovery
(www.zenon.com)
A system was developed to reclaim and reuse wastewater generated during equipment cleaning used in water-based paint-production operations. The system vastly reduces the volume of wastewater contaminated with metals and solvents that must be disposed of as hazardous waste. Energy savings resulted from the reduced fuel use for transporting and incinerating the waste. The process has cumulatively saved over 30 billion Btu of energy.

### Pallet Production Using Postconsumer Wastepaper
A process produces paper pallets made of 40% postconsumer waste paper. Substituting virgin wood with this recycled product reduces by 60% the energy required to produce pallets, saves landfill space, and decreases air and water pollution. The process has cumulatively saved over 2 billion Btu.

### Pervaporation to Recover and Reuse Organic Compounds
(www.mtrinc.com)
A membrane technology was developed which treats small-volume, less than 20 gallons per minute, waste streams contaminated with organic compounds. Small-volume wastewater streams are difficult and expensive to treat with most conventional organic-compounds control technologies. The three installed units cumulatively saved 57 billion Btu.

### PET Bottle Separator
Recycling certain plastics for conversion into fuel oil necessitated the development of a separation process that could sort containers of PET (polyethylene terephthalate), high-density polyethylene, and aluminum. One bottling plant using this process recycled 18 million pounds of PET and saved a total of 1.2 trillion Btu of energy.

### Pinch Analysis and Industrial Heat Pumps
(www.veritechenergy.com)
Pinch analysis was used to locate the most productive process modifications and heat pump opportunities within a complex process to improve overall process efficiency. A pinch analysis of a wet-corn-milling plant showed that adding two new thermal vapor recompression heat pumps to existing evaporators could reduce overall process fuel use by 33%. These two heat pumps have cumulatively saved 917 billion Btu.

### Plating Waste Concentrator
A low-cost, vapor-recompression evaporation system was developed for the plating and surface-finishing industry to reduce water pollution and recover costly plating chemicals. The waste concentrator was designed with two evaporators, one to concentrate the wastewater and the other to use waste heat as an energy source. Recovery of plating metals, reduced hazardous material treatment costs, and energy recycling all contributed to improved operating costs and energy efficiencies. This technology was used in 62 applications and resulted in a cumulative energy savings of 3 trillion Btu.

### Powder Paint Coating System
The current standard for applying anti-chip primer to vehicles is a solvent-borne paint spray system that has a transfer efficiency (ratio of paint solids deposited on the vehicle to total volume used) of about 50%. A powder anti-chip process that contains no solvents and, considering recycling, has an effective transfer efficiency exceeding 99% was developed. The system virtually eliminates VOC emissions and paint sludge generation, eliminating the costs to transport and dispose of sludge. Energy requirements for the powder process are much lower than for solvent-based processes due to greatly reduced air-heating requirements and the elimination of energy requirements for incinerating VOCs. This system has been installed in 14 locations in the United States and has saved more than 5.6 trillion Btu since 1996.

### PowerGuard® Photovoltaic Roofing System
(www.sunpowercorp.com)
A roofing system was developed that offers building insulation, shading, roof protection, and solar power generation encompassed in a single roofing panel. These have been installed on commercial or residential buildings that have flat or low-slope roofs. Since its introduction in 1994, more than 21 MW have been installed across the United States for an energy savings of 385 billion Btu.

### Real-Time Neural Networks for Utility Boilers
(www.neuco.net)
A computer model was developed that uses an advanced form of artificial intelligence known as neural networks to optimize combustion in coal-fired boilers. This system improved boiler efficiency by as much as 5% and reduced $NO_x$, $CO_2$ and $SO_x$ emissions. The cost of reducing $NO_x$ emissions using the model is much lower than the cost of installing low-$NO_x$ burners or catalytic converters. The system has been installed on 64 boilers and has saved more than 57 trillion Btu since 1995.

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### Recovery of Acids and Metal Salts from Pickling Liquors

Steel fabrication processes often use pickling (immersing steel in acid) to remove oxide layers from recently heated steel. The Pickliq® process was developed to make sulfuric acid recovery cost-effective for smaller installations. The process combines diffusion dialysis, energy transfer, and low-temperature crystallization technologies to efficiently recover acids and metal salts. It has demonstrated significant gains in production capacity, quality control, and productivity. Since its introduction in 1995, the process has saved more then 11 billion Btu in the United States.

### Recuperators

A cross-flow ceramic recuperator made of cordierite (a magnesium-aluminum silicate) was developed to recover heat from exhaust gases in high-temperature (up to 2600°F) furnaces. Corrosion and oxidation resistant, the compactly sized recuperator eliminated the need for a flue gas dilution system. These units cumulatively saved over 24 trillion Btu in energy and reduced both thermal and emissions pollution.

### Removal of Bark from Whole Logs

A machine, the Cradle Debarker™, was developed that removes bark from delimbed tree stems in a process that strips off less wood, allows for greater operator control, and improves the productivity of the debarking process. Unlike drum debarkers, which use a covered cylinder, the open top of this debarker lets the operator remove stems that have completed the debarking process and recycle others that require further processing. The four debarker units have cumulatively saved 132 billion Btu.

### Restaurant Exhaust Ventilation Monitor/Controller

(www.melinkcorp.com)

Typical exhaust hoods in restaurants operate at full speed all day long and sometimes all night long even when cooking is not taking place. A microprocesor-based controller for commercial kitchen ventilation systems was developed that optimizes system performance for four key parameters: kitchen comfort, fire safety, occupant health, and energy efficiency. It monitors and reduces the fan speed during idle periods of kitchen activity to save energy and employs sensors that monitor heat and smoke levels for safety. More than 2,700 units have been sold and have saved more than 600 billion Btu since 1994.

### Retractable® Labyrinth Packing Seals for Turbine Shafts

(www.turbocare.com)

This invention is a redesigned shaft-sealing ring for utility and industrial steam turbines that self-adjusts from the gap required for start-up to that required for normal operation. The result is less wear damage and improved turbine efficiency. The packing seals are still available for sale from TurboCare, Inc. More than 600 of these seals have been installed and have saved more than 74 trillion Btu. Additionally, spinoff technologies were developed to further improve steam power efficiency.

### Reverse Brayton Cycle Solvent-Recovery Heat Pump

A reverse Brayton cycle heat pump was developed to economically and efficiently recover solvents from numerous industries. This heat pump reduces the demand for new solvents, saving petroleum feedstock and the energy used to produce virgin solvents, and captures for reuse solvents that would have been released to the atmosphere. Ten heat pumps have been installed and have cumulatively saved 4.98 trillion Btu.

### Robotic Inspection System for Storage Tanks

(www.solexrobotics.com)

This technology consists of a remotely operated robotic inspection vehicle that is submerged in bulk liquid storage tanks to gather input on structural and corrosion problems. This system replaces the time-consuming conventional inspection process of draining the tank, washing it out, inspecting it, and then refilling it. This technology has cumulatively saved 280 billion Btu.

### Scrap Tire Recycling

This process converts scrap tires into high-value products, conserving energy and new materials while reducing the amount of scrap tires sent to landfills. This treatment process combines surface-treated rubber particles with other polymers such as polyurethane, epoxy, and polysulfide to form unique composites with improved strength, tear resistance, and resilience. This process has saved a cumulative 0.16 trillion Btu in natural gas.

# Historical ITP Technology Successes



### Selective Zone Isolation for HVAC Systems

(www.retrozone.com)

A method for selectively controlling air flow from a central HVAC system can now fit into ducts that cannot accept conventional dampers because of poor access. The flexible dampers can save 20% to 30% of a typical heating and cooling bill in a large house or commercial building by sealing off unoccupied rooms. More than 4000 systems have been sold and have cumulatively saved 305 billion Btu.

### SIDTEC™ Condenser Maintenance Program

(www.gewater.com)

An on-line condenser tube cleaning system uses ultra-high molecular weight polyethylene tube cleaners to remove both soft and hard deposits. The system maintains system efficiency and keeps the thermal power plant operating. Twelve power plants have used the system and have cumulatively saved 136 trillion Btu.

### Slot Forge Furnace/Recuperator

A high-performance slot forge furnace design that incorporated a ceramic shell-and-tube recuperator was developed to recover approximately half of the heat energy previously lost in the furnace exhaust gases. Additionally, modified recirculation burners, improved temperature and air/fuel ratio controls, and lightweight furnace wall insulation reduced energy requirements per pound of steel by approximately 4100 Btu. The use of this technology resulted in a cumulative energy savings of 13 trillion Btu.

### Smart Screening Systems for Mining

A smart screening system was developed that vibrates only the screen rather than the entire machine and supporting structure in the material separation process. The system saves energy by replacing the massive electrical motor and eccentric shaft with miniaturized "smart" motors combination with multi-staged resonators. The motors are programmed to vibrate the screening panel at an optimal set rate, even as the material load varies over time, thus optimizing the throughput and energy savings of the screening system. Since its introduction in 2003, the 44 units installed in the United States have saved 3 billion Btu.

### Solar Process Heat

This project was developed to expand the use of solar process heating systems primarily within the government and institutional sectors. Reducing the need for fossil fuels, solar heat supplies water preheating, process hot water, and steam as well as process hot air, cooling, and refrigeration.

### SolaRoll® Solar Collector System

A flexible rubber tubing solar collector system was developed to be used to heat hot water, swimming pools, and building heating systems. The collectors are an extrusion of ethylene-propylene-diamine rubber and are primarily used for heating swimming pools. The systems replace conventional natural gas or electric heat pump systems. More than 35 million square feet of SolaRoll® have been sold and have saved more than a cumulative 25 trillion Btu of energy.

### SOLARWALL® Air Preheating System

(www.solarwall.com)

A solar air heating system heats incoming ventilation and makeup air using a metal cladding system installed on the south-facing wall of a building. This system also reduces a buildings heat loss in the winter and lowers the cooling loads in the summer by preventing solar radiation from striking the south wall of the building. More than 40 systems with over 200,000 square feet of wall are operating in the United States and have cumulatively saved 76 billion Btu. A spinoff technology has been developed that resulted in a combined solar heat and power system.

### Solvent Recovery from Effluent Streams

(www.mtrinc.com)

A membrane system was developed for recovering volatile organic compounds and chlorofluorocarbons from petrochemical waste streams. This system allows solvents to be recovered from waste streams that are too diluted or too concentrated with solvents to use other methods. In addition to eliminating the environmental release of these solvents, the 27 units in operation in the United States have saved more than 15 trillion Btu since 1990.

### Stalk and Root Embedding Plow

(www.romeplow.com)

A stalk and root embedding plow was invented that reduces costs and saves time in preparing cotton fields for planting. Disposing of cotton stalks and roots in the field after harvest is an energy-intensive operation. Nationwide, many cotton farmers use conventional tillage practices that involve shredding the stalks and making several tillage passes over the field to prepare a new seedbed. The plow deeply entrenches whole stalks and roots into the soil in one pass, eliminating the need to shred the stalks. The 79 plows sold in the United States have saved a cumulative total of 123 billion Btu of energy.

## IMPACTS

### Steel Reheating for Further Processing
(www.praxair.com)
A low $NO_x$, oxygen-burner retrofit using 100% oxygen was developed for steel reheating that requires less fuel to heat steel. These burners result in energy savings of 60% per ton of steel while increasing the quality of the metal. Emissions are reduced enough to eliminate the need for $NO_x$ removal equipment and the steel is more uniformly heated resulting in better mill performance and an increase in productivity. Since its introduction in 1998, this system has saved 1 trillion Btu.

### System 100® Compressor Controls
(www.cccglobal.com)
A compressor control system was developed that allows the operation of both pipeline and process compressors to operate efficiently without surge or recycle. The compressors are usually powered indirectly by natural gas (steam for process compressors and gas-powered turbines for pipeline compressors). Energy savings are typically in the 5% to 10% range. Total sales of the control systems were more than 3600 units and they have cumulatively saved more than 400 trillion Btu.

### The Solar SKYLITE Water Heater
(www.solarroofs.com)
A solar skylight water heater system was developed that uses lightweight, low-cost polymeric materials. A typical installation uses two solar collectors and the entire system can be installed in a few hours. The system can serve as a skylight and provide energy to the home's water heater. More than 1400 systems have been installed and these have cumulatively saved more than 75 billion Btu of energy. A spinoff technology was developed that improves solar energy capture.

### Thin Wall Casting of Stainless Steel
An alloy of cast stainless steel composition was developed that allows the use of the Hitchiner counter-gravity casting process for stainless steel parts rather than conventional sand casting. Using the Hitchiner process allows components to be cast with wall thickness of less than 3mm - nearly two to three times less than conventional casting. This process increases automation, increases throughput by a factor of two to three compared with the conventional process, and produces a significantly higher yield with very low defect rates. The use of this alloy has saved over 460 billion Btu since 2000.

### Ultrasonic Tank Cleaning
(www.telsonic.com)
Chemical and pharmaceutical companies typically use volatile organic compound (VOC)-emitting solvents to clean their storage tanks in a process that is both labor and energy-intensive. An ultrasonic tubular resonator was developed that eliminates the use of VOC-emitting cleaning solvents and reduces cleaning time from about 1 day to 1 hour. The unit is small and can be placed into the tank through an opening in the top, eliminating the need for maintenance workers to enter the tank as required with conventional cleaning. Energy savings from the use of this technology are based on decreased cleaning energy use as well as the reduced use of solvents. Since 1995, this technology has saved more than 40 billion Btu.

### Use of Recovered Plastics in Durable Goods Manufacturing
(www.mbapolymers.com)
An advanced mechanical recovery technology that can effectively recover plastic waste material from complex manufacturing scrap and end-of-life durable goods including automobiles, appliances, electrical, and electronic equipment was developed. This technology separates as many as three different plastics at one time in a mixed waste stream and segregates metal, metal coatings, rubber, glass, foam, and fabric from the plastic waste. Since its introduction in 1996, this technology has cumulatively saved over 400 billion Btu.

### Variable-Frequency Microwave Furnace
(www.microcure.com)
Microwave heating can speed the curing of thermo-setting resins and polymer-matrix composites. Conventional microwave furnaces use standing waves that create a non-uniform energy distribution in the working cavity. A variable-frequency microwave furnace was developed that eliminates non-uniform energy distribution and provides reproducible heating with every batch. Various types of polymer products can be uniformly cured, often in 5% of the time of conventional processing. The 48 units in the United States have saved 47 billion Btu since 1995.

### V-PLUS™ Refrigerant Oil Cooling System
(www.vilter.com)
The V-Plus system injects refrigerant liquid into the outlet stream of a screw-compressor for industrial refrigeration and cooling systems. The result is increased system capacity, extended system lifetime, and energy savings. Over 250 units have been installed and have saved more than 1 trillion Btu since 1982.

# Historical ITP Technology Successes



### Wallace Energy Systems Solar Assisted Heat Pump Water Heater

A system was developed for extracting heat from a source (air or water) and applying this heat to water. The heat pump water heater provides both water heating and space cooling. The systems can be used in applications that need large amounts of hot water and cooling, such as laundries and schools. More than 103 units are in use and have cumulatively saved 118 billion Btu.

### Waste Atactic Polypropylene to Fuel

This pyrolysis process converted a polypropylene plastic by-product, called atactic polypropylene, to fuel oil and gas. A total of 17 million pounds/year of atactic polypropylene was pyrolyzed into 2 million gallons/year of commercial-grade fuel oil that yielded a cumulative energy savings of 500 billion Btu.

### Waste Energy Recovery

Two waste-to-energy plants were constructed, one in Honolulu, Hawaii and one in Tacoma, Washington, that burn the combustible portion of municipal solid waste (MSW). The combustible MSW materials are burned to produce steam, which in turn, is used to power a conventional steam turbine/generator to produce electricity. These plants reduce the amount of electricity that must be produced by fossil fuels, as well as the amount of MSW that must be disposed of in landfills. These two installations have yielded more than 35 trillion Btu of energy since being commercialized.