Armstrong®

GLOBAL EXPERTISE FOR THERMAL EFFICIENCY AND DECARBONIZATION

FOR INDUSTRIAL AND INSTITUTIONAL CUSTOMERS ALIKE, ARMSTRONG BRINGS NET ZERO WITHIN REACH

All over the world, companies are under growing pressure to increase sustainability, limit reliance on fossil fuels, and reduce environmental emissions. Most are looking for a ready-to-implement, out-of-the-box solution. But while there is a systematic methodology to decarbonization, what's right for one facility may be wrong for another. Armstrong is here to do what's right for you.

AS YOUR SAGE, TRUSTED ADVISOR, ARMSTRONG CAN HELP YOU REACH NET ZERO MORE SEAMLESSLY THAN ANYONE IN THE WORLD.

Armstrong has been helping companies improve efficiency, lower energy use and reduce environmental emissions for over a century. We're a global leader in thermal utility system management with trained thermal utility engineers in locations, worldwide. Armstrong has extensive expertise in steam and condensate, hot water, heat transfer, humidification, flow measurement and remote monitoring, and our proprietary thermal utility management software ecosystem includes AI for first-in-class steam trap management.

AS ALWAYS, ARMSTRONG IS YOUR THERMAL UTILITY PARTNER.

We take a holistic approach that considers your entire thermal utility system, as well as the unique requirements of your facilities and industry. Armstrong handles everything—from comprehensive thermal studies and mapping of existing plants to on-site thermal utility management and designing new, energy-efficient facilities and utility systems. Our experts are hands-on, responsive, and with you every step of the way, throughout installation, implementation, training and everyday management.

ARMSTRONG'S DISTINCTIVE METHODOLOGY

Based on knowledge and insight gained from user feedback sessions and decades of performing hundreds of global thermal utility assessments, Armstrong's engineers have developed a repeatable, three-step decarbonization process—Optimize. Minimize. Decarbonize. Using this distinctive methodology, we'll design a tailor-made plan of action that leads you through your transition to net zero and beyond.

THE THERMAL DECARBONIZATION **JOURNEY**

OPTIMIZE THERMAL EFFICIENCY

Armstrong's experts will show you how to maximize the efficiency of energy use within your plant and production processes by eliminating energy losses, desteaming, electrification, industrial heat pumps, system monitoring and waste heat recovery. Optimizing thermal efficiency is a "no regret" common first step in the Roadmap to Thermal Decarbonization.

TECHNOLOGY

Widely Applicable: Improve Steam Systems | De-Steaming | Direct Heat Recovery | Heat Pumps

CO_2 Impact: -50% to -60% Below Current
Energy Demand: -40% to -50% Below Current
OpEx: -30% to -40% Below Current
CapEx: 2 to 3 Times Current Yearly OpEx

MINIMIZE PROCESS THERMAL INTENSITY

We'll establish your baseline of utility generation, including fuels and energy used, efficiency, operational practices, and heat usage. Your plan will identify areas within your plant and processes where energy use can be minimized or eliminated by applying solutions such as reducing setpoints, upgrading process equipment, and decreasing cycle times. You'll receive overall observations of system deficiencies and the potential impact of neglecting them, followed by recommended next steps.

TECHNOLOGY

Widely Applicable: Improved Energy Efficiency | Decreased Carbon Intensity of All Types of Process Equipment

CO_2 Impact: -10% to -20% Below Current
Energy Demand: -10% to -20% Below Current
OpEx: -10% to -20% Below Current
CapEx: Already in "End of Life" CapEx

DECARBONIZE THERMAL GENERATION

Armstrong, together with our partners, will show you how to decarbonize your primary energy sources. From installing carbon capture on fossil fuel installations to producing heat with renewable energy sources, we can facilitate the solutions you need to reach your goal. Optimizing and minimizing, together, can cut your current thermal demand in half—simplifying this final, most challenging step: decarbonization of thermal generation.

TECHNOLOGY

Widely Applicable:
Electrical Boilers (Steam & Hot Water) | Shallow Geothermal | Carbon Capture

Locally Available:
Biomass / Biogas / Biomethane | Hydrogen | Solar Therm

CO_2 Impact: Reaching Net Zero
Energy Demand: No Impact
OpEx: 2 to 3 Times Above Natural Gas
CapEx: 3 to 5 Times Current Yearly OpEx

OUR PROPRIETARY EFFICIENCY METHODOLOGY HAS UNITED NATIONS AND KYOTO PROTOCOL APPROVALS.

Armstrong's advanced steam system efficiency methodology has been approved by the United Nations Framework Convention on Climate Change (UNFCCC), and ours is the first efficiency methodology to be approved for international trading of resultant carbon dioxide (CO_2) emissions under the Kyoto Protocol.

YOUR ROADMAP TO DECARBONIZATION—A PRAGMATIC, TAILOR-MADE PLAN OF ACTION

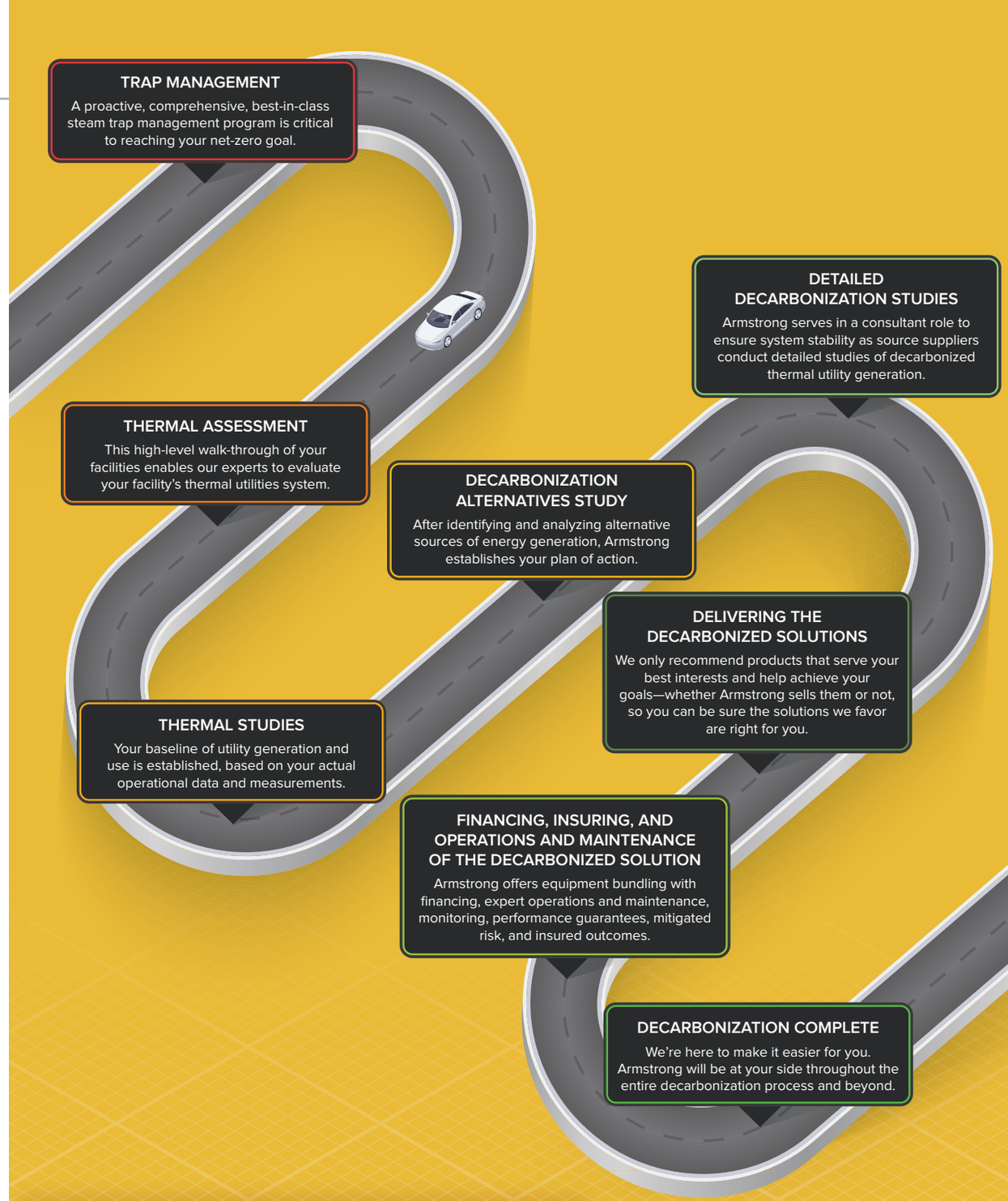
Designed specifically for your company, plant and industry, your Roadmap to Decarbonization will provide all the steps necessary for reaching your net-zero goal. This comprehensive, site-specific plan will cover thermal mapping of your facilities, planned redundancies, equipment, technology, software, funding, bundling, expert operations and maintenance, and mitigated risk. Armstrong's engineers take everything into consideration, including:

- Your goals and objectives
- Production process
- Maintenance and reliability
- Safety
- Energy reduction and efficiency
- Existing or potential issues
- Foreseeable production and product trends for the future

Whether it's real-time monitoring of your steam traps or producing heat with renewable energy sources—Armstrong recommends only the best solutions to help you reach your net-zero goal. Even after implementation is complete, our support continues.

WHEREVER YOU ARE ON YOUR PATH TO NET ZERO, ARMSTRONG WILL MEET YOU AT YOUR POINT OF NEED.

Our expertise, flexibility and in-depth understanding of thermal utility infrastructure allows us to begin the process wherever it makes the most sense for you. Your starting point will be based on your company's objectives and the unique requirements and conditions of your facilities.



ROADMAP TO DECARBONIZATION

A PRAGMATIC, TAILOR-MADE PLAN OF ACTION

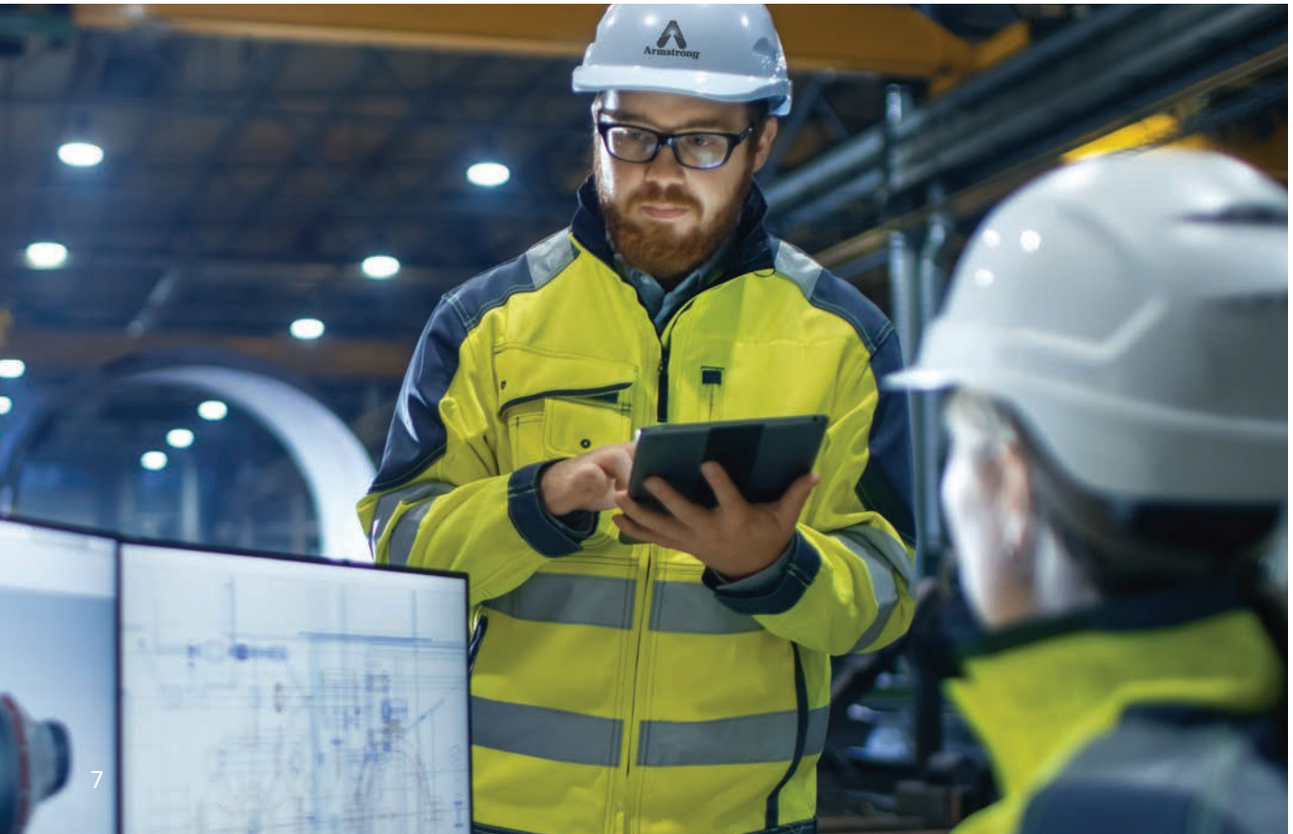
THERMAL UTILITIES STUDIES AND MAPPING

No one has more experience in thermal utility studies and mapping than Armstrong. During the past 25 years, our trained experts have performed hundreds of comprehensive thermal utility assessments and studies for some of the largest, most successful companies in the world, including globally recognized category leaders and Fortune 500 corporations.

THERMAL ASSESSMENT

Armstrong's factory-trained representatives or our own thermal utilities engineers perform a high-level walk-through of your facilities to evaluate your thermal utilities system. Our experts will:

- Establish an initial baseline of your thermal utilities
- Identify pain points within the thermal utilities infrastructure, from generation, distribution and use to condensate return
- Provide overall observations of system deficiencies, potential impact if these are not addressed
- Recommend next steps



COMPREHENSIVE THERMAL STUDIES

Based upon actual operational data and measurements, Armstrong's experts establish a baseline of utility generation and use.

Conduct Thermal Mapping Analysis of Your Plant's Thermal Systems

- Heating/cooling production and distribution
- Heat utilization
- Heat recovery systems
- Condensate return/usage
- Monitoring and measuring effectiveness

Identify Opportunities for Optimization

- Elimination of losses
- Potential application of different heat generation methods, e.g., desteaming, electrification
- Potential application of different heat recovery methods, e.g., pinch analysis, heat pump solution, thermal storage, etc.
- Budgetary savings estimates with simple ROI
- Determine capital and non-capital projects

Establish a Plan of Action

- Define immediate goals and objectives
- Define long-term goals
- Determine cost-effective, reliable, future-proof solutions
- Prioritize projects and identify next steps

TRAP MANAGEMENT SERVICES

Proactive trap management is one of the most important steps you can take towards tracking and reducing CO_2 emissions and reaching your net-zero goal. Armstrong offers leading-edge technology, software, equipment and services for best-in-class trap management that includes consistent and efficient monitoring of a site's steam trap population.

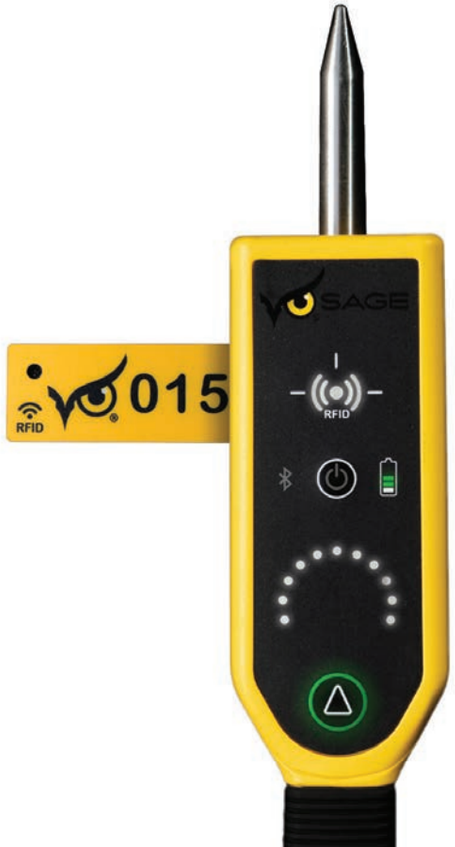
SAGE® SMART STEAM SYSTEM MANAGEMENT SOFTWARE

- Energy loss and emission loss measurements
- Historical reporting and trend analysis
- Maintenance work order reports
- Performance; monetary losses; testing methods
- Multiple inputs (manual, SAGE UMT®, wireless monitoring)
- Global facility integration (benchmarking)
- Data is customer-owned
- Subscription-based model

In 2016, Armstrong brought you SAGE®, the most powerful platform for steam system management available. During the first two years, SAGE® users added nearly 650,000 traps and updated them over 4 million times. With the help of SAGE®, our customers have identified two billion pounds per year in CO_2 savings and $150 million in potential steam loss savings.

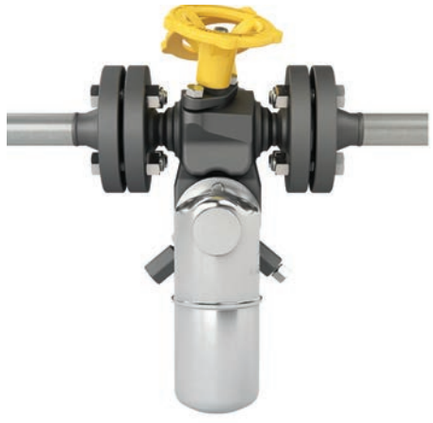
SAGE UMT® AUTOMATIC STEAM TRAP TESTER

- Simpler, faster, more accurate trap surveys
- Detects traps in good, cold and blow-through condition
- Non-contact infrared temperature sensor
- RFID technology significantly reduces time required to locate and identify traps
- Works seamlessly with SAGE®
- Data is uploaded to the cloud by SAGE® for secure storage and automated backups



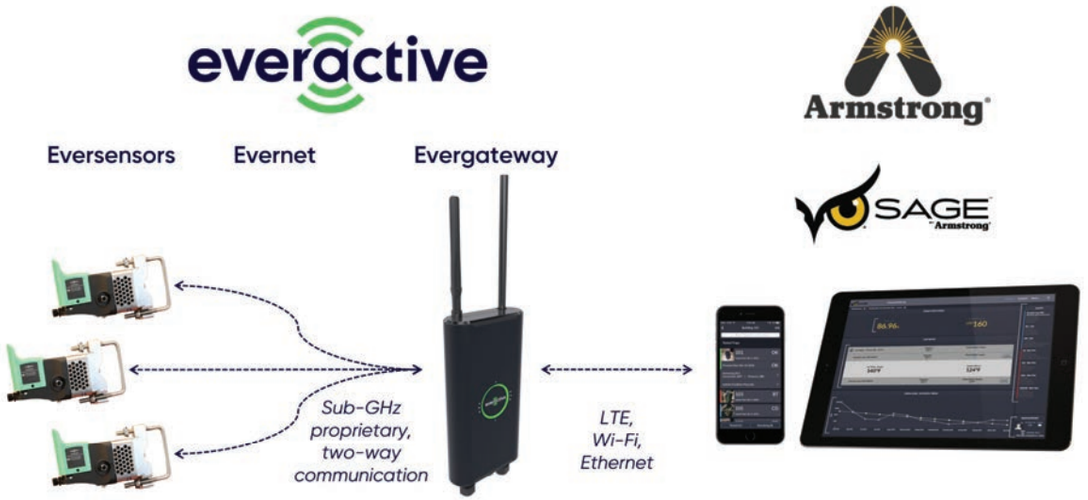
STATE-OF-THE-ART TRAP VALVE STATIONS

- Simpler steam trap testing
- Fast, easy replacement of failed steam traps—with no need for a system shutdown
- Designed to eliminate risk, improve safety and save space



EVERACTIVE BATTERYLESS STEAM TRAP MONITORING

- Real-time monitoring of critical process traps or your entire steam trap population
- Connects directly to SAGE®
- Harvests energy from the heat of the steam
- No cost for batteries or maintenance to replace
- Real-time alerts and notifications; 24/7 wireless transmission
- Subscription-based model

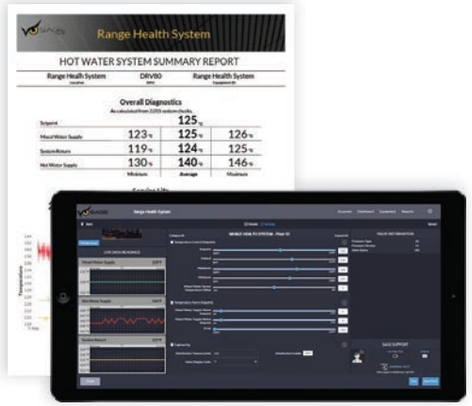


MONITORING AND MEASURING

You can't manage or improve what you don't measure. Armstrong eliminates that problem with groundbreaking technology and equipment for thermal utility system monitoring and measuring.

ADVANCED FLOW MEASUREMENT TECHNOLOGY FOR STEAM, LIQUID AND GAS

- VERIS Accelabar®
- VERIS Verabar®
- Armstrong Vortex Meter



STEAM AND HOT WATER SYSTEM MONITORING AND DOCUMENTATION

- SAGE® Smart Thermal Utility System Management software

HEAT TRANSFER EFFICIENCY

In order to reach your overall decarbonization objectives, it's important to ensure the maximum amount of primary energy used within your plant ends up in the process. Armstrong's experts will help you lower energy consumption and costs, reduce emissions, and improve production and efficiency in your facilities with custom-engineered equipment and system packages for waste/process heat recovery.

- Energy recovery coils
- Condensing economizers
- Air-cooled heat exchangers
- Geothermal heat exchangers
- Focus on waste heat streams from process heating, exhaust stacks, flash vents, hot process water discharge, etc.
- Biomass air pre-heater solutions
- Low temperature heat sinks
- Complete series of coolers and heating coils

CONDENSATE MANAGEMENT

Armstrong addresses the ongoing challenge of water conservation with leading-edge treatment of hot water from condensate. We can significantly reduce your need for makeup water, heat energy (fossil fuels), and chemicals required to regenerate it back to usable steam. We also provide solutions for heat recovery from condensate unreturnable due to contamination. Armstrong offers a full range of condensate recovery and management products and solutions, including pumps.

DESTEAMING

The conversion of steam systems to hot water—also known as desteaming—is a key step in optimizing thermal efficiency. Desteaming can also be applied to other direct steam injection applications by choosing different technologies to achieve the same results, such as using adiabatic humidifiers to desteam humidification. Armstrong offers state-of-the-art solutions to help you maintain precision hot water temperatures, eliminate live steam, and generate all the hot water your plant needs at 99.7% efficiency—no boiler required.

MORE EFFICIENT HOT WATER GENERATION FOR PROCESS OR WASHDOWN

- Flo-Direct® Complete Thermal Exchange Gas-Fired Water Heater
- Armstrong Combitherm Industrial Heat Pump

PRECISION HOT WATER TEMPERATURE CONTROL

- Emech® Digital Control Valves
- Delta2 Series SMD 3-Way Control Valves
- The Brain® Digital Recirculating Valve

CUSTOMIZABLE, LOW ENERGY CONSUMPTION HUMIDIFICATION

- EvaPack™ Adiabatic Cooling and Humidification

OPERATIONS AND MAINTENANCE SERVICES

Backed by Armstrong's world-class utility and engineering resources, our highly trained experts provide comprehensive on-site operations and maintenance of your thermal utility system—including decarbonization solutions. Advantages include:

- Utility performance tracking, measuring energy use per unit of product produced
- Improved reliability, energy efficiency, environmental compliance and sustainability
- Lower overall thermal utility operating costs
- Reduced volatility in total operational budgets

RENEWABLE ENERGY SOURCES

Guided by our thermal studies and research, Armstrong, together with our partners, will help you decarbonize your facilities' primary energy sources. We can also help secure financing, provide guarantees of performance, insure outcomes, and operate and maintain your thermal utilities throughout the continuum.

WE PARTNER WITH RESPECTED RENEWABLE ENERGY COMPANIES THAT SPECIALIZE IN ALTERNATIVE OR RENEWABLE ENERGIES

Armstrong doesn't favor any particular decarbonization alternative or technology. The only options we provide are those that will ensure the safety, integrity and reliability of your thermal utilities. Our recommendations maximize use of free energy sources and include only the best solutions to reach your unique goals and objectives—whether Armstrong sells them or not.

IDENTIFYING SOURCES OF ALTERNATIVE OR RENEWABLE ENERGY

Before recommending the appropriate alternative or renewable energy sources for your facilities, Armstrong's experts will take a variety of factors into consideration, including: your site location and existing utilities, availability, budget, reliability, and your current and future thermal needs. Potential sources include:

- Geothermal
- Wind
- Solar
- Biofuels
- Hydrogen
- Thermal storage
- Carbon capture (reuse or storage)
- Renewable NG and electricity available from utilities suppliers

To schedule a meeting or learn more,
visit armstronginternational.com/decarbonization.

INTELLIGENT THERMAL UTILITIES SOLUTIONS FROM A GLOBAL
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