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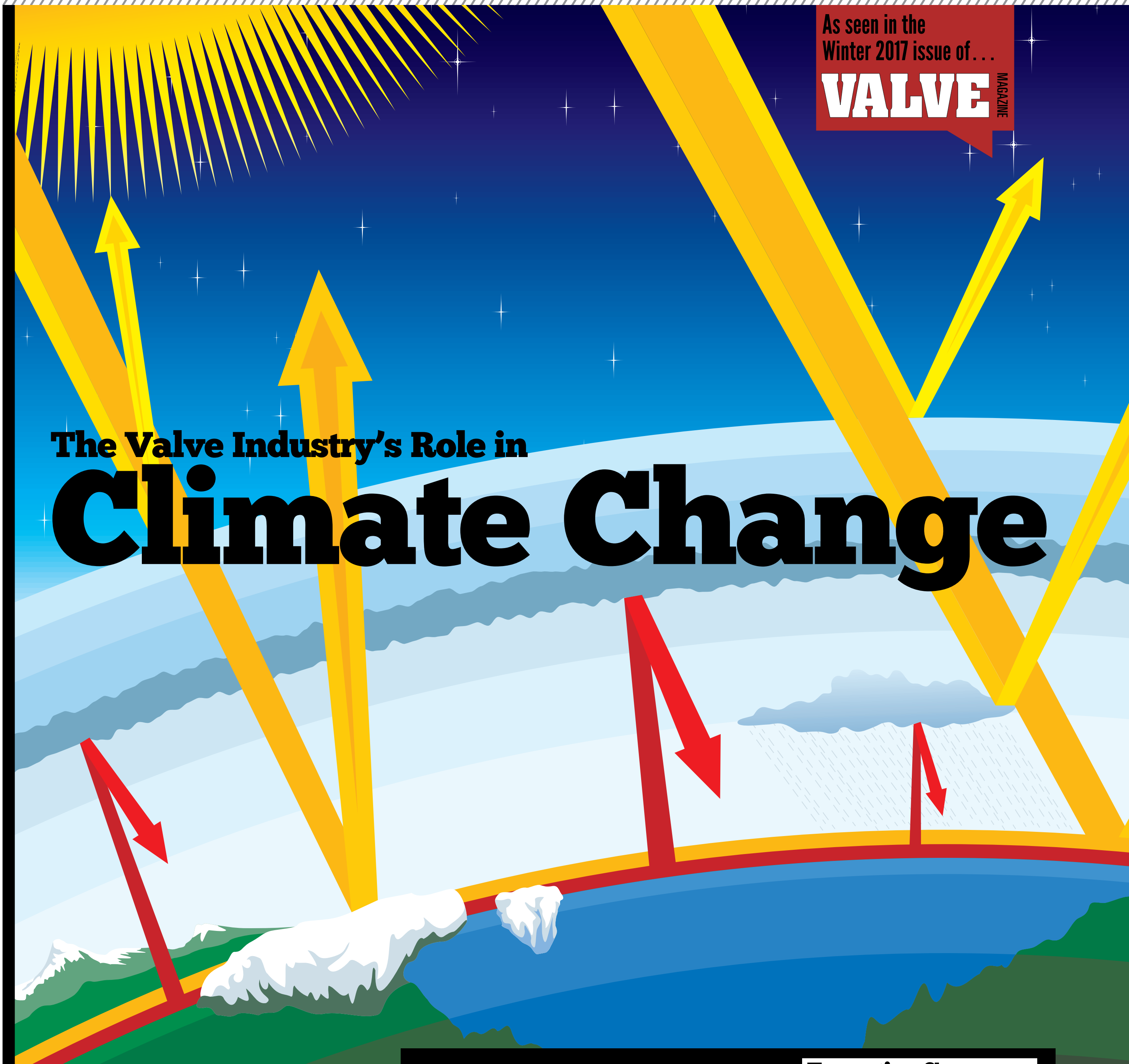


## The Valve Industry's Role in

# Climate Change

BY JOHN V. BALLUN, P. E.

The world may not agree on all the causes of climate change, but most people realize our actions over the last 150 years have directly contributed to greenhouse gas (GHG) buildup, most notably accumulation of carbon dioxide and methane. The concern about global warming is based on regular measurements and projections that document quantitatively how these GHGs are added to the atmosphere at a rate far faster than natural processes can remove them. Moreover, these gases are transparent when it comes to

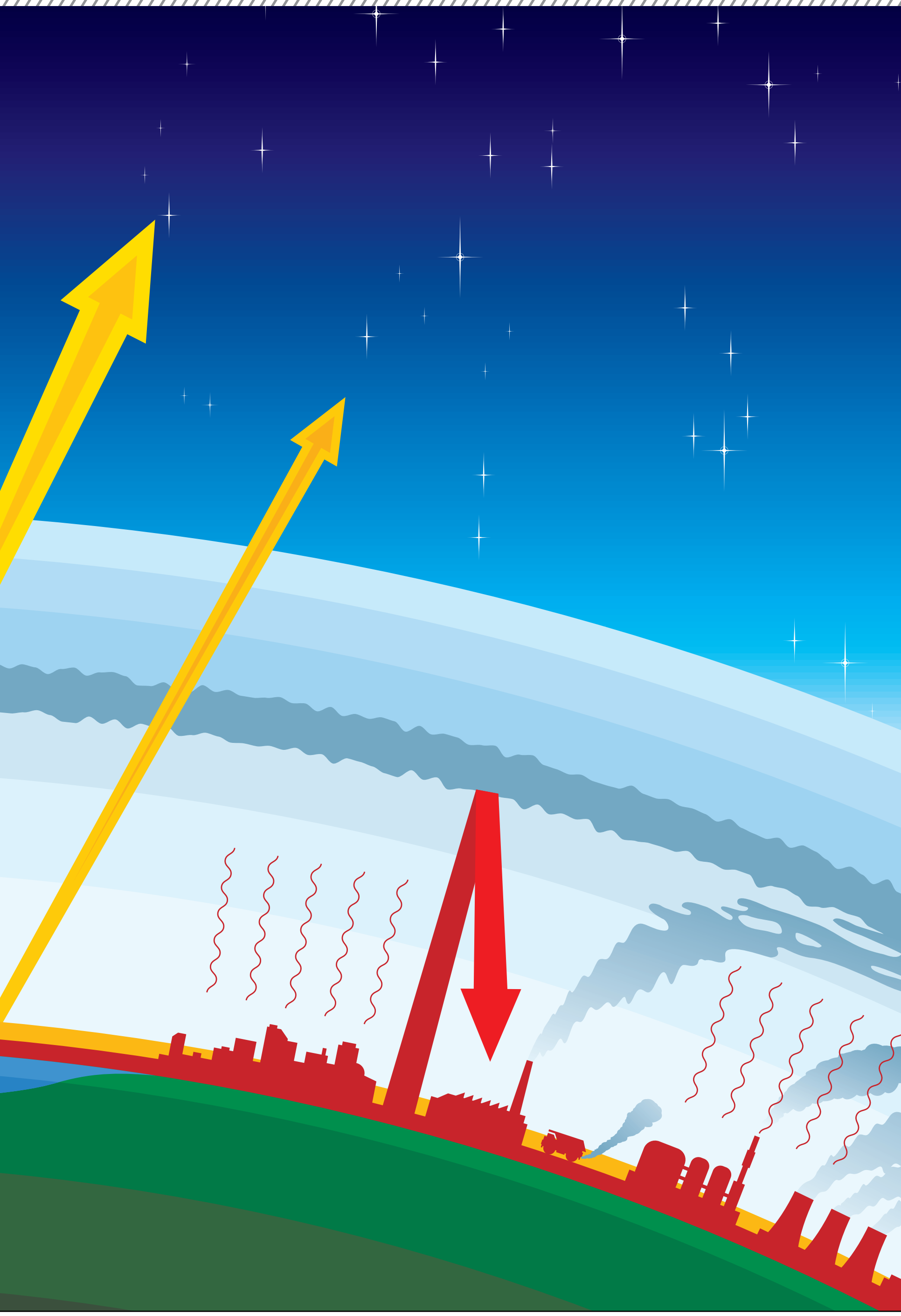

### Executive Summary

**SUBJECT:** The valve industry offers technical solutions to mitigate the accumulation of greenhouse gases, which has an effect on climate change.

**KEY ISSUES:**

- How valves save energy
- Solutions from valve technology
- Social response of valve makers

**TAKE AWAY:** Advances in valve technology and the management of valve factories with social responsibility can save energy and reduce the effects processes have on emissions and the environment.



solar radiation while absorbing infrared radiation expelled from the earth's surface. This acts like a blanket over the planet and causes the greenhouse effect, which most of the world agrees is affecting our climate.

Energy balance equations clearly reveal that the result is increased global temperatures and higher sea levels over this century.[1] The debate continues about how severe the planet's situation is, but science tells us we better take notice and take action soon.

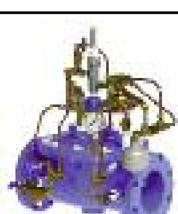
Although the valve industry's role is not often recognized, the industry can be critical in mitigating climate change. This occurs through education of valve users on how to reduce energy consumption and how to control emissions through valve selection, advanced valve technology and modern factory management. While governments around the world contemplate various treaties and policies, the valve industry actively participates in solutions.

## ENERGY SAVINGS

Valves are vital to most fluid systems because they control and contain flow and pressure, release gases, and prevent backflow and leakage. Their ability to minimize energy consumption, thereby reducing carbon footprint, is often overlooked.

Pumping systems need significant energy to overcome the combination of the static head of the system and the friction head of the piping. The friction head is caused by roughness of the pipe's inside surface as well as local flow disturbances from fittings and valves. Although valves come in

**Table 1. Typical NPS 12 Valve Flow Coefficient Data[2]**

| TYPE OF VALVE | Control Valve | Swing Check Valve | Eccentric Plug Valve | Tilted Disc Check Valve | Butterfly Valve | Ball Valve |
|---|---|---|---|---|---|---|
| PORT SIZE | 100% | 100% | 80% | 140% | 90% | 100% |
| $C_V$ (gpm) | 1,800 | 4,200 | 4,750 | 5,400 | 6,550 | 21,500 |
| Illustration |  |  |  |  |  |  |

many varieties, they cause friction head in similar ways.

Valve body geometry dictates the general flow area through the valve. A common practice is for valves to restrict the flow area to below 80% of the pipe area. Also, the internal contours of the body and seat may be rough or contain cavities and transitions, which creates excessive turbulence. The design of the closure member is important for two reasons: First, the lowest head loss is achieved if the closure member swings or rotates out of the flow path. Second, the closure member for check valves should have contours that mean they fully open at low fluid velocities and create a smooth flow path through the valve.

Computing the head loss produced by various types of valves is normally simple—the most ubiquitous flow coefficient for valves is the $C_v$ flow coefficient, which is defined as the amount of water (in gallons per minute or gpm) that will pass through a valve with a 1 psi pressure drop. Hence, the more efficient the valve, the greater the $C_v$. Table 1 presents the flow characteristic and generic $C_v$ values for several general valve types showing that the full port ball valve has the highest $C_v$ given its full, unobstructed flow path.

To save energy, it is important to consider the head loss between types of valves; the head loss between various suppliers of a given valve type does not typically produce significant changes in system operations. This fact is also the reason piping system computer simulations accurately model system behavior based on generic valve characteristics data.

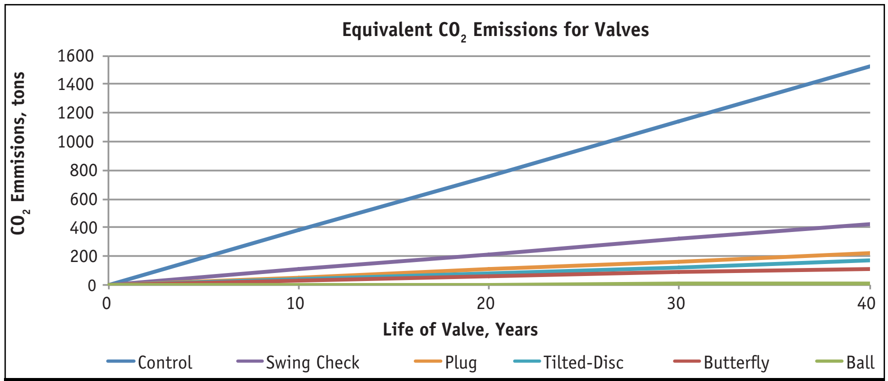



Figure 1. Valve choice has a dramatic effect on emissions.

The flow conditions of the system also can affect the valve head loss. In general, head loss is a function of fluid velocity squared. That means a doubling of the line velocity will increase the pipe, fitting and valve head losses four-fold. This is why pump discharge velocities are typically held to the 8- to 16-foot-per-second range, and pipeline velocities are kept to the 4- to 8-foot-per-second range. Since valve coefficients and head loss are a function of velocity, the overall cost of energy consumption versus pipe costs should be evaluated to see where there is an optimum pipe size and velocity that provides the lowest present value of installation costs plus annual operating costs.

Water and wastewater plants in the United States annually consume about 75 billion kilowatt hours (kW-hr) of energy.[3] Nearly 80% of the energy is consumed by potable water plants for high-service pumping to overcome the static head and friction losses of distribution systems. Water utilities have an opportunity to employ various energy saving strategies, including valve selection, that can result in a 20-50% reduction in energy consumption, thereby reducing operating costs.

Figure 2. Air valves on pump discharge reduce air in pipelines in Chino, CA.

The head loss from valves can be directly converted into an energy cost related to electrical power needed for the pumping to overcome the additional head loss from the valve, using this equation[4]:

$$A = (1.65\ Q\ \Delta H\ S_g\ C\ U) / E$$

Where:

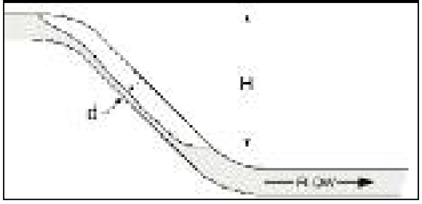
- $A$ = annual energy cost, dollars per year
- $Q$ = flow rate, gallons per minute
- $\Delta H$ = head loss, feet of water
- $S_g$ = specific gravity, dimensionless (water = 1.0)
- $C$ = cost of electricity, \$/kW-hr
- $U$ = usage, percent x 100 (1.0 equals 24 hours per day)
- $E$ = efficiency of pump and motor set (0.80 typical)

An example for a Nominal Pipe Size (NPS) 12 control valve operating at 12.7 feet per second would be:

$$A = (1.65 \times 4500 \times 14.42 \times 1 \times .08 \times 0.5) / 0.8$$
$$= \$5355 \text{ per year}$$

If the control valve in this example has a 40-year life, the total energy cost will be \$214,200, which could

Figure 3. Head loss (H) due to an air pocket in a pipeline



be reduced to $1,488 if a low head loss valve such as a full-port ball valve was used. What's more, larger valves handling higher flow rates consume even greater amounts of energy. This makes it clear that valve selection plays an important role in energy and cost savings.

Moreover, saving electrical energy reduces the need for burning fossil fuels, which further reduces ways to create GHGs. On a national average, for every kW-hr of electricity used, about 1.14 pounds of $CO_2$ emissions are generated. This means in the example above the use of a ball valve instead of the control valve could result in savings of 1,525 tons of $CO_2$ emissions over the 40-year life of the system (Figure 1).

## AIR RELEASE

Another family of valves important to energy conservation are air valves. Even after a pipeline is commissioned, air is continually introduced into pipelines from vertical pumps, entrained air and external connections. It often comes as a surprise to pipeline designers that the cause of a pumping system's inefficiency or stoppage can be a result of air in a pipeline because many people assume it is easier to pump air than water.

Every time a vertical pump is started, however, the air in the pump column must be expelled by the air valve mounted on top of the discharge pipe (Figure 2.) When a pipeline contains highpoints followed by descending runs, air will inevitably be trapped because of the buoyancy of the air unless the pipeline is equipped with automatic air valves. Figure 3 shows that trapped air forms a long pocket along the pipe descent with a constant depth "d". Since the air is at the same pressure along the air pocket, the head loss may be equal to the vertical height of the pocket or dimension "H".[5]

When several highpoints in a pipeline exist, the head losses are additive. Therefore, during initial pump startup, the line can appear to be blocked because the pump cannot overcome the sum of the head losses in all of the highpoints—even at the pump shutoff pressure.

Using automatic air valves eliminates the air pocket and restores the pumping efficiency of the pipeline.

The importance of air valves cannot be overlooked. These valves not only maintain the flow efficiency of a pipeline, they also perform many other functions including surge control, corrosion prevention and vacuum protection. Their location and sizing are covered in American Water Works Association Manual M51.

Figure 4. Tank blanketing vapor recovery regulators reduce emissions from petroleum tanks.

Figure 5. A technician works on a valve certified to meet new EPA emission standards.

## VALVE TECHNOLOGY

Not that many years ago natural gas valve actuators may have been powered by the process fluid, which consists mostly of methane. The pressurized gas was used to drive a valve actuator cylinder and then was expelled to the atmosphere. This was before GHGs were monitored and their impact fully understood. Today, we know that certain GHGs such as methane have 25 times the impact on the greenhouse effect as others such as carbon dioxide. As a result, process valves are now powered by clean gases or fluids.

A drive-by of any refinery reveals the noticeable odor of hydrocarbon fugitive gas emissions. Historically, one cause was that when tanks were filled with petroleum, the hydrocarbon-laden gases in the tank were expelled to the atmosphere through a vent valve. Technology has changed, however, and now vent valves have been replaced with vapor recovery regulating valves that automatically control the blanketing pressure over the fluid in the tank as it is filled, allowing the excess gas to flow into a vapor reclamation system.

Another cause of emissions is leakage through valve stem packing. The valve industry worked with the American Petroleum Institute (API) to develop valve packing and valve testing standards to verify that valves meet emission requirements the U.S. Environmental Protection Agency (EPA) has established. API standards now follow EPA low-emission requirements of 100 parts per million (ppm) for five years and provide testing and qualification steps for valve packing and valve assemblies at various mechanical and thermal cycles. While no valve is perfect, the valve industry is prepared to meet the requirements set for fugitive emissions to reduce effects on the environment.

Regulating fuel valves control the operation of power plants and furnaces across the country. The valve industry continually works on creating and using more precise and efficient process control technologies to conserve fuel and eliminate waste in these energy systems. Next-generation fuel pressure regulator valve assemblies, for example, are now used for engines to maintain fuel system pressure, assure quick starts and protect fuel systems from overpressure by returning excess fuel to fuel tanks. Valves

Figure 6. Specially designed ball valves (blue valve) are used to safely isolate a geothermal wellhead.

Figure 7. Efficient equipment with recycled fluid is used to test FBE-coated valves.

used in this service are located within the in-tank fuel pump module, and they are designed to handle customer-specific applications by determining the opening pressure and flow characteristics needed for optimum fuel system performance. By more precise control of flow rates and pressures, fuel is conserved, and engines and furnaces run more efficiently while producing lower emissions.

Finally, recent improvements in ball valve technology have allowed greater energy conservation. New materials and manufacturing processes mean ball valve seating systems have advanced greatly over the last decade. Both metal seats and resilient seating technology have been reengineered to provide low- to zero- leakage under extreme conditions. The advent of five-axis computer numeric coding machining capabilities means ball valve manufacturers can now make perfectly matching spherical ball and seat-metalized surfaces. As a result, a ball valve can be used for traditional high-temperature globe valve applications in power plants, which saves energy and reduces GHGs from the ball valve's extremely high $C_v$.[6]

Similarly, design enhancements have occurred such as a specially machined ball with recesses, which forms a raised sealing surface in both the open and closed positions. This provides self-cleaning action during operation to extend use of the valve in applications where sediment is a problem. Such valves are used on geothermal wellheads at pressures to up to 508 psi (3500 kilopascal) and temperatures reaching 500°F (260°C) with fluids consisting of moderate saline chloride brines containing total dissolved solids[7] (Figure 6). Leak-tight valves with robust integrity improve the efficiency of fluid processes and prevent the release of the process fluid to the atmosphere.

Evolving valve technology also contributes to new energy technologies. A global emphasis has been placed on new energy generation systems to mitigate climate change, including renewable energy sources such as biomass, hydroelectricity, geothermal power and nuclear power. Valve technology is following that development to support these evolving energy technologies. For example, the safe, high-performance nuclear valves available for decades are now used with new, passive nuclear plant designs and high-temperature recycling reactor waste systems to make nuclear energy generation an attractive solution.

## VALVE FACTORIES

U.S. valve manufacturers and other industries take social responsibility seriously and actively engage in activities that mitigate climate change. Examples include using energy-efficient lighting and equipment in factories. Meanwhile, coating processes for valves have migrated from solvent-based coatings to coatings with high solids content to reduce volatile organic compounds. More advanced coatings include powder-based coatings with zero emissions such as fusion bonded epoxy (FBE).

It is now common practice for factories to sort and recycle spent materials as well. Many quality management systems require excess and scrap materials be carefully controlled, segregated, and shipped to recycling centers for reprocessing, often back into the same foundries to produce castings for new valves. Valve production also can use large volumes of water for cleaning and testing final products. Recycling systems are employed to reuse water to reduce the burden on our municipal water and wastewater systems (Figure 7).

An important focus in the valve industry is lean manufacturing practices. Lean manufacturing is not about cutting jobs, but rather improving processes to reduce waste. Many tools are employed to accomplish these goals, but all of them are designed to improve the efficiency of the overall manufacturing process.

## CONCLUSION

Valves not only play an important role in the function of piping systems, they also can reduce energy consumption and help mitigate the release of greenhouse gases. For example, proper selection and placement of air release valves can greatly enhance the energy efficiency of fluid systems. While it is important for purposes of efficiency to calculate the head loss and energy costs associated with valves, these energy savings also translate into a reduction in the world's carbon footprint. The valve industry has evolved rapidly with new technologies and products to help in these efforts, and it will continue to find ways to contribute to the mitigation of climate change. VM

**John V. Ballun**, president and CEO of Val-Matic Valve, is a regular contributor to VALVE Magazine. Reach him at jvb@valmatic.com.

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