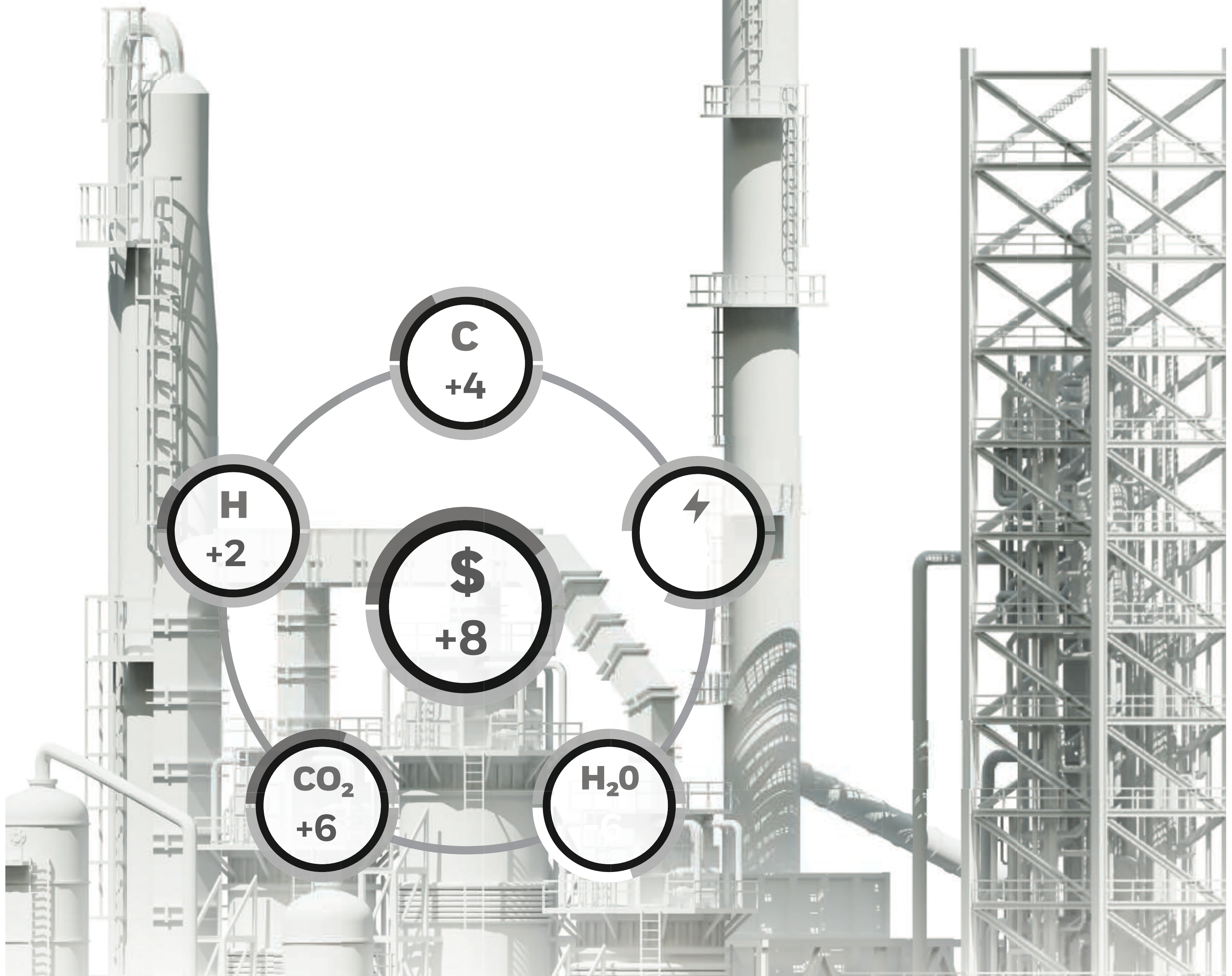
HYDROCARBON ENGINEERING

March 2020



DEALING WITH THE DELHI DILEMMA

Shruti Parkar and Raghavendra Swami Kannaraya, CECO Environmental, India, outline how India's new fuel regulations are driving refinery modernisation.

India has a lethal problem with its air. As other developing nations have, it must find a way to grow its infrastructure – industrial production, power generation, refining and wastewater treatment – while balancing the social health of its citizens. With air quality technologies becoming more widely

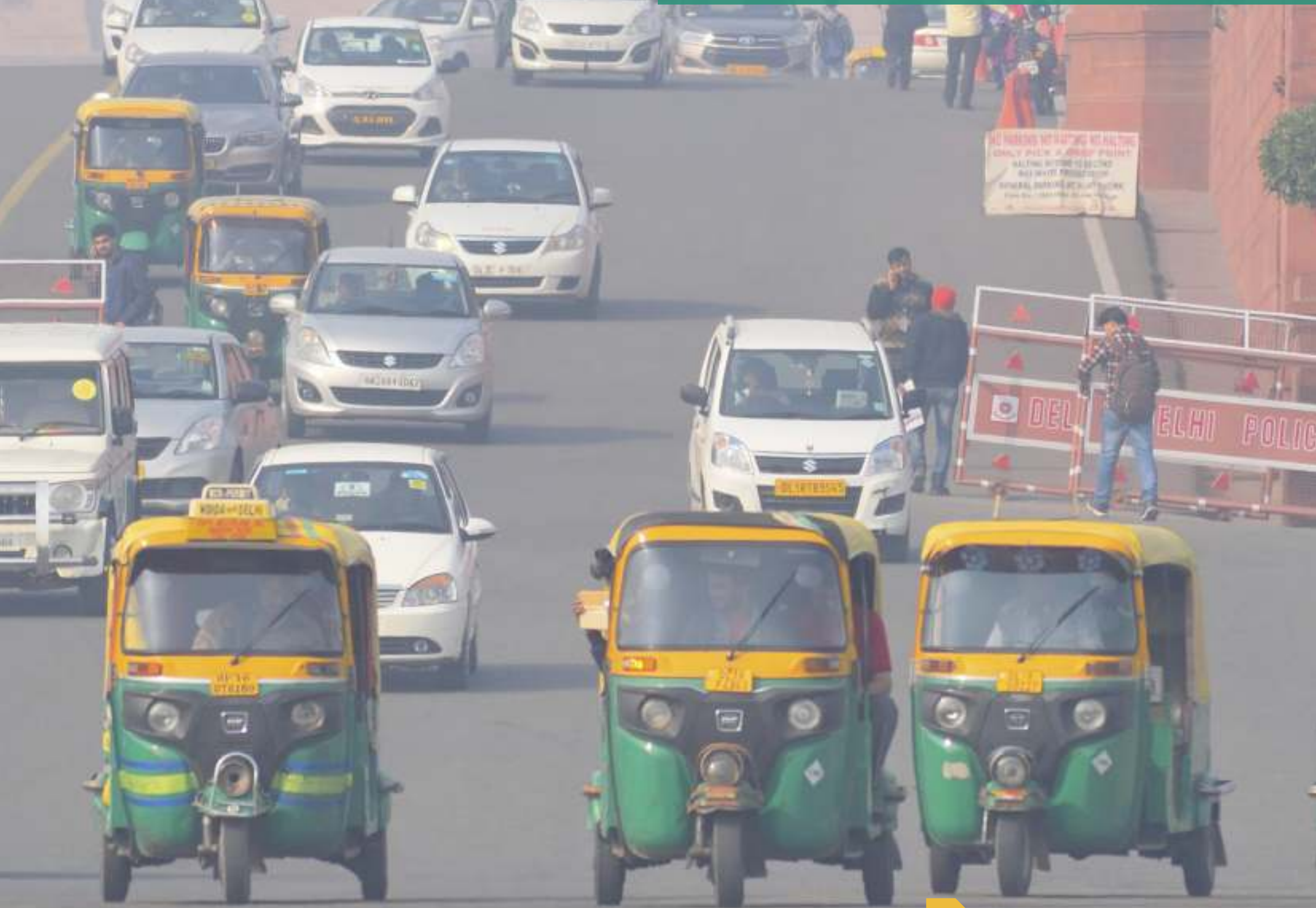


Figure 1. The FCC cyclone is lowered into the refinery. It is a key component of refinery operations and profitability. Having efficient and reliable cyclone systems is key to achieving state-of-the-art performance.

The energy industry is taking on an important role in driving necessary change for India's largest cities. Key multinational players are forming partnerships with local oil and gas entities to modernise existing, and build out new, refinery infrastructure. This is not a new role for oil and gas companies and power generation plants to drive and support the evolution of developing societies. With new and modernised refineries, India is able to drive new regulations that require automobiles to run on higher quality fuels – resulting in a significant reduction in the air pollutants associated with adulterated fuels.

The single biggest source of air pollution in Delhi is vehicle exhaust, an indirect consequence of overcrowding. This results in

available to advanced and developing nations, it may be easier for India to manage the issue.
Atmospheric pollution in India is the fifth largest cause of death in the nation – recently estimated to kill approximately 2.5 million people a year. Specifically, the World Health Organization has found that India has the world's highest death rates from asthma and chronic respiratory illness. In Delhi in particular, suffocating air quality has irreversibly damaged the lungs of 2.2 million children (approximately 50% of the total number of children in the city) – a public-health crisis that will go on causing sickness and premature death for decades.

So where is all this pollution coming from? The answer is not simple. In fact, the problem has multiple sources and components that reflect India's developing nation status, including the transition from an agricultural to an industrial-technological economy, poverty-related pollutants and urban overcrowding.

One energy-related major pollution source, driven by poverty at one end and opportunity at the other, is the dilution of gasoline with cheaper petroleum derivatives, notably kerosene. This problem is partly the unintended consequence of a tax policy meant to reduce tailpipe pollution. Throughout South Asia, gasoline is taxed more heavily than diesel, which in turn is taxed more heavily than kerosene, naphtha, and similar lower-grade hydrocarbons. This policy was intended to encourage the use of public transport rather than private cars and to avoid placing extra burdens on motor freight operators, whose trucks run on diesel. Instead, gasoline in India was becoming more adulterated with kerosene, naphtha, and diesel fuel, up to 80 – 90% in some cases, while diesel fuel was adulterated with kerosene. Emissions from fuel adulteration is one of the top contributors to urban air pollution.

emissions of nitrogen oxide (NO_X), sulfur, carbon monoxide, volatile organic compounds (VOCs), and – in some ways the deadliest – carbon microparticles, which lodge in lung tissue. At average trip speeds between 5 and 20 km/hr – common during rush hour in Indian cities – cars' pollutant emissions are 4 – 8 times as much as when the average speed is 55 – 70 km/hr. The NO_X emissions cause photochemical smog that mixes with the smoke and exhaust particulates, hanging in a heavy, choking layer over the city for days or even weeks at a time, especially in November to December because of local climate conditions. It is also worth noting that NO_X is many times more potent than carbon dioxide as a heat-trapping greenhouse gas.

At ground level, the VOC emissions contribute to asthma, allergies, and cancer among other grave health problems. Black carbon particles in the pervasive smoke add to the problem. And in Delhi's sprawling, often unplanned neighbourhoods, illegal factories churn out VOCs from paints and plastics and NO_X and sulfur compounds from unfiltered furnaces and boilers.

To its credit, the national government is now joining the under-resourced Delhi city administration and its counterparts in other Indian cities like Mumbai, Chennai, Kolkata, and Pune in taking some stronger measures to address the air quality crisis. The city is attempting to shut down illegal factories and, as mentioned earlier, has tightened regulations along the petroleum supply chain, from refining to consumption. As a result, this is creating a dynamic era for the energy industry as modernisation and new energy infrastructure is needed. Economically, this in turn has resulted in unique multinational partnerships to finance and develop the build out in order to produce quality fuels in compliance with new regulations.

Figure 2. Scrubbers are pollution control devices that use liquid to wash unwanted pollutants from a gas stream, or that inject a dry reagent or slurry into a dirty exhaust stream to 'wash out' acid gases. Scrubbers are one of the primary devices that control gaseous emissions, especially acid gases.

Joining in the infrastructure modernisation and build out are a growing number of technology companies that bring air pollution control expertise. Technology engineers who specialise in the various control and abatement technologies are working with refineries and other industrials to evaluate production, growth projections, emissions and local regulations in order to specify the right technologies. Some of the most commonly utilised air pollution emissions control and abatement technologies can be organised by the air pollution issues they address:

Fuel quality and byproducts

Refineries are installing advanced fluidised catalyst cracking (FCC) cyclone technology to convert heavier hydrocarbon fractions of crude oil into gasoline and other useful products and to raise the quality of gasoline to the government of India's new standards. The better-quality gasoline combines with more efficient engines, also mandated by new government standards, to reduce exhaust emissions. Other teams are helping to upgrade the production of polypropylene, a refining by-product that is a key ingredient in plastics.

Refinery exhaust emissions at the stack

Petroleum refining generates large volumes of NO_X, notably in the ethylene 'cracking' process. Refineries are installing selective catalytic reduction systems and, more specifically, upgrading ammonia injection grid (AIG) technology to cut NO_X emissions by as much as 95%. Companies such as CECO Peerless, who have been working towards this goal for decades, have already helped prevent millions of tonnes of particulates from being released into the air.

Eliminating particulates and dust associated with polypropylene

Industrial scrubbers and cyclones along with other dust collection and exhaust systems are increasingly added during refinery upgrades, especially in the case of byproduct production such as polypropylene, which are a key ingredient in plastics.

Reducing toxic VOCs and hazardous air pollutants (HAPs)

Regenerative thermal oxidisers (RTOs) and industrial dry and wet-bed scrubbers are specified in a broad range of industrial applications from plastics, composites, paint and coatings manufacturers to scrap metal yards. These technologies often work together to scrub and channel pollutants through filter and exhaust systems so that the air is toxin-free and safe to breathe by the time it is emitted back into the atmosphere.

One of the largest oil and gas companies in Delhi recently acquired a large-scale RTO from CECO Environmental which will address a wide range of air pollution issues, including:

- VOC abatement.
- Helping the oil and gas company be in compliance with new NO_X and SO_X emission regulations.
- Remove/reduce hazardous air pollutants (HAPs) and odorous emissions.

Operating principles of selective catalytic reduction systems

As flue gases are combusted in gas turbines and process furnaces, NO_X is formed. A selective catalytic reduction (SCR) system is a post-combustion technology, which injects an ammonia (NH_3) based reagent into the flue stream to reduce NO_X emissions by up to 95%. Typically, these systems are adaptable to a wide range of temperatures and flow rates, and help power generators and oil and gas operations meet regulatory compliance requirements.

They are specified in the processing of various fuels such as natural gas, refinery gas, coal, biomass, and various fuel oils.

Benefits include the following:

- Low total cost of ownership.

- High efficiency with up to 95% NO_X emission reduction.
- Minimal life cycle costs with optimal performance systems.
- Reduced assembly time with pre-assembled modular construction.
- Enhanced design for smaller system footprint.

Operating principles of tower-type RTO

The VOC laden air is directed by the poppet valve mechanism to flow through one or more beds into the combustion chamber. These beds have been previously heated and because of the intimate contact between the air and ceramic material very high rates of heat transfer are produced. This results in the air being preheated very close to the required oxidation temperature by the time it reaches the combustion chamber.

The air then enters the combustion chamber where a small amount of heat is added by a fuel-fired burner to combustion temperatures. The thermal oxidation process then takes place and the pollutants are destroyed.

The clean air then exits the combustion chamber through another bed or beds that have been previously cooled. As the air passes through these beds it is cooled by the same heat transfer process. After passing through the cooled beds the air exits the RTO system at a temperature only slightly higher than the inlet temperature.

After several minutes the first set of beds (inlet) becomes depleted of heat while the second set of beds (outlet) becomes saturated with heat. At this point the flow of air through the beds is reversed with the formerly inlet beds acting as the outlet beds and the formerly outlet beds acting as the inlet beds. In this way each bed periodically extracts heat from the clean gas stream exiting the combustion chamber and then releases this heat into the polluted gas entering the combustion chamber. This method is thermal regeneration. The combination of thermal oxidation and regenerative heat recovery allows the RTO system to efficiently destroy VOC laden air with minimal operating costs.

Typical applications include petrochemical, biodiesel, natural gas processing, refining, composites and plastics, amongst others.

Conclusion

These contributions are only a beginning. There are many other ways air quality technology can help engineer solutions that solve the air pollution problems of developing and mature nations. On a larger scale, it will truly be a collective effort to make a significant impact on achieving higher air quality for India that must include industries such as manufacturing, transportation and energy along with banking finance cooperation with national, regional, and urban governments.

Achieving a level of air quality and protecting India's shared environment is possible while it grows into a mature, productive and affluent society.