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Shift to Gas: A Contribution on the Path to Sustainability

by Eric Koenig

Executive summary

In order for the global community to achieve its goal of limiting global warming to 1.5°C – the mandate reached at COP21 – low-emission alternatives must be quickly embraced and integrated. Natural gas offers a quick, relatively clean, and inexpensive interim step in the global transition from high CO2 emissions fossil fuels to renewable energy sources. This paper examines the implications and potential benefits of the shift to gas conversion.

Introduction

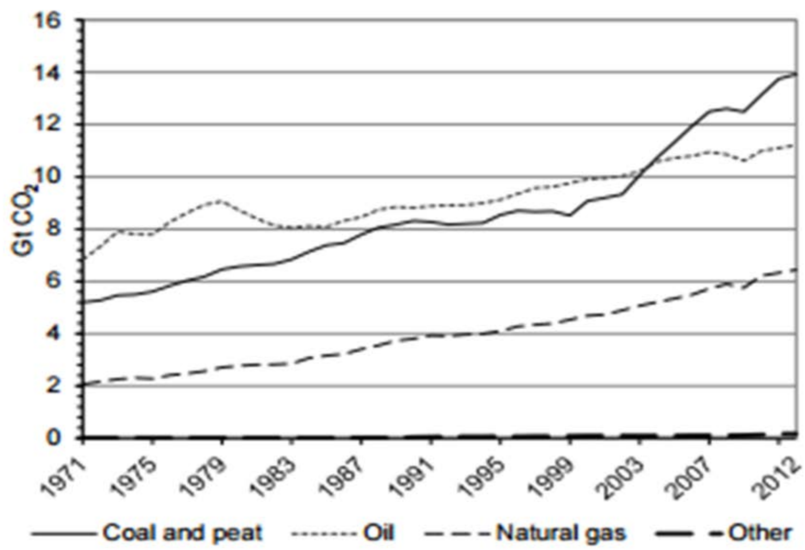
Today we live in a largely hydrocarbon-powered world. Fossil fuels represent about 80% of the primary source for power generation. Coal is plentiful in many countries such as China or India; oil reserves are still abundant and technology enables 250+ years of gas reserves. Wind and solar also represent huge potential for growth. Yet, we stand at a crossroads as we recognize the cumulative negative effects of CO_2 emissions and the impact of global warming. If CO_2 emissions are to be reduced we quickly need to adapt our energy production mix and consumption patterns.

As a result of increased energy demand, energy production and energy consumption business models are changing. Energy consumers seem ready to accept some degree of flexibility in their consumption schemes. In emerging countries the demand is for more reliable, dependable energy distribution.

Although coal, oil and natural gas are often lumped together as fossil fuels, from a CO_2 emissions perspective they are very different. In fact, natural gas is by far the lowest producer of CO_2 emissions among the three. Natural gas also is easy to access across regions with both developed and emerging economies. Of the fossil fuels that supply the majority of global energy today, coal is by far the biggest contributor of CO_2 emissions (see **Figure 1**). In addition, coal plants also lead the way in the release of harmful pollutants and particulates into the air.

Figure 1

World CO_2 emissions by fuel (Courtesy of IEA/OECD Emissions from Fuel Combustion)



Political will is another important catalyst that can help to accelerate the CO_2 emissions reduction process. Legislation around carbon pricing, incentives for cleaner energy and comprehensive education programs will all add to the momentum. A robust and high enough CO_2 price for example would be a key enabler of the coal to gas migration.

The commitments made at the 2015 global climate conference, COP21, including the pledge by representatives of 195 countries to limit global warming to 1.5°C above pre-industrial levels, are poised to change how mankind meets its power needs, impacting the business decisions of energy producers and consumers alike – and the health of the planet our children will inherit.

Some of these decisions will catalyze the creation of a global energy network of interconnected, efficient producers and consumers where energy costs and CO_2 emissions are low, and where reliability, safety and efficiency levels are high for all

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populations regardless of geographical location and financial status. This is a world where energy supply is plentiful, cheap, and increasingly renewable. It's a world where automation simplifies the complex task of managing a profitable energy supplier.

Regardless of the type of fuel utilized to generate electricity, the major potential for CO_2 emission reductions resides in the energy efficiency gains made at end use (as opposed to the energy generation side). In addition to reductions that can be gained from the shift to natural gas and, potentially, from carbon capture and storage, further reductions need to be provided by the following:

- Energy efficiency measures in commercial and residential buildings and in industrial processes, including energy production processes themselves.
- The further development of "green" transportation fuels such as recharging networks for electrical vehicles, compressed natural gas for transportation on roads, and liquefied natural gas for truck and bus fleets and for marine transport environments.
- The further expansion of renewable energies such as biogas, solar and wind power generation.

The clock is ticking. Today, global warming is on the rise, and greenhouse gas generation – from industry to the home – is negatively impacting global climactic conditions. The challenge the world faces is how to fuel continued economic growth, especially in developing countries and in the face of a surging global population, while cutting down by half the amount of carbon emissions that are released to the atmosphere.

Natural gas, although a fossil fuel, produces a much lower rate of both CO_2 emissions and particulates when processed (see **Figure 2**). While renewable energy programs and technologies strive to grow their foothold as a means for producing clean energy, they cannot do so today at scale. This white paper proposes an important transitional step: An ambitious, shift to gas in the coming 10 to 15 years. This paper will demonstrate how such an initiative will reduce global CO_2 production by 25%, while being complementary to the efforts of growing renewable energy generation. If the prospect of Carbon Capture and Storage (CCS) is factored in, CO_2 levels could be reduced by an additional 35%.

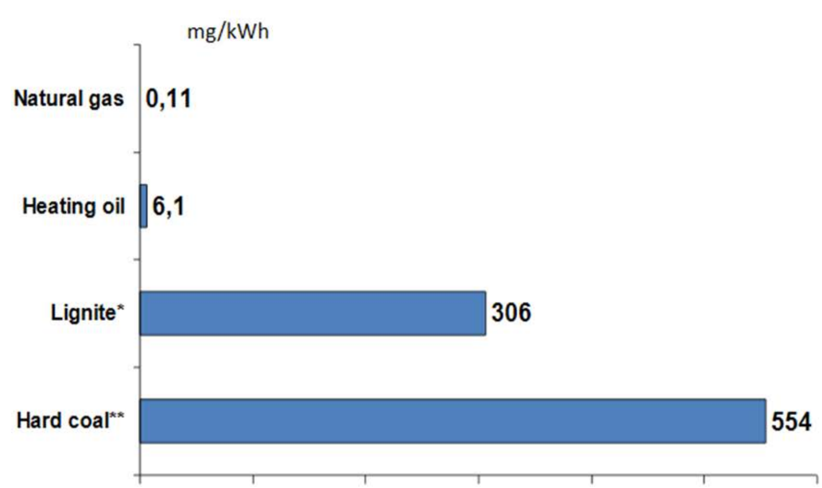


Figure 2

Particulate emissions from heating systems (Courtesy of the International Gas Union)

Why should natural gas be considered an interim step? Why not simply advocate a wholesale switch from coal to renewable energies? The intermittent nature of certain renewable energies such as solar and wind (i.e., no sun or wind that day, no energy produced) implies that natural gas has a role to play. Solar plants and wind power generation need a permanent 'backup' to compensate for built-in intermittencies. Nuclear, although clean from a CO_2 emissions perspective, has a very long start-up time, and hydro sites are limited in numbers and not available in arid and semi-arid regions. Battery technologies are still very expensive and can only accommodate very short intermittency periods. Today, much of this backup is provided by high CO_2 emitting fossil fuel plants with coal being predominant. Natural gas, along with combined cycle combustion turbines, will cost roughly one third of what conventional coal power plants can offer today for the same capacities, and will generate much less CO_2 impact. This is why natural gas is a compelling solution at this particular point in time to support renewable energies development.

This paper will explore three aspects of the shift to gas migration proposition. First an analysis will be presented as to why such a move makes economic and environmental sense. Second the role of natural gas vis-à-vis renewable energies will be explored. Third the advantages and disadvantages of additional measures, such as Carbon Capture and Storage solutions (CCS), will be discussed in relation to how they might further magnify the benefits of the shift to natural gas.

The case for natural gas

The shift to natural gas in power generation, specifically for the generation of electricity, holds multiple advantages. Natural gas burns cleaner, and emits far less CO_2 pollutants into the atmosphere. Throughout its production cycle, gas also consumes fewer natural resources such as water. The following sections take a closer look at some of these natural gas advantages.

Reduced greenhouse gas emissions

At COP21, 195 countries agreed to pursue measures to curb global warming in an effort to limit it to 1.5°C. Key among these measures is reducing greenhouse gas emissions. Switching from coal to natural gas for power generation would help meet this goal. Coal-generated power is the largest contributor of greenhouse gas emissions. By contrast, gas is the cleanest burning fossil fuel. Compared to coal, natural gas reduces CO_2 emissions by ~60% (see **Figure 3**), nitrous oxide (NOx) emissions by 80%, and produces almost no sulphur dioxide (SO_2) or mercury[1] .

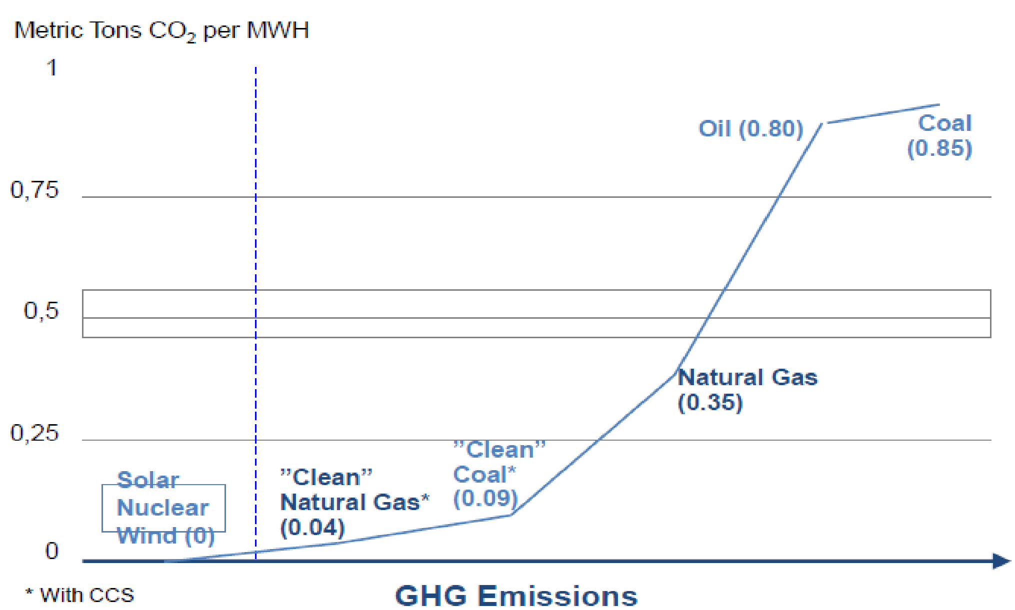


Figure 3

Comparison of natural gas and coal CO_2 emissions (courtesy of the International Gas Union)

Improved air quality

The use of natural gas in power generation also pollutes the air less than burning coal. For example, China, which consumes as much coal as the rest of the world combined, regularly battles poor air quality. In December 2015, Beijing issued its first ever air pollution “red alert” when levels of deadly contaminants, attributable directly to the burning of coal, were recorded at 40 times the limit recommended by the World Health Organization. Coal’s noxious effects on air quality are well documented, contributing to high mortality rates, lung cancer, asthma and stunted lung-development in children. China alone experiences 4,000 premature deaths per day as a result of poor air quality.

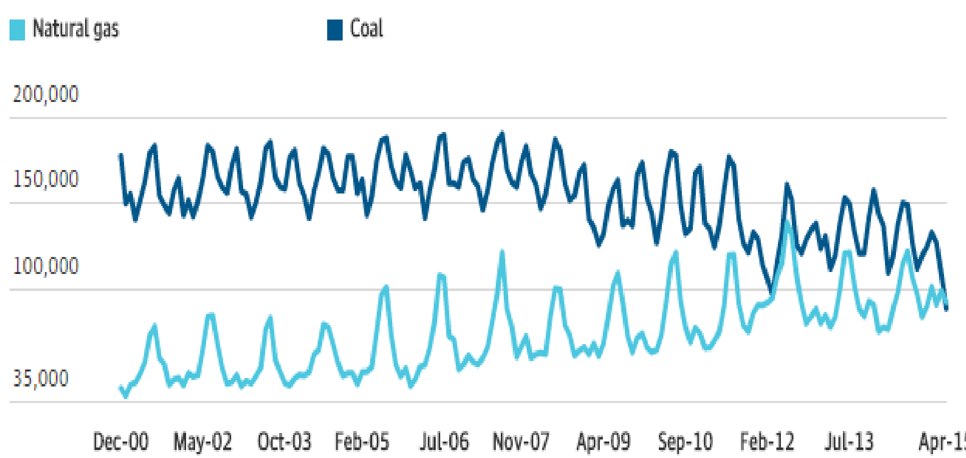
Less resource-intensive

Coal is not a sustainable source for power generation as evidenced by its disproportionate impact on CO_2 emissions and air quality. But sustainability also considers other factors, such as natural resource use. Here, too, natural gas is an alternative sustainable choice to coal, with gas-fueled generation consuming 40-60% less fresh water than coal-fueled generation.[2] The resource-intensity of source fuels is important because, in addition to global warming and its associated negative impacts, the demand for water has increased as more agricultural land is needed for growing populations.

Natural gas is now gaining momentum as an earth-friendly choice over coal. While the urgent environmental benefits of this switch are clear, the economics of gas vs. coal are equally compelling. Natural gas is both plentiful and affordable. Estimates project current natural gas reserves capable of meeting the world’s energy needs for the next 50 years. The total available pool of natural gas supplies are projected to last in excess of 100 years. This nexus of attributes – cheap, plentiful and environmentally beneficial – has driven a 2% compound annual growth rate (CAGR) for natural gas (almost twice that of coal), and has positioned natural gas as the primary fuel for power generation in the U.S. by 2020 (see **Figure 4**).

Figure 4

US electricity production by fuel in thousand megawatt hours (courtesy of the International Energy Agency)



The environmental and economic arguments for natural gas over coal position it well in the transition to a renewable-energy future. An increasing reliance on natural gas for power generation, however, does come with risks. While natural gas is by far the cleanest-burning fossil fuel, its extraction, processing and transport can leak methane, a more potent greenhouse gas than CO_2. Yet these risks are manageable.

[2] The Energy Foundation, The Hewlett Foundation, The Last Straw Water Use by Power Plants in the Arid West, April, 2003

According to a June 2015 working paper by the World Resources Institute, "reducing natural gas leakage to one percent or less of total production is an achievable and cost-effective benchmark." Such solutions include an aggressive regimen of retrofits throughout the drilling, production and transmission infrastructure, as well as the development of gas capture technologies that can re-route leaks back through the normal gas processing loop.

Natural gas as a complement to renewables

The climate accord resulting from COP21 is a clear signal that an era of zero-emission, clean-energy solutions, i.e., "renewables," is coming. Investors and established business interests alike, including fossil-fuel producers, are now pledging an end to "business as usual" and taking steps to embrace a sustainable future.

Yet the actions required to enable such a transition present a challenge. Renewables today account for only about 10% of the world's power generation,[3] with most of that coming from hydro-electric sources. How and when will 100% renewable-power generation be achievable? Two immediate problems face the adoption of renewable solutions: scale and maturity.

The size of the population on planet earth is a challenge for renewables in their current state of evolution. Consider a 500 MW gas-power generation plant, large enough to power a city of 250,000 people. Such a plant requires a few acres of land, a small incoming gas pipeline to supply the fuel, and a power line to export the power. Below is what a similar power capacity renewable-generation asset would look like:

1. Solar – The same power-generation capability with solar panels would require 500 square kilometers or 200 square miles of solar farms. If available land is a constraint, consider how many rooftops would be required, and then the complexity of the implementation and integration of that rooftop solution. Sometimes, existing building structures may also not permit the installation of solar panels.
2. Wind – The generation footprint for wind in this example would require ~200 wind turbines (or possibly 100 of the largest off-shore versions), potentially spread over tens of kilometres of prime coastline or habitable/workable land.
3. Hydro – Most of the major rivers and locations for hydro-electric projects have already been tapped. Dams are also large-scale projects and can be disruptive, in that they may require massive displacements of the native population (human, animal, and fauna alike).

These issues of scalability are also an extension of the second constraint slowing the mass implementation and adoption of renewables – technological maturity. Renewable technologies (i.e., wind and solar), have come very far in a short period of time. However, they are not yet efficient enough, or cost-effective enough, to meet growing global energy demand on their own.

Today, renewables provide intermittent power and require back up for all those occasions when the sun doesn't shine and the wind doesn't blow. The need for back-up can be at least partly reduced by demand side management (the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education). But until storage technologies, such as batteries, can themselves scale, renewables will require a back up fuel.

[3] U.S. Energy Information Administration (EIA)

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This is why the idea of a “bridge” fuel that can provide a lower-emission, more environmentally friendly alternative to coal is now so appealing. Natural gas is ideally suited to this purpose. It also can leverage the existing power generation and distribution infrastructure relatively quickly and inexpensively. Displacing coal with natural gas would “buy time” while technologies driving renewables and energy storage continue to improve.

The International Energy Agency has proposed several possible migration scenarios. Their “450 Scenario” suggests that the global usage of coal and oil begins to decline in 2015 and that, by 2040, natural gas becomes the the most consumed fossil fuel. Their ‘New Policies’ scenario is more conservative. It forecasts a limited growth of oil and coal, with a sustained growth of natural gas (see **Figure 5**).

Of course, many other scenarios are possible, with the most desireable being sustained growth of renewables and gas, accompanied by a rapid decline in coal usage. In this ideal scenario, these changes would be accompanied by widespread acceptance and proliferation of standardized benchmark energy efficiency measures.

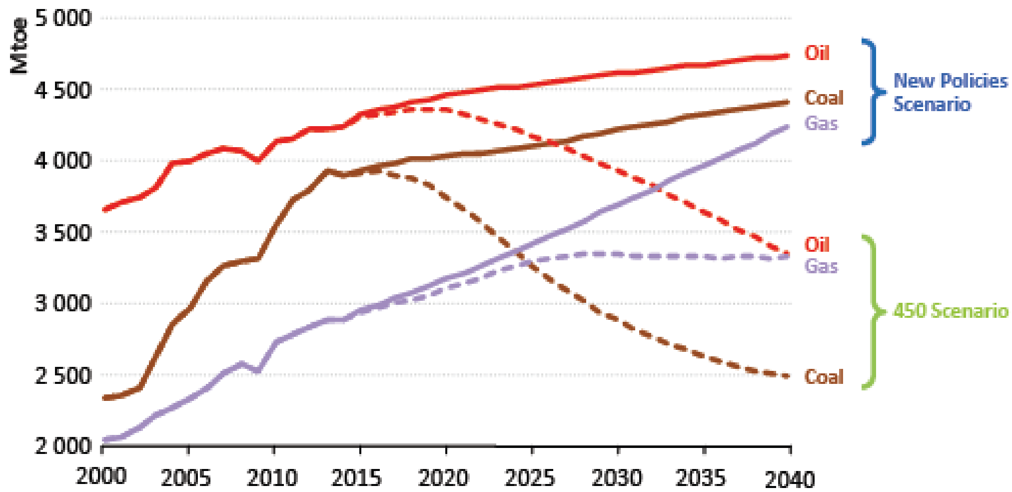

Figure 5

Global fossil fuel demand in the “450 Scenario” relative to the “New Policies Scenario” (courtesy of IEA)

Critics, however, caution that any further use of fossil fuels misses the point: relying on these GHG-producing energy sources, even temporarily, could take needed focus off renewable technology development and implementation. While this argument merits consideration, it does not address the overriding need for a near-term practical solution to meet growing global energy demand while reducing current CO_2 levels.

Other critics cite the inherent price volatility of natural gas as a reason to distrust it as an economical substitute for coal, but when considering the “externalities” of coal – the true costs of treating the harm it causes, including climate change, disease and mortality rates – the economics of natural gas remain appealing.
In sum, both criticisms make sense in isolation, but the world’s ongoing demand for energy requires a balanced approach that lowers emissions while keeping the planet moving. Using natural gas as a short-term replacement for coal delivers environmental and business benefit without forfeiting the long-term goal of getting to zero-emission economies.

Additional considerations

The tangible benefits of switching from coal to natural gas – improved air quality as a result of lower emissions, and better use of resources – make a compelling argument for rapidly reducing the use of coal (see **Figure 6**)[4].

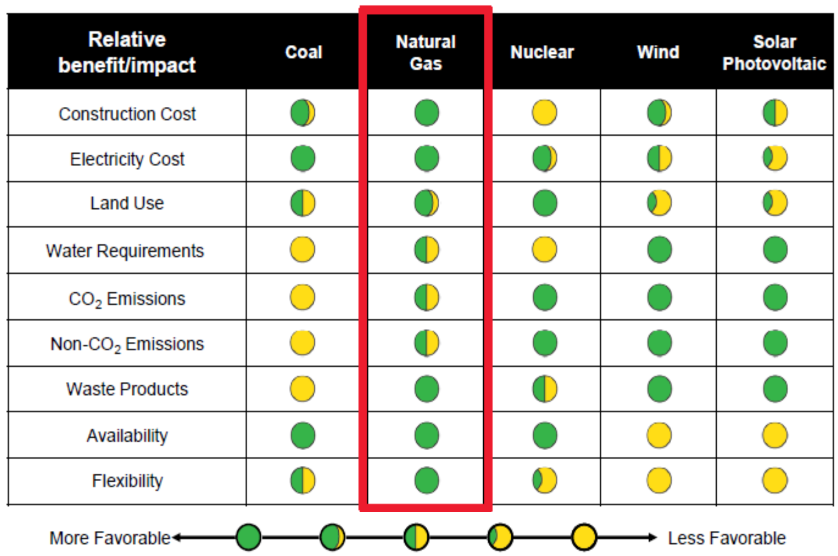

Figure 6

Comparison of benefits and drawbacks of the various sources of energy

Additional technological and regulatory innovations stand to amplify the CO_2 emission reduction benefits that will result from a coal to natural gas transition. Developments to watch include:

- **Carbon capture and storage (CCS) solutions** – CCS is a technology that enables the capture of CO_2 produced from fossil fuel combustion. It becomes relevant whenever large quantities of CO_2 are produced (e.g., in a power generation plant). The infrastructure needed to support a CSS implementation is significant and such an approach would be expensive to deploy at industrial scale. However, the CO_2 produced would be easy to liquefy and transport (e.g., via pipelines that use the same existing and available natural gas pipelines). The CO_2 that is gathered can then be re-injected in a depleted gas reservoir or in other such unused, vacant underground spaces.

  While still early in its development, this technology for capturing and storing CO_2 emissions could play a beneficial role in the natural gas production lifecycle, reducing global CO_2 emissions by an additional 35%. Using CCS technology, a natural gas power plant would emit ~5% of the CO_2 of a new conventional coal power plant operating without CCS[5].

- **A price on carbon** – Much discussed heading into COP21, plans for a global carbon trading mechanism did not materialize from the talks. That said, business leaders around the world have increasingly called upon governments to set a price on carbon so that they can build it into their cost of operations (creating "certainty" for planning purposes). Such a price on carbon would

[4] EPRI, Generation Technology Assessment, Choosing Electricity Generation Technologies, Oct., 2012

[5] Intergovernmental Panel on Climate Change (IPCC); Natural Gas Supply Association; IGU

further tilt the economic balance toward natural gas over coal, as businesses and the fossil-fuels industry itself would have to pay more for their GHG emissions.

- Fuel for fleets – Along with providing cleaner power for industry and the home, natural gas has additional advantages over coal. Natural gas is being steadily adopted for use in “captive” fleets – such as postal service vehicles and municipal buses – improving emissions in the transportation sector. And while electric cars, which are growing in popularity, are essentially emissions free, if the electricity that powers them is sourced from coal-generation, how efficient can they really be?
- Transition from old to new jobs – Perhaps the biggest argument against the global adoption of natural gas over coal is its perceived impact on jobs. While millions are employed in the coal industry, especially in the developing world, the innovations needed to make the transition from coal to natural gas to renewables should spur robust job creation. These jobs would not be restricted to the technology/innovation sector, but would include the building and retrofitting of plants and pipelines, as well as their ongoing service and maintenance.

Conclusion

The shift from coal to natural gas on the one hand, as well as the development of renewable energy generation, green transportation, and energy efficiency measures for buildings and industries on the other, are necessary and complementary steps for curbing the impact of climate change being driven by carbon emissions. Technology is one of the answers for addressing this issue. From generation to transmission and delivery to consumption, all steps in the cycle can be rendered highly efficient. Traditional entrenched habits can be overcome if the new approaches make life simpler. Relatively inexpensive technologies now make energy consumption much easier to manage.

In buildings we can measure consumption, monitor infrastructure in order to identify waste, and execute measureable plans for lighting, power and HVAC energy reductions. In transportation we can grow the networks of smart charging stations or natural gas infrastructure for transportation so that more people can drive cleaner cars. We can continue to improve on battery and fuel cell technologies. Factories can improve output drastically while cutting emissions through the use of advanced automation systems that manage discrete, batch and continuous manufacturing processes. Power utilities can continue to develop smart grids and expand microgrids so that renewable energies can play an expanded role. Oil and gas companies can leverage existing infrastructures to migrate to cleaner, safer means of energy production and delivery. Citizens in their homes can also deploy systems that will allow them to be rewarded financially for energy consumption behavior patterns that promote environmental stewardship, while optimizing the rapidly changing nature of energy supply and demand. All of these are possible today within the realm of existing technologies, and more exciting developments are on the horizon.

Schneider Electric’s goal is to help the world to increase economic growth while consuming less energy and curbing man-made carbon emissions. We contribute by sharing resources and developing technologies dedicated to energy efficiency and CO_2 reductions. We leverage Internet of Things (IoT) technologies from smart sensors to advanced controls and analytics, simulation and 3D training systems, Enterprise Asset Management solutions, energy sustainability business consultancy services, integrated power and control systems, and gas trading and sustainability dashboard software as a service (SaaS) solutions. Schneider Electric will support the developments associated to the shift to gas by enabling this transformation with modern technologies in gas production, transportation and distribution. We commit to support gas companies in building more efficient gas processing and pipelines infrastructures to bring us to end users in pursuit to achieve a carbon-neutral world.

About the author

Eric Koenig is responsible for Schneider Electric Oil & Gas segment strategy and marketing. He holds master's degrees in Automation and Business Administration from the INPL University in Nancy, France. In addition to his current position in the Oil & Gas segment, he has broad industrial automation and energy efficiency systems experience. He has also been involved in Schneider Electric business acquisition activities over the last fifteen years.

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