Industrial Combined Heat & Power for the Energy Transition

Reduces carbon footprint and improves efficiencies in an era of escalating energy pricing

1 Executive Summary

For decades, the industrial sector has depended on fossil coal to generate low-cost electricity, a strategy that is becoming much less economically and environmentally sustainable. A key step of a successful energy transition will be using renewable energy, along with all other available energy resources to their fullest**.** There is a growing realization that some CO2 emissions are simply unavoidable, but the path to minimize those emissions must be embraced whenever realistic. The CO2 released from a combined heat and power (CHP) facility is displacing another source, either coal or gas, and by capturing the heat, **a CHP plant will have a significant net decrease in CO2 emissions. This paper will describe in greater detail the rationale.**

Key drivers for CHP applications: Even though there is a strong societal pressure to only add renewable electricity resources, we conclude that a combination of increasing electricity rates, constraints on importing more power to a facility, and a drive to reduce total corporate emissions of CO_2 will incentivize industrial users to more readily adopt CHP, based on the factors below:

Affordability- Electricity costs are rising much faster than natural gas costs in many regions.

Throughout history, every major economic power has relied on high-energy density fuels to maintain their global position. In the 14th century, Marco Polo discovered this with China's use of coal—a preferred energy source that saved forests from being razed for firewood as demand grew. Coal was low cost, widely available, and capable of providing "energy on demand." Since 2008, coal mining and use in the United States has been steadily declining, with much of that decline directly associated with the retirement of 284 GW of the coal power plant fleet.

For the industrial sector, coal's wide availability and impact on low-cost electricity have discouraged some industries from moving to newer energy technologies. Industries that have grown accustomed to coal and 4 cent/kWh power rates are cautious about shifting to a new resource but are being incentivized to consider alternatives in light of rising electricity rates and pending regulatory requirements. Additionally, increasing supplies of intermittent renewable energy are also reaching industrial consumers, placing zero-carbon resources at their disposal. **Natural gas is being produced in volumes 50% greater than a decade ago and can be obtained by industrial users at close to the same cost as power utilities to fuel their CHP plants**.

Reliability- Reliable service is affected by shifting supply sources and intermittency.

The United States is experiencing a resurgence of investment and expansion in many industries, like manufacturing and data centers creating a growing need for more electrical and thermal energy. Over the next 15 years, many of the remaining 329 GW of base load coal power generation will retire, removing more than 25% of the system's lowest cost electricity energy providers, with the obvious potential to put upward pressure on retail rates. Beyond generation, costly upgrades to transmission will be required to accommodate the new generation mix of renewables, and new locations for dispatchable energy to replace that coal generation, which will be passed on to consumers. Supplying new generation, shifting to new energy resources, and rebuilding the transmission and distribution network is expected to stress overall system economics and reliability. **The industrial sector should anticipate these changes and maintain a position of flexibility that maximizes reliability within the fence-line at the lowest cost.**

Sustainability – The critical role of natural gas & Hydrogen (H2) fuels in taking steps to decarbonize.

Decarbonization is a trend that has been underway for over 30 years in the United States. Much of the reduction came through regulatory applications like The Clean Air Act, or automotive industry C.A.F.E.[1] standards. In industry, economics and innovation substantially influenced the trend in reducing CO2 emissions. Aging thermal plant expenditures and enormous success of shale gas reserves development have resulted in replacement of the highest CO2 emitters.

The industrial sector can obtain further successes with the electrification of heat, replacing fossil fuels. Highly efficient dispatchable CHP systems can fill the need when renewable energy is not available, reducing the need for utilities to operate inefficient and expensive peaking units. Additionally, as they become economical, new technologies such as innovative electric and thermal energy storage devices can be expected to play a role in industrial decarbonization, while CHP systems can still be used to improve plant efficiency and reliability. **While electricity from renewable sources is growing at 12%[2] per year, it alone may not meet industry's massive needs, nor provide 24/7 electrical supply.**

[1] Corporate Average Fuel Economy.

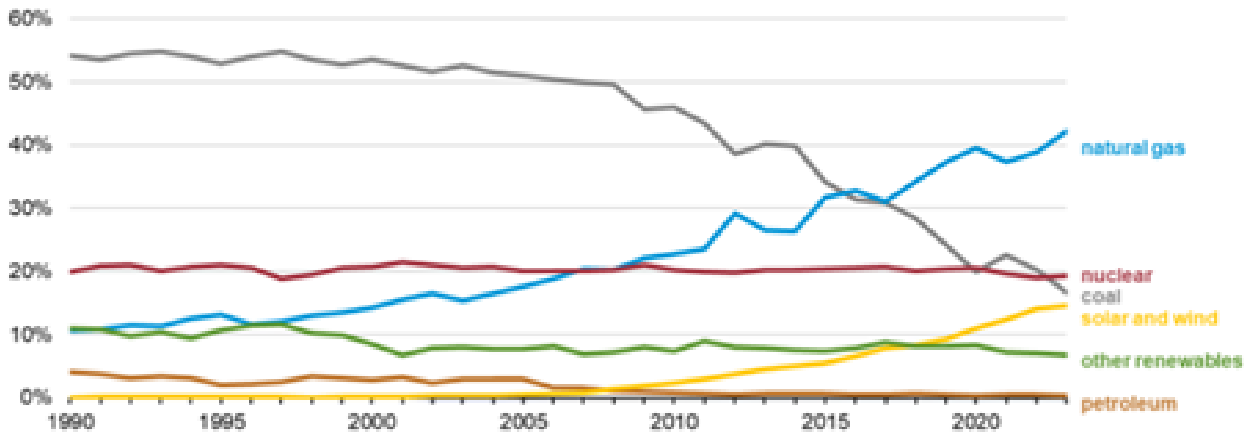
[2] Generation from all renewables: wind, solar, hydroelectric, biomass; 2012-2022 net generation.

Availability - Limited Alternatives for industries today.

Many industries will be faced with a dual threat: the risk of increasing electricity prices and the pressure to reduce carbon emissions. Most industrial customers have already optimized their operations already relying on fuel switching, energy optimization, or electrification with renewable energy. As the required next step in long-term resource planning, many are evaluating new technologies such as carbon capture, H2, and novel energy concepts for practical applications in the future.

On-site generation offers a buffer against increasing electricity prices, eliminates transmission losses, reduces the need for electrical upgrades, enhances reliability, and provides more potential for electrification of process heat with lower-cost electricity. Also, installing the newest designs will position the facility for a future that could include hydrogen-based fuels, while immediately reducing the carbon footprint of the plant, regardless of what technologies are developed in the future. **A viable optimization today and tomorrow for many industrial processes is an on-site CHP plant, which can effectively almost double the efficiency of the usage of natural gas**.

Share of U.S. electric power sector generation by fuel source, 1990–2023



Data source: U.S. Energy Information Administration, *Monthly Energy Review*, March 2024, Table 7.2a, Electricity Net Generation Total (All Sectors), and Table 10.6, Solar Electricity Net Generation
Note: Solar and wind excludes small-scale solar generation.

2 Overview

The energy transition taking place in North America is powered by complimentary & conflicting forces.

Energy producers and users want to focus on reducing emissions of greenhouse gases while also maintaining a source of reliable low-cost energy. Yet there also is a much greater emphasis on the energy transition's environmental component, primarily to address challenging issues related to climate change. The dynamics in play require balancing a complex mix of five factors:

1. *economics* (replacing equipment that is costly to maintain and/or incurring new capital expenditures).
2. *demographics* (an aging work force in key industries and high- and low-cost electricity regions).
3. *deployment* of new technologies (development of shale gas).
4. *introduction of new power generation technologies* (solar and wind energy).
5. *regulations* (pending emissions regulations addressing CO2).

The market price of delivered energy will be a strong function of which resource is chosen and how it is delivered (high-voltage transmission, natural gas by pipeline, liquid fuels), where it is consumed, and regulation of the carbon footprint along the supply chain. Rapid technological innovation and broad-spectrum regulation are affecting traditional market pricing mechanisms. The recent appearance of "negative market prices" for power is unique to this new era of energy.

For the industrial sector, electricity, coal, petroleum, and natural gas have been the basic feedstocks. Within this sector, electricity is mostly consumed and sometimes produced. Often the production of electricity is due to the recovery or reuse of waste energy. This sector has been effectively transitioning away from high-carbon fuels, reducing coal usage 50% over the last 10 years.

Here we propose that much more can be done to improve the efficiency of natural gas utilization[3] through combined heat and power (CHP). We conclude that the industrial sector is likely to face significant changes in electricity prices that will force the industry to consider changing how it consumes energy, and in what forms. For decades, the industrial sector has been accustomed to relatively low-cost electricity. The market for this low-cost, long-term arrangement is rapidly changing. **Gas-fired CHP reduces CO2 contribution from the plant and provides efficiency improvements while positioning for future Hydrogen-based fuels.**

[3] For the past 30 years, the use of natural gas for CHP has been relatively constant, despite significant increases in domestic natural gas supplies.

3 A New Era for Energy

Taking measured steps in a shifting energy landscape.

Previous eras oversaw changes from one fuel or technology to a newer one. Most notable ones are the:

- Switch from biomass to coal.
- Substitution of electricity.
- Widespread adoption of natural gas as a fuel for power.

Entering each new phase resulted in massive economic and demographic shifts. The evolution of a rural agrarian economy to an industrial one had an enormous boost in economic output. Perhaps not too surprising, then, is the fact that the largest economies continue to generate the most carbon-based emissions. The difference today is the acceptance that all anthropogenic emissions have the potential to affect the environment. Priority pollutant regulation has been highly effective on emissions from coal plants, directly for priority pollutants and indirectly for CO2. Indirectly, this effort may have also been responsible for substantially reducing the lowest cost energy provider, coal, as a primary energy supplier.[4]

Rising electric rates and fuel costs are <u>not</u> closely linked.

Figure 1 reveals the trends in the cost of delivered power in the industrial sector. From 1982 through 2000, the electric power prices were flat, even declining into the turn of the century. These first two decades represent an era where coal and nuclear power entered service. Those energy resources, while capital intensive, produced a supply of abundant low-cost electricity. But the chart also suggests those prices to the industrial sector have been steadily increasing since 2000.

In addition to electricity prices, Figure 1 also highlights a significant shift in the energy supply of natural gas. In the early 2000's, nearly 100,000 MW of new gas turbines began commercial operation, the majority in combined cycle plants, which achieved almost twice the efficiency of traditional steam plants. This significant shift to gas arrived just as domestic reserves of conventional natural gas were on decline and ushered in the last 20,000 MW of new coal thermal plants built in the U.S.

[4] Nuclear power sources have also been substantially reduced from the generation portfolio due to similar economic pressures, even though it is a near-zero carbon resource.

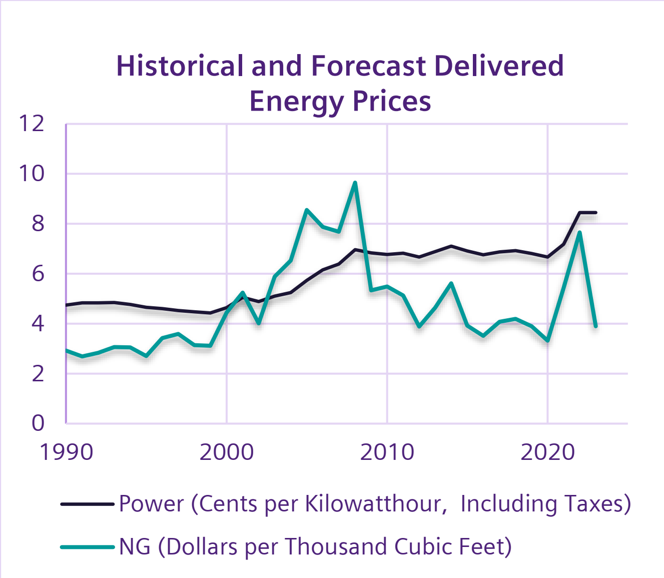


Figure 1: Energy rates for the U.S. industrial sector.

But in another energy sector, oil and gas exploration companies had developed entirely new tools to extract natural gases (and oils) trapped in shale gas formations. The sheer scale of the success didn't become evident until late 2008, when gas prices began to decline from the highest levels in 40 years.

Perhaps more concerning is the sharp increase in electricity prices since 2020. This will be a growing concern for industrial operators as the low-cost (coal) resource are deactivated, placing upward pressure on the price of electricity. This wide disparity is driven by the decisions made in the past in the specific rate base and is constantly changing.

In contrast to electric retail industrial power rates, energy supplied as natural gas from the shale resource base has been essentially steady since the massive expansion of the shale industry and more uniform in delivered cost.

The low-cost utility base load generation equipment is reaching retirement age and regulatory uncertainty.

A key metric that can be used to assess the long-term potential specific elements in power fleet: years of service. The bulk of 329 GW the existing operating coal plants have practically reached retirement threshold. Recent EPA rules requiring capital intensive carbon capture for coal plants by 2034 could seal operating coal plants fate earlier. For utility customers this means the loss of 25% of the low-cost generation base.

Coal-fired combined heat and power plants are also at risk for retirement.

Coal-based industrial operations probably face the same future as large central power stations—aging equipment operating on high-carbon fuel and limited options. One approach might be to exploit the abundance of wind and solar generation. However, a map of renewable resources and existing cogeneration facilities indicates that there is little overlay between the two. Direct substitution of an old resource with a new one may not be as simple as "plug and play."

With shifting geography of new supply, and loss of a traditional resource, it will be difficult to confidently determine how these changes will impact delivered power prices. We believe that the low-risk, long-range solution to mitigate energy spikes for industrial users is to more tightly associate energy use with a well-established supply of natural gas. Fortunately, industrial operators can access natural gas at prices comparable to the large utility users.

Regional differences in electric rates will significantly impact the potential for electrification.

Where electric rates are low, there is a large potential to take steps to increase electrification of existing fossil-fueled processes. Employing electricity created by renewable sources is a good alternative if it is affordable and supplied by a reliable system and can be a very effective strategy to improve sustainability. As rates continue to increase, every region of the country will have to determine the potential for electrification staying economical.

The bulk of the planned new generation additions are a mix of wind, solar, and electrochemical batteries. Wind generation is often sited in areas remote from the potential users, suggesting that the investment cost of the wind (and possibly) solar would also have to include the transmission costs, as was done with the Texas CREZ system. As noted later, the price tag for the CREZ investment was $6.9 billion.

4 Addressing the Carbon Challenge in today's economic climate

Reducing CO2 impacts to the climate depends on taking steps to reduce emissions whenever viable.

At one point, the United States consumed over a billion tons per year of coal, primarily to generate electricity. Coal use for power generation peaked in 2008, with over 800 thermal steam plants burning coal to produce power, while also releasing over a billion tons of CO_2 into the atmosphere. But in 1950, industrial, commercial, residential and transportation consumed over four times the amount of coal used to produce electricity. Over those intervening years, coal use in residential and transportation disappeared, and by the 1970's, coal dominance was limited to the power generation sector.

Much of the discussion on greenhouse gas (GHG) emissions has focused on carbon released as carbon dioxide to the atmosphere through combustion. This pathway represents 90% percent of the man-made greenhouse gas emissions on a mass scale. Combustion-related emissions, and non-combustion ones, also contribute to the total GHG emissions. These include:

1. Carbon dioxide-primarily from combustion.
2. Methane and similar light hydrocarbons.
3. SF_6, typically used in substation breakers, and high GWP process gasses.
4. N_2O, with both industrial and agricultural sources.

As shown in Figure 3 **fossil fuel burning results in nearly three-quarters of all the GHG emissions**, hence a logical reason for targeting combustion sources, along with non-CO_2 gases, including nitrous oxide and methane in minor roles. By sector, the industrial, transportation, and power sectors are near equal players.

A realistic view of CO2 emissions needs to consider Scope 1,2, & 3 values generated.

It is possible to shift emissions between sectors. For industrial customers, there is a complex mix of emissions located upstream and downstream of local operations. Emissions can be catalogued into three groups: Scope 1 (those primarily released in production), Scope 2 (emissions released by importing energy from another source), and Scope 3 (emissions attributable to losses and downstream).

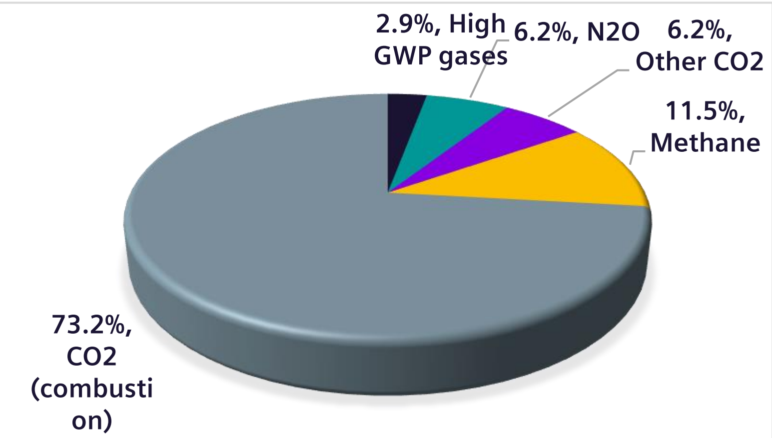


Figure 2: U.S. greenhouse gas emissions, 6.43 billion tons of CO2 equivalent. (DOE)1

For sound financial reasons, industrial processes are optimized to maximize production efficiency. Now that window has expanded to include CO_2 generated on site, but unlike other parts of the world, there is no direct carbon tax. Typically, these reductions are achieved using the least disruptive means: process optimization, fuel switching, and electrification.

Pursuing the electrification option shifts CO_2 emissions Afrom on-site to off-site, but unless specifically contracting renewable sources, it could increase the carbon footprint of the facility significantly through Scope 2 and 3 emissions[5]. **One solution that is both financially and environmentally viable is onsite combined heat and power facilities that can significantly reduce Scope 2 & 3 emissions that were formally associated with purchased electricity.** Figure 2 highlights where CO_2 emissions are produced in four broad areas, but it's not obvious that the production of the electricity itself is optimally located within that sector.

In our analysis, there is no "one size fits all" solution. The average CO_2 efficiency of the North American Generation fleet is 0.65 tons/MWh[6]. Since the generation mix and transmission losses vary significantly across the regions, some investigation and system modeling will be necessary for each application.

Growing electric demand is part of a metamorphosis of a new industrial economy.

Whatever the ultimate energy path the nation pursues, it will likely be very different from the historical path of almost full dependency on fossil fuels. Coal will find fewer markets in the power sector, natural gas and hydrogen-based derivatives will be used increasingly, and energy consumers will demand more electricity over what many experts consider an aging transmission and distribution infrastructure, as demand is projected to grow by 1% every year through 2050 according to the EIA's Annual Energy Outlook completed in 2023 (AEO 2023).

"No regrets" CO2 emissions reduction decisions for step-by-step reductions.

Trigeneration, Cogeneration, or Combined Heat and Power (CHP) are the designations given to industrial-based energy conversion processes, which essentially changes chemical energy into useful thermal energy, and then into electrical energy. **The difference between CHP and central station power plants is that the waste energy from the process of making electricity is used to a much greater extent.** Several energy conversion system designs (heat engines) can covert chemical energy into electrical energy, all with varying efficiencies and levels of useful exhaust energy.

In addition to economics, the power-to-heat relationship of an industrial process will be a significant factor in deciding what technology is best suited for onsite generation. Carbon capture technology will require access to significant amounts of thermal energy, a fact that will be of critical importance in the hardware selection. The type of core technologies include:

[5] The U.S. aluminum industry was primarily developed in areas with substantial excess generation from hydroelectricity.

[6] Based on 2022 net generation and CO2 emissions from coal, oil, and gas operations only.

- The workhorse technologies (gas turbine and reciprocating engine) can reject enough heat to generate steam or hot water. Each technology plays separate and unique roles in CHP operations.
- Electrical vapor compression technology, which increases low-grade steam to higher temperatures and pressures using a special purpose compressor, is one method of improving the use of recovered heat. An industrial heat pump could also be integrated into the process to use all the available energy rejected in the electrical generation process.

Natural gas will remain the bridge fuel to H2-based fuels for the future.

Fuel combustion has been responsible for most greenhouse gas emissions[7]. Fuel costs also are a major factor in the delivered price of electricity, with coal being a major fuel source for electricity. In those parts of the country with heavy reliance on coal power generation, electricity prices have historically been low - so low as to encourage new industrial transplants from foreign investors.

For most of the industrial base, electricity cost is one of the biggest factors in product costs. Data from EIA reveals that this cost is the most important component in the most product shipments (Figure 3) excluding H2, which is off the scale. Moving forward, the following limitations are confining the industrial sector.

1. The cost of delivered electricity is increasing.
2. The low-cost sources of power are disappearing.
3. Electricity is a significant component in product cost.
4. Use of natural gas has not changed, despite increasing abundance and competitive pricing.
5. Existing constraints on the ability to import more power.

This graph suggests that for small-to-medium industries, electricity is the largest cost driver in their product stream. At the same time, the cost of natural gas supplied is a weak function of size. Additional data in the survey reveal that larger industrial producers also generated a substantially larger quantity of electricity on site, probably influencing the drop in the size of the electrical cost in the value of products shipped. Industrial consumers ideally could obtain the same price for natural gas as power generation customers. Perhaps more appealing is that many of the larger utilities using gas for power generation are reluctant to acquire long-term contracts for natural gas. This leaves power markets tightly coupled to the vagaries of spot gas prices. **Risk aversion by larger central power operators could easily be off set with long-term contractual arrangements by a CHP operation.**

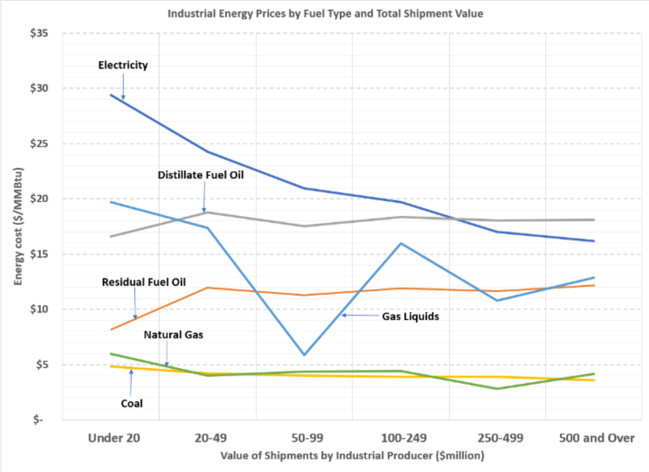


Figure 3: Electricity ($/MMBtu) was often the most expensive energy source in the product stream.[8]

CHP can reduce CO2 emissions, increase reliability & affordability.

In the mid 1980's, there was significant growth of cogeneration or trigeneration, now referred to as CHP. The key factor for that growth was that not only did the selected equipment make electricity, but it also produced heat and steam more economically in an era of very high fuel costs, driven by an oil supply crisis.

Shift of baseload generation from coal to intermittent renewable and CHP is the future.

For some industrial operations, coal is both a key commodity and a major component in the product stream. But there are challenging headwinds facing expanded, or continuous use, of coal. With the substantial closing of large U.S. thermal plants, coal mines have fewer domestic customers. Economics suggest that a drop in supply should be associated with an increase in price. Examining data from EIA, we believe that this shift has already been underway and is likely to continue. **This trend would suggest that, in addition to increasing electrical power prices, the industrial sector will likely experience increases in coal prices for their operations**.

NERC 2023-2024 Winter Reliability Assessment:
A large portion of the North American bulk power supply is at risk of insufficient electricity supplies during peak winter conditions

[7] This is accurate for most developed economies. In some parts of the world, deforestation via burning or land clearing can easily exceed emissions from heat engine cycles.

[8] EIA, Manufacturing Energy Consumption Survey, 2018. Compiled from data in Table 7.5

We believe industrial on-site CHP can act as both a supplier to the grid, while operating with self-sufficiency and protection from unexpected grid interruptions.

Upgrading the current grid to accommodate significant shifts in the type of electric supply will also be needed and is likely to be expensive. The Texas Competitive Renewable Energy Zone (CREZ) transmission cost $6.9 billion to construct, over a seven-year period. According to the Baker Institute[9], the costs translated into $4.485/MWh for interconnection. For a CHP, since electricity is such a significant cost component, future grid expansions could predictably increase product cost, assuming there is no leverage to decouple the cost by offsetting the source with on-site supply.

In addition, there is the expectation that energy consumption within the sector will continue to grow as shown in Figure 4. Less widely used is the concept of storing the rejected energy in some type of thermal basin. This might include heating (or cooling) water to be used at a later specified time.

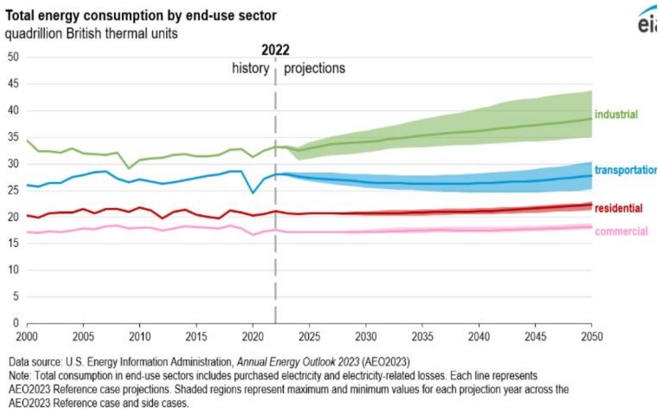


Figure 4: EIA energy growth forecast.

Energy storage is considered critical as the scale of non-dispatchable resources (principally wind and solar) continues to grow. And it can also be part of a decarbonization strategy even when coupled with continued use of fossil resources that have the highest CO_2 emission profile.

5 Renewable Enabling Energy Storage Options

Storage of renewable energy is the long-term solution, but CHP is available now.

Energy storage has played a largely unacknowledged role in the global decarbonization effort. Much of the world's most effective non-fossil energy storage is associated with hydroelectric power generation. They are effectively static storage systems, with few losses associated with waste heat or with frictional losses. Pumped storage is, however, dependent on the geography and topology of the land, as well as capital intensive.

Once chemical energy is released, a good portion of it is typically either wasted or lost, most often as heat, as much as 50 percent depending upon the process[10]. The component efficiencies in industrial processes may be as low as 10% or up to 90%.

In the last decade, new, large, commercial electrochemical storage methods have been introduced. These are typically battery energy storage, or BESS; packages that provide short duration storage of several hours. High capital cost remains a stumbling block, since the duration and capacity are linearly related to cost, with minimal effects of scale. While there are over 570 individual BESS facilities operating in the U.S. (representing a combined 36,000 MWh of energy storage disbursed in 9,000 MW of capacity), nearly all of these are found in large power generation applications.

CHP as Energy Storage

CHP and cogeneration already serve indirectly as an energy storage solution in some cases. In the fossil power industry, it was expected that large utilities would maintain reserves of coal for 30, 60, or 90 days—a de facto method of energy storage.

One significant change that developed in the last decade is that wind and solar now account for significant volume of electricity to be distributed on the grid when available. The unique cyclic nature of those resources shows that supply cannot always be meshed with demand, regardless of the size of the installed base. A CHP with grid connectivity could effectively provide grid support.

There are many novel electrical energy storage concepts being explored involving physical, electrical, thermal, or chemical storage, but limited commercialization.

The most significant research and development efforts have been expended on improved electrochemical energy storage (BESS). Most of the BESS systems put into service by power providers are based on the current Lithium-ion battery which exhibit some of the highest energy densities achievable (300-450 Wh/liter), but they are energy deficient compared to conventional liquid fuels.
As electrochemical storage technology evolves, the logical expectation is for applications to move beyond the domain

9 Julie Cohn, Ph.D., Olivera Jankovska, M.Sc., "Texas CREZ Lines: How Stakeholders Shape Major Energy Infrastructure Projects", Nov. 2020, https://doi.org/10.25613/261m-4215

10 https://www.energy.gov/eere/iedo/waste-heat-recovery-basics#:~:text=It%20is%20estimated%20that%20between,equipment%20surfaces%20and%20heated%20products.

of the utility. A combination of more efficient CHP/Cogen, coupled with energy storage may become a new feature of how these associated industries support one another.

Some examples of heat energy storage include injecting and extracting heat from solid masses or flowing liquids and gases. While thermal energy storage has clear engineering applications, it doesn't easily find a spot on the corporate ledger or the balance sheet. A few simple examples of energy storage include:

- Air preheating. Heat exchangers that recovery energy from hot gases to preheat fresh air.
- Thermal storage. Heating, or cooling, a material (which is typically thermally isolated) for later recovery.
- Phase change materials. Complex salts that can absorb and release energy at a specified temperature.
- Recovery of energy from natural storage vaults (e.g. geothermal).

The current state-of-the-art application typically involves a mass of material that has a relatively high heat capacity, good thermal conductivity, and a high density (to minimize the overall storage volume). Metals are obvious choices in applications like air preheating. But to date, most non-chemical storage materials rely on rock, sand, or even water and provide reliable and repeatable results.

6 Summary

Doing nothing in a changing environment is not a viable option for most businesses.

The major shifts in technology, fuel resources, and regulatory policy are substantially influencing the trajectory of the current energy transition. It is evident we are experiencing increasing electricity prices delivered to all sectors of the economy from the energy transition. Less obvious is that the accelerated removal of the lowest cost provider of electricity (coal) from the nation's generation portfolio over the next several years may be responsible for more increases.

This shift also implies that elevated power prices may be effectively "baked in" for the next 15 years, barring any radical shifts in generation sources. Additionally, new electricity consuming entrants in data centers and financial processing are expected to become a growing burden, competing for supply, and pushing prices up even further.

The industrial sector could decouple from the expected increase in electricity with on-site use of CHP, while reducing the carbon footprint of facilities. This would also reduce the burden of expanding the transmission interconnection.

Some options that the industry will face:

Option 1. "Do-nothing" option. This level of complacency will likely be dangerous for any member of the industrial sector. In today's information age, actions and lack of action are transparent to all stakeholders. The economic and social changes coming are expected to be extreme and long lasting. Natural gas prices seem to be the least variable for the foreseeable future.

Option 2. Electrify industrial processes. One popular decarbonization option being explored is to electrify industrial processes to use the renewable energy being brought onto the grid. Electrification will increase the electrical demand at the site, require capital investment and increasingly relying on escalating electrical energy prices. Using industrial electrification of heat to replace onsite fossil fuel generated heat exacerbates the short-term CO_2 reduction efforts unless directly tied to renewables, since existing electricity generation is the least efficient use of energy resources for Scope 1,2, 3 emissions. There is also a growing concern over grid resiliency, which will introduce new risks impacting smooth and predictable industrial operations.

Option 3. Produce power and heat on-site via CHP. Where both electricity and process heat are needed, customers can reduce their grid imports while maximizing the efficient use of fuels. The benefits of Combined Heat and Power (CHP) plants on-site, coupled with Mechanical Vapor Recompression (MVR) and Heat Pumps (HP), are the most practical way to meet industrial process needs and reduce their carbon footprint.

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