Combined Heat & Power, 2013: Are We There Yet?

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ABSTRACT

Combined Heat & Power (CHP) or cogeneration, while widely familiar, and in use in a significant number of industrial facilities, remains largely under-appreciated and under-utilized as a means of meeting U.S. energy and economic goals. CHP provides maximum fuel efficiency for delivering steam and power via fossil fuels, thus minimizing emissions while supporting U.S. industrial competitiveness. CHP is fuel flexible and utilizes proven technologies, offers much lower capital costs than renewable technologies, is safe, and highly reliable. With all of these attributes, why does CHP remain a minor player on the U.S. energy scene? Is this situation changing, and what can be done to accelerate implementation? As the U.S. emerges from the economic downturn, increased demand for energy in industry will provide opportunities for cost-effective solutions. In August 2012, the White House issued an Executive Order on Accelerating Investment in Industrial Energy Efficiency calling for a national goal of deploying 40 gigawatts of new, cost effective industrial CHP in the U.S. by the end of 2020. In addition there are new EPA Maximum Achievable Control Technology (MACT) regulations on industrial boilers that require industrials nationwide to substantially reduce emissions from coal and oil boilers emissions. This paper explores the current policy, technology, financial environment, and barriers to using CHP as well as key players' roles in making CHP investments. An investment analysis that lays out the business case from the point of view of a plant manager, corporate energy manager and chief financial officer is provided to better understand the decision process and prospects for utilizing CHP.

Introduction

Combined heat and power (CHP) or cogeneration, is an efficient, clean, and well-known approach to generating electricity and useful thermal energy. Compared to purchasing electricity and burning a fuel in an on-site furnace or boiler, a typical efficiency of 70 to 80% or higher can be achieved. This represents a reduction in primary energy consumption of over 30% compared to central station electricity and on-site thermal generation.

History

Cogeneration, or CHP, has a long history in the U.S. In 1882, Thomas Edison as head of the Edison Illuminating Company, created the world's first commercial power facility at Pearl Street Station in New York City and used cogeneration. This facility produced electricity to supply hundreds of customers and used the thermal energy to heat buildings in the neighborhood. Many early users of CHP were industrial facilities that generated electricity and used the thermal energy for heating or processes. CHP declined through much of the 20th century with the rise of large steam turbine generators and growth of central station utilities.

The passage of the Public Utility Regulatory Policies Act (PURPA) in November 1978, created the impetus for a resurgence of cogeneration and significant growth in CHP capacity. PURPA provisions encouraged energy efficient cogeneration and renewable small power production by requiring electric utilities to interconnect with "qualifying facilities" (QFs).[1] CHP facilities had to meet minimum fuel-specific efficiency standards in order to become a QF.[2] PURPA required utilities to provide QFs with reasonable standby and back-up charges, and to purchase excess electricity from these facilities at the utilities' avoided costs - the equivalent of the cost of producing power by conventional means.[3] As there was substantial growth in power demand during this time and new capacity was often substantially more expensive than the price customers paid for electricity, this avoided cost often represented a very attractive sales rate for cogenerators. Any excess power generated could be sold to the grid at attractive prices. PURPA also exempted QFs from the same level of burdensome regulations as were required by central station utilities. This relieved QFs from regulatory oversight under PURPA and from constraints on natural gas use imposed by the Powerplant and Industrial Fuel Use Act (FUA) of 1978.

Growth of CHP

As Figure 1 shows, most of the current U.S. CHP capacity was added in the period of the 1980s to 2005. While PURPA promoted CHP development, it also had unforeseen consequences. PURPA was enacted at the same time that larger, more efficient, lower-cost combustion turbines and combined cycle systems became widely available. These technologies were capable of producing greater amounts of power in proportion to useful thermal output compared to traditional boiler/steam turbine CHP systems. Therefore, the power purchase provisions of PURPA, combined with the availability of these new technologies, resulted in the development of very large merchant plants designed for high electricity production. A variety of forces in 2005-2006 effectively ended the large CHP capacity additions to the U.S. energy economy. Increasing deregulation of utilities, open access to electricity transportation by utilities, a revision of PURPA regulations to limit mandatory purchase provisions in regions with competitive power markets, and a period of very volatile and high natural gas prices (to a large extent caused by disruption of gas supplies by Hurricanes Katrina and Rita) combined to discourage CHP installations.

Total CHP capacity plateaued at about 80 GW in the early 2000s. Capacity additions from about 2006 to 2012 were only a small fraction of what they had been in the previous 20 years. In 2012, the U.S. had 82 gigawatts (GW) of CHP capacity, accounting for about 7% of total U.S. capacity, with about 87% in the manufacturing sector.

Future Potential of CHP

The future potential of CHP in the U.S. is large. A 2008 study on CHP in the U.S. by Oak Ridge National Laboratory stated that CHP solutions "represent a proven and effective near-term energy option to help the United States enhance energy efficiency, ensure environmental quality,

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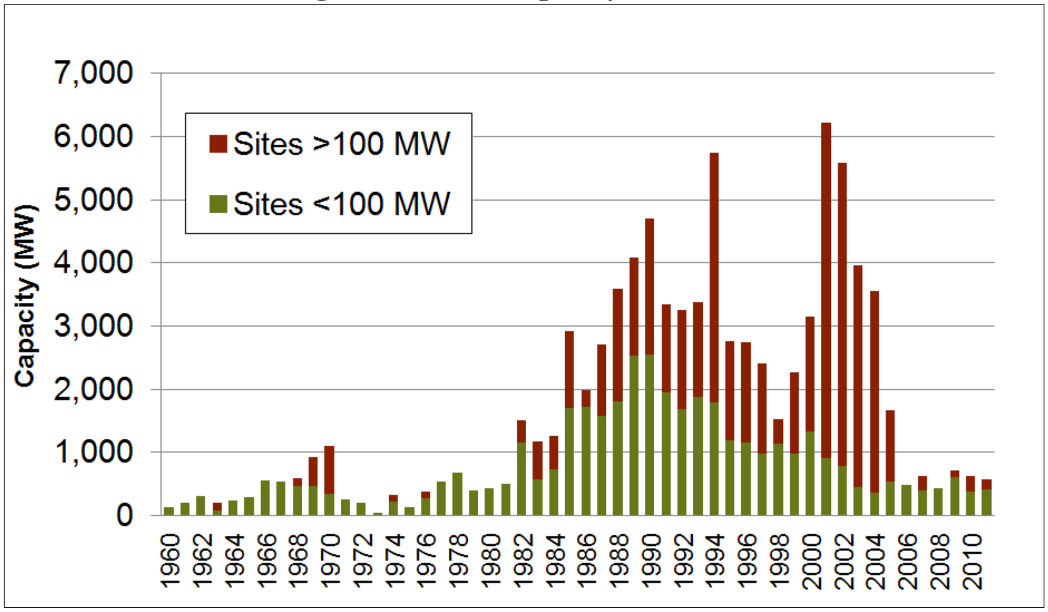
[1] The terms "cogeneration" and "combined heat and power" both refer to the simultaneous generation of electricity or mechanical power and useful thermal from a single source and are used interchangeably in this report.
[2] Efficiency hurdles were higher for natural gas CHP.
[3] Avoided cost is the cost an electric utility would otherwise incur to generate power if it did not purchase electricity from another source.

promote economic growth, and foster a robust energy infrastructure" (ORNL 2008). ORNL estimated that if the U.S. "adopted high-deployment policies to achieve 20 percent of generation capacity from CHP by 2030, it could save an estimated 5.3 quadrillion Btu (Quads)". And "Cumulatively through 2030, such policies could also generate $234 billion in new investments and create nearly 1 million new highly-skilled, technical jobs throughout the United States. CO_2 emissions could be reduced by more than 800 million metric tons (MMT) per year…"

Figure 1. CHP Capacity Additions



Source: ICF CHP Installation Database

A 2012 joint DOE/EPA publication, "Combined Heat and Power: A Clean Energy Solution" promoted a path for reaching the 40GW goal established by the Administration. The report stated that achieving the goal would save energy users $10 billion a year, save one quadrillion Btus, and reduce emissions by 150 million metric tons of CO_2 per year compared to current energy use.

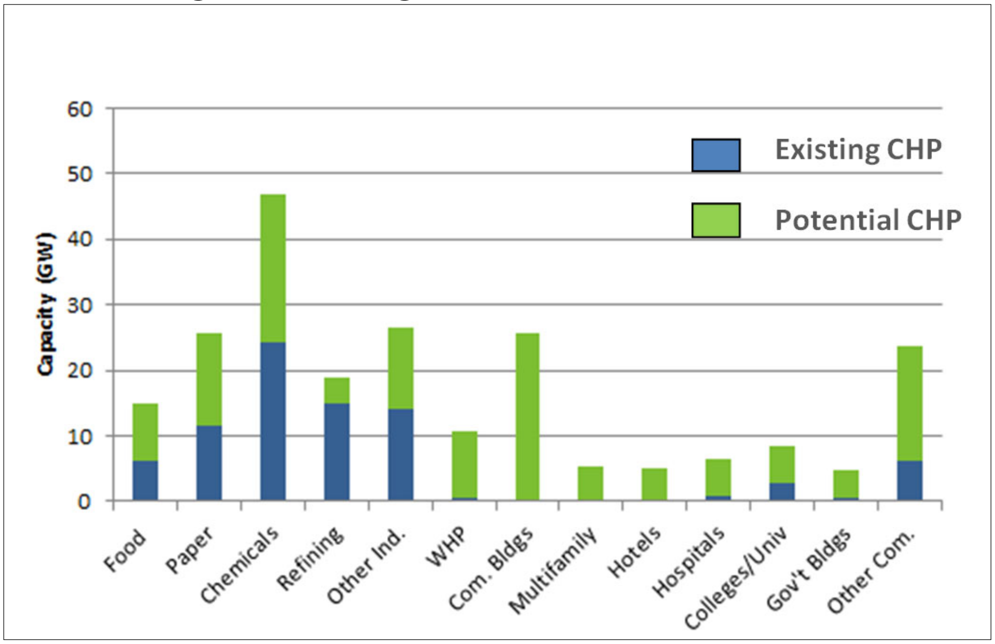
ICF, utilizing a robust set of data from a variety of sources, has estimated that there is a technical potential of an additional 130 GW of CHP capacity at existing commercial and industrial facilities.[4] Figure 2 shows data from the DOE/EPA report, which was based on the ICF estimate. It shows that much of this new capacity is in traditional users of CHP such as chemicals, petroleum refining, and pulp and paper industries. But there is also substantial potential in a wide range of industrial, commercial and institutional sectors that have not extensively utilized CHP in the past.

[4] In the DOE/EPA report, data sources included the DOE EIA Commercial Buildings Energy Consumption Survey (CBECS), the DOE Manufacturing Energy Consumption Survey (MECS) and various market summaries developed by DOE, Gas Technology Institute (GRI), and the American Gas Association. Existing CHP installations in the commercial/institutional and industrial sectors were also reviewed to understand the required profile for CHP applications and to identify target applications.

Advantages of Combined Heat and Power

Combined heat and power's fundamental economic and environmental advantages are mutually beneficial to suppliers and users of energy, as well as the overall economy and public.

Figure 2. Existing CHP vs. Technical Potential



Source: US DOE CHP: A Clean Energy Solution

The thermodynamic efficiency advantage of CHP is well understood. A CHP system that fully utilizes waste heat recovery (e.g. for useful production of steam) can exceed 80% overall efficiency. This compares to central power stations that typically operate in the 35% to 50% efficiency range. When comparing overall CHP system efficiency to the typical central power station (for electricity) and boiler system (for steam) scenario, CHP offers reductions in total primary fuel consumption on the order of 30% to 35%. This translates to equivalent CO_2 emissions reduction, assuming the same fuels. However, natural-gas fired CHP systems often displace a mix of central station capacity including coal-fired generation resulting in CO_2 emission reductions approaching 60% and even greater reductions in pollutants such as SO_2, NO_X and mercury.

CHP systems offer technology and fuel flexibility to fit diverse applications. Traditional boiler-steam turbines, reciprocating engines, and combustion turbine applications comprise the majority of existing CHP capacity. Additionally, proven technologies such as fuel cells and micro-turbines are increasingly being used in smaller scale CHP applications. While CHP systems also offer a wide-range of fuel flexibility, the current price outlook and environmental advantages of natural gas make it the CHP fuel of choice where available.[5]

Renewable energy has received enormous visibility and economic subsidies in recent years. However, when the relatively low capacity factors of wind and solar plants are considered (typically in the range of 30% and 16%, respectively), the cost of these renewable energy

[5] 72% of the existing 82 GW of CHP capacity is fueled by natural gas (ICF CHP Database 2013)

projects is often very high. Figure 3 demonstrates the economic advantage of a modest sized CHP project versus a large-scale combined cycle plant. It also highlights the need for continued incentives to support renewable energy projects in an environment of relatively low cost natural gas fuel. The CHP project, while not free of greenhouse gas emissions, is a least cost option that also offers a reduction of approximately 60% in source energy and carbon versus a coal plant and creates at least as many jobs as a wind or solar project of similar capacity.

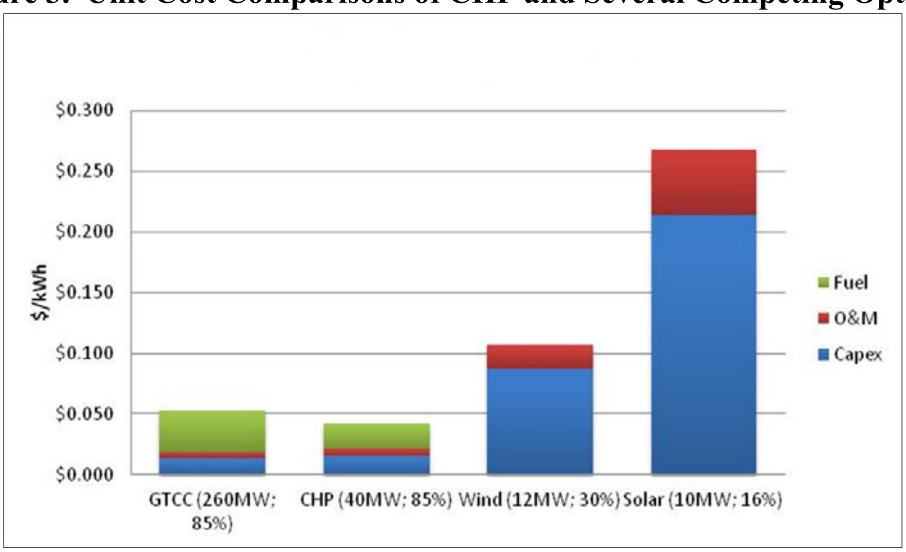
Finally, in many parts of the country, aging infrastructure, load growth, and the addition of renewable energy plants have created congestion and a need for massive investment in transmission and distribution infrastructure. The addition of CHP at industrial sites actually unloads the grid by siting generation at the point of demand. This results in cost savings for both the end-user and potentially reduces investment requirements by the utility.

The Current Environment for CHP Investment

There are a number of strong signs of encouragement for potential CHP investors. Four of the most significant drivers are:

Federal and state policymakers are beginning to recognize the benefits of CHP and are taking actions to encourage deployment. President Obama's 2013 State of the Union address stated: "Our first priority is making America a magnet for new jobs and manufacturing." The President announced the launch of three manufacturing hubs, where businesses can "turn regions left behind by globalization into global centers of high-tech jobs." In addition to manufacturing, the President talked about combatting climate change and new initiatives "to reduce pollution, prepare our communities for the consequences of climate change, and speed the transition to more sustainable sources of energy." While no major budget proposals have yet been forthcoming from the President's rhetoric, the bully pulpit of the President can have a beneficial effect on both Federal government programs affecting CHP, and state and public service commission officials, as well as potential users of CHP.

Figure 3. Unit Cost Comparisons of CHP and Several Competing Options



Source: Pace Global, a Siemens Business

President Obama's August 2012 Executive Order: "Accelerating Investment in Industrial Energy Efficiency" was more specific to CHP.[6] A key policy highlighted in the order was "to reduce energy use through more efficient manufacturing processes and facilities and the expanded use of Combined Heat & Power (CHP)". The order directs certain executive department and agencies to:

a. "convene national and regional stakeholders to identify, develop and encourage the adoption of investment models and State manufacturers to encourage investment in industrial energy efficiency and CHP";
b. "provide public information on the benefits of industrial energy investment and CHP"; and,
c. "use existing Federal authorities, programs and policies to support investment in industrial energy efficiency and CHP".

The order established a national goal of 40 gigawatts of new, cost-effective industrial CHP in the U.S. by the end of 2020.

President Obama's 2013 State of the Union message also talked about the "reshoring" of manufacturing. This involves companies moving their production facilities back to the U.S. A number of companies have calculated the most recent labor costs, fuels and materials costs, shipping, customs duties and other fees, and all the other costs of doing business overseas and have concluded that the U.S. is a cost-effective place to do business. The extent of this phenomenon is difficult to measure, but anecdotal evidence such as the examples provided by the President, suggests this is accelerating.

The development of shale gas resources is a "game changer" that has fundamentally altered the natural gas supply and price outlook in North America by promising an extended period of moderate and less volatile natural gas prices that will improve the economics for CHP. The revolution in recovering natural gas from shale formations is the result of large-scale application of horizontal drilling and hydraulic fracturing techniques in the shale development that began in the early 2000s.

The Barnett shale formation in Texas was one of the first to be tapped. Other large shale formations include the Haynesville shale in Louisiana, the Fayetteville shale in Arkansas, and (perhaps the largest) the Marcellus shale that extends southward from New York State, through Pennsylvania and into the Appalachian Mountains. The amount of shale gas supplied to the U.S. market has grown by a factor of 14 since 2005, displacing imports and more than offsetting declines in other North American production resources (ICF CHP 2013).[7]

The development of shale gas has had a significant moderating effect on natural gas prices. Prices in the five years prior to the recession averaged about $7.50/MMBtu; since 2008, gas prices have averaged about $4/MMBtu. Continuing advancements in technology are driving reassessments of long term gas outlook as analysts project more and more shale gas is economically recoverable at prices below $5 per MMBtu. Estimates of the natural gas resource base in North America that can be technically recovered using current exploration and production technologies now range from 2,000 to over 4,000 trillion cubic feet (Tcf) - enough

[6] Executive Order: "Accelerating Investment in Industrial Energy Efficiency"
[7] ICF Internal estimates based on historical production data

natural gas to supply the United States and Canada for 100 to 150 years at current levels of consumption.[8] Henry Hub gas prices remain in the $4 to $7 range through 2030 in current EIA projections; sufficient to support the levels of supply development in the projection, but not high enough to discourage market growth. Continuing moderate, and less volatile, gas prices will be a strong incentive for CHP market development (EIA 2013).

Environmental pressures are opening up near term opportunities to displace coal and oil boilers with clean CHP. At the end of 2012, the U.S. Environmental Protection Agency (EPA) finalized the Clean Air Act pollution standards National Emissions Standards for Hazardous Air Pollutants for Major Sources: Industrial, Commercial, and Institutional Boilers and Process Heaters. This is commonly known as the Boiler Maximum Achievable Control Technology (MACT). This rule applies to a wide range of large and small boilers burning coal or oil. Compliance with the rule will likely require many existing coal boiler operators to refit or replace their boiler. DOE estimated that there is a target of 791 coal boilers in 351 facilities representing a potential of about 18,000 MW that will need to be upgraded or replaced (DOE 2013). DOE has piloted and is now providing through its regional Clean Energy Application Centers technical information and technical support on clean energy options to industry. CHP will be proffered as a potential cost-effective option.

Industry replacing coal boilers with CHP units would be eligible for a variety of government benefits. Benefits include the provisions of the Energy Improvement and Extension Act of 2008, specifically:

a. 10% investment tax credit (ITC) for the first 15 MW of CHP property (The unit must be <50 MW, produce at least 20% useful thermal and 20% electricity, have an efficiency of 60% or greater, and be placed into service before January 1, 2017)
b. 5 year depreciation under the Modified Accelerated Cost Recovery System.

There is a growing interest by federal and state officials that CHP can play an important role in keeping critical infrastructure up and running during natural or manmade disasters. This was highlighted by recent (2013) experience with Superstorm Sandy where complexes and facilities which were served by CHP had fewer outages and faster recovery.

Barriers to CHP Growth and Some Potential Remedies

One of the most significant barriers to growth in CHP over the last 10 years has been disincentives created by electric utilities. If an industrial customer installed CHP, the utility would not only lose revenue from a customer that had a relatively steady, predictable load, but could have requirements to supply backup and supplemental power at the industrial customer's peak load as well as buy back power when the customer had a slack period. To discourage CHP, some utilities charged very high rates for supplying backup and supplemental power but bought back excess power at very low rates. In addition, some utilities required the customer to install expensive power conditioning and control equipment purported to be needed to overcome power

[8] The lower limit is based on DOE's natural gas resource estimate for the United States in EIA's Annual Energy Outlook 2012; the upper limit is based on ICF International's estimates of recoverable North American resources as of spring 2012

quality problems. At the same time attractive electricity rates may have been offered at the expense of other ratepayers to reduce the appeal of self-generated power.

While most of the advantages of CHP are widely accepted, CHP has not benefitted from state or federal programs to the degree renewable energy has. For example, the federal investment tax credit offers a 30% credit for solar and small wind, whereas the credit for CHP is 10%. However, during this period of fiscal challenge, there is momentum building in favor of CHP in recognition of it as an economically-favored source of clean energy. For example, several states (including CA, MD, NC, NJ, NY, TX and OH) have extended benefits previously reserved for renewable technologies to CHP. In 2012 Ohio expanded the definition of its Renewable Portfolio Standard and Energy Efficiency Resource Standards to include CHP and waste heat to power. Heightened awareness of the benefits of CHP will support a continuing trend toward inclusion of CHP in both federal and state energy plans and incentive programs.

However, numerous additional barriers remain that must also be addressed if CHP is to grow in relation to its economic and environmental merits. These include the following, stated with reference to potential solutions:

- Friendlier standby electric rates from utilities (based on the fair cost-of-service estimate) are needed to support the reliability requirements of industrial hosts, without economic burdens that often derail CHP projects and do not accurately reflect the cost of providing service.
- Standardized processes, timelines and costs for interconnection with the grid are highly desirable, yet remain an intimidating development challenge in many jurisdictions.
- An ability to sell excess power to the market at a fair price and without regulatory constraints would enable optimum sizing and maximum efficiency for new CHP.
- CHP potential should be an essential component of utility integrated resources plans, which aim to meet utility objectives at least cost. Currently, CHP is seldom proactively considered in such planning.
- Many industrial companies prefer to not invest their capital in power generation facilities. Recent accounting rule changes regarding leases and energy sales contracts have removed the off-balance sheet benefit of hosting 3^{rd}-party owned CHP plants. Many states, such as those that maintain a regulated retail electricity model, generally disallow the sale of energy from an on-site generator owned by a 3^{rd} party to an end-use customer. Many states also do not allow sales of power from a CHP system at one site to another commercial or industrial facility unless they share a common boundary and there are no public right of ways in between. These complex issues warrant attention as they limit end-users from partnering with those interested in CHP development for mutual benefit.

CHP Application Case Study: University Application

In addition to the economic and environmental attributes of CHP, on-site CHP can also enhance reliability and reduce investments in emergency generation. This case study summarizes the situation at a mid-sized university in the Southwest. To date, the facility purchases all its power from the grid and produces low-pressure steam in natural gas-fired boilers. The university launched an initiative to improve the reliability of their electricity supply, including the installation of back-up generating capacity to support business continuity during power outages. Facilities management was interested in ensuring a reliable supply of electricity while the budget office was most concerned about the capital investment required.

In order to improve the reliability of the existing electrical supply, a new, 100% redundant substation will be added, capable of providing enough power to meet the existing and future needs of the university. Despite the boost in reliability from redundant supply, risk management is interested in pursuing emergency back-up power on campus, to be able to provide basic needs for the residents and staff on campus during grid power disruption events.

The university began by considering only diesel-fired emergency generator sets, sized to the critical loads on campus. The budget office expressed concern over investing millions of dollars in diesel generators which would likely run only on rare occasions. Without a payback or financial justification the project stalled. Facilities management began looking into other technologies that could provide financial justification and meet the power reliability requirements of the university.

Following consideration of CHP, the solution yielded a sizable reduction in emergency generation investment that a 4 MW natural gas-fired cogeneration plant that would provide low cost energy while operating in baseload mode. CHP can provide approximately half of the university's emergency power needs and 25% of its average power load. The steam production from the cogeneration plant is just below the minimum steam demand requirement of the university. The addition of 25,000 lbs/hour of duct firing capacity allows the CHP plant to meet the entire campus steam requirement except on the coldest days of the year.

The university budget office was quick to support this alternative for its measurable payback despite the slightly larger investment compared to additional emergency generators. The project challenges were: available space, fuel supply, and emissions constraints. In keeping with architectural guidelines, all buildings on campus must appear in the same style, whether a powerhouse, library, or residence hall. Creativity was required in selecting a suitable location near the steam header, while considering the height requirement of the heat recovery boiler. The second challenge was the low pressure natural gas fuel supply. A gas compressor was added to the CHP project to ensure adequate pressure for the turbine selected. The final constraint was the nitrogen oxides ($NO_{x)}$ emissions cap that the university would prefer to remain below. After evaluating the emissions factors of the proposed plant, it was determined to equip the cogeneration plant with Selective Catalytic Reduction (SCR). This would yield about the same NO_x emissions as the existing boilers, eliminating any concerns about the university crossing the Title V limit.

Table 1. Project Summary

Cogen Power Output	4.0 MW
Cogen Steam Output	11,000 lbs/hr; 36,000 duct firing
Displaced Power Price	7.7₵/kWh
Current Fuel Cost	$5.58/MMBtu
Installed Cost	$9.0 MM
Net Annual Savings	$1.54 MM
Simple Payback	5.8 years

Source: Pace Global, a Siemens Business

The attractive economics above represent the 4MW CHP plant on an incremental basis. As the load being served by the CHP plant does not require emergency generation as it is already backed up by the grid, this project effectively eliminates 4MW of previously planned investment in gen sets. If factored into the CHP project economics, the simple payback in years is approximately reduced by half.

CHP Application Case Study #2: Industrial Application

The scale of a CHP project must be sufficient to overcome the project development complexities and barriers discussed above. With scale comes efficiency, but also higher investment costs. With U.S. industries facing global pricing pressures, capital availability is often a primary hurdle that is difficult to overcome. In this example, a creative solution was deployed leading to a successful project while preserving capital.

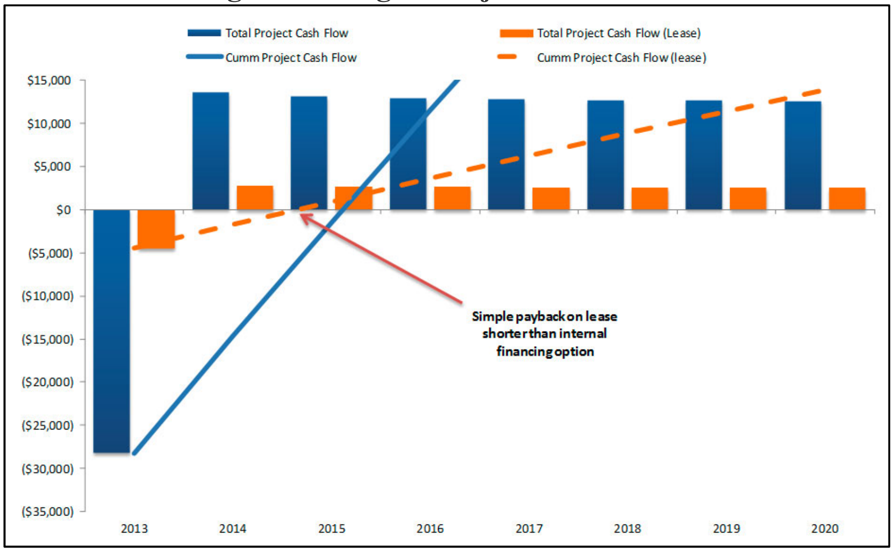
The facility in question is a mid-sized industrial facility with a large process steam requirement. To date the facility used a combination of fuels, primarily bunkering fuels, in older vintage steam boilers running through low-pressure extraction steam turbines to generate a portion of the site's steam and power load. As facility performance improvements have been made, the plant had become more thermally efficient and steam turbine power production declined. As such, power purchases were becoming larger and much more expensive as demand charges were ratcheted up by the local utility. The facility was at an inflection point. With pending environmental regulation dictating expensive emissions control retrofits, the opportunity came to look at the broader economics of the facility.

With the transformation of the natural gas market in the U.S. and the pending environmental regulations (utility and boiler MATS) making oil and coal economically challenged, a combined cycle natural-gas fired system was determined to be an optimal fit for the plant. However, the industrial owner was not interested in investing scarce capital into a power plant.

To move forward, the plant manager decided to pursue a novel concept; the facility would develop the project on their own, but finance the project using a lease structure that preserved the owner's capital while maintaining the operational benefits and cost savings from the project. This provided the facility with the financing required to meet the needs of the shareholders while achieving the net energy cost reduction necessary to keep the plant cost-competitive.

With an optimally sized CHP facility in place, the site host has seen a dramatic reduction in overall energy expenditures and has been able to completely eliminate electricity purchases. Furthermore, as a component of the system design, contingent operations were considered and a smaller, multiple unit design was chosen for its ability to deliver higher levels of system reliability without giving up significant losses in economies of scale. The capital equipment lease structure allowed for a "non-capital" financing, minimizing capital expenses, and maximizing energy savings relative to historical operations. The following chart shows the benefit of a lease financing option relative to leveraging internal capital. The simple payback was actually reduced by 50% while preserving a very strong ROI.

Figure 4. Cogen Project Cash Flows



Source: Pace Global, a Siemans Company

Conclusions and Recommendations

2013 is seeing many of the conditions needed to spur on a strong resurgence of CHP. This includes a growing economy, attention from all levels of government, more favorable policies of regulatory bodies, and recognition by users that CHP is a viable option for many energy needs. Low natural gas prices, increased industrial demand, favorable economics of CHP systems as well as technical support to analyze benefits, all incentivize CHP investments. More favorable treatment by public service commissions and federal regulatory requirements to replace existing equipment (coal boilers) provide a carrot and stick to accelerate CHP use. A deregulated electric utility market is starting to develop approaches so that the utility can realize benefits from assisting with CHP.

However, there is still a large amount of uncertainty in many of these factors and significant continuing barriers to CHP, that lead us to conclude that while 2013 might see some slow, steady growth in CHP that it might be somewhat longer before the CHP floodgates open.

We believe there are a number of actions which could be taken to accelerate the use of CHP. First, potential users of CHP have to see the clear business case for installing CHP (or in some cases adding additional CHP units or replacing existing units.) Feasibility studies and awareness materials must make clear how reduced energy costs and increased reliability affect the bottom line. Users need the tools to estimate technical feasibility, cash flows and return on investment without having to conduct expensive engineering design studies.

Second, the regulatory environment needs to be streamlined and utilities need to have sufficient incentives to make them facilitators of CHP installations rather than barriers to CHP implementation.

Third, strong financing solutions for CHP investments need to be identified and documented and alternative financing models need to be developed which address market and technology risks and allow both internal and external financial decision makers to understand the business case for CHP in specific applications.

Fourth, new drivers for CHP investments need to be found. The natural gas industry is interested in finding robust long term markets for new shale gas. Participation by the gas industry and its trade associations at a minimum could help reduce the perception of market risk, provide good data on technology performance, and spur the design of new models for implementation along with financing approaches to provide win-win situations for all the players.

Finally, federal and state government could provide the kind of policy and financial support which could address the range of barriers to new CHP. The President's Executive Order of 2012 (White House 2012) was a good start. It could be followed up with significant new programs and resources to specifically address industry and regulatory needs. New, successful approaches need to be developed, piloted, documented in case studies, and disseminated through effective communication channels. These approaches should include all the major partners and address key barriers so they are models for the industry and can be used to accelerate CHP investment.

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