Cogeneration has the potential to increase the efficiency of any power cycle by using the same fuel source to simultaneously produce electricity and heat. This boost in efficiency can prove itself to be a worthwhile investment opportunity, according to a system’s thermo-economic structure. Cogeneration is a process whereby waste heat energy is recycled to provide heat input to another portion of a power cycle. In a Rankine cycle, heat extracted from the turbine has the capacity to heat the working fluid in another portion of the cycle in an effort to increase thermal efficiency. Modern day power-plants operating on a Rankine cycle require that the turbine stage extract as much work as possible out of the thermal fluid (Schmidt et. al, 2006). By optimizing the amount of heat extracted at different stages of the power cycle, the realization is made that power systems increase efficiency and minimize exergy destruction by applying a cogeneration system.

There are different scenarios that involve the process of cogeneration. These processes include those with no cogeneration, thermal-match cogeneration, electrical-match cogeneration, or maximum cogeneration. No cogeneration exists when thermal energy is generated entirely for use by the cycle, meaning that all electrical power is purchased from a utility company and none is generated from heat. Thermal-match cogeneration produces thermal energy at temperatures and pressures much higher than that required for the power cycle processes. Electric power is generated by the steam at elevated conditions, afterward recovering the steam for use in generating power. The cogeneration system is sized so that thermal energy generated from the system is just enough to meet the demands of the cycle. In electrical-match cogeneration, thermal energy is again produced at elevated temperatures and pressures, similar to the thermally match case. Electrical power is produced first with the steam, and the recovered steam is then used to power the cycle. The difference in this cogenerative effort is that now the cogeneration system is sized to meet electrical power demands of the cycle. Finally, maximum cogeneration is exists when thermal energy is produced in excess of the cycle. Once electrical power demand is met from producing excess steam, the remainder of steam is dumped to the heat sink, usually the atmosphere. This cogeneration system is sized for maximum economic gain, such as maximum cash flow, or minimal fuel investment (Hu, 1985).

Analyzing the exergy use of a system, each component is measured from the same reference state, where changes in exergy correlate to costs of producing, fueling, and operating a power system. Exergy provides a different spectrum for engineers to analyze the efficiency of a power system. To illustrate the ability exergy has in optimizing a thermo-economic portfolio, consider the rising cost of conventional fuels consumed by power-plants. The necessity to conserve fuel is a driving factor to implement cogeneration into a power cycle. State of the Art design implemented into a system attempts to optimize the total cost of operation. Advanced technology comes with a high price tag, but the savings in fuel cost from minimizing the irreversibility of heat transfer and exergy destruction create a more efficient operation. State of the art cogeneration components can include heat-recovery steam generators, heat exchangers turbines, and feedwater heaters.

Cogeneration has proven to save energy that was once thought to be waste. There is a caveat in cogeneration: whether or not to maximize power of the system or to make the system economically friendly. (pg. 247, Schmidt) (pg. 50 yellow book) Not only does cogeneration benefit an energy system, but some disadvantages exist as well. Various areas cogenerations affects are overall system efficiency, fuel types, dependability, and environmental modifications.

Overall system efficiency is affected by cogeneration since the system is made more self-sufficient. By using some of the waste energy generated in the cycle to power another mechanism, the money used to power the system decreases and pollution is eliminated. A major concern with cogeneration is whether or not to maximize the thermal efficiency of the system and decrease the amount of money saved, or to regulate the temperature of the waste steam to a value that is not too costly. Usually, equilibrium between cost and thermal efficiency for a cycle is calculated so all criteria are met.

Cogeneration has the option of using various types of fuel as the working fluid of the system. Depending on the type of power cycle used, the working fuel could be a water vapor, refrigerant, or fuel mixture. By implementing cogeneration, fuel is conserved by being recycled through the system instead of released to the surroundings. The recycling process also saves energy in areas than the power cycle system.

Cogeneration also outputs a much more dependable amount of energy to the public. Cogeneration has proven to be much more efficient than the conventional fossil steam plant. Approximately 75% of the heat is utilized for power and heat for a cogeneration cycle with only about 25% exhaust steam. But in a fossil steam plant, only 35% of the energy from fuel is obtained as power; the exhaust gases from the condenser and boiler that end up being waste are 48% and 15%, respectively (Boyce, 2002). Not only do cogeneration cycles output more dependable power, but also if any kind of emergency such as natural disasters affected a power plant cogeneration would be a viable means of energy.

By using cogeneration, not only is energy recycled but also sources that are under constant worry of depletion such as fossil fuels and petroleum are conserved. Not only are these valuable resources preserved, but the energy required to transport and produce these resources are conserved. Also since waste energy is recycled in cogeneration power cycle, the vapor waste that was expelled from the system can longer harm the environment. Many power plants are under constant scrutiny from environmentalist groups about how waste adversely affects animal habitats and causes irreparable damage. Cogeneration power plant cycles eliminate unnecessary waste by utilizing it to actually improve system performance, which coincidentally helps the environment.

It is evidenced in industry that state of the art design and analysis of existing systems has led to development of more efficient technology. Cogenerative systems implemented into existing power-plants take into account various system characteristics. Some generalized parameters include fuel chargeable to electric power, overall system efficiency, electricity per steam flow, minimum process steam required, emission problems, capital costs, gross payback period, unit size and operational lifetime (Hu, 1985). These standards can be critiqued based on a cost/benefit analysis as well as technical inspection with emphasis placed on criteria pertinent to different levels of cogeneration.

There are many factors that contribute to defining the current state of the art cogeneration plant. These deciding elements include political stability, social growth, and economic development. Political stability of a country can affect the current technologies by implementing different regulatory policies. Interpretation of these policies can in turn determine how manufacturers and corporations carry out certain projects. Industries will be forced to follow rules pertaining to many areas, including those for manufacturing and building costs, energy regulations, and environmental laws. The increasing of advancement of society’s can also have a major influence on the designs and definitions of the current state of the art. As more knowledge about different trends in cogeneration is attained, many companies will begin to formulate new ways to implement projects that will utilize the advantages of these concepts, creating technologies that will influence and change the current state of the art. The economic conditions of a society also have a significant influence in what the state of the art of cogeneration plants are decided to be. The economic development at a certain time can determine the costs of certain materials by either increasing or decreasing their prices. This factor will influence the purchase of these materials that could be used to manufacture the different components of the plant (Limaye, 1987).

A cogeneration plant that has been decided as the current state of the art is one that employs the combined cycle. The simple arrangement of a combined cycle is comprised of gas turbines and steam turbines that recover heat to produce steam for a steam turbine generator. The typical cycle obtains output heat from an open gas circuit and inputs that energy into a heat recovery steam generator. Multiple pressure boilers, extraction steam turbines, and condensers can be used to better the performance. A combined cycle can obtain up to 80% utilization of fuel input and an efficiency that varies between 50 to 58% compared to the other cycles that have less than 50% efficiency. Other advantages of the combined cycle are low gas emissions, low capital costs, small space requirements, and fast initialization of machinery (Poullikkas, 2004).

The combined cycle can be applied to many applications, which include those for heating and electricity. In plants that employ the current state of the art to provide heating to inhabited areas, maximum steam outputs are necessary for the fuel inputs that are used. This consideration results in plants having additional boilers. Efficiency of the plant can be increased by inserting extra units. Usually the efficiency required for this heating application requires high energy efficiency and provides the highest economic value (Hu, 1982). For electricity production, condensers are inserted to provide flexibility in the electrical output. The configuration of these types of plants is similar to that of the heating applications but is smaller in size and limited by the consumer demand and rate costs. Thus, the combined cycle will be used to maximize the heat the fuel ration to meet the demands (Hu,1985).

As of now, the implementation of this current state of the art has provided more benefits than other cycles that have been discovered. Although these benefits are useful for the current societal needs, there are still flaws in efficiency and output production. As knowledge of cogeneration grows and new technologies are created, the current state of the art will be replaced to help overcome these problems.