AN OVERVIEW ON COGENERATION SYSTEM

Sayak Pal
Lecturer
Electrical Engineering Department
Technique Polytechnic Institute,
Hooghly, India
sayakpal30@gmail.com

Shamik Chattaraj
Lecturer
Electrical Engineering Department
Technique Polytechnic Institute,
Hooghly, India
chattaraj.shamik@gmail.com

Snehashis Das
Lecturer
Electrical Engineering Department
Technique Polytechnic Institute,
Hooghly, India
snnehashis@gmail.com

Tamal Hazra
Student
Electrical Engineering Department
Technique Polytechnic Institute,
Hooghly, India
tamalhazra02@gmail.com

***Abstract*— The contribution of cogeneration plants to a reduction in primary energy consumption will be important not only in lowering emissions to the atmosphere but also in cutting production costs by increasing the overall efficiency of fuel conversion to the electricity and heat used by process industries. Some basic factors of cogeneration, tri-generation & multi generation system have been discussed in this paper. Relation between cogeneration and gas turbine has been shown here. This paper shows basic details of cogeneration and some of its applications.**

***Keywords*— Cogeneration, Efficiency, Tri-generation**

I. INTRODUCTION

Fossil fuel crisis is a very much talkative topic in now days. Fossil fuel is the main source of energy throughout the world. Due to its depleting layer, maximum countries in the world are searching for new resources of energy. Renewable energy is one of the results of that search. But concept of cogeneration can also be helpful to mitigate the energy crisis. But cogeneration is not new concept. It came to Europe in the last segment of 1880s and in the USA early 1900s. During this time maximum industries produced their own electrical energy from coal fired power plants. Many of these industrial plants used the exhaust steam for its industrial process purposes. But due to some unavoidable circumstances, the cogeneration concept came to halt. In early 1970s when the fuel cost started to uprising and uncertainty of fuel supply, again triggered the cogeneration [1]. It was in particular for bigger industries where different types of large quantities steams were needed. In very recent small cogeneration systems have introduced to make inroads in the food, pharmacy, light manufacturing industries etc.

II. COGENERATION

It is the combination of two energy sources from a primary energy source. The primary energy sources typically mechanical energy and thermal energy. Mechanical energy can be used in generator for production of electrical energy or to drive various types of motors, fans, and pumps etc. which are

used in various industrial activities. Thermal energy has application in production of steam, hot water, hot air for cooled water etc. Cogeneration is also known as combined heat and power (CHP) [1]. Cogeneration has various applications in different sectors of economic activities. The system efficiency some time reaches to 85% which can be shown by given figure.

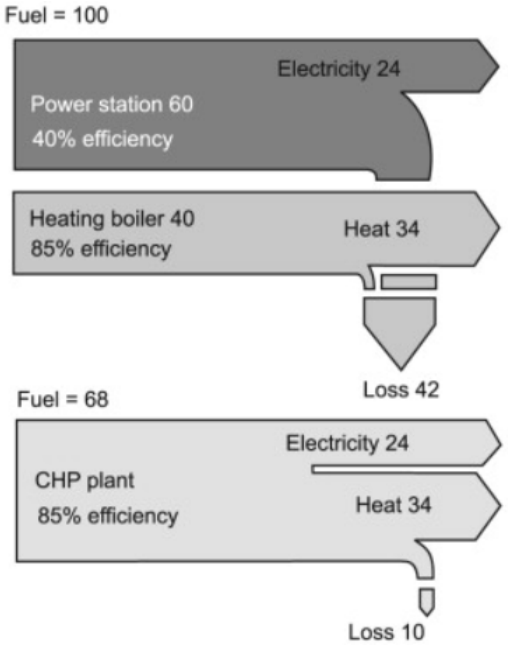

Fig. 1. Advantage of cogeneration

From the above figure, it is considered that power station will need 24 units of electrical energy and boiler needs 34 units of heat energy and also consider total fuel is 100 units. The input fuel (separately) to power plant is 60 and in boiler are 40 respectively. It is because for plant and boiler the efficiencies are 60% and 85% respectively. Fuel loss is 100-(24+34)=42. It is totally uneconomical system. But if cogeneration (CHP) considers, with 85% efficiency, only 68 fuel units are required and loss only 10 units of fuel. So in cogeneration total system efficiency is highly improved, less amount of fuel is needed and loss decreases considerably. Cogeneration also reduces emission of greenhouse gases. Production of electrical energy on site remove utility burden on the network and transmission losses.

III. MAIN COMPONENTS OF COGENERATION

There are mainly four main components present in a cogeneration facility. They are as follows (a) prime mover or turbine (b) a turbo alternator (c) A heat recovery boiler is installed to generate steam from energy contained in the exhaust gas of the turbine. Energy extraction can be

maximized by set up a standard economizer at the output side coif the heat recovery boiler & (d) control system.

IV. MAIN COMPONENTS OF COGENERATION

Technology	Fuel	Typical Size (MWe)	Electrical Efficiency	Heat to power ratio (HTPR)	Overall Efficiency
Spark ignitionn reciprocating engine	Natural gas / bio gas / diesel	0.0 0.3 to 6	25% to 43%	1:1 to 3:1	70% to 92%
Compression ignition reciprocating engine	Natural gas / bio gas / diesel / heavy fuel oil	0.2 to 20	35% to 45%	0.5:1 to 3:1	65% to 90%
Combied cycle turbine	Natural gas / bio gas / diesel / heavy fuel oil	3 to 300	35% to 55%	1.1:1 to 3:1	73% to 90%
Open cycle turbine	Natural gas / bio gas / diesel	0.2 5 to 50	25% to 42%	1.5:1 to 5:1	65% to 87%
Back pressure Steam turbine	None	0.5 to 500	7% to 20%	3:1 to 10:1	Maximum 80%
Extraction steam turbine	None	1 to 100	10% to 20%	3:1 to 8:1	Maximum 80%

V. FACTORS FOR SELECTION OF COGENERATION SYSTEM

The following factors can be considered in regarding cogeneration selection.

- Normal and terminal load (maximum or minimum) demand and steam load demand on the plant.
- Importance of electrical load or steam load.
- Load variation or fluctuation with respect to time.
- Types of fuel available for the process (Natural gas/bio gas/diesel/heavy fuel oil).
- Life span of various systems in the plant and maintenance cost.
- Local environmental conditions: space available, soil conditions, raw water availability, infrastructure etc.
- Project cost and long term benefits.
- Total project completion time.

VI. TRI-GENERATION & MULTI- GENERATION

Tri-generation is the combination of cooling, heating and power. It is the simultaneous process of electrical power production, heating and cooling from a single energy sources. The single energy source may be a fossil fuel or renewable energy source. One common tri-generation system is to use high temperature heat to drive steam turbine after that low temperature heat is used to produce cooling. The main difference of cogeneration and tri-generation is that in later part both heating and cooling are produced simultaneously. In tri- generation a cooling absorption system is used for providing cooling from thermal energy. To improve the overall efficiency the existing tri- generation system can be converted into multi- generation system. Output will be more than three products from single energy resources. In multi- generation system part of the electricity or cooling or heating is often utilized to produce an extra product viz. hydrogen or dry cleaning purpose etc. multi- generation increases system efficiency which reduces the energy losses. It indicates reducing of fuel usage as well as less amount of CO_2 emission. Ultimately multi-generation helps to minimize the global warming effect by this process. Below figure shows how system efficiency increases from single output to multi output.

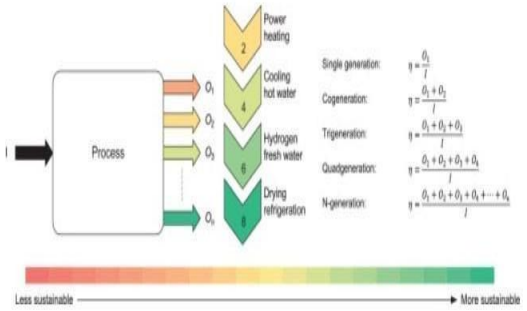

Fig. 2. Multi-generation energy efficiencies as the number of output increases [3]

VII. COGENERATION & GAS TURBINE:

Process plants are often used cogeneration because they want better return on investment (ROI)[4] on the process than utility. In this case cogeneration is more useful than two separate two sources of energy i.e. electrical and thermal. In process control plants both the energies are required. The following calculations are important to understand the whole methodology.

Consider, E=electric energy generated, ΔH=heat energy from process steam, Q=heat added to the plant from fuel.

Now cogeneration efficiency, ηco= (E+ΔH)/Q.

For separate electricity and steam generation, the heat added the unit of total energy is ((e/ηe)+(1-e)/ ηh), where e= electric fraction of total energy output=(E/E+ΔH), ηe=electric efficiency, ηh= heat efficiency. The combined efficiency for separate generation is ηc=1/((e/ηe)+(1-e)/ ηh). In most of the cases, ηco > ηc , which gives better ROI.

VIII. APPLICATION OF COGENERATION

Cogeneration is utilized in following process control industries such as petrochemicals, Fertilizers, Sugar, textiles, paper, food & dairy, hotel.

REFERENCES

[1] Alipour, Manijeh, Behnam Mohammadi-Ivatloo, and Kazem Zare. 2014. "Stochastic RiskConstrained Short-Term Scheduling of Industrial Cogeneration Systems in the Presence of Demand Response Programs." Applied Energy 136 (December): 393– 404.

[2] doi:10.1016/j.apenergy.2014.09.039.

[3] Brown, Tom, David Schlachtberger, Alexander Kies, and Martin Greiner. 2016. "Sector Coupling in a Highly Renewable European Energy System." In 15th Wind Integration Workshop. Vienna.

[4] https://www.sciencedirect.com/science/article/pii/B978012417203600 0053

[5] https://www.sciencedirect.com/science/article/pii/B978075067969550 0089

[6] European Commission. 2016. "An EU Strategy on Heating and Cooling. COM(2016) 51 Final." doi:10.1017/CBO9781107415324.004. European

[7] Union. 2012. "Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency."

[8] Grohnheit, Poul Erik. 1993. "Modelling CHP within a National Power System." Energy Policy 21 (4): 418–29. doi:10.1016/0301-4215(93)90282- K.

[9] Haghrah, A., M. Nazari-Heris, and B. Mohammadi-ivatloo. 2016. "Solving Combined Heat and Power Economic Dispatch Problem Using Real Coded Genetic Algorithm with Improved Mühlenbein Mutation." Applied Thermal Engineering 99 (April): 465–

[10] 75.doi:10.1016/j.applthermaleng.2015.12.136.

[11] International Energy Agency. 2014. "Linking Heat and Electricity Systems." Paris.

[12] International Renewable Energy Agency. 2016. The Power To Change : Solar and Wind Cost Reduction Potential To 2025.

[13] Lowe, Robert. 2011. "Combined Heat and Power Considered as a Virtual Steam Cycle Heat Pump." Energy Policy 39 (9). Elsevier: 5528–34. doi:10.1016/j.enpol.2011.05.007. in a Highly Renewable European Energy System." In 15th Wind Integration Workshop. Vienna.

[14] https://www.sciencedirect.com/science/article/pii/B978012417203600 0053

[15] https://www.sciencedirect.com/science/article/pii/B978075067969550 0089

[16] European Commission. 2016. "An EU Strategy on Heating and Cooling. COM(2016) 51 Final." doi:10.1017/CBO9781107415324.004. European

[17] Union. 2012. "Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on Energy Efficiency."

[18] Grohnheit, Poul Erik. 1993. "Modelling CHP within a National Power System." Energy Policy 21 (4): 418–29. doi: 10.1016/0301-4215(93)90282- K.

[19] Haghrah, A., M. Nazari-Heris, and B. Mohammadi-ivatloo. 2016. "Solving Combined Heat and Power Economic Dispatch Problem Using Real Coded Genetic Algorithm with Improved Mühlenbein Mutation." Applied Thermal Engineering 99 (April): 465–75.doi:10.1016/j.applthermaleng.2015.12.136.

[20] International Energy Agency. 2014. "Linking Heat and Electricity Systems." Paris.

[21] International Renewable Energy Agency. 2016. The Power To Change : Solar and Wind Cost Reduction Potential To 2025.

[22] Lowe, Robert. 2011. "Combined Heat and Power Considered as a Virtual Steam Cycle Heat Pump." Energy Policy 39 (9). Elsevier: 5528–34. doi:10.1016/j.enpol.2011.05.007.