Micro-Combined Heat and Power Systems

An Online Continuing Education Course for Engineers

Course Number: HV-3007

Credit: 3 Hours / 3 PDH / 3 CPD

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Introduction

A product that is just emerging in the residential sector is micro-combined heat and power systems. A micro-combined heat and power system (m-CHP) is a power source that will simultaneously generate useful heat, cooling effects, and power for residential or small commercial applications. Micro-CHP systems are generally considered to be systems of 15 kW electrical demand or smaller.

Combined heat and power (CHP) generation systems are not new. In fact, they have been around for well over a century. In the late 1800's steam was the prime mover for mechanical equipment in industrial plants and the steam was also used to generate electricity for lighting. In the early 1900's steam driven equipment was replaced with electric motors, but combined heat and power systems, also known as co-generation systems, continued to be used in industrial plants and, in fact, co-generation is still a popular concept for industry. Building on the success of co-generation in the industrial sector, products are now appearing in the residential sector that will supply both the heat and power needs of a residential home.

The components of a m-CHP system include a prime mover, a heat exchanger for hot water, a heat exchanger for building heat, an electrical generator, and maybe an absorption chiller, and a desiccant dehumidifier. The prime mover may be a reciprocating engine, turbine, fuel cell, or some other type of energy source that can be used to produce electricity. The waste heat from the prime mover is then used to 'fuel' the other components of the m-CHP system.

A major distinction between industrial CHP systems and m-CHP systems is that industrial CHP systems generate electricity and heat is the useful by-product for other functions. However, with a m-CHP system, the systems are primarily driven by the heat demand of the home and electricity is a by-product. This difference is significant, because if there is not a major heat load, then the system cannot economically generate a useful amount of electricity. This may mean that m-CHP systems will only find a niche market in predominately cold climates.

In this course, we will look at the various components of a micro-combined heat and power system including the prime movers that are the back-bone of the system, heat exchangers, absorption chillers, and desiccant dehumidifiers. But, first let's begin with an overview of m-CHP systems.

II. Micro-Combined Heat & Power Systems

When considering m-CHP systems a logical question is "how can m-CHP units that use gas fired prime movers be more efficient than central station electricity generation?" In fact, a m-CHP prime mover is generally much less efficient than a central station generator that uses coal, nuclear, or even gas to fire its boilers. Central station units lose about 50% of their energy in waste heat during production and the power still must be transmitted to the load center where the end user is located. To transport the power generated by a central station generator, the voltage must be increased for transmission to the distant load center. Losses occur during this transformation. Furthermore, energy is loss in the transportation of electrical energy across the high voltage transmission lines. Once the power is transported to a general area the voltage must be reduced and then transported across lower voltage distribution lines to residential neighborhoods where the voltage is again reduced to levels suitable for use within a home. Each of the voltage transformations and each power line that distributes the power consume some of the power generated by the central station generator. The end result is that only about 45% of the energy produced is actually available for consumption at the end user. Figure 1 shows a typical electric power system.

Electric Power System Components

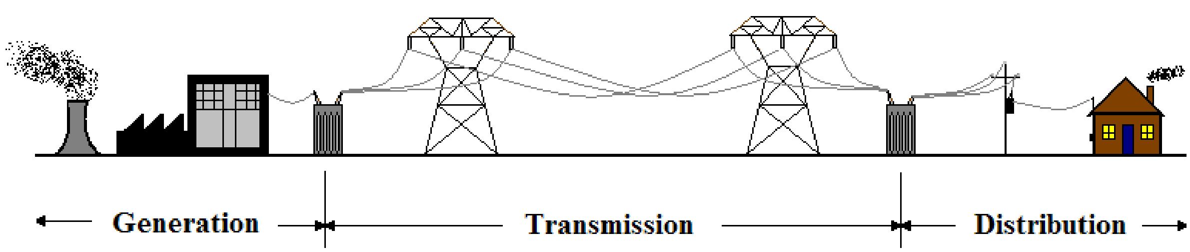
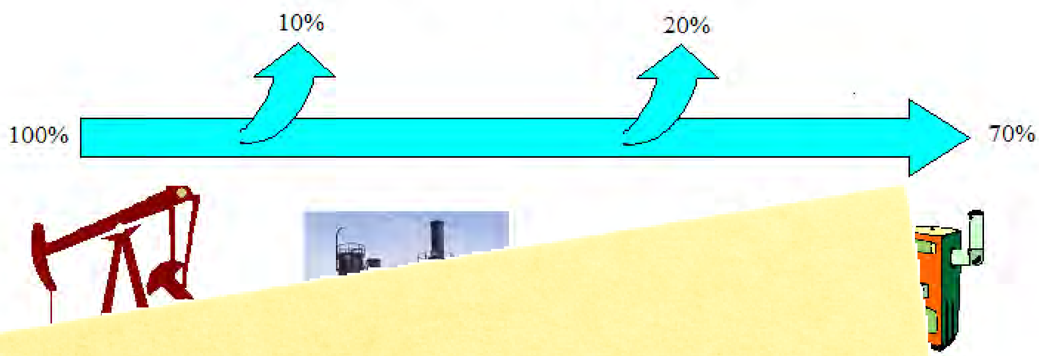


Figure 1

Contrast this with a m-CHP system where the electricity is generated right at the end user and the waste heat from the unit is utilized for space heating and domestic hot water. Since the m-CHP avoids transportation losses, the end user efficiency can approach 75% - if the waste heat can be fully utilized.

Figure 2 shown below is a representation of the energy transport from a natural gas field to the end use in the home. Approximately 10% of the energy is consumed in retrieving the natural gas and another 20% is lost in processing and delivery of the gas. This leaves 70% of the energy available for the m-CHP system.

Micro-CHP Energy Transport



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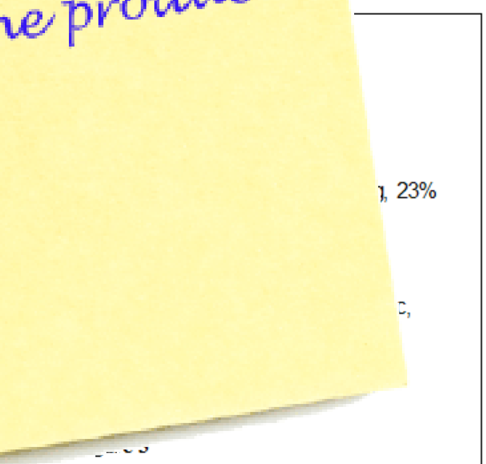

Figure 4 s... is a typical application of m-CHP. In this example natural gas is supplied to the m-CHP system. The system generates electricity which is fed into the main AC panel in the house (shown as the green line on the diagram). Waste heat from the m-CHP system generates hot water, which is supplied to heating radiators throughout the house and to the hot water storage tank (hot water is shown in red on the diagram). Hot water is also supplied to the absorption chiller, which provides cooling in the house. The remaining waste heat is exhausted through the flue vent.