Community - Biomass Combined Cooling Heat and Power (CCHP)

Renewable Energy landfill diverted waste fueled Microgrid resiliency systems

Overview

Murphy International's **Biomass CCHP System** is a range of proven renewable energy, biomass-fueled combined cooling heat and power systems (**CCHP**) that delivers cost effective, low-carbon heat and low-cost resilient microgrid electric power for a variety of municipal buildings such as hospitals, low income housing, leisure centers, schools, industrial centers and residential housing developments.

HIGHLIGHTS

- Generate heat and electricity from woody biomass, landfill diverted waste (SRF)
- Low carbon, renewable energy, and other biomass fuels that are even cheaper than the grid
- Better returns than heat-only biomass technologies
- Easy integration into existing heating and cooling systems (HVAC, hot water)
- Small footprint – simple installation, complete containerized solution
- Central fuel recycle facility to support differing sized aggregate Biomass systems at local buildings

Our Zero Waste, Clean energy production process uses both dedicated and landfill diverted biomass to generate electricity and both heating and cooling. Murphy International believes recycling and renewable energy makes the world safer, cleaner, our communities sustainable and more resilient.

Benefits: Working together for a better Future.

- Our intention is to be an asset to the communities in which we serve. To that end, we are local partners committed to: *Think locally, act locally*.
- Our community-based practices are designed to encourage local job creation and economic growth.
- We use local labor and contractors whenever possible and make every effort to position our developments in already disturbed areas close to existing utility substations.
- Our projects are meant to benefit the community in which they are located. We encourage community participation with; education, feedback, and work with local leaders to ensure ordinance compliance and minimal visual impact.
- We want to see the community thrive. We commit to listening to the feedback of community members regarding protected spaces and we will reinvest in our communities wherever possible.
- We are owner-operators of the majority of our projects. We also participate in public-private partnerships. We generally enter into a minimum 20-year agreement with the city or municipality. This means we have a vested interest in the well-being of the communities in which we work ad strive to be good neighbors and business partners.

Murphy International offers turnkey fully assembled renewable energy Biomass Combined Cooling and Heat and Power (CCHP) self-contained systems for rapid deployment in standard electric sizes from 250Kw, 500Kw, and 1Mw to Multiple MW sizes. With typical applications to provide reliable micro grid dependability and low cost energy for municipalities, island communities, commercial and industrial, resort, hospital and university applications. Our modular Biomass CCHP systems combine a combustion boiler, an ORC electric generator, along with an heat pump-absorption chiller and provide hot water generation to meet application loads. A central recycling center for biomass fuel processing allows us to build CCHP systems at multiple sites integrated by a central Smart Grid software Distributed Energy Resource Management System (DERM). The systematic deployment of these distributed energy systems as the basis of a community microgrid provides resilient and stable energy supplies for vital community facilities and assets. Microgrid systems help communities to achieve local resilience for vital services and interdependent community assets:

Hospitals, police, fire, emergency
Lighting, street lights, traffic lights
Pumping, refrigeration, HVAC
City water and wastewater
Cell towers, telecom, Internet
Gas stations, grocery stores, pharmacies

A microgrid is an electricity transmission system that can be "islanded off" from the main power grid in the event of some problem with the larger grid. The microgrid would carry locally generated energy to a defined locations to keep those areas supplied with power in the event of a broader system failure.

Our systems are further enhanced with optional containerized PV solar to optimize economics with low cost energy fully integrated with our state-of-the art software control system. The combination brings an economy of scale and provides efficient district energy and cooling while diverting waste from local landfills.

Our proven Biomass Combined Cooling Heat and Power (CCHP) Systems, provide resilience and base load power for both grid and off-grid applications, also known as cogeneration, is:

- **The concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy.**
- **Combined Cooling Heating & Power (CCHP) refers to CHP where cooling is also included.**
- **A type of distributed generation, which, unlike central station generation, is located at or near the point of consumption.**
- **A suite of technologies that can use a variety of fuels to generate electricity or power at the point of use, allowing the heat that would normally be lost in the power generation process to be recovered to provide needed heating and/or cooling.**

The Concept of Cogeneration and Combined Cooling Heat & Power (CCHP)

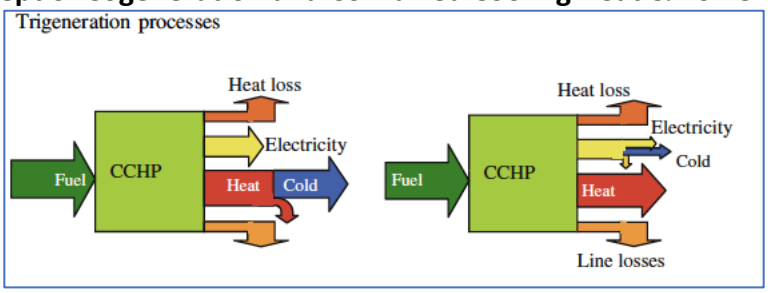

Table 1 CCHP Typical Heat Balance

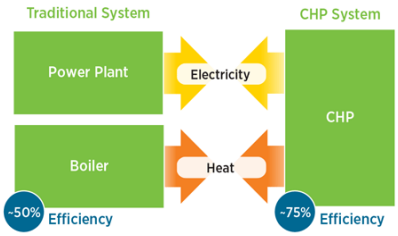

Figure 1 Biomass CCHP Layout

Figure 2 CCHP Process Flow Diagram

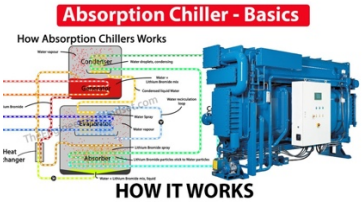

Figure 3 Absorption Chiller Basics

CCHP technology can be deployed quickly, cost-effectively, and with few geographic limitations. CCHP can use a variety of fuels, both fossil and renewable-based including biomass and solar. It has been employed for many years, mostly in industrial, large commercial, and institutional applications. CCHP may not be widely recognized outside industrial, commercial, institutional, and utility circles, but it has quietly been providing highly efficient electricity and process heat to some of the most vital industries, largest employers, urban centers, and campuses in the global community. It is reasonable to expect CCHP applications to operate at 65-90% efficiency, a large improvement over the national average of ~50% for these services when separately provided.

Figure 4 Optional Solar PV -Container-safeguard

Combined heat and power (CHP) positively impacts the health of local economies and supports national policy goals in a number of ways. Specifically, CHP can:

- **Enhance our energy security by reducing our national energy requirements and help businesses weather energy price volatility and supply disruptions**
- **Advance climate change and environmental goals by reducing emissions of CO2 and pollutants**
- **Improve business competitiveness by increasing energy efficiency and managing costs**
- **Increase resiliency of our energy infrastructure by limiting congestion and offsetting transmission losses**
- **Diversify energy supply by enabling further integration of domestically produced and renewable fuels**
- **Improve energy efficiency by capturing heat that is normally wasted.**

Our modularized power plants are based on proven technology suitable for demanding fuels from low to high caloric and moisture content values. Typical systems are based on the following steps:

- **Biomass fuel is burned in a combustor made according to the same, well-established techniques used for hot water boilers. These combustors and accessories - elements such as filters, controls, automatic ash disposal and biomass feed mechanisms - are safe, reliable, clean and efficient.**
- **Hot water is used as heat transfer medium, providing several advantages, including low pressure in the boiler, large inertia and insensitivity to load changes, simple and safe control and operation. The adopted for the hot side also ensures a very long oil life. Using a water boiler avoids the need for licensed operators, as required for steam systems in many countries.**
- **High efficiency Hybrid Multi Fuel biomass, Agriculture waste, wood, SRF - Varied moisture content, good emissions and low erosion rate Robust fuel feeding and bottom ash equipment w/ Sophisticated superheater design.**
- **An Organic Rankine Cycle turbogenerator converts the available heat to electricity. Through the use of a properly formulated working fluid and an optimized machine design, both high efficiency and high reliability can be achieved. The condensation heat of the turbogenerator produces hot water at typically 70°C-100°C, a temperature suitable for district heating and other low-temperature uses such as wood drying and cooling through absorption chillers.**
- **Optional wind and Solar PV systems are integrated to optimize low-cost generation and are fully integrated within the systems.**

Figure 1 Typical ORC site

ORC Technology

Organic Rankine Cycle technology is used to generate heat and electric power from renewable sources. Over the last 10 years ORC technology has been successfully demonstrated for application in small, decentralized biomass CCHP plants. Murphy international has designed, built, and operate ORC plants.

Figure 2 ORC PACKAGE

Figure 3 Multiple Mw Package

Over the last 15 years, ORC technology has proven its value for small, decentralized biomass CCHP plants from 250Kw up to around 5 MWe. The technology involves biomass fuel being burned to heat oil within a boiler, which is then used within an Organic Rankine Cycle unit to vapourize an organic working fluid that drives a turbine to generate power. The ORC also heats water alongside the power generation, which can be used for space heating/cooling purposes and hot water supply. Waste heat from the system is recovered to continue heating the boiler, with the organic working fluid cycling back around the system to keep driving the turbine.

ORC technology functions similarly to a traditional steam turbine, but instead of water, the ORC system vapourizes a high molecular mass organic fluid, offering cycles with superior electric performance and several mechanical advantages:

- **slower turbine rotation**
- **lower pressure**
- **no erosion of piping and blades.**

The ORC turbogenerator is pre-assembled onto one or more skids and can be easily transported. The thermodynamic cycle and relevant components are illustrated in Figure 2. Figure 3 illustrates the differences between turbines that work with water and turbines that use high molecular mass working fluid.
Advantages of ORC turbo-generators are:
Technical advantages

- **high cycle efficiency**
- **very high turbine efficiency (up to 90%)**
- **low turbine mechanical stress due to low peripheral speed**
- **low turbine RPM, allowing direct drive of electric generator without gear reduction**
- **no erosion of blades, due to the absence of moisture in the vapor nozzles.**

Operational advantages

- **simple start-stop procedures**
- **automatic and continuous operation**
- **no operator attendance needed**
- **quiet operation**
- **high availability. Partial load operation down to 10% of nominal power**
- **high efficiency event at partial load**
- **low O&M requirements: about 3-5 hours/week**
- **long life**

MICROGRID & CONTROLS

DEFINITION

- **A group of interconnected loads and distributed energy resources**
- **Clearly defined electrical boundaries & acts as a single controllable entity with respect to the grid**
- **Connects & disconnects from the grid and able to operate in both grid-connected or island-mode.**

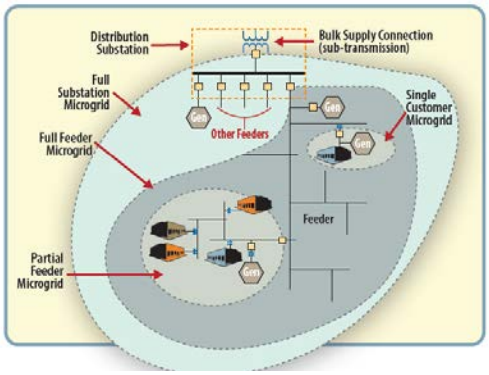

Figure 4 Microgrids: Basics to Advance

***Microgrid energy management systems** help local communities to capture local energy resources – such as solar, wind, and biomass – at higher levels. This yields many community benefits:*

- Keeping energy dollars local
- Reducing dependence on energy that must be transported over long distances
- Shrinking total environmental footprint

Figure 8 Microgrid Community Benefits

Murphy International's system is a microgrid consisting of the aggregation of Biomass CCHP systems with optional wind and/or solar photovoltaic generation, load controls, energy storage, and existing dispatchable generators.

Figure 5 ORC Site with Air Cooling

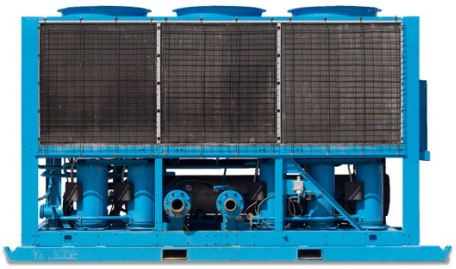

Figure 6 100 Ton A/C Absorption Low Temp Cooler

Our mission is simple: provide solutions that enable our customers to implement, run, and optimize an on-site energy system that meets their specific goals. We bring to the table expertise from across the energy spectrum to make this happen. With the Biomass CCHP systems ability to connect and disconnect from the grid, you have more flexibility and the opportunity to generate significant cost savings. Energy can be purchased from the grid when rates are low and generated locally when costs are high. Excess energy can be sold back to your local utility. Our team of energy experts helps develop an energy strategy and implementation that's configured around your needs. Our automated control technology is the "glue" that brings your new Biomass CCHP and existing assets together into a single, operable microgrid. It provides a detailed view of all power assets so you can proactively manage generation and usage accordingly. During outages, you can easily island your operations from the grid. The automation controls create a seamless grid that's resilient and cyber secure. In addition to monitoring standard power generation, they integrate the CCHP and our optional wind and solar, and legacy systems, like existing diesel generators. Even assets from different suppliers can be integrated. Create and manage your energy mix without fear of outages or power interruptions.

In summary, Murphy International's Biomass CCHP energy plants consist of pre-engineered, ready-made modules. For you, this means faster project development and completion with better quality and lower implementation risks. High fuel flexibility – agricultural, industrial and landfill diverted waste, innovative technology and service capabilities play key roles in the our solutions. The use of local renewable biomass fuels ensures reliable and sustainable energy supply as well as improves local employment opportunities. With Murphy International taking full responsibility over the process or the EPC delivery, you will be able to build a solid basis for your micro grid power plant and its profitability.