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Document 8
Data Management Document
Appendix S 06 - Energy Research

8.11.000 APPENDIX S 06 - ENERGY RESEARCH

8.11.001 Configuration Management

Version	Date	Name
v1	091015	nwk

8.11.002 List of sections

8.11.010 BIOGAS

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas originates from biogenic material and is a type of biofuel.

One type of biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as biomass, manure or sewage, municipal waste, green waste and energy crops.[1] This type of biogas comprises primarily methane and carbon dioxide. The other principal type of biogas is wood gas which is created by gasification of wood or other biomass. This type of biogas is comprised primarily of nitrogen, hydrogen, and carbon monoxide, with trace amounts of methane.

The gases methane, hydrogen and carbon monoxide can be combusted or oxidized with oxygen. Air contains 21 percent oxygen. This energy release allows biogas to be used as a fuel. Biogas can be used as a low-cost fuel in any country for any heating purpose, such as cooking. It can also be used in modern waste management facilities where it can be used to run any type of heat engine, to generate either mechanical or electrical power. Biogas can be compressed, much like natural gas, and used to power motor vehicles and in the UK for example is estimated to have the potential to replace around 17 percent of vehicle fuel.[2] Biogas is a renewable fuel, so it qualifies for renewable energy subsidies in some parts of the world.

Production

Biogas is practically produced as landfill gas (LFG) or digester gas. A biogas plant is the name often given to an anaerobic digester that treats farm wastes or energy crops. Biogas can be produced utilizing anaerobic digesters. These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste. There are two key processes: Mesophilic and Thermophilic digestion.[3]

Landfill gas is produced by wet organic waste decomposing under anaerobic conditions in a landfill.[4] [5] The waste is covered and mechanically compressed by the weight of the material that is deposited from above. This material prevents oxygen exposure thus allowing anaerobic microbes to thrive. This gas builds up and is slowly released into the atmosphere if the landfill site has not been engineered to capture the gas. Landfill gas is hazardous for three key reasons. Landfill gas becomes explosive when it escapes from the landfill and mixes with oxygen. The lower explosive limit is 5 percent methane and the upper explosive limit is 15 percent methane.[6] The methane contained within biogas is 20 times more potent as a greenhouse gas than carbon dioxide. Therefore un-contained landfill gas which escapes into the atmosphere may significantly contribute to the effects of global warming. In addition landfill gas' impact in global warming, volatile organic compounds (VOCs) contained within landfill gas contribute to the formation of photochemical smog. Sweden produces biogas from confiscated alcoholic beverages.[7]

Composition

The composition of biogas varies depending upon the origin of the anaerobic digestion process. Landfill gas typically has methane concentrations around 50%. Advanced waste treatment technologies can produce biogas with 55-75%CH_4 [9] or higher using in situ purification techniques[10] As-produced, biogas also contains water vapor, with the fractional water vapor volume a function of biogas temperature; correction of measured volume for water vapor content and thermal expansion is easily done via algorithm.[11]

In some cases biogas contains siloxanes. These siloxanes are formed from the anaerobic decomposition of materials commonly found in soaps and detergents. During combustion of biogas containing siloxanes, silicon is released and can combine with free oxygen or various other elements in the combustion gas. Deposits are formed containing mostly silica (SiO_2) or silicates

(SixOy) and can also contain calcium, sulfur, zinc, phosphorus. Such white mineral deposits accumulate to a surface thickness of several millimeters and must be removed by chemical or mechanical means. Practical and cost-effective technologies to remove siloxanes and other biogas contaminants are currently available.[12]

Applications

Biogas can be utilized for electricity production on sewage works,[13] in a CHP gas engine, where the waste heat from the engine is conveniently used for heating the digester; cooking; space heating; water heating; and process heating. If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion engine or fuel cells and is a much more effective displacer of carbon dioxide than the normal use in on-site CHP plants.[14]

Methane within biogas can be concentrated via a biogas upgrader to the same standards as fossil natural gas, and becomes biomethane. If the local gas network allows for this, the producer of the biogas may utilize the local gas distribution networks. Gas must be very clean to reach pipeline quality, and must be of the correct composition for the local distribution network to accept. Carbon dioxide, water, hydrogen sulfide and particulates must be removed if present. If concentrated and compressed it can also be used in vehicle transportation. Compressed biogas is becoming widely used in Sweden, Switzerland, and Germany. A biogas-powered train has been in service in Sweden since 2005.[15][16]

Biogas has also powered automobiles. In 1974, a British documentary film entitled ‘Sweet as a Nut’ detailed the biogas production process from pig manure, and how the biogas fueled a custom-adapted combustion engine.[17]

Scope and potential quantities

In the UK, sewage gas electricity production is tiny compared to overall power consumption - a mere 80 MW of generation, compared to 70 GW on the grid. Estimates vary but could be a considerable fraction from digestion of [18].

In developing nations

Biogas is also extensively used or being aggressively developed in rural China,[20] Nepal,[21][22] Vietnam,[23] rural Costa Rica,[24] Colombia,[25] Rwanda,[26] and other regions of the world where waste management and industry closely interface.

Deenabandhu Model (India)

The Deenabandhu Model is a new biogas-production model popular in India. (Deenabandhu means "helpful for the poor.") The unit usually has a capacity of 2 to 3 cubic metres. It is constructed using bricks or by a ferrocement mixture. The brick model costs approximately 18,000 rupees and the ferrocment model 14,000 rupees, however India's Ministry of Non-conventional Energy Sources offers a subsidy of up to 3,500 rupees per model constructed.

ARTI biogas plant

The Appropriate Rural Technology Institute developed a compact biogas plant which uses food waste, rather than dung or manure, to create biogas. The plant is sufficiently compact to be used by urban households, and about 2,000 are currently in use – both in urban and rural households in Maharashtra, India. Few ARTI biogas plants have been installed in other parts of India or the world. The design and development of the ARTI biogas plant won the 2006 Ashden Award for Sustainable Energy 2006 in the Food Security category.[27]

Gober gas

In India biogas produced from the anaerobic digestion of manure in small-scale digestion facilities is called gober gas; it is estimated that such facilities exist in over 2 million households. Gober gas (also spelled gobar gas, from the Hindi word gober for cow dung) is biogas generated from cow dung. A gober gas plant is an airtight circular pit made of concrete with a pipe connection. First, manure is dumped in the pit. Then, water or wastewater is added to the manure and the concoction is sealed in the airtight concrete pit with a gas pipe leading to stove unit in the kitchen serving as the only egress for gas. When the control valve on the gas pipe is opened the biogas is combusted for cooking in a largely odourless and smokeless [manner]. After the anaerobic microbial process has been exhausted, the residue left in the concrete pit is often used as fertiliser. Owing to the process's simplicity in implementation and use of cheap raw materials, it is often regarded as one of the most environmentally sound energy sources for rural needs.[28][29][30] Some designs use vermiculture to further enhance the slurry produced by the biogas plant for use as compost.[19]

The concept is also rapidly growing in Pakistan. The Government of Pakistan subsidises the construction of movable gas chamber biogas plants by up to 50 percent.

Legislation

The European Union presently has some of the strictest legislation regarding waste management and landfill sites called the Landfill Directive. The United States legislates against landfill gas as it contains these VOCs. The United States Clean Air Act and Title 40 of the Code of Federal Regulations (CFR) requires landfill owners to estimate the quantity of non-methane organic compounds (NMOCs) emitted. If the estimated NMOC emissions exceeds 50 tonnes per year the landfill owner is required to collect the landfill gas and treat it to remove the entrained NMOCs. Treatment of the landfill gas is usually by combustion. Because of the remoteness of landfill sites it is sometimes not economically feasible to produce electricity from the gas.

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8.11.020 COGENERATION (CHP)

Cogeneration or combined heat and power (CHP) is the use of a heat engine or a power station to simultaneously generate both electricity and useful heat.

Conventional power plants emit the heat created as a by-product of electricity generation into the environment through cooling towers, flue gas, or by other means. CHP or a bottoming cycle captures the byproduct heat for domestic or industrial heating purposes, either very close to the plant, or - especially in Scandinavia and eastern Europe - as hot water for district heating with temperatures ranging from approximately 80 to 130 °C. This is also called decentralized energy.[1]

In the United States, Con Edison distributes 30 billion pounds of 180 °C steam each year through its seven cogeneration plants to 100,000 buildings in Manhattan?the biggest steam district in the world. The peak delivery is 10 million pounds per hour (corresponding to approx. 2.5 GW)[2][3] This steam distribution system is the reason for the steaming manholes often seen in "gritty" New York based movies.

By-product heat at moderate temperatures 100-180°C) can also be used in absorption chillers for cooling. A plant producing electricity, heat and cold is sometimes called trigeneration or more generally: polygeneration plant.

Cogeneration is a thermodynamically efficient use of fuel. In separate production of electricity some energy must be rejected as waste heat, but in cogeneration this thermal energy is put to good use.

Overview

Thermal power plants (including those that use fissile elements or burn coal, petroleum, or natural gas), and heat engines in general, do not convert all of their thermal energy into electricity. In most heat engines, a bit more than half is lost as excess heat (Refer Second law of thermodynamics and Carnot's theorem). By capturing the excess heat, CHP uses heat that would be wasted in a conventional power plant, potentially reaching an efficiency of up to 89%, compared with 55%[4] for the best conventional plants. This means that less fuel needs to be consumed to produce the same amount of useful energy.

Some tri-cycle plants have utilized a combined cycle in which several thermodynamic cycles produced electricity, and then a heating system was used as a condenser of the power plant's bottoming cycle. For example, the RU-25 MHD generator in Moscow heated a boiler for a conventional steam powerplant, whose condensate was then used for space heat. A more modern system might use a gas turbine powered by natural gas, whose exhaust powers a steam plant, whose condensate provides heat. Tri-cycle plants can have thermal efficiencies above 80%.

An exact match between the heat and electricity needs rarely exists. A CHP plant can either meet the need for heat (heat driven operation) or be run as a power plant with some use of its waste heat.

CHP is most efficient when the heat can be used on site or very close to it. Overall efficiency is reduced when the heat must be transported over longer distances. This requires heavily insulated pipes, which are expensive and inefficient; whereas electricity can be transmitted along a comparatively simple wire, and over much longer distances for the same energy loss.

A car engine becomes a CHP plant in winter, when the reject heat is useful for warming the interior of the vehicle. This example illustrates the point that deployment of CHP depends on heat uses in the vicinity of the heat engine.

Cogeneration plants are commonly found in district heating systems of big towns, hospitals, prisons, oil refineries, paper mills, wastewater treatment plants, thermal enhanced oil recovery wells and industrial plants with large heating needs.

Thermally enhanced oil recovery (TEOR) plants often produce a substantial amount of excess electricity. After generating electricity, these plants pump leftover steam into heavy oil wells so that the oil will flow more easily, increasing production. TEOR cogeneration plants in Kern County, California produce so much electricity that it cannot all be used locally and is transmitted to Los Angeles. CHP is one of the most cost efficient methods of reducing carbon emissions of heating in cold climates. [5]

Types of plants

Topping cycle plants primarily produce electricity from a steam turbine. The exhausted steam is then condensed, and the low temperature heat released from this condensation is utilized for district heating.

Bottoming cycle plants produce high temperature heat for industrial processes, then a waste heat recovery boiler feeds an electrical plant. Bottoming cycle plants are only used when the industrial process requires very high temperatures, such as furnaces for glass and metal manufacturing, so they are less common.

Large cogeneration systems provide heating water and power for an industrial site or an entire town. Common CHP plant types are:

- Gas turbine CHP plants using the waste heat in the flue gas of gas turbines

- Gas engine CHP plants in the US use a reciprocating gas engine which is generally more competitive than a gas turbine up to about 5 MW.[6]

- Combined cycle power plants adapted for CHP

- Steam turbine CHP plants that use the heating system as the steam condenser for the steam turbine.

- Molten-carbonate fuel cells have a hot exhaust, very suitable for heating.

Smaller cogeneration units may use a reciprocating engine or Stirling engine. The heat is removed from the exhaust and the radiator. These systems are popular in small sizes because small gas and diesel engines are less expensive than small gas- or oil-fired steam-electric plants. Some cogeneration plants are fired by biomass [7], or industrial and municipal waste.

MicroCHP

"Micro cogeneration" is a so called distributed energy resource (DER). The installation is usually less than 5 kWe in a house or small business. Instead of burning fuel to merely heat space or water, some of the energy is converted to electricity in addition to heat. This electricity can be used within the home or business or, if permitted by the grid management, sold back into the electric power grid. In a comparison by Claverton Energy Research Group, it was found that in the UK case where heat would otherwise be produced by burning fossil fuels in a boiler, micro cogeneration is a more cost effective mean of reducing CO2 emissions than photovoltaics.[8]

MiniCHP
"Mini cogeneration" is a so called distributed energy resource (DER). The installation is usually more than 5 kWe and less than 500 kWe in a building or medium sized business. Current (2007) Micro- and MiniCHP installations use five different technologies: microturbines, internal combustion engines, stirling engines, closed cycle steam engines and fuel cells. One author indicates that microCHP based on Stirling engines is the most cost effective of the so called microgeneration technologies in abating carbon emissions. [9] Advances in reciprocation engine technology is, however; adding efficiency to CHP plant particularily in the Biogas field. [10] MiniCHP has a large role to play in the field of carbon reduction in buildings where more than 14% of carbon can be saved by 2010 using CHP in buildings according to the author. [11]

Cogeneration in Europe
Europe has actively incorporated cogeneration into its energy policy. In September 2008 at a hearing of the European Parliament's Urban Lodgment Intergroup, Energy Commissioner Andris Piebalgs is quoted as saying, "security of supply really starts with energy efficiency." [12] Energy efficiency and cogeneration are recognized in the opening paragraphs of the European Union's Cogeneration Directive 2004/08/EC. This directive intends to support cogeneration and establish a method for calculating cogeneration abilities per country. The development of cogeneration has been very uneven over the years and has been dominated throughout the last decades by national circumstances.

As a whole, the European Union currently generates 11% of its electricity using cogeneration, saving Europe an estimated 35Mtoe per annum a day.[13] However, there is large difference between Member States with variations of the energy savings between 2% and 60%. Europe has the three countries with the world's most intensive cogeneration economies: Denmark, the Netherlands and Finland.[14]

Other European countries are also making great efforts to increase their efficiency. Germany reported that at present, over 50% of the country's total electricity demand could be provided through cogeneration. So far Germany has set the target to double its electricity cogeneration from 12.5% of the country's electricity to 25% of the country's electricity by 2020 and has passed supporting legislation accordingly in "Federal Ministry of Economics and Technology, (BMWi), Germany, August 2007. The UK is also actively supporting combined heat and power. In light of UK's goal to achieve a 60% reduction in carbon dioxide emissions by 2050, the government has set the target to source at least 15% of its government electricity use from CHP by 2010. [15] Other UK measures to encourage CHP growth are financial incentives, grant support, a greater regulatory framework, and government leadership and partnership.

According to the IEA 2008 modeling of cogeneration expansion for the G8 countries, expansion of cogeneration in France, Germany, Italy and the UK alone would effectively double the existing primary fuel savings by 2030. This would increase Europe's savings from today's155.69 Twh to 465 Twh in 2030. It would also result in a 16% to 29% increase in each country's total cogenerated electricity by 2030.

Governments are being assisted in their CHP endeavors by organizations like COGEN Europe who serve as an information hub for the most recent updates within Europe's energy policy. COGEN is Europe's umbrella organization representing the interests of the cogeneration industry, users of the technology and promoting its benefits in the EU and the wider Europe. The association is backed by the key players in the industry including gas and electricity companies, ESCOs, equipment suppliers, consultancies, national promotion organisations, financial and other service companies.

Cogeneration in the United States
Perhaps the first modern use of energy recycling was done by Thomas Edison. His 1882 Pearl Street Station, the world's first commercial power plant, was a combined heat and power plant, producing both electricity and thermal energy while using waste heat to warm neighboring buildings.[16] Recycling allowed Edison's plant to achieve approximately 50 percent efficiency.

By the early 1900s, regulations emerged to promote rural electrification through the construction of centralized plants managed by regional utilities. These regulations not only promoted electrification throughout the countryside, but they also discouraged decentralized power generation, such as cogeneration. They even went so far as to make it illegal for non-utilities to sell power.[17]

By 1978, Congress recognized that efficiency at central power plants had stagnated and sought to encourage improved efficiency with the Public Utility Regulatory Policies Act (PURPA), which encouraged utilities to buy power from other energy producers.

Percentage of US energy produced by cogeneration
Cogeneration plants proliferated, soon producing about 8 percent of all energy in the U.S.[18] However, the bill left implementation and enforcement up to individual states, resulting in little or nothing being done in many parts of the country.

In 2008 Tom Casten, chairman of the company Recycled Energy Development, said that "We think we could make about 19 to 20 percent of U.S. electricity with heat that is currently thrown away by industry."[19]

Outside the U.S., energy recycling is more common. Denmark is probably the most active energy recycler, obtaining about 55% of its energy from cogeneration and waste heat recovery. Other large countries, including Germany, Russia, and India, also obtain a much higher share of their energy from decentralized sources.[18][19]

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8.11.030 DISTRICT HEATING

District heating (less commonly called teleheating) is a system for distributing heat generated in a centralized location for residential and commercial heating requirements such as space heating and water heating. The heat is often obtained from a cogeneration plant burning fossil fuels but increasingly biomass, although heat-only boiler stations, geothermal heating and central solar heating are also used, as well as nuclear power. District heating plants can provide higher efficiencies and better pollution control than localized boilers.

The core element of a district heating system is usually a cogeneration plant (also called combined heat and power, CHP) or a heat-only boiler station. Both have in common that they are typically based on combustion of primary energy carriers. The difference between the two systems is that, in a cogeneration plant, heat and electricity are generated simultaneously, whereas in heat-only boiler stations - as the name suggests - only heat is generated.

The combination of cogeneration and district heating is very energy efficient. A thermal power station which generates only electricity can convert less than approximately 50 % of the fuel input into electricity. The major part of the energy is wasted in form of heat and dissipated to the environment. A cogeneration plant recovers that heat and can reach total energy efficiency beyond 90 %. Other heat sources for district heating systems can be geothermal heat, solar heat, surplus heat from industrial processes, and nuclear power.

Nuclear energy can be used for district heating. The principles for a conventional combination of cogeneration and district heating applies the same for nuclear as it does for a thermal power station. One use of nuclear heat generation was with the Ågesta Nuclear Power Plant in Sweden. In Switzerland, the Beznau Nuclear Power Plant provides heat to about 20,000 people.[1] Russia has several cogeneration nuclear plants which together provided 11.4 PJ of district heat in 2005. Russian nuclear district heating is planned to nearly triple within a decade as new plants are built.[2]

Heat distribution

After generation, the heat is distributed to the customer via a network of insulated pipes. District heating systems consists of feed and return lines. Usually the pipes are installed underground but there are also systems with above ground pipes. Within the system heat storages may be installed to even out peak load demands.

The common medium used for heat distribution is water, but also steam is used. The advantage of steam is that in addition to heating purposes it can be used in industrial processes due to its higher temperature. The disadvantage of steam is a higher heat loss due to the high temperature.

Also, the thermal efficiency of cogeneration plants is significantly lower if the cooling medium is high temperature steam, causing smaller electric power generation. Heat transfer oils are generally not used for district heating, although they have higher heat capacities than water, as they are expensive, and have environmental issues.

At customer level the heat network is connected to the central heating of the dwellings by heat exchangers (heat substations). The water (or the steam) used in the district heating system is not mixed with the water of the central heating system of the dwelling. Typical annual loss of thermal energy through distribution is around 10%, as seen in Norway's district heating network.[3]

Pros and cons

District heating has various advantages compared to individual heating systems. Usually district heating is more energy efficient, due to simultaneous production of heat and electricity in combined heat and power generation plants. The larger combustion units also have a more advanced flue gas cleaning than single boiler systems. In the case of surplus heat from industries, district heating systems do not use additional fuel because they use heat (termed heat recovery) which would be disbursed to the environment.

District heating is a long-term commitment that fits poorly with a focus on short-term returns on investment. Benefits to the community include avoided costs of energy, through the use of surplus and wasted heat energy, and reduced investment in individual household or building heating equipment.

District heating networks, heat-only boiler stations, and cogeneration plants require high initial capital expenditure and financing. Only if considered as long-term investments will these translate into profitable operations for the owners of district heating systems, or combined heat and power plant operators. District heating is less attractive for areas with low population densities, as the investment per household is considerably higher. Also it is less attractive in areas of many small buildings; e.g. detached houses than in areas with a few much larger buildings; e.g. blocks of flats, because each connection to a single-family house is quite expensive.

International variation

Since conditions from city to city differ, every district heating system is uniquely constructed. In addition, nations have different access to primary energy carriers and so they have a different approach how to address the heating market within their borders. This leads not only to a different degree of diffusion but also to different district heating systems in general throughout the world.

History

District heating traces its roots to the hot water-heated baths and greenhouses of the ancient Roman Empire. District systems gained prominence in Europe during the Middle Ages and Renaissance, with one system in France in continuous operation since the 14th century. The U.S. Naval Academy in Annapolis began steam district heating service in 1853.

Although these and numerous other systems have operated over the centuries, the first commercially successful district heating system was launched in Lockport, New York, in 1877 by American hydraulic engineer Birdsill Holly, considered the founder of modern district heating. The future of many of these systems are in doubt. The same kind of problems many district heating operations in former Soviet Union and Eastern Europe have today, many North American steam district heating systems began to experience in the 1960s and 1970s. In North America, the owners (in many cases power utilities) lost interest in the district heating business and provided insufficient funding for maintenance, and the systems and service to customers started to deteriorate. The result was that the systems started losing customers. The reliability decreased and finally the whole system closed down. For example, in Minnesota in the 1950s there were about 40 district steam systems, but today only a few remain.[9]

Paris has been using geothermal heating from a 55-70 °C source 1–2 km below the surface since the 1970s for domestic heating. [15] In the 1980s Southampton began utilising combined heat and power district heating, taking advantage of geothermal heat "trapped" in the area. The geothermal heat provided by the well works in conjunction with the Combined Heat and Power scheme. Geothermal energy provides 15-20 %, fuel oil 10 %, and natural gas 70 % of the total heat input for this scheme and the combined heat and power generators use conventional fuels to make electricity. "Waste heat" from this process is recovered for distribution through the 11 km mains network. [15][16]

Market penetration of district heating

Penetration of district heating (DH) into the heat market varies by country. Penetration is influenced by different factors, including environmental conditions, availability of heat sources and economic and legal framework. In the year 2000 the percentage of houses supplied by district heat in some European countries was as follows:

Country	Penetration (2000)[17]
Iceland	95%
Denmark	60% (2005)[4]
Estonia	52%
Poland	52%
Sweden	50%
Slovakia	40%
Finland	49%
Hungary	16%
Austria	12.5%
Germany	12%
Netherlands	3%
UK	1%

In Iceland the prevailing positive influence on DH is availability of easily captured geothermal heat. In most East European countries energy planning included development of cogeneration and district heating. Negative influence in The Netherlands and UK can be attributed partially to milder climate and also competition from natural gas supply.

Energy consumption

According to Helsingin Energia, consumption of energy by district heating in Helsinki since 1970 peaked in 1971, at 67 kWh/m?/year, falling to 43 kWh/m?/year in 1997, since when it has not fluctuated greatly.[18] Figures for Sweden suggest that the average Swede using district heating receives 4500 kWh/year from the system.[19]

District cooling

The opposite of district heating is district cooling. Working on broadly similar principles to district heating, district cooling delivers chilled water to buildings like offices and factories needing cooling. In winter, the source for the cooling can often be sea water, so it is a cheaper resource than using electricity to run compressors for cooling.

The Helsinki district cooling system uses otherwise wasted heat from summer time CHP power generation units to run absorption refrigerators for cooling during summer time, greatly reducing electricity usage. In winter time, cooling is achieved more directly using sea water. The adoption of district cooling is estimated to reduce the consumption of electricity for cooling purposes by as much as 90 per cent and an exponential growth in usage is forecast. The idea is now being adopted in other Finnish cities. The use of district cooling grow also rapidly in Sweden in a similary way [20].

Cornell University's Lake Source Cooling System uses Cayuga Lake as a heat sink to operate the central chilled water system for its campus and to also provide cooling to the Ithaca City School

District. The system has operated since the summer of 2000 and was built at a cost of $55–60 million. It cools a 14,500 tons load.

In August 2004, Enwave Energy Corporation, a district energy company based in Toronto, Canada, started operating system that uses water from Lake Ontario to cool downtown buildings, including office towers, the Metro Toronto Convention Centre, a small brewery and a telecommunications centre. The process has become known as Deep Lake Water Cooling (DLWC). It will provide for over 40,000 tons (140 megawatts) of cooling—a significantly larger system than has been installed elsewhere. Another feature of the Enwave system is that it is integrated with Toronto’s drinking water supply.

In January 2006, PAL technology is one of the emerging project management companies in UAE involved in the diversified business of desalination plant, sewerage plant to district cooling system. More than 400,000 Tons of district cooling projects are already in the pipe line whilst negotiating other key projects in the region. In 2006, a district cooling system came online in Amsterdam's Zuidas, drawing water from the Nieuwe Meer[21][22]

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8.11.040 HYDRONICS

Hydronics is the name for the use of water as the heat-transfer medium in heating and cooling systems.

Some of the oldest and most common examples are steam and hot-water radiators. Historically, in largescal commercial buildings such as high-rise and campus facilities, a hydronic system may include both a chilled and a heated water loop, to provide for both heating and air conditioning. Chillers and cooling towers are used separately or together as means to provide water cooling, while boilers heat water.

The addition to the market of chiller boiler systems Chiller_Boiler_System allow this proven form of green hvac to be used in homes and smaller commercial spaces.

In addition, many larger cities have a district heating system that provides, through underground piping, publicly available steam and chilled water. By paying a service fee, a building in the service district may be connected to these.

Hydronic systems are of two basic types:
- Steam or Hot water
- Chilled water

Hydronic systems are classified in five ways:
- Flow generation (forced flow or gravity flow)
- Temperature (low, medium, and high)
- Pressurization (low, medium, and high)
- Piping arrangement
- Pumping arrangement

Hydronic systems may be divided into several general piping arrangement categories:
- Single or one-pipe
- Two pipe steam (direct return or reverse return)
- Three pipe
- Four pipe
- Series loop

Single-pipe steam

In the oldest modern hydronic heating technology, a single-pipe steam system delivers steam to the radiators where the steam gives up its heat and is condensed back to water. The radiators and steam supply pipes are pitched so that gravity eventually takes this condensate back down through the steam supply piping to the boiler where it can once again be turned into steam and returned to the radiators.

Despite its name, a steam radiator does not primarily heat a room by radiation. If positioned correctly a radiator will create an air convection current in the room, which will provide the main heat transfer mechanism. It is generally agreed that for the best results a steam radiator should be no more than one to two inches from a wall.

Single-pipe systems are limited in both their ability to deliver high volumes of steam (that is, heat) and the ability to control the flow of steam to individual radiators (because closing off the steam supply traps condensate in the radiators). Because of these limitations, single-pipe systems are no longer installed.

In order to work correctly, these systems depend on the proper operation of thermally closed air-venting valves located on radiators throughout the heated area. When not in use, these valves are open to the atmosphere, and radiators and pipes contain regular air. When a heating cycle begins, the boiler produces steam, which expands, rises, and displaces the regular air in the system. The regular air exits the system via the air-venting valves on the radiators, as well as air-venting valves placed on the steam pipes themselves. The valves close when steam reaches them, due to a small amount of alcohol in them turning into vapor and exerting mechanical force to close the valve. When the heating cycle ends, the steam in the radiators cools, the air-venting valve reopens, and regular air again enters the system.

To increase heat delivered to an area served by a radiator, a larger air-venting valve can be installed. Some more modern valves can also be adjusted so as to allow for more rapid or slower venting. In general, valves nearest to the boiler should vent the slowest, and valves furthest from the boiler should vent the fastest. Ideally, steam should reach each valve and close each and every valve at the same time, so that the system can work at maximal efficiency; this condition is known as a "balanced" system.
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The most common problems with air-venting valves occur when they are painted over, crushed, or clogged with rust, often leading to homeowner frustration. Improperly trained service technicians often respond to complaints by increasing boiler steam pressure rather than replacing air-venting valves. This actually makes matters worse, by causing high pressure steam to leak or otherwise, as well as wasting heating oil and energy. Investing in new air-venting valves for an old or troublesome single-pipe steam system, as well as taking the time to correctly size and adjust them, will reduce or eliminate many headaches once completed and lower heating fuel use and bills.

Two-pipe steam systems
In two-pipe steam systems, there is a return path for the condensate and it may involve pumps as well as gravity-induced flow. The flow of steam to individual radiators can be modulated using manual or automatic valves.

Two pipe direct return system
The return piping, as the name suggests, takes the most direct path back to the boiler.

Advantages
Low cost of return piping in most (but not all) applications, and the supply and return piping are separated.

Disadvantages
This system can be difficult to balance due to the supply line being a different length than the return, The further the heat transfer device is from the boiler the more pronounced the pressure difference. Because of this it is always recommended to: minimize the distribution piping pressure drops; use a pump with a flat head characteristic, include balancing and flow measuring devices at each terminal or branch circuit; and use control valves with a high head loss at the terminals.

Two pipe reverse return system
The return piping takes the same basic path as the supply back to the boiler.

Advantages

This system is often considered "self balancing", however, valves should always be included.

Disadvantages
The installer or repair person cannot trust that every system is self balancing without properly testing it. Very large scale systems can be built using the two-pipe principle. For example, rather than heating individual radiators, the steam may be used in the reheat coils of large air handlers to heat an entire floor of a building.

Water loops
Modern systems almost always use heated water rather than steam. This opens the system to the possibility of also using chilled water to provide air conditioning.

In homes, the water loop may be as simple as a single pipe that "loops" the flow through every radiator in a zone. In such a system, flow to the individual radiators can not be modulated as all of the water is flowing through every radiator in the zone. Slightly more complicated systems use a "main" pipe that flows uninterrupted around the zone; the individual radiators tap off a small portion of the flow in the main pipe. In these systems, individual radiators can be modulated. Alternatively, a number of loops with several radiators can be installed, the flow in each loop or zone controlled by a zone valve connected to a thermostat.

In most water systems, the water is circulated by means of one or more circulator pumps. This is in marked contrast to steam systems where the inherent pressure of the steam is sufficient to distribute the steam to remote points in the system. A system may be broken up into individual heating zones using either multiple circulator pumps or a single pump and electrically operated zone valves.

Boiler water treatment
Domestic (home) systems may use ordinary tap water, but sophisticated commercial systems often add various chemicals to the system water. For example, these added chemicals may:
- Inhibit corrosion
- Prevent freezing of the water in the system
- Increase the boiling point of the water in the system
- Inhibit the growth of mold and bacteria
- Allow improved leak detection (for example, dyes that fluoresce under ultraviolet light)

Air elimination
All hydronic systems must have a means to eliminate air from the system. A properly designed system that is air-free should provide many years of excellent performance. Air causes irritating system noise in addition to interrupting proper heat transfer as the system fluids circulate throughout the system. In addition, unless reduced below an acceptable level, the oxygen found within water will cause corrosion. This corrosion can cause rust and scale to build up on the system piping. Over time these particles can become loose and travel throughout the system. The particles can reduce flow and even clog the system in addition to causing damage to pump seals and other system components.

Steam system
In steam systems, individual radiators are usually equipped with a thermostatic bleed valve. At room temperature, the valve opens the radiator to the air, but as hot steam flows into the radiator and pushes the contained air out, the valve heats and eventually closes, preventing steam from escaping into the room.

Water-loop system
Water-loop systems can also experience air problems. Air found within hydronic water-loop systems may be classified into three forms:

Free air
Various devices such as manual and automatic air vents are used to address free air which floats up to the high points throughout the system. Automatic air vents contain a valve that is operated by a float. When air is present, the float drops, allowing the valve to open and bleed air out. When water reaches (fills) the valve, the float lifts, blocking the water from escaping. Small (domestic) versions of these valves in older systems are sometimes fitted with a Schrader-type air valve fitting, and any trapped, now-compressed air can be bled from the valve by manually depressing the valve stem until water rather than air begins to emerge.

Entrained air
Entrained air is air bubbles that travel around in the piping at the same velocity as the water. Air "scoops" are one example of products which attempt to remove this type of air.

Dissolved air
Dissolved air is also present in the system water and the amount is determined principally by the temperature and pressure (see Henry's Law) of the incoming water. On average, tap water contains between 8-10% dissolved air by volume. Removal of dissolved, free and entrained air can be achieved with a high-efficiency air elimination device that includes a coalescing medium that continually scrubs the air out of the system.

Accommodating thermal expansion
Water expands and contracts as it heats and cools. A water-loop hydronic system must have one or more expansion tanks in the system to accommodate this varying volume of the working fluid. These tanks often use a rubber diaphragm pressurised with compressed air. The expansion tank accommodates the expanded water by further air compression and helps maintain a roughly-constant pressure in the system across the expected change in fluid volume.

Automatic fill mechanisms
Hydronic systems are usually connected to a water supply (such as the public water supply). An automatic valve regulates the amount of water in the system and also prevents backflow of system water (and any water treatment chemicals) into the water supply.

Safety mechanisms
Excessive heat or pressure may cause the system to fail. At least one combination over-temperature and over-pressure relief valve is always fitted to the system to allow the steam or water to vent to the atmosphere in case of the failure of some mechanism (such as the boiler temperature control) rather than allowing the catastrophic bursting of the piping, radiators, or boiler. The relief valve usually has a manual operating handle to allow testing and the flushing of contaminants (such as grit) that may cause the valve to leak under otherwise-normal operating conditions.

SOURCE: http://en.wikipedia.org/wiki/Hydronics

8.11.050 GAS FLARE

A gas flare or flare stack is an elevated vertical stack or chimney found on oil wells or oil rigs, and in refineries, chemical plants and landfills used for burning off unwanted gas or flammable gas and liquids released by pressure relief valves during unplanned over-pressuring of plant equipment.[1][2][3] In landfills, the primary purpose of this device is to vent and/or burn waste gas which results from the decomposition of materials in the dump.

Recently, under the Kyoto Treaty, garbage collecting companies in some developing nations have received a carbon bonus for installing burning chimneys for the methane gas produced at their landfills, preventing methane from reaching the atmosphere. After the burning, this gas is converted to heat, water and CO2, and according to the Third assessment report of the IPCC, as Methane is 23 times more powerful a greenhouse gas than CO2 the greenhouse effect is reduced in the same order.

On oil production rigs, in refineries and chemical plants, its primary purpose is to act as a safety device to protect vessels or pipes from over-pressuring due to unplanned upsets. This acts just like the spout on a tea kettle when it starts whistling as the water in it starts boiling. Whenever plant equipment items are over-pressured, the pressure relief valves on the equipment automatically release gases (and sometimes liquids as well) which are routed through large piping runs called flare headers to the flare stacks. The released gases and/or liquids are burned as they exit the flare stacks. The size and brightness of the resulting flame depends upon how much flammable material was released. Steam can be injected into the flame to reduce the formation of black smoke. The injected steam does however make the burning of gas sound louder, which can cause complaints from nearby residents. Compared to the emission of black smoke, it can be seen as a valid trade off. In more advanced flare tip designs, if the steam used is too wet it can freeze just below the tip, disrupting operations and causing the formation of large icicles. In order to keep the flare system functional, a small amount of gas is continuously burned, like a pilot light, so that the system is always ready for its primary purpose as an overpressure safety system. The continuous gas source also helps diluted mixtures achieve complete combustion.

Flaring and venting of natural gas in oil wells is a significant source of greenhouse gas emissions. Its contribution to greenhouse gases has declined by three-quarters in absolute terms since a peak in the 1970s of approximately 110 million metric tons/year and now accounts for 0.5% of all anthropogenic carbon dioxide emissions.[4] The World Bank estimates that over 100 billion cubic metres of natural gas are flared or vented annually, an amount worth approximately 30.6 billion dollars, equivalent to the combined annual gas consumption of Germany and France, twice the annual gas consumption of Africa, three quarters of Russian gas exports, or enough to supply the entire world with gas for 20 days. This flaring is highly concentrated: 10 countries account for 75% of emissions, and twenty for 90%.[5] The largest flaring operations occur in the Niger Delta region of Nigeria. The leading contributors to gas flaring are (in declining order): Nigeria, Russia, Iran, Algeria, Mexico, Venezuela, Indonesia, and the United States.[6] In spite of a ruling by the Federal High Court of Nigeria (that forbade flaring) in 2005, 43% of the gas retrieval was still being flared in 2006. It will be prohibited by law as of 2008.

Russia has announced it will stop the practice of gas flaring as stated by deputy prime minister Sergei Ivanov on Wednesday September 19, 2007.[7] This step was, at least in part, a response to a recent report by the National Oceanic and Atmospheric Administration (NOAA) that concluded Russia's previous numbers may have been underestimated. The report, which used night time light pollution satellite imagery to estimate flaring, put the estimate for Russia at 50 billion cubic meters while the official numbers are 15 or 20 billion cubic meters. The number for Nigeria is 23 billion cubic meters.[8]

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