Turbines for Biomass Plants
Products for Biomass-fired Power Generation and District Heating & Cooling Applications

www.siemens.com/energy
Biomass to Fuel the Future

Today we see many compelling environmental and economic reasons to use biomass as a power generation fuel.

Combusting biomass feedstock to create electricity does not contribute to global warming and helps avoid the release of other harmful emissions. Also, viable fuels are produced in many industries with no additional processing costs involved, further strengthening the financial feasibility of new plants on favorable sites. Additionally, many countries have established subsidies to make biomass based power generation economically viable. The possibility of firing a biomass plant on diverse feedstocks is an additional support for project economics and ensures security of fuel supply. As we are striving to move to a low-carbon economy, biomass energy for both industry and electricity generators will become an increasingly important – and sustainable – source of baseload power.

Although most biomass generation uses well-known technology, many breakthroughs in both the energy transfer and delivery of feedstock are on the horizon. Coupled with new climate regulations and increasing fossil fuel prices, industry and electricity generators are increasingly seeking the benefits of building new biomass capacity. Engaging experienced equipment manufacturers is an important step toward commissioning a new biomass plant. Over the long term, having a partner with an installed biomass base of over 3.5 GW can only improve the success of your biomass development strategy.

Biomass Combustion Technology

The two most common technologies used to combust biomass are stoker boilers and fluidized bed combustion boilers. Depending on how the biomass is pre-treated before combustion, one or another type of boiler may be more appropriate to ensure consistent steam parameters, the most efficient use of factory inputs, and environmental compliance.

Feedstock characteristics are also used to determine which type of boiler is the most appropriate for a biomass plant. While stokers and fluidized bed boilers can be used for similar applications across industries, recovery boilers are used to both generate steam and to recycle chemical factory inputs, especially in forest products industries, the pulp and paper industry uses special recovery boilers to combust the organic residues resulting from the process of wood pulping, and to both generate process steam and electricity.

Whichever combustion technology is used in your biomass plant, a Siemens steam turbine will ensure high plant performance. These flexible machines can even optimize electric output in plants which have steam parameters affected by inconsistent feedstock moisture content. This is possible by integrating industry-leading steam cycle technology.

Typical biomass fuels include a wide variety of material. Some common fuels are forestry by-products, agricultural wastes, municipal wastes, landfill gas, and syngas. There are also many next-generation biomass feedstocks in different stages of commercialization. These new fuels have the potential to dramatically scale plant sizes and the feedstock supply chain, creating significant opportunities for additional generation fleet expansion.
Steam Turbines for Biomass Plants

Whereas in Europe, due to subsidiary regulations, typically steam turbines up to 40 MW are used, other regions prefer a power output up to 120 MW. The Siemens industrial steam turbine portfolio can be used with any biomass boiler to generate power from 75 kW up to more than 250 MW. The Siemens experts will assist in selecting the optimum turbine that meets all application requirements while at the same time it minimizes the investment cost.

The Siemens steam turbine portfolio is characterized by efficiency and durability. Turbine generator sets have been deployed in almost 100 biomass-fueled plants in the past decade with an outstanding record of applicability and reliability.

Siemens can also supply your steam turbine with auxiliary equipment such as generator, a condenser system, monitoring and control systems and power transmission equipment.

**Tailored Turbines & Leading Technology**
Siemens turbines are available for back-pressure or condensing operations in a single or multi-stage design. They can also be equipped with single or multiple controlled and uncontrolled extractions (bleeds) to satisfy particular process or district heating as well as cooling requirements. Additionally, Siemens offers turbine-generator packages with a reheat feature, further optimizing plant performance and efficiency.

Turbines with reheat can improve overall plant efficiency by up to 3%, further mitigating the release of harmful emissions by burning less fuel. Each turbine, along with its customized features, is built to meet specific demands.

**Stevens Croft**
**Lockerbie, Scotland**
As one of the UK’s largest biomass-fueled power stations, Stevens Croft powers 70,000 homes while displacing 140,000 tons of CO₂ per year. It also sustains up to 300 jobs in the regional economy. Stevens Croft is considered a milestone in biomass power plant development and has acted as an example of system efficiency.

Steam turbine: SST-800
Power output: 50.3 MW
Inlet pressure: 137 bar / 1,987 psi
Inlet temperature: 535 °C / 995 °F
Fuel: Green & waste wood
Increasing Cycle Efficiency with Reheat

Integrating a steam reheat system into a biomass plant is one of the best ways to increase overall plant performance. With the Siemens reheat turbine package, live steam is run through a high pressure (HP) turbine, sent back to the steam generator to increase steam temperature, then run through a low pressure (LP) turbine. Raising the temperature of steam that is going from a high to a low pressure turbine allows for greater output using the same amount of fuel. Geared single-casing reheat solutions up to 60 MW are also available in the Siemens portfolio.
Environmental Benefits

Combined Heat and Power

Combined heat and power generation, also known as cogeneration, is used for many different purposes. Harnessing heat created by power generation increases plant outputs, reduces fuel consumption, and creates another valuable commodity which can improve plant economics. Whatever the application of a cogeneration system might be, efficient conversion of waste heat into a commercial resource is a critical necessity. All Siemens turbines can employ extractions, bleeds, and other features to meet the customer specifications.

CO₂ and Emissions Reduction

Biomass generation is known to be a carbon-neutral power source and is being adopted as an important alternative to fossil fuel baseload generation. Using a highly efficient Siemens turbine can create additional long-term environmental advantages for industries and electricity generators seeking to further decrease their carbon and emissions footprints. Less fuel consumption over a plant’s lifetime due to industry-leading efficiency results in significant cost savings and fewer system pollutants, compared to less efficient machines. This is especially true if the biomass system incorporates a Siemens reheat steam turbine or is deployed in a Combined Heat and Power (CHP) application.
Biomass plants at Industrial Facilities

Biomass is a common on-site energy source for industries which produce a usable feedstock as waste during factory operations. Installing a biomass power plant to burn this waste is the best solution for closing the factory input cycle while cutting energy costs and maintaining high power availability. Waste biomass is an efficient fuel and is usually characterized by naturally low emissions. Using a highly efficient turbine may also result in increased operational savings as punitive environmental and greenhouse gas policies become more prevalent at both the national and international levels.

Siemens has a comprehensive range of experience in creating solutions for biomass industrial power applications. Siemens steam turbines can be found in facilities on every continent and across industrial sectors. Our engineering and sales teams are expert at optimizing turbine packages for highly specific and complex processes.

Sierra Pacific Industries
Aberdeen, Washington, USA

This 18 MW unit was installed and commissioned in 2002 at a Sierra Pacific Industries lumber mill. The cogeneration unit generates power and provides steam to several kilns with various loads depending on ambient conditions, the time of year, and lumber quality. The biomass boiler burns sawdust from lumber mill operations and additional fuels from the forest and land nearby.

Steam turbine: SST-300
Power output: up to 18 MW
Inlet pressure: 85.5 bar / 1,240 psi
Inlet temperature: 482 °C / 900 °F
Fuel: Forest industry by-products

Wisaforest Pulp and Paper Mill
Pietarsaari, Finland

The Wisaforest Mill’s biomass generator is one of the largest 100% biomass-fired power plants in the world. In addition to supplying electricity and process steam to the mill’s operations, it also provides district heating to the surrounding town of Pietarsaari.

Steam turbine: SST-800
Power output: 143 MW
Inlet pressure: 100 bar / 1,450 psi
Inlet temperature: 505 °C / 941 °F
Fuel: Pulp and paper mill by-products
Dedicated Biomass Power Stations

The location of a biomass plant used for electricity production is usually dependent on the regional availability of feedstock. The size of dedicated biomass power stations is also often driven by local biomass availability. Transport costs of the usually bulky fuel play a major role in the plant’s economics. Rail and especially water shipping has reduced transport costs significantly, which has led to the development of a global biomass market. As the market for commoditized biomass fuels expands, so will the expansion of centralized biomass electricity production fleets.

Because of decades of experience supplying, building, and servicing equipment in biomass plants, Siemens steam turbines and turbosets are exceptionally well-suited for pure power generation. With high efficiencies and minimal outages, Siemens machines maximize electric MWh generated. With a leading efficiency profile, a Siemens turbine further reduces a plant’s lifetime emissions footprint while delivering superior efficiency gains. These advantages and more positively impact plant financeability.

Biomass Power Plant Simmering
Vienna, Austria

The Simmering biomass power plant, owned by the Viennese utility Wien Energie, is exclusively fed with fresh wood from the forest. Producing 23.4 MWe electricity in summer and 15.06 MWe plus 37 MWth for district heating in winter, the plant reduces Vienna’s CO₂ emissions by 144,000 tons per annum. In operation with heat extraction, total efficiency is 83%.

Steam turbine: SST-400, Reheat
Power output: 23.4 MW
Inlet pressure: 120 bar / 1,740 psi
Inlet temperature: 520 °C / 968 °F
Fuel: Fresh wood

Afval Energie Bedrijf
Amsterdam, Netherlands

Afval Energie Bedrijf (AEB; Waste and Energy Company Amsterdam) burns 1.7 million tonnes of waste per year and has recently increased its energy generation efficiency from 22% to 30%. This 8% increase resulted from installing a new SST-700 with a steam reheat system. AEB not only generates power from Amsterdam’s municipal waste, but also recovers and sells materials from the waste stream such as metals and gypsum.

Steam turbine: SST-700, Reheat
Power output: 74 MW
Inlet pressure: 125 bar / 1,813 psi
Inlet temperature: 440 °C / 824 °F
Fuel: Municipal solid waste
District Heating and Cooling

District heating and cooling using a cogeneration system is one of the most efficient applications of a biomass plant. Usually a plant generates thermal energy at a centralized location and distributes steam to a larger number of buildings for space and water heating. District heating plants can provide higher efficiencies and better pollution control than stand-alone solutions. The process is normally governed by the total heat load and electrical energy is supplied as an additional benefit.

Whether a cogeneration application is for a district energy system, a heating or cooling system, or any other application, Siemens expertise ensures that your project will maintain optimal performance in markets with demand fluctuation. Any Siemens steam turbine can also feature extraction customization as required. The Siemens engineering staff is expert at designing turbines which can maximize output and plant value for seasonal load and demand variations.

Biomass District Heating Plant Igelsta Södertälje, Sweden

Sweden’s largest biomass plant Igelsta is situated in Södertälje, west of Stockholm. Inaugurated in March 2010, it uses a biomass fuel mix consisting of about 90% renewable fuels like forest refuse, wood chips, tree bark, and 10% non-recyclable waste paper and plastic. It produces 200 MW heat and 85 MW electricity, the equivalent of heating 50,000 households and generating electricity for 100,000 residences.

Steam turbine: SST-800
Power output: 90 MW
Inlet pressure: 85 bar / 1,305 psi
Inlet temperature: 540 °C / 1,004 °F
Fuel: Biomass mix

Biomass Power Plant Eccleshall, UK

The Eccleshall power plant was commissioned in September 2007 and has 13 MW of thermal and 2.65 MW of electrical capacity. The fuels burned range from woodchips, compost oversize, straw to miscanthus. The plant generates enough electricity to power 2,600 homes, equivalent to the local town of Eccleshall, making it one of the first carbon-neutral towns in the UK.

Steam turbine: SST-110
Power output: 2.6 MW
Inlet pressure: 41 bar / 595 psi
Inlet temperature: 450 °C / 842 °F
Fuel: Biomass mix
Gas Turbines for Biomass Plants

Digester Systems
Digester systems are used mostly at facilities which have access to large amounts of feedstock that emits methane as part of its decomposition. One unique feature of this type of gaseous biomass is that it can be used both for steam-generation and as a fuel for gas turbines. This flexibility makes building digester systems very attractive for many food and beverage, agricultural, and municipal solid waste process facilities.

Landfill Gas-Fueled Gas Turbines
Landfill gas-fueled gas turbines are usually located at existing landfills or in close proximity to facilities which process waste. At existing landfills, naturally occurring methane is collected through a piping system, cleaned, and then routed to a combustion turbine to generate power. Because society will always generate waste, landfill gas is considered a renewable energy source and is often eligible for government incentive programs.

Siemens flexible gas and steam turbines can be used to add value to both landfill gas and digestable feedstock assets. A Siemens gas turbine can use biomass-derived fuels to create power at maximum efficiencies. All gas turbines can come equipped with a dry-low emission combustion system which operates in a wide variety of load ranges and fuels.

Experience in landfill gas and digestion-based power generation using both gas and steam turbines, individually or as a combined cycle, makes Siemens an ideal partner for this unique technology. For more information on Siemens gas turbines, please visit our website www.siemens.com/energy/gasturbines.

UNH Cogeneration Plant
Durham, New Hampshire, USA
Rewrite as The University of Hampshire (UNH) cogeneration plant, fired on landfill gas, supplies 85% of the heat and 75% of the power demand of UNH Durham. By utilizing a Siemens gas turbine with a Heat Recovery Steam Generator (HRSG), UNH Durham was able to cut their greenhouse gas emissions by 40%. UNH Cogen was recognized by the US Environmental Protection Agency (EPA) as a “Project of the Year 2010” at their Landfill Methane Outreach Program annual conference.

Gas turbine: SGT-300
Power output: 7.9 MW
Combustion system: Dual-fuel
Dry-Low Emissions (DLE)
Fuel: Landfill gas, natural gas, distillate fuel
Process Control in Biomass Plants

The economic viability of biomass plants depends on the degree of process efficiency in biofuels production as well as biomass for biochemical products and heat and power generation. For economic, safe and sustainable operation in biomass plants we offer the right products, solutions and services for the integration of automation and electrical infrastructure.

With Totally Integrated Automation (TIA) and Totally Integrated Power (TIP) Siemens is the only provider of a comprehensive range of products and systems for the automation and the energy management of biomass plants.

Numerous aspects have to be considered for the planning and implementation of automation, control, drive, instrumentation and electrical system components for biomass plants. The requirements depend on the plant type and size, the used feedstock, the production process itself and the further processing, e.g. raw biogas mostly used for combustion in combined heat and power plants. Also local requirements in terms of layout and design as well as compliance with governmental regulations are important.

The use of TIA and TIP provides the full range of control and diagnostic options from the field level to the production control level up to the management level because all field devices, automation and drive components are monitored. Mechanical components such as motors, pumps, valves, or heat exchangers are also supervised. Plant monitoring can be performed locally, decentralized, or via remote services - various options for increasing productivity and reducing TCO considerably.

Modular DCS, SCADA, and MES solutions are part of our offer with different graphical configuration tools – either integrated directly in SIMATIC PCS 7 or using WinCC flexible. This enables the efficient parameterisation of field devices and set-up of electrical components. The benefits of an automation and visualization system are to handle the measurements and clearly visualize these process values. That includes messages, alarms, trend analyses and reports for preventive or condition-based maintenance as well as the integration of third party equipment and package units such as compressors, gasifiers, safety and energy management concepts.

Agratec Biogas Power Plant
Jessen, Germany

One of the largest biogas plants in Europe has been installed in Jessen, Germany, by Agratec AG. In four CHP plants, the company produces power and heat to support 12,500 households with energy.

Feedstock: whole plant silage, corn silage, grass silage, cereals

Process: Dry fermentation, post digestion, gas processing and desulfuration

Products: Power and heat as well as organic solid and liquid fertilizer as a by-product

Energy: 5.3 MW of power and 5.1 MW of heat will be generated in four CHP plants
Siemens offers a broad portfolio of medium- and low-voltage components including power monitoring. Connecting them to the process control system, the world’s largest installed fieldbus PROFIBUS, provides universal integration in the electrical infrastructure and in communications.

Central engineering, operation and monitoring of field technology, of smart motor-control centers, drives and switchgears with one system facilitates power measuring and provides transparency for production and electrical processes thanks to an integrated view.

In combination with the integrated plant asset management functionalities and energy management it helps to improve plant availability and to reduce energy consumption.

The best way to ensure highest plant availability and efficiency is to keep track of all relevant processes at all times and to manage the plant as a whole. To ensure just this, we provide so-called MAV concepts over the entire lifecycle as well as efficient and user-friendly systems for plant operation and monitoring.
Inbicon Biomass Refinery
Kalundborg, Denmark

The Danish company Inbicon A/S designed its refinery in Kalundborg, Denmark, as one of the first “second generation” biofuels plants to turn straw into bioethanol and pellets. The plant is fully integrated, designed for commercial production with automatic operation 24/7 and a limited staff.

**Feedstock:** 33,000 tons of straw p.a.

**Process:** Fermentation and distillation

**Products:** Per year, 5,300 tons of fuel, 12,100 tons of cattle feed from the C5 molasses and 14,300 tons of pellets from the lignin

**Energy:** Energy integration with a power plant, energy surplus brings down the cost for both plants

**Siemens Solution:** Power distribution, control systems and process instruments
Siemens industrial steam turbines

The complete product portfolio

<table>
<thead>
<tr>
<th>Type</th>
<th>Power Output (MW)</th>
<th>Steam parameters up to:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>SST-040</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>SST-050</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>SST-060*</td>
<td>0.75</td>
<td>6</td>
</tr>
<tr>
<td>SST-100</td>
<td>0.75</td>
<td>6</td>
</tr>
<tr>
<td>SST-110*</td>
<td>0.75</td>
<td>8.5</td>
</tr>
<tr>
<td>SST-111*</td>
<td>0.75</td>
<td>12</td>
</tr>
<tr>
<td>SST-150*</td>
<td>0.75</td>
<td>12</td>
</tr>
<tr>
<td>SST-200</td>
<td>0.75</td>
<td>10</td>
</tr>
<tr>
<td>SST-300*</td>
<td>0.75</td>
<td>50</td>
</tr>
<tr>
<td>SST-400*</td>
<td>0.75</td>
<td>50</td>
</tr>
<tr>
<td>SST-500</td>
<td>0.75</td>
<td>65</td>
</tr>
<tr>
<td>SST-600*</td>
<td>0.75</td>
<td>100</td>
</tr>
<tr>
<td>SST-700*</td>
<td>0.75</td>
<td>175</td>
</tr>
<tr>
<td>SST-800*</td>
<td>0.75</td>
<td>250</td>
</tr>
<tr>
<td>SST-900</td>
<td>0.75</td>
<td>250</td>
</tr>
</tbody>
</table>

*Steam turbine types mostly used for biomass applications

Siemens industrial gas turbines

The complete product portfolio

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Type</th>
<th>5</th>
<th>10</th>
<th>15</th>
<th>20</th>
<th>25</th>
<th>30</th>
<th>35</th>
<th>40</th>
<th>45</th>
<th>50</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Hz or 60 Hz</td>
<td>SGT-100</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-200</td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-300</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-400</td>
<td>13/15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-500</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-600</td>
<td>25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-700</td>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-750</td>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SGT-800</td>
<td>47/50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>