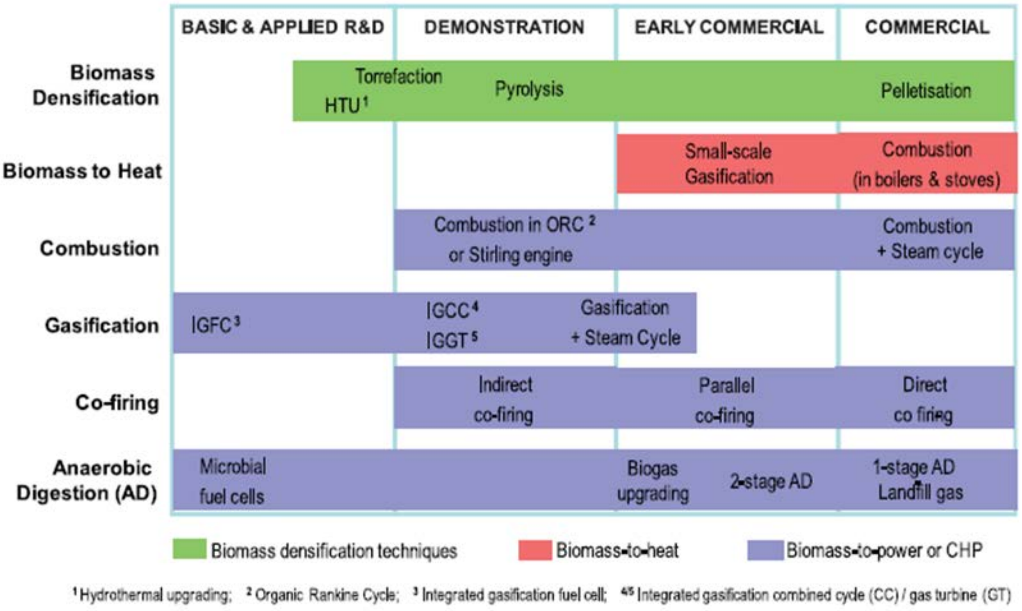
Technology Fact Sheet

Technology Name	**Biomass combustion and co-firing for electricity and heat**[i]
Subsector	**Electricity supply**
Background\Notes, Short description of the technology option	Combustion is the most common way of converting solid biomass fuels to energy. Worldwide, it already provides over 90% of the energy generated from biomass, a significant part of which in the form of traditional uses for cooking and heating. This is mostly the case in developing countries, where biomass combustion provides basic energy for cooking and heating of rural households and for process heat in a variety of traditional industries in developing countries. However, many of these traditional applications are relatively inefficient and may go together with high indoor air pollution and unsustainable use of forests. Biomass of different forms can also be used to produce power (and heat) in small-scale distributed generation facilities used for rural electrification, in industrial scale applications, as well as in larger scale electricity generation and district heating plants. Several feedstock and conversion technology combinations are available to produce power and combined heat and power (CHP) from biomass. Two technologically mature and cost-attractive options involve burning biomass in standalone units or co-firing it with fossil fuels in standard thermal power plants. Standalone biomass combustion Standalone biomass combustion can be done using different types of feedstock, sizes of applications and conversion routes. a) Biomass-based generators: Vegetable oils, such as jatropha, can replace diesel in diesel generators to produce electricity for off-grid applications or independent mini-grids. b) Biomass-based power plants: The heat produced by direct biomass combustion in a boiler can be used to generate electricity via a steam turbine or engine. The electrical efficiency of the steam cycle is not high but it is currently the cheapest and most reliable route to produce power from biomass in stand alone applications (IEA Bioenergy, 2009). c) Biomass-based cogeneration (CHP) plants: Co-generation is the process of producing two useful forms of energy, normally electricity and heat, from the same fuel source. Co-generation significantly increases the overall efficiency of a power plant (and hence its competitiveness) if there is an economic application for its waste heat (IEA Bioenergy, 2009). In the case a good match can be found between heat production and its demand, combined heat and power (CHP) plants, also called cogeneration plants, can have overall (thermal + electric) efficiencies in the range of 80-90%. The process of using the heat from biomass combustion for industrial processes (e.g. for drying of products such as tiles), is well established in some industries, e.g., pulp and paper, sugar mills, and palm oil mills.) d) Waste-to-energy plants based on Municipal Solid Waste (MSW): Municipal solid waste (MSW) is a very diverse and usually heavily contaminated feedstock, requiring robust technologies and strict controls over emissions, increasing the costs of waste-to-energy facilities, leading to MSW remaining a largely unexploited energy resource despite its significant potential in most countries (IEA Bioenergy, 2009). Biomass co-firing Biomass co-firing (or co-combustion) involves "supplementing existing fossil-based (mostly pulverised coal) power plants with biomass feedstock" (IEA Bioenergy, 2009). The biomass fuels usually considered range from woody to grassy and straw-derived materials and include both residues and energy crops. The fuel properties of biomass differ significantly from those of coal and also vary considerably between different types of biomass. Properties of biomass which differ from those of coal are ash contents, a generally high moisture content, potentially high chlorine content, relatively low heating value, and low bulk density. These properties affect design, operation, and performance of co-firing systems (IEA Bioenergy, Task 32, 2002). There are three types of biomass co-firing: a) Direct co-firing: The biomass is burnt directly in the existing coal furnace. Direct co-firing can be done either by pre-mixed the raw solid biomass (generally in granular, pelletised or dust form), with the coal in the coal handling system or by the milling it and directly injecting it into the pulverised coal firing system.

	b) Indirect co-firing: The biomass is first gassified before the resulting syngas is combusted in the coal furnace; and c) Parallel co-firing: The biomass is burnt in separate boilers, with “utilisation of the steam produced within the main coal power station steam circuits” (IEA Bioenergy, 2009). “Indirect and parallel co-firing options are designed to avoid biomass-related contamination issues, but have proven much more expensive than the direct co-firing approach as additional infrastructure is needed. Parallel co-firing units are mostly used in pulp and paper industrial power plants” (IEA Bioenergy, 2009). **Source: http://climatetechwiki.org/technology/biomass**  **Figure 1: Development status of the main upgrading technologies (green), biomass-to-heat technologies (red) and biomass-to-power and CHP technologies (blue) (source: IEA, 2009)**
Implementation assumptions	Biomass combustion in small-scale application is gaining increasing attention as a means for rural electrification in developing country areas where extension of national grid would be too costly. The technology used for vegetable oil-based power production (e.g. diesel generators) is very well-known and requires little or no adaptation. For industrial applications, direct co-firing in large-scale modern coal plants is today the most cost effective use of biomass for power generation. This technology only requires minor investment to adapt handling and feeding equipment without noticeably affecting boiler efficiency, provided the biomass is not too wet and has been pre-milled to a suitable size. Furthermore, electric efficiencies for the biomass-portion range from 35% to 45%, which is generally higher than the efficiency of biomass dedicated plants (IEA, 2007). A range of liquid biomass materials (e.g. vegetable oil, tallow) is also co-fired in existing plants on a commercial basis, however at a scale much lower than for the solid biomass. The biomass co-firing ratio is mainly controlled by the availability of biomass and is usually limited to around 5-10% on a heat input basis (IEA Bioenergy, 2009). The most cost-effective biomass-to-energy applications are those relatively large scale (30-100 MWe), and using low cost feedstocks which are available in large volumes, such as agricultural residues (e.g. bagasse), or wood residues and black liquor from the pulp and paper industry. However, in a fragmented biomass supply market, the cost of purchasing large quantities of biomass may increase sharply as the distance to suppliers (and thereby logistical cost) increases. At the same time, an increasing number of viable smaller scale plants (5-10 MWe) using other types of residues are emerging throughout Europe and North America (IEA Bioenergy, 2009). In both cases, the biggest challenge is provision of a constant stream of biomass feedstock. Video 1 is an illustration of a biomass installation in the United Kingdom.
Implementation barriers	IEA Bioenergy (2009) sums up the the critical issues in biomass logistics as: “The specific properties of biomass: low energy density, often requiring drying and densification;

	seasonal availability and problematic storage requiring further pre-treatment. Factors limiting the supply: availability and appropriateness of mechanized equipment; and inadequate infrastructure to access conversion facilities and markets." The main solutions to these issues, according to the IEA Bioenergy (2009) are "the development of advanced densification and other pre-treatment technologies, diversifying procurement geographically and in terms of biomass types, and the optimisation of fuel supply chains from field to plant gate (including the development of specialized harvesting and handling equipment), leading to lowest delivered costs" (IEA Bioenergy, 2009). The sustainability of biomass-based technologies including biomass combustion depends on the current source of existing fossil fuel reserves and their reliability on one the hand and the risks involved with securing sufficient supplies of biomass over a long term, on the other hand (OECD/ IEA, 2007).
Reduction in GHG emissions (megatonnes CO2-eq)	
Impact statements	
Country social development priorities	Increased income and jobs in the agriculture and forestry sectors, which now supply part of the feedstock used in power and heat production (agricultural and forest residues) Job creation in the industrial sector for designing, building and operating the plants. Increasing inclusion in the economic system: well-organized farmers unions can gain access to energy markets.
Country economic development priorities – economic benefits	Increasing energy security and saving foreign currency by reducing the dependence on imported fossil feedstock, such as coal. Diverting part of expenses for imported fossil fuels to farmers supplying the biomass feedstock; Diversifying the industrial sector; Supporting rural electrification with all its developmental benefits.
Country environmental development priorities	Reduced GHG emissions from the power sector. Many agricultural and forest residues can be assumed to be carbon neutral, which leads to significant attributable GHG emission reductions. Reduced NOX and SOX emissions compared to coal combustion. NOx emissions can be further reduced by implementing primary and secondary emission reduction measures. The most important consideration when collecting biomass residues for energy use is to not to exceed the biological requirements of the soil (part of residues must be left on the field and on the forest floor to return vital nutrients to the soil). On a macro level, competition between traditional forestry-based sectors (e.g. fiber board and pulp & paper) can develop as increasing amount of woody biomass is combusted or co-fired in power generating facilities.
Costs	
Capital costs	For small-scale combustion units using vegetable oil, the main cost will be feedstock cost. The attractiveness of such installations will depend heavily on the relative prices of diesel and vegetable oil. For industrial scale installations, economies of scale are very important. Investment cost is about 3,500 Euro/kWe for a 5 MWe plant, but goes down to about 2,000 Euro/kWe for a 25 MWe plant. Usually, dedicated biomass power plants were only competitive "when using large quantities of free waste that had to be disposed of, such as MSW, black liquor from the pulp and paper industry and agriculture residues such as bagasse" (IEA Bioenergy, 2009). More recently, an increasing number of viable smaller scale plants using other type of residues (forestry, straw, etc.) are emerging throughout Europe and North America. Co-generation has been shown to reduce the cost of power production by 40-60% for stand-alone plants in the range 1-30 MWe. However, the scale of biomass CHP plants is often limited by the total local heat demand and by its seasonal variation, which can significantly affect economic returns unless absorption cooling is also considered (IEA Bioenergy, 2009).

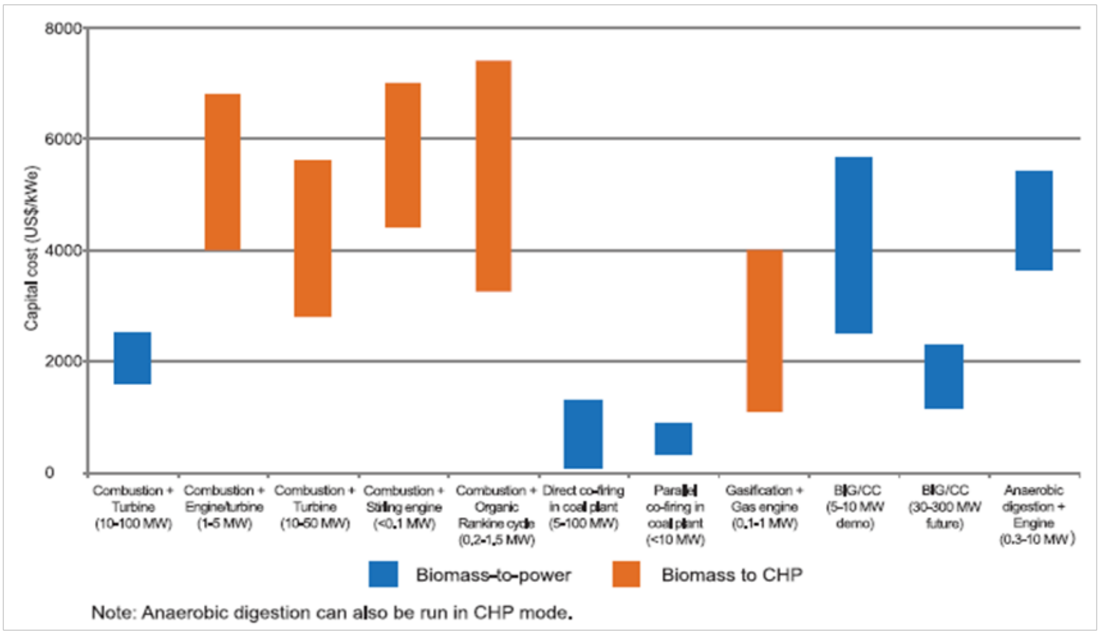


Figure 2: Capital cost for available biomass-fuelled technologies for power (blue bars) and CHP (orange bars) (source: IEA, 2009)

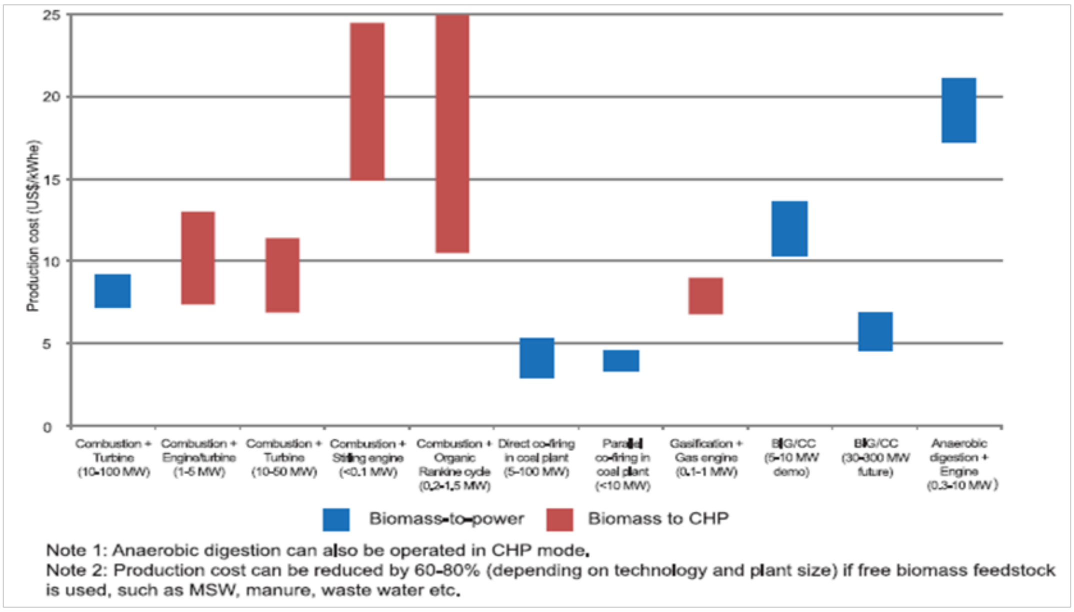


Figure 3: Production cost for available biomass-fuelled technologies to power (blue bars) and CHP (red bars). For the sake of making comparison possible, the production costs have been calculated based on the capital costs given in Figure 2 and on the following assumptions for each of the technologies considered: (1) Plant lifetime = 20 years, (2) Discount rate = 10%, (3) Heat value=5US$/GJ (for CHP applications only), (4) Biomass cost=3 US$/GJ (source: IEA, 2009)

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[i] This fact sheet has been extracted from TNA Report - Technology Needs Assessment for climate change mitigation - Republic of Moldova. You can access the complete report from the TNA project website **http://tech-action.org/**