

Giant King<sup>®</sup> Grass--Dedicated Tropical Biomass Energy Crop  
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## **Biomass for Electricity**

In most of the world, biomass energy means electricity (and heat) generated by burning wood or sugarcane bagasse. Wood and wood waste have many competing uses such as construction materials, and pulp and paper. Most of the world's wood resources are spoken for, and cutting down the rain forest is not an option. Coal-fired electricity plants in Europe, Japan and Korea are aggressively seeking wood pellets from around the globe to meet their carbon emission reduction goals. Sugarcane bagasse is routinely used to produce heat and electricity for sugar mills and the excess is sold to local electricity grids. However sugar cane bagasse production is seasonal and not available for reliable 24/7 base electricity. There is very little excess sugarcane bagasse available in the world. Biomass can also be used to produce biofuels and bio plastics, but this article will emphasize electricity generation.

The simplest application of biomass is to produce electricity. This can be done through direct combustion (burning) of the biomass in a steam boiler, or through anaerobic digestion to produce biogas that is used to fuel an engine/generator. High temperature gasification is another for option. Generous subsidies for biomass electricity in Europe has incentivized about 10,000 anaerobic digesters in Europe using agricultural and food waste, manure and even corn (maize) is grown as a dedicated energy crop. Biogas power plants are generally small size from 1-3 megawatts. The largest biomass power plants utilize direct combustion. Some utilize 100% biomass and these range in size from 10 – 30 MW. Many use biomass pellets as a substitute for 20% of the coal in large coal-fired power plants. Pelletizing is not necessary for local direct combustion , but pellets are easier to transport in bulk shipments over long distances.

## **Dedicated Energy Crops**

In order to get a power plant or other biomass project financed, the investors require a guaranteed source of biomass. Agricultural waste can be used in a power plant, but it has been proven to be very difficult to get a long-term, fixed price contract. Giant King Grass and other dedicated energy crops provide the reliable and guaranteed source of biomass that is needed for financing.

Although wood has been grown as a dedicated crop for pulp and paper, there is very little worldwide experience with dedicated energy crops. Wood is an option, but typical trees take 20 years to regrow and it takes 20 years to reabsorb the carbon dioxide emitted from burning wood. A fast-growing tree can be harvested every four years.

Perennial grasses are an attractive option as dedicated energy crops. Some can be harvested in the first year and subsequently harvested up to three times per year. As in all agriculture, the cost of the biomass is proportional to the yield per acre. Higher yield means lower cost. Perennial grasses can be planted on marginal lands that are currently fallow and do not displace food crops.

The climate conditions determine which grasses can be grown in a particular area. In climates with freezing winters and short growing seasons, switchgrass is an option and has reasonable yield. Miscanthus can also be grown in freezing area and has higher yield than switchgrass. Arundo Donax can also be grown in a freezing areas, but is considered an invasive species in many regions.

Tropical regions are often ideal for energy crops because of the year-round growing season and availability of land and water. The energy crop can be used locally to produce electricity or biofuels, or be made into pellets for bulk transport to countries in Europe, Japan and Korea to replace part of the coal in coal-fired power plants.

The energy crops suitable for freezing areas, are often unsuitable for tropical areas and new options are available. For example switchgrass is not a tropical grass, and miscanthus is less than ideal. The Pennisetum genus is a tropical grass and Pennisetum purpureum also known as elephant grass or Napier grass is widely used as animal feed in many tropical areas.

### **Giant King<sup>®</sup> Grass**

VIASPACE has a proprietary hybrid called Giant King<sup>®</sup> Grass that is a very high yield tropical energy crop and the rest of this article will focus on Giant King<sup>®</sup> Grass as a concrete example.



Caption: Giant King Grass can be harvested at 4– 5 m tall every six months.

Giant King Grass can be harvested twice a year at 4-5 m tall. It is perennial and regrows after each cutting for 7 to 10 years. It is a proprietary natural hybrid, and is not genetically modified. It is a tropical crop and needs warm weather, sunshine and water. It will withstand an overnight frost, but is not perennial in a freezing area. It is not suitable for most of Europe.

Giant King Grass is quite attractive in terms of water use and fertilizer use efficiency which is defined as the amount of water or fertilizer required to make a ton of dry biomass.

Giant King Grass has been tested extensively for use in direct combustion, anaerobic digestion and as a feedstock for cellulosic biofuels. In most properties it is very similar to corn straw, but has much much higher yield in terms of tons per hectare. A typical proximate analysis is shown below.

Proximate Analysis	Unit	Sun Dried As Received	Giant King Grass Bone Dry
<b>Total Moisture</b>	<b>%</b>	<b>14</b>	<b>0</b>
<b>Volatile Matter</b>	<b>%</b>	<b>65.68</b>	<b>76.37</b>
<b>Ash</b>	<b>%</b>	<b>3.59</b>	<b>4.17</b>
<b>Fixed Carbon</b>	<b>%</b>	<b>16.74</b>	<b>19.46</b>
<b>Total Sulfur</b>	<b>%</b>	<b>0.11</b>	<b>0.13</b>
<b>HHV</b>	<b>MJ/Kg</b>	<b>15.85</b>	<b>18.43</b>
<b>LHV</b>	<b>MJ/Kg</b>	<b>14.52</b>	<b>-</b>

Giant King Grass is a noninvasive species and is planted from cuttings like sugarcane. The agriculture is also similar to the well-established techniques for growing sugarcane. Giant King Grass can be planted by hand or with machines, and it can be manually or mechanically harvested.



Giant King Grass is growing in California and Hawaii in the US, and has been exported to St. Croix, Virgin Islands, South Africa, China, Myanmar, Pakistan, Philippines, Nicaragua, Jamaica, and Guyana. The US Department of Agriculture inspects the Giant King Grass prior to export and issues a phytosanitary certificate.

It makes sense to think of growing Giant King Grass in a tropical region and either using it there to produce electricity, or making pellets which are easy to transport and shipping them to Europe, or to make biofuels, biochemicals or bio plastics in factories adjacent to the Giant King Grass plantation and shipping the finished bio-products to markets in the developed world.

### **Electricity Generation using Direct Combustion**

A high quality direct combustion power plant can have 30% or higher efficiency from the lower heating value of the fuel to electricity produced. The direct combustion power plant can burn Giant King Grass or other fuels at moisture levels of 50% or lower. When Giant King Grass is harvested it has about 75% moisture and must be dried down to 50% or lower in order to be burned. A 12 MW biomass power plant requires 18 metric tons per hour of Giant King Grass at 50% moisture (9 tons per hour of dry matter). This is equivalent to 36 tons per hour of freshly harvested Giant King Grass. The power plant operates 7884 hours per year and therefore needs to 284,000 tons of Giant King Grass to be harvested every year. With the high yield of Giant King Grass, in a tropical climate with irrigation and two harvests per year, the 12 MW power plant can be produced on 840 ha of land. This is 70 ha per megawatt. In a temperate area with a lower yielding grass and only one crop per year, the amount of land needed will be 3 to 5 times larger.



Caption: 30 MW biomass power plant using corn straw and rice husk as fuel.

The boiler for direct combustion of agricultural straws and grasses must have a special design to accommodate the higher levels of chlorine in these fuels compared to wood. The chlorine causes both high temperature and low temperature corrosion. In addition the ash from these fuels has a



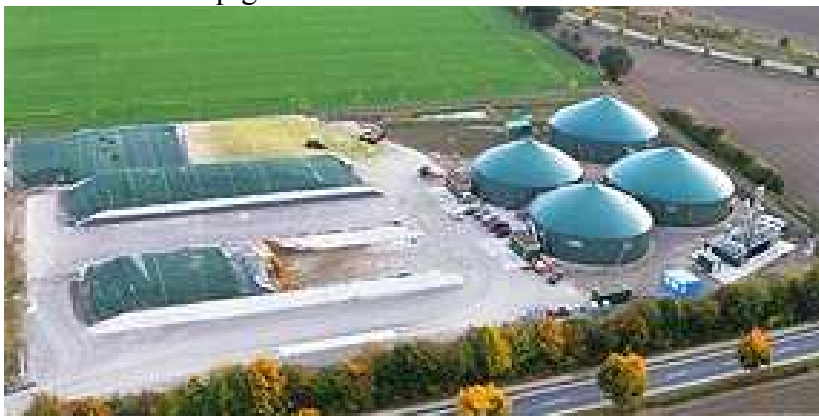
lower melting temperature that causes slagging. Simply putting grass or straw into a wood boiler will cause it to fail within one year. Special boiler designs are available and boilers designed for grass and straw can also burn wood or sugarcane bagasse. A properly designed boiler can use a mixture of fuels such as Giant King Grass with rice husk. The sizes of direct combustion power plants for grasses and straws range from 10 to 35 MW.

In a tropical area, just-in-time harvesting can be employed to reduce the amount of biomass that needs to be stored for the power plant. Logistics are simplified and costs are reduced if the power plant and plantation can be co-located.

The biomass power plant is environmentally friendly. It requires a bag filter to capture particulates, but no other emission controls are needed to meet World Bank standards. Emissions are much lower than with a coal power plant, and further reducing nitrogen oxides and other emissions is straightforward using technology developed for existing power plants. Giant King Grass ash is good fertilizer and can be put back on the fields.

### **Electricity Generation using Anaerobic Digestion**

Giant King Grass and other biological materials can be digested in an industrial version of a cow's stomach to produce biogas which is typically 60% methane and 40% carbon dioxide. The biogas is then used to power an engine which turns a generator to produce electricity. Excess heat can be used for industrial processes and to produce hot water. After the biogas has been produced, the remaining digestate is an excellent organic fertilizer that can be put back on the fields. Biogas power plants are typically 1 to 3 MW in size. Giant King Grass has been tested for anaerobic digestion and about 100 ha are needed for 1 MW in a tropical area with sufficient rainfall or irrigation. Anaerobic digesters can use a mixture of organic materials for digestion. For example Giant King Grass and cow manure or pineapple waste. For anaerobic digestion, Giant King Grass is cut four times a year at about 10 feet tall. If Giant King Grass is cut at 8 feet tall or shorter, it is excellent animal feed with high-protein for cattle, dairy cows, goats, sheep, horses and even pigs.



A typical biogas power plant with four digesters producing about 2 MW.

### **12 MW Power Plant in Nicaragua with 840 ha Giant King Grass Plantation**

VIASPACE and its partner AGRICORP, a large Nicaraguan agribusiness company are developing a 12 MW Giant King Grass power plant with an 840 ha Giant King Grass plantation to provide the fuel. The Giant King Grass is grown on a 4200 ha plantation that is growing rice for AGRICORP. A rice mill is on the plantation and rice husk will provide about 7% of the fuel for the power plant. Nicaragua has a tropical climate with rainy and dry seasons. The plantation is located on Lake Nicaragua, the largest freshwater lake in Central America which is used to irrigate the plantation during the dry season.



Aerial view of the 12 ha of Giant King Grass in Nicaragua. Giant King Grass in Nicaragua.



Layout of Giant King Grass plantation and power plant in Nicaragua. Maximum distance from power plant is 3 km.

Giant King Grass has been well growing in Nicaragua for more than two years. 12 ha are planted and they serve as the nursery for the propagation materials needed for the 840 ha plantation.

A major advantage of the project in Nicaragua is that the power plant and plantation are co-located, so that the biomass transport distances a maximum of 3 km. This simplifies logistics and reduces costs significantly.

An EPC contractor has been selected and permitting is under way. The project will be financed by international development banks and the equity provided by local investors and VIASPACE.

The feasibility study has been completed and concludes-- The proposed integrated Energía Reino Verde 12 MW biomass power plant and 925 ha Giant King Grass plantation project is technically feasible and financeable.

The summary of the feasibility study is below.

- The AGRICORP partner is one of the largest and most respected companies in Nicaragua
- Giant King Grass energy crop is well-established on the Miramontes plantation
- Crucial irrigation infrastructure in place
- EPC contractor is very experienced in Central America and the rest of the world
- Boiler technology is well proven for corrosive fuels
- Power plant operator is very experienced
- Project provides clean, renewable base electricity which is needed for industrial and social development in Nicaragua
- Diversifies energy electricity sources for Nicaragua
- Project provides needed rural jobs for farmers and power plant employees

### **Short Biography:**



Dr. Carl Kukkonen is CEO of VIASPACE, a US renewable energy company that develops biomass power plant projects together with partners in tropical and subtropical regions. VIASPACE's proprietary high yield energy crop, Giant King<sup>TM</sup> Grass, is suitable for direct combustion and anaerobic digestion power plants, and is also excellent animal feed.

Previously, Dr. Kukkonen directed a research center at the NASA/Caltech Jet Propulsion Laboratory. Dr. Kukkonen earned a BS in physics from The University of California, Davis and a Ph.D. in theoretical physics from Cornell University. Dr. Kukkonen was awarded the NASA Exceptional Achievement Medal and is a member of the Space Technology Hall Of Fame.