Giant King Grass: A Dedicated Energy Crop

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“Cultivating Electricity: Growing the Fuels That Feed Our Power Plants”
VIASPACE is a publicly traded company on the US OTC Bulletin Board
– VIASPACE stock symbol VSPC.OB

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Closed Loop Biomass Power Plant

- Power plant co-located with Giant King Grass (or other biomass) plantation
- Water and sunshine in—clean, low carbon electricity out
Biomass Electricity

• Wood or agricultural products as the fuel?
  – Wood is a better boiler fuel with higher calorific value, lower ash, higher melting temperature ash and lower chlorine compared to corn straw, wheat straw or grass
  – But wood has other higher value uses than fuel
    • Lumber, pulp and paper
  – Trees take 4-20 years to grow which means that it takes 4-20 years to get cash flow, and up to 20 years to recycle the CO$_2$ which may be too late
  – Much of the wood in the world is spoken for and it takes a long time to grow more
Agricultural Waste or Dedicated Energy Crops

- Agricultural waste is initially free or low-cost, but price rises quickly when there is a demand
  - This is the experience in China, Thailand, India

- Agricultural waste only available on spot market, and banks and investors will not finance a power plant project without a long-term fuel supply contract

- Dedicated agricultural energy crops such as perennial grasses are very attractive
  - Short rotation (harvest annually or more often) means quick cash flow and rapid recycling of carbon dioxide
  - High yield means low cost. Long-term contracts available
  - Can grow on marginal land
  - Can be used for anaerobic digestion as well as combustion
Yield Comparison of Perennial Grasses

<table>
<thead>
<tr>
<th>Perennial Grass (Genus-Species)</th>
<th>Dry Mass (US ton/acre/year, mt/ha/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phalaris--Reed Canary Grass</td>
<td>2.0 – 3.6</td>
</tr>
<tr>
<td>Panicum--Switchgrass</td>
<td>5-9</td>
</tr>
<tr>
<td>Miscanthus--Miscanthus x Giganteus</td>
<td>13-21</td>
</tr>
<tr>
<td>Pennisetum--Pennisetum Purpureum</td>
<td>24 –27</td>
</tr>
<tr>
<td>Giant King Grass</td>
<td>44</td>
</tr>
</tbody>
</table>

Notes: data taken from the literature. Sources are available upon request

- Reed Canary Grass data from US state of Michigan and Ontario Canada
- Switchgrass data from trials by the University of Illinois in the state of Illinois
- Miscanthus data from trials by the University of Illinois in the state of Illinois
- Pennisetum Purpureum data from trials at the University of Florida in the state of Florida

Important factors to consider in interpreting the data.

- Phalaris and Panicum are cold weather grasses that can tolerate a long freeze. The growing season is relatively short in the cold areas
- Miscanthus can tolerate moderate but not deep freezes. Cold weather induces senescence
- Pennisetum Purpureum and Giant King Grass are tropical and subtropical grasses. The do not survive a long freeze. The growing season can be 12 months and these crops can be harvested more than once a year
Agricultural Waste is Disbursed And Seasonal

Off-site storage of dried, baled seasonal feedstock

100 km collection for agricultural waste

Dedicated Giant King Grass Plantation & Power Plant Could Fit in Center Square
Advantages of High Yield & Co-location

- 30 MW power plant can be fueled by Giant King Grass grown on 1600 ha (4000 acres)
- High yield and co-location short distances means low cost fuel
  - Less expensive than agricultural waste
- Maximum transport distance is 2 km (1.25mi)
VIASPACE Giant King Grass
Giant King Grass
Highest Yield=Lowest Cost

• Very high yield
  – 100 dry mt/ha/year (44 US t/acre)
• Sustainably grown, not a food crop, grows on marginal land
• Perennial grass, harvest 2x/year
• Not genetically modified
• Not an invasive species
• Needs sunshine, warm weather & rain or irrigation-no freezing
• Fertilizer use is modest
• No pesticide
• Extensive bioenergy test data
Giant King Grass Test plot 6 ½ months after planting Cutting, measuring & propagating
200 inches tall (5m) plant
Weighs 36.7 pounds (16.6 kg)
Composite picture because 17 ft plant is too tall to get in a single picture.

Corner cleared for regrowth test.
test plot with drip irrigation

One week

Two weeks

Two weeks
New Growth & Regrowth at Four weeks

Germination rate 95-98%
Above: growth and regrowth at five weeks

Right: regrowth at 7 ½ weeks
Biomass Options to Produce Clean Electricity

• Direct combustion--Burn Giant King Grass in a boiler to produce high pressure steam which turns a generator to make electricity
  – Sizes from 10 – 35 MW

• Anaerobic Bio digestion of Giant King Grass to produce biogas which is burned in an engine or turbine which turns a generator
  – Typical sizes from 0.5 – 3.0 MW

• High temperature gasification to syngas

• Co-fire pellets in existing coal power plant to reduce carbon dioxide emissions
30 MW Biomass Power Plant Uses Agricultural Waste Today

Uses corn straw and rice husk as fuel today Suitable for Giant King Grass
Biomass Power Plant
Combustion Issues
100% Grass/Straw Boilers

- Grass and straw have higher ash, lower melting temperature ash, and higher chlorine compared to wood
- Many boilers designed for wood cannot use straw
- Water cooled grate, special boiler design, staged air & materials to control slag & and corrosion, and flue gas cleaning to meet air emissions standards
- Power plants suitable for grass and straw are available
Giant King Grass Has Been Extensively Tested With Consistent Results

<table>
<thead>
<tr>
<th>Proximate Analysis</th>
<th>Unit</th>
<th>Sun Dried As Received</th>
<th>Giant King Grass Bone Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Moisture</td>
<td>%</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Volatile Matter</td>
<td>%</td>
<td>65.68</td>
<td>76.37</td>
</tr>
<tr>
<td>Ash</td>
<td>%</td>
<td>3.59</td>
<td>4.17</td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>%</td>
<td>16.74</td>
<td>19.46</td>
</tr>
<tr>
<td>Total Sulfur</td>
<td>%</td>
<td>0.11</td>
<td>0.13</td>
</tr>
<tr>
<td>HHV</td>
<td>MJ/Kg</td>
<td>15.85</td>
<td>18.43</td>
</tr>
<tr>
<td>LHV</td>
<td>MJ/Kg</td>
<td>14.52</td>
<td>-</td>
</tr>
</tbody>
</table>
Giant King Grass & Waste Straws Have Same Properties
Giant King Grass Pellets as Coal Replacement

• Giant King Grass pellets can replace up to 20% of coal in an existing coal-fired power plant
  – Burning coal and biomass together is called cofiring
  – Requires small modification

• Preserves large capital investment in existing power plant with 30 year additional life

• Meets carbon reduction targets

• 16M tons of pellets used globally today
  – 46M tons by 2020

• Grass is grown, dried and pressed into pellets and shipped in bulk like shipping grain

• Large global demand
  – Particularly in Europe
  – Korea, China, Japan emerging
Giant King Grass Pellets-- Tested by Many Independent Laboratories

Biomass Energy Lab, a JV of Timber Products Inspection & Control Union is only US lab accredited for European biomass fuel quality testing.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>As-Received</th>
<th>Oven Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Moisture (%)</td>
<td>7.62</td>
<td>2.61</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>2.42</td>
<td></td>
</tr>
<tr>
<td>Volatiles (%)</td>
<td>72.60</td>
<td>78.59</td>
</tr>
<tr>
<td>Fixed Carbon (%)</td>
<td>17.28</td>
<td>18.71</td>
</tr>
<tr>
<td>Gross Calorific Value (GJ/Tonne)</td>
<td>18.38</td>
<td>19.90</td>
</tr>
<tr>
<td>Net Calorific Value (cV)(GJ/Tonne)</td>
<td>17.20</td>
<td>18.81</td>
</tr>
<tr>
<td>Net Calorific Value (cP)(GJ/Tonne)</td>
<td>17.13</td>
<td>18.74</td>
</tr>
<tr>
<td>Carbon</td>
<td>44.63</td>
<td>48.31</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>4.88</td>
<td>5.28</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.69</td>
<td>0.75</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>Oxygen</td>
<td>39.69</td>
<td>42.96</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1140</td>
<td>1234</td>
</tr>
</tbody>
</table>
### Test Data on Giant King Grass

<table>
<thead>
<tr>
<th>Composition Determination</th>
<th>Amount (a.r.)</th>
<th>Amount (o.d.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Moisture</td>
<td>8.81</td>
<td></td>
</tr>
<tr>
<td>Moisture Airdry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>4.66</td>
<td>5.11</td>
</tr>
<tr>
<td>Volatile matter incl. moisture</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volatile matter</td>
<td>70.34</td>
<td>77.14</td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>16.18</td>
<td>17.75</td>
</tr>
<tr>
<td>Gross Calorific Value</td>
<td>4055.2</td>
<td>4446.9</td>
</tr>
<tr>
<td></td>
<td>16.978</td>
<td>18.618</td>
</tr>
<tr>
<td>Nett Calorific Value (cV)</td>
<td>3742.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.667</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6735.7</td>
<td></td>
</tr>
<tr>
<td>Nett Calorific Value (cP)</td>
<td>15.592</td>
<td></td>
</tr>
</tbody>
</table>

国家煤炭质量监督检验中心  
China National Coal Quality Supervision and Testing Center
Giant King Grass and Factory

110 ha (270 acre) test site provides:
- seedlings for large energy projects
- demonstration of production
- sample quantities for customers

Note CEO standing at lower right. Giant King Grass is 4 m tall
Field Dried Grass & Regrowth
Field Dried Grass Transported to Nearby Factory

Co-location of plantation and factory means grass does not need to be baled
Chipper, Rotary Dryer and Hammermill
Biogas is produced when Giant King Grass decomposes without oxygen (anaerobic digestion).

Biogas is composed of methane (55%) and carbon dioxide and used to generate electricity and heat.

- Organic fertilizer is the byproduct.

Giant King Grass has been independently tested for biogas yield and the results are excellent.

- Biogas plant generating 1 MW of electricity and 1 MW of heat plus organic fertilizer.
- Giant King Grass is cut every 30-45 days at 3-5 feet tall for biogas.
Cellulosic Biofuels, Biochemicals & Bio Plastics

• 1\textsuperscript{st} generation bio ethanol is made from sugar cane, corn or recently cassava
  – Making fuel from food is being restricted or prohibited

• 2\textsuperscript{nd} generation is cellulosic ethanol made from
  – corn straw— not the corn grain
  – Sugar cane bagasse—after the sugar is removed
  – Dedicated energy crops such as Giant King Grass

• 2\textsuperscript{nd} generation processes utilize the polymeric sugars trapped in the stalks and leaves
  – Requires pretreatment and enzymatic hydrolysis
  – Currently more expensive and not yet commercial
Giant King Grass tests by 3 independent companies. Giant King Grass has essentially the same composition as corn Stover and miscanthus per dry ton.
Sugar Data & Projected Ethanol Yield (gal/ton)
# Compare Giant King Grass Yield to Corn & Miscanthus

<table>
<thead>
<tr>
<th>Yield Dry Matter</th>
<th>Giant King Grass</th>
<th>Corn Stover</th>
<th>Miscanthus</th>
</tr>
</thead>
<tbody>
<tr>
<td>US ton/acre</td>
<td>44</td>
<td>3.5-4.7</td>
<td>14-18</td>
</tr>
<tr>
<td>Metric ton/ha</td>
<td>100</td>
<td>8.6-11.6</td>
<td>30-40</td>
</tr>
</tbody>
</table>

**Yield**: The yield comparison amongst Giant King Grass, corn Stover and Miscanthus is not an exact apples-to-apples comparison.

- Corn will grow in cold areas, whereas Giant King Grass cannot tolerate freezing temperatures.
- Corn is an annual crop and must be planted every year which causes additional expense. The annual planting also has issues for soil erosion, soil organic matter and some of the corn and wheat must be left on the field for nutrient recycling and to mitigate soil erosion, etc.
- Giant King Grass and Miscanthus are both perennial grasses. Giant King Grass requires tropical and subtropical regions and can be harvested several times a year for many years. Miscanthus will grow in cold areas.
Land-Use Efficiency

![Ethanol (gal/acre) Graph]

- **Corn Grain**: 500
- **Corn Stover**: 300
- **Sugarcane**: 600
- **Miscanthus**: 2400
- **Giant King Grass**: 3500

*Ethanol (gal/acre)*
Feedstock is the Largest Cost of Cellulosic Ethanol

Giant King Grass and co-location can reduce feedstock cost by 40-50% making cellulosic ethanol profitable.
Advantages of Giant King Grass

• “Platform” energy crop for many bioenergy applications
  – Electricity, pellets, biofuels, biochemicals & bio plastics

• Low cost--Can meet cost targets for energy & biofuels applications because of high yield
  – Less expensive than agricultural waste
  – Can be used in combination w/ agricultural waste

• Perennial crop
  – Do not have to plant every year, just harvest
  – Short rotation—first harvested in 6.5 months

• Provides reliable, well documented, consistent quality fuel or feedstock with predictable, affordable price
  – Fuel supply reliability required for project financing
VIASPACE Business

- VIASPACE works on integrated plantation and bioenergy, pellet or biorefinery projects
- VIASPACE is seeking quality project opportunities
- VIASPACE will work with partners, project developers or act as project developer
- Potential R&D collaborations
- Giant King Grass samples available
Thank You
Dr. Carl Kukkonen  
CEO Biography

1998-PRESENT    VIASPACE Inc. CEO

1984-1998    NASA/Caltech Jet Propulsion Laboratory (JPL)  
Director Center for Space Microelectronics Technology  
Manager of Supercomputing  
  – Led staff of 250 with $70 million annual budget  
  – On review boards of 14 leading universities  
  – NASA Exceptional Achievement Award 1992  
  – Space Technology Hall of Fame 2001

1977-1984    Ford Motor Company  
  – Developed direct injection diesel engine  
  – Ford’s expert on hydrogen as an automotive fuel  
  – Research in Physics Department

1975-1977    Purdue University postdoctoral fellow

1968-1975    Cornell University MS & PhD in theoretical physics

1966-1968    University of California Davis BS physics
Biomass is Low Carbon Fuel
Plants Breathe Carbon Dioxide

• Plants use sunlight & CO₂ to grow. Carbon is stored in the plant
• Burning biomass or biofuels simply recycles the CO₂ stored in the plant
  – Time can be 6 mos - grass to 20 yrs-trees
• Biomass is carbon neutral except from
  – Fertilizer, harvesting, & delivery
Applications of Giant King Grass

- Direct combustion in electric power/heat/steam plant
- Pellets for co-firing with coal
- Briquettes for boilers
- Biogas/anerobic digestion
- Cellulosic liquid biofuels—ethanol/butanol
- Biochemicals and bio plastics
- Pyrolysis to bio oil
- Catalytic conversion to bio diesel
- High-temperature gasification
- Torrefaction to bio coal
- Pulp for paper and textiles

Applications that are commercial today with agricultural & forestry waste that can use Giant King Grass instead

Low cost of Giant King Grass will allow commercial applications in future
Direct Combustion
Biomass Power Plant

Biomass fuel handling
Special boiler burns biomass to create steam
High pressure steam turbine turns generator to make electricity
Sizes of Biogas power plants are 0.5 to 3 MW

70 hectare Giant King Grass per 1 MW power

Provides 24/7 electricity for remote area, factory or to the grid

Biogas power plant and plantation should be co-located to minimize fuel transportation costs

Waste heat and organic fertilizer have value

Giant King Grass has both higher biogas yield per kilogram and higher kilogram yield per hectare than competing biomass

- Lower cost feedstock and electricity & higher profit

1.5 MW biogas engine generator set
Bio-Methane Yield/Hectare of Land

- Biogas production uses fresh Giant King Grass with yield of 375 mt/ha
- Measured biogas yields are 160-190 cubic meters of biogas/tonne of fresh grass
  - Methane content is 57% of biogas
- Bio-methane yield is 94 -111 m3/ha/day
- Giant King Grass bio-methane yield is 3.4 - 4.0 million BTU per hectare per day
- 1 MW of electricity requires 70 ha
Giant King Grass—Scalable & Sustainable Development

• Giant King Grass plantation co-located with a power plant, pellet mill, bio-methane facility or biorefinery
  – Scalable, integrated, clean energy module that can be replicated throughout the world

• Provides local employment for farmers and power or processing plant operators

• Provides clean electricity

• Provides energy security & independence

• Money stays in country rather than sent overseas to purchase fuel