Giant King Grass
An Energy Crop for Cellulosic Biofuels & Electric Power Plants

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Biofuels and Jatropha Markets Asia
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VIASPACE
Company Background

• Founded in 1998 as a spin out from the NASA/Caltech Jet Propulsion Laboratory (JPL)

• Became a public company in 2005. Traded on the U.S. OTC bulletin board with stock symbol VSPC

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VIASPACE Focus

• **Renewable Energy--Giant King Grass**
  – Non-food feedstock for low carbon, liquid biofuels for transportation including cellulosic ethanol
  – Low carbon biomass replacement for coal in electric power plants
  – Feedstock for bio-methane production

• **Alternative Energy--Fuel Cell Cartridges**
  – Disposable methanol fuel cartridges for fuel cell powered portable electronics-- notebook computers and mobile phones
Worldwide Trend to Cellulosic Biofuels

• China has made renewable biofuels a national priority and banned biofuels made from food crops
• The Obama administration has called for U.S. national low-carbon fuel standard
• The State of California has passed the world's first low-carbon fuel standard that favors biofuels made from grass and other non-food materials
• BP plans to build a cellulosic ethanol plant in Florida using grass as feedstock
• Toyota’s new hybrid vehicles can be “even greener” using cellulosic biofuels
Nonfood Biofuels--From Which Feedstock?

• Liquid biofuels for transportation
  – Gasoline replacement from nonfood cellulosic feedstocks including dedicated energy crops such as fast-growing grasses and agricultural waste like bagasse, corn stalks, wheat straw and wood chips
  – Bio-diesel from Jatropha, palm oil, algae, grass, etc.

• Biomass for direct combustion in an electric power plant
  – Agricultural waste
  – Dedicated, fast-growing energy crops such as grass or trees
Advantages of Giant King Grass

• Supports China’s national priorities
  – Renewable and locally produced non-food energy
  – Cleaner environment with reduced carbon emissions
  – Improved agriculture to feed the population

• Fast growth produces much higher yield per hectare of land
  – Much higher productivity than switchgrass or miscanthus or food crops
  – Land can support both food and fuel needs
  – Can grow on marginal lands as well

• Provides multiple opportunities-- feedstock for liquid biofuels, as coal replacement for electricity generation, renewable methane & animal feed
Giant King Grass

• Rapid growth to 4 m height
• Very high productivity
  – Up to 350 tonnes/hectare (wet)
• Perennial grass with 7 year life
• Best in tropical and subtropical areas.
  – 4 or more harvests per year possible
  – Little growth below 10 C, frost will kill tops, roots can survive
• Originally developed as feed for cows, sheep, pigs, fowl and fish
  – Suitable as fresh grass, silage or dried and processed into meal
Giant King Grass

• Natural hybrid of Pennisetum Purpureum (also known as elephant grass or Napier grass) with another grass
  – Not genetically modified
• Widely adaptive and stress resistant
• Modest need for fertilizer
• No pesticide needed in most cases
Giant King Grass

- Suitable for wide range of soils including acidic red loam and mildly saline soil
- Can be planted on drylands, paddy fields, hillsides, plains
- Needs >100 days of sunshine per year, 800mm rain or irrigation
- Propagated by division or seedlings
Grassoline

• Grassoline—a new term for renewable, low carbon liquid biofuels made from grass

• Examples
  – Cellulosic ethanol, methanol and green gasoline

• Does not use food crops such as corn for its production
  – Does not cause high food prices and resulting world hunger

• Note: In 2008 one third of the US corn crop was used to make ethanol
• Cellulosic biofuels offer the most environmentally attractive and technologically feasible near-term alternative to oil

• Grassoline will come from agricultural waste and dedicated energy crops such as fast-growing grasses

• The US can grow enough of these feedstocks to replace about one half the country’s total consumption of oil without affecting food supplies
Scientific American
July 2009--Highlights

- Most energy crops can grow on marginal lands that would not otherwise be used as farmland
- Cellulosic biomass can be converted into any type of fuel – ethanol, ordinary gasoline, diesel and even jet fuel
- A plant producing 34,000 barrels/day of Grassoline would require 5,000 tons of biomass every day
- The move toward Grassoline can fundamentally change the world
Grassoline Can Be Low Carbon

Burning grass or grassoline releases CO₂

New grass crop absorbs CO₂
Grass to Ethanol by Gasification
Grass to Ethanol by Fermentation

**BREAKING DOWN CELLULOSE WITH AMMONIA**

Although there are many possible ways to pretreat plant fibers to get at the cellulose—acids and heat are most commonly mentioned—the ammonia fiber expansion (AFEX) process offers a unique combination of low energy requirements, low costs and high efficiency.

**RAW MATERIALS**
Feedstock is ground into small pieces and delivered to the plant.

**RECYCLING**
Ammonia disrupts the plant material, pulling cellulose away from the lignin matrix. The ammonia is recycled.

**DISTILLATION**
Ethanol is distilled from the water.

**PRESSURE COOKING**
Feedstock mixes with ammonia, a strong base, under heat and pressure.

**FERMENTATION**
Treated cellulose is broken down into sugars by enzymes and then fermented into ethanol.

**TRANSPORTATION**
Trucks carry the ethanol into the nation’s fueling infrastructure.
Co-firing Coal and Biomass

• An existing coal-fired electrical power plant can be modified to burn biomass instead of coal for up to 30% of its fuel
  – Grass, wood or other agricultural products

• Carbon dioxide smokestack emissions are the same as 100% coal, but the next crop of grass absorbs the carbon dioxide emitted from the burned grass as it grows

• Simplest and fastest way to partially clean up coal power plants and introduce renewable biomass fuels on a large scale
  – Converting existing coal power plants, compared to building new plants
Trend to 100% Biomass Power Plants

• FirstEnergy in Ohio, USA is converting an old coal-fired power plant to 100% biomass
  – Preferable to upgrading the emissions controls of the coal plant or converting to natural gas

• Dragon Power in China has built and operates 19--100% biomass power plants
  – 12 to 30 MW, operating on agricultural waste
  – Benefits from China’s substantial subsidies for biomass generated electricity

• Biomass power plants encouraged in India

• Biomass can provide electricity 24 hours a day
  – Solar only when sunny, wind only when windy
100% Biomass Power Plants

• Agricultural waste such as corn straw, wheat straw and wood chips is currently used for fuel
  – However quantity and quality of agricultural waste varies with season

• Dedicated energy crops are desired for 50% or more of power plant fuel requirements
  – Reliable with consistent quality
Giant King Grass as Dedicated Energy Crop

• 30 MW grass-fired electricity generating plant needs 460 tonnes of grass every day
• Average household in Shanghai uses 1200 kWh/year or average power of 0.14 kW
  • Average household in US uses 11,200 kWh/year—1.3 kW
• 30 MW plant can supply 214,000 Chinese households
• 30 MW power plant requires 1000-2200 hectares of land (using Giant King grass with yield of 350 tonnes/hectare wet and 75-175 dry)
• One hectare can provide electricity for 98-214 Chinese households
Renewable Methane (Natural Gas)

- Biomethanation (anaerobic digestion) is a source of renewable energy because it produces methane gas that can be burned to generate electricity and heat.
- Microorganisms break down biodegradable material in the absence of oxygen.
  - Widely used today to treat wastewater sludges and organic waste because it reduces volume of the waste destined for landfills.
- Identified by United Nations Development Program as a decentralized energy source.
- Giant King Grass is a candidate feedstock.
Giant King Grass

Status

• Land leased in Guangdong province in southern China

• First crop of 1.2 million seedlings planted in October 2008
  – Propagated to 3M seedlings
  – Another propagation in 2009

• In discussions to grow grass in other regions in China and other countries
  – Tropical and subtropical areas with adequate rainfall or irrigation
New Planting in China
Additional Land in China
Role of Biomass for Energy-Summary

• Waste from current agriculture should be utilized for energy production, but not enough waste available for large scale use

• Dedicated energy crops required
  – Highly productive crops
    • Without negative side effects such as soil depletion or invasive species
  – Prefer crops that can grow on marginal land

• Displacing food crops will not be allowed
Role of Biomass for Energy-Summary

• Analysis shows that there is enough land on Earth to grow for food and fuel as well if the crop has high productivity (yield)
  – For use in liquid biofuels and for direct combustion

• Direct combustion of biomass allows 24 hour electricity generation
  – Solar energy only when the sun shines
  – Wind energy only when the wind blows

• Biomass together with solar, wind and ocean power can make a big contribution
  – All alternative fuels are currently more expensive than coal or oil and need government subsidies
VIASPACE
Business Strategy

• Focus on growing and supplying feedstock for biofuels & fuel for electric power plants
• Expand land under cultivation
  – Grow seedlings to enable rapid expansion
• Sell grass initially as animal feed
  – Generate early revenue
• Seek strategic partnerships with biofuel producers and biomass power plants
  – Long-term grass supply contracts
Business & Financial Opportunities

• Business opportunities
  – Joint venture with VIASPACE for Giant King Grass cultivation in other regions
  – Supply contract for Giant King Grass from VIASPACE for biofuels, biomass or animal feed

• Financial opportunities
  – Purchase VIASPACE stock listed on the OTC bulletin board--symbol VSPC in the open market as an investment in renewable energy
  – Direct investment in the company to speed expansion
Backup Slides
CEO Background

Dr. Carl Kukkonen

2005 - present  VIA SPACE Inc. CEO
- Publicly traded on the OTC BB symbol VSPC

1998-2005  ViaSpace Technologies (incubator)
- Founded and led 7 startup companies

1984-1998  NASA/Caltech Jet Propulsion Laboratory
Director, Center for Space Microelectronics
& Manager of Supercomputing
- Led staff of 250 with annual budget of $70M
- On review boards of 14 leading universities

1977-1984  Ford Motor Company,
Principal Research Scientist and Engineer
- Ford's expert on hydrogen as an alternative motor fuel
- Developed new direct injection diesel engine

1975-1977  Purdue University
Postdoctoral Research Fellow

1975  Cornell University
PhD, Physics

Kukkonen with Al Gore
Is There Enough Land for Energy Crops?

- Is there enough land to grow biomass to provide 41% of global electricity and replace coal?
- World electricity use $0.72 \times 10^{20}$ joules
  - Priority is to replace coal which is most polluting
  - Photovoltaics and wind will also contribute
- Total world land 13 billion hectares
- Total cropland 1.5 billion hectares
  - 11.5% of total world land

*Other includes solar, wind, combustible renewables, geothermal & waste*
Is There Enough Land for Energy Crops?

- Energy crop yield depend on climate, rainfall, fertilizer and crop type
- Biomass yield can range from 5 to 350 tonnes/hectare/year
- Biomass energy content typically 10,000-20,000 joules/kg vs coal 26,000 j/kg
  - Use 15,600 for calculations
- Biomass power plant efficiency 31%
There is Enough Land for High Yield Crops

- Calculation of additional land needed to grow enough biomass to replace all coal used globally to produce electricity

% Increase in World Cropland = \( \frac{4.4}{\text{Yield}} \times 100\% \)

- Probably cannot expand cropland by more than 10% due to climate, soil, deforestation and other issues

- Yields > 44 tonnes/hectare/yr are desired

- Giant King Grass yield is up to 175
  - Switchgrass is up to 25
High Yield Biomass Has Large Potential

• Can replace all coal used to generate electricity worldwide by planting **new land (not using existing cropland)** with the area equal to:
  – 18% of today’s world cropland using switch grass
    • May be difficult or impossible to find that much new land
  – **Only 3-6% using Giant King Grass**
    • Land probably available

• Liquid biofuel plants and biomass power plants likely to be smaller than conventional plants and located near the sources of the biomass

• Supplying biomass is a recurring business for the 50 year life of the biofuel or power plants
### Compare Feedstock

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<th>Coal US</th>
<th>27GJ/mt</th>
<th>$50/mt</th>
<th>$1.85/GJ</th>
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<tr>
<td>Coal Max.</td>
<td>27GJ/mt</td>
<td>$100/mt</td>
<td>$3.70/mt</td>
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<tr>
<td>Oil</td>
<td>6.1GJ/barrel</td>
<td>$70/barrel</td>
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<td>Nat. Gas</td>
<td>$5.00/Mbtu</td>
<td>$5.27/GJ</td>
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<td></td>
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<tr>
<td>Biomass</td>
<td>15.6GJ/mt</td>
<td>$36/mt</td>
<td>$2.31/GJ</td>
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- **Coal is cheapest**
  - Most electricity is from coal
  - But most carbon dioxide and other pollutants
- **Natural gas is next**
  - Cleanest fossil fuel
  - Much electricity from natural gas
- **Oil is most expensive**
  - Little electricity from oil
- **Biomass needs subsidy to compete with coal**
- **Biomass has least net carbon dioxide emissions**
Biomass vs Corn to Ethanol—Land Use

- Is it a more efficient use of land to grow corn or biomass for biofuels?
- Biomass with yields above 25 tonnes/hectare/year exceed the land productivity of corn to produce ethanol
  - Switchgrass can be as high as 25 tonnes/hectare/year
  - Giant King Grass exceeds 75
- High yield is key

<table>
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<th>Feed-stock</th>
<th>Yield</th>
<th>Ethanol GJ/hectare</th>
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<tbody>
<tr>
<td>Corn US</td>
<td>472 bu/hectare</td>
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<td>Biomass 11.2 mt/ha</td>
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<td>Biomass 25 mt/ha</td>
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<tr>
<td>Biomass 75 mt/ha</td>
<td>293</td>
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GIANT KING GRASS
FOR FISH FOOD

Grass carp are fed exclusively
Giant King Grass
Not necessary to process the grass