



CLEAN ENERGY FOR  
A CLEANER TOMORROW

## GIANT KING® GRASS: Versatile Biomass for Bioenergy and Biorefineries

**Dr. Carl Kukkonen**  
CTO VIASPACE Inc., USA

[kukkonen@viaspace.com](mailto:kukkonen@viaspace.com)  
[www.viaspace.com](http://www.viaspace.com)

**ABFC2016**

**Advanced Bioeconomy Feedstocks Conference**  
Four Seasons Hotel, Miami, FL • June 6-8, 2016

# Direct Combustion, Anaerobic Digestion, Cellulosic Biofuels, Biochemicals, Animal Feed



**Six-month-old  
Giant King Grass  
in California**

# Giant King<sup>®</sup> Grass Overview

Characteristics	Cost	Range
<p>Very high yield proprietary hybrid (non-GMO), harvested twice a year at 15+ feet</p> <p>Composition like Corn Stover and Miscanthus</p>	<p>Projected lowest cost delivered to the power plant or bio refinery</p> <p><b>10x</b> the yield of Corn Stover and <b>3x</b> the yield of Miscanthus per acre</p>	<p>Warm weather climates –tropical regions including Southern U.S., Hawaii, Puerto Rico, Virgin Islands, Guam)</p> <p>Grows on marginal land</p>

High potential “platform” energy crop for biopower, biofuels, biochemicals and other bioproducts



# GKG Characteristics: Fast Growing Perennial Grass

After Cutting



2 Months  
Animal Feed



3 Months  
Biogas Production



6 Months  
Biofuels & Biopower



# Cost: GKG Advantaged in Key Cost Categories

Costs	Key Drivers	Performance
Growth	Land Use	✓ Highest yield per acre of land
	Water Use	✓ Highest yield per acre-foot of water
	Land Quality	✓ Grows well on marginal land
	Land Amendments	✓ Perennial crop improves land over time through the addition of organic matter.
Harvesting / Logistics	Harvesting	✓ Can use standard equipment
	Transportation	✓ Co-location of biorefinery or power plant and plantation reduces transportation distances and costs
	Storage	✓ Just-In-Time, year-round harvesting reduces or eliminates need for significant storage



# VIASPACE Develops Projects in Addition to Being a Feedstock Supplier



**10-35 MW Direct Combustion Power Plant**  
**1-10 MW Anaerobic Digestion Power Plant**



**VIASPACE can provide**

- **Agricultural support**
- **Business plan development**
- **Financial models**
- **Prefeasibility studies**
- **Bankable feasibility studies**

**VIASPACE partners  
provide technology  
& EPC contracting**

# GKG Projects in Development: Nicaragua Biopower

## 12 MW biomass direct combustion power plant

- 84 GWh of salable baseload electricity
- Well proven technology
- connected to the Nicaraguan grid

## Fueled by 2,100 acre Giant King Grass plantation

- Co-located with power plant
- Irrigation from Lake Nicaragua for reliability
- Cultivation similar to sugarcane

## VIASPACE partner is AGRICORP, a large agribusiness company in Nicaragua

- Land and expertise for plantation operations

EPC contract signed, debt financing letter of intent from IDB and FMO, local utility will operate

**Giant King Grass growing well on part of 10,000 acre rice plantation not suitable for rice**



# GKG Projects in Development: AD Plant on St. Croix, US Virgin Islands

Tibbar Energy USVI is developing an anaerobic digestion (AD) biogas power plant on St. Croix, US Virgin Islands

Primary feedstock is Giant King Grass, which will be grown on 1,500+ acres

Biogas used to power generator to produce 7MW of base-load renewable electricity.

Tibbar will be the only base-load renewable energy project independent of fossil fuel in the USVI

Giant King Grass is harvested 4-5 times a year at 8-10 feet tall for anaerobic digestion



Giant King Grass on St. Croix




Typical Anaerobic Digestion Plant



# Giant King Grass Nursery: San Diego County, California

- Primary nursery facility is in San Diego County, California and source of propagation material
- Giant King Grass is vegetatively propagated like sugarcane, but at a higher ratio for improved scalability
- Shipments and exports inspected and approved by USDA



UNITED STATES DEPARTMENT OF AGRICULTURE ANIMAL AND PLANT HEALTH INSPECTION SERVICE PLANT PROTECTION AND QUARANTINE	FOR OFFICIAL USE ONLY	
PHYTOSANITARY CERTIFICATE	PLACE OF ISSUE San Diego, California	
TO: THE PLANT PROTECTION ORGANIZATION(S) OF	NO. <b>F-C-06073-04005380-7-N</b>	
	DATE INSPECTED	

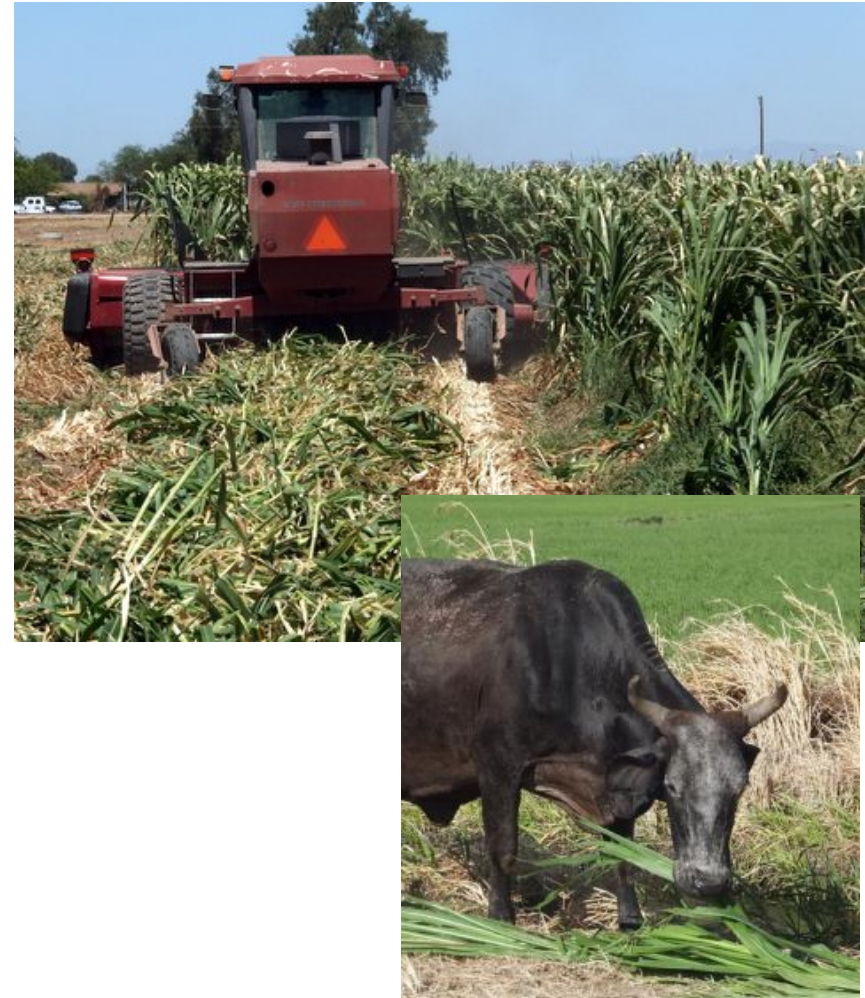
# Giant King Grass in Hawaii Second VIASPACE Nursery





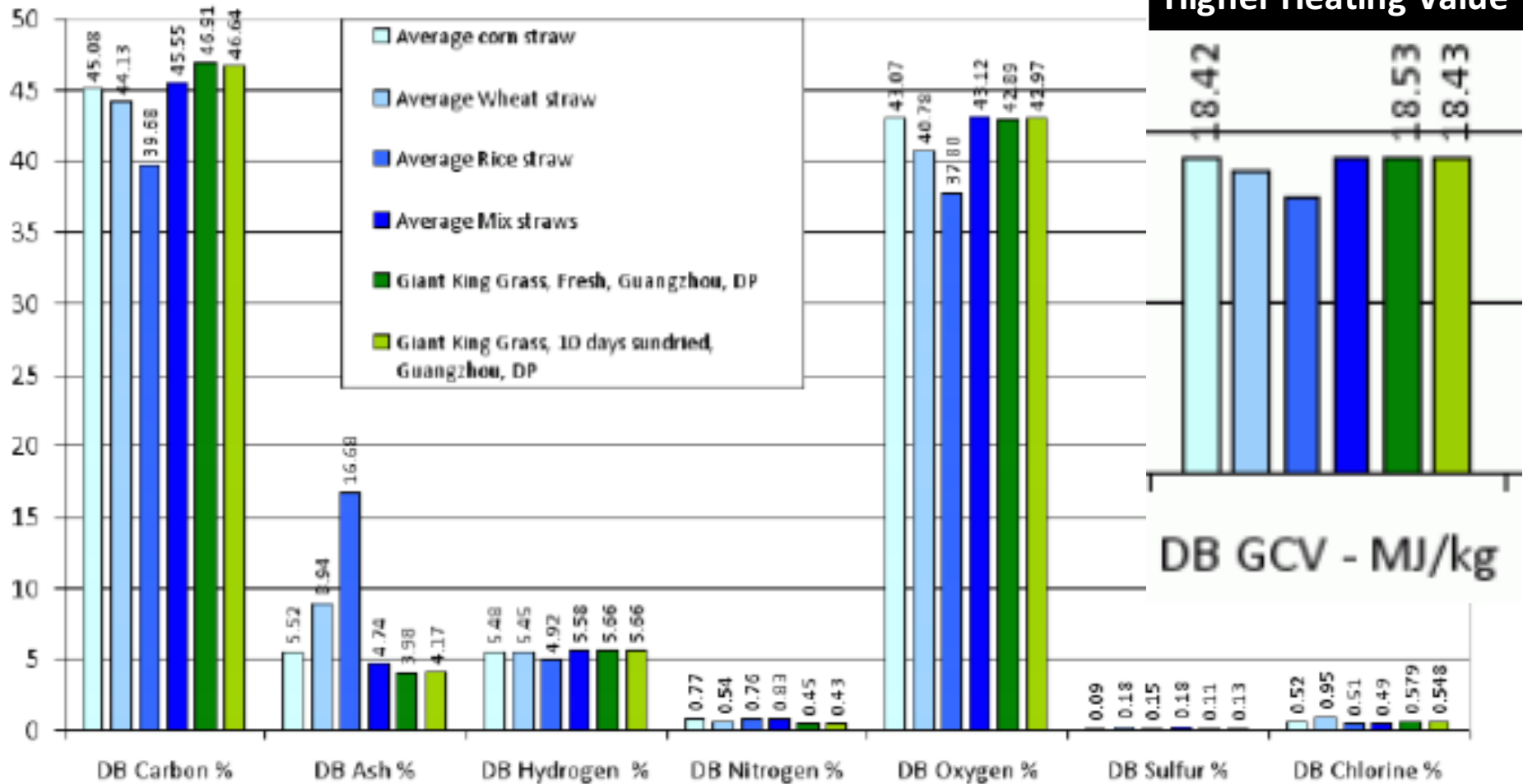
# GKG Research: Imperial Valley California

- University Of California Desert Research Center
- Growth in high temperature desert conditions
- 6 month harvest for bioenergy
- 2 month harvest for animal feed
  - High protein 14-17%
  - High Yield

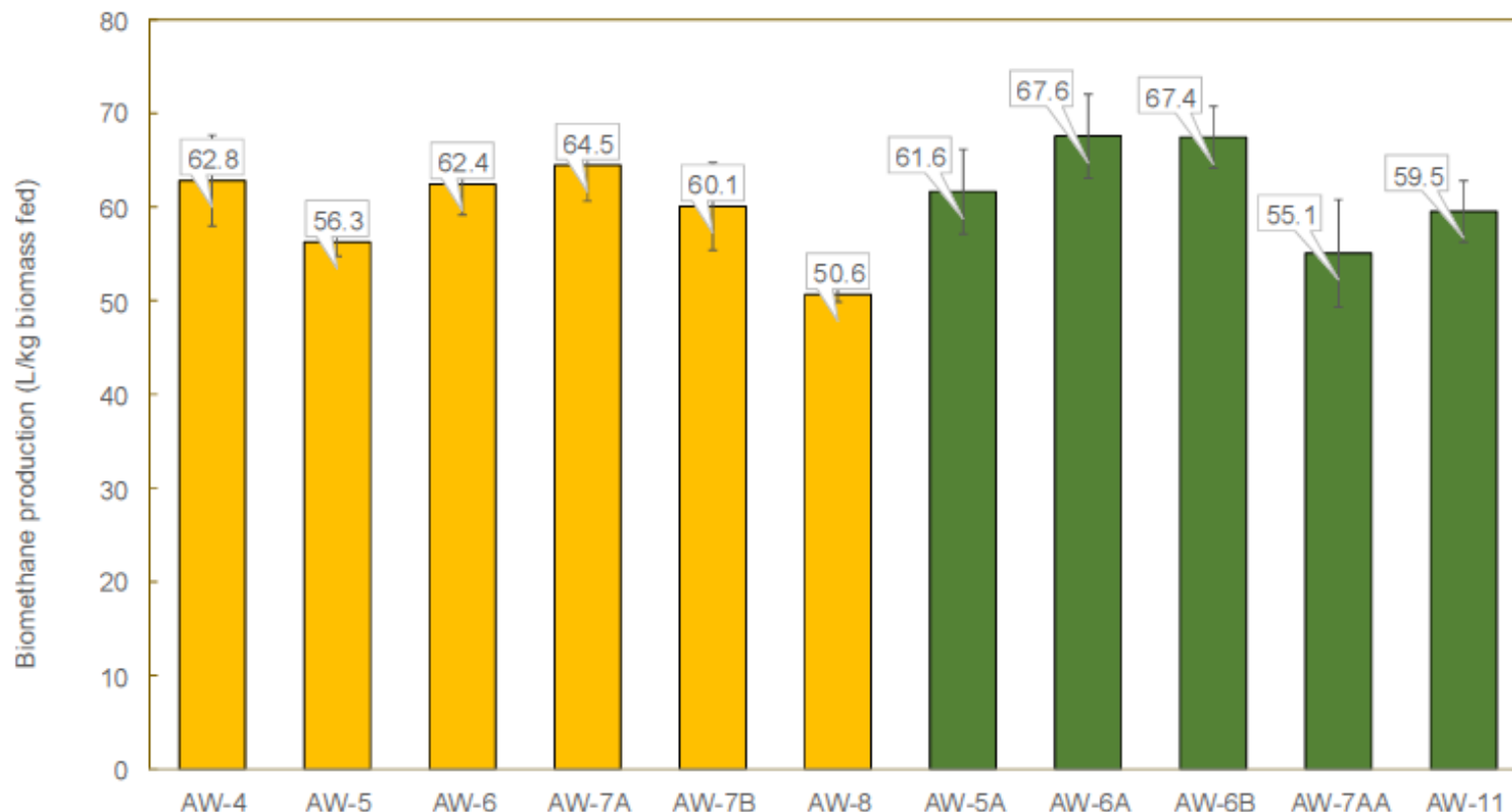




# Giant King Grass & Agricultural Waste Straws Have Same Properties



# Biomethane Production from GKG



**Figure 1.** Overall biomethane production (@ STP) normalized by total biomass fed for the six GKG samples assessed in Batch #1 (yellow columns) and five in Batch #2 (green columns); callouts show the overall values; error bars represent the standard deviation obtained from replicates (three independent bioreactors).

# GKG Composition for Biofuels & Biochemicals

**Giant King Grass analysis by 3 independent companies:**

<i>Composition Dry Weight %</i>	Giant King Grass	Corn Stover	Miscanthus
<i>Glucan</i>	43.0	37.4	44
<i>Xylan</i>	22.3	21.1	22
<i>Arabinan</i>	2.9	2.9	2
<i>Lignin</i>	17.4	18.0	17
<i>Ash</i>	4.5	5.2	2.5-4



Sugars used for  
biofuels and  
bioproducts

Byproducts

Notes and references:

Giant King Grass: average of samples cut at 4 m tall; Data from Novozymes, POET, TMO

Corn Stover: Aden et al. NREL/TP-510-32438, 2002

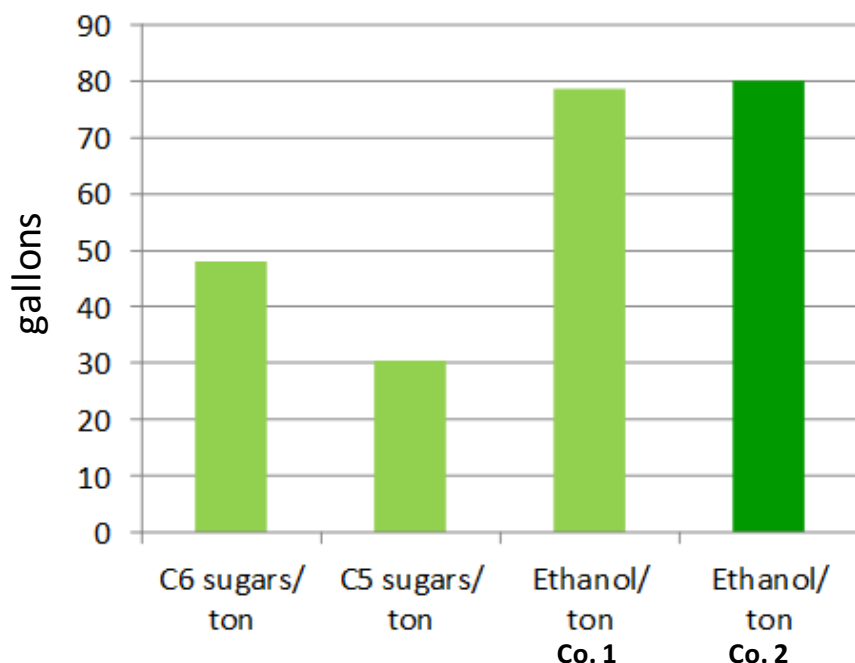
Miscanthus: Murnen et al. Biotechnology Progress 23, 4, 846-850, 2007 and other sources

**Giant King Grass composition is equivalent or slightly better than Corn Stover and Miscanthus for biofuels and bioproducts**



# Independent Pretreatment & Enzymatic Hydrolysis Testing

## Sugar (meas.) and Ethanol Yields (est.)



**“Giant King Grass ethanol production is very similar to corn straw and Giant King Grass is probably easier to process”**

– POET scientist

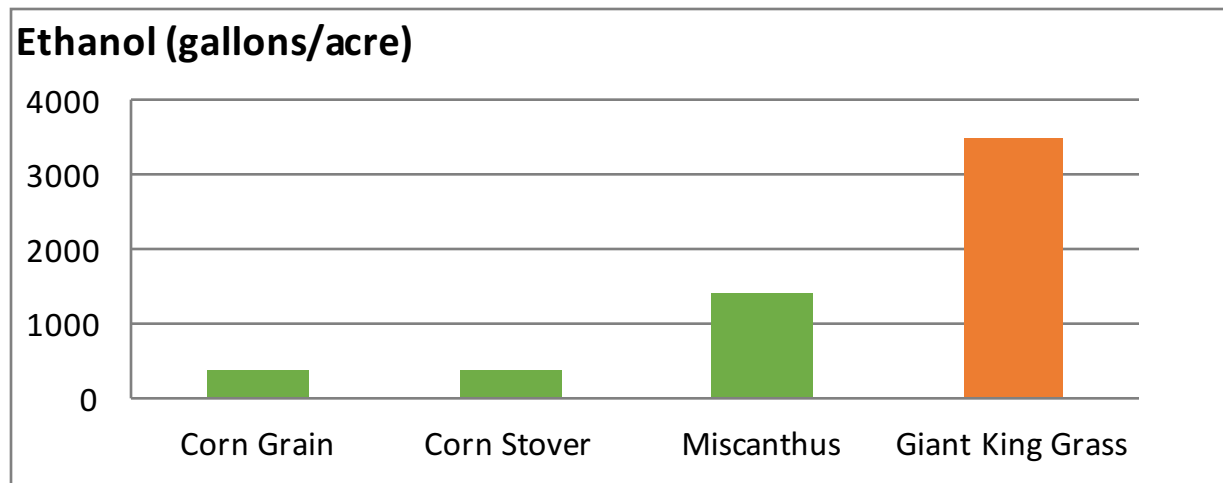
- Conversion of hemicellulose (xylan) to xylose >90%
- Conversion of cellulose (glucan) to glucose > 85%

# High Land Use Productivity

Highest land use efficiency...

Yield Dry Matter	Giant King Grass	Corn Stover	Miscanthus
US ton/acre	42	3.5-4.7	14-18
Metric ton/ha	94	8.6-11.6	31-40

... results in highest productivity per acre.



Giant King Grass yields two harvests per year in warm climates compared with one harvest per year for corn and miscanthus.

# 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

Preserves large capital investment in existing power plant w/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

## Composition Determination

Parameter	Amount (a.r.)
Total Moisture	8.81
Moisture Airdry	
Ash	4.66
Volatile matter incl. moisture.	
Volatile matter	70.34
Fixed Carbon	16.18
Gross Calorific Value	4055.2
	16,978



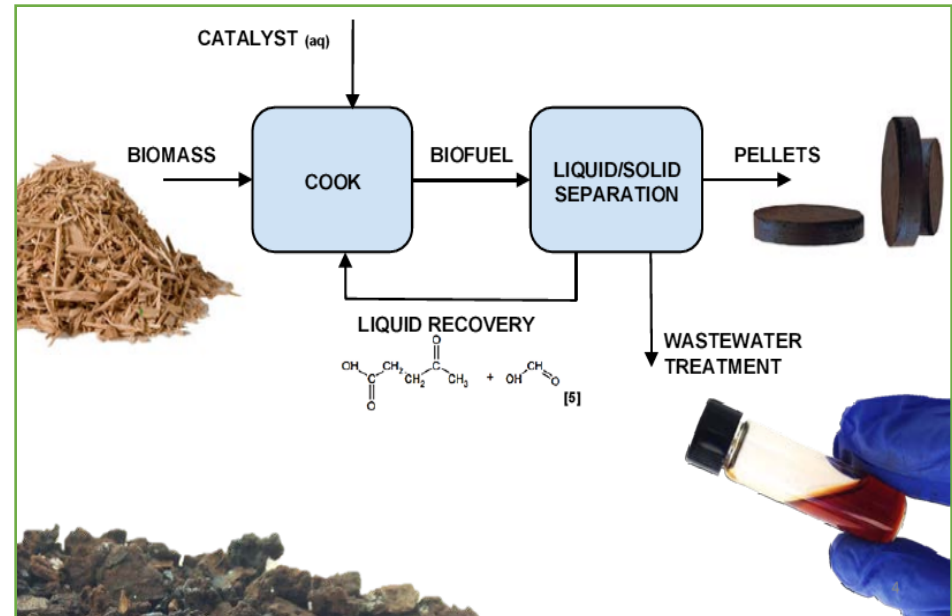


# Hydrothermal Process Conversion of Giant King Grass to Bio-coal

Partnered with PCS Biofuels, Inc. to convert GKG to drop-in coal replacement using its patented Polymer Carbon Solid (PCS) thermal catalytic process.

Results for PCS GKG biofuel:

- Same energy density as metallurgical coal (~24MJ/Kg)
- Burns cleanly without generating sulfur, mercury or other emissions found in coal
- Hydrophobic and can be stored outdoors like coal and pulverized in the same machines as coal.
- Ash content is similar to that of a good coal
- High melting point, above 950°C; no co-firing problems expected



# Giant King Grass – Platform Crop

## Multiple Applications

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

## Independent Testing Data

- Proximate & Ultimate analyses
- Trace metals
- Ash composition & melting temperature
- Biomethane production
- Cellulosic sugar composition
- Pretreatment and enzymatic hydrolysis
  - C5 and C6 sugars
- Bio coal analysis
- Animal feed nutrition

Energy content HHV: 18.4 MJ/dry kg= 4400 kcal/kg=7900 BTU/lb  
 Biogas production: 539-758 liters/dry kg; 51-57% methane  
 Biofuels analysis: Glucan 43%; Xylan 22%; Arabinan 3% Lignin 17%  
 Cellulosic ethanol projection: 80 gallons per US ton)  
 Cellulosic ethanol yield projection: 3,500 gallons per acre  
 Biocoal: 24 MJ/kg HHV

# Summary: Giant King<sup>®</sup> Grass

## Advantages

- High yield dedicated energy crop producing 21 dry tons per acre per harvest when harvested for biofuels and biopower twice a year at 14+ feet tall
- Perennial crop, cut and regrow for 7 – 10 years
  - No need to plow & replant every year
  - Promotes strong subsoil environment
- Natural proprietary grass, not genetically modified
- Will grow on marginal land, does not displace food crops
- Well suited for bioenergy applications
- Provides reliable, low cost fuel or feedstock for 24/7 operations 365 days/year

## Limitations

- Tropical and subtropical grass requiring non-freezing areas for perennial growth
- Giant King Grass has high water use efficiency and is drought tolerant, but needs consistent rainfall or irrigation for optimum production

### Giant King Grass

**Lowest Cost Feedstock  
Because of High Yield**

**High Energy Content**

**Composition like Corn Straw**





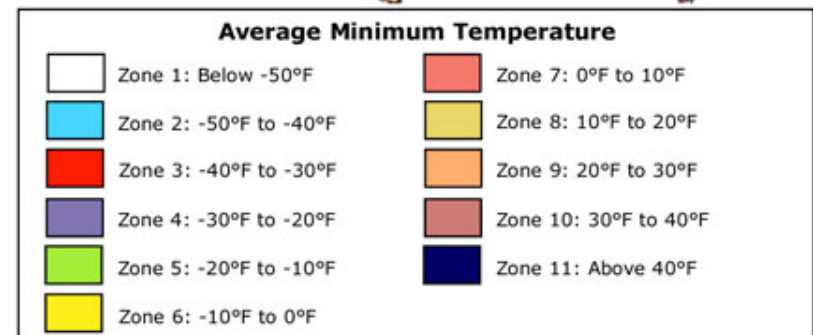
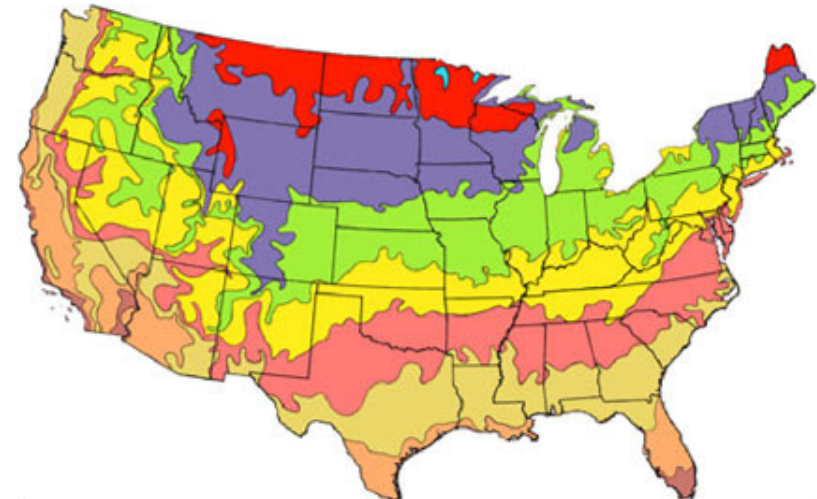
THANK YOU!

# Giant King Grass U.S. Range

Giant King Grass is a tropical and subtropical grass suitable for Southern U.S. (zones 8+ on map), Hawaii, Puerto Rico, Virgin Islands, Guam, American Samoa

Giant King Grass will survive a short freeze – the roots survive and plant re-grows when the weather warms – but not an extended period of freezing weather

Giant King Grass requires warm weather, sunshine and sufficient rainfall or irrigation.



# VIASPACE Background

- VIASPACE is a publicly traded company: Symbol VSPC
  - Fully reporting to SEC and audited
  - Headquartered in California, USA
- Originally founded in 1998 as an incubator to commercialize technology from Caltech/NASA Jet Propulsion Laboratory (JPL)
  - Dr. Carl Kukkonen, founder, directed a JPL research center
  - Original products came “via” the “space” program
- VIASPACE now focused on biomass for biofuels, bioproducts and bioenergy
- Giant King® Grass is a proprietary high-yield, dedicated energy crop currently being grown in California, Hawaii, St. Croix (US Virgin Islands), and other countries in Africa, Asia, Central and South America
- Experienced management and technical team