



# GIANT KING GRASS

A Dedicated Energy Crop  
for Bioenergy and Biorefineries

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# 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**



# VIASPACE



**Dr. Carl Kukkonen, CEO**

**VIASPACE Inc., Irvine, California USA**

**[www.VIASPACE.com](http://www.VIASPACE.com) [Kukkonen@VIASPACE.com](mailto:Kukkonen@VIASPACE.com)**

- Headquarters in Irvine, California USA
- A public company listed on the US OTC Bulletin Board with stock symbol VSPC

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# Giant King Grass 4m Tall



# Giant King Grass Summary



- Giant King Grass is high yield nonfood fuel for electricity & heat generation and feedstock for cellulosic biofuels, biochemicals and bio plastics
- Almost identical to corn straw and wheat straw with 10 times the biomass yield per hectare
- Giant King Grass provides a reliable, consistent quality source at affordable price
  - High yield means less land and low cost
  - Consistent quality allows process optimization
- Co-location of plantation & power or ethanol plant leads to further savings through simpler logistics <sup>5</sup>









# Giant King Grass



## Very high yield

- Fresh cut yield of 375 wet metric tons/hectare (167 t/acre) for biogas production (70-75% moisture)
- Sun dry to 25% moisture to burn in a power plant reduces yield is 125-180 mt/ha (56-80 t/acre)
- 100 bone dry mt/ha (45 t/acre)

## Perennial in subtropical & tropical areas

- Plant once, grows for many years
- Grows on marginal land





# Giant King Grass

- Not genetically modified
- Not an invasive species
- Productive in first year
- Needs sunshine, warm weather & rain or irrigation
- Fertilizer use is modest
- Can be grown in acidic or mildly saline soil
- No pesticide required



# Giant King Grass & Factory



Note CEO standing at lower right of picture. Giant King Grass is 4 m tall



# Giant King Grass After Harvest



Field dried grass and regrowth 10 days after second harvest

# Field Dried Grass & 14 Day Regrowth





# Field Dried Grass Transported to Factory



# Chipper and Rotary Dryer





# Green Log Machine



**Most Green Log processes are common to a pellet mill**

- Growing**
- Harvesting**
- Chipping**
- Drying**
- Hammer mill**

# Green Log™ Fireplace Logs





# Applications of Giant King Grass



- Direct combustion in electric power plant
- Pellets for co-firing with coal
- Briquettes for process steam and heat
- Biogas production
- Cellulosic liquid biofuels--ethanol/butanol
- Biochemicals and bio plastics
- Pulp for paper and cellulosic textiles
- High-temperature gasification
- Torrefaction to bio coal & pyrolysis to bio oil
- Catalytic processes to bio diesel

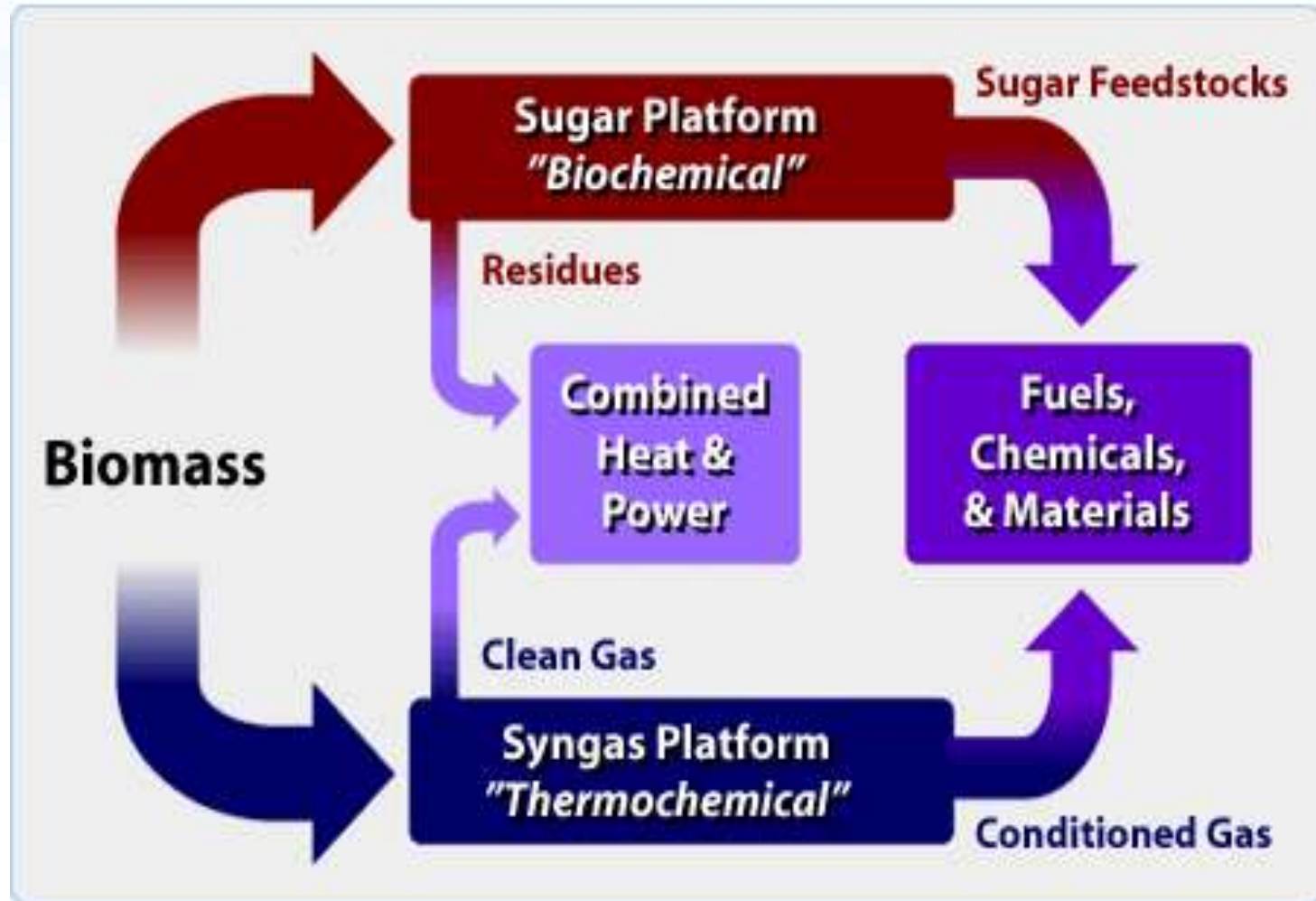
**Commercial  
Today**

**Low cost of  
Giant King Grass  
will allow  
commercial  
applications  
in future**

**Extensive Independent Testing, But Not Yet in Production**

# Biorefinery-Biomass Conversion Example

## Biorefinery Concept





# Giant King Grass for Biorefinery



- Independent testing by TMO in England and two undisclosed companies
- Composition analysis
- Pretreatment & enzymatic hydrolysis
- Results show Giant King Grass is the same as corn or wheat straw per ton
- High yield of Giant King Grass in tons per hectare promises low cost feedstock for biorefinery

# Compare to Corn & Wheat Straw



<i>Composition Dry Weight %</i>	Giant King Grass	Corn Straw	Wheat Straw
<i>Glucan</i>	43.0	37.4	38.8
<i>Xylan</i>	22.3	21.1	22.2
<i>Arabinan</i>	2.9	2.9	4.7
<i>Lignin</i>	17.4	18.0	16.1
<i>Ash</i>	4.5	5.2	5.8

Notes and references:

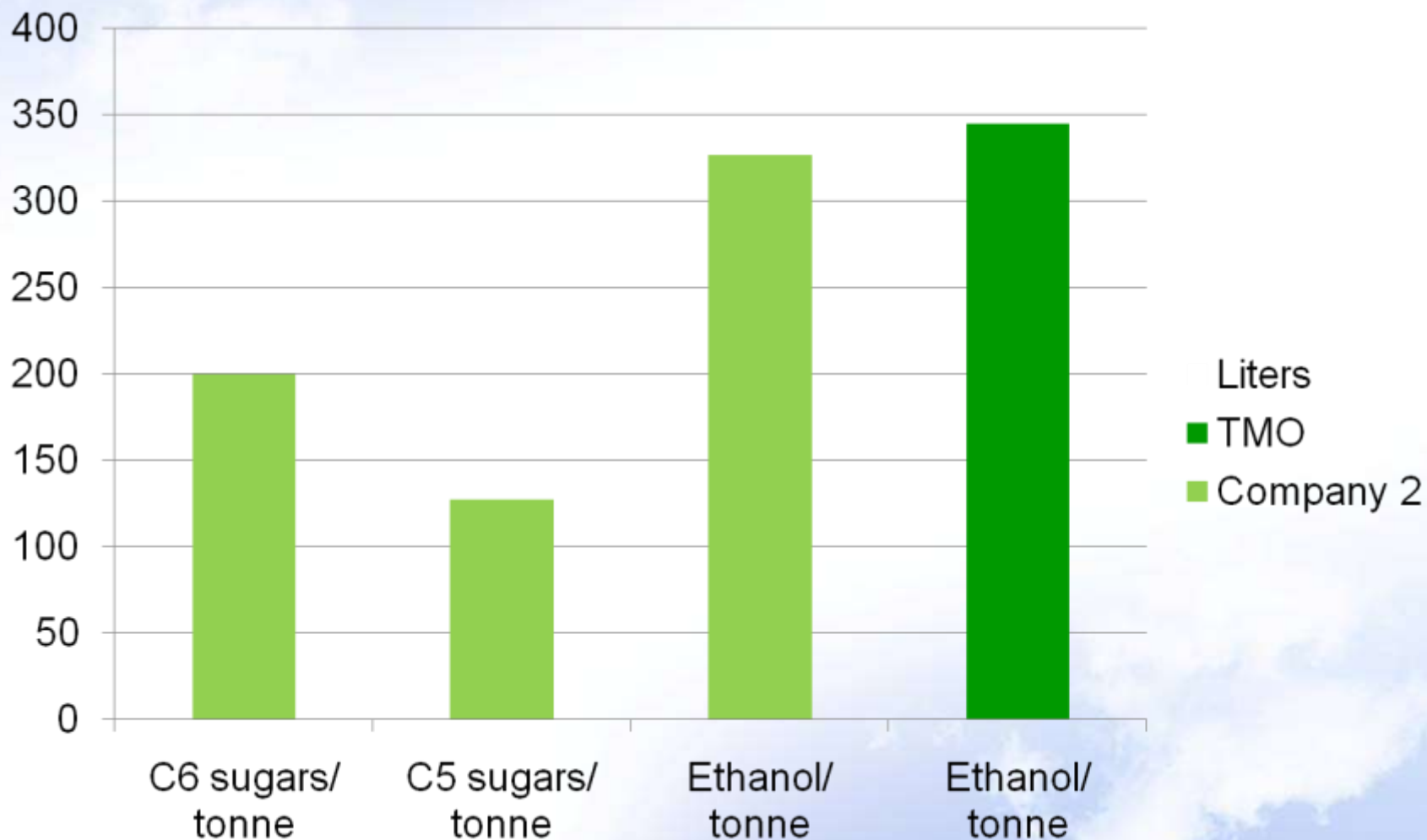
Giant King Grass: average of samples cut at 4 m tall

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

Wheat Straw: Erdei et al. Biotechnology for Biofuels 2010 3:16



# Sugar Data & Projected Ethanol Yield (L/tonne)



# Pretreatment & Enzymatic Hydrolysis



- Conversion of hemicellulose (xylan) to xylose >90%
- Conversion of cellulose (glucan) to glucose > 85%
- “Giant King Grass ethanol production is very similar to corn straw and Giant King Grass is probably easier to process”



# Compare Yield to Corn & Wheat Straw



Yield Dry Matter	Giant King Grass	Corn Straw	Wheat Straw
US ton/acre	44	3.5-4.7	1.6-2.8
Metric ton/ha	100	8.6-11.6	4.0-6.9

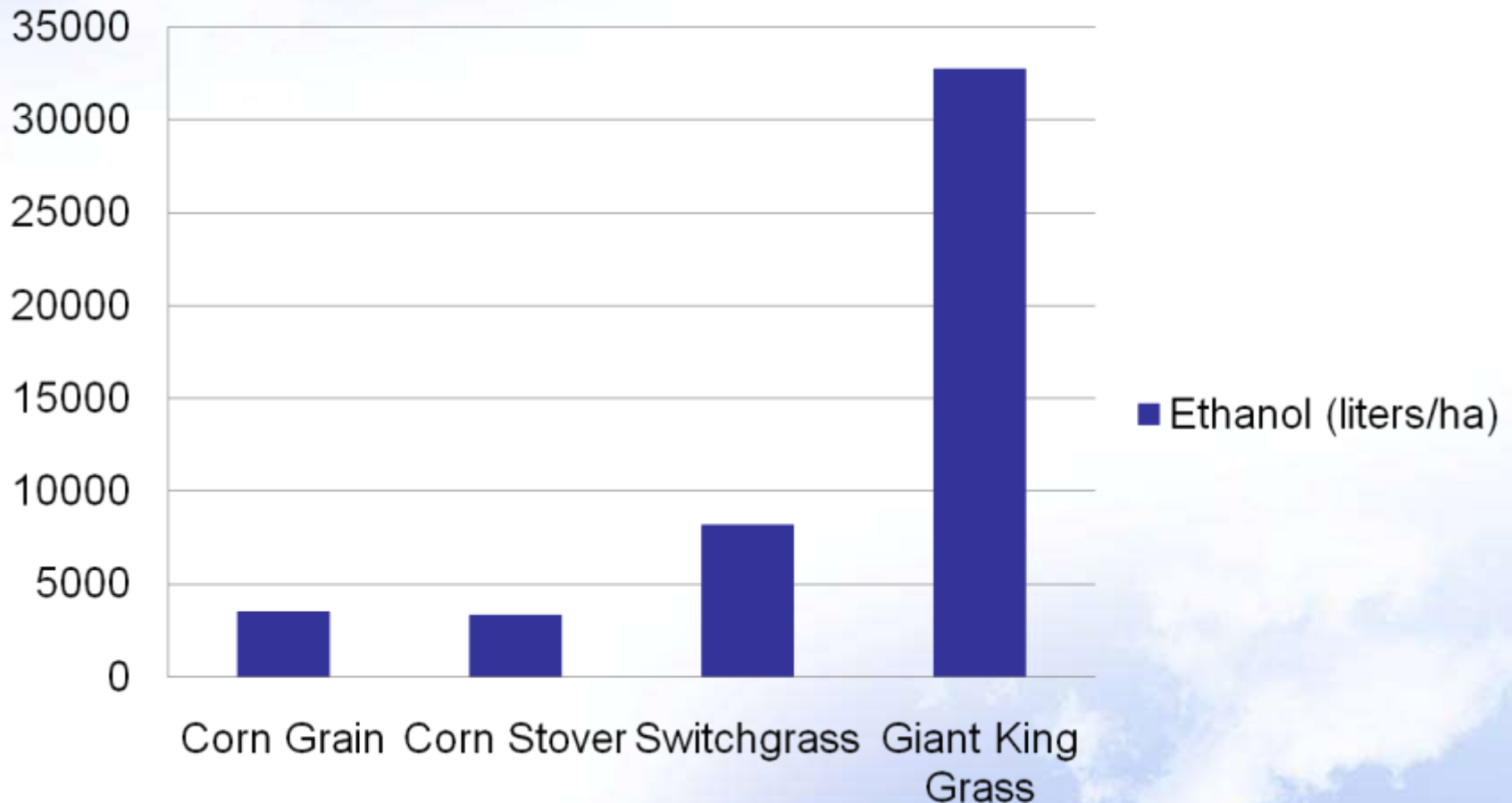
**Yield:** The yield comparison amongst Giant King Grass, corn straw and wheat straw is not exactly a fair comparison.

- Corn and wheat will grow in cold areas, whereas Giant King Grass cannot tolerate freezing temperatures
- Corn and wheat are annual crops 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 is a perennial grass that can be harvested several times a year for many years. Because of this, the soil ecosystem remains relatively intact and this is a major advantage in soil erosion, carbon sequestration and potential nitrogen fixation from the atmosphere to reduce external fertilizer needs

# Land-Use Efficiency



Ethanol (liters/ha)





# Co-located Biorefinery & Plantation

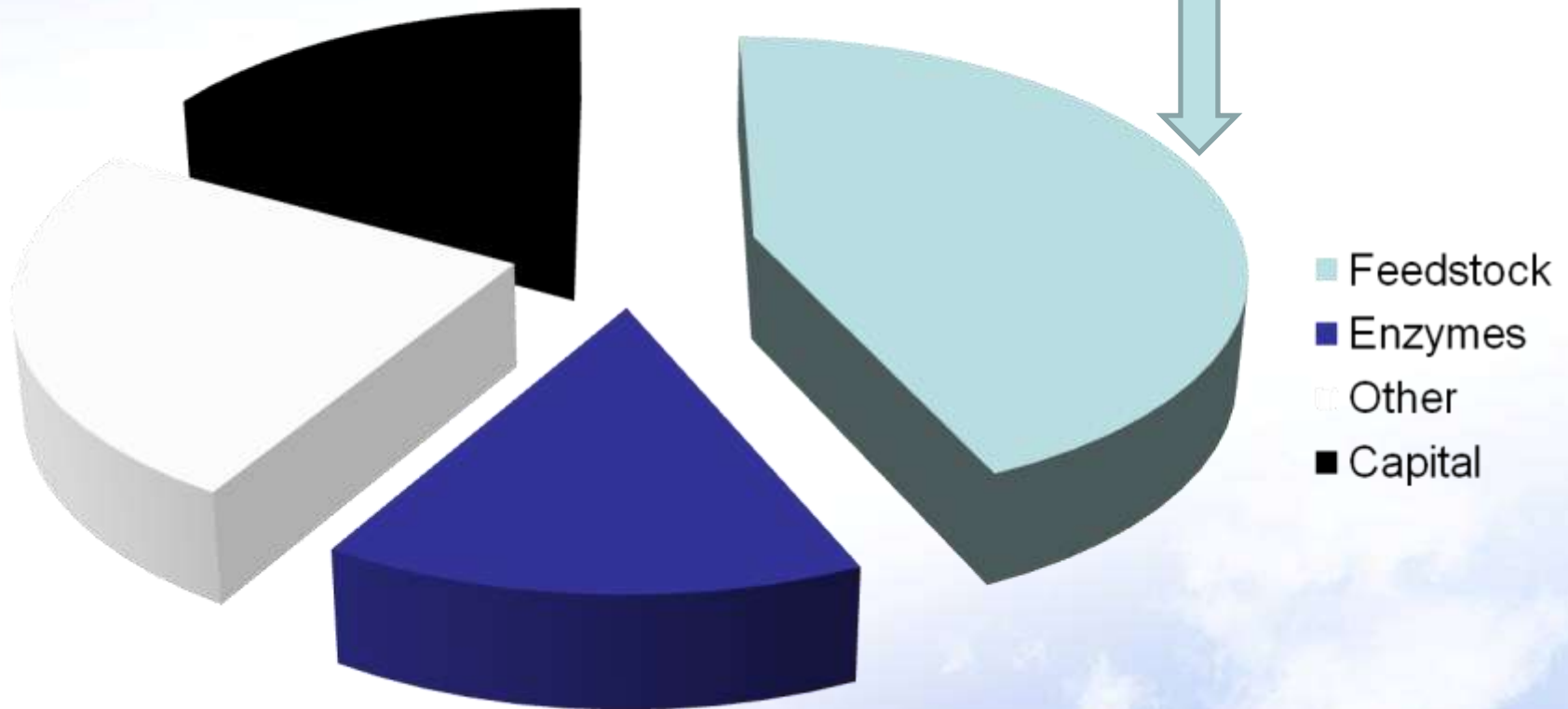


- High yield of Giant King Grass means minimal plantation size
  - 25M ethanol gallons per year (95M L) can be produced on 3200 Ha (7900 acres)
- Logistics are much simpler
  - Maximum grass transportation distance 3 km
  - Can utilize just in time harvesting in tropical area because not tied to food crop harvesting
  - Do not have to dry and store feedstock
- Results in much lower cost feedstock

# Feedstock is the Largest Cost of Cellulosic Ethanol



**Giant King Grass and co-location can reduce feedstock cost by 40-50%**





# Giant King Grass & Biorefinery



- Potential products from cellulose
  - Ethanol, butanol
  - Lactic acid > polylactic acid > bioplastics
  - Pulp> Paper, viscose textile fibers
- Potential products from hemicellulose
  - Ethanol, butanol
  - chemicals such as furfural and acetic acid
- Lignin for combustion, fiber strengthener for structural plastics, adhesives and epoxy resins
- Wastewater for biogas and organic fertilizer
- Material recovery from liquids

# Biochemical Building Blocks



Building Blocks
1,4 succinic, fumaric and malic acids
2,5 furan dicarboxylic acid
3 hydroxy propionic acid
aspartic acid
glucaric acid
glutamic acid
itaconic acid
levulinic acid
3-hydroxybutyrolactone
glycerol
sorbitol
xylitol/arabinitol



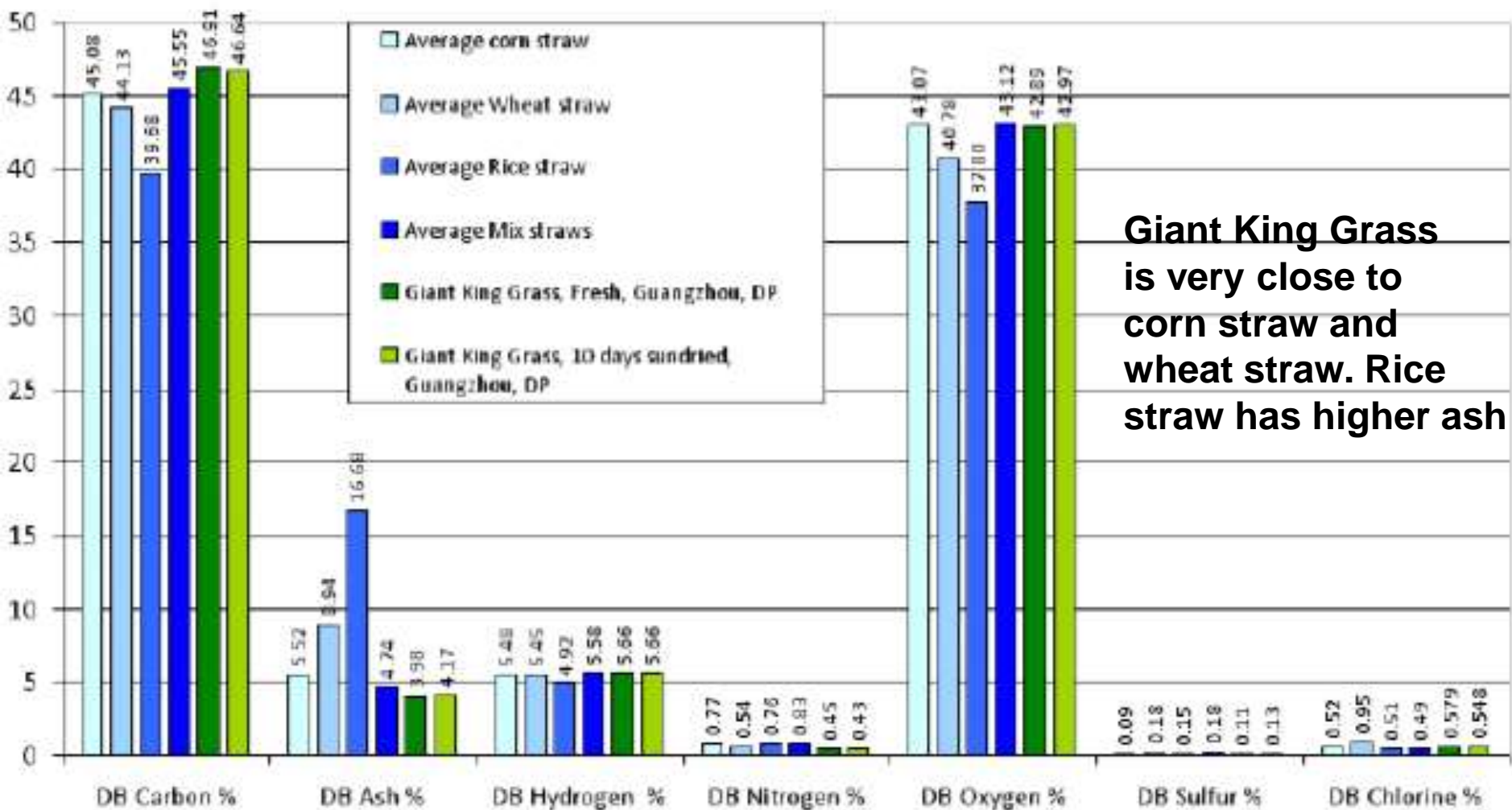
# Direct Combustion in Biomass Power Plant



- Giant King Grass has excellent energy content of 18.4 MJ (megajoule) per dry kilogram HHV equivalent to
  - 5.1 kilowatt hours thermal/kg
  - 7900 BTU/pound
  - 4400 kcal/kilogram
- Giant King Grass properties similar to corn straw (stover)
- 1 kWh electricity requires 0.72 kg of dry Giant King Grass



# Ultimate Analysis by DP Clean Tech



# Agricultural Waste is Disbursed And Seasonal

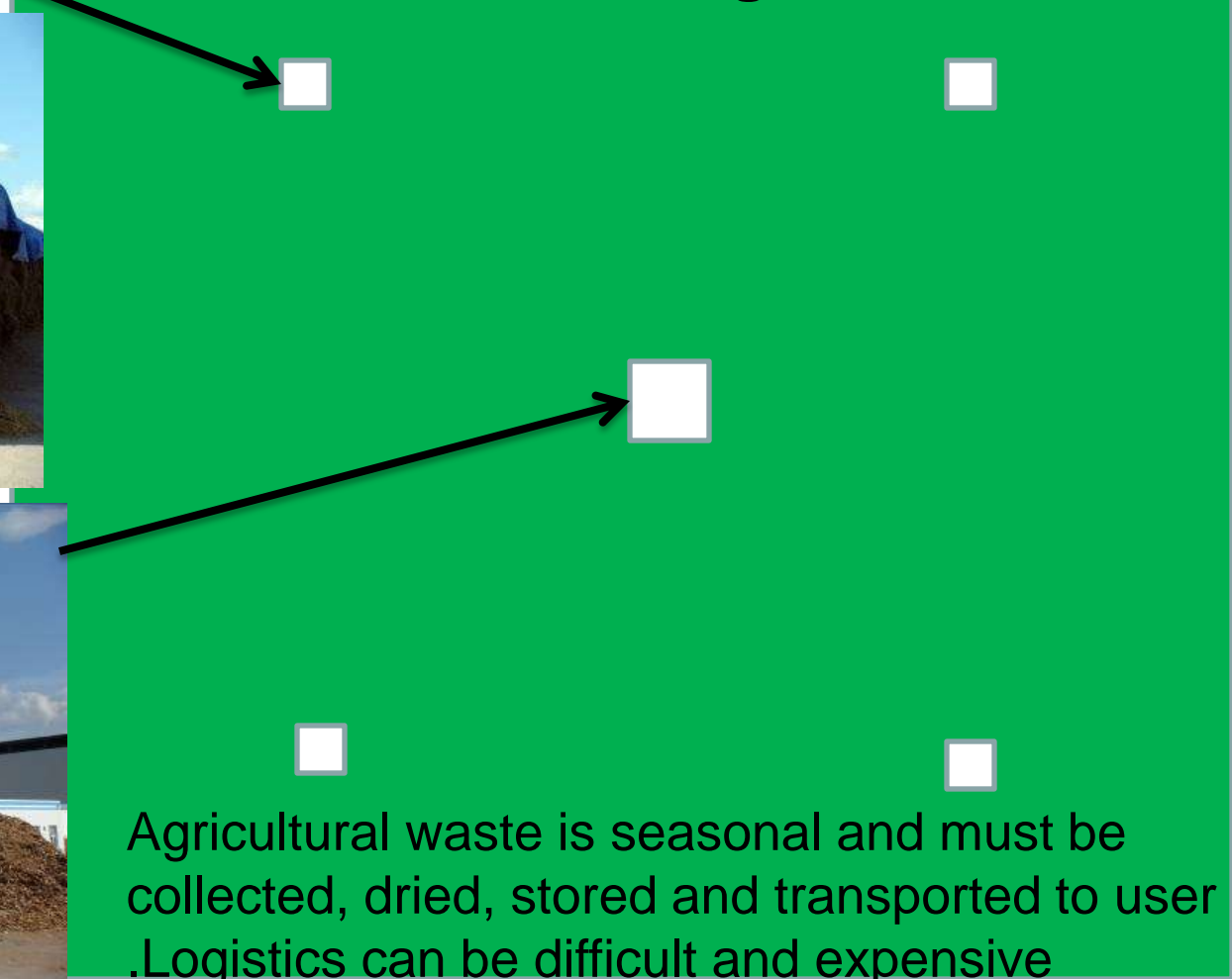


Off-site storage of dried, baled seasonal feedstock



Power or ethanol plant

← 100 km collection for agricultural waste →



Agricultural waste is seasonal and must be collected, dried, stored and transported to user  
Logistics can be difficult and expensive



# Giant King Grass Pellets as Coal Replacement

- Giant King Grass pellets co-fired up to 20% w/ coal
  - Requires small modification to existing coal power plant
  - Dry & press into pellets
- Preserves existing power plant investment & meets carbon reduction targets
- Large global demand
  - Particularly in Europe
  - Japan & Korea emerging
- Dedicated energy crops favored over waste



# Giant King Grass for Energy Pellets



- Standard grade
  - 18.4 GJ per ton HHV
  - 4% ash
  - Chlorine same as corn straw or wheat straw
- Premium grade
  - 19.4 GJ per ton HHV
  - 3% ash
  - Chlorine reduced by 65%
  - Low potassium

# Giant King Grass for Bio-Methane

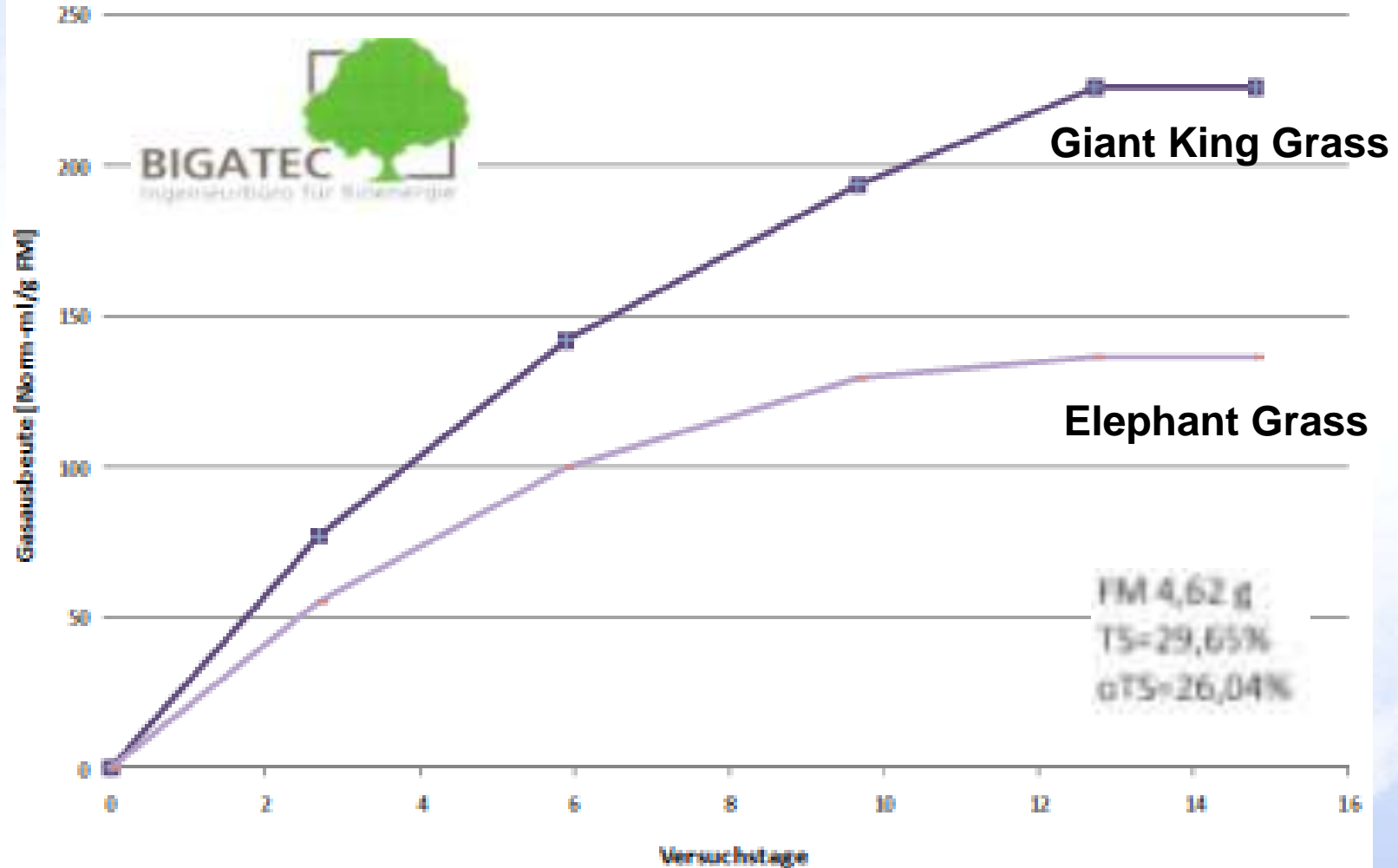
- Giant King Grass has very high bio-methane yield
  - 91 liters methane/kg fresh grass
  - 0.36 m<sup>3</sup>/kg volatile solids
  - Compared to 0.22 for municipal solid waste, 0.21 for rice straw
  - Organic fertilizer is byproduct



**Biogas plant generates 1 MW electricity and 1 MW heat for greenhouse using anaerobic digestion and corn as feedstock. Can use Giant King Grass**



# Biogas Yield per Gram of Fresh Grass



Anaerobe Gasproduktion in Anlehnung an DIN 38 414 S8

# Biomass Briquettes



- Replace oil, natural gas & coal in boilers to provide industrial heat and steam
- Cement, ceramics, brick, chemical, food processing, ethanol, textile, rubber, etc.



# High Temperature Gasification



- Feedstock for synthesis gas to produce liquid biofuels incl. methanol and gasoline, diesel and jet fuel by the Fisher Tropsch process and also biochemicals



- Producer gas to replace oil, natural gas & coal in boilers and engines that cannot directly burn biomass for process heat & steam



# Giant King Grass Scalable & Sustainable Development



- Giant King Grass plantation co-located with a power plant, pellet mill, bio-methane or biorefinery
  - Scalable integrated module that can be replicated throughout the world
- Provides local employment for farmers and power plant operators
- Provides energy security and independence

# Advantages of Giant King Grass



- Low cost--Can meet cost targets for energy & biofuels applications because of high yield
- Perennial crop
  - Do not have to plant every year, just harvest
- Is harvested in the first year
  - Other crops can take 2-4 years
- Provides reliable, consistent quality fuel or feedstock with predictable, affordable price
  - Fuel supply reliability required for project financing

# VIASPACE Business



- VIASPACE only works on integrated plantation and bioenergy or biorefinery projects
  - VIASPACE can act as project developer or work with local project developer
- VIASPACE is seeking quality project implementation opportunities
  - Also opportunities for university and industry research, development and demonstration collaborations



# Potential R&D Collaborations



- Biorefinery fermentation process optimization possible if Giant King Grass is sole feedstock
  - Pretreatment
  - Conversion of polysaccharides
  - Specific enzymes
- Define optimal product mix and trade-offs
  - Cellulose utilization for paper pulp, dissolving pulp, ethanol, butanol, polylactic acid (for bio plastics)
  - Hemicellulose to chemicals or to biofuels
  - High-value applications of lignin

# Potential R&D Collaborations



- Use of Giant King Grass as fresh wet feedstock for fermentation biorefinery without drying
- Giant King Grass as feedstock for thermochemical conversion such as high temperature gasification, pyrolysis, torrefaction
- Sustainability and carbon analyses
- Feedstock logistics from the field to the processing plant
- Direct combustion products from a biorefinery
- Provide samples and pilot process quantities to biorefinery developers

# **ADDITIONAL SLIDES**



# Today's Bioenergy Feedstocks



- Food crops such as corn, soy or sugarcane for ethanol
- Used cooking oils, poultry fat and beef tallow, soy and canola oil for bio diesel
- Forestry & wood waste such as bark and sawdust for pellets and power plants
- Agricultural waste including corn Stover, wheat straw, rice husks to be burned in power plants to generate electricity or produce pellets, biogas and liquid biofuels
- Municipal solid waste biomass

# Today's Bioenergy Feedstocks



- Use of food crops for fuel is being restricted or banned in most of the world
- Supply of waste oils is limited
- Wood waste pellets are widely used and there is demand for more pellets
  - Competition with pulp and paper industry
- Agricultural waste has limitations
  - Seasonal & only available after the food is harvested
  - Collection radius is large which costs energy
  - Must be stored until the next harvest is available
  - No long-term pricing. It is a spot market only
  - Prices have risen dramatically with increased demand

# Dedicated Energy Crops are Needed



- High yield dedicated biomass crops needed (in addition to agricultural and forestry waste)
  - Provide large quantities of consistent quality
  - High yield means low cost & efficient use of land
  - Must grow on non-food land
- With a dedicated energy crop, it is possible to obtain a reliable long-term source of fuel or feedstock at a known and affordable price
  - A long-term feedstock supply agreement needed to obtain financing for the power or biofuel plant



# Land-Use Efficiency Example



- Biomass with yields above 10 tonnes/hectare/year exceed the land efficiency of corn to produce ethanol
  - Cellulosic ethanol is not yet commercially viable
- Perennial crops such as grasses lead to less soil depletion and erosion
- High yield of Giant King Grass makes most efficient use of land

Assumes 78.5 gallons ethanol per dry ton (327 l/mt) for cellulosic ethanol

Feed-stock	Yield Mt/ha	Ethanol Liter/ha	Ethanol Gallon /acre
Corn US	9.4	3500	375
Corn-straw	9.4	3320	355
Switch-grass	25	8180	880
Giant King Grass	100	32700	3500