

# Giant King Grass for Bioenergy & Pellets



Clean Energy for a  
Cleaner Tomorrow



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- VIASPACE is a publicly traded company on the US OTC Bulletin Board
  - VIASPACE stock symbol VSPC.OB

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- Renewable energy source that can be locally grown and provide jobs & energy security
  - Less expensive than imported oil or gas
- Can generate electricity 24 hours per day
  - Solar and wind are transient not base power
  - Less expensive than solar and wind
- Burning & regrowth is carbon neutral
- Sustainable growth
- In the future, biomass can produce liquid biofuels, biochemicals and biomaterials

# 100% Biomass Power Plants Hundreds in Use Today



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- All use agricultural or forestry waste as fuel
  - Corn, wheat, rice straw, rice husk, bark, branches etc
  - Waste prices have risen dramatically
  - Agricultural waste has not been available with long term contracts—spot market only
  - Banks will not finance projects without long term fuel supply contract
- Dedicated energy crops can be grown as fuel
  - Perennial grasses, fast growing trees
  - Reliable, low cost, financeable fuel
  - However no power plants yet operating in the world



# Yield Comparison of Perennial Grasses



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Perennial Grass (Genus-Species)	Dry Mass (US ton/acre/year, <u>mt/ha/yr</u> )	
<u>Phalaris</u> -- Reed Canary Grass	2.0 – 3.6	4.5-8.1
<u>Panicum</u> -- <u>Switchgrass</u>	5-9	11-20
<u>Miscanthus</u> -- <u>Miscanthus</u> x <u>Giganteus</u>	13-21	29-47
<u>Pennisetum</u> -- <u>Pennisetum Purpureum</u>	24 – 27	54-61
Giant King Grass	44	100

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. They do not survive a long freeze. The growing season can be 12 months and these crops can be harvested more than once a year



# VIASPACE Giant King Grass



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# 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 2-3 times per year
- Not genetically modified
- Not an invasive species
- Needs sunshine, warm weather & rain or irrigation-no freezing
- Fertilizer use is modest
- No pesticide



# 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***



# Closed Loop Biomass Power Plant



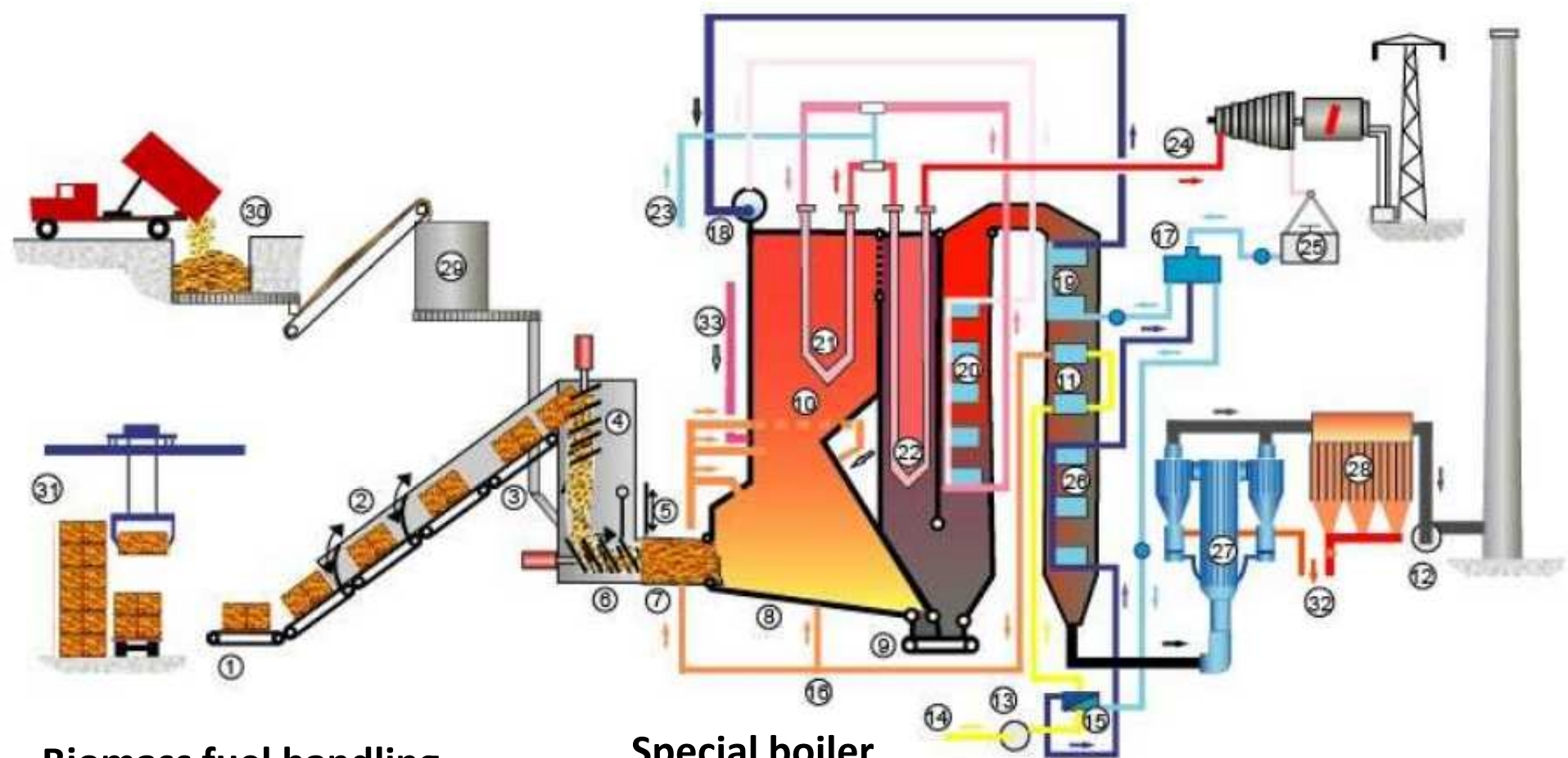
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- Power plant integrated with Giant King Grass plantation
- Water and sunshine in—clean, low carbon electricity out



**VIASPACE** ← **Power Plant Partner** → **Customer**

# Direct Combustion Biomass Power Plant



**Biomass fuel handling**

**Special boiler  
burns biomass  
to create steam**

**High pressure steam  
turbine turns generator  
to make electricity**

# Giant King Grass & Biomass Power / Steam Plant



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- Giant King Grass has excellent energy content of 18.4 MJ (megajoule) per dry kilogram HHV equivalent to 4400 kcal/kg, 7900 btu/lb
- Burn in a power plant instead of coal or oil
- Giant King Grass properties similar to corn & wheat straw
- 30 MW power plant requires 1600 ha of Giant King Grass



30 MW Power Plant Uses  
Corn Straw Today  
-Suitable for Giant King Grass



# Giant King Grass Energy Analysis



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<b>Proximate Analysis</b>	<b>Unit</b>	<b>Sun Dried As Received</b>	<b>Giant King Grass Bone Dry</b>
<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>

# Biomass Power Plant Uses Agricultural Waste Today



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# Biomass Power Plant





# 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



- Wood pellets are dominant today
  - 16 M mt/year
  - Made from sawdust and forestry waste
  - Small residential and commercial boilers can use 100% pellets
  - Replace 20% of coal in existing power plants
    - Minor modification to expensive power plant
  - Dedicated energy forests are being planted
- Agricultural pellets are emerging
  - Most wood waste is already committed for pressed wood products & pellets
  - Pellet market is growing to 46M mt/year by 2020
    - Need more supply
  - Do not cut down rain forests
  - Today made from waste e.g. corn or wheat straw
  - Dedicated , sustainable energy crops are attractive

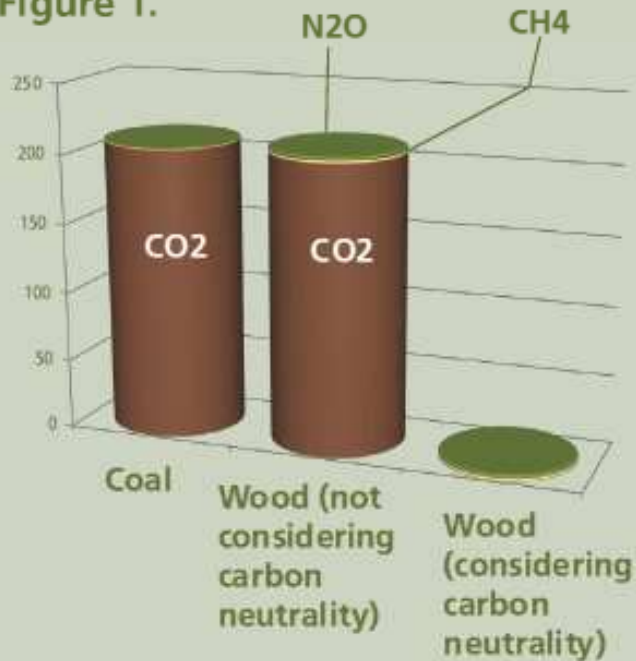
# Pellets to Replace Coal

- Biomass has much lower CO<sub>2</sub> emissions and lower NOX, SO<sub>2</sub>, HCL, Hg and As emissions

## Greenhouse Gas Emissions of Coal and Wood

lb-CO<sub>2</sub>e/MMBtu

Figure 1.



## Forest Biomass and Air Emissions

### Uncontrolled Emissions Comparison

Pollutant	WOOD LB pollutant/ LB/MMBtu	COAL LB/MMBtu	NATURAL GAS combined cycle turbine LB/MMBtu
NOX	0.220	0.510	0.0371
CO	0.600	0.025	0.0075
SO <sub>2</sub>	0.025	0.890 (coal sulfur content varies)	0.0028
VOC	0.017	0.003	0.0043
PM	0.570	0.460	0.0083
CO <sub>2</sub>	206.94	214.04	116.97
HCl	1.900E-02	6.100E-02	None
Hg	3.500E-06	1.600E-05	None
Mn	1.600E-03	1.200E-03	None

Source: ORCAA Assessment 2/3/2010, Ecology 2/24/2010



# Coal Compared to Wood & Agricultural Pellets



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	Density kg/m <sup>3</sup>	Moisture % wet basis	LHV (NCV) MJ/kg	Ash % dry matter
Coal	850	10 – 15	24	12
Wood pellets	650	<10	17.3	0.5
Straw pellets	600	<10	15	5.2
Giant King Grass pellets	600	8.8	15.6	5.1

	Nitrogen % dry matter	Sulfur	Chlorine
Coal	1.3	0.35	0.01
Wood pellets	0.22	0.03	0.02
Giant King Grass pellets	0.79	0.20	0.13

Data shows that wood pellets have higher energy density and lower nitrogen, sulfur and chlorine content than straw or Giant King Grass pellets

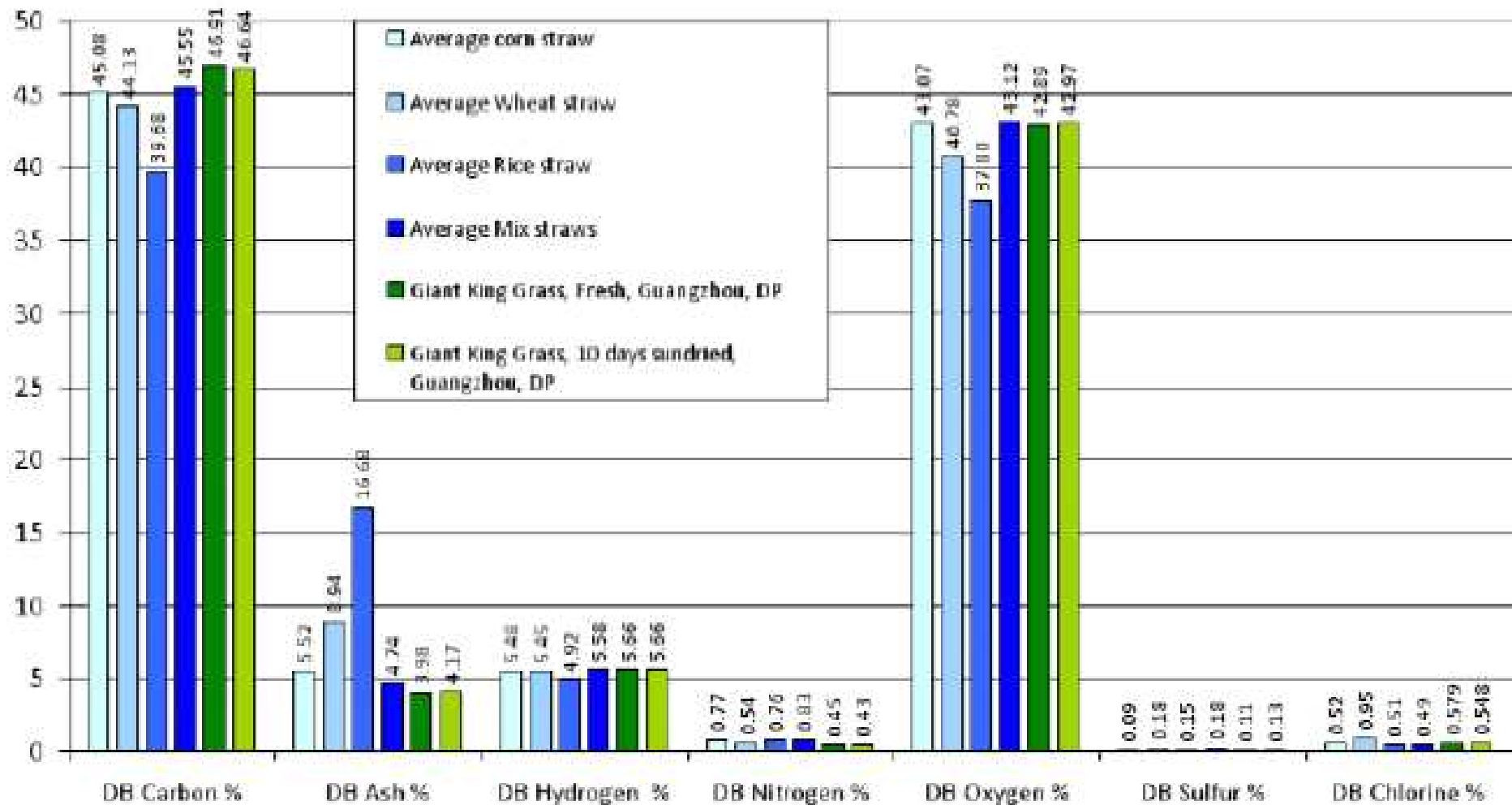
# Why Giant King Grass?



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- Dedicated energy crop, sustainably grown
- Can be harvested 6 ½ months after planting and every 5 months thereafter
  - Wood crops are 4-20 year harvest cycle
- Very high yield means lowest cost pellets
  - Generally lower cost than agricultural waste
- Single cultivar means consistent quality
- Can harvest all year long in tropical area
- Simple logistics if pellet mill is co-located with plantation and both are near a port

# Giant King Grass & Waste Straws Have Same Properties





# Giant King Grass Pellets-- Tested by Many Independent Laboratories



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## Compositional Analysis: Proximate/Ultimate Analysis

Parameter	As-Received	Oven Dry
Total Moisture (%)	7.62	
Ash (%)	2.42	2.61
Volatiles (%)	72.60	78.59
Fixed Carbon (%)	17.28	18.71
Gross Calorific Value (GJ/Tonne)	18.38	19.90
Net Calorific Value (cV)(GJ/Tonne)	17.20	18.81
Net Calorific Value (cP)(GJ/Tonne)	17.13	18.74
Carbon	44.63	48.31
Hydrogen	4.88	5.28
Nitrogen	0.69	0.75
Sulfur	0.09	0.09
Oxygen	39.69	42.96
Chlorine	1140	1234



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



# Test Data on Giant King Grass

## Composition Determination

Parameter	Amount (a.r.)	Amount (o.d.)
Total Moisture	8,81	
Moisture Airdry		
Ash	4,66	5,11
Volatile matter incl. moisture.		
Volatile matter	70,34	77,14
Fixed Carbon	16,18	17,75
Gross Calorific Value	4055,2	4446,9
	16,978	18,618
Nett Calorific Value (cV)	3742,1	
	15,667	
	6735,7	
Nett Calorific Value (cP)	15,592	



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

**TLR**  
international laboratories

**SGS**

# Giant King Grass and Factory



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- 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**



# Giant King Grass After Harvest



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**Field dried grass and regrowth 10 days after harvest**



# Field Dried Grass & Regrowth



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# Field Dried Grass Transported to Nearby Factory



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**Co-location of plantation and factory means grass does not need to be baled**

# Chipper, Rotary Dryer and Hammer Mill





# Green Log Machine



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

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

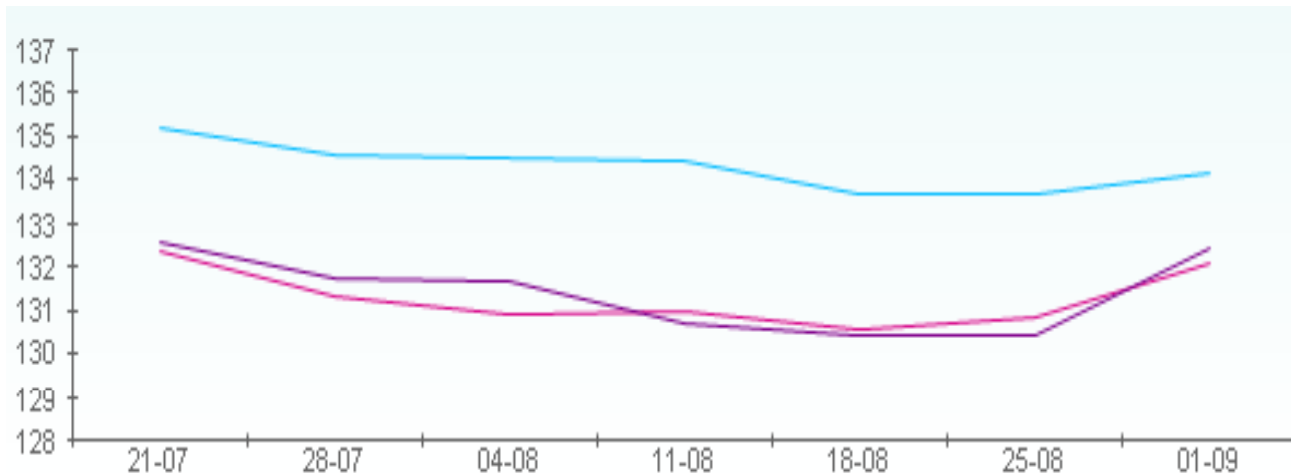


**Stack of Green Logs**



- Feedstock cost
  - Cost of wood waste or agricultural waste
  - Cost to grow dedicated energy crop
- Pelletizing cost
  - Capital equipment to build pellet mill
  - Electricity cost– largest single cost
  - Labor
- Transportation to port & port charges
  - Pellet mill should be close to port, but similar cost to coal
- Ocean transport
  - Expensive, but similar to coal
  - Cost depends on distance

- **ENDEX INDUSTRIAL WOOD PELLETS PRICING**



- Wood pellet price is €132/mt = \$186/mt delivered at Rotterdam October 2011
- Energy basis €7.6/GJ = \$10.75/GJ @17.3GJ/mt

# Giant King Grass -4m Tall



- Both wood pellets and agricultural pellets are more environmentally friendly than coal
- Wood pellets are technically superior, but there is not enough wood to meet demand
- Agricultural pellets are the best alternative
- Dedicated sustainably grown energy crop pellets such as Giant King Grass have significant advantages
  - Will use Giant King Grass as an example. Physical properties are very similar to miscanthus etc.



- Wood pellets have about 10% higher energy density compared to agricultural pellets
  - Not an issue. Price is based on energy content
- Agricultural pellets have more ash than wood
  - Not an issue if replacing coal which has even more ash, but can be a problem with residential stoves that were designed for wood pellets
- Agricultural ash has a lower melting temperature than wood ash
  - Not an issue in industrial applications with 20% cofiring with coal. Slagging and deposits may occur in certain high temperature boilers that use 100% agricultural biomass. Proper combustor and boiler design solves this problem.

- Agricultural straw pellets have higher chlorine
  - This is not an issue when cofiring with coal because the aluminum silicates in coal neutralize the effect of the chlorine. Chlorine related corrosion is an issue with simple substitution for wood in existing boilers. Proper boiler design solves this issue.
- Straw pellets have higher nitrogen and sulfur emissions than wood but both are lower than coal and meet European emission standards

- Pellet demand is rising quickly
- Wood pellets are the best alternative to coal, but supply is limited
- As pellet demand increases, agricultural pellets, especially pellets from dedicated, sustainably grown energy crops will be in great demand
- Long-term contracts for dedicated energy crop pellets will be attractive for customers
- Giant King Grass pellets will be the lowest cost because of high yield, year round production and simple logistics due to co-location

# Cellulosic Biofuels, Biochemicals and Bioplastics Applications of Giant King Grass





# Cellulosic Biofuels, Biochemicals & Bio Plastics



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- 1<sup>st</sup> generation bio ethanol is made from sugar cane, corn or recently cassava
  - Making fuel from food is being restricted or prohibited
- 2<sup>nd</sup> 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<sup>nd</sup> 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 for Fermentation-Based Biorefinery



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<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

Notes and references:

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

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 tests by 3 independent companies.**

**Giant King Grass has essentially the same composition as corn Stover and miscanthus per dry ton**

# Compare Giant King Grass Yield to Corn & Miscanthus



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Yield Dry Matter	Giant King Grass	Corn Stover	Miscanthus
US ton/acre	44	3.5-4.7	14-18
Metric ton/ha	100	8.6-11.6	30-40

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

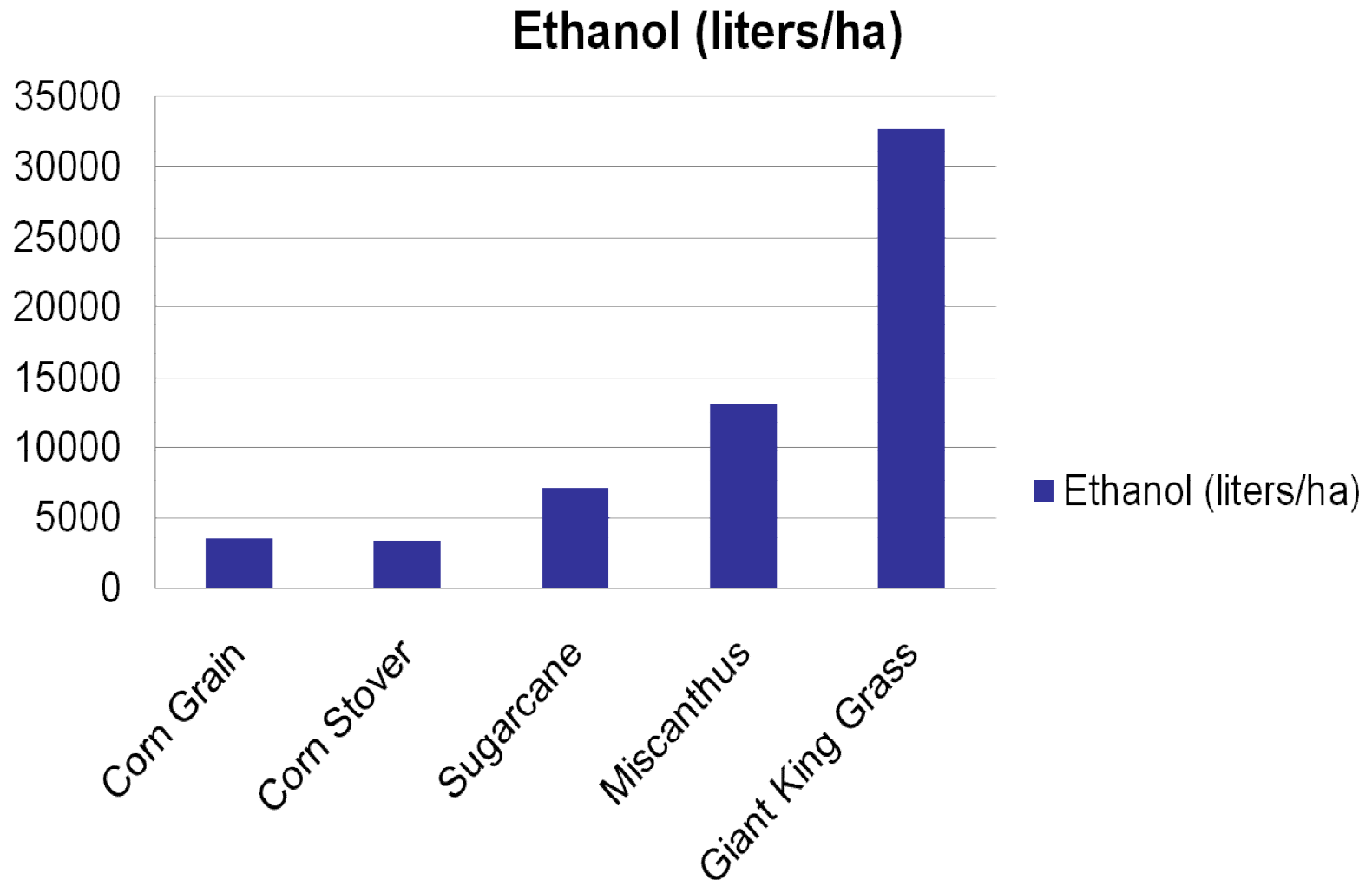
- Corn will grow in cold areas, whereas Giant King Grass cannot tolerate freezing temperatures
- Corn is an annual crop and must be planted every year which causes additional expense. The annual planting also has issues for soil erosion, soil organic matter and some of the corn and wheat must be left 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 per Hectare



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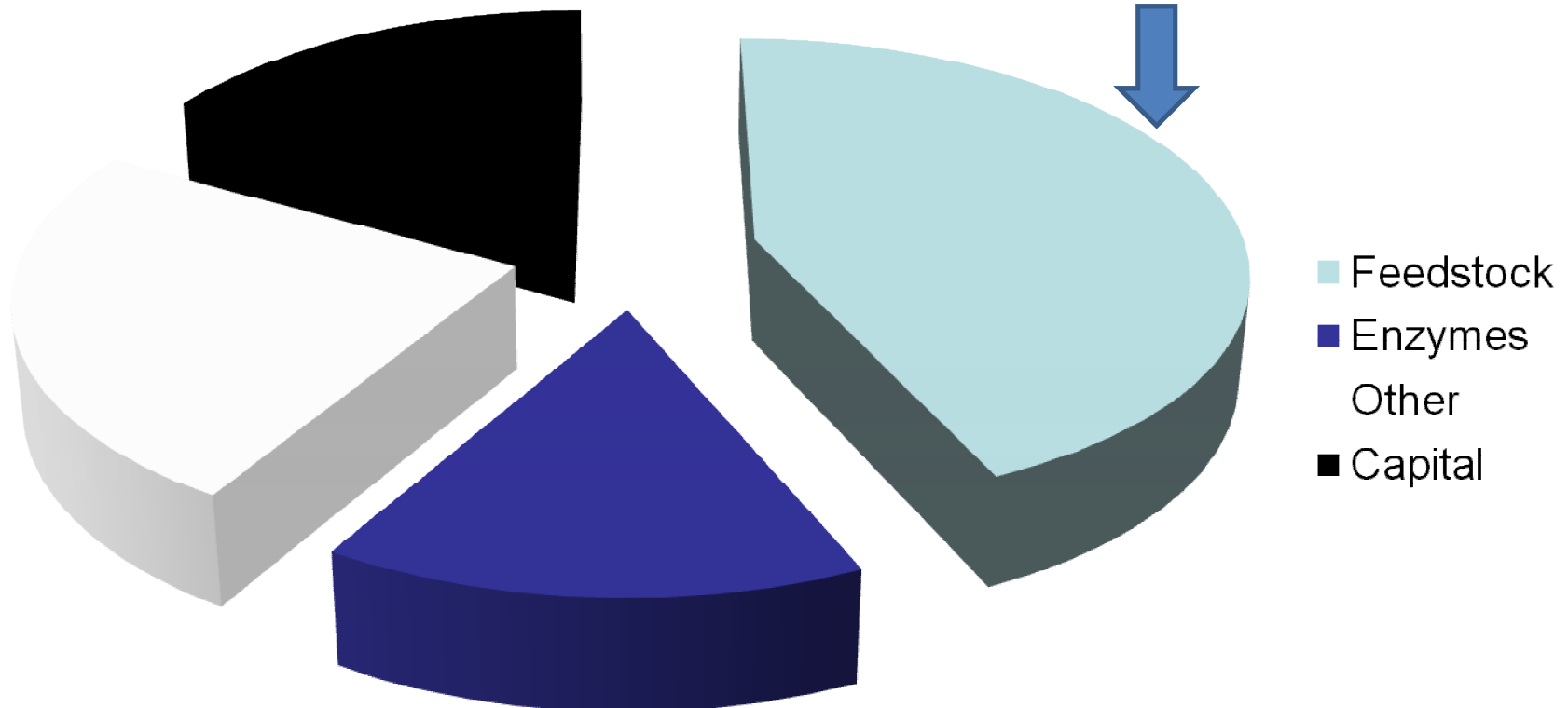


# Feedstock is the Largest Cost of Cellulosic Ethanol



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



- 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

- 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

# Advantages of Giant King Grass



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- “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 works on integrated plantation and bioenergy, pellet or biorefinery projects
  - 90 MW biomass power plant in Thailand
  - Plantation & pellet mill in Dominican Republic
- VIASPACE is seeking quality project opportunities
- VIASPACE will work with project developer or act as project developer
- Potential R&D collaborations
- Giant King Grass samples available

# Thank You



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# Dr. Carl Kukkonen

## CEO Biography



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**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 automotive fuel
- Research in Physics Department

**1975-1977 Purdue University postdoctoral fellow**

**1968-1975 Cornell University MS & PhD in theoretical physics**

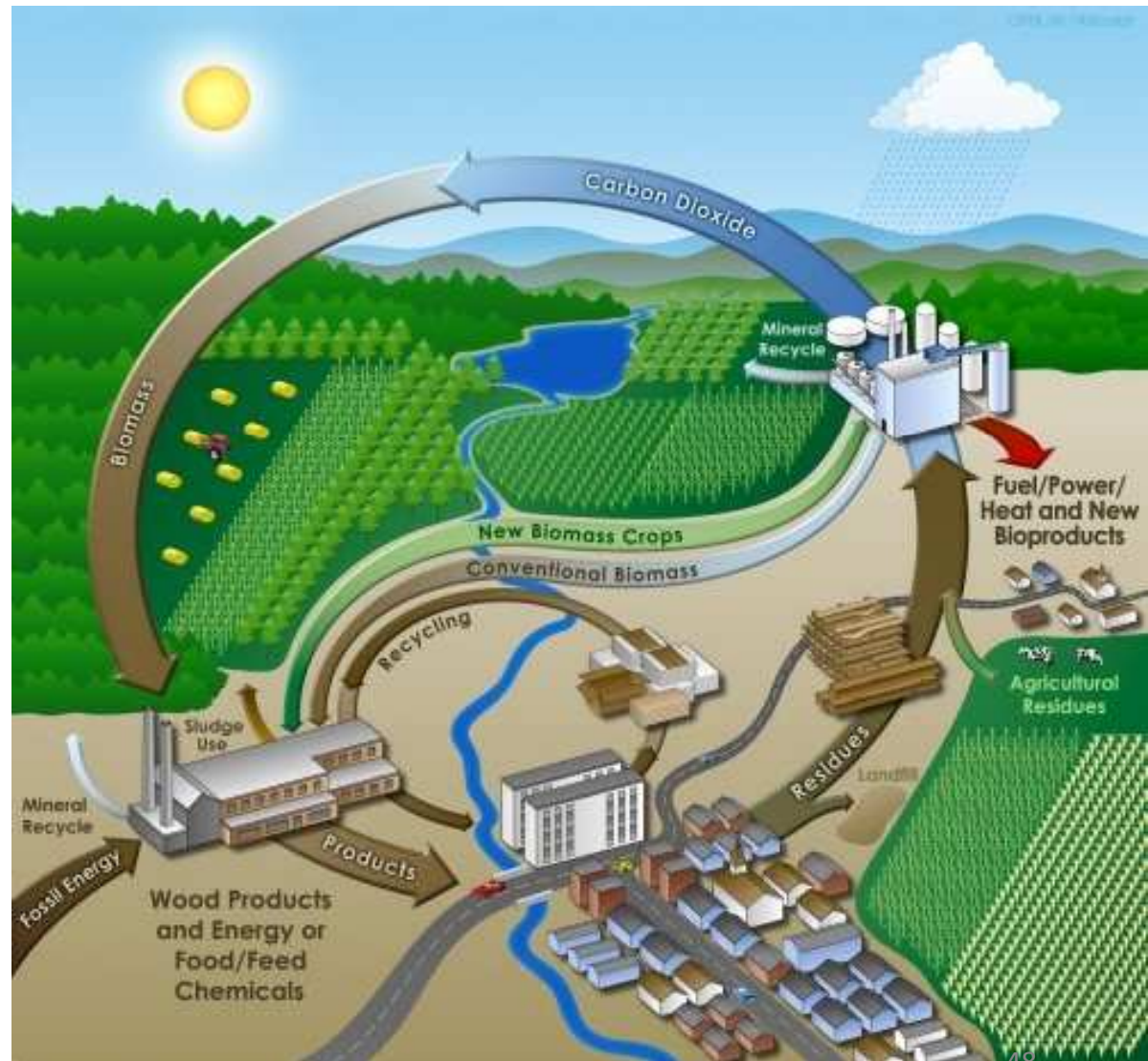
**1966-1968 University of California Davis BS physics**



# Biomass is Low Carbon Fuel

## Plants Breathe CO<sub>2</sub>

- Plants use sunlight & CO<sub>2</sub> to grow. Carbon is stored in the plant
- Burning biomass or biofuels simply recycles the CO<sub>2</sub> stored in the plant
  - Time can be 6 mos - grass to 20 yrs-trees
- Biomass is carbon neutral except from
  - Fertilizer, harvesting, & delivery





# Compare Biomass Costs to Fossil Fuel



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<b>Coal US price</b>	27GJ /mt	\$60 /mt	<b>\$2.22 /GJ</b>
<b>Coal Europe</b>	27GJ /mt	\$100 /mt	<b>\$3.70 /GJ</b>
<b>Oil</b>	6.1GJ /barrel	\$90 /barrel	<b>\$14.45 /GJ</b>
<b>Nat. Gas</b>		\$5.00 /Mbtu	<b>\$5.27 /GJ</b>
<b>Bio- mass</b>	18.4 GJ/mt	\$42 /mt <small>China</small>	<b>\$2.28 /GJ</b>

- Coal is cheapest fuel
  - Most electricity is from coal
  - But most carbon dioxide and other pollutants
- Biomass is next cheapest
  - With near zero net carbon dioxide emissions
  - Generate electricity and produce cellulosic biofuels
- Natural gas is next
  - Cleanest fossil fuel
- Oil is most expensive

Gigajoule=278 kilowatt-hr

mt=metric ton=tonne=2204 lb

Biomass is dry mt and HHV

# Why Biomass Pellets ?

- Biomass is renewable, sustainable & carbon neutral
  - much lower CO<sub>2</sub> emissions compared to coal
- However biomass is very bulky and difficult to ship over long distances— think of a bale of hay
- Pellets are densified biomass
  - Dried, ground into a powder and squeezed into a pellet, which is easy to ship in bulk--like grain
- Most importantly, biomass pellets can be substituted for up to 20% of coal in existing power plants (with only minor modifications) thus reducing emissions while preserving the hundreds of millions of dollars in power plant capital investment

- Biogas (methane and carbon dioxide) is produced through anaerobic digestion (bio digestion) of Giant King Grass
  - with organic fertilizer as valuable byproduct
- The biogas is burned in an engine generator set to generate clean electricity
  - With heat as valuable byproduct
- Biogas electricity is widely used in Europe
  - 4000 biogas power plants in Germany alone

# Biogas from Giant King Grass



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*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*

- 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
  - Can be put back on grass fields
  - Biogas is the greenest option
- Bio-methane is the "green" energy equivalent of methane, the principal component of natural gas
- Biogas can also be upgraded to pure methane and inserted into the existing natural gas pipelines
- Giant King Grass has been independently tested for biogas yield and the results are excellent<sup>52</sup>



# Biogas to 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*<sub>53</sub>

- Solar Photovoltaic cells directly convert sunlight into electricity without heat
  - Fuel is free, but equipment cost is highest
  - Only 5.3 hours per day of production
  - Low operations and maintenance, but few jobs created
  - No good electricity storage options for nights and cloudy days—cannot provide base 24/7 power
  - Electricity price is 3-4 times coal electricity
    - Battery storage doubles the price
- Solar Thermal—Mirrors collect and focus light like a magnifying glass
  - Equipment is less, but electricity is 2-3 times coal

- Wind
  - Wind is free but not dependable
  - Equipment cost is half of solar, but 1.5 times coal
  - Average utilization is 34%--8 hours/day
  - Must be located in windy area and transmission lines to user can be difficult—can be offshore
  - Low operations & maintenance, but few jobs
  - No way to store the electricity—not base power
  - Electricity cost is 1.5 times coal



- Biomass Electricity

- Fuel is not free. Same or 20% higher than coal
- Equipment is similar to coal plant—20% more
- Operates 24 hours per day and provides base power
- Growing the fuel provides jobs for farmers
- Operating power plant provides jobs
- Lower equipment cost and higher utilization more than compensates for fuel cost
- Biomass electricity cost is 30% of solar photovoltaic, 45% of solar thermal, less than wind and provides base power
- Biomass electricity is 20% more than coal
- If cost is the only driver, coal is cheaper



# Solar, Wind, Biomass & Coal



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	Capital Cost (\$M/MW)	Utilization (% )	Fuel Cost (\$/kwhe)	Electricity Price \$/kwhe	Comment
Solar Photovoltaic	3-5	22	0	0.30-.40	Day only
Thermal	3-4	31	0	0.20-.26	Needs grid back-up
Wind	1.5	34	0	0.10-.15	Windy only Needs grid back-up
Biomass	1.4	83	0.025	0.09	24 hr/day
Coal	1.2	85	0.024	0.08	24 hr.day

Low carbon biomass electricity is only slightly more expensive than coal. Biomass can be used as base power. Solar and wind are more expensive and only provide transient power. Battery storage will dramatically increase the cost of solar and wind. Electricity from oil is about \$0.20-.25/kwh.