

Giant King Grass— Dedicated Crop for Bioenergy & Biofuels



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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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

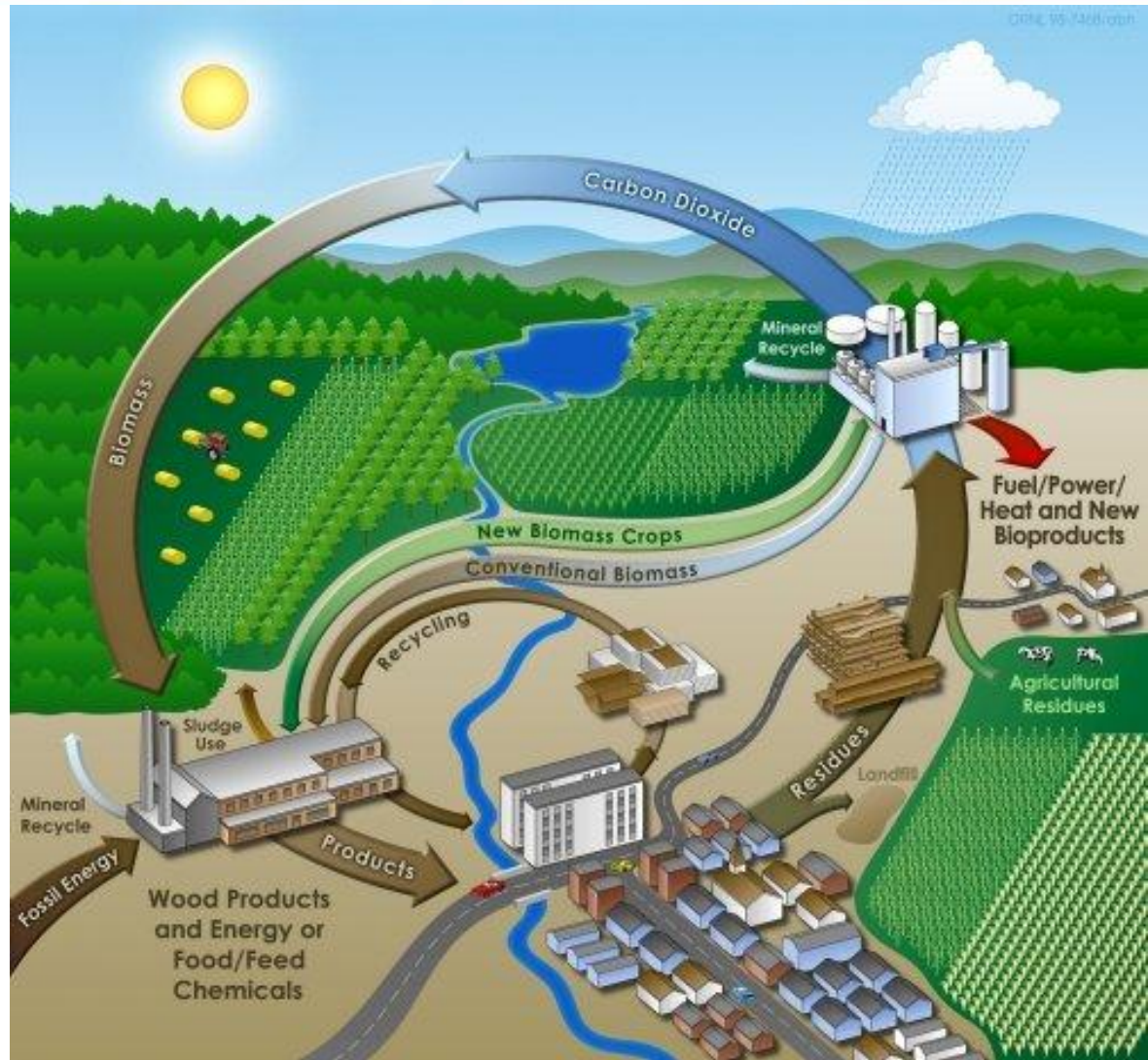
1968-1975 Cornell University MS & PhD in theoretical physics

1966-1968 University of California Davis BS physics



Biomass is Low Carbon Fuel

- Biomass energy is solar energy & CO₂ captured in plants by photosynthesis
- Burning biomass or biofuels simply recycles the CO₂ stored in the plant
- Biomass is carbon neutral except
 - Fertilizer, harvesting, & delivery contribute some carbon dioxide



- 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
- In the future, biomass can produce liquid biofuels, biochemicals and biomaterials
- Little market for biomass (except corn) now in US
- Focus on developing world

Compare Biomass Costs to Fossil Fuel



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

- 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

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 operating in the world

- Food versus fuel
 - Most countries have restricted or prohibited the use of food for fuel
 - Corn & palm oil are examples
 - Displacing food land will be restricted
- Is there enough land for biomass?
 - FAO (UN) reports that that “250-800 M ha of additional agricultural land could be brought into production without encroaching upon areas of high ecological or social value”
 - 80M ha of Giant King Grass with its high yield could replace all coal in the world—9% size of US

- Size
 - Coal/natural gas/nuclear~1000MW
 - Large 100% biomass ~30MW
 - Need 33 biomass power plants to replace 1000MW
 - Biomass power plants—distributed generation
- Environmental
 - Biomass has much lower CO₂ emissions and lower NOX, SO₂, HCL, Hg and As emissions than coal
 - Sustainable growth will be required
 - Do not cut down the rainforest

Note: Most general observations apply to all perennial grasses such as switchgrass, Miscanthus and elephant grass. High yield and resulting low cost of Giant King Grass allows bioenergy projects with good financial returns.

VIASPACE Giant King Grass



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Giant King Grass

- 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



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> -- <u>Reed Canary Grass</u>	2.0 – 3.6	4.5-8.1
<u>Panicum</u> -- <u>Switchgrass</u>	5-9	11-20
<u>Miscanthus</u> -- <u>Miscanthus x 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

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
- Pyrolysis to bio oil
- Catalytic conversion to bio diesel
- Biochemicals and bio plastics
- High-temperature gasification
- Torrefaction to bio coal
- Pulp for paper and textiles

Applications that are commercial today with other feedstock

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

Giant King Grass to Produce Clean Electricity



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- Direct combustion--Burn Giant King Grass in a boiler to produce high pressure steam which turns a generator to make electricity
 - 100% biomass--sizes from 10 – 35 MW
 - Co-fire pellets with coal in existing power plant
- Anaerobic Bio digestion of Giant King Grass to produce biogas which is burned in an engine which turns a generator
 - Sizes from 0.5 – 3.0 MW
 - Thousands of bio digesters in Europe
- High-temp gasification & engine/generator

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

Feedstock
Production

Feedstock
Handling
& Management

Boiler and
Power Plant
Design

Boiler
Manufacturing

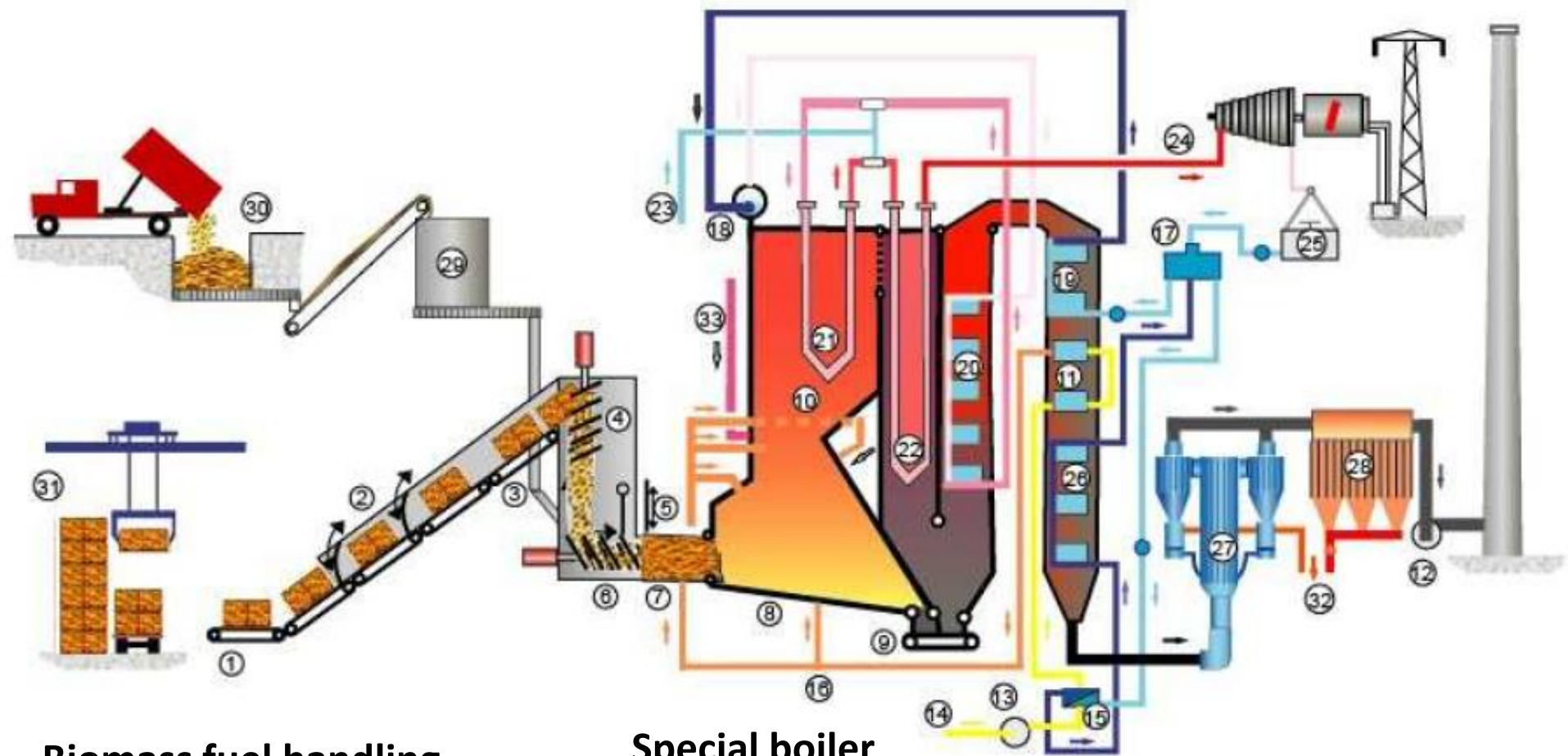
Power Plant
Construction

Power
Generation
& CER
Business

Transmission

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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Proximate Analysis	Unit	Sun Dried As Received	Giant King Grass Bone Dry
Total Moisture	%	14	0
Volatile Matter	%	65.68	76.37
Ash	%	3.59	4.17
Fixed Carbon	%	16.74	19.46
Total Sulfur	%	0.11	0.13
HHV	MJ/Kg	15.85	18.43
LHV	MJ/Kg	14.52	-

Biomass Power Plant Uses Agricultural Waste Today



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Biomass Power Plant



Giant King Grass Pellets as Coal Replacement



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- 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



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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



국립산림과학원
KOREA FOREST RESEARCH INSTITUTE

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



- 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

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*₃₁

Bio-Methane Yield/ Hectare of Land



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- 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

Cellulosic Biofuels, Biochemicals and Bioplastics Applications of Giant King Grass



Cellulosic Biofuels, Biochemicals & Bio Plastics



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- 1st generation bio ethanol is made from sugar cane, corn or recently cassava
 - Making fuel from food is being restricted or prohibited
- 2nd 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
- 2nd 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.

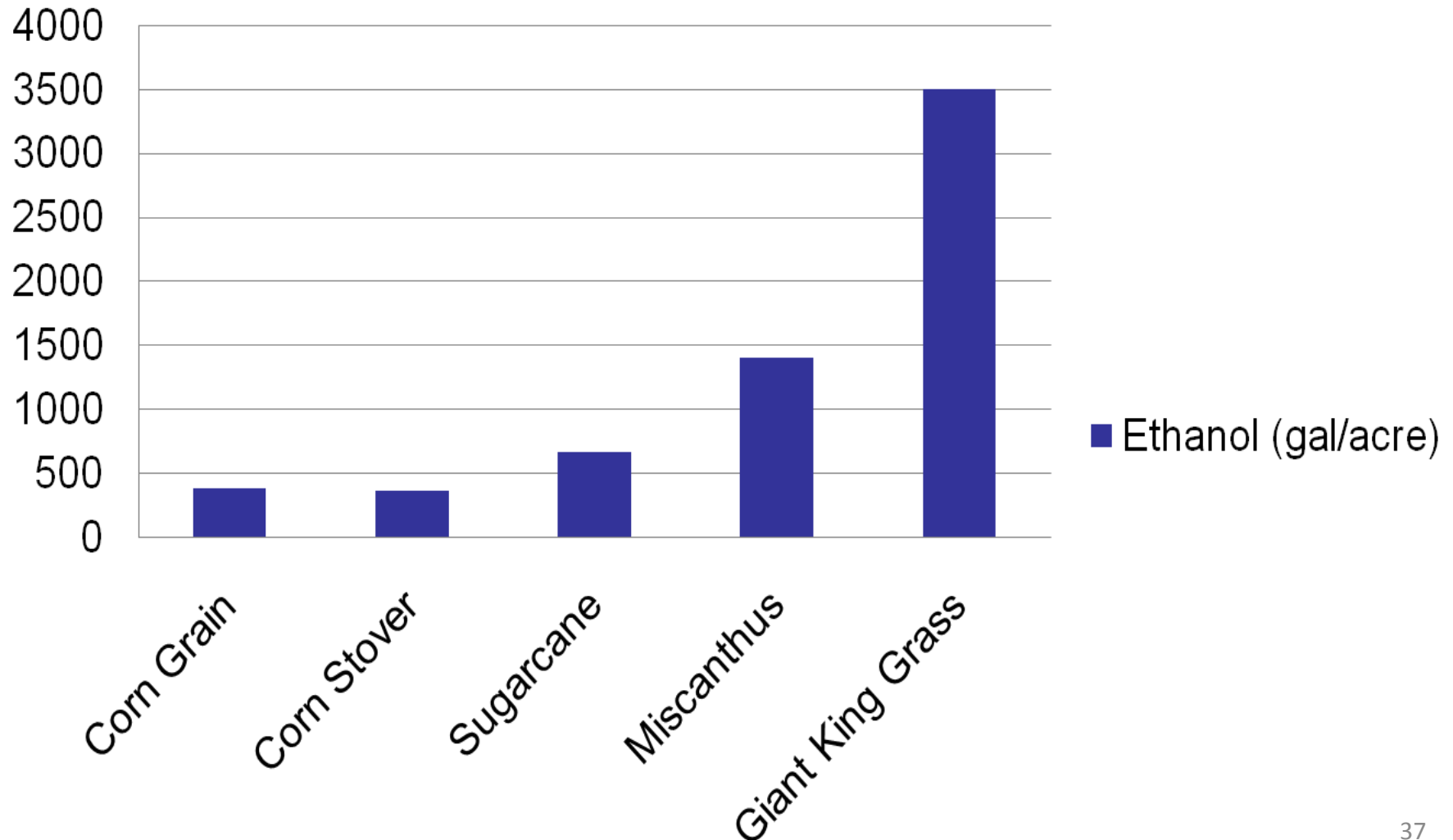
Land-Use Efficiency

Ethanol per Acre



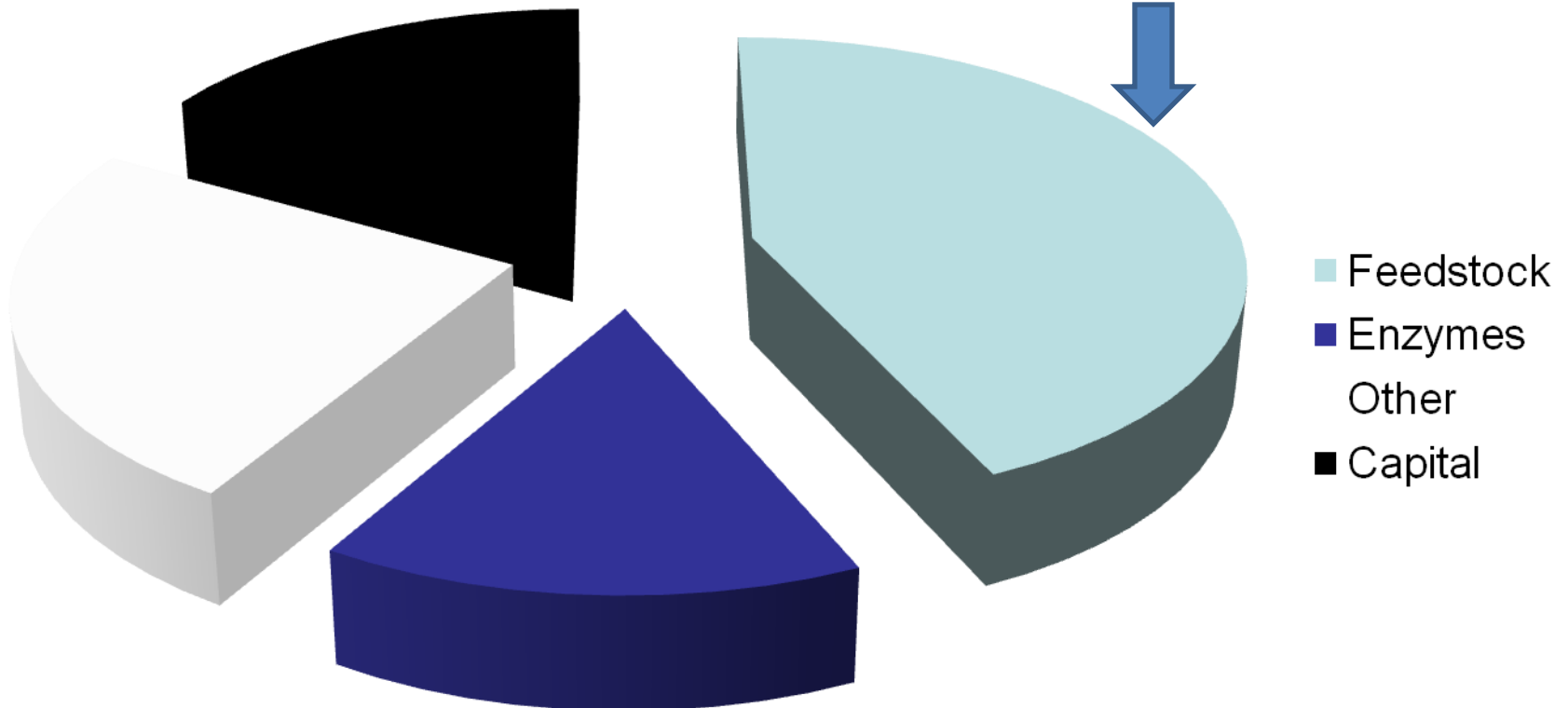
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Ethanol (gal/acre)



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**



- 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 generation. 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 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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