Perennial Grass as a Dedicated Energy Crop

VIASPACE Clean Energy for a Cleaner Tomorrow

For Electricity Generation and Cellulosic Biofuels

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11th International Conference on Clean Energy
Nov 2nd-5th 2011
Taichung, Taiwan

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  - VIASPACE stock symbol VSPC.OB

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Biomass is Low Carbon Fuel

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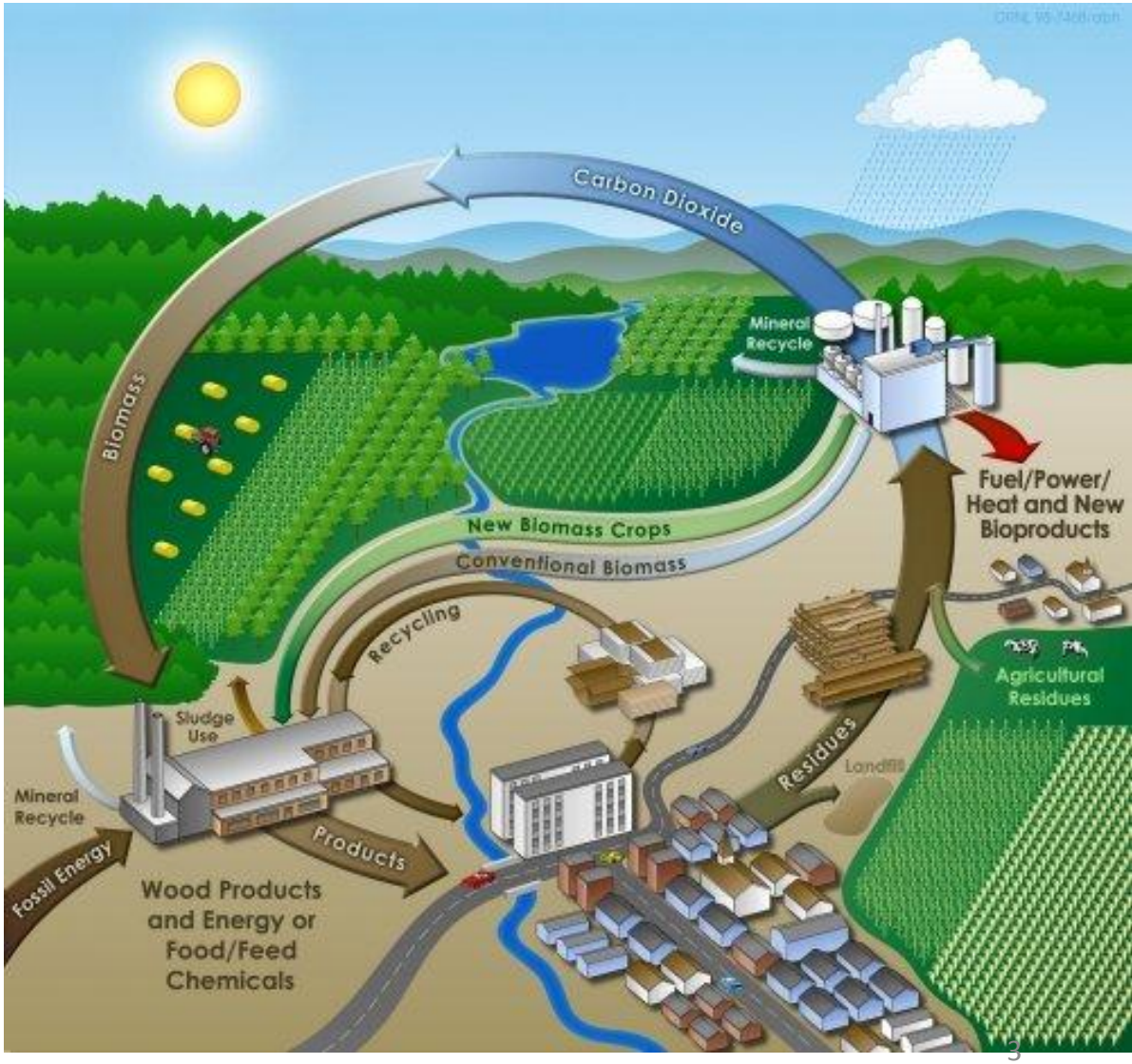
- Biomass energy is solar energy & CO_2 captured in plants by photosynthesis
- Burning biomass or biofuels simply recycles the CO_2 stored in the plant
- Biomass is carbon neutral except
  - Fertilizer, harvesting, & delivery contribute some carbon dioxide



VIASPACE Giant King Grass

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Advantages of Biomass

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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 and cannot provide base power
  - Less expensive than solar and wind
- Low carbon– nearly carbon neutral
- In the future, can produce liquid biofuels, biochemicals and biomaterials

Agricultural Waste or Dedicated Energy Crops

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- Current biomass fuels and feedstock are agricultural waste such as corn straw, wheat straw & rice straw, or forestry and wood waste
  - Wastes from food crops are seasonal and generally not available on long-term contracts
    - Spot market only- price and availability is unpredictable
    - Not enough waste products to meet demand
- Dedicated energy crops are grown entirely for energy use and not tied to a food harvest
  - Sustainably grown under long-term contracts which is important for project financing

Dedicated Energy Crops --Examples

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- Jatropha, oil palm and other oily plants
  - Jatropha has not been successful so far
  - Palm oil has food uses
- Specialty trees used in pulp and paper industry
- Algae—lots of R&D, but not near-term
- Perennial grasses
  - Switchgrass, Arundo Donax & Miscanthus for temperate areas
  - Giant King Grass, elephant grass and others for tropical and subtropical regions
    - Will use Giant King Grass as concrete example

Giant King Grass

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- 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
- Fertilizer use is modest
- No pesticide

Applications of Giant King Grass

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- 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 coversion 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

Two Simple Options 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
  - Sizes from 10 – 35 MW
  - Similar to coal-fired power plants
- 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

Direct Combustion Biomass Power Plant

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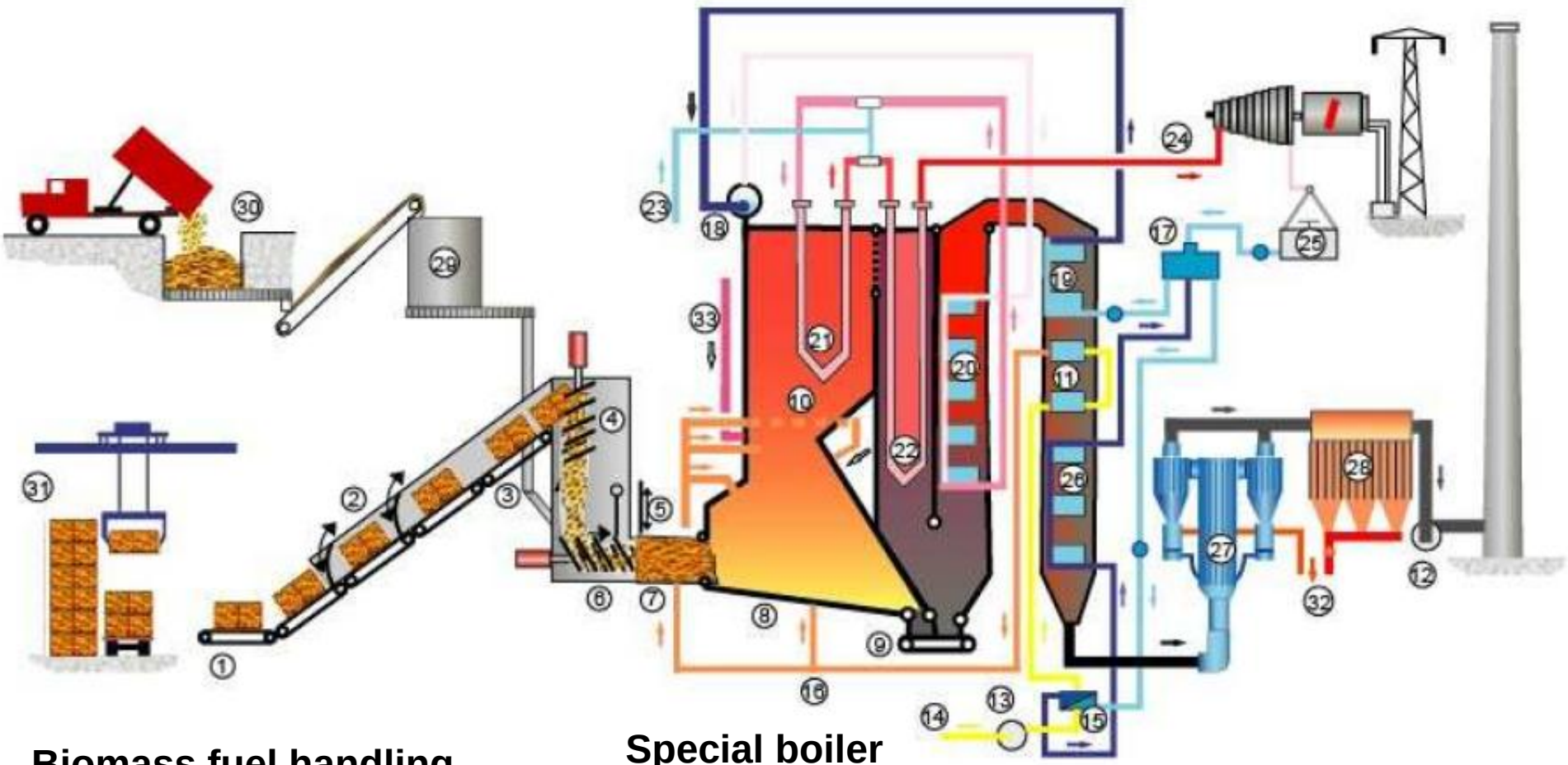

Biomass fuel handling

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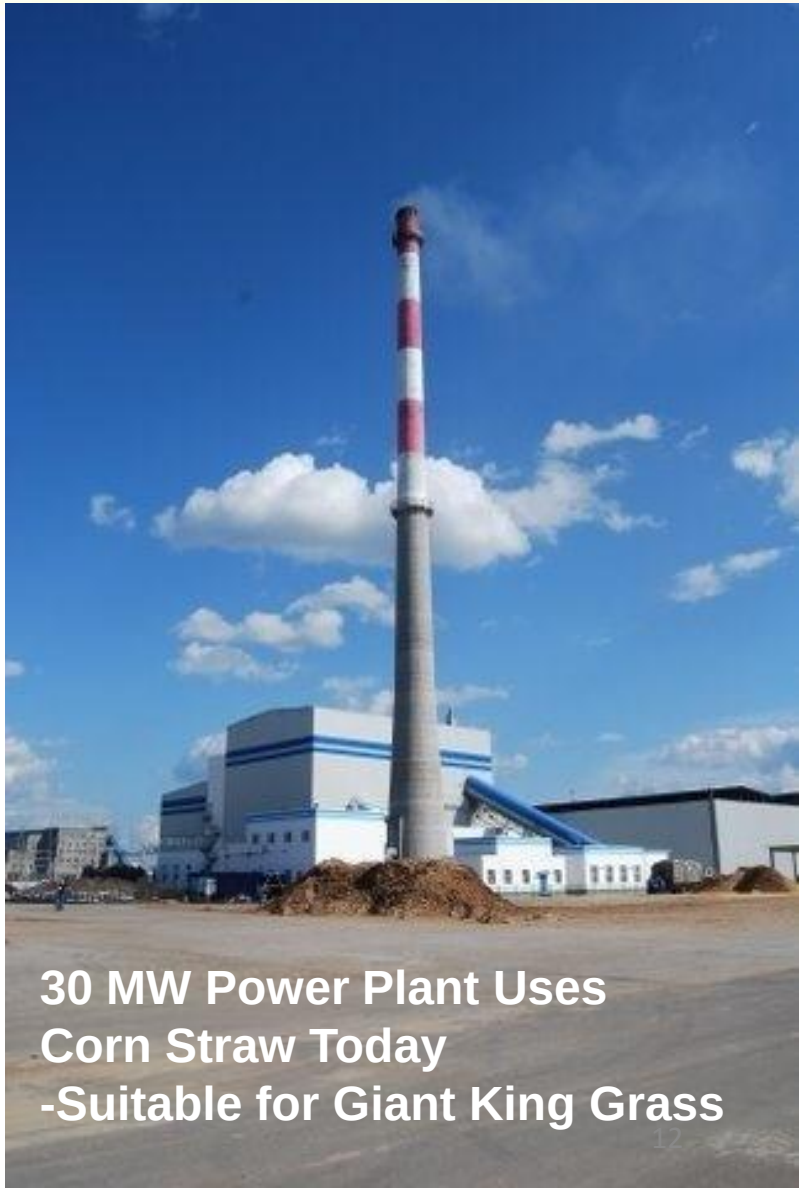
- Giant King Grass has excellent energy content of 18.4 MJ (megajoule) per dry kilogram HHV equivalent to 4400 kcal/kg, 7900 btu/lb
- Burn in a power plant instead of coal or oil
- Giant King Grass properties similar to corn & wheat straw
- 30 MW power plant requires 1600 ha of Giant King Grass



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	-

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 power plant
  - Requires small modification
  - Dry grass & press into pellets
- Preserves existing power plant investment & meets carbon reduction targets
- Large global demand
  - Particularly in Europe
  - Korea, China, Japan emerging

Test Data on Giant King Grass

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- Giant King Grass pellets have been tested by several independent laboratories

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	

SGS

KFRI

국립산림과학원
KOREA FOREST RESEARCH INSTITUTE

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 Hammermill

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Biogas Electricity

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- 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

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- 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

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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Composition Dry Weight %	Giant King Grass	Corn Stover	Miscanthus
Glucan	43.0	37.4	44
Xylan	22.3	21.1	22
Arabinan	2.9	2.9	2
Lignin	17.4	18.0	17
Ash	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.

Sugar Data & Projected Ethanol Yield (L/tonne)

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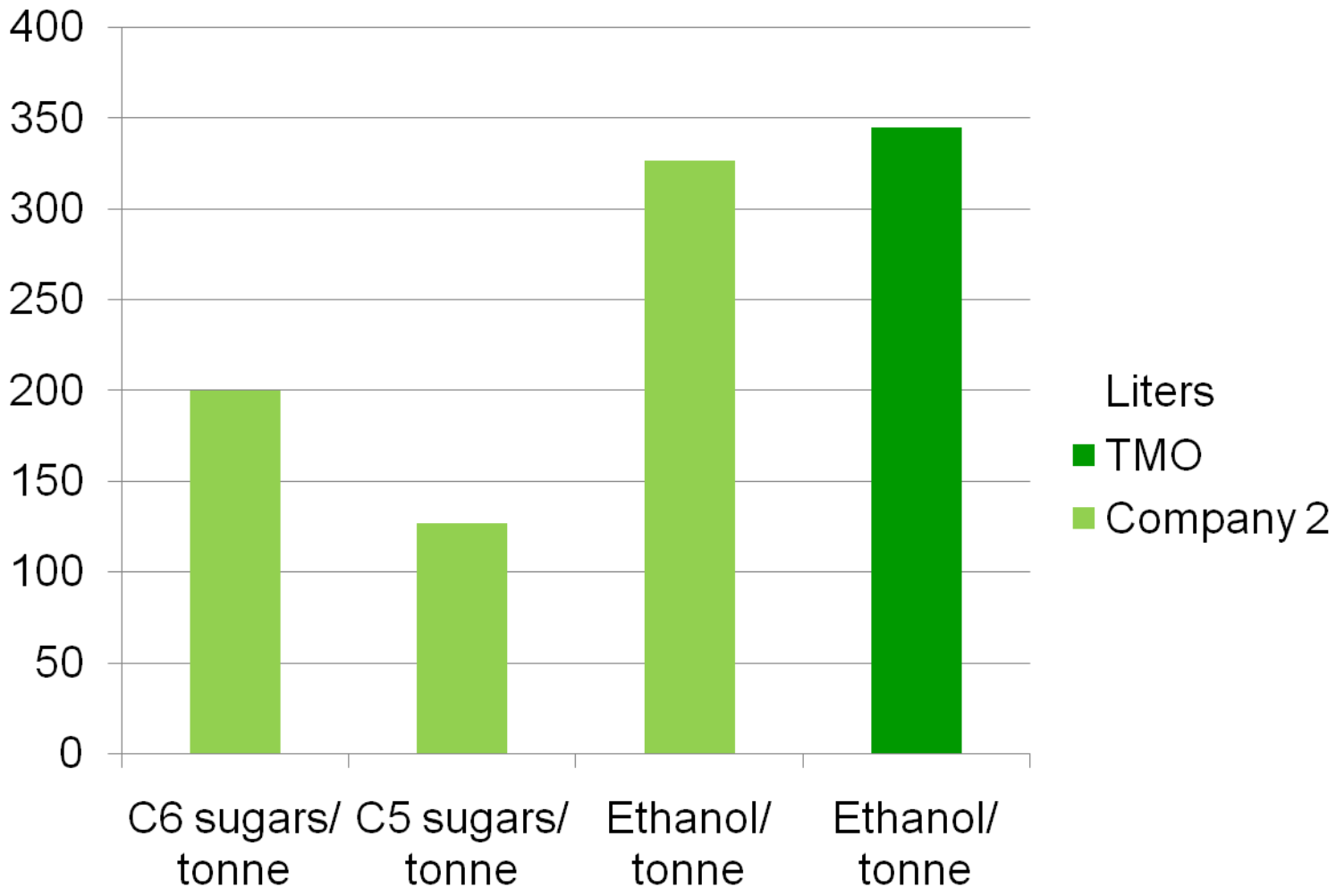

Land-Use Efficiency
How Many Liters/Hectare

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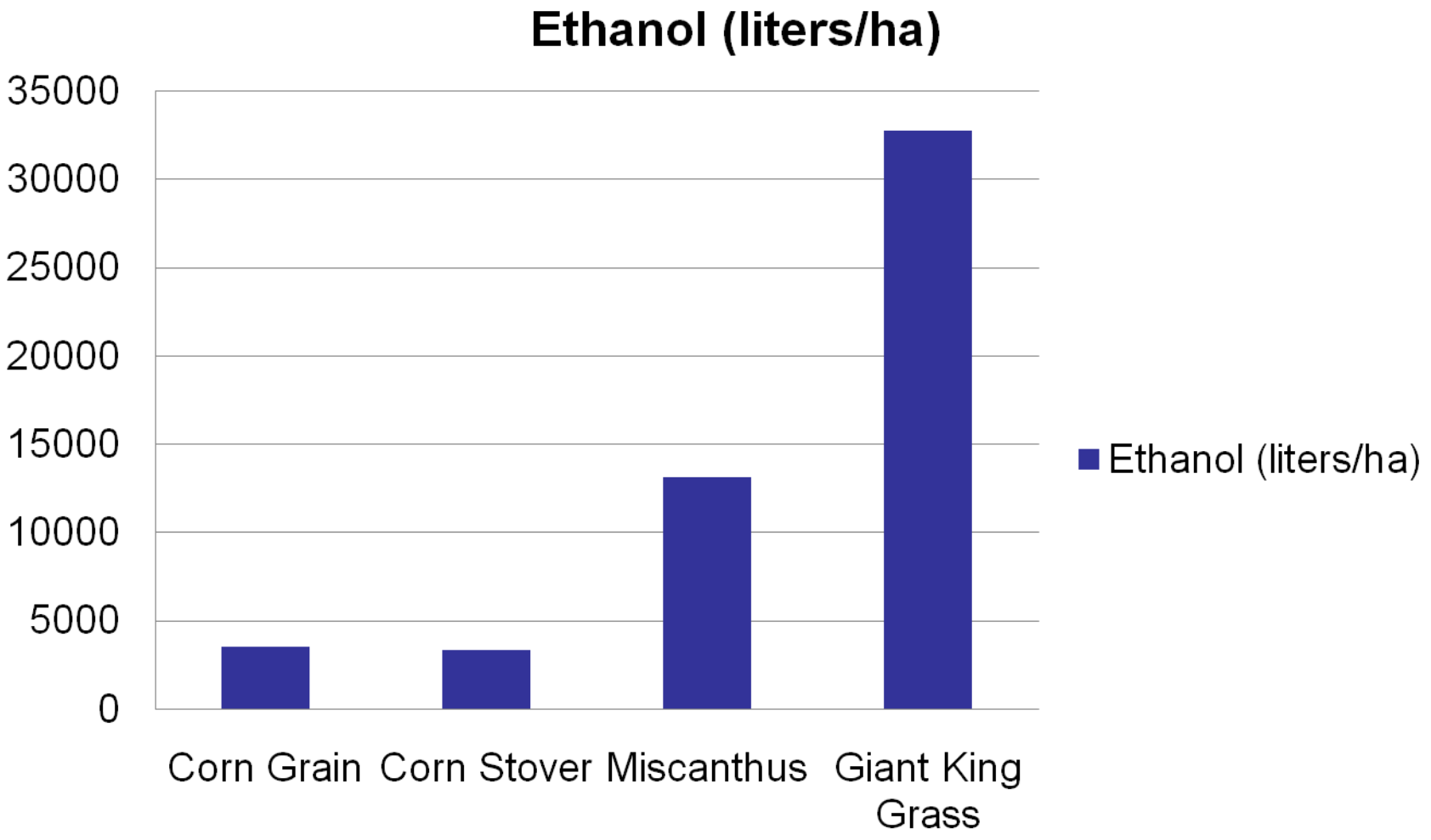

Feedstock is the Largest Cost of Cellulosic Ethanol

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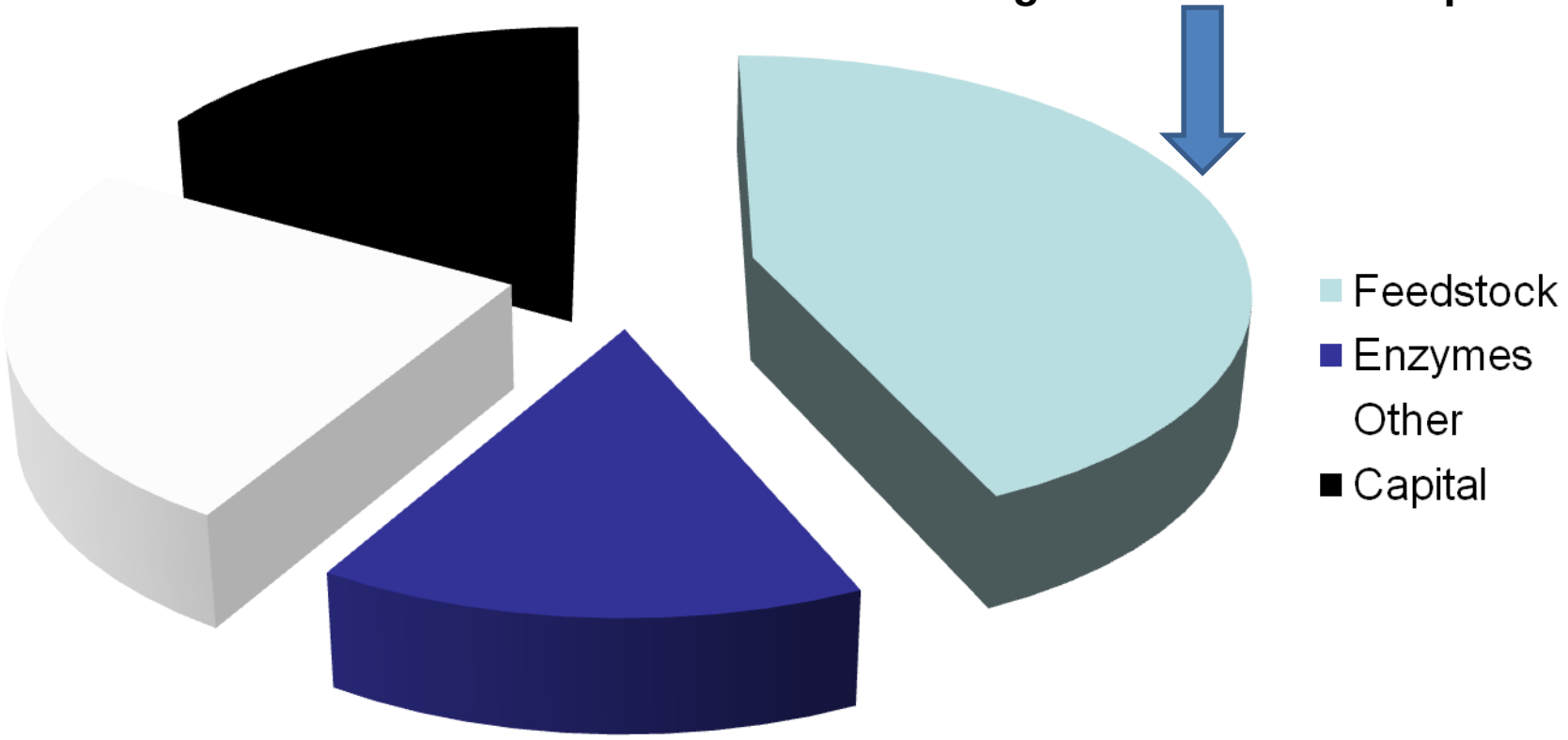
Giant King Grass and co-location can reduce feedstock cost by 40-50% making cellulosic ethanol profitable



Giant King Grass & Biorefinery

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- 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--Scalable & Sustainable Development

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- 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

Summary

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- Perrenial grasses such as switchgrass, miscanthus and Giant King Grass are versatile fuels and feedstock for electricity generation and biofuels production
- Because of its high yield, Giant King Grass is the lowest cost fuel or feedstock
- Co-location of power plant or biorefinery with Giant King Grass plantation greatly simplifies logistics and further reduces cost

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 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