Dedicated Energy Crops for Bioenergy

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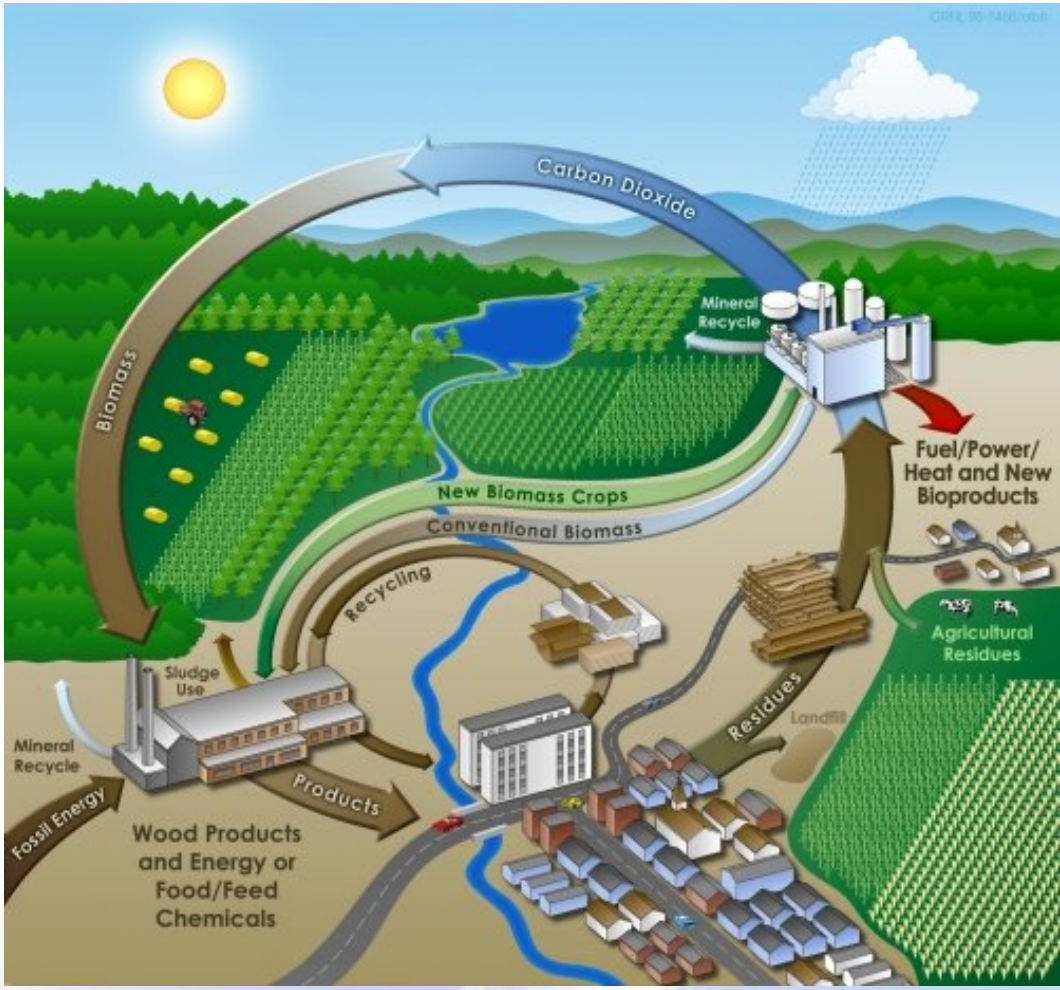
Why Biomass?

- Renewable energy source
- Can be locally grown and provide energy security—do not need to import fuel
- Low carbon– nearly carbon neutral
- Can generate electricity 24 hours per day
  - Solar and wind cannot provide base power
- Can produce liquid biofuels, chemicals, biomaterials through fermentation or syngas
- Less expensive than solar and wind

Biomass is Renewable & Low Carbon Fuel

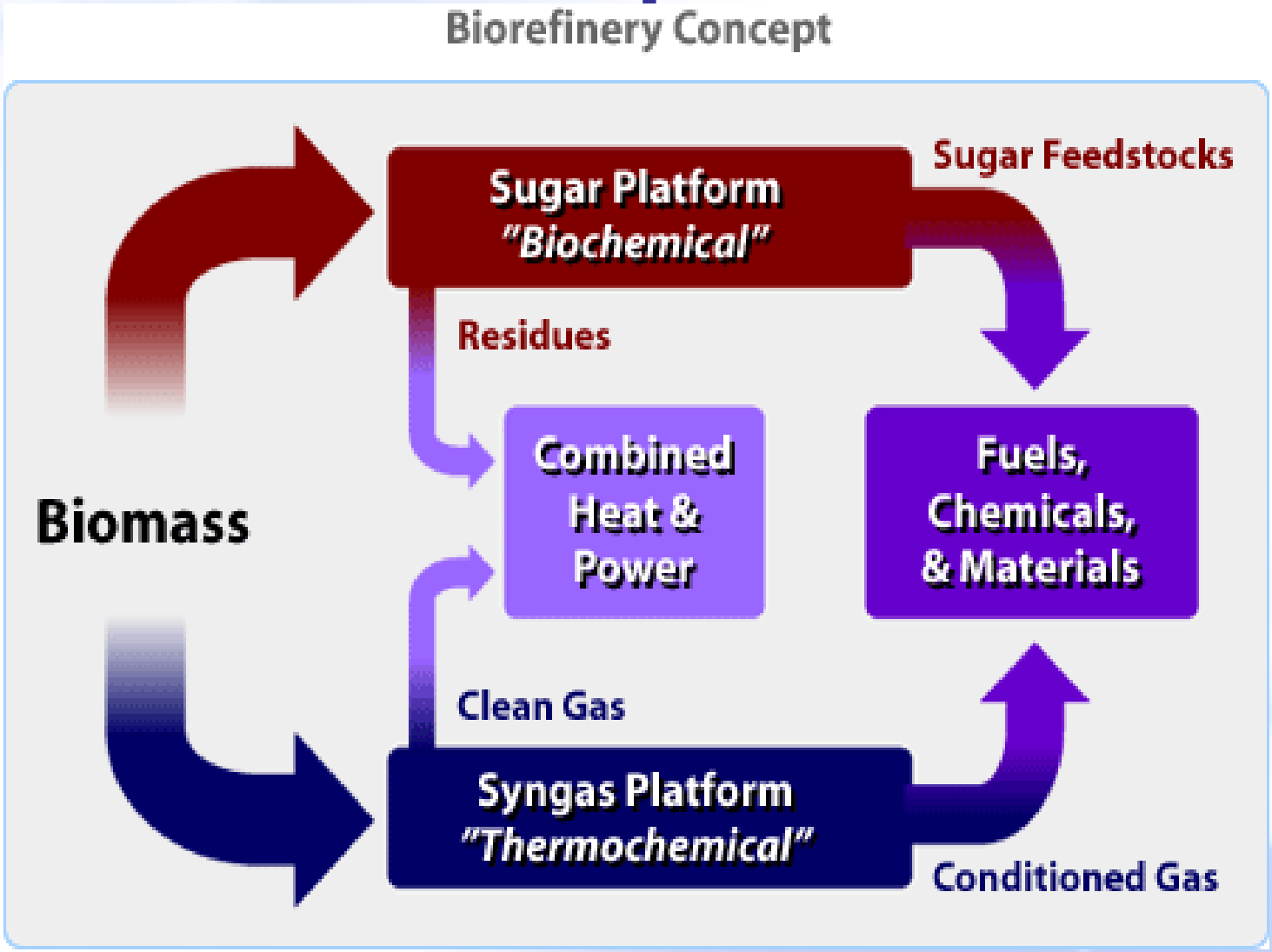
- Biomass energy is solar energy & CO2 captured in plants by photosynthesis
- Burning biomass or biofuels simply recycles the CO2 stored by the plant
- Carbon neutral except
  - Fertilizer, harvesting, & delivery contribute some carbon dioxide



Bioenergy and Biomass Feedstock

- Industry and universities are developing technologies for utilizing biomass for low carbon biofuels, electricity generation and to produce biochemicals and biomaterials
  - Most assume that the biomass will be readily available at reasonable price
  - Most plan to use agricultural and forestry waste
- Recent power plant experience shows that waste biomass has become expensive and scarce as demand has risen
- Dedicated non-food energy crops are needed

Biorefinery-Biomass Conversion Example



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
- Agricultural waste including corn Stover, wheat straw, rice husks to be burned in power plants to generate electricity
- Forestry & wood waste such as bark and sawdust for pellets and power plants
- 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
- 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 as a fuel & feedstock (in addition to 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 will be possible to obtain a reliable long-term source of fuel or feedstock at a known price
  - A 20 year feedstock agreement may be needed to obtain financing for the power or biofuel plant

Dedicated Energy Crops--Examples

- Jatropha, oil palm and other oily plants
  - Jatropha has not been successful so far
  - Palm oil has food uses
- Specialty trees similar to those used in the pulp and paper industry
- Algae—lots of R&D, but not near-term
- Perennial grasses
  - Switchgrass & miscanthus for temperate areas
  - Giant King Grass and others for tropical and subtropical regions

Giant King Grass

- Very high yield and therefore low-cost
  - 375 wet metric tons/hectare (167 t/acre) for biogas production (70% moisture when harvested)
  - Sun dry to 25% moisture to burn in a power plant reduces yield to is 125-180 mt/ha (56-80 t/acre)
  - 100–135 bone dry mt/ha (45-60 t/acre)
- Much higher yield than other crops
- Perennial in subtropical & tropical areas
  - Plant once, grows for many years
  - Annual crop in freezing areas

Applications of Giant King Grass and Other Biomass

Direct Combustion in Biomass Power Plant

- Giant King Grass has excellent energy content of 18.4 MJ (megajoule) per dry kilogram equivalent to
  - 5.1 kilowatt hours thermal/kg
  - 7900 BTU/pound
  - 4400 kcal/kilogram
- Properties similar to corn straw (stover)
- 1 kWh electrical requires 0.72 kg of Giant King Grass
  - 27% generation efficiency

30 MW Biomass Power Plant in China

- Corn straw and rice husks as fuel today
  - Large 50 km collection radius
  - 600+ metric tons fuel/day
  - 186,000 mt/year
  - Seasonal crops, must transport & store for months
- 1500 ha (3705 acre) if Giant King Grass
  - 2-3 km collection radius
  - Just in time harvesting simplifies logistics

Cut at 4m tall for burning

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 CAPEX & meets carbon reduction targets
- Large global demand
  - Particularly in Europe
  - Japan & Korea emerging
- Dedicated energy crops favored over waste

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

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

- Syngas to produce chemicals such as ammonia & liquid biofuels incl. methanol and gasoline & diesel via the Fisher Tropsch process

Giant King Grass for Bio-Methane

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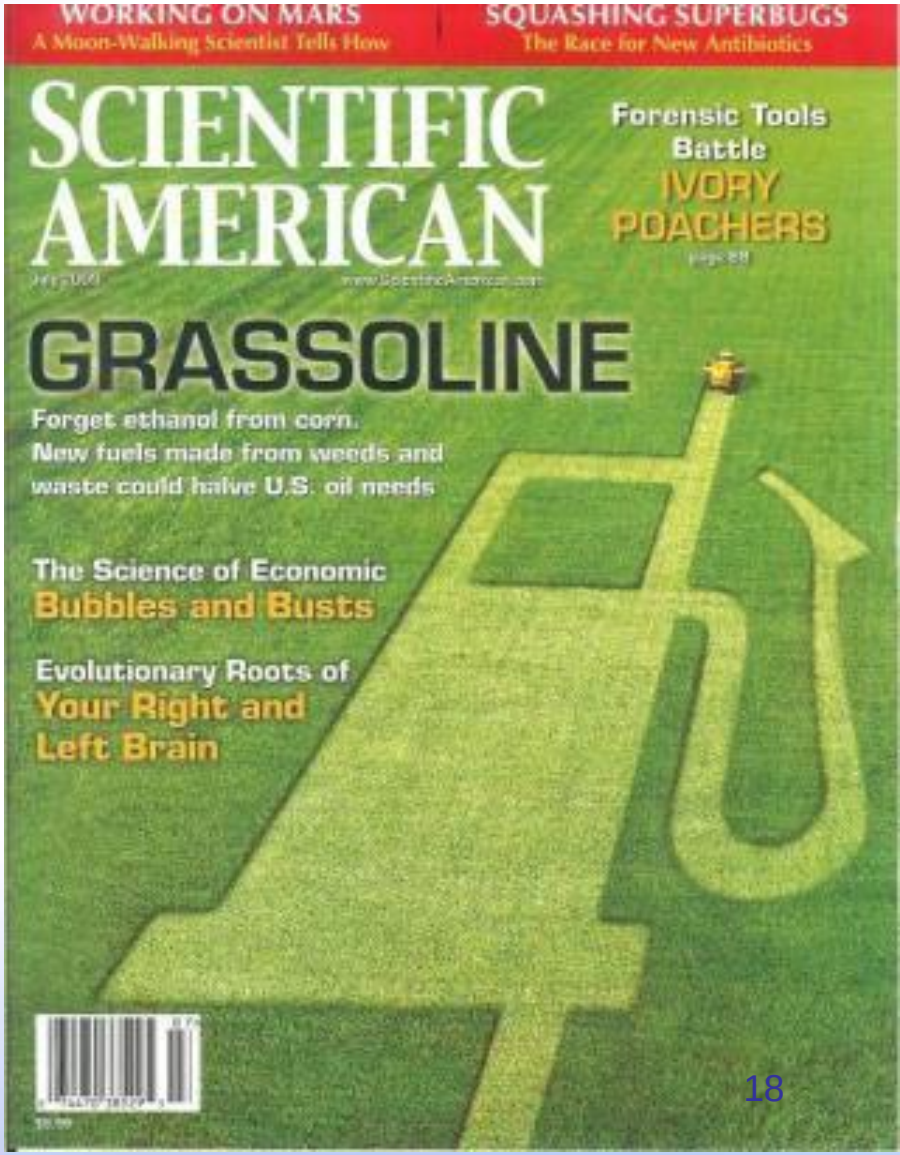
- Giant King Grass has very high bio-methane yield
  - 91 liters methane/kg fresh grass
  - 0.36 m^3/kg volatile solids
  - Compared to 0.22 for municipal solid waste, 0.21 for rice straw
  - Organic fertilizer is byproduct

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

Emerging Markets for Giant King Grass

- Grassoline, cellulosic liquid biofuels
- Biomass derived chemicals and bio plastics
- Torrefaction, pyrolysis, other densification
- Bio anhydrous ammonia as fertilizer



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

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	8835	945
Giant King Grass	100	35340	3785

Assumes 85 gallons ethanol per dry ton (353 l/mt) for cellulosic ethanol

Compare Energy Crops

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ENERGY CROP	YIELD (mt/ha)	ENERGY (MJ/kg)	PRICE ($US/mt)	ENERGY YIELD (GJ/ha)	CASH YIELD ($US/ha)
Switchgrass	25	17.9	50	448	1250
Miscanthus	39	17.9	50	698	1950
Jatropha	1.6-2.0	42	700	67-84	1120-1400
Palm Oil	3.5-5.0	42	700	147-210	2450-3500
Giant King Grass	100-135	18.4	50	1840-2484	5000-6750

Giant King Grass has highest mass, energy & financial yields

Grass yields are dry metric tons per hectare. Switchgrass and Miscanthus are grown in temperate regions. Giant King Grass is grown in tropical and subtropical regions with two or more harvests per year. Jatropha and Palm Oil are grown in tropical and subtropical regions. The grasses are suitable for direct combustion, bio-methane production and cellulosic biofuels such as ethanol. Jatropha and Palm Oil are used for bio-diesel. Comparison is illustrative only. All of these biomass crops are needed. **1 hectare=2.47 acres; 1 mt/ha=0.445 ton/acre**

Planting in Southern China

Giant King Grass planted late April 2009

Giant King Grass in early August 2009

10 days after planting

First Year Harvest
November 10, 2009

Giant King Grass Year 2

Giant King Grass

- Natural hybrid of two grasses
  - Not genetically modified
  - Not an invasive species
- Productive in first year
- Needs >100 days sunshine and >800mm rain or irrigation
  - Does better with more of both
- Can be grown in acidic or mildly saline soil
- No pesticide required

New Planting
September 28, 2009

Giant King Grass & Factory July 2010

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

Green Log Factory

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Single 5-Pound (2.27 kg) Logs

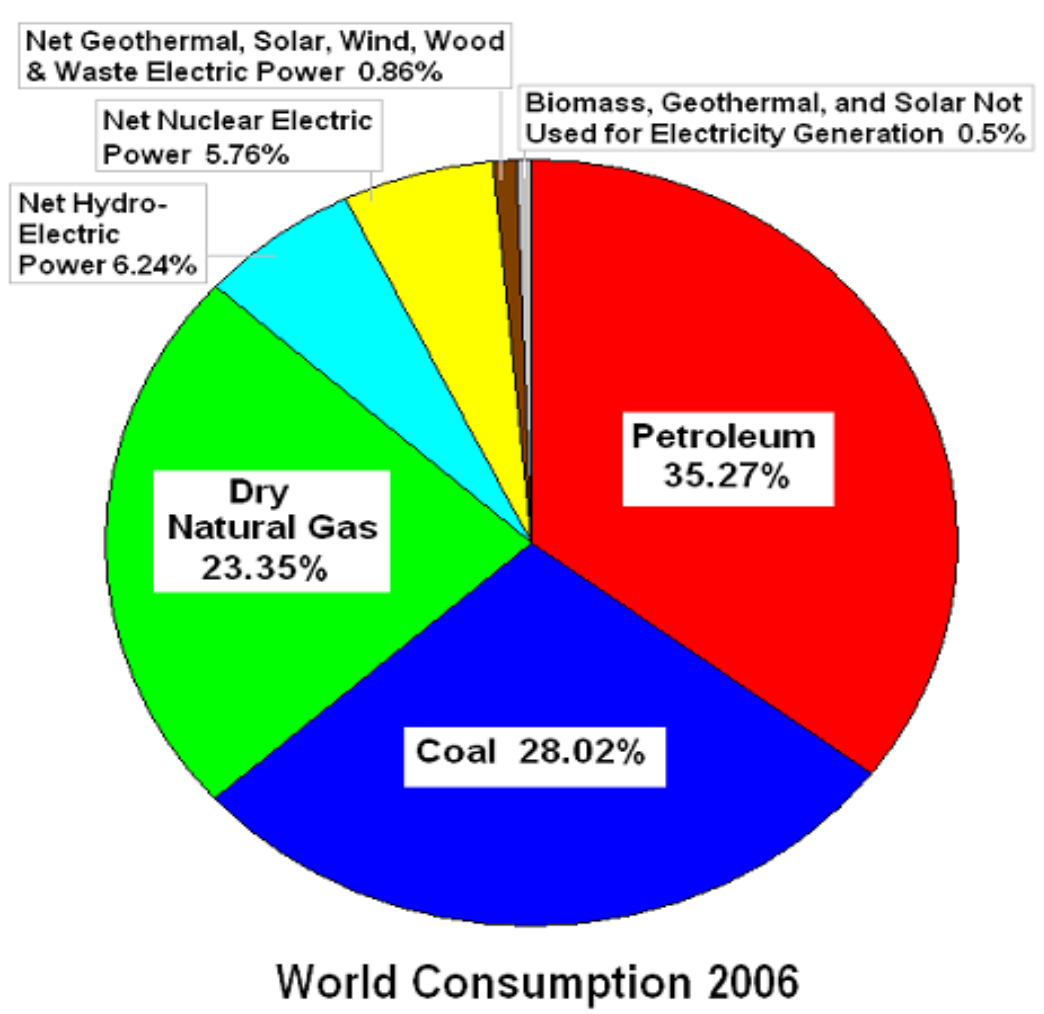
Carton of Six 5-pound (2.27 kg) Logs

Advantages of Giant King Grass

- Low cost because of extremely high yield
  - Can meet the cost targets for all energy and biofuels applications
- Perennial crop, simple to grow
  - 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 feedstock
  - Assured supply required for project financing

Is There Enough Land to Grow Biomass?

- World Wildlife Foundation estimates that “250-800 M Ha of additional agricultural land could be brought into production without encroaching upon areas of high ecological or social value”
- 80 M Ha of Giant King Grass could replace all world coal
- 250 M Ha replaces all oil
- HIGH YIELD IS THE KEY



2007 world consumption 495 Quad
Oil replaced by cellulosic ethanol 353l/mt

ADDITIONAL SLIDES

Dr. Carl Kukkonen CEO Biography

1998-2005 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

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

Solar, Wind, Biomass & Coal

	Capital Cost ($M/MW)	Utilization (%)	Fuel Cost ($/kwhe)	Electricity Price $/kwhe	Comment
Solar Photovoltaic	3-5	22	0	0.30-.40	Day only Needs grid back-up
Thermal	3-4	31	0	0.20-.26	
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.

Compare Biomass Costs to Fossil Fuel

Coal US	27GJ /mt	$50 /mt	**$1.85 /GJ**
Coal Max.	27GJ /mt	$100 /mt	**$3.70 /GJ**
Oil	6.1GJ /barrel	$70 /barrel	**$11.48 /GJ**
Nat. Gas		$5.00 /Mbtu	**$5.27 /GJ**
Bio-mass	18.4 GJ/mt	$42 /mt China	**$2.31 /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 Feedstock Prices

Application	Current prices	Price per gigajoule ($/GJ)
Biogas production	$10-13/mt (75% moisture)	$2.17-$2.83
Direct combustion power plant	$30-40/mt (25% moisture)	$2.17-$2.90
Pellet/briquette production	$30-50/mt (20% moisture)	$2.04-$3.40
Biofuels feedstock	$50-55/mt (20% moisture)	$3.40-$3.74

Prices being paid today for agricultural waste in China, Thailand and India

Giant King Grass can meet or beat current feedstock prices

Plus provide a reliable, consistent source of supply for the lifetime of the project

Giant King Grass Energy Analysis

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 Energy Analysis

Ultimate Analysis	Unit	Bone Dry
Carbon	%	46.64
Hydrogen	%	5.66
Nitrogen	%	0.43
Chlorine	%	0.548
Total Sulfur	%	0.13
Oxygen	%	42.97

DP Cleantech has 19 Biomass Power Plants Operating in China

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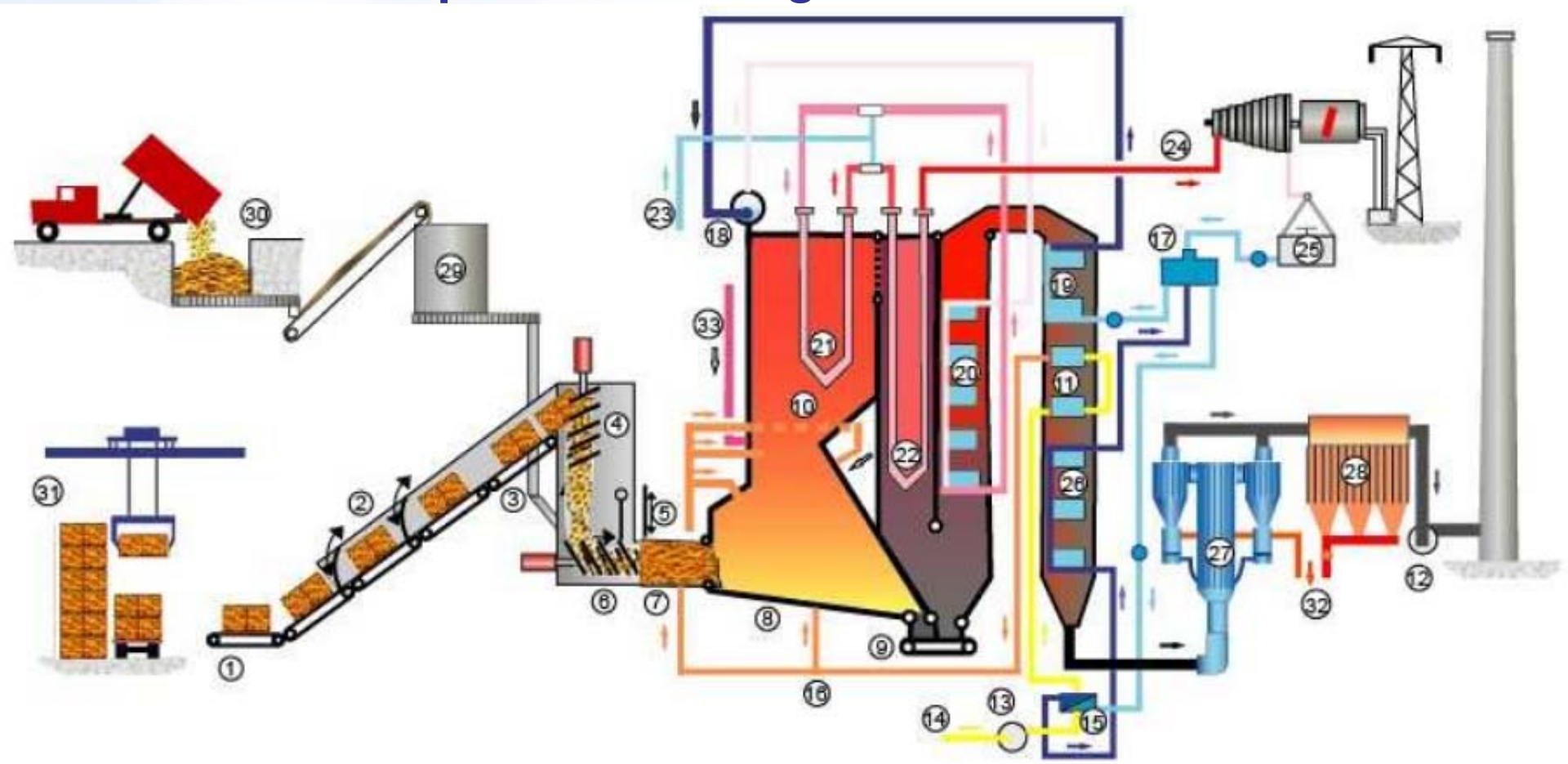
Power Plant Optimized for Agricultural Waste/Corn Straw



Giant King Grass Has Properties Almost Identical to Corn Straw

Giant King Grass Bio-Methane Yield

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ATRES
engineering biogas

Anaerobic Fermentation Test

Method : In accordance with DIN EN ISO 11 734 / VDI RL 4630.

Substrate:	Type/Origin:	King grass / Chi	
	Amount:	7,01	g
	Dry Matter (DM):	27,4	%
	Volatile Solid (VS):	93,4	% DM
Inoculums:	Origin:	ATRES	
	Temperature:	38	°C
	pH value:	7,8	-

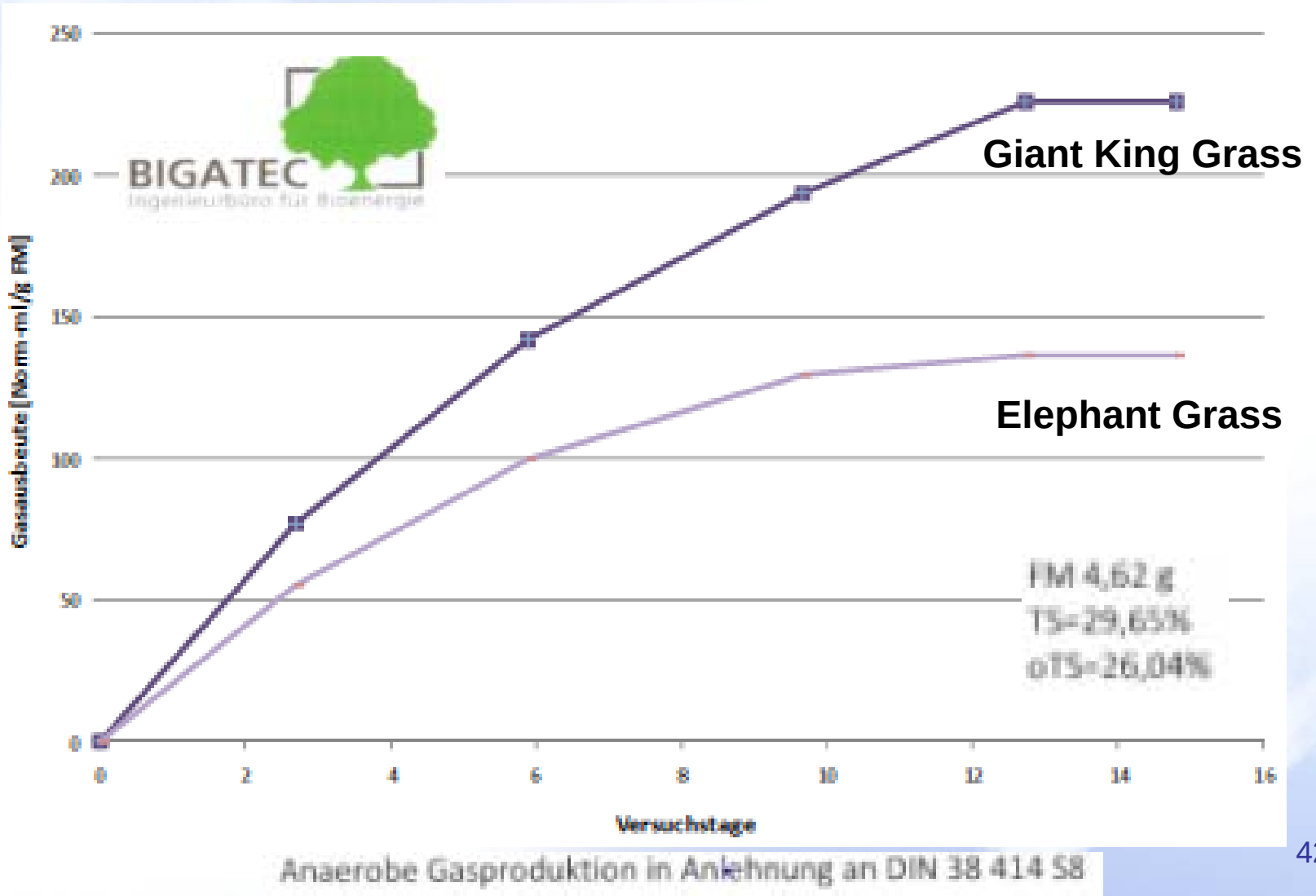
1.5 MW biogas engine/generator

Nr.	Parameters	Unit	Results
1	Duration of the experiment	d	27
2	Methane content	%	57
3	Biogas production of the substrate (fresh substrate)	l_N/kg	160
4	Methane production of the substrate (fresh substrate)	l_N/kg	91
5	Specific biogas production (based on volatile solid of the substrate)	l_N/kg-VS	626
6	Specific methane production (based on volatile solid of the substrate)	$l_{N\text{-}CH4}$/kg-VS	357

Cut at 1m Tall Every 25-30 Days for Biogas

1 MW biogas plant requires 70 ha of Giant King Grass

Biogas Yield per Gram of Fresh Grass



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