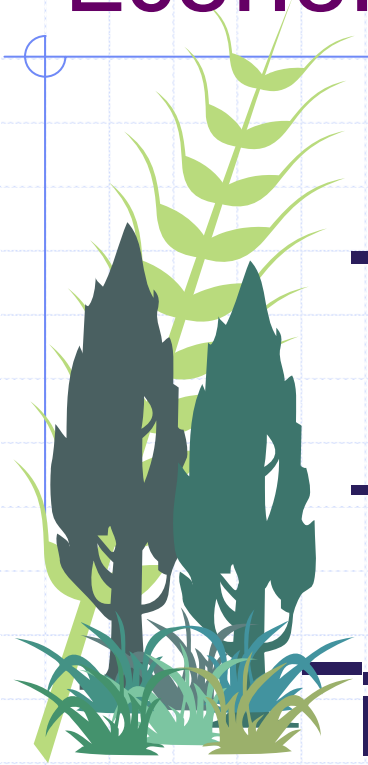
미국의 바이오에너지 곡물에 대한 개론

Biomass Flows in the U.S. Economy



Biomass

Fiber

Process Residues

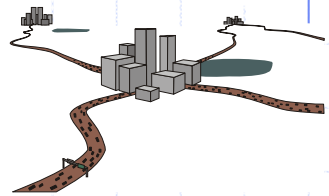
black liquor

sawdust

bark

Materials

pulp
paper
lumber
plywood
cotton



Consumers

MSW clean fraction
yard trimmings
constr. & demolition wood
non-recyclable organics

Crops, Animals

stalks & straws

harvest residues

Process Residues

forest slash

bagasse

dung

Food

Energy Services

heat
CHP
electricity

forest harvest for energy

short rotation woody crops
herbaceous energy crops

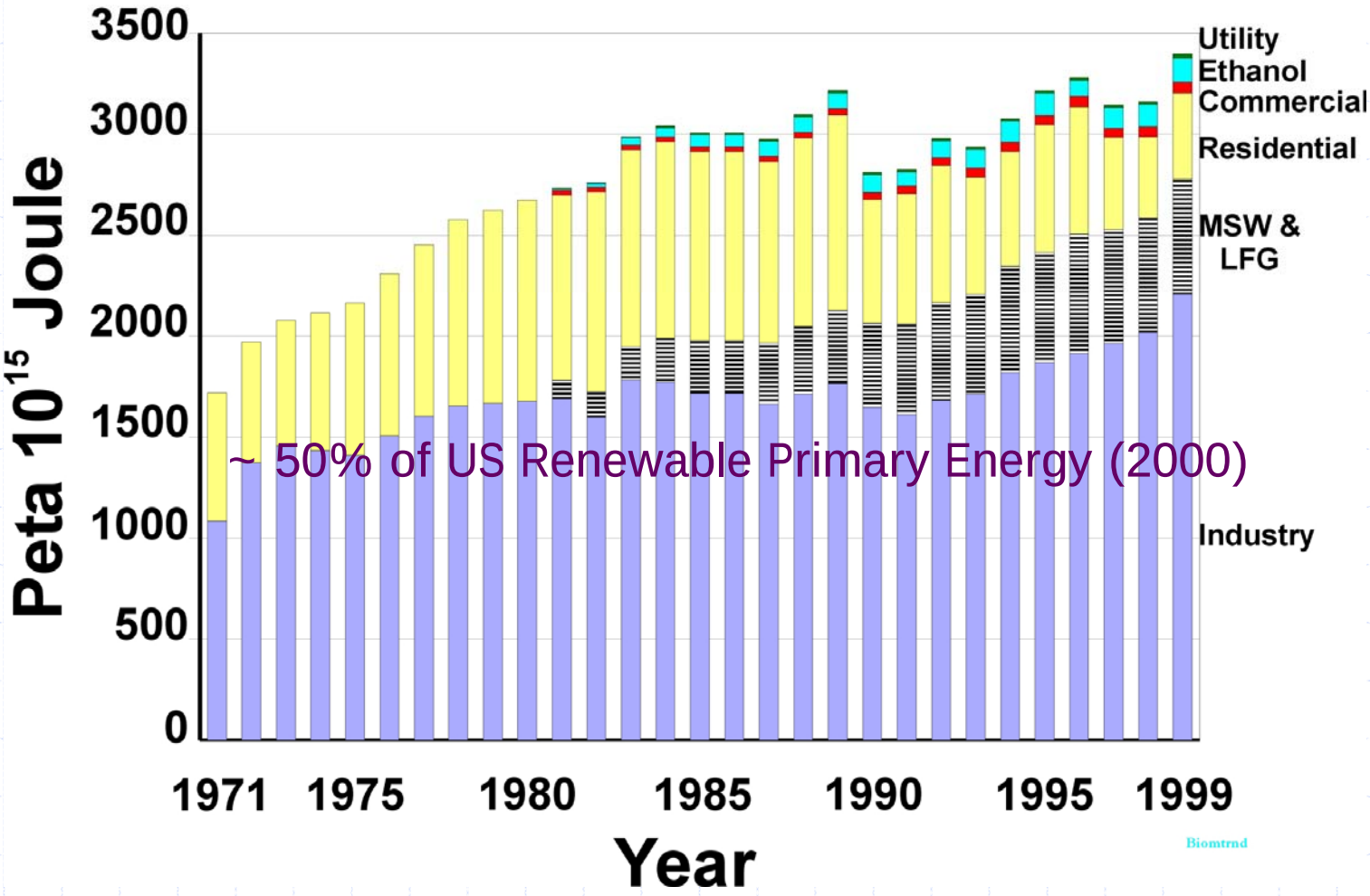
Bioenergy

Biofuels

charcoal
ethanol
hydrogen

Source: Overend, NREL

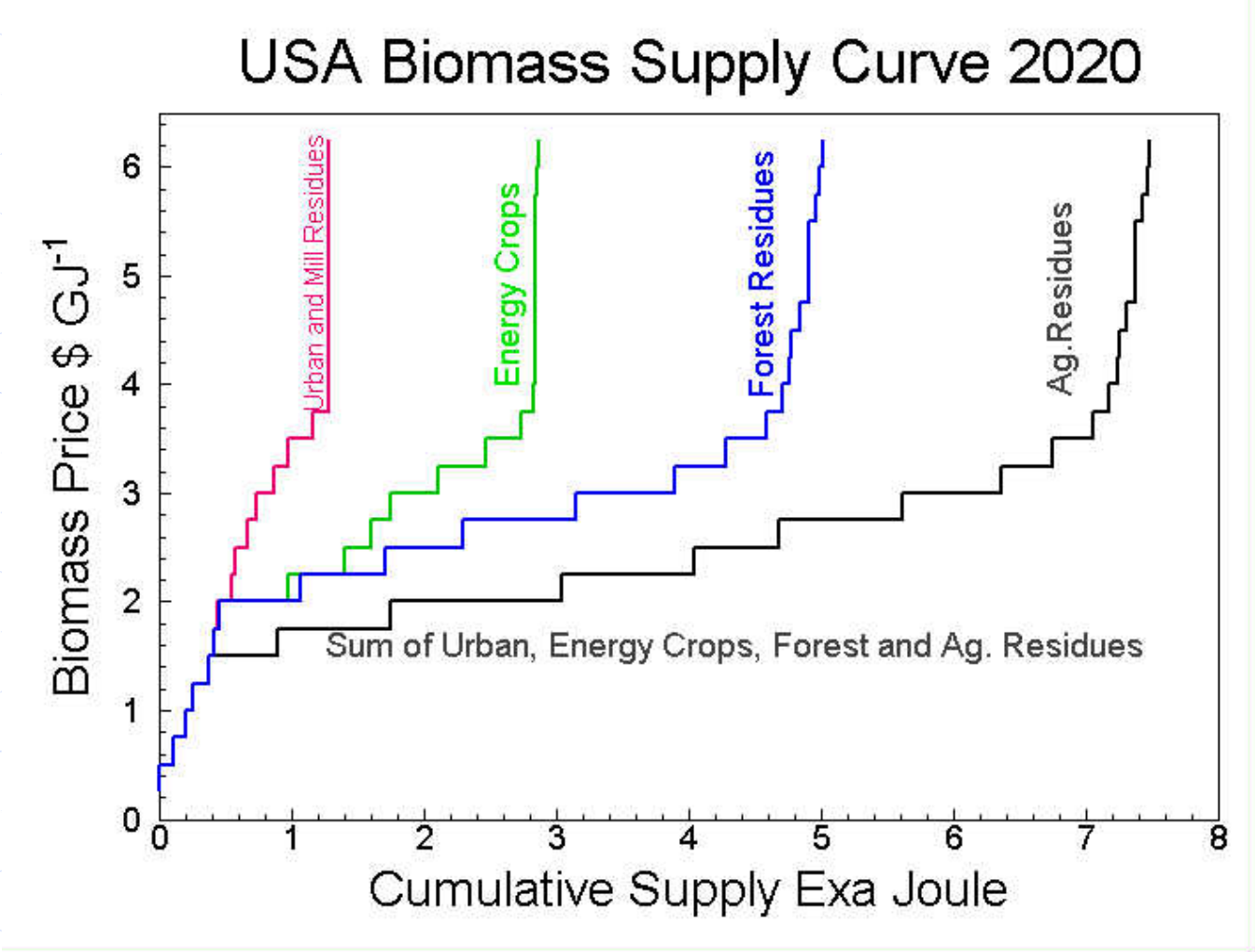
US Biomass Primary Energy



Power Generation

- Power Generation in the U.S.
  - 3,691 billion kWh per year (2001)
  - 52% from coal
  - 21% from nuclear
  - 17% from natural gas
  - 8% from renewable energy (11% Bio/3%Wind)
- Biomass could supply about 20% of power resources:
  - 25% from urban & mill wood residues
  - 37% from energy crops
  - 29% from crop residues
  - 9% from forest residues

EIA - USA Supply Curve



Resource Sustainability and Environmental Issues

- New Energy Crops
  - Diversity
  - Exotics and genetics
  - Wildlife habitat
  - Chemical application
- Biomass residues
  - Higher value uses
  - Chemical contaminants
- Timber Harvests

Conversion Sustainability and Environmental Issues

- Air Emissions
  - NOx
  - PM
  - PICs
- Energy Balance
  - Production
  - Processing
  - Transportation

Conversion Technologies

Cofiring

Landfill Gas

BioRefining

Direct-fired

Gasification

Direct-fired Power Plants

- Stoker and fluidized bed boilers - 10 to 50 MW
- Source of most existing biomass power generation
- Efficiency = 20% to 24%
- New plants with BACT & LAER controls have very low emissions

Pollutant	**Permit Limit**	
Particulate	0.02 lb/MMBtu	BACT
NOX	0.075 lb/MMBtu	LAER
SO2	0.08 lb/MMBtu	BACT
CO	0.09 lb/MMBtu	BACT
VOC	0.009 lb/MMBtu	BACT

Biomass Gasification

- Low to medium-Btu biogas:
  - NOx control (reburn)
  - Advanced power cycles
    - Combined cycles
    - Fuel cells
  - BioRefining
- Full-scale test facility operational in Vermont
- Efficiency = 35 to 45%
- Developing technology

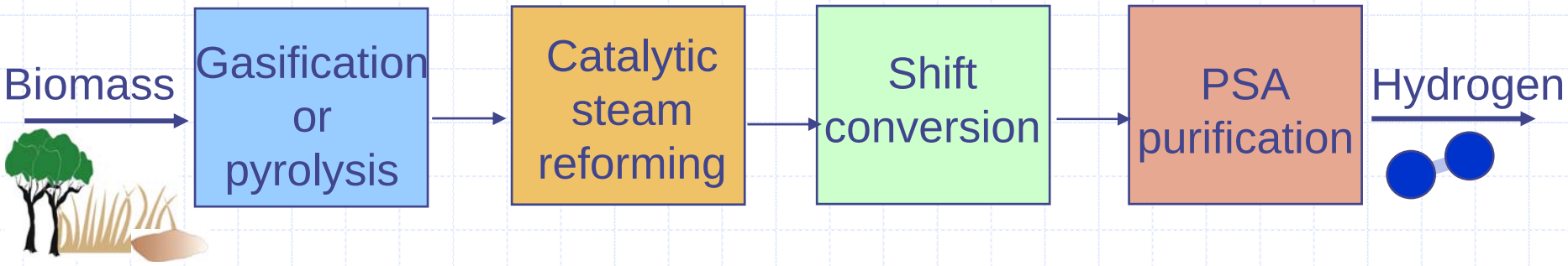
Biomass Cofiring

- Substituting biomass for coal in existing power plants
- Directly displaces coal with immediate benefits
- High efficiency biomass conversion 33% to 35%

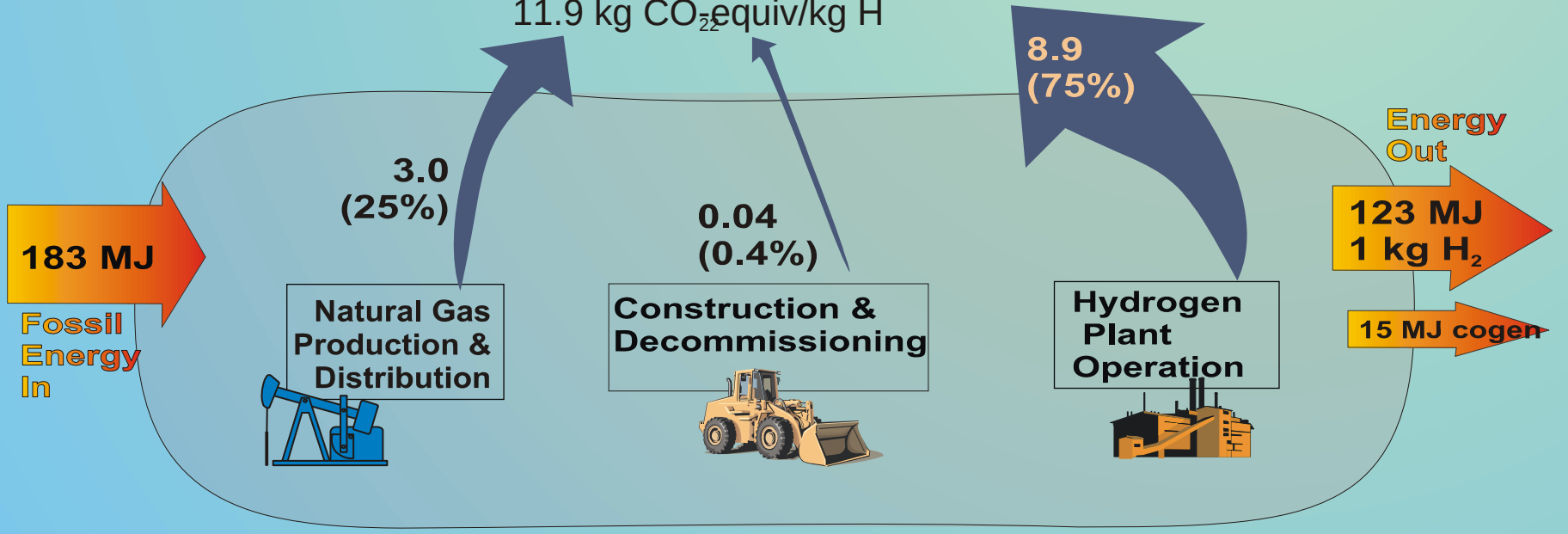
- Reduces :
  - SOx
  - NOx
  - CO2/GHG
  - Mercury

Biomass to H_2 Technologies

- Indirectly-heated gasification
- Oxygen-blown gasification
- Pyrolysis
- Biological gasification (anaerobic digestion, landfill gas)



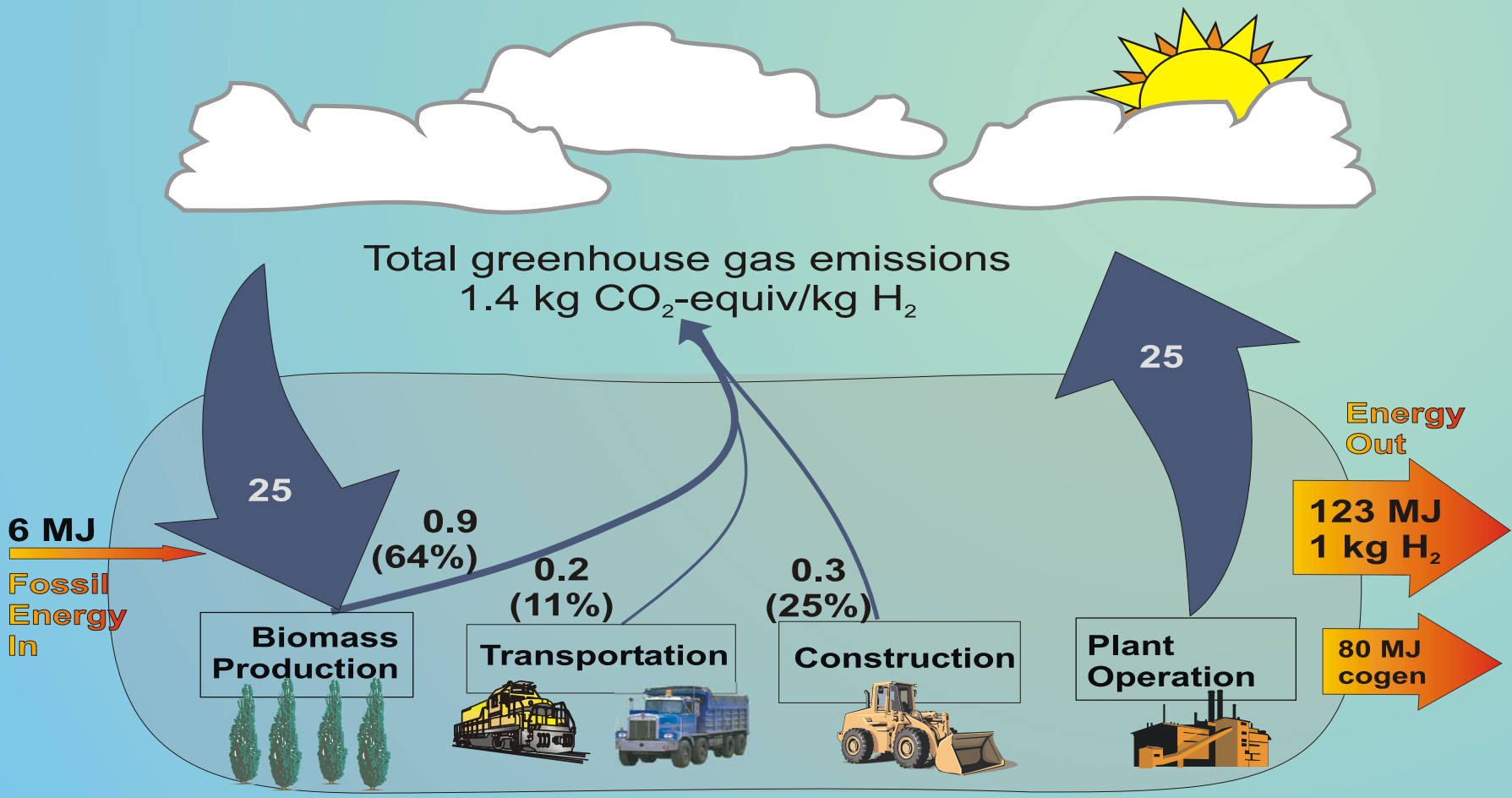
Life Cycle GWP and Energy Balance for Steam Methane Reforming



Net energy ratio = (123 MJ + 15 MJ) / 183 MJ = 0.75

Source: National Renewable Energy Laboratory, Golden, CO

Life Cycle GWP and Energy Balance for Biomass Gasification / Reforming using Energy Crop Biomass



Net energy ratio = (123 MJ + 80 MJ) / 6 MJ = 33.8

Source: National Renewable Energy Laboratory, Golden, CO

The Salix Consortium

A New York Experiment with Willow Energy Crops

Progress Against Our Objective

Primary Objective: Demonstrate the environmental value and economic viability of willow energy crops

- Positive benefits documented for avian habitat
- Breeding program resulted in a 20% increase in yields
- Dunkirk fuel processing system delivers up to 14 MW
- Emission test results prove NO_X and SO_2 reductions
- Approximately 360 acres commercially ready
- Power from WilloWatts competitively priced in developing Green Power Market

First Large Scale Harvest

270 tons of Willow and Bush Industry residues converted to power

Dunkirk Emissions Testing

- Test Period 6 days 12 hours per day
- Cofiring rates up to 14MW (~15%)
- Emission results for NO_X, SO_2, PM, PM-10 and Formaldehyde

Realizing the Vision

Primary Objective:

Lay the foundation for a commercial willow production enterprise

- New York Green-e advisory board recommended a green-e standard that included cofiring energy crops and residues
- Consortium working with NYSERDA and NYPA to ensure that Salix Project power will count toward E.O. 111
- Governor announced New York RPS
- Consortium has identified two institutional buyers and several marketers interested in WilloWatts
- Consortium is working with landowners to layout details of long-term willow production contracts
- Consortium working with NRG on contract for tolling electric conversion services

Rural Economic Benefits

Pioneer Farms in Western New York

- Idle acreage becomes productive

- Local wood products industries find market for byproducts

Bush Industries, 8th Largest U.S. Furniture Manufacturer

The Last Hurdles

- Power Contracts
  - NYSDEC approval for commercial operations
  - Power production agreements with NRG
  - Secure green power contracts
- Willow Enterprise
  - Secure acreage for commercial operation
  - Form crop production services enterprise
  - Increase harvest efficiency

Time Line: Key Action Items

- Submit emission testing report – 3/7
- Obtain regulatory approval for commercial operation – 7/1
- Obtain green power purchase commitments – 4/1
- Long term operating agreement with NRG – 4/1
- Finalize contracts – 9/1
- Identify and lock-up choice acreage 4/1
- Establish alternative markets – 4/1
- Form production enterprise – 8/1
- Finalize equipment title transfers – 8/1
- Finalize production equipment/processes required to increase production efficiency – 6/1

Conclusion