Sunflower/NISTAC Integrated Bioenergy Center

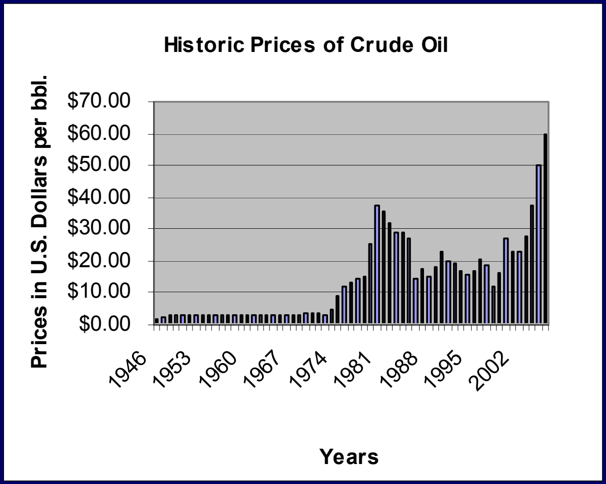
An Alliance with NISTAC

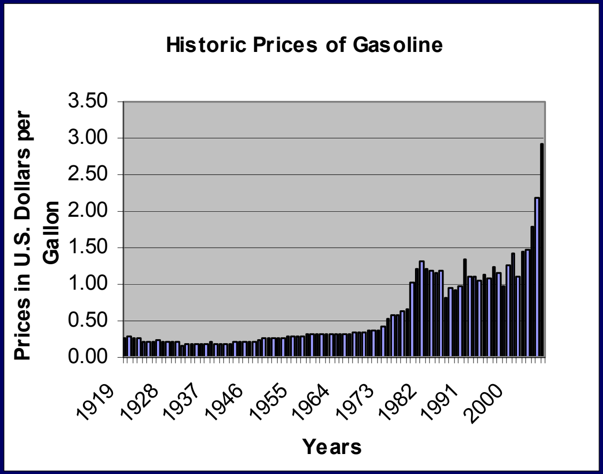
Integrated Bioenergy Center

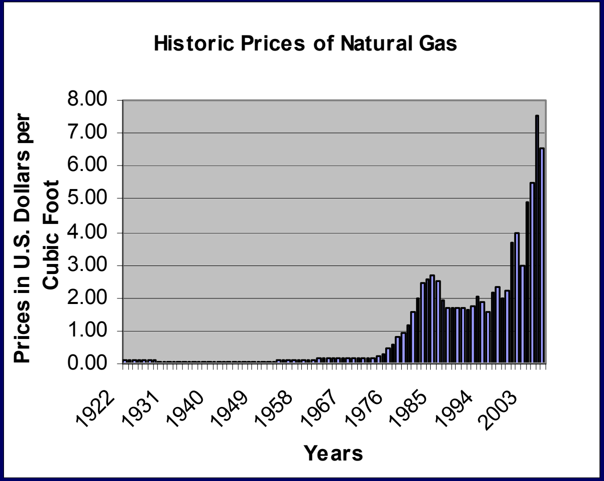
- **Alliance with the National Institute for Strategic Technology Acquisition and Commercialization (NISTAC)**
  - ***Goal is to develop a bioenergy project that will integrate a number of commercial or near commercial renewable energy technologies with the coal-based power plant located at Holcomb Station***

Global Energy Markets

Comparative Historic Prices of Fuel Alternatives

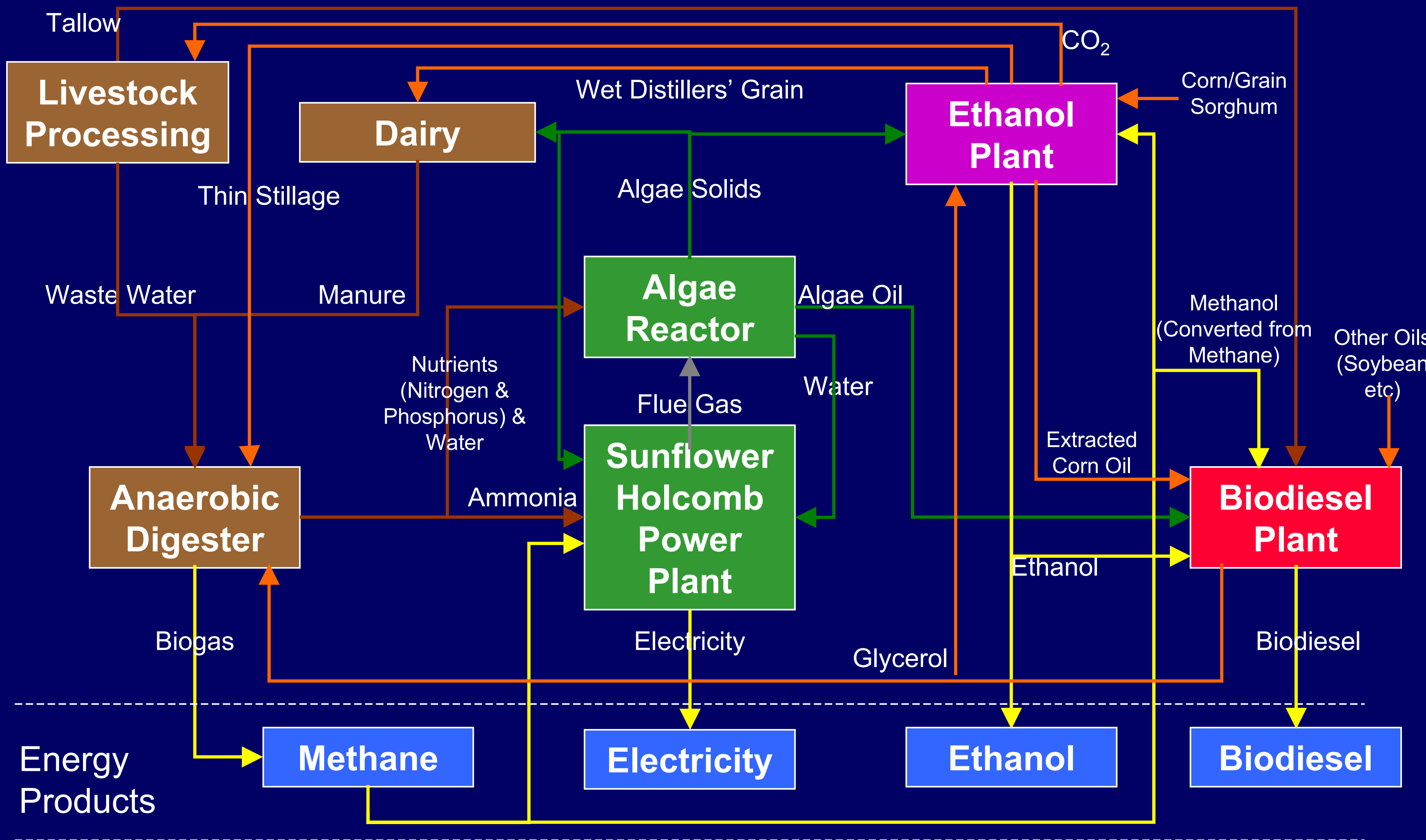






Sunflower Integrated Bioenergy Center

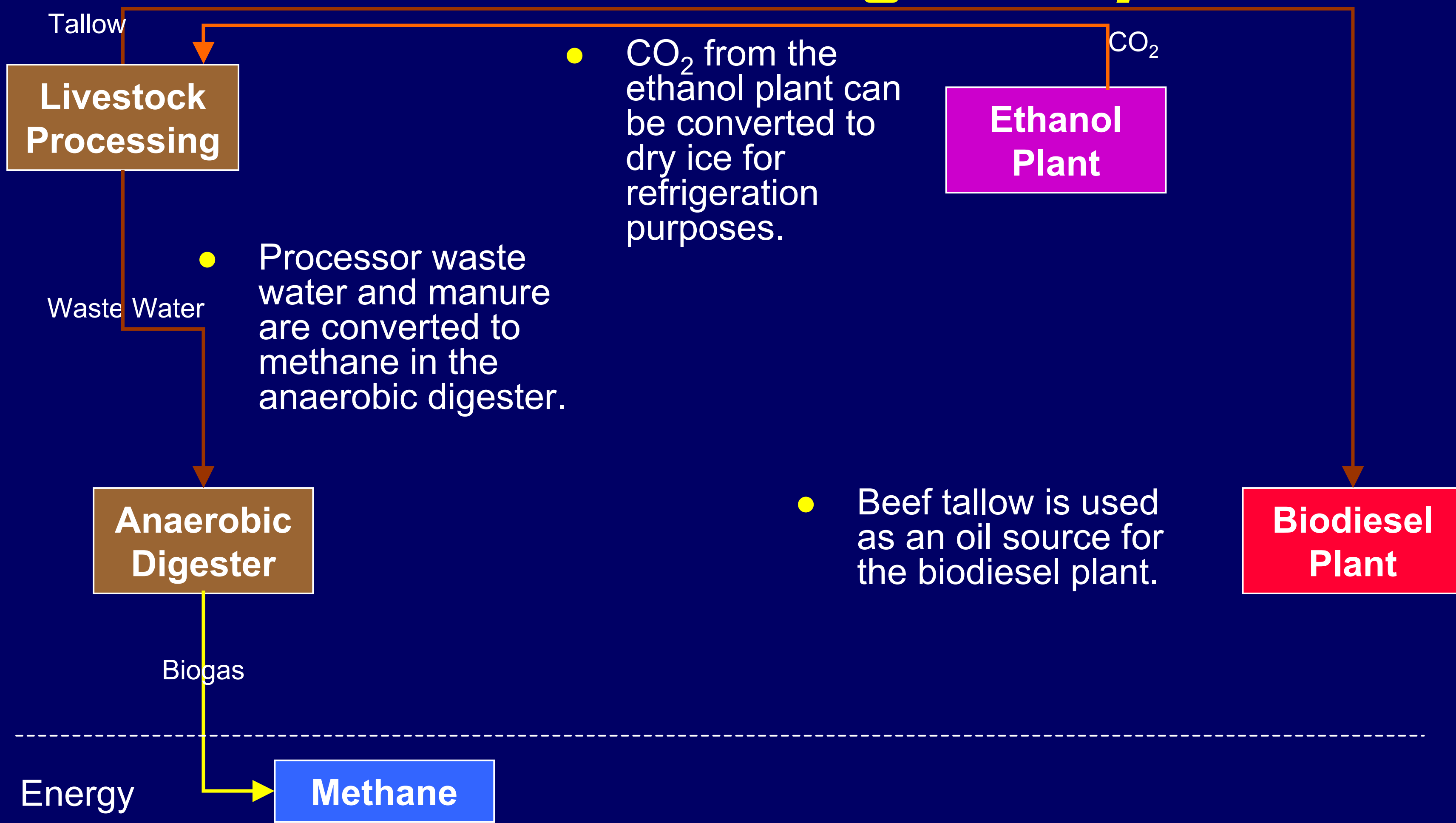
2006 Alliance with NISTAC



Reduced Waste Streams = CO_2, NOx, SOx, Nutrient Load (Nitrogen & Phosphorus), Heat, & Waste Water

Livestock Processing Subsystem

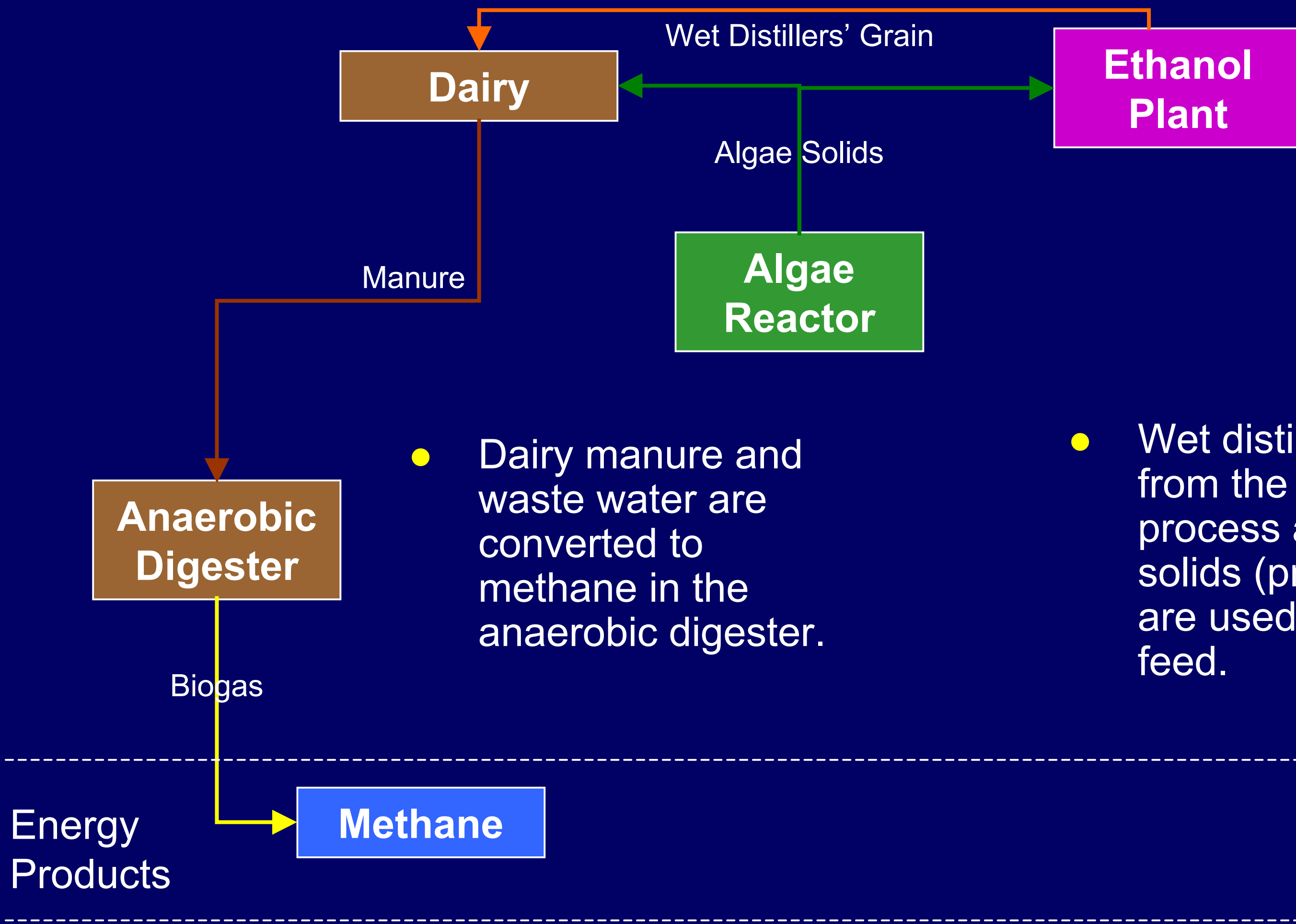
- CO_2 from the ethanol plant can be converted to dry ice for refrigeration purposes.
- Processor waste water and manure are converted to methane in the anaerobic digester.
- Beef tallow is used as an oil source for the biodiesel plant.



Livestock Processing

- Holcomb station is in close proximity to several large processing facilities.
- A significant quantity of beef tallow is produced – one processor can supply enough oil for a large biodiesel plant.
- Access to tallow allows for the immediate construction of the biodiesel plant while other oil sources are scaled up. Tallow is also a low cost feedstock.
- Waste water from the processing plant can create value in the form of methane, reusable water, and a nutrient source for the algae system.
- Processors currently purchase CO_2 (for dry ice refrigeration) which could be supplied from the ethanol plant.

Dairy Subsystem



- Dairy manure and waste water are converted to methane in the anaerobic digester.
- Wet distillers grain from the ethanol process and algae solids (protein residue) are used for cattle feed.

Dairy

- Southwest Kansas is home to a growing number of large dairy operations.
- Access to land, water, feed (including distillers grain), and suitable climate conditions are driving this growth. All of those conditions are present in Holcomb.
- Dairies must construct manure and waste water management systems – an anaerobic digester offers additional value.

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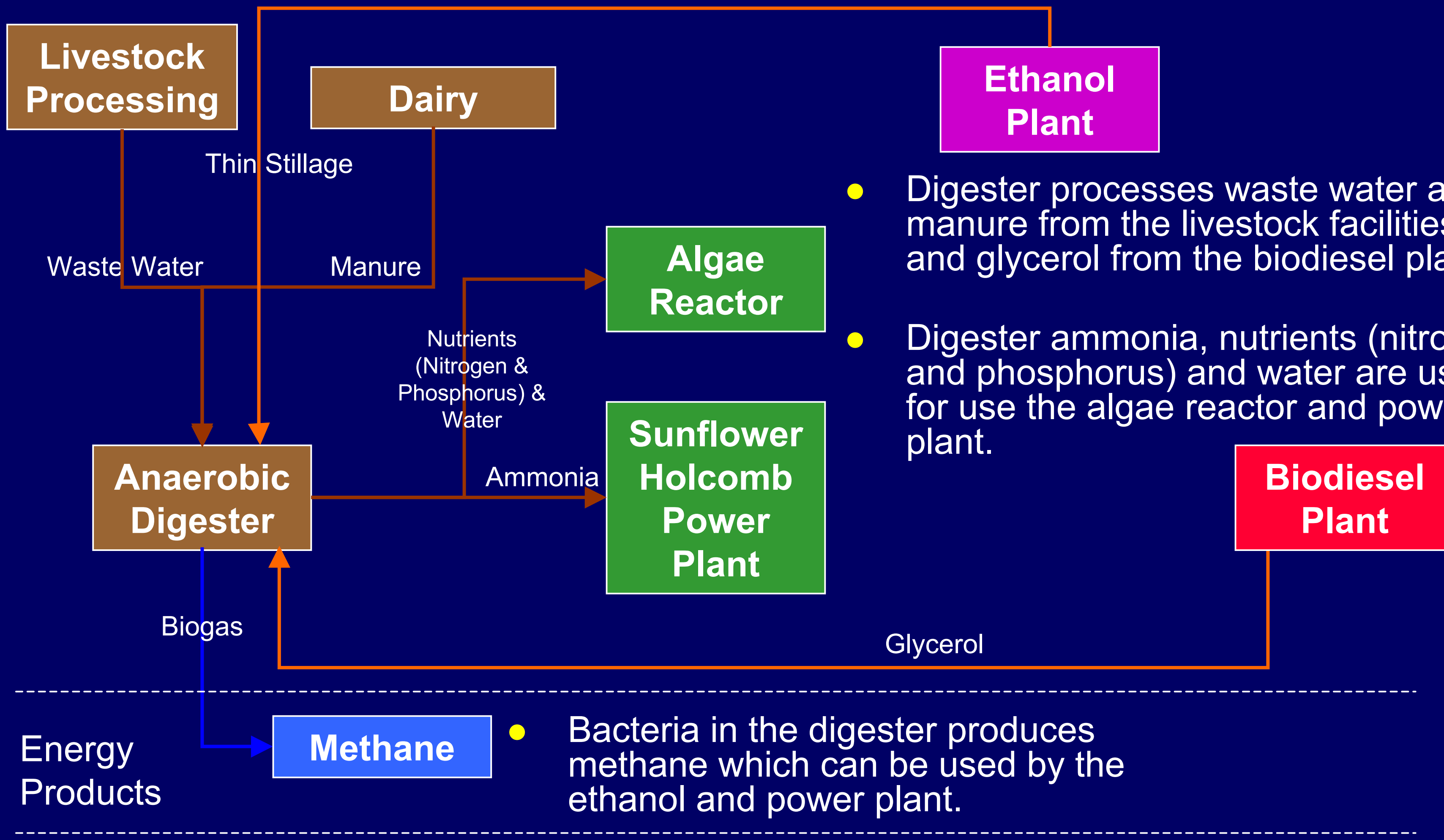
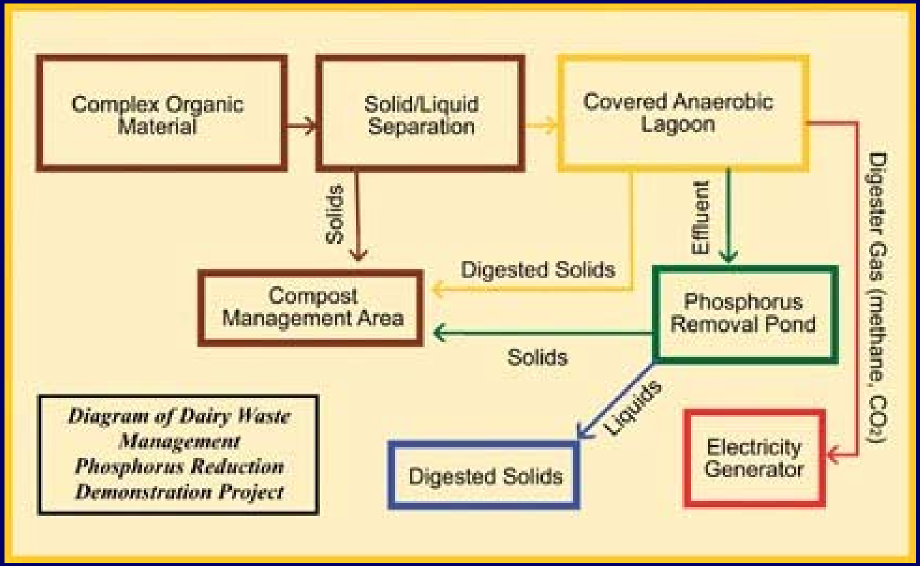
Anaerobic Digester Subsystem



- Digester processes waste water and manure from the livestock facilities and glycerol from the biodiesel plant.
- Digester ammonia, nutrients (nitrogen and phosphorus) and water are used for use the algae reactor and power plant.
- Bacteria in the digester produces methane which can be used by the ethanol and power plant.

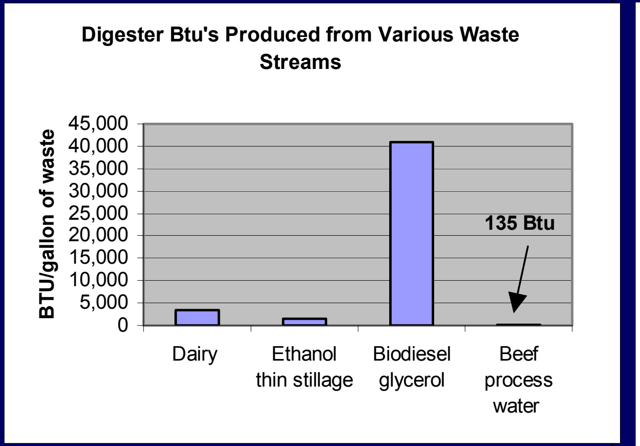
Anaerobic Digester

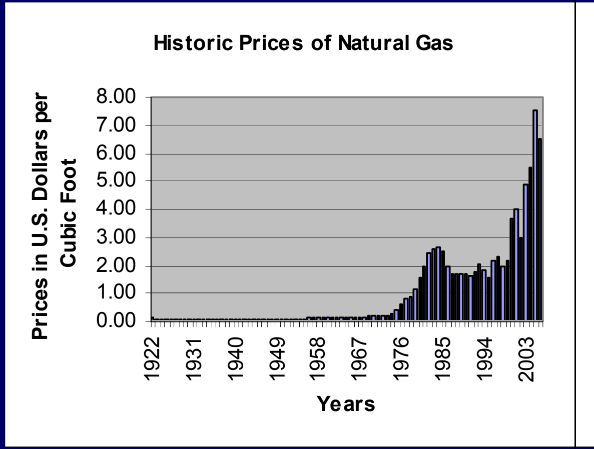
- Anaerobic digesters have been used throughout the world for many decades to process waste water and provide biogas.
- Recently digesters have gained popularity because of improved economics related to natural gas.
- Several of the subsystems at the Holcomb site will require waste water management – the gas generated can supplement natural gas usage.
- The digester also creates valuable products such as ammonia, nutrients for the algae (nitrogen and phosphorus) and eventually water for the power plant.

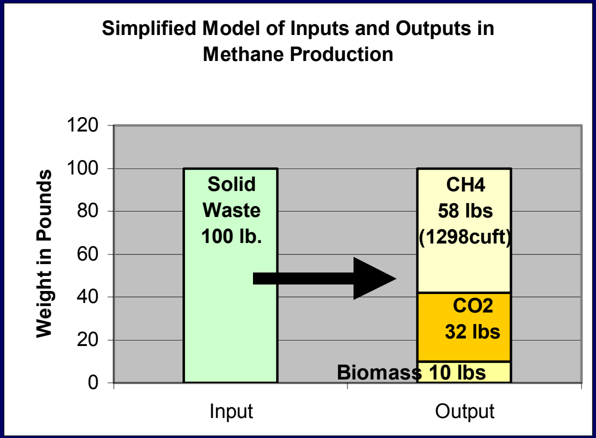


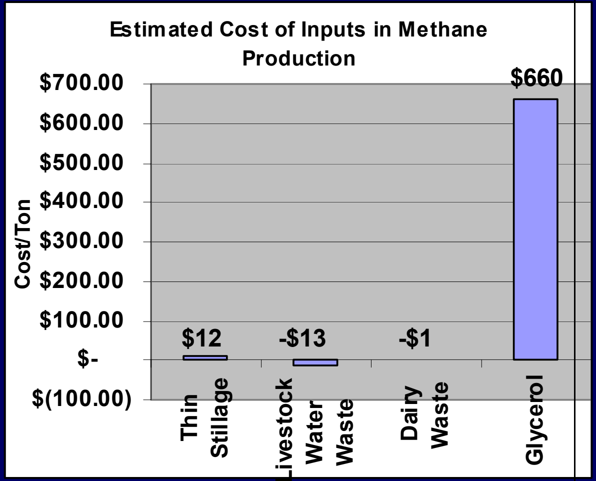
Methane

Methane Digester Market and Process Data







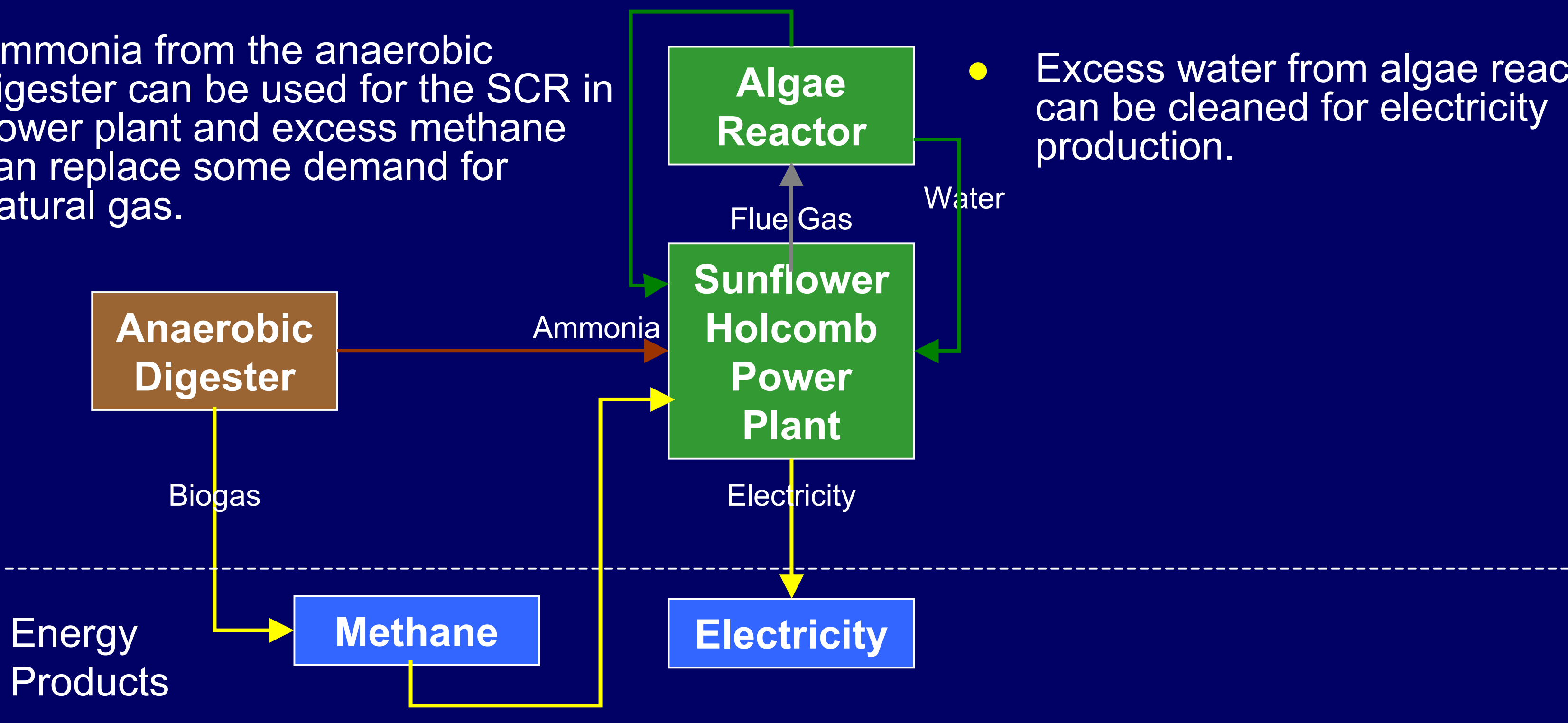


Coal-based Power Plant Subsystem

- Flue gas emissions from the power plant are stripped as they flow through the algae reactor creating algae oil and solids.

- Ammonia from the anaerobic digester can be used for the SCR in power plant and excess methane can replace some demand for natural gas.

- Excess water from algae reactor can be cleaned for electricity production.

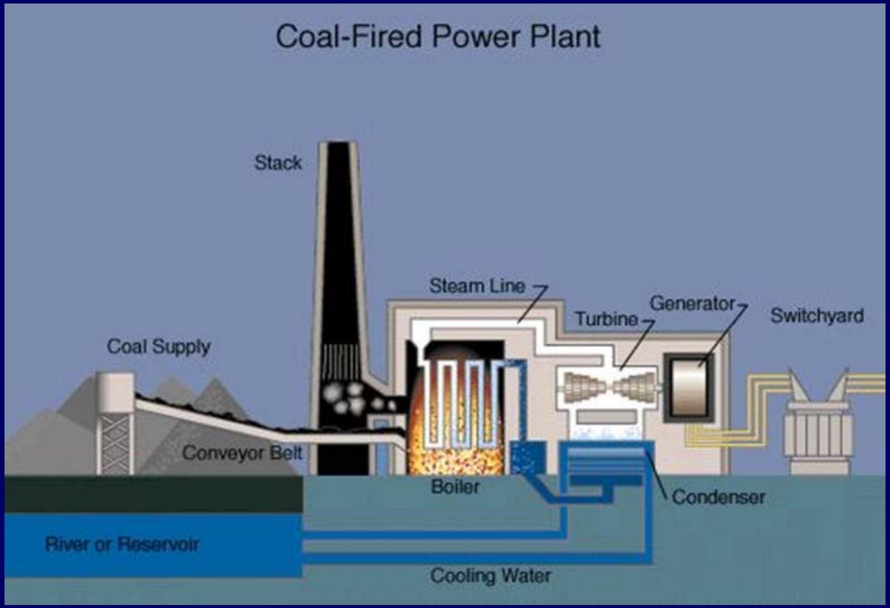


Coal-based Power Plant

- Holcomb station offers several resources for an integrated bioenergy facility including access to CO_2 and NOx (flue gas), land, water, rail, natural gas, and economies of scale for other integrated systems.

- The generation expansion at Holcomb is a tremendous regional economic opportunity and an integrated bioenergy facility affirms Sunflower's commitment to community development and renewable energy.

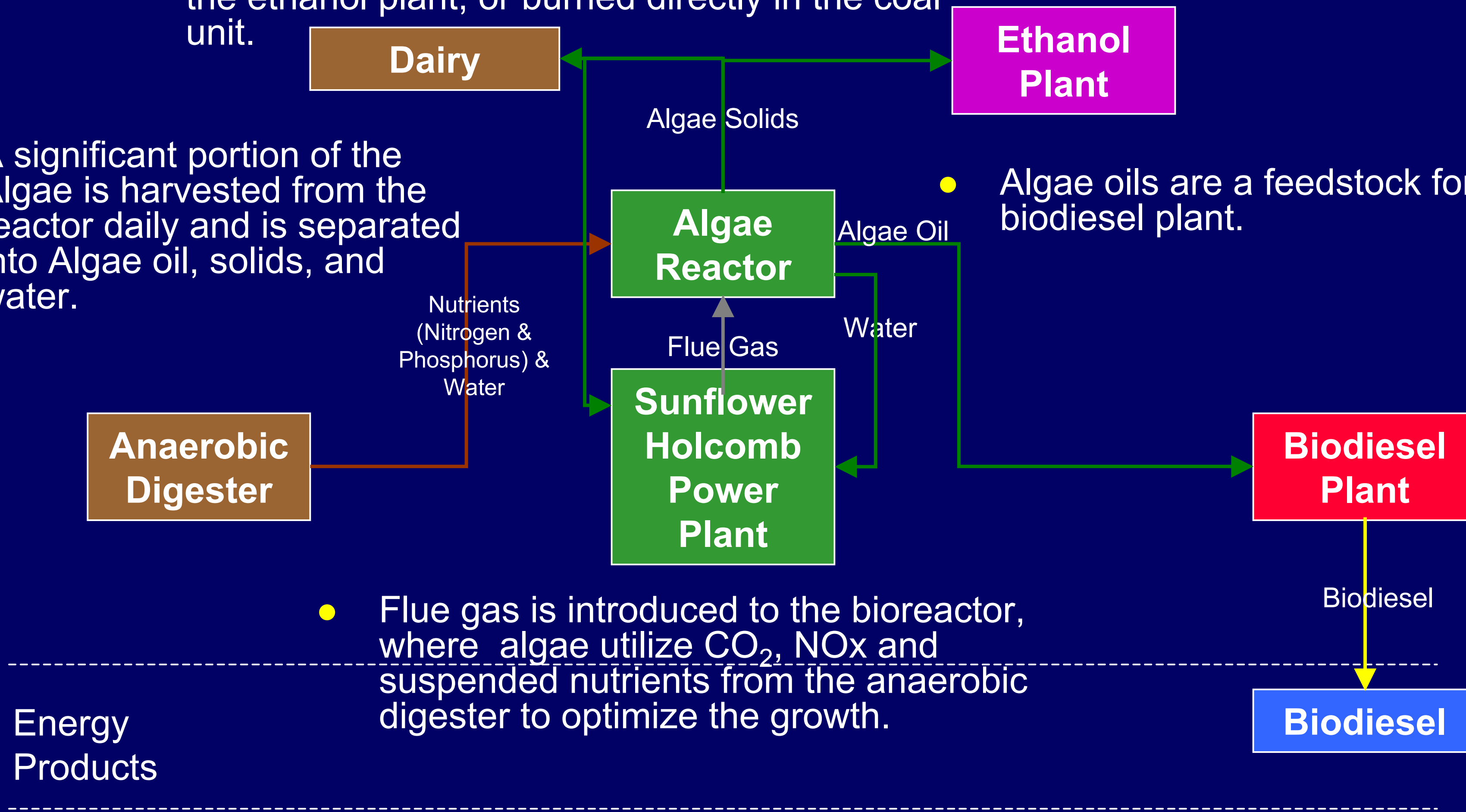
- Sunflower has negotiated large and complex power plant operation and integration agreements similar to the processes required for an integrated bioenergy facility.



Algae Subsystem

Converts CO2 emissions into renewable fuels

- Algae solids are used as animal feed, starch for the ethanol plant, or burned directly in the coal unit.
- A significant portion of the Algae is harvested from the reactor daily and is separated into Algae oil, solids, and water.
- Algae oils are a feedstock for the biodiesel plant.
- Flue gas is introduced to the bioreactor, where algae utilize CO_2, NOx and suspended nutrients from the anaerobic digester to optimize the growth.



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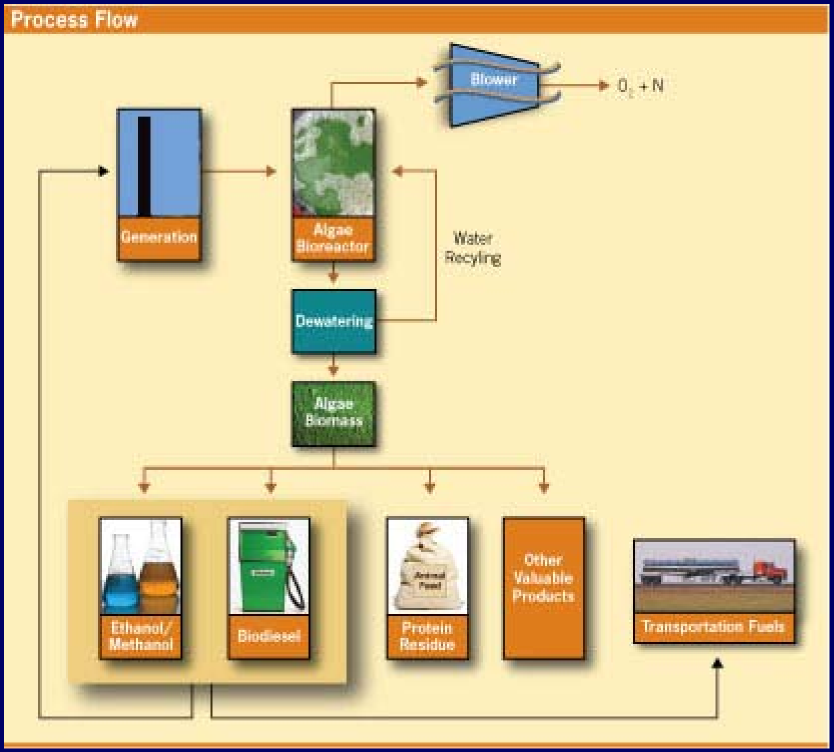
Algae Reactor

Converts CO2 emissions into renewable fuels

- Microalgae is the most primitive plant form - typically one or two cells.
- This simple structure allows algae to be very efficient at converting sunlight, CO_2, and nutrients into oil (for biodiesel) and starch (for ethanol).
- The algae reactor is capable of utilizing the waste CO_2 and NOx in flue gas and the nutrients from livestock/processing waste to create valuable energy products.
- Algae systems have been research for decades including work by the National Renewable Energy Laboratory. Production was found to be viable but most work was done when fuel prices were half of what they are today.
- No large scale algae reactor is in operation today but significant investment has been made recently in conjunction with higher global energy costs.

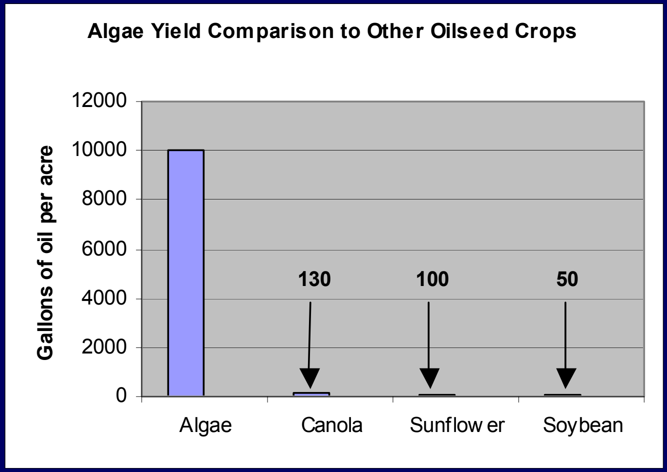
Algae Reactor

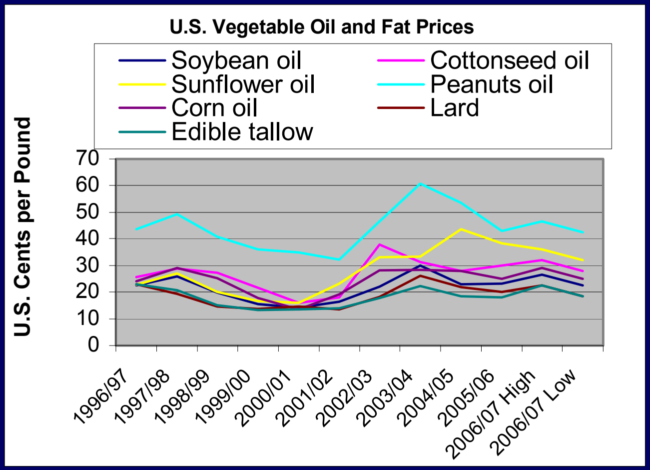
- Flue gas is diverted from the power plant in a manner that does not disrupt normal generation operations.
- CO_2 and NO_x are consumed in the bioreactor by algae through photosynthesis and other biological processes. Algae are suspended in water with nutrients from the anaerobic digester.
- Algae is harvested daily and is sent through a dewatering process which may utilize flue gas as a dryer.
- Algae biomass is then separated into oil (60% by weight for some algae) and solids. Those solids can be fed to livestock, burned in the power plant, or the starch may be utilized by an ethanol plant.

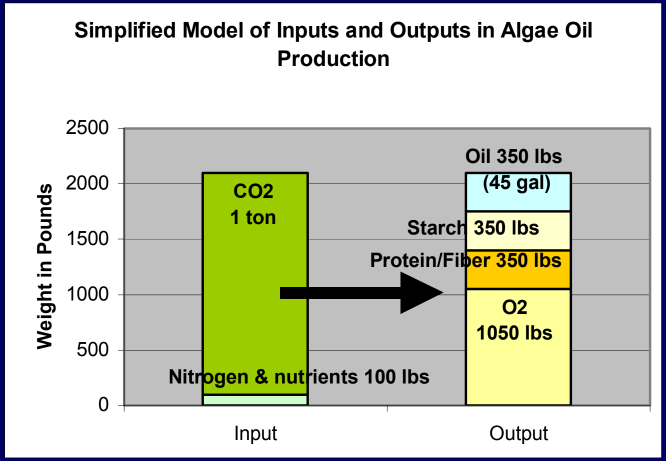


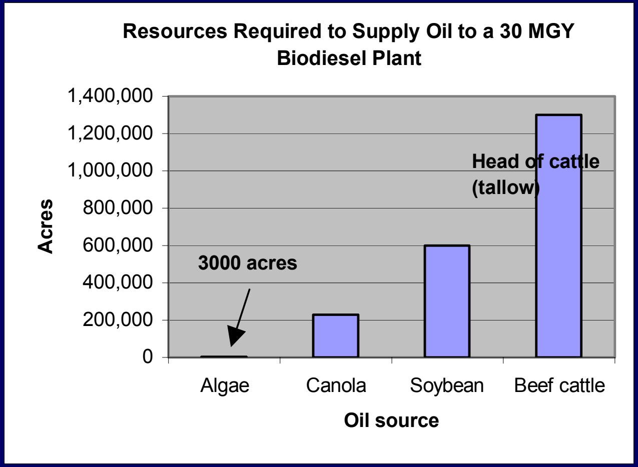
Algae

Algae Market and Process Data









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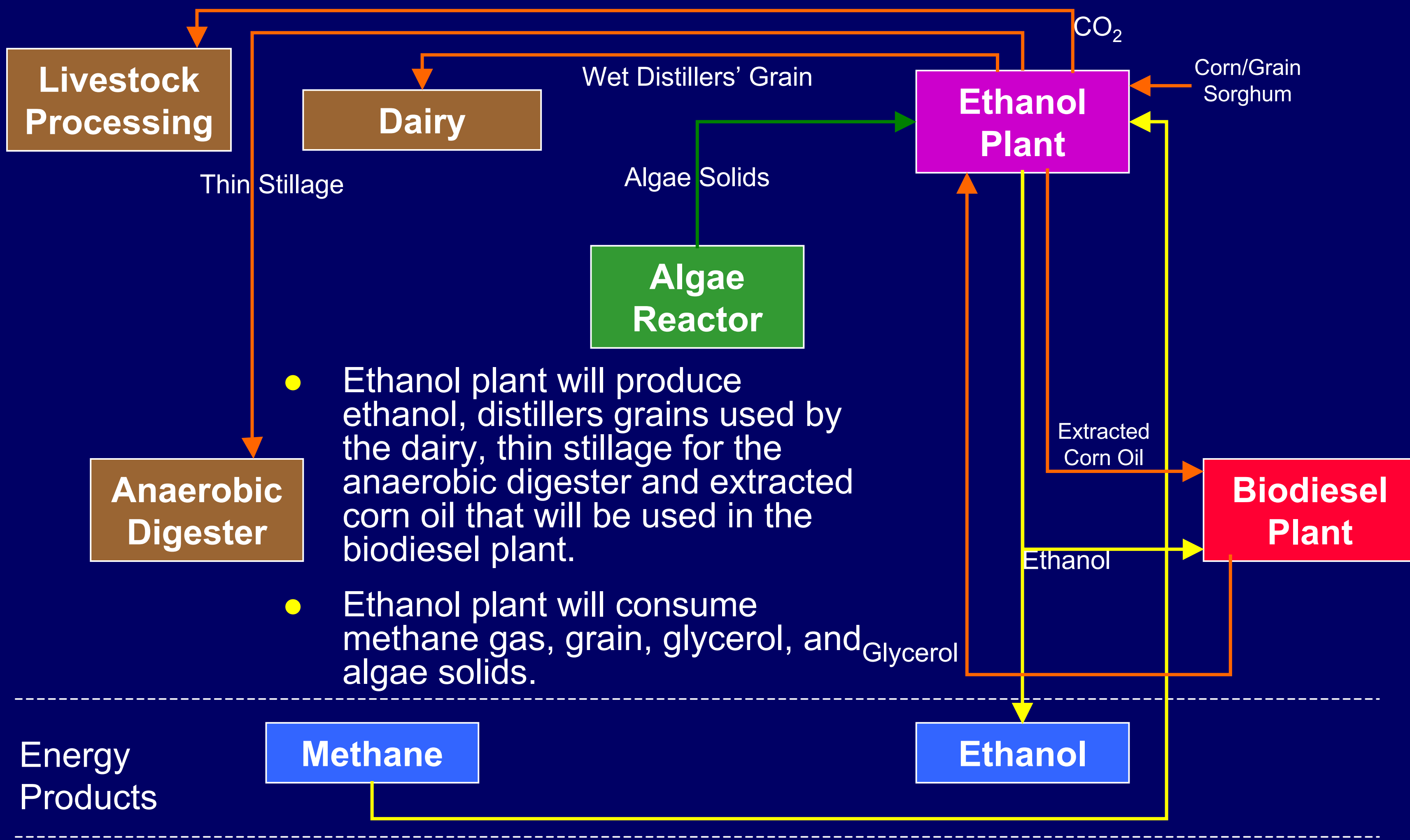
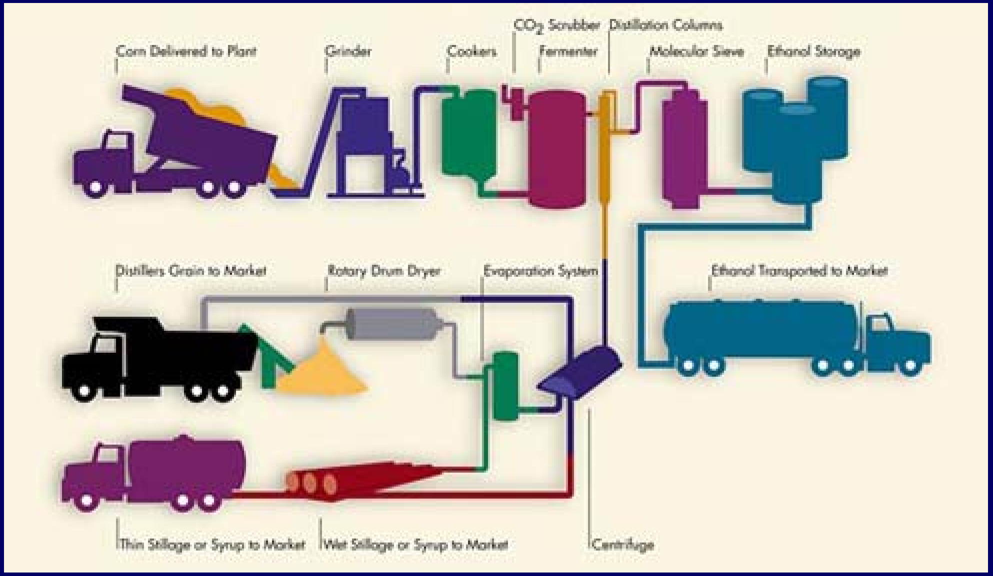
Ethanol Subsystem



- Ethanol plant will produce ethanol, distillers grains used by the dairy, thin stillage for the anaerobic digester and extracted corn oil that will be used in the biodiesel plant.
- Ethanol plant will consume methane gas, grain, glycerol, and algae solids.

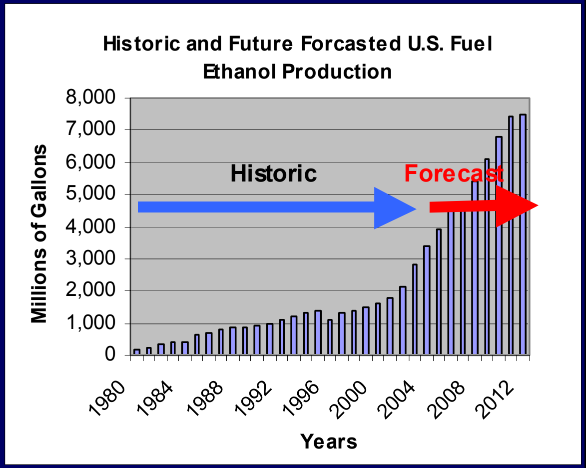
Ethanol Production

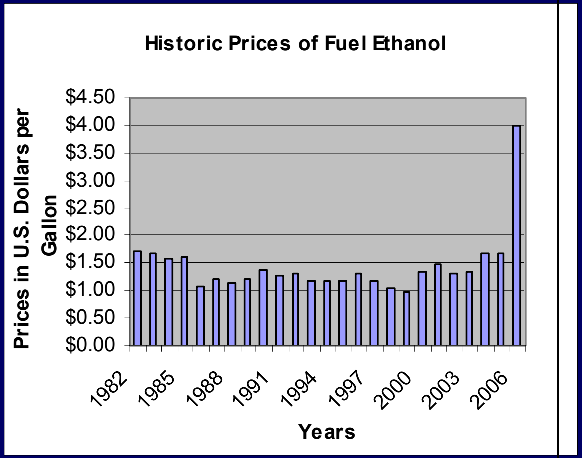
- Ethanol is produced by converting carbohydrates found in grain into sugar which is then converted to ethanol through fermentation.
- The ethanol industry has grown rapidly due to the renewable fuels standard, the ban on MTBE, and higher oil prices.
- Ethanol plants require access to land, water, grain markets, and livestock facilities for use of distillers grain. All of these are key components of the Holcomb site.
- Powering the ethanol plant on over 90% renewable fuels allows the facility to receive a substantially higher tax incentive.

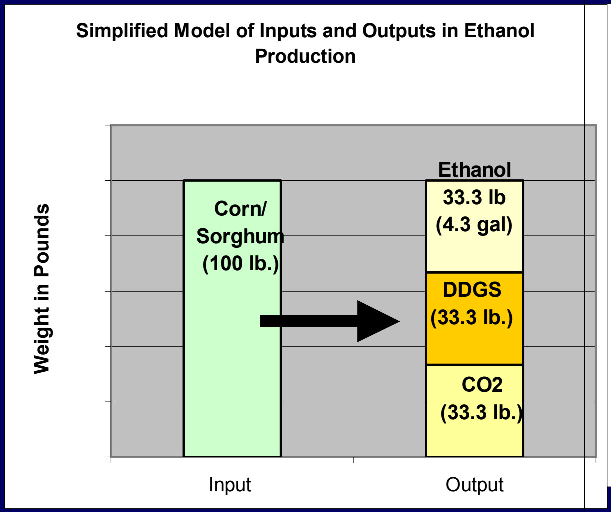


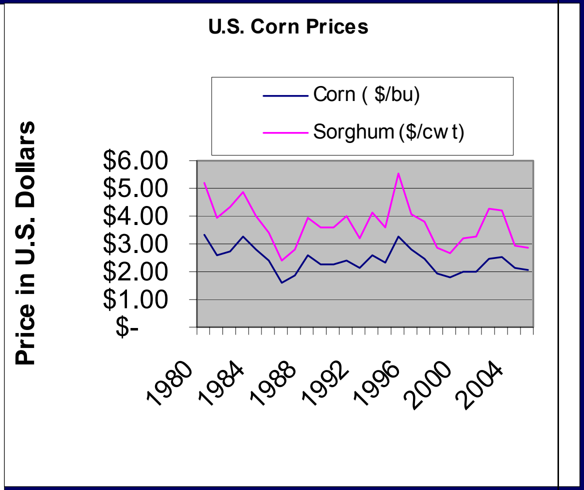
Ethanol

Ethanol Market and Process Data



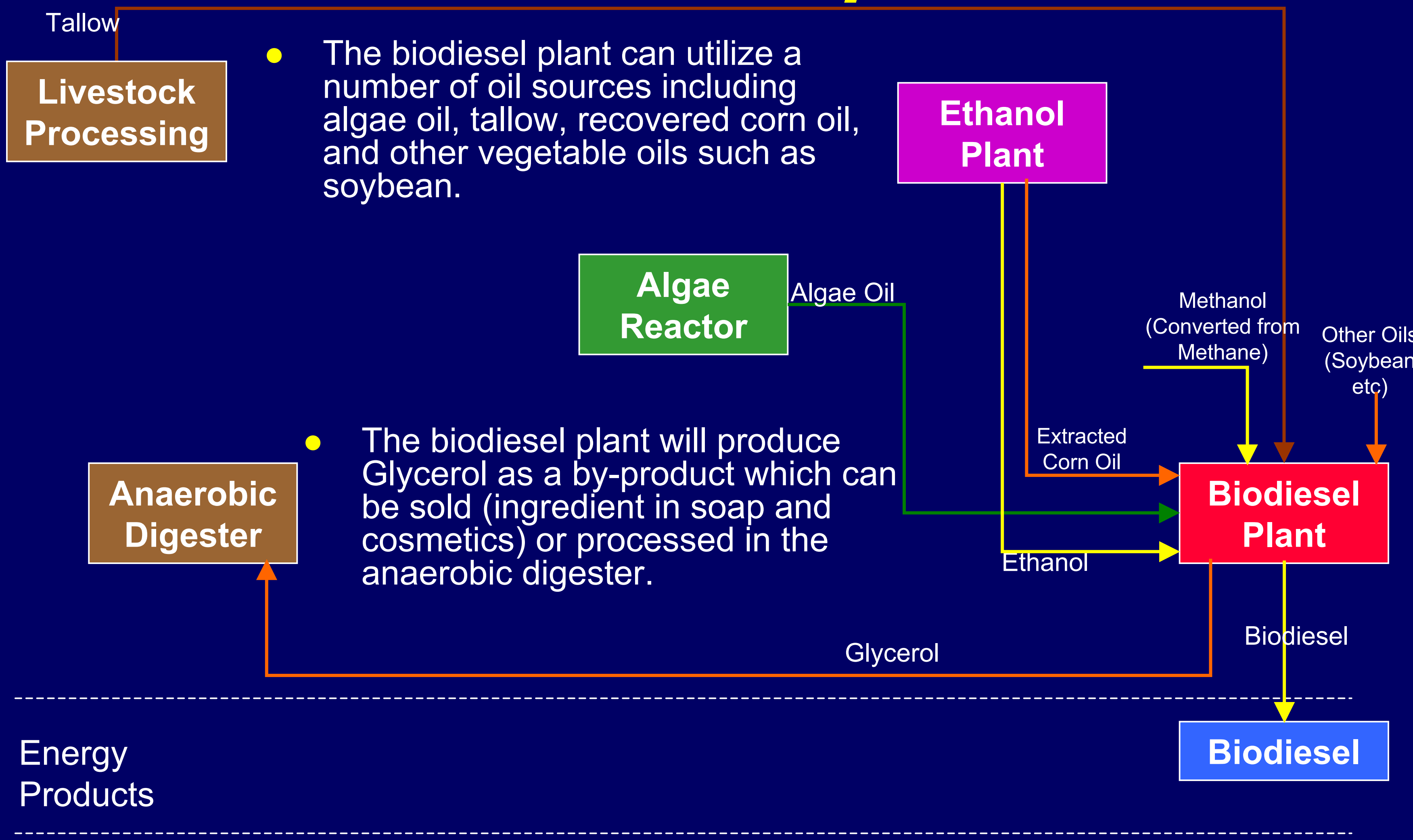






Biodiesel Subsystem

- The biodiesel plant can utilize a number of oil sources including algae oil, tallow, recovered corn oil, and other vegetable oils such as soybean.
- The biodiesel plant will produce Glycerol as a by-product which can be sold (ingredient in soap and cosmetics) or processed in the anaerobic digester.



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Biodiesel Plant

- Biodiesel is a fuel that has many of the same characteristics as normal petroleum diesel including similar energy content, improved lubricity and higher flash and cloud points.
- Biodiesel is derived from "cutting" triglycerides found in vegetable oils and animal fat using simple alcohol in the presence of an alkali catalyst (transesterification).
- The first diesel engines were designed to run on peanut oil so that developing countries could rely on agriculture infrastructure.
- Growth in the biodiesel industry will be limited by the access/cost of oil sources. Many of the vegetable oils (soy, canola, etc.) used today take many acres to grow and have food value. Algae oil may offer improved yields.

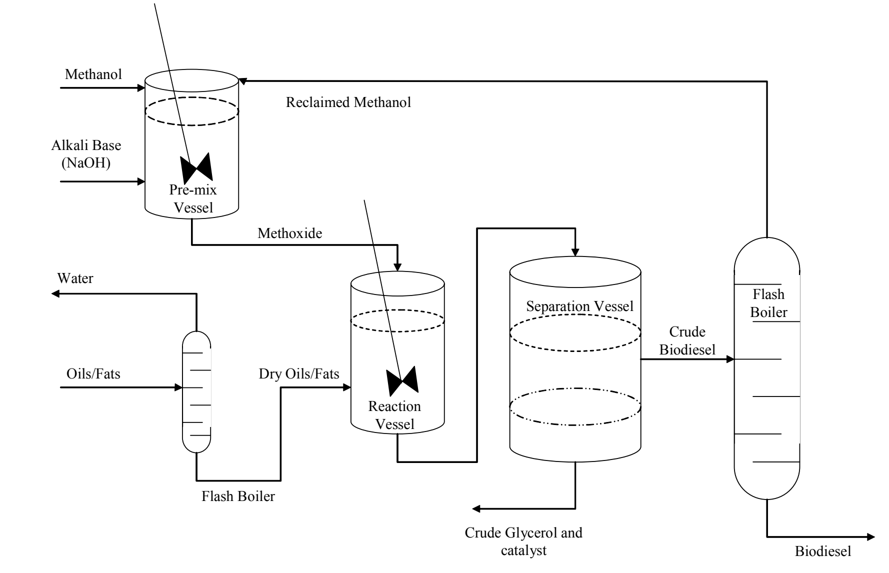
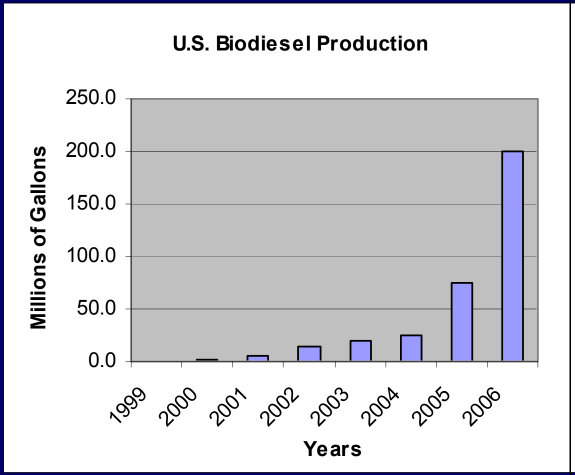
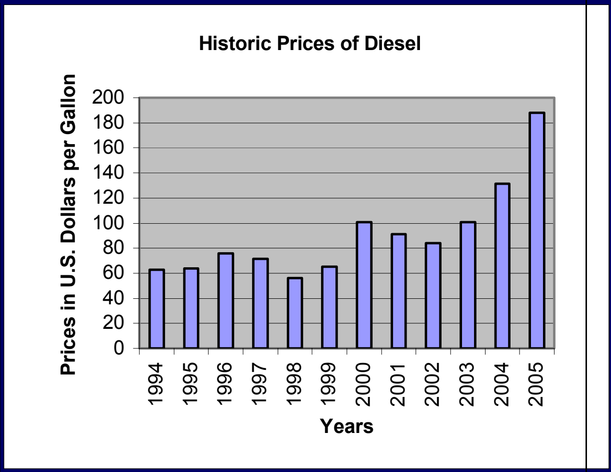


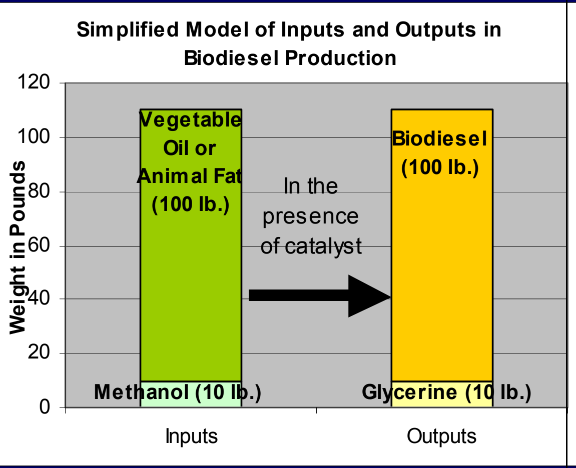
Fig. BD-2: Simplified Production Process Schematic

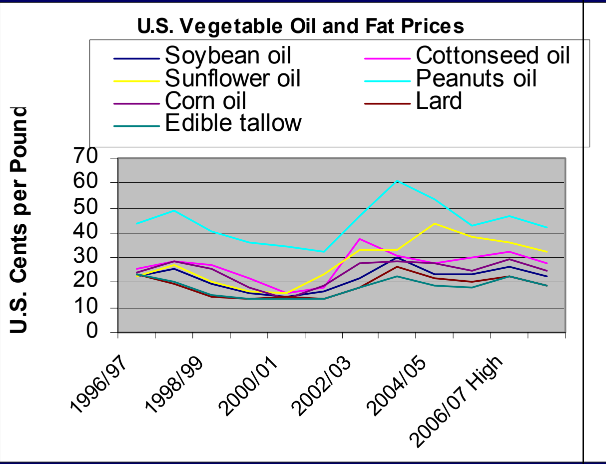
Biodiesel

Biodiesel Market and Process Data









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Expected Benefits

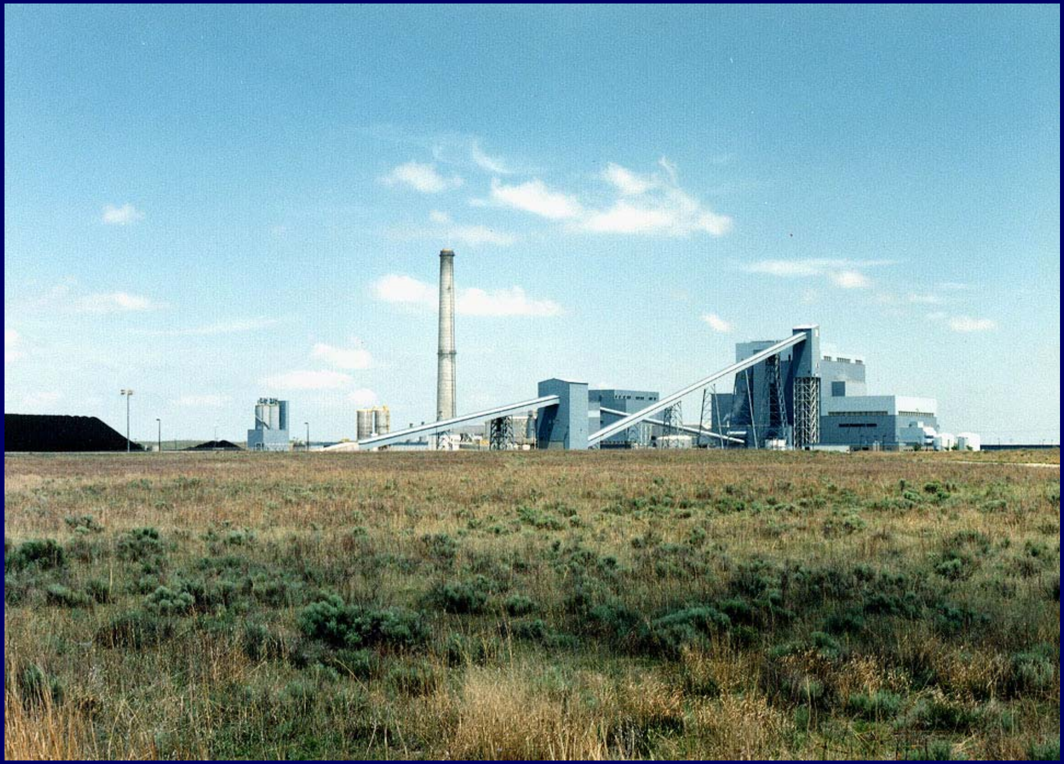
- Efficiencies of integration
  - Improved economics over stand-alone system
  - Water re-use
  - Utilized waste streams
  - Flue gas
- New job creation
- Additional regional economic activity
- Shared human resources

Next Steps

- Finalization of Integrated Bioenergy Report for Sunflower, the Kansas Bioscience Authority, and NISTAC
- Founding partners formation and meeting
  - Business structure methodology
  - Local participation
  - Unlocking farm equity for value-added agriculture
- Technology and financial partner selection
- Subsystem feasibility studies
  - Economic
  - Engineering for integration
  - Environmental / water
- Ethanol plant construction 2007

Holcomb Expansion Project

Holcomb Station - 1983

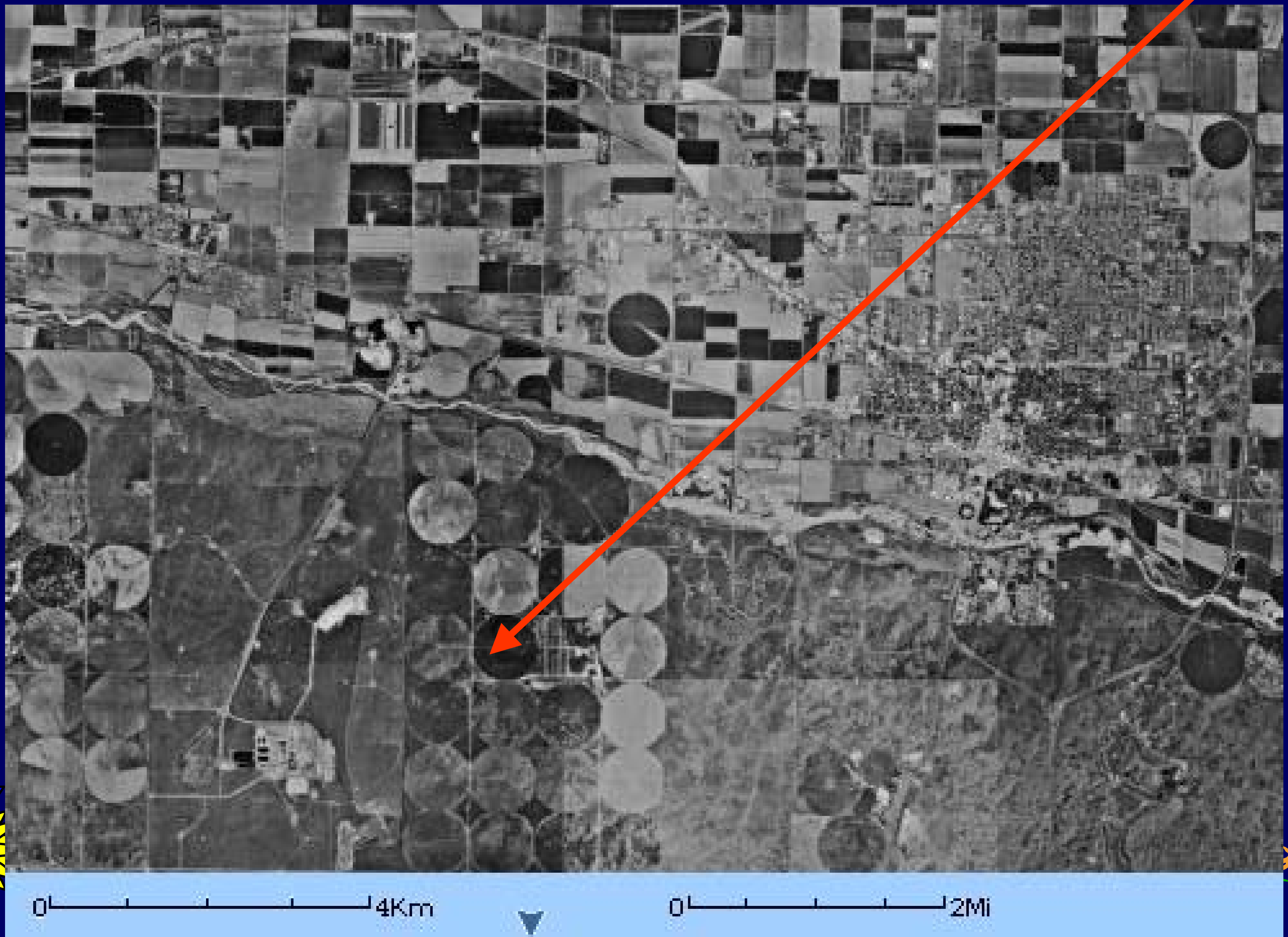


- –360 MW Capacity
- –PRB (Powder River Basin) Coal-fired
- –Low NOx burners
- –Spray dryer for SO2/Acid Gas control
- –Baghouse for particulate control

Typical Base Load Emissions:

150 ppm NO_x * 50 ppm SO_2 * 25 ppm CO * 16 % Moisture * 12% CO_2

Holcomb Project Site



Project Background

- **"Maximize the value of Sunflower's assets for the benefit of the Member Systems"**
  - **Strategic planning revealed added value available at Holcomb Station**
- **Sunflower sought to develop site potential by seeking outside investments in new plant with Sunflower operating and maintaining new generation**
  - **Goal was to find other utilities that needed long-term baseload power supply**

Project Benefits for Sunflower

- New revenue sources
  - » Development fees
  - » Common facilities agreements
  - » Operation and maintenance agreements
- Lower average fuel and operating expenses
- Project benefits will offset expenses that otherwise would have been charged to Member Systems

Alternative Design Considerations

- Many design factors and generation technologies were considered
  - Engineering evaluation of type, size, and duty-cycle of capacity needed
  - Economic evaluation of the fuel choices
  - Evaluation of alternatives for the new capacity addition
  - Preserving existing plant infrastructure investment was a prime directive
  - Evaluation of environmental impact essential factor in selection

Alternative Design Considerations

- Renewable energy sources are not suitable for base-load applications
  - » Wind is politically correct but is not technically correct for base load
  - » Can provide energy used to offset natural gas purchases
- Natural-gas based fuel costs too high for base-load energy
  - » Natural gas is suitable for peaking and intermediate load applications
- Circulating fluidized bed units typically 250 MW or smaller
  - » CFB is less fuel efficient and more costly to build and to operate than super-critical pulverized-coal
- Integrated gasification combined-cycle (IGCC) generation not quite ready for base-load requirements:
  - » Units are inherently more expensive to construct
  - » Have substantially lower availability and substantially higher operating costs
  - » No reference plant for PRB fuels has been developed

Design Selection

Decision made to use super-critical pulverized coal-based generating units using low-sulfur coal

- Supercritical steam cycle is the most energy efficient design
- PRB coal is by far the most available and economical coal source
- Pulverized coal is the only demonstrated technology available

Project Participants

Sunflower Electric Power Corporation
A Touchstone Energy® Cooperative

Six Member Systems serving more than 122,500 consumers in central and western Kansas

TRI-STATE
Generation and Transmission Association, Inc.
A Touchstone Energy® Cooperative

Forty-four Member Systems serving more than 1.2 million consumers in Colorado, New Mexico, Wyoming, and Nebraska

Golden Spread Electric Cooperative, Inc.
A Touchstone Energy® Cooperative

Sixteen Member Systems serving more than 185,000 retail consumers in the Oklahoma Panhandle and 24% of Texas

Project Structure

- Sunflower and Tri-State signed agreements to build two generating units
- Golden Spread signed agreement for 400 MW investment in eastern grid unit
  - Additional participants will consist of Sunflower and other regional public utilities
  - Sunflower will provide up to 150 MW to Member systems and MKEC (Aquila's former Kansas Electric properties)
- Total EPC cost of the three plants is expected to be $3.6 billion
  - Tri-State will manage the construction activities
  - Pending final approvals by Sunflower and Tri-State boards, Bechtel Corporation will be the EPC contractor.
    - » Schedule, price and performance guaranteed

Project Economic Benefits

- Over a 35-year period will exceed $8 billion

- Construction Impact (6 year period)
  - 3,600 jobs created (direct and induced) in Kansas
  - Annual payroll of more than $116 million

- Continuing Impact (35-year study period)
  - More than 400 full-time jobs (direct and induced) created in Kansas
  - Annual payroll of more than $24 million

Studies completed by Dr. Ralph Gamble, a noted Fort Hays State University Economics professor

Holcomb Station - 2013

Artist's Rendering

Water Use – Zero Discharge

- Water supply for each new plant is expected to be about 9,000 acre-feet to be diverted from the High Plains Aquifer (Ogallala).
  - Units will use about 25,000 acre-feet agriculture water rights currently owned by Wheatland Electric Cooperative (Wheatland)
  - 2200 acre-feet appropriation rights for industrial use
  - Annual water diverted will be 40% less than that currently diverted of the number of acre feet diverted from Ogallala
- No discharge of waste water from facility
  - Existing water and waste water treatment facilities will be used
  - Some additional storage basins may be required
  - New RO and other water treatment by Wheatland

Land Use

- Expand existing 120-acre dry industrial monofill to 190 acres to accommodate additional volumes from additional units (15.4 million cubic yards)
  – Landfill application filed March 2005
  – Application under active consideration June 2006
  – Expect draft permit for public comment Fall/Winter 2006
- Develop existing 'plant' site for generating units
- Additional substation development
- Currently farmed acres will be re-seeded to native grasses
  – Once established, nearly all the acres will be grazed
  – Process will take several years to accomplish

Air Emissions

- **Construction of the new plants will cause concerns about to the impact this project will have on the environment.**
  - **Sunflower and its partners are committed to operating the plants in strict compliance with all applicable federal and state environmental laws**
- **Sunflower filed an application for a construction air permit with the KDHE in February 2006**
  - **Public hearing will be held to take comments from the public expected in Fall 2006**
  - **The air permit will establish specific limits emissions for all regulated pollutants**

Air Emissions

- Plant is located in an area classified as attainment for all criteria pollutants, and that will not change
- Air pollution control equipment will be designed and built to meet all state and federal requirements for all regulated emissions

Unit Design Features

- 3 x 700 MW super-critical PRB coal-fired units
- Lime spray dryer flue gas de-sulfurization (LSD-FGD) for SO_2
- Lo-NO_X burners (LNB), over-fire air (OFA), and Selective Catalytic Reactors (SCR) for NO_X
- Fabric filter for filterable particulate matter (PM)
- Activated Carbon (PAC) for mercury control
- Construction is expected to begin in mid-2007
  - Construction period for each unit is 42-48 months
  - Total construction period of up to 96 months

Proposed Emission Limits

- SO_2 – 0.10 lb/mmBtu (30-day rolling average)
  - 0.5% sulfur limit (annual basis)
  - 1.23 lb/mmBtu boiler outlet limit
- NO_X – 0.07 lb/mmBtu (30-day rolling average)
- PM – 0.012 lb/mmBtu (30-day rolling average)
- CO – 0.150 lb/mmBtu
- VOC – 0.0035 lb/mmBtu
- Pb – 16.4 lb/TBtu
- Hg – NSPS limit
  - 0.097 lb/mmBtu for low sulfur sub-bituminous coal
  - 0.021 lb/mmBtu for low-sulfur western bituminous coal

Dispersion Modeling Results

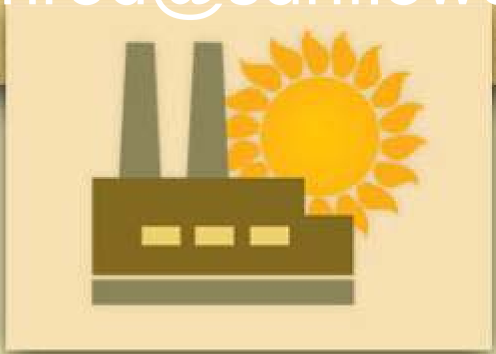
- NO_X, CO, Pb concentrations did not exceed 'screening' level concentrations
- SO_2 and PM_{10} - Refined analysis assuming simultaneous full-load operation of all units
  - No exceedance or near approach to any time-average NAAQS or PSD increment for SO_2 and PM_{10}.

What's Next?

- Completion of final design details
- Execute agreements with EPC Contractor
- Public information meetings throughout the region (July – September)
- Open house @ Holcomb High School – August 24, 2006
- Pubic hearing on Air Permit – October 2006
- Final permit decision – Fall 2006
- Financial closing – first quarter 2007
- Construction commence – second quarter 2007
- Construction complete – mid-2013 to mid-2014

For more information:

Wayne Penrod
Executive Manager, Environment
Sunflower Electric Power Corporation
PO Box 1020
Hays, KS 67601
785-623-3313
wepenrod@sunflower.net



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www.sunflower.net

Eastern Plains Transmission Project