CHP in the U.S. Ethanol Industry

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Overview

- EPA CHP Partnership
- The Ethanol industry in the United States
- Why CHP for Ethanol
- What are the critical factors impacting CHP
- Case study

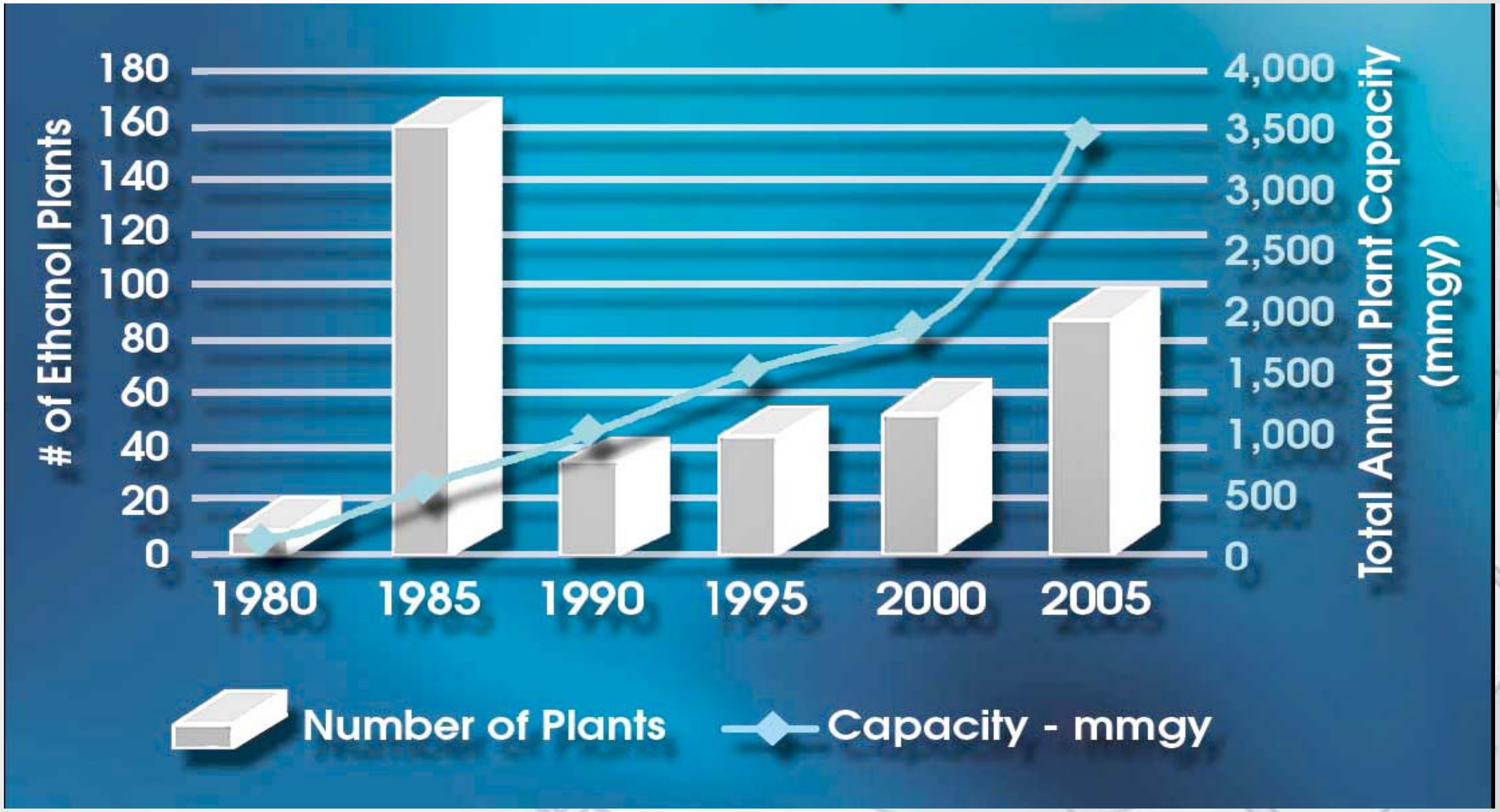
What is the EPA CHP Partnership?

- Voluntary program that seeks to reduce the environmental impact of power generation by promoting the use of CHP.
- Provide services and tools for Partners to assist with CHP project development, regulatory barriers, market transformation.
- Actively providing education/ outreach and direct project assistance to promote CHP in ethanol facilities since 2003.
- EPA Combined Heat & Power Partnership
  – www.epa.gov/chp

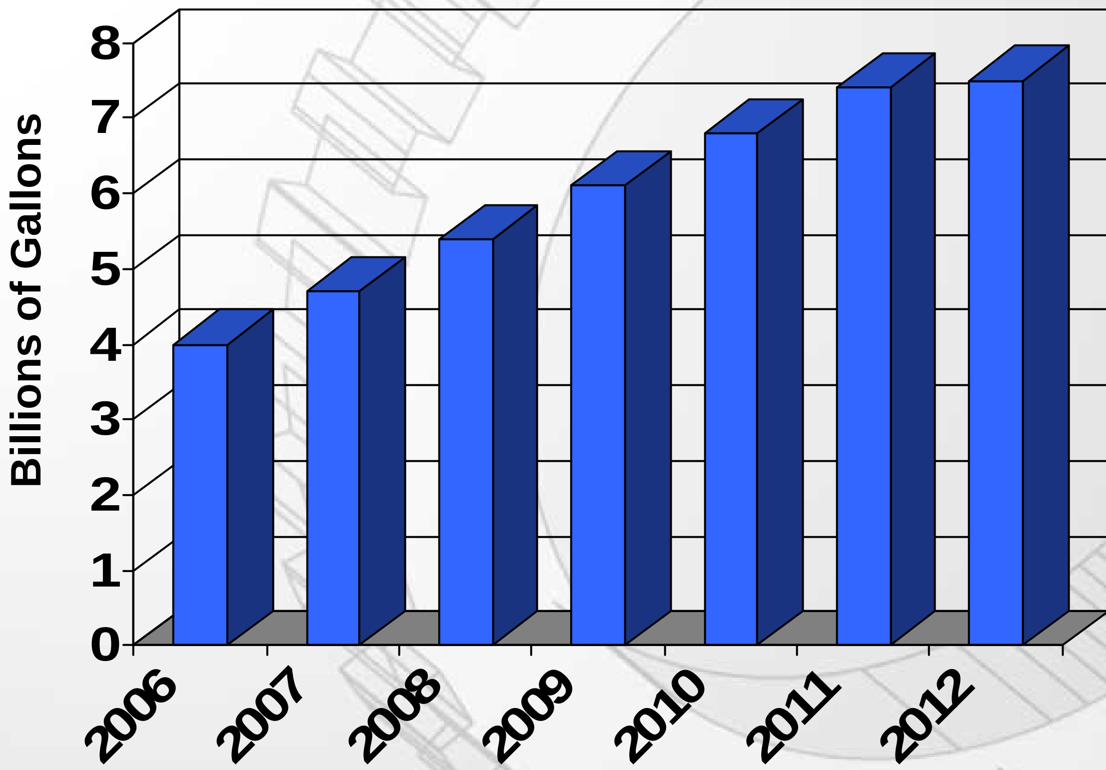
Ethanol Drivers

- Originally promoted in early 1980s as an octane enhancer and gasoline product extender
  - Resulted in a many very small, very inefficient ethanol producers – most shut down
- Now used as an oxygenate for compliance with federally mandated programs
  - Replacement for MTBE (22 states have banned MTBE as of 2005)
- Increased value perceived as gasoline prices climb
- Renewable Fuels Standard will dramatically increase market demand

U.S. Ethanol Plants and Capacity



The Renewable Fuels Standard Will Require the Doubling of Ethanol Capacity by 2012



The Ethanol Industry Is Poised for Significant Growth

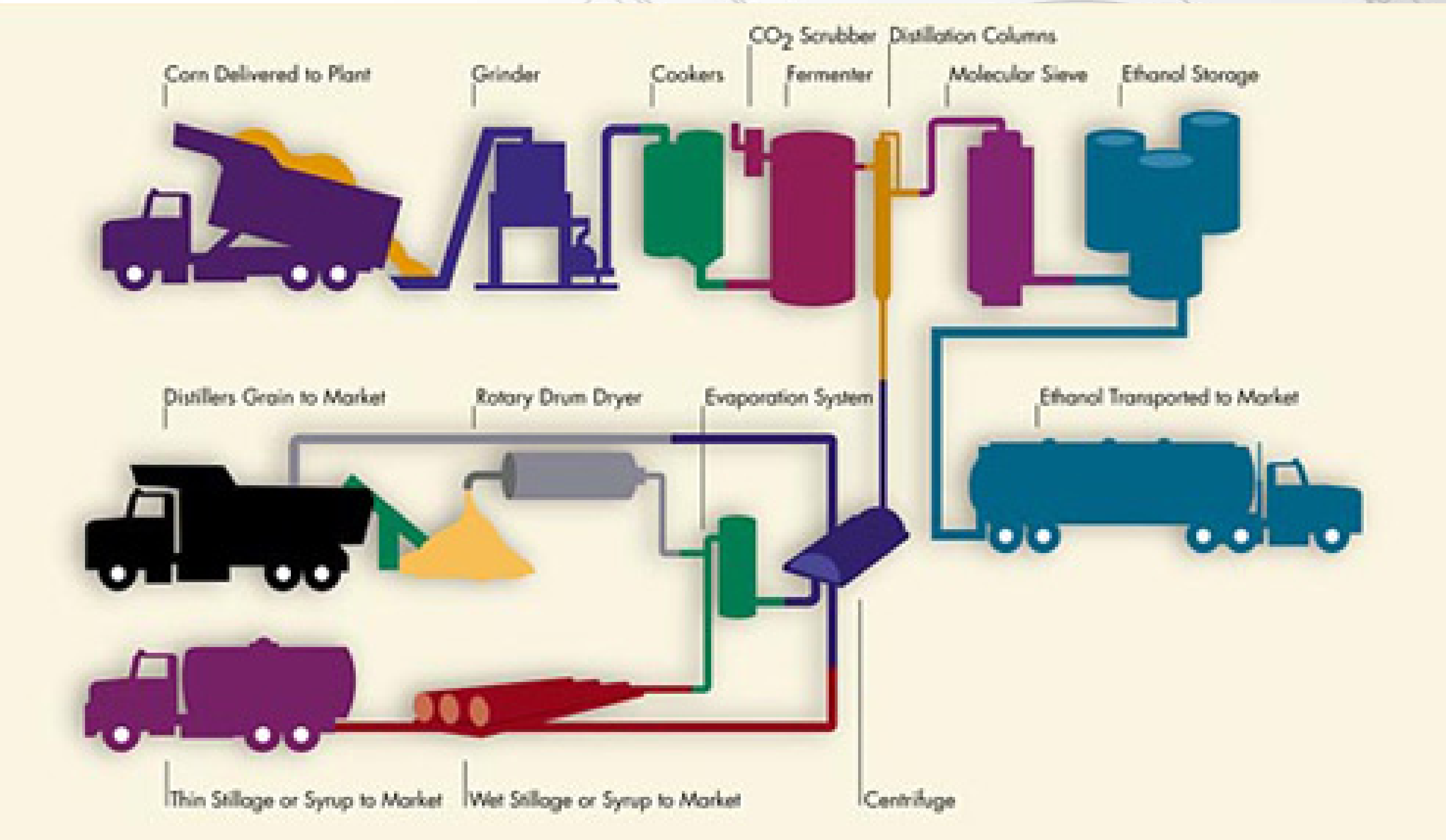
- The industry produced 3.4 billion gallons of ethanol in 2004
- The Renewable Fuels Standard will provide a market for nearly 8 billion gallons by 2012
- There are currently 90 operating plants with 20 under construction or expansion
- The industry will invest an estimated $6 billion to build 4.3 billion gallons of new ethanol capacity by 2012

Ethanol Plants in North America

How Is Ethanol Produced?

- Wet Corn Milling
  - Large “chemical” plant
  - Ethanol is one byproduct
- Dry Corn Milling
  - Dedicated ethanol production
  - Small to medium size range
  - Fastest growing market segment
- Cellulosic Ethanol
  - Emerging process
  - Enables wide range of feedstocks

Dry Corn Mill Process



Source: Renewables Fuel Association

Why CHP Is a Good Fit for Dry Mill Ethanol Plants?

- Energy is the second largest cost of production for dry mill ethanol plants
- Electric and steam demands are large and coincident
  - Typical power demand is 2 to 6 MW
  - Typical steam use is 40 - 150,000 lb/hr
- Electric and steam profiles are relatively flat
- Operating hours are continuous – 24/7
- Energy costs are rising

What Can CHP Offer the Ethanol Plant?

- Can yield energy cost savings from 10 to 25 percent
- Reliable electricity and steam generated on-site
- Provides a hedge against unstable energy costs
- Improves competitiveness
- Reduces greenhouse gas emissions and other environmental impacts

CHP Options for Ethanol Plants

- Boiler/Steam Turbine CHP
  Short payback, limited electric capacity
- Gas Turbine CHP
  If sized to electricity load, additional steam needed
- Gas Turbine/Supplemental Firing CHP
  Can be sized to meet both steam and electric loads
- Biomass Fueled
  Least cost fuel but capital intensive; Tax credit for biomass electricity; Green electricity if sold
- Integrated VOC destruction
  Produce power with steam from Thermal Oxidizer, incorporate VOC destruction in turbine or boiler systems

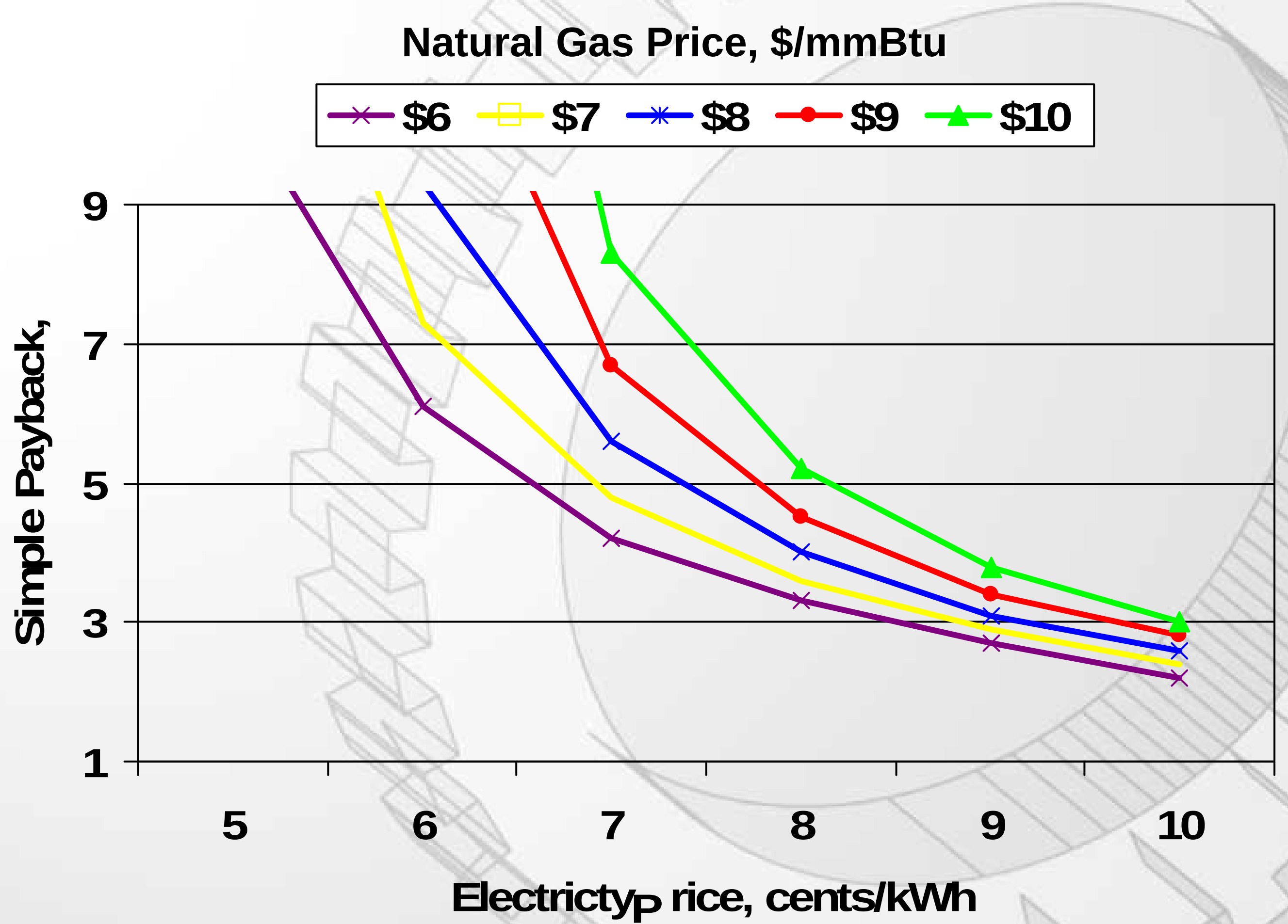
What Are the Economics of CHP for the Ethanol Industry?

- Considered “typical” 50 mmgal/yr dry mill plant
- Looked at gas turbine with duct fired HRSG and coal boiler with steam turbine
- Calculated operating cost savings and simple payback

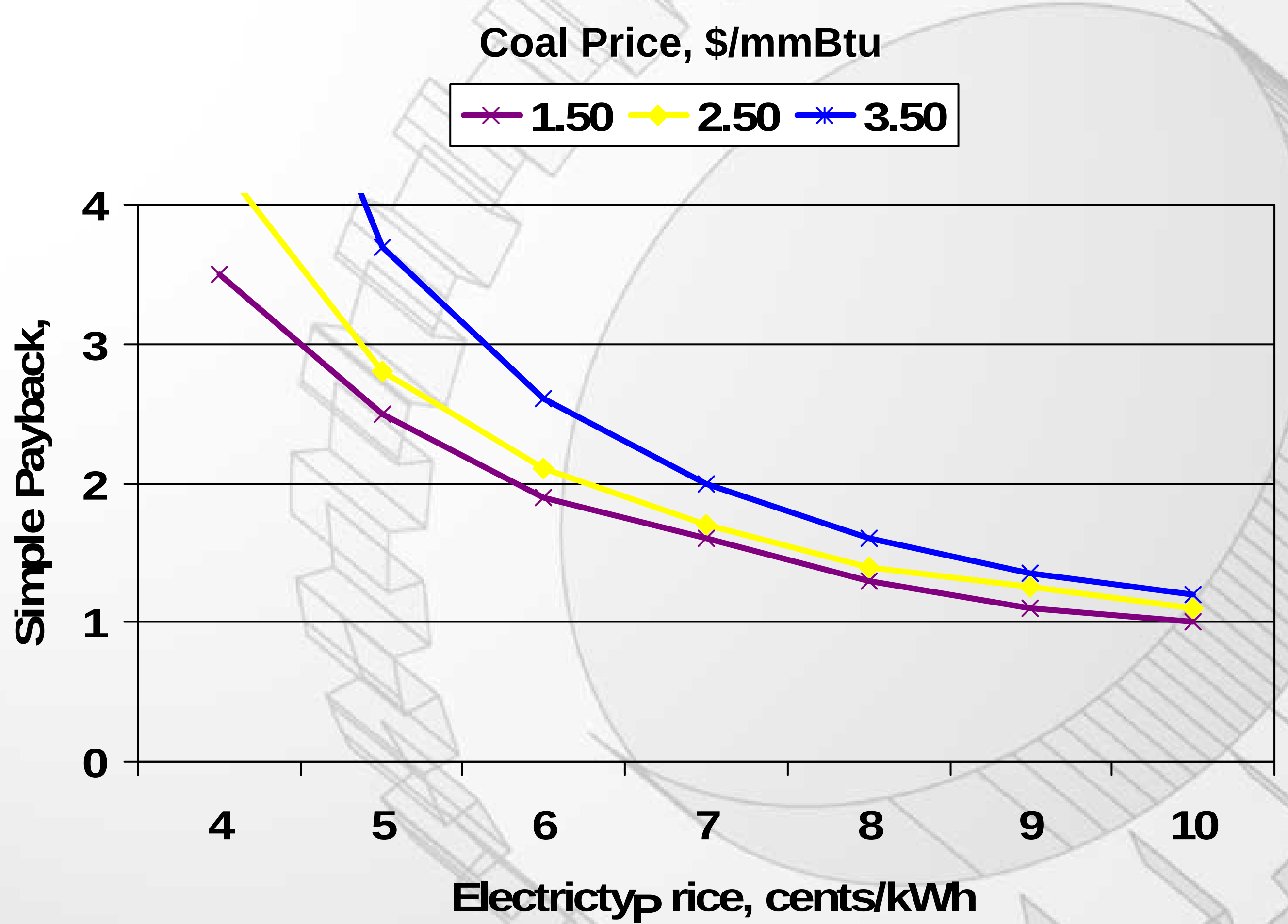
Plant Operating Assumptions

Plant Capacity, mmgal/yr	50
Operating Hours	8760
Electric Use, kWh/gal	0.96
Annual Electric Use, MWh	48,180
Baseload Electric Demand, MW	5.5
Steam Use, lb/gal	19.3
Steam Use, lbs/hr	110,000
Annual Steam Use, mmlbs	963,600
Annual Boiler Fuel Use, mmBtu	1,206,300
Annual Drier Fuel Use, mmBtu	605,000
Electric Costs, $/kWh	0.06 – 0.10
Gas Costs, $/mmBtu	6.00 to 10.00
Coal Costs, $/mmBtu	1.50 to 3.50

Sensitivity to Electricity and Natural Gas Prices - Gas Turbine CHP w/Duct Firing



Sensitivity to Electricity and Coal Prices - Boiler/Steam Turbine CHP



CHP at U.S. Ethanol Plants

- CHP is currently operating at five plants
  - U.S. Energy Partners, LLC, Russell, Kansas – 15 MW gas turbine
  - Northeast Missouri Grain, LLC, Macon, Missouri – 10 MW gas turbine
  - Adkins Energy, LLC, Lena, Illinois – 5 MW gas turbine
  - Otter Creek Ethanol, LLC, Ashton, Iowa 7 MW gas turbine
  - East Kansas Agra Energy, LLC, Garnett, Kansas – Thermal Oxidizer/HRSG with 2 MW steam turbines
- CHP is under consideration for a number of new and expanding plants
  - Biomass CHP systems -
  - Coal boiler/steam turbine systems incorporating VOC destruction

Challenges to Implementing CHP in the Ethanol Industry

- Unfamiliarity with technologies
- Not normally offered by plant engineering and designer community
- Lack of capital
- Questions about permitting
- Concern about natural gas prices
- Other pressing priorities

Critical Industry Challenges

- Existing ethanol production is concentrated in the Midwest
  - Historically moderate electricity prices
  - Served by electric cooperatives and municipal utilities
- Half of the plants are farmer-owned cooperatives
  - Marginal credit ratings
- Plants are designed and constructed by a limited group of suppliers
  - "Cookie-cutter" designs
- Financiers encourage cookie cutter designs to minimize risk

Case Study

The Russell Energy Center

Russell, Kansas

U.S. Energy Partners, LLC/ City of Russell

- 40 million gallons per year plant in Russell, Kansas
- Two gas turbines – 15 MW electric, 65,000 lbs/hr steam
- Joint project between plant and municipal utility
- 10 to 20% savings on process steam

Cost Sharing Strategies: The Utility's Concerns

- Business Climate
  - RTO's will hasten negotiations for transmission rights
  - Transmission costs will increase
  - Reliability concerns are a high priority with customers
- Planning for Load Growth
  - Many RECs and municipals project shortfalls in baseload capacity
  - On-site power at industrial customers' sites can shore up resources for R&C base
- General unfamiliarity with 1 – 50 MW CHP systems

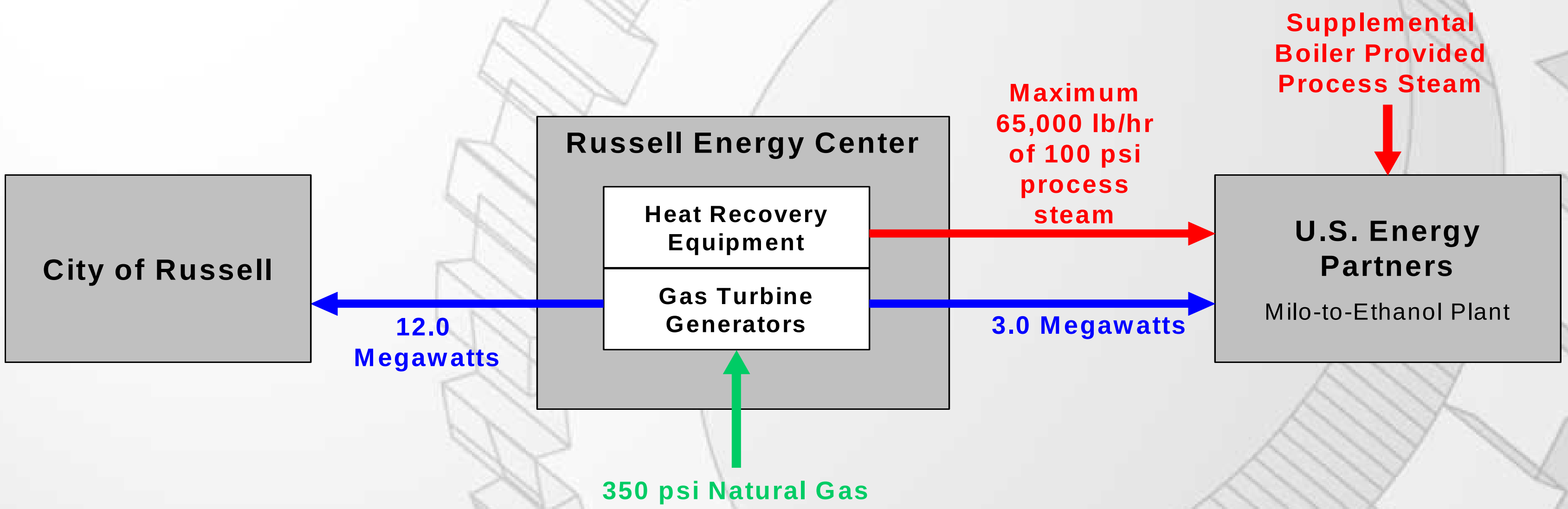
Cost Sharing Strategies: The Thermal Host's Concerns

- Business Climate
  - Operations increasingly sensitive to disturbances in power supply
  - Energy price volatility putting pressure on profits
  - Energy costs now visible at CFO level
- Why hasn't CHP become more mainstream?
  - Opportunity costs associated with large capital purchases
  - Energy plant operations not always a core competency
  - Difficulties with grid interconnection
  - Fuel price risk

The Russell Energy Center Solution

- Equipment and installations costs shared
  - Utility owns CT genset
  - Ethanol plant owns waste heat recovery equipment
  - Installation costs shared 50/50
- The utility operates the facility
  - Allows ethanol plant to focus on core competencies
  - Utility has option to wheel excess capacity into their system
  - The utility can negotiate more favorable fuel prices
  - Baseload capacity is acquired for central plant prices
- Energy cost savings create mutual benefits
  - System efficiencies of 75 to 90% minimizes operational costs
  - Steam contracted for at a discounted rate
  - Payback periods accelerated

U.S. Energy Partners, LLC/ City of Russell



The Path Forward

- Evaluating environmental, economic, and energy benefits of CHP at ethanol plants
- Educating and networking with plants, developers, and other key players
  - Awareness high among users
  - Focusing on engineer/developers
  - Educating financial sector on competitive benefits of CHP
- Need to explore potential to burn VOCs in gas turbine CHP systems

Appendix

- Detailed Economic Assumptions and Results

Gas Turbine CHP Systems Assumptions

	Gas Turbine w/Duct Firing
Capacity, MW	5.2
Run Hours	8500
Gas Turbine Fuel, mmBtu/hr	67.2
Duct Burner Fuel, mmBtu/hr	49.8
Steam Output, lb/hr	76,600
Power to Steam Ratio	0.23
O&M Costs, $/kWh	0.008
Capital Costs	
Turbine Genset, $/kW	415
HRSG, $/kW	200
Interconnect, $/kW	60
Misc Equipment, $kW	80
Engineering, installation, etc, $/kW	450
Total Installed Cost, $/kW	1,205

Gas Turbine CHP w/Duct Burner – Energy Results

	W/O CHP	W/ CHP
Purchased Electricity, MWh	48,180	3,980
Generated Electricity, MWh	0	44,200
Boiler Steam, mmlbs	963.3	318.3
Boiler Fuel, mmBtu	1,204,500	397,866
CHP Steam, mmlbs	0	645.3
CHP Fuel, mmBtu	0	986,275
Total Fuel, mmBtu	1,204,500	1,384,141

Gas Turbine CHP w/Duct Burner – Financial Results

	W/O CHP	W/ CHP
Purchased Electricity, 1000 $	3,373	289
Boiler Fuel, 1000 $	9,636	3,183
CHP Fuel, 1000 $	0	7,890
Energy Costs, 1000 $*	*13,009*	*11,362*
O&M Costs, 1000 $	0	354
Standby Charges, 1000 $ ($3/kW)	0	187
Total Operating Costs, 1000 $	*13,009*	*11,903*

* Does not include DDGS drier fuel

Operating Savings = $1,106,000

(based on $0.07/kWh electricity and $8.00/MMBtu gas)

Gas Turbine CHP w/Duct Burner – Payback

Retrofit at existing plant:
Capital Costs = $6,266,000 Payback = 5.6 yrs

New plant:
Capital Costs = $5,366,000 Payback = 4.9 yrs

CHP System	$6,266,000
- Boiler credit	$ 900,000
	$5,366,000

Boiler/Steam Turbine CHP System Assumptions

	Boiler/Steam Turbine
Electric Capacity, MW	3.0
Run Hours	8760
Boiler Fuel, mmBtu/hr	151.3
Steam Output, lb/hr	110,000
Overall Efficiency, % (HHV)	79
Power to Steam Ratio	0.08
O&M Costs, $/kWh	0.004
Incremental Capital Costs	
Steam Turbine Genset, $/kW	400
Incremental Boiler Costs, $/kW	325
Total Incremental Cost, $/kW	725
Coal Price, $/mmBtu	2.50

Coal Boiler/Steam Turbine CHP – Energy Results

	W/O CHP	W/ CHP
Purchased Electricity, MWh	48,180	22,680
Generated Electricity, MWh	0	25,500
Boiler Steam, mmlbs	963.3	963.3
Boiler Fuel, mmBtu	1,204,500	1,325,000

Coal Boiler/Steam Turbine CHP– Financial Results

	W/O CHP	W/ CHP
Purchased Electricity, 1000 $	3,373	1,588
Boiler Fuel, 1000 $	3,011	3,316
Energy Costs, 1000 $*	*6,384*	*4,904*
O&M Costs, 1000 $	0	102
Standby Charges, 1000 $ ($3/kW)	0	108
Total Operating Costs, 1000 $	*6,384*	*5,114*

* Does not include DDGS drier fuel

Operating Savings = $1,270,000

(based on $0.07/kWh electricity and $2.50/MMBtu coal)

Coal Boiler/Steam Turbine CHP– Payback

Incremental Capital Costs = $2,175,000

Steam Turbine	$1,200,000
Incremental Boiler	$ 975,000

Payback = 1.7 yrs

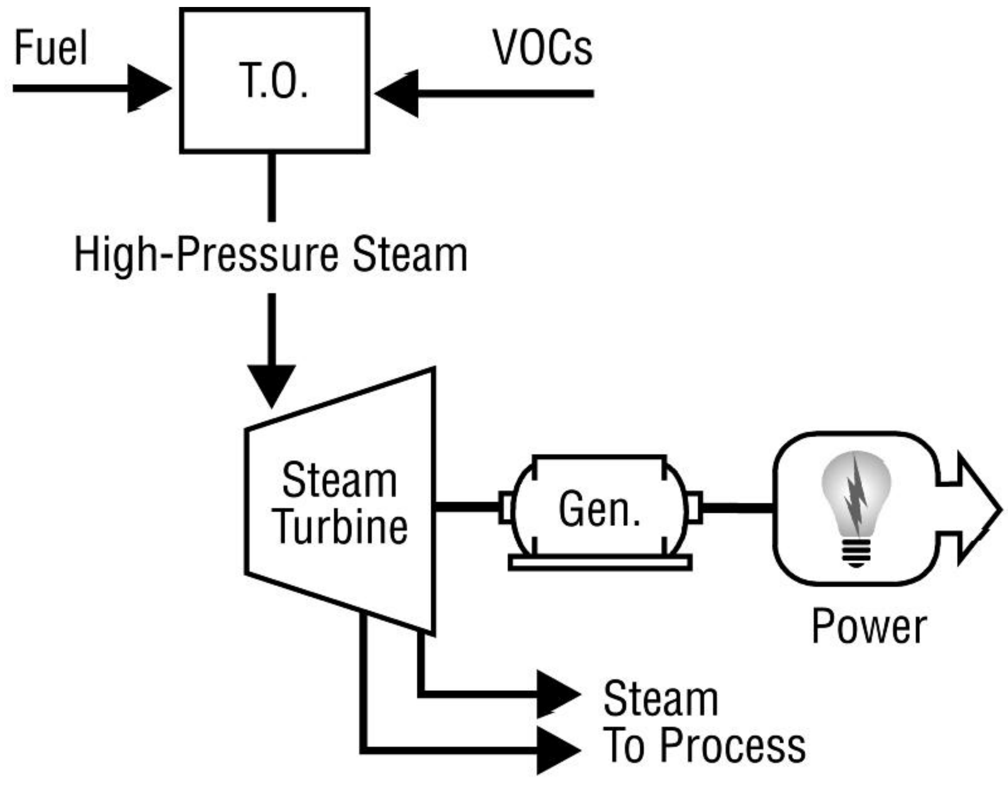
Critical Issues Affecting CHP Economics

- Reasonable projections of fuel and retail electricity prices are key
- Understanding and accounting for specific electric rate structures is critical
  - Demand rate
  - Standby tariffs
- Site requirements will impact capital costs
  - Space and access
  - Permitting
  - Interconnection

Critical Issues Affecting CHP Economics (continued)

- In general, CHP system should be sized to supply within-the-fence energy needs
  - Difficult to sell excess power
  - However, explore opportunities to partner with utility
- Increased thermal utilization improves economics
  - Increasing thermal output displaces less efficient boiler output
- Consider the entire range of potential savings
  - Credits for displaced boiler capacity
  - Are there operating savings from increased reliability?

Thermal Oxidizer/Steam Turbine CHP



Gas Turbine/VOC Destruction CHP