Edwardsport IGCC

Purdue University – ME 422 Power Plant Technology
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Edwardsport IGCC Project

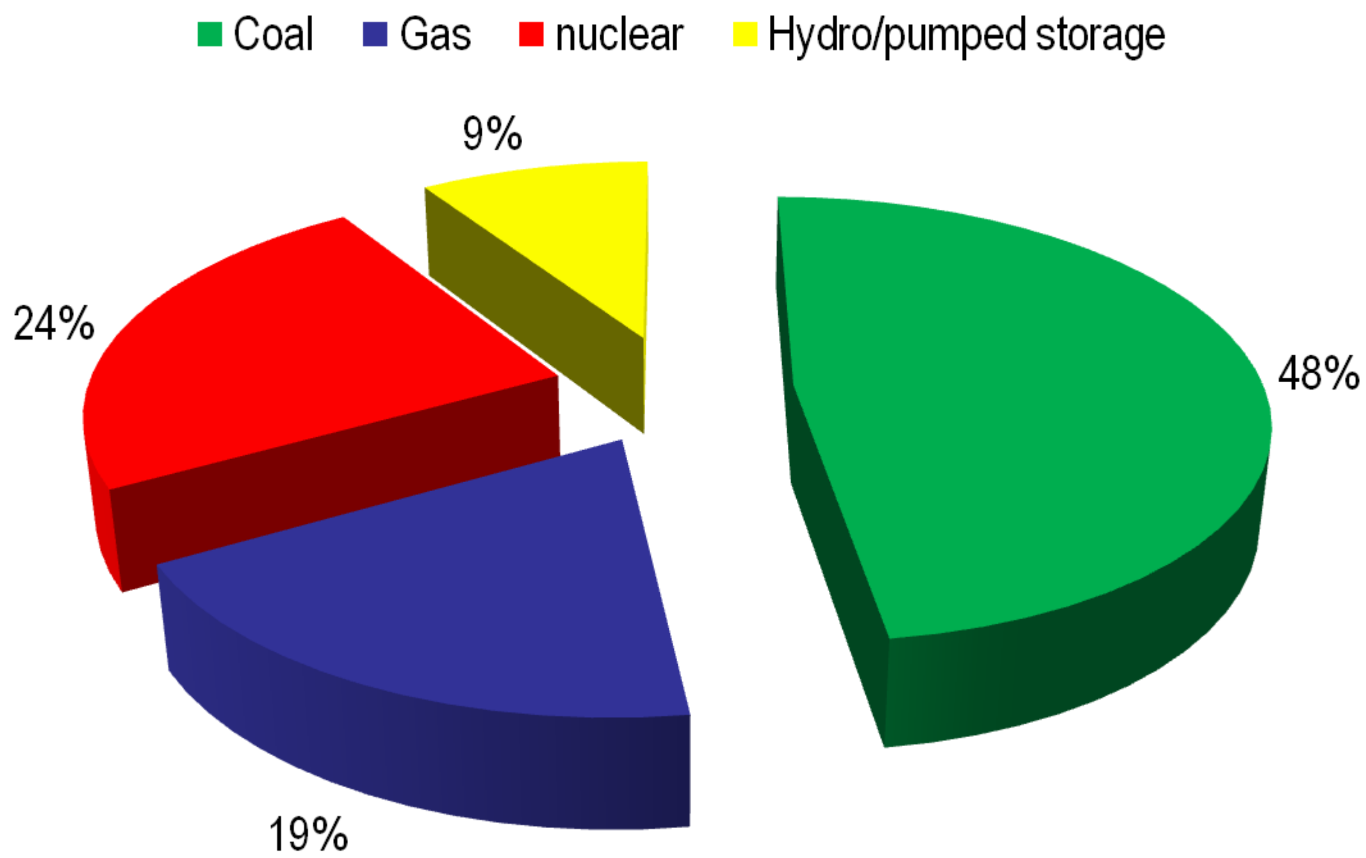
- Who is Duke Energy
- Edwardsport Project Background, Highlights and Status
- What is Gasification?
- Edwardsport Project Background – Why IGCC?
- IGCC vs. Pulverized Coal. A Comparison
- Equipment make-up of an IGCC
- Operational Challenges
- Why not Other Renewables? Wind, Solar
- Questions

Duke Energy Fast Facts

- Headquarters => Charlotte, N.C.
- Employees => 18,000*
- 4,000,000 Customers*
  - 2,400,000 in the Carolinas
  - 825,000 in Ohio/KY
  - 775,000 in Indiana
- Revenue => $12.7 billion**
- Assets => $51.6 billion*
- U.S. Generating Capacity Approx. 36,000 MW.
  - Approx. 28,000 MW regulated
  - Approx 8,000 MW non-regulated

*As of June 30,2008
** As of December 30, 2007

Regulated Generation Mix



New Generation in Design or Under Construction

- IGCC
  - Edwardsport, IN -   632 MW – On line 2012
- Pulverized Coal
  - Cliffside Unit 6, near Gaffney, NC 825MW – On Line 2012
- Natural Gas Combined Cycle
  - Buck, 620 MW near Rowan County, NC: On Line 2011 - 2012
  - Dan River, 620 MW near Rockingham County, NC: On Line 2012 - 2013
- In December of 2007 Duke Energy submitted a construction and operating license application to the NRC for a proposed 2,000 MW Nuclear Station in South Carolina. If approved and if the company decides to construct, the station would come on line sometime in the next decade.

Edwardsport IGCC Project - Highlights

- Net Output: 632 MW
- Heat Rate: < 9,000 Btu/kWH
- Target Availability: 85%
- Low Emissions Profile
- Total Installed Cost: $2.35 billion
- Bulk Materials:
  - 1MM cubic yards of soil to be moved
  - 94,000 cubic yards of concrete
  - 12,000 tons of structural steel
  - 330,000 linear feet of piping
  - 3.6MM feet of electrical cable
- Projected Commercial Operation Date: Summer 2012

Project Milestones and Status

- Initiated Project Development – June 2004
- Initiated Front End Engineering and Development (FEED) Study – February 2006
- Received Federal Investment Tax Credit Award ($133.5 Million) – November 2006
- FEED Study Report submitted to Indiana Utility Regulatory Commission (IURC) - April 2007
  - Total Installed Cost => $1.985 billion
  - Schedule => 47 Months FNTP to substantial completion
- Received Duke Energy Board of Director Approval – October 2007
- Received Certificate of Public Convenience and Necessity (CPCN) Order from IURC– November 2007
  - Included condition regarding study of CO_2 capture & sequestration

Project Milestones and Status (cont)

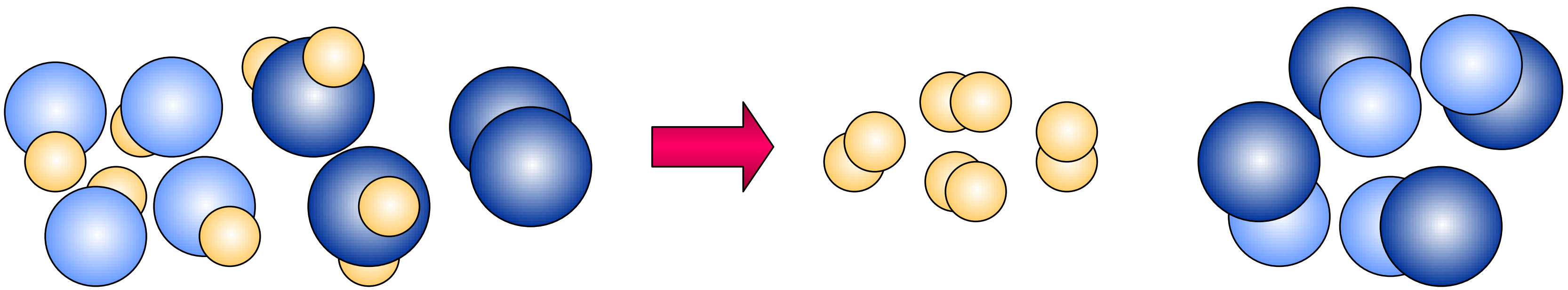
- Received Air Permit on January 25, 2008
- Began Construction on March 11, 2008
- Received IURC approval to increase the cost estimate to $2.35B January 7,2009. Cost increases were the result of commodity increases
- Status
  - Site Work Essentially Complete
  - Underground Mechanical and Electrical Services Being Installed
  - 50% of Detailed Engineering Complete
  - 50% of Deep Foundations (Piling) in Place
  - Above Ground Foundations set to Start
  - 90%+ Engineered Equipment on Order

OK

So………………What is Gasification?

Gasification

A commercially proven process that converts hydrocarbons, such as coal and petroleum coke, into hydrogen and carbon monoxide (synthesis gas).



CH + H_2O + O_2 → H_2 + CO

(Coal) (Water) (Oxygen) (Hydrogen) (Carbon Monoxide)

GE Process – a little more detail

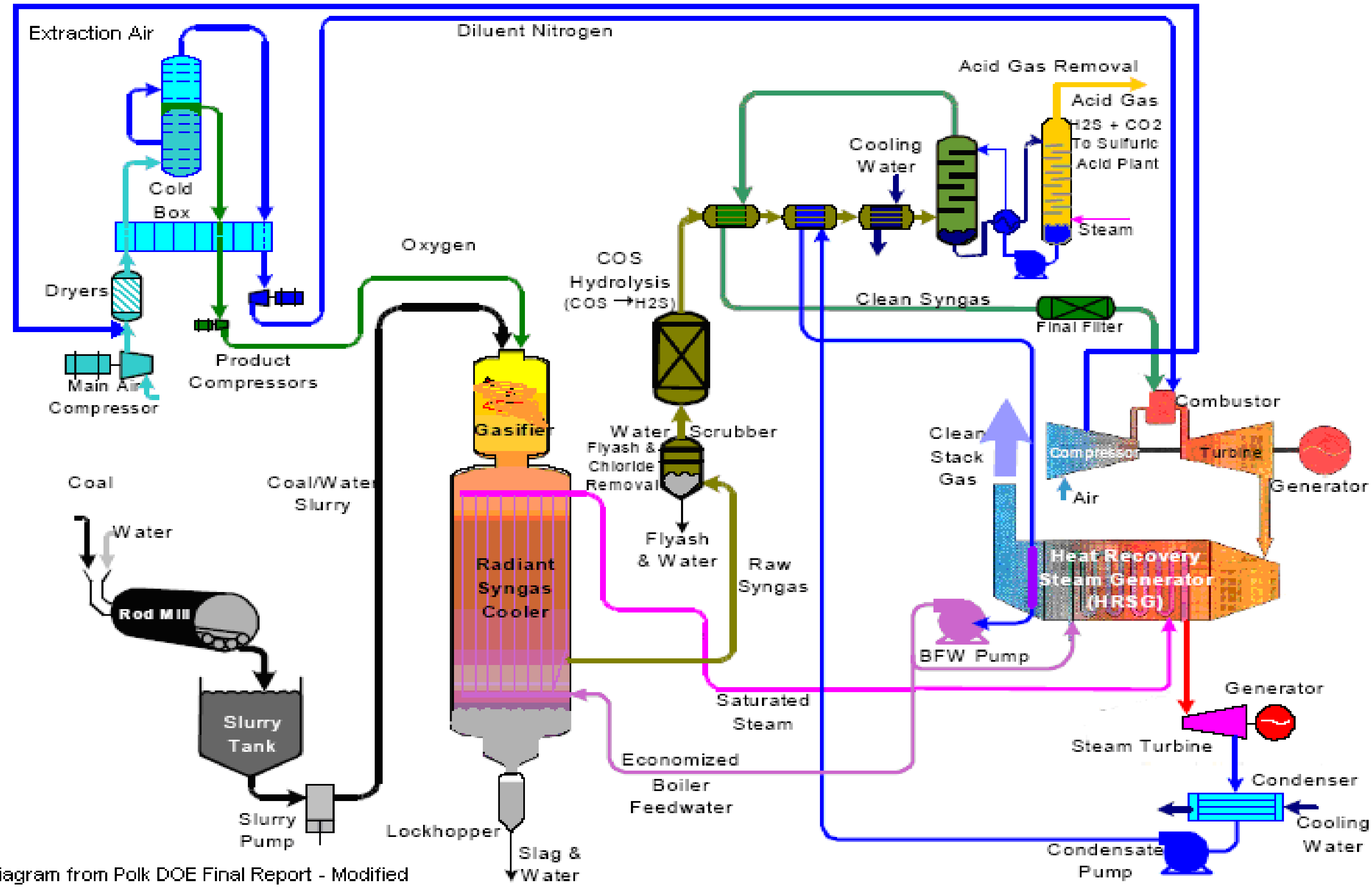


*Diagram from Polk DOE Final Report - Modified

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Major Equipment

- Two trains of General Electric radiant quench gasification equipment
  - Two 1,800 cubic foot entrained flow gasifiers
  - Two Radiant Syngas Coolers
  - Two trains of gas cooling particulate removal, sulfur conversion, and mercury removal equipement
  - Two trains slag of removal equipment
  - Two trains of sulfur removal consisting of physical solvent contact absorption – common stripper
- Two General Electric 7FB IGCC syngas combustion turbines
  - 232 MW Each
- Two Doosan, 2 pressure heat recovery steam generators
- One General Electric four flow, reheat steam turbine
  - 320 MW
- Two trains of Air Products air separation equipment – integrated into process
- One 345kV switchyard
- Balance of Plant Equipment
  - Coal unloading and handling system of truck and rail delivery of coal and removal of byproducts
  - Raw water supply and treatment
  - Wastewater treatment system
  - One 20 cell mechanical draft cooling tower
  - One General Electric Mark VIe distributed control system

How Did Duke Energy Ever Pick IGCC? Isn't That More Expensive?

- Short Answer: It does cost more, about 20% more on a $/kW basis. But the term expensive is a relative terms.
- In Indiana, a Utility is required to submit an updated Integrated Resource Plan (IRP) every two years. The IRP is developed by examining generation needs and resources on the system. If needs are identified they are categorized as base load, intermediate duty or peaking needs. Potential solutions and costs are evaluated with the solution having the lowest Net Present Value Revenue Requirement (NPVRR) being the preferred option. Among those factors contributing to the NPVRR:
  - Capital cost of the alternative, including financing costs
  - Fuel cost over the life of asset including expected emissions allowance costs
  - Operation and Maintenance costs over the life of the asset
  - Expected availability over the life of the asset
  - Net Heat Rate (efficiency) of the solution

How Did Duke Energy Ever Pick IGCC? Isn’t That More Expensive (cont)

- In the case of Edwardsport our IRP indicated we needed base load capacity in the 600MW range in the 2012-2013 timeframe. IGCC was identified as having the lowest NPVRR. The IURC agreed and issued Duke a CPCN for the plant.
- Aspects that influenced that selection
  - Tax credits – Local, state and Federal Tax Credits have helped offset the cost. These are in place to encourage the development of these emerging technologies. Among those was $133.5MM Federal Tex credit that originated from the 2005 Energy Bill. These credits total about $400/kW and work to close that 20% cost premium we discussed earlier.
  - Emissions – An IGCC has a much lower emissions profile than a traditional Pulverized Coal Plant – Lower emissions means lower costs since emissions allowances are a rider to fuel costs.

Why Not Traditional Pulverized Coal? Aren't Those Cleaner Than They Used To Be?

- Again, the short answer is yes but…..not as clean as an IGCC

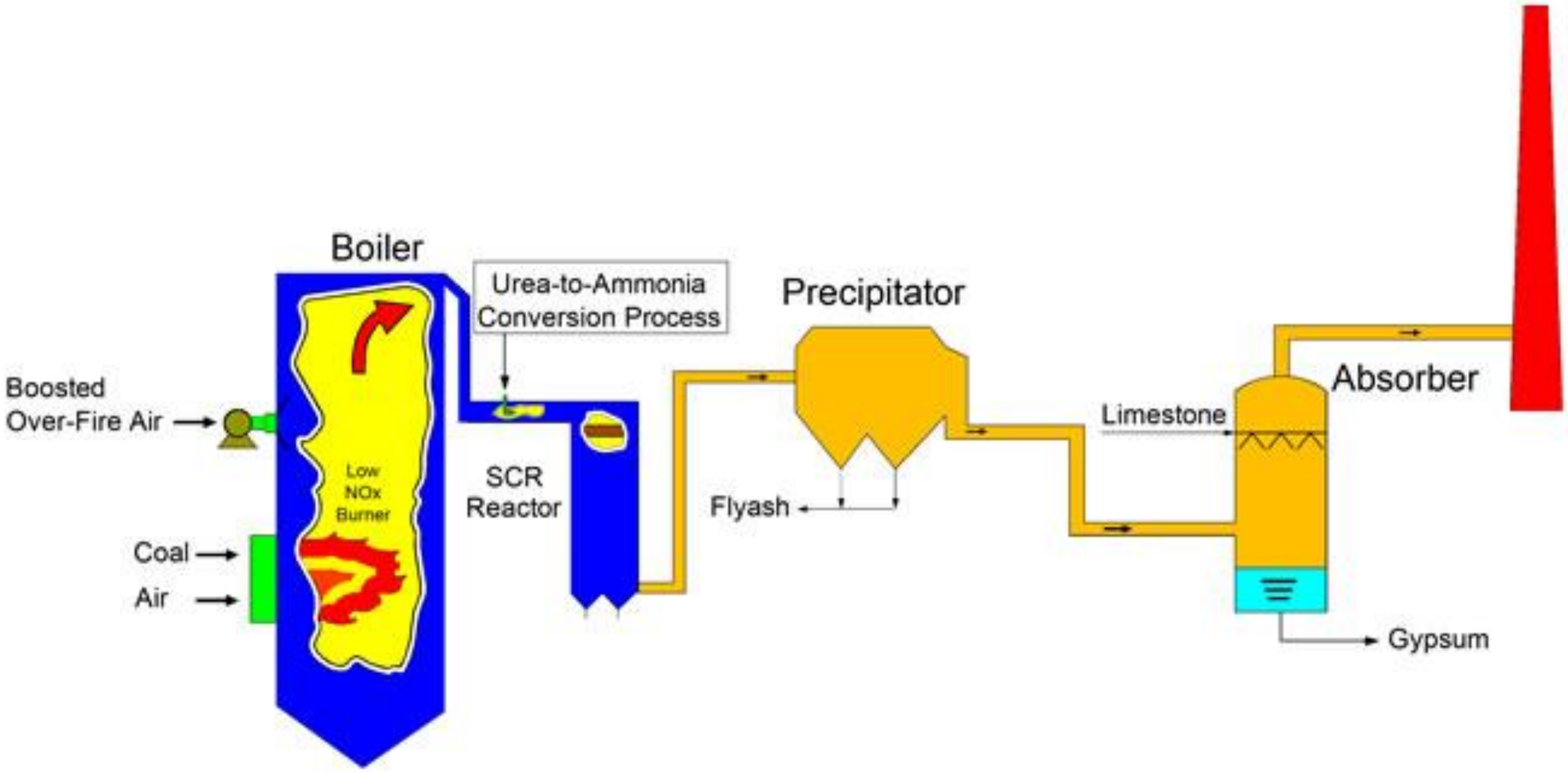
Pollutant	NSPS Standards Lb/MM Btu	Edwardsport IGCC Lb/MM Btu
SO_2	.14	.014
NO_x	.11	.02
PM-10	.015	.007
Hg	2×10^{-5}	2.75×10^{-6}

- Edwardsport is generally an order of magnitude cleaner on all of the criteria pollutants.

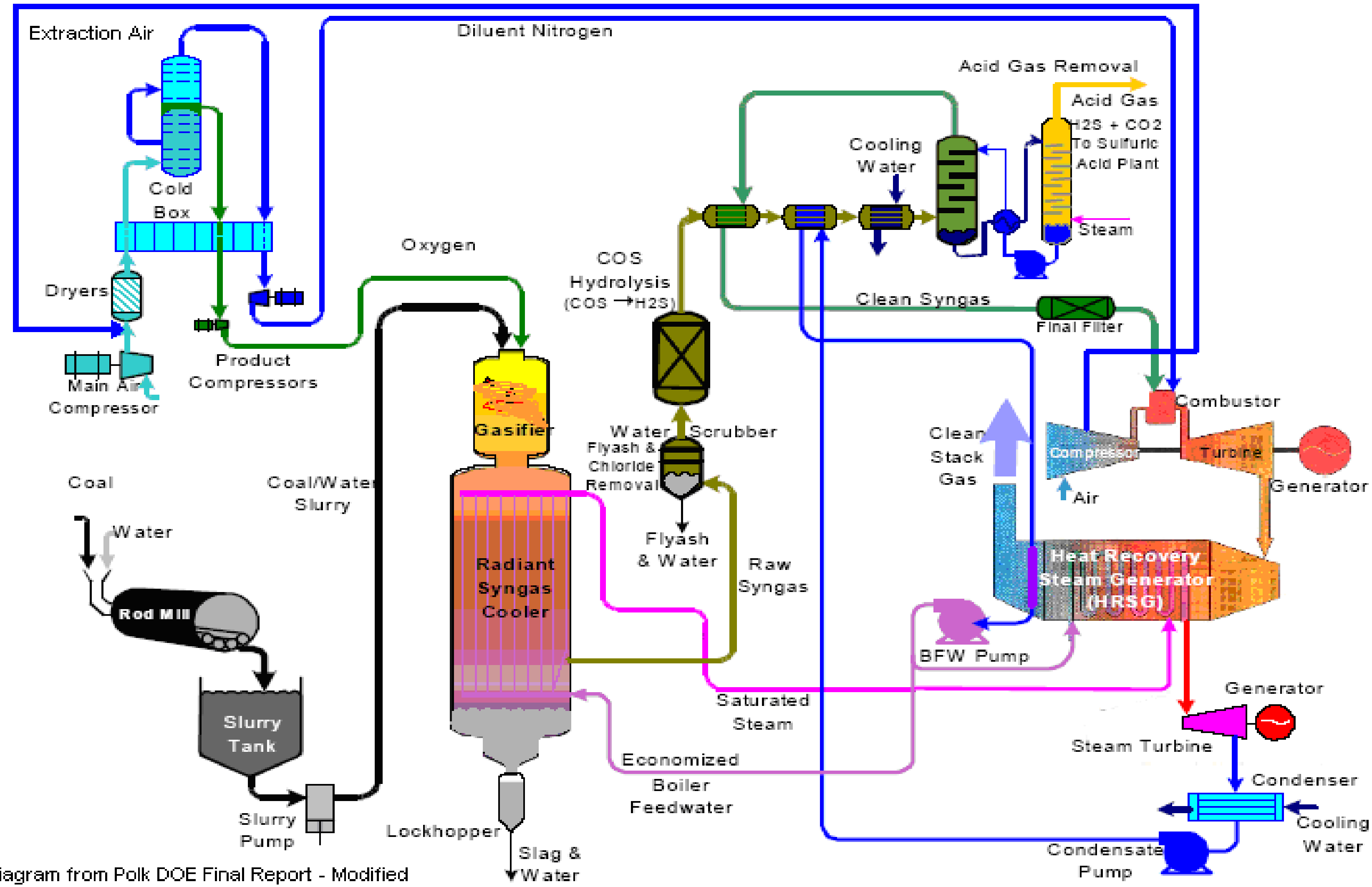
How Can IGCC be Cleaner than Traditional PC?

- The key to being cleaner lies in the fact that in an IGCC, pollutants are removed before combustion.   In a typical PC plant they are removed post combustion.
- At Edwardsport, particulate, sulfur and mercury are all removed between the gasifier and the combustion turbines. (pre combustion) At this point they are more concentrated and removal technologies are much more efficient.
- In a typical PC plant, particulate and sulfur, and to the extent possible, mercury removal are all after the boiler (post combustion).
- Post combustion means after air is added and he pollutants are diluted so that their concentrations are much lower. This means they are harder to remove.

Typical Modern Coal Plant



IGCC



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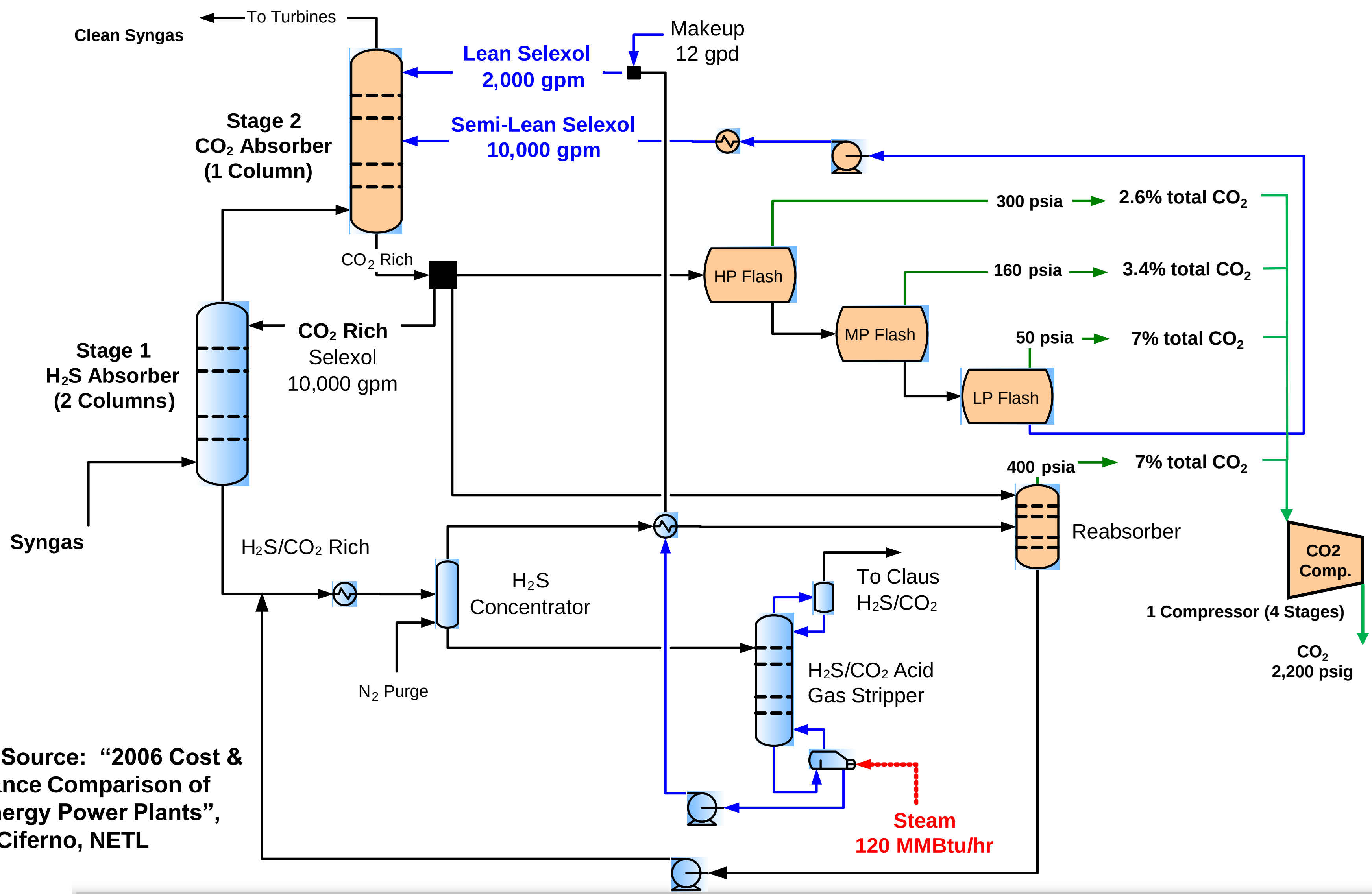
Well…….What About CO_2?

- Everyone is aware of Global Warming concerns brought about by greenhouse gasses. The most notable of those being CO_2
- While CO_2 is not a regulated pollutant today there is widespread belief that the climate legislation is likely forthcoming. As a matter of fact, under a recent Court decision the EPA may be reconsidering the classification of CO_2 as a pollutant under the Clean Air Act
- Most importantly Duke Energy believes climate legislation is coming and would prefer to help shape that legislation rather than simply be subject to it. In short we would prefer to lead the way on this issue. Edwardsport provides that opportunity.

How Does an IGCC Remove CO_2

- 20% CO_2 removal can be accomplished by adding another Selexol absorber in the Acid Gas Removal Section. After the sulfur is removed Selexol is preferential to CO_2 .
- 50+ % removal is accomplished using a water gas shift reactor and then captured by adding additional Selexol absorber capacity.
- Compression and drying equipment can be added incrementally.

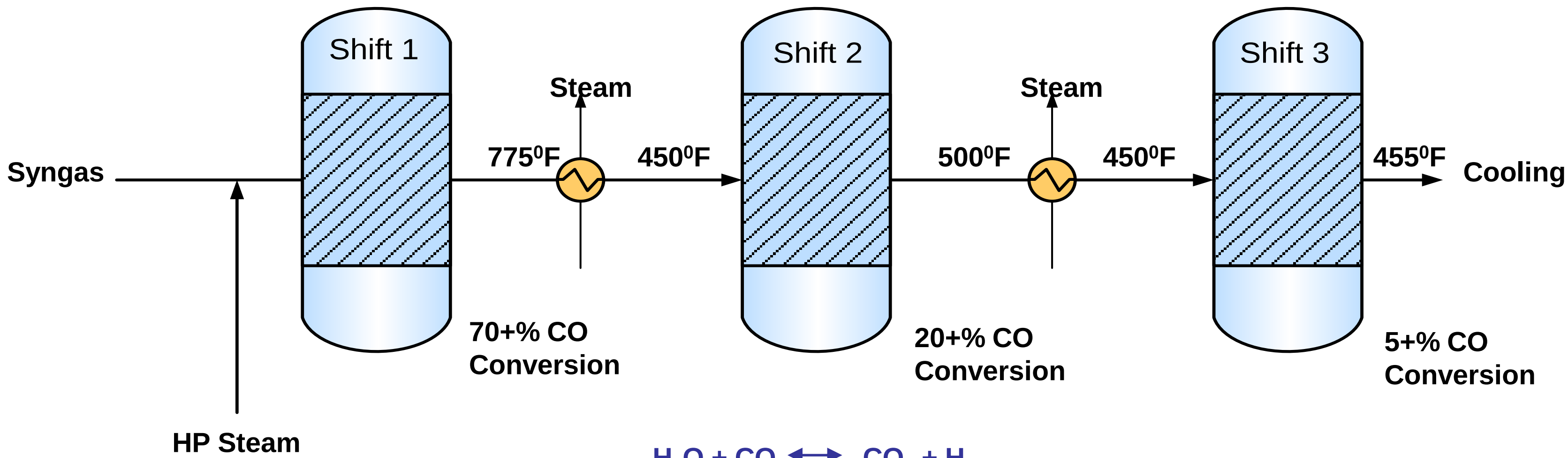
Selexol Process w/ 20% Un-shifted CO_2 Capture



Modified Source: "2006 Cost & Performance Comparison of Fossil Energy Power Plants", Jared P. Ciferno, NETL

Water-Gas Shift Reactor System (WGS)

<u>Design</u>:
Haldor Topsoe SSK Sulfur Tolerant Catalyst
Up to 90+% CO Conversion w/ two shift reactors
H2O/CO = 2.3 (Project Assumption)
Overall ΔP = ~30 psia



$H_2O + CO \longleftrightarrow CO_2 + H_2$

A Water-Gas Shift Reactor converts CO to CO2 with the use of water vapor in the form of high pressure steam. The reaction is exothermic and additional syngas cooling is required

This shift catalyst is Co-Mo (cobalt-molybdenum) which requires sulfur to maintain the catalyst in an active state.

Now That We Have Removed the CO_2 What Do WE Do With

- Sequestration – pump the liquid CO_2 deep underground and store it in geologic formations. Not commercially proven. Liability issues need to be resolved on a national scale.
- Enhanced Oil Recovery/ Enhanced Gas recovery consumption - Pump the liquid CO_2 into the formations holding oil and natural gas. Increased pressure enhances recovery of these resources. Proven but opportunities are limited to oil producing regions or must be piped to these areas.
- Commercial uses – Food, dry ice, etc. Concern with ability to take volume.
- Issues related CO_2 storage / disposal are universal to any technology capturing CO_2

Other Benefits of IGCC

- Reduced water consumption – not insignificant
- Saleable By-Products
  - 99% pure elemental sulfur is a commodity
  - Slag – low carbon content opens up several markets
- 38% Efficiency can be higher depending on feedstock
- Poly-generation potential including synthetic natural gas and certain chemicals
- Ability to use a variety of high sulfur, high ash coals and petroleum petcoke feedstocks

Operational Challenges

- Water management. Concern over chemistry and corrosion issues related to the large amount of water being re-cycled through various chemical processes. Will be a learning curve to find the sweet spot.
- Learning to operate with a different mindset. Operating gasification is a different core business for Duke as compared to operating PC and NG plants. This will require a more co-operative effort between the technical and operations groups, even for day to day operations
- Several pieces of equipment have been or are being developed specifically for this project. This means there will not be a large data base of operating history from which to draw.

Operational Challenges (cont.)

- Emissions compliance. As this is new technology to Duke and first of a kind for this class IGCC, we will have to be extra vigilant with our air water and solid waste streams to make sure we live up to our reputation and billing as "cleanest coal plant in the world".
- Confidentiality issues. Many of the equipment and processes at Edwardsport are covered under one or more confidentiality agreements and IP law. This is a change for Duke and will impact when , how and by whom we have our plant maintained
- CO2 capture. Should this plant be retro-fit for CO2 capture it will add complexity at a time we are going through the growing pains of a new technology.

What About Renewables

- Renewables such as wind and solar are sources of clean energy that are becoming more prevalent and being mandated by some state commissions. What Duke is doing:
  - Wind
    - Duke Energy has a power purchase agreement for 100 MW of capacity from a wind farm in Benton County, Indiana.
    - Non Regulated Group has wind projects in Wyoming and Texas totaling 180 MW and looking to do more.
  - Solar
    - Power Purchase agreement for 16 MW from nation's largest soar farm. Located in North Carolina
    - Approval from NC Public Service Commission for a distributed rooftop project.
    - Various smaller project in OH, KY and IN

What About Renewables

- Why not More? Or…….Why not instead of Edwardsport?
- Edwardsport is base load:
  - Base Load means a consistent supply in all conditions, in all weather, 24 hours per day, 365 days per year.
  - Renewables have limitations
    - Wind
      - Effective only with wind speeds between 9 – 25 MPH
      - Siting can be an issue. Need a large area for multiple turbines, generally high (very visible) ground. Issues with public perception.
      - Capacity severely discounted by Independent System Operators
        - » Only counts as 20% of nameplate
        - » Wind turbines are about 1.5MW each. Discounted to 20% means that the 632 MW of Edwardsport would need slightly over 2,100 wind turbines installed.
    - Solar – Sun needs to be shining and electricity storage on this scale is not developed
- Bottom line is that they are here, they are growing, and they will continue to grow but they are not yet to the point of completely replacing fossil fuels. In summary they are part of but not the total solution.

Site Photos

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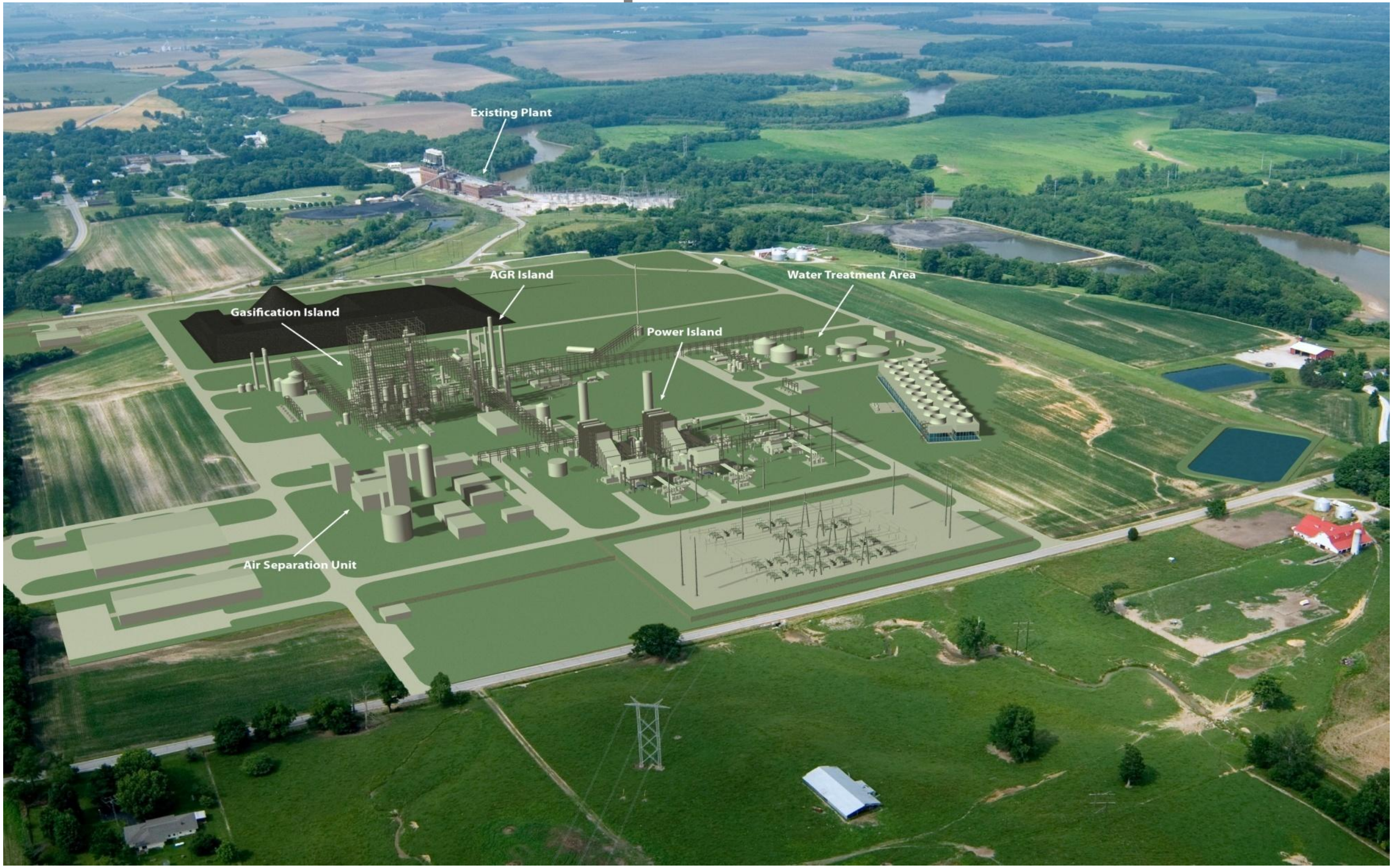
Edwardsport IGCC Site



QUESTIONS?

For More Information on Duke Energy Go To:

*www.**duke-energy**.com*