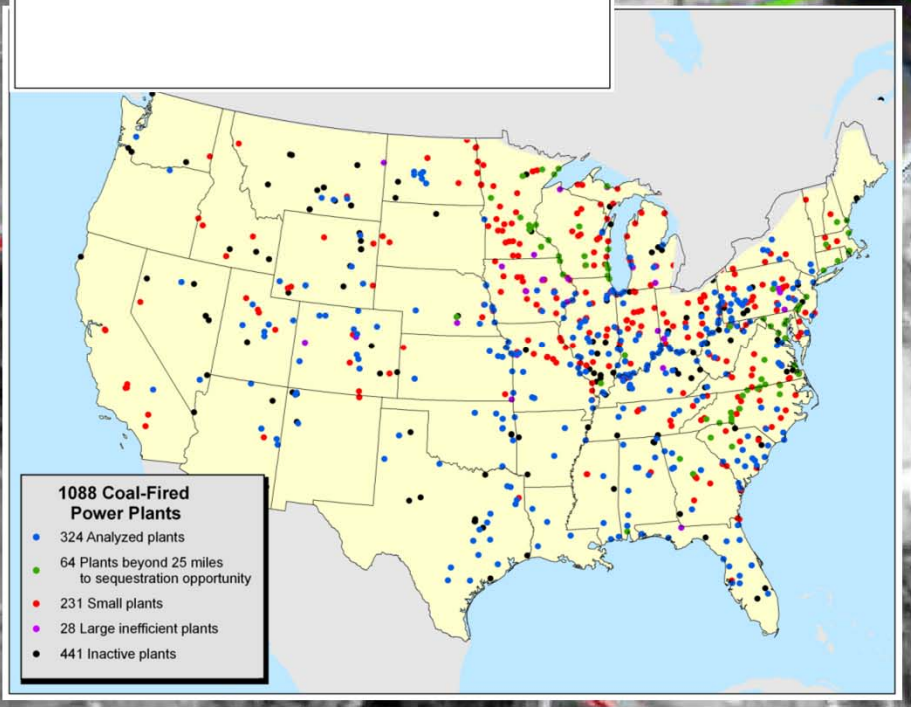
Modeling of the Costs of CCS for the Nation's Existing Coal-Fired Power Plant Fleet



Presented to:

U.S. Energy Association

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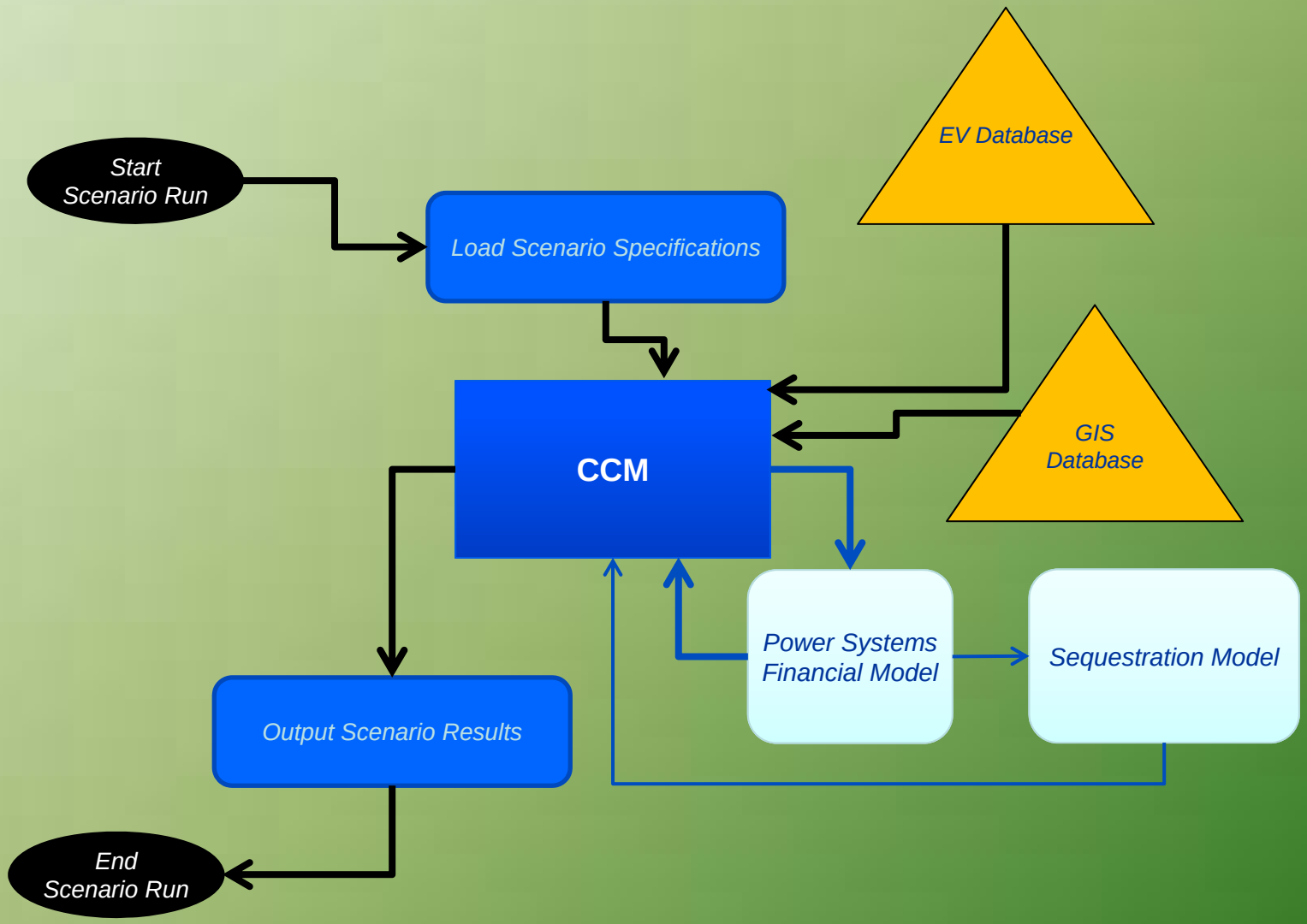
Jeffrey Eppink
Enegis, LLC

Carbon Capture Model

- **This work was funded by the U.S. DOE/NETL. Enegis would like to gratefully acknowledge their support and guidance**

- **The Rationale**
  - 50% of the nation's electric generation is from coal
  - The fate of coal-fired generation is uncertain in a carbon-constrained world
  - Overall goal is to develop cost/supply curves for retrofitting a scenario sample of the nation's fleet of CFPPs
- **The Model**
  - Quantifies the cost and assess the feasibility of retrofitting the nation's fleet of coal-fired power plants (1088 Units, 332 GW)
  - Uses the NETL study, *Carbon Dioxide Capture from Existing Coal-Fired Power Plants,* (Conesville Study) used as a foundation in terms of cost and layout
  - Models costs based on cumulative examination of individual units
  - Includes assessment of emissions for SOx and NOx

Modeling Mechanics



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Sources of Information

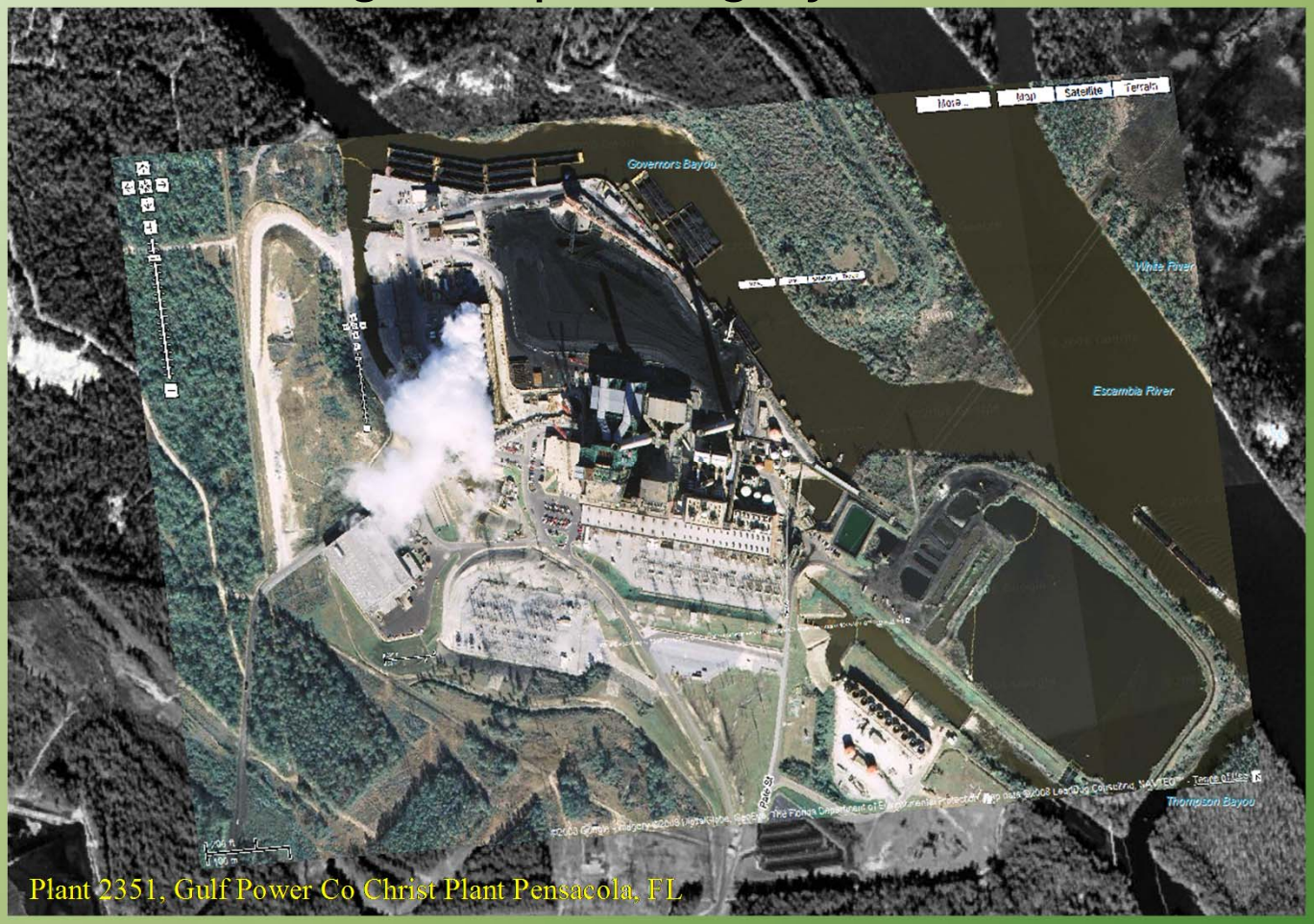
- **GIS Data Sources**
  - Microsoft Terraserver—USA Imagery

Example showing typical image quality

Source: Microsoft Terraserver, Enegis, LLC, analysis

Sources of Information

- **GIS Data Sources**
  - Google Maps Imagery

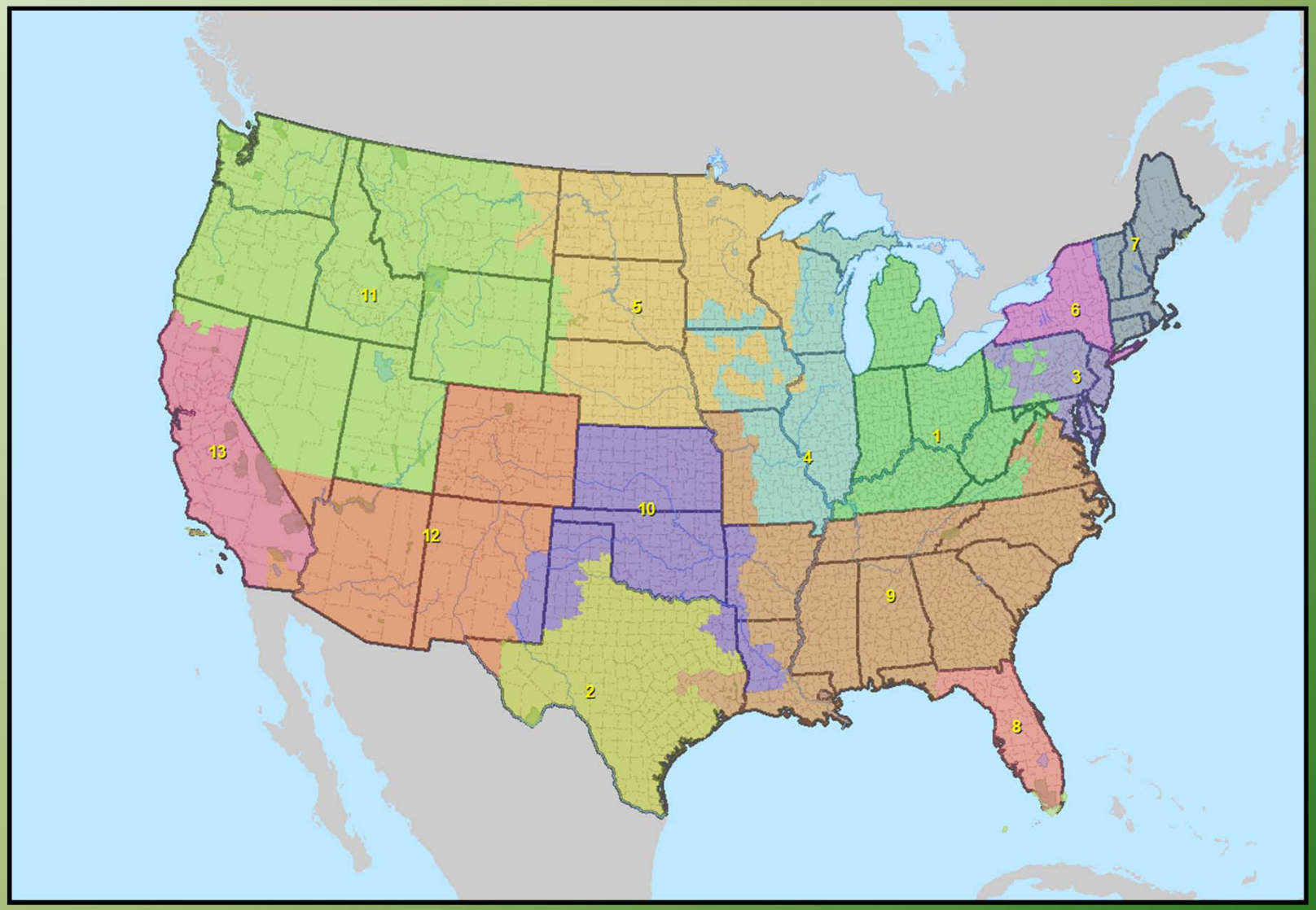


Example Google Maps imagery (color) on a Terraserver Image Base

Source: Microsoft Terraserver, Google Maps, Enegis, LLC, analysis

Sources of Information

- **Electricity Market Modules (EMMs)**



Source: EIA, see http://www.eia.doe.gov/oiaf/aeo/assumption/electricity.html

CAPEX

- **Investment CAPEX**
  - The CCM computes IC by the equation:

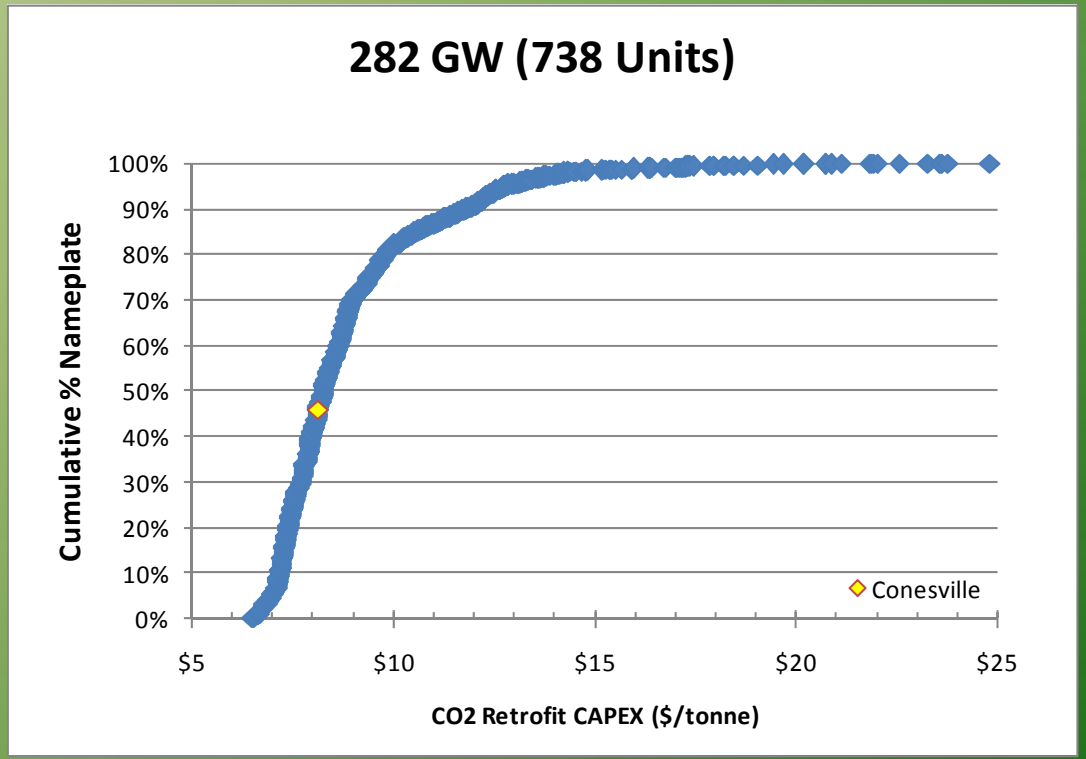
(Letdown Turbine Cost + CO_2 Scrubber and Absorber Cost + FGD Cost + NOx Cost)

+

(CO_2 Separation and Compression Cost + Additional Cooling Cost)

+

Additional Land Cost



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Primary FGD

- **EPRI Study: *Current Capital Cost and Cost-Effectiveness of Power Plant Emissions Control Technologies* (January 2010)**
- **Wet and Dry FGD CAPEX Functions of Nameplate**
- **CCM Methodology**
  - If No FGD then
    - Assume new Wet FGD Construction
    - Calculate Wet FGD CAPEX using Nameplate Function
  - If Wet or Dry FGD then
    - Assume no FGD CAPEX needed
    - FGD outlet concentration of 50 ppm

Sulfur Polishing

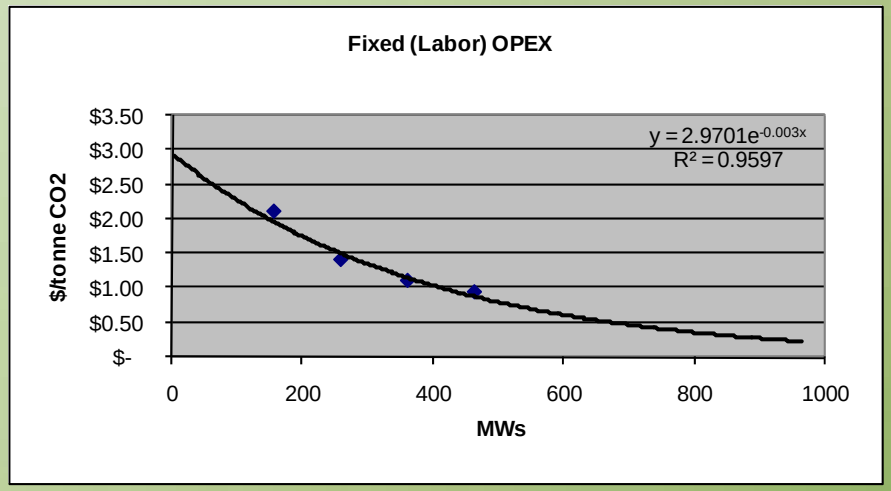
- **Sulfur Polishing used for scrubbing after Primary FGD down to environmental target of 10 ppm**
  - Requires calculation of the unit-specific tonnage of SO_X to be scrubbed by polishing
- **CAPEX calculated as function of tonnage**
  - $94.57 /ton SO_X polished (NETL)

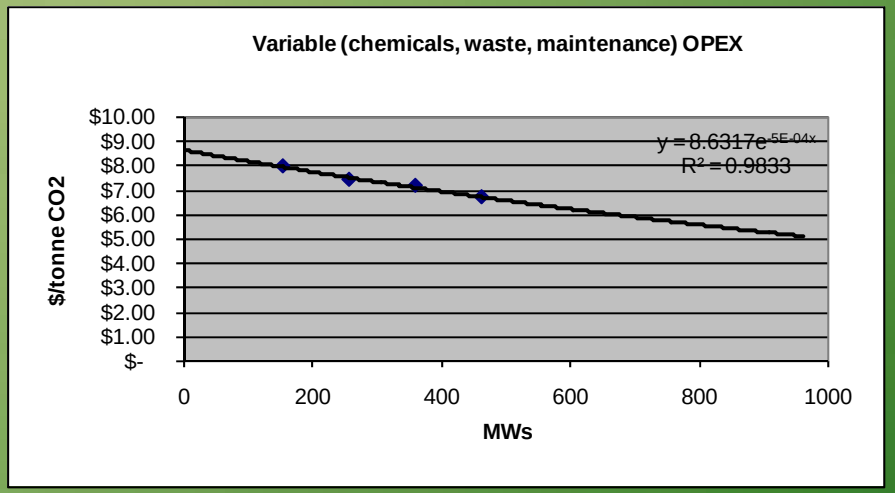
NOX/SCR

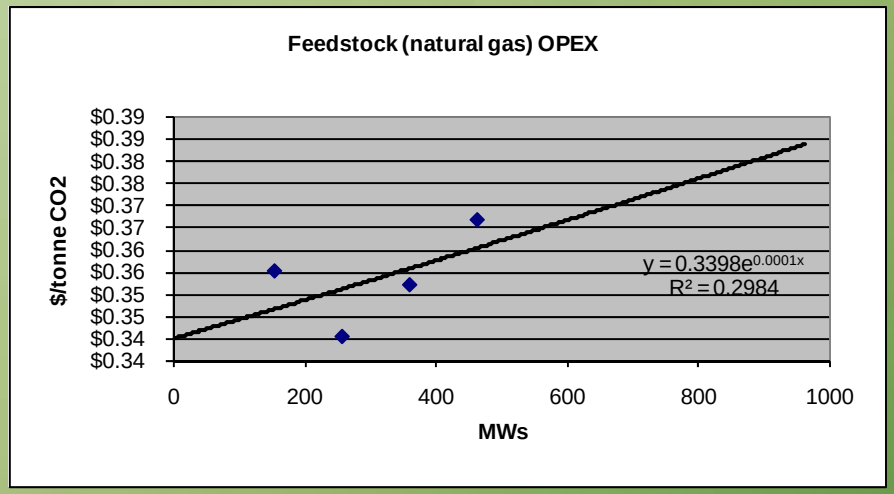
- **EPRI Study: *Current Capital Cost and Cost-Effectiveness of Power Plant Emissions Control Technologies* (January 2010)**
- **SCR CAPEX Functions of Nameplate:**
  - If No SCR NO_X Control then
    - Calculate SCR CAPEX using Nameplate Function
  - If SCR NO_X Control
    - Assume no CAPEX needed

OPEX

- **Based on the scenarios in the Conesville Study, calculated as the sum of:**







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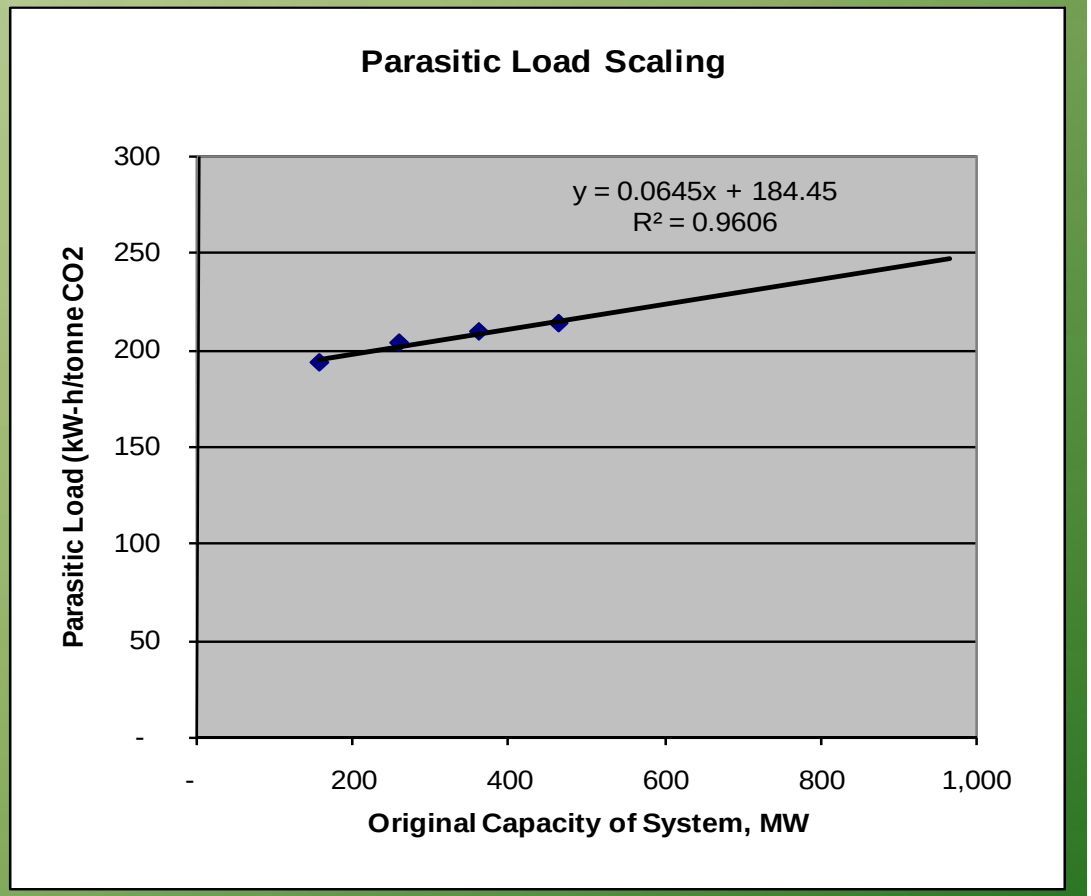
Parasitic Load

- **Computed as the Sum of the Parasitic Loads of:**
  - Newly installed NOx equipment
  - Newly installed SO_2 control equipment
  - Additional cooling
  - Parasitic steam for amine regeneration (212.91 kWh/tonne $C0_{2)}$
  - CO_2 retrofit components



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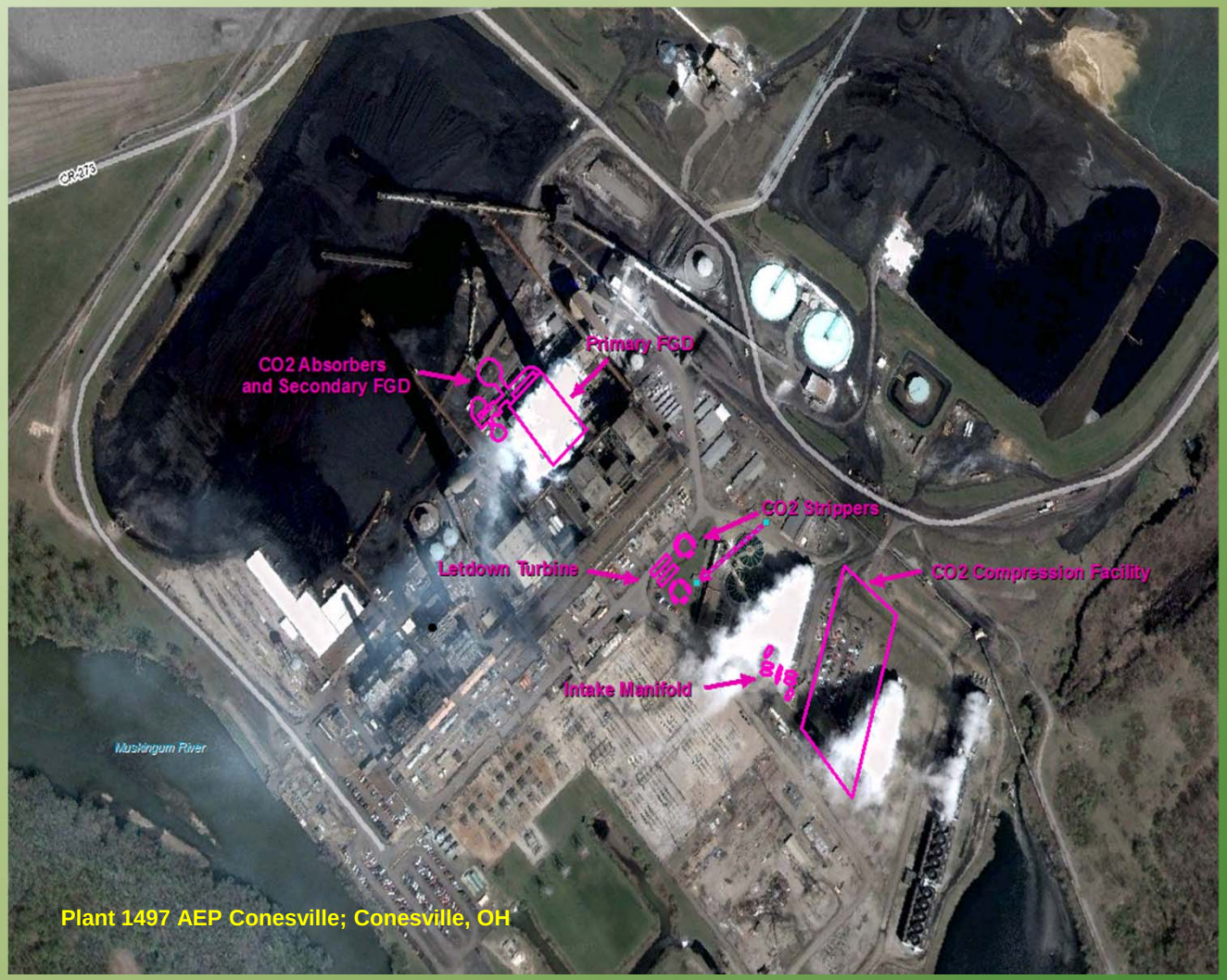
Physical Size and Cost Scaling

- **Physical Size and Cost Scaling**

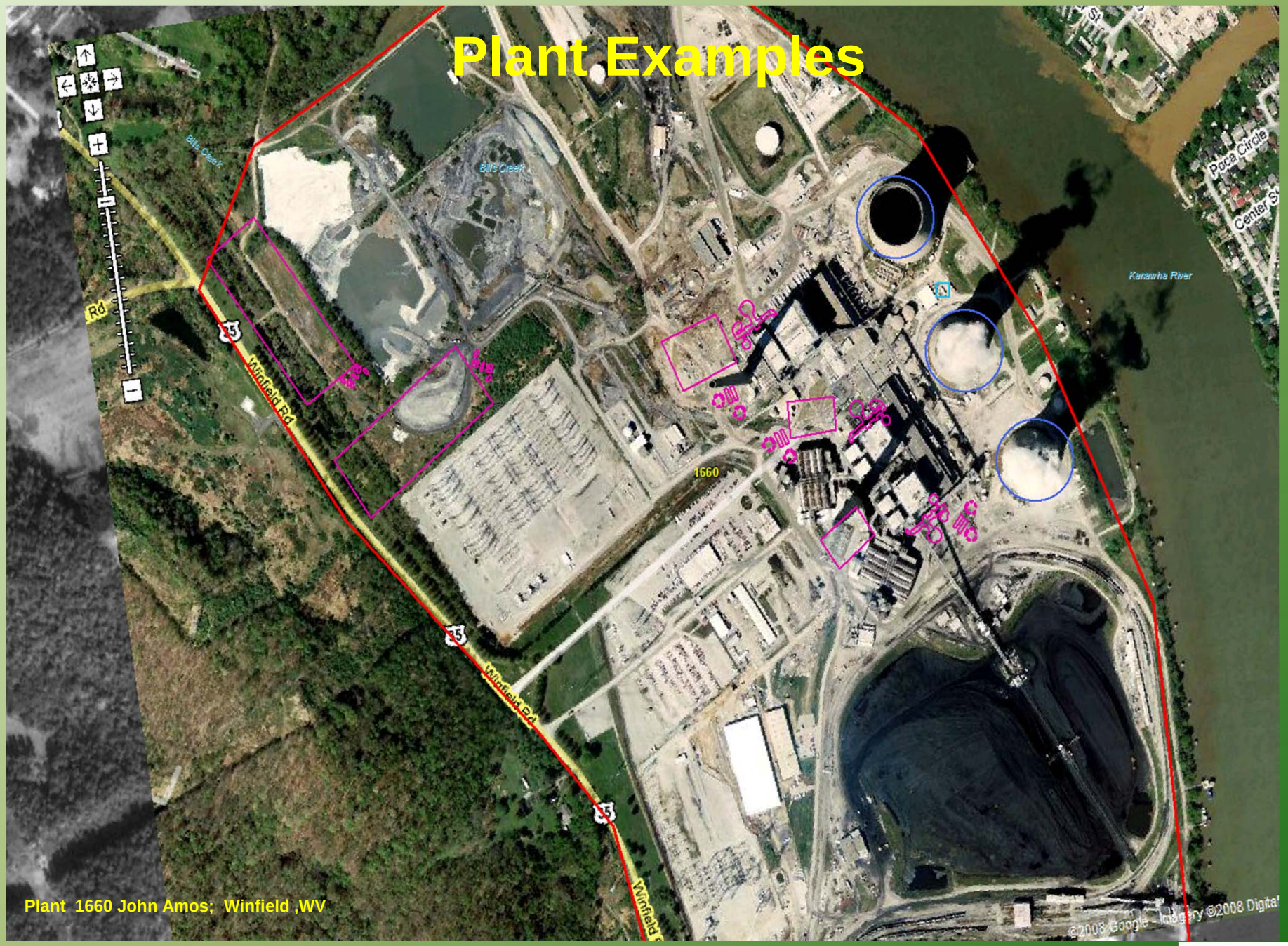


– **Required equipment geometries were digitized from the Conesville report so they could be scaled, relocated, and rotated to accommodate the remaining plants in the population**

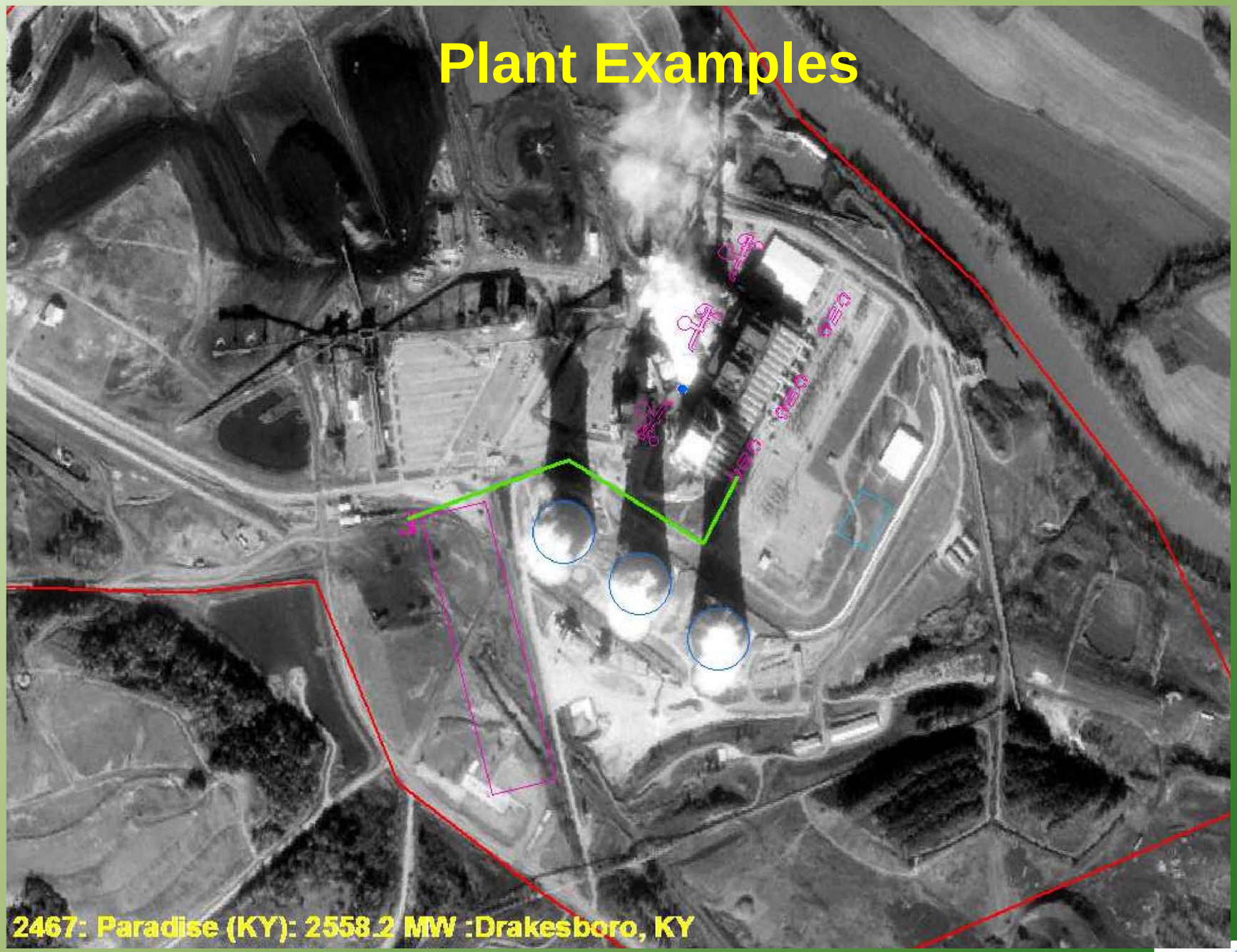
Construction Difficulty Factors

- **Two types of Construction Difficulty Factors**
  - Retrofit component conflict: More difficult engineering
    - E.g., conflict building letdown turbines, scrubbers, or compression field
    - Increase CAPEX by a scaled factor
      - Results of proprietary FGD construction difficulty study indicate CAPEX increases up to 200%
      - A separate factor will be used for each component and can be adjusted as a scenario
  - Existing structure conflict: Component relocation
    - E.g., Railroad or substation
    - Increase CAPEX by a function of nameplate capacity as a relative portion of overall construction costs
- **Retrofit component conflict cost impacts generally >> existing structure conflicts**

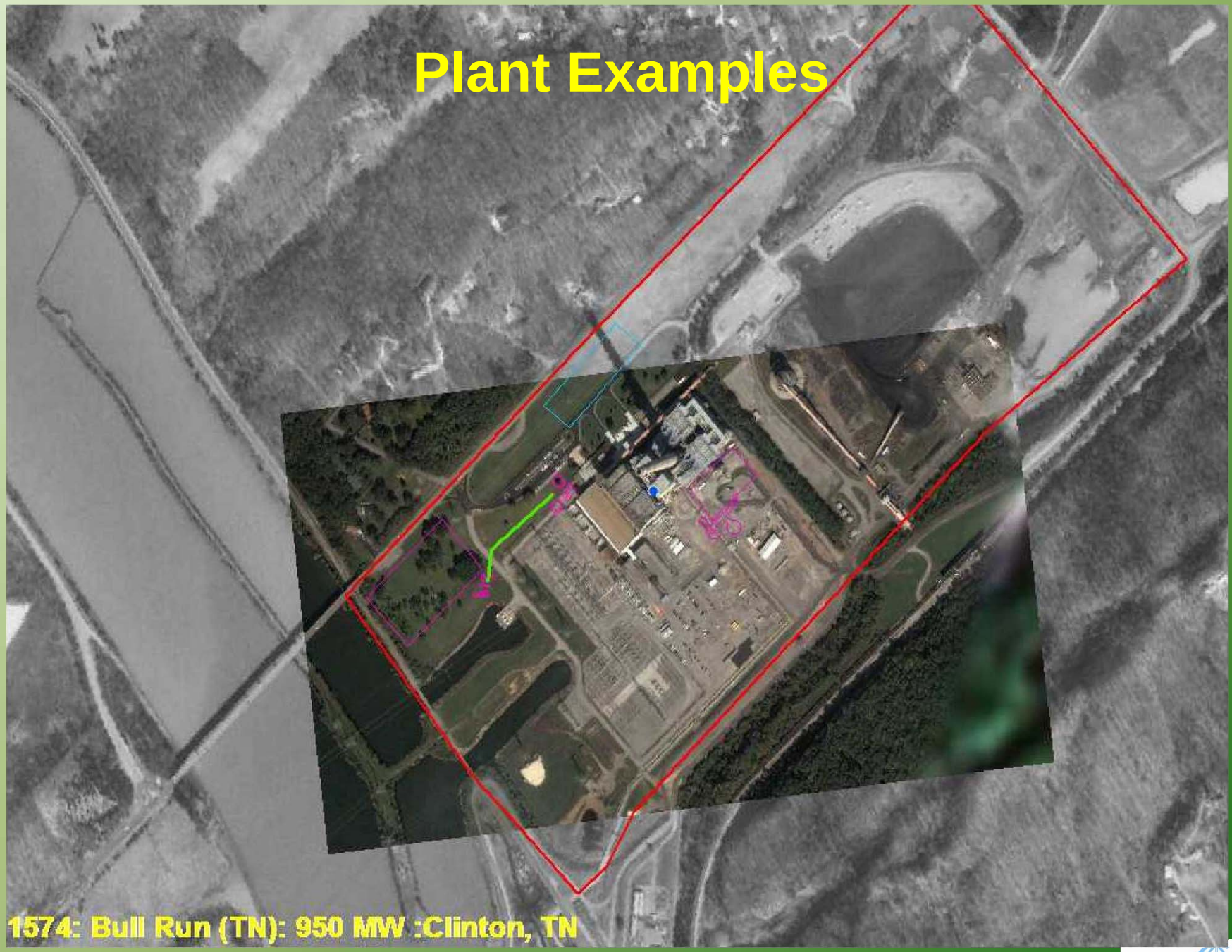
Plant Examples



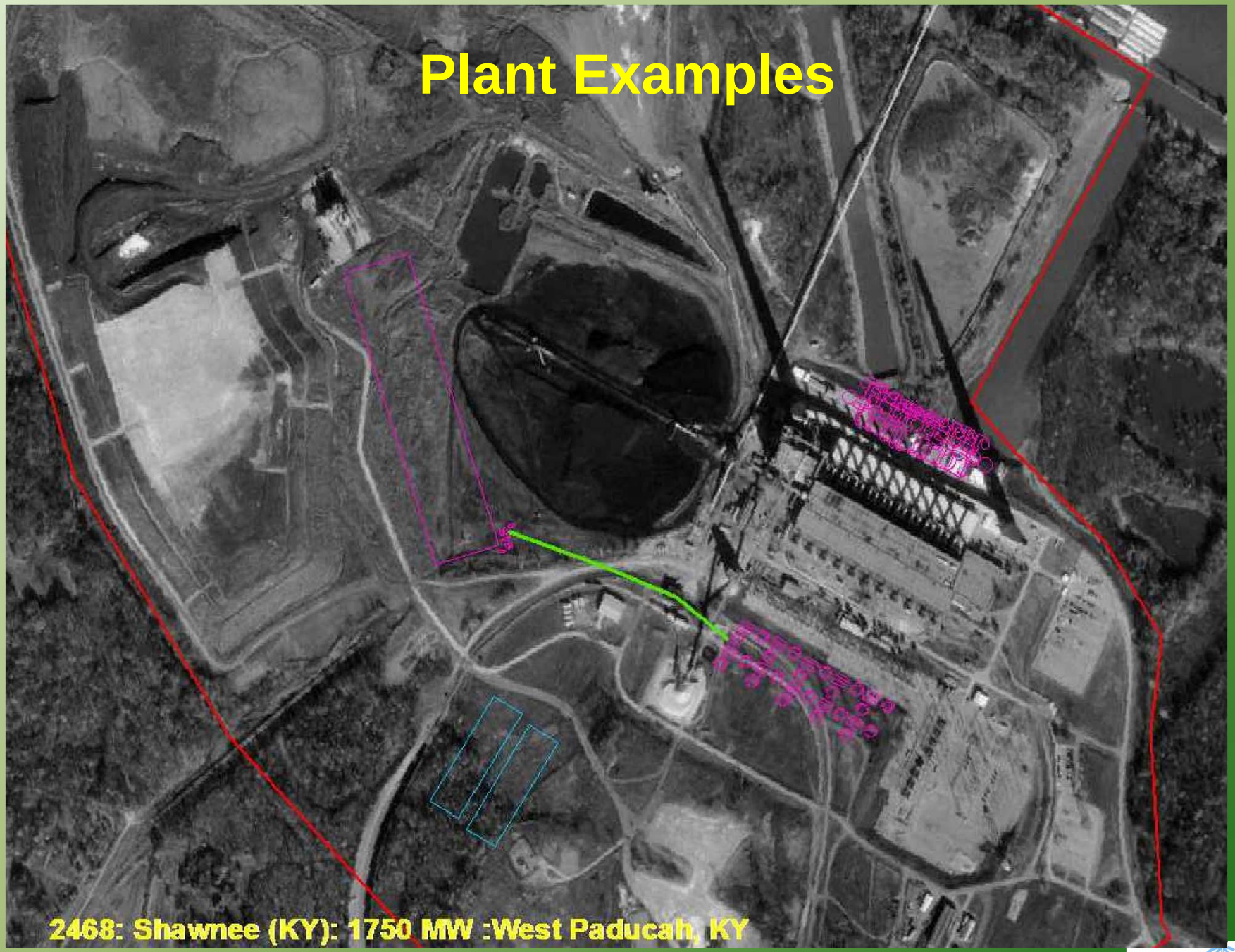
Plant Examples



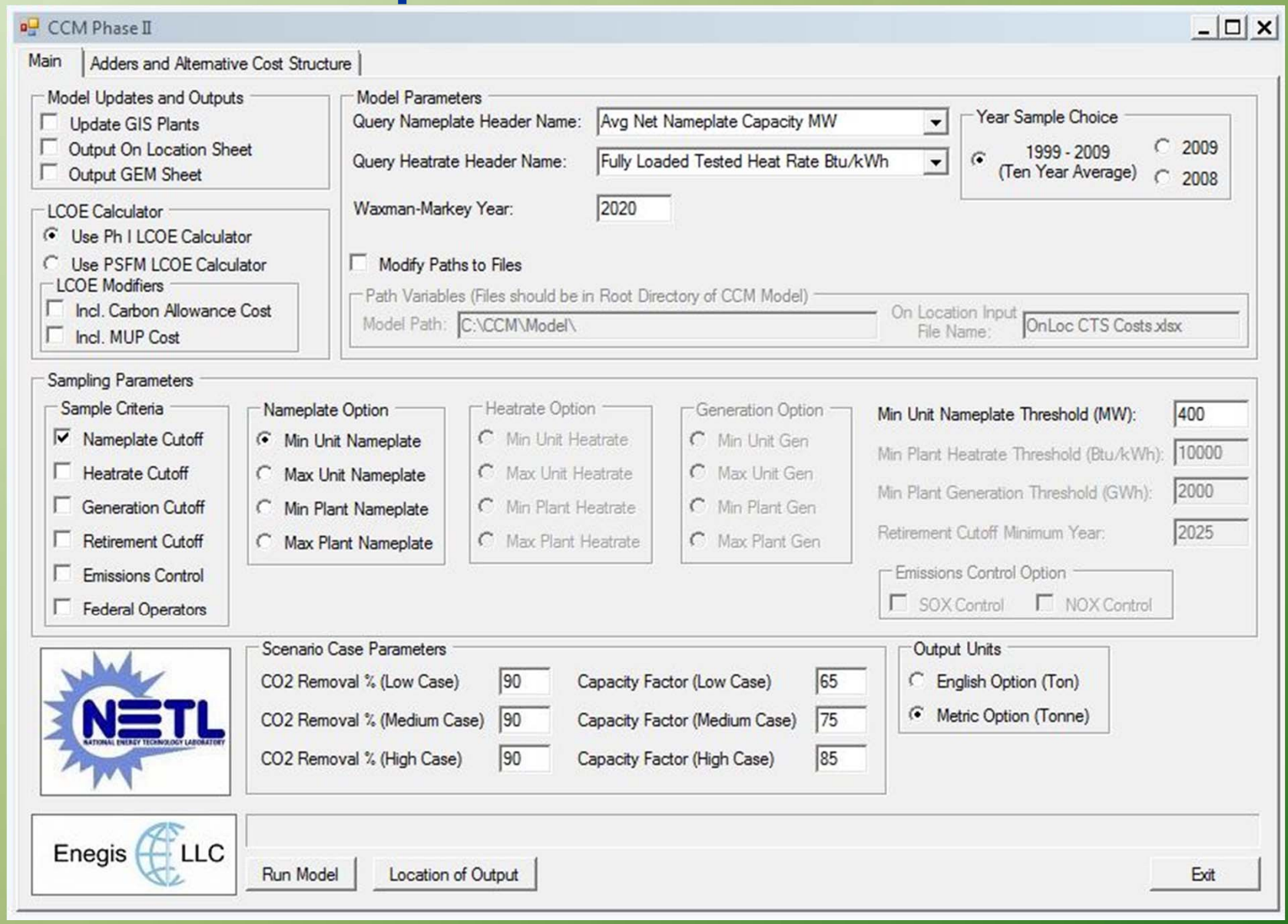
Plant Examples



Plant Examples



Graphical User Interface



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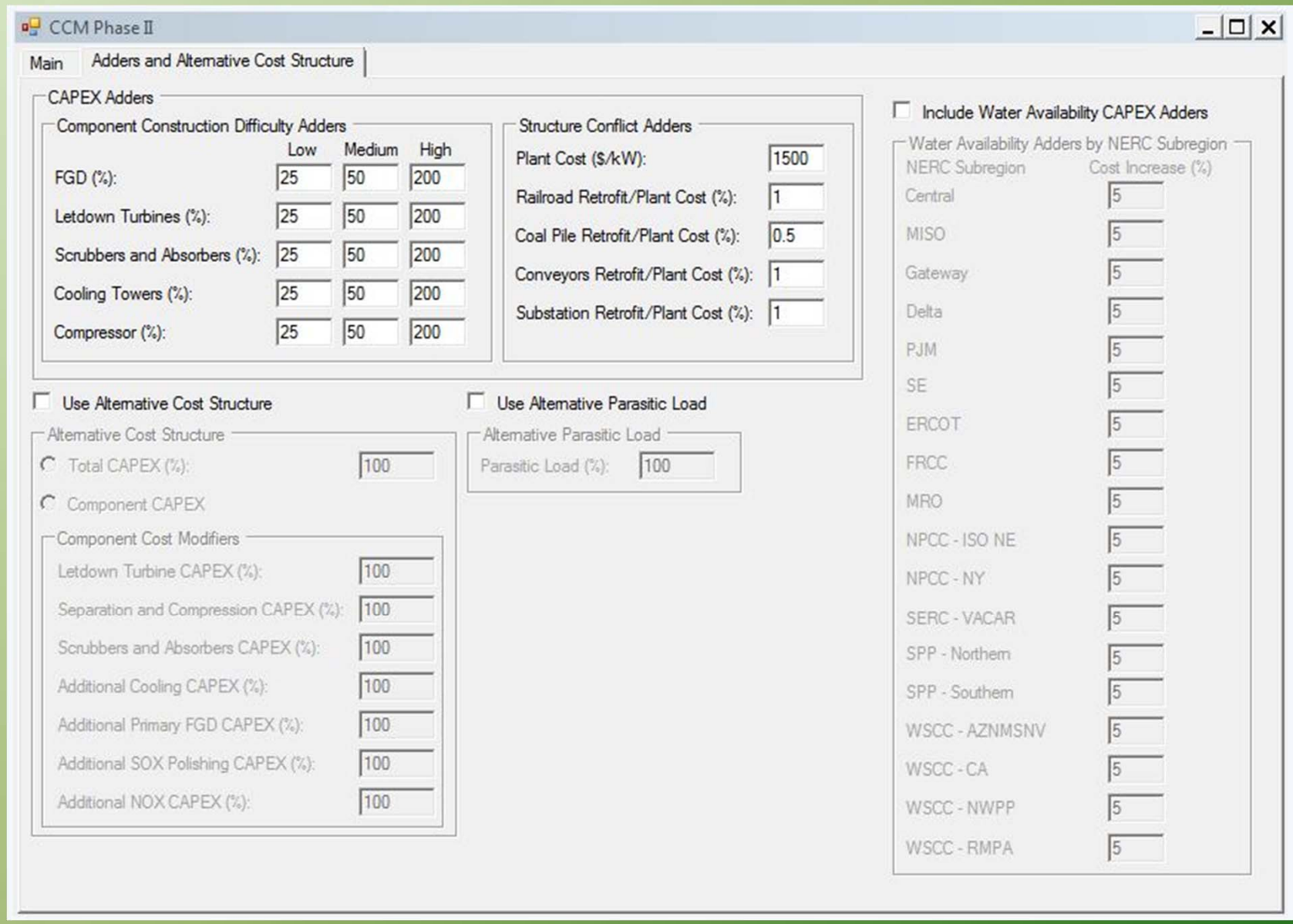
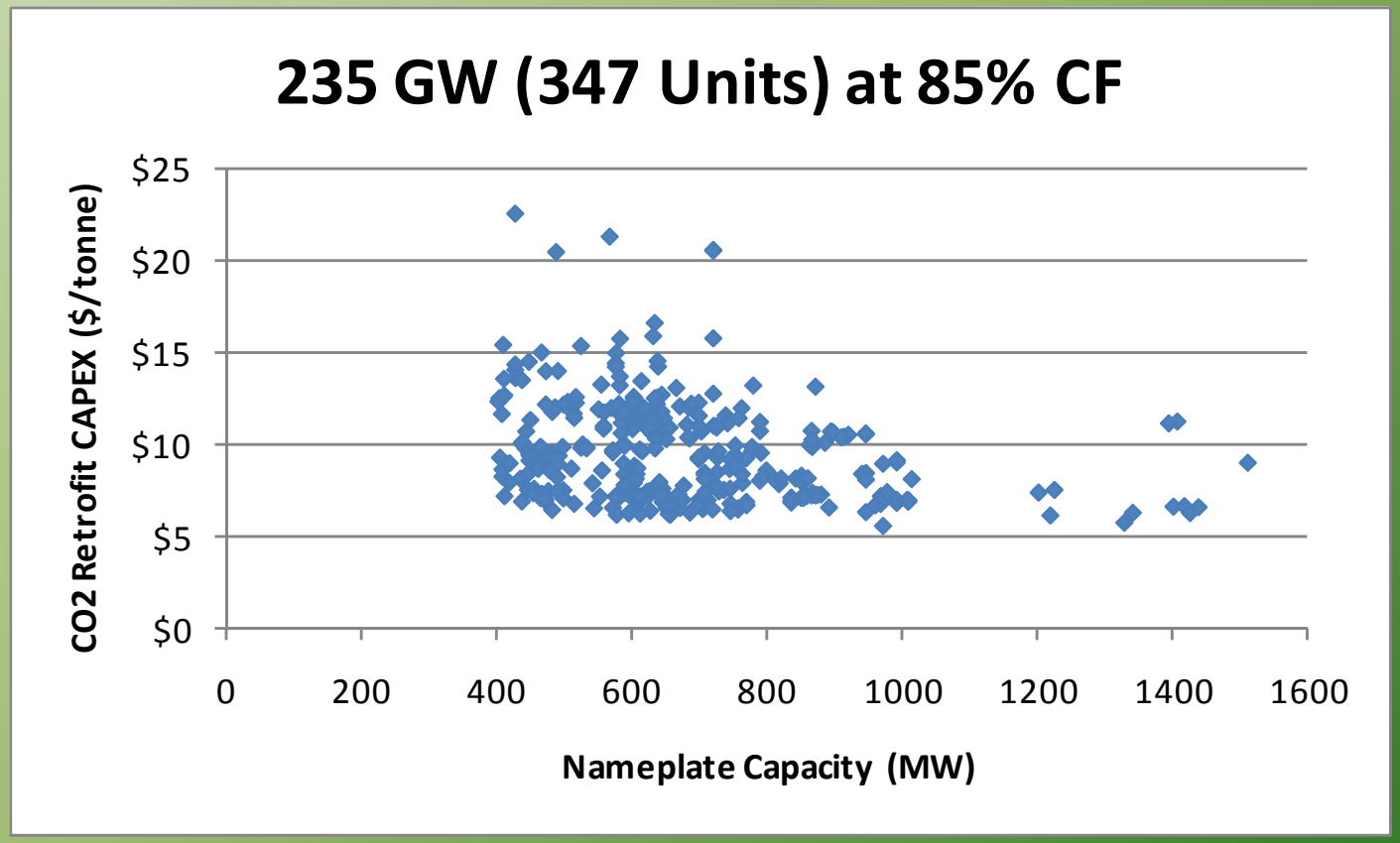
Adders and Alternative Cost Structures Tab



Scenario: ≥ 400 MW Unit Sample

- A model run was performed on the sample of units with a generation capacity of 400 MW and above
- Scenario CAPEX



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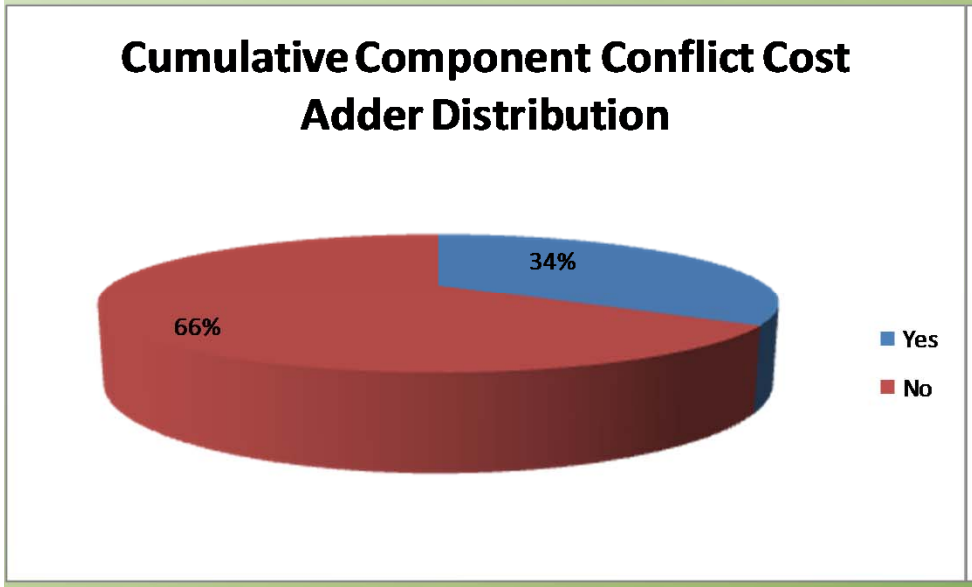
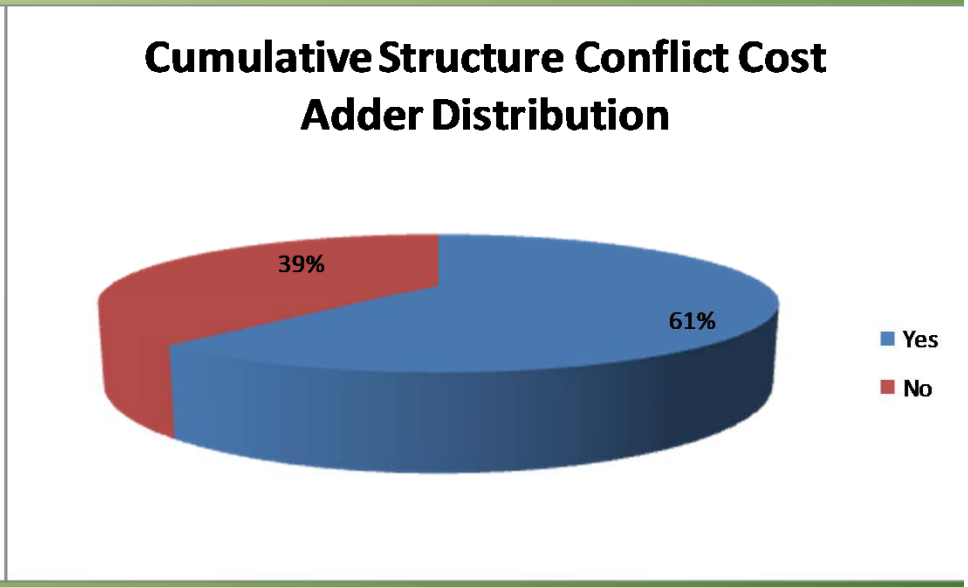
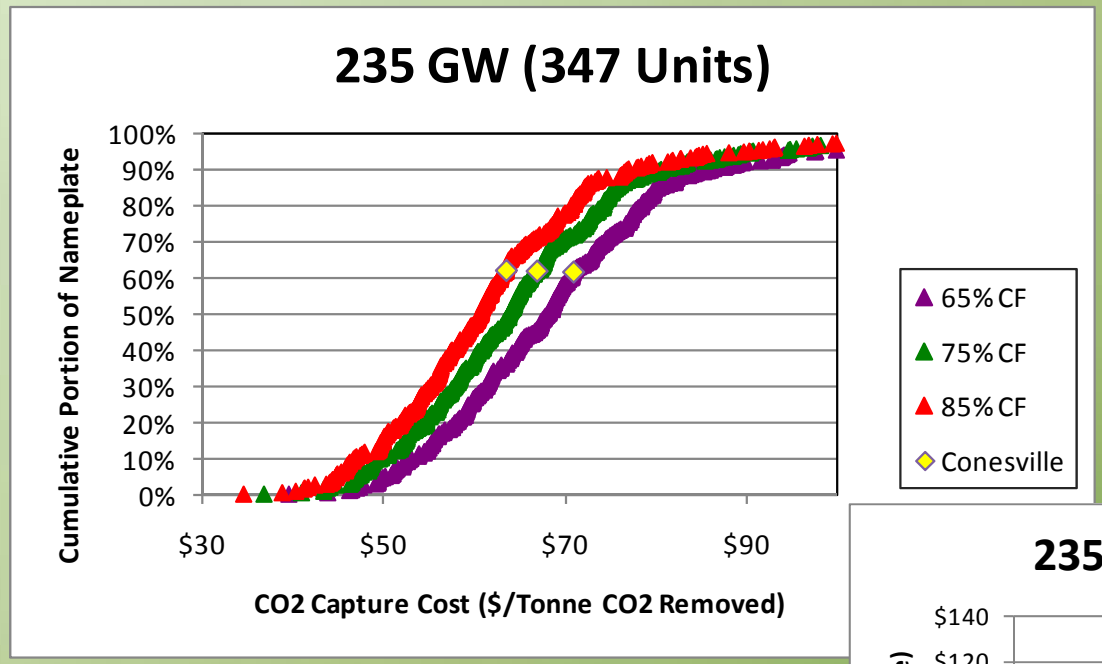
≥ 400 MW Unit Sample

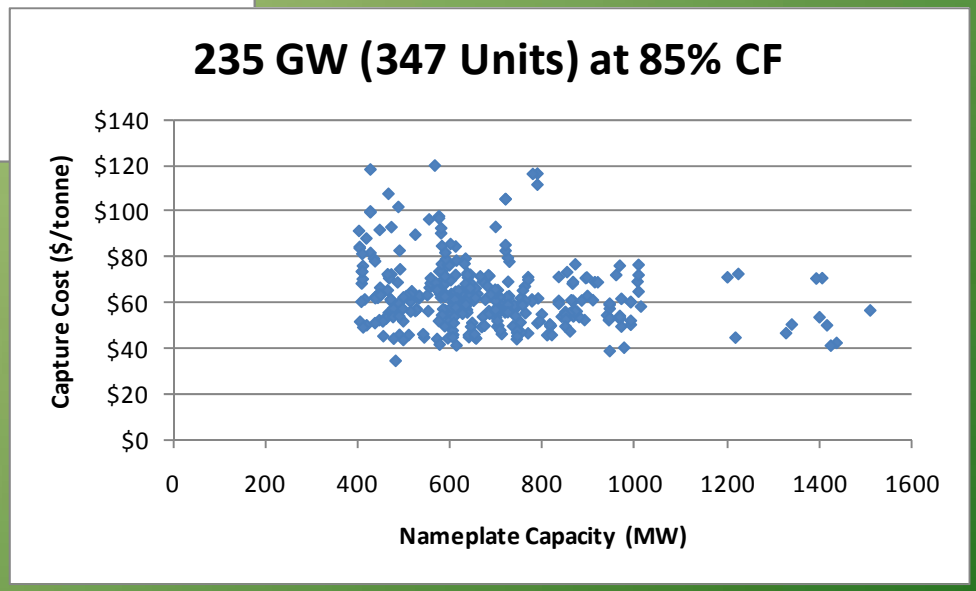
Construction Cost Adders





Scenario Carbon Capture and Storage Cost





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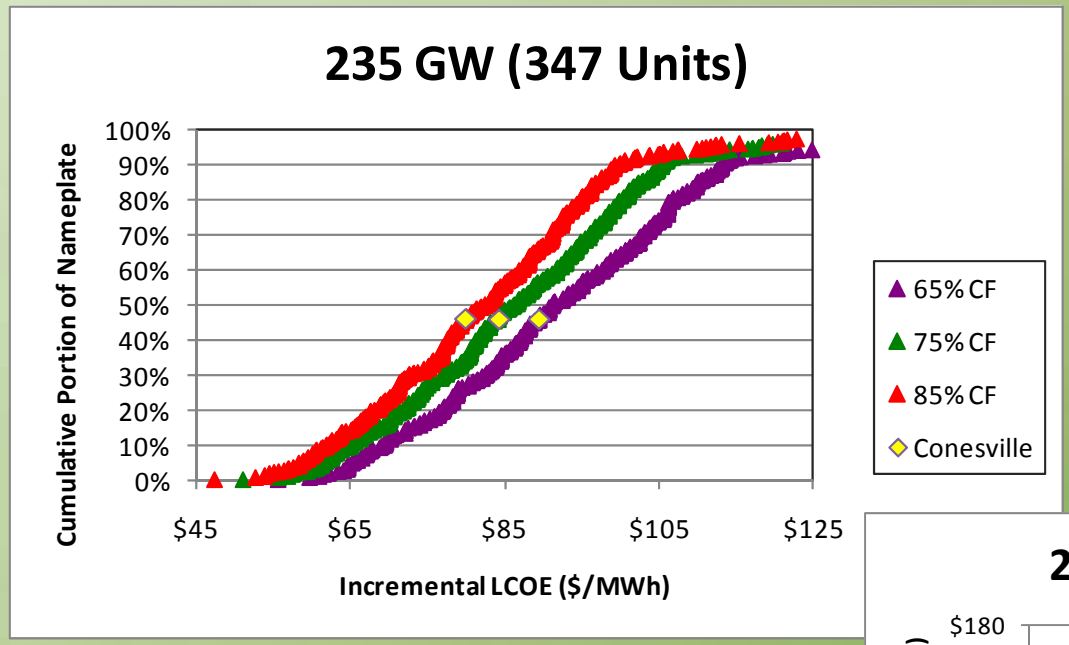
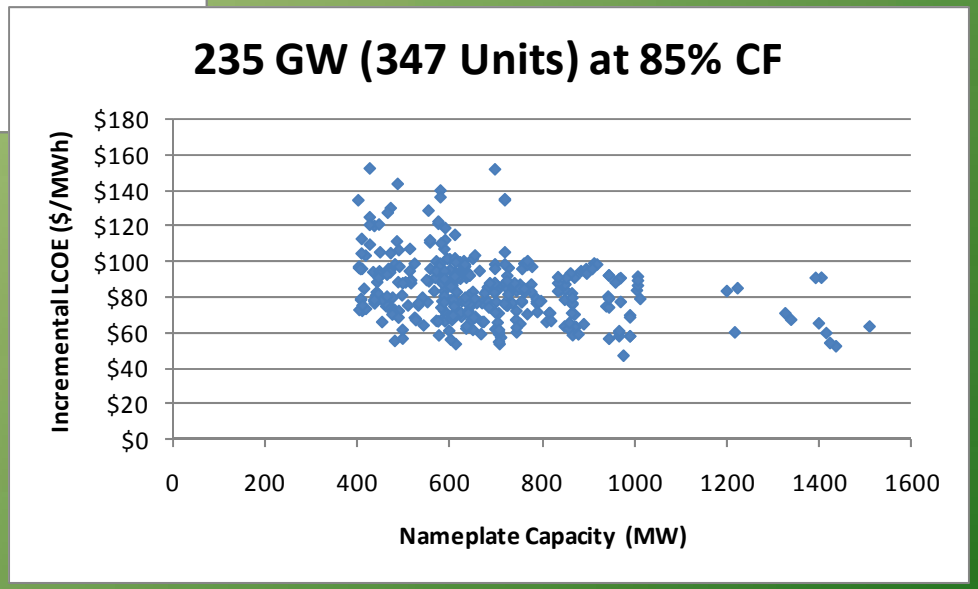
Scenario Incremental LCOE





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Benefits/Uses

- **Tailor analyses to examine an operator's portfolio of plants as a screening tool to assess the viability of retrofit**
- **Analyze electric generation/carbon-mitigation scenarios in a possible carbon-constrained world**
  - Cumulative frequency cost/supply curves
  - Alternative CO_2 allowances
- **Assess the costs of individual units and their components, including air emissions equipment**
- **Assess different alternative technology/situations for carbon capture and storage scenarios**
- **Model CFPP emission compliance costs relative to EPA Air Transport rule**
- **The Phase I Report can be found at: http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&Source=Main&PubId=289**

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