Clean Coal-Wind Hybrid
Improving Transmission Utilization & Facilitating Wind Integration

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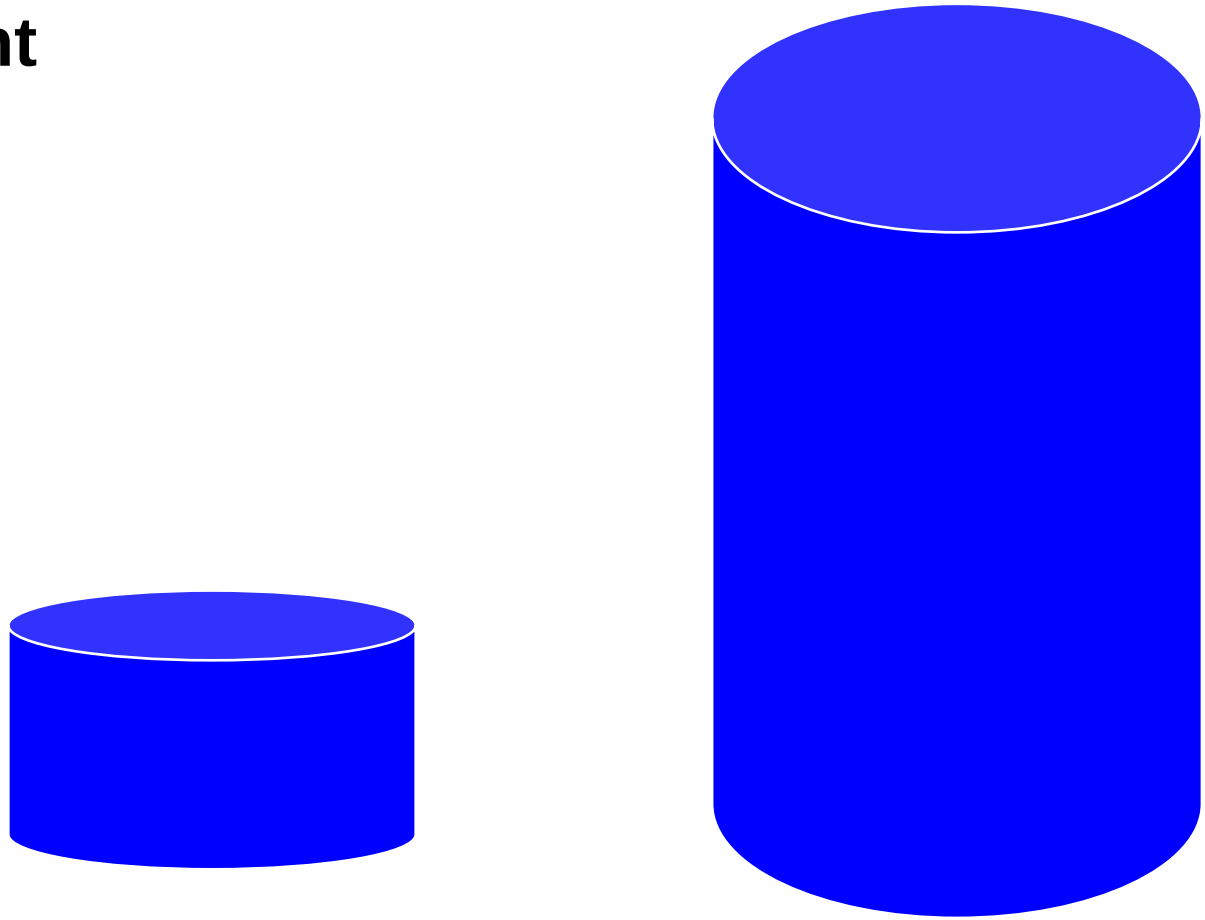
Clean Coal: Global Context

- **One Fat tire, for the first one who guesses this right**



Outline of the Presentation

- Background information on the Clean Coal-Wind hybrid feasibility study
- What is a Clean Coal-Wind Hybrid?
- Economic rationale for a Clean Coal-Wind Hybrid
- Analytical approach
- Preliminary results based on work in progress
- Conclusions and next steps

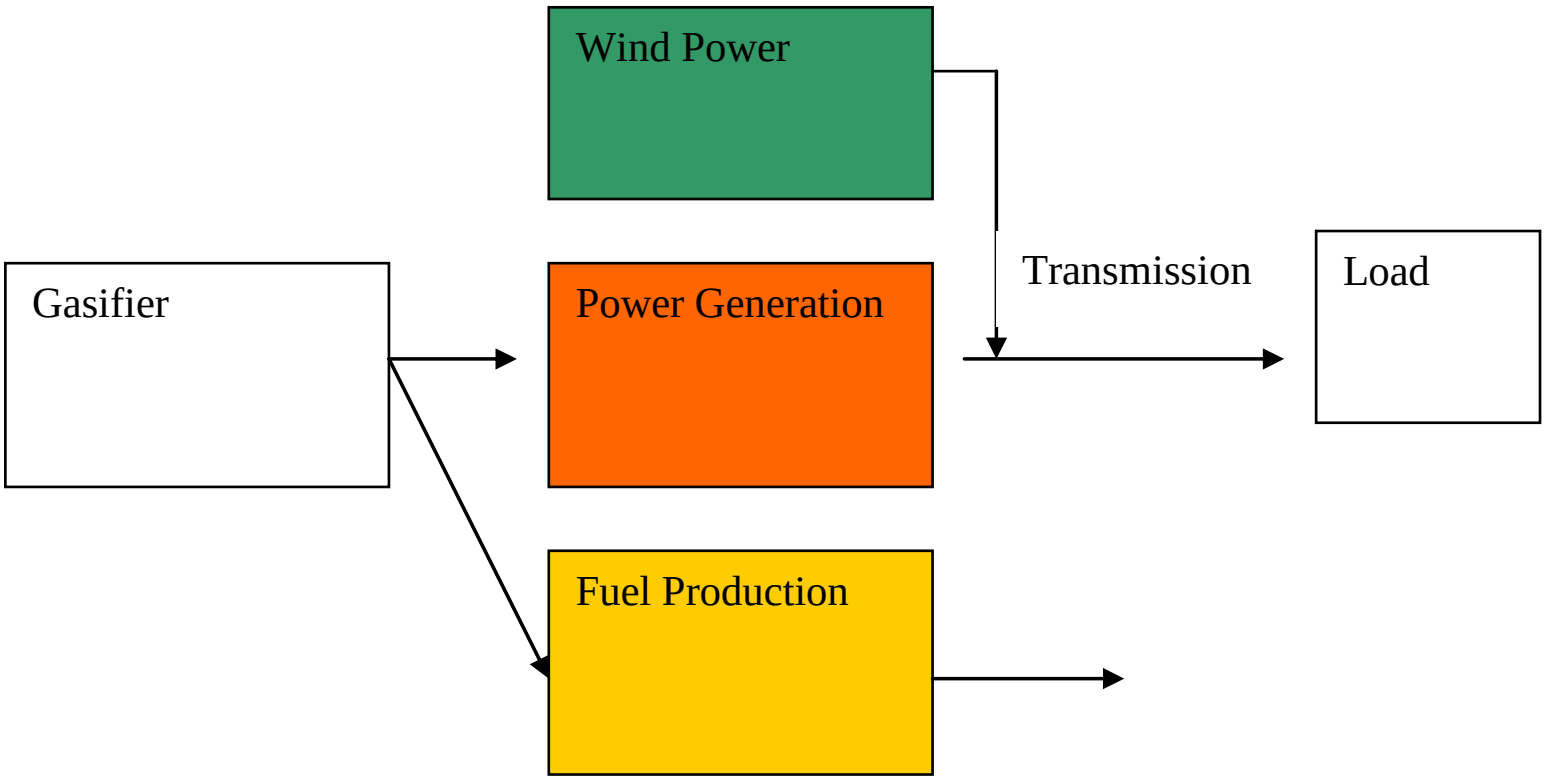
Clean Coal-Wind Hybrid Feasibility Study

- Context
  - Global Context: Carbon constrained world
  - High quality wind and cheap coal resources in Wyoming
  - Requires long distance transmission
- Objective: Screening level analysis of the economic merit and technical feasibility of a clean coal-wind hybrid generation option
- Study initiated by WIEB
  - Core Analytic Team: staff from LBNL, NETL, NREL, and WEIB
  - Steering Committee: includes representatives of stakeholders
- Status
  - Results will be finalized during next 1-2 months

What is a Coal-Wind Hybrid?

- **A Sample Configuration**
  - 3000 MW IGCC + CCS, 1500 MW wind plant, and a Fuel Production Facility located in Wyoming
  - Connected to the load center (e. g., Southern CA) via a 3000 MW long distance transmission line
- **Operation**
  - IGCC operation
  - When wind output is 0, IGCC + CCS plant operates at 3000 MW, all of the syngas produced by the gasifiers is utilized for power production
  - When wind output is 1,500 MW, IGCC + CCS plant is backed down to 1500 MWs, half of the output from the gasifiers is used for power generation while the other half is used for fuel production
- **Results into**
  - High transmission utilization (> 90%)
  - Firm 3000 MW, 24*7 power delivery at the load center
  - Clean Generation Option: 90% of the CO2 generated is captured
  - Backing down of only the power generation unit in the IGCC + CCS system (which is only ~ 20% of the total capital cost), other components utilized at high capacity factor

Coal Wind Hybrid from an Economic Perspective



Economic Rationale for Coal-Wind Hybrid

- **Improve the utilization of transmission lines**
  - **Transmission utilization is low if only wind power is transmitted**
  - **Economic opportunities in improving the utilization of transmission lines**
- **Second best option to firm-up the wind resource**
  - **Firming up wind at source is not the first best option**
    - Objective is to meet load
    - Aggregating wind resources reduces the variance in wind generation
  - **However, if it occurs in addition to improving transmission utilization, it certainly has economic value**

Key Economic Considerations

- Tradeoffs between generation and transmission costs
  - Backing down of power generation unit to accommodate wind generation: Increases generation costs per unit of output, at the same time, reduces transmission costs per unit of electricity transmitted
  - Capital intensity of generation and transmission influence the economics
- Advantages of a fuel production/storage facility
  - Only the power generation unit is backed down, other components of the system are utilized at a high capacity factor
- Tradeoffs between fuel production and transmission costs
  - Lower capacity factor on the fuel plant
  - Cost of storage

Overview of the Analysis

- **Objective**
  - **Evaluating economic merit**
    - Comparing different hybrid configurations
    - Comparison with competing options
  - **Evaluating technical feasibility**
    - Ramp rate constraints on the power generation and fuel production units
- **Analytical Approach**
  - Screening level analysis using a spread-sheet based model
  - Comparison based on levelized costs: approximate corrections for capacity value, capacity factor, and the timing of the generation
  - Sensitivity Analysis
  - Limitations of screening level analysis
- **Cost and parameter assumptions/estimates**
  - Primarily based on information provided by NETL & NREL
  - Substantial inputs by stakeholders
- **Results**
  - Work in progress

Resource Options Considered

- Hybrid options
  - Hybrid with fuels production (SNG, Syncrude, methanol)
  - Syngas storage (system is sized lower than the power generation unit)
  - CCGT-wind hybrid, CT-wind Hybrid, Hypothetical Hybrid Benchmark
  - All Coal-wind hybrid options have 3000 MW of coal generation , 1500 MW wind generation, 3000 MW of transmission line
- Competing options
  - Stand alone coal, stand alone wind (with capacity overbuild), NGCC, PC, solar concentric power etc
- Options not considered
  - EE: Economical than most advanced generation options
  - Advanced gas: cost of saved CO2 ~ $80/Ton, buying permits more economical
  - PC + CCS: More expensive than IGCC + CCS
  - IGCC without CCS: without CCS, IGCC does not offer economic advantages over PC. IGCC has lower emissions of mercury and sulfur and has lower water requirements

Preliminary Results Based on Work in Progress

- Coal-Wind Hybrid with a fuel production/or syngas storage is feasible given current technology
  - Ramp rates on power generation and fuel production units are adequate to accommodate the variation in wind output
- Coal-wind hybrid with fuel production or syngas storage is the most economical option among other hybrid alternatives (CCGT-wind hybrid, CT-wind Hybrid, and coal-wind hybrid without fuel production or storage) under most scenerios we consider
- Coal-wind hybrid with fuel production/storage has economic merit and compared to a stand alone benchmark, savings range from ~ $300 M to $1500 M over the life of the project
- Coal-wind hybrid is competitive with or more economical compared to
  - NGCC generation above a NG price $5.5/MMBtu (at a carbon price of $40/TonCO2)
  - PC generation above a carbon price of $20/TonCO2
- Results are screening level: future work required for precise estimates

Questions/Comments