Attachment 1
Design Basis for Techno-economic Analyses Deliverables

This attachment sets forth the minimum criteria to be used in the Techno-economic Analyses (TEA) Deliverables required as project deliverables for awarded projects. Table 1 provides the minimum requirements and additional recommendations on the TEA design basis. Table 2 provides the minimum reporting requirements for the TEA. As applicable, requirements are further delineated by primary product (i.e. power or liquids).

References are made to the following NETL publications to provide additional detail on the design basis requirements and recommendations. The following publications can be located at http://www.netl.doe.gov/research/energy-analysis

- NETL's *"Cost and Performance Baseline for Fossil Energy Plants,"* referred to as "Baseline Studies"[1]
  - *"Volume 1: Bituminous Coal and Natural Gas to Electricity"*
  - Supplement to Volume 1 *"Updated Costs (June 2011 Basis) for Selected Bituminous Baseline Cases"*
  - *"Volume 3: Low Rank Coal and Natural Gas to Electricity"*
  - *"Volume 4: Bituminous Coal to Liquid Fuels"* (anticipated completion June 2014), referred to as the "CTL Baseline"
- NETL's *"Production of Zero Sulfur Diesel from Domestic Coal,"* referred to as the "CBTL study" [2]
  - Update to 2011 dollars anticipated completion June 2014
- NETL's "*High Value Gasification Products: Crude Methanol Cases*", referred to as the "Crude Methanol study" (anticipated completion April 2014)
- NETL's Series of Quality Guidelines for Energy Systems Studies (QGESS)[3]

Table 1 - Design Basis Requirements for TEA

PARAMETER	MINIMUM REQUIREMENTS	RECOMMENDATIONS
Case Configurations	One reference IGCC case using conventional technology and one IGCC case using advanced technology. AND One reference gasification-based liquids production case using conventional technology and one gasification-based liquids production case using advanced technology.	If applicable, one of the power or liquid fuels cases in the Baseline Studies or the liquids fuels cases in the CBTL study or the Crude Methanol study could be replicated and utilized for the reference case(s).
Fuel Type	The fuel type(s) shall be the same for the conventional and advanced cases. If multiple fuels are used (i.e. co-feeding or coal and biomass or coal and natural gas), the fractions of each fuel shall be the same for the conventional and advanced cases. QGESS on "Specification for Selected Feedstocks" provides the specifications for natural gas and multiple coal types. The coal type for use in the TEA is limited to: Illinois #6 (Bituminous), Montana Rosebud PRB (Sub-bituminous), Wilcox Group (TX lignite) or Beulah-Zap (ND lignite). Coal must be the predominant fuel (i.e. >50% by energy content).	

[1] http://www.netl.doe.gov/research/energy-analysis/energy-baseline-studies
[2] http://netl.doe.gov/research/energy-analysis/publications/details?pub=dc5dbbe6-6028-4634-8229-a821ae6c9a7a
[3] http://www.netl.doe.gov/research/energy-analysis/quality-guidelines-qgess

PARAMETER	MINIMUM REQUIREMENTS	RECOMMENDATIONS
Product Specifications	<u>Power Cases</u> 100% power	
	<u>Liquids Cases</u> The liquid fuels cases shall either maximize diesel production via Fischer Tropsch (FT) or maximize methanol production. Methanol need not be chemical grade (consistent with the Crude Methanol study). Additional co-products are anticipated (i.e. FT naphtha and LPG). Net power imports or exports are allowed, but shall be minimized.	
CO_2 Removal	<u>Power Cases</u> >90% based on the raw syngas carbon content	
	<u>Liquids Cases</u> For FT: ≥87% based on the raw syngas carbon content. For Methanol: ≥90% based on the raw syngas carbon content. NETL studies show this level of capture results in coal-to-FT liquids and coal-to-gasoline via methanol with life cycle GHG emissions equal to or lower than the petroleum baseline.	
CO_2 Purity	Satisfy "Conceptual Design Limits" for Enhanced Oil Recovery as listed in Exhibit 2-1 of the NETL QGESS titled "CO_2 Impurity Design Parameters".	
CO_2 Delivery Pressure	2,215 psia	
Plant Size	<u>Power Cases</u> Enough hydrogen-rich fuel gas production to fill two advanced F-class turbines (232 MW each) as defined in the Baseline Studies. Adding in the steam turbine power and net of auxiliary loads, the net capacity is typically in the range of 500-550 MW.	
	<u>Liquids Cases</u> 50,000 bpd of product (includes all liquid by-products).	
Ambient Conditions	Choose from locations in the Baseline Studies based on fuel type and/or adjust for delivery (i.e. PRB coal delivered to the Midwest at ISO conditions is acceptable, but lignite cannot be delivered and must be used in Texas or North Dakota).	
System Boundaries	1. Delivered coal entering the power plant, through high-pressure, high-purity CO_2 stream crossing the plant boundary 2. Combustion air or intake air to cryogenic air separation unit 3. Flue gas to stack 4. Net electricity conditioned and sent to electric grid 5. Raw make-up water 6. Waste streams generated by the power plant, including the CO_2 capture system, should be adequately treated on-site prior to disposal either by landfill or other commercial disposal options.	
Power Block	<u>Power Cases</u> Two advanced F-class Turbines (nominally 232 MW each) and one heat recovery steam generator and steam turbine consistent with the Baseline Studies.	<u>Liquids Cases</u> An advanced F-class Turbine is recommended for any power generation needs within the plant.

PARAMETER	MINIMUM REQUIREMENTS	RECOMMENDATIONS
Additional Design Considerations	In addition to those items defined above, the basis for the cases and the *conventional* technologies should be similar to that used for the cases within the NETL studies including: 1. Site Characteristics 2. Air Separation Unit Design 3. Gasifier Design 4. Steam or Gas Turbine Cycle Conditions 5. Environmental Controls and Performance 6. Cooling System 7. Balance of Plant	
Material and Energy Balances	Material and energy balances shall be performed around the complete power or liquids plant and around all major pieces of equipment therein, including all heating and cooling duties and electric power requirements. All material and energy balance calculations must be accurate, and equilibria, physical and thermodynamic properties must be calculated using rigorous models.	
Process modeling and cost estimating software	There are no specific software requirements for developing the material and energy balances, or costing the capture process. However, all material and energy balance calculations must be accurate, and equilibria, physical and thermodynamic properties must be calculated using rigorous models. Similarly, mass and heat transfer models employed must be based upon a rigorous mathematical description of transport phenomena.	AspenPLUS is preferred process modeling software.
Availability and Capacity Factor	<u>Power Cases</u> The reference case shall assume availability and capacity factor equal to 80%, consistent with the Baseline Studies. If the advanced technology will impact the availability of the entire plant, the basis for such a change shall be clearly stated.	
	<u>Liquid Fuels Cases</u> The reference case shall assume availability and capacity factor equal to 90%, consistent with the CTL Baseline, the CBTL study and the Crude Methanol study (spare gasifier capacity must be consistent with this availability assumption). If the advanced technology will impact the availability of the entire plant, the basis for such a change shall be clearly stated.	
Year Dollars	June 2011	
Capital cost estimating	The code of accounts for the capital cost estimate shall follow those used in the Baseline Studies. Engineering fees, contingencies and owner's costs shall follow the QGESS "Cost Estimation Methodology for NETL Assessments of Power Plant Performance."	The NETL QGESS, "Capital Cost Scaling Methodology" is recommended to scale the accounts with equipment common to base cases within the NETL studies.
Operating and Maintenance (O&M) Costs	Operating and maintenance cost (O&M) shall be itemized and shall utilize the costs in the 2011 Dollar supplement to Volume 1 of the Baseline Studies. Coal and natural gas costs shall follow the costs in the QGESS "Fuel Prices for Selected Feedstocks in NETL Studies". Hybrid poplar costs (in 2011$/ton) shall be a function of the	

PARAMETER	MINIMUM REQUIREMENTS	RECOMMENDATIONS
	quantity consumed as follows: $1.25 \times 10^{-11} X^3 - 2.95 \times 10^{-7} X^2 + 3.47 \times 10^{-3} X + 128$ Where: X = (1 – BMS) x (AR BF) BMS = Biomass moisture fraction AR BF = As received biomass feed (tons per day)	
Co-Product Costs	<u>Liquids Cases</u> For net power imports and exports, the power price shall be assumed to be $60/MWh. Liquid co-product prices shall be indexed to the primary product (diesel/methanol) using the same ratios in the corresponding NETL studies.	
CO_2 Transport and Storage	Transport and storage (T&S) cost for CO_2 shall be location specific as follows: Midwest - $10/tonne Texas - $10/tonne North Dakota - $15/tonne Montana - $22/tonne	
Finance structure, discounted cash flow analysis and required selling price of product	<u>Power Cases</u> Utilize high risk IOU finance structure (capital charge factor = 0.124) and methodology set forth in the Baseline Studies and the QGESS on Cost Reporting Methodology. <u>Liquids Cases</u> Utilize Commercial Fuels Projects finance structure set forth in NETL's "Recommended Project Finance Structure for the Economic Analysis of Fossil-Based Energy Projects"[4] (capital charge factor = 0.237) and calculate the crude oil equivalent required selling price as in the CTL Baseline Study or CBTL study and/or the methanol required selling price as in the Crude Methanol study.	Alternate discounted cash flow analysis approaches and reporting of required selling price may be utilized in addition to the required approach.

[4] http://netl.doe.gov/research/energy-analysis/publications/details?pub=8c0c1dde-c78c-4fec-a0e0-f11feb2561cd

Table 2 - Reporting Requirements for TEA

PARAMETER	MINIMUM REQUIREMENTS
Process Flow Diagram	A process flow or block flow diagram shall be included that identifies all major process equipment for the power or liquids plant including CO_2 capture and compression systems, separation vessels, heat exchangers, pumps, compressors, etc. Complete stream tables showing operating pressures, temperatures, compositions and enthalpies for all streams entering or leaving major process equipment shall be included.
Performance Reporting Requirements	Using the NETL Studies as a template, the final report shall include the following: 1. Plant and component descriptions 2. Performance summary including breakdown of gross power generation, auxiliary power requirements and net plant efficiency at the same level of detail as the NETL Studies 3. Air emissions tables 4. Carbon, sulfur and water balances
Cost Estimating Reporting Requirements	Capital Costs: The code of accounts for the capital cost estimate shall follow those used in the NETL Studies. For each account, costs shall be broken down into bare erected costs, engineering fees, process contingency and project contingency, adding up to an account-level total plant cost. The total plant cost, owner's costs and total overnight cost for the entire plant shall also be reported. O&M Costs: Itemized operating and maintenance costs shall follow those used in the Baseline Studies. For power cases: Cost of electricity (first-year as defined in the QGESS on Cost Estimation Methodology) shall be reported. For liquids cases: Crude oil equivalent required selling price for FT liquids cases, and/or required selling price for methanol production cases (first-year). For power and liquids cases, the COEs and required selling prices shall be reported both with and without the cost of CO2 T&S defined in Table 1 above. Cost of capturing CO_2 shall be reported (if a reference non-capture plant is available).
Advanced Technology Details	Additional details are required regarding the advanced technology including: 1. Itemized equipment list for equipment unique to the advanced technology and other equipment required for the integration of the advanced technology into the power or liquids plant. 2. Estimates for equipment and consumables unique to the process being developed. If possible, capital cost estimates for unique equipment will be made based on similar equipment that may exist for other type processes. If equipment analogs do not exist for unique equipment the developer must do a bottoms-up estimate of the unique equipment.
Sensitivity Analyses	Sensitivity of required selling price (COE or liquids-equivalent) shall be performed on the following parameters: 1. Critical advanced technology performance parameters 2. Capital cost of advanced technology 3. Non-coal fuel prices 4. Sales of CO_2 at plant gate prices of \$0-60/tonne 5. Cost of CO_2 emissions of \$0-60/tonne 6. For liquids cases: - Power price for net imports/exports at \$60-135/MWh - Finance structure by assessing capital charge factors of 0.12-0.25 -

PARAMETER	MINIMUM REQUIREMENTS
Additional deliverables	Process models with brief documentation and economic spreadsheet tools/models shall be provided. Methods and models used must be documented in the TEA.

Table 3 - Hybrid Poplar Design Analysis[5]

Ultimate Analysis	Dry Basis, %	As Received, %
Carbon	52.36	26.18
Hydrogen	5.60	2.80
Nitrogen	0.37	0.19
Sulfur	0.03	0.02
Chlorine	0.00	0.00
Ash	1.48	0.74
Moisture	0.00	50.00
Oxygen	40.16	20.08
Total	100.0	100.0
Heating Value	**Dry Basis,**	**As Received, %**
HHV, kJ/kg	18,113	15,396
HHV, Btu/lb	8,438	4,219
LHV, kJ/kg	17,593	8,796
LHV, Btu/lb	7,938	3,969

[5] http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&Source=Main&PubId=426