Wabash River Integrated Methanol and Power Production from Clean Coal Technologies (IMPPCCT)

Quarterly Technical Progress Report No. 01

For the Period

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and

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ABSTRACT

The Wabash River Integrated Methanol and Power Production from Clean Coal Technologies (IMPPCCT) project is evaluating integrated electrical power generation and methanol production through clean coal technologies. The project is conducted by a multi-industry team lead by Gasification Engineering Corporation (GEC), and supported by Air Products and Chemicals, Inc., Dow Chemical Company, Dow Corning Corporation, Methanex Corporation, and Siemens Westinghouse Power Corporation. Three project phases are planned for execution over a three year period, including:

I. Feasibility study and conceptual design for an integrated demonstration facility, and for fence-line commercial plants operated at Dow Chemical or Dow Corning chemical plant locations
II. Research, development, and testing to define any technology gaps or critical design and integration issues
III. Engineering design and financing plan to install an integrated commercial demonstration facility at the existing Wabash River Energy Limited (WREL) plant in West Terre Haute, Indiana.

This report describes management planning, work breakdown structure development, and feasibility study activities by the IMPPCCT consortium in support of the first project phase.

Project planning activities have been completed, and a project timeline and task list has been generated. Requirements for an economic model to evaluate the West Terre Haute implementation and for other commercial implementations are being defined. Specifications for methanol product and availability of local feedstocks for potential commercial embodiment plant sites have been defined.

The WREL facility is a project selected and co-funded under the fifth phase solicitation of the U.S. Department of Energy's Clean Coal Technology Program. In this project, coal and/or other solid fuel feedstocks are gasified in an oxygen-blown, entrained-flow

gasifier with continuous slag removal and a dry particulate removal system. The resulting product synthesis gas is used to fuel a combustion turbine generator whose exhaust is integrated with a heat recovery steam generator to drive a refurbished steam turbine generator. The gasifier uses technology initially developed by The Dow Chemical Company (the Destec Gasification Process), and now offered commercially by Global Energy, Inc., as the E-GAS™ technology.

In a joint effort with the U.S. Department of Energy, working under a Cooperative Agreement Award from the “Early Entrance Coproduction Plant” (EECP) initiative, the GEC and an Industrial Consortia are investigating the application of synthesis gas from the E-GAS™ technology to a coproduction environment to enhance the efficiency and productivity of solid fuel gasification combined cycle power plants.

The objectives of this effort are to determine the feasibility of an EECP located at a specific site which produces some combination of electric power (or heat), fuels, and/or chemicals from synthesis gas derived from coal, or, coal in combination with some other carbonaceous feedstock. The project’s intended result is to provide the necessary technical, economic, and environmental information that will be needed to move the EECP forward to detailed design, construction, and operation by industry.

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ACRONYMS AND DEFINITIONS

Acronym	Description
ASU	Air Separation Unit
BFW	Boiler Feed-Water
BGL	British Gas Lurgi
CEP	Commercial Embodiment Plant
CT	Combustion Turbine
CCT	Clean Coal Technologies
DOE	Department of Energy
EECP	Early Entrance Coproduction Plant
E-GAS™	Title of Global Energy, Inc.'s Gasification Process
GEC	Gasification Engineering Corporation
GJ	Giga Joule
GPMEOH	Gas Phase Methanol
HHV	Higher Heating Value
HRSG	Heat Recovery Steam Generator
HTHRU	High Temperature Heat Recovery Unit
IGCC	Integrated Gasification Combined Cycle
IMPPCCT	Integrated Methanol and Power Production from Clean Coal Technologies
LGTI	Louisiana Gasification Technology Incorporated
LOX	Liquid Oxygen
LPMEOH™	Liquid Phase Methanol (process)

Acronym	Description
MDEA	Methyl-Di-Ethanol Amine (solvent)
MMBtu	Million British Thermal Units
Mt	Metric Ton
MTPD	Metric Ton Per Day
MW	Mega Watt
NETL	National Energy Testing Laboratory
NOx	Oxides of Nitrogen (symbol)
O&M	Operating & Maintenance
PSE	Power Systems Engineering
RD&T	Research, Development & Testing
SFC	Synthetic Fuels Corporation
SWPC	Siemens Westinghouse Power Corporation
Syngas	Synthesis Gas
TPD	Tons Per Day
WBS	Work Breakdown Structure (activities)
WREL	Wabash River Energy Ltd.

1.0 BACKGROUND

1.1 E-GAS™ Process Background

The Gasification Engineering Corporation (GEC) develops and markets the E-GAS™ coal gasification process that is utilized at the Wabash River Energy Ltd. (WREL) Facility in West Terre Haute, Indiana. The WREL facility is located at Cinergy Corporation's Wabash River Generating Station. GEC and WREL are wholly owned subsidiaries of Global Energy, Inc., headquartered in Cincinnati, Ohio.

The E-GAS™ process features an oxygen-blown, continuous-slagging, two-stage, entrained-flow gasifier, which uses natural gas for start-up. Coal or petroleum coke is milled with water in a rod-mill to form a slurry. The slurry is combined with oxygen in mixer nozzles and injected into the first stage of the gasifier, which operates at 2600°F and 400 psi. A turnkey, Air Liquide, 2,060-ton/day low-pressure cryogenic distillation facility that WREL owns and operates, supplies oxygen of 95% purity.

In the first stage, slurry fuel undergoes a partial oxidation reaction at temperatures high enough to bring the coal's ash above its melting point. The fluid ash falls through a taphole at the bottom of the first stage into a water quench, forming an inert vitreous slag. The synthesis gas produced by this reaction then flows to the second stage, where additional coal slurry is injected. This coal is pyrolyzed in an endothermic reaction with the hot synthesis gas to enhance the heating value of the synthesis gas and to improve overall efficiency of the process.

The synthesis gas then flows to the high-temperature heat-recovery unit (HTHRU), essentially a fire tube steam generator, to produce high-pressure saturated steam. After cooling in the HTHRU, particulates in the synthesis gas called char are removed in a hot/dry filter and recycled to the gasifier where the carbon content in the char is converted into synthesis gas. The synthesis gas is further cooled in a series of heat exchangers, is water scrubbed for chloride removal, and is passed through a catalyst, which hydrolyzes carbonyl sulfide into hydrogen sulfide. Hydrogen sulfide is removed from the synthesis gas using a methyl-diethanol-based amine solvent in an absorber/stripper column process. The “sweet” synthesis gas is then moisturized, preheated, and piped over to the power block.

The key elements of the power block are the General Electric MS 7001 FA (GE 7 FA) high-temperature combustion turbine/generator, the heat recovery steam generator (HRSG), and the repowered steam turbine. The GE 7 FA is a dual-fuel turbine (synthesis gas for operations and No. 2 fuel oil for startup) that is capable of generating a nominal 192 MW when firing synthesis gas, about seven percent (7%) higher power production than the same turbine fired on natural gas. The enhanced power production is attributed to the increased mass flows associated with synthesis gas. Steam injection is used for control of nitrogen oxides (NOx) within the combustion turbine. The required steam flow is minimal compared to that of conventional systems as the synthesis gas is moisturized at the gasification facility, by recovery of low-level heat in the process. The water consumed in this process is continuously made up at the power block by water treatment systems, which clarify and further treat the river water intake.

The HRSG for this project is a single-drum design capable of superheating 754,000 lb/hr of high-pressure steam at 1010°F, and 600,820 lb/hr of reheat steam at 1010°F when operating on design-basis synthesis gas. The HRSG configuration was specifically optimized to utilize both the gas-turbine exhaust energy and the heat energy made available in the gasification process. The nature of the gasification process in combination with the need for strict temperature and pressure control of the steam turbine led to a great deal of creative integration between the HRSG and the gasification facility. The repowered steam turbine produces 104 MW, which combines with the combustion turbine generator’s 192 MW and the system’s auxiliary load of approximately 34 MW to yield 262 MW (net) to the Cinergy grid.

The Air Separation Unit (ASU) provides oxygen and nitrogen for use in the gasification process, but is not an integral part of the plant thermal balance. The ASU uses services such as cooling water and steam from the gasification facilities and is operated from the gasification plant control room.

The gasification facility produces two commercial by-products during operation. Sulfur, which is ultimately removed as 99.99 percent pure elemental sulfur, is marketed to sulfur users. Slag is targeted as an aggregate in asphalt roads and as structural fill in various types of construction applications. In fact, the roads at the WREL facility have been top-coated with asphalt incorporating slag as the aggregate. Furthermore, at least two surrounding area sites have been audited, approved, and have used WREL generated slag as structural fill under the Solid Waste Management Rules of Indiana. Another beneficial use of the slag by-product is as a fluxing agent during petroleum coke operation as this feed is typically deficient in mineral content required for proper slag fusion and flow. For this use, WREL has retained a reserve supply of slag generated from coal gasification.

The E-GAS™ process flow diagram presented in Figure 1 illustrates the features and components described in the above text. In Table 1, the WREL production statistics are presented by year in both English and Metric units. In Table 2, the WREL thermal performance variables are compared to the process design basis for both coal and petroleum coke feedstocks.

Please refer to the listing in Section 8.1 of this report for additional information on the Wabash River Coal Gasification Plant.

Figure 1: E-GAS™ Process Flow Diagram

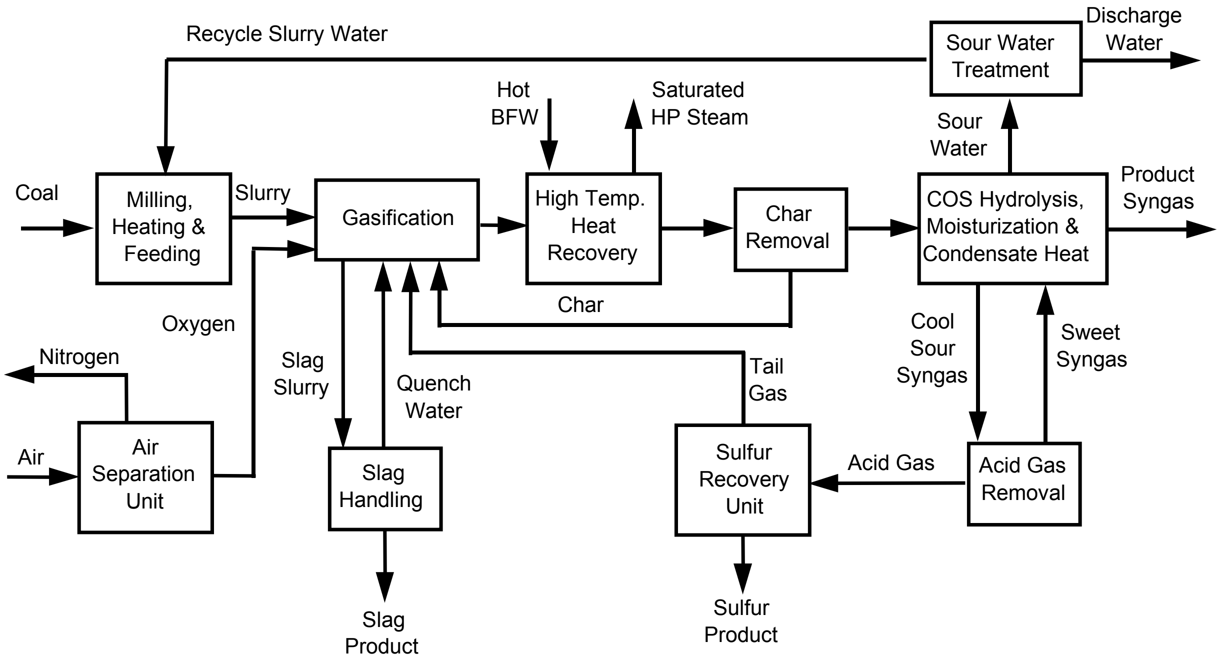

Table 1: WREL Gasification Production Statistics

Production Variable	Production Year				
	1996	1997	1998	1999	2000
Gasifier Operation, Hrs	1,902	3,885	5,279	3,496*	3,406**
Dry Synthesis Gas Produced, GJ (MMBtu)	2,922,015 (2,769,683)	6,555,626 (6,213,864)	9,316,716 (8,831,011)	6,132,874 (5,813,151)	5,497,588 (5,210,984)
Coal Processed, Mt (Tons)	167,270 (184,381)	356,368 (392,822)	500,316 (551,495)	335,538 (369,862)	290,034 (319,703)
Longest Operating Campaign, (days)	19	46	82	60	104

* Three months of production were lost to the GE 7FA compressor failure & repair.
** Three months of production were lost during commercial negotiations required when the WREL Facility transitioned to market-based operation.

Table 2: Overall Thermal Performance of Gasification at WREL

Performance Feature	Design	Actual Performance	
		Coal	Coke
Nominal Throughput, TPD	2550	2450	2000
Synthesis gas Capacity, MMBtu/hr	1780	1690†	1690†
Combustion Turbine, MW	192	192	192
Steam Turbine, MW	105	96	96
Aux. Power, MW	35	36	36
Net Generation, MW	262	261	261
Plant Efficiency, % (HHV)	37.8	39.7	40.2
Sulfur Removal Efficiency, %	>98	>99	>99

† Synthesis gas capacity referenced for coal and petroleum coke are the actual quantities fed to the combustion turbine when 192 MW (100%) of power generation occurs.

1.2 EECP Background Information

The request for Cooperative Agreement Proposals under the "Early Entrance Coproduction Plant (EECP)," Solicitation Number DE-SC26-99FT40040 was issued on February 17, 1999, by the United States Department of Energy.

The objective of this effort is to determine the feasibility of an EECP located at a specific site which produces some combination of electric power (or heat), fuels, and/or chemicals from synthesis gas derived from coal, or, coal in combination with some other carbonaceous feedstock. The scope of this effort includes:

a. Market analysis to define site-specific product requirements (i.e. products needed by market, market size, and price), process economics, feedstock availability and feedstock cost;
b. System analysis to define feedstocks, feedstock preparation, conversion to synthesis gas, synthesis gas cleanup, and conversion of synthesis gas to market-identified products;
c. Preliminary engineering design of the EECP facility;
d. Preparation of a Research, Development, and Testing (RD&T) plan that addresses the technical uncertainties associated with eventual design, construction, and operation of the EECP;
e. Implementation of RD&T plan;
f. Revision of the preliminary engineering design; and
g. Preparation of a project financing prospectus for obtaining private sector funding to perform the detailed design, construction, and operation of the EECP.

Efforts under Solicitation No. DE-SC26-99FT40040, must support an EECP that at a minimum:

1. Is a single-train facility of sufficient size to permit scaling to commercial size with minimal technical risk;
2. Provides the capability of processing multiple feedstocks (must be capable of processing coal) and producing more than one product;
3. Is undertaken by an industrial consortia;
4. Reduces risk such that future coproduction plants may be deployed with no government assistance; and
5. Meets or exceeds environmental requirements and discusses the issue of carbon dioxide reduction by one or more routes, which include mitigation, utilization, and sequestration.

Using a focused RD&T Plan, the EECP project will enhance the development and commercial acceptance of coproduction technology that produces high-value products, particularly those that are critical to our domestic chemical, fuel, and power requirements. The proposed project will resolve critical knowledge and technology gaps on the integration of gasification and downstream processing to co-produce some combination of power, fuels and chemicals from coal and other carbonaceous feedstocks. The project's intended result is to provide the necessary technical, economic, and environmental information that will be needed to move the EECP forward to detailed design, construction, and operation by industry.

2.0 INTRODUCTION

The Wabash River Integrated Methanol and Power Production from Clean Coal Technologies (IMPPCCT) project is a $4.92 million cooperative agreement between the United States Department of Energy (DOE) and the Gasification Engineering Corporation (GEC) to evaluate the integration of gasification-based electrical generation and methanol production processes to determine the economic and technical feasibility of power/chemicals coproduction. A multi-industry team led by GEC and consisting of Air Products & Chemicals, Inc., Dow Chemical Company, Dow Corning Corporation, Methanex Corporation, and Siemens Westinghouse Power Corporation will perform the IMPPCCT study.

The consortium for the Wabash River IMPPCCT plans to analyze and develop a concept of methanol and power production based on GEC's E-GAS™ Gasification Process utilizing coal and other feedstocks. In a 3-Phase, 36-month project, this team plans to review and fully analyze the domestic methanol market, examine the criteria needed and develop a robust financial model to study the economics of full-scale implementation of this gasification-methanol coproduction concept. Potential Dow Chemical and Dow Corning sites for the commercial embodiment plant will be examined. Feasibility studies, testing and engineering, and financing of IMPPCCT based on addition of methanol production facilities at the Wabash River Energy Limited (WREL) Gasification Plant in West Terre Haute, Indiana will be developed to enable the commercialization of the gasification-methanol production concept.

The vision of this project is to demonstrate the commercial viability of producing electric power, process energy (steam), and chemicals (methanol) from coal and other hydrocarbon feedstocks to satisfy the demands of at least two types and corresponding sizes of host chemical complexes. An efficient, low capital, integrated facility will convert the feedstock initially to synthesis gas and ultimately to electric power, process energy, and methanol with a series of reliable, commercially proven, and environmentally sound unit operations. The chemical products, required process energy, and at least a portion of the electric power will be delivered to the host chemical complex for further conversion to higher value products. Any products in excess of the requirements of the host chemical complex will be sold through readily accessible distribution networks. The commercial embodiment will be technically verified from the IMPPCCT demonstration and commercially verified by economic model and project financing prospectus.

3.0 EXECUTIVE SUMMARY

The Wabash River Energy Limited (WREL) facility is a project selected and co-funded under Round IV of the U.S. Department of Energy's Clean Coal Technology Program. In this project, coal and/or other solid fuel feedstocks are gasified in an oxygen-blown, entrained-flow gasifier with continuous slag removal and a dry particulate removal system. The resulting product synthesis gas is used to fuel a combustion turbine generator whose exhaust is integrated with a heat recovery steam generator to drive a refurbished steam turbine generator. The gasifier uses technology initially developed by The Dow Chemical Company (the Destec Gasification Process), and now offered commercially by Global Energy, Inc., as the E-GAS™ technology.

The project demonstration was completed in December 1999, having achieved all of its objectives. The facility built for this project is located at Cinergy Corporation's Wabash River Generating Station near West Terre Haute, Indiana.

The WREL project successfully demonstrated commercial application of the E-GAS™ coal gasification technology in conjunction with power generation. Operating time exceeds 18,000 hours, with over 5 million MWh of power produced. The combustion turbine generates 192 MWe and the repowered steam turbine generates 104 MWe. With the system's parasitic load of 34 MWe, net power production is 262 MWe, which meets the target goal. The plant operates successfully on baseload dispatch in the Cinergy power grid, and continues to operate as a privately owned facility providing power to Cinergy.

Gasification is an environmentally superior means of utilizing domestic coal resources for power production. It also offers the opportunity to use lower quality, less expensive feedstocks such as petroleum coke. Petroleum coke operation was tested and has been commercially demonstrated at the WREL Facility since August of 2000, resulting in over 3300 hours of operational experience.

Sulfur removal from the gasifier's solid feed is recovered and sold, as is the slag byproduct. Sulfur removal exceeds 97%, resulting in SO_X emissions of 0.1 lb / million Btu, which is far below regulatory requirements of 1.2 lb / million Btu. Particulate emissions are less than the detectible limit and NOx emissions are 0.15 lb/million Btu, which meets the current target for coal-fired power generation plants. The WREL Facility is one of the cleanest, if not the cleanest, solid fuel-based power plants in the world.

In a joint effort with the U.S. Department of Energy (DOE), a Cooperative Agreement was awarded under the "Early Entrance Coproduction Plant" (EECP) Solicitation to Gasification Engineering Corporation (GEC). An Industrial Consortia is investigating the use of synthesis gas produced by the E-GAS™ technology in a coproduction environment to enhance the efficiency and productivity of solid fuel gasification combined cycle plants.

The objectives of this effort are to determine the feasibility of an EECP located at a specific site which produces some combination of electric power (or heat), fuels, and/or chemicals from synthesis gas derived from coal, or, coal in combination with some other carbonaceous feedstock. The project's intended result is to provide the necessary technical, economic, and environmental information that will be needed to move the EECP forward to detailed design, construction, and operation by industry.

On October 7, 1999, the GEC signed the Cooperative Agreement with the DOE and began working on non-disclosure and engineering service agreements with the consortium subcontractors.

For the reporting period, activities were limited to development of the Project Management Plan and Initial Feasibility Study work. Early Feasibility Study work is focused on concept definition, development, technical assessment, and economic considerations for adding methanol production capability to the coal gasification plant at the WREL facility in West Terre Haute, Indiana. This implementation called IMPPCCT for Integrated Methanol and Power Production from Clean Coal Technologies includes the scope necessary to incorporate such capability to the plant's existing gas cleanup and combined cycle power generation systems.

On December 1, 1999, members of the consortium and GEC discussed the project and technology overview including summaries of the phased approach, schedule, and spending profile with the DOE in a project kick-off presentation.

In mid-December, 1999, the consortium met to outline the project and modeling execution strategies. In addition, frameworks of the work breakdown structure and task schedules defining scope of deliverables were discussed and is being developed to govern work in all phases.

Regarding the Initial Feasibility Study, preliminary concept definition was complete with the adoption of a product specification for co-produced methanol. In addition several likely gasification feedstocks were identified and evaluated, resulting in the generation of a preliminary mass and energy balance for the gasification portion of the facility.

For the period of reporting, a total of two and three-tenths percent (2.3%) of the authorized Phase I funding ($1,546,902) was spent.

4.0 ACTIVITIES

4.1 Contractual Activities

On October 7, 1999, the GEC signed the Cooperative Agreement, Instrument Number DE-FC26-99FT40659, with the DOE. After execution, GEC notified all subcontractors of award status and began working on non-disclosure and engineering service agreements (subcontracts) in an effort to assemble and mobilize the consortium.

GEC, as the potential host for the IMPPCCT / EECP implementation and the "E-GAS" technology owner, acts as the prime contractor under the Cooperative Agreement with the DOE. The engineering service agreements between GEC as prime contractor and all industrial subcontractors are being structured to mirror the requirements of the Cooperative Agreement between DOE and GEC.

The other consortium members, Air Products and Chemicals Inc., The Dow Chemical Company, Dow Corning Corporation, Methanex Corporation, and Siemens Westinghouse Power Corporation, have all agreed to execute engineering service agreements with GEC pending approval of subcontractor status from DOE.

Each subcontract includes language outlining responsibility for work scope performance and accountability for the participant-funded cost share with respect to the terms and conditions that will be identical to the Cooperative Agreement. Each sub-contractor has provided a letter of intent to GEC, confirming their agreement for this subcontract arrangement.

With the purpose of mobilizing all subcontractors and In lieu of executed subcontract arrangements, letters of Limited Notice to Proceed were issued to the commercial representatives for each industrial partner in the consortium on November 1, 1999.

The subcontract documents will also provide for periodic progress reports related to the technical progress and project management issues from each subcontractor to GEC. The team members from each consortium company will manage their own work internal to their respective organization.

4.2 Project Planning Activity

The feasibility study is initially focused on the technical and economic considerations for adding methanol production capability to the coal gasification plant at the WREL facility in West Terre Haute, Indiana. This implementation called IMPPCCT includes a scope of work sufficient to attach coproduction capability, more specifically, to the WREL plant's existing gas cleanup and combined cycle power generation systems.

In keeping with the focus for the feasibility study, several meetings were conducted between GEC and each subcontractor for the period spanning October 1 through November 29, 1999 via teleconference. These meetings were intended to provide agreement, definition, and direction for the lead and subordinate roles within the technology and economic modeling groups created to prosecute the two aspects of this study. Both groups worked jointly to identify and refine the tasks involved to complete each section of the Work Breakdown Structure (WBS) as identified in the Cooperative Agreement. In this cooperative effort, participants of the two-team arrangement refined the WBS to develop significant portions of the Project Management Plan.

While both the technology and economic modeling teams forged ahead with development of the Management Plan, future roles for each group were determined. Both groups would be assigned roles in concept definition, development, and technical assessment under the initial feasibility study. The technology team would endeavor to complete subsystem technical assessment and design, perform IMPPCCT site and environmental analyses, resolve integration issues and establish required research, development, and test plans as necessary for Phase II. The economic modeling team would undertake development of a robust financial model, incorporating a comprehensive marketing assessment to complete the economic evaluation. The model will test the sensitivity of gasification to methanol/power coproduction plants to economic and production variables. The model is also expected to prove essential for completion of the preliminary Project Financing Plan.

On December 1, 1999, members of the consortium and GEC discussed the project and technology overview including summaries of the phased approach, schedule, spending profile, and integration challenges to the DOE in a project kick-off presentation (see Appendix 9.1). In addition, members of the consortium detailed historical perspective and future potential increases in market demand for methanol in the chemical industry for the production of formaldehyde, acetic acid, MTBE, ethylene, fuels, and other derivatives such as methyl chloride.

On December 15 through 17, 1999, the consortium met to finalize the project and modeling execution strategies developed during the October and November teleconferences. The established framework for the WBS was detailed into a comprehensive Phase I project timeline with task schedules and scope definition for all deliverables during meetings of the specified timeframe. All the inputs are being organized into a final publishable format. Additionally GEC submitted to the industrial consortium a draft of the Project Management Plan text for review and comment.

Continuing actions required to complete the Project Management Plan development include the generation of a budget by task, broken down by industrial participant. Action items were assigned to each consortium member to refine budgets from the proposal based on the fully defined task schedule and scope of deliverables.

4.3 Initial Feasibility Study Activity

While both the technology and economic modeling teams endeavored to finalize the Project Management Plan, the technology group initiated effort on the assigned concept definition development and technical assessment tasks associated with the Initial Feasibility Study.

Accomplishments in this area included development of a preliminary mass and energy balance and typical synthesis gas variation of Illinois basin coal and two typical petroleum coke feeds to the E-GAS™ gasifier. Utilizing these feed gas balances, the next phase of concept definition and development will require analysis of the coproduction potential of each feedstock when utilizing either the gas or liquid phase methanol processing units. Targeting developing the most advantaged IMPPCCT economics, Air Products will review the application of the LPMEOH™ Process while Methanex performs similar analysis of the gas phase methanol (GPMEOH) processing and purification systems to the E-GAS™ gasification process. Resulting from these reviews, a primary IMPPCCT feedstock and the preferred methanol synthesis production unit selections will take place.

Other activities centered on developing the most effective product specification for co-produced methanol from the WREL site. This effort though mainly prosecuted within the concept definition tasks is related to preliminary Marketing Assessment efforts and was facilitated by the economic modeling team. The team determined it vital to balance the most likely customer's specifications with a global marketing strategy to promote the most efficient coproduction process with flexibility to meet the larger market requirements. The effort resulted in the adoption of the Methanex "AA" grade methanol specification (see Appendix 9.2) as the requirement for IMPPCCT methanol coproduction.

5.0 RESULTS AND DISCUSSION

The consortium for the Wabash River IMPPCCT, led by GEC, and including Dow Corning Corporation, Dow Chemical Company, Air Products and Chemicals, Inc., Methanex Corporation, and Siemens Westinghouse Power Corporation, began to analyze and develop a concept of methanol and power production based on GEC's E-GAS^{TM} gasification process utilizing coal and petroleum coke feedstocks. The team initiated efforts to analyze the domestic methanol market and examined other criteria needed to develop a robust financial model for full-scale implementation of this gasification-methanol coproduction concept. Feasibility studies, testing and engineering, and financing of an IMPPCCT based on addition of methanol production facilities at the WREL gasification plant in West Terre Haute, Indiana will be developed to enable the commercialization of the gasification to electric power and methanol production concept.

The technology and economic modeling teams successfully and exhaustively defined all tasks in the Work Breakdown Structure that will result in the development of the economic tools, design, and financial plan for the IMPPCCT EECP. Definition of all tasks under the WBS was established with development of a schedule and scope of deliverables to the DOE. Culmination of these efforts was the generation of a draft Project Management Plan. Continuing Project Management Plan development efforts will define the consortium budgets by task.

The team has completed initial efforts regarding concept definition and development for the IMPPCCT facility with the generation of preliminary mass and energy balances providing typical synthesis gas variation for the most likely feeds to the E-GAS^{TM} gasifier. Illinois basin coal and two typical petroleum coke feeds were evaluated in this effort. Utilizing these feed gas balances, further concept definition and development will result from analysis of the coproduction potential of each feedstock when coupled with either the gas or liquid phase methanol processing units.

Initial feasibility studies concluded this reporting period with the development of a methanol product specification. Based on end-user requirements and a broad marketing strategy, the team adopted the Methanex "AA" grade methanol specification as the requirement for IMPPCCT methanol processing unit.

6.0 CONCLUSIONS

Phase I of the IMPPCCT EECP study was successfully launched through the Cooperative Agreement Award and via kick-off meetings conducted with the DOE and the industrial consortium during this reporting period. The draft Project Management Plan will be instrumental in governing the activities of modeling and technology teams through all phases of the project.

Phase I will be performed by all team members, GEC, Air Products, Methanex, Dow Corning, Siemens Westinghouse, and Dow Chemical. The Phase I focus is on development of the advanced economic model, analysis of the commercialization potential for the gasification to methanol/power coproduction concept for future Commercial Embodiment Plants (CEP), and preliminary engineering and environmental work for implementation of the methanol production addition at WREL for IMPPCCT demonstration. GEC will utilize the analysis of potential IMPPCCT feedstocks to the gasification section, develop a preliminary site layout, determine synthesis gas quantities available to IMPPCCT, assess final synthesis gas cleanup needs, provide the preliminary environmental assessment, review modifications and tie-ins to the existing infrastructure at IMPPCCT site, and work jointly with Air Products and Methanex to develop the most advantages IMPPCCT economics based on either liquid or gas phase methanol processing units. Air Products will review the application of the LPMEOH™ Process and methanol purification systems while Methanex performs similar analysis of the GPMEOH processing and purification systems.

7.0 FUTURE PLANS

During the next reporting period, the Project Management Plan will be completed, reviewed by all consortia members, and submitted to the DOE for approval. Roles for all members of the project organization will be finalized. A WBS for the project that results in development of the economic tools, design and financial basis for the EECP will be fully defined. All tasks will be identified and defined with budget, schedule and scope of deliverables. Probable cases for CEP will be identified and visualized.

The technology team will continue its effort in the concept definition development and technical assessment tasks associated with the initial feasibility study. The coproduction potential utilizing either the gas or liquid phase methanol processes will be further investigated. Resulting from these reviews, a preferred methanol synthesis production process will be selected.

8.0 REFERENCES

8.1 References on Wabash River Coal Gasification Plant

1. "Wabash River Coal Gasification Repowering Project, An Update", Department of Energy Topical Report No. 20, September 2000, summarizes the history of the Wabash River facility and its construction and four year demonstration under the DOE's Clean Coal Technology program. http://www.lanl.gov/projects/cctc/topicalreports/documents/topical20.pdf

2. "Wabash River Coal Gasification Repowering Project Final Technical Report", August 2000, 358 pages. This is a very detailed look at the Wabash River facility and its operation 1995-1999. http://www.lanl.gov/projects/cctc/resources/pdfs/wabsh/Final%20_Report.pdf

3. "DOE-Sponsored Wabash River Project Inducted Into Power Plant Hall of Fame" http://www.fetc.doe.gov/newsroom/index.html (look down the index for the Above Title)

4. The Gasification Technology Council maintains a website (www.gasification.org) that includes a library of the papers presented at recent conferences. Papers presented by Global Energy, except as noted:

   "Gasification of Petcoke using the E-GAS™ Technology at Wabash River", October 2000
   http://www.gasification.org/98GTC/Gtc00180.PDF

   "An Overview of the Past Year's Activities for the Wabash River Repowering Project", Oct 2000
   http://www.gasification.org/98GTC/Gtc00260.PDF

   "Wabash River in its Fourth Year of Commercial Operation", October 1999
   http://www.gasification.org/98GTC/gtc99010.pdf

   "Improved Performance of the "Destec" Gasifier", October 1999
   http://www.gasification.org/98GTC/gtc99140.pdf

9.0 APENDICES

9.1 Presentation at Kick-Off Meeting by IMPPCCT team on 12/1/99

Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Kick-off Meeting

By

Wabash River IMPPCCT Team

December 1, 1999

Pittsburgh, PA

DYNEGY GLOBAL ENERGY AIR PRODUCTS DOW DOW CORNING METHANEX SIEMENS Westinghouse

U.S. Department Of Energy
Federal Energy Technology Center

Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Agenda

- 12:30 p.m. Welcome/Introduction — Brad Tomer
- 12:40 p.m. Project Overview — Phil Amick
- 1:30 p.m. Technology Integration Issues — Doug Benedict / Doug Strickland
- 2:00 p.m. Break
- 2:15 p.m. Methanol Market Consideration for Commercial Embodiments — Mark Bearden
- 2:45 p.m. General Discussion

Project Overview

Phil Amick

Project Overview

• Organization Chart	Phil Amick
• Objective`s of Phases	Phil Amick
• IGCC Technology Description	Phil Amick
• Liquid Phase Methanol Technology Description	Doug Benedict
• Modeling / Commercial Embodiment	Mark Bearden
• Schedule / Milestones / Funding	Tom Lynch

Coal → Power

Lower Feedstock Costs → Higher Value Products

tipping fees

coproduction

reduce O&M

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**Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies**

Project Overview

Organization Chart

Phil Amick

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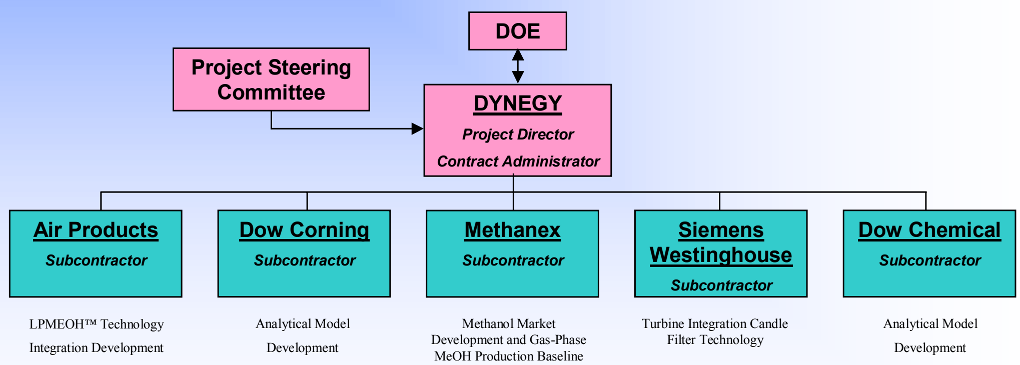
Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Organization Chart



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Project Overview

Objective of Phases

Phil Amick

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Objectives for Phases:

- Analyze and Develop a Concept for Methanol Production
- Complete a Feasibility Study for Wabash
- Evaluate Commercial Embodiment Plants
- Analyze the Domestic Methanol Markets
- Develop a Robust Financial Model

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Project Overview

IGCC Technology Description

Phil Amick

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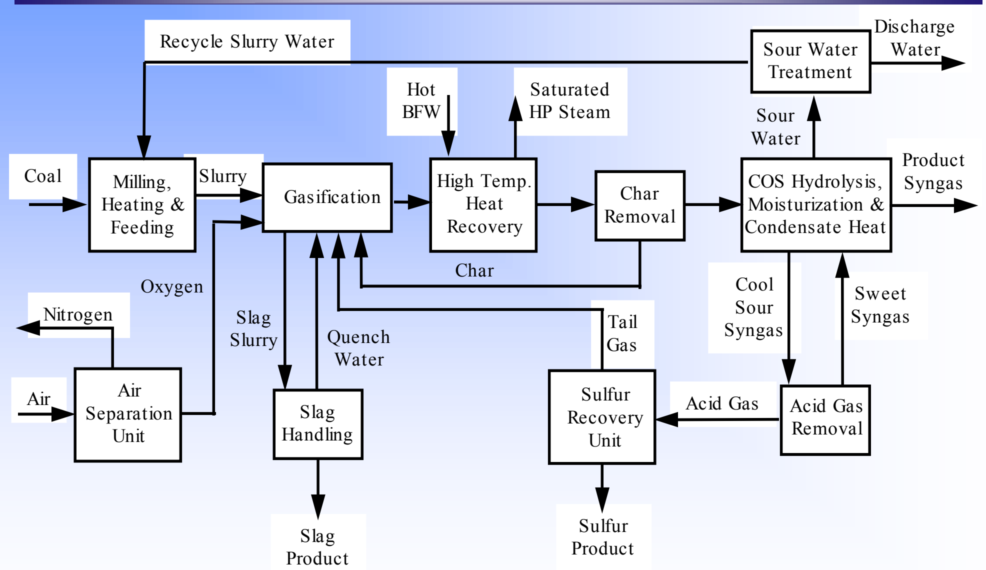
"DESTEC" GASIFICATION EXPERIENCE

PILOT PLANT	36 TPD	1975
PROTO 1	400 TPD	1979
PROTO 2	1600 TPD	1983
LGTI	2400 TPD	1987
WABASH	2550 TPD	1995

Over 65000 hours hands on operations

Wabash River IMPPCCT, Integrated Methanol and Power Production from Clean Coal Technologies



Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Coal Gasification Combined Cycle
State of the Art Plant
Wabash River

- 40% Thermal Efficiency (HHV)
- High sulfur feedstock utilization
- Over 70% availability last 2 years (syngas plant)
- Still the lowest capital cost coal IGCC built
- 30% reduction from Year One O&M budget

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Wabash River IMPPCCT,
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Coal Gasification Combined Cycle
State of the Art Plant
Wabash River

Cleanest Coal Fired Plant in the World

- With 3-6% S fuels, as low as 0.03 lb/MMBtu SOx
- No particulate emissions, zero percent opacity
- Minimal wastewater
- No solid wastes
- NO x same as NGCC (~ 12 ppm attainable)
- CO2 improved by virtue of efficiency

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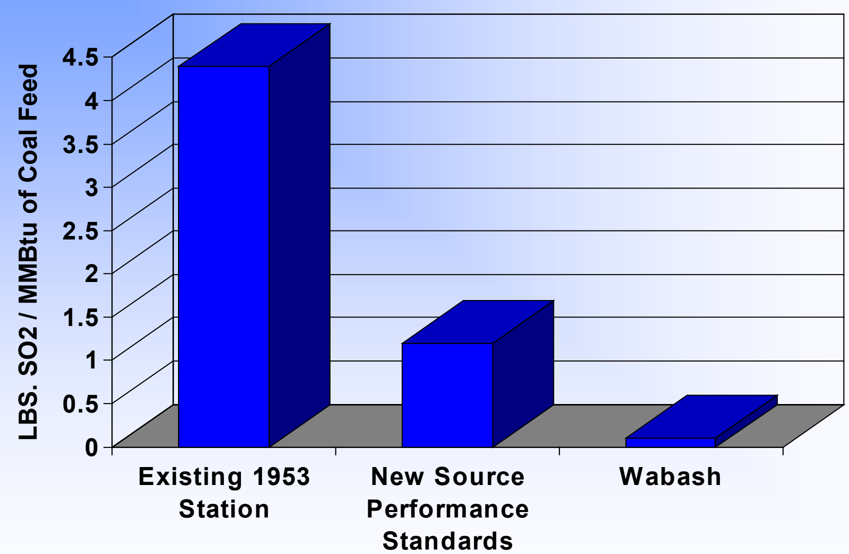
Integrated Methanol and Power Production from Clean Coal Technologies



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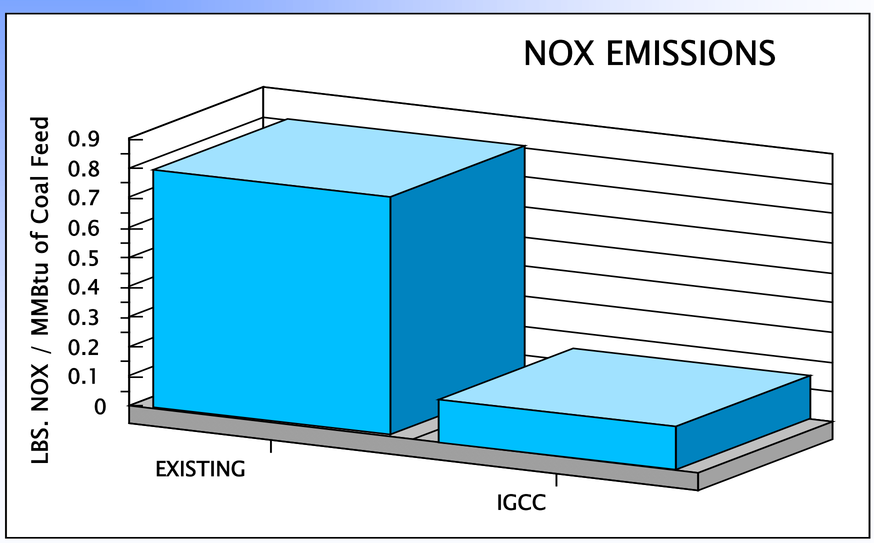
Integrated Methanol and Power Production from Clean Coal Technologies



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Project Overview

Liquid Methanol Technology Description

Doug Benedict

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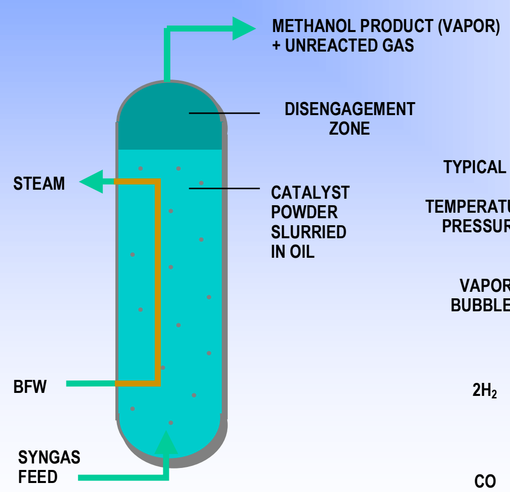
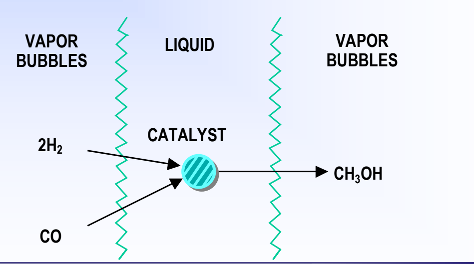
LPMEOH™ Reactor and Reaction Schematics



TYPICAL METHANOL SYNTHESIS CONDITIONS

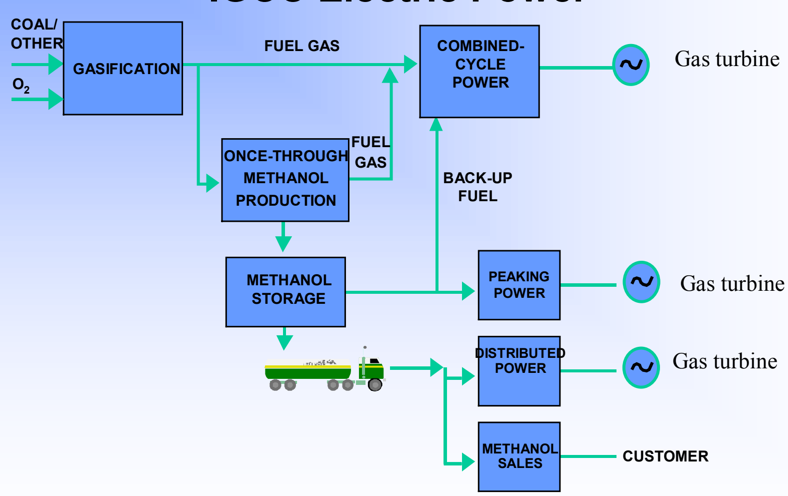
TEMPERATURE	250°C	(482°F)
PRESSURE	50 - 100 BARA	(725 - 1450 PSIA)



LPMEOH™ Technology Advantages

- Efficient Temperature Control / Heat Removal
  - Able to directly process syngas rich in carbon oxides
  - Eliminates need for shift reactor to provide balanced gas feed
- Robust Reactor Design
  - Suitable for rapid ramping, idling, and even extreme stop/start actions

Once-through Methanol Coproduction with IGCC Electric Power



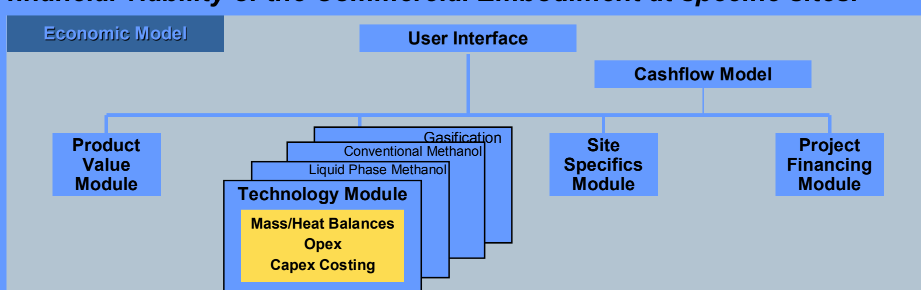
Project Overview

Modeling Approach

Mark Bearden

Project Economics Model Model/Methodology 1

A comprehensive economic model will be developed to assess financial viability of the Commercial Embodiment at specific sites.



Financial Model Characteristics

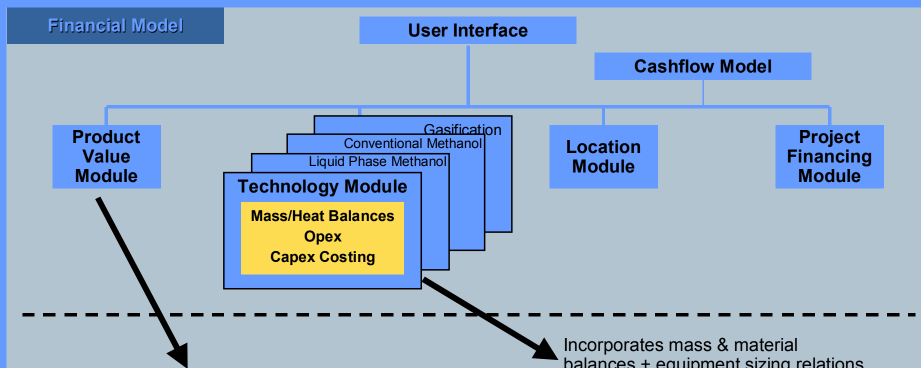
- Capital captured for specific flowsheet
- Heat/material balances by subsytem for operating cost, efficiency, emission
- Detailed capital costs by subsystem largely from process simulator
- Capital costs adjusted by site for labor and infrastructure differences
- Product value by location based on local market analysis

Economic Approach

- Site specific evaluation based on methanol demand
- Market Sensitivities for product sales
- Project financed—levered cashflows
- Sensitivity analysis on key parameters
- Reliability analysis impact included
- Real IRRs / NPVs—$1999

Project Economics Model Model/Methodology 2

The cash-flow model is Excel™--based at the high level, and linked to more sophisticated submodels as appropriate.



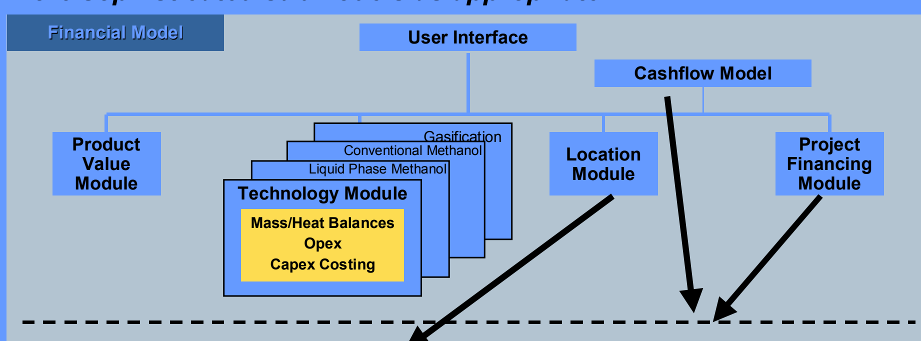
- Market conditions for methanol, power and heat
- Considers transients in markets (e.g. Time of day power pricing)
- Linked to & specific for each location
- Input & validation by Methanex (methanol), Dynegy (power), Dow + Dow Corning (heat + methanol + others)

Incorporates mass & material balances + equipment sizing relations (e.g. kinetic & heat transfer functions)

- Is linked to or linearized from process model (e.g. Aspen)
- Could include elements of dynamic behavior (as opposed to quasi-steady) as necessary
- Input & validation provided by Methanex (Methanol) and APCI (methanol + oxygen), Dynegy (gasification), and Siemens (gas cleanup & power)

Project Economics Model Model/Methodology 3

The cash-flow model is Excel™-based at the high level, it is linked to more sophisticated submodels as appropriate.

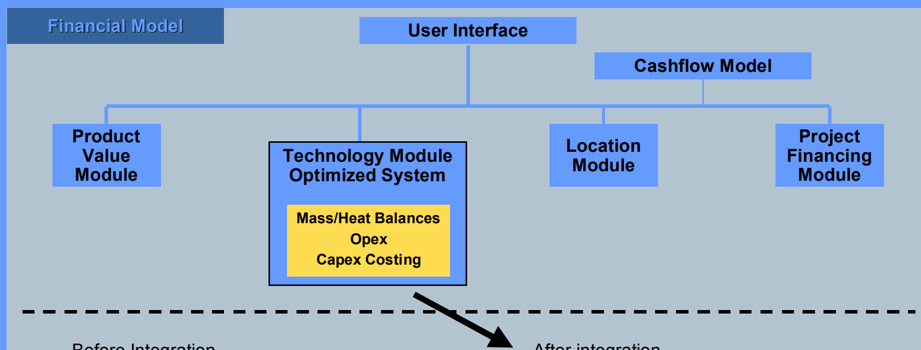


- Incorporates information on location (existing infrastructure / equipment)
- Local cost of construction
- Availability of navigable water, rail, pipelines, and other transportation infrastructure
- Local cost of coal and other feedstocks
- Local utility information

- Incorporates overall project economics
- Financial assumptions (discount rates, tax rates, etc.)
- Some inputs will be related to location module (e.g. subsidies or tax credits)
- Incorporates transfer pricing model

Project Economics Model Model/Methodology **4**

Proprietary "black box" models comprise initial process flowsheets. Process integration will increase efficiency and reduce capital



Before Integration

- Separate non-interacting proprietary process modules
- Each module requires input and output specifications to the economic model

After integration

- Equipment represented by the each module is modified to maximize the performance of the entire system
- Modules provide input and output between themselves in addition to the economic model
- Process simulator such as Aspen used for integrated system
- Proprietary (e.g. reactor) models OK
- Cost estimation software (e.g. IPE)

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Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Project Overview

Schedule / Milestones / Funding

Tom Lynch

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Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Phase I

Element Code	Reporting Element	Year: 2000 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Task 1.1	Project Plan												
Task 1.2	Initial Feasibility Report												
Task 1.3	Subsystem Technical Assessment												
Task 1.4	Subsystem Design Studies												
Task 1.5	Market Assessment												

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Integrated Methanol and Power Production from Clean Coal Technologies

Phase I Continued

Element Code	Reporting Element	Year: 2000 Jun	Jul	Aug	Sep	Oct	Nov	Dec	2001 Jan	Feb	Mar	Apr	May
Task 1.6	Site Analysis												
Task 1.7	Environmental Assessment												
Task 1.8	Economic Assessment												
Task 1.9	Research, Development & Test Plans												
Task 1.10	Reliminary Project Financing Plan												
Task 1.11	Phase I Concept Report												

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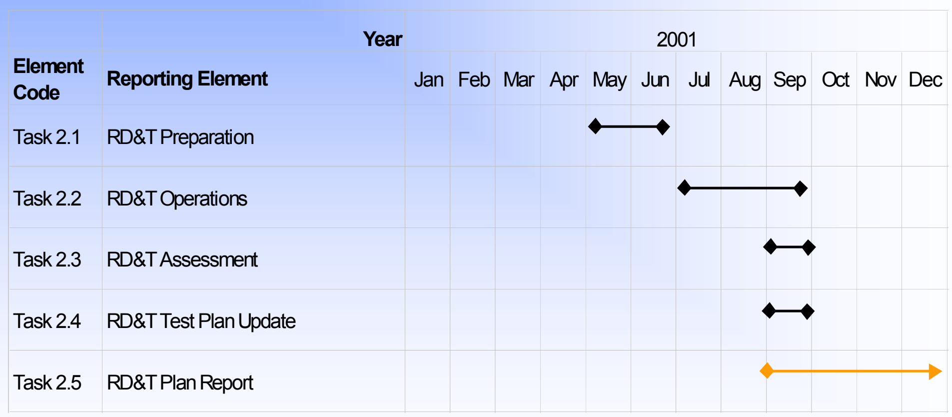
Phase II



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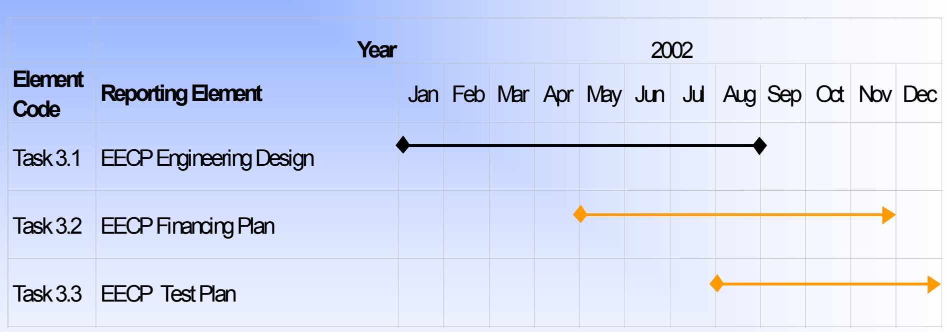
Phase III



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Funding

Budget Period	DOE Cost	Dynegy Power Corp.	Total	DOE Share	Recipient Share
1	$ 1,546,902	$ 386,726	$ 1,933,628	80%	20%
2	$ 1,003,810	$ 540,513	$ 1,544,323	65%	35%
3	$ 721,052	$ 721,052	$ 1,443,004	50%	50%
Total	$ 3,271,764	$ 1,648,291	$ 4,920,505		

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Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Technology Integration Issues

Doug Benedict / Doug Strickland

Technology Integration Issues

- Synthesis Gas Trace Contaminants: Identification, Concentration, & Removal
- Impact of Potentially Varied Gasification Feedstock
- Determination of Optimum Operating Pressure for LPMEOH™
- LPMEOH™ Turndown Ratio and Production Flexibility
- Energy Optimization via LPMEOH™ Waste Heat Recovery
- Gas Turbine Fuel Delivery Adaptation to LPMEOH™ Once Through Gas

Technology Integration Issues

Synthesis Gas Trace Contaminants: Identification, Concentration, & Removal

Design Basis - Allowable Feed Gas Contaminants

Contaminant	Maximum Allowable Concentration+ (ppmv.)
Sulfur Components Any form (including H_2S, COS)	.06
Total Halides Any form (including F, Cl, Br, I)	nil (1)
HCN	0.01
Iron (specifically as $Fe(CO)_5$)	0.01
Nickel (specifically as $Ni(CO)_4$)	0.01

+ Instantaneous basis, as measured to the inlet of the LPMEOH™ Loop, prior to the addition of recycle gases from the LPMEOH™ reactor.

(1) Halides are a known catalyst poison. The impact of trace halide poisoning on catalyst performance is not quantified. It is expected that concentrations of up to 10 ppbv. could be tolerated.

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Syngas Trace Contaminants: Identification, Concentration and Removal

	Coal Feed	Petroleum Coke Feed	
Contaminant	Illinois #6 Basin 11/98	Mobil – Joliet 11/97	Shell – Deer Park 09/99
H_2S	100.92	63.43	75.50
COS	30.03	24.40	15.60
CH_3SH	1.80	0.0	1.40
CS_2	0.10	0.71	0.28
$(CH_3)_2S$	0.92	0.003	0.27
$(CH_3)_2S_2$	0.00	0.0	0.0
HCN	< 1	< 1	< 1
Ni	< 9 ppbv	<13 ppbv	< 3 ppbv
Fe	-	-	-
Group VII	< 1 ppbv	< 1 ppbv	< 1 ppbv
NH_3	< 1	< 1	< 1

Unless Noted, Indicated Values are Average Dry Volume PPM

Technology Integration Issues

Impact of Potentially Varied Gasification Feedstock

Impact of Potentially Varied Feedstocks

	Coal Feed	Petroleum Coke Feed	
Contaminant	**Illinois #6 Basin 11/98**	**Mobil – Joliet 11/97**	**Shell – Deer Park 09/99**
H_2	32.93	33.33	32.30
CO	46.35	48.39	50.72
CO_2	15.76	15.25	13.61
CH_4	2.29	0.51	0.76
N_2 / Ar (Inerts)	2.66	2.51	2.60

Indicated Values are Average Dry Volume%

Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Feed Gas Compositions Tested at LaPorte

VOL %	Texaco "CO-Rich"	Shell	Dynegy	Alt. CO-Rich	"Balanced"	Lurgi	"H_2-Rich"
H_2	35	32	41	37	55	60	71
CO	51	65	41	54	19	21	18
CO_2	13	2	16	8	5	1	7
CH_4	-	-	-	-	-	17	-
N_2	1	1	2	1	21	1	4
	100	100	100	100	100	100	100

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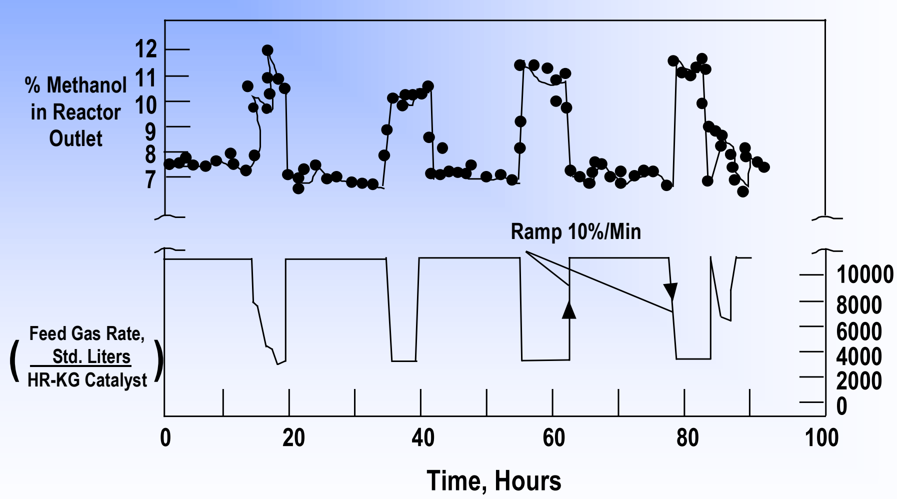
Integrated Methanol and Power Production from Clean Coal Technologies

LaPorte LPMEOH™ Load Following Test



Technology Integration Issues

Determination of Optimum Operating Pressure for LPMEOH™

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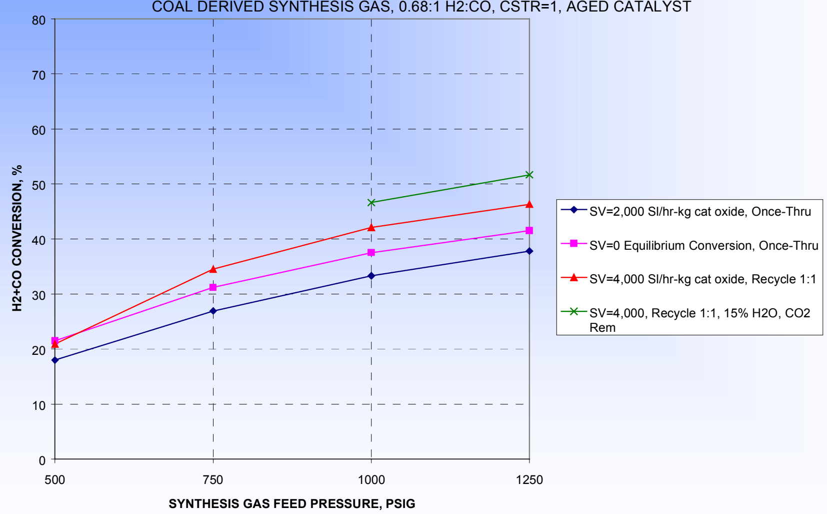
Integrated Methanol and Power Production from Clean Coal Technologies

Figure 4 COAL SYNTHESIS GAS CONVERSION VS PRESSURE

COAL DERIVED SYNTHESIS GAS, 0.68:1 H2:CO, CSTR=1, AGED CATALYST



Technology Integration Issues

LPMEOH™ Turndown Ratio and Production Flexibility

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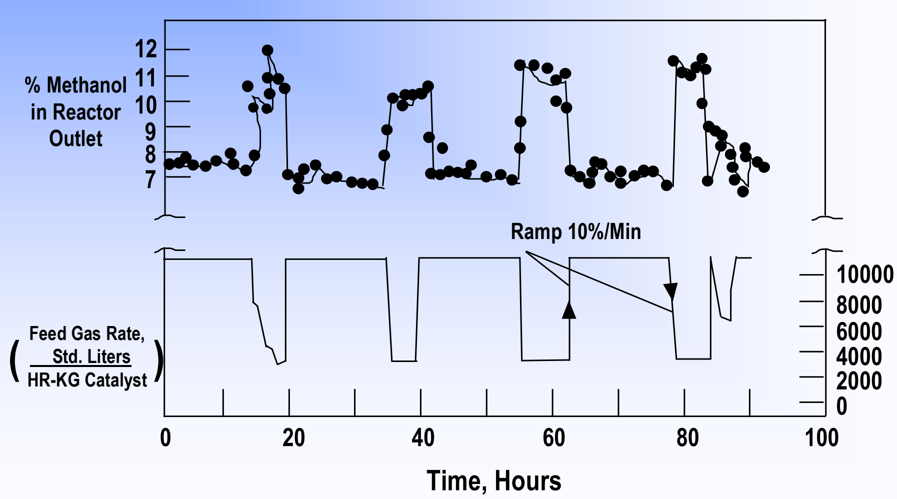
LaPorte LPMEOH™ Load Following Test



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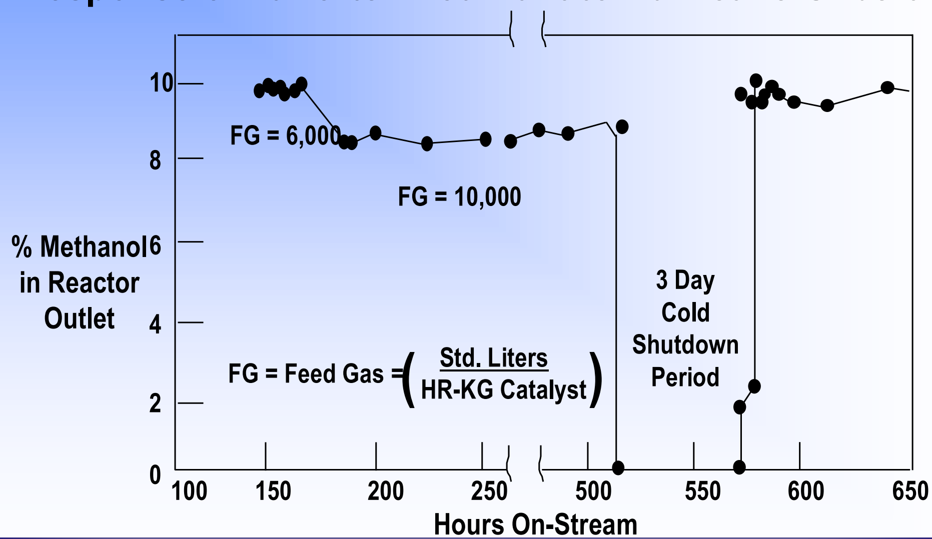
Response of LaPorte Pilot Plant to Hurricane Gilbert



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Technology Integration Issues

Energy Optimization via LPMEOH™ Waste Heat Recovery

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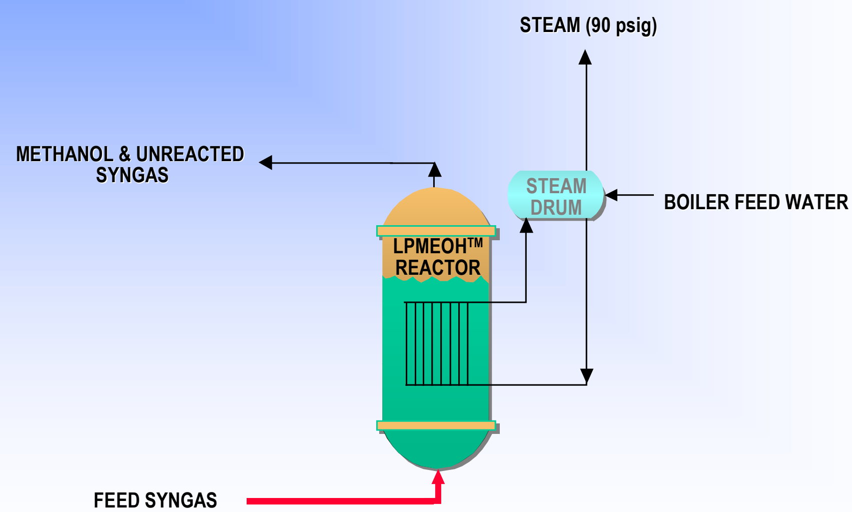
LPMEOH™ Energy Recovery System



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Technology Integration Issues

Gas Turbine Fuel Delivery Adaptation to LPMEOH™ Once Through Gas

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WABASH RIVER

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Break

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Methanol Market Considerations for Commercial Embodiments

Mark Bearden

Global Methanol Production Capacity

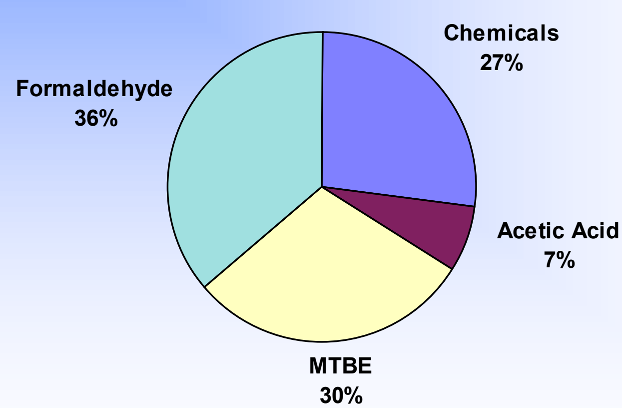
Global Methanol Capacity Location	kilotonnes per annum 1997 Capacity
Africa	800
Canada	1,840
Eastern Europe	4,402
Latin America	5,243
Middle East	3,572
Japan	264
Oceania	2,424
East Asia	4,034
United States	7,512
Western Europe	3,740
	33,831

US Methanol Producers

US Methanol Producers

Company	Location	Capacity (1996)
Air Products and Chemicals	Pensacola. FL	180
Ashland	Plaquemine, LA	465
Beaumont Methanol	Beaumont, TX	840
Borden	Geismar, LA	780
BP-Sterling	Texas City, TX	450
Coastal	Cheyenne, WY	75
Eastman	Kingsport, TN	195
Enron	Plaquemine, LA	375
Fortier Methanol	Westwego, LA	570
Georgia Gulf	Plaquemine, LA	495
Hoechst-Celanese Canada	Bishop, TX	500
	Clear Lake, TX	600
Lyondell	Houston, TX	720
Quantum	Deer Park, TX	660
Sand Creek	Commerce City, CO	90
Terra Meth Industries	West Covina, CA	17
Terra International	Woodward, OK	150
Texaco	Delaware City, DE	270
UNICO	Colorado	80
		7,512

Methanol Distribution



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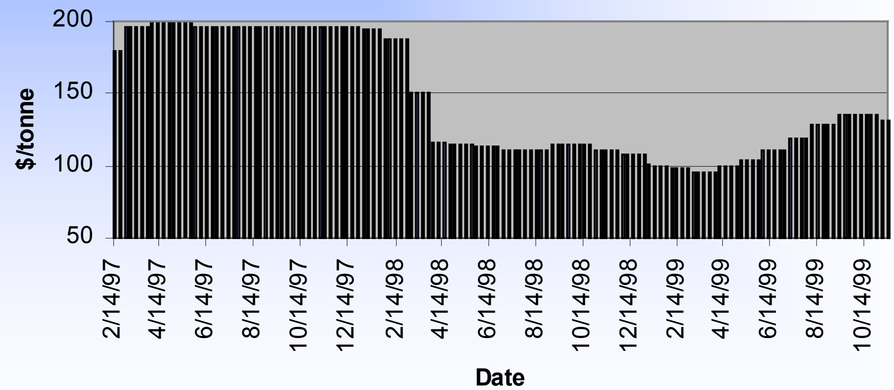
US Gulf Coast Methanol Prices

USGC Methanol Price 97,98, 99



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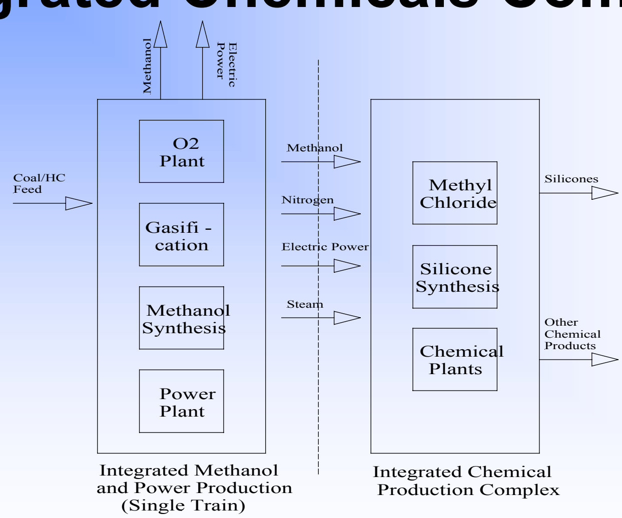
Integrated Chemicals Complex



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Silicone Production from Methanol

- The US silicone industry consumes about 3,000 TPD of methanol (7,000 TPD globally)
- The industry is growing at about 6% annually

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Silicone Chemistry

$$CH_3OH + HCl \rightarrow CH_3Cl + H_2O$$

$$2\,CH_3Cl + Si(Cu) \rightarrow (CH_3)_2SiCl_2 + Cu$$

$$2\,(CH_3)_2SiCl_2 + 2H_2O \rightarrow (CH_3)_2Si(OH)_2 + 2HCl$$

$$n(CH_3)_2Si(OH)_2 \rightarrow \left(\begin{array}{ccccc} & CH_3 & & CH_3 & \\ & | & & | & \\ - & Si & -O- & Si & -O- \\ & | & & | & \\ & CH_3 & & CH_3 & \end{array} \right) + nH_2O$$

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Conclusions for chemical methanol complexes

- Methanol markets available which fit single train IMPCCT plants
- Healthy growth expected for products using methanol as intermediates
- Power markets not yet studied

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Methanol for Olefin Production

- Ethylene / Propylene ratio is variable with reactor temperature and metathesis
- Existing plants may be retrofitted
- Near term commercialization feasible
- Methanol Transportable

Wabash River IMPPCCT, Integrated Methanol and Power Production from Clean Coal Technologies

US Ethylene Producers

Company	Sites	kta	% of Total
BP Amoco	2	1,401	5.36%
Chevron	2	1,555	5.95%
Condea Vista	1	454	1.74%
Dow-UCC	5	4,288	16.42%
DuPont	1	590	2.26%
Eastman	1	676	2.59%
Equistar	7	5,210	19.95%
Exxon-Mobil	5	3,748	14.35%
Formosa	2	715	2.74%
Huntsman	3	1,094	4.19%
Javelina	1	82	0.31%
Koch	1	11	0.04%
Phillips	1	2,075	7.94%
Shell	2	2,271	8.69%
Sun	2	158	0.60%
Union Texas	1	578	2.21%
Westlake	3	1,214	4.65%
	40	26,120	100.00%

Value of Product produced ~14Billion$

Source: World Petrochemicals, SRI Consulting, Jan., 1999

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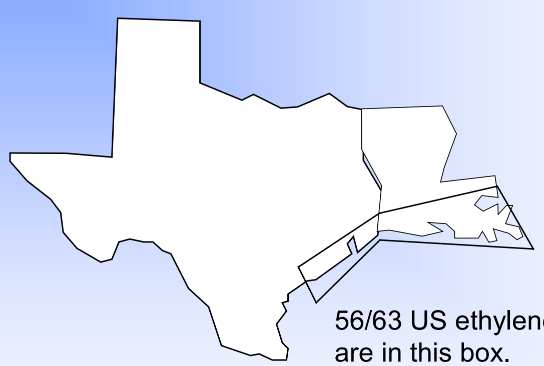

56/63 US ethylene plants are in this box.

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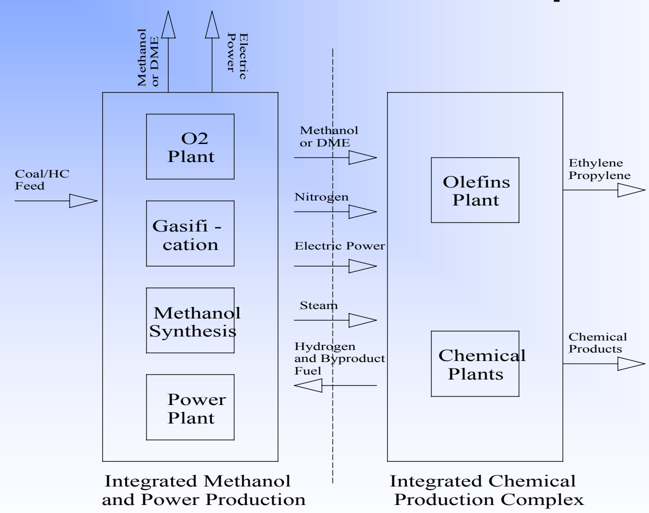
Integrated Chemical & Olefins Complex Concept



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Methanol to Olefins (MTO) Chemistry: Methanol Dehydrates to form light olefins

$$2CH3OH \xrightarrow[\text{SAPO 34 Zeolite}]{} C2H4 + 2H2O$$

$$3CH3OH \rightarrow C3H6 + 3H20$$

$$4CH3OH \rightarrow C4H8 + 4H2O$$

Methanol for Olefin Production

- Methanol Price and Availability
  - Availability: Methanol market is much smaller than olefins market. Additionally, 5-7 lbs. of methanol are required per pound of ethylene produced.
  - Large methanol plants are 2,000 tonnes per day, (TPD). Feeding a large (3000 TPD ethylene plant would require 15 - 20,000 TPD
- Converting all US crackers to MTO would generate too much propylene

U.S. Department Of Energy
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Wabash River IMPPCCT,
Integrated Methanol and Power Production from Clean Coal Technologies

Methanol value for Olefins

UOP/Norsk Hydro Yield assumed
Source UOP presentation to Dow 11/97

			Unit Ratios				
Feeds	Max C2H4	Max C3H6	Max C2H4	Max C3H6	Prices	Max C2H4	Max C3H6
Methanol	660	660	4.925	6.735			
H2O	198	198					
Air	172	64					
(Units are MTA)	1030	922					
Olefin Products							
C2H4	134	98	1.000	1.000	0.226	0.226	0.226
C3H6	87	130	0.649	1.327	0.185	0.120	0.245
C4H8	27	36	0.201	0.367	0.115	0.023	0.042
Olefins	248	264					
Other Products							
Lights	15	6	0.112	0.061	0.0541	0.006	0.003
C5+	14	14	0.104	0.143	0.078	0.008	0.011
Flue Gas	184	68					
Water	569	569					
	782	657		Product value		0.383	0.528
				desired cash margin		0.100	0.100
Total	1030	921		Value of Feed			
					$/lb	0.058	0.064
					$/MT	126.89	140.14

Projected Methanol Demand for US Olefins

Methanol to Olefins (MTO) integration into ethylene production

Numbers are kta	2000	2005	2010	2015	2020
Ethylene Production	25,271	29,296	33,962	39,371	45,642
Increment	736	853	989	1,147	1,329
MTO ethylene production	0	1,906	7,193	13,322	20,428
Steam cracker production	25,271	27,390	26,769	26,049	25,214
Propylene Production	13,847	16,446	19,533	23,199	27,553
Increment	468	556	661	785	932
MTO propylene	0	1,239	4,675	8,659	13,278
Cracker Propylene	8,845	9,586	9,369	9,117	8,825
Refinery Propylene	5,002	5,621	5,488	5,422	5,450
Methanol Requirement	0	9,386	35,428	65,617	100,615

Conclusion for methanol for olefins

- US olefin production offers a number of opportunities for IMPPCCT projects
- The methanol production plant must be substantially larger than current state-of-the-art (multi-train IMPPCCT)
- Power market must be studied in Gulf Coast

General Discussion

Appendix 9.2 Grade "AA" Methanol Specification

TABLE I: Chemical and Physical Characteristics of Grades A & AA Methanol

Characteristic	Requirement	
	Grade A Methanol	**Grade AA Methanol**
Acetone, percent by weight, maximum	0.003	0.002
Acidity (as acetic acid) percent by weight, maximum	0.003	0.003
Appearance	Free of opalescence, suspended matter & sediment	Free of opalescence, suspended matter & sediment
Carbonizable impurities, color, Pt-Co, maximum	No. 30	No. 30
Color, Pt-Co, maximum	No. 5	No. 5
Distillation range at 760 mm, maximum	1.0 °C (and shall include 64.6° ± 0.10°C)	1.0 °C (and shall include 64.6° ± 0.10°C)
Ethanol, percent by weight, maximum	——	0.001
Nonvolatile matter, mg per 100 mL, maximum	10	10
Odor	Characteristic, nonresidual	Characteristic, nonresidual
Permanganate time	No discharge of color in 30 minutes	No discharge of color in 30 minutes
Specific gravity at 20° / 20 °C, maximum	0.7928	0.7928
Water, percent by weight, maximum	0.15	0.10

TABLE-2 : METHANOL SPECIFICATION
Conforms to US Federal Specification Grade AA

COMPONENT	ENHANCED SPECIFICATION (For Design Purposes)	IMPCA	GRADE AA	TEST METHOD
Methanol Purity, Wt%	99.9 Min.	99.85 Min.	N/I	IMPCA 001-92 ASTM D891-94
Water, Wt%	0.05 Max.	0.1 Max.	0.1 Max.	ASTM E 346-94, E-1064-92
Acetone & Aldehydes (1), ppm wt	< 10; [0.001 Wt%, Max.]	N/I	20	ASTM E 346-94, D-1612-90
Ethanol, ppm wt	< 10	50	10 Max.	ASTM E-346-94
Acidity (as Acetic Acid) (1); ppm wt	< 20; [0.002 Wt%, Max.]	30	30	ASTM E-346; D-1613-91
Trimethylamine (TMA) (1)	30 ppb Max.	N/I	N/I	ASTM method app. pending
Chlorides (1), ppm wt	< 0.1	0.5	N/I	IMPCA 002-92
Iron (1) ; ppm wt	< 0.15	0.1	N/I	
Appearance Hydrocarbons	Free of suspended matter, opalescence and sediment	S	S	Visual; (O-M-232-G, 4.2.4.3)
Turbidity	< 0.25 NTU	N/I	N/I	
Specific Gravity at 20/20 C	0.7926	0.791-0.793	0.7928	ASTM E-346; ASTM D-891-94
Distillation Range	Not more than 1^0C and shall include 64.6 ± 0.1^0C at 760 mm Hg	S	S	ASTM E-346; D-1078
Nonvolatile Components, mg/100 ml	10 Max.	S	S	ASTM D-1353-90
Odor	Characteristic, non-residual	S	S	ASTMD-1296
Permanganate (1)	No discharge of color in 60 minutes	S	30 minutes	ASTM E-346; D-1362; D-1363-94
Carbonizable Substances	No discoloration; no darker than color standard No. 30 ASTM D1209	S	S	ASTM E-346-92; D-1209
Color	No darker than color standard No. 5 of ASTM D1209-93, Platinum Cobalt scale	S	S	ASTM E-346; D-1209-93
Notes: (1) Enhanced	S =Same as enhanced	N/I = Not Included in the specification		