

STUDY TO EVALUATE THE FEASIBILITY OF BUILDING AN ANAEROBIC DIGESTER GAS (ADG) TO METHANOL SYSTEM AT THE NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION'S (NYCDEP) JAMAICA WATER POLLUTION CONTROL PLANT (WPCP)

PROJECT FACT SHEET

SUMMARY

This study, co-funded by the New York State Energy Research and Development Authority (NYSERDA), was performed to evaluate the economic and process viability of converting anaerobic digester gas (ADG) to methanol. Data generated from the Jamaica Water Pollution Control Plant (WPCP) (Queens, New York), where the methanol plant was assumed to be located, were used in the evaluation. The Jamaica WPCP produces 500,000 standard cubic feet per day (SCFD) of ADG, which could theoretically be converted to 9.4 tons per day (tpd) of methanol. The assumption was also made that “conventional” technology would be used to convert the ADG to methanol.

An overall capital cost of \$14.39 million was calculated for the project, with annual operating costs of \$569,000. Capital costs were derived using a factored estimate approach and an overall multiplier on equipment of 4.39, a typical multiplier for chemical facilities comprised of a broad mix of equipment (e.g., tanks, pumps, heat exchangers). The overall project duration was assumed to be approximately 12 months, with construction beginning in the 4th month.

Net Present Value (NPV) calculations were performed to determine economic viability. The result of the base calculation indicated that the NPV of the project was approximately (-)\$11.4 million. Even with the assumption that the annual operating costs could be reduced to zero, the calculated NPV was negative. A positive NPV was calculated after the assumption was made that the methanol-selling price could be increased substantially. It is also suggested that a positive NPV could be achieved if capital costs were significantly decreased through the development of new technologies, or if the production rate could be increased to capture the economies of scale found at the industrial level. However, based on current conditions, the project was deemed not to be an economically viable venture.

SCOPE OF STUDY

The study included the following:

- Identification of the process design criteria and summary of the pertinent process data;
- Development of process flow diagrams (PFDs) and a heat and mass balance, including utility balances;
- Development of a preliminary P & ID, including the main control logic and instrumentation;
- Development of an equipment list;
- A preliminary overall General Arrangement Drawing (GA);
- Calculation of operating costs, including energy;
- Calculation of capital costs, including construction;
- Evaluation of environmental benefits;
- Economic evaluation; and

- Evaluation of the technical risks that could affect (adversely or positively) project economics.

SCOPE OF FACILITIES

The assumption was made that the methanol plant would be comprised of the following facilities:

- Interconnecting piping from the digester flare to the inlet purification unit;
- Inlet purification unit, including H₂S removal, and a reduction in CO₂ levels;
- Steam/methane reformer, including the steam generation equipment;
- Methanol production unit;
- Methanol storage facility;
- Boiler feed water facility for steam production and usage in the reformer;
- Cooling water unit (tower and pumps) for usage in the reformer;
- Water effluent system;
- Electrical power to the plant, and associated equipment to deliver the power levels required; and
- Any other utilities required by the plant, including instrument and plant air, and nitrogen.

PROCESS DESCRIPTION

The assumption was made that “conventional” technology would be used to convert the ADG to methanol.

This includes conversion of ADG to syngas in a steam methane reformer, followed by subsequent conversion to methanol in methanol synthesis reactors. The specific process components included:

- **Inlet Purification:** The ADG is processed to remove hydrogen sulfide (H₂S), a reformer catalyst poison, and carbon dioxide (CO₂), such that the ratio of the carbon monoxide (CO) and hydrogen (H₂) are in the correct proportion for producing methanol.
- **Reforming:** The ADG is pre-heated and remaining trace amounts of sulfur are removed. Steam is injected into the ADG. The ADG is further preheated in the convection section of the reformer. The ADG enters the reformer and passes through the catalyst, where the reforming reaction occurs. The syngas produced in this process is cooled, and the heat produced is used to generate steam.
- **Methanol Synthesis:** The syngas is compressed and combined with synthesis loop recycle gas (described below). The conversion efficiency of methanol synthesis is low, therefore the recycle gas stream is four to five times greater than the entering syngas stream. Trace amounts of oil are removed, which could foul the methanol catalyst. The mixture enters the first methanol converter. The hot reacted gases leave the converter and enter a second converter. The effluent is cooled and the methanol is separated from the uncondensed gases, which are recycled back to the first converter. The methanol (83.5 wt %) is routed to an underground storage tank.
- **Boiler Feed Water and Steam Generation**
- **Utilities**

CAPITAL COST ESTIMATE

The overall capital cost estimate breaks down as follows:

Item	Cost	% of Total
Equipment	\$3 310 000	22.8%
Building	Excluded	
Bulk materials	\$3 060 000	21.1%
Construction labour and supervision	\$3 390 000	23.4%
Engineering	\$1 500 000	10.4%
Indirects	\$530 000	3.7%
Freight	\$330 000	2.3%
Spares	\$500 000	3.5%
Unidentified items	\$230 000	1.6%
Owner's costs	Excluded	
Contingency	\$1 640 000	11.3%
Total	\$14 490 000	100%

OPERATING COST ESTIMATE

While they may not be complete, the following costs give a fair indication of what would be expected for the proposed facility:

Consumables	Usage	Units	Cost	\$/hr	per annum	notes
Power	191	kWh	\$0.115	\$22.02	\$193 000	1
H ₂ S media					\$4 900	2
Soda Ash	0.09	lb/hr	\$0.40	\$0.04	\$300	2
Dehydration media					\$500	3
CO ₂ membranes					\$5 600	3
Zinc Oxide					\$200	3
Reformer Catalyst					\$3 000	3
Water	5	gpm	\$0.01	\$0.05	\$500	4
Nitrogen					\$500	3
BFW chemicals	1	lb/hr	\$0.05	\$0.05	\$400	3
Water treatment chemicals	1	lb/hr	\$0.05	\$0.05	\$400	4
					<u>\$209 300</u>	
Manpower	6 Operators		\$60 000		\$360 000	5
				Total	\$569 300	

Notes:

1. Taken from published data
2. Vendor quote
3. Estimate
4. Price is an estimate based on typical commercial rates

PROJECT VIABILITY

TECHNICAL RISK

As proposed, the technical risk associated with the project is very low. First, the ADG to methanol conversion process is based on conventional industrial technology. Second, a similar project is operational in Beaver County, Utah, where 27.5 tpd of 100% methanol is being produced from ADG generated from pig waste. Additionally, new, smaller, lower cost reformers are under development for fuel cell application, which could potentially be scaled up to process the volume of ADG produced by the Jamaica WPCP. Of course, the use of a newly developed technology would increase the risk of the project.

ECONOMIC VIABILITY

The following assumptions were used in developing the economic model to evaluate project viability:

- ADG is “free”;
- Methanol price is \$1.02/USG;
- Plant operates 355 days/year;
- Plant life is thirty years;
- Depreciation rate is 30%;
- Cost of money is 13%; and
- Corporate tax rate is 40%.

Based on these assumptions, a preliminary NPV calculation was performed. The resulting NPV, calculated on a discounted basis, was (-)\$11.4 million, including taxes, which indicates that the capital cost cannot be repaid during the methanol plant’s lifetime.

In an attempt to determine the threshold for project viability, the assumptions were altered, and the NPV subsequently recalculated. The results of this analysis yielded the following:

- If the annual operating costs were reduced to zero, the NPV improved marginally to (-)\$8.1 million.
- If the tax rate was reduced to 10%, the NPV remains essentially changed at (-)\$11.1 million.
- If the annual operating costs were reduced to zero and the tax rate to 10%, the NPV again improved marginally to (-)\$7.2 million.
- If the methanol-selling price was increased to \$4 per gallon, a positive NPV of \$4.7 million was generated, with a calculated payback duration of 10 years.
- If the methanol-selling price was increased to \$4 per gallon and the tax rate reduced to 20%, a positive NPV of \$8.0 million was generated, with a shorter payback duration of 7 years.

Additionally, it is assumed that a positive NPV may be achieved if capital costs are significantly decreased through the development of new technologies, as discussed above, or if the production rate could be increased to capture the economies of scale found at the industrial level. [Note: Supplementing ADG with natural gas could increase the

production rate. However, given the current price of natural gas, this would improve project economics only if the production rate was increased substantially, which then raises the question of available space to site the plant.]

SUMMARY

As proposed, the combination of capital costs, operating costs and current commodity selling price do not make this an economically viable venture. However, the viability of the project could potentially change if capital costs were reduced due to the development of new, appropriately-sized reforming technologies, operating costs were reduced, the production rate was increased, and/or the commodity selling price were increased.