GUIDELINES FOR EVALUATION OF NATURAL GAS PROJECTS

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ABSTRACT

This paper is objected to give guidelines for natural gas projects appraisal. These guidelines are summarized in modeling of natural gas demand forecast and energy pricing policies for different gas consumers mainly in the manufacturing, mining, transport, trade and agriculture sectors. Analysis of the results is made through sensitivity analysis and decision support system (DSS)

1 INTRODUCTION

In most countries and especially the rapid growing economies of the Far East and some Gulf States, governments and utility companies invest in energy infrastructure to facilitate economic growth. With the growth of industry, there is an increasing need for commercial energy based on oil, natural gas or coal. So it is needed to have an energy supply system that is technically good and economically efficient including price. Natural gas price is not easy to determine because it is not a perfect substitute for other fuels for its high transmission costs and its depletion.

The investment in energy infrastructure requires a detailed analysis of long-term demand of energy. The method used to support investment decision in this area is development project appraisal which has to cover many areas and to answer many questions. Sponsors of private investment projects are interested mainly in financial viability while policy makers (government, international funding agencies) require the appraisal show economic viability of the project as well: Guidelines for project appraisal require financial and economic appraisals.

Economic appraisals shows project effect on the economy while financial appraisal shows profitability of the investment to the investors methodological issued for the application of the general
Theory of financial and economic project appraisal need to be clarified. For natural gas infrastructure, aspect to be considered are financial viability , economic viability, natural gas demand, energy pricing policy , opportunities and environmental applications.
Methodological issues are :

1. Address how to estimate long-term demand of natural gas.
2. Concern the correct pricing of energy.
3. Sensitivity analysis.
4. Address how to support the process of decision making.

Fig. 1 illustrates general outline of the study. Block 1 through 5 shows steps needed to determine aggregate demand per geographical area. Bloc 6 through 10 cover the aggregate supply of natural gas. After balancing supply and demand NPV's are calculated (Block 12) and the optimal choice is selected (Block 13). Sensitivity analysis (Bloc 14) is used to further analyze the optimal plan. Feed back loops should be considered : the price of gas will determine the demand which determine the investments that in turn will determine the price of gas thus could restrict the demand

2 STUDY STEPS

It covers the following steps

1. Long Term Energy Demand
2. Energy pricing.
3. Demand forecast
4. Analysis
5. Sensitivity analysis

2.1 Long Term Energy Demand

The model used is preferable to other econometric and descriptive models when evaluating the opportunities for natural gas in the manufacturing sector (other models are rather abstract and are based on total energy use) by linking the process distribution for fuel type to their costs and benefits, setback value for fuel is calculated to determine the choice of fuel. As historical data are required , technical descriptions of the production processes are linked to regional statistical data at the ISIC five digital level to obtain the manufacturing sector's total demand of natural gas. This is beneficial to the ministry of petroleum for the evaluation of the effects of comprehensive energy pricing policies for all fuels. Should new production process emerge, the processes can be easily added and a complete re-evaluation is not required.

Also , new technologies can be added to every production process. This will help to set the path for future energy demand management. This model as it is based on the use of energy in the production process, it allows comprehensive and reliable analysis of energy pricing policies .

2.2 Energy Pricing Plans

Energy prices are on of the best tools for energy demand management. The objectives to be achieved by the governments in energy policies are mainly :

- Economically efficient pricing which promotes economic growth through efficient allocation of resources within the energy sector and between the energy sectors the real economic costs of supplying energy.
- Promotion of social equity where governments often tries to improve the situation of the poor price discrimination for demand categories will be faced.
- Resource mobilization both financially and fiscally government will maximize foreign exchange earning through export or import substitution of energy sources (oil, coal and natural gas and in transformed form (fertilizers, methanol, fiscal resource mobilization is achieved by allowing producers and distributors of energy to recover their costs and to earn enough to finance their growth and development.
- Usage of energy resources for environment protection, i.e. repayment of oil products by natural gas will mitigate pollution

Some of these objectives may conflict ,e.g. social equity through subsidized prices may conflict with resource mobilization , so energy policy has to permit trade-off between different goals. It is more as art than the application of economic theory.

Short run marginal cost (SRMC) plus scarcity is hardly is hardly applied to less developing countries (LDC's) as a basin for energy pricing as it does not take into consideration long term needs of a growing economy.

Long term marginal cost (LRMC) is viewed as the best approximation for energy pricing. This is because alsos many investment projects in the oil and gas field are based on long term contracts which implies that the transmission capacity has already been sold before it is installed. LRMC pricing also fulfills the objective of resource mobilization in the sense that no subsidies are required. Other objectives such as life line rates for the poor and environment protection can lead to changes of the LRMC. But LRMC is difficult to implement because the determination of the correct LRMC for different types of consumers is often not possible. The average incremental cost (AIC) can be used to estimate the LRMC. Fully distributed cost (FDC) pricing needs more information.

Since natural gas is a depletable resource, depletion allowance (DA) has to be included in the economic cost of natural gas to adjust for the consumption foregone. It depends on price of replacement fuel for the gas used, whose value depends on LNG price. Offshore and onshore purchase gas prices has to be considered .

2.3 Demand Forecast

2.3.1. Basis and Assumptions

- Long term forecast for economic growth.
- All heat applications equipment uses the most profitable new technology.
- Production capacities are fully utilized in the first year.
- No energy saving technical programs that lead to decrease in demand of energy in the future (or 0.5% per year in industrial applications).
- Structural economic model at sub-sectional level will be developed. Gross value added (GVNR) for the total period will be developed,

then allocate GVAR over the six main sectors (agriculture, mining, quarrying, manufacturing, electricity, transport and trade).

2.3.2. Geographical Distribution

This raises two issued:

- What part of the present and future potential demand for natural gas can be reached by the transmission system ?
- What investments in distribution are necessary to reach the customers?

We have four regions : Nile Delta, Suez Canal Area, Uppper Egypt and Sinai.

2.3.3 Demand by Non Bulk Consumers

The forecast is done by using the assumption previously discussed in 2.3.1 and is mainly for manufacturing sector excluding fertilizers, basic chemicals, cement and iron, and steel sub-sectors.

Physical intensity ratio is developed for each sub-sector, then netback, GVAR and potential gas consumption for new and existing facilities

- Then penetration level is developed. It s assumed if reduction in costs is more tan 7% of the total, conversion to natural gas will take place depending on profitability criteria.
- Then combining demand per million GVAR with assumption of economic growth (Section 2.1) on geographical distribution in section 2.2. Total demand for each year is devolved in BCF/year.

2.3.4 Fertilizer as Bulk Consumer

- Installed and planned fertilizer capacity are developed. 0.893 mge/kg ammonia and 0.107-0.145 mge per kg of urea is needed from natural gas based on 0.6 kg ammonia per Kg of urea is needed . 50 (0.6x 0.893 + 0.107) 0.643 mge is needed from natural gas per KG of urea. Netback value of urea is calculated based on one ton of urea need 21.4 – 2.75 MMBTV of natural gas. If natural gas in the Far East is # 0.5/MMBTV and shipment equal netback value for natural gas in JAWA= (21.4 X0.5 + 20)/21.4 = #1.43 and (23.7 X0.5 + 24)/214 equal $ 1.68. production, so price of less than #2 is needed for urea to maintain advantage of domestic urea production over imported urea.

- Urea export, should be profitable from the financial point of view. If subsidy is given to importing countries to obtain foreign currency rather than economically profitable trade, so export only if surplus over domestic demand is foreseen.

- Domestic demand for nitrogen fertilizer.

The main growth of urea demand are for developing new areas beside the increase in fertilization intensity. The speed of this process depend on the ratio of fertilizer process and average crop prices.

2.3.5Rest Of Basic Chemicals

Petrochemicals are of prime importance in tis sector as natural gas is used bot as feedstok and as an energy source. Natural gas mge per metric ton of petrochemical derivatives is given in Table 1

TABLE 1 NAATURAL GAS CONSUMPTION FOR PETROCHEMICAL PRODUTS

	MEG/TON		MEG/TON
PE	99.0	LAB	116.0
PP	41.5	SBR	382.0
PVC	166.0	LAB SULFONATE	58.0
PS	91.3	PTA	404.0
EG	307.0	PAN	132.8
VCM	334.0	PROPYLENE	471.0
SM	474.0	METHANOL	887.0

Total gas demand will be developed based on the planned production of petrochemicals along the planning period. The share of energy costs in the total costs of producing petrochemicals is 5-10% (average 6.8%) of the value of the end product which is high percent to justify natural gas choice as fuel export of petrochemicals seems feasible over domestic demand.

Natural gas forecast demand is developed assuming 85% capacity utilization and an average of 303mge/ton petrochemical. Since the study is dealing with long term plans, calculation of netback value is not possible., as production process is not known, But since energy pricing policy is based on fuel oil parity pricing, it is reasonable to assume that natural gas will be used whenever it is available.

2.3.6 Non- Petrochemicals

The method utilized in section 2.1, 2.2, and 2.3 is used assuming that growth in non petrochemicals is equal to the growth in GVAR. For existing facilities te value of natural gas is analyzed in the same way in section 2.2. For new investments, the netback values are given in table 2 below

TABLE 2 : NETBACK VALUE OF NATURAL GAS IN CHEMICAL PROCESS

		NETBACK VALUE	
		NEW INVESTMENTS	CONVERSION
35 A	Alkalies & chlorine	236	156
35 B	Inorganic pigments	173	82
35 C	H_2 S04 contact process	165	145
35 D	No_2 Sio3	199	135
35 E	Ca(No3)2	224	135
35 F	Fatty acids	205	149
35 G	Resin, plastics and synthetic fiber	318	151

The table shows that natural gas has an advantage for new investments (over 154) for existing investments, natural gas has no premium except environment premium (but only 35A) . Finally natural gas demand forecast is calculated as for petrochemicals.

2.3.7 Cement Sector

Cement production and planned capacities will be developed for bot domestic and export purposes. For domestic demand, forecast will be based on GVAR.

- Domestic Demand.

Consumption per capita is developed by using non agricultural real gross value added (GVAna)

-Export Demand

Based on the last years exports as P/O of production is calculated together with its growth rate.

Cement production is mainly determined by domestic demand due to his transportation cost. The main reason for export is the excess capacity, need for foreign exchange earned from export. Export is feasible if FOB price is higher than variable production cost ,. Fixed costs are 40-45% of the total costs.

Investment in cement production for export is profitable only if FOB price is higher than the domestic price. If utilization capacity is less than 75%, cement export will be profitable.

Lack of infrastructure (export facilities near the cement factory) is a limitation for export.

- Demand of Natural Gas

It depends on its netback value with respect to coal and /or fuel oil. Basic data are given in table 3.

TABLE 3 : INVESTMENT, O&M COSTS FOR TON CEMENT PRODUTION

	Invest. $	O&M $	Fuel (MMBTU)
Coal (Existing)	7.0	1.0	3.414
Oil (Existing)	1.18	0.053	3.414
Natural gas (Existing)	0.72	0.025	3.557
Natural gas (New)	0.72	0.025	3.000

For coal, 3.414 MMBTU (or 135 Kg) is needed , for natural gas 3.557 MMBTU per metric ton, and for new plants only 3 MMBTU/t is needed. Netback of natural gas is 2.2 – 2.75/MMBTU for new plants. If the price is fixed at $2.52 so the conversion of natural gas is not profitable and profitable for new investment.

Due to technological progress new installations use less energy than old plants due to dry process technique - on average 106 mge/ton for dry process in the new installation is used . Future prices for natural gas and fuel oil will not justify natural gas usage in cement production except for high quality cement.

2.3.8 Iron and Steel

Three steps are recognized in the production of steel :

- Pellets from ore(locally or imported)
- Sponge iron from pellets using either direct reduction technique based on coke (the most energy consuming step)
- Steel from sponge iron and/or scrap.

In some plants natural gas is used as feedstock for the production process and in thermal applications and power generation.

Steel production is forecasted for the planning period. Natural gas demand based on high energy efficiencies process (continuous instead of bath) has decreased consumption from 17.8 MMBTU/ton to 11.3 MMBTU/ton

Demand forecast is based on steel production and specific consumption for both feedstock and power generation is developed.

-Value of Gas in the Production of Steel

The price of feedstock gas is based on $10.65/MMBTV. For thermal application it is $2/MMBTV. The price will be fuel oil parity for thermal application and power generation. Gas consumption for one ton of steel is 11.3 MMBTV which implies netback value of $ 11. 25 – 1.77 per MMBTV. Steel production price is $ 20 – 250 /ton out of which is $ 14-20/ton for natural gas (7-9%) gives netback value of $ 1.25 – 1.77/MMBTV for new plants, gas price is $ 1.9/MMBTU. For less electricity consumption plants, netback value will be $ 1.6 - $ 2.0 /MMBTV , a decrease of 1% in other costs means possible increase of netback value by $ 0.23 – 0.28. If demand of steel grows with growth in real gross domestic product (GDP) of the manufacturing sector , future demand of gas for feed stock, thermal and power needs can be calculated.

2.3.9 Gas Demand By Power Sector

It is based on simple least cost approach. Long term planning in the electricity sector has three basic components:

- Long term electricity demand.
- Optimal mix of energy sources to meet the demand.
- Appropriate pricing of electricity.

Least cost approach is explained by the choice of technology depends on daily, weekly and seasonal fluctuations of electricity demand. These fluctuations can be combined in the annual load duration curve which describes in hours duration of peak, intermediate and base loads . For each part of load duration curve, the technology with the lowest cost will be used per generated kwh.

Assume three types of power plants gas turbine, gas combined cycle and power plants using coal , using a unitized capital cost per KW, variable costs and production hours for the tree demand, total demand per technology could be developed.

-Electricity Demand

- Assuming growth of electricity with GDP.
- Assuming $150/capita gives electricity consumption of 1100 Kwh per capita. Growth in population and assuming 15% transmission and distribution losses , electricity demand will be developed .

-Captive Power

The role of captive power in general is decreasing due to increasing capacity and reliability EEA. Use of some industries (textile, pulp and paper) to captive power is mainly due to sensitivity of the production process for power disturbances, reliability of EEA power supply and efforts to avoid peak load hour tariff. Generation costs for captive power is higher than the average electricity costs delivered by EEA. Industrial customers prefer electricity from EEA provided that power system is reliable. So captive power is reliable . So captive power is expected through EEA , so current level of captive power is assumed to be constant

- **Optimal Fuel Mix**

Electricity could be supplied by hydro power schemes, coal based power, geothermal, solar, gas turbine, steam turbine based on diesel oil or dual fuel.

Present capacities should be tabulated together with EEA supply per load category (base, intermediate and peak) to develop options for incremental supply for EEA if not available.

For the decision of fuel mix, generating costs for the tree alternative techniques, options for incremental electricity supply is given in Table 4.

TABLE 4: OPTIONS FOR INCREMENTAL ELECTRICITY SUPPLY

TURBINE UNIT	GAS	GCC	COAL
Plant size MW	100	1500	2400
Unit size Mw	100	300	600
Efficiency Mj/kwh	19	7.2	9
Investment $/kw	270	550	650
Lifetime years	15	20	25
O&M % of invest.	5	3	3
Investment profile %	-		
Year 1	-	10	20
Year 2	-	30	40
Year 3	50	40	30
Year 4	50	10	10

Excluding nuclear power plants based on cost information so it is not consider.

For evaluation between the three techniques, annual investment to be discounted, assuming load duration, curve remains valid for the total planning period. It is concluded that price of gas should be between $ 1.85-1,95/MMBTU , then natural gas demand curve could be developed

2.3.10 Commercial and Residential Gas Demand

At present E-gas operates through its affiliated six companies distribution systems in 20 cities.

Present gas sales to bot industries, commercial and residential are developed. The alternative fuel for residential are kerosene and LPG. Gas sales are low compared to high distribution costs and in general not profitable. Areas with higher commercials such as hotels may have a higher potential.

Since demand by commercials and residential is small and connection costs are high, this market section offers little or no potential for strong market development. Its annual growth will be assumed to be equal to GVA of the rest of the sector. It is in the range of 2.5% of total demand of natural gas.

So it is concluded that natural gas use is profitable in general except for some sub-sectors (steel, cement) in new investment it is preferable to use natural gas instead of fuel oil.

In the total demand for natural gas, power sector plays an important role (60%). Demand by power sector is much more sensitive to price changes than the demand by the manufacturing sector.

2.4 Analysis and Decision Support

Model to forecast demand for different types of consumers were discussion on the basis of some factors (energy price, economic growth, supporting industries etc.). Other factors not discussed are pipelines routes, investment costs , availability of gas reserves, feasibility studies * comprehensive report as the most likely results, with a limited sensitivity analysis. In rapidly changing economy, it is used to obtain the most likely result which is often obsolete. To deal with this problem we either continue to review the results or acquire a software system that allows reevaluation of the results in the light of new developments. Decision support system (DSS) can be divided into support to the following sub problems :

- Energy pricing policy.
- Current and future markets for natural gas.
- Investment , operating and maintenance costs.
- Master plan for investment.
- Financial and economic analysis.

For each sub-problem, agencies/holding companies are responsible . The outcome of DSS is to show if investment in gas transmission is financially and economically sound all over its phases.

2.5 Sensitivity Analysis

Only one factor a t a time is discussed based on world bank guidelines for project evaluation. Factors values for deterministic sensitivity analysis are:

- Investment cost		± 25%
- Construction time		± one year
- Gas reserves		± 20%
- Real GVA		
- Energy prices		± 5%
- Relative gas to oil price		± 10%
- Purchase price		± 5%
- Coal price		± 3%
- Other costs		± 25%
- Discount rate	1.0%	± 2%
- New reserves		± 20 TCF

The most important risk factors were found to be in correct pricing of different forms of energy and insufficient reserves which, may lead to insufficient profits through decreased prices, or to use of natural gas in the power sector as replacement for coal instead of natural gas as a replacement for oil products.

3. Case Study. JAVA (INDONESIA) Gas transmission project

Indonesia has many natural resources among which are oil , natural gas and coal. The country's oil resources are limited and without findings. Indonesia will become an oil importer within the next decades. Therefore the government wants to diversify the domestic fuel mix. Natural gas is one of the Options. Further Indonesia is one of Asia's rapid growing economies, its * oil based part of the manufacturing sector is mainly concentrated in West and East Java . Supply of natural gas requires a comprehensive gas transmission and distribution system which is not yet available in Java. The financial and economic evaluation of the project is executed according to the world bank's standards for project appraisal. Three aspects are studied : Duration of long term forecast for natural gas demand on Java, determination of pricing policy and the use of sensitivity analysis in investment planning. GASOP is DSS tool to support theses analyses . Results are summarized as follows :

- Part of gas needed is available in west Java and Java Sea. But during the next twenty years a pipeline is needed from East Kalimantan and west Java requires considerable investment. Java's current potential demand is too small to make this investment profitable.
- Investment is splitted into three phases : phase I ($181MM) for west Java, Phase II ($ 1543 MM) between west Java and Kalimantan and phase III ($172MM) in compressor stations

- Market development is achieved by using west Java's gas reserves.
- Natural gas supply to some bulk consumers (Steel & fertilizers) is not wise because of low value . Cement sector should continue to use coal as new investments for conversion has marginal profitability..
- Total demand of these three manufacturing sub sectors are expected to grow from 237MMCFD in 1993 to 480 MMCFD.
- The sub-sectors demand will grow from 94 MMCFD in 1993 to 982 MMCFD in 2013.
- Part of power sector will use natural gas when available . Gas has to compete with oil products and coal. Gas serves as a replacement to coal in the intermediate load. Demand for the power sector is expected to grow from 64MMCFD in 1993 to 782MMCFD in 213,
- In combining these forecasts , project demand will be developed.
- Confronting this demand with potential supply, till 2009 demand will be covered from west Java's reserves after which Phase II will have to be finalized.
- Because natural gas has a premium over fuel oil in new investments in manufacturing, fuel oil parity price ($2.6/1000CF) is used in pricing policy based on border price of oil.

4. CONCLUSIONS AND RECOMMENDATIONS

- To justify and appraise natural gas projects, through feasibility study is badly needed. Modeling is part of the feasibility study and is needed especially in rapidly developing economies in order to update the feasibility study.
- Project phasing may be needed to justify the new investment.
- For future studies it is recommended to include in the study the following:
    - o For future economic growth estimates to be embedded in an overall economic model to link economic activity to cost of production (including energy) i.e. to show how energy policy affects economic growth.
    - o In most countries energy sector is changing rapidly from public to private enterprises which will create competition instead of monopoly to improve energy supply. So utilities privatization might strengthen the energy supply system in less developed countries and will reduce financial burden for the governments

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