

## Energy Subsidies Removal Act; an Economic Modeling for Urea & Ammonia Industries (Case Study: Iran)

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**Abstract:** The urea and ammonia industries play important role in Agricultural sectors. Moreover, the export of urea and ammonia is also an annual source of significant value added currency earnings. Hence, the price level of natural gas, as a feeding source for the urea and ammonia plants, is an important factor for economic survival of such plants. After implementing the energy price subsidies removal act in Iran, all producers of urea and ammonia in domestic market are worried for projects future's economy and feasibilities. Such uncertainties are more expedited for grass root and under construction projects. In this paper, based on an economic simulation model, the economic prospect of new Iranian urea and ammonia projects is evaluated. It is hoped that such model results could also be applied by those developing countries, having similar scenario of subsidies removal as well as entering open access market. The simulation results are examined, using two different approaches. First approach considers uncorrelated relation between both natural gas and urea and ammonia prices but in the second one the correlation between price variables is considered to be linear. The obtained results by both approaches show that for achieving around 20% targeted Internal Rate of Return (IRR) in urea and ammonia plants, in this article should apply discrimination policy for feed natural gas price. Such unique remedy should be applied in all projects during payback period. Hence, the government can fix the same price for all units as a rational price level. On the contrary, following the approved subsidies removal act, if the government dictates high gas price then many crises are expected in developments of urea and ammonia projects.

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**Keyword:** Urea Ammonia Plants, Subsidies Removal, Feed Natural Gas, Price Crises

### 1. Introduction

Ammonia is an essential feed stock for a wide range of downstream nitrogen based products such as urea. In the recent years the consumptions of nitrogen fertilizers have significantly grown especially among developing countries. For instance, the Persian Gulf region now supplies 13% of Ammonia and 19% of Urea globally (Hoar, 2009). Such demand growths bounds the fertilizer manufacturers to raise their production from normal levels to upper capacity limits, while keeping the product costs under tight scrutiny, especially against an adverse dynamic feedstock prices.

This paper investigates the role of natural gas in the economy of urea and ammonia projects. The consumption trend outlook confirms that, manufacturers have generally launched projects to structurally adapt the output capacity of their plants to the new demand levels. This demand increase is partially fulfilled through the erection and commissioning of green-field plants. The remaining part is covered by relocation of dismissed plants from western hemisphere to farmers' closer locations. This process was implemented partially through

optimization and debottlenecking of the existing assets.

The largest share of ammonia is primarily used in the production and consumption of fertilizers, while the remaining amounts are used in industrial and other applications. The annual growth of ammonia production is rating within 2-3%. Growth in ammonia production is directly related to demands of phosphate and nitrogen fertilizers, as nearly 90% of ammonia and ammonium derivatives are applied by mineral fertilizer worldwide (Higashi, 2009). China, United State and Morocco are presently the three top market leaders in the production of ammonium phosphate worldwide. International ammonia prices are highly dependent on natural gas prices. Therefore, any unexpected variation in the natural gas price becomes a cause of uncertainty as how to tackle the crises and compete with the market price.

The cost of natural gas for urea and ammonia in Iran was around 12 US \$ for each 1000 cubic meter (m<sup>3</sup>) which is equal to 0.33 US \$ per million BTU. After implementation of subsidies removal act, the price of same amount of natural gas may raise above 90 US \$ which is destructively unexpected by the relevant industries. What should be the rational

targeted price for the feeding gas? The answer to this question is not yet finalized or it has various disputed answers. In order to reach to an acceptable solution, the effect of energy subsidies removal on urea and ammonia industries is evaluated in this paper by two approaches; firstly, the prices of urea, ammonia and feed gas are considered to be independent of each other while, in the second approach a linear correlation between input and output prices is being assumed.

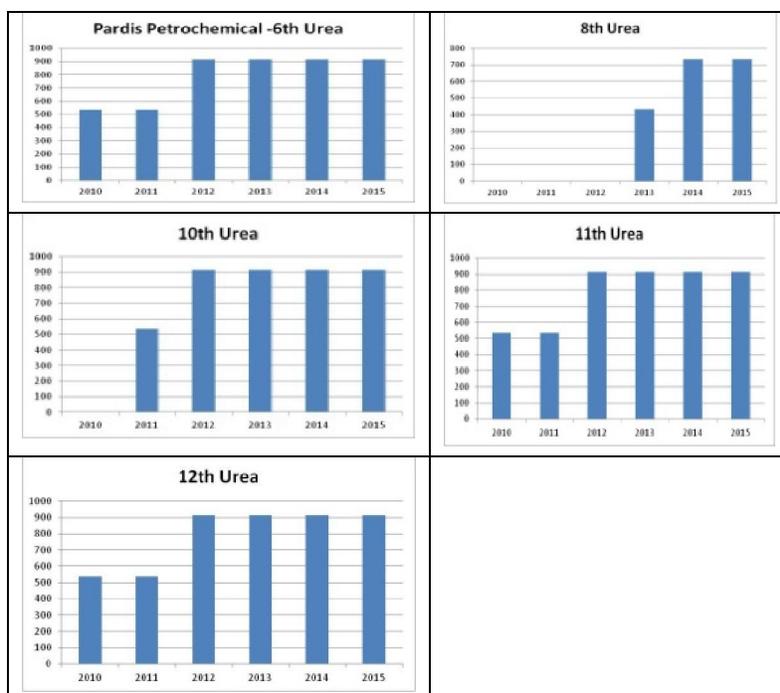
The Iranian Urea-Ammonia Industries are initially introduced and then the methodology of study and Algorithm of model simulation which are the objective contributions of this investigation are presented in the paper. Finally, the purposed remedy for the concerned industries inclusive of petrochemicals who want to employ market base natural gas pricing is presented in the paper.

## 2. Urea and Ammonia Industries in Iran

Black sea and Persian Gulf (Middle East) are the two main urea trade centers, having important role in determining the global prices. Black Sea hub covers the Latin American and European markets while Persian Gulf supplies Urea to North America, Asia and Oceania. Besides these two trade centers, there are

also some regional trade centers such as Caribbean and NOLA (New Orleans, Louisiana). The regional fluctuations are also important since they can effect and change the harmony of main supply hubs. There are 9 active urea and ammonia brown-field units with the total capacity of around 3.6 MMT/Y in Iran (Iran Statistics Center, 2009). Besides, there are also four small non-active production units, located in Esfahan, Mazandaran, Ghazvin and Markazi provinces, just being used for urea distributing purpose (Complexes of National Petrochemicals Industry, 2011). As per statics of Iranian National Petrochemical Company, there are six green-field companies, namely as; Pardis, Kermanshah, Shiraz, Khorasan and Razi, with the total nominal capacity of 4.4 MMT per year.

Total consumption of Nitrogen fertilizers was 2,300,466 tons in 2008 (Jahad Agriculture Ministry Statistics, 2010). Iran has no importing of Urea fertilizer and it is evidence of independency in this field. It means that the market of Urea fertilizer is saturated and the exploitation of any new capacity should be done with the aim of export markets. As mentioned above, 90% of Urea consumption was used as Urea fertilizer and 10% of it was used for industrial purposes. The amounts of urea supply in coming years are predicted in Figure 1.



Source: Iranian National Petrochemical Company (NPC), 2010

Figure 1. The forecast of the facilities of Urea supply in Iran 2010-2015 (1000 ton /Year)

According to the present data, the yield of urea production is about 85% of units' nominal capacity which indicates a nearly perfect performance. It is to be noted that the production yield during the first year of utilization does not rise beyond 50% and it relatively increases in the coming years. For instance, in year 2009, the supply of Urea in Iran was about 3 MMT and in years 2006 and 2011(SRI Data 2006 and 2011), the production yields of urea factories in Middle East were 86.9% and 83.9% respectively. Hence, in this simulation, the yield of production is considered as 85%.

### 3. Energy Subsidies Removal Act

In order to aim fully reduce/remove the payment of various subsidies, the Iranian government presented a detailed program under the title of "Targeted Subsidies Plan" to the parliament. After which in January 2010, the parliament did approve the said plan under law article of one hundred and twenty three. According to this law, the government has to settle the energy prices as average of domestic sale price of natural gas. Hence, the price of feed stock for industrial units like urea factories will be determinable between 0% to 65% of natural gas export basket price. In order to estimate the price of the needed gas for urea factories, it is necessary to determine the price of Iran's gas export's basket. Based on above mentioned policy the natural feed gas price for projected and planned urea and ammonia plants in Iran was estimated.

**Table1.** Results of Natural Gas Price Subsidies Removal Plan

Results of natural gas subsidies removal as per plan	Results of natural gas subsidy removal act in reality
The minimum price of natural gas for households will reach around 75% of the average natural gas export price (~200 \$/1000 CM)(transport and other fees are excluded (40 \$/1000 CM). Within 5 years, this price will gradually reach to around 250\$/1000 CM (Predict by authors). For a minimum period of 10 years, the price of gas for industries, refineries and petrochemicals will be a maximum of 65% of the average gas export price i.e. 115 \$/1000 CM .	The actual price paid by the consumers is 80 \$/1000CM and perhaps this price will further increase to 120 \$/1000CM in near future. This indicates a substantial contradictive amount between planned and real implementing costs.

In Industries and Petrochemical Plants there is no clear policy (discrimination policy for different petrochemical plant – gas price based on plant technology and age of the plant) for petrochemical grass root project floor price is around 90 \$/1000 CM

but it is understood that it is subject to change by negotiation.

### 4. Methodologies

The model is simulated as per following different methods;

#### 4.1. Economics Model

Generally for economics analysis, the Incremental capital cost and operating costs, which are applicable to all industrial projects, are evaluated(UNIDO, 1998). In addition, Net Present Value (NPV) is also evaluated. Economics evaluation value is given as per the following expression:

$$\text{Revenue} - (\text{CF} + \text{Equity} + \text{OPEX} + \text{Feed Gas Cost} + \text{Tax} + \text{Insurance}) \quad (1)$$

Capital Expenditure is composed of "EPC and licensing as Plant Cost" and "land, feed gas, civil construction work and structural and housing requirements as Owner's Cost."

Project feasibility and FEED study in Iran, are added to the Owner's cost.

Following is model input base on project costing.

Financial Terms Used for this Study is:

- Operation period of the Urea Plant: 25 Years
- Depreciation Norms (n): Some Years Digit method, 10 to12 year
- Financing terms (i): Interest rate= about 15% per year

Urea process EPC cost the range for Iranian Urea and Ammonia Grass root and under construction projects considered the range is between 600-700 million, Based on Stamicarbon technology.

Operational Expenditure (OPEX) like CAPEX is project input and after project operation in this article should be considered it annually. The Operational Expenditure is composed of "Fixed cost (labor, maintenance & repair and general expenses, etc.)" and Variable cost (make-up catalyst / Chemical and utilities).

In this study, 3% to 5% per year of the plant's EPC Cost is applied to the Owner's cost. This figure is driven from an assessment of the previous Urea Ammonia project's, executed in Iran or other regional countries.

Feedstock, electricity and fuel gas consumption are incorporated as variable costs in our study.

The Net Present Value (NPV), defined as the following equation, is also applied in our economic simulation evaluations:

$$NPV = -I + \sum Bi / (1+r)^i \quad (2)$$

$I$  = Investment

$B_i$  = Revenue – Expense in  $I$ -th year

$r$  = Discount rate, 15%

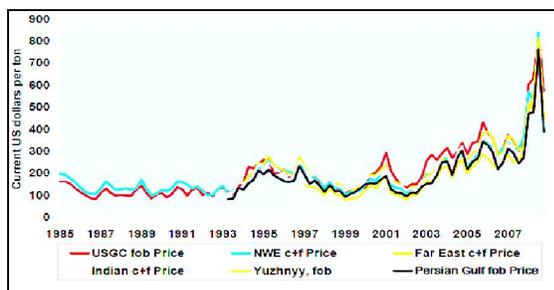
The IRR shows the profitability of investment. In industrial projects normally petrochemical and urea and ammonia investors in Iran expect 20% for IRR as a targeted IRR.

**4.2. Monte Carlo Urea and Ammonia Simulation**

In mathematical finance, the Monte Carlo option model uses Monte Carlo methods to calculate the value of an option with multiple sources of uncertainty or with complicated features.

The term 'Monte Carlo method' was coined by Stanislaw Ulam in 1940s. The first application to option pricing was by Phelim Boyle in 1977 (for European options). In 1996, M. Broadie and P. Glasserman showed how to price Asian options by Monte Carlo. In 2001 F. A. Longstaff and E. S. Schwartz developed a practical Monte Carlo method for pricing.

Monte Carlo Methods allow for a compounding in the uncertainty (Cortazar and Others, 2008). For example, where the underlying is denominated in a foreign currency, an additional source of uncertainty will be the exchange rate: the underlying price and the exchange rate must be separately simulated and then combined to determine the value of the underlying in the local currency. In all such models, correlation between the underlying sources of risk is also incorporated (Geweke, 1994); further complications, such as impact of commodity prices or the inflation on underlying can also be introduced. Since simulation can accommodate complex problems of this sort, it is often used in analyzing real options where management's decision at any point is a function of multiple underlying variables.



Sources: AFA 2010 + Nexant 2009

Figure 2. Global Ammonia Price Time Series

For this reason make the first model in this article consider following formula for urea price.

$$d(P_{urea}) = \mu P_{urea} + \sigma P_{urea} dW_t \quad (3)$$

Also in this article consider same formula for ammonia price;

$$d(P_{Ammonia}) = \mu P_{Ammonia} + \sigma P_{Ammonia} dW_t \quad (4)$$

Factors in above mention formulas are;

$\mu$  = drift

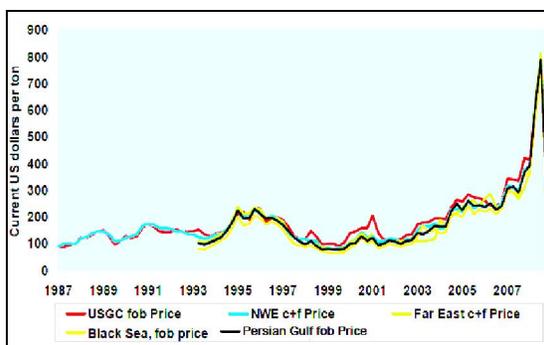
$\sigma$  = Volatility

$dW_t$  = is found via a random sampling from a normal distribution

$P_{urea}$  and  $P_{Ammonia}$  = Urea Price and Ammonia Price (\$/Ton)

In this article applied following data for Urea and Ammonia simulation:

Compare Urea and Ammonia price fluctuation show that ammonia price is more fluctuated than urea.



Sources: AFA 2010 + Nexant 2009

Figure 3. Global Urea Price Time Series

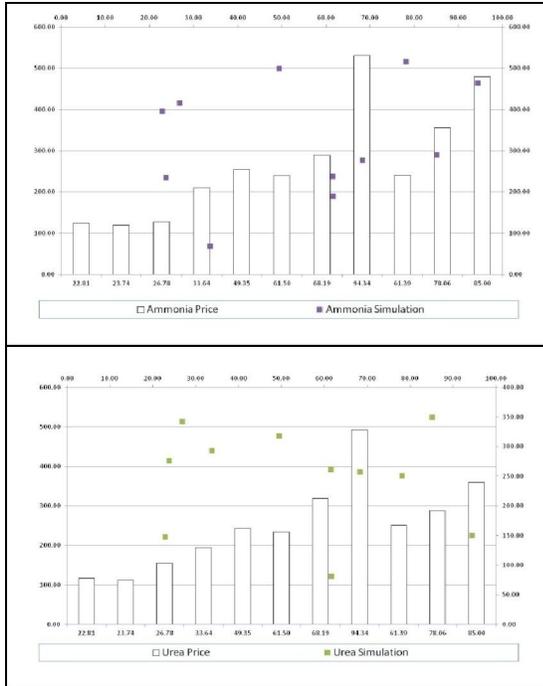
Based on average price of mentioned above time series from different region in this paper run Monte Carlo simulation for urea and ammonia price results after 10000 times iteration and simulated it as in following and then feed results to main model as a urea and ammonia stochastic prices input.

**5. Results**

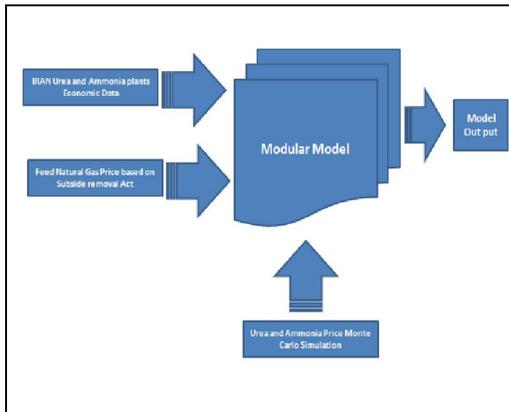
**5.1. Modular Model Algorithm Results**

As in this paper already explained all above mentioned variables will feed to main model and after processing; model output will produce, main outputs are NPV and IRR and based on these factors in this paper develop our analysis, and in this paper presented simple algorithm of modular mode as in following:

Based on model algorithm and previous explanation in this paper consider two approaches for model output; first feed natural gas price and urea and ammonia prices like as independent variables and then in this paper consider linear correlation between variables based on expected IRR by urea and ammonia investors. In this paper will try in two separate parts evaluate model results.



**Figure 4.** Ammonia and Urea Price based on Monte Carlo simulation (by 10000 times iteration)



**Figure5.** Simulation model algorithm

**5.2. Independent Variable Results**

New Iranian Urea and Ammonia plants have following common assumptions;

Based on mentioned above assumption in this paper considered 3 following scenarios;

CAPEX = 600 Million \$

CAPEX=650 Million \$

CAPEX 700 Million \$

If CAPEX exogenously considered 600 Million \$ simulation model output results are:

**Table 2.** Model Assumptions (Inputs)

Plant Size (tone per Year)	506328
Plant Size (tone per day) Urea+ Ammonia	913.75
OPEX (% of CAPEX)	3
Gas feed volume (BCM per year)	0.57
Capacity utilization(%) 1st year	90%
Capacity utilization(%) 2nd year	95%
Capacity utilization(%) 3 rd year	98%
Capacity utilization(%) 4th till 20th year	100%
Economic life (Year)	25
Total CAPEX (\$/Million)	\$354
Feed Gas Price (\$/1000 CM)	90
Base urea forward price (US\$/ton)	277
Base Ammonia forward price (US\$/ton)	276

**Table3.** Model output@600 Million US \$

IRR	15%
NPV (million \$)	-53.24

If CAPEX exogenously considered 650 Million \$ simulation model output results are:

**Table4.** Model output@650 Million US \$

IRR	14%
NPV (million \$)	-76.42

If CAPEX exogenously considered 700 Million \$ simulation model output results are:

**Table5.** Model output@700 Million US \$

IRR	12%
NPV (million \$)	-99.60

In all mentioned above outputs sensitivity analysis show that project have more sensitivity against feed gas price in cost side and Urea and Ammonia Price in income side.

Also sensitivity analysis dictated to us that if there is no correlation between feed natural gas price and productions price; in this situation in this paper will have more economic problem for development of urea and ammonia plant in Iran.

Also summary of results are:

**Table6.** No correlation model results

CAPEX	NPV (million \$)	IRR (%)
600	-53.24	15.0%
700	-75.42	14%
750	-99.60	12 %

With regard to output of model it seems pricing policy based on feed natural gas price around 90 \$/1000 CM (that impose by government to Urea and Ammonia units) perhaps bankrupt some of grass root Urea and Ammonia units or stop under construction plant in this situation the Iranian Government should

consider discrimination pricing policy for feed natural gas price and they could adjust feed gas price based on Urea and Ammonia plant EPC cost and selected technology.

According to CAPEX scenarios, price discrimination for obtaining expected IRR summarized in following table.

In this situation and based on price discrimination pre assumption in this paper should consider different feed gas price and it is necessary that each urea and ammonia private unit submitted our documented cost to authority center.

**Table7.** Feed Natural Gas Price Discrimination for getting targeted IRR~ 20%

CAPEX	Feed Natural Gas Price (\$/1000 CM)
600	52
700	35
750	18

The results indicated that feed natural gas price is around 90\$/1000 CM is more than expectation of who will develop urea and ammonia grass root project in build up period in Iran.

In this paper shall emphasize that bench mark for decision making of discrimination price policy is projects documented cost.

Also perhaps it is necessary that investors revise expected IRR.

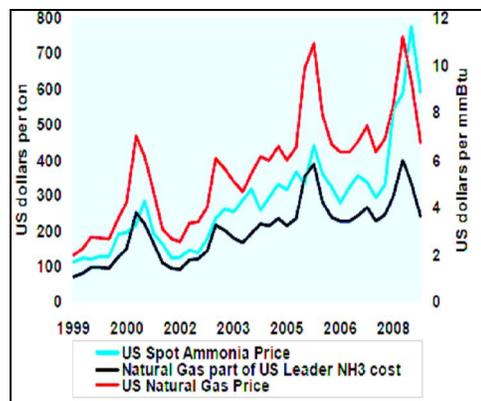
**5.3. Correlation Results**

Natural feed gas price is exogenous variable and impose by government to petrochemical plant and in this paper believe that government consider logical correlation between feed gas price and urea and ammonia products price for obtaining rational price for grass root and under construction urea and ammonia projects .

US experience in urea and ammonia industry confirms our proposal and present mentioned reality3.

As you seen in figure 7 ammonia price in US market have same fluctuation with feed gas price and also urea has same fluctuation.

Regarding to this approach there is logical correlation between Urea and Ammonia prices and feed natural gas price.



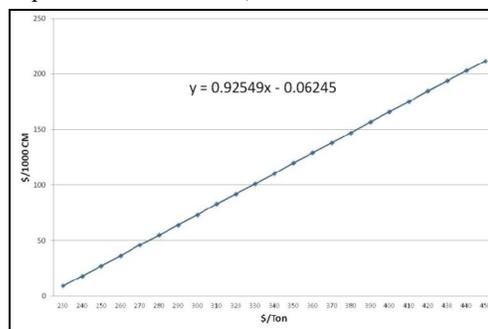
Source: Nexant 2009

**Figure6.** Effect of US Natural Gas on Ammonia Price

Here first in this paper fixed IRR based on investors' expectation and then based on different urea and ammonia price obtained feed gas price and generate two dimension time series and hence estimate two variables regression between feed gas price and urea and ammonia prices.

In other world project will be protected against Urea and Ammonia price volatility and also fluctuation.

1- Linear pricing formula between feed natural gas and Urea and Ammonia Price if CAPEX equal 600 million \$ is;

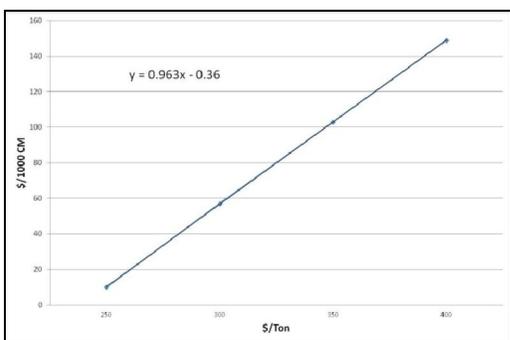


**Figure 7.** Feed Gas Price vs. Urea and Ammonia Price (CAPEX=600 million \$, IRR=20%)

If in this article consider linear correlation between feed gas price and urea and ammonia price for IRR=20% and for all units that have CAPEX equal 600 million \$, the pricing formula as in follow;

$$Feed\ Natural\ Gas\ Price = 0.925 * (Urea\ or\ Ammonia\ Price) - 0.062\ (5)$$

2-Linear pricing formula between feed natural gas and Urea and Ammonia Price if CAPEX equal 650 million \$ is.

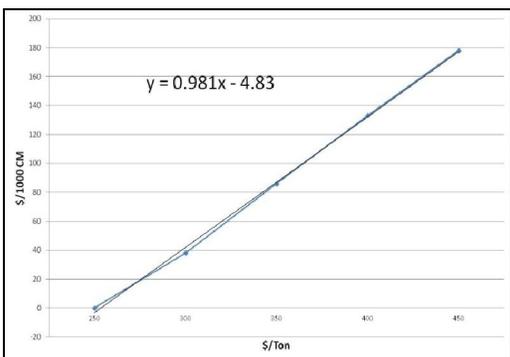


**Figure 8.** Feed Gas Price vs. Urea and Ammonia Price (CAPEX=650 million \$, IRR=20%)

If we consider linear correlation between feed gas price and urea and ammonia price for IRR=20% and for all units that have CAPEX equal 650 million \$, the pricing formula as in follow;

$$\text{Feed Natural Gas Price} = 0.963 * (\text{Urea or Ammonia Price}) - 0.36 \quad (6)$$

3-Linear pricing formula between feed natural gas and Urea and Ammonia Price if CAPEX equal 700 million \$ is;



**Figure 9.** Feed Gas Price vs. Urea and Ammonia Price (CAPEX=700 million \$, IRR=20%)

If we consider linear correlation between feed gas price and urea and ammonia price for getting IRR=20% and for all units that have CAPEX equal 700 million \$, the pricing formula as in follow;

$$\text{Feed Natural Gas Price} = 0.981 * (\text{Urea or Ammonia Price})$$

## 6. Conclusion

Feed natural gas price have a significant effect on economy of the urea and ammonia project, for this reason this factor should precisely calculate and then consider as an input for development of petrochemical and urea and ammonia units.

If there is no relation between input and output price in each time project have impact with unforeseen and stochastic situation and we have not any economic stability for project economic, because in one side feed gas price impose exogenously and in the other side urea and ammonia price have volatility and fluctuation based on international market behavior in this case the relation between domestic market and international market become interrupted.

If we consider correlation between input and output price can be covered major part of the project economics and can be controlled project exposure.

Also in all mentioned approaches and for more efficiency we have to consider input price discrimination for different urea and ammonia units in Iran and also after obtaining significant economic harmony between units, it is possible to consider unique pricing policy for all units in long run and after build up period.

We believe mentioned mechanism is applicable for all development countries that want to enter international competitions market for minimizing damage to energy intensive projects.

It seems present policy by Iran government regarding to petrochemical units in long term, gradually decrease urea and ammonia development and also decrease role of Iran as a urea and ammonia exporter in Persian Gulf region against Saudi Arabia and other regional exporter.

This policy could be changed role of Iran from exporter of urea and ammonia to importer in long term. Therefore, It is believe policy changes by Iranian Government and consider rational feed gas price could be guaranteed urea and ammonia economics in Iran.

Finally calculation of optimal price with regard to output price can solve many problems and Iranian government can simultaneously control and decrease Urea and Ammonia high margin and also increase unit efficiency and project economic potential.

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