

# Economic and Environmental Evaluation of Iran Gas Flaring Reduction With GPPs: Case study of NGL-۳۲۰۰ Plant of Iran

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## Abstract

The Statistics are indicated flare of ۴۰ percentage of Associated Petroleum (APG) in Iran that in this volume, Iran have fourth rank in world and first rank in Middle East. Economic and environmental dimensions of flare of this gas has led to in country is planned projects for gathering APG. In between these projects, NGL Unit has the main share in gathering of APG that in this between, NGL-۳۲۰۰ Unit, with capacity of ۱۴,۱۰ million cubic meters in day, is important due to gathering of APG from oil fields of karon West. Therefore, in present research, using Cost-Benefit Analysis method and financial index of Net Present Value (NPV), Internal Return Rate (IRR) and payback period is evaluated NGL-۳۲۰۰ project. The result of economic evaluation demonstrate that if this unit is acted with ۱۰۰ percentage of capacity, then NGL-۳۲۰۰ project will have economic feasibility in IRR ۲۸,۲۹ percentage. Also, the result of sensitivity analysis of project illustrate that first if feed of this unit have decrease excess ۲۲ percentage, then this project don't will have economic feasibility, second in the event of review NGL-۳۲۰۰, if nominal capacity of this unit have decrease excess ۴۰ percentage, then will be lost economic feasibility of NGL-۳۲۰۰ project. Thirdly for given IRR ۲۰ percentage, APG price should be ۰,۱ cent in current nominal capacity and ۳,۲۴ cent in nominal capacity Equivalent to ۰۰ percentage of current capacity.

**Key Word:** Associated Petroleum Gas, Net Present Value, Internal Return Rate, NGL-۳۲۰۰

**JEL Classification:** D۱۱, R۴۸, Q۳۰, Q۴۸

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## ۱- Introduction

Today, environmental issues are among the most important issues in different countries of the world. So that plans to prevent the spread of environmental pollutants including greenhouse gases are implemented in many countries and treaties such as the Kyoto Protocol and recently the Congress of Parties ۲۱ (COP ۲۱)<sup>۱</sup> also emphasize the implementation of these plans at the international level. However, the share of energy sector in greenhouse gas emissions is ۶۹% according to report of the International Energy Agency (IEA) in ۲۰۱۴<sup>۲</sup>. Among the different activities in the energy sector, especially in the oil and gas industry, burning associated gas<sup>۳</sup> is one of the factors that contributes significantly to the greenhouse gas emissions, so that the greenhouse gas emissions from burning associated gas in ۲۰۱۳ will lead to the ۱% increase in total emissions of environmental pollutants.<sup>۴</sup> Accordingly, the collection of associated gas flaring (gases in a burner) is important for reducing the emissions of environmental pollutants. In addition to the importance of collecting these gases in terms of the environment, the economic value of compounds in associated gas such as light gas and gas liquids has added to the importance of collecting associated gas.

According to World Bank statistics in ۲۰۱۴, Iran has been the fourth largest in the world<sup>۵</sup> and first in the Middle East in terms of burning gases in ۲۰۱۴, with ۷,۶۵% of the world's flaring gases<sup>۶</sup>. The high level of burning associated gas in Iran has led policy makers to put together projects to collect associated gas, along with the economic and environmental problems arising from it.

The creation of gas and liquid gas plants or natural gas liquid (NGL) units<sup>۷</sup> is one of the most important projects in the policy of collecting associated gas which has a high share in the collection of these gases.<sup>۸</sup>

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<sup>۱</sup>. Congress of Parties ۲۱ (COP ۲۱)

<sup>۲</sup>. IEA (۲۰۱۴), p.۷

<sup>۳</sup>. Associated Gas

<sup>۴</sup>. PBL Netherlands Environmental Assessment Agency (۲۰۱۴), p.۱۲

<sup>۵</sup>. The volume of flaring gas in the world is ۱۴۰ billion cubic meters in ۲۰۱۴ that Iran's share is ۱۰,۷ billion cubic meters per year.

<sup>۶</sup>. WB/IGU/SE&ALL Regional Gas Seminar (۲۰۱۵)

<sup>۷</sup>. Natural Gas Liquids (NGL)

<sup>۸</sup>. The capacity of NGL units on the agenda is equal to ۶۰ million cubic meters per day for associated gas.

Unfortunately, projects for construction of NGL units that have been on the agenda since ۲۰۰۴ are still unclear to date due to various reasons:

- √ Geographical barriers (geographical conditions, distribution of associated gas producing fields and staying away from the consumer market)
- √ Technical conditions (quantity and quality) of associated gas
- √ High capital costs of projects for using associated gas and financing problems
- √ Structural and institutional barriers (priority for increasing oil and gas production for the national oil company, lack of transparency of the information required in relation to associated gas)
- √ Lack of transparency in government policies and the lack of sufficient rules and regulations

Are still unfinished and only Siri NGL has been exploited with a capacity of ۴,۰۴ million cubic meters per day.

Thus, the Ministry of Petroleum has moved NGL units to the private sector to eliminate these constraints and intends to sell associated gas to these units. Considering the private sector's entry into the associated gas market, the economic justification for the projects in this area will be very important. It is clear that despite the environmental importance of collecting associated gas, if these projects are not economically justified for the private sector, it will not be sustainable in the construction or operation phase.

Investigating the NGL assignment units shows that the NGL-۳۲۰۰ unit, which is on the agenda for collecting associated gas from the oil fields of West Karoun, is more important for the following reasons.

- ۱- The National Oil Company plans to increase oil production by one million barrels from fields in West of Karoun
- ۲- Increased production of associated gas by ۷ million cubic meters per day for the next ۴ years
- ۳- Establishment of NF۳ unit by Bandar Imam Petrochemical Company for the use of NGL-۳۲۰۰ products

In addition, field studies in relation to CO<sub>2</sub> emissions for associated gas flaring in Iran suggest that the flaring of per ۱۰۰۰ cubic feet of associated gas will release ۶۳,۳ kg of CO<sub>2</sub> in the air. Based on this estimate and given the capacity

of 100 million cubic feet per day of NGL-3200, the release of 31,60 thousand tons per day (11,0 million tons) will be prevented if this unit is exploited.

According to the above, the NGL-3200 unit is economically evaluated in the present study. For this reason, this study is organized in five sections. In the following, NGL unit was first described in a technical way, and the current status of existing and expected NGL units of the country has been explained. Then, the research theoretical and empirical literature is presented in the third section. In the fourth section, the results of the financial-economic evaluation of NGL-3200 are stated and policy proposals have been proposed in the final section.

## 2- Status of existing and expected NGL units in Iran

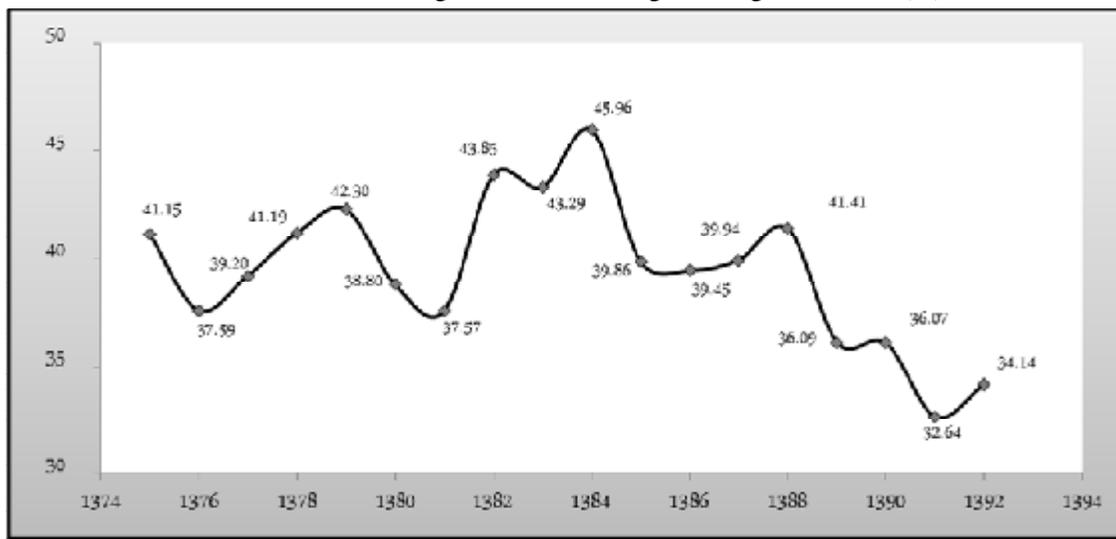
The gathering of associated gas with the transfer of gas from Ahvaz, Maroun and Aghajari operation units for domestic use and the establishment of gas and liquefied petroleum gas plants of 600-100 and the Bidboland facilities began since 1960s. Then, the problem of using associated gas to extract gas liquids as feed for petrochemical industries and creating gas injection facilities in oilfields was introduced in the early 1970s, and various projects were undertaken to collect associated gas. Despite this, only 20% of the associated gas was collected and more than 80% of it was Flared by the year 1978. Due to sanctions and 8 years of imposed war, a break-up period has taken place in associated gas gathering projects since 1978. In 1989, the five-year development plans of the country re-considered the reduction of pollution and the burning of associated gas. At present, 12 NGL units with a capacity of 96,44 million cubic meters per day are working to collect associated gas from oil fields considering the Siri NGL unit.<sup>1</sup> It is worth noting that 99,9 million cubic meters per day of light gas can be produced by processing this capacity of the NGL units. Nevertheless, only 30,63 million cubic meters per day of light gas (33,0 percent of the total light gas production) were produced from the processing of associated gas in these units in 2014.<sup>2</sup> The study of NGL units in recent years shows that the light gas produced in these units was 91,6% of capacity on average during the period of 2007-2014. This reflects the lack of using large capacity of the existing NGL units in the country for collecting associated gas, mainly due to a significant drop in oil production from the old fields of the National Iranian South Oil

<sup>1</sup>. 12 NGL units for the collection of associated gas include NGL-100, NGL-200, NGL-300, NGL-400, NGL-500, NGL-600, NGL-700, NGL-800, NGL-1200, NGL-1300, NGL-1500, and Siri NGL

<sup>2</sup>. Hydrocarbon balance of the country in 2013 (2014), p. 106

Company, as well as the old installations of some NGL units of this company. Despite the presence of various NGL units for the use of associated gas and preventing the burning of these gases, a significant portion of the associated gas are still flaring at the operational areas of the National Iranian Oil Company according to the following chart.

**Chart ۱-** The share of gases in associated gas during ۱۹۹۶-۲۰۱۳ (%)



For this reason, the National Oil Company has put on the agenda ^ new NGL units since ۲۰۰۴ to collect gas in the burner. The performed studies show that only Khark NGL units of ۳۲۰۰ and ۳۱۰۰ have physical progress of ۰۷, ۶, and ۰ percent respectively, and the rest of the plans have not made any progress. The total capacity of these projects is ۶۴,۹۹ million cubic meters per day (۰۷,۱۸ million cubic meters per day of associated gas and the rest is for rich gas). The supply of these units is as follows:

- ۱- Part of this capacity is related to the burning associated gas.
- ۲- The other part is the associated gases that are currently being used by other NGL units. For example, Zylayy associated gas is processed in the NGL-۶۰۰ unit and delivered to the gas company, but the associated gas of the mentioned oil field will be sent to the unit for processing by the operation of the NGL-۱۷۰۰ unit.
- ۳- Part also concerns the development of new oilfields and Khami & Bangestan reservoirs.

According to the statistics presented by the National Iranian Oil Company's Consolidated Plan, it is now expected to use ۹,۸۶ billion dollars for full

utilization of NGL projects and 57,18 million cubic meters of associated gas are collected annually with their implementation<sup>1</sup>. Among the projects, NGL Khark units and 3200 units with capacity of 16,98 and 14,10 million cubic meters per day are the country's largest projects for the collection of associated gas which requires a total investment of 4,2 billion dollars to make full use of them.

## 3- Financial-economic evaluation of NGL-3200

### 3-1- NGL-3200 projects input and output cash flows

The NGL-3200 unit with a capacity of 14,10 million cubic meters per day for the purpose of collecting associated gas from the oil fields of the Arvand Operational Zone (West Karoun), including Jafir, Yadavaran, Azadegan, Yaran, and Darkhoein, are on the agenda of the National Oil Company. 4,9 million Cubic meter per day of light gas and 4,9 thousand barrels per day of gas liquids will be recovered from processing of associated gas in this unit.<sup>2</sup> The following assumptions are considered in the financial-economic evaluation of NGL-3200:

1- The associated gas input capacity is 14,10 million cubic meters per day (5,166 billion cubic meters per year)

2- The gas output capacity is equivalent to 4,9 million cubic meters per day and delivered to the National Oil Company for free<sup>3</sup>

3- Ethane production at a rate of 2337,2 tons per day and its domestic sales amounted to 240 dollars per ton<sup>4</sup>, LPG production at a rate of 3023,8 tons per day and exports amounted to 360 dollars per ton<sup>5</sup>, and production of condensate gas at 1062 tons per day and its exports amounted to 423,2 dollars per ton (46,94 dollars per barrel)<sup>6</sup>

4- Annual growth in operating costs at a rate of 0%.

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<sup>1</sup>. According to Mr. Moshtagh Ali Gohari, Deputy Director of National Oil Company Consolidated Planning on 30,05,2014

<sup>2</sup>. It should be noted that information on the capacity and the amount of production of various products in this unit is obtained based on field information.

<sup>3</sup>. According to the Ministry of Oil's decision, the NGL units should be supplied to the National Oil Company for free light output gas.

<sup>4</sup>. The ethane price is intended based on the approved petrochemical feed prices.

<sup>5</sup>. <http://gasenergyaustralia.asn.au/reports-and-submissions/saudi-aramco-lpg-prices/> (2016)

<sup>6</sup>. Customs of the Islamic Republic of Iran (2016), Preliminary Foreign Trade Statistics of the Islamic Republic of Iran for the first quarter of 2016

◦- Annual growth of product prices at a rate of ۲%: This assumption is achieved by examining the time series of product price changes over a period of ۱۰ years.

۶- Associated gas Prices: There are two scenarios for gas prices in the burner.

Scenario ۱: The price of gas in the burner is based on the National Oil Company (NIOC) price and without regard to the value of CO<sub>۲</sub> collected equivalent to ۳,۰ cents per cubic meter of gas at the torch.

Scenario ۲: The price of the gas in the burner is based on the National Oil Company (NIOC) price and considering the value of the collected CO<sub>۲</sub>

Since the private sector, through the construction of a NGL unit and reducing the negative externalities resulting from the burning of associated gas, is one of the tasks of the government to reduce the external impacts of economic activities, and therefore discounts for the private sector in the associated gas prices should be considered. This can be economically a positive incentive for the private sector. It should be noted that about ۷۰% of pollutants (carbon) have (carbon tax) prices below ۱۰ dollars per ton according to available statistics<sup>۱ 4</sup>, so the price of CO<sub>۲</sub> per ton is equivalent to ۰ dollars per ton (average price) in this article that the price of carbon per cubic meter would be ۱,۱۲ cents considering the following table which should be deducted as a discount from the NIOC's declared price.

**Table ۱** - Estimated carbon price released per cubic meter

	Carbon price (dollars per ton)	The amount of carbon emissions (tons per day)	Value per ton of carbon (cents)	Carbon price per burning per cubic meter (cents)
Carbon price	۰	۳۱۶۰.	۱۰۸۲۰.۰۰	۱,۱۲

۷- The rate of the dollar is equivalent to ۳۳۰۰۰ riyals and the annual growth of ۱,۰ percent: This rate is assumed by examining the behavior of exchange rate changes over different time periods.

۸- Construction of the ۴ year project and its operation for ۱۰ years: The technical information obtained from experts and specialists in the field of construction and operation of gas refueling units is based on this assumption.

<sup>1</sup>. World Bank (۲۰۱۶), State and Trends of Carbon Pricing, p.۲۴.

٩- Equity shareholder and long-term facility are ٢٥% and ٧٥% of the capital cost: According to the National Development Fund rules, the employer must provide at least ٢٥% of the cost of the capital.<sup>١</sup>

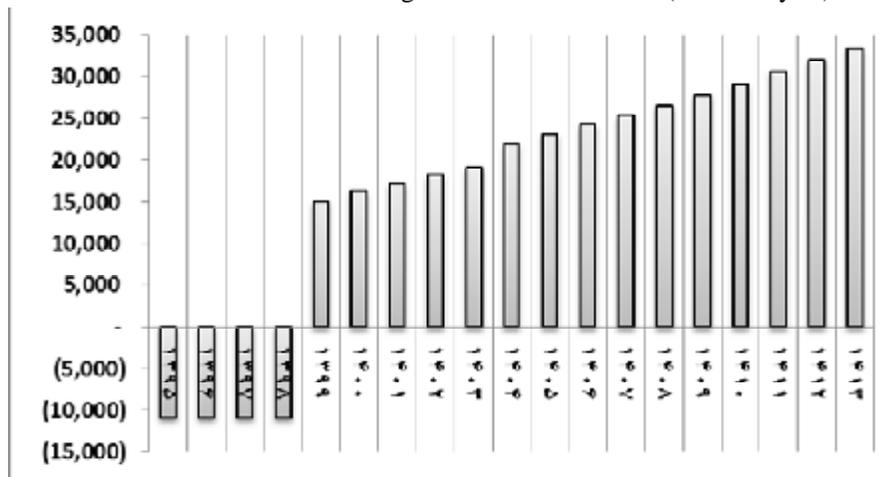
١٠- Long-term foreign currency loan rate of ٨% and ٥-year repayment period: This assumption is based on loans paid by the National Development Fund<sup>٢</sup>.

١١- Payment of installments in equal installments (Total principal and interest)

١٢- ٢٢% discount rate: the choice of the discount rate in cost analysis is an important issue that the analyst may reach different results with different assumptions in this regard. In any case, the rationale for choosing the discount rate is the opportunity cost. This rate is the cost of resource opportunity. In this study, the choice of discount rate was a major challenge and issue. Regarding the inflation rate and interest rate, the discount rate in this study is ٢٢%.

Based on the above assumptions, income and expenditure cash flows of the NGL-٢٢٠٠ are in accordance with Chart (٧) and Table (١):

Chart ٧- Net cash flow during the life of NGL-٢٢٠٠ (billion Riyals)



### ٣-٢- Financial-economic indexes of NGL-٢٢٠٠ unit

In this section, the financial indicators derived from the cost-benefit analysis of the NGL-٢٢٠٠ project are presented. These results are based on the main assumption that this unit operates at a nominal capacity of ١٠٠%, and there is no fluctuation in the supply of feed (associated gas) to this unit. As shown in Table (٧), the IRR project NGL-٢٢٠٠ is ٢٨,٢٩%, and its NPV is greater than zero

<sup>1</sup>. For more information, refer the National Development Fund website.

<sup>2</sup>. Ibid.

based on the assumptions that mentioned above or in other words, the NGL-۳۲۰۰ project has economic justification.

**Table ۲-** Indices of NPV, IRR and return periods of NGL-۳۲۰۰ project

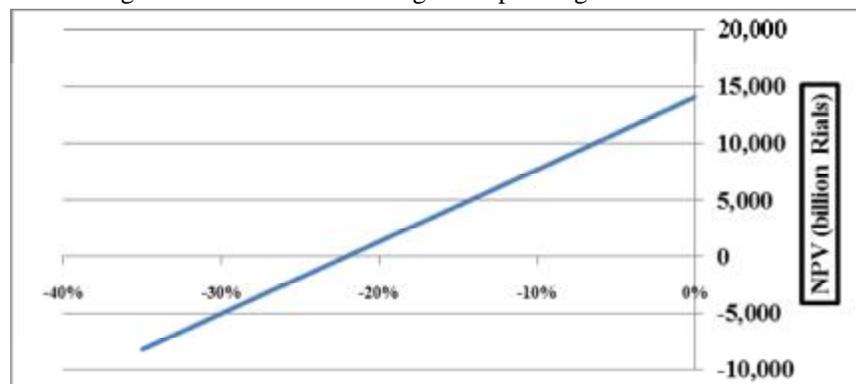
Scenarios related to the price of Flaring	IRR (percent)	Return on capital (year)
Scenario ۱	۲۸,۲۹	۳,۰
Scenario ۲	۲۹,۹۰	۳,۳

### ۳-۳- One-factor sensitivity analysis

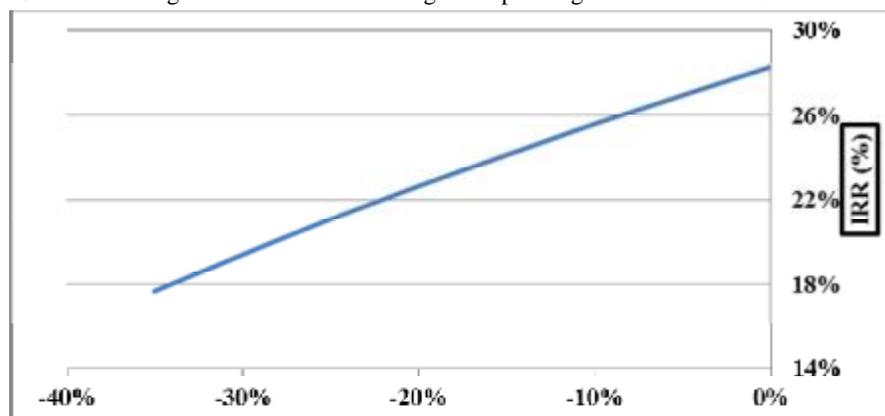
#### ۳-۳-۱- Sensitivity analysis with respect to operating rates

Investigating the response of the NGL-۳۲۰۰ project financial indicators to the change in operating rates show that when the amount of operation from NGL-۳۲۰۰ unit is reduced from ۷۸٪ (۲۲٪ reduction in feed unit), then the net present value is negative and the internal rate of return (IRR) will be less than the discount rate and the project will not have economic justification.

**Chart ۳-** Change in NPV relative to changes in operating rates from the NGL-۳۲۰۰ unit



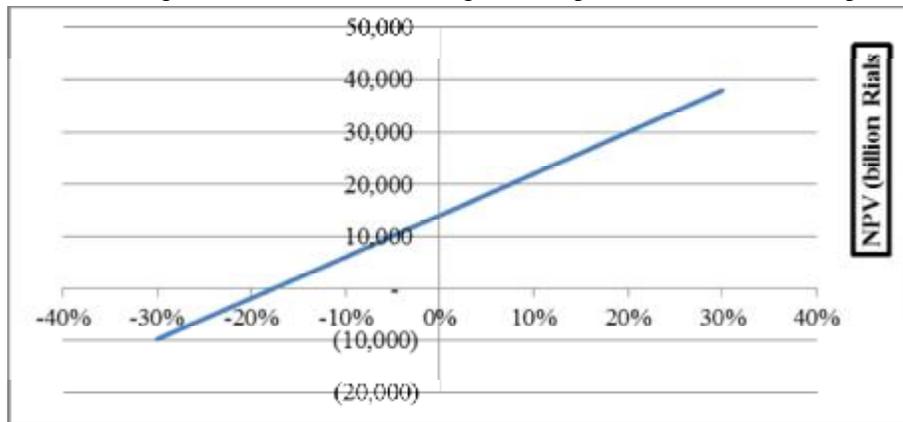
**Chart ۴-** Change in IRR relative to changes in operating rates from the NGL-۳۲۰۰ unit



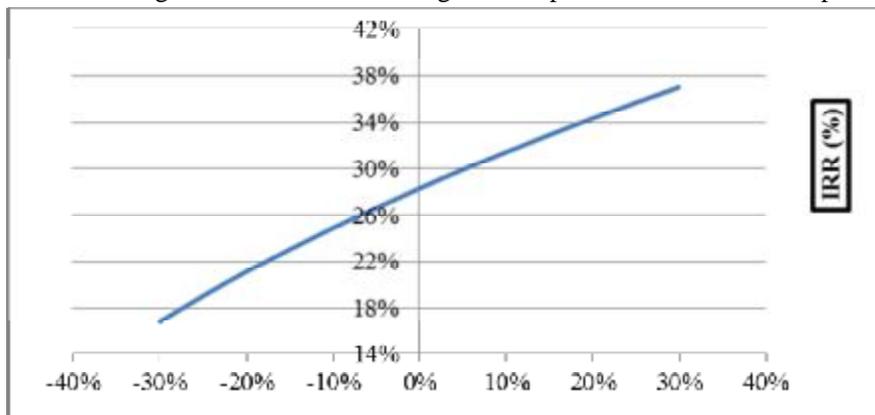
#### ۳-۳-۲- Sensitivity analysis relative to the price of products

By changing the price of the products, the financial indicators will change the NPV and IRR. The results of the sensitivity analysis indicate that when the price of products from associated gas is reduced by more than 1%, then NPV is negative and the IRR will be also lower than the discount rate, and project will have no economic justification.

**Chart ٥-** Changes in NPV relative to changes in the price of NGL-٣٢٠٠ unit product

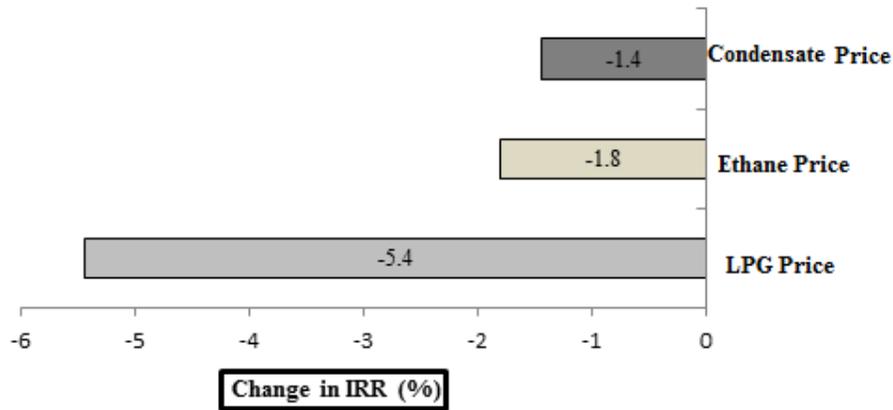


**Chart ٦-** Change in IRR relative to changes in the price of NGL-٣٢٠٠ unit product



In addition, the examination of the degree of influence of the price of NGL-٣٢٠٠ unit product shows that the IRR of this unit is the most dependent on the price changes of the LPG. So that a 1% reduction in the price of LPG, ethane, and gas condensate prices would reduce the IRR by 0.5%, 1.8% and 1.5%, respectively.

**Chart V-** Impact of 10% reduction in product prices on IRR of NGL-3200 units

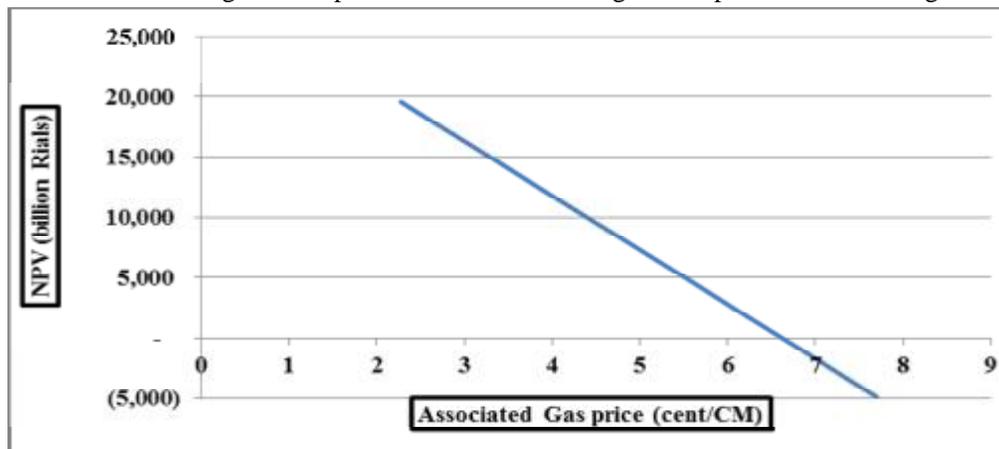


**3-3-3- Sensitivity analysis with respect to associated gas prices**

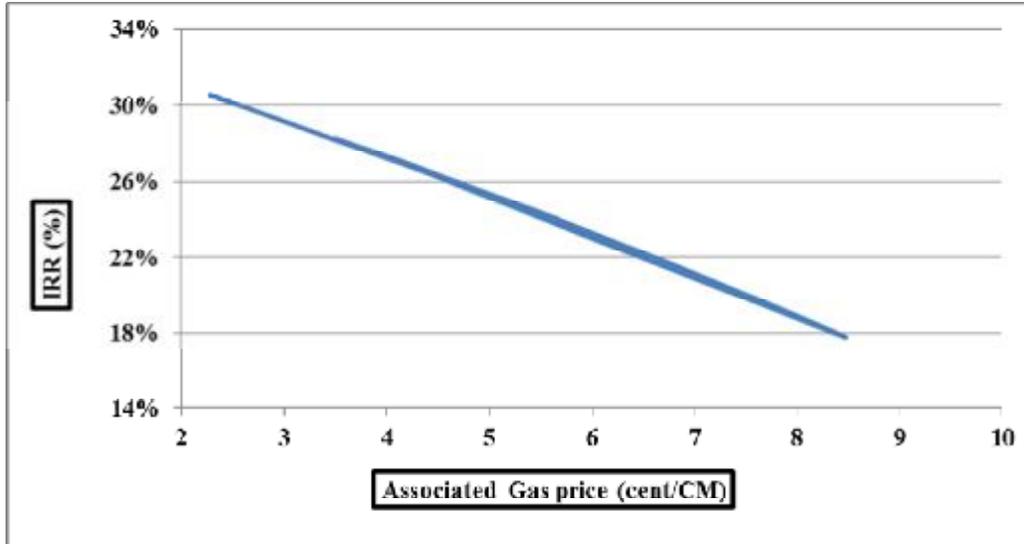
The price of associated gas is one of the factors affecting financial indicators. As shown in the charts below, when the price of associated gas increases from 6,6 cents per cubic meter, then the NPV will be negative and the IRR will fall below the discount rate.

The point to be mentioned here is that the price of associated gas should be determined in such a way that the IRR of project will reach 20% according to the National Oil Company in 2014. The results of the sensitivity analysis show that when the price of associated gas is about 6,6 cents per cubic meter, then the internal rate of return of the project will be 20%.

**Chart A-** Changes in net present value with a change in the price of associated gas



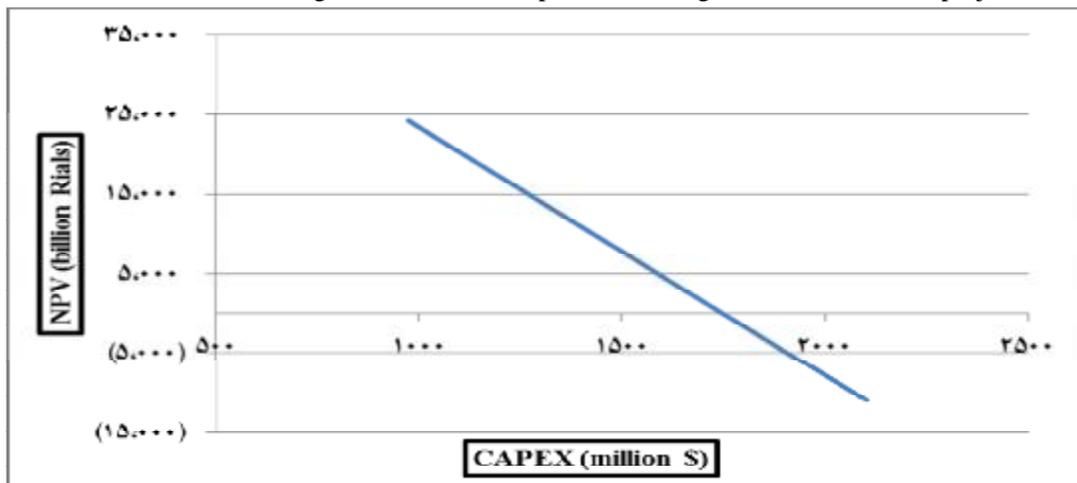
**Chart ٩-** Changes in IRR with changes in associated gas prices



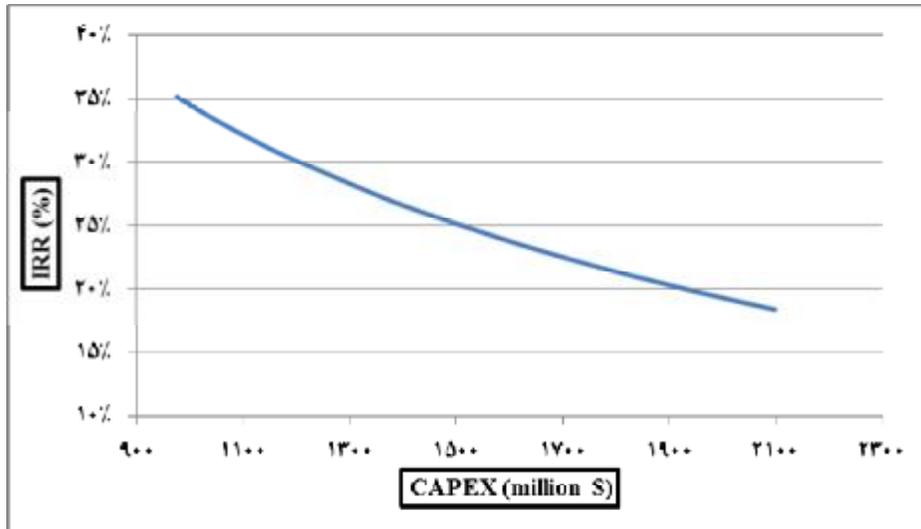
**٣-٣-٤- Sensitivity analysis of capital cost**

As mentioned above, cost of capital is another impressive factor in the NGL-٣٢٠٠ plan, whose changes can affect the financial indicators of the project. The results of the sensitivity analysis of NGL-٣٢٠٠ project indicate that if the capital cost of the project increases to ١٥%, then the net present value of the project will be negative and the IRR of the project will be below the discount rate and the project will have no economic justification.

**Chart ١٠-** NPV changes relative to the capital cost changes of the NGL-٣٢٠٠ project



**Chart 11 - IRR changes to capital cost changes of the NGL-3200 project**



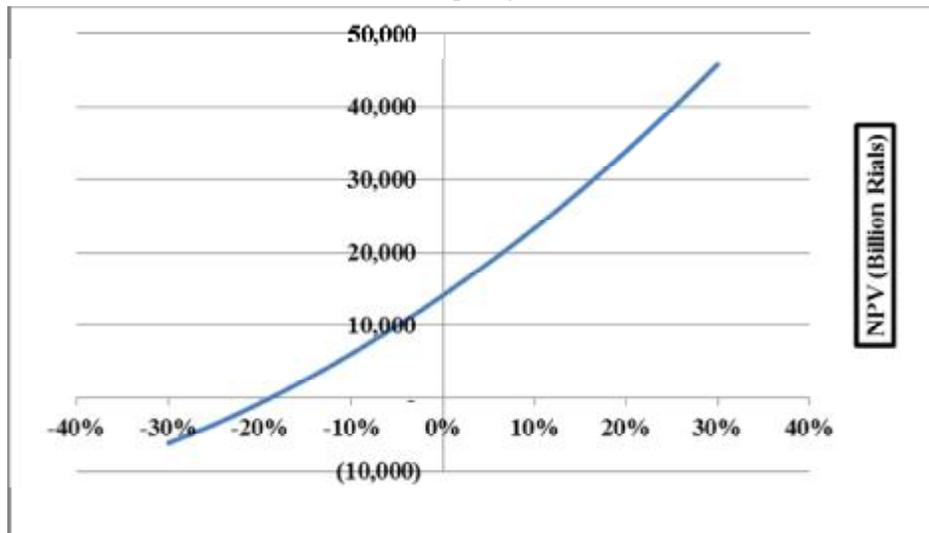
### 3-4- Multi-factor sensitivity analysis

In order to make economic assessment somewhat closer to reality, the sensitivity of the NPV and IRR financial indicators to the change in the combination of some of the important and influential factors mentioned above is analyzed and evaluated in this section. According to the following conditions:

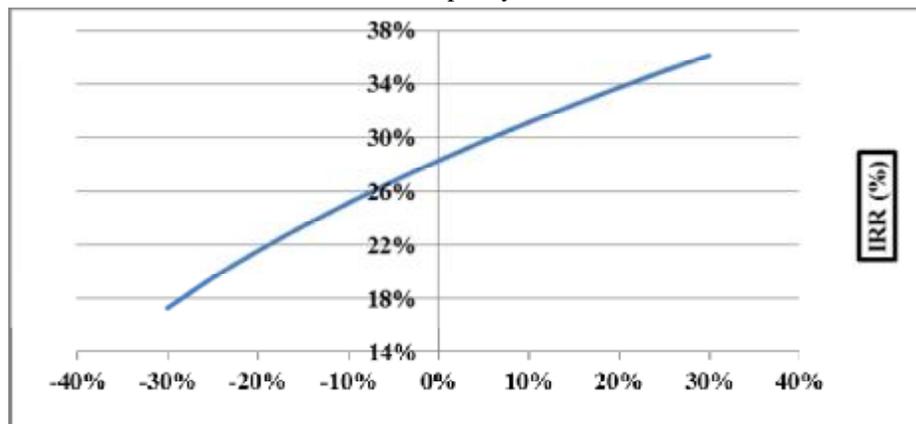
- 1- The possibility of associated gas production from oil fields in the west of Karoun by half the capacity of NGL-3200 units up to 4 years in the future
- 2- Changes in the prices of products from the processing of associated gas due to changes in the price of crude oil
- 3- Changes in the price of associated gas due to the new formula for feed of NGL units

The following charts indicate the reaction of NPV and IRR financial indices to changes in product prices, associated gas prices and nominal capacity changes from NGL-3200 unit. As shown in these charts, when the mentioned factors decrease by more than 20%, then NPV is negative and the IRR will be lower than the discount rate, or in other words, the NGL-3200 project will have no economic justification.

**Chart ۱۲-** Change in NPV relative to changes in product prices, associated gas prices and operating capacity



**Chart ۱۳-** Change in IRR relative to changes in product prices, associated gas prices and operating capacity



#### ۴- Conclusions and policy suggestions

The statistics show that ۴۰٪ of the associated gas produced is flaring in Iran on average. The volume of gases in the burner prior to the imposition of recent oil sanctions (before ۲۰۱۱) was approximately ۳۸ million cubic meters per day and it was ۲۶ million cubic meters per day during the sanctions period, due to a decrease in oil production. The economic and environmental significance from the burning of associated gas has led to a number of different plans for the collection of associated gas in the country are on the agenda. Gas and liquefied petroleum gas plants, or the NGL, are among the most important projects that have been put into operation in recent years to collect associated gas. The study of the physical progress of these projects shows that only Siri NGL unit has

been operated in the course of more than 10 years, and Khark NGL unit has progressed by 57% and the rest of these units (including 6 NGL units) did not make significant progress. Of course, the Ministry of Oil has given these units to nongovernmental sectors in the current situation due to some problems including financial problems. However, some NGL units are of particular importance among the remaining NGL units. The NGL-3200 unit is one of the projects that is of particular importance due to the collection of associated gas from the oil fields of the west of Karoun. It is worth noting that the west Karoun fields are among the fields that the National Iranian Oil Company has been focused on to increase oil production and intends to invest \$ 2 billion in these fields, which will lead to an increase in associated gas production. Given the particular importance of the NGL-3200 unit, timely utilization of this unit by the nongovernmental sector to collect associated gas produced in oil fields of the west of Karoun requires financial and economic justification. Accordingly, the economic justification of the NGL-3200 unit has been investigated in this research. The financial-economic assessment of the NGL unit indicates that:

1- If the feed of NGL-3200 unit is fully supplied, then the NPV of project is positive and the investment costs will return at an Internal Rate of Return of 28,29% over 3,0 years.

2- If the utilization rate of the capacity of NGL-3200 project is less than 48%, then the project will not be economically feasible.

3- Assuming a change in the price of products (including ethane, LPG and gas condensate) and the constancy of other conditions, if the price of products is reduced by more than 14 percent, then the project will not have economic justification.

4- The study of the degree of influencing product prices on NPV and IRR indices shows that LPG price change has the most effect on these indices, so that the decrease of 10% in prices of LPG, ethane and gas condensate decreased by 0,8, 1,8 and 4,9 percent of IRR respectively.

5- Sensitivity analysis of the NGL-3200 project to associated gas price changes shows that if the price of this factor exceeds 6,6 cents per cubic meter, then it does not have an economic justification.

6- If the full feed supply of the NGL-3200 unit is at a cost of 0,1 cents per cubic meter of associated gas, IRR of the project will be 20%.

٧- If the capital costs of the NGL-٢٢٠٠ project grow more than ١٥%, then the project loses its economic justification.

٨- Assuming a change in combination of product prices, associated gas prices and nominal capacity of the NGL-٢٢٠٠ unit, if these factors have decreased more than ٢٠%, then the project does not have an economic justification.

Based on the results presented above, it is suggested that

١- Given that the production of associated gas from the west Karoun fields will be equal to ٥٠% of the nominal capacity of the NGL-٢٢٠٠ project in the next ٤ years, so only one of these units will be put into operation for up to four years.

٢- By halving the nominal capacity of the NGL-٢٢٠٠ unit, the pricing formula for associated gas should be designed in such a way that the price of this factor is not more than ٤,٦٥ cents.

٣- In the construction of the NGL-٢٢٠٠ unit, it should be considered that the increase of more than ١٥% of the capital cost of the project will make the project lose its economic justification.

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