

# A comparison of Electricity Production Costs in far from Production Centers between CHP and Gas Power Plant Sample: Gonabad City

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## ABSTRACT:

In Iran because of the existence of Competitive market for power production, the existence of competitors in the national and international market and the policies of ministry of Power production in producing the market for producing power with the least cost; it is urgent to determine exactly the cost of power production. The first step in this regard would be to compute the cost of power production within the power station, thus it would be necessary to determine the cost of different ways in which power is produced. This would provide managers with the tools for controlling and supervising power costs and plans. In this paper, the cost of power production in the combined cycle power plant for the case Shahid Kaveh power plant of Ghaenat city will be examined. Then the cost of power production in a CHP power plant for the case of CHP power plant in Gonabad belonging to Sanat Yaran Energy Fadak Ghadr has been studied. Eventually, comparing power production costs in combined Cycle Power Plant with CHP power plant, it has been concluded that a CHP power plant is superior to a combined Cycle Power Plant in efficiency, power tolls, power quality and etc.

**KEYWORDS:** The cost of electricity, costs, CHP, Gas power plant.

## 1. INTRODUCTION

As a foundational industry which guarantees the economic growth in each country, electricity has a significant role in shaping the structure of producing for each country's development. This will provide the grounds for the economic, industrial, cultural and social development.

Thus, continuous movement toward economic development and increasing the level of efficiency requires continuous attempts to produce, transfer and distribute energy. Rapid improvements in technology as well as day to day increase of competition between power plant companies in national and international market, makes managers produce high quality products with low costs.

Today, massive scientific and technological developments in extensive and complicated units along

with day to day progression in material quality necessitate the financial computations in various stages of power production. In power industry, since it would be hard to save energy in large amounts and since there are various ways of production, the need to compute the cost of each way in power production is one of the most important needs for production planning.

Thus, by analyzing the cost of power production, managers can make decision in regard with sales price, amount of production, quality, changes in transmission lines, using new production techniques, etc. it would be clear that the efficiency of such decisions relies on accuracy, precision, and efficiency of the calculation of power cost.

The commitment of power industry in order to perform principle number 44 of the constitution in regard with delivering part of the power production activities to the

private section justifies the fact that it is necessary to do more computations on the exact cost of power production. Researches which have directly investigated this issue are as follows:

In reference [1] which has been done by a number of researchers in Fars power section, the cost of each kilowatt of electricity produced based on the type of material and used (natural gas or gasoline) have been determined in table (1).

**Table 1.** The overall cost of one kilowatt of electricity

Costs	Fuel (natural gas)	Fuel (gasoline)
Changing costs	8.8	17.6
Constant costs	5.7	5.7
Total	14.5	23.3

The result of research in reference [2] has been shown in table (2).

**Table 2.** Factors affecting computation of overall power cost

Factors affecting computation of overall power cost	Amount of relativity
Appropriate categorization of costs	51.7%
Determination and separation of costs centers in power industry	85.5%
Determination and separation of costs within operation costs	83.4%
Determination and differentiation in plant operating costs	71.9%

The results from reference [3] indicate that there is not any significant difference in the cost of power production through three methods of gas, steam and combined cycle.

The result from reference [4] shows that there is not solidarity and consistency in the computation system of regional power plant systems in regard with the calculation of non-production costs as well as the lack of consistency between the cost calculation system with the production process in the organization of power plant companies.

The purpose of research in reference [5] has been to calculate the overall cost of power production in Fars

power plant, which eventually resulted in designing a standard cost calculation system. In reference [6], the cost of operation along with the various factors of the study and also finding out that whether it is direct or opposite, has been examined.

## 2. CLASSIFICATION OF THE COSTS:

The overall cost consists of three sections of primary materials, payment and extra load. In the current research, the fuel cost has been considered as the primary material. Other costs such as depreciation costs, cost long term fixing, technical support unit costs, operation costs, and etc. have been considered as the extra costs. Thus, the costs of power production, apart from fuel costs, include other costs totally considered as extra costs.

### 2.1. Fuel cost:

Cost of fuel is one of the most major expenses in any power plant. Since there is a direct relation between fuel consumption on the one hand and the amount of production on the other hand, fuel cost is often considered as the changeable cost. The amount of fuel consumption depends on such conditions as the amount of production, the efficiency of power plant, and temporal value of the fuel.

### 2.2. The cost of salary and payment

### 2.3. The internal expenses of the power plant (water, electricity, fuel, ...)

### 2.4. The expenses of long term detention:

Throughout the years when power plants are operating, they need several series of repairmen. The first category of such repairs is current and day to day repairs. The second group of such repairs includes long term and basic repairs. Such repairs are often performed on periodically occasions when the power plant's operations are stopped.

### 2.5. Unpredictable expenses:

Such expenses as mentioned by ministry of industry, mine and commerce include 5 percent of the above.

## 3. THE OVERALL COST OF POWER PRODUCTION IN SHAHID KAVEH COMBINE CYCLE POWER PLANT IN GHAENAT CITY:

The information in this study have been obtained by interview and questionnaire form financial technicians of the power plant, library research, financial and non-financial research during past years from Shahid Kaveh power plant, regional power company of Khorasan, and the gas power plant management company. Finally, by using the analytical and inductive techniques, the method of spending costs to the overall power cost in gas units and combined cycles were determined.

### 3.1. Introducing Shahid kaveh combined cycle power plant:

Shahid kaveh combined cycle power plant is situated in southern Khorasan County Kilometer 4 of Ghaenat Mashhad road, next to post 400K.V of Ghaenat with a width of 120 hectares. This company has been established by the Company of distribution of electricity of Iran.

The gas unit of combined cycle power plant of Ghaenat includes 4 gas units which has the capacity of 630 megawatt electricity in ISO conditions. By operating the steam section, (2 units) for turning the gas units into combined cycle, the capacity of the power plant will reach to 950 in ISO conditions.

The main fuel in this power plant is natural gas produced by Iran's National Gas Company. In order to use gasoline as the alternative fuel, two metal reservoir with the capacity of 20000 cubic meter were equipped with floor heater, foam fire extinguishing system, and the water spray cooling system for extinguishing possible fires. The power plant contains a 400 KV post with 5,1 switch which contains six output. The output posts are directed to old Ghaenat post (2 lines), Birjand, Tabas, Torbat jam, and Shadmehr[7].

### 3.2. The factors affecting overall power cost in combined cycle power plant of Shahid Kaveh on Ghaenat:

It should be mentioned that at the time when the current study had been done, the financial information of Shahid kaveh power plant of 2013 had not been categorized yet, therefore, the comparison was done for 2012. The influence of each of the elements on the overall cost of power produced was obtained by dividing the cost to the real production, which was 2,227,000 megawatt hour.

#### 3.2.1. The cost of fuel:

Based on the information obtained from the power plant, the role of fuel cost in overall cost for one megawatt electricity in F5 gas units and combined Cycle power plant, are calculated according Table (3). The actual power production of these units is 222700 megawatt hour a year.

**Table 3.** the cost of fuel in the overall cost of the power plant

Explanation	Costs (Rial)
Cost of gas fuel	585,246,000,000
Cost of gasoline fuel	210,386 ,000,000
total	795,632 ,000,000
Amount of fuel in overall cost of per	357,266

megawatt hour electricity	
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As it has been observed, producing electricity through gasoline in the gas method results in an increase in the fuel costs. The reason for this is the fact that the temporal value of gasoline's price is higher than gas.

#### 3.2.2. The cost of salary and payment of the employees:

According to the regulations and instructions, considering rewards, off days, and insurance, each employee is paid as much as 18 month of salary each year that is shown at table(4).

**Table 4.** The salary and the yearly payment of employees of power production-F5 gas units

Cost title	Costs (Rial)
Administration	690,000,000
Security	759,000,000
Office of financial and administrative services	6,831,000,000
Office of chemistry shift	1,656,000,000
total	9,936,000,000
The amount of salary and payment cost in the overall cost of per megawatt hour electricity	4,718

#### 3.2.3. Internal costs of the power plant:

These costs include costs of water, electricity, and the fuel consumed within the building itself, according to table (5).

**Table 5.** Internal costs of the power plant

Explanation	Costs (Rial)
Water, electricity and fuel energy	1,366,200,000
Amount of internal costs in the overall cost of a megawatt hour electricity	613

#### 3.2.4. The cost of long term repair:

In the Shahid Kaveh power plant, the small scale repairs are done by the personnel, but repairs with a larger scale are done by contractors. The cost of repairs due to the time unit is assigned to the case study, The results are summarized in table (6).

**Table 6.** The cost of long term repair in the overall cost of power production-F5 gas units

Explanation	Costs (Rial)
Cost of log term repair	12,000,000,000
The amount of the cost of repair in the overall cost of each megawatt hour of produced electricity	5,270

**3.2.5. Unpredictable costs:**

Table (7) shows unpredictable costs.

**3.2.6. The cost of office work and sales:**

According to the standards of Ministry of Industry, Mine, and Commerce, the cost of office work and sales includes 1 percent of the above items. Table (8) shows cost of office work and sales.

**Table 7.** Unpredictable costs of production

Explanation	Costs (Rial)
fuel	795,632,000,000
salary and payment	9,936,000,000
Water, electricity and fuel energy	1,366,200,000
long term repair	12,000,000,000
Total	818,934,200,000
5 percent of the above items.	40,946,710,000
Amount of Unpredictable costs in the overall cost of a megawatt hour electricity	18,386

**Table 8.** The cost of office work and sales

Explanation	Costs (Rial)
fuel	795,632,000,000
salary and payment	۹,۹۳۶,۰۰۰,۰۰۰
Water, electricity and fuel energy	1,366,200,000
long term repair	12,000,000,000
Unpredictable costs	۴۰,۹۴۶,۷۱۰,۰۰۰
total	859,880,910,000
1 percent of the above items.	859,880,920

Amount of office work and sales costs in the overall cost of a megawatt hour electricity	3,862
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**3.2.7. The cost of depreciation of production installation:**

Since establishing each kilowatt of combined cycle power plant has a cost as much as 500 dollars, considering the current dollar rates, the cost of establishing a 636 megawatt power plant of Ghaen is obtained as follow:

$$636(\text{MW}) \times 1000 (\text{KW}) \times 500 \$ \times 26500 \text{ Rial} = 8,427,000,000,000$$

According to the office of Shahid Kaveh Ghaen power plant dissipation is 18 years old. That is calculated as follows:

$$8427000000000/18=468166666700$$

The following table shows the amortization expense.

**Table 9.** The cost of depreciation cost in the overall cost of electricity in F5 gas units:

Explanation	Costs (Rial)
The cost of depreciation of production installation	468,166,666,700
The amount of depreciation cost in the overall cost of a megawatt hour electricity	210,223

**3.2.8. The cost of technical support units:**

The cost of technical support unit includes the cost of employees, instruments, tool purchase, and other expenses. Since a significant part of such costs are related to the salary, reward, and other employee cost, the best criterion for determining such costs in gas units in combined cycle blocks is by person versus the number of working hour in the unit. Accordingly, the role of each of the production criterions from the total cost of technical support unit will be shown in table (10).

**Table 10.** Amount of the cost of technical support unit in the overall cost of power production- F5 gas units

Explanation	Costs (Rial)
The cost of technical support units	3,000,000,000
The amount of technical support units in the overall cost of a megawatt	1,317

hour electricity	
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### 3.2.9. The cost of operating production installations within the power plant

These costs often include the cost of reward and payment of the employees. These costs are divided into two sections of the cost of operating 4 gas shifts and the costs of operating four stem shift (combined cycle) by the accounting unit. The amount of operation cost in the overall cost of each megawatt electricity produced in gas units and combined cycle units are as table (11):

**Table 11.** the amount of operation cost in the overall cost of power production –F5 gas units

Explanation	Costs (Rial)
Cost of operation of four gas shift	2,000,000,000
Amount of operation cost of installation in overall cost of produced power	878

Finally, the finding from this study in regard with the overall cost of electricity produced in the gas structure of Shahid Kaveh power plant are as indicated in table (12).

**Table 12.** The cost of producing one megawatt electricity on F5 gas units

Explanation	Costs (Rial)
Fuel cost	357,266
Salary and payment	4,461
Internal costs of power plant	613
Cost of long term repair	5,270
Unpredictable costs	18,386
Financial and sales costs	3,861
The cost of depreciation of production installation	210,223
Cost of technical support unit	1,317
Operation cost	878
Cost of one megawatt hour electricity in gas unit	602,275

References: [8], [9], [10], [11], [12].

## 4. THE OVERALL COST OF POWER PRODUCTION IN CHP POWER PLANT OF GONABAD

### 4.1. Introducing CHP power plant of Gonabad

CHP power plant of Gonabad city belongs to Sanat Yaran Energy Fadak Ghadr company, situated in Gonabad industrial park. It includes four internal

combustion generator with a power of 1,56 megawatt with the capacity of producing 546000 megawatt per hour. Each generator is connected to the 20 kilovolt network through a 4/20 kv transformer with a 2000 kilovolt power by a 20 kilovolt Bus.

### 4.2. Factors affecting power production in the CHP power plant in Gonabad City

#### 4.2.1. Fuel cost:

Per MW of power generation fuel engine is 250 cubic meters per hour, considering the price of 800 Rial per cubic meters per hour of natural gas share in the cost of fuel, cost per MW of CHP in the following table (13) was calculated.

**Table 13:** The cost of fuel in the overall cost of the CHP

Explanation	Costs (Rial)
Cost of gas fuel	9,734,400,000
Amount of fuel in overall cost of one megawatt hour electricity	178,285

#### 4.2.2. The cost of salary and payment of the employees

Another advantage of CHP plants is low manpower as a 6-megawatt power plant operated by 4 staff. Table (14) shows the salary and the yearly payment of employees of the CHP.

**Table 14.** The salary and the yearly payment of employees of the CHP

Explanation	Costs (Rial)
Administration	180,000,000
Operator (3 people)	۴۰۵,۰۰۰,۰۰۰
Total	۵۸۵,۰۰۰,۰۰۰
The amount of salary and payment cost in the overall cost of per megawatt hour electricity	10,714

#### 4.2.3. The internal cost of the power plant

This includes the costs of water, electricity, phone and the consumed fuel within the building as it is shown in table (15).

**Table 15.** The internal costs of the power plant:

Explanation	Costs (Rial)
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Water, electricity and fuel energy	17,914,000
Amount of internal costs in the overall cost of a megawatt hour electricity	328

#### 4.2.4. The cost of long term repair

Table (16) indicates the role of long term repair in CHP power plants.

**Table 16.** The role of long term repair in CHP power plants

Explanation	Costs (Rial)
Cost of log term repair	1,060,868,000
The amount of the cost of repair in the overall cost of each megawatt hour of produced electricity	19,429

#### 4.2.5. Unpredictable costs

According to the standards of the Ministry of Industry, Mine, and Commerce, unpredictable costs include 5 percent of the above items, which are shown in table (17).

**Table 17.** Unpredictable costs of production

Explanation	Costs (Rial)
Fuel	9,734,400,000
Salary and payment	ΔΔΔ,000,000
Internal costs of power plan	17,914,000
Cost of long term repair	1,060,868,000
Total	13,398,182,000
5 percent of the above items	569,909,100
The amount of Unpredictable cost in production	10,437

#### 4.2.6. Administrative and sales costs:

According to the standards of the Ministry of Industry, Mine, and Commerce, administrative and sales costs include 5 percent of the above items, which are calculated in table (18).

**Table 18.** Administrative and sales costs

Explanation	Costs (Rial)
Fuel	9,734,400,000
Salary and payment	585,000,000
Internal costs of power plan	17,914,000
Cost of long term repair	1,060,868,000
Unpredictable costs	569,909,100
Total	11,968,091,100

1 percent of the above items	11,968,091
The amount of administrative and sales costs	2,191

#### 4.2.7. The cost of depreciation of production installation

According to the statement by the technical support unit of Sanat Yaran Energy Fadak Ghadr Company, the depreciation of the power plant is 15 years. It is due to the fixed capital requirements, including capital expenditures of 136 876 226 054 Rial (cost of motors, electrical equipment such as transformers, buildings, etc.) and costs of operation.

Thus, the cost of depreciation in this CHP power plant is as table (19).

**Table 19.** Share depreciation costs of CHP

Explanation	Costs (Rial)
Annual depreciation cost of production facilities	9,125,081,736
The amount of depreciation cost in the overall cost of a megawatt hour electricity	167,126

#### 4.2.8. The cost of depreciation before production

This includes 20 percent of the overall cost before production. The costs before production include costs of the plan, counseling, getting permit from the government, personnel training, (2% of the yearly salary), and the cost of launching and experimental production (15 days costs of water, electricity, fuel, material, salary and payment). Therefore, the amount of this will be calculated according to table (20).

**Table 20.** The cost of depreciation before production

Explanation	Costs (Rial)
The cost of depreciation before production	1,136,312,2224
The amount of depreciation cost before production	20,811

Briefly, the overall cost of one megawatt electricity in CHP power plants is shown in table (21).

**Table 21.** Cost of one megawatt electricity in CHP units

Explanation	Costs (Rial)
Fuel	178,285
Salary and payment	10,714
Internal costs of power plant	328
Cost of long term repair	19,429

Unpredictable costs	10,437
Financial and sales costs	2,191
The cost of depreciation of production installation	167,126
The cost of depreciation before production	20,811
Cost of one megawatt hour electricity in CHP units	409,321

References: [9], [10], [13].

## 5. CONCLUSION

According to table (21) and (12), the production of electricity in CHP units (409,321 Rial) is cheaper than in the gas unit (602,275), which will be cheaper even more by efficiency and the sale of steam. Also, considering line losses, post transformer losses, transmission cost, changing voltage level of Posts and maintenance costs and manpower required lines and substations and change of the voltage level in posts, the cost of 1 megawatt electricity from a gas power plant compared with a CHP power plant will be more for a center such Gonabad city, which is far from production center. Also, we can refer to the technical advantage of CHP power plant as follows [14]:

1. Decrease in the need to increase the capacity of network electricity.
2. Quick and easy installation and operation process.
3. Power production with higher quality and the possibility of using the resulting heat simultaneously.
4. High saving of energy consumption.
5. Toll reduction and expanding the capacity of energy transmission lines.
6. Increase in the safety of energy production for consumers.
7. Reduction of environmental pollutants.
8. Creating more jobs.

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