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Ranking of CCHP System Implementation in Tehran in terms of Qualitative and Quantitative Criteria

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Abstract

One of the most important ways to increase energy efficiency is to reduce distribution costs and avoid wasting energy. In this article, combined cooling, heating and power plant at the capacity of 5 MW (target power plant) and 1, 8 and 25 MW (alternative options) were studied. Using the principles of clean development mechanism, assessment before fulfillment and social cost-benefit analysis, techniques such as internal rate of return, payback period, and the present value were used. The results were analyzed from the perspective of qualitative tests such as utility, Hicks-Caldor efficiency and Pareto optimality. The mentioned capacities, were assessed from an economic perspective in three scenarios including the sale of power, the sale of electricity and heat and sale of electricity, heat and environmental revenues. The results confirmed the CCHP financial and economic feasibility (except for 1-megawatt power plant in electricity sales scenario). Also in the case of unlimited resources, the executive priority for establishing power plants in the first two scenarios includes the capacities of 25, 8, 5 and 1 MW respectively. Furthermore, by using the environmental revenues, 1-megawatt power plant performance gains priority over 5 and 8-megawatt power plants. Based on the results and technical, economic and environmental benefits of cogeneration power plants, expanding the system is recommended as an economic strategy to increase the efficiency of the power industry.

Keywords: Ranking, Economic evaluation, present value, rate of return, cleans development mechanism, CCHP.

JEL Classification: D29, R29, R12.

1. Introduction

The use of the central heating system began in the third and fourth centuries BC in the Roman and Greek empires. In 1888, in Hamburg, Germany, the first synchronous power and heat generation system was activated to provide heat to the City Hall (Chitchian, 2004: 106).

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In 1973 and 1979, the world experienced major energy crises, mostly due to oil shocks. Between 1973 and 1983, the price of fuel and electric energy was five times higher. Then all the industries requiring electrical energy carried out studies in the field of savings resulting from the use of a co-generation system. Similarly, governments set new rules to remove barriers to the production of co-production. For example, in 1978, the US government approved the National Energy Law (including fuel consumption law, natural gas policy, and legal policies for power plants) Miri et al., 2004: Preface).

Technological advances in the 1980s-90s made the installation of Co-generations systems in the small centers possible and since the mid-1990s the notion of decentralized generation became commonplace (Breez, Rafieesakhaee, 2007: 85).

2. Method

In Net Presence Value, all cash flows predicted over the lifetime of the project converted to present values and the project surplus or deficit is obtained.

$$NPV = PV_B - PV_C = \sum_{t=0}^{n} \frac{(\mathrm{B_t} - \mathrm{C_t})}{(1+i)^t} \qquad (1)$$

In relation 1, B is the income, C is the cost, i denotes the discount rate, t represents the time and n is the useful life of the project.

Another indicator is the internal rate of return, in which the NPV value for it is zero (Oskunezhad, 2015: 173).

Another indicator is the Payback period, which indicates the time it takes to return the initial investment (Oskunezhad, 2015: 152).

Table 1: Decision making based on evaluation indicators

Row	NPV	IRR	PP	Decision
1	NPV > 0	ROR > MARR	n< MAPP	Accepted
2	NPV < 0	ROR < MARR	n > MAPP	Rejected
3	NPV = 0	ROR = MARR	n = MAPP	Without distinction

Source: Blank; ZaytoonNezhad 2014

In the third case, the investor's specific indicators, such as risk aversion, are discussed.

Among the qualitative criteria of the project evaluation we can mention: Absolute and relative Efficiency test with the aim of reviewing the social surplus of the plan, Pareto optimization (which forms the root of the cost-benefit analysis) with the aim of examining the improvement of the status of a member of the community without the deterioration of others' conditions and the Hicks-Calder model with the aim of examining the ability of the winners of the plan to compensate for the losses suffered (Henderson, Gharabaghian, 2013: 292-290). From other aspects of the economic evaluation of the investment plan is assessment of its environmental impact, which is referred to as Clean Development Mechanism.

3. Data and Analysis

Based on previous studies, Tehran was selected as the power plant site (KasraeeNezhad et al., 2015).

Table 2: General specifications of power plants

Row	Title	Feature			
1	**Project Name**	**Combined cooling, heat and power**			
2	Nominal Capacity (MW)	1	5	8	25
3	Guaranteed purchase rate	900	900	900	900
4	Job creation (people)	15	17	17	20
5	Land (m²)	1000	2000	3500	4000

Source: Ministry of Energy reports

Table 3: Power Plant Costs

Row	Cost Title	Amount (million Rails)			
		1 MW	**5 MW**	**8 MW**	**25 MW**
1	Capital Cost	21777.9	77987.75	97229	194955.5
2	Operation Cost	9321.6	49364	73011.8	26719.1

Source: KasraeeNezhad, 2014

According to the nominal capacity of the plant and the current purchase tariffs, revenues were predicted in three sales scenarios, power sale based on the Ministry purchase price, the heat sales based on the market price and the emission reduction certificate based on the global carbon market price.

3.1. Scenario 1: Selling Power

Table 4: Economic results

Row	Index	Amount			
		1 MW	**5 MW**	**8 MW**	**25 MW**
1	NPV (MR)	-662	36286.71	40608.16	197106.8
2	IRR (%)	8.51	24.05	24.56	36.15
3	PP (Month)	56.3	37.4	36.9	28.7

Source: Research findings

Table 5: Priority of the proposed power plants

Row	Priority	Power plant		
		NPV	IRR	PP
1	First	25 MW	25 MW	25 MW
2	Second	8 MW	8 MW	8 MW
3	Third	5 MW	5 MW	5 MW
4	Fourth	1 MW Rejected		

Source: Research findings

3.2. Scenario 2: Selling Heat & Power

Table 6: Economic results

Row	Index	Amount			
		1 MW	5 MW	8 MW	25 MW
1	NPV (MR)	10883	44005.18	51078	302806.8
2	IRR (%)	25.52	30.47	31.26	44.9
3	PP (Month)	34.5	32.5	31.7	24.2

Source: Research findings

By applying the proceeds from the sale of heat, the implementation of the 1 MW power plant is justified in terms of the current value index. The priority of the power plants in this scenario will be as shown in the following table.

Table 7: Priority of the proposed power plants

Row	Priority	Power plant		
		NPV	IRR	PP
1	First	25 MW	25 MW	25 MW
2	Second	8 MW	8 MW	8 MW
3	Third	5 MW	5 MW	5 MW
4	Fourth	1 MW	1 MW	1 MW

Source: Research findings

If the power plant, in addition to selling Power to the grid, sells recycled heat to the surrounding units, the overall economic indicators will generally improve. Nevertheless, the results show that this improvement is fairly equal in all power plants and the results related to prioritization do not change.

3.3. Scenario 1: Selling Heat, Power & CER

Table 8: Economic results

Row	Index	Amount			
		1 MW	5 MW	8 MW	25 MW
1	NPV (MR)	43205	50536.73	76168.35	449988.35
2	IRR (%)	43.28	34.8	35.4	57.4
3	PP(Month)	25	29.6	29.1	19.6

Source: Research findings

Table 9: The priority of the proposed power plants

Row	Priority	Power plant		
		NPV	IRR	PP
1	First	25 MW	25 MW	25 MW
2	Second	8 MW	1 MW	1 MW
3	Third	5 MW	8 MW	8 MW
4	Fourth	1 MW	5 MW	5 MW

Source: Research findings

With the addition of environmental revenues, the overall economic feasibility of power plants will improve, as the 25 megawatt power plant is in a very good position for implementation. In addition, due to the fact that by increasing capacity of the power plant, the amount of emission is reduced, the relative effect of environmental revenues on a power plant with a smaller scale is higher. The increase in the IRR and the PP in the 1 MW power plant changed executive priorities from the perspective of these two indicators.

4. Conclusion

The most important factors in determining the capacity of a power plant are the demand, infrastructure and capacity of the region. In this paper, due to the small scale of the studied power plants, a basic hypothesis was considered that there is a demand and ability to absorb Power produced by the system.

Based on the results obtained, the construction and implementation of the CCHP power plant is feasible for the target power plant and alternatives other than the 1 MW power plant. In all the examined cases, the 25 MW power plant received the first executive priority from the perspective of all three indicators. Also, besides the environmental performance based on which the 1 MW power plant gained the second priority in terms of the IRR & PP, in other cases, the 8 MW and 5 MW power plants were assigned to the second and third priorities, respectively.

A review of the quality criteria of a power plant assessment also confirms the feasibility of developing a co-generation system. From the perspective of Absolute Efficiency Test, increasing social welfare and service to the community justify the implementation of the power plant. Relative Efficiency test points to the priority of the implementation of 25 MW based on quantitative indicators of the economic evaluation.

From the Pareto's optimal approach, reducing cost and pollution, due to the combination of two systems of electricity generation and heat, will bring society closer to optimal conditions.

From the perspective of the Hicks-Calder's pattern, the spread of distributed generation, by strengthening the infrastructures and employment in remote areas, will have a positive effect on population distribution and income in the country. These positive effects can be calculated for community groups.

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Relying on the economic results achieved and technical and environmental benefits of CCHP, it can be argued that the expansion of the simultaneous production system will lead to the improvement of the power industry from economic and technological perspectives.

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