Figure 1: The NPV for the Saydoun Chain of Dams (Market value)

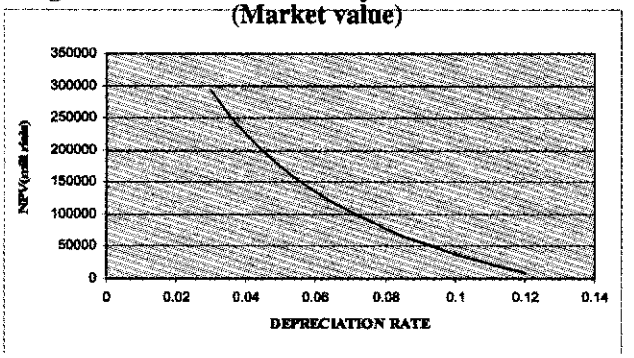
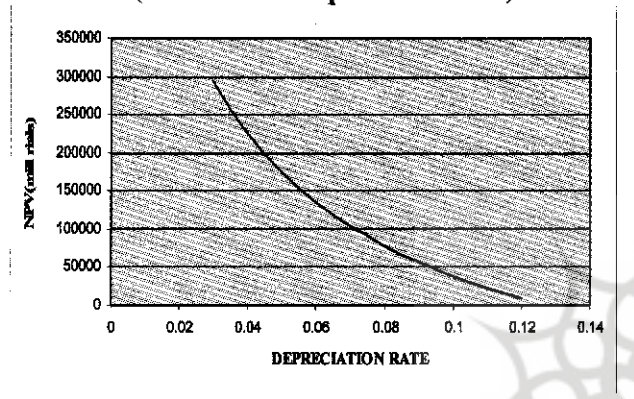


Figure 2: The NPV for the Saydoun Chain of Dams (Thermal Power plant substitute)



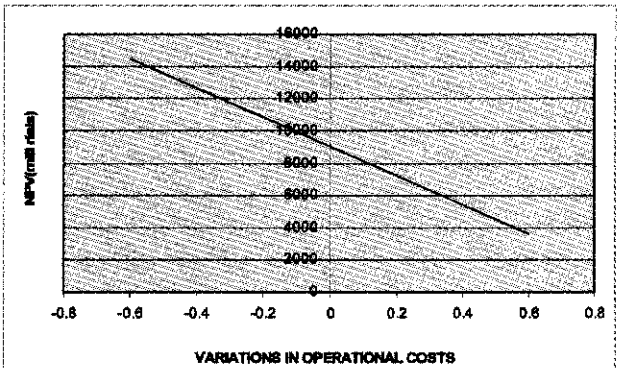
tional lifespan of the equipment 25 years. (The diesel component was determined to be 15 years though) The estimated costs for rehabilitating the various components after 25 years was calculated at being 100% of the original investment costs of the original components.

The Sensitivity Analysis

The sensitivity analysis for the project was carried out on various indexes such as costs, income, the minimum absorbed return rate and the increased power cost rates. The results are incorporated in the figure below. (The depreciation rate is set as being 8%)

The figure 3 shows that the project in comparision to the minimum absorbed rate of return (MARR) is very sensitive so that at low depreciation rates, a 10% change in the depreciation rate will bring about a 60% change in the net per value rate (NPV) and this shows that with an increase in the government's expectations of these projects, the economic indices such as NPV and B/C will decrease drastically. A sensitivity analysis for the operational costs was also independently carried out. The obtained results and following figure show that the project has the minimum sensitivity to changes

Figure 3: The Sensitivity Analysis for Operational Costs.



in operational costs inassuch that changes on a ±20% scale in operational costs, cause a change in the NPV rate on a scale of 25000 to 20,000 which is equivalent to 5000 million rials. In comparision to the changes in the NPV rate for the other indexes, this change shows a significant decrease. This in itself is a unique financial aspect of the Saydoun project and similar projects. This can be better illustrated by calculating the DPP factor.

The Calculating of the Factor (DPP)

In a cross section of the annual pure cash flow (in which t = 0, 1, ..., 8) the DPP factor equals the smallest positive numerical valve i.e n:

$$\sum_{t=0}^{n} A_{t,x} \geq 0$$

The DPP factor for the Saydoun HEPP Project was calculated with a return rate of 23%. The results are shown in figure 1 below. In this figure the total costs include current costs and the primary investment return rate which are influenced by the interest rate, and the column related to the profit earned includes the amount of income accrued from power sales based on the Energy Sales Market's prices. This figure portrays the fact that should we increase the return rate profit to its maximum level within a 10 year duration, we will be able to repay the loan in 7 years. There will also be no negative cash flow at the beginning of the 7th year. If the "Public investment" equals 23%, and if the IRR evaluation of the project shows the minimum economic return rate, with a profit rate of 23%, in a short period and suitable conditions, the primary investment rate of return will be easily reimbursed, thus showing the high financial viability of this specific project and other similar projects.

nomic evaluation of The Saydoun project which is a small HEPP development project using the aforementioned rates, the incorporating of the costs for the most optimal Thermal power plant alternative in the calculating of the earned interest rate in order to compare both power plants. The using of a Thermal Power plant alternative as a substitute for a hydroelectric power plant is the most simple and common method used in the calculating of benefits incurred, as proposed by The Federal Energy Regulations Committee (FERC) of the United States. This method has been widely used for the suitable evaluation of various HEPPs in the United States, and in Iran has been so used as to take the conditions of produced Energy into consideration and to approximately evaluate Energy costs according to economic and national standards.

The Utilizing Of The Power Sales Market Rates (Guaranteed Rates)

The Using of the Power Sales Market rates as the basis of calculating the obtained benefits is based upon the rates quoted by the Governmental Management Organization. According to the study carried out by Jiandony, et al. for the implementation of a small HEPP project, it was observed that due to the smallness of scale, it is possible to delimit and simplify the amount of data required. By incorporating the following it is possible to shorten the period of study, designing and project implementation:

* The operating of all the Turbine - Generator Series simultaneously

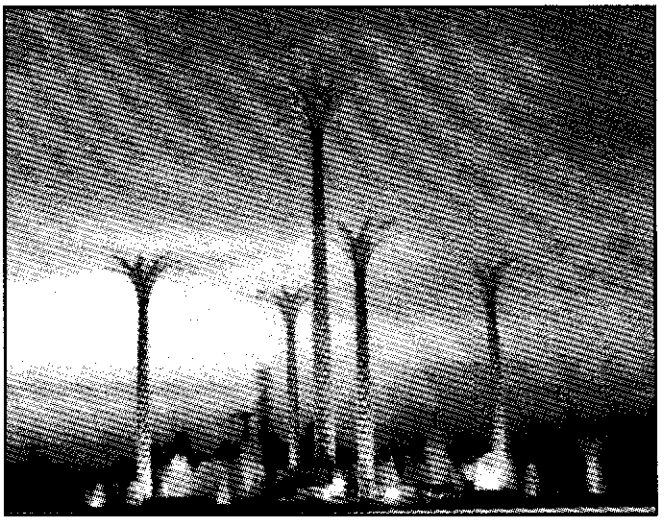
(similar to SHP projects)

* The determining of a practical rate for the operations, maintenance and installation / disassembling costs

* The utilizing of a general economic index for the accrued costs, (such as $/KW for engineering costs $/KWh for energy costs) in order to estimate the costs of energy transmission without breaking down the aforementioned costs (The above rates have been currently estimated as being $ 300 USD/KW for installed capacity and $ 0.375 USD/KWh)

* The simplifying of the cash flow balance by simulating costs - on condition that no data exists. (This can also be done by using import costs)

* In this article the various methods of evaluation include the present value rate, the benefit over cost ratio, and the internal rate of return and the following formulas have been utilized in order to simulate the aforementioned:



$$(1)\quad NPV = \sum_{i=0}^{n} \frac{B_i - C_i}{(1+i)^n}$$

$$(2)\quad {}^{B}\!/_{C} = \frac{\sum_{i=0}^{n} B_i/(1+i)^n}{\sum_{i=0}^{n} C_i/(1+i)^n}$$

In these formulas Bi refers to the annual income, Ci refers to the annual equivalent income, n refers to the economic duration of the project and i refers to the depreciation rate By considering fig. 1 as zero and using a repeating module suitable for computer analysis, the internal rate of return (IRR) can also be calculated. The Primary investment rates for small hydroelectric power plants includes Construction costs such as diversion structures, associated hydraulic structures, waterways, hydropower plant and auxiliary structures, regulating dam, and access roads and the costs for electro - mechanical equipment.

The project under study is the Saydoun system of chain dams with an installed capacity of 21 MW, a designed flow of 8m3/s and a head of 117 meters. This hydropower plant is to be installed on the Saydoun River in the Khuzistan province. The following figures show the final calculations for the project:

Considerations

The period of construction was determined as being 3 years, the rate of interest during construction was defined as being 8%, The rate of increase for power costs and maintenance/ operations costs was considered to be 3%. The operational lifespan of the various structures was estimated to be 50 years and the opera-

Articles

Economic Feasability of Constructing Small Hydropower Schemes in the Khuzistan Region The Saydoun powerplant chain: A Specific Study

By:Turan Nikoo, Lamieh Torfi, Mehri AliMohamadi, Vahid Rezaei

Abstract :

One of the most common renewable energy resources existant, is the energy obtained from small hydroelectric power plants. Due to the negative effects of fossil fuels on the environment and their limited resource, small hydro electric power plants are finding more and more advocates in recent years. An economical study of these kinds of power plants show that due to the low costs of construction during the first years of operation, a positive cash flow incurs which shows its economic viability. In this article the Saydoun power plant chain (consisting of three hydro power plants i.e Saydoun 1, Saydoun 2 and Saydoun 3) which all together have a capacity of about 21MW and which are located on the Saydoun tributary of the Karun river in the Khuzistan Province have been taken into account. In the consideration of the economical benefits, three methods of evaluation have been used.

a)The using of international energy tariffs.

b)The using of alternative Thermal power plants.

c)The using of local power tariffs.

These in themselves show that in the alternative thermal power plant option, although there is a falling off of the benefit - costs ratio over a period of time and thus a decrease in the cash flow, the sensitivity of the project has a decrease of 5% relative to the depreciation value. It is with due consideration of the aforementioned that the benefit over cost ratio with a depreciation value of 8%, has been calculated at 1.2 which shows the project has high economic and industrial benefits.

Introduction

In the evaluation of General projects, like all other types of economic studies, it is essential that each option be analyzed from a suitable point of view. If this does not take place accordingly, then in the description of the option some major points might remain undefined; thus the general rule is to assume a point of view that will take each and every aspect of the project into account. In Iran, in the evaluation of small hydropower plants - with an inherent potential of over 4200 MW - a review of the benefits are considered to be an important element in the determining of the type of hydropower plant to be built. Basically the standard means of estimating the amount of accrued interest is the consumer's capability of payment in a competitive power sales market. Various studies have shown that in Hydroelectric Power plants (HEPPs) there are various techniques for the estimating of the amount of interest return rate. The most important being:

A. The Actual costs or the costs of a simulated market

B. The costs of the most optimal thermal power plant alternative

C. The determined costs as per The Governmental Management Organization rate

Both (A) and (B) are based on the consumer's capability of payment whereas in (C) in addition to the aforementioned, public benefits might also be taken into account. The Actual costs or the costs of a simulated market can only be determined within the framework of a competitive power sales market and it is therefore seldom used, (due to the fact that the costs of the most probable option imposes limits upon the amount of earned interest.) In small hydroelectric power plants special considerations exist for the economic analysis and methods of evaluation used. In Iran the benefits of small hydroelectric power plants arise from the sales of power with a guaranteed rate according to governmental decree.

In this paper we will be focusing on both the eco-

cash flow, which can be very interesting. We have long experience in working in gas projects, so we would very much like to work also in gas projects in Iran. But a gas project in a buy back scheme is very complicated because the gas chain consists of many elements and you need to be aligned all through the chain and you need to have the same incentives. So in a sense, we come back to the problems of the buy back scheme.

What future plans do you have for investments in Iran? Is there any particular field you are interested in or have under negotiation?

There are three fields in southern Iran where we've been studying increased oil recovery. This has been a significant study, which we have conducted together with NIOC, and we have spent quite significant amounts of money to find out how to get more oil out of those reservoirs. We operate in fields where we have recovery factors of 60%, which is very high, and we use different techniques to achieve that. We have looked together with NIOC for ways of enhancing the recovery of these existing fields. We also like to engage ourselves in further work in this regard and make greater investments in that. So, beyond South Pars 6, 7 & 8, that is our primary focus.

How is your work coming along in South Pars 6, 7 & 8?

The South Pars 6, 7 & 8 Project consists of three platforms, and has three pipelines that extent from the platform to the shore. We have already put in place three jackets, so the stretches are out there, and are now in the process of putting in the pipelines. We are now putting in the second pipeline. The topsides are now being constructed and are about 50% complete. The target for the project is that it should be onstream by August 2006.

How do you think that the controversial Horton case has affected Statoil's relationship with Iran?

My feeling is that the case has had a negative impact on our relationships here in Iran. I can, in a sense, understand that it will have a negative impact and a lot of negative publicity was of course created. No proof was ever found of any illegal action or any corrupt activities, but of course there were a lot of newspaper speculations and it created an impression that was in no way founded in this specific case. So that has, of course, not been good for our relationship.

Can you tell us what your view is of Iran's energy sector in the recent years and how it has been functioning under Iran's Petroleum Minster, Bijan Zanganeh?

The history of the Iranian energy sector is a very proud history, with lots of important achievements through the years. Yesterday, we had the privilege of going to the Ahvaz area, where we saw all the destruction that had been caused in the war with Iraq, and saw the way that the facilities there had been rebuilt by Iranian companies without any foreign assistance, which I think is a very impressive performance. We have not been engaged in Iran for a very long period of time; however, in this period of time we have enjoyed, I think, a positive relationship with the authorities, who have a straightforward approach. I also think that during the tenure of Minister Zanganeh the sector has been opened; but as I said in our discussion about the buy back agreements, I think that there are still many things that can be done to improve the buy back system.

Is there anything else you would like to add to ensure further cooperation?

Only to say that, as a foreign company we would very much like to work in Iran, but we can only do this to the extent of the role defined by the authorities, through the terms they offer. They decide on the role that we can have, but fundamentally we are interested in cooperating with Iran.

How are Iran and Statoil cooperating in the oil and gas sector?

At the moment, our cooperation is primarily focused on the South Pars Phases 6, 7 & 8 projects. In addition to that we have undertaken studies with NIOC on the Zagross Enhanced Oil Recovery Project. But our main focus is the South Pars Gas Field.

What difficulties do you see Iran having for attracting investments into these projects from foreign investors such as yourself?

The role of the foreign investor has to be defined by the local authorities, and how this is done is, of course, entirely up to Iranian authorities, who must determine to what extent they want to attract foreign investments. I think the problem we are facing as a foreign investor, and that other foreign investors may also be facing, is the fact that, at the moment, the role of the international oil companies in a project like South Pars is primarily defined to be that of a contractor, which means that the only thing that we are supposed to do is to built the project with the specified share of local content and deliver it at a certain date and we are paid back through the project's revenues. We are not exposed to the market, we do not have any possibility of improving the economics for ourselves, like increasing the efficiency of the projects or by increasing the volumes, and we have no upside in terms of long term value creation through reservoir management. My feeling is that we are invited in, but we are only allowed to use part of our expertise. I think that is the problem facing us, and it is, in my opinion, a weakness of the system.

What legal steps would you propose to reform the system to allow foreign investors to work better with the Iranian side?

I don't know exactly what the legal measures would be, but the principles would be that we as foreign investors are treated as a full participant and not only working in a specific role, which means that we could be an investor in a project in line with, for instance, NIOC, so we could invest together with them, we could take the same risks and get the same upsides and we would work better because we would have the same interests. In this way I think it would be a lot easier to work with the Iranian side.

How would you assess the buy back scheme that is currently being used in many projects in Iran?

I do not think it is an appropriate scheme for the long term, I think it is a scheme which confines us to a very small role where we are not able to use our skills to the full; so I do not think that the present buy back regime is an attractive regime for the future, some things have to be done to make it more attractive.

Is there a different scheme that is already being used in other places that you would suggest in this regard?

If you look at, for instance, the profit sharing agreements they have in Algeria, they are more attractive than the buy back scheme, which has been introduced in Iran. I think it is not only a question of whether it is attractive to us or not, that is not the most important thing, I think the most important thing, is for Iran to decide what is the best for Iran. I cannot understand that the best for Iran would not be that they get the best of us, and I think they get more of us in a PSA than they get in a buy back scheme. Of course it is an Iranian decision, but my view is that they would be getting more of us in a PSA Algerian-style than they would get in a buy back Iranian-style.

Which projects do you find more attractive, oil or gas projects?

I think we would be equally interested in gas and oil projects. Gas projects are different from oil projects in the sense that they are more complicated but very often they have a much longer time horizon and therefore they give you a long-term