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Case Study for Solar-Powered Large-Scale Pumping Irrigation Project; Baskil Coastal Villages Irrigation Project

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Abstract— The idea of solar energy to be used for pumping in agricultural projects is widespread in all world geography. Rapid developments in the growth level of countries and the agriculture-based industry facilitate the use of solar energy in pumping systems. Because solar panels require the sun to produce energy. When agricultural irrigation is needed, there is plenty of sunshine in the summer, especially in the months. In these months, while growing the plants with solar energy, it will also provide electricity for pumping to meet the need for irrigation to agricultural lands in higher jeans.

Elazig-Baskil region has the land of the world's finest and preferred apricot fruit, which is very rich in sugar and other minerals. However, the biggest obstacle to the development of apricot cultivation in the region is water distress. If this fertile land can be reached with water, it would be able to start a professional apricot farming area of 5000 hectares. In this study, a case study was conducted for the solar-powered pumping irrigation project which we developed to irrigate the relevant region. A preliminary feasibility study was conducted with the cost studies and economic analysis of the two-skirt project, which was investigated for the watering possibilities of this land of 8000 hectares.

Index Terms— Irrigation, pumping, rantability, solar energy.

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1 INTRODUCTION

Solar energy is the most abundant energy source in the world. Solar energy is also an environmentally conscious form of energy which can be a solution to today's energy crisis. Solar panels (a number of photovoltaic cells) are widely used to operate street lamps nowadays, run water heaters and accommodate domestic loads. The cost of solar panels is continuously decreasing, which encourages its use in various sectors. One of the applications of this technology is its use in irrigation systems for agriculture. Solar-powered irrigation system, the need for energy can be a viable alternative to farmers in today's conditions.

Our country is experiencing a rapid social and economic development and transformation. In the developing process, the healthy growth of the economies of the countries develops in proportion to sustainable and modern agriculture. The main goal of sustainable agriculture; ensuring food safety of the world's population by improving and securing the living conditions of rural people. In the realization of this goal, aqueous agriculture in particular developing countries plays a crucial role.

Irrigation; It is a fundamental and indispensable factor in increasing and securing agricultural production in arid and semi-arid regions that aim to increase rural prosperity and prioritize the human dimension. However, the performances of irrigation systems in developing countries and especially in our country are seen as expected. Water shortages and organization problems are the most important factors affecting irrigation system performance negatively. In this context, it should be noted that the benefits of projects prepared for making reliable and economical agriculture are at least the maximum and adverse effects of the environment.

In addition, today, the rapidly growing population has increased rapidly in consumption. The aim of this project is to make some of the land that is suitable for aqueous agriculture which is not fully benefited in our country and to be implemented as a production system. The irrigation project will undertake a second task, such as providing jobs and employment in the region.

Elazig-Baskil region has the land of the highest quality and preferred apricot fruit of the world in terms of sugar ratio and other rich minerals. However, the biggest obstacle to the development of apricot cultivation in the region is the water shortage. If this fertile land can be combined with water, 5000 hectares of professional apricot farming can begin. In this study, the opportunities for irrigation of an area available for apricot farming 5000 hectares were investigated, and this irrigation could be performed by pumping from the Karakaya Dam Lake, which is adjacent to the plots. In order to transport water from the dam lake to the agricultural land in the higher jeans, a pre-sighted case study of the use of solar energy was made. The cost studies and economic analysis of the developed project demonstrated the benefits of a preliminary feasibility.

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2 Photovoltaic Pumping Technology

Due to the increasing population and climatic factors, water resources tend to depleting in many parts of the world. In this context, the need for pumping water from wells, reservoirs and rivers is increasing. The demand for a pump system is defined by two basic components as the average height needed to be upgraded and the daily flow needed.

Irrigation with photovoltaic systems is specifically designed to take water and irrigation in areas where mains power is insufficient or expensive. The advantages are practically low maintenance, long life, no fuel requirement, contaminated and finally easy to install. The disadvantages are the initial high initial investment costs and the variability of solar panels according to current weather conditions. However, this problem can be solved by storing water in the regulation pools.

Photovoltaic pumping systems consist of three main components: photovoltaic panels, motors and pumps. Depending on the design, they can use storage batteries and a charge regulator. Batteries offer the advantage of irrigation when the intensity of solar radiation is low (on cloudy days or at dawn or dusk). However, there are no large capacity batteries for large-scale irrigation systems. Water storage method is widely used.

3 Project work

3.1 Location of the Project

The project site is located within the borders of the Eastern Anatolia region of our country and in Elazığ province. Baskil Coastal Villages Irrigation project; The coastal villages between Bilaluşağı village and Kömürhan Bridge are required to be carried out on the coastline, which has a very fertile land of approximately 50 km long. The project area, 50 km west of Elazig Province, is located in the Pafta of Malatya – K40-C3, K41-D4, MalatyaL41-A1, L41-A2, L41-B1.

The transportation of the project area is provided in a 5 km way after the separation of Kuşsarayi, located 48 km on the Elazig-Malatya highway. It is also possible to reach the project area from the village roads of Baskil region. Location map of the Project field is presented in Figure 1.

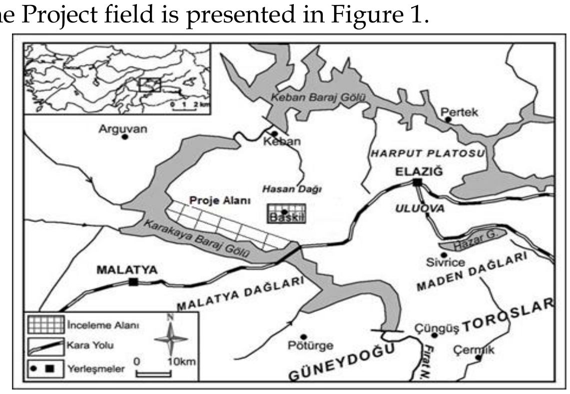


Fig. 1. Project location map

3.2 Rainfall

The average annual rainfall is 497.4 mm. The most precipitation falls in April, the minimum rainfall is seen in August. Average rainfall values ranging from 1976 to months are given in Figure 2.

3.3 Temperature

The average annual temperature is 12.9 °C. The highest temperature in the region is 42.2 °C in July and the lowest temperature is-19.4 °C in February. Average temperature values ranging from 1976 to months are given in Figure 2 [1].

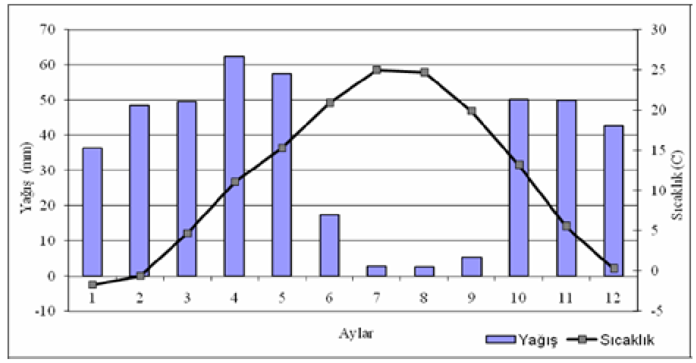


Fig. 2. Baskil meteorological station for many years precipitation-temperature relationship

Especially, because the low temperatures seen in spring are higher than Elazig, agricultural products produce a positive result especially in terms of loss. The value of the temperature in terms of agriculture is advantageous except when the timeless and extreme minimum and maximum temperatures are seen. Since the average high temperatures in July and August are above 32 °C, our Baskil district is one of the hottest regions after the southern East Anatolia and Mediterranean shores in the summer season.

3.4 Evaporation

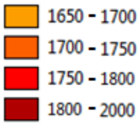
The annual and mean evaporation values in the basin where the project area is located are given in the table below [2].

TABLE 1
Annual evaporation values of Elazig province

	J	F	M	A	M	J	J	A	S	O	N	D
Avg.				117	203.6	345.7	351.4	350.5	256.2	110.2		
Log.	0	0	0	7.0	9.5	13.0	14.5	13.5	13.0	7.0	0	0

3.5 Project Area Solar Energy Potential

The fundamental factor affecting efficiency in the conversion of solar energy into both heat energy and electrical energy is the intensity and geographical structure of solar radiation. It is the boundary zone of the Eastern Anatolia region and the Central Anatolia region of Elazig Province and is located on the highest generation of solar radiation as seen in the Atlas of solar energy in Turkey. As can be seen from Figure 3, there is an electrical power generation above the annual 1650 kWh/KWP value in regions within the Elazig province.



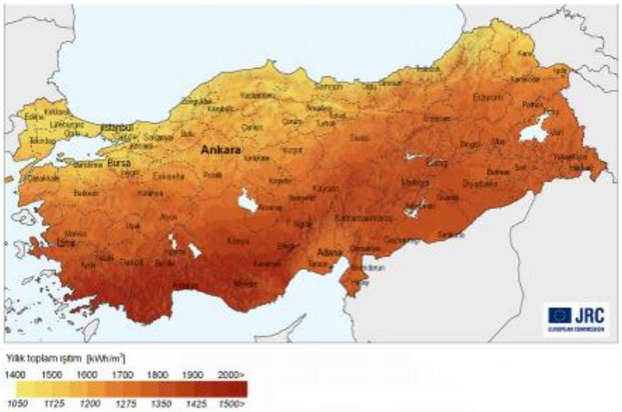


Fig. 3. Normalized photovoltaic energy production capacity [3]

3.6 Earthquake Situation

Our country is located on the Alpine-Himalayan mountain belt, one of the most important active generations of the world. In our country, there are two important fracture lines which produce earthquakes at various times. These are the North Anatolian fait (KAF) and the Eastern Anatolian fait (DAF). In our country, which is located under K-G jamming tensions between the African-Arab continent and the North European-Asian (Eurasia) continent, the energy accumulated along the KAF and DAF lines is caused by time, ejaculation and earthquake events.

In the field of examination and in the area where the facilities are to be established, there are tectonic events. It is known that earthquakes have been seen frequently in the region since the ancient times. 93% of the population on the active earthquake zone and approximately 98% of the earthquake risk in our country, worked on the field Council of Ministers, 18 April 1996 date and 96/8109 according to the decision of the Turkish earthquake zones entered into force in accordance with the map 2. Danger zone [4].

3.7 Economy

Especially after the Karakaya Dam, the region's economically efficient and agricultural income-generating lands were submerged, so a large proportion of the population had migrated to the surrounding provincial centres and major cities, which are more economically and socially developed.

The economy of coastal villages is more based on agriculture. Currently, 80% of the peasant's income is provided from apricot. More contemporary and conscious agricultural methods have been applied to the foreign countries and the quality standards to be exported are reached [5].

Standard quality has been achieved in the production of vegetables and fruits. Especially pear, apple, cherry, quince, pomegranate, peach, plum quality and taste is very high level.

4 Determination of Water Requirement

Irrigation project is projected to open a field of 5000 ha. In order to determine the need for water to be used for aqueous agriculture in a field of this magnitude, the following acceptance and study were carried out. Results are presented in Table 2 and Table 3.

TABLE 2
USE OF THE VEHICLE

LAND UTİLİZATİON RATE	K	GROWTH RANGE
½ APRİCOT	0.50	APRİL 15-SEPTEMBER 15
¼ GRAİN	0.75	15 APRİL-1 JUNE
¼ VEGETABLES	0.65	15 APRİL-1 OCTOBER

TABLE 3
WATER REQUIREMENT

MONTHS	APRİL	MAY	JUNE	JULY	AUGUST	SEPTEMBER
P	8.85	9.82	9.82	9.99	9.47	8.38
h_y(mm)	40	20	10	-	-	-
T(°C)	20°	25°	30°	35°	40°	30°
f= $\frac{1.8t+32}{100}P$	6.01	7.56	8.44	9.49	9.77	7.20
$U_{tahıl}$=25.4.k.f u'=U_t-h_y u'.yüzde	114.49 74.49 9.30	144 124 31	-	-	-	-
$U_{kayısı}$=25.4.k.f u'=U_t-h_y u'.yüzde	-	96.0 74.4 9 19	107.0 97.0 48.5	120.5 120.5 60.25	124.0 124.0 62.0	91.44 91.44 45.72
sebze U_s=25.4.k.f u_s.yüzde	- 99.0 12.5	124. 81 31.2 5	139.34 35.0	156.67 39.0	161.0 40.0	118.87 30.0
∑ u'	21.8	81.2 5	83.5	99.25	102	75.72

Irrigation module 50% according to irrigation efficiency;

$$q = \frac{Umax\ 10^4}{30.86400} = \frac{102.10^4}{30.86400.0,5} = 0,80 \text{ lt/sa/ha}$$

$$Q=5000ha.0,80.1,15 \quad Q=4,60m^3/s$$

4.1 Monthly Water Needs

$$q_{nisan} = \frac{U_{nisan}\ 10^4}{30.86400\eta} = \frac{21.8.10^4}{30.86400.0,5} = 0,17 \text{ lt/sa/ha}$$

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$Qis= 8000.ha.0,17.1,15= 1,56 m^3/s$

$V_{nisan}= 1,56.86400.15= 2,02.10^6\ m^3$

$$q_{mayıs} = \frac{81.25.10^4}{30.86400.0,5} = 0,62\ lt/sa/ha$$

$Qis= 8000ha.0,62.1,15= 5,7 m^3/s$

$V_{mayıs}= 5,7.86400.30= 15,26.10^6\ m^3$

$$Q_{haziran} = \frac{83.5.10^4}{30.86400.0,5} = 0,64\ lt/sa/ha$$

$Qis= 8000ha.0,64.1,15= 5,9 m^3/s$

$V_{haziran}= 5,9.86400.30= 15,30.10^6\ m^3$

$$Q_{temmuz} = \frac{99.25.10^4}{30.86400.0,5} = 0,76\ lt/sa/ha$$

$Qis= 8000ha.0,76.1,15= 7 m^3/s$

$V_{temmuz}= 7.86400.30= 18,90.10^6\ m^3$

$$Q_{ağustos} = \frac{102.10^4}{30.86400.0,5} = 0,80\ lt/sa/ha$$

$Qis= 8000ha.0,80.1,15= 7,36 m^3/s$

$V_{ağustos}= 7,36.86400.30= 19,71.10^6\ m^3$

$$Q_{eylül} = \frac{75,72.10^4}{30.86400.0,5} = 0,58\ lt/sa/ha$$

$Qis= 8000ha.0,58.1,15= 5,37 m^3/s$

$V_{eylül}= 5,37.86400.30= 13,93.10^6\ m^3$

Total irrigation water requirement $\sum V= 85, 15.\ 10^6\ m^3$
If the area is distributed with the rate of water need; 5000 ha $V= 53.22\ 106\ m^3$

5 Offered Facilities

It is composed of approximately 5000 hectares of land, consisting of Tabanbükü, Imisash, Çiğdemlik, Hacimehmetli, Konacık and seafaring villages starting from the vicinity of Bilaluşağı and Kale Mahallesi. Main structure of irrigation structure: Pump station, regulation pool, penstock pipe, mechanical and electrical installations, power transmission line, 45 km main channel and 100 km in the top-side of the channel line consists of 150 km. By means of the water retrieval structure and pump promotion line to be held in the Castle district, the water will be taken from the Karakaya Dam Lake and the regulation pool is 840 m high. From here, the 45 km-long main channel will have a water farming of 5000 ha land. Irrigation Duct 0100 lt/sec/ha and main Channel 5 m^3/s capacity is planned. Water retrieval structure, pumping line and satellite image of the main channel route are presented in Figure 4.

Fig. 4. Stage 1 project components

5.1 Reservoir Operation Policy and Optimization

The waterproofing structure of Baskil coastal villages Irrigation project is fed by Karakaya Dam Lake and has a reservoir which can be taken continuously. Water obtained through the construction of the current pumping station from here to the regulation pool with penstocks will be promoted and transferred from here to secondary and tertiary channels with the transmission channel. The water-taking structure will undergo a total current of 53.22 hm^3 years. During the optimization work, the calculation was made according to the largest need flow rate and the design flow was calculated as 4.6 m^3/s. However, a third of this flow rate will be pumped as the rotation will be made for irrigation. As a result, the water pick-up structure to be established on the Karakaya Dam Lake and the pump station 1.5 m^3/s the optimum flow was selected and the installed power of the pumps was calculated as 5.0 MW.

5.2 Water Retrieval Structure

The water retrieval structure of Baskil coastal villages Irrigation project is planned at the most appropriate topographic, geological and hydrological l_{oc}ation on the Karakaya Dam Lake. With a tower-type designed water-taking structure, it will be possible to get water from 690 m jeans.

5.3 Pumping Station

The pump station location was selected according to the most suitable topographic and geological parameters on the shore of the dam Lake. The size of the pump station to be placed on the right beach is 30x15 m and the height is 20 m.

Baskil Coastal Villages Irrigation project will consume an average annual 5.6 million kWh of energy. In order to meet the energy consumed, the energy needs will be met with the solar field to be installed in the region and the energy produced outside the irrigation periods will be generated by giving income to the grid.

5.4 Forced Pipe

In Baskil coastal Villages Irrigation project, the Penstock route was chosen where topographic and geological conditions were best suited. The penstock will be passed on as sturdy as possible. As a result of penstock optimization, the thickness of the meat was found to be between 9 mm and 12 mm, Ø 1000 mm in diameter and 730 m in length.

5.5 Transmission Structure

The currents taken with the water-receiving structure will be transmitted to the irrigation areas via the transmission channel. The project flow rate is 2.0 m^3/s for rectangular cross-section channel 45650 m long.

Type : Rectangular section
Length : 45650.00 m
Width : 2.00 m
Water Height : 1.5 m
Transmission Design Flow : 1.5 m^3/s
Tilt : 0.002 m/m

5.6 Regulation Pool

The regulation pool, which is at the end of the forced pipe transmission system, must be sufficient volume in order to ensure the necessary regulation for irrigation water. Storage of the regulation pool and solar panels according to current weather conditions will be possible during periods of variable. Due to the terrain conditions where the regulation pool is to be made, the difference between the most and the length is maximized and 14000 m^3 capacity of reinforced concrete section regulation pool is planned.

5.7 Energy requirement

According to the months, the energy consumption values in parallel with the requirement of irrigation water are presented in Table 4.

TABLE 4
ENERGY CONSUMPTION VALUES

Months	April	May	June	July	August	September
Pump flow (m3/s)	1	1,5	1,5	1,5	1,5	1,5
Pump Power (MW)	3,3	5	5	5	5	5
Energy (Gwh/yıl)	0,6	1	1	1	1	1

5.8 Energy Supply

The energy needed in the Baskil coastal Villages Irrigation project will be provided from the 5 MWP solar power plant to be installed in the region.

TABLE 5
BASKIL 1 MW PVSYST ENERGY SIMULATION

	Horizontal spherical radiation	Temperature °C	Energy
January	55,8	-1,10	74,4
February	73,4	0,40	94,7
March	130,5	5,40	146,8
April	155,1	11,20	149,8
May	209,9	16,40	187,3
June	245,4	22,30	203,2
July	253,0	26,80	209,7
August	227,2	27,10	203,1
September	177,3	21,90	182,3
October	127,4	15,20	156,3
November	77,4	7,20	106,1
December	54,9	1,10	73,6
Years	1787,2	12,86	1787.2

The 1 MW AC power Plant for the region is projected to produce 1752.6 MWh annually as a result of pvsyst simulation as shown in Table 5. Therefore, the total power generated by the 5 MW plant to be established in the region will be around 9 million kWh [6].

6 PROJECT COST

6.1 Fundamentals of Expenses Calculation

The exploration costs of the proposed facilities for the Baskil coastal Villages Irrigation project have been removed. During the calculations, the findings of the facilities were found. The unit prices of the DSI General Directorate of Project and Construction department were used in the calculation of the discovery costs 2017. Since electromechanical equipment will be supplied from abroad, the average of the prices taken from overseas firms is based on calculating the discovery. Apart from these, the prices of domestic manufacturers are based on some of the equipment that can be purchased domestically. Tedaş unit prices were utilized when removing the discovery of the energy transmission line.

6.2 Exploration, Plant, Project and Investment Costs

The cost of the plant was found by removing individual quantities for the Baskil coastal Villages Irrigation project facilities, including 5% for construction works and 5% unexpected expenses for electromechanical equipment. In order to determine the total cost of the project, the cost of surveying project control and expropriation fee were added. Cost study is presented in Table 6.

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TABLE 6
COST STUDIES

İŞİN CİNSİ	YATIRIM YILLARI				TOPLAM (TL)
	1		2		
	6 ay	6 ay	6 ay	6 ay	
İŞLETME,ŞANTİYE TESİSLERİ	1.000.000	-	-	-	1.000.000
ULAŞIM YOLLARI	100.000	100.000	-	-	200.000
SU ALMA YAPILARI	-	518.064	-	-	518.064
İLETİM KANALLARI	6.671.570	7.238.730	8.507.360	5.794.021	28.211.681
REGÜLASYON HAVUZU	-	608.180	651.460	-	1.259.640
CEBRİ BORU	-	-	324.234	349.248	673.482
POMPA İSTASYONU	-	-	481.200	-	481.200
5 MW GES TESİS VE EKİPMANLAR	4.671.570	6.338.734	7.507.360	7.794.021	26.311.685
BİLİNMEYEN (%5)	388.579	423.249	498.213	307.163	1.617.203
İNŞAAT TOPLAMI	**12.831.719**	**15.226.957**	**17.969.827**	**14.244.453**	**60.272.955**
POMPA TAKIMLARI VE MONTAJ	-	-	3.113.592	3.015.146	6.128.738
ENERJİ NAKİL HATTI	-	-	-	1.000.000	1.000.000
BİLİNMEYEN(%5)	0	0	155.680	200.757	356.437
ELEKTRO MEKANİK TOPLAMI	0	0	3.269.272	4.215.903	7.485.174
TOPLAM TESİS BEDELİ	**12.831.719**	**15.226.957**	**21.239.098**	**18.460.356**	**67.758.130**
KAMULAŞTIRMA	1.000.000	1.000.000	1.000.000	1.000.000	4.000.000
SİGORTA GİDERİ	1.000.000	1.000.000	1.000.000	1.000.000	4.000.000
ARA TOPLAM - 1	**2.000.000**	**2.000.000**	**2.000.000**	**2.000.000**	8.000.000
KDV HESABI	2.669.709	3.100.852	4.183.038	3.682.864	13.636.463
TOPLAM PROJE BEDELİ	**17.501.428**	**20.327.809**	**27.422.136**	**24.143.220**	**89.394.593**
YATIRIM DÖNEMİ KREDİ FAİZİ	**0**	**2.625.214**	**3.049.171**	**4.113.320**	**9.787.706**
YATIRIM DÖNEMİ KREDİ MASRAFI	**148.762**	**172.786**	**233.088**	**205.217**	**759.854**
TOPLAM YATIRIM BEDELİ	**17.650.190**	**23.125.809**	**30.704.395**	**28.461.758**	**99.942.153**

6.3 Investment Program

The necessary permits and documents must be obtained before Baskil coastal villages Irrigation project can be implemented. After the preparation of the final projects, construction is planned to begin with the application projects.

The completion period of the facilities to be made within the scope of the project is determined as 2 years. In the last 6 months of construction, electromechanical equipment will be assembled. Baskil Coastal Villages Irrigation project is planned to be completed within 2 years including preparatory period.

7 ECONOMIC ANALYSIS

7.1 Annual Benefits

The project's life expectancy has been projected as 50 years while the economic evaluation of the facilities of Baskil coastal villages Irrigation project has been evaluated. For the project to be built for irrigation, the benefits of agriculture and country determined by DSI are based on. The average of Turkey 2000 kg per hectare was accepted. Income per Kilo, the weight of apricot production in the average of 3 TL/kg was taken. In this respect, the 5000 ha area is calculated that the annual income of 30 million TL can be obtained. As a result of the calculations made by accepting 5 of our country's development coefficient, the indirect contribution of this production to our country's economy would be TL 150 million.

7.2 Annual Expenses

The annual expenses taken into consideration within the scope of the project are examined in two parts and the expenses of interest and depreciation are combined with the cost of operation and maintenance. The 0.09603 value, which corresponds to 9.5% interest rate and 50 annual economic project life, is used as interest and depreciation factor for irrigation investments. Interest + depreciation expense, annual business and maintenance expense are also added. For operating and maintenance expenses, the operating and maintenance factors in accordance with DSI criteria are taken into consideration for each unit. As a result of these principles, the total annual expense of the project was calculated as 15,568,177 TL.

7.3 Income Expense Rate

When calculating the revenue rate of the project, the annual income and annual expenses found in other departments were taken into consideration. The income rate of Baskil coastal villages Irrigation project has been calculated as 1.93 as a result of dividing the annual expenses worth 15,568,177 TL in 30 million TL.

8 CONCLUSION

Our country shows a rapid social and economic development. In parallel with this development, projects should be developed and necessary investments must be made in order to obtain the professional agriculture based products from domestic sources. If the irrigation project of Baskil coastal Villages is implemented, the fertile lands on the shore of the Karakaya Dam Lake will be effectively assessed, global warming, the decreasing agricultural rearm due to human impact, in some way with the arrival of water will be under control.

Purpose in irrigation projects prepared for the development of soil and water resources; to increase agricultural production and ultimately to maximize the welfare of the population engaged in agriculture.

To feed the rapidly growing population, to meet the raw material needs of our industry, to increase the share of the agricultural sector in the balance of foreign payments depends on the increase in production in agriculture areas. Since the possibility of increasing the amount of our agricultural fields is limited, the agricultural production provided from the unit area to take advantage of this sector, i.e. the most effective factors in achieving the highest level of efficiency in accordance with the potential of natural resources at the beginning comes irrigation.

Use of solar energy technologies; to gain diversity and reliability in energy supply, provide important job opportunities, support rework in the energy market, reduce import fuel dependence, rural communities living in distant and isolated places it has significant socio-economic benefits, such as accelerating its electrification. The idea of using solar energy for

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pumping in agricultural projects is becoming widespread in the world geography.

Consequently, the project site has a large and productive agricultural potential. However, the most important problem encountered in the region is the lack of water. The completion of the irrigation project of Baskil coastal villages will expand. In this way, agricultural products will increase, and in some areas more than one product can be purchased annually. The project is of great importance for our country's economy. Because the region contains the best apricot species in the world. Especially if the production of this fruit, which has been exported in recent years, is considered to be the ceiling, the agricultural economy of the region will grow considerably. Baskil Coastal Villages Irrigation project is completed, 5000 hectares is a project that will take the irrigation of the agricultural area.

For the promotion process from the Karakaya Dam Lake, solar energy will make the fields and the region to be the center of attraction in terms of solar energy irrigation. According to the solar energy Potential Atlas (GEPA) data of our country, which is described by the Electrical Works Surveying administration, solar energy radiation values and land structure of this region are very favorable for investments to be made here.

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