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THE EFFECTS OF INCENTIVES ON RENEWABLE ENERGY RESOURCES FOR HOME USERS

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Abstract

In this study, economical and emission analysis for meeting the electricity demand of a randomly selected house which has renewable energy sources was carried out. The house chosen as an example is in Balikesir city. As a household load, the average daily electricity needs of a family of four were accepted and different scenarios were planned using the Hybrid Optimization Model for Electric Renewable (HOMER) program to meet this need. Several scenarios were dealt with as to whether the systems designed for grid-connected photovoltaic, wind turbine and hybrid systems were indigenous manufacturing incentives. In addition, energy unit costs and total investment costs were determined and economic analysis was carried out. When the results of the study are examined, grid-connected photovoltaic, wind turbines and hybrid systems were found to be significantly less than the costs incurred by net present costs when they were established within the scope of domestic manufacturing incentives.

Key words: *Renewable, energy, incentive, investment, domestic.*

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1. Introduction

Energy is one of the most important factors affecting and shaping everyday life. The need for energy resources is growing as the world's population, economic activities and living standards increase. Due to the limited availability of fossil fuels, negative environmental impacts, fuel costs, and costs associated with transporting fuel to the energy generating system, countries have shifted towards using clean, environmentally friendly and renewable energy sources [1]. This situation has increased investment in these types of resources. Due to the high cost of investment, it has become compulsory to examine in more details further the incentives and feasibility studies related to the issue.

Especially in the recent period, an increase in efforts on the use of combining solar energy systems has been observed. In order to meet the demand of 375 households in Bozcaada, Kalinci made cost analysis using Hybrid Optimization Model for Electric Renewable (HOMER) program for hybrid systems composed of different components [2]. Demiroren, in the simulations made with HOMER; worked on the calculation of the cost of the cheapest electricity, finding reduced lowest total net present cost of renewable energy systems and examination of the system structure and by creating load profiles in the program with hourly data taken from TEİAŞ, indicated that wind energy would be an appropriate investment for Gökçeada[3]. Güler created four different scenarios at HOMER to meet the load demand of a hotel in Aydın, stated that the grid-connected wind energy system is the optimum result [4]. Rohani and Nour, using the program HOMER, designed a hybrid system for 500 KW, 1 MW, and 5 MW loads in Abu Dabi to meet the energy needs of 250, 500 and 2500 households respectively and compared the net energy costs of the systems consisting of different combinations of wind, solar, battery and diesel generator [5]. Kıymaz has evaluated the renewable energy potential of Başkent University Bağlıca Campus region using HOMER program [6]. Özkök analyzed using HOMER software for the cases where the power demand of a house is met by roof photovoltaic systems of 3KW, 4KW and 5KW capacities in pilot cities selected according to for the lowest and highest solar radiation in each geographical area [7].

In this study, Balikesir city in Turkey economic and emission analyzes were conducted to meet the electricity demand of a randomly selected house with renewable energy sources. The HOMER program was used to simulate system operation and to calculate the technical-economic parameters in each design. With the HOMER program, grid-connected PV modules, wind turbines and hybrid systems were designed to meet the domestic electricity needs and economic analyzes of designs from each design data were made. Through the HOMER program, the average solar radiation and average wind speed values of the studied region were obtained and the values and profitability of the investments in the present case were examined considering factors such as the cost of the initial investment, the total investment cost, sales grid tariff.

2. Load and Renewable Energy Characteristics

Balikesir, both located in the Marmara and the Aegean Sea coast, with 14.272 km2 area is among Turkey's large cities with a total population of 1,189,057 [8]. Balıkesir power plant is 2623 MW installed capacity and there are a total of 41 electric power plant in the province. The power plants in Balıkesir are producing about 9.766 GWh of electricity per year [9]. In this study, electricity consumption of a house with a daily average consumption of 11.30 KWh and a maximum consumption of 1.9 KW was determined by the HOMER software as an autonomous load. The hourly average load profile consumed during the day used in the model is shown in Figure 1. In addition, the meteorological, daily radiation, clarity index and wind speed values of the city were obtained through the HOMER program as shown in Table 1.

Table 1. Monthly Average Wind Speed, Radiation and Reduction Index Values for Balikesir City.

	Wind speed (m/s)	Radiation (KWh/m²)	Clarity Index
January	5.510	1.720	0.400
February	7.010	2.380	0.418
March	6.410	3.630	0.474
April	5.640	4.740	0.491
May	4.680	6.080	0.551
June	4.730	7.060	0.609
July	4.800	7.130	0.632
August	4.440	6.200	0.612
September	4.730	4.880	0.586
October	6.480	3.090	0.493
November	5.480	1.970	0.428
December	5.620	1.420	0.366

The costs of the components used in the study were found through market research and the project life of the components was taken as 20 years. In order to make an effective comparison in the system designs, the photovoltaic panel, the wind turbine, the inverter and the battery were assessed on the basis of equivalent capacity and number in each scenario according to the nature of the scenario applied. The capacity and quantity of the components used in the study are shown in Table 2 and the cost analysis of the components is shown in Table 3.

Table 2. System Components.

	Units	**Photovoltaic System**	**Wind Turbine System**	**Hybrid System**
PV array	KW	3	0	3
Wind	KW	0	3	3
Inverter	KW	3	3	3
Battery	unit	6	6	6
Initial Investment Cost	$	4.380	4.030	6.130

Table 3. Cost Analysis of Components.

Units	**Initial Investment**	**Replacement Cost**	**Operating and Maintenance Cost**
Photovoltaic Panel (3KW)	$2100	0	$60 /year [12]
Wind turbine (3KW)	$2000	$2000	$20 /year [13]
Battery (6 units)	$130/unit	$130/ unit	$4.00/ units [14]
Inverter(3KW)	$1250	0	$60 /year [15]

3. Incentive Systems

According to the Renewable Energy Law numbered 6094, the amount of energy that is sold to the grid and taken from the grid will be recorded by the bidirectional meter and if the energy to be sold is more than the received energy, the excess energy charge will be available from distribution companies. The government incentive for production plant based on solar energy is 13.3 $ cents/KWh, domestic production incentive is 6.7 $ cents/KWh, for production facilities based on wind energy, these values are 7.3 $ cents/KWh and 3.7 $ cents/KWh respectively, grid sales tariff guarantee is 10 years and domestic production incentive guarantee is 5 years [16].

In the scope of the study, photovoltaic (PV) system, wind energy system and PV-wind hybrid system are designed each of which is grid-connected and system stability, short-circuit, harmonics and energy quality were neglected in grid-connected systems. In each design, incentives were evaluated under the law numbered 6094, when generated electrical energy given to the grid which is more than demand. In

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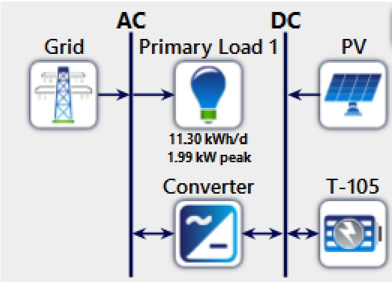
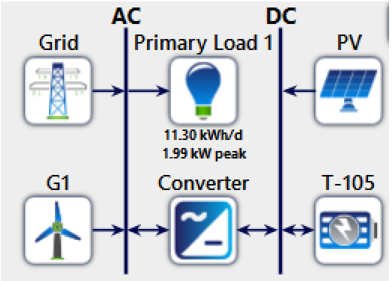
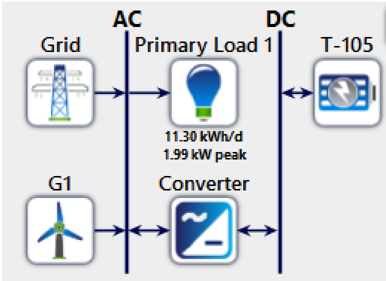
the design of no 1 in the study, for every renewable energy source, it was considered that the mechanical and / or electro-mechanical components used in production facilities were imported, in the design of no 2 it is considered that all of these equipments were domestic. Within the scope of the study, it has been accepted that incentives will be utilized during the project.
The cost of electricity consumption in Turkey is 33,1833 TRkurus/KWh excluding VAT KWh [17]. In the scenarios, considering the daily exchange rate, the price of electricity purchased from the grid was taken as 0.125 $ cents/KWh [18]. The systems used in the study are given in Figure 1 and the codes of the systems in Table 4.



(a) Photovoltaic



(b) Wind turbine



(c) Hybrid System

Fig. 1. System designs.

Table 4. Component System Codes

	If indigenous manufacturing incentive	If indigenous manufacturing not incentive
Photovoltaic System(PV)	PV1	PV2
Wind turbine System(WT)	WT1	WT2
Hybrid System(HB)	HB1	HB2

4. Economic Parameters

4.1. The Annual Real Interest Rate

The Annual Real Interest Rate, the discount rate used for conversion to and from annual costs by one-time costs, it depends on the nominal interest rate, as described below.

$$i = \frac{i' - f}{1 + f}$$

i = real interest rate
i'= nominal interest rate
f= annual inflation rate

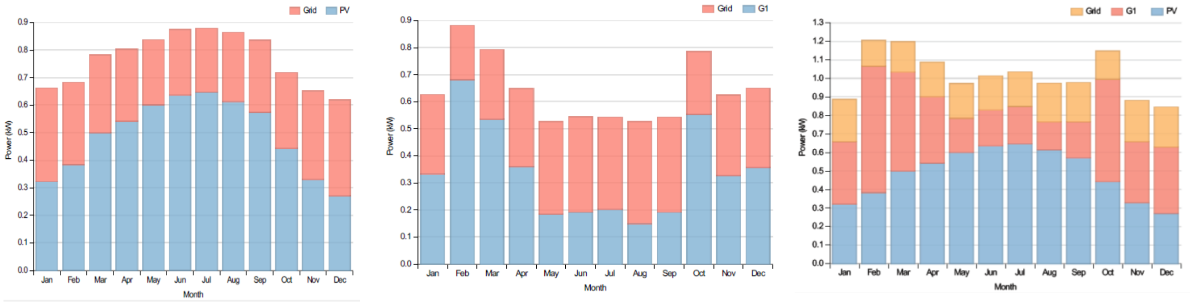
The annual nominal interest rate to be used in the HOMER Program is 10.32 according to the data of the Central Bank [18]. According to TurkStat official data, the annual inflation rate f for Turkey is taken as 9.22[19]. According to the data, annual real interest rate i = 1.01% (i=(0,1032-0,0853)/(1+0,0853)).

4.2. Net Present Cost (NPC)

The total net present cost (NPC) of a system is the present value of all the costs that it incurs over its lifetime, minus the present value of all the revenue that it earns over its lifetime. Costs include capital costs, replacement costs, O&M costs, fuel costs, emissions penalties, and the costs of buying power from the grid. Revenues include salvage value and grid sales revenue [20].
HOMER calculates the total NPC by summing up the total discounted cash flows in each year of the project lifetime. The total NPC is HOMER's main economic output, the value by which it ranks all system

configurations in the optimization results, and the basis from which it calculates the total annualized cost and the levelized cost of energy.

Monthly average electricity generation for each design is given in Figure 2.



(a) Photovoltaic (b) Wind turbine (c) Hybrid System

Fig. 2- Monthly average electricity generation

5. Results and Discussion

Within the scope of the study, benefit-cost and emission analysis were carried out taking into consideration the investment costs of each design through the HOMER program. The emission values according to designs are given in Table 5.

Table 5. Emission Values

	Photovoltaic	Wind turbine	Hybrid
Carbon dioxide	61.07	741	-1804
Sulfur Dioxide	0.26	3	8
Nitrogen Oxide	0.13	2	2

In the HOMER program, in order to make meaningful economic criteria, systems designed with a base (reference) system selected from the scenarios are compared and these criteria show the differences between the two systems. As a reference system for each design a grid connection to meet a home's autonomous load used in the design was selected, each of the cases where the designed photovoltaic, wind turbine, and hybrid systems were grid-connected was taken as the current system (designed system), the net present values of the systems and the initial investment costs were determined and compared. The results obtained according to whether or not there is indigenous manufacturing incentive for each design are shown in Table 6.

Table 6. Reference System-Designing System Comparison

		Base System (Reference System) ($)	Designed System ($)
Net Present Value	**PV1**	9297	7256
	PV2		4302
Initial Investment Cost	**PV1-PV2**	0	4380
Net Present Value	**WT1**	9297	9572
	WT2		8588
Initial Investment Cost	**WT1-WT2**	0	4030
Net Present Value	**HB1**	9297	1812
	HB2		-3209
Initial Investment Cost	**HB1-HB2**	0	6130

In the designs made; it was determined that the initial investment cost of the grid connection received as the base(reference) system is zero and the net present value for each system is 9297 $. In the study, only the grid-connected system was taken as the reference system, whereas grid-connected photovoltaic

(PV) systems, wind energy systems and PV-wind hybrid system design were made, present worth, return on investment, internal rate of return and the payback period of each designed system are calculated. In the study, the results obtained for each design are shown in Table 7.

Table 7. Investment Potential of Systems

	PV1	PV2	WT1	WT2	HB1	HB2
Present Worth ($)	2.041	4995	275	709	7.485	12.506
Return on investment (%)	8.1	11.9	5.2	6.5	12.3	16.9
Internal rate of return (%)	5.2	10.3	0.3	2.7	10.7	16.1
Payback period (year)	13.06	8.20	19.35	15.34	8.12	5.79

When the table showing the system investment potentials is examined; it is seen that, the present worth in the designed systems are greater values when there are indigenous manufacturing incentives, the incentives are very effective on the investment and the profit margin of investors is considerably increased.

Return on investment; since it is evaluated as the ratio of earned amounts to investment amounts in investments, shows that return on investment is higher when there are indigenous manufacturing incentives in investments, so, as the incentive increases, the amount earned from the investment is also increasing.

Internal rate of return; expresses what proportion of the investment will create added value, it is seen that internal rate of return is higher when there is indigenous manufacturing incentive in investments, and so, as the incentive increases, the value of the investment also increases.

The payback period; shows the indication of how long it would take to recover the difference in investment costs between the current system and the base case system, it is seen that the payback periods are shorter when there are indigenous manufacturing incentives in investments, as the incentive increases, the investment payback period also decreases.

5. Results and Discussion

In this study, different scenarios generated by grid-connected, to meet the electricity needs of a home in Balıkesir, each scenario of system designs was made using the HOMER program, cost-benefit analysis and emission analysis were carried out taking into consideration the investment costs. In the study, only the grid-connected system was taken as the reference system, whereas grid-connected photovoltaic (PV) systems, wind energy systems and PV-wind hybrid system design were made, present worth, return on investment, internal rate of return and the payback period of each designed system were calculated. The calculations made in the designed systems were dealt with according to whether they are local manufacturing incentives or not.

When the data obtained in the study are examined; in the investments of renewable energy systems, when there are indigenous manufacturing incentives, it is observed that present worth of the systems, the return on investment rates, internal rates of return are increase, payback period is decrease according to the situation without incentives.

In this study, it is seen that, for grid-connected photovoltaic, wind turbine and hybrid systems, the present values are 4995 $, 709 $ and 12506 $ respectively, investment returns are 11.9%, 6.5% and 16.9% respectively, internal rates of return are 10.3%, 2.7% 16.1 respectively and payback periods were 8.2 years, 19.35 years and 5.79 years, respectively under the scope of incentive.

When the incentives on the sales tariff provided by the state are increased or the incentive period is extended, investments for renewable energy sources will increase, and an effective, profitable and sustainable investment will also reduce external dependency.

It has been concluded that the use of hybrid energy systems, in which the return of investment is higher than photovoltaic and wind turbines, and that the payback period is shorter, has to be widespread.

In investments made for renewable energy sources, increasing the amount of government-supplied indigenous manufacturing incentives for established systems or prolonging incentive periods, will increase the profitability of the investment as well as increase the domestic producers and thus lead to an effective competition environment for the production of quality materials in the country. Indigenous manufacturing incentives will also contribute to the employment of the country through the employment of qualified personnel in this field.

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