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A DYNAMIC SYSTEM MODELING FOR FACTORS AFFECTING STUDDING OF RENEWABLE ENERGIES AS AN ENTREPRENEURIAL OPPORTUNITY IN IRAN

S. Dindar [1,2] M.A. Forghani [1] M. Rashidinejad [3] M. Hasani Marzooni [4]

1. Management Department, Shahid Bahonar University, Kerman, Iran
ssdindarss@yahoo.com, forghani@mail.uk.ac.ir
2. Young Researchers Society, Shahid Bahonar University, Kerman, Iran
3. Electrical Engineering Department, Shahid Bahonar University, Kerman, Iran, mrashidi@uk.ac.ir
4. Electricity Economics and Management Group, Niroo Research Institute, Tehran, Iran, mhasani@nri.ac.ir

Abstract- Several changes have been taking place in the energy sector as a result of the development of renewable energies and the implementation of renewable technologies. The use of renewable energies offers the opportunity to create new employments. Creating major changes in the energies systems such as adding renewable energies to the energies portfolio will require coordinated actions guided by perceiving of the complex system in which it occurs. This study is conducted to investigate the complexity of this system, so that it can help the decision makers in order to adopt the appropriate policies and strategies in order to deploy the renewable energies more effectively especially for the entrepreneurial opportunities that can be created by these green technologies. We will describe our model in terms of three sub-models including investment, employment and energies economy sections. It will be examined how the renewable energies industry works as a complex system by using a benchmark modeling in Iran.

Keywords: System Dynamics, Investment, Employment, Economic Development.

I. INTRODUCTION

In the present age, entrepreneurship as the driving force of economic growth and development is regarded, and is considered as the most important factor for creating employment. Developing the use of renewable energies is not only efficient for both the energies policies and environmental concerns, it also has a significant positive impact on human resource employments.

According to the fourth 5-year state's development plan in Iran, it has been obligated to serve the 500 MW of electricity consumption from renewable energies sources [1]. Jones (2012) developed an abstract model of a local photovoltaic market [2]. Hasani-Marzooni and Hosseini (2012) proposed an improved decentralized market based model for long-term capacity investment decisions in a liberalized electricity market with significant wind power generation [3].

Mostafaeipour et al. (2011) examined the status and wind power potential of the city of Shahrbabak in Kerman province in Iran [4]. Kessides and Wade (2011) complemented the previous work on the economics of different energies resources by examining growth potential of alternative electricity supply infrastructures [5]. The renewable energies supply chains were examined in [6]. Tourkolias and Mirasgedis (2011) exploited input-output methodology for estimating the direct, indirect, and induced employment effects associated with the renewable energies technologies and updated by using a more recent version of the input-output table for Greek economy [7]. Wei et al (2010) presented an analytical job creation model for the US power sector from 2009 to 2030 and the resulting model is used for job projections under various Renewable Portfolio Standards (RPS), energies efficiency, and low carbon energies scenarios [8]. The investigation of Alvarez et al. (2009) demonstrated increase of direct and indirect employment in Spain caused by exploitation of renewable energies sources in electricity production. This study revealed how such 'green jobs' policy clearly hinders Spain's way out of economic crisis [9].

The study of Pollin et al (2009) provided quantitative estimates for the direct, indirect and induced employment which comprise considerable investments in renewable and other clean energies technologies and have developed a formal model to estimate the broad magnitude of the induced employment effects more systematically [10]. Ramos-Hernanz et al. (2012) developed two different computer models to simulate the behavior of a photovoltaic cell, to be able to represent the *I-V* and *P-V* curves [20]. Mammadov (2012) examined the productivity of flat solar collector. He concluded that by taking into consideration all-important showings of the energy plant, the very solar collector was validated due to the technical opportunities, ecological safety, and economical serviceability [21]. Compared to fossil-fuel power plants, renewable energies generate more jobs per unit of installed capacity, per unit of power generated and per dollar invested.

In most countries, the renewable energies production is increasing, therefore opening new business opportunities for industrial development [11]. Meijer et al analyzed how perceived uncertainties and motivation influence an entrepreneur's decision to act. Empirical results showed that technological, political, and resource uncertainties are the most dominant sources of perceived uncertainties influencing entrepreneurial decision-making [12]. Roy and Wong (2000) provided a review to cost-effectiveness of Canadian direct job creation programs introduced by the Canadian federal government [13].

In this paper, the important factors that affect the entrepreneurship process in using of renewable energies are modeled. Functionality of proposed mechanisms on power generation investment is illustrated by simulation studies. Remaining parts of this paper are structured as follows. Problem statement is identified in Section II. Section III describes general model and its sub-models. Concluding remarks are provided in Section IV.

II. PROBLEM STATEMENT

Using the abundant blessings God has provided us is one of the basic principles of human survival. Iran has a considerable amount of natural resources for modernizing its energies supply [1], but investment and installation rates in renewable energies during 1992-2008 has been slow and in some years has been trivially fixed. Consequently, the growth of employment in this area has been slow. There are some inhibitors in developing renewable energies in Iran. Abundant and inexpensive fossil fuels, lack of road map and comprehensive plan, governmental structural problems associated with renewable energies and executive, technical and privatization barriers are some of the problem related to the renewable energies investments in Iran.

III. MODEL DESCRIPTION

Two different generating technologies are considered for renewable generation modeling, wind and solar. Since our purpose is to describe the implications of different policies and investors behavior in entrepreneurial process in using of renewable energies to generate power, system dynamics approach is used to comprehend dynamics of interactions between components of entrepreneurship developments in field of renewable sources. In this model we have three sub-models including investment phase, employment process, and energies-economy assessment.

We will describe the structure of these sub-models. To represent the feedback structure of the sub-models, the system dynamics evaluation of the whole system will be presented. A causal loop diagram is an appropriate tool in system dynamics concepts [14]. This diagram consists of variables and arrows. The arrows define causal effects of the variables. Positive (negative) sign indicates that if the cause or independent variable increases then the effect or dependent variable will increase (decrease). Such a decision model enables the companies to find out the possible consequences of their different investment decisions and the impact of using business opportunities in the field of renewable energies.

A. Investment Sub-Model

The dynamics of the sub-models is determined by the feedback loops of the causal loop diagram. The following sub-model shows factors affecting behavior of investors to invest in installed capacity of renewable power plant. Predicted annual cash flows by using incoming (revenues) and outgoing (expenses) are employed for economic assessment of a project or an investment decision. For this purpose, net present value of investment is used.

More the net present value of project causes more tendency of investor to invest in renewable energies projects. The causal loop diagram of the investment sub-model is depicted in Figure 1. In this part the dynamics of costs and benefits are simulated in system dynamics model to trace dynamics of renewable capacity investment.

A.1. Project Costs

There are several factors that affect the cost per unit of electricity generated by renewable. These factors may vary from one country to another and from a region to another region. In renewable generation technologies, variable costs are regarded trivial since no fossil fuels are used while investment costs are high. For economic evaluation of a project, total costs including fixed and variable costs should be considered. Variable costs expressed as a term of energies amounts generated, but fixed costs do not depend on energies production.

Most important part of fixed costs in power systems expansion projects is the investment costs, which are firstly funded [3]. In evaluating initial investment costs, apart from the cost of purchasing equipment, funding for other essential requirements such as ground, transmission lines, etc. must be considered. Maintenance and operation (O & M) costs and salvation value are regarded as the variable costs. Salaries of project staffs are also considered as a part of operating costs.

A.2. Project Revenues

We considered two categories of incomes, consist of revenues from government incentives and revenues from selling of electricity. Revenues from government incentives include willingness of government to pay for employing the renewable energies in electricity production. Some regulatory incentives such as utility direct subsidies (e.g., feed in tariff in Europe or federal production tax credit in the U.S.) and fixed premium as well as indirect incentives (e.g., tax exemption policies), and tradable green certificate have been used by governments in order to promote renewable energies sources in several countries [15].

Some other regulatory incentives such as CO_2 emission tax credit may be used for reduction of greenhouse gases effects as the environmental purposes [16]. Revenues from selling electricity depend on labor productivity to produce and guaranteed purchase price for renewable electricity in Iran that based on the growth of annual inflation rate. So the annual net cash flow is evaluated as follows:

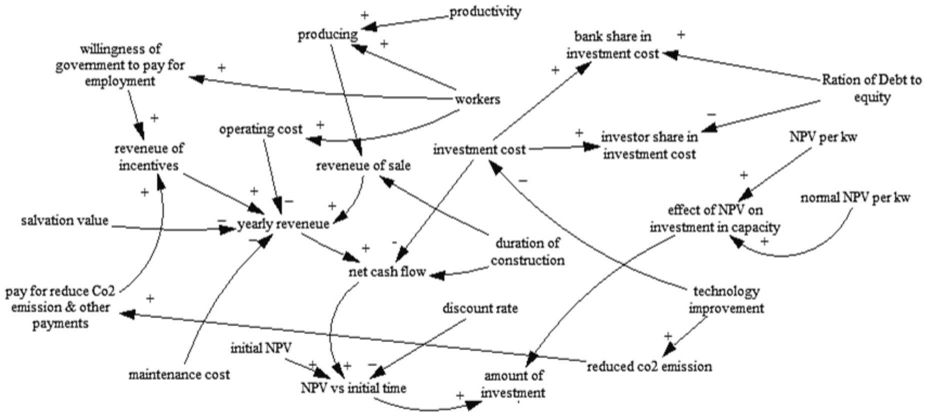

Figure 1. The causal loop model for long-term assessment of investment sub-model

$$Net\ Cash\ Flow_t = Revenues\ for\ Selling_t + Incentives_t - \\ - Operating\ Costs_t - Maintenance\ Costs_t - \\ - Salvation\ Value_t \quad (1)$$

So that some time delays are inevitable in the phases of decision-making, permission allowing, and construction, only the government incentives can be taken into consideration by investors in order to create new jobs in construction and installation processes.

Besides, the large amounts of investment costs should be provided preliminary. Thus, the net cash flow is firstly negative. Then, the annual net cash flow will increase after the project installation and power plant operation since the annual sale revenue and revenue from new job creation in the O & M will be achieved. After some time elapses, the net cash flow will be gradually reducing due to the increasing of maintenance cost over the lifetime of power plant. Therefore, the Net Present Value (NPV) of the project is defined as follows:

$$NPV = \left(\frac{NCF_1}{(1+i)} + \frac{NCF_2}{(1+i)^2} + \cdots + \frac{NCF_{n-1}}{(1+i)^{n-1}} + \frac{NCF_n}{(1+i)^n}\right) - C \quad (2)$$

where, NCF is the annual net cash flow, C and i are the fixed investment costs and the discount rate, respectively, and N is the lifetime of power plant in terms of years.

B. Employment Sub-Model

A combination of clean energies investments create in excess of three times more jobs per a given amount of spending than the fossil fuel industry [10]. Hence, study of employment effects of renewable technologies is very important. The following sub-model describes direct and induced employment effects of renewable technologies. Figure 2 shows the causal loop of employment sub-model. Here we explain components of the technology, or power plant, under consideration. Two job-function groupings for direct employment are considered as follows:

- Construction, Installation, and Manufacturing (CIM)
- Operations, maintenance, and fuel processing

Items in first group are typically reported in 'job-years per MW installed' while the second group is reported in 'jobs per peak MW over the lifetime of the plant'. By converting the CIM job-years per peak MW to average jobs per megawatt over the lifetime of the plant, we can combine one-time employment (e.g. installation) with ongoing employment. Next, the total jobs per peak megawatt (MW_p) is normalized to total jobs per average megawatt (MW_a) by dividing the jobs per peak MW by the capacity factor which is the fraction of a year that the facility is in operation.

A job generation summary of the studies that were normalized about wind and solar technologies mentioned in Table 2 in [8]. Induced effects are the expansion of employment that results when people who are paid in the construction or steel industries spend the money they have earned from producing these immediate and intermediate goods for clean energies industries on other products in economy. The magnitude of the induced effect will depend on the present economic conditions in the country.

High unemployment rate means that there will be a large number of people which are able and willing to take jobs if new job opportunities open up. If there is slack in the economy's physical resources, then the capacity to expand the employment will be greater and consequently, the induced effects will be larger. If the economy is operating at a high level of activity, there is not likely to be a large employments gain beyond what resulted from the initial direct and indirect effects [10]. In our model we used the mean of the normalized data from these studies about two given technologies (wind and solar). Then according to the installed capacity of these technologies in Iran in the given time horizon, the sum of employments in two technologies for the two job-function groupings is considered.

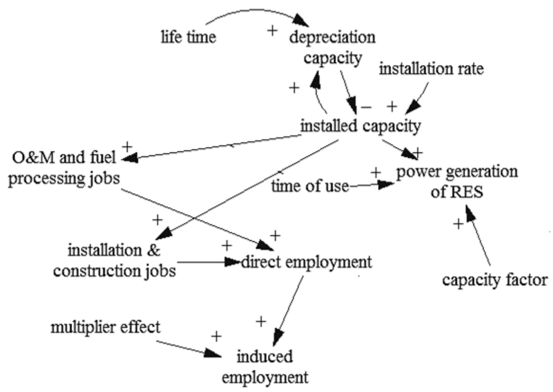

Figure 2. The causal loop model for employment sub-model

The analyses of USA Central Bank (Fed) give an idea about the multiplier effect. The multiplier effect of other industries has been used for employment multiplier of renewable generation industry in our analysis [11]. Therefore, according to Tourkolias's opinion, the employment multipliers measure the total change in employment resulting from an initial change in employment as consequence of the change in the output of one or more economic sectors [7]. Induced employment is defined as follows:

$$\begin{aligned} Induced\ Employment &= (Multiplier\ Effect - 1) \times \\ &\times (Direct\ Employment) \end{aligned} \quad (3)$$

The Generated Energies (GE) and the Depreciation Capacity (DC) of a renewable generation technology will be defined from the following equations:

$$GE = IC \times CF \times TU \quad (4)$$

$$DC = \frac{IC}{LT} \quad (5)$$

where, IC, CF, LT, and TU are installed capacity, capacity factor, lifetime, and time of use, respectively.

C. Energies Economy Sub-Model

Energy is a vital source since it is one of the major inputs for the industry. Developing new energies has an important role for changing natural resources into energies in which play an important role in sustainable development of each country. The clean energies industry has been focused as a key area for investment for both environmental and economic reasons and it is a driver force for significant, positive economic growth through the continual innovations. Climate change, global warming, and recent worldwide economic crisis have emphasized the need for low carbon emissions. As a result of population growth, improving the health standards, and the developmental activities, the energies demand is also increasing. The sub-model depicted in Figure 3 shows the economic and environmental impacts of using renewable sources for electricity production.

C.1. Gross Domestic Product

Gross Domestic Product (GDP) refers to the total market value of all final goods and services produced by all resident units in a country (or a region) over a certain period of time (usually measured over a year). GDP, therefore, is an important index indicating the economic strength of a country or a region. It is considered as the primary factor in an economic system [17].

In our study, annual GDP intended as an indicator of economic development that is affected by GDP of prior period and the growth rate. The growth rate is affected by the oil export, the economic development restriction caused by CO_2 emission, and the installed renewable generation capacity. In our system dynamics model, GDP is calculated from the following equation:

$$GDP_t = GDP_{t-1} \times (1 + \ Growth\ Rate) \quad (6)$$

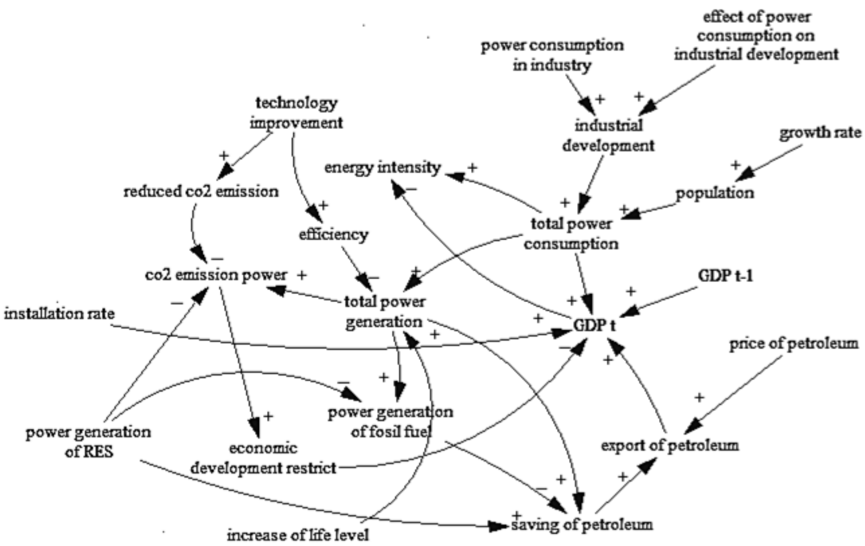

Figure 3. A causal loop model for energies-economy sub-model

C.2. Total Power Consumption

The forecast of power consumption is mainly influenced by the population growth, industrial development, and the growth of life level due to the technologies development. In this study, the ratio of industrial power consumption to the total power consumption is considered as the index of industrial developments. Total power consumption refers to the total consumption of various kinds of energies consuming sectors such as industrial, residential, commercials, and agricultural sectors in the region in a given period.

In this model, consumption of all energies resources including both fossil fuels and renewable energies are considered.

C.3. Energies Intensity

Energies intensity is the ratio of energies use to the output of economic or material resources. Here, the electrical energies are only considered. At the national level, energies intensity is the ratio of the total amount of domestic primary energies use or final energies use to GDP.

The energies intensity is the factor, which indicates the role of energies consumption in a country's GDP growth. It is an important indicator measuring the cost of a country's economic growth [18]. So, the Energies Intensity (EI) in a year is calculated as follows:

$$EI_t = \frac{Total\ Energy\ Consumption_t}{GDP_{t-1}} \tag{7}$$

C.4. Population

Population and the population quality have important roles in the social economy. In general, the population in a region is influenced by many factors such as immigration and emigration rate [17]. In this study, equation related to population is described as follows:

$$Population_t = Population_{t-1} \times (1 + Growth\ Rate) \tag{8}$$

C.5. Total Electric Power Generation

Total electric power generation of country is assumed to be generated from two types of resources, fossil fuel, and renewable capacity. Besides, the energies efficiency is defined by dividing the total electric power consumption into the total electric power generation. Along with the continuing global warming, environmental constraints are expected to play an increasingly important role in the energies resources management among energies planners. Since the emission of power generation from renewable sources is almost trivial, therefore CO_2 emission from total electric power generation is related to fossil fuel recourses.

Emission tax acts as a barrier to economic development by imposing social costs that will effect on the GDP. Increasing the share of renewable sources in electric power generation will increase the amount of petroleum reservoirs, which in turn, increases the capacity to export the petroleum. Consequently, the GDP will increase. In his study, the employment rate is used to determine the variable of increase of life level, so that increasing the employment in the field of renewable energies has a positive effect on life level.

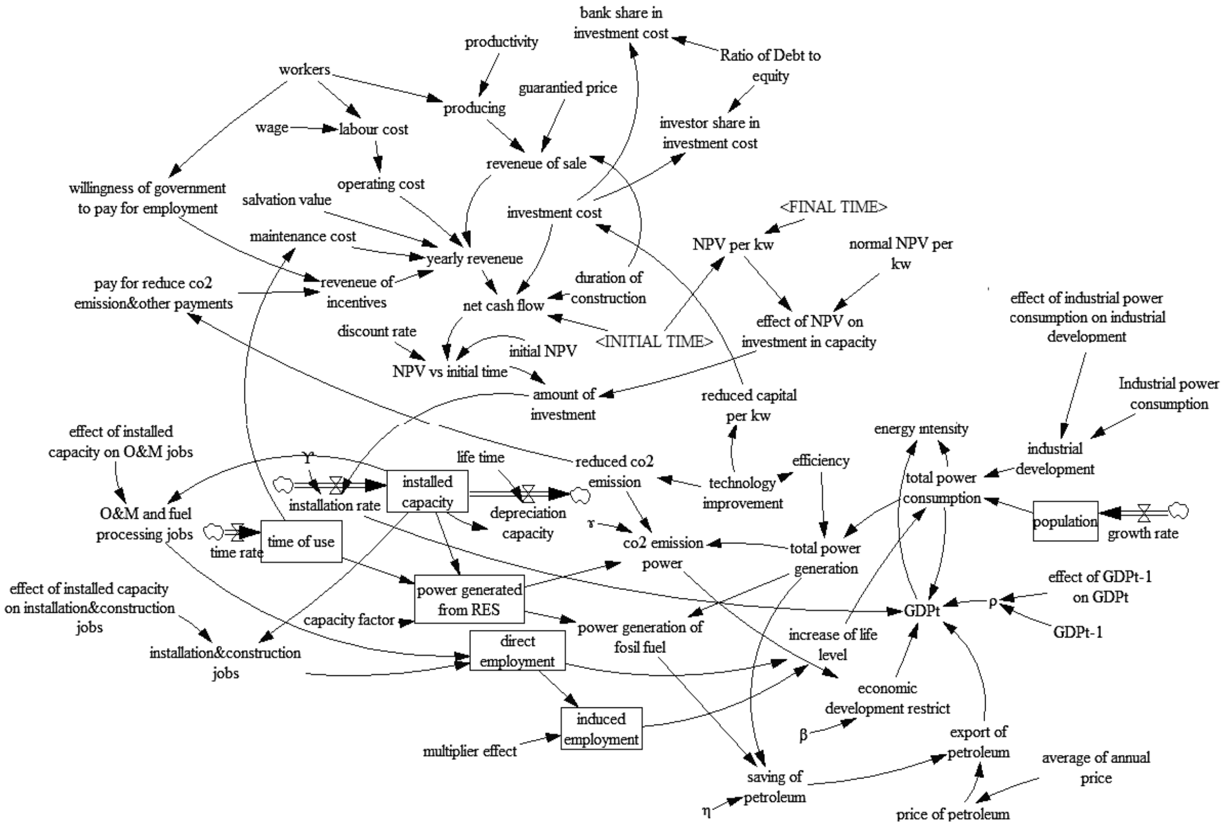

Figure 4. Stock and flow diagram of the general model

C.6. Technology Improvement

Developing new energies is not created without technology. The dramatic increase in size and technological knowhow, coupled with economy of scale from fast growing production volumes have greatly reduced cost of wind power to point where some high yield onshore wind farms are approaching price competitiveness with some other fossil fuel alternatives such as combined cycle gas power plants. The overall aim is to maximize electricity production whilst minimizing infrastructure, O & M costs, and socio-environmental impacts [19]. Science and technology investments cause technology improvements that have a positive effect on reducing CO_2 emission, capital per kW power and efficiency.

D. Stock and Flow Diagram of the General Model

The energies models are complex models which involves all the social, economic, and environmental factors. Energies models are developed for energies planning, formulating strategies, and recommending energies policies.

Entrepreneurial process modeling in the field of renewable energies is an essential component for the sustainable progress of any country. The focus is on employment effects of utilization of renewable energies in the electric power generation industry. Growing populations, economic development, increasing energies consumption, environmental constraints, climate changes, limited fossil resources, and global warming all are the factors, which demonstrate the need for more effective approaches in energies systems planning.

Renewable energies are being seriously considered as a replacement option for fossil fuels. Although the causal loop diagram is useful in dynamic modeling, it is unable to specify the stock and flow structures of the system, which are important concepts of dynamic system theory. Stock and flow diagram is also used to achieve a better description of system dynamics [14-17]. As mentioned in sub-models description earlier, we have presented the relationships between the parameters in each sub-model in the form of causal loop diagrams as shown in Figures 1, 2, and 3. The stock and flow diagram is created from the causal loop diagram and the differential equations for each stock element in the diagram.

Figure 4 shows stock and flow diagram developed in detail for description of entrepreneurship-related system. The stock (level) variables are shown as rectangular boxes, which represent the accumulated flows to that level. The source and sink of the structure are represented by a cloud. The cloud symbol indicates infinity and marks the boundary of the model. Stock characterizes the state variables of the system and creates delays by accumulating the difference between inflow to a process and its outflow mathematically formulated below:

$$\text{Stock}(t) = \int_{t_0}^{t} \left(\text{Inflow}(\tau) - \text{Outflow}(\tau)\right) d\tau + \text{Stock}(t) \qquad (9)$$

IV. CONCLUSIONS

In this paper, the important factors that affect the entrepreneurship process in using of renewable energies are modeled. The model consists of three sub-models including investment, employment, and energies economy sections. Three sub-models describe an entrepreneurship process which starts with an innovation (use of renewable energies instead of fossil fuels power plants) and will continue to pursue an opportunity and job creation that impacts on overall economic of a country.

To view the renewable energies industry as a system in the system dynamics modeling, a set of parameters and the relationships between them in each sub-model have been described in this paper. The proposed model of this paper can help the decision makers in order to adopt the appropriate policies and strategies in order to deploy the renewable energies such as wind and solar more effectively especially for the entrepreneurial opportunities.

Previous similar studies implemented some approaches for estimating the employment benefits associated with the exploitation of renewable energy sources. These approaches include the use of input-output methodology for estimating the direct, indirect, and induced employment effects associated with the renewable technologies and the 'opportunity cost of labor' approach for expressing these effects in monetary terms.

However, in this paper system dynamics concepts are used to model structural characteristics of entrepreneurial process such as long-term investor's behavior, economic and employment effects, relationship between variables, feedbacks, and time delays. Dynamic approaches of the previous studies have only analyzed the subsystems of investment and energies-economic separately but we examine three sub-models involved in entrepreneurial process within general system by an integrated approach and discuss interactions between this three sub-models.

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BIOGRAPHIES

Sedighe Dindar received the B.Sc. degree in Mathematics from Zahedan University, Zahedan, Iran, in 2009. She is currently pursuing the M.Sc. degree in Entrepreneurship Management, Shahid Bahonar University, Kerman, Iran. Her research interests include energy economy, system dynamics, entrepreneurship, and renewable energies.

Mohamad Ali Forghani was born in Kerman, Iran in 1961. He received his B.Sc. degree in Electrical Engineering and the M.Sc. and Ph.D. degrees in Industrial Engineering from Amirkabir University of Technology, Tehran, Iran. Currently, he is an Assistant Professor at Management Department, Shahid Bahonar University, Kerman, Iran. His research interests are optimization and supply chain Management.

Masoud Rashidinejad received his B.Sc. degree in Electrical Engineering and M.Sc. degree in Systems Engineering from Isfahan University of Technology, Isfahan, Iran. He received his Ph.D. degree in Electrical Engineering from Brunel University, London, UK, 2000. He is currently an Associate Professor in Department of Electrical Engineering, Shahid Bahonar University, Kerman, Iran. His areas of interests are power system optimization, power system planning, electricity restructuring, and energies management.

Masoud Hasani Marzooni was born in Babol, Iran in 1978. He received the B.Sc., M.Sc., and PhD degrees all in Electrical Engineering from Sharif University of Technology, Tehran, Iran, in 2001, 2004, and 2011, respectively. He is currently with the Electricity Economics and Management Group of Niroo Research Institute, Tehran, Iran. His current research interests include restructured power system planning and operation as well as power system economics.