Economic and environmental effects for using renewable energy in the production of some vegetable crops under greenhouse conditions

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Abstract: Greenhouses are the most intensive form of agricultural production, with yield per unit of cultivated area up to 10 times higher than traditional agriculture, especially vegetable crops to protect them from adverse environmental conditions. It is also an important way to produce some vegetable crops of special nature in production such as tomatoes and cucumbers. The idea of greenhouses was aimed at vertical expansion in agricultural production, especially the production of vegetables in non-seasons with high quality, due to the fact that most countries face increasing population with limited agricultural area. Recently, the trend towards finding alternative sources of energy has increased because current sources of energy are considered to be depleted resources and will not be sufficient to meet the needs. Thinking about renewable sources of energy for electricity generation, especially in remote areas, beyond the processing centres, as well as the effort, time and costs needed, in addition, this energy is not pollute the environment, besides achieving sustainable development and improve the social and economic conditions of the desert Bedouins. The paper concluded that the amount of CO_2 emissions resulting from the cultivation of one crop of vegetables (tomatoes or cucumbers) under greenhouse conditions was equivalent to 452.16 kg per year, equivalent to 101.304 dollars per year. When replacing conventional energy with renewable energy, the results showed lower costs of electricity Production using solar energy instead of conventional fuel, where the initial cost was $ 0.91 per day while the second cost was $ 5.64 per day, as well as the non-transportation costs of oil and gasoline, Periodic maintenance, and extinction. As well as the costs resulting from the treatment or removal of the effects of pollution caused by generators as a result of burning fuel, pollution of the environment from plants, animals, soil and water. As well as their direct impact on human health.

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Key words: Greenhouse, Solar energy, Alternative energy, CO_2 emissions, Economic study.

1. Introduction:

Agriculture is the only supplier of human food in recent times, as demand for food has increased due to high population growth rates in the world and Egypt in particular and increasing incentives for agro-industry for ecological innovations, sustainable food production, and increased demand from customers. The relationship between agriculture and the environment has changed radically resulting from the use of energy and synthetic materials (fertilizers, agrochemicals and plastics) in agricultural operations [1]. Worldwide, the area of greenhouse production is rapidly expanding which can be defined as “factories for the plant production.” The importance of greenhouses lies in protecting crops from adverse meteorological conditions, improve productivity and quality of crops, and ensure the presence of floricultural and vegetable products throughout the year to meet the demands of consumers and the needs of trading organisations. To ensure stability of microclimate conditions in greenhouses in the winter to satisfy the demands of the growing cycles, it is often necessary to use auxiliary power for proper control of the indoor air temperature. The wide use of fossil fuels (diesel, fuel oil, liquid petroleum gas (LPG)) for heating greenhouses strongly influences the costs and the environmental sustainability of horticultural and ornamental production in protected areas [2].

Greenhouse cultivation is the most intensive form of crop production with a yield per cultivated unit area up to 10 times superior to that of a field crop. Vegetable, ornamental and fruits crops are cultivated worldwide under greenhouse conditions. Greenhouse equipment and covering material provide a controlled microclimate that may be adapted to the needs of the crops, resulting in higher yield, quality and in the lengthening of the market availability of the products. Greenhouse production requires the use of large amounts of energy, water and agro-chemicals, and it usually generates huge quantities of wastes to be disposed of. Investment, labour and energy costs per unit area are much larger in the greenhouse industry than in any other agricultural sector [3]. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts: (1) the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given, (2) the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs [4]. specifically, sustainable agriculture means a maintenance of the adaptive capacity of farming systems, which allows the preservation of natural resources and the ability to farm and produce food in the future without reducing the options available for following generations. Many advocates of sustainable agriculture claim that modern intensive agriculture, which includes greenhouse horticulture, has undermined values such as the conservation of the natural resources and the safety of food products that are associated with sustainable agriculture. Such growing environmental interest has prompted several authors to study and propose solutions to improve sustainability with regard to particular aspects of greenhouse systems [5].

In the end, sustainable development is not a fixed state of harmony, but rather a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are made consistent with future as well as present needs.

Working with natural soil processes is of particular importance, as greenhouse systems are designed to take maximum advantage of existing soil nutrient and water cycles, energy flows, beneficial soil organisms, and natural pest controls. So, by capitalizing on existing cycles and flows, environmental damage can be avoided or minimized.

It is common to use kerosene, diesel or propane in power generators in agricultural operations. While these systems can provide power where needed, there are some significant drawbacks, including:

- Fuel has to be transported to the generator's location, which may be quite a distance over some challenging roads and landscape.
- Their noise and fumes can disturb livestock.
- Fuel costs add up, and spills can contaminate the land.
- Generators require a significant amount of maintenance and, like all mechanical systems, they break down and need replacement parts that are not always available.

Other systems, such as solar energy, can provide the same amount of energy needed for agricultural operations within an agricultural greenhouse.

Such systems also aim to:

- Produce food that is nutritious and uncontaminated with pollutants that might harm human health.
- Using a great variety of farming strategies allows producers to meet their needs in their operations, their environments and their communities.

The primary goals of this paper include:

- ❖ Providing a more profitable farm income.
- ❖ promoting environmental direction, including:
  - Reducing dependence on conventional fuel resources.
  - Minimizing adverse impacts on safety, wildlife, water quality and other environmental resources.
  - Promoting stable prosperous farm families and communities to change the life style.

This paper aims to present the economics of producing some vegetable crops under the conditions of greenhouse in the Shalatin area. It also highlighted the importance of replacing conventional fuel by using solar energy in energy production to reduce CO_2 emissions.

2. Methodology:

The research relied on descriptive analysis method as well as simple and appropriate calculation methods for many data and information obtained through the questionnaire for the region. In addition to relying on the scientific sources that dealt with the issue of generating electricity from solar energy. As well as some research data collected through personal interviews with a group of researchers in energy and environment research centres.

Renewable energy resources:

The concept of sustainable agriculture is predicated on a delicate balance of maximizing crop productivity and preserving economic stability, with reducing the utilization of finite natural resources and detrimental environmental impacts [6]. A sustainable agricultural system is based on the prudent use of renewable and/or recyclable resources. A system which depends on exhaustible (finite) resources such as fossil fuels cannot be sustained indefinitely. A sustainable system would use renewable energy sources such as biological, geothermal, hydroelectric, solar or wind. Now, the government moving towards sustainable energy policy making should be characterized by clarity and transparency, where sustainable energy approach promotes renewable energy in the agriculture sector especially in remote or rural areas all over the world where solar energy is available in abundance.

Renewable energy technologies are ones that consume primary energy resources that are not subjected to depletion, for examples solar energy, wind energy, geothermal energy and biomass. Solar energy is the energy derived directly from the Sun. Along with nuclear energy, it is the most abundant sources of energy on Earth, in addition to the sun delivering yearly more than 10 000 times the energy that humans currently use. It's also one of the energy that, in its production or consumption, has minimal negative impacts on human health and the healthy functioning of vital ecological systems, including the global environment which has attracted more attention during recent years [7].

Table (1): Sources of renewable energy in agricultural farms

Energy source	Technology	Size
Solar energy	Domestic solar water	Small
	heaters Solar water heating for large demands	Medium-large
	PV roof grid-connected systems generating electric energy	Medium-large
Wind energy	Wind Turbines (grid-connected)	Medium-large
Hydraulic energy	Hydro plants in derivation schemes	Medium-small
	Hydro plants in existing water distribution networks	Medium-small
Biomass	High efficiency wood boilers	Small
	CHP plants fed by agricultural wastes or energy crops	Medium
Animal manure	CHP plants fed by biogas	Small
Combined heat and power (CHP	High efficiency lighting	Wide
	lighting High efficiency electricity	Wide
	Householders' appliances	Wide
	High efficiency boilers	Small-medium
	Plants coupled with refrigerating absorption machines	Medium-large

As shown in table (1) the sources of renewable energy in agricultural farms [8], the solar energy can be utilized in its varied forms, for example solar PV, direct solar thermal, and renewable fuels and wind can offer the solution to the world's energy problems and ultimately make the environment sustainable for future generations by reducing environmental pollution from fossil fuel energy usage.

3. Result and discussion:

Study Area:

Red Sea Governorate stretches along the coast of the Gulf of Suez and the Red Sea, It is also strategically important in terms of national security for the country. One of the most important areas of the Red Sea are Halayib and Shalateen, which have total Full back desert area about 40,145 km2, in addition to the area populated of approximately 9,601 km2. The three major towns namely Halayib, and Aburmad and Shalateen, it has a moderate climate throughout the year. The area is characterized by soil fertility and on this basis was the orientation to the establishment of greenhouses to provide agricultural crops such as tomato, cucumber and pepper to the people of the region and agricultural development and provide employment opportunities for young people [9].

Even though solar photovoltaic systems are still a very expensive way of producing electricity, they can be the best option for rural areas with no energy system. It is possible that in villages where houses are placed widely apart a solar photovoltaic system would turn out to be cheaper than using a diesel or gasoline drive to produce electricity.

In this paper the importance of solar energy usage shows where the study area is one of the remote areas to use gasoline fuel in the operation of machines in agriculture.

Advantages of using solar energy to secure energy for remote areas:

Most of the remote areas are very far from the transmission and distribution lines of the National Grid for Electricity and Water, which requires the use of solar energy for several advantages:

1. It is able to invest in remote areas and rural areas for a long period of more than 25 years because of the long life time of the systems, and here lies its economic feasibility.

2. There is sufficient space for solar panels to be located opposite cities where such spaces are not available.

3. Ease of installation, lack of maintenance, and do not require the availability of technicians in remote areas.

4. Possibility of using the largest number of solar powered devices without need for storage batteries, which reduces the cost of the operation of these devices during the day only, which are essential in the farm, for example agricultural pumps for watering plantations, fruit and vegetable drying machines, soil sterilization and heating of house, solar cooker, solar heater and simple solar water pump.

5. The system only requires washing the solar panels from dust to increase their efficiency.

6. Do not use traditional energies, so the solar energy project is clean and free of pollution.

7. Solar energy reduces the costs of water and electricity infrastructure in remote areas, as the expansion of these networks and their delivery to

these areas is a very expensive process in the case of the use of conventional energy.

Economic study:

Table (2) Tomato and Cucumber production cost:

Item	Cucumber	Tomato
Investment Cost	23.100 LE	23.100 LE
Variable Cost	28.310 LE	25.525 LE
depreciation of fixed capital cost*	2.310 LE	2.310 LE
Total Variable Cost	30.620 LE	27.835 LE
Total Cost	51.410 LE	50.935 LE
Total Production	135 Ton	90 Ton
Total price	2000 LE/ton	1500 LE/ton
Total price / year	270.000 LE	135.000 LE
Total revenue	218.590 LE	84.065 LE

Source: data were collected and calculated from the questionnaire.

* depreciation of fixed capital cost = 10% from fixed cost.

From the previous table (2), it turned out the following:

- The area unit of the greenhouse is 6 X 40 = 240 M^2.
- The project's life is usually at least 10 years.
- Based on the above, depreciation is calculated by dividing the fixed costs by the number of years of the project.
- The depreciation cost is added to the operational costs of the project to contribute to the recovery of the capital after the end of the period of the project and the approximate half of the value is deducted each loop or any agricultural season twice a year.
- The revenue is accounted here by the value of the product inside the greenhouse farm containing in this study on the 10 lines in the greenhouse.
- the value of production is calculated by multiplying the average amount of expected production per plant by the price of plants in the greenhouse.

Environmental study:

Shalatin (the study area) is one of the cities where diesel fuel generator is used to generate electricity in the greenhouse and it can have an indirect impact on the environment. There are large quantities of fossil fuels to generate electricity that produce gaseous emissions such as carbon dioxide (CO2), nitric oxide (NO), nitrogen dioxide (NO2), and sulfur dioxide (SO2) in quantities directly related to the consumed fuel energy for each greenhouse process. The emission of this hydrocarbons in the atmosphere in large quantities will certainly have a role in contributing to global warming, and thus will have significant negative effects on the impact on the balance of heat and climate change in the city. It is worth mentioning that the study area is surrounded by hills and highlands, which leads to the survival of the exhaust fumes of generators in the absence of air current within the atmosphere of the city, therefore will adversely affect the increase in pollution and climate change and reduce the proportion of green space and lead to the increase of drylands. On this basis, some treatments have been proposed in this study regarding the necessity of adopting the modern techniques in controlling and following production of energy for greenhouse such as the use of solar panels. The combustion of fossil fuels leads to the emission of greenhouse gases, and the exact size of greenhouse gas emissions depends on the type of fuel burned and the type of combustion technology used to burn it. Figure (1) shows that gasoline engines produce the highest CO2 emissions per unit of produced energy, which use natural gas producing the lowest emissions. As already noted, the use of renewable energy technologies makes it possible to reduce greenhouse gas emissions. For example, when biogas is used, emissions of harmful gases (CH4) are reduced more than carbon dioxide.

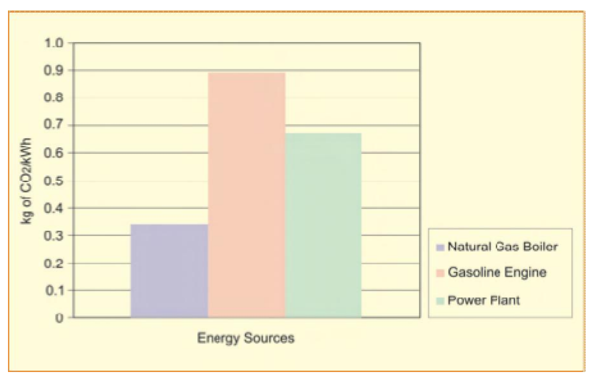

Figure (1) co2 emissions per kwh of electricity or thermal energy produced.

Source: many previous technologies studies.

All greenhouse cultivation systems, regardless of geographic location, comprise fundamental climate control components; depending on their design and complexity, they provide more or less climate control, and condition to a varying degree plant growth and productivity.

Air temperature – as well as solar radiation and air relative humidity – is one of the most important variables of the greenhouse climate that can be controlled. It conditions not only crop development and production but also energy requirements, which can account for up to 40 percent of the total production costs.

The second important variable is humidity, traditionally expressed in terms of relative humidity. Relative humidity within the range of 60–90 percent has little effect on plants. Values below 60 percent may occur during ventilation in arid climates, or when plants are young with small leaves, and this can cause water stress. Serious problems can occur if relative humidity exceeds 95 percent for long periods, particularly at night as this favours the rapid development of fungus diseases [10].

Following the energy crisis of the early 1980s, when limited energy supplies led to the first significant rise in energy prices, greenhouse energy usage became a major research issue. With the recent increased interest in global warming and climate change, the use of fossil fuels is again on the political agenda and many governments have set maximum CO2 emission levels for various industries, including the greenhouse sector [11].

There are two main ways to increase greenhouse energy efficiency:

- reduce the energy input into the greenhouse system.
- increase production per unit of energy.

The challenge is to meet both needs: improved energy efficiency combined with an absolute reduction in the overall energy consumption and related CO2 emissions of the greenhouse industry. Technological innovations must focus on energy consumption for the return to productivity, quality and societal satisfaction.

Table (3) CO_2 Emissions Calculations:

Item	Power (Kwatt/ hour)	Operation Time (hour)	Energy consumed (mega Joule /Day)	gasoline Quantity (litter/Day) (13)	CO_2 Emissions Kg/litter (14)
Irrigation Motor	2.5	2	13.5	0.4	1.072
ventilation fans	2	10	54	1.6	4.288
converter	2	10	54	1.6	4.288
Storage Battery	2.5	3	20.25	0.6	1.608
Total/Day	9	---	141.57	4.2	11.256
Total/Month	---	----	4247.1	126	337.68
Total/ year	---	---	50965.2	1512	4052.16

Source: data were collected and calculated from Intergovernmental Panel on Climate Change (IPCC).

Table (3) shows that, the amount of carbon emissions resulting from the use of a 10 kg/ liter generator for the operation of a variety of machines used for growing vegetables (tomato or cucumber) like (spray motors, ventilation fans, light bulbs, batteries for energy storage…. etc.), reaches 4052.16 kg annually as a result of planting one greenhouse with one vegetable crop. Which may prove the harmful impact of the use of biofuels to the environment, especially in remote areas characterized by the presence of mountains and plateaus, which works to reserve these emissions and increase its concentration.

CO2 Price Forecast:

Synapse Energy Economics is a research and consulting firm specializing in energy, economic, and environmental topics. Since its inception in 1996, Synapse has grown to become a leader in providing rigorous analysis of the electric power and natural gas sectors for public interest and governmental clients.

Based on analyses of some sources described in global reports, and relying on Synapse experience, it has developed Low, Mid, and High forecasts for CO2 prices from 2015 to 2050. In these forecasts the proposed Clean Power Plan together with other existing and proposed. [12]

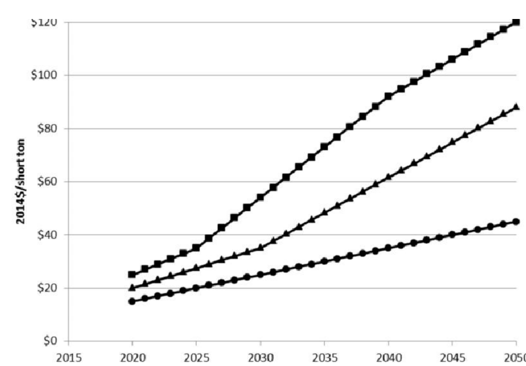

Figure ES - 2: Synapse 2015 CO2 Price Trajectories:

Figure (2) show that, The price of carbon emissions is expected to increase from $ 15 per tonne currently to $ 120 per tonne by 2050 to reduce carbon emissions that have the greatest direct impact on global climate change.

Table (4) shows that the cost of generating 10 kilowatts of solar energy is economically feasible, since the cost of $ 0.91 per day is paid for the costs of the system compared to the traditional power generator (gasoline), which costs $ 5.64 per day, Carbon emissions from fuel combustion caused by generators and pollution of the environment from plants, animals, soil and water as well as their impact on human health, as well as the non-calculation of the costs of transportation of gasoline, periodic maintenance, and extinction.

Table (4): Comparison between the cost ($) of solar power generation with conventional fuel (gasoline)

Items	Price (1) $	The generator's operation costs 10 kW (2)		Total price / year 1+2	Life time (3)		CO_2 Emissions cost (4)	Cost/day= (1+2+4)/3
		Gasoline/month	Gasoline/year		year	Day		
Electric generator	1750	14.805	177.66	1927.66	1	360	101.304	5.64
Solar Energy	8214	------	——	8214	25	9000	-------	0.91

Sources: calculated from previous tables.

Even though solar photovoltaic systems are still a very expensive way of producing electricity, they can be the best option for isolated desert areas with no energy system. It is possible that in communities where houses are spaced widely apart a solar photovoltaic system would turn out to be cheaper than using a diesel or gasoline drive to produce electricity. Regardless of which energy supply is chosen for a desert community (fossil fuel engine, solar photovoltaic system), the main economic issue is whether village residents can afford it. In this regard, existing financial schemes, including micro-financing, need to be evaluated using the criterion of affordability for desert residents.

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