Priority of Reduction Ways for Heating Systems in Yazd Greenhouse

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Abstract

Increasing needs to greenhouse agriculture in the world and increasing the price of energy, reduction of energy used and final value of the products in rivalry, had has influence on managements and researchers. The aim of this paper is to design energy basket for reducing in energy used and showing the properly greenhouse. Until now, many ways regarded for reducing energy in greenhouse. In this paper with combining different ways for energy reduction, a proper way presented that is compound with fossil fuel and new ways. These goals contain, performing cost, the amount of reduction in energy and possibility. This paper used AHP for this purpose and directly it has attention on reduction of price in products of greenhouses.

Keywords
Energy consumption, greenhouse, several aims, preference, energy basket

Introduction
World population and resources they need increase every day. The upper volume of population increases the need for food and agriculture land. In other hand, the suitable land for agriculture is limited and decrease every day. This change caused that agriculture change from ancient ways to modern one, and this shape needs greenhouse and closed space. In greenhouse, the environment should change to profitable condition for growing plant and herb. This matter needs assignment cost and energy. Increasing in costs for energy preparation caused that experts for holding and decrease of producing costs think to decrease energy cost. Reduction in energy cost dose via decreasing fuel and energy consumption, using of proper cover for greenhouses and utilization from new and renewable energy. One issue performs after omitting subsidies in Iran was increasing in actual cost of greenhouse products. Thus, this question engenders that how actual cost deflates. The first and easy way, is managing and reduction in energy consumption, especially fuel energy that used for heating greenhouse. If they can manage energy, it can prospect that actual cost decrease too. Energy has salient increased now and this increasing consist in future and this matter can more influence on actual cost because growing plant needs suitable condition, preparing essential energy and transmission way of it to herb for Photosynthesis, and finally economic producing is very important.

The importance of heating energy in greenhouse is so high that if energy source turn off for a short time about one or two hour in cold condition it can caused destroying plan or frozen them. In this condition, there is no way for saving plant, and farmer suffers extremely loss. Therefore using of energy source has vital role in continuing of greenhouse activity. In addition, of importance of energy consumption and preparing essential energy, it should consider that fossil energy source decrease swiftly and using of it has many difficulties like allotting, increasing price, destroying of heater and so on.

With considering these matters, with adding environment pollution (co_2, co, and other greenhouse gas to them), it can see that greenhouse products are too expensive. Thus base on using solar energy, geothermal energy, phase change material, and heat exchanger systems expanded in the world.

Literature Review

These years greenhouse agriculture increased saliently in Iran. In most cases, growing plant in greenhouse did with imitating from other countries. The low cost of energy in past, caused that farmers and experts think less on energy costs and increasing ways for it, but suddenly increasing in energy price with omitting subsidies caused that in competitor condition, implant of greenhouse product is not economic. This paper in fact had done in Iran condition and with considering greenhouse structure for Yazd province. It survey improvement of fuel consumption in greenhouse of Yazd province and finally offer mean while preference of reduction fuel consumption ways.

Characteristic of an energy axis greenhouse in Yazd province

A greenhouse has five parts: plants, inside air, inside cover, outside cover and external air [1]. Greenhouse performs in various shapes and models but most of greenhouses in Yazd are Quonset or Quonsets greenhouse. A greenhouse with several Quonsets has a similar structure with sails like several cylinders and building is metallic that cover with polyethylene [2]. The most important matter in greenhouse is solar energy. Solar energy observe from different ways, with greenhouse cover, water vapor, plant, soil, and some part of is shown out of greenhouse, that mostly done this ways: reflection from out surface, plant, and soil sheet and reflexive from outside surface when the sun angle is low, early morning and evening[3].

Various ways in different papers discussed for reduction energy consumption. Sharma research offer eight ways for greenhouses energy utilization as below [4]:

Other ways also in various researches surveyed for energy reduction and all of them try to decrease energy in greenhouse anyhow. Shape of greenhouse is one of them that can decrease energy spend. From five-study shape contain, even span, uneven-span, vinery, modified arch and Quonset, the best structure is uneven-span and have most absorb of solar energy [5]. In addition, this kind of greenhouse is better in wasting energy from other shape [6]. Thermal curtain is another way for decreasing energy. Thermal curtain divide greenhouse into two parts and separate plants from upper part of greenhouse and caused that radiation of sun decrease in summer [7]. This way restrict from flow heat inside greenhouse, When heat flow exist in greenhouse, there is waste or absorb heat and when it happen the degree inside greenhouse is more than outside, and vice versa[8].In this place, topics of ventilation of inside greenhouse air are considerable.

Another way for reducing energy consumption is using of mulch in soil coating of greenhouse. Black mulch that has straight relation with soil can cause improvement and effectiveness of storing energy in soil and increase air and soil temperature [9]. Water aquifer used as a source of energy. Water aquifer, in shape of couple cavity heat flow convertor system, use for greenhouse heating or for cooling it. In the case of heating, the cold air of greenhouse during night becomes warm by aquifer water [10]. Because of solar radiation, and Yazd condition this source of energy cannot forget. This rich and endless energy source alone is one of energy factor that incompletely consonant with environment. Photovoltaic greenhouse use solar energy and solar energy change into electricity and heat, that heat transmit to greenhouse and electricity store in solar batteries, batteries are very important and during night it sent stored energy to electrical device[7]. Another way for reducing energy is radial heaters because of ordinary heaters problems this paper do not attention to them. These heaters transfer energy with electromagnet radiation that past in a right way and heat soil and plant and then heat greenhouse air, the main profit of these heaters are reducing energy from other cases and with heating plants instead of air temperature produce steady heating [23].

Using of multilayer greenhouse, reduce energy cost. The greenhouse built in several layer and structure for various layer install inside greenhouse and depend on solar radiation angle. The number of layer change, and it caused that instead of one greenhouse, energy distributed in several greenhouses and the implant volume require for limited space with lower energy than other greenhouse [18].

The combine ways will consider in research, two of them that presented in research are, using phase change materials in north wall. For east-west greenhouse, the maximum radiation falls on north wall. Thus, phase change material takes place in this part and during night with convection and radiation, it comes back to greenhouse [4]. Another way is combination of air exchanger and solar panel, that in this way two system compound, photovoltaic system use for starting equipments and provide require electricity and energy store in batteries for night and operate

blower, and they remain parts is exactly similar of air collector system[x].maybe there was other way for reducing energy for greenhouse in the world but these are the main ways.
Thus in a totality arrangement 17 ways discussed that classify into five groups:

1. Cases that use earth as a source of energy
2. Cases that use sun as a source of energy
3. Cases that change greenhouse or greenhouse structure
4. Cases that use special equipment
5. Cases that improvement energy efficiency and prevent heat escape

This research is important in this way that survey various reduction method for energy consumption in greenhouse with multiple target, prioritize them and then show the better way for reducing energy, this paper choose characteristic of a special greenhouse in energy consumption view, that has lower energy consumption and has been economics. Reducing ways for energy consumption surveyed in literature review. The combination way is important than other ways, this manners are compatible with each other and complimentary of one another, it means they cover their problems and defects. Many ways exit for improvement energy consumption in the world. In the north and cold aria of the world have attention to warming of the greenhouse whereas in warm places, the matter is different and they need cold air for growing plant, but in this paper-warming greenhouse in winter has considered in Yazd. Moreover, other energy needs, as electricity for heat reduction in summer can do in another research.

In the second part, research way and AHP model presented and in the third part the result assess and priority of energy reduction displayed and finally the better greenhouse represented.

Research Way and Model

Because it cannot be considering all parameters in this research, some of them ignored. The first matter related the direction of the greenhouse. In the north hemisphere, the best direction for greenhouse is east-west direction [2]. Thus in this research the orientation of greenhouse suppose east west. This type has the best radiation in winter and less in summer [14]. The equipment used in greenhouse assumes is the best one and have the best energy productivity. The height in all greenhouses is consisting because the height and appearance characteristic has not effect on greenhouse cost. Greenhouse ventilation system is auto. The vast heat and extra moisture is harmful for herb thus it should be a suitable ventilation system in greenhouse up to fix inside air temperature and moisture [16]. One of the problems in greenhouse ventilation is interring the outside air need to increase its temperature to greenhouse degree and moisture, and inside air has high energy that vast with existing [17]. Cover for all greenhouses is two layer polyethylene. The two-layer polyethylene has upper productivity and needs lower energy in comparison to other covers [2]. Thus, this cover discussed for all of greenhouse in this paper. This paper assumed all part of greenhouse is implanted and cost has not related to implant surface.

For choosing the better way for reducing energy three factors have important role, contain economic subject of plan (include the primary cost and incomes), system quality or quality that energy preparation way got it and finally environment pollution and the amount of pollution environment, and in summery they are:
1: quality, 2: environment pollution and 3.benefit on cost.

Because the 17 ways has not remarkable air pollution, the secondary heating systems take for evaluating air pollution. These three factors are the main parameter for decision-making in AHP, it decided to compare 17 ways with three factors, and base on it, the information needs gather. Because of low information, the heat radiator and earth cavity heating system ignored. The AHP model presented in fig.1, as shown, three factors discussed in the upper part and 15 ways compare with three factors. Model for research presented in Figure 1.

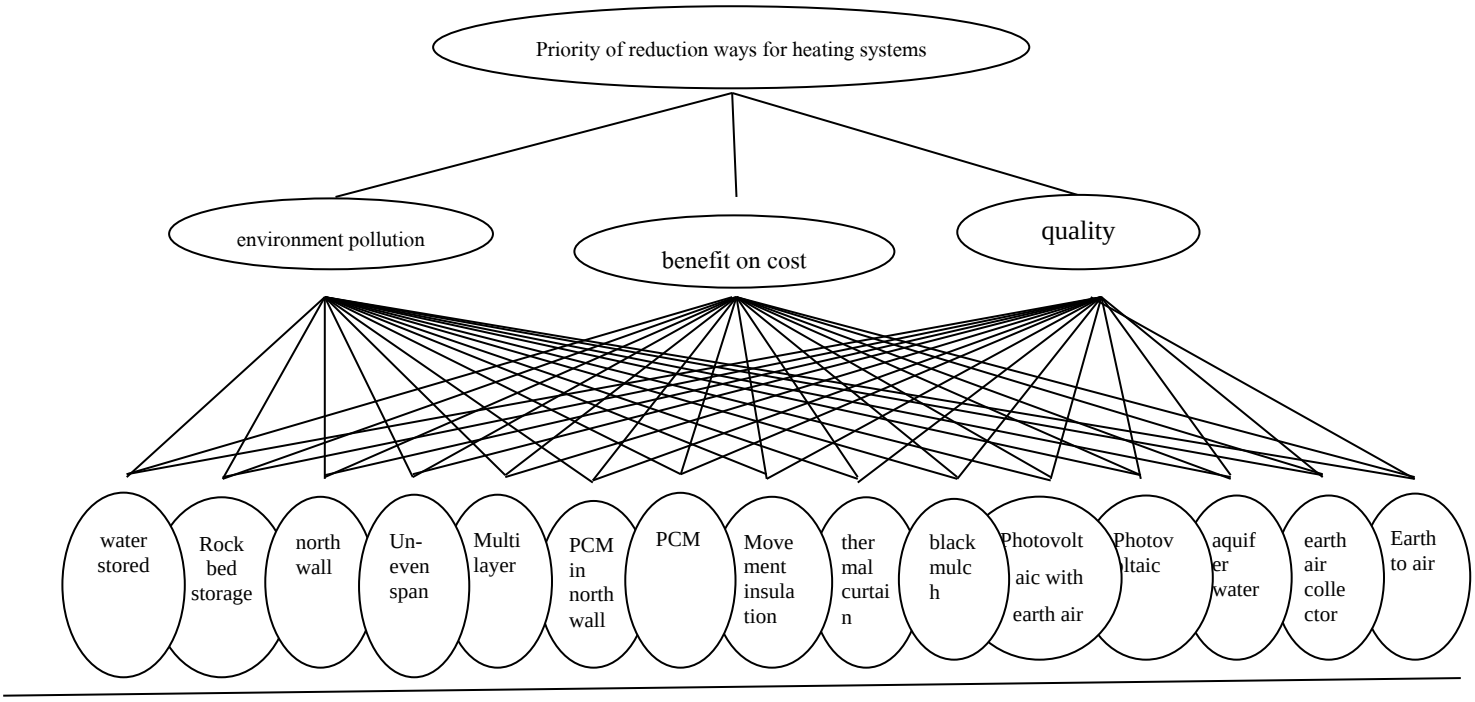

Figure 1: Research model

The Computation Method

Calculation of quality

Quality have important role for choose heating system in greenhouse, and it is important, how a system have profitable action from quality view. Because holding and maintenance is very important in care and fixing equipment and with scheduling, systems have similar effectiveness thus this factor cannot take as quality factor for systems, and what is important for choosing proper energy for place is consistency and stability of it during its work. Thus because greenhouse need consistent temperature during the day, the best characteristic that shows quality is, changing temperature especially accidently changes and it can influence on products quality and actually in influence on volume of produce goods, thus changing in temperature is a quality parameter and standard deviation for air temperature is one of the decision-making basement. Table 1 shows it.

Table 1: Heating and quality number

ID	Heating system for green house	Quality number
1	Un- even span greenhouse	18.7142846
2	Using black mulch	178.8981376
3	Using earth air collector	47.76076117
4	Using aquifer water	22.0987396
5	Multilayer greenhouse	50.91654645
6	Using phase change materials (PCM) in north wall	42.21077428
7	Photovoltaic with earth air collector systems	30.62445954
8	Earth to air systems	23.770389
9	Photovoltaic greenhouse	235.0380505
10	Using water stored	44.01486656
11	Rock bed storage systems	23.51278413
12	PCM	16.58937081
13	Using thermal curtain	15.38864428
14	Building north wall	58.94705019
15	Movement insulation way	16.17603401

Calculating of benefit on cost

Life expectancy of equipment for heating systems is not survey in researches thus rate of return (ROR) is not a profit parameter and instead of it, benefit on cost use for evaluating performance of plans from economic view. Firstly, the cost of creating of each method except structure or building of greenhouse, land, and variable cost of greenhouse and other things, is not related to energy discussed, and calculating perform with elements that papers presented. Value list of manager organization and value list of oil minister department, have used for estimating costs. Calculating benefit perform with this matter that in this greenhouse do not use fuel for heating and the amount of saving in cost take as benefit.

Table 2: Cost values for each system.

ID	Heating system for green house	Benefit on cost
1	Un- even span greenhouse	11.02521945
2	Using black mulch	1.499023817
3	Using earth air collector	0.105862396
4	Using aquifer water	3.852821089
5	Multilayer greenhouse	0.012369454
6	Using phase change materials (PCM) in north wall	0.04771659
7	Photovoltaic with earth air collector systems	0.409967557
8	Earth to air systems	3.457998559
9	Photovoltaic greenhouse	0.881208449
10	Using water stored	0.299381795
11	Rock bed storage systems	9.719472502
12	PCM	0.04771659
13	Using thermal curtain	1.160488919
14	Building north wall	6.481234973
15	Movement insulation way	0.370395739

Calculating related environment pollutions

For evaluating environment pollution, the secondary system considered, and whatever each system depended to secondary System, it has more pollution value for environment. With considering it, because the secondary system works with natural gas (they are ordinary heater), the amount of co_2 produced in each greenhouse calculated by ICCP site information, table 3 shows it.

Source of data	Data provider	Unit	Value	Description	Fuel 2006	Fuel 1996	Gas	IPCC 2006 Source/Sink Category	IPCC 1996 Source/Sink Category	EF ID
2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Tables 1.4 and 2.5	IPCC	kg/TJ	56100	CO2 Emission Factor for Stationary Combustion (kg/TJ on a net calorific basis)	Natural Gas	Natural Gas	Carbon Dioxide	1.A.4.c.i - Stationary	1A4c1 - Stationary	118290

As regards heating needs for each greenhouse, and with presented number in table 4,the amount of co_2 in each way calculated, table 5 show it:

ID	Heating system for green house	environment pollution
1	Un- even span greenhouse	0.7756021
2	Using black mulch	1.5759609
3	Using earth air collector	0.55718
4	Using aquifer water	0.9388703
5	Multilayer greenhouse	0.5706551
6	Using phase change materials (PCM) in north wall	0.4340238
7	Photovoltaic with earth air collector systems	0.32873
8	Earth to air systems	0.3964189
9	Photovoltaic greenhouse	0.5531062
10	Using water stored	0.7765423
11	Rock bed storage systems	0.8179077
12	PCM	0.3835705
13	Using thermal curtain	0.3067937
14	Building north wall	0.4631677
15	Movement insulation way	1.3534649

The above information inserts in AHP software and the result discussed in next section.

Survey Results

Base on presented information in previous section and performing calculation inter to AHP software, and shows the prefer pattern for greenhouse place on warming situation specially in Yazd greenhouse, using of thermal curtain is better than others and phase change material and movement curtain are it the next. Figure 1 shows this result.

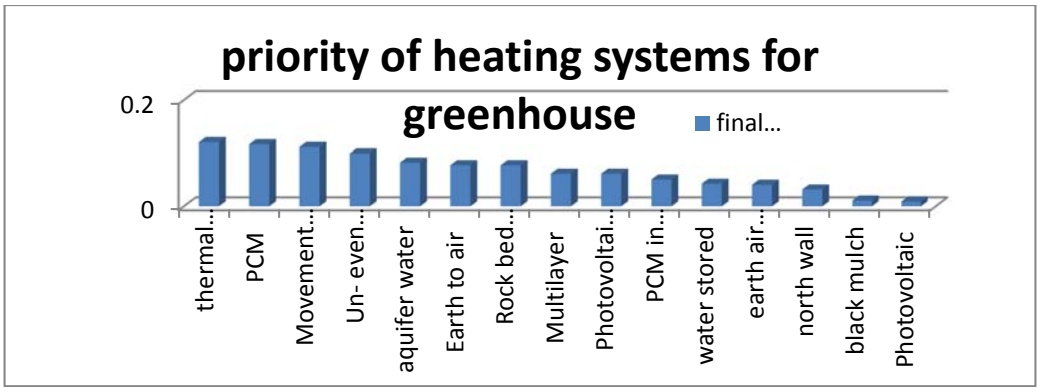

Figure 1: pattern for greenhouse place on warming situation

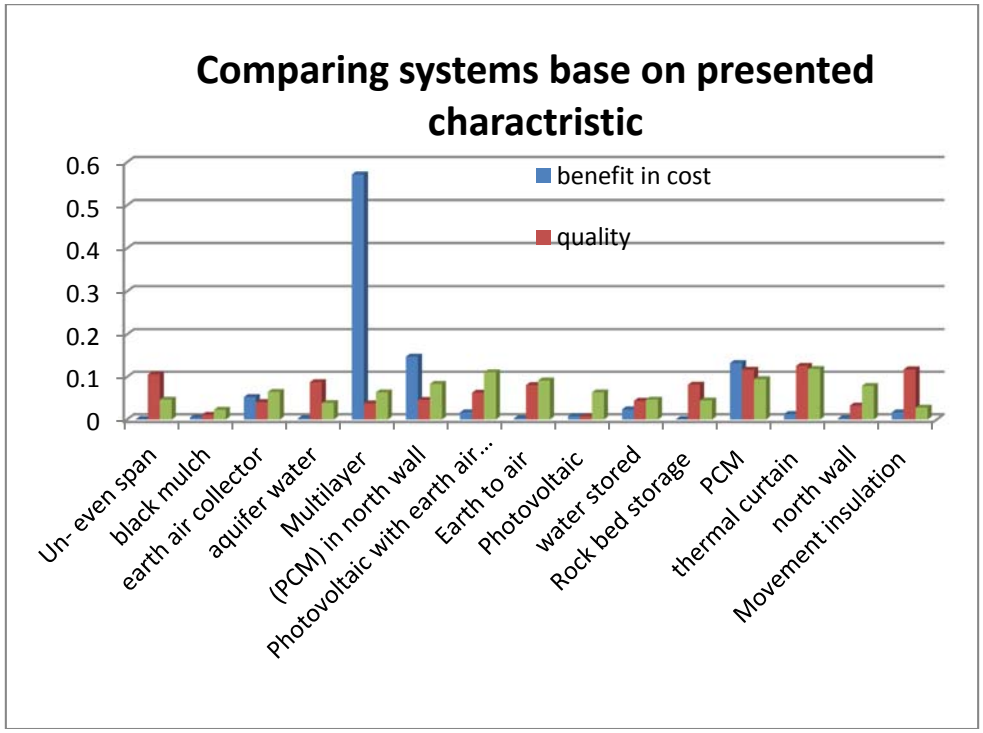

Figure 2: Benefit on cost in several layer greenhouse

As shown in Figure 1 photovoltaic greenhouse is in the last place. If notice to each parameter, Figure 2 resulting. Figure 2 shows that benefit on cost in several layer greenhouse is different from others and it can influence on result thus with considering this fact that multi-layer greenhouse is not first greenhouse selected this greenhouse omit from evaluating and calculation performed again and they have the following result. As result show, with omitting the multilayer greenhouse, little change in result exist and phase change material greenhouse is in first priority.

Resulting

In this paper as shown, various systems for reducing energy consumption in greenhouse surveyed. Finally, 15 systems evaluating for heating greenhouse discussed. This 15 kind are bases on three factors: quality, environment pollution and benefit on cost, these systems compared and the result showed the better systemic greenhouse that use phase change material. Although in calculating, the cost of creating of this kind of greenhouse is higher than other and it is not an economic way, but this kind of greenhouse serves more heating needs for greenhouse and the needs for secondary systems are very lower than other. And heat insert and withdraw in this system gradually, thus changing of temperature in this system is lower from other ways.

For future research in this case offered that combination way evaluate more, as in curves presented photovoltaic greenhouse is in the last row but combination photovoltaic greenhouse has upper place than simple one.

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Biography

Ali Mostafaeipour is an assistant professor of Industrial Engineering at Yazd University, Iran. He has been teaching at Yazd University since 1989. He studied at Winona State University (University of Minnesota) in state of Minnesota, USA; University of Wisconsin at Platteville, Wisconsin, USA; Alabama A&M, Alabama, USA; and Iran University of Science and Technology, Tehran, Iran. He has served as a committee member, guest speaker, and co-chairman of 62 international conferences. He has been reviewer of 17 international journals mainly Elsevier. He has presented 43 mostly International conferences throughout the world. He has undertaken and managed 18 research projects, and holds 3 patents. He has been editorial board of several professional journals. Finally, he has published 21 journal articles mostly at Elsevier (ISI), and authored 4 books. His research interest lies in renewable energies, wind energy, value engineering, economic evaluation, and feasibility study of projects.