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Research Article

BRIGHT PROSPECTS OF BIOGAS IN 2011- 2021 IN ISFAHAN, IRAN

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ABSTRACT
The current study investigated the prospects of biomass in the three fields, environment, economy and employment, analyzed by gathering statistics of the most popular pollutants in Isfahan province during two consecutive years and by studying the population data in the future decade. According to the current study, 28 percent of the province electricity will be met by utilizing the scientific capacity of the biomass, and if thermal usages are considered, 5 percent of the province gas will be also met. In addition, 21 percent of the unemployment problem in the province will be solved by using the environment resources. If the fertilizer from the biogas is utilized, one can reduce the import of chemical fertilizers to the country to 37%, which will prevent to move around 15 million dollars from the country. In the field of environment, we will observe a 90% reduction in the pollutant emission by utilizing the biomass resources. According to the current study, investment on such resources by selling the resulted fertilizer and electricity can be a very good potential in making money in addition to meeting the construction cost.

Keywords: *Biogas, Energy, Economy, Electricity and Gas, Employment*

INTRODUCTION
Organic waste materials as an integral part of the human's life have always made him to find some ways to remove them. One of the most common ways in removing them is land-filling; thereby the gases which are resulted from the process of decomposing these materials go to the environment and atmosphere which the most of it is methane. Controlling and using this gas in the advanced nations allow the use of this gas as a fuel, which is done by different ways (Borsi *et al.*, 2004). Although the use of energy from fossil fuels has a rapid economic growth in different nations, environmental pollutant emission caused by them faced the world to the threatening changes (Yazdandad *et al.*, 2011). In this respect, utilizing biomass to generate energy and reduce environmental pollutants has a specific importance. Biogas is the gas which contains 50-70 percent of methane, 30-50 percent of carbon dioxide and a limited amount of other gases with thermal value of 21-24 MJ/m3 (Bond and Templeton, 2011). This gas can be used to generate heat, warm water as well as electricity with a very lower price than other fossil fuels such as natural gas, Propane and fuel oil (Ahmadpour *et al.*, 2010), and it will lead to save fossil fuels in addition to cheapness (Sartipi, 2009).

Background of Biomass in Iran and the World
The most fundamental history of methane gas from fermentable materials was started by Volta in 1776 (Asadi, 2012). Of course, starting research on anaerobic fermentation and its use in agriculture relates to a person called Dioy. He, in 1808, produced 3.0 liter methane from manure and by using vacuum distillation (Abbasi *et al.*, 2012). After Dioy, Gaon supplied lighting of Paris streets by biogas from biomass energy. In Iran, Mohammad Ebn Hossein Amoli known as Shaych Bahaei was out of the persons who used methane produced by bath sewage as a fuel (Renewable Energy Organization of Iran). After the Islamic revolution, some sporadic activities about biogas have been done, including construction of 10 units of biogas in Sistan and Balouchestan as well as Ilam by IAEA (Yavari *et al.*, 2012).

Study Methodoloy
In the current study, the qualitative and quantitative data of the most common pollutants of the province were first gathered from the municipalities, refineries, Organization of Agriculture Jahad-Isfahan, Organization of Renewable Energies and Statistical Yearbook of Iran in the two consecutive years. Then, according to the existing data, the rate of biogas usable from biomass resources was estimated, and according to it the potential of the resources to generate electricity and gas was calculated. Finally,

according to the practical potential of utilizing biomass resources in the province and comparing it to gas and fossil plants, the environmental, economic effects and employment caused by developing of biogas plants were analyzed.

The Study Area

Isfahan province has about 4.800.000 people from whom 66 percent lives in cities and 34 percent lives in villages. Also, it has an area equals to 107044.3 Km^2 which constitutes 6.6 percent of the country area. This province ends in the north to Markazi, Qom and Semnan provinces, in the south to Fars and Kohgiloyeh provinces, in the east to Lorestan and Chahar Mahal Bakhtiari Provinces. Esfahan Regional Electric Company has 2120288 power consumers, from whom 1702611 consumers belong to the household sector. Power distribution of the province can be observed in the figure 2. Also, the rate of distributed power in the province has been 12507296 MWh in 2011 (the last statistics). In the figure 3, the rate of consuming power was shown according to the type of consumption on the years 2001, 2006 to 2011 in Esfahan regional electricity.

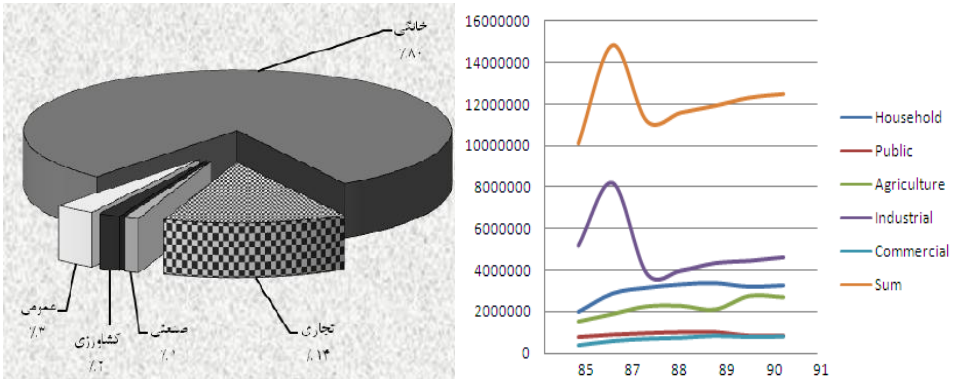

Figure 1: The rate of electricity consuming in Isfahan province according to the type of consumption (MWh) and distribution of the types of power consumers in 2011 (Esfahan Regional Electricity Company, 2011)

Advantages of Biomass Technologies

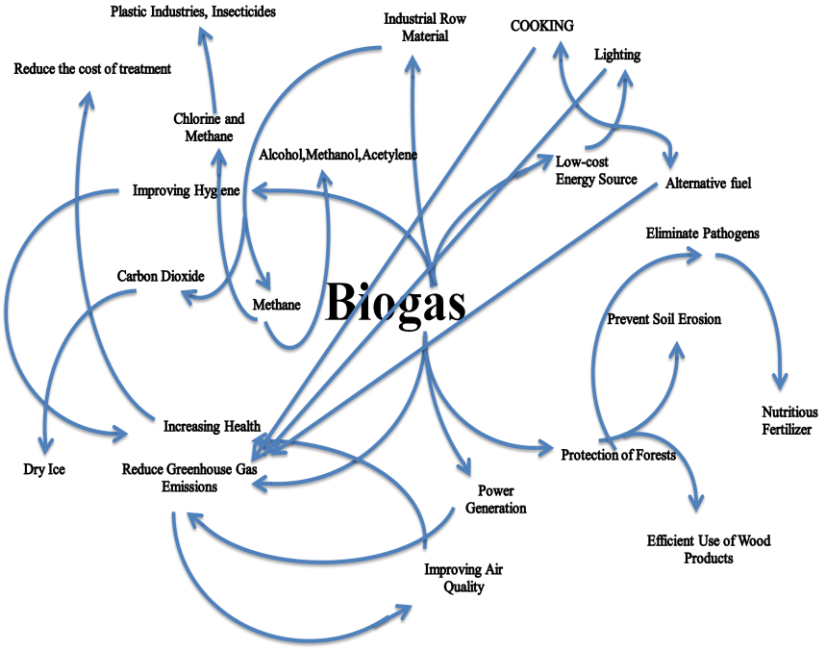

Figure 2: The relationship of biogas advantages with each other (Aslani and Wong, 2014; Meisami and Saeidi, 2009; Monzavi, 2009)

Table 1: Pollutant emissions and the percentage of dry materials versus types (management of waste companies in Isfahan province, 2011; Office of water treatment plants of Isfahan province, 2011; Veterinary Directorate General of Isfahan Province, 2011)

Environmental pollutants of Isfahan province	2011 (kg/year)	Organic dry material (%)
Municipal solid waste (organic)	365421652	20
Sewage	278148177-556296354	25
Livestock waste	3946380000-7103484000	13-16
***Bird droppings**	1839560667	25

** Bird droppings relate to the two types of laying and broiler chickens*

Although each biogas resource is capable to generate methane gas which is usable in different industries, the aforesaid resources in table 1 are more available and allow more to be utilized in order to generate power or other cases such as fuel etc. Due to the different capacity of the environmental pollutants to generate biogas, the volume of biogas generated by each of the pollutants according to the percentage of organic dry materials and the potential of each pollutant to generate biogas is shown in table 2.

Table 2: The amount of biogas generated by organic dry materials and the volume of biogas generated by each resource (Kelly, 1984; Bond and Templeton, 2011)

Environmental pollutants	Daily production $(\frac{\text{kg}}{\text{animal}-\text{person}})$	Amount of biogas produced from 1 Kg of dry organic materials $(\frac{m^3}{kg})$	Maximum amount of biogas produced by the pollutant $(\frac{m^3}{\text{year}})$
Municipal solid waste (organic)	…	0.35-0.5	182710826
Sewage	0.5	0.35-0.5	278148177
Livestock waste	8	0.2-0.3	2131045200
***Bird droppings**	0.8	0.35-0.8	1471648533

Livestock waste and sewage in some resources and tests reached to more than the amount mentioned; in this study the minimum amounts were considered. The mentioned amounts are according to the biogas containing 55% methane.

Economic Analysis of Development of Biomass Energy

Environmental Impacts of Biogas

Emission of the pollutants resulting from biomass combustion is usually less than fossil fuels. Also, using biomass can remove the problems concerning to waste disposal and recycling in other industries including forestry and wood production, food processing and municipal solid waste in urban centers. Biogas production technologies reduce the amount of carbon dioxide released from fossil duels in two ways. First, replacing biogas with solid fuels for cooking and heat generation reduces carbon dioxide. Second, it prevents concentration of carbon dioxide by helping reforestation and improving soil conditions. In the table bellow, a comparison of fossil fuel plants and gas turbine with biogas plants can be seen.

Table 3: Pollutant emission in the types of plants (Koodehi and Karbasi, 2006-2008; Nazari *et al.*, 2009)

Biogas plants	**Fossil fuel plants**			**Gas turbine plants**			**Type of plants**
35-99 $\frac{grco_{2_{eq}}}{kwh}$	1.13 $\frac{kg}{kwh}$			59 $\frac{kg}{kwh}$			Greenhouse gas emissions
	SO_2	NO_X	CO_2	SO_2	NO_X	CO_2	
	2.75 $\frac{gr}{kwh}$	2.4 $\frac{gr}{kwh}$	640 $\frac{gr}{kwh}$	0 $\frac{gr}{kwh}$	2.295 $\frac{gr}{kwh}$	450 $\frac{gr}{kwh}$	

Biogas Potential to Generate Power

Biogas has a special importance in addition to make the environment healthy because this gas is generated without spending any costs. Accordingly, one can consider biogas acceptable, economically. According to the fact that generating electric power from biogas is more economic than direct combustion of biogas, utilizing it will be an important step in power sector. Of course, it is worth to mention that the uses except electrical energy generation will not also be useless. In the table bellow, biogas potential for different uses was estimated.

Table 4: Theoretical and practical potential for the pollutant emissions types (Bond and Templeton, 2011; Management of Waste Companies in Isfahan province, 2011; Office of Water Treatment Plants of Isfahan Province, 2011; Veterinary Directorate General of Isfahan Province, 2011; Kelly, 1984; Souri, 2010)

Practical potential of urban ($\frac{M^3}{Year}$)gas supply	**Theory potential of urban gas ($\frac{M^3}{Year}$) supply**	**Practical producible ($\frac{Mwh}{Year}$)electricity ***	**Theory of producible ($\frac{Mwh}{Year}$)electricity**	**Type of pollutant**
72404024.15	144808048.3	299645.75	599291.5	**Solid Waste**
110223612.7	220447225.4	456163	912326	**Urban sewage**
337793334.8	1688966674	1397965.64	6989828.2	**Livestock droppings**
233271948.4	1166359742	965401.44	4827007.2	**Poultry droppings**
42540597.02	425405970.2	403638.89	4036388.9	**Agricultural wastes****
796233517.1	3645987660	3522814.72	17364841.8	**Total**

** Solid waste and urban sewage due to easier achievement 50% theory, livestock droppings and poultry dropping 20%, agriculture wastes 10% theory due to more difficult achievement (urban gas is actually natural gas)*

*****According to Atlas of Producible Energy from agricultural and woodsy waste***

According to the table 4, theoretical and practical potential to generate electricity and gas from pollutants can be seen in the figures 3 and.

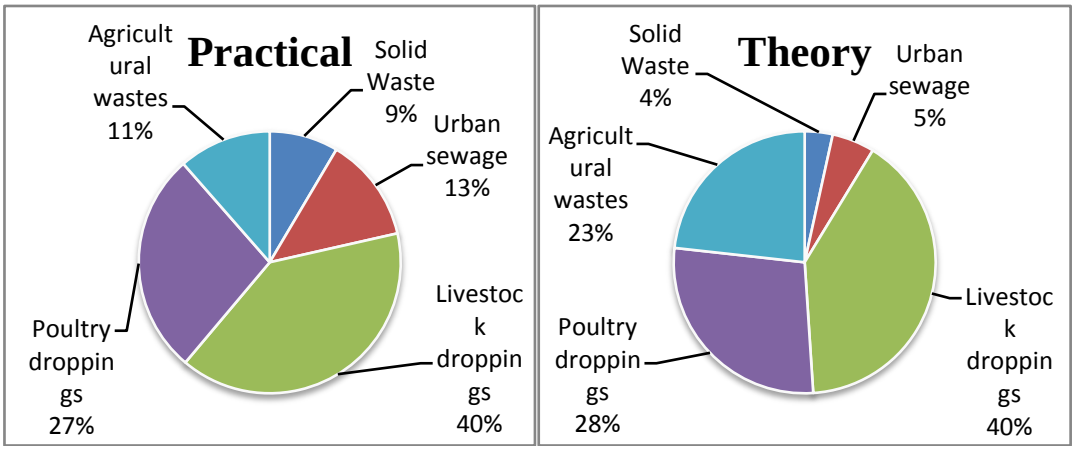

Figure 3: Theoretical and practical potential of the pollutants to generate power (according to the table 4)

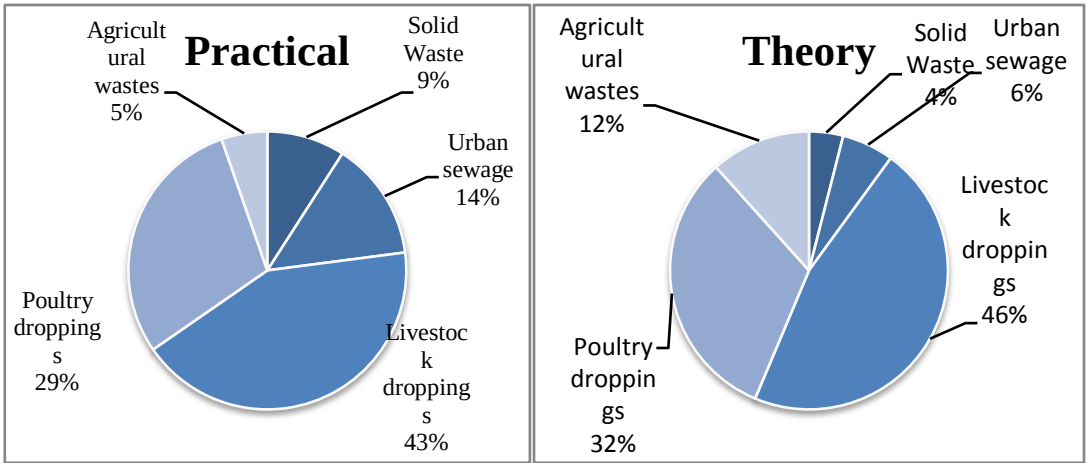

Figure 4: The gas reachable from theoretical and practical potential of the pollutants (according to the table 4)

According to the table 4, if the practical potential of biogas is utilized, reduction of greenhouse gas emissions will be estimated as follow.

Table 5: Environmental impacts of utilizing the practical potential of the pollutants (Koudehi and Karbasi, 2006-2008; Nazari *et al.*, 2009)

Type of pollutant	Reduction of greenhouse gas emissions to fossil fuel plant	Reduction of greenhouse gas emissions to gas turbine plant
Solid waste	308934.7-328112.1	147126.1-166303.4
Urban sewage	470304.0-499498.5	223976.0-253170.5
Livestock droppings	1441302.6-1530772.4	686401.1-775870.9
Bird droppings	995328.9-1057114.6	474012.1-535797.8
Agricultural waste	416151.7-441984.6	204186.7-224019.6
Percentage of emission Plant pollution of biomass plants	Compared to fossil fuel plant 4-9%	Compared to gas turbine plant 6-17%

In the graphs of figures 5 and 6, reduction of the pollutant emissions in the two plants, gas and fossil plants, was compared.

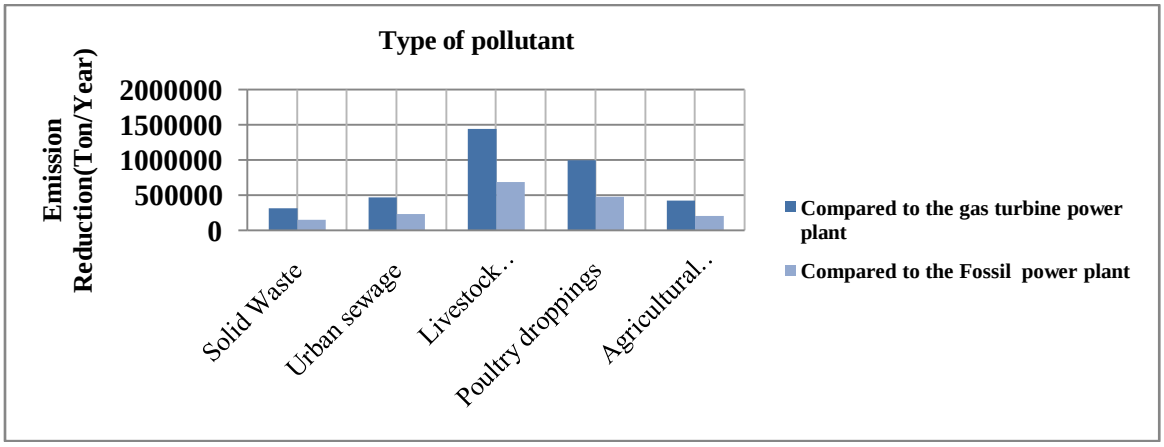

Figure 5: Minimum reduction of greenhouse gas emissions according to the type of the pollutants (Koudehi and Karbasi, 2006-2008; Nazari *et al.*, 2009)

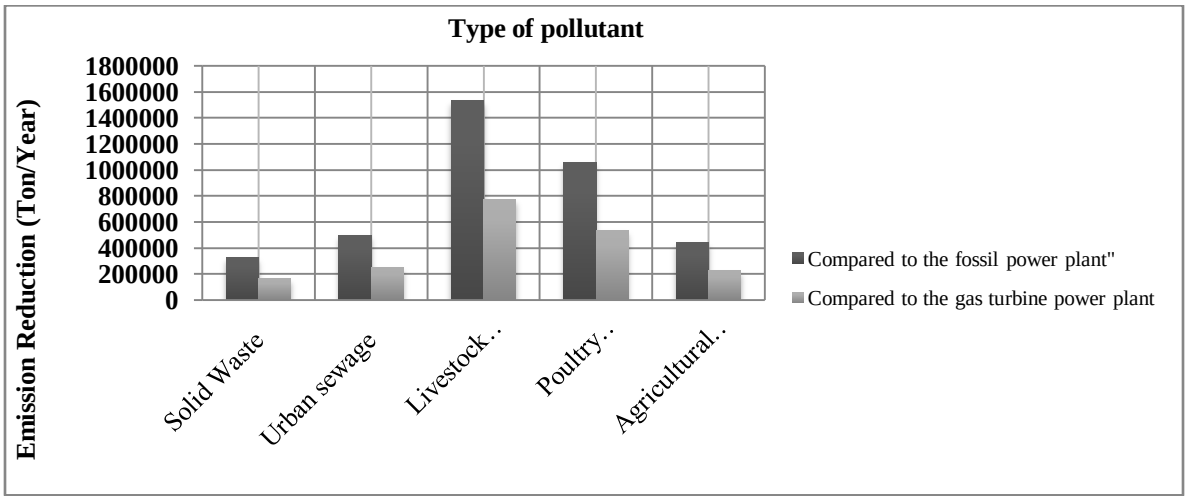

Figure 6: Maximum reduction of greenhouse gas emissions according to the type of the pollutant (Koudehi and Karbasi, 2006-2008; Nazari *et al.*, 2009)

Social Impacts of Biomass

As it was mentioned, not utilizing the biomass resources is a most important factor to accumulate greenhouse gases especially methane in the atmosphere.

According to the aforesaid problems, biomass will have some social advantages in addition to removing economic and environmental pollutions. Creating employment in the places of utilizing biomass energy is one of them, which is impressive compared to other renewable resources.

According to the studies conducted by different organizations, renewable energy resources compared to fossil resources create more employment, which can be one of the reasonable reasons to invest in biomass.

According to the research, in a biomass plant, 33.75 and 101.25 people in a year in the period of 20 year construction and utilization get a job by working 7500 hours to each MW. According to what was said, the results from the rate of employment can be shown in the table 6.

Table 6: Prediction of creating employment, if the practical potential of biogas is utilized (Souri, 2010)

Type of pollutant	Em Eployment during construction $(\frac{\text{Person}}{\text{Year}})$	Employment during utilization $(\frac{\text{Person}}{\text{Year}})$
Solid waste	1350	4050
Urban sewage	2058	6176
Livestock droppings	6277	18832
Bird droppings	4353	13061
Agriculture waste	1822	5467
Total	15860	47586

Production of Natural Fertilizer

According to the country cultivation which is about 16 million hectares, at least 600.000 to 1.000.000 tons of phosphate chemical fertilizer is imported, which is spent 300 million dollars. In this regard, bio-fertilizers can be used to prevent this cost. In addition, studies show that if bio-fertilizer is used, crops will increase 10 to 45 percent. Also, using this fertilizer can reduce application of chemical fertilizer to half or less, which will result in reduction of the destructive effects of chemical fertilizers including carcinogenesis of such fertilizers. According to the amount of pollutants, the amount of bio-fertilizer removable from pollutants is shown in the graph 7.

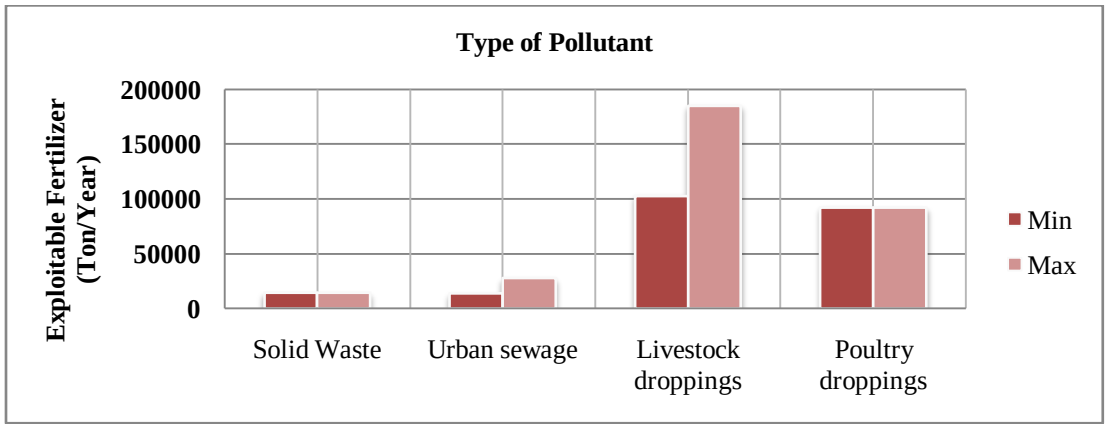

Figure 7: The amount of bio-fertilizers removable from pollutants (Management of Waste Companies in Isfahan Province, 2011; Office of Water Treatment Plants of Isfahan Province, 2011; Veterinary Directorate General of Isfahan Province, 2011)

Economic Advantages of Utilizing Biomass

To evaluate the economic advantages of developing biogas plants, different factors of generating electricity and gas, economical pollutions, selling fertilizer and economic advantages of employment were considered. According to the last information gathered from Statistics Organization of Iran and Regional Electricity Office of Esfahan Province in 2012, the amount of electricity distributed is 12507296 MWh, which the undesirable status of the environment in recent years, increasing the purchase price of electricity of the renewable plants was considered as a motivator to develop such plants. Accordingly, the rate of purchasing electricity from renewable plants by Department of Energy in 2013 was determined 4442 Rials for each KWh electricity. Selling price of gas was also calculated according to the table proposed by National Iranian Gas Company in 2014. According to the aforesaid table, the amount of

selling gas by considering 130 Rials toll in minimum combustion was estimated 490 Rials for each cubic meter. The cost of each kilogram chemical fertilizer was also determined 1350 to 1750 Rials/Kg depending on the type of the fertilizer by Iran Service Company. The cost was obeyed to estimate the economic advantages of bio-fertilizer. According to the studies conducted, in the common plan of the environment group of Department of Energy and JICA Company, for each ton reduction of carbon dioxide 60 dollars, each ton of sulfur dioxide 100 dollars and each ton of nitrogen dioxide 800 dollars must pay as a cost, which these figures was utilized in calculation of the economical benefits of bio-plants. According to the data, the economic benefits of utilizing biomass resources can be seen in the figure 8.

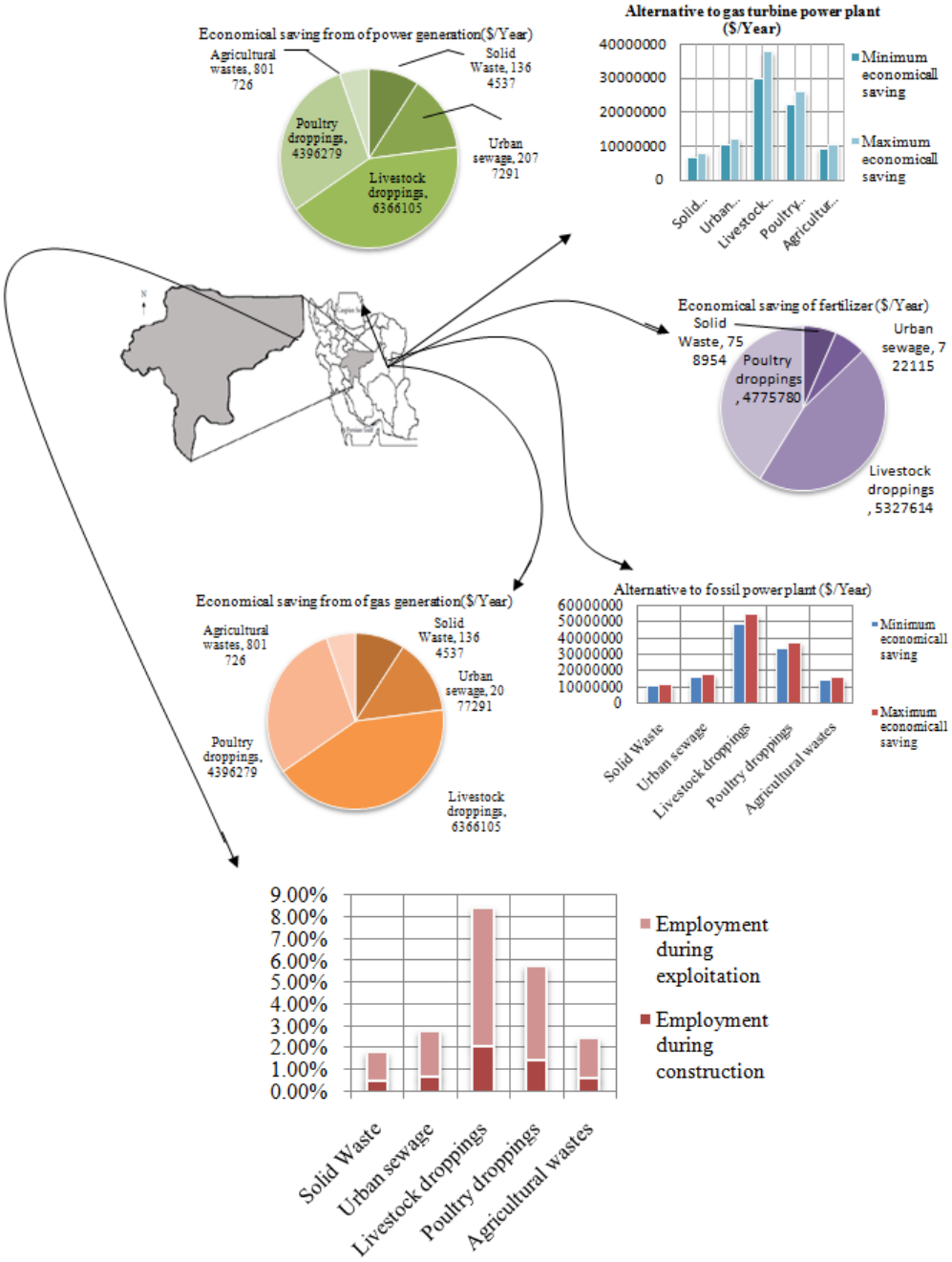

Figure 8: Economical benefits of utilizing biomass in different fields (according to the table 4 to 6; Department of Energy, 2013; Rahimi *et al.*, 2009)

Conclusion

Increasing growth of population, urban development as well as national economy makes it necessary to generate electricity on the country. Currently, about 98% of national electricity is met by fossil fuel plants, which because of limitation of fossil fuel resources and obtaining the environmental criteria for substantial make it necessary to utilize renewable energies. According to the study conducted, livestock droppings will be the most proper resource to utilize biomass energy in Isfahan province. Also, using biomass resources to generate electricity has more economic profit than supplying urban gas.

According to the biomass resources in the province, if practical utilizing it is done, 28 percent of the electricity consuming in the province will be supported, and if it is used to supply urban gas, it will be able to supply 5 percent of the province gas including domestic, industrial and commercial gas. On the other hand, this resource will be able to solve 21 percent of unemployment problem in the province yearly. On the other hand, by importing phosphate chemical fertilizers to the country, 300 million dollars will be spent; utilizing this resource will reduce 4.9 percent of the cost, which equals to 15 million dollars. If the environmental pollutions are considered, according to the pollutant emissions of the plants in Isfahan province which was calculated about 12 million tons, using the technologies to utilize biomass resources, we will observe a 90 percent reduction in the cost.

According to the reports of Renewable Energy Organization of Iran, investment in biomass plants will has a cost of 500 to 4000 dollars/KW, and the cost of generating heat from biomass was estimated 1 to 5 cents, and the cost of generating electricity was considered the same in the calculations. According to the aforesaid information, the cost of utilizing the practical potential of biomass and on the other hand the cost of utilizing, generating and transforming electricity will be about 300 to 1000 million dollars. According to the huge resources of biomass in the province, the income from selling electricity, producing fertilizers and environmental considerations will be 600 million dollars in a year. Considering costs and incomes show that utilizing the resources of the aforesaid energy is not economic in the first year, and after two years will be profitable by returning the investment done. As the bio-energy has potential resources in Isfahan province, investment on it, according to the current study, will have economical benefits. As the current study reveals, biomass resources are available accumulate and sporadically, and include various resources.

As release of such resources in the nature leads to produce water, soil and air pollutants and contain considerable greenhouse gases, it is hoped that by proper planning, the required activities to utilize these resources and develop biomass energy in the province are done and in the next decades it will find a proper place in the energy basket of the province.

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