SCIREA Journal of Environment

http://www.scirea.org/journal/Environmental

March 24, 2019

Volume 3, Issue 1, February 2019

Utilization of Waste Heat And CO_2 In Greenhouses Integrated Into Biogas-To-Electricity Systems That Use Agricultural Wastes: An Integrated Model Approach- A Rewiev

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Abstract

Along with the increasing world population and advancing technology, energy needs increase with each passing day and, consequently, necessitate the search for new energy sources. Increasing energy production has led to environmental pollution that has reached levels that threaten human health. This study proposes a model that can be used to reduce the hazardous waste of a biogas-to-electricity facility. The study suggests utilization of waste CO_2 as a fertilizer and the heat of the waste gas to heat the system as means to avoid energy loss and to reduce harm to the environment. To provide ease of application to mass and energy wastes, in addition to the biogas unit, a greenhouse integrated model was proposed. A green engineering project that uses the maximum amount of natural resources, consumes minimum energy, and obtains maximum mass conversion was presented.

Keywords: Biogas, Energy, Waste Heat, CO_2, Greenhouse

Introduction

Agriculture systems that minimize the risk of pollution and consumption of natural resources (soil, water, and atmosphere) and increase the crop yield are required if we are to leave a sustainable world to future generations.

According to estimations of F. Denhez (2007), unless the necessary measures are implemented, by 2020, the total CO_2 emission is expected to reach 605 million tons with an annual 6.3% increase between 2005 and 2020. If the necessary measures are implemented, the decrease in the total CO_2 emission during the same period is expected to be approximately 75 million tons.

Increasing emission of greenhouse gases as a result of human activities (notably CO_2, CH_4, and N_2O) is commonly considered to be the cause of climate change. Among these gases, carbon dioxide, in particular, raises a serious concern (Ramaswamy 2001). Projects that reduce greenhouse gases are preferred to prevent the danger posed by atmospheric CO_2, which affects various resources (oceanic, geological, biological, etc.) (www.unfccc.de). Article 3.4 of the Kyoto Protocol emphasizes the agricultural role of the CO_2 buildup in tillage and advocates sustainable CO_2-capture methods.

Various studies have been conducted on the effects of fertilizer applications on the carbon balance of agricultural lands. Those studies have adopted carbon inventory methods or simulation modeling approaches (Gong et al. 2009; Mandal et al. 2007; Shen et al. 2007; Triberti et al. 2008). To adopt those approaches, the carbon balance of an ecosystem should be investigated in the light of not only carbon assimilation, but also of various climate conditions and management applications.

Another issue to be factored into greenhouse gas emission is the application of fertilizers on agricultural lands. Unconscious fertilizer use can increase the nitrous oxide (N_2O) amount in soil and affect methane (CH_4) formation (Bowman et al. 2002); an increase of N_2O in soil causes the release of nitrogen compounds into surface and ground waters (Kato et al. 2009).

Furnaces and burned fuels constitute the majority of the main generators of environmental pollution. Flue gases pollute the atmosphere, and the ashes from the burned matter pollute soils and waters. There finally are methods to calculate the dispersion of pollutants in the atmosphere. Economic parameters and methods are of significant importance (Nie et al. 2011); therefore, this paper discusses the utilization methods individually.

Energy needs is an integral part of the universe and dates back to the beginning of human history. Energy demand increases with increasing population and development, different technologies are available to meet the energy demand. In many process, there are both heat and electricity needs. Combined heat and power systems, that producing both heat and power, is required. It is called cogeneration technology. Cogeneration systems runs smoothly with many energy and heat applications (Adıgüzel et al. 2015)

Climate change is located among most dangerous environmental problems in the world (Terwel, et al. 2009) One of the most important reasons is greenhouse gas emissions GHG. Generally GHG emissions are considered on wrong agricultural practices (Johnson et al. 2007a; Zhang et al. 2014; Qiaoet al. 2012; Smith et al. 2007; Linquist et al, 2012; Hou et al. 2000; IPCC 2007; Wood and Cowie 2004; Kongshaug 1998; Houghton et al. 1996; Houghton et al. 2001; Reicosky et al. 2000; US EPA 2005; Weiske and Petersen 2006; Frye 1984) and industrial sources (Phillips et al. 1980; Archer et al. 2002; UNESCO and SCOPE 2007; Hoffert et al. 2002; Hirsch 2006)

The holistic view of the Life Cycle Assessment (LCA) can help to measure the natural balance of changes in a power generation system. A decrease in the value of the greenhouse emission will not lead to an increase in the environmental impact. Previous LCA studies have examined the life cycle performance of various power plant configurations by means of alternative CO_2-capture systems, transportation, and injection methods (Akai et al. 1997; Fiaschi et al. 2000; Doktor et al. 2001; Lombardi 2003; Koornneef et al. 2008; Pehnt and Henkel 2009; Singh et al. 2010). The waste heat and CO_2 emissions of many processes have brought along various negative effects on the environment and, therefore, researchers worldwide have tried to develop methods for heat recovery and reduced CO_2 emission (Bisio 1997; Akiyama et al. 2000; Yu et al. 2009; Andoet al. 1985; Xu et al. 2007; Mizuochi et al. 2001; Akiyama et al. 2000; Xie et al. 2005; Kashieaya et al. 2010).

As a result of anaerobic degradation, 50–80% CH_4 (methane); 20–50% CO_2 (carbon dioxide); and small quantities of gas mixtures containing hydrogen, carbon monoxide, nitrogen, oxygen, and hydrogen sulfide are formed (Speece 1996). This biologically produced gas is called biogas, and its composition varies with raw materials and ambient conditions. The calorific value of a biogas containing 99% CH_4 (natural gas) is 37.3 MJ/m^3, and the calorific value of a biogas containing 65% CH_4 is 24.0 MJ/m^3 (Staffort 1980).

This study proposed a process that showed that the waste greenhouse gas and heat from a biogas-to-electricity system could be used in the greenhouse that was integrated into the system. The contribution and losses of the process were discussed theoretically, and the environmental impact of the process was investigated. The proposed process was compared with the literature.

Recommendations and Conclusions

Modeling approaches to assess the impact of environment and air pollution:

The system that was proposed to utilize the waste heat and CO_2 from the cogeneration unit of a cattle farm with a capacity is illustrated in Figure 1. The usability of the wastes from the system can be discussed under two main categories. The biogas, electricity, and CO_2 that can be obtained from a farm containing 1.000 cattle are calculated below.

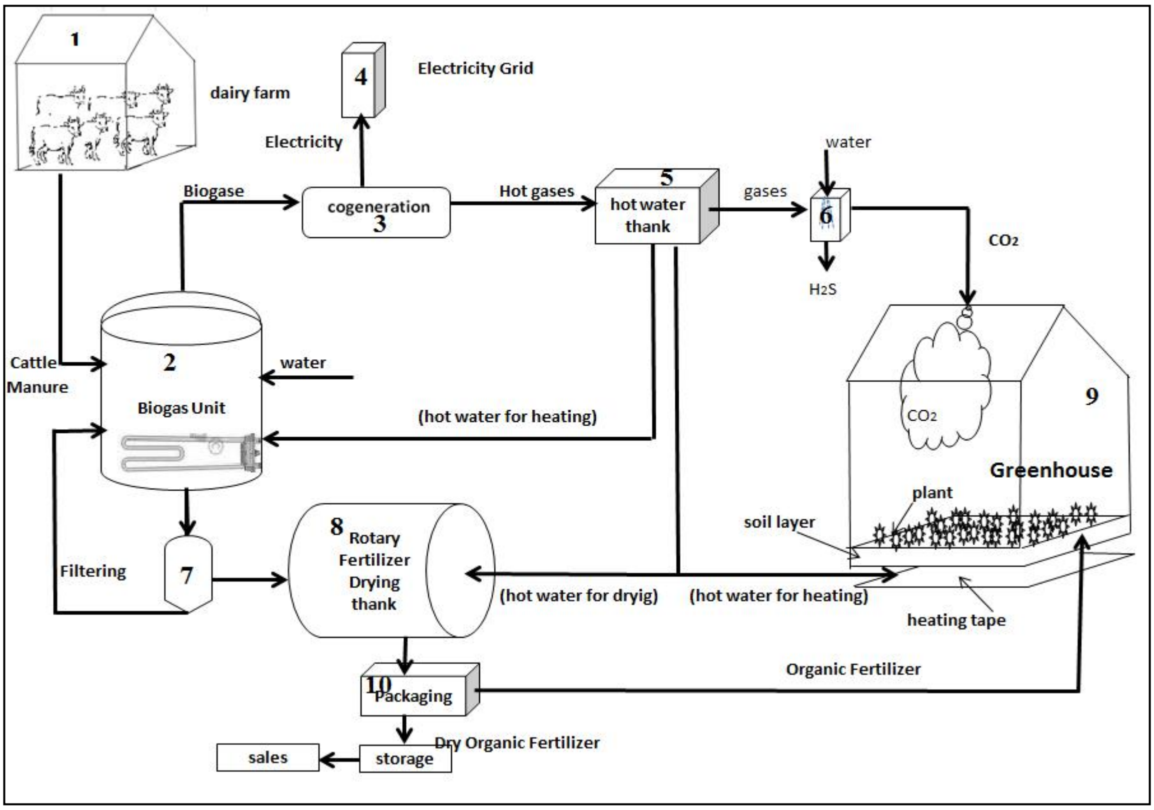

Fig.1. Placement of farm greenhouse and biogas systems in the process.

The importance of the process in the prevention of CO_2 emission

Table 1. Biogas plant and coal equivalent capacity by the number of animals (Fatma,2011).

Animal	Animal Number	Age Fertilizer amount	Biogas amount	Coal equivalent

	(Piece)	(Tons / year)	(m3/year)	(Tons / year)
Beef	11.054.000	39.794.400	1.313.215.200	1.181.894
Sheep Goat	38.030.000	26.621.000	1.544.018.000	1.389.616
Chicken Turkey	243.510.453	5.357.230	417.863.937	376.078
Total	292.594.453	71.772.630	3.275.097.137	2.947.587

Table 1. shows that Biogas plant and coal equivalent capacity by the number of animals. Under normal conditions, the burned methane and the resultant CO_2 are both gases, and their mole numbers are equal to each other. Therefore, combustion of 500 m^3/day methane results in 500 m^3/day CO_2. This is a serious amount in terms of air pollution. The importance of carbon dioxide in plant growth is an indisputable fact. Introducing that nutrient into the plant growth medium considerably increases plant growth. In plant growing, carbon dioxide in addition to that required by plants can be artificially given to plants by different methods to increase the yield (Tezcan 2011). Many studies have reported the positive effect of CO_2 on plants (Aktaş 1995; Ay, 2010; Sevgican 1989; Peet and Wolfe 2000; Wurr and Hand 1998).

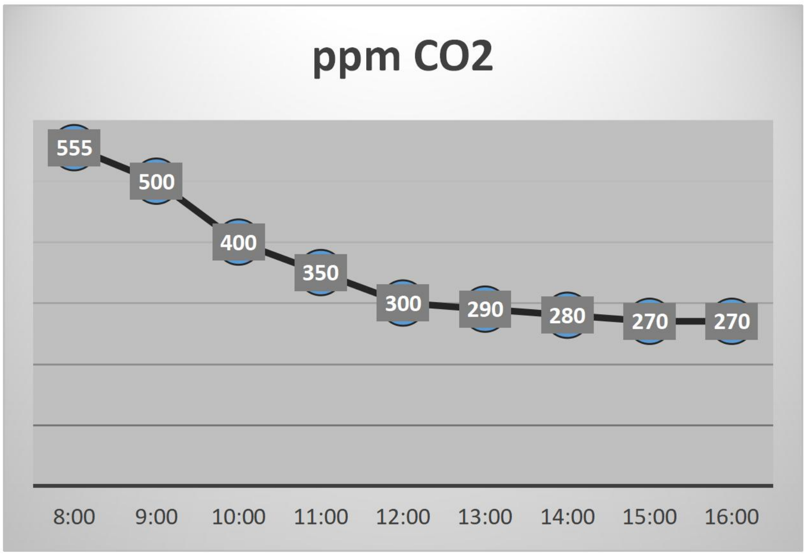

Fig.2. The presence of CO_2 inside the greenhouse in photosynthesis under light.

Figure 2 shows the average CO_2 level in a day in a banana greenhouse between the hours of 9:30 and 15:30. No extra process step was followed in the greenhouse. The CO_2, which increases in the morning as a result of plant respiration during the night, gradually decreased with sunrise and the onset of photosynthesis (Özsayın 2009; Zhang et al. 2014).

The average CO_2 level in the outdoor environment is 300–600 ppm, whereas the CO_2 levels can reach 800–1500 ppm in a plant growth environment, an amount that is 3 to 6 times higher than that of the outdoor environment. Ultimately, the increase in the carbon dioxide amount results in faster and greater plant growth. A 100–200% increase in plant growth can be obtained with increased CO_2 amounts. The genetic structures of plants cause different reactions to CO_2 fertilization. Although some studies showed that there were differences among varieties, the average increase in the yield is approximately 50–55% (Okay and Demirtaş 2007).

The utilization of the resultant waste (CO_2 and heat) of biogas production from animal waste is of great importance, both for economy and for prevention of environmental pollution. The hazardous effect of greenhouse gas release on the environment is a known fact, but using greenhouse gases at specific rates as plant fertilizers in greenhouses can help to utilize the otherwise-harmful CO_2 as a beneficial material in plant growth (The CO_2 requirement during photosynthesis can be met with the waste CO_2, and using the compost organic fertilizers to meet the fertilizer requirement in the greenhouse can increase the plant yield. Integrating greenhouses, which utilize the fertilizer, CO_2, and waste heat, into facilities that produce biogas, electricity, and fertilizer from animal wastes will enable obtaining economic gain from those wastes.

Importance of waste-heat utilization

A system that only produces electricity with a simple cycle and uses the heat energy obtained from fuel combustion in boilers has a low efficiency. Considering the high fuel prices and the consequent increase in electricity prices, the combined use of electrical energy and heat energy and/or obtaining energy from cogeneration systems are a must.

Certain conditions are required to produce electricity from biogas:

1. The temperature of the fermenter should be kept at 30 °C. The temperature of the fermenter should be kept at 30 °C to allow biogas formation. The heat obtained from waste gases can meet the energy requirement of this process.

2. The heat obtained from 1 m^3 of biogas (4700–5700 kcal/m^3) is equal to 4.70 kWh of electrical energy and results in $47x10^5$ kcal/m^3 of heat output.

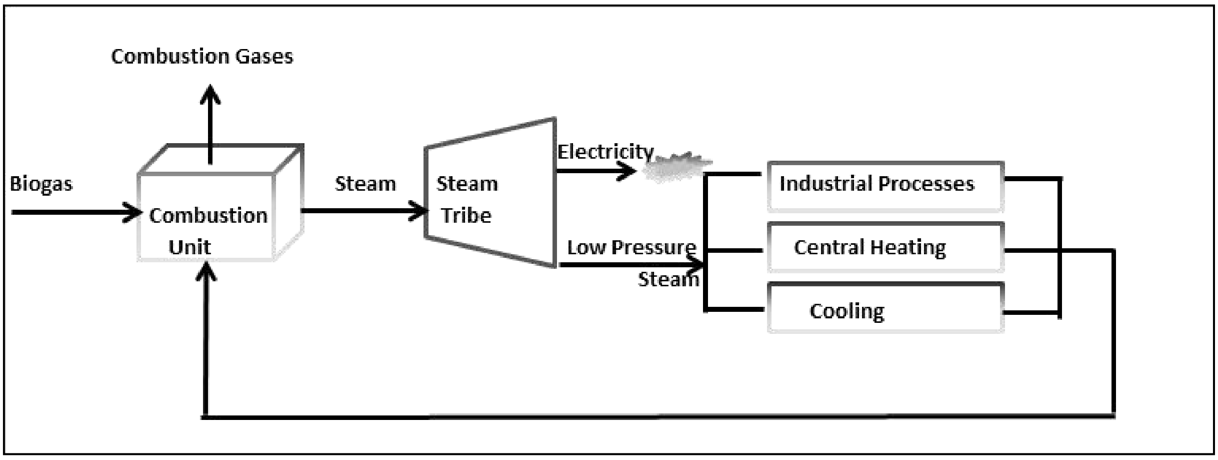

Fig.3. Schematic representation of process that obtained electricity and heating from combustion unit.

This heat can be used to meet the heat requirement of the system. Figure 3 represents the process schematically. (This transfer is dependent on the specific heat of the heating fluid and the transfer coefficient of heating pipes; heat loss should also be considered.) The energy loss of the system can be reduced further by choosing the pipe material according to the heat transfer coefficients of the pipes carrying the water of the system. The heat value of the generator has a critical role in effective biogas production. The optimum temperature is 30–35 ºC. To maintain such a high temperature, cold zones should especially be heated, which, in turn, incurs an additional cost. Biogas production is usually hindered at ambient temperatures below 10 ºC (Olgun 2009).

This is the point at which the utilization of the waste gases of combustion becomes an important issue. The efficiency of a waste heat recovery system is directly associated with the amount and heat content of the gas released into the atmosphere. The gases released at 450–530 °C by simple-cycle gas turbo-generators are passed through heat exchangers to obtain additional heat and/or electrical energy by lowering their temperatures to 100–50 °C and thus to obtain an increase in the total cycle efficiency from 30% to 45–75%.

Here, QH and QL are in Kcal/kg units. C, H, S, and W are weight % in the fuel. The waste heat from the process will be used to heat the fermenter tank, dry the fertilizer, and heat the greenhouse. The heating cost of a greenhouse is the main factor that affects its profitability. In recent years, this type of integrated processes has been preferred in Turkey and other countries for being low in cost and environmentally friendly (Chen et al. 2015; Vadiee and Martin 2013; Bot 2001; Chau et al. 2009; Sethi and Sharma 2008; Chou et al. 2004; Nayak and Tiwari 2010; Ozgener and Hepbasli 2007; Benli and Durmus 2009; Lee et al. 2013).

Therefore, the use of renewable energy sources in greenhouse heating has gradually become widespread. Along with the current technological developments in greenhouse heating systems, new processes that offer solutions regarding the issues in operating the systems are required. This positive development will have an important role in the prevalent use of these systems.

3. As an important step in terms of plant quality and environment, another waste will be utilized by using the compost organic waste (as an organic fertilizer) of the biogas unit in the greenhouse. This is a very important step for plant quality and environment pollution. This is a fertilizer that has high agricultural value (Fixen and Johnston 2002; Oenema et el. 2001; Velthoff et al. 2003)

And GHG emissions that are arising from chemical fertilizer utilization (Johnson et al., 2007; Reicoskyet al. 2000; CAST 1992; Jarecki and Lal. 2003; Lassey 2007; IPCC 2001; Etheridge et al. 1998; Oenema 2001) are avoided.

This project offers the requirements expected from an engineering project, which should include maximum natural resource use, maximum conversion rate, and minimum energy consumption. By utilizing the harmful wastes (feces to fertilizer and biogas and biogas to energy, fertilizer, and CO_2) while releasing minimum harmful waste, this system can be regarded as an important process for green engineering.

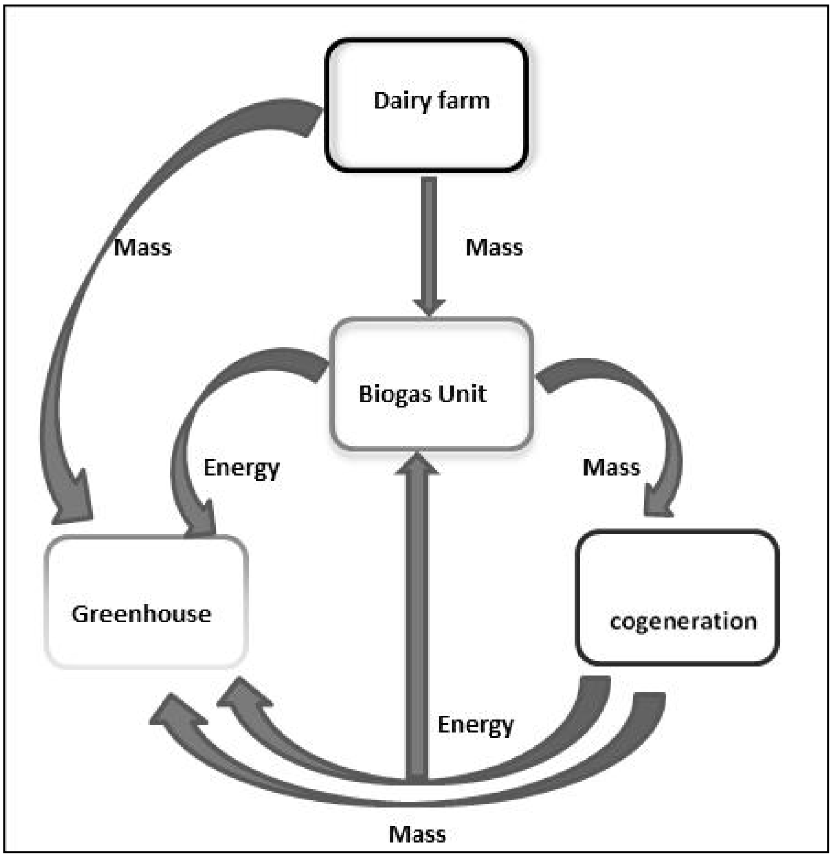

Fig. 4. The movement of mass and energy in the process

Figure 4 shows the mass and energy flows in the system. As the figure shows, by using the produced energy in almost every step of the system, waste energy was minimized. Furthermore, harmful mass wastes such as CO_2 and fertilizer were first converted to energy and then used as natural fertilizers to obtain maximum efficiency from the waste. When the entire system is considered, the mass waste is advantageous in terms of mass and energy efficiency. Figure 4 shows that the system operates as if it is a cycle of its own.

The project embodies various advantages, such as reduced global warming and greenhouse gas release, prevention of air pollution, increased energy efficiency and recovery, avoidance of fossil fuel use, contribution to employment opportunities, introduction of a new product, and a different and feasible system.

Specific contributions of the process are:

1- A way to produce agricultural products for longer periods in regions such as Turkey and Siberia, where winters are longer,
2- Significant prevention of carbon dioxide emission from biogas,
3- Minimization of energy loss due to waste gases from combustion,

4- A process that is profitable with its maximum mass and energy efficiency and minimum harmful waste formation if the other losses of the system are ignored (win-win),

5- Efficient utilization of the animal wastes of the system as natural fertilizers at the beginning,

6- Avoidance of environmental pollution due to animal waste, and

7- Substantial reduction of the costs of heating the biogas tank, drying the fertilizer, and heating the greenhouse.

In conclusion, this project is feasible in regions where the agricultural period is shorter and continental climate is common, because it prolongs the agricultural period by using the waste heat of the system to heat the greenhouse. This project will significantly contribute to the economy by utilizing the wastes of agriculture, animal breeding, and energy production activities.

References

1) Adıgüzel, ,N.,Ö. Çomakli, İ. Ekmekci, S. Pusat. 2015. Economical evaluation of a cogeneration system for a building complex. Advances in Mechanical Engineering, 1–7.
2) Akai, M., N. Nomura, H. Waku, M. Inoue. 1997. Life-cycle analysis of a fossil-fuel power plant with CO2 recovery and a sequestering system. Energy. 22: 249-255.
3) Akiyama, T, K. Oikawa, T. Shimada, E. Kasai, J.I. Yagi. 2000. Thermodynamic analysis of thermochemical recovery of high temperature wastes. ISIJ Int. 40: 286–91.
4) Akiyama, T, T Shima, T. Kasai, J.I. Yagi. 2000. Feasibility of waste heat recovery from molten slag. China–Jpn Int. Acad. Symp. 53–65.
5) Aktaş, M. 1995. Bitki Besleme ve Toprak Verimliliği. Ankara Üniversitesi Ziraat Fakültesi Yayınları: 1202, Ders Kitabı: 347 s.
6) Ando, J., T. Nakaha, H. Onous, S. Tchimura, M. Kondo. 1985. Development of slag blast granulation plant characterized by innovation of the slag treatment method, heat recovery, and recovery of slag as resources. Mitsubishi Heavy Indust. Techn. Rev. 87: 136–42.
7) Archer, D.W.,J.L. Pikul, W.E. Riedell. 2002. Economic risk, returns and input use under ridge and conventional tillage in the northern Corn Belt, USA. Soil and Tillage Research ,67:1-8.
8) Ay, E. 2010. Hava Kirliliği ve Modellemesi, Sakarya Üniversitesi Fen Bilimleri Enstitüsü Çevre Mühendisliği Bölümü, 110s.

9) Benli, H., A. Durmus. 2009. Evaluation of ground-source heat pump combined latent heat storage system performance in greenhouse heating. Energy Build. 41:220–228.
10) Bisio, G. 1997. Energy recovery from molten slag and exploitation of the recovered energy. Energy. 22(5):501–9.
11) Bouwman, A.F. , L.J.M. Boumans, N.H. Batjes. 2002.Emissions N2O and NO from fertilized fields: summary of available measurement data. Global Biogeochem. Cycles. 16 :1058.
12) Bot, G.P.A. 2001. Developments in indoor sustainable plant production with emphasis on energy saving. Comput Electron Agric. 30:151–65.
13) CAST,1992. Preparing U.S. Agriculture for Global Climate Change, Task Force Report No. 119, Council for Agricultural Science and Technology, Ames, IA
14) Chau, J.,T. Sowlati, S. Sokhansanj, F. Preto, S. Melin, X. Bi. 2009. Economic sensitivity of wood biomass utilization for greenhouse heating application. Appl Energy. 86:616–21.
15) Chen, J., F. Xu, D. Tan, Z. Shen, L. Zhang,Q. Ai. 2015. A control method for agricultural greenhouses heating based on computational fluid dynamics and energy prediction model. Applied EnergyVolume. 141(1):106–118.
16) Chou, S.K., K.J. Chua, J.C. Ho, C.L. Ooi. 2004. On. the study of an energy-efficient greenhouse for heating, cooling and dehumidification applications. Appl Energy. 77: 355–73.
17) Çanka Kılıç,F. 2011. General Outlook of Biogas, The Importance of Its Usage, And Biogas in Turkey. Mühendis ve Makine, Vol. 52 (617) ,pp. 94-106
18) Denhez, F. 2007. Küresel Isınma Atlası, NTV yayınları, İstanbul, 82s.
19) Doktor, R.D., J.C., Molburg, N.F. Brockmeier, M. Lynn, G. Victor, R. Massood, J.S. Gary. 2001. Life-cycle analysis of a shell gasification-based multi-product system with CO2 recovery. Proc. 1st Nat. Conf. Carbon Sequestration, Washington, D.C., USA.
20) Etheridge, D.M., L.P. Steele, R.J Francey, R.L. Langenfields. 1998. Atmospheric methane between 1000 A.D. and present: evidence of anthropogenic emissions and climate variability. Journal of Geophysical Research, 103: 15979-15993.
21) Fiaschi, D.,L. Lombardi, G. Manfrida. 2000. Life cycle assessment (LCA) and exergetic life cycle assessment (ELCA) of an innovative energy cycle with zero CO2 emissions. Proc. 5th Int. Conf. Greenhouse Gas Control Technologies, Cairns.
22) Fixen, P.E., A.M. Johnston. 2002. Nutrient budgets in North America. In: Plant Nutrient Use in North American Agriculture: Producing Food and Fiber, Preserving the

Environment, and Integrating Organic and Inorganic Sources. PPI/ PPIC/FAR Technical Bulletin 2002(1):79–87.

23) Frye, W.W.1984. Energy requirements in no tillage. In: Phillips, R.E., Phillips, S.H. (Eds.), No-tillage Agricultural Principles and Practices, Van Nostrand Reinhold, 127-151.
24) Gong, W., X.-Y. Yan, J.-Y. Wang, T.-X. Hu, Y-B. Gong.2009. Long-term manuring and fertilization effects on soil organic carbon pools under a wheat–maize cropping system in North China Plain. Plant Soil. 314 (2009):67–76.
25) Hirsch, A.I., A.M. Michalak, L.M. Bruhwiler, W. Peters, E.J. Dlugokencky, P.P. Tans. 2006. Inverse modeling estimates of global nitrous oxide surface flux form 1998–2001, Global Biogeochem. Cycl.,20.
26) Hoffert, M.I., K. Caldeira, G. Benford, D.R. Criswell, C. Green, H. Herzog, A.K. Jain, H.S. Kheshgi, K.S. Lackner,J.S. Lewis, H.D. Lightfoot, W. Manheimer, J.C. Mankins, M.E. Mauel, L.J. Perkins, M.E. Schlesinger, T. Volk, T.M.L. Wigley. 2002. Advanced technology paths to global climate stability: energy for a greenhouse planet. Science. 298:981-987.
27) Hou, A.X., G.X. Chen, Z.P. Wang, O. Van Cleemput, H.W. Patrick. 2000. Methane and nitrous oxide emissions from a rice field in relation to soil redox and microbiological processes. Soil Sci. Soc. Am. J. 64:2180–2186.
28) Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. Van Der Linden, X. Dai. 2001. Climate change 2001: the scientific basis, vol. 881. Cambridge: Cambridge University Press;
29) Houghton, J.,T. Meiro, L. Filho, B.A Callander, N. Harris, A. Kattenburg, K. Maskell. 1996. Climate change 1995: the science of climate change: contribution of working group I to the second assessment report of the Intergovernmental Panel on Climate Change, vol. 19390. Cambridge University Press;
30) IPCC,2007. Climate change 2007. mitigation of climate change. In: Metz B, Davidson OR, Bos PR, Dave R, Meyer LA, editors. Contribution of theWorking Group III to the Fourth Assessment report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Cambridge University Press..
31) IPCC, 2001. Climate change 2001: the scientific basis. In: Houghton, J.T., Ding, Y. (Eds.), Noguer, M., van der Linden, P.J., Dai, X., Maskell, K. (Eds.), Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K. and New York, NY, USA, 881.

32) Jarecki, M.,R. Lal. 2003. Crop management for soil carbon sequestration. Critical Reviews in Plant Sciences. 22:471-502.
33) Johnson, J.M.F., A.J. Franzluebbers, S.L. Weyers, D.C. Reicosky. 2007a. Agricultural opportunities to mitigate greenhouse gas emissions. Environmental Pollution. 150:107-124.
34) Kato, T., H. Kuroda, H. Nakasone.2009 Runoff characteristics of nutrients from an agricultural watershed with intensive livestock production. J. Hydrol. 368 (2009):79–87.
35) Kashieaya, Y, I.N. Yutaro, T. Akiyama.2010. Development of a rotary cylinder atomizing method of slag for the production of amorphous slag particles. ISIJ Int. 50(9):1245–51.
36) Koornneef, J., T.V. Keulen,A. Faaij, W. Turkenburg. 2008. Life cycle assessment of a pulverized coal power plant with postcombustion capture, transport and storage of CO2. Int. J. Greenhouse Gas Control. 2(4): 448–467.
37) Kongshaug, G.1998. Energy consumption and greenhouse gas emissions in fertilizer production. IFA Technical Conference, Marrakech, Morocco. 28:18.
38) Lassey, K.R. 2007. Livestock methane emissions: from the individual grazing animal through national inventories to the global methane cycle. Agricultural and Forest Meteorology 142:120-132.
39) Lee, I.B., J. Pascual, S.W. Hong, I.H. Seo, K.S. Kwon, T. Bartzanas. 2013. The past, present and future of CFD for agro-environmental applications. Comput Electron Agric, 93:168–83.
40) Linquist, B.A., K.J. van Groenigen, M.A. Adviento-Borbe,C.M. Pittelkow, C. van Kessel. 2012. An agronomic assessment of greenhouse gas emissions from major cereal crops. Global Change Biol. 18:194–209.
41) Lombardi, L. 2003. Life cycle assessment comparison of technical solutions for CO2 emission reduction in power generation. Energy Convers. Manage. 44: 93–108.
42) Mandal, B. , B. Majumder, P.K. Bandyopadhyay, G.C. Hazra, A. Gangopadhyay, R.N. Samantaray, A.K. Mishra, J. Chaudhury, M.N. Saha, S. Kundu 2007.The potential of cropping systems and soil amendments for carbon sequestration in soils under long-term experiments in subtropical India Global Change Biol., 13:357–369.
43) Mizuochi, T, T. Akiyama, T. Shimada, E. Kasai, J.I. Yagi. 2001. Feasibility of rotary cup atomizer for slag granulation. ISIJ Int. 41:1423–1428.

44) Nayak, S., G.N. Tiwari. 2010. Energy metrics of photovoltaic/thermal and earth air heat exchanger integrated greenhouse for different climatic conditions of India. Appl Energy. 87:2984–93.
45) Nie, Z, A. Korre, Ş. Durucan.2011. Life cycle modelling and comparative assessment of the environmental impacts of oxy-fuel and post-combustion CO2 capture, transport and injection processes. Energy Procedia. 4:2510–2517.
46) Okay, D.,Ç. Demirtaş. 2007. Bursa Koşullarında Sıcaklık ve CO2 Değişimlerinin Mısır Bitkisinin Verim ve Evapotranspirasyon Üzerine Etkisinin Belirlenmesi. Yüzüncü Yıl Üniversitesi, Ziraat Fakültesi, Tarım Bilimleri Dergisi . J. Agric. Sci.. 17(2): 81-87.
47) Olgun, M. 2009. Tarımsal Yapılar. Ankara Üniversitesi Ziraat Fakültesi Ders Kitabı:529, Yayın No:1577, Ankara.
48) Oenema, O., A. Bannink, S.G. Sommer, G.L. Velthof. 2001. Gaseous nitrogen emissions form livestock farming systems. In: Follett, R.F., Hatfield, J.L. (Eds.), Nitrogen in the Environment: Sources, Problems, and Management, Elsevier, Amsterdam, The Netherlands, (Ch. 10), 255–289.
49) Ozgener, O.,A.A. Hepbasli. 2007.Review on the energy and exergy analysis of solar assisted heat pump systems. Renew Sust Energy Rev. 11:482–96.
50) Özsayın, S. 2009. Karbondioksit Gübrelemesi, Akdeniz Üniversitesi Ziraat Fakültesi Toprak Bölümü Lisans Tezi, 56s.
51) Peet, M.M.,D.W. Wolfe. 2000. Crop Ecosytem Responses to Climate Change- Vegetable Crops, CABI Publishing , New York.
52) Pehnt, M., J. Henkel. 2009. Life cycle assessment of carbon dioxide capture and storage from lignite power plants. Int. J. Greenhouse Gas Control 3(1):49–66.
53) Phillips, R.E.,R.L. Blevins, G.W. Thomas, W.W. Frye, S.H. Phillips. 1980. No-tillage agriculture. Science. 208:1108-1113.
54) Qiao, J., L. Yang, T. Yan, F. Xue, D. Zhao. 2012. Nitrogen fertilizer reduction in rice production for two consecutive years in the Taihu Lake area. Agric Ecosyst Environ. 146:103–12.
55) Ramaswamy, V. 2001. Radiative forcing of climate change Intergovernment Panel on Climate Change, Climate Change 2001: The Scientific BasisCambridge University Press, Cambridge, UK .349-416
56) Reicosky, D.C., J.L. Hatfield, R.L Sass. 2000. Agricultural contribution to greenhouse gas emissions. In: Reddy, R., Hodges, H. (Eds.), Climate Change and Global Crop Productivity. CABI Publishing, Wallingford, (www.unfccc.de)

57) Sethi, V.P., S.K. Sharma. 2008. Survey and evaluation of heating technologies for worldwide agricultural greenhouse applications, Sol Energy, 82:832–59.
58) Sevgican, A. 1989. Örtü Altı Sebzeciliği. Tarımsal Araştırmaları Destekleme ve Geliştirme Vakfı Yayın. Yalova. . 19: 62-65.
59) Shen, Z., L.-Z. Yang, Y.-M. Yao, D.-D. Wu, J. Wang, R. Guo, S. Yin.2007. Long-term effects of fertilizer managements on crop yields and organic carbon storage of a typical rice–wheat agroecosystem of China. Biol. Fertil. Soils. 44:187–200.
60) Singh, B.,A.H. Strømman, E. Hertwich. 2011. Life cycle assessment of natural gas combined cycle power plant with post-combustion carbon capture, transport and storage. International Journal of Greenhouse Gas Control.5(3):457-466.
61) Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S.O. Ogle, F. Mara, C. Rice, B. Scholes, O. Sirotenko. 2007. Agriculture. In: Metz, B., Davidson, O.R., Bosch, P.R., Dave, R., Meyer, L.A. (Eds.), Climate Change 2007:Mitigation. Contribution of working group III to the fourth assessment report of the Intergovernmental Panel on Climate Change). Cambridge University Press, Cambridge, UK and New York, NY, USA. 497–540.
62) Speece, R.E.1996. Anaerobic Biotechnology for Industrial Wastewater. Arche Press, Tennesse,
63) Staffort, D.A., D.L. Hawkes, H.R. Horton. 1980. Methane production from wasteorganic matter , revision of a 1974 Agriculture Canada Publication, no: 1528, Canada.
64) Terwel, B. W.,F. Harinck,N. Ellemers. 2009. Competence,Based and Integrity,Based Trust as Predictors of Acceptance of Carbon Dioxide Capture and Storage (CCS). Risk Analysis. 29(8):1129-1140.
65) Tezcan, A., A. Atılgan,Ö. Hasan.2011. Seralarda Karbondioksit Düzeyi, Karbondioksit Gübrelemesi ve Olası Etkileri .Süleyman Demirel Üniversitesi Ziraat Fakültesi Dergisi 6 (1): 44-51.
66) Triberti, L.,A. Nastri, G. Giordani, F. Comellini, G. Baldoni, G. Toderi.2008. Can mineral and organic fertilization help sequestrate carbon dioxide in cropland?. Eur. J. Agron., 29:13–20.
67) UNESCO and SCOPE. 2007. Human Alteration of the Nitrogen Cycle: Threats, Benefits and Opportunities. April 2007-No. 4. UNESCO-SCOPE, Paris, France.
68) US EPA, 2005. U.S. Greenhouse Gas Inventory Reports: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990e2004. US EPA #430-R-06- 002. United States Environmental Protection Agency, Office of Atmospheric Programs (6207J), Washington,

DC 20460. Available from:
http://epa.gov/climatechange/emissions/usinventoryreport.html.

69) Vadiee, A., V. Martin. 2013. Energy analysis and thermoeconomic assessment of the closed greenhouse – the largest commercial solar building. Appl Energy. 102:1256–66.

70) Velthoff, G.L.,P.J. Kuikman, O. Oenema. 2003. Nitrous oxide emission from animal manures applied to soil under controlled conditions. Biol. Fertil. Soils. 37:221– 230.

71) Weiske, A., S.O. Petersen. 2006. Mitigation of greenhouse gas emissions from livestock production. Agriculture, Ecosystems & Environment. 112:105-106.

72) Wood, S., Cowie, A. A.,(2004), Review of greenhouse gas emission factors for fertiliser production, IEA Bioenergy Task, 38,20.

73) Wurr, D.C.E.,D.W.Hand.1998. Climate change: a response surface study of the effects of CO2 and temperature on the growth of beetroot, carrots and onions. J. Agric. Sci., Camb. 131:125–133.

74) Xie, D.,B. Washington, T. Norgate, S. Jahanshahi. 2005. Dry granulation of slag-turning waste into valuable cement binder. CAMP-ISIJ Int. 18:1088–1091.

75) Xu, YT, Y. Ding,Z.P. Cai, Q. Liu, S.F. Ye.2007.Development of heat recovery from blast furnace slag using granulation methods. China Metall.17(9):23–5.

76) Yu, QB, J.X. Liu, C.X. Dou, X.Z. Hu.2009. Dry granulation experiment of blast furnace slag by rotary cup atomizer. J Northeast Univ (Nat Sci). 30(8):1163–1165.

77) Zhenggang, N., A. Korre, S. Durucan. 2011. Life cycle modelling and comparative assessment of the environmental impacts of oxy-fuel and post-combustion CO2 capture, transport and injection processes. Energy Procedia. 4:2510–2517.

78) Zhang, X., S. Yina, Y. Li, H. Zhuang, C. Li, C. Liua. 2014. Comparison of greenhouse gas emissions from rice paddy fields under different nitrogen fertilization loads in Chongming Island, Eastern China. Science of the Total Environment. 472:381–388.