

Energy resources development, sustainable management and the environment: progress and future perspective - a review

Abstract

The demand for energy continued to outstrip supply and necessitated the development of biomass option. Residues were the most popular forms of renewable energy and currently biofuel production became much promising. Agricultural wastes contained high moisture content and could be decomposed easily by microbes. Agricultural wastes were abundantly available globally and could be converted to energy and useful chemicals by a number of microorganisms. Compost or bio-fertiliser could be produced with the inoculation of appropriated thermophilic microbes which increased the decomposition rate, shortened the maturity period and improved the compost (or bio-fertiliser) quality. The objective of the present research was to promote the biomass technology and involved adaptive research, demonstration and dissemination of results. With a view to fulfill the objective, a massive field survey was conducted to assess the availability of raw materials as well as the present situation of biomass technologies. We may concluded from the review paper that biomass technology should be encouraged, promoted, invested, implemented, and demonstrated, not only in urban areas but also in remote rural areas.

Keywords: agricultural wastes, biomass resources, energy, environment, sustainable development, CCL, GHGs, CFCs, CO₂

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Introduction

The present review article makes an attempt to comprehensively review various aspects of biomass energy sources, environment and sustainable development. This includes all the biomass energy technologies, energy efficiency systems, energy conservation scenarios, energy savings and other mitigation measures necessary to reduce emissions globally. Nevertheless, some residues have negative effects and should be treated to preserve a durable environment. Hence, sensibility and legislative text to organize the treatments of industry activities waste should be more reinforced Bessou et al.¹ At the beginning of the century, the management of the industrial activities residues is classified urgently in the list of challenge. Since the agro-alimentary industries are growing fast with increased food production in order to realise the food security for growing population. Technological innovations are the support to obtain a final product that can be recycled and used with a minimum of risking Omer.² Recent attempts to stimulate alternative energy sources for heating and cooling of buildings have emphasized the utilization of the bio-energy from agricultural residues, industry wastes, forestry and other renewable energy sources Pernille et al.³ There is strong scientific evidence that the average temperature of the earth surface is rising. This is a result of the increased concentration of carbon dioxide (CO₂), and other greenhouse gases (GHGs) atmosphere as emitted by fossil fuels burning Robinson.⁴ The global warming will eventually lead to substantial changes in the world climate, which will, in turn, has a major impact on human life and the environment. Energy use can be achieved by minimizing the energy demand, by rational energy use, by recovering heat and the use of more green energies. This will

lead to decrees fossil fuels emission. This study is a step towards achieving this goal. The adoption of green or sustainable approaches to the way in which society is run could be seen as an important strategy in finding a solution to the energy problem. The key factors in reducing and controlling CO₂, which is the major contributor in global warming, are the use of alternative approaches in energy generation and the exploration of how these alternatives are used today and may be used in the future as green energy sources. Even with modest assumptions about the availability of land, comprehensive fuel-wood farming programmes offer significant energy, economic and environmental benefits. These benefits would be dispersed in rural areas where they are greatly needed and can serve as linkages for further rural economic development. The nations as a whole would benefit from savings in foreign exchange, from energy security, and socio-economic improvements. With a nine-fold increase in forest plantation cover, the nation resource base would be greatly improved. The non-technical issues, which have recently gained attention, include:

- i. Environmental and ecological factors (e.g., carbon sequestration, reforestation and revegetation).
- ii. Renewables as a CO₂ neutral replacement for fossil fuels.
- iii. Greater recognition of the importance of renewable energy, particularly modern biomass energy carriers, at the policy and planning levels.
- iv. Greater recognition of the difficulties of gathering good and reliable biomass energy data, and efforts to improve it.

- v. Studies on the detrimental health efforts of biomass energy particularly from traditional energy users. Emphasis should be placed on full local manufacture Abdeen.⁵

Energy is an essential factor in development since it stimulates, and supports economic growth and development. Fossil fuels, especially oil and natural gas, are finite in extent, and should be regarded as depleting assets. The efforts are oriented to new energy sources. The clamour all over the world for the need to conserve energy and the environment has intensified as traditional energy resources continue to diminish whilst the environment becomes increasingly degraded. Alternative energy sources can potentially help to fulfill the acute energy demand and sustain economic growth in many regions of the world. Bioenergy is beginning to gain importance in the global climate change fight. Biogas, biofuels and woody biomass are other forms of energy sources that can be derived from organic waste materials. These biomass energy sources have significant potential in the fight against climate change Abdeen.⁶ Conservation of energy and rationing in some form will however have to be practiced by most countries, to reduce oil imports and redress balance of payments positions. Meanwhile, the development and the application of nuclear power and some of the traditional solar, wind, biomass and water energy alternatives must be set in hand to supplement what remains of the fossil fuels. The encouragement of greater energy use is an essential development component. Such a programme should as far as possible be based on renewable energy resources Abdeen.⁷ Large-scale, conventional, power plant such as hydropower has an important part to play in development. It does not, however, provide a complete solution. There is an important complementary role for the greater use of small scale, rural based-power plants. Such plant can be used to assist development since it can be made locally using local resources, enabling a rapid built-up in total equipment to be made without a corresponding and unacceptably large demand on central funds. Renewable resources are particularly suitable for providing the energy for such equipment and their use are also compatible with the long-term aims. Bioenergy is energy from the sun stored in materials of biological origin. This includes plant matter and animal waste, known as biomass. Plants store solar energy through photosynthesis in cellulose and lignin, whereas animals store energy as fats. When burned, the above mentioned materials break down and release energy exothermal energy, releasing carbon dioxide (CO₂), heat and steam. The by-products of this reaction can be captured and manipulated to create power, commonly called bioenergy. Biomass is considered renewable because the carbon (C) is taken out of the atmosphere and replenished more quickly than the millions of years required for fossil fuels creation. The use of biofuels to replace fossil fuels contributes to a reduction in the overall release of carbon dioxide into the atmosphere and hence helps to tackle the global warming Abdeen.⁸

Methods, materials and approach

With a view to fulfill the objective, a massive field survey was conducted to assess the availability of raw materials as well as the present situation of biomass technologies. The data were analyzed. Agricultural residues recycling helps to reduce the intensity of use of natural resources, decreases the need for waste disposal, decreases the specific energy consumption in manufacturing and also provides reasonable levels of profits for those in the business.

In compiling energy consumption data it could be possible to categories usage according to a number of different schemes:

- I. Traditional sector- industrial, transportation, etc.
- II. End-use- space heating, process steam, etc.
- III. Final demand- total energy consumption related to automobiles, to food, etc.
- IV. Energy source- oil, coal, etc.
- V. Energy form at point of use- electric drive, low temperature heat, etc.
- VI. The aim of any modern biomass energy systems must be:
- VII. To maximize yields with minimum inputs.
- VIII. Utilization and selection of adequate plant materials and processes.
- IX. Optimum use of land, water, and fertiliser.
- X. Create an adequate infrastructure and strong research and development (R & D) base.

Bioenergy development

The biomass energy resources are particularly suited for the provision of rural power supplies and a major advantage is that equipments such as flat plate solar driers, wind machines, etc., can be constructed using local resources and without the high capital cost of more conventional equipment. Further advantage results from the feasibility of local maintenance and from the general encouragement of the local manufacture in building up small scale rural based industry. The available energy sources are listed in Table 1.² Currently, the 'non-commercial' woody fuels, crop residues and animal dung are used in large amounts in the rural areas of developing countries, principally for heating and cooking; the method of use is highly inefficient. Table 2, Omer² presented some renewable applications. Table 3, Omer² lists the most important of energy needs. Table 4, Omer⁹ listed methods of energy conversion.

Table 1 Sources of energy Omer.²

Energy Source	Energy Carrier	Energy End-Use
Vegetation	Fuel-wood	Cooking, Water heating, Building materials
		Animal fodder preparation
Oil	Kerosene	Lighting, Ignition fires
Dry cells	Dry cell batteries	Lighting, Small appliances
Muscle power	Animal power	Transport, Land preparation for farming
		Food preparation (threshing)
Muscle power	Human power	Transport, Land preparation for farming
		Food preparation (threshing)

Table 2 Renewable applications Omer.²

Systems	Applications
Water supply	Rain collection, purification, storage and recycling
Wastes disposal	Anaerobic digestion (CH ₄)
Cooking	Methane
Food	Cultivate the 1 hectare plot and greenhouse for four people
Electrical demands	Wind generator
Space heating	Solar collectors
Water heating	Solar collectors and excess wind energy
Control system	Ultimately hardware
Building fabric	Integration of subsystems to cut costs

Table 3 Energy needs in rural areas Omer.²

Transport	e.g., Small vehicles and boats
Agricultural machinery	e.g., Two-wheeled tractors
Crop processing	e.g., Milling
Water Pumping	
Small industries	e.g., Workshop equipment
Electricity generation	e.g., Hospitals and schools
Domestic	e.g., Cooking, heating and lighting

Table 4 Methods of energy conversion Omer.⁹

Muscle Power	Man, Animals
Internal combustion engines	Petrol- spark ignition
Reciprocating	Diesel- compression ignition, Humphrey water piston
Rotating	Gas turbines
Heat Engines	
Vapour (Rankine)	
Reciprocating	Steam engine
Rotating	Steam turbine
Gas Stirling (Reciprocating)	Steam engine
Gas Brayton (Rotating)	Steam turbine
Electron gas	Thermionic, thermoelectric
Electromagnetic radiation	Photo devices
Hydraulic engines	Wheels, screws, buckets, turbines
Wind engines (wind machines)	Vertical axis, horizontal axis
Electrical/mechanical	Dynamo/alternator, motor

Considerations when selecting power plant include the following:

- Power level- whether continuous or discontinuous.
- Cost- initial cost, total running cost including fuel, maintenance and capital amortised over life.
- Complexity of operation.

- Maintenance and availability of spares, and life and suitability for local manufacture.

In some countries, a wide range of economic incentives and other measures are already helping to protect the environment. These include:

- Taxes and user charges that reflect the costs of using the environment, e.g., pollution taxes and waste disposal charges.
- Subsidies, credits and grants that encourage environmental protection.
- Deposit-refund systems that prevent pollution on resource misuse and promote product reuse or recycling.
- Financial enforcement incentives, e.g., fines for non-compliance with environmental regulations.
- Tradable permits for activities that harm the environment.

Biomass utilization and development of conversion technologies

It is an accepted fact that renewable energy is a sustainable form of energy, which has attracted more attention during recent years. There is a great amount of renewable energy potential, environmental interest, as well as economic consideration of fossil fuel consumption. Sustainable energy is 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. It is an accepted fact that renewable energy is a sustainable form of energy, which has attracted more attention during recent years. A great amount of renewable energy potential, environmental interest, as well as economic consideration of fossil fuel consumption and high emphasis of sustainable development for the future will be needed. Explanations for the use of inefficient agricultural-environmental policies include: the high cost of information required to measure benefits on a site-specific basis, information asymmetries between government agencies and farm decision makers that result in high implementation costs, distribution effects and political considerations Yongabi et al.¹⁰ Achieving the aim of agricultural and environmental schemes through:

- Sustain the beauty and diversity of the landscape.
- Improve and extend wildlife habitats.
- Conserve archaeological sites and historic features.
- Improve opportunities for countryside enjoyment.
- Restore neglected land or features, and
- Create new habitats and landscapes.

Role of chemical engineering policy

Turning to chemical engineering and the experience of the chemical process industry represents a wakening up but does not lead to an immediate solution to the problems. The traditional techniques are not very kind to biological products, which are controlled by difficulty and unique physico-chemical properties such as low mechanical, thermal and chemical stabilities. That is the issue of selectivity. The fermentation broths resulting from microbial growth contain a bewildering mixture of many compounds closely related to the product of interests. There is the question of selectivity. The fermentation

broths resulting from microbial growth contain a bewildering mixture of many compounds closely related to the product of interests. By the standards of the process streams in chemical industry, fermenter is highly impure and extremely dilutes aqueous systems Table 5.¹¹ The disadvantages of the fermentation media are as the following: mechanically fragile, temperature sensitive, rapidly deteriorating quality, harmful if escaping into the environment, corrosive (acids, chlorides, etc.), and troublesome (solids, theological, etc.), and expensive. Thus, pilot plants for scale-up work must be flexible. In general, they should contain suitably interconnected equipment for: fermentation, primary separation, cell disruption fractionalizes and clarifications, purification by means of high-resolution techniques and concentration and dry. The effects of the chlorofluorocarbons (CFCs) molecule can last for over a century.

Table 5 Typical product concentrations exiting fermenters Abdeen.¹¹

Product	Concentration (kg/m ³)
Ethanol	70-120
Organic acids (e.g., citric)	40-100
Vitamin B12	0.02
Interferon	50-70
Single-cell protein	Oct-30
Antibiotics (e.g., Penicillin G)	02-May
Enzyme protein (e.g., protease)	02-May

- I. An important consideration for operators of wastewater treatment plants is how to handle the disposal of the residual sludge in a reliable, sustainable, legal and economical way. The benefits of drying sludge can be seen in two main treatment options:
 - i. Use of the dewatered sludge as a fertiliser or in fertiliser blends.
 - ii. Incineration with energy recovery.
- II. Use as a fertiliser takes advantage of the high organic content 40%-70% of the dewatered sludge and its high levels of phosphorous and other nutrients. However, there are a number of concerns about this route including:
 - i. The chemical composition of the sludge (e.g., heavy metals, hormones and other pharmaceutical residues).
 - ii. Pathogen risk (e.g., Salmonella Sp., Escherichia coli, prionic proteins, etc.).
 - iii. Potential accumulation of heavy metals and other chemicals in the soil.
- III. Sludge can be applied as a fertiliser in three forms: liquid sludge, wet cake blended into compost, and dried granules. The advantages of energy recovery sludge include:
 - i. The use of dewatered sludge is a 'sink' for pollutants such as heavy metals, toxic organic compounds and pharmaceutical residues. Thus, offering a potential disposal route for these substances provided the combustion plant has adequate flue gas cleaning.
 - ii. The potential, under certain circumstances, to utilize the inorganic residue from sludge incineration (incinerator ash), such as in cement or gravel.

- iii. The high calorific value (similar to lignite) of dewatered sludge.
- iv. The use of dewatered sludge as a carbon dioxide neutral substitute for primary fuels such as oil, gas and coal.

Energy efficiency

Energy efficiency is the most cost-effective way of cutting carbon dioxide emissions and improvements to households and businesses. It may have many other additional social, economic and health benefits, such as warmer and healthier homes, lower fuel bills and company running costs and, indirectly, jobs. Britain wastes 20 per cent of its fossil fuel and electricity use in transportation Andrea et al.¹² This implies that it would be cost-effective to cut £10 billion a year off the collective fuel bill and reduce CO₂ emissions by some 120 million tones CO₂. Yet, due to lack of good information and advice on energy saving, along with the capital to finance energy efficiency improvements, this huge potential for reducing energy demand is not being realized. Traditionally, energy utilities have been essentially fuel providers and the industry has pursued profits from increased volume of sales. Institutional and market arrangements have favoured energy consumption rather than conservation. However, energy is at the centre of the sustainable development paradigm as few activities affect the environment as much as the continually increasing use of energy. Most of the used energy depends on finite resources, such as coal, oil, gas and uranium. In addition, more than three quarters of the world's consumption of these fuels is used, often inefficiently, by only one quarter of the world's population. Without even addressing these inequities or the precious, finite nature of these resources, the scale of environmental damage will force the reduction of the usage of these fuels long before they run out. Throughout the energy generation process there are impacts on the environment on local, national and international levels, from opencast mining and oil exploration to emissions of the potent greenhouse gas carbon dioxide in ever increasing concentration. Recently, the world's leading climate scientists reached an agreement that human activities, such as burning fossil fuels for energy and transport, are causing the world's temperature to rise. The Inter governmental Panel on Climate Change has concluded that "the balance of evidence suggests a discernible human influence on global climate". It predicts a rate of warming greater than any one seen in the last 10,000 years, in other words, throughout human history. The exact impact of climate change is difficult to predict and will vary regionally. It could, however, include sea level rise, disrupted agriculture and food supplies and the possibility of more freak weather events such as hurricanes and droughts. Indeed, people already are waking up to the financial and social, as well as the environmental, risks of unsustainable energy generation methods that represent the costs of the impacts of climate change, acid rain and oil spills. The insurance industry, for example, concerned about the billion dollar costs of hurricanes and floods, has joined sides with environmentalists to lobby for greenhouse gas emissions reduction. Friends of the earth are campaigning for a more sustainable energy policy, guided by the principal of environmental protection and with the objectives of sound natural resource management and long-term energy security. The key priorities of such an energy policy must be to reduce fossil fuel use, move away from nuclear power, improve the efficiency with which energy is used and increase the amount of energy obtainable from sustainable, renewable sources. Efficient energy use has never been more crucial than it is today, particularly with the prospect of the imminent introduction of

the climate change levy (CCL). Establishing an energy use action plan is the essential foundation to the elimination of energy waste Andrea et al.¹² A logical starting point is to carry out an energy audit that enables the assessment of the energy use and determine what actions to take. The actions are best categorized by splitting measures into the following three general groups:

- i. **High priority/low cost:** These are normally measures, which require minimal investment and can be implemented quickly. The followings are some examples of such measures:
 - I. Good housekeeping, monitoring energy use and targeting waste-fuel practices.
 - II. Adjusting controls to match requirements.
 - III. Improved greenhouse space utilization.
 - IV. Small capital item time switches, thermostats, etc.
 - V. Carrying out minor maintenance and repairs.
 - VI. Staff education and training.
 - VII. Ensuring that energy is being purchased through the most suitable tariff or contract arrangements.
- ii. **Medium priority/medium cost:** Measures, which, although involve little or no design, involve greater expenditure and can take longer to implement. Examples of such measures are listed below:
 - i. New or replacement controls.
 - ii. Greenhouse component alteration, e.g., insulation, sealing glass joints, etc.
 - iii. Alternative equipment components, e.g., energy efficient lamps in light fittings, etc.
- iii. **Long term/high cost:** These measures require detailed study and design. They may be best represented by the followings:
 - I. Replacing or upgrading of plant and equipment.
 - II. Fundamental redesign of systems, e.g., CHP installations.

This process may often be a complex experience and therefore the most cost-effective approach is to employ an energy specialist to help.

Results and summary

Alternatively energy sources can potentially help fulfill the acute energy demand and sustain economic growth in many regions of the world. Bioenergy is beginning to gain importance in the global fight to prevent climate change. The scope for exploiting organic waste as a source of energy is not limited to direct incineration or burning refuse-derived fuels. Biogas, biofuels and woody biomass are other forms of energy sources that can be derived from organic waste materials. These biomass energy sources have significant potential in the fight against climate change. Recently, there are many studies on modern biomass energy technology systems published Bhutto et al.¹³ & Cihan et al.¹⁴ Vegetation and in particular forests can be managed to sequester carbon. Management options have been identified to conserve and sequester up to 90 Pg C in the forest sector in the next century, through global afforestation Singh et al.¹⁵ & Duku et al.¹⁶ For efficient use of bioenergy resources, it is essential to take

account of the intrinsic energy potential. Despite the availability of basic statistics, many differences have been observed between the previous assessments of bioenergy potential Cheng¹⁷ & Bessou et al.¹ On some climate change issues (such as global warming), there is no disagreement among the scientists. The greenhouse effect is unquestionably real; it is essential for life on earth. Water vapour is the most important GHG; followed by carbon dioxide (CO₂). Without a natural greenhouse effect, scientists estimate that the earth's average temperature would be -18°C instead of its present 14°C Kothari et al.¹⁸ There is also no scientific debate over the fact that human activity has increased the concentration of the GHGs in the atmosphere (especially CO₂ from combustion of coal, oil and gas). The greenhouse effect is also being amplified by increased concentrations of other gases, such as methane, nitrous oxide, and CFCs as a result of human emissions. Most scientists predict that rising global temperatures will raise the sea level and increase the frequency of intense rain or snowstorms Andrea et al.¹² Globally, buildings are responsible for approximately 40% of the total world annual energy consumption. Most of this energy is for the provision of lighting, heating, cooling, and air conditioning. Increasing awareness of the environmental impact of CO₂, NO_x and CFCs emissions triggered a renewed interest in environmentally friendly cooling, and heating technologies. Under the 1997 Montreal Protocol, governments agreed to phase out chemicals used as refrigerants that have the potential to destroy stratospheric ozone. It was therefore considered desirable to reduce energy consumption and decrease the rate of depletion of world energy reserves and pollution of the environment. One way of reducing building energy consumption is to design buildings, which are more economical in their use of energy for heating, lighting, cooling, ventilation and hot water supply. Passive measures, particularly natural or hybrid ventilation rather than air-conditioning, can dramatically reduce primary energy consumption. However, exploitation of renewable energy in buildings and agricultural greenhouses can, also, significantly contribute towards reducing dependency on fossil fuels. Therefore, promoting innovative renewable applications and reinforcing the renewable energy market will contribute to preservation of the ecosystem by reducing emissions at local and global levels.

Conclusion

The move towards a low-carbon world, driven partly by climate science and partly by the business opportunities it offers, will need the promotion of environmentally friendly alternatives, if an acceptable stabilization level of atmospheric carbon dioxide is to be achieved. The biomass energy, one of the important options, which might gradually replace the oil in facing the increased demand for oil and may be an advanced period in this century. Any country can depend on the biomass energy to satisfy part of local consumption. Development of biogas technology is a vital component of alternative rural energy programme, whose potential is yet to be exploited. A concerted effort is required by all if this is to be realized. The technology will find ready use in domestic, farming, and small-scale industrial applications. Support biomass research and exchange experiences with countries that are advanced in this field. In the meantime, the biomass energy can help to save exhausting the oil wealth. The diminishing agricultural land may hamper biogas energy development but appropriate technological and resource management techniques will offset the effects. Even with modest assumptions about the availability of land, comprehensive fuel-wood farming programmes offer significant energy, economic and environmental benefits. These benefits would be dispersed in

rural areas where they are greatly needed and can serve as linkages for further rural economic development. The nations, as a whole would benefit from savings in foreign exchange, improved energy security, and socio-economic improvements. With a nine-fold increase in forest-plantation cover, the nation's resource base would be greatly improved. The international community would benefit from pollution reduction, climate mitigation, and the increased trading opportunities that arise from new income sources. Furthermore, investigating the potential is needed to make use of more and more of its waste. Household waste, vegetable market waste, and waste from the cotton stalks, leather, and pulp; and paper industries can be used to produce useful energy either by direct incineration, gasification, digestion (biogas production), fermentation, or cogeneration. Therefore, effort has to be made to reduce fossil energy use and to promote green energies, particularly in the building sector. Energy use reductions can be achieved by minimizing the energy demand, by rational energy use, by recovering heat and the use of more green energies. This study was a step towards achieving that goal. The adoption of green or sustainable approaches to the way in which society is run which could be an important strategy in finding a solution to the energy problem. The key factors to reducing and controlling CO₂, which is the major contributor to global warming, are the use of alternative approaches to energy generation and the exploration of how these alternatives are used today and may be used in the future as green energy sources. Even with modest assumptions about the availability of land, comprehensive fuel-wood farming programmes offer significant energy, economic and environmental benefits. These benefits would be dispersed in rural areas where they are greatly needed and can serve as linkages for further rural economic development. The nations as a whole would benefit from savings in foreign exchange, improved energy security, and socio-economic improvements. With a nine-fold increase in forest-plantation cover, a nation's resource base would be greatly improved. The international community would benefit from pollution reduction, climate mitigation, and the increased trading opportunities that arise from new income sources.

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Conflicts of interest

The author declares that there are no conflicts of interest.

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