Role of Solar Energy in Reducing GHG Emissions from Residential Sector of Bangladesh

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Abstract

Over the decades there has been increasing worldwide debate concerning the impact of human activities on the global climate system due to the emission of green house gases (GHG) such as carbon di oxide (CO_2), methane (CH_4), nitrogen di oxide (N_2O) and some other particulare matters. The concentration of these gases has been increasing abruptly in the atmosphere since after industrialization. It is alarming that the increased rates of some of these gases are so high that within a few decades these will become double. We propose an energy chain for Bangladesh and it consists of all types of energy resources and techniques of resources extraction, transportation, installation, generation and uses of all form of energy. We apply the numerical model ENPEP (Energy and Power Evaluation Programme) to the energy chain to estimate the GHG emission level and to identify the energy generation technology and primary energy resources for mitigation of the GHG emission gaining a sustainable long term energy development of our country. By taking 10%-12% contribution of solar energy it is estimated that the emission of carbon-di-oxide gas will decrease up to 21% by the year 2033 comparing with the projection of non introducing solar energy.

Key words: Green house gas, (GHG), energy sector.

Introduction

Bangladesh has limited energy resources. The present per capita energy and electricity consumption is very low [1-3]. Therefore, the future energy planning is very complex for the country. Proper and accurate estimations of the mid-term and the long-term projections of energy and electricity demand and assessment of emissions for different economic growth scenarios, is necessary for planning and management of energy sector in Bangladesh. In addition, for environment-friendly and sustainable energy development of the country, the details numerical assessment of renewable energy resources such as solar and wind, other indigenous fossil fuel resources such as gas and coal and imported alternatives such as nuclear and petroleum products, are very important for assessing and analyzing their long-term prospects and for conducting detailed financial analysis and environmental impacts [4-6]. We apply the ENPEP model of the energy chain of Bangladesh for a time horizon 2004 to 2033 for energy scenario for 7% annual growth and the GHG mitigation options in residential sector.

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Methods

ENPEP Model

The ENPEP for Windows model has its origins in the DOS version of the Energy and Power Evaluation Program (ENPEP), which is developed by Argonne National Laboratory (ANL) under the auspices of the U.S. Department of Energy (DOE) and the International Atomic Energy Agency (IAEA). It fully utilizes the Windows operating environment and provides the user with a graphic interface for designing a comprehensive model of the energy system of a country or region. Each network node type corresponds to a different sub model in BALANCE and is associated with specific equations that relate the prices and energy flows on the input and output links of the node. The following node types are available in BALANCE:

- *Depletable Resource Node*: Models the production of a depletable resource that is either imported or domestically produced, such as crude oil, coal, or natural gas.
- *Renewable Resource Node*: Models the production of a renewable resource (e.g., biomass or solar energy).
- *Decision/Allocation Node*: Models the selection of fuels or energy forms from alternative sources of supply.
- *Conversion or Processing Node*: Models the conversion or processing of a resource, fuel, or product to another form. Examples include a boiler that converts fuel oil to steam, an automobile that converts gasoline to miles traveled, and a distillation process that converts biomass to ethanol.
- *Multiple-Input Node*: Models special conversion processes that have more than a single form of input fuel, such as a solar heater that uses LPG as a backup fuel.
- *Demand Node*: Models the final demand for a fuel or a form of useful energy such as process steam, and direct heat
- *Multiple Output (Refining) Node*: Also called a multiple-output-link node, this node is typically used to model the petroleum refining process in an aggregate form. More generally it can be used to model any process with two or more products.
- *Stockpile Node*: Models stockpiling of resources for use at some future time.
- *Pricing Node*: Models government price regulations and pricing policies, such as taxes, subsidies, and tariff structures.
- *Electricity Dispatch Node*: Models the loading and output of electricity generating units.

Description of the ENPEP model

The ENPEP for Windows model works with an energy sector network that consists of nodes and links. The nodes represent processes, such it is in as a petroleum refinery, while the links represent energy flows between pairs of nodes. The energy network is developed by defining the energy flows among 10 types of nodes. Each node type corresponds to a different sub model in BALANCE and is associated with specific equations that relate the prices and energy flows on the input and output links of the node. The algorithm within the BALANCE module processes a system of simultaneous nonlinear equations and inequalities. These relationships, defined by input parameters associated with each node in the energy network, specify the transformation of energy quantities and prices through the various stages of energy production, processing, and use. An equilibrium model, represented by the energy network, is solved by finding a set of energy prices and quantities that satisfy all relevant equations and inequalities. To find the solution, the model requires initial estimates of values of fuel importation and production quantities at the bottom of the network. Then the prices of fuel on each successive link going up the network are computed from the prices equations defined by the various nodes. Next the solutions to all the quantity equations associated with the nodes are computed for successive links going down the network. If all equations in the network are satisfied by the initial estimated quantities, a solution to the model has been found. Otherwise, the quantities at the bottom of the network are automatically adjusted, and all equations are solved again. This iterative process continues until the proper values for the quantities at the bottom of the network are attained. The equilibrium modeling approach used in the BALANCE Module is based on the concept that the energy sector consists of autonomous energy producers and consumers that carry out production and consumption activities, each optimizing individual objectives. In contrast, optimization models of the entire energy sector, such as linear programming formulations, can take on the interpretation of a central planning authority that has control over all energy flows and prices in the entire energy sector. The solution of an equilibrium model, such as the BALANCE program, should be interpreted as what is likely to happen, given that the assumptions about the relationships and data in the model are correct. In some circumstances, the output can also be interpreted as prescriptive, indicating what should happen or what will happen. For example, the model solution may prescribe what value energy prices should be set at in order to recover all costs of production and processing, if all government price controls are removed in a run of the model and prices are allowed to reflect only costs.

Application of the ENPEP Model

ENPEP for Windows model was used to simulate energy market and determine energy supply and demand balance for 30 years. To achieve this goal, the BALANCE module of ENPEP for Windows processes a representative network of all energy production, conversion, transport, distribution, and utilization activities as well as the flows of energy and fuels among those activities. The environmental aspect is also taken into account by calculating the emissions of various pollutants. In addition to energy costs, the model also calculates the environmental costs.

Results and Discussion

Residential Sector Network

Figure 1 represents the residential sector network of energy demand in Bangladesh. The residential sector mainly depends on gas, oil, biomass and electricity. In this sector biomass is consumed heavily. In the middle of the chain we observe that the conversion of gas to heat,

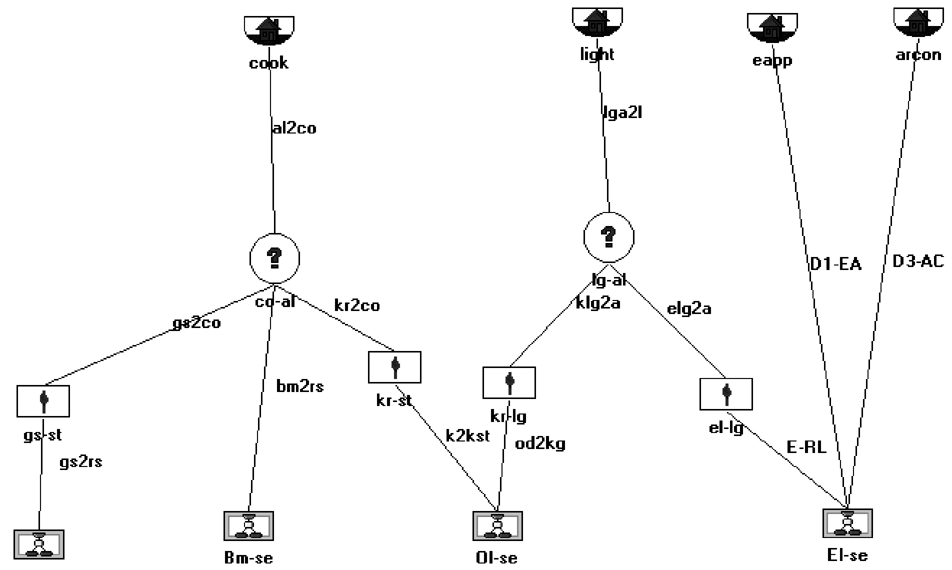

Fig. 1: Residential sector network.

Kerosene to heat, kerosene to light emits a great amount of greenhouse gases. Actually, the biomass emits the major greenhouse gases. In the final demand side kerosene and gas are mainly used for cooking, and kerosene and electricity are used for light and air-conditions.

Residential sector emission

In the residential sector the emissions of the greenhouse gases are mainly emitted from gas, oil (kerosene) and biomass. Here we estimated the total amounts of carbon-di-oxide gas emissions in the base year 2004 and it is 3410000 metric tons. Within five years this will increase up to 29% and this will be 35989682 metric tons in 2033, which will increase up to 90% of the base year. It is estimated that the emission of CH_4 and NO_X gases of the residential sector in the base year 2004 are 335.76 and 4186 metric tons and within five years it will increase up to 29% of the base year emission. It is also estimated that the amount of CH_4 and NO_X gases by the year 2033 will be 3540.62 and 44143 metric tons respectively which will increase up to 90% of the base year emission. The calculated data of CH_4 and NO_X are shown in the Table: 1.

Table 1: CH_4 and NO_X emission in the different years

Year	2004	2009	2014	2019	2024	2029	2033
CH_4 (tones)	335.76	475.34	686.85	1015	1530	2330	3540
NO_X(tones)	4186	5929	8563	12664	19078	29060	44143

3.3. Introduction of solar energy in residential sector

At present 2.4MW solar plants are installed in different parts of our country which contributes 0.06% of our total energy. There is a great possibility to set up more solar plants. If we increase the share of the solar energy to 12% within 30 years, the greenhouse gas will be reduced considerably. Fig 2 shows that the share of solar energy with other energy in the year 2033.

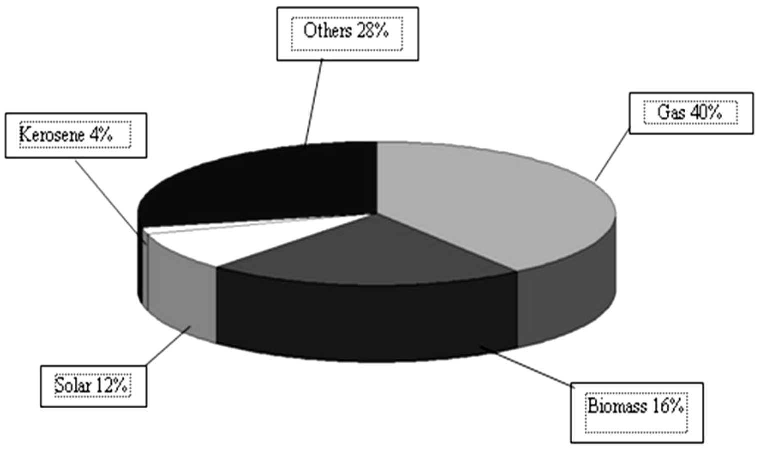

Fig. 2: share of the solar energy with other energy in the year 2033.

By taking 10%-12% contribution of solar energy, it is estimated that the emission of the carbon-di-oxide gas will be 22821679 metric tones which will reduce up to 21% in the year 2033. Fig 3 shows co_2 emission reduction in the different years:

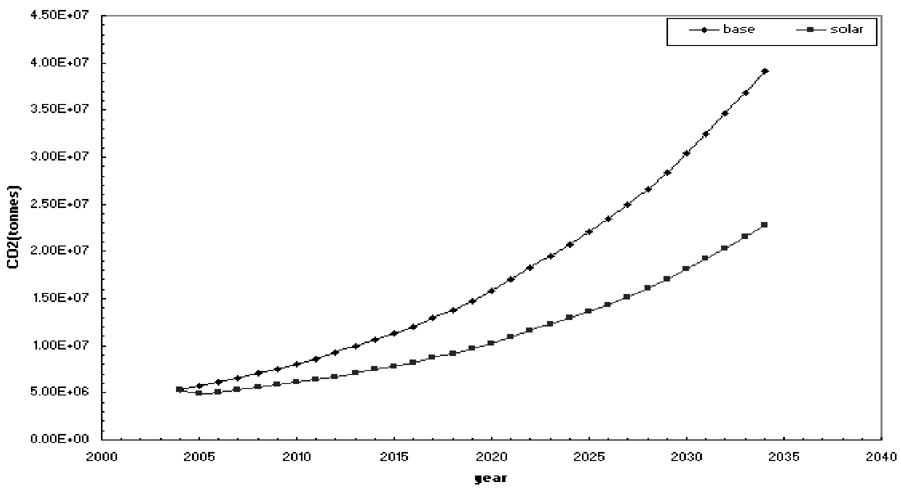

Fig. 3: CO_2 emission reduction in the different years.

Fig 4 shows that the emission of the methane gas will be 3041.103 metric tons in the year 2033 which will reduce up to 19% of the projection of non-introducing solar energy.

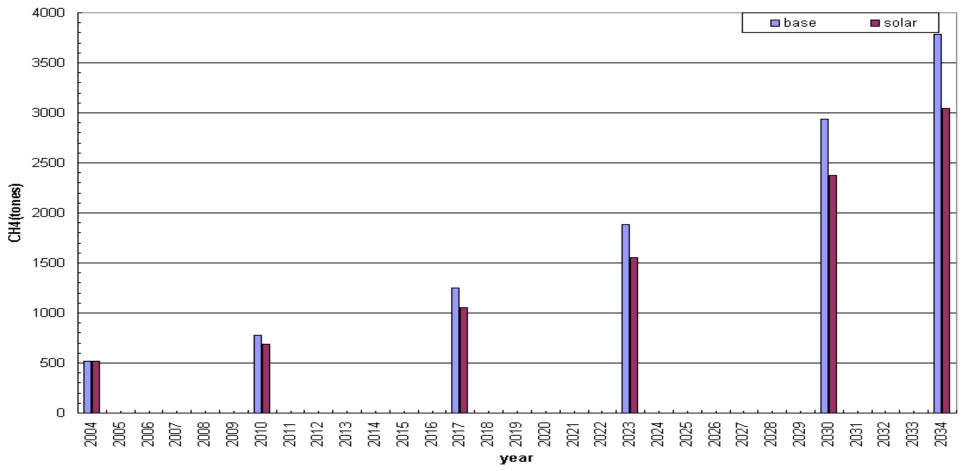

Fig. 4: CH_4 emission reduction in the different years.

Conclusion

GHG such as CH_4, N_2O, NO_X and particulate matters are increasing with time and the main contributor of GHG emissions is 16% followed by transport sector. Therefore, some mitigations options are necessary for developing environmental friendly energy sector of the country. The findings of this study will be useful for the researchers for developing environmental friendly energy generating technologies and the policy makers in planning energy for long-term energy development.

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