ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 8, Issue, 02, pp.26664-26668, February, 2016

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

IMPORTANT ROLE OF RENEWABLE ENERGY SOURCES IN MITIGATION OF CO_2 E MISSIONS IN INDIAN CONTEXT

*Nawaz, I.

Department of Mechanical Engineering, Faculty of Engineering & Technology, Jamia Millia Islamia, Jamianagar, New Delhi-110025, India

ARTICLE INFO

Article History:
Received 29th November, 2015
Received in revised form
14th December, 2015
Accepted 18th January, 2016
Published online 27th February, 2016

Key words:

Industrialization, CO_2 concentration, Power production, Fossil fuels, Energy demand, Renewable energy sources, CO_2 mitigation.

ABSTRACT

Due to impact of global industrialization, on developed countries, there has been a sharp increase of CO2 concentration from 270ppm to 400ppm, during the 20th century. This is due to use of fossil fuels for power production, among other reasons. This has challenged the existence of human beings and other organisms. If not controlled, the survival of living organisms will be in danger. In order to balance the ecological system comprising air, water and biosphere, less polluting renewable energy sources should be used to meet energy demand. Renewable energy sources are recognized as clean sources of energy and optimal use of them minimizes environmental impact. Hence renewable energy sources provide an excellent opportunity for mitigation of CO2 emission. In this presentation, a review has been attempted on scope of CO2 mitigation, through renewable energy sources, in Indian context. The potential of CO2 mitigation has also been estimated and compared with the base value of CO2 emissions. The estimation has been done by examining various alternatives. The methodology developed can be profitably applied to explore other possibilities, as well.

Citation: **Nawaz, I. 2016.** "Important role of renewable energy sources in mitigation of CO_2 emissions in Indian context", *International Journal of Current Research,* 8, (02), 26664-26668.

INTRODUCTION

It is well recognized that renewable energy can make a substantial contribution in energy scenario of any region. Indeed the role of renewable energy needs to be seen not merely as an "alternate energy", but as key component to provide a nation's energy needs. Relevance of renewable energy is basically due to increasing tempo of various activities which produce carbon dioxide that is released into the earth's atmosphere. This is the main cause of the phenomenon of "global warming" with harmful consequences. One answer to the problem of global warming is to replace current technologies with alternatives that have comparable or better performance, but do not emit carbon dioxide. Renewable energy, particularly solar energy fulfils this condition and provides substantial benefits for climate, health, and economy. In any case it is expected that there will be a shortage of conventional fuel supply in future. Therefore, greater use of renewable energy would be inevitable. Thus one expects it to be the major future technology, for power production in India.

***Corresponding author: Nawaz, I.**
Department of Mechanical Engineering, Faculty of Engineering & Technology, Jamia Millia Islamia, Jamianagar, New Delhi-110025, India.

In order to ensure healthy air and a stable climate for future generations, we must make responsible decisions about our energy sources. Innovative technologies and forward-thinking policies are needed to offer practical and affordable solution to reduce our dependence on fossil fuels. The conventional system threatens the health of human communities by polluting the air and contributing to global warming. If left unchecked, heat-trapping emissions, such as CO_2, are expected to cause irreversible damage to communities throughout the world.

The power scenario in India

The growth of national demand for electric power in India is likely to be around 5-6 % over the span of next 15 years (planningcommission.nic.in/sectors/index.php?sectors=energy, 2014). This would require about 30,000 MW of capacity addition every year over that period (www. livemint.com/... /India-faces-daily-power-outage-of-30000-MW.html,2014).
Demand is expected to double by the year 2020, with reference to the present installed capacity of about 272,687 MW (powermin.nic.in/power-sector-glance-all-india, 2015). It has been estimated that the present power shortage results in an annual loss of production of about 2 % of the national income (planningcommission.nic.in/sectors/index.php?sectors=energy,

2015). One may note that, fossil fuels will continue to be major energy sources, and will continue to play a critical role in the economy. India will be compelled to rely in large measure on vast coal reservoirs as a source of power generation. At the same time it will need to develop programmes and policies that will reduce dependence on fossil fuels, in order to achieve sustainable economic growth as well as environmental stability. The average electricity consumption per capita in India is quite low as compared to developed countries; it is just 1000 kWh per person per year. This is four times lower than China which is one notch higher on the list with 4,000 kWh (www.livemint.com/.../India-faces-daily-power-outage-of-30000-MW.html, 2014). The world average is 2,782 kWh (pib.nic.in/newsite/erelease.aspx?relid=74497, 2014). The electricity installed capacity in India from different energy sources is shown in Table 1.

Table 1. All India Installed capacity of power (MW) (powermin.nic.in/power-sector-glance-all-india)

Fuel/Technology	MW	% age
Total Thermal:	189,498	69.5
Coal	165,236	60.6
Gas	23,062	8.5
Oil	1,200	0.4
Hydro	41,632	15.3
Nuclear	5,780	2.1
Renewable energy	35,777	13.1
Total:	272,687	100%

Renewable energy scenario in India

India has one of the highest potentials in the world for harnessing renewable energy. It is bestowed with rich natural resources and geographical and climatic conditions that support the promotion of renewable energy. Prominent among them are solar, wind, biomass and small hydro. Till recently, the share of grid connected solar PV was negligible, (only around 40 MW) and most of the national focus was on off-grid solar PV and residential solar thermal options. Around 440 MW of Solar PV was installed in the last year and it is expected soon to increase many folds due to high incentives of government schemes (https://energypedia.info/wiki/India_Energy_Situation). Small hydro and biomass technologies represent the remaining component of the grid connected renewable energy mix. Government of India also visualize geothermal energy as an interesting renewable energy source for India.

A few sites in Andaman Nikobar Islands have already been identified for pilot projects. At present, India has the world's largest programmes for renewable energy. India has set a target for itself of achieving overall renewable energy installed capacity of 41,400 MW by 2017 and 72,400 MW by the year 2022. To achieve this ambitious target, India will have to add 40,130.39 MW of renewable energy installed capacity. To achieve a target of 72,000 MW of installed capacity for renewable energy, India will have to make an investment of around US$ 46.billion**.** Almost similar investment will be made in upgrading the transmission and distribution (T&D) infrastructure and old renewable plants; which will be approaching their end of life. NOVONOUS estimates that India will have to invest US$ 83.35 billion in the renewable energy sector till 2022 (www.novonous.com/renewable-energy-market-india-2014-2022, 2014). According to the India Renewable Energy Status Report 2014, the total renewable energy potential from various sources in India is 249,188 MW. Estimated potential and installed capacity of renewable energy sources in India (as on 31 May, 2015) is shown in Table 2 (mnre.gov.in/file-manager/akshay-urja/january.../page30.html, 2015; mnre.gov.in/mission-and-vision-2/achievements 2015).

Table 2. Estimated potential and power generation from renewable energy sources

Sources/Technology	Potential (MW)	Installed capacity (MW)
Wind Power	1,02,772	23,444
Solar Power (PV)	1,00000	3,744
Small Hydro Power	20,000	4,055
Biomass Power	17,536	1,410
Bagasse Cogeneration	5,000	3,008
Waste to Power	3,880	115
Total	249,188	35,776

Amount of CO_2 generated

Electrical energy is to be generated by consumption of fossil fuels (coal, natural gas and oil) and also by other means (hydro, nuclear and renewable energy sources). In the following analysis; respective shares of these sources are denoted by η_i where i=coal, gas, oil. Thus the symbols for shares are:

Coal: η_c (present value is 60.6%)

Natural gas: η_g (present value is 8.5%)

Oil: η_o (present value is 0.4%).

Similarly, we denote the amount of CO_2 emitted (in kg) due to fossil fuel consumption, by the symbol a_i; when any of the above fuels is used to generate 1 kWh of electrical energy. Thus the symbols are:

Coal: a_c (present value is 0.98 kg/kWh) (10)

Natural gas: a_g (present value is 0.52 kg/kWh) (10)

Oil: a_o (present value is 0.77 kg/kWh) (10)

Total amount of CO_2 produced (in kg) for each kWh of generated electrical energy is therefore given by:

$A = \sum \eta_i a_i$; i=coal, natural gas and oil.

If the shares of these fossil fuels (which are presently η_i) are varied to new values η_i'; then the amount of CO_2 emitted will correspondingly change. Thus the amount of CO_2emitted will become;

$$A' = \sum \eta_i' a_i$$

These ideas may be expressed in the form of percentage change or relative change. Suppose a particular share η_i (of i^{th} source) is sought to be changed and the relative change is α_i. Then $\eta_i' = (1+\alpha_i)\eta_i$; where α_i may be positive or negative. This means that the relative difference between η_i' (new shares) and η_i (old share) is α_i. Hence the relative change in (overall) CO_2 emission will be:

$$\frac{A-A'}{A}$$

We may now calculate the amount of CO_2 added to the atmosphere, taking into consideration the whole population of the country.

Total amount of CO_2 added annually

= (A)×(per capita energy consumption in kWh)×(Population of the country)

Amount of CO_2 Mtigation

Example 1: The present and suggested shares of fuels are given in Table 3(a)

Expected relative decrease in CO_2 emission= $\frac{A-A'}{A}$

Now

$$A = \sum \eta_i a_i$$

= (60.6×0.98) + (8.5×0.52) + (0.4×0.77) + (13.1×0) + (17.4×0)

=64.12 (Base value)

$$A' = \Sigma \eta_i' a_i$$

= (59.6×0.98) + (9.4×0.52) + (0.5×0.77) + (13.1×0) + (17.4×0) = 63.68

Hence relative reduction in CO_2 =

$$\frac{A-A'}{A} = \frac{64.12-63.68}{64.12} = 0.69\%$$

Example 2

Alternatively, we may let the shares of energy generation from natural gas and oil remains unchanged. The suggestion now is to reduce the share of energy from coal from 60.6% to 59.6%; and increase the renewable energy share from 13.1% to 14.1%. Thus the suggested scheme of shares of various fuels is given in Table 3 (b).

Expected relative decrease in CO_2 emission= $\frac{A-A'}{A}$

Now

$$A = \sum \eta_i a_i$$

= (60.6×0.98) + (8.5×0.52) + (0.4×0.77) + (13.1×0) + (17.4×0) =64.12 (Base value)

$$A' = \Sigma \eta_i' a_i$$

= (59.6×0.98) + (8.5×0.52) + (0.4×0.77) + (14.1×0) + (17.4×0) =63.14

Hence relative reduction in CO_2 =

$$\frac{A-A'}{A} = \frac{64.12-63.14}{64.12} = 1.53\%$$

One may see that the second scheme is better; because CO_2 mitigation is almost doubled. It may be noted that renewable energy sources and other sources of energy have the advantage that CO_2 emission from them is zero.

Table 3(a). The present and suggested shares of fuels

S. No.	Fuel/Sources	Present Share (η_i)	Suggested Shares (η_i')	α_i	CO_2 emitted per kWh (a_i)
1.	Coal	60.6%	59.6%	-0.0165	0.98
2.	Natural gas	8.5%	9.4%	0.106	0.52
3.	Oil	0.4	0.5	0.25	0.77
4.	Renewable energy sources	13.1%	13.1%	Zero	zero
5.	Others	17.4%	17.4%	Zero	zero

Table 3 (b). The present and suggested shares of fuels

S. No.	Fuel/Sources	Present Share (η_i)	Suggested Share (η_i')	α_i	CO_2 emitted per kWh (a_i)
1.	Coal	60.6%	59.6%	-0.016	0.98
2.	Natural gas	8.5%	8.5%	zero	0.52
3.	Oil	0.4%	0.4%	zero	0.77
4.	Renewable energy sources	13.1%	14.1%	0.076	Zero
5.	Others	17.4%	17.4%	zero	Zero

Example 3

By weight: Per kWh

From Table 1

(A)

Coal: $0.606\times0.98 = 0.59388$ kg
Gas: $0.085\times0.52 = 0.0442$ kg
Oil: $0.4\times10^{-3}\times0.77 = 3.08\times10^{-3}$ kg
Total: 0.641 kg/kWh (Base value)

(B)

Coal: $0.596\times0.98 = 0.58408$ kg
Gas: $0.094\times0.52 = 0.04888$ kg
Oil: $5\times10^{-3}\times0.77 = 3.85\times10^{-3}$ kg
Total: 0.637 kg/kWh

The change in CO_2 emission in terms of weight is given by
$\Delta W = A - B$

$=0.641-0.637$
$=4\times10^{-3}$kg/kWh i.e. 4gm/kWh

(C)

Coal: $0.596\times0.98 = 0.58408$ kg
Gas: $0.085\times0.52 = 0.0442$ kg
Oil: $0.4\times10^{-3}\times0.77 = 3.08\times10^{-3}$ kg
0.631kg/kWh

In this alternative, the weight change in CO_2 emission is given by

$\Delta W = A - C$

$=0.641-0.631$
$=0.01$kg/kWh i.e. 10 gm/kWh

First strategy

The suggestion is to reduce coal and simultaneously increase oil and gas share; then
Expected CO_2 mitigation= 4gm/ kWh

Second strategy

Here the plan is to reduce coal; increase renewable energy sources and make no change in oil and gas. Then

Expected CO_2 mitigation= 10gm/ kWh

Now, 1 kWh is equivalent to 0.114W

Therefore, 1/0.114 kWh is equivalent to 1W or

8.77 kWh is equivalent to 1W

First strategy

CO_2 mitigation is $4\times8.77=35.1$ gm per Watt of power
$=35.1\times10^3$ kg
$=35.1$ ton/MW

Second strategy

CO_2 mitigation is $10\times8.77=87.7$ gm per Watt of power
$=87.7\times10^3$kg
$=8.77$ ton/ MW

One may note that present installed power capacity=272,687 MW

CO_2 Mitigation

First strategy

$35.1\times272{,}687=9.58\times10^6$ ton

Second strategy

$87.7\times272{,}687=23.9\times10^6$ ton
Per capita CO_2 mitigation may now be found.
Let population of India=125 Crore presently.

First strategy

CO_2 mitigation$=9.58\times10^6/125\times10^7$ ton
$=0.0191$ to19.1 kg per capita

CO_2 Mitigation Scenario

CO_2 mitigation=0.641 kg/kWh
$=0.641\times8.77$ kg/kW
$=5.62$ kg/W
$=5.62\times10^6$ kg/MW

Hence,

CO_2 mitigation $=5.62\times10^6\times272{,}687$ kg
$=15.3\times10^{11}$ kg
$=15.3\times10^8$ ton
$=1.53\times10^9$ ton

Per capita CO_2 mitigation

$=1.53\times10^9/125\times10^7$ ton
$=1.22$ ton (per capita) or 1220 kg per capita per year

Table 4 (a). First strategy

Per capita CO_2 (before)	Per capita CO_2 (after first strategy)	Reduction
1220kg	1212kg	7.7 kg

Table 4 (b). Second strategy

Per capita CO_2 (before)	Per capita CO_2 (after second strategy)	Reduction
1220 kg	1201 kg	19g

Analysis

The amount of CO_2 in atmosphere is increasing due to a number of reasons. One of them is the use of fossil fuels to generate electricity and other forms of energy. Such use of fossil fuels leads to increase in CO_2 levels in atmosphere. Hence it is an essential goal to diminish the dependence on fossil fuels; particularly coal.

Two strategies have been proposed in the present study to achieve the goal of CO_2 reduction. The first among them is to reduce the coal share, and at the same time increase the share of oil and gas. This results in 0.69% reduction in CO_2 emissions as compared to base value (relative to base value as before). An alternative strategy explored is to decrease the share of coal and correspondingly increase the share of renewable energy sources. This later strategy proves to be better; since the reduction expected in CO_2 emission is 1.53%. We are thus led to conclude that replacement of fossil fuels (particularly coal) by renewable energy sources (particularly solar energy) is a very sensible policy option. Hence all encouragement must be given to increase the use of solar energy.

Recommendations to address the issue of CO_2 mitigation

- Mandatory, progressive targets should be identified to reduce emissions associated with all major energy sectors. They include power generation, transportation, manufacturing and energy use in commercial and residential buildings. They targets ought to focus on near-, mid-, and long-term timeframes.
- Flexible approaches should be found to motivate CO_2 emission limits. Such limits may vary across economic sectors. Depending on particular sector; provision may be made for market-based incentives; governmental loan guarantees; tax credits; technology research incentives and other appropriate policy measures.
- Approaches should be promoted at global level to ensure sustainable atmospheric CO_2 component and encourage cooperative action by all countries. The efforts should include and large emitting nations in the developed and developing world in order to implement CO_2 emission reduction strategies.
- Investments in research should be made to develop cost-effective renewable and efficient energy technology. At the same time, one must aim to improve the performance of carbon energy systems, and support the research for new, clean energy systems.
- Increased emphasis should be placed on investment in education and training of the workforce to equip them in application of advanced energy technologies.
- Enhanced development of infrastructures should be encouraged to implement technologies that have the potential to mitigate CO_2 emissions.

Conclusion

The quantitative model described in the present study seeks to relate the quantum of energy with various important variables which characterize the situation of a country viz., its population and per capita energy demand. One recognizes that sources of energy production are of two major types namely; renewable and non-renewable. The nature and impact of the two are widely different and is the cornerstone of sensible policy. It may be noted that energy consumption is occurring in various sectors with their own specific requirements. In the Indian context, we have enumerated them in the present study. While one can perhaps do little about population, it is possible to devise planning strategies which may suitable regulate energy demand. Two strategies specially aimed at CO_2 mitigation have been examined in this study. Imagining a situation, in which renewable energy share is not altered; a readjustment among conventional fossil fuel shares may reduce CO_2 amount by 7.7 kg per person. This is equivalent to a reduction of 0.6% (in the back ground of CO_2 amount being 1220 kg per person presently).

The second strategy is more significant. In this strategy, the suggestion is to replace a part of fossil fuels by renewable energy sources. This yields much better results since CO_2 mitigation is predicted to be 19 kg per person. In the back drop of the present CO_2 amount of 1220 kg per person, this is a reduction of 1.6%. These examples provide powerful support for encouragement of renewable energy sources.

In the final analysis, the choice of renewable and non-renewable sources is man controlled; to a very large extent. Constrains on consumption pattern are largely dictated by the existing situation of the country but suitable healthy intervention is possible by imagining creative policy measures. The quantitative model proposed here, links the various parameters with one another and the model is flexible enough to accommodate various strategies. The advantage of the model is that if a parameter is suitably varied; the effect on the rest of the variables may be estimated. The model thus has its utility in making energy planning realistic and goal oriented.

REFERENCES

Akshay Urja - Ministry of New and Renewable Energy mnre.gov.in/file-manager/akshay-urja/january.../page30.html

Electricity emissions around the world shrinkthatfootprint.com shrinkthatfootprint.com/electricity-emissions-around-the-world

Energy Division - Planning Commission, Government of India planningcommission.nic.in/sectors/index.php?sectors=energy

India Energy Situation - energypedia.info https://energypedia.info/wiki/India_Energy_Situation

India faces daily power outage of 30,000 MW - Livemint www.livemint.com/.../India-faces-daily-power-outage-of-30000-MW.html

Ministry of New and Renewable Energy - Physical Progress ... mnre.gov.in/mission-and-vision-2/achievements/

Per capita consumption of electricity - Press Information Bureau pib.nic.in/newsite/erelease.aspx?relid=74497

Power and Energy - Planning Commission, Government of India planningcommission.nic.in/sectors/index.php?sectors=energy

Power Sector at a Glance ALL INDIA | Welcome To Minsitry of Power powermin.nic.in/power-sector-glance-all-india

Renewable Energy Market in India 2014 - 2022 | NOVONOUS www.novonous.com/renewable-energy-market-india-2014-2022

****