

## CO2 Emission Reduction by using Renewable Energy in Iran: Towards Sustainable Development

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**Abstract** In general terms, energy sources are classified as renewable and non-renewable energy types. Renewable energy is fuelled by a source that is sustainable in economic, social and environmental terms. It is usually defined the fuel source, for example, solar, wind, biomass, tidal, etc., but it has other relevant characteristics that are important. Renewable energy has the capacity to provide cost-effective energy to remote communities' without the added investment of providing fossil generation. Because of high CO<sub>2</sub> generated by fossil fuel in Iran and necessity of changing in energy consumption in this country, this Meta-Analysis study was conducted for showing Iran's situations regarding to use of RE for CO<sub>2</sub> emission reduction. For doing this, all of the available related and published papers have gathered and analyzed by content analysis method. From 110 papers, 35 cases were desired and discussed about CO<sub>2</sub> emission and the role of renewable energy to reduce the amount of GHG, particularly CO<sub>2</sub> in Iran. For content analysis, these papers were read and reviewed, line by line for several times and extracted main concepts. Then by categorizing these concepts, the main influence factors on CO<sub>2</sub> emission reduction were recognized. The results of this study showed those seven categories such as: GHG, Generation of RE, Energy Consumption, Environment, Government Orientation, Rural Development, and Economy shall be considered. The paper refers some suggestions according to the findings.

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### Introduction:

In general terms, energy sources are classified as renewable and non-renewable energy types. Renewable energy is fuelled by a source that is sustainable in economic, social and environmental terms. It is usually defined the fuel source, for example, solar, wind, biomass, tidal, etc., but it has other relevant characteristics that are important. Renewable energy has the capacity to provide cost-effective energy to remote communities' without the added investment of providing fossil generation. In the last 25 years 1.3 billion people living in developing countries have gain access to electricity, but population has increased by 2 billion in the same period so there are 700 million more people without electricity than was the case 25 years ago. Because of the remoteness, cost and demographics the grid will never reach most of them, and this suggest that Remote Area Power System( RAPS) are then, likely to be the only way of supplying power to them (Ghobadian, et al., 2009).

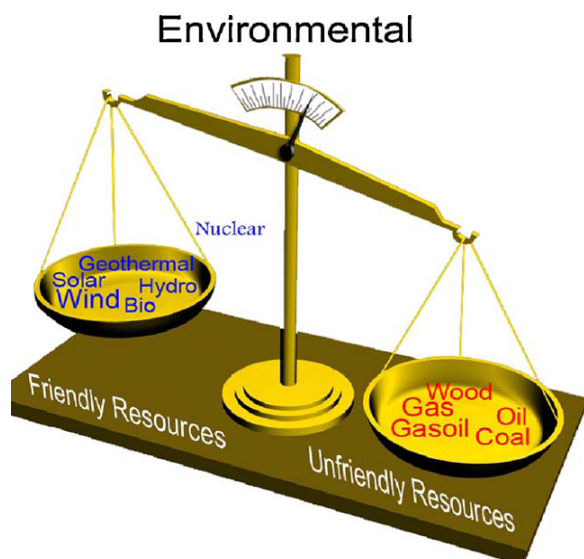
In the other hand, world population growth beside economic development has increased energy consumption. The energy consumption was increasing from 6630 million tons of oil equivalent

(Mtoe) in 1980 to 11,295Mtoe in 2008 worldwide. By current increase in energy consumption rates, energy supply will be a real challenge in a near future for the whole world and even for currently rich oil countries. The world energy production in 2000 and 2007 was 1.65(ton oE) and 1.82 (ton oE) (Dehghan, 2011) per capita respectively, that indicating growth rate of 10.3 percent. Therefore, many countries have paid high attention to utilize alternative sources of energy particularly the renewable ones to meet their growing energy demands and have taken actions in the development and application of renewable energy technologies for

Sustainable development. Moreover, the current environmental issues specially greenhouse gas emission enhance these efforts.

Iran's Energy Security is based on oil as a primary source of energy. The energy production in the country in 2000 was 1.84(ton oe) per capita which has been increased to 2.6 (ton oE) in 2007, showing 41% increase in energy production rate. According to incremental rate, energy production is anticipated to reach around 4 (ton oE) per capita by 2020 due to the social and economical

development, ecological improvement and promotion of life standard.

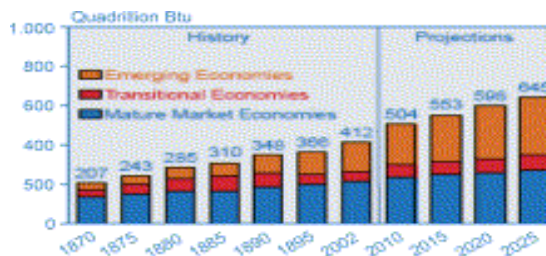


**Fig. 1. Environmental friendly scaled energy balance (Ghorashi and Rahimi, 2011)**

However fossil fuel reserves are limited and usage of fossil fuel sources have negative environmental impacts. Since the first oil crisis, renewable energy sources have gained in great importance due to their inexhaustibility, sustainability, ecological awareness and supply of energy security. So, renewable energy sources are expected to play an important role especially in electrical energy generation balance (Fig. 1) (Mostafaeipour, 2010).

#### **Current Co2 emission in the world and Iran: In the World:**

Increasing human welfare accompanies have resulted in the development and use of greater and more up-to-date services and product. Manufacturing product and providing services has always required resources consumption. One of the main resources for this is energy (Fig. 2). In today societies, one of the important energy types used in manufacturing products and providing services is electrical energy. Therefore, the development of human societies has always faced an increase in power consumption. It is anticipated the henceforth, this increasing trend in electricity usage will reach 32,922 terawatt hours in the year 2035 (approximately two times the amount used in the year 2008) (IEA, 2010).



**Fig. 2. World energy demand growth**

To be able to respond to the increased in electricity production should also be increased. Thus, increase in electricity production is one of the requisites for the economic growth and sustainable development of countries. Also, with regard to the description of sustainability not considered sustainable on a long-term basis.

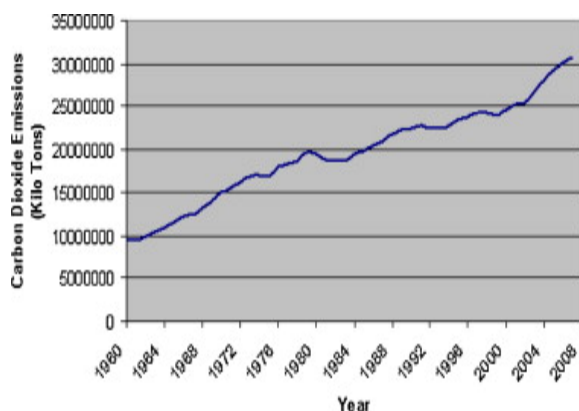
The use of alternative selection with greater sustainability for electricity production can be asset to sustainable development of countries. One of the most efficient options in this regard is renewable energies. This is because renewable energies have less environmental effects, are more adaptable, are inexhaustible and have potential for distributed production.

Fortunately, the world's inhabitants have become aware of the bad effects of fossil fuel usage and advantages of renewable energies, and it is anticipated that the distribution of these resources will increase in the future. Even in the Middle East region, as the heart of the fossil reserves world, it is anticipated that the renewable share in electricity production will reach 16% in the year 2035 from 1% in the year 2008 (IEA, 2010).

Global environmental issues are getting more attention especially increasing threat of global warming and climate change. Higher global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level are some evidence of warming of the climate system. The intergovernmental panel on climate change (IPCC) reported a 1.1 to 6.4 degree of centigrade increase of the global temperatures and a rise in the sea level of about 16.5 to 53.8 cm by 2100 (IPCC, 2007). Co2 emission which is a global pollutant is the main greenhouse gas that causes 58.8% of global warming and climate change (Saboori and Soleimany, 2011).

Rapid increase of Co2 emission is mainly the result of human activities due to the development and industrialization over the last decades (Fig. 3).

Each year, only agriculture emits 10 to 12 percent of the global total of estimated greenhouse gas ( GHG) emission ( Shabanali Fami, et al., 2010).



**Fig. 3. Global total carbon dioxide Emission**

The energy consumption pattern of the world indicates that the share of oil and coal in the world's total energy consumption are 33% and 27%, respectively. The energy consumption pattern also shown that 10% of the total energy in the world is derived from biomass while 90% is provided by fossil and conventional energy, resulting in the overall natural climates such as global warming etc. and worldwide competition for the energy resources. Coal, oil, and natural gas are fossil fuels. Their application as energy sources is highly unsustainable due to the depletion of the limited energy sources and also the emission of greenhouse gases into the environment. Greenhouse gases contribute to global warming and also have other impacts on the environment and human life. Recently, the potential threat of global climate change has increased, and fossil fuel usage has the highest contribution to greenhouse gas emission.

The undesirable effects of consumption fossil fuel such as atmospheric pollution due to CO<sub>2</sub> emission and making problems such as air pollution, acid rain, GHG, climate change, earth warming can never be avoided entirely, but can be reduced.

#### **In Iran:**

Iran located in the Middle East region, had of 72 million in the year 2008 and is a developing country (Fig. 4). In fact, Iran is one of the biggest oil and natural gas producers of the world. This issue has also affected energy structure of Iran, and oil and gas have allocated 445 and 545 of the total energy share, respectively, 90% of the electricity, and 80% of Iran export share ( Bagheri Moghaddam, et al. , 2011).

Today the sustainable realistic development and growth is one which does not have diverse effect on environment and should not damage the

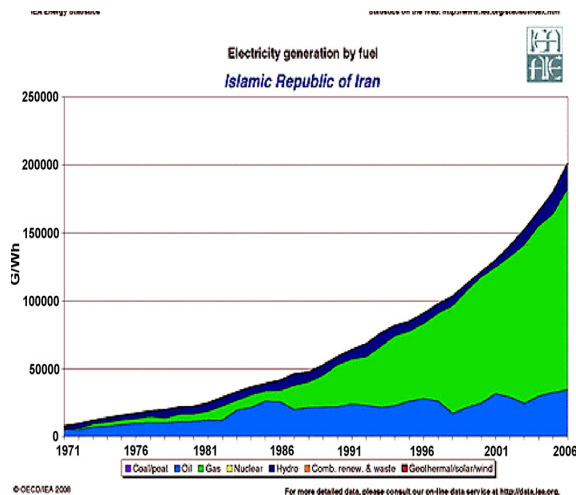
natural resources. As mentioned before Iran is the second Middle Eastern country with respect to enjoying various energy resources. Beside abundant conventional sources of energy, like oil and natural gas, the country is based with large renewable energy resources such as solar, wind, biomass, geothermal, hydro, etc. Moreover, life of oil reserves are limited and the share of next generation must be considered so that they may have better option to utilize these badly treated treasures.



**Fig. 4. Location of Iran in Middle East.**

Iran, as a developing country, will be confronted with a significant increase in electricity demand in future years (Fig. 5). Being a petroleum producing country has resulted in extreme subsidies for energy production from fossilized resources such as oil and gas. This issue is one of the most important factors regarding under development of renewable energies in Iran. Expansive use of fossil resources in providing the necessary energy has resulted in Iran being among the 20 countries that have a share in the 75% spread of greenhouse gases.

Because of political economy condition and environment crisis in Iran, in ranking Environment Sustainability Index (ESI) it is graded 132 among 146 country and from 100 score, scored 39.8 (Anonymous, 2005). In Iran, the cost of air pollution was 1.6% GDP (1810million US\$) and cost of environmental degradation is about 8.8% (10000 million US\$) of Iran's GDP (World Bank, 2005) and estimated will receive to 10.9% GDP in 2019 (Shafie Pour Motlagh et al., 2005). Also, cost of emission CO<sub>2</sub> is 1.36% GDP of Iran (World Bank, 2005).



**Fig. 5. Electricity generation by fuel for Iran (Najafi, 2001)**

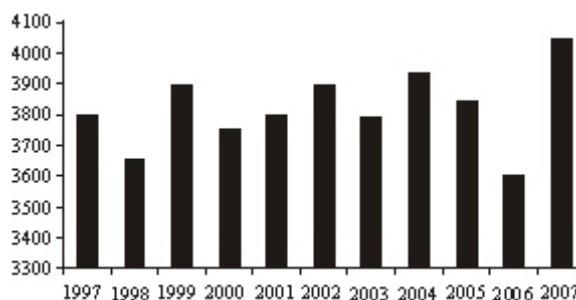
Unfortunately among developing countries, Iran the OPEC's second largest produced and exporter country experienced a significant rise in pollutant emission and energy consumption in recent years. Iran has a high per capita energy consumption comparing with other developing countries. Iran's CO<sub>2</sub> emission is considerable and placed the country among the top ten emitting countries (International Energy Agency, 2010).

Recently the potential threat of global climate change has increased, and fossil fuel usage has had highest contribution to greenhouse gas emission. In 2009 the fossil fuels associated CO<sub>2</sub> emission was about  $527 \times 10^6$  tones in Iran.

Air pollution means combination of air with gases to lead to decrease in quality of the air. Pollutant elements are carbon dioxide, Monoxide, Sulfur Dioxide and etc.

Estimated annual losses of mortality due to urban air pollution are 640 million dollars that is equivalent 0.57 percent of GDP. The disease caused of urban air pollution creates 260million dollars (0.023 percent of GDP) for the economy of Iran (World Bank. 2005).

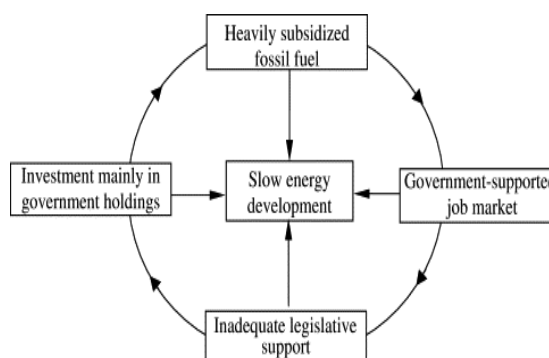
If gases emission factor of generative electricity was fixed, pollutant emission and social cost must have increased considerably. It is expected by existent trend GHG and air pollutants emission will increase. So, increase of technology level and replacement of age-old and depreciated machineries and equipment correct management and increasing efficiency of fuel (Fig. 6) (Asakereh, et al., 2010).



**Fig. 6: Social cost of GHG and air pollutants emission of Consuming fossil fuel and electricity in agriculture (Milliard Iranian Rial, 1USD = 8910 IRR (Anonymous, 2009))**

Lower price of electricity has increased the growth rate of electricity consumption, and consequently acted as one main agent on the increase of the environmental pollution rate. In 2009, the total amount of air pollutants resulting from electricity generation especially CO<sub>2</sub> was estimated to be over 128 million tone (mousavi, et al., 2012).

According to above results, in spite of valuable resources of RE in Iran, development of this alternative method for replacement of fossil fuel, confront with some barriers that have demonstrated in Fig.7.



**Fig. 7. Barriers of Renewable Energy Development in Iran**

#### Materials and Methods:

This Meta- Analysis study has conducted to recognize the effect of renewable energy on CO<sub>2</sub> emission reduction in Iran. For doing this, all of the available related and published papers have gathered and analyzed by content analysis method. Among 110 papers, 35 cases were desired and discussed about CO<sub>2</sub> emission and the role of renewable energy to reduce the amount of GHG, particularly CO<sub>2</sub> in Iran. For content analysis, these papers were reviewed, line by line for several times and extracted main concepts. Then by categorizing these concepts, the main influence factors on CO<sub>2</sub>



emission reduction were recognized in seven categories.

**Results:**

This part is derived from papers analysis based on Grounded Theory analysis that contains some categories as follow:

- 1) Because of focusing the most papers on GHG issue, so, one of the categories is named “GHG”. According to researches and writers’ paper, Co2 emission is a main pollutant gas that is caused 58.8% of climate change and earth warming. As mentioned before, Iran has a bad condition from this point view. Co2 emission due to the power generation in Iran has increased 240% during past 18 years. In this pollution, power plants with 27.6% were the main pollutant resources. Energy intensity has increasing rate too, and it is required to reduce it.

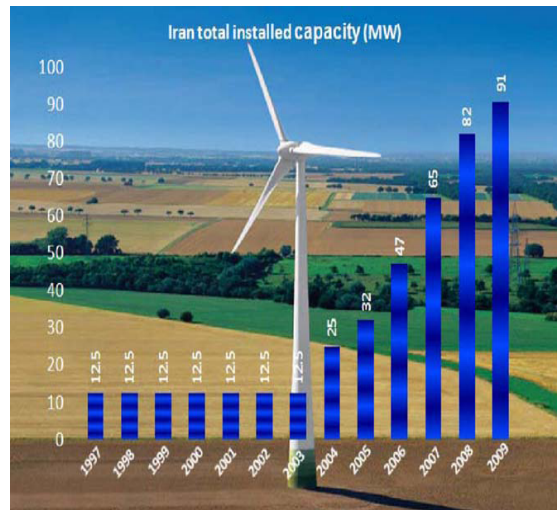
To address to this problem, it seems renewable energy is an appropriate solution, because Co2 emission by renewable energy generation such as wind, solar and biomass is very low, and among these methods, wind energy has a lowest pollution. Biofuel such as bioethanol can help to solve this problem. Fortunately, Iran has 28<sup>th</sup> record among 46 wind energy producer countries, and to be able to manufacture of seven parts of wind turbine, internally. Existence of other renewable energy resources can help to produce clean energy in Iran. For example, this country has planned to generate 96000 MW solar electricity to 2020.

Good policy decisions and supporting of government, investment, increasing of private sector share to renewable energy generation, and indigenous technical experts are some capability of this country.

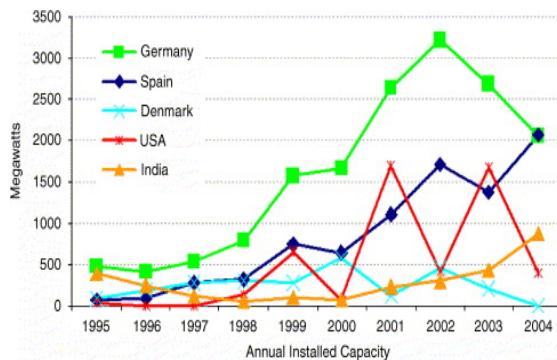
By using these appropriate potentials conditions, and resources, it is possible to reduce CO2 emission in Iran.

- 2) Second category is “Generation of RE”. Today, the share of RE in Iran is low, but it has growth increasingly (Fig. 8, 9, 10, 11). RE generation can provide good conditions for export of more quantity of fossil fuel. According to Iran’s’ plan, share of RE in electricity generation will be reached to 38% that can be increased to 57%. Agricultural wastes ( residues crops, horticulture, animal, forest and

agricultural industries), municipal solid wastes, beside of other reach resources such as solar- the average radiation days in Iran is 2800 hour per year-, wind and geothermal can provide generation more of RE in Iran. For example only wheat residues can generate 3 GL bioethanol, also this amount is 0.2 GL for corn. Bioethanol producing from agricultural residues can ideally replace 25% of total gasoline consumption in this country. The annual gasoline consumption is 24 GL at present in Iran (14, E12). If rule imposed to use E5 (5% ethanol in gasoline as a blend fuel) as a fuel, the annual saving can reach 1.2 GL. If E10 is used, the saving can reach 2.4 GL. This fuel is environmental friendly.



**Fig. 8. Growth of Wind Energy in Iran (Mirhosseini, et al., 2011)**



**Fig. 9. Annual wind power capacity installations in countries with leading turbine manufacturers, 1995–2004.**



Fig. 10. Geothermal prospects of Iran ( Ghobadian, 2009)

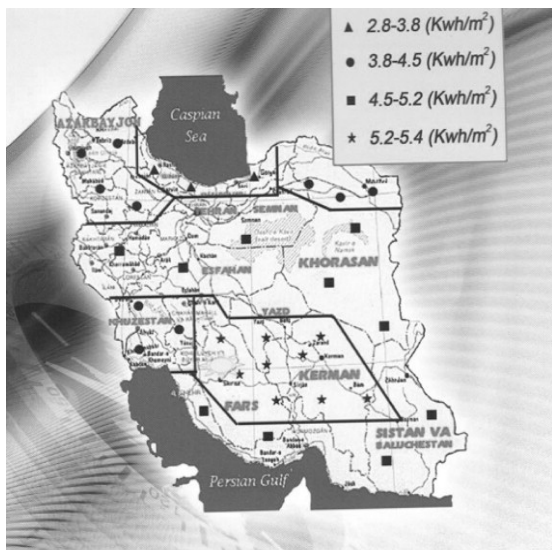


Fig. 11. Iran solar energy map

As it can be seeing, RE generation in Iran, regarding to resources and potentials is possible and can have an important role in CO2 emission reduction.

3) The category of “Energy Consumption”

Increasing human welfare accompanies have resulted in development and use of greater and more up-to-date services and products (Bagheri Moghaddam et al., 2011). This process has required resources consumption. One of the main resources is energy. In Iran increasing of economic growth in one hand, and low price of energy due to energy subsidy in the other hand are roots of energy

consumption, increasingly. For example, imported gasoline was approximately 23 and 25 million liters daily in 2004 and 2005 respectively. So, energy consumption in Iran is high to compare with world countries, even with developing countries (Fig.11). In the recent years, with a new policy-gradually eliminate of energy subsidy- government is decided to control this. In addition, using of some resources such as wood for heating and cooking in rural areas, beside of low energy efficiency in agricultural sector can be one of the reason for increasing energy consumption, that produce Co2.

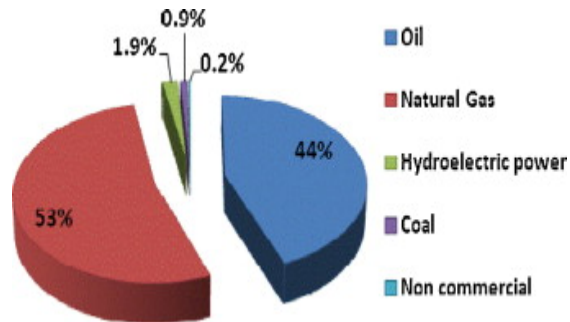


Fig.12. Total energy consumption in Iran by type ( Najafi and Ghobadian, 2011)

For energy consumption control, it is required that in addition of public and expertise education and training, to provide infrastructure for optimize consumption. For example, by training in agricultural sector on development of organic agriculture, it is possible to reduce 25-50% of energy needs in this sector.

4) Category of “Environment”

Today, Iran has a 132nd record among 146 world countries regarding to ESI (Environmental Sustainable Index) that is not desired. Air pollution cost is 1.6% of GDP and the environmental degradation cost is 8.8% of GDP, that predict to reach 10.9% up to 2019.

Chang climate and rain reduction are side effect of fossil fuel consumption. As mentioned before, to use RE can control these side effects. Of course, for reduction of air pollution, subsidy elimination policy can be very effective. International decisions such as IPCC for CO2 emission reduction to 6% globally till 2012 and new strategies in Iran related to develop of agricultural sustainability and organic agriculture can help to reduce CO2.

5) Category of “Government Orientation”

Government orientation or its policy has important role on energy issues. In spite of many

papers emphasize in this study on positive Iranian government orientation for RE, but still there isn't any defined plan with details for this part of energy generation. Particularly, the lack of guarantee for buying RE produced by private sector. Totally, it seems the orientation of government for RE is positive and based on reduction of fossil fuel consumption and consequently, increasing the RE share in country's energy generation. Investment and financial supporting by government on RE estimated positive and affect on producing and emission GHG reduction. Among this process, CO<sub>2</sub> as a main pollutant resource can be influenced.

#### 6) Category of "Rural Development"

One of the groups that always has difficulty, regarding to welfare factor, contain energy, is rural people in the remote areas. In the developing countries, and also in Iran, some parts of remote in the rural areas haven't access to electricity for lighting or oil and gas for heating and cooking. Because to reach sustainable development isn't possible without rural development, it is very important to address their problems, especially energy. The development of renewable energy sources also enables Iran to produce and distribute electricity in rural and remote areas, which would play an important role in increasing the infrastructural development in these areas as well as increasing welfare, while protecting environment and the health of these people. This is particularly important since the level of poverty in the areas with rich wind, high solar radiation and deal amount of biomass.

One of the main and important character of RE for rural development is possibility for establishment of small or local energy network, that has a shortest distance to consumption and maintenance of this networking is very low, to compare with grid network.

#### 7) Category of "Economy and Costs"

High costs of fossil fuel, despite of reach oil and gas reserves in Iran from one hand, and CO<sub>2</sub> emission and social costs in different parts, specially in agricultural sector that up to 2007 has growth, increasingly, and this estimation that annual losses of mortality due to urban air pollution are 640 million dollars (0.57% of GDP), in the other hand, it is necessary to find alternative for fossil fuel.

According to experts and researchers analysis, RE such as wind, solar and biomass can provide and earn continues income for farmers. In other hand, RE generation can be low cost in long term,

specially when conclude environmental costs. Fortunately, investment in RE in Iran and to reduce fossil fuel, not only reduce the rate of CO<sub>2</sub> emission, but this country will be able to export more oil and gas to global market, or better than this, can produce many productions from oil and gas and then export these to other countries. By this way, Iran can earn deal amount of income for its productions.

#### Conclusion:

Providing a solution to environmental problems that we face today requires long-term action for sustainable development. According to results of many papers analyzing in this research that have published in Iranian and International journals, we can conclude and demonstrate Iran's' conditions and situations regarding to effect of using renewable energy on reducing Co<sub>2</sub> emission, as a most important issue in energy sector and so sustainable development in this country. For doing this following points can be concluded:

- 1) Regarding to existence of 2800 h/ year sunshine hours in Iran, it is expected to develop of using solar and photovoltaic in the country, particularly in the remote areas that have not access to sufficient energy. It can be helped these poor areas to achieve appropriate development towards sustainable rural development.
- 2) Iran has a desired situation for wind energy and increasing investment in wind energy generation in the recent years and, furthermore, elimination of energy subsidies by government, help to development of renewable energy. In addition, progressive technologies for manufacturing wind turbine can increase using of renewable energy and consequently reduction of CO<sub>2</sub> emission.
- 3) Beside of wind and solar resources in Iran, this country has good conditions for using biomass to generation some kinds of energy such as biogas, bioethanol, biofuels, particularly in the rural and remote areas. Furthermore, geothermal in some parts of Iran such as north and western north is another resource that can help to reduce fossil fuel consumption and consequently, reducing of CO<sub>2</sub> emission.
- 4) The future energy needs for all of the different parts of Iran must be an integration of sustainable technologies that have the least amount of environmental pollution. Renewable energy methods can



addressed to this need, and naturally reducing of using fossil fuels can be resulted to reducing of GHG, and so, CO<sub>2</sub> emission in this country.

Totally, according to the results of this study and reviewed papers related to the effects of RE on CO<sub>2</sub> emission reduction in Iran, because of desire renewable energy resources and overall conditions in this country, it is possible to reduce the amount of CO<sub>2</sub> by using RE for generating power and energy. By this way in one hand reduction of CO<sub>2</sub> is occurred, and in other hand we can provide some advantages such as, creating employment for people, specially for youth, health, better using of fossil fuel resources, reduction of GHG, avoiding of earth warming, achievement of rural development and finally providing conditions for achieving sustainable development

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