WORKSHOP

2nd International Workshop on the Renewable Efficient Energy Technology

College of Engineering and Technology

Arab Academy for Science and Technology and Maritime Transport

May 7-9, 2012
Socio-Economic and Environmental Impact of Renewable Energy

Prof Dr. Ibrahim Soliman
Professor of Agricultural Economics University of Zagazig Egypt
Team Leader of EU-FP7 SUSTAINMED PROJECT in Egypt

INTRODUCTION

Continuously rising energy demand combined with increasingly limited natural resources are challenging energy suppliers, either for industry or consumers impose to rethink how we produce and use energy.

Renewable energy implies naturally replenished. It is energy which comes from renewable natural resources such as sunlight, wind, rain, tides, and geothermal heat. About 16% of global final energy consumption comes from renewables, with 10% coming from traditional biomass, which is mainly used for heating, and 3.4% from hydroelectricity. New renewables (small hydro, modern biomass, wind, solar, geothermal, and biofuels) accounted for another 3% and are growing very rapidly. The share of renewables in electricity generation is around 19%, with 16% of global electricity coming from hydroelectricity and 3% from other new renewables.

This article is a case study to present the socio-economic impacts of introduction of renewable energy to replace the conventional fuel sources. The later is a depletable natural resource and its usage cause much harmful impact on environment. The conventional energy sources are petroleum oil and/or coal.

Environmental impacts of the renewable energy arise from the externalities of the individual projects that adopt such technology. Externalities could be positive (benefits) or negative (costs), however they are not considered through the regular market mechanism. These externalities refer to the utilization of the resources and the public goods, where not all economic agents act as price takers and not all economic agents have complete information. This condition is called a market failure. It is, also, due to that there are not well-defined private property rights in all inputs to and outputs from production and consumption activities.

Once, the prices emerging in markets cannot, generally, be taken to express the relative social valuations required for efficient allocation of resources. Then, there is a role for social appraisal of any appropriate technology package introduced to the economy. For example, establishment a factory in a small town definitely generates income to its enterpriser and could be appreciated by the local community, as it provides some job opportunities. However, no body care about the pollution stems from smoke of fuel combustion and/or the plant’s disposal going to water, land or air. Therefore, the owner does not compensate the society for either the morbidity or the probable premature death due to pollution.
Replacement of conventional fuel for hydroelectrical energy to operate a certain processing plant creates external benefits as providing clean energy that will protect people from the probable premature death, due to the combustion of the conventional fuel. Therof, inclusion of the environmental impacts in the project evaluation is a must, using the social appraisal by applying the cost benefit analysis. It is, in its appropriate term, the procedure to consider the benefits and costs generated by the externalities of development. This does not assume that project appraisal can never proceeds based on valuation and aggregation at market prices. However, under the theme of the sustainable development, with its four dimensions (economic, technological, environmental, and human development) any conceivable project requires to be subjected to a cost benefit analysis. In words almost all projects include some of its consequences under either external costs or benefits, where market prices are regarded as inappropriate and the cost benefit analysis should be applied using the appropriate social prices.

This study generates a case study model for social project appraisal that simulates the socio-economic evaluation of a depletable resource and environment protection from pollution effects. The model evaluates a project that generates an "environmental friendly electrical energy" using "Hydroelectric". The external costs avoided by substitution of non-polluting hydroelectricity for fuel-fired electricity are benefits to be attributed to the project, as are the depletable fuel resource savings. It was quantified in the model in terms of:

I. Access a cheap clean rebeable source of energy,
II. Save a deplorable natural resource (conventional fuel), and
III. Reduces the morbidity and/or the probable premature death.

It also, preserves water for irrigating additional newly reclaimed land for agricultural production. Even though, the model in this study is restricted to evaluate the feasibility and validity of the first three outcomes.

It should be mentioned that The applied appraisal model concerns the relative prices, rather than the absolute prices. If the general price level is constant, absolute and relative prices are the same. Therefore, in cost benefit analysis, any anticipated movements in the general price level, but not in relative price, should be ignored.

**Direct Costs of Renewable Energy**

The quantities of inputs, which are required during construction, at all stages, are valuated using market prices. It is assumed that in terms of inputs for construction, maintenance, and shutdown, the market prices are appropriate for social valuation. This assumption would not necessarily be appropriate in all conceivable circumstances. For example if the project was established on a "natural reserve region".

Estimates of the construction costs are $200 million for the first 5 years. The running and maintenance costs at market price reach $0.5 million a year over the
successive 45 years after establishment. The average electricity output will be 6,570 GW/h. GW/h stands for gaga watt/hour. A watt is a unit of power, equal to 0.293 Btu "British Thermal Unit" per hour, which is the amount of energy required to raise the temperature of one pound of water one degree from 3 to 4UC. Giga stands for 10 watts. The planning assumption is to create such volume of electricity a year for 45 years. However, the investment costs are not fully allocated for electricity generation, it is mainly for saving water for additional aricultural establishment.

**Direct Benefit from saving the Conventional Fuel Costs**

By building a hydroelectric plant the electricity supply system reduces its fuel costs for meeting the given demand for electricity to the extent that output from the hydroelectric plant would be of zero fuel cost ,when displaced from conventional energy plant (oil) and allocated to hydroelectric energy. In practice, determining the quantities of savings of the conventional fuel attributable to the hydroelectric plant should involve the modeling of the entire electricity supply system.

Then the output from the proposed plant displaces oil, implied valuation of the depletable resource savings. The quantity of the saved oil input depends on the thermal efficiency of the burning power stations. A widely used ready reckoned factor as a conversion factor was used.

The average electricity output will be 6,570 GW/h. GW/h stands for gaga watt/hour. A watt is a unit of power, equal to 0.293 Btu "British Thermal Unit" per hour, which is the amount of energy required to raise the temperature of one pound of water one degree from 3 to 4UC. Giga stands for 10 watts. The planning assumption is to create such volume of electricity a year for 45 years. The "Ready Reckoner' conversion factor used is 500 tons of fuel to generate 1 GW/h of electricity. The operating rate a year is 75%. It means that the hydroelectric plant reduces (saves) 3.285,000 tons of fuel per year. The market price of fuel is $40 per ton in the base year of the project.

**External Benefit from Saving a Depletable Resource**

The market price of petroleum oil is not the appropriate social valuation per ton of input saved. There are two reasons for this assumption: (1) petroleum oil is a non-renewable resource, (2) Burning petroleum oil to generate electricity, gives rise to external costs. The natural resources economic concept implies that such continuous consumption of a depletable resource (petroleum oil) would increase sharply its scarcity.

It implies that efficiency in inter-temporal allocation requires that the price of a non-renewable resource rises over time at a proportional rate equal to the interest rate, assuming constant marginal extraction costs. Since the cost benefit analysis is concerned with efficiency in allocation, the value of coal saving in each year of the project's life should be at the price corresponding to efficient inter-temporal allocation. Although, during the most probable outcome of this model, the price of petroleum oil
rises at a proportional rate equal to the interest rate, in more detail model other
dimensions should be considered. These are:

(a) The change in interest rate,
(b) The extraction costs, and/or,
(c) The vast new petroleum oil deposits that may discovered

The Coal price is assumed to rise annually at a proportional rate equal to 5
percent interest rate. The following equation is used to generate the annual coal price in
the successive future years:

\[ Pt = P_0 (1+r) T. \]

Where, \( Pt \) = Coal price in the target year \( t \),
\( P_0 \) = the price in the onset year,
\( T \) is the number of years between \( P_0 \) and \( P_t \)
Therefore:

\[ Pt = $40 (1+0.05) T \]

**Avoidance of pollution is a positive externality**

It is well known that burning conventional fuel to generate electricity gives rise to
pollution problems especially atmospheric pollution. Qualification of arising benefit is
so difficult. The atmospheric pollution from compustion of the conventional fuel such as
petroleum products has adverse effects on material structures giving rise to corrosion
and to the burden of required cleaning costs, it has also, adverse effects on plants
and animals including man. In quantitative terms, most research attention has focused
on the effects on human health. This is should not to be taken to imply that the other
effects of atmospheric pollution due to coal combustion are trivial, but, clearly, there is
much uncertainty involved. The impacts of acid-rain problem is a clear evidence.

Considering human health effects, the estimating costs attributable to the
burning of Solar fuel to produce electricity is two-stage process:

**1) To quantify the health effect:**

Such stage includes much uncertainty and it requires a great deal of research
effort. The health effects express increasing morbidity (disease incidence) and mortality
due to fuel combustion. Relatively little is known about the former, accordingly, the
study regards only here the probability of increased mortality as the only estimate
that has significant published research output.

Estimate of health effect is based upon the mortality effects of the various
pollutants emitted from conventional fuel combustion. Thereof, it was derived from the
emissions from a typical one GW/h plant operating at 75% load-factor, which
means that the plant is running 75% of the year.

The applied estimate was 80 extra deaths per year attributable to plant
operation. However, the range of estimates for the excess mortality, attributable to such
a plant, in the literature, was from 10 to 100 persons a year. Since there are 365
days in the year and 24 hours in a day, one GW/h plant operating at 75% load-factor
sends out 6570 GWT per year. This is the estimated average yearly output of the
hydro plant, which would mean 80 fewer premature deaths per year.

(2) Social valuation of Reduction in Mortality.
The second stage is Putting a value on human life. It is a difficult area for
discussion. The basic principle here is as elsewhere that social valuation should reflect
willingness to pay. Now clearly, if an individual is asked what he would be willing to pay
to prevent his owns certain prospect death, his answer will be the largest sum of money
on which he can lay his hands. However, development plans do not give rise to the
prospects of certain life or death for specific individuals. Rather they give rise of
decrease or increase in mortality rates of the whole populations, and hence to changes
in the probability of death for individual members of that population. Individuals can and
do make choices which involve changes in the probability of death, as for example,
when they travel by car rather than walk in urban areas, demonstrating that they value
time saved more than the increased probability of death. In principle, then, one can infer
willingness to pay for changes in the probability of death from observed behavior. The
implementation of this principle is difficult.

One approach, which has been adopted, is to look at wage rate differentials
across occupations of varying degrees of riskiness. Other things equal, it is an
observable fact that wage rates are higher for riskier jobs. Although few studies about
this subject have been done, the range of variation in the values they estimated for a
human life is rather large. Although it is a difficult and contentious problem, it is a
vial appraisal for environmental impacts of development. Accordingly, it is impossible to
be avoded.

If a project appraisal does not involve changes in the probability of premature
death for members of the population of the beneficiaries, then it is implicitly iguned
valuing human life. The net benefit of such project does not consider premature death
as social costs. It is in fact reflects the society willing to accept such net benefits as a
trade off against the expected premature deaths of a certain numbers of its population.
If the argument is that premature deaths cannot be traded off against benefits to society
under any circumstances, it means that this project should be rejected, what ever the
large net benefit is. As positive way of thinking to pay an amount of funds accepted by
the society to protect population from premature death attributed to the project
implementation, such it should be less than the project's net benefits.

The study used an average across countries and across occupations, of the
increase in the annual wage due to the probability of premature death, although the
range of variation in the estimated values is rather large. Thereof, the study derived an
adjusted scale that deffrintiate between the skill requirements and unpleasant working
conditions.It is that an increase in the risk of premature death of 0.001 in the probability
of premature death is associated with an increase in the annual wage of $100 (the literature estimates ranged from $28 to $5,000). It is assumed that this $100 is the compensation required by a typical individual for an increase of 0.001 in the probability of premature death. Therefore, the total willingness of 1,000 people to pay for a 0.001 reduction in the probability of death would be $100,000. Consequently, it means one fewer premature death. Then $100,000 would be taken as the social valuation of the saving of one life. Accordingly, for 80 expected premature death attributed to the fuel compustion for 1-GW/h of electricity production, means $8 million dollars a year.

Summary & CONCLUSION

The study provides the basic parameters and technical coefficients of the cost benefit analysis model for the socio-economic and environmental impact of introducing a renewable energy source (Hydroelectric) that replaced the conventional depleted fuel source. The study applied this model for quantitative profile of the socio-economic and environmental impact as net present value of replacement the conventional depleted fuel for a renewable energy source. It shows that the avoidance of premature mortality is the main source of benefits, even though it is an external benefit, which in most feasibility studies is ignored.
Table 1 Basic Parameters and Technical coefficients of the Cost Benefit analysis Model:

<table>
<thead>
<tr>
<th>Technical Coefficient</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Running costs/year</td>
<td>0.5</td>
<td>Million $</td>
</tr>
<tr>
<td>Reckoner conversion factor</td>
<td>500</td>
<td>Tons</td>
</tr>
<tr>
<td>Electricity out put/year</td>
<td>6,570</td>
<td>Giga Watt/h</td>
</tr>
<tr>
<td>Reduction in conventional fuel burn/year</td>
<td>2.628</td>
<td>(000) tons</td>
</tr>
<tr>
<td>Price/ton of coal</td>
<td>40</td>
<td>$</td>
</tr>
<tr>
<td>Interest rate</td>
<td>5%</td>
<td>%</td>
</tr>
<tr>
<td>Load factor of electrical plant</td>
<td>75%</td>
<td>%</td>
</tr>
<tr>
<td>Plant operating capacity/hour</td>
<td>1</td>
<td>Giga Watt/h</td>
</tr>
<tr>
<td>Premature deaths per year*</td>
<td>80</td>
<td>Person</td>
</tr>
<tr>
<td>An increase in the annual wage due to the</td>
<td>100</td>
<td>$</td>
</tr>
<tr>
<td>probability of premature death</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The social valuation of the saving of one</td>
<td>100,000</td>
<td>$</td>
</tr>
<tr>
<td>life</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 A Profile of the Cost Benefit Analysis of Utilization of the Renewable Energy

<table>
<thead>
<tr>
<th>Item</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel savings*</td>
<td>3.379</td>
</tr>
<tr>
<td>Pre Mature Mortality Reduction</td>
<td>111</td>
</tr>
<tr>
<td>Total benefits</td>
<td>114.379</td>
</tr>
<tr>
<td>Costs of Hydroelectric Energy</td>
<td>19.2</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>95.179</td>
</tr>
<tr>
<td>B/C Ratio</td>
<td>5.96</td>
</tr>
</tbody>
</table>

* such value includes not only the direct cost but also the additional external costs which reflect the depletion characteristic of the conventional fuel (Petrolim or Coal) as a natural resource.
REFERENCES

Ministry of Agriculture and Land Reclamation of Egypt (1994) "New Land Development Study" Conducted by Social Studies Consulting Institute and Sponsored by US AID of Cairo
Ministry of Irrigation and Public Work, Egypt (1994) "Unpublished Reports and Studies"