100 % OF ENERGY FROM RENEWABLES – IS THIS AN ACHIEVABLE GOAL OR AN IMPROBABLE SLOGAN?

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Abstract

The aim of this paper is to examine the possible contribution from renewables from several perspectives – (a) meeting the oft-stated slogan that today the contribution is about 2 % and the aim to raise it to 10 % from several enthusiasts of renewable energy including the ministry of non-conventional energy sources (b) ignoring it in favor of conventional fossil fuel energy through large power stations, since these are really the only substantive ones most people in power are familiar (c) examining how small industrial units with energy cost contribution to product is large, can survive with rising fuel prices, (d) how to combine the above objectives despite the *devastating lack of awareness* of most men in power – be it in politics, bureaucracy or industry – leaders and followers alike, about how to overcome the serious situation that the country is in through short and long term strategies and (e) how to convert the difficulties into blessings by large scale renewable energy generation by synergizing and benefiting from global aims of green house gas reduction plans.

It will be argued that if the aim is to add MW and MWh to the country's electric supply, it is necessary to move away from "uniform support to all renewables" model to "selective appropriate support" model. *Minihydel and Biomass based power generation are identified for adding MWs with good plant load factor; wind power generation follows next at relatively low plant load factor. Encouraging solar water heating systems will help conserve electrical energy used for heating in urban areas. Support for solar photovoltaic power should be based on considerations of impossibility of others for the specific application.*

Rural energy servicing for heating/cooking calls for newer technological interventions. A careful study by NCAER on the "improved Chula" program of MNES over the earlier five years showed significant move towards fuel wood from agro-residues for many reasons including impropriety of the stoves for the use of agro-residues. A new approach to stove design for multi-fuel option will also be discussed.

1. Introduction

Over the last decade, ministers and bureaucrats, and consultants have been championing the cause of renewables with several slogans - "We must respond to the global call of reducing the green house gas emissions. We will increase the contribution of renewables from 2 % to 10 % - moving from 1800 MWe to 9000 MWe in five years. To help this, we need to create for renewables, a level playing field, the lack of which is the reason for the slow growth of renewables. We must encourage all the renewables as much as possible." and so on. The fact that India is one of the very few countries that has a ministry for renewables and a bank for renewables (IREDA – Indian Renewable Energy Development Agency) like India is also used by technology developers and marketing agencies overseas to sell their products in this country by all means – fair and not-so-fair. This obviously will put such agencies at greater advantage compared to indigenous ones, since the financial strength of these organizations is far superior to indigenous organizations. The concentration of the technologies overseas has been in solar photovoltaics and wind. mini and micro-hydel schemes are akin to major hydel schemes in respect of water management. In so far as water turbines are concerned, there has been native talent. The electrical segment has no great new elements and surprises and can be managed indigenously. It is the biomass whose foundations for development were laid significantly in this country. This has advantages and disadvantages. The advantages are that we need to set standards for the technology and know how to grow it in the country.

Also, the costs of the technology can be controlled easily. The disadvantage is that it has to compete with "unfairness" of other technologies that are better known amongst the powers to be.

2. Relative Costs Of Installation And Energy

It is necessary to examine the relative costs of installation and cost energy generation from various alternate sources of renewable energy – SPV, Wind, Micro-hydel and Bioresidue (biomass has other societal uses which are accounted for and the residue alone is intended for use in power generation; this is the reason for the choice of the word Bioresidue), roughly in the perceived order of importance by the proponents of renewable energy. It is important to compare these against a reference case, namely, the centralized thermal power from coal (which meets about 70% of the country's needs). These are shown in Table 1 below. The cost of energy indicated here accounts for interest on investment in addition to operation and maintenance costs, While SPV, the most known of the alternate sources has a niche place at small power level, and sensitive locations where cost is a minor factor in the power package, *it is obvious that for the money intended to be spent on a kWe of SPV, one can get ten kWe from Bioresidue source and then thirty times the energy delivered*. If the intention of the ministry/government is to achieve 10 % of the total power in terms of renewables, quite obviously, it has to be based on the lowest cost option and this burden will fall on Bioresidue, mini-hydel, and wind in the order of importance. Hence, the first act required on the part of MNES is to recognize this and generate promotive measures accordingly. The mini-hydel route whose capacity can vary anywhere between a few tens of kW's to tens of MW's is better understood because of long experience with hydro-power stations in the country. On the other hand, *the bioresidue thermo-chemical conversion route is the least of the developed and needs inputs from several fundamental disciplines before the technology can mature and get accepted by the industrial community.*

Table 1: Costs of installation and energy from renewables

Type		Installations cost, Rs.Crores/MWe	Cost of Energy Rs/Unit	Comments
SPV		30 to 40	10 to 15	Good for special applications, a few kWe class, PLF ~25 %
Wind		4 to 5	5 to 8	High wind area, Good for Grid interfacing, PLF ~ 25 %
Micro-Hydel		4 to 6	4 to 6	Special locations, grid interfacing and PLF up to 70 %
Bioresidue	Diesel engine	2 to 3.5	3.5 to 4	Both agro-residues and residues from plantation; can be used for both grid and stand alone applications, 3 kWe to 3 MWe, PLF ~ 75 %
	Gas engine	2.5 to 4	2.0 to 4.0	
Thermal power (centralized)		3 to 5	2.20 to 2.75	100 to 1000 MWe, PLF ~ 80 %

PLF = plant load factor; Diesel engine is operated in dual-fuel mode at 75 to 80 % diesel replacement.

We can analyze the issues concerning bioresidue approach further. The currently installed total MWe through renewables is 1000 MWe wind, ~500 MWe mini-hydel, 500 MWe bioresidue. If one determines the amount of energy generated, wind will produce only a third of the energy generated from bioresidue certainly and mini-hydel, possibly. Therefore, there is greater case for promoting bioresidue and mini-hydel from the point of view of total energy generated as well. Assuming that 10 % renewables is shared at 5% bioresidue, 3 % mini-hydel and 2 % wind, these translate to 5000 MWe for bioresidue, 3000 MWe for mini-hydel and 2000 MWe for wind as the targets from renewables. These imply a fifty-fold increase in the installed capacity. *This is so large an increase that one must examine all the associated issues related to the possibility of achieving this capacity installation*. We shall examine these now.

3. Bioresidue-To-Energy Technology – Validation? Standardization?

Structurally, bioresidues are cellulosic, or lignaceous. Sugar and starch are simpler forms of "biomass". Leaves, seeds, vegetables, and fruits belong to the category of cellulose, sugar and starch. Bacteria can digest these materials. Tree trunk, bark, and shells of seeds, straws contain a fair amount of lignin and inorganic residues and cannot be digested by bacteria. They need to be handled through thermochemical conversion. Most leafy biomass will have ash content less than 3 %. Other lingo-cellulosic materials have ash content as much as 25 %, naturally; handling them for densification through briquetting leads to pickup of inorganics – sand, grit etc – by as much as 4 to 10 %. Certainly, the additional pickup of a few % may be unavoidable, but larger than unacceptable. This is one subject that the operators must keep in mind. The thermochemical conversion process implies conversion of solids to clean gas by retaining as much calorific value as possible. This process called gasification can be accomplished by using air, steam, or simply the bioresidue as it were at temperatures of 1200 to 1600 K through several routes. The simplest and most economical of these is the downdraft air gasification, the close top WW II class design or the more recent open top, twin-air entry, reburn gasification system. Classically, the WW II class design is suited for woody biomass with little ash (< 2 %) and leads to serious ash fusion problems for agro-residues with higher ash content, largely because, the entry of air through the nozzles leads to generation of high temperatures locally leading to ash fusion, particularly due to fluxing agents like Potassium salts coming from the soil or the fertilizer. One has some choice in reducing the fluxes by drawing air from the top in the open top twin air entry design. There are five manufacturers in the country at this time; only a few of them have put in substantial effort into producing technology in a standardized manner. Yet the practices required for promoting the technology are largely missing – the manuals available for operation and maintenance are inadequate. The technical performance of the system – gas composition vs load, diesel replacement vs. load, possible deposits of tar and particulate at different locations on the gas path itself is not declared by the manufacturers. Dependence on the nature of biomass, possible problems and methods of overcoming from the time of installation till date would be expected to be documented to enable confidence building amongst prospective clients, administrators and industrial groups. As more and more systems built in different places by different manufacturers are seen to be working, their data documented, working systems in different situations capable of being seen by all concerned, it can be imagined that the foundations of large scale power generation would have been laid. The current situation is that some overenthusiastic manufacturers, without adequate effort in examining all the issues of a given requirement, have sold the equipment; systems have not performed to expectations and the final agony has not been limited to return of the system; it has led to lack of confidence in the technology itself. Ministry's efforts to monitoring have not happened in the last several years. Hence there have been no attempts at damage control. Unless MNES steps in to reduce such actions occurring in the country, there will be occasional setbacks that need to be overcome before technology can take off. While it would have been advantageous for the manufacturers to have dealt with these aspects of validation and standardization by themselves and set out their own documentation rather than as a part of regulatory measure, MNES is forced to engage in creating standards for the performance of the systems (better late than never!) with the participation of gasifier action research centers at New Delhi, Bombay, Bangalore and Madurai Kamaraj University.

4. Bioresidue Availability And Current Use?

Both agro-residues and plantation residues constitute the availability of bioresidues. The total agricultural output in the country is about 180 million tonnes. The residue from the agricultural operations is estimated at 500+ tonnes. Of this, sugarcane residue – bagasse is a captive fuel of the sugar industry. Sugarcane tops and leaves are most usually burnt on the field (only a small part is used as fodder in some areas). The ostensible reason for this approach is to keep back the nutrients on the field. The same objective can be achieved by using the material for thermochemical conversion before being returned to the soil from where it was brought. Barring a few industries that use about 15 % of the trash along with bagasse in the boilers, most of the material goes to enhance the CO2 emission into the atmosphere by combustion in the open. Thus there is a strong case to use the residue for power generation (about 20 million tonnes from 300 million tonnes of sugarcane). The straws from paddy and wheat are largely used as fodder in most places. Rice husk is used for most thermal applications. Several power stations at 6 MWe level have been built (one in Madhya Pradesh and another in Andhra Pradesh) using fluidized bed boilers with rice husk as the primary fuel. Several more power stations with steam route are being planned in the coming few years. Disposal of the ash is a serious environmental hazard and the current approach is simply to spread it on ground. The nutritional value is absent since the residue has some carbon and large fraction of Silica. An economic process for extracting precipitated Silica from the ash has been developed at IISc and currently efforts are in progress to demonstrate it at industrial level throughputs.

Thus, it is possible to overcome the disposal problem by generating an economic route for using the waste. Other large amounts of residues are the coconut plantation wastes, stalks of cotton, mustard, and groundnut plants available in different parts of the country at the time of the harvest in a short duration. These are stored for some time in an indiscriminate manner and if used at all, they are used as cooking fuel or as fuel for bath water heating at very low end use efficiency. Hence opportunities exist in terms of preprocessing through drying, pulverizing, and briquetting so the material is available at high density – 1000 to 1200 kg/m3, so that material can both be stored for long durations and transported over much large distances. This also implies a large number of job opportunities in the rural sector. To plan either on a small scale or a national scale it is important to obtain an assessment of the biomass produced, biomass used and the bioresidue for power generation. MNES has mounted a 500-taluk biomass assessment program and about 350 taluks have been completed. These reports have to be integrated into usable publicly available documentation for enabling potential investors/entrepreneurs to decide on the power generation strategies. A major effort to combine the remote sensing technique (using Regional Remote Sensing Satellite Center) with geographic information system (GIS) along with information on the current uses for other societal needs like fodder, roofing, value added products to generate computerized information for the use of industrialists/ administrators is now sanctioned to IISc. This effort will make use of the results from the taluk level biomass assessment to establish the biomass use, trade and related aspects that can be known from site surveys.

In a series of studies made by Dr. Natarajan of NCAER (National Council of Applied and Economic Research), he has concluded that the rural energy scene has changed over the lat two decades. While in the earlier era, most of the fuel wood was being sold in towns and cities with the villages depending on agrofuels for domestic needs, with the invasion of liquefied petroleum gas (LPG) into the cities and towns, fuel wood which was being generated in the villages has remained largely unsold and is being used in the villages themselves. The expectations of the villagers in terms of user-friendliness of stoves in being less demanding on attention both for feeding as well as power control, after noticing the use of LPG stoves in relatively well-to-do communities, has also added to taking recourse to fuel wood known for a longer time than other fuel sources leading to felling of trees to larger extent. This has an impact on the possible actions needed to be initiated towards meeting the rural fuel needs for cooking while also looking for fuel for power generation. Briquetting approach referred to earlier provides a route for other possible directions of use. It is possible to let the rejects from briquetting operation, which turn out to be small pieces be used for a newly designed cook stove which burns fine pieces of biomass. Perhaps, after the introduction of such stoves, which can burn these kinds of biomass efficiently into the market, and the stoves make penetration into the rural scene in a natural way, the tree felling activity for domestic needs can be controlled. The stoves are described in **http://cgpl.iisc.ernet.in.** Otherwise, the briquettes can be sold in urban marketplace involving the industries.

5. Wastelands And Fuel For Transportation

While agro-residues form one segment of resource of bioresidue for power generation, plantation residues form the other. All over the country, lands owned by farmers are used to grow eucalyptus and other plantations. These are sold largely to paper industry that deal with several of the plantations much in the same manner as sugar industry does with sugar cane growers. There are also wastelands of several kinds – degraded, fallow, and others that have remained unused largely, partly because the quality of the land for growing biomass is not adequate, partly because vested interests use them for illegal encroachment. The magnitude of this land area varies between 60 to130 million hectares. Even at the lowest level, the extent of the wasteland is very large. It is possible to combine the availability of this land with the need to obtain oils – of non-edible kind by leasing the land to industrialists to grow one or more of the 140+ varieties of non-edible seed bearing trees in large areas. Many trees like Jatropha and others are known to be hardy can be grown in semi-arid climates with uneven rainfall. Several varieties like Neem, Sal, and Mohua can be grown in select climates. Even though they are a part of the rural landscape for over a few hundred years with the oil from the seeds providing the oil for wick lamps, and the seeds from these trees are used in the detergent industry through a privately organized market with the people who collect the seeds getting the lowest returns and the intermediate agencies getting perhaps the largest returns, very little national data bank on the availability and trade routes is documented. There is need for doing such an act soon to enable national planning. It is not adequately recognized that the non-edible oils have a calorific

Table 3 Productivity of oils from various oil seed plants

Specie	Oil fraction, %	Current estimated/ million tonnes/yr	Oil Tonnes/ hectare/ye ar
Castor	45 – 50	0.25	0.5-1.0
Jatropha	50 – 60	0.20	2.0-3.0
Mohua	35 – 40	0.20	1.0-4.0
Sal	10 – 12	0.20	1.0-2.0
Linseed	35 – 45	0.15	0.5-1.0
Neem	20 – 30	0.10	2.0-3.0
Pongomia	30 – 40	0.06	2.0-4.0
*	10 – 50	0.50	0.5-2.0

Non-edible oil seeds and bioresidues in India: The magnitude of oil depends on the nature of irrigation, whether productivity is perennial, etc. Solid Bioresidue = 5 – 10 dry tonnes /hectare/year; [* *Jute plant seed, mango kernel, flame of the forest tree nuts, Indian coral, kokum butter tree nuts, Ink nut, soap nut, milk weed, watermelon, yellow oliander, tamane oil tree nuts, crotan oil tree seeds, palm, prickly poppy, wild walnut, almond, kamal, tung oil tree, silk cotton, bullet wood tree nuts, iron wood tree nuts, bastord sandal nuts, pilu nus, kamal nuts, foon tree seeds*]

With these productivities per hectare, one can make simple estimates of the total amount of oils and residues that can be produced. Assuming that an average of 0.5 tonne of oil and 5 tonnes of dry lingocellulosic bioresidues per hectare per year (it must be noted that these are the lowest productivities achieved and so, these are pessimistic estimates) can be generated, one can expect to generate about 30 million tonnes of non-edible oils and 300 million tonnes of solid bioresidues. These imply 17000 MWe capability from the oils and 30,000 MWe from solid bioresidues. At the mean production level of oils and bioresidues, the output implies 25,000 MWe from oils and 50,000 MWe from solid bioresidues. These are so impressively large, it would only be foolish not to pay attention to these routes of energy generation. It would also possible to device solutions in which the liquid fuels can be reserved for transport purposes for all rural needs so that rural economy belonging to 70 % of the population can be made weakly dependent on the ever-burdening fossil fuel economy.

6. Fossil Fuels and Industries

Several industrial processes like those with aluminum melting, drying a variety of industrial products at high throughput has a significant contribution of energy in the final product. In a few situations, the margin of profit for survivability per unit product is small and it is the large production that makes up for the sustenance of the industry. In such cases, increase in fossil fuel prices on which the industries are strongly dependent will cause the margins to drop and survivability of the industrial segment itself will be in question. It is in this context that bioresidue based thermal systems, which naturally imply producer gas based systems because of the requirements of fine control of power will be needed. Typical calculations show that the return on investments will be possible within 12 to 18 months in most situations. The only role that subsidy will do is to enable the first thirty to forty investors gain confidence in the systems since the gasification packages are new to the entire industrial community. In these cases, the motivation of the industries is simply self-interest, coinciding with national imperatives.

7. Lack of Awareness, And Its Impact

Participation in conferences, industrial meets and workshops inaugurated by ministers, bureaucrats has shown that in the minds of most people, non-conventional energy is a good subsidy driven program for solar photovoltaic power generation at the respectable end, and Gobar gas at the rural end. Wind, if mentioned, many would agree as something they see working at specific places where there is large wind. Solar photovoltaics, they think is very good alternate energy source and Government should encourage it. Biomass is a good source for rural cooking, but there are problems of smoke and soot; for overcoming these there are smokeless chulhas which the government is propagating. In any case, the overall feeling is that the ministry can at best be a very minor partner in the total development scene.

One would expect the degree of awareness amongst ministers in charge, at present or earlier would be much better because of their proximity to the place of decision-making. But their sense of awareness turns out to be not very different from commoner's view. That this happens inspite of many of the ministers making "good" speeches at inaugural meetings implies only that good scriptwriters at the ministry are at work. It might be that the ministers believe that the activities of the ministry are strongly linked to causing changes in the rural scenario and what is largely in the minds of people who visit them confirms their ideas, no matter what the officers in the ministry project internally.

The Pundits in the Ministry of Power believe that one of the inevitable “poor” cousins (measured in terms of how much finances they need to manage) that they need to be with is the MNES, which must be flaunted with nice slogans that the international groups, and funding agencies accept a “correct” attitude of the government (like the flowers in the braid of a poor lady who has to present reasonably well at a family function). Other segments of the government like the Ministry of Environment and Forests and Ministry of Rural Development are aware of the MNES but consider perhaps that the activities of MNES are a minor perturbation in the governmental activities.

Major Financial institutions like IDBI, ICICI and nationalized banks like SBI, Canara Bank and others do not concern themselves with renewable energy as a major national activity; if they are forced to do, they would make cautious statement indicating that the financial viability should be checked out before finances are committed or simpler, no portfolio has been created for these activities. When they are approached on an individual scale, they might admit that they are totally unaware of the technology and the implications to the society and they would indeed want to help, but the process of clearance is long. This also implies that the awareness amongst the FI community is poor.

IREDA can be looked upon as the banking arm of MNES for renewable energy. However, as a banking agency in existence for over a decade, even though there are good projects which have been successful, particularly in the area of cogeneration in sugar industries, the increase in non-performing assets (NPA) to as much as 30 % shows that the health of this banking sector has to improve substantially. In new technology area, it is better to perform stably at a slower pace in the early stages rather than claim lot of support for projects that are “new.”

While what I have indicated here shows a very bleak situation of awareness, there are exceptions. These are largely in the areas of cogeneration in sugar mills and large scale agro-residue based power generation (3 to 6 MWe) where the funding has come from nationalized banks and IREDA in many instances.

It must be realized to accomplish progress even when all the participants in a program are on the same wavelength is not easy because the magnitude of the task undertaken is so vast that with even the minor differences in perception and action, accomplishments fall-off substantially.

8. International Drivers

International concerns on green house gas emissions and protecting the environment and Indian participation in various forums are known. Though the biggest environmental polluters belong to the industrialized countries, the responsibility for protecting the environment will also belong to other countries. New dimensions in terms of carbon credits through the Clean Development Mechanism (CDM) are coming on to the international scene. Several governments and expert bodies are examining the framework for carbon credit at this point of time. While the agenda for most governments is to use the environmental aspects as points of leverage to benefit from others, for oil importing countries like India, where the economy will be affected significantly by international oil prices, the general situation can be used for “renewabalizing” the entire life. What is missing is the ability to combine international compulsions with national requirements to country’s advantage. One of the important economical strategies would be to grow as much of biomass as possible; in doing so, combine oil generation with also growing woody species so that energy security is ensured. If renewable energy has to grow significantly, there is no doubt that all the important functionaries will need to at least agree on a minimum strategy for growth and not attempt to work at cross purposes.

9. Fossil Fuel Power vs. Renewable Power?

The centralized power generation accounts for 95 % of the national needs with 70 % from coal. Doubtlessly, renewables constitute a small fraction from this perspective. Yet there are large segments of the country which are far removed from the pitheads and carrying high ash coals are simply too expensive and strategically undesirable. Any problems to the transportation sector will also cripple the power generation system located far from the pithead. Similarly any geo-political issue leading to cut-off of or interruptions in the petroleum supplies will be disastrous for the survival of habitations concentrated around cities. It is therefore very valuable for a large number of power stations based on bioresidues and mini-hydel sources to be active and pumping into the grid. This will make the grid more stable overcoming the current situation of poor grid stability. Hence it is very valuable to treat renewable power as complementary to centralized power and not a competitor, as one is usually tempted to imagine. The attitude of cooperative arrangement will enhance the strength inside the country to progress on power generation capability from renewables.

10. What Are the Actions to Be Undertaken For Achieving 10 % Energy For Renewables?

The recipe that emerges from the above discussion is as follows.

1. All principal actors or stake holders as may be called – MNES, Industry, Research institutions should recognize that bioresidueto-energy and mini-hydel must be given prominence of a higher order than other renewables.

2. Enhancement of biomass availability by using wastelands for growing multi-specie plantation that includes non-edible oil bearing trees, both fast growing and other varieties which might take time to grow, but spread their roots deep underneath to stabilize the soil and provide more steady output of seeds and tree fallings must be encouraged with industrial participation with wastelands being given on long term lease. This should be a priority item of the government involving MNES, MoEF, and the State governments.

3. Manufacturers, Research institutions and institutions for standard must be involved under the aegis of MNES to create a *national registry* of the gasification systems, their performance with various bio-fuels, maintenance and operability of the systems, and aspects of component life.

4. MNES must have a portfolio of working projects that are working well according to industrial standards all across the country to widely publicize the success and enthuse other industries. This needs wide industrial participation. A few of these projects need major financial support from MNES. The total magnitude can be to a total extent of 25 - 30 x 1 MWe and 0.5 MWe class systems. This will take a few years to accomplish and is a crucial part of the development strategy.

5. Corporate offices of financial institutions, and nationalized banks must be encouraged to set up their own technical support systems that can depend on the national registry discussed above, in part, to generate internal procedures for clearing projects based on new technology and issue these as office orders to all their branches. It is entirely possible that this effort will take a few years and can be completed during the execution of action in item 4.

With the five-pronged strategy that can take a typical five-year plan to execute with vision and deep commitment, one can hope to have created a road map for power sector growth with several hundreds of power stations all over the country. If the foundations are not laid along the lines indicated, it is most likely that the dream of renewables making significant contribution to national energy needs will remain a dream for those who wish to dream and a slogan for the powers to be.

11. References

Most of the work related to the paper by the author and his colleagues have been published in journals and can be accessed at the home page **http://cgpl.iisc.ernet.in.**