Integrating Renewable Electric Power Sources

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ABSTRACT

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Electrical energy is a necessity in our lives, but is not exactly energy what is needed, what is really needed is electric power. Power is defined as the change of energy, so it cannot exist without energy, but energy can exist or be available and not be cost effective to obtain reliable electric power from it. Although it looks like a semantic issue, there are implications that create confusion.

Electric power generated or converted from energy sources need to be reliable, stable, and with the needed quality and quantity to supply the connected variable loads (this means available when needed and as needed). These are serious constraints that limit the use of some renewable sources particularly wind and solar photovoltaic (PV) sources.

The most widely used energy sources that can provide reliable continuous electric power are from fossil fuels, nuclear, and hydraulic. For all these, the fuel can be stored for feeding as needed to provide continuity. But Wind is not available continuously with needed minimum in most places and PVs are only useful for some hours during sunny days, therefore storage will be needed , but double conversion will be required for the storage means and this will impose other constrains.

Energy Return on Investment (EROI) is defined as the total energy that a system can provide in its useful life in relation to the total energy needed to make or produce it; if less energy is produced than the needed one to make the system, then that system is not a solution. This maybe the case for the (PV) systems as evaluated by other researchers. Wind has not been evaluated so far.

PV systems imposes an integration and synchronization problem when used interconnected with the grid. Their inclusion in the grid will complicate the stability of the system and inherently reduce the efficiency of the generation system if interconnected at AC level, although this effect can be overcome if not continuously interconnected with the grid but supplying the appropriate load.

1. INTRODUCTION

Characteristics:

The following characteristics or issues are very important to consider in order to obtain a reliable and efficient system.

a. Electrical Energy sources shall not be overloaded (this becomes a critical issue when AC interconnection is used).
b. Sources are more efficient at maximum or near rated output
c. Large units are more efficient than smaller ones
d. Electric energy generating systems can fail at any time even when preventive maintenance is vigorous.
e. Generating systems response to sudden load changes is too slow for large systems.

Considering the above characteristics, to obtain a reliable and efficient system will require a distributed redundant system that will leave some renewable sources out of the equation unless reliability is “negotiated” and the interconnection is done at a lower level as a DC interconnection at the distribution side .

Possible Sources:

The most widely energy sources used are from fossil fuels (oil, coal, natural gas), nuclear, and hydraulic. They are all useful to provide stable, continuous, and reliable electric power with the quality and quantity required to be supplied to the variable loads encountered in any electric power system since the “fuel” can be stored for feeding as needed.

But, the only renewable one is Hydro, where available and conditions for large reservoirs, but not enough water or land for reservoirs available for small countries or islands. And at the rate that we are using oil will exhaust it in the very near future (estimates are close to 25 years[2)]. Other fossil fuels(natural gas, coal) should last longer, (estimates are near 100 years or more), but the fact is that they will come to an end sooner or later (Callarotti, Colón, 2011). Therefore their use does compromises the future generations.

Geothermal potential is possible for only a few countries and biomass or organic wastes is possible in any place, but for limited capacity.

Sun radiation and wind are available in most countries, abundant in the tropics, but definitely not continuous. PVs respond to normal incident radiation (does not respond to diffused radiation) that limits their useful output to few hours during sunny days (when no clouds present). Their use will then be limited as a complement or supplement when available.

Other possible sources are at different research or developing stages.

1.1 THE GENERATION DILEMMA

1.1.1 Reliability Issue

Large generation units are more efficient than smaller ones and electric power generators are more efficient at full load, therefore an efficient system shall have all units as large as possible and working them all at, or near full load. But, load varies continuously and sometimes unpredictable, and units cannot be overloaded (if overloaded, the excess loads must be disconnected from the grid or the system will collapse); and the response time for large systems is to slow to react to sudden changes and very slow (several hours , if fuel input is reduced or shut down to save fuel).

Therefore the operational or running capacity have to be equal or larger than the maximum demand plus an extra amount equal or larger than the largest unit to avoid interruptions.

Even further, since generating units will need to be turned off periodically for maintenance or repairs, and they can fail for many reasons, and at any time, another extra capacity equivalent to the larger size unit is also needed and readily available.

A reliable system will then have to include several diverse and distributed units with a total operational (running) capacity of at least the maximum demand that can happen within the response of the units plus extra running capacity equivalent to the maximum unit.

The total installed capacity and ready to operate shall include two to three extra units with capacity equivalent to the maximum unit. Any alternative energy unit added, replaced, substituted, or to reduce the generation capacity of the prime system to save fuel costs, will have to be predictable and continuous for a longer time than the response time of the units that can overcome its capacity.

In other words, if the load variation or loss of generation power from alternate sources cannot be predicted ahead of time, and/or the response time of the units in place is larger than the time to have available the alternative source (as solar photovoltaic or windmills), the added non continuous source will affect the reliability. Therefore, if the system is to be maintained as a reliable one, no reduction of electric generation from the other sources in place can be done which means increased costs for the electric energy generated and no reduction in negative effects from the generating system.

In order to overcome these limitations, energy storage must be available. But, it will require to store electricity or converting the energy to other means for storage which means extra costs (energy and $$). And the EROI for PVs is close to unity and the added needed storage capability will make it worse.
This is the problem with PV systems and possible with Wind if not sustained above a minimum.

1.1.2 Integration Issue

Since PVs power is not continuous and changes even when available (due to clouds and sun angle), if used supplying the grid, their inclusion complicates the stability of the system since it will contribute to a larger variation of the load seen by the grid.

Furthermore, PVs, if tied to the grid, will reduce the efficiency due to the mismatch of voltages and impedances. A DC power converted to provide power to an AC system with much lower impedance will reduce the efficiency of the PVs by at least 30% that already has a questionable EROI! Notwithstanding, this mismatch problem can be reduced and the synchronization problem eliminated if the integration of both systems is done at DC level that can be done at the distribution or user side where voltage change for matching is not needed.

AC power (sinusoidal waveform) is used due the inherent advantage in the generation from rotary machines driven by turbines and the inherent advantage from transformers to change the voltages to reduce transmission losses. But, at the user side, a sinusoidal waveform is not really needed. Most loads have to change it to various DC voltages (convert the AC input to DC and then to the needed output voltages) and those that needs AC to operate (AC Motors), does not have to be a sine wave. Actually the only loads that need AC power can be more efficient if supplied with a variable and adjustable frequency to change their speed as needed and reduce the starting currents making them more efficient (large motors are required to use that type of driver units to reduce in-rush currents). And those driver units for AC motors also need DC to operate.

Although this solution for integrating PV systems with e grid as a DC link does not make the PV more efficient and does not improve the EROI, it indeed reduces the stability problem with the grid and eliminates the synchronization problem. A conceptual block diagram is shown to illustrate the idea. This not a novel idea, a similar integration system is used within Uninterruptible Power Systems, except for the controlling circuits to prioritized the power flow in the machine.

1. Tables

Table 1: Estimated Lifetime (Callarotti, R. 2011)

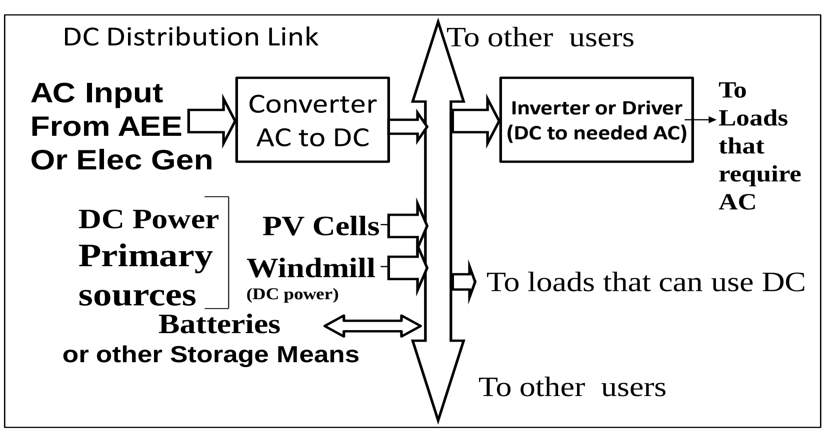
Source	Lifetime(years)
Fossil Fuels	
Oil	<~25…?
Coal	~100.. ?
Natural Gas	~100…?
Nuclear	~>100..?

Table 2: Response Time for Power Plants. (PREPA, 2011)

System	Aprox. Response Time
Hydroelectric	Few Minutes
Gas Turbine (Fuel #2) (30-50 MW Units)	15-20 minutes
Boiler Units Bunker C (Fuel #6) Natural Gas, Coal	10 -12 Hours

2. Figures

DC Distribution Link (Colon , 2011)



3. CONCLUSIONS

Considering all the above factors and constraints, the inclusion of non continuous generating systems as the solar photovoltaic and wind power generator units to the grid will increase the generation costs in the system with no reduction in negative effects from the actual system. The only benefit will result for the individual owners.

A DC distribution or converting system at the user side, although it will not overcome the system impact stated above, it will permit a better integration for PV systems increasing the efficiency, reducing the stability problem, and eliminating the synchronization problem, providing a better solution for the individual user.

REFERENCES

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Note: This paper is an adaptation from another papers that the author submitted and accepted to be presented in other Conferences: LACCEI Tenth Conference and “The 1st International Conference in Alternative Energy, ICAE 2011”. The paper was not presented in the LACCEI Tenth Conference because administrative or technical problems when submitted and the one for the 1st Conference, the author had to cancel the presentation due to personal reasons.

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