INVESTIGATING WIND POWER'S EFFECTIVE CAPACITY: A CASE STUDY IN THE CARIBBEAN ISLAND OF LA MARTINIQUE

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INTRODUCTION

In this paper, we report on the experimental determination of the effective capacity of wind and photovoltaic (PV) power generation with respect to the utility load requirements of the Island of La Martinique [1]. La Martinique is a French Overseas Department in the Caribbean Sea. The case study spans two years, 1990 and 1991. We consider wind generation at three locations in different wind regimes, and PV generation for fixed and tracking flat plate systems.

The results presented include: (1) An overview of typical solar and wind power output at each considered site, presented in contrast to the Island's electric load requirements; and (2) Effective capacities quantified for each resource as a function of penetration in the utility generation mix.

METHODS

Defining Effective Capacity

The *effective capacity* of a generating resource is its effective contribution to the generating capacity available, utility-system wide or locally, to meet electrical demand. This should not be confused with the commonly used term *capacity factor*, which represents the ratio between the average output of the considered generator and its rated capacity.

Because renewable electrical generation resources such as wind or solar are not dispatchable, they are generally assumed to have no effective capacity, and are considered strictly as energy producers. However, recent studies [2,3,4] have shown that, at least in the case of solar PV production, the effective capacity of the resource may be considerable, because the resource may be highly correlated with peak loads. Effective capacities as high as 80% of rated PV capacity have been observed for several US utilities [3]. In this paper we show that wind power generation may also exhibit sizable effective capacities.

Importance of Effective Capacity

A large portion of the value of a generating resource is a function of its utility-wide and/or localized effective capacity. Indeed, the value of a generating resource to a utility is defined in terms of (1) energy value and (2) capacity value. In addition, when considering distributed generation applications, the resource should also be valued in terms of *transmission and distribution (T&D)*. This value element is largely dependent on the resource's localized effective capacity.

Quantifying Effective Capacity

Several parameters have been introduced to quantify a generator's effective capacity. Here, we use two parameters which offer complementary measures of effective capacity.

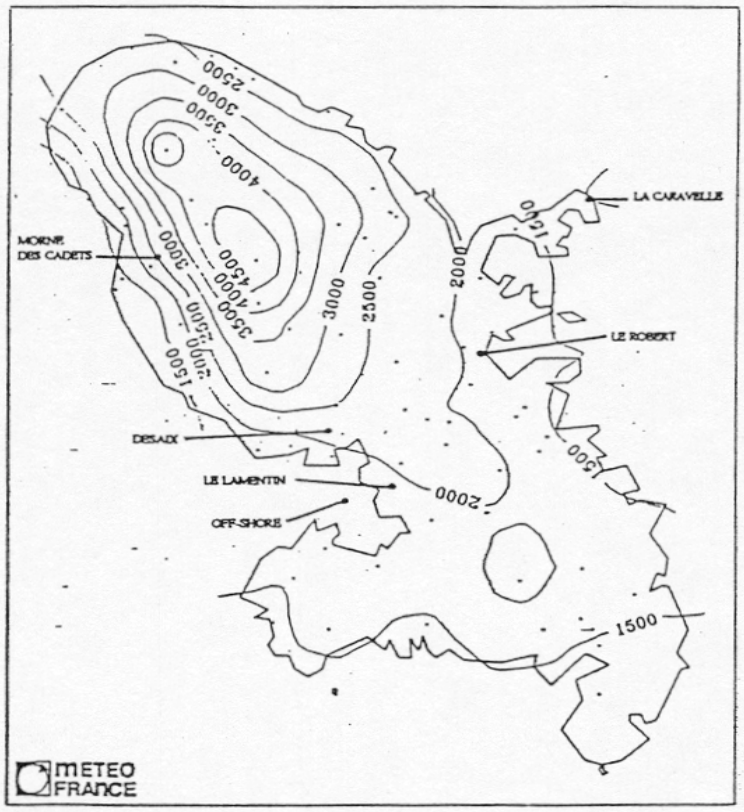

FIGURE 1: ANNUAL RAINFALL IN LA MARTINIQUE

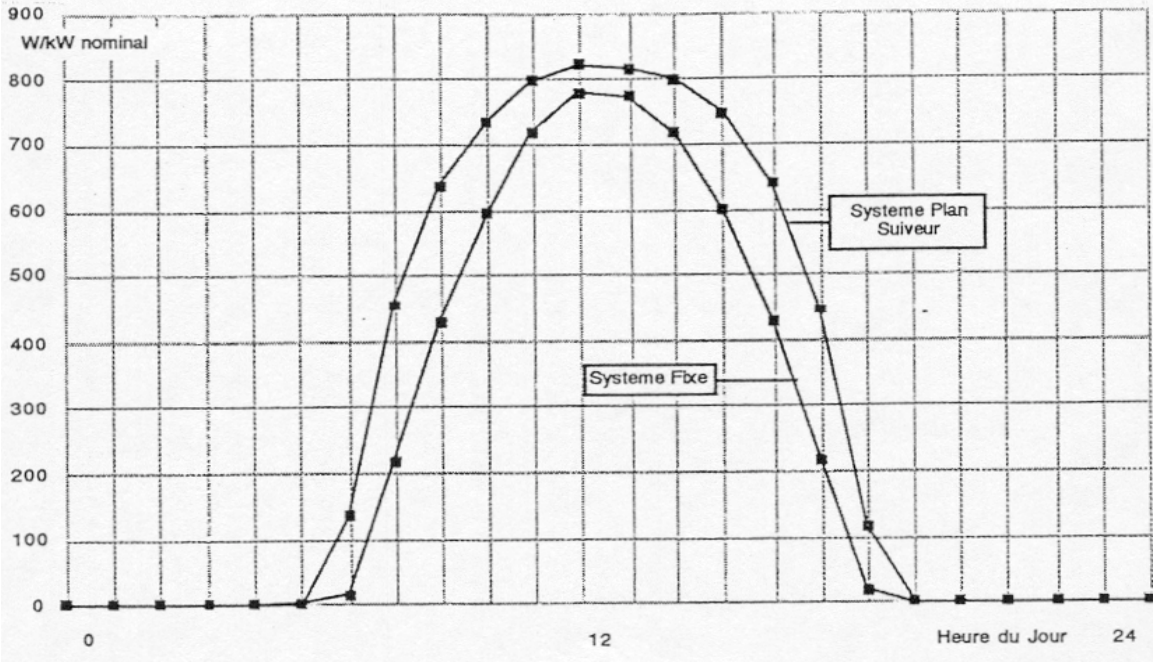

FIGURE 2: AVERAGE DAILY PV OUTPUT IN LA MARTINIQUE FOR FIXED AND TRACKING ARRAYS (1 KW NOMINAL)

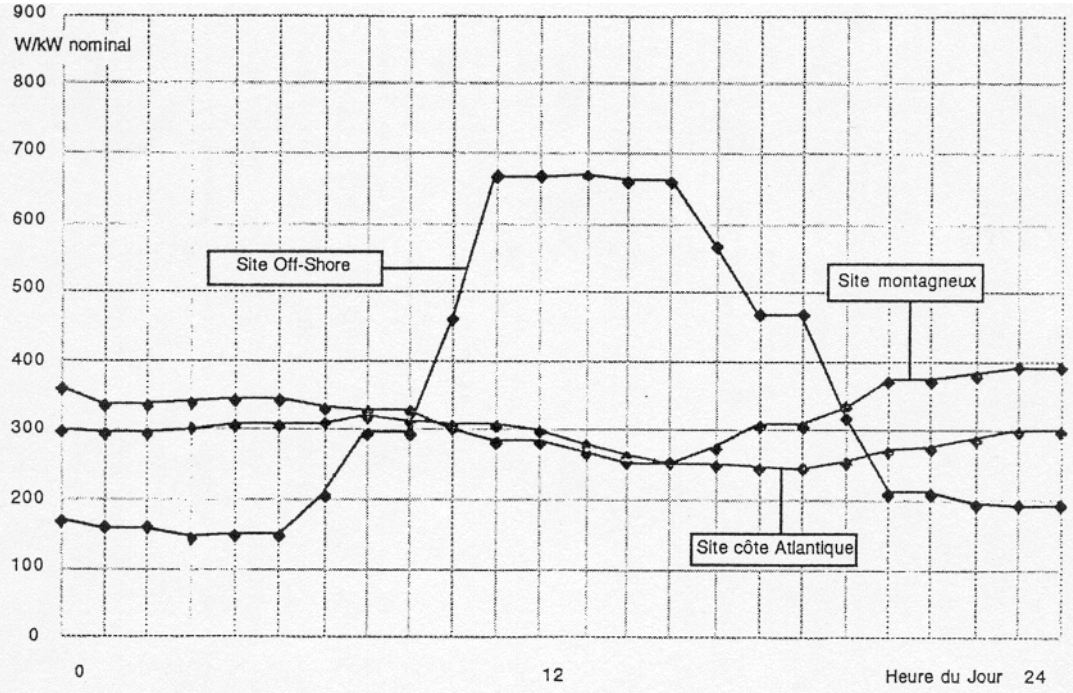

FIGURE 3: AVERAGE DAILY WIND POWER GENERATION AT THREE SELECTED SITES (1 KW NOMINAL)

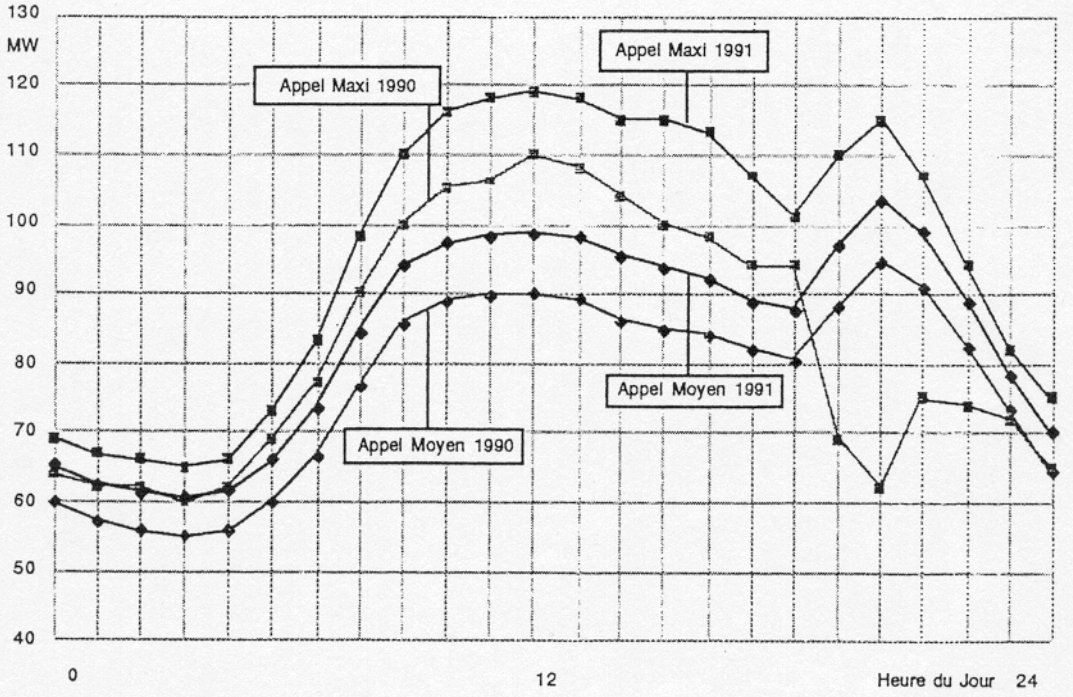

FIGURE 4: AVERAGE AND PEAK DAILY LOAD PROFILES IN LA MARTINIQUE IN 1990 & 1991

With an ELCC approaching 60% at low grid penetration, the effective capacity of PV is found to be substantial for La Martinique.

Wind effective capacities are not quite as high, however, the ELCC of one wind location, which benefits from mid-day thermal enhancement, is considerable and even tends to exceed that of PV as grid penetration increases.

MBES Benchmark

The minimum buffer energy storage necessary to insure 100% ELCC to each considered resource is plotted in Figure 6. Two grid penetration levels are reported, respectively 5% and 15%. The MBES for each resource is compared to the amount of stored energy that would have been necessary to achieve the same 100% ELCC without the help of the wind (PV) resource.

At 5% grid penetration (i.e., installed capacities of the order of 6 MW), only one hour worth of storage (i.e., 6 MWh) would be necessary to insure a 100% capacity credit to the two PV and one of the wind strategies. This is to be compared with almost four hours (24 MWh) worth of energy reserve to meet the same loads without the renewable resources.

Note that the concept of storage is used here as a measure of effective capacity. In practice, one could envision deploying small size storage together with wind/PV, and in cases where storage is already present (e.g., pumped hydro), its load control effectiveness could be greatly enhanced through the deployment of the renewable generation resource.

DISCUSSION

In this paper, we have shown that wind power generation may have a substantial effective capacity. In La Martinique, wind generation has been considered to have serious development opportunity based solely on its energy production value. The added benefit of an effective capacity that may approach 50% should, when properly accounted for, strengthen this opportunity and could make a critical difference between project success and failure.

This case study merits to be extended to other locations, as much remains to be learned about wind's effective capacity. Similar studies should be undertaken for other islanded networks similar to La Martinique -- e.g., other Caribbean islands, international isolated networks, localized loads -- as well as for interconnected US utilities or sub-utilities where localized capacity would constitute a premium.

Results for PV are less surprising today, and given La Martinique's load profile, are found to be fully consistent effective capacities observed for US utilities. Economic implications for the island are also less immediate, because grid-connected PV is not yet near its economic viability threshold -- in part because local electricity retail rates, which are tied to mainland France rates, do not fully reflect local costs. However, with effective capacities approaching 60% -- and 100% with minimized storage systems -- PV could become a very attractive grid support option for the island's grid.

ACKNOWLEDGEMENT

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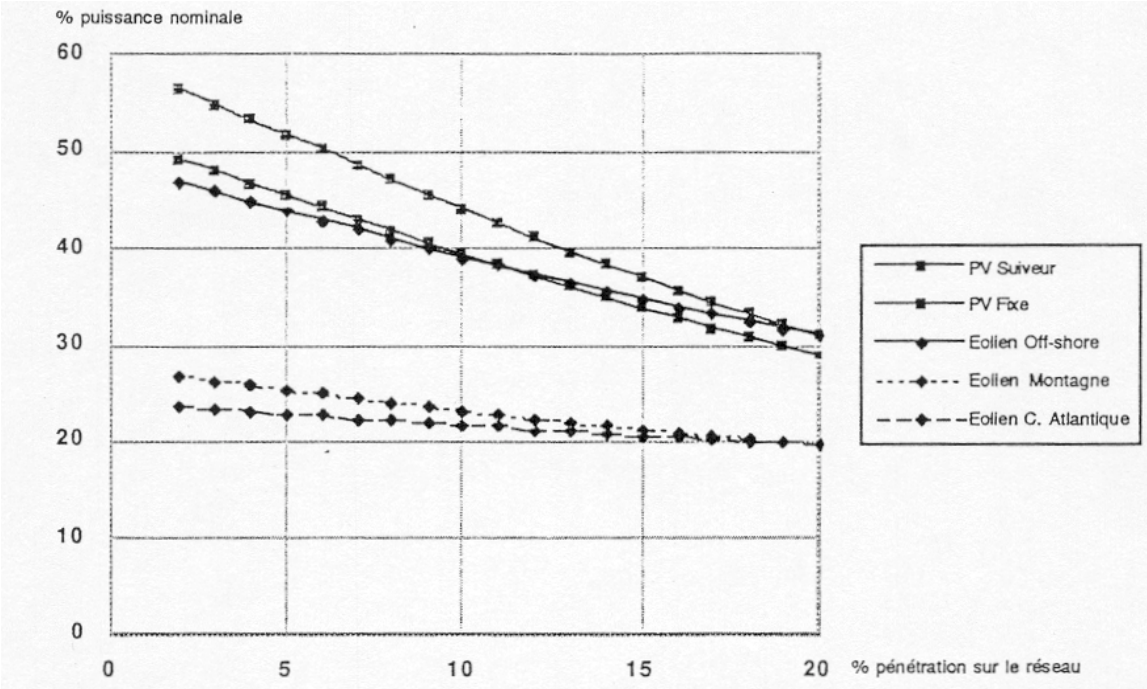

FIGURE 5: ELCC OF PV AND WIND FOR LA MARTINIQUE AS A FUNCTION OF RESOURCE PENETRATION ON THE GRID

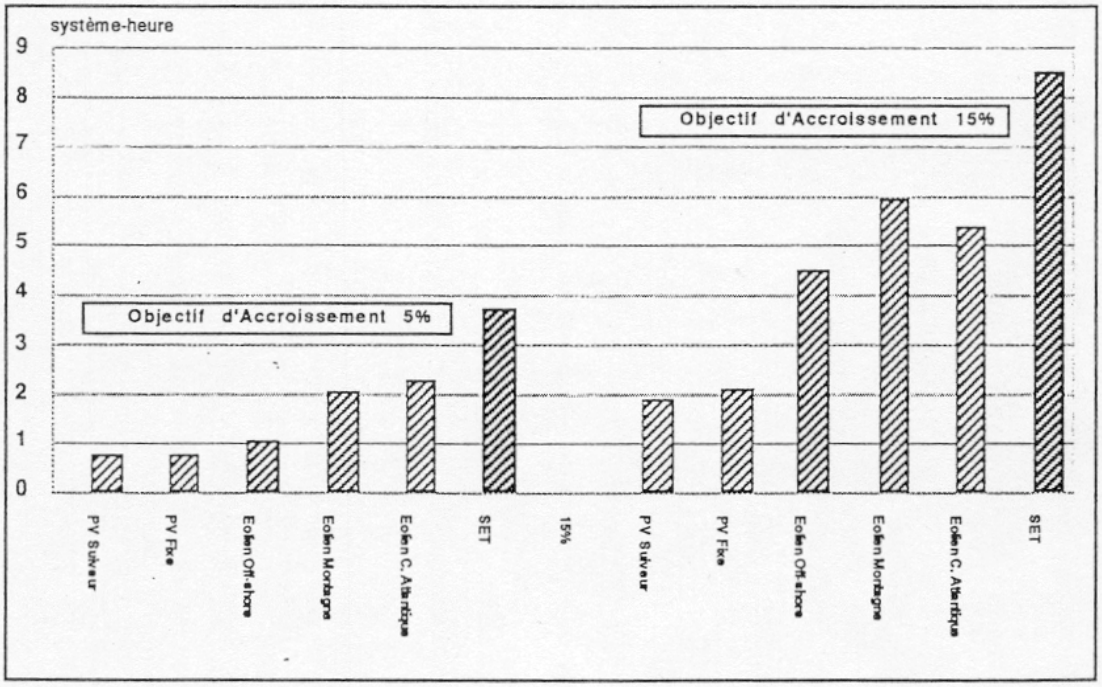

FIGURE 6: MINIMUM BUFFER ENERGY STORAGE FOR TWO GRID PENETRATION LEVELS

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