EE292K Project Proposal: Locational Marginal Pricing in Presence of Renewables

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Abstract

We propose a locational marginal pricing (LMP) scheme in presence of renewables. Renewables are time varying and non-deterministic hence our pricing scheme is based on real-time sensor inputs. The scheme is based on online learning techniques (stochastic optimization) which make it independent of any assumption on knowledge of distribution function. Further, optimal prices in presence of renewables are quite erratic, we would like to dampen these variations and study the sub-optimality of corresponding solution we get.

1 Description

Cost of generation of energy through renewables is quite low (or even negative), since the fuel is essentially free and generation is backed up by renewable energy credits. But the output of such a power plan is unpredictable, which makes it challenging to come up with optimal pricing scheme.

The locational marginal prices are computed by solving optimal power flow (OPF) problem. Let us first discuss the OPF formulation for deterministic case (without renewables):

$$\begin{aligned} \text{minimize } & \sum_{i=1}^{N} C_i(P_i) \\ \text{subject to } & L_{ki} \leq l_{max} \\ & P_i \leq P_{max} \end{aligned} \tag{1}$$

Here the objective function is represented as sum of cost functions power injection into the grid. First constraint represents the maximum heat dissipation limit of transmission line and second constraint represent maximum power generation limit of power plant. Traditionally, DC approximation has been used to simplify this problem to convex problem. DC approximation assumption includes unit voltage levels, non-resistive transmission lines and small phase difference among bus. These assumptions might not hold especially in case of renewables, for example, phase difference might not be small since renewables may not include actual rotation parts. Hence, we will use recently proposed convex optimization formulation for OPF [2], this formulation do not require any DC approximation but is valid only for tree networks.

In presence of renewables, the maximum power generation is non-deterministic (depends on wind conditions in case of wind mill). Hence the appropriate formulation for this case would be:

$$\begin{aligned} \text{minimize } & E\left(\sum_{i=1}^{N} C_i(P_i)\right) \\ \text{subject to } & E(L_{ki}) \leq l_{max} \\ & P_i \leq P_{max}^{wind} \end{aligned} \tag{2}$$

this means we want to minimize average cost function, with constraint on average heat dissipation in transmission line. P_{max}^{wind} represent maximum generation limit of wind mill for specific wind conditions which is variable. We propose a scheme to solve (2) and hence obtain the optimal locational marginal prices. The scheme do not assume knowledge of distribution of wind available to us, instead we will use online-learning techniques (used in [1]) which samples wind condition periodically (real-time sensor inputs) and possibly adapts to any change in wind distribution.

The optimal prices in presence of renewables are quite erratic because of variability in power generation. Figure 1 shows this variability with time in case of wind energy. Note that good wind condition means higher power generation has lower LMP and vice-versa. Hence, we would further investigate on how we can dampen this variability and as a result how much we loose on optimality.

References

[1] S. Firouzabadi, D. O'Neill, and A.J. Goldsmith. Optimal power line communications control policies using stochastic optimization. In *Power Line Communications and Its Applications (ISPLC), 2010 IEEE International Symposium on*, pages 96 –101, march 2010.

[2] Baosen Zhang and D. Tse. Geometry of feasible injection region of power networks. In *Communication, Control, and Computing (Allerton), 2011 49th Annual Allerton Conference on*, pages 1508 –1515, sept. 2011.

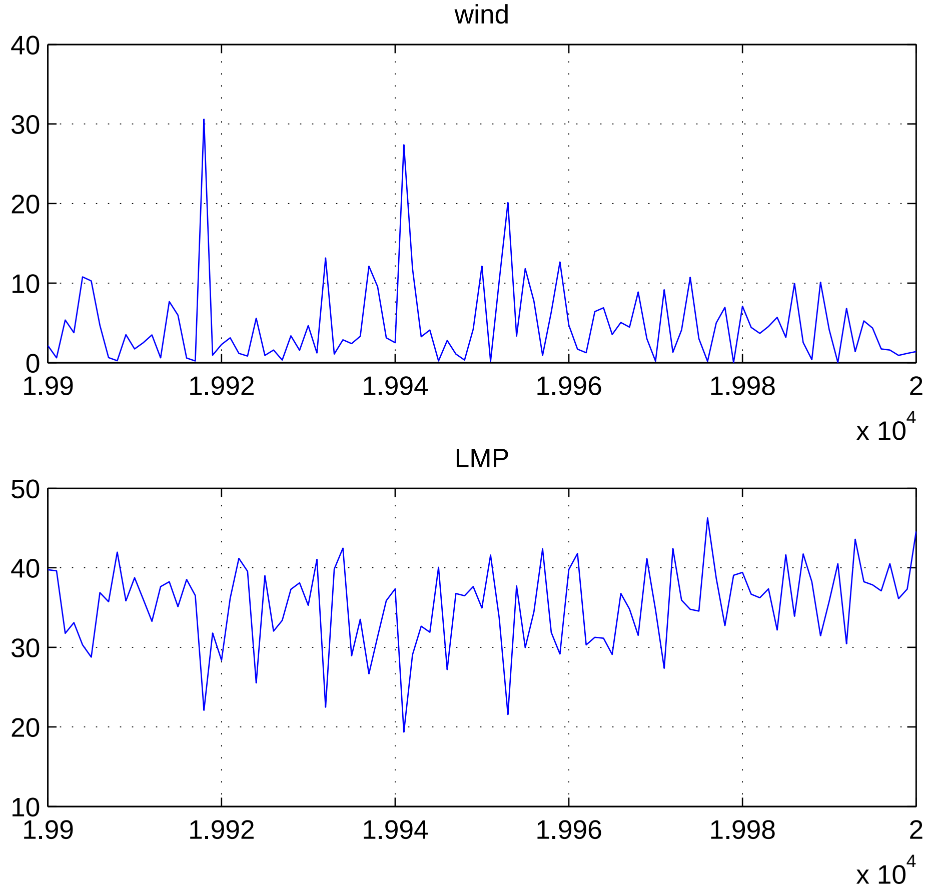

Figure 1: Shows wind conditions (top) and corresponding optimal value of LMP (bottom) varying over some time duration