

# **Decision Making under Uncertainty: Some Essays on Contemporary Operations Management**

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## **Abstract**

Sound decision-making is integral to the functioning of an entity. These decisions are generally shrouded with uncertainties that prevail in the future. In light of the uncertainties, a sound decision would hedge risks to the best possible level. Planning exclusively for the most likely event may lead to losses. The proposed thesis looks into two broad areas viz., decisions pertaining to the power sector and decisions in light of the Covid 19 pandemic.

Public policies expressing more reliance on renewable sources have been a global phenomenon, though its scale may differ. Reasons for a surge in the push for more use of renewable sources could range from a rise in the awareness towards the dwindling resources to a push by respective governments to reduce their dependencies on imports of coal or gas. Few other nations have realized the adverse impact of the greenhouse gases emitted from conventional power stations. The energy produced from renewable energy sources (barring a few like Biomass) cannot be stored economically. Thus, it is best to use these resources intermittently with conventional sources of energy. The existing grid system has made it possible for intermittent use of such energy sources. Though renewable energy is ecologically viable, it is less reliable because these generations depend on the availability of the respective sources of energy. In this thesis, we strive to look at three significant aspects of the energy sector in light of the increased focus on renewable energy: forecasting demand for better planning of capacity and operations, devising a mechanism to improve the capacity utilization

factor of renewable energy-based power plants and understanding the capacity decisions of utilities.

Mid-term load forecasting (MTLF) is essential for utilities and power plants to plan their operations, capacities and to decide on the power purchase agreements in advance. However, most of the MTLF models in practice forecast aggregate demand for a day or a week, or a month leading to either over-estimation or under-estimation of demand. Additionally, since the current MTLF model forecast demand at an aggregate level, due consideration is not given to the seasonality seen in the electricity demand. This thesis proposes a robust MTLF model that considers triple seasonality levels observed in the demand data. The model accurately forecasts hourly electricity demand for an entire year at the year's commencement. Compared to the benchmark models, our method entails estimating significantly fewer variables. We compare our model's performance with the existing triple seasonal models using data from six European countries with various economic and demographic conditions. Our model outperforms the existing triple seasonal models and is more robust, with a lower standard deviation in the mean absolute percentage error across six countries.

An incessant increase in the RE capacity is fraught with a low capacity utilization factor. Low utilization of RE capacity defeats the goal of decarbonizing the electricity. Pricing can effectively align consumers' demand with the supply availability from renewable energy-based power plants. We explore the impact of a Time of Use (TOU) retail pricing in a capacitated and deregulated electricity market to improve renewable energy-based power plants' capacity utilization factor (RE). Conventional TOU mechanisms strive to flatten the load curve. However, flattening the load curve may prove detrimental, especially if the available RE capacity and demand peak simultaneously. The thesis also accounts for the pragmatic constraints of a customer's behavior by bounding the rationality and practicality of changing the demand indefinitely. Our experiments and analytical models identify the

conditions favoring proposed TOU pricing and improving RE utilization. We compare TOU with the fixed tariff retail pricing. Our experiments indicate that the distributor, champion of TOU, benefits the most when the existing capacity of RE and NRE (non-renewable-based power plants) is high. Our analysis also emphasizes the need for reining in subsidies provided for RE's promotion since an uncontrolled increase in RE capacity may not augur well for the power sector. A high RE capacity may render them unprofitable on the one hand. On the other hand, a rise in the intermittent RE capacity would decrease the electricity supply's reliability.

We study a utility firm's decision on investment levels in renewable energy-based power plants (RE) and non-renewable-based power plants (NRE), with incumbent power plants in existence. The incoming NRE plants are technologically more advanced than the incumbent plants. As a result, the incoming NRE has higher efficiency, which translates into a lower marginal cost of generation and lower carbon emission for every unit of power generated. On the other hand, the RE plants are greener and have a lower marginal cost of generation. However, they supply electricity intermittently based on the availability of the renewable sources that drive them. We attempt to characterize the investment decisions. We consequently study the impact of the carbon emission cap regulations on investment decisions on both RE power plants and NRE power plants.

In the last essay, we study the impact of Covid-19, and ensuing safety- apprehension in consumers, on the profitability of services or facilities. We strive to capture the consumers' behavior by mapping them along two dimensions: one, willingness to pay to access the facility, and two, the physical distance maintained between consumers in the facility. We develop several interesting results with critical managerial implications for marketing practice. Through our analytical model, we explain the current practice prevalent in airlines and theaters.

The thesis has strived to deal with three different aspects of decision-making – strategic (Essay 1 and 3), tactical (Essay 2 and 4), and operational (Essay 2 and 4). We believe that the

insights derived from these studies would enrich both literature and practice with a better understanding of some of the aspects which have not been adequately addressed in the extant literature.