

Probabilistic characterization of electricity consumer responsiveness to economic incentives

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Abstract— Within a framework of assessment of demand response as an efficient flexibility resource for electric power systems, the main objective of this paper is to present an empirical methodology to obtain a full characterization of residential consumers' flexibility in response to economic incentives. The aim of the proposed methodology is to assist a hypothetical demand response provider in the task of quantifying flexibility of a real population of consumers during a supposed trial that would precede a large-scale implementation of a demand response program. For this purpose, mere average values of predictable responsiveness do not provide meaningful information about the uncertainties associated to human behavior so a probabilistic characterization of this flexibility based on Quantile Regression (QR) is suggested. The proposed usage of QR to model individual observed flexibility provides a concise parametric representation of consumers that allows a straightforward application of classification methods to partition the sample of consumers into categories of similar flexibility. The modelling approach presented here also depicts a full picture of uncertainty and variability of the expected flexibility and enables the definition of two specific risk measures for the context of demand response that have been denominated flexibility at risk (FaR) and conditional flexibility at risk (CFaR). The application of the methodology to a case study based on a real demand response experience in Spain illustrates the potential of the method to capture the complexity and variability of consumer responsiveness. The particular case study presented here shows non-intuitive shapes in the individual conditional distribution functions of flexibility and a potential high variability between different individual flexibility profiles. It also demonstrates the possible decisive influence that interaction effects between socio-economic factors, such as the number of occupants, the business as usual electricity consumption and the education level of consumers, may have on demand responsiveness.

Index Terms— Demand response; Flexibility; Empirical analysis; Probabilistic; Incentives; Elasticity; Quantile regression

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