

基于问卷调查的居民家庭可控负荷统计分析

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Statistical analysis of household controllable load based on questionnaire survey

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摘要:针对现阶段精确到单个居民可控负荷的大量数据,多来源于国外,不适用国内居民可控负荷参与需求响应的问题,通过问卷调查的方式统计了国内某小区居民可控负荷,分析了其用于削峰及提高风电和光伏消纳水平的可行性及潜力。首先基于客观、易于回答等原则设计了居民可控负荷调查问卷,发布后收集到有效答卷466份。而后利用问卷调查数据质量综合评价体系对统计所得问卷进行了评估。基于评估所得结果,利用Python对评价等级为良好以上的问卷信息进行了量化处理,采用自下向上的分层建模思路,结合居民可控负荷数学模型,计算了居民可控负荷的需求响应潜力。最后通过对比各类居民可控负荷的需求响应潜力,可知国内可参加需求响应的居民可控负荷有空调、电热水器、洗衣机等;将居民可控负荷曲线与风电、光伏发电典型出力对比,可知居民可控负荷具备提高光伏发电和风电消纳水平的潜力。

关键词:居民家庭可控负荷;需求响应;问卷调查;需求响应潜力

Abstract: In view of the fact that a large number of data that are accurate to single household controllable load at this stage are mostly from abroad and are not suitable for domestic residents to participate in demand response, household controllable loads in a residential area in China by questionnaire survey is counted, and feasibility and potential for peak shaving and improving the consumption level of wind power and photovoltaic are analyzed. Firstly, based on the principle of being objective and easy to answer, the household controllable load questionnaire is designed, and 466 valid answers are collected after publication. Then the questionnaire survey data quality comprehensive evaluation system is used to evaluate the statistical questionnaire. Based on the evaluation results, Python is used to quantify the questionnaire information with good evaluation level and above, and the demand response potential of household controllable load is calculated by using the bottom-up hierarchical modeling idea and combining with the mathematical model of household controllable load. Finally, by comparing the demand response potential of various types of controllable loads of residents, it is known that household controllable loads in China can participate in demand response are air conditioning, electric water heaters, washing machines, etc. By comparing household controllable load curve with the typical output of wind power and photovoltaic power generation, it can be seen that household controllable load has the potential to improve the consumption level of photovoltaic power generation and wind power.

Key words: household controllable load; demand response; questionnaire; demand response potential

0 引言

随着“碳达峰、碳中和”目标的提出,风电和光伏发电的渗透率将会进一步提高,风电和光伏发电的消纳将会更加困难。需求响应(demand response, DR)作为需求侧管理的重要技术,是提高新能源发电的消纳的灵活资源之一^[1]。

根据DR参与规模的不同,可分为两类:①以单个居民用户为研究对象;②以负荷聚合商(load aggregator, LA)为研究对象。文献[2]基于单个居民用户,提出了计及舒适度的家庭能源中心运行模型,但

单个居民家庭负荷过小,不具备直接参加DR的条件,因此需要LA聚合。聚合商在日前实施调度安排时必须清楚把握管辖区域居民负荷的用电行为,进而预测出可控聚合量,才能合理制定出各阶段负荷调度量。目前,由于非侵入式负荷检测技术尚未广泛使用^[3],且对居民可控负荷参与需求响应的研究数据多采用国外负荷数据,部分文献通过仿真或问卷调查获取所需数据。需求响应一般是以区域为单位进行,文献[4—5]采用国外可控负荷数据进行研究,不能反应国内情况。文献[6]以各类居民可控负荷为研究对象,通过仿真获取研究数据。文献[7]对上海市某地区电动汽车出行大数据进行数理统计,获取出行和充电行为特征指标,但统计对象仅为电动汽车。文献[8]对江苏南京某社区64户居民家庭可控负荷安装智能插座,测量了其用电历史数据,建立

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