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Impacts of Load Shifting on Renewable Energy Integration

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Abstract

While renewable energy generation from time variable sources keeps increasing, end-user interactions through smart grid development and the adoption of smart appliances lead to significant changes in consumer behavior. Hence, renewable energy generation must be curtailed more frequently when the expected demand is surpassed. Likewise, demand side measures should be considered more thoroughly so that appropriate capacity limits for new generation units can be defined. An analysis of load shifting is performed for São Miguel Island, Azores, and indicates that through defined rules of load shifts the base load limit can be elevated and new limits for the maximum installed capacity can be set. The effects of load shifts are crucial for decision makers since investments in additional renewable energy capacities can be limited and back-up capacities can be reduced.

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Keywords: Demand side management; energy planning; load shifting; renewable energy integration

1. Introduction

Within the new energy paradigm the power system is characterized through the biased interaction of demand and supply. While demand and renewable energy based generation can alter significantly throughout the year, season or over the day and peak electricity demand might only occur for a few minutes or hours per year [1], [2], behavioral

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changes through demand side measures and flexible end-uses might decrease the maximum peak substantially [3]. Indeed, demand side management (DSM) measures need to be considered to smoothen and reduce the peaks [4]. Typical measures include peak clipping, conservation, load building, valley filling, load shifting and flexible load shape [5]. Several other behavioral and policy measures have been studied. Abaravicius (2007) focused on reducing peak load via customer flexibility [6]. Though, the results demonstrate that customer´s electrical expenses need to be reduced to improve consumption patterns. Breukers et al. developed a toolbox to improve energy DSM. The tool should help intermediaries in planning and implementing energy DSM projects. Within their work it was found that behavioral changes should fit into context to be durable [7]. With carefully designed demand side policies significant peak capacity reductions are achievable [8].

Especially for isolated islands or islands with limited grid connection capacity, alternatives to reduce the peaks are vital during hot summer days, when tourism and cooling demand are high [9]. In order to provide energy security it is important, that both, the peak as well as annual demand will be reduced, smoothened and balanced [10]. With the aim of increasing renewable energy penetration levels the role of DSM measures within the demand profile receives even greater attention, since the overall supply system can be (re)sized and operated more appropriately.

The possibilities of introducing load shifting have been analyzed for the case of São Miguel, Azores, Portugal (37.7804° N, 25.4970° W). The island seemed of particular interest since it has great geothermal potential and it is expected that through load shifts the base load technologies could be operated more smoothly and consistently.

2. Identifying load shifting potentials

The primer step to identify load shifting potentials is to analyze the current end-uses through an analysis by economic sector. The more detailed the end-uses are clustered the more adequate the load adjustments and shifting strategies can be defined. Since no such detailed breakdown of electricity consumption for São Miguel could be obtained, Figure 1 illustrates an overview of the residential and commercial sector in the EU-27 that may be used as reference case [11]. In addition, the emerging use of electricity for transportation purposes might be analyzed. The industry sector has been omitted from analysis since industrial uses tend to be limited on islands.

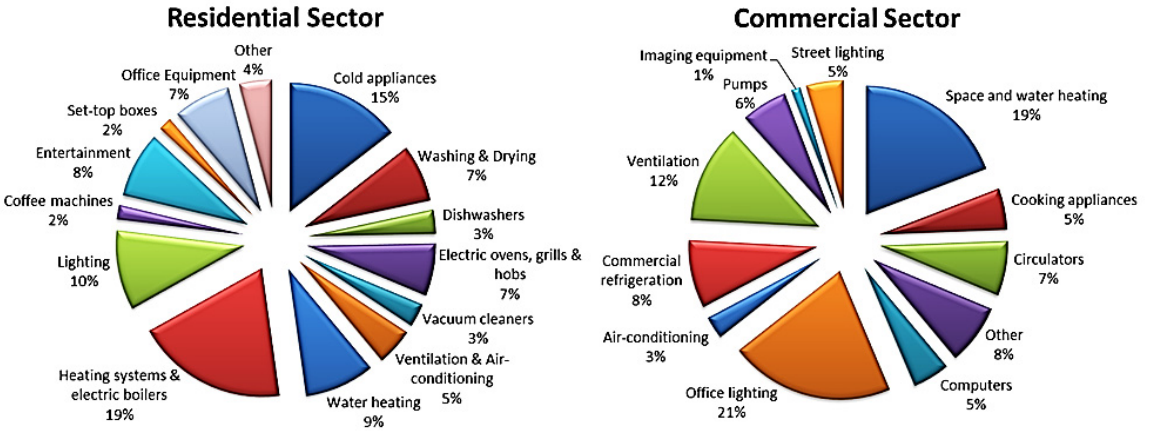

Fig. 1. Residential and commercial sector electricity consumption breakdown in the EU-27, 2009 [11]

The end-uses with the greatest potential for time-of-use shifts are electric vehicles (EV) in the transport sector [12], [13], [14] and wet appliances (include dishwashers, washing and drying which have a total share of 10.2%) in the residential sector [15], [16]. A study indicates that the flexibility window per wet appliance is on average 8 hours [17]. Hence appliances, which are smart and usually operated during the afternoon peak, can be run during (late) night hours. Recent studies also analyze the potential for ambient pre-cooling/heating [18], [19] as well as pre-heating of water [20].