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Energy efficiency measures for buildings in Hebron city and their expected impacts in the distribution grid

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Abstract

The energy efficiency in buildings could represent one of the main opportunity, within a wide strategic scenario, to achieve energy independence of Palestine. In fact, the reduction of building energy demand due to the implementation of energy efficiency measures leads to a consequent decrease of the energy provision needs. For this reason an analysis of the potential reduction of the energy consumption in building need to be performed and a possible estimation of costs should be identified for defining a energy strategic plan of Palestine. This paper intends to highlight the potential of the energy efficiency measures in different building typologies of Hebron city in Palestine and their impact in the electrical distribution grid. The effectiveness of the different measures are estimated by means of software simulations and their optimal combination is also identified in order to maximize the reduction of energy demands. Finally, the variation of power losses in the distribution grid due to the retrofit action and a preliminary estimation of possible economic effort for the implementation of the proposed actions are also exposed.

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Keywords: Energy efficiency in Palestine; power losses in distribution grid; energy independence

1. Introduction

The increase of energy demand in Palestine due to population (i.e. +26% from 2007 to 2014) and urban growth [1] is recently forcing a technology transition from fossil fuels to Renewable Energy Sources (RES), like wind and solar, oriented also to energetic independence [2,3]. In fact, the energy provision in Palestinian territories is highly dependent from boundaries countries where, for example, the electricity needs are mainly covered through an import from Israel [1]. This holds particularly true in Hebron city where the present electricity needs are totally covered by the Israel Electric Corporation (IEC).

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Nomenclature

A_b	Surface area of a given reference building typology b in a city area (m^2)
$A_{tot,b}$	Total surface area of a given building typology b in a city area (m^2)
E_d	daily energy demand for a given subnet (kWh)
$E_{d,j}$	daily energy demand of j-th MV/LV transformer (kWh)
g	solar factor of glazed surfaces
$HLF(t)$	nomalized hourly load profile for a given subnet (p.u.)
$k(d)$	correction factor of the daily energy consumption in a given subnet
$P_b(t)$	load profile of a given reference building typology b (kW)
$P_{tot,b}(t)$	aggregated load profile for a given building typology b in a city area (kW)
$P_{sp,b}(t)$	load profile per unit of surface area of a given reference building typology b (kW/m^2)
$S_{n,j}$	rated power of j-th MV/LV transformer (kVA)
t_L	light transmittance of glazed surface
U	thermal transmittance (W/m^2K)

In this context, the energy independence of Hebron city can be potentially reached by the introduction of RES generation, as presented in [4], combined to energy storage systems, as discussed in [5], where the implementation of PV generation coupled with battery storage systems increases the exploitation of PV reducing also flux inversion (presently not allowed by IEC) at primary substation level of Hebron electric grid. However, more effectiveness condition can be obtained if RES generation is combined to a reduction of the existing energy needs through the implementation of energy efficiency measures in existing buildings, paving the way for urban regeneration and improvement of the quality of life [6].

Presently the most relevant energy consumption is covered by electricity which represents 35% of the whole energy demand, since space heating and cooling demands in Hebron buildings are covered by means of air-conditioner/heater (i.e. reversible heat pumps) with split units [7]. In particular, residential buildings need of 40% of the whole yearly electricity demand of the city, while industrial and commercial users need of 33% and 23%, respectively. Hence, deep energy retrofit actions need to be implemented in the whole Hebron buildings to reduce the overall electricity energy consumption of the city and to decrease the energy dependency from Israel. In fact, a significant reduction of the electricity demand can be expected through energy refurbishment of buildings as already observed in similar studies of Middle-East area where buildings suffer scarce thermal insulation [8–11], like in Hebron city. As a consequence, these energy efficiency measures have an impact also on the electrical distribution network (DN), which is presently slightly underloaded but reliable in Hebron [12], changing the energy requirements of final users [13–15]. Thus, this paper intends to identify at city scale the potential expected reduction on energy consumption due to energy retrofit in buildings and the consequent reduction of power losses in the DN.

The RENEP (Renewable Energy for Palestine) project, an initiative in the framework of the PMSP (Palestinian Municipality Support Program) [16] with the participations of SiTI, Ai Engineering s.r.l., the Municipality of Torino and the Metropolitan City of Torino, aims to study and evaluate the potential effects owing to the energy efficiency measures which could be implemented in different building typologies. Simulations of buildings energy behavior by means of IES<VE> software [17] were performed to evaluate and estimate the energy saving which potentially can be obtained by the implementation of the energy retrofit in buildings. Later, also the impact in the distribution grid through load-flow simulations and analysis were performed by means of NEPLAN [18]. The approach has been implemented by using real data collected on the fields, thanks to the collaboration with Hebron Municipality and HePCo (Hebron Power Company), the local utility responsible for the management of the electric grid.

2. Building Model

The Hebron urban environment is characterized by a great variety of building typologies which can be grouped into 4 main categories: commercial, educational, industrial and residential. For the scope of this work, some repre-