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Prioritising Energy Efficiency Measures in Maltese Restaurants

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Abstract: The 2018 Energy Performance of Buildings Directive (EU) 2018/844, focuses on building energy renovation. With the increase in tourists and working opportunities in Malta, the restaurants' sector is experiencing a business boom. Despite this sector being a major energy consumer, the energy performance of restaurants in Malta has been given little attention. This paper investigates the energy performance of four representative restaurants in Malta. Refrigeration accounted for the highest share of 40% electricity consumption, followed by kitchen exhaust ventilation, domestic hot water and space cooling, which accounted for about 50%, while lighting consumed only 6%. Energy saving potential was primarily identified for refrigeration, water heating and air-conditioning. Although, the fuel sources used for cooking equipment accounted for more than 50% of the overall energy used in these restaurants, electricity is the fuel of primary concern as on average it contributes to 70% of total carbon emissions and results in the highest operational cost. The total potential of carbon emission savings was found to be 17%, when the recommended energy efficiency measures are applied. A benchmark of 14.51 kWh primary energy per person served was established for energy-efficient restaurants. This paper provides evidence-based results that are useful for policy makers to introduce fiscal incentives to support the transition of Maltese restaurants to nearly-zero energy status.

1. Introduction

One of the main targets of the European Commission is to enhance energy efficiency in buildings. Buildings consume 40 % of the total primary energy consumption buildings in the EU making them the largest energy consuming sector in Europe [1,2] but also the one with the highest potential for energy efficiency and energy saving. This is demonstrated in the EU energy efficiency plan (EEEP) [3], which stated that the implementation of appropriate energy policies in the building sector could endorse important reductions of energy use and higher penetration of renewable sources.

In this paper, the focus is on the sector of restaurants, given that they hardly feature in any energy study or specific policy framework in the EU or worldwide. In addition, restaurants consume about 2.5 times more energy per square meter than other commercial buildings [4]. The guideline of the Chartered Institution for Building Services Engineers (CIBSE) [5] indicates that energy savings can be as high as 20% in a commercial kitchen. It must be stated that despite this high energy saving potential for restaurants, peer reviewed papers and guidelines from renowned sources in Europe and worldwide addressing this sector are very limited, unlike references for other commercial buildings such as hotels and offices. Locally (specific to Malta's Mediterranean weather conditions), there have been absolutely no studies regarding the energy performance of restaurants thus emphasizing the importance of this work. One of the overall aims of this study is to conduct detailed analysis on how restaurants can become more energy efficient. The following are the main objectives of this paper:

1) To profile the energy consumption patterns of some typical Maltese restaurants.
2) To analyse effective energy efficiency measures that best fit the profile of energy use in restaurants.
3) To perform an economic analysis to prioritise investment in energy efficiency options.
4) To illustrate the environmental benefits of implementing energy efficiency measures.

2. Literature Review

Article 2.5 of the Maltese subsidiary legislation 409.15 [6], classifies restaurants in three different categories, being first, second and third class. Among them one finds fast food establishments, coffee shops and cafeterias, family restaurants and fine dining restaurants [7]. Different classes of restaurants can provide a suitable way of clustering them in order to study their energy performance, based on seating capacity, comfort and other specifications, as detailed in the said subsidiary legislation.

Following extensive investigation, no trace was found of previous energy or benchmarking studies that were carried out on Maltese restaurants. The most relevant reference could be extracted from CIBSE TM:50 [5], which states that the typical energy benchmark for a traditional restaurant is 4.7 kWh/meal, while for the good practice it is 4.15 kWh/meal. However, one should take note of the different climatic conditions between the locations of the restaurants studied to set these benchmarks and those for the restaurants under this study.

While restaurants use about 2.5 times more energy per square metre than other commercial buildings [4], the guideline of the Chartered Institution for Building Services Engineers [5] indicates that energy saving potential can be as high as 20% in a commercial kitchen, while the U.S. Department of Energy claims that energy consumption in restaurants can be reduced by approximately 50% [8]. It must be stated that despite this high energy saving potential for restaurants, peer reviewed papers and reference guidelines that focus on restaurants are very limited at International and EU levels.

3. Methodology

For this study, four typical local restaurants were chosen. The restaurants were chosen in such a way to have diverse operational characteristics in different locations around Malta, as depicted in the below table. Such diversity will enable one to appreciate whether energy performance is dependent on the type, location and class of a restaurant.

The method used for operational energy auditing is compliant with ISO 50002 [9]. For restaurants A and B, Type 2 (detailed monitoring) method for auditing was used, while for restaurants C and D Type 1 (walk-through audit) was applied. According to CIBSE [5], different energy services end uses should be taken into consideration in an energy audit. These include cooking (equipment), HVACR (i.e. heating, ventilation, air-conditioning, cooling, and refrigeration) and lighting. For each restaurant, the calculated electric energy values were summed and compared to the electricity bills for at least one-year. Calibration of the base scenario with actual measured energy consumption data is necessary to be able to correctly quantify the actual operational savings once retrofit measures are proposed. Prior to calibration, it was ensured that the utility bills cover only the restaurant concerned, excluding any other ancillary buildings. Calibration was only carried out for restaurants A and B given the limited availability of actual energy bills for restaurants C and D.

Table 1: Restaurants chosen for study

Restaurant ID	Restaurant type	Class	Location	Seating capacity indoor area	Seating capacity outside area	Building envelope characteristic	Average age of equipment (years)	Cooking Fuel	Renewables
Restaurant A	Traditional Maltese Restaurant	B	Southern harbour region	96	0	Thick limestone walls, no exterior glazing	6	Wood, predominantly LPG, electricity	Biomass (wood)
Restaurant B	Large family Restaurant	B	South eastern district	119	134	Single floor, concrete walls, insulated roof, large windows to wall ratio (approx. (50%)	>10	Predominantly LPG, electricity	Solar (PVs and solar water heating)
Restaurant C	Fine dining Restaurant	A	Northern district	120	0	Two floors, large glazing façade	10	Predominantly LPG, electricity	None
Restaurant D	Small family Restaurant	C	South eastern district	20	36	Single floor, double limestone walls, small window to wall ratio	>10	Predominantly LPG, electricity	None

4. Results

As expected, one notes that Maltese restaurants have high energy consumption for space cooling and refrigeration, while energy consumption for space heating is minimal given our temperate climate with hot summers. In fact, refrigeration accounted for the highest share of 40% electricity consumption, followed by kitchen exhaust ventilation system, domestic hot water and space cooling, which accounted for about 50%, while lighting consumed only 6% (refer to Figure 1). Interestingly, it was noted that the exhaust flow rate in the kitchens of both Restaurants A and B, was lower than the minimum flow rates recommended by the ASHRAE handbook [10]. Therefore, the energy demand for the kitchen's flow rate was considered as that required by the standard and any energy savings was based on that level of "*corrected*" baseline energy consumption.

Energy saving potential was primarily identified for refrigeration, water heating and air-conditioning. Although, the fuel sources used for cooking equipment (refer to Figure 1), i.e. liquified petroleum gas or natural wood, accounted for more than 50% of the overall energy used in these restaurants, electricity is the fuel of primary concern given that it is the main CO_2 emitter (70% on average of total CO_2 emissions in these restaurants) and it also resulted in the highest operational cost. The total potential of CO_2 emissions savings was found to be 17%, if the recommended energy efficiency measures are applied, as shown in Figure 2.

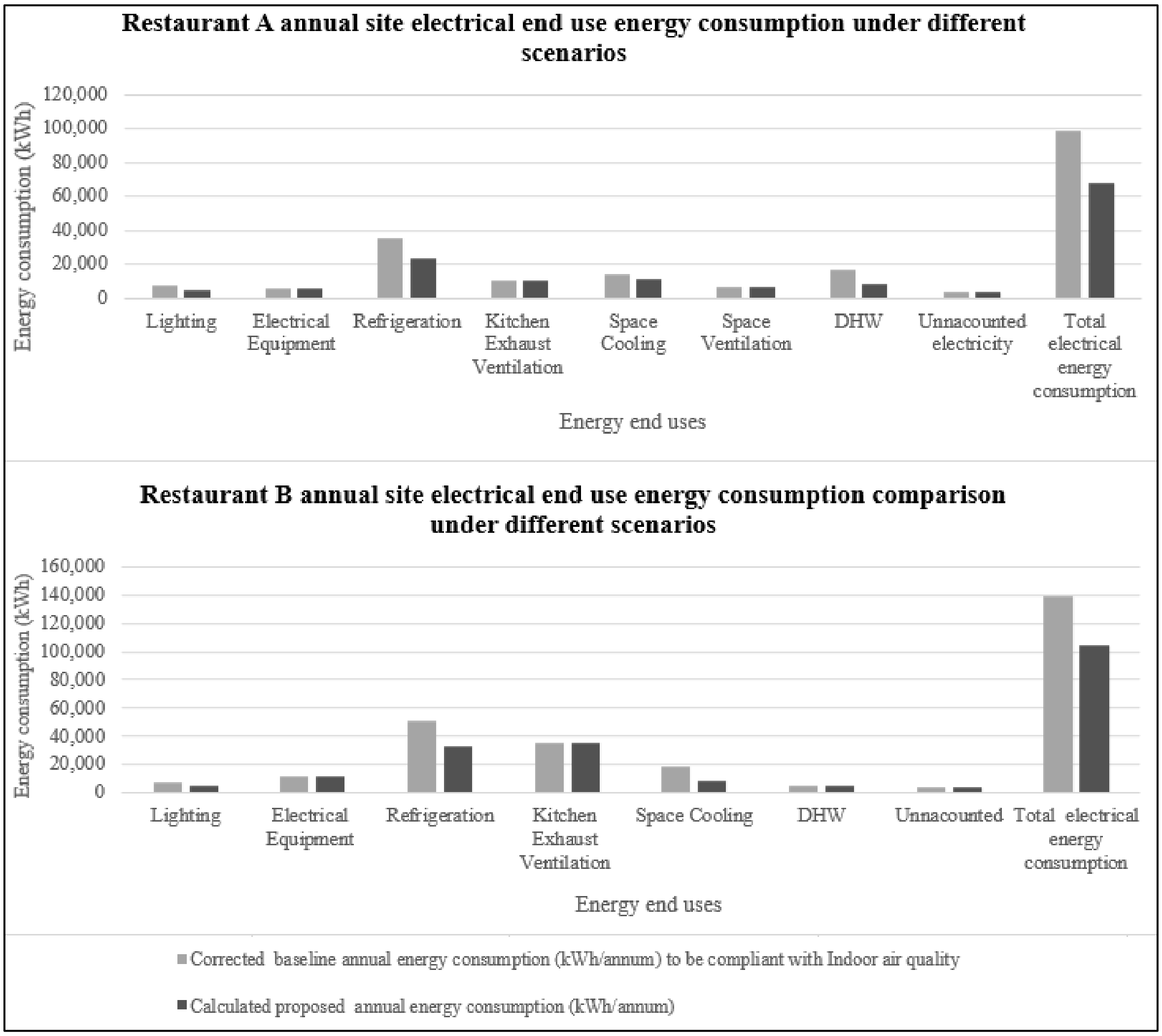

Figure 1: Restaurants A and B annual site electrical end use energy consumption

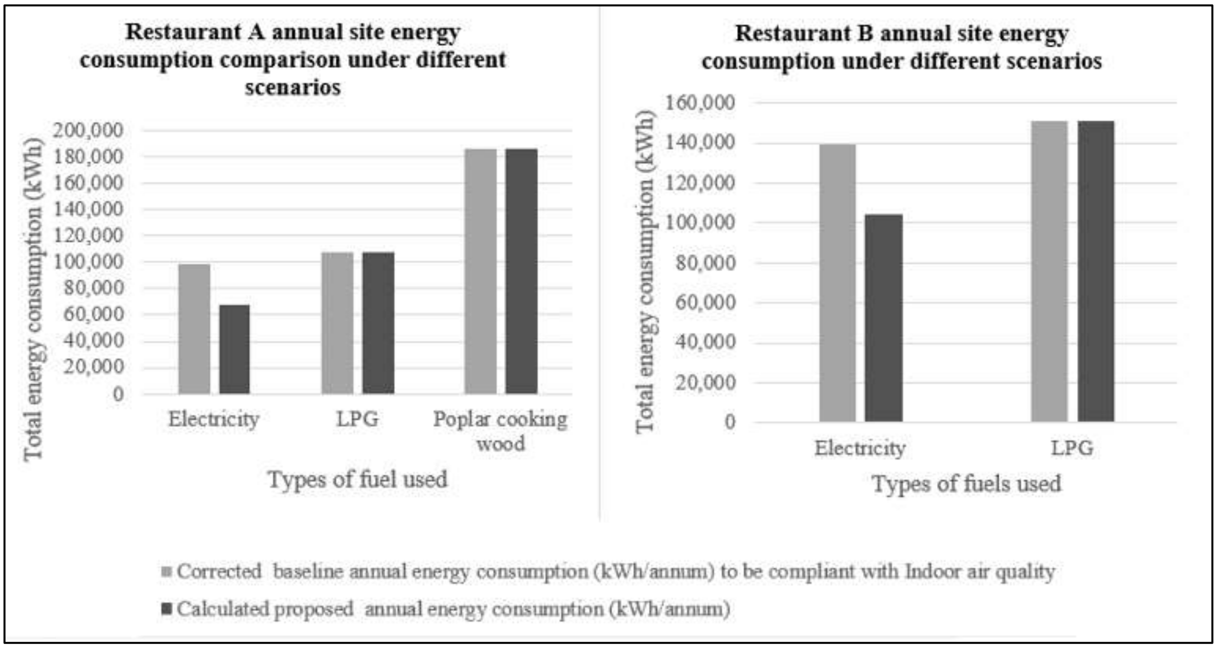

Figure 2: Bar chart showing restaurant A and B base and proposed site energy consumption scenarios by fuel type

The simple payback period for the proposed measures was also determined, as shown in Figure 3. Clearly, renovation of air-conditioners and refrigeration equipment have a long simple payback period.

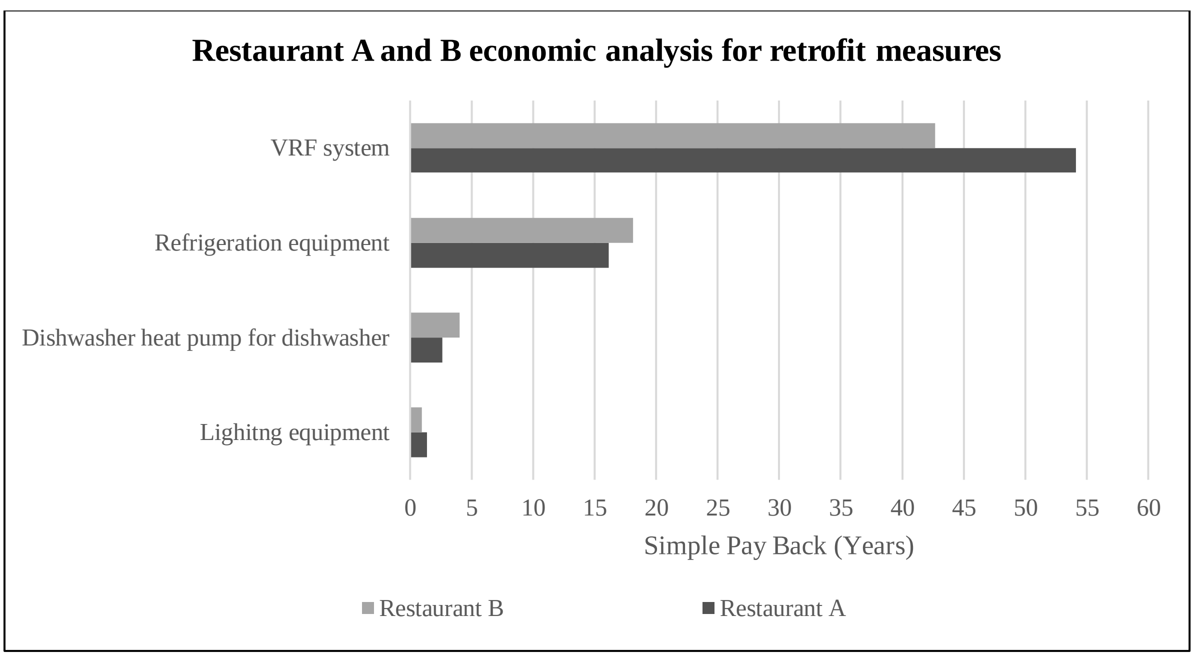

Figure 3: Bar chart depicting the simple payback period for different retrofit measures

Benchmarking of the existing operational energy of the restaurant and the renovated proposal are shown in Table 2.

Table 2: Baseline and improved operational site and primary energy and the corresponding carbon dioxide emissions for Restaurants A and B

Restaurant A and B site energy				
	Baseline site annual energy consumption (kWh/annum)		Improved site annual energy consumption (kWh/annum)	
	A	B	A	B
Electricity	98,440	129,412	67,898	103,950
LPG	107,624	150,696	107,624	150,696
Poplar cooking wood	186,069	N/A	186,069	N/A
Total site energy	392,133	280,108	361,592	254,646
Site kWh/m^2/year	1,140	662	1,051	602
Site kWh/person served	11.21	12.31	10.34	11.19
Site kWh/cover/year	4,084	1,506	3,767	1,369

Restaurant A and B primary energy				
	Baseline annual primary energy consumption (kWh/annum)		Improved primary energy annual energy consumption (kWh/annum)	
	A	B	A	B
Electricity	196,879	258,824	135,796	207,899
LPG	118,386	165,766	118,387	165,766
Poplar cooking wood	186,069	N/A	186,069	N/A
Total Primary energy	501,335	424,590	440,252	373,665
Primary kWh/m^2/year	1,457	1,004	1,279	883
Primary kWh/person served	14.34	18.66	12.59	16.42
Primary kWh/cover/year	5,222	2,282	4,585	2,008

Restaurant A and B Operating CO_2 emissions				
	Baseline operating kg CO_2 emissions per annum		Improved operating kg CO_2 emissions per annum	
	A	B	A	B
Electricity	44,495	58,494	30,690	46,985
LPG	23,139	32,400	23,139	32,400
Poplar cooking wood	4,652	N/A	4,652	N/A
Total Operating kgCO_2	72,286	90,894	58,481	79,385
Operating kgCO_2/m^2/year	210.13	214.88	170	187.67
Operating kgCO_2/person served	2.07	4	1.67	3.49
Operating kgCO_2/cover/year	753	489	609	427

5. Discussion

One interesting outcome was that the best energy efficiency measure does not necessarily yield the best financial viability from a private investor point of view. Upgrading to energy efficient LED lighting provided the best payback period of less than two years, despite lighting load contributing to only 6% of the total electric energy. In contrast, upgrades of refrigeration and space cooling equipment resulted in payback periods of more than 15 years and therefore require fiscal incentives to make them financially feasible. The installation of heat pump dishwashers can be feasible but require custom-made solutions depending on the hot water demand. Given the high pay-back periods for many retrofit measures, restaurateurs must prioritise simple energy management solutions to reduce operational energy costs. A number of these measures can be identified such as timing of opening of freezers and food preparation scheduling, switching off air-conditioners outside opening hours and installing air curtains or creating separate air zones between kitchens (warm area) and dining areas (air-conditioned areas).

A benchmark of 14.51 kWh primary energy per person served was established for energy-efficient restaurants. By comparing the baseline and proposed improved benchmarks with other benchmarks (United Kingdom) found in CIBSE, it is seen that the CIBSE TM 50 [3] good practice traditional restaurant benchmark of 4.12 kWh/meal match the calculated site energy proposed results of 10.34 kWh/person served for restaurant A and 11.19 kWh/person served for restaurant B, if one assumes that on average each person consumes 2.5 meals (plates served) in a restaurant. Despite the similarity, this study was essential to give an indication and confidence to local restaurateurs of what a typical benchmark for restaurants in Malta is, given a different climate, different building envelope characteristics and different operating schedules. The similarity in benchmarks between the UK and Malta could have resulted given that the summation of end uses average one another. For example, a higher space heating demand for the UK balances out the higher space cooling requirements for Malta.

The use of solar photovoltaic (PV) systems can further improve the resulting energy performance benchmarks for restaurants. When considering the installed 25 kW_p solar photovoltaic (PV) system in restaurant B, the site energy performance benchmark drops from the improved value of 11.19 to 9.38 kWh per person served, while the operating CO_2 emissions drops from 3.05 to 2.67 kg CO_2 emissions per person served. Despite these improvements when including solar PVs, such benchmarks cannot be considered as typical given that the potential of installing PVs in restaurants is limited. Furthermore, as reviewed in literature, PVs should not be installed to balance out high energy consumption of inefficient equipment given that unlike PVs, energy efficiency has the capability of reducing peak demand and provide long-term benefits.

The initial attempt was to also carry out an energy audit for restaurant C and D in detail as was done for restaurants A and B. However, this was not possible given that actual metered data was not available from the energy meter bills and only estimated data was provided. In the future, this restriction should be counteracted thanks to the implementation of smart metering, which will enable restaurateurs to better monitor and manage their energy consumption. Despite this limitation, a walkthrough energy audit was carried out for restaurants C and D, which showed similar outcomes.

6. Conclusion

When analysing energy consumption by fuel type, the fuel sources used for cooking equipment (i.e. LPG or wood), is the primary site energy consumer but from a primary (source) energy point of view, electricity is the main carbon emitter for restaurants, given its higher emissions generation per unit of energy consumed. Electricity also results in the highest operational cost. Therefore, energy efficiency of electricity-powered services are to be given a priority.

The measures with the highest potential for energy savings include the replacement of existing refrigeration equipment with energy efficient equipment, the installation of hot water heat pumps for dishwashers and an upgrade to space cooling equipment. However, the potential for energy savings does not directly translate into economic feasibility. While, upgrading to energy efficient LED lighting provides the best payback period of less than two years, upgrades of refrigeration and space cooling equipment result in a payback of more than 15 years and therefore require fiscal incentives to make them financially feasible. Given the high pay-back periods for many retrofit measures, restaurateurs must prioritise energy management solutions to reduce operational energy costs.

For both restaurants, the total potential of primary energy savings when compared to the baseline scenario is approximately 12%. From the various energy performance benchmarks considered, benchmarks normalised per person (or meal) served, provide the best energy performance indicator for restaurants. When considering the implementation of all retrofit measures, the resulting average (energy efficient) performance benchmark based on site energy is 10.77 kWh (equivalent to primary energy of 14.51 kWh) per person served.

This paper provides evidence-based results that can be useful for policy makers to introduce fiscal incentives to support the transition of Maltese restaurants to lower energy consumption and for some of them even to reach nearly-zero energy status.

7. References

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