Toward Sustainable Dynamic Consumer Response Structure for Residential Buildings in Egypt

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***Abstract*: Load variations in power systems are increasing due to more variable renewable energy and electrification. The variations can be partly dealt with through controlling flexible loads in buildings i.e. Demand Side Management (DSM)). This work evaluates how five different tariff schemes (Base Case, Energy Rate, Measured Power, Time of Use and Tiered Rate) affect the value of DSM in buildings totally powered by electricity (cooling, heating, lighting and appliances). The tariffs schemes were evaluated to investigate incentives provided to the consumer for increased energy efficiency and enhance peak load shaving through DSM. Tariffs' evaluation based on simulation for a single-family house in Egypt, 45 cases were conducted considering different parameters (class of consumption, location, type of tariff). The simulation and algorithmic results showed that the suggested tariff schemes offering remuneration through DSM enable lower bills for consumers beside attain peak load shaving then increase energy efficiency.**

***Keywords*: Energy, Energy efficiency, Energy tariffs, demand side management, Energy consumption in Egypt.**

I. INTRODUCTION

The primary aim of load shifting (or peak clipping) is to lower the peak demand of the electricity system as a whole or for key parts of the network. Thereby to reduce the need for investment in generation and transmission capacity and to lower electricity supply costs. The pricing mechanisms and contractual frameworks examined in this paper include conventional tariff (Base case) versus four new suggested tariffs named: 1) Energy rate, 2) Time of use (TOU) as well as 3) Measured Power and 4) Tiered Rate. Egyptian Electricity Holding Company (EEHC) objective is to remove 95-99% of green- house gas emissions in the power sector by 2030; which will require large scale integration of various renewable energy systems. This will affect future power grid investments and the value of flexible resources in the power sector, DSM is one of the flexible resources categories [1].

The electricity bill consists of three parts: subsidy, energy cost and taxes. The energy part usually makes up the highest share, and its billing process regulated in Egypt by EEHC. Many respondents point out that, the tariff schemes have not been researched enough [2]. Hence, there is a need to know what kind of impact the suggested tariffs will have.

This research aim to analyze and predicts how household customers in Egypt are affected by practicing different tariff schemes, and how they can reduce their electricity bill costs through DSM then increase energy efficiency. The load profiles are generated using the simulation software Design Builder based on a reference house in Egypt that satisfies the requirements of the most recent Egyptian building code.

II. BACKGROUND

International research has been done on how buildings can play an active role in the power system through DSM and reaction to price signals [3]. Periods and infrequent high peak prices (critical peak pricing) are more effective at reducing peaks than static penalty hours (time-of-use pricing, TOU) [3].

A model maximizing load factor and minimizing energy costs through DSM measures have been developed [4]. The results show that load shifting can both increase the load factor on the grid and save costs for consumers [4]. However, the analysis does not consider different pricing schemes.

Another research studied the impact of different grid tariffs on three different households is investigated [5]. The study finds that peak demands are reduced with power-based grid tariff schemes, and that a tariff scheme based on a penalty charge when load exceeds a subscription limit provides most robust peak shaving. They also find that a big variation in spot price of electricity can reduce the incentive to shave peaks due to arbitrage possibilities [5].

Also, in another study twelve net purchase and sale tariff schemes were investigated, as well as their effect on micro-grids [6]. It was found that fully volumetric billing (based only on price per kWh) can induce high load peaks and encourages customers to minimize their grid interaction. They also found that power-based tariff schemes combined with fixed charges are favorable to reduce peak load from micro grids, and they suggest negotiation of such rates since customers contribute with different load and generation profiles [6].

III. METHODOLOGY

Nine residential buildings were simulated in three different and dominant climatic zones in Egypt defined in EREC [7]: Alexandria, Cairo and Aswan, which represent moderate, hot semi-arid and hot arid zones as figure (1) describes. This study investigates 45 cases of different flat consumption-weighted design parameters (A, B and C) for each location (Cairo, Alex and Aswan). The test groups were compared in respect to the 4 new suggested tariffs, in addition to the current tariff as well.

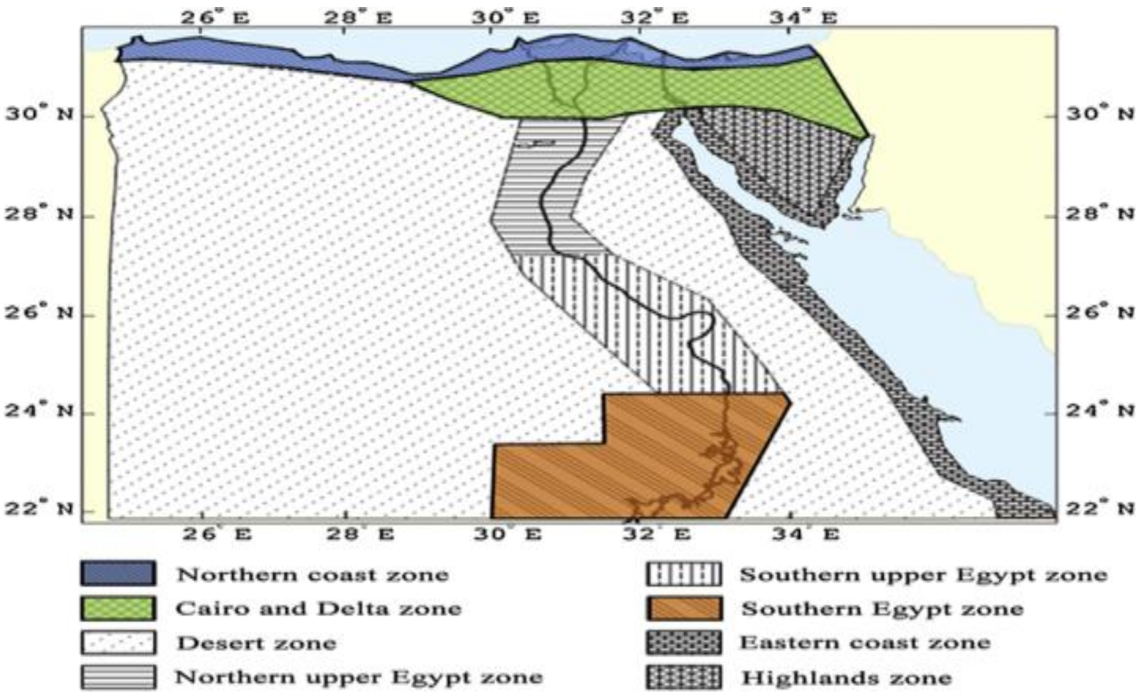


Figure 1: Egypt's climatic zones classification map according to EREC [8]

Simulations were conducted via dynamic building simulation tool Design Builder (DB), for averaged annual simulation for each flat as well as the cost of this consumption for the year 2020.

A new algorithm was developed and implemented in Microsoft Excel. The algorithm works as a tool to investigate the effectiveness of different grid tariff schemes to trigger building installations of energy efficient appliances and control systems, as well as applying load shifting within the building.

The algorithm proceeds the energy demand of the building and the outdoor temperature at the location as inputs from DB. Excel post processes the calculation of total demand, cost for all tariffs, and amount of daily consumption shifted and amount of savings per kWh.

The aforementioned work associated to three different collective energy consumption classes (A, B and C) as Shown in tables (1, 2, and 3). was elicit related to the recommendation of A field survey was conducted for estimating the electricity consumption patterns in five governorates namely: Cairo, Giza, Alexandria, Ismailia, and Menia, which included designing a questionnaire and collecting data on energy consumption patterns. DRTPC designed the questionnaire via the data collection team from the Information and Decision Support Center (IDSC) of the Cabinet of Ministers according to the related laws, and all data collection activities done by IDSC [8].

A systematic random sample of 1000 households was collected from each of the five governorates under study. Data analysis was performed by DRTPC expert team, who also designed the data analysis model and performed the statistical analysis using both Microsoft Excel as well as other statistical packages. The collected data also included details about the appliance capacity and/or power, age, frequency and duration of use, etc. The data thus helped to estimate the monthly energy consumption of each of the 5000 households.

Where, yellow line refers to the appliances with the highest saturation level and Relevance energy consumption Weight,

Meanwhile Red line refers to the time with at most historical peak load and correlated maximum energy demand.

1. Class (A) represents monthly power demand interval <5 kw/month, as shown in table (1).
2. Class (B) represent monthly power demand interval 5< B<10 KW/month, as shown in table (2).
3. Class (C) represent monthly power demand interval C > 10 KW/month, as shown in table (3).

3.1 Class (A) represents monthly power demand interval <5 kw/month, as shown in table (1).

Table 1: Appliances saturation level and consumption analysis for Class A

					Time & Duration				Energy				Operating Duration	Energy Consumption /Day	Day Count	Total Energy	Relevance Weight
	Appliances	Power	Quantity	Total	6:00 - 12:00	12:00 - 17:00	17:00 - 22:00	22:00 - 6:00	6:00 - 12:00	12:00 - 17:00	17:00 - 22:00	22:00 - 6:00					
		(Watt)		(Watt)	6 hrs	5 hrs	5 hrs	8 hrs	6 hrs	5 hrs	5 hrs	8 hrs	(hrs)	(KW hr)	30	(KWhr)	
1	Lightning (2*40W)	80	3	240	0	0	5	5	0	0	1.2	1.2	10	2	30	72	33.8%
2	Television	110	1	110	2	1	5	2	0.2	0.1	0.6	0.2	10	1	30	33	15.5%
3	Refrigerator	125	1	125	3	3	3	4	0.4	0.4	0.4	0.5	13	2	30	49	22.9%
4	Computer	40	0	0	0	0	5	2	0	0	0	0	7	0	30	0	0.0%
5	Deep Freezer	270	0	0	2	2	2	3	0	0	0	0	9	0	30	0	0.0%
6	Electric Heater	1200	0	0	3	1	2	2	0	0	0	0	8	0	8	0	0.0%
7	Manual Washing Machine	200	1	200	0	0	2	0	0	0	0.4	0	2	0	8	3	1.5%
8	Automatic Washing Machine	425	0	0	0	1	2	0	0	0	0	0	3	0	8	0	0.0%
9	Electric Oven	2300	0	0	0	0	2	1	0	0	0	0	3	0	4	0	0.0%
10	Fan	100	1	100	1	3	5	2	0.1	0.3	0.5	0.2	11	1	20	22	10.3%
11	Vacuum Cleaner	1200	0	0	0	1	1	0	0	0	0	0	2	0	8	0	0.0%
12	Iron	1100	1	1100	1	0	1	0	1.1	0	1.1	0	2	2	8	18	8.3%
13	Dryer	3400	0	0	0	0	2	1	0	0	0	0	3	0	8	0	0.0%
14	Microwave	1500	0	0	1	1	1	0	0	0	0	0	3	0	20	0	0.0%
15	Air Conditioner	1000	0	0	0	3	5	5	0	0	0	0	13	0	15	0	0.0%
16	Suction	200	0	0	2	2	2	0	0	0	0	0	6	0	30	0	0.0%
17	Dish Washer	1800	0	0	0	1	0	0	0	0	0	0	1	0	4	0	0.0%
18	Ceiling Fan	75	1	75	2	2	5	2	0.2	0.2	0.4	0.2	11	1	20	17	7.7%
	Total			1950	17	21	50	29	1.9	0.9	4.5	2.3	117	10		213	

3.2 Class (B) represent monthly power demand interval 5< B<10 KW/month, as shown in table (2).

Table 2: Appliances saturation level and consumption analysis for Class B

					Time & Duration				Energy								
	Appliances	Power	Quantity	Total	6:00 - 12:00	12:00 - 17:00	17:00 - 22:00	22:00 - 6:00	6:00 - 12:00	12:00 - 17:00	17:00 - 22:00	22:00 - 6:00	Operating Duration	Energy Consumption/ Day	Day Count	Total Energy	Relevance Weight
		(Watt)		(Watt)	6 hrs	5 hrs	5 hrs	8 hrs	6 hrs	5 hrs	5 hrs	8 hrs	(hrs)	(KWhr)	30	(KWhr)	
1	Lightning (2*40W)	80	5	400	0	0	5	5	0	0	2	2	10	4	30	120	17.9%
2	Television	110	1	110	2	1	5	2	0.2	0.1	0.6	0.2	10	1	30	33	4.9%
3	Refrigerator	125	1	125	3	3	3	4	0.4	0.4	0.4	0.5	13	2	30	49	7.3%
4	Computer	40	1	40	0	0	5	2	0	0	0.2	0.1	7	0	30	8	1.3%
5	Deep Freezer	270	1	270	2	2	2	3	0.5	0.5	0.5	0.8	9	2	30	73	10.9%
6	Electric Heater	1200	1	1200	3	1	2	2	3.6	1.2	2.4	2.4	8	10	8	77	11.5%
7	Manual Washing Machine	200	1	200	0	0	2	0	0	0	0.4	0	2	0	8	3	0.5%
8	Automatic Washing Machine	425	0	0	0	1	2	0	0	0	0	0	3	0	8	0	0.0%
9	Electric Oven	2300	0	0	0	0	2	1	0	0	0	0	3	0	4	0	0.0%
10	Fan	100	1	100	1	3	5	2	0.1	0.3	0.5	0.2	11	1	20	22	3.3%
11	Vacuum Cleaner	1200	1	1200	0	1	1	0	0	1.2	1.2	0	2	2	8	19	2.9%
12	Iron	1100	1	1100	1	0	1	0	1.1	0	1.1	0	2	2	8	18	2.6%
13	Dryer	3400	0	0	0	0	2	1	0	0	0	0	3	0	8	0	0.0%
14	Microwave	1500	0	0	1	1	1	0	0	0	0	0	3	0	20	0	0.0%
15	Air Conditioner	1000	1	1000	0	3	5	5	0	3	5	5	13	13	15	195	29.1%
16	Suction	200	1	200	2	2	2	0	0.4	0.4	0.4	0	6	1	30	36	5.4%
17	Dish Washer	1800	0	0	0	1	0	0	0	0	0	0	1	0	4	0	0.0%
18	Ceiling Fan	75	1	75	2	2	5	2	0.2	0.2	0.4	0.2	11	1	20	17	2.5%
	Total			6020	17	21	50	29	6.5	7.3	15.1	11.4	117	40		669	

3.3 Class (C) represent monthly power demand interval C > 10 KW/month, as shown in table (3).

Table 3: Appliances saturation level and consumption analysis for Class C

					Time & Duration				Energy								
	Appliances	Power	Quantity	Total	6:00 - 12:00	12:00 - 17:00	17:00 - 22:00	22:00 - 6:00	6:00 - 12:00	12:00 - 17:00	17:00 - 22:00	22:00 - 6:00	Operating Duration	Energy Consumption /Day	Day Count	Total Energy	Relevance Weight
		(Watt)		(Watt)	6 hrs	5 hrs	5 hrs	8 hrs	6 hrs	5 hrs	5 hrs	8 hrs	(hrs)	(KWhr)	30	(KWhr)	
1	Lightning (2*40W)	80	8	640	0	0	5	5	0	0	3.2	3.2	10	6	30	192	11.4%
2	Television	110	1	110	2	1	5	2	0.2	0.1	0.6	0.2	10	1	30	33	2.0%
3	Refrigerator	125	1	125	3	3	3	4	0.4	0.4	0.4	0.5	13	2	30	49	2.9%
4	Computer	40	1	40	0	0	5	2	0	0	0.2	0.1	7	0	30	8	0.5%
5	Deep Freezer	270	1	270	2	2	2	3	0.5	0.5	0.5	0.8	9	2	30	73	4.3%
6	Electric Heater	1200	2	2400	3	1	2	2	7.2	2.4	4.8	4.8	8	19	20	384	22.8%
7	Manual Washing Machine	200	1	200	0	0	2	0	0	0	0.4	0	2	0	10	4	0.2%
8	Automatic Washing Machine	425	1	425	0	1	2	0	0	0.4	0.9	0	3	1	15	19	1.1%
9	Electric Oven	2300	1	2300	0	0	2	1	0	0	4.6	2.3	3	7	4	28	1.6%
10	Fan	100	2	200	1	3	5	2	0.2	0.6	1	0.4	11	2	20	44	2.6%
11	Vacuum Cleaner	1200	1	1200	0	1	1	0	0	1.2	1.2	0	2	2	8	19	1.1%
12	Iron	1100	1	1100	1	0	1	0	1.1	0	1.1	0	2	2	8	18	1.0%
13	Dryer	3400	1	3400	0	0	2	1	0	0	6.8	3.4	3	10	8	82	4.9%
14	Microwave	1500	1	1500	1	1	1	1	1.5	1.5	1.5	1.5	4	6	20	120	7.1%
15	Air Conditioner	1000	2	2000	0	3	5	4	0	6	10	8	12	24	20	480	28.6%
16	Suction	200	1	200	2	2	2	1	0.4	0.4	0.4	0.2	7	1	30	42	2.5%
17	Dish Washer	1800	1	1800	0	1	1	0	0	1.8	1.8	0	2	4	15	54	3.2%
18	Ceiling Fan	75	2	150	2	2	5	2	0.3	0.3	0.8	0.3	11	2	20	33	2.0%
	Total			18060	17	21	51	30	11.8	15.7	40.1	25.7	119	93		1681	

IV. DESCRIPTION OF TARIFF SCHEMES

4.1 Base case

The current tariff scheme in Egypt is an energy-based tariff. The total energy consumption and cost/HH/month was calculated using the electricity tariff derived by the Egyptian Ministry of Electricity and Energy for the residential sector. The model used for calculating current tariff, consist of 7 stages for different consumption class shown in table 4

Table 4: The value of electricity consumption and the government subsidies for different levels of consumption [8]

Watt		LE
0	50	0.3
51	100	0.4
0	200	0.5
201	350	0.82
351	650	1
651	1000	1.4
0	<1000	1.45

4.2 Energy rate (ER)

It consists of two parts. One part is a fixed monthly cost equal for all customers in the same class, and the other is an energy cost based on the individual customer's energy consumption (see table 5). A draw-back of the ER scheme is that there is no penalty cost related to high loads (see figure 2).

Table 5: Division of cost for the energy rate tariff

ENERGY RATE TARIFF		
Energy class	**Fixed cost (EGP/Year)**	**Energy cost (EGP/kwh)**
Class A	72	0.5
Class B	180	1
Class C	300	1.4

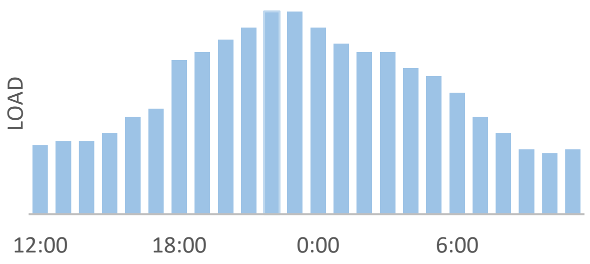


Figure 2: Illustration of the energy-based (ER) tariff scheme

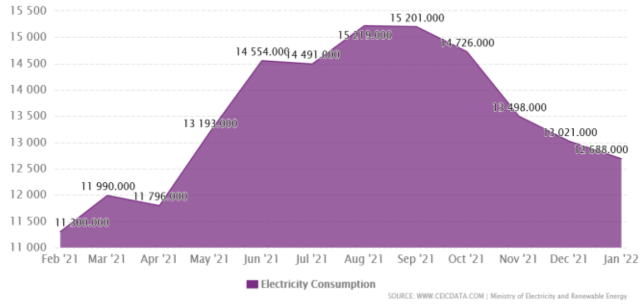
4.3 Time-of-use (TOU)

Some hours have higher energy price than others (see table 6), based on the data provided by EEHC. The hours with high pricing are the hours which historically have led to high loads. In Egypt, the TOU scheme is suggested to have a higher price during summer (April to Oct), because higher consumption occurs in summer as shown in figure (3), especially during night (18:00 – 6:00) assigned as peak hours, as these have been the critical hours for stress on the grid as shown in figure (4).

A drawback of this model is that the income will rely on consumption, which depends on the outside temperature that varies largely from year to year.

Table 6: Illustration of the time-of-use (TOU) tariff scheme

TIME OF USE TARIFF				
Energy consumption class	**Fixed cost (EGP/Year)**	**Energy cost summer night (EGP/kWh)**	**Energy cost winter (EGP/kWh)**	**Energy cost summer night (EGP/kwh)**
Class A	72	0.3	0.5	1.2
Class B	180	0.5	0.5	1.2
Class C	300	1	1.4	1.8



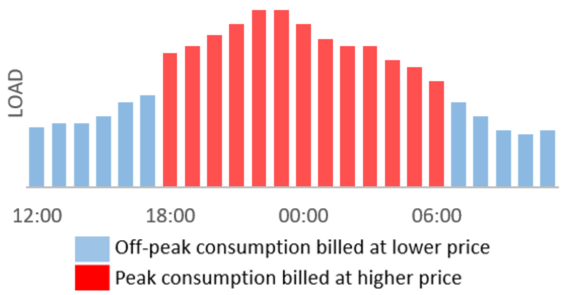


Figure 3: Egypt's electricity monthly consumption, 2021 **Figure 4: Illustration of the time-of-use (ToU) tariff scheme**

4.4 The Measured power (MP)

It consists of three parts: a fixed part, an energy part and a power part (see table 7). The power part is based on the highest load averaged over an hour (kWh/h) during the measuring period. Note that there is only one hour during the measuring period making up the costs, and the hour with the highest load cannot be known in advance. We assume a measuring period of 24 hours, which means there is a new opportunity to save costs by shaving the highest load every day. Large industrial customers could subject to the MP scheme; however, the measuring period can be up to 12 months for industrial customers making it hard to react to. The cost for the energy part is based on the marginal cost rate.

Table 7: Division of cost for the measured tariff

MEASURED POWER RATE TARIFF			
Energy class	**Fixed cost (EGP/Year)**	**Energy cost (EGP/kwh)**	**Measured power cost (Highest peak daily)**
Class A	72	0.3	0.5
Class B	180	0.5	0.5
Class C	300	1	0.5

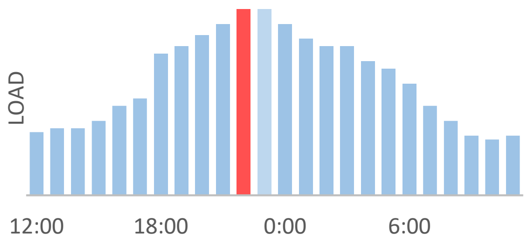


Figure 5: Illustration of the measured power (MP) tariff scheme

Drawbacks of this model are that customers may be charged for high loads at times when the grid has good capacity. The longer the measuring period, the smaller is the probability for coincidence between peak demand for the customer and the grid. Moreover, if a peak has already occurred in the measuring period, the customer can continue to induce high loads within the size of the penalty peak without extra charge.

4.5 The Tiered rate (TR)

The customer pays an overuse cost if their load is above a set limit. This tariff consists of four parts: a fixed part, a subscription part, an energy part and an overuse part (see table 8). As the overuse part of the tariff is accounting for all hours and loads that are above the subscription limit, one hour of overuse will not lessen the customer's economic incentive to avoid overuse at later hours. (TR) scheme assume 10 choices of limits generating demand profiles.

Table 8: Division of cost for a tiered rate tariff

TIERED RATETARIFF				
Energy consumption class	**Fixed cost (EGP/Year)**	**Energy cost (EGP/kwh)**	**Subscription cost (EGP/kWh/year)**	**Overuse cost (EGP/kWh/h)**
Class A	72	0.3	396	1
Class B	180	0.5	660	1
Class C	300	1	1320	1

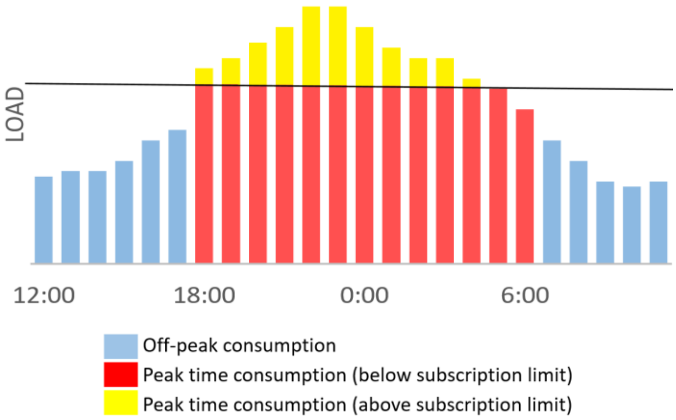


Figure 6: Illustration of the tiered rate (TR) tariff scheme

V. SIMULATION TOOL

5.1 Dynamic simulation models are increasingly and frequently used; these models represent physical behavior at various levels of detail [9]. In this research Design-Builder (DB) was selected, as it has worldwide accreditation and supports numerous regulatory and voluntary standards [10].

5.2 Case study models' description

Nine single residential buildings were used in the simulations. The simulated buildings placed in three different locations in Egypt (Cairo, Alexandria and Aswan), conducting three different energy consumption classes (A, B and C). Every building consists of 6 floors; each floor has four residential flats which represent the case study with an approximate area of 86 m2. The average number of occupants per flat is four persons. The building floor model is shown in figure 7 and the typical plan for a flat in the building is shown in figure 8.

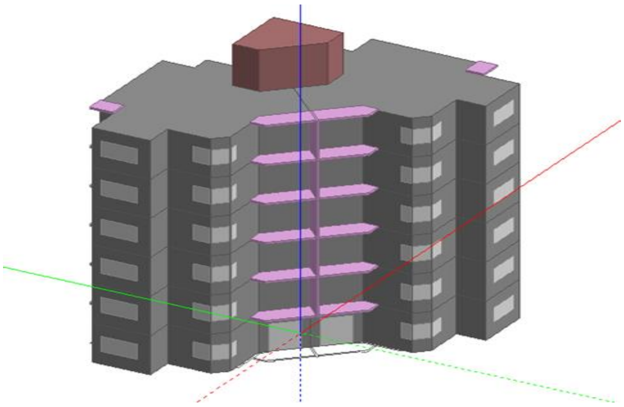


Figure 7: Simulated building model

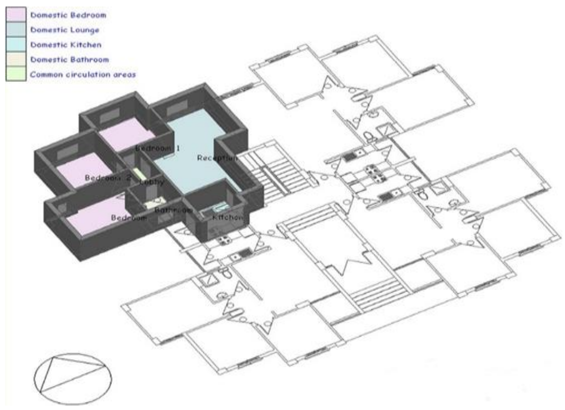


Figure 8 (a): Typical plan for a flat in the building

VI. RESULTS

The following section illustrates and compares the annual cost related to use the five tariff models, for three different climatic zones Cairo, Alex and Aswan respectively in the year 2020 with respect to classes (A), (B) and (C). Where (EGP/HH/year) represent the energy cost in Egyptian pound/household/year, and total EGP/HH/Year represent the total energy cost included household consumption cost in addition to governmental subsidy value, as well as absolute governmental subsidy value; in which different tariffs are compared in the same plot.

6.1 Results of Class A .

Figure 8 illustrates and compares the load demand for average yearly consumption for the case study using base case tariff in Cairo, Alex and Aswan related to class A. The graph reveals that the cases with Cairo and Alex have a significantly higher energy demand than the ones in Aswan.

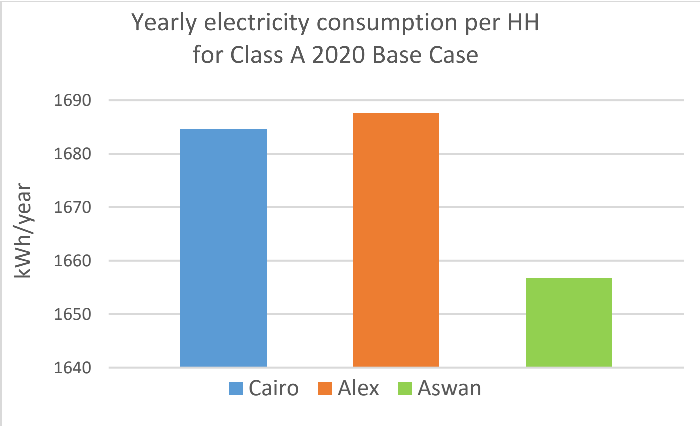
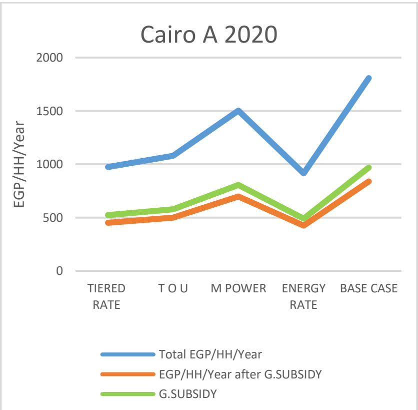
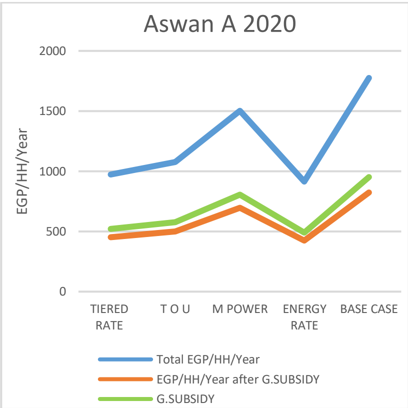


Figure 8 (b): Class A load demand

The results show that Cairo, Alex and Aswan cases of Class A have nearly the same trend. Figures (9), (10) and (11) reveal that the cost with the Energy rate tariff is the one with the lowest cost, and measured power tariff clearly is the highest cost amongst the four new tariffs models. The cost of the currently used Base case is obviously large compared to the other four suggested models. Time of use gives higher cost than tiered rate and energy rate, while Tiered rate has a slightly higher cost than Energy rate. Subsidy value is directly proportional with tariffs cost.





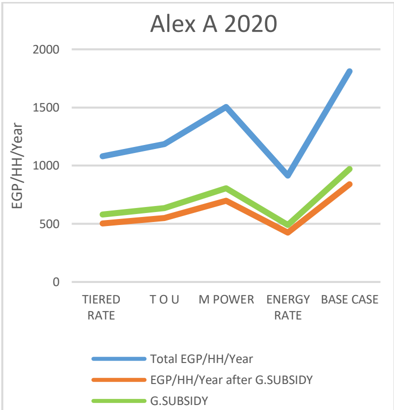


Figure 9: Cairo 2020 class (A) cost for the five tariff **Figure 10: Alex 2020 class (A) cost for the five tariff models** **Figure 11: Aswan 2020 class (A) cost for the five tariff models**

6.2 Results of Class B.

The plot in figure (12) illustrates and compares load demand for average yearly consumption for base cases selected in Cairo, Alex and Aswan related to class B. The graph reveals that the case of Alex has the lowest demand and case of Aswan has a significantly higher energy demand than Alex and Cairo.

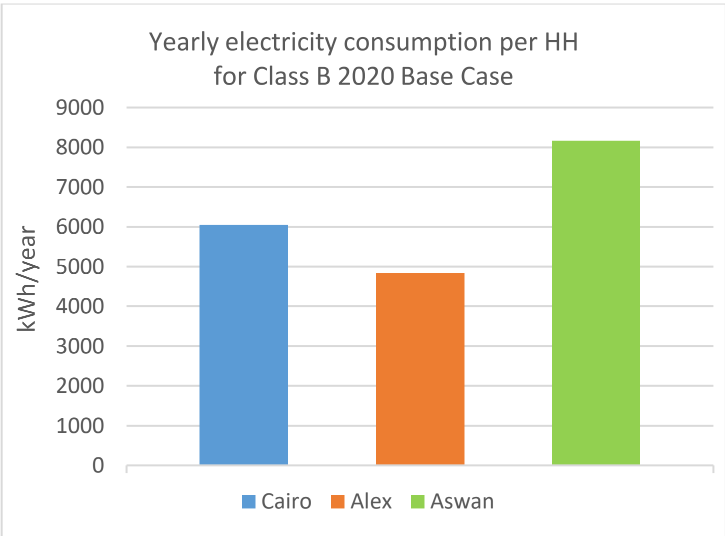


Figure 9: Class B load demand

The results show that Cairo, Alex and Aswan the cases of Class B have the same trend. Figures (13), (14), and (15) reveal that the cost is highest with a Base case used today compared to the other four suggested models. Among the newly suggested tariffs, the cost with the energy rate tariff is the one with highest cost, and tiered rate tariff clearly has the lowest cost. Measured power gives higher cost than time of use. The highest subsidy value corresponded to the base case tariff, followed by energy rate amongst the four suggested tariffs.

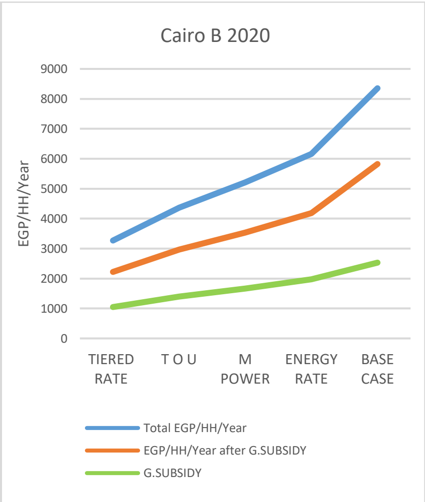


Figure 13: Cairo 2020 class (B) cost for the five tariff models

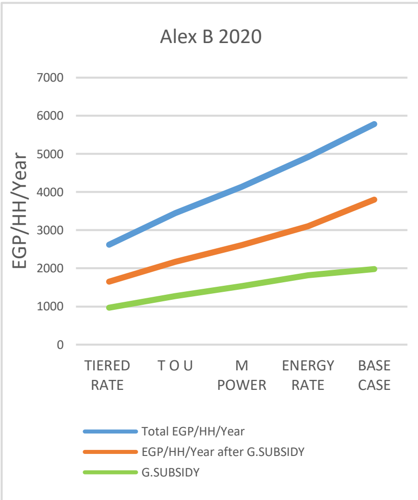


Figure 10: Alex 2020 class (B) cost for the five tariff models

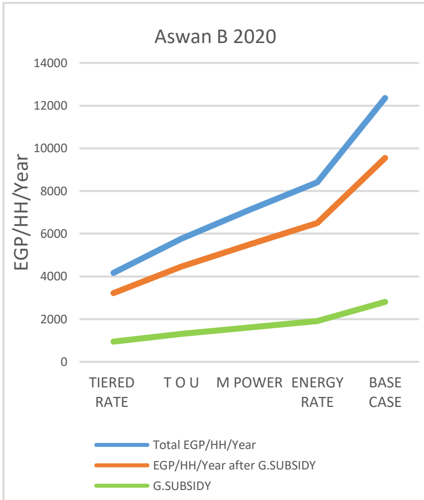


Figure 11: Aswan 2020 class (B) cost for the five tariff models

6.3 Results of Class C.

Figure 16 illustrates the different load demand for average yearly consumption for base cases selected in Cairo, Alex and Aswan related to class C. The graph reveals that the case of Aswan has a significantly higher energy demand than the ones with Cairo and Alex.

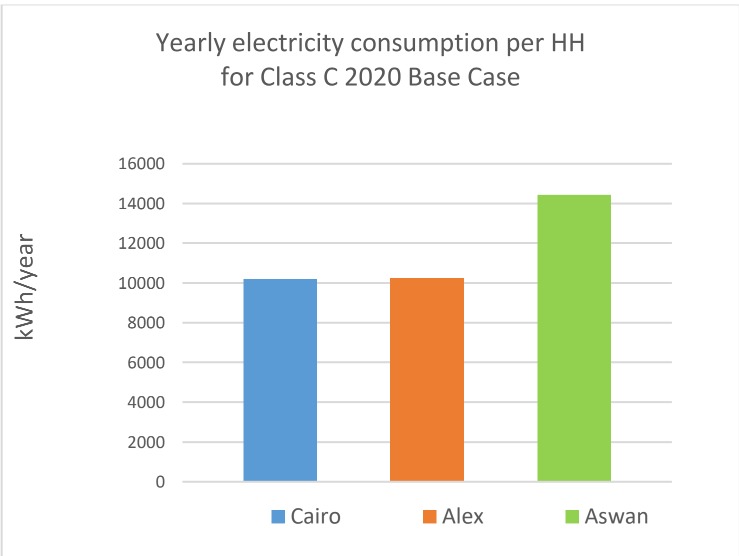


Figure 12: Class C load demand

The results show that Cairo, Alex cases of Class C have the same trend, but Aswan has different trend. Figures (17), and (18) reveal the cost with the Base case and the four suggested models are all close to some certainty. Cost with measured power rate tariff is the highest, and energy rate tariff has the lowest cost amongst the four new tariff models. Tiered rate gives higher cost than time of use. The highest subsidy value was with measured power and tiered rate amongst the four suggested tariffs, and the lowest value is associated with energy rate tariff.

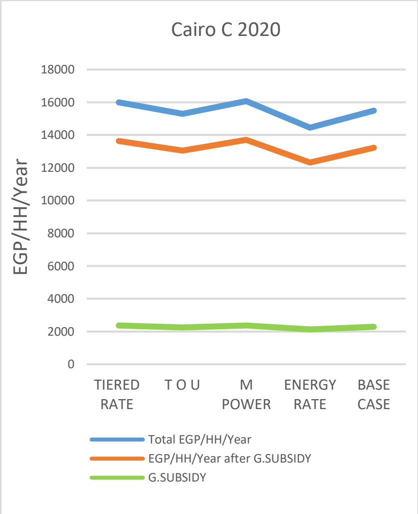


Figure 13: Cairo 2020 class (C) cost for the five tariff models

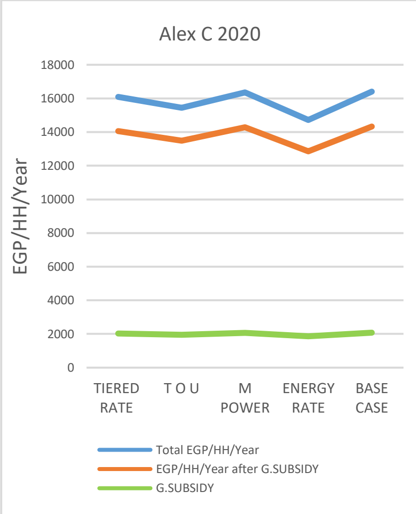


Figure 14: Alex 2020 class (C) cost for the five tariff models

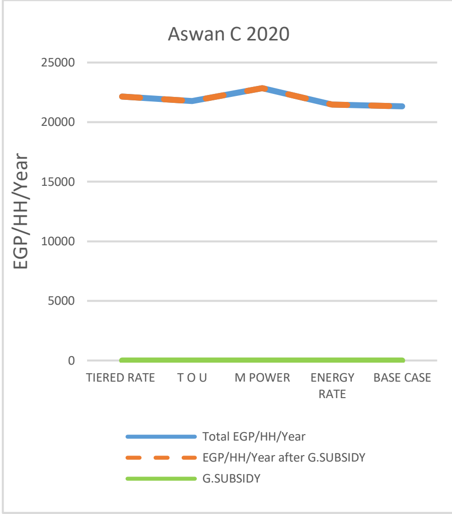


Figure 15: Aswan 2020 class (C) cost for the five tariff models

Figure 19 reveals that the cost of all the models is very close to some certainty, in which the base case has the lowest cost, and the cost with measured power rate tariff is the highest. Energy rate tariff has the lowest cost amongst the four new tariff models. Tiered rate gives slightly higher cost than time of use. There is no subsidy amongst the four suggested tariffs, since the average monthly consumption of households exceeds 1000 kWh.

VII. CONCLUSION

To be able to investigate and compare the tariffs (base case and suggested tariffs), a new algorithm had to be made, as no tool able to run the calculations was found. The algorithm had to be able to calculate the total annual cost for different building load profiles due to each five tariffs model, together with and without governmental subsidy correlated to enhance required load shift. The algorithm also needed to calculate the according amount of annual and daily load shift necessary to obtain the ideal cost reduction. Idealistic, it would be generic, so it could also be used in further work concerning energy rates and load shift in buildings.

The algorithm has been developed to investigate the EGP/HH/year and correlated subsidy cost for 45 different cases, due to combinations of 3 different parameters of building location and consumption class design. The cost of each case for EGP/HH/year with and without governmental subsidy, in an Egyptian context, has been investigated for the base case tariff and the four different suggested tariff models. However, there are still lots of information in the outputs that could be analyzed further, and used for further research. New cases can also be investigated with the algorithm.

The main conclusion from these case calculations is that an implementation of any of the suggested power tariffs will increase the grid rent payment for customers whom continue to use electricity with the typical consumption pattern of today. Amendment of consumer energy consumption behavior resulted in controlling load profile during peak hours, reduce the cost, but only with load shift are the models able to reach an annual cost lower than for the base case energy tariff. This indicates that all models will work as incentives to load shift and a change in consumption pattern.

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