Outside Cold Air Temperature Impact to Energy Consumption in Air Conditioning System Bangkok Metropolitan Area in 2019

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Abstract

Electrical consumption data from Metropolitan Electricity Authority (MEA) was collected and compared between normal warm weather in November, 2019 and cold weather in December, 2019 for seven days. Questionnaire asking target group as working people, elderly people and students and classified building type into office, single house, townhouse condominium or apartment with at least 100 samples each. Then, 10 personal interviews was focus group for each building type. It was found that air temperature in November 2019 was 23-33 degree Celsius while 18-28 degree Celsius in December (AccuWeather, 2020: TMD, 2019). In December 2019, the outside air temperature was in comfort zone during the daytime while in the night time it was below thermal comfort. It was found that nobody turned on air condition in the building both in the office during the daytime and in their residences during the night time. Calculating electrical cost at 4.22 baht per kilowatt-hour (MEA, 2020) the energy reduced roughly about 1,000 MW per hour which cost about 4,220,000 baht hourly, 101,280,000 baht a day, or 708.96 million baht a week. It equivalents to 1,000,000 ton of split-type air condition or 500,000 to of chilled water air condition system.

Keywords: Energy consumption, Cool weather, Cooling load, Metropolitan Electricity Authority (MEA), Enthalpy

Introduction

Business and residential sectors have majority electrical energy consumption in Bangkok area, about 69 percent of total consumption. Bangkok has lack of database as how many tons of air-conditioning installed and operated in Bangkok Metropolitan area. To calculate back during the cold weather compared with normal weather with required air-conditioning system, we would estimate actual requirement and Cooling Load demand. During December 2019, the air temperature had reduced rapidly for about 2 weeks. It was an opportunity to explore how people in Bangkok area behave. Moreover, it would be possible to gather residential building performance as the infiltration effect to users. Most houses, townhouse, and condominium in Thailand have a lot of air leakage construction joint detail since it has no need to design an air tight system. People will stay indoor most of the day almost 24 hours. Stay in their rooms during the night, stay in office building during the day, and stay in car, bus, and train during travelling. Therefore, to make comfort built environment for people is more important. To design energy efficient building, the air tight construction details are very important but it also needs the appropriate mechanical system to circulate indoor and outdoor fresh air. It requires extra operation cost which most residents in Thailand have more concerned.

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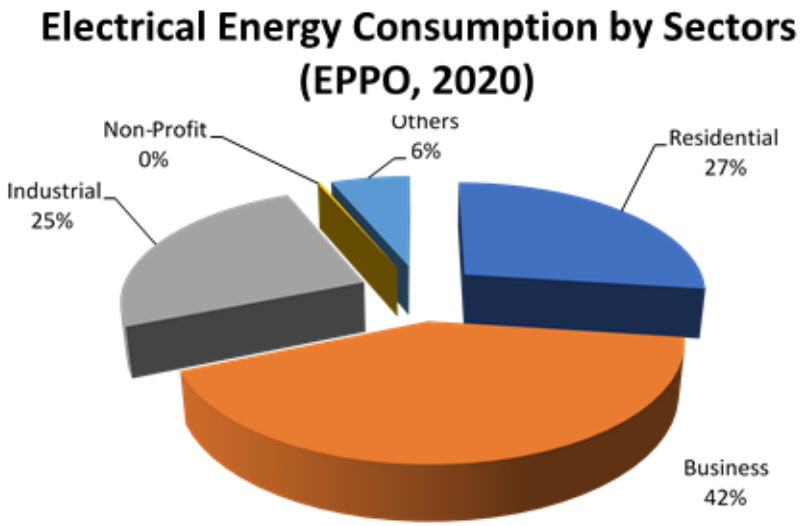


Figure 1. Electrical Energy Consumption by Sectors (EPPO, 2020).

Data from Energy Policy and Planning Office (EPPO, 2020), Ministry of Energy has shown that more than half of energy budget in urban area are office and residential buildings. If we promote energy conservation to those sectors, it can reduce a significant number of energy budgets. During daytime, people are at work places in their office buildings. Buildings have heat gain all day long. It is a reason that the energy consumption is almost double compared to residential buildings which operate during night time without solar radiation heat gain. Even energy conservation regulation has been enforced since 1992 but most architects still in a process of develop energy conversion design experiences. From then, it is about 25 years. Small number of architects can design energy conservation buildings. Building life is another influence factor that costs energy consumption until the end of their structure which is about 30 years or more. Then, the portion of energy conservation buildings are still very less in urban energy budget consumption.

Installing air condition systems in residential buildings are mostly estimated by local contractors which using traditional cooling load calculation as 1,000 to 1,200 Btu per square meter. Normally, they would install an oversize air conditioning system for the only reason that they would not be blamed if it is not cool fast enough. This situation will effect high energy consumption and also cause health problem since high humidity and cool indoor air temperature inside a room. Fungus and bacteria would have good environmental condition to grow and enjoy propagation.

Methodology

This research collected electrical consumption data from Metropolitan Electricity Authority (MEA) by comparing the amount of electrical consumption between normal warm weather and cold weather in the same working day (Monday through Friday) and holiday for seven days. Then, researcher conducted Google questionnaire asking target group as working people, elderly people and students. Questionnaire classified building type into office, single house, townhouse condominium or apartment with at least 100 samples each. Researcher conducted 10 personal interviews as focus group for each building type.

Results

Using questionnaire (December 4th-10th, 2019) asking working people, elderly people, and students, It is found that not even single person turned on air condition in the building both in the office during the daytime and in their residences during the night time. During a week of December 4th to 10th, people never turned on air conditioning system because the weather is very cold more than their comforts. Even during the night time, when they sleep, they closed all windows

and doors but they still put the blanket on and they still feel very very cool. This happened because construction in Thailand has a lot of infiltration details. Those infiltrations occurred since they need natural ventilation which is normally practice in hot and humid climate. Therefore, when the weather is very cold, cold air outside building can easily leaks into rooms and indoor spaces.

Comparison on Wednesday November 6th and December 4th, 2019 in Figure 2 (a) showed the parallel curves during working day. Graph profile has lowest consumption on 4:00 -5:00 am because of low ambient outside air temperature and all inside materials has the same temperature as inside air temperature. Then, it raised from 6:00 am because of people begin to weak up and use all appliances until peak load at 11:00 am and 14:00 pm. During office hours, water cool chiller would be turned on around 7:00 am (about 2 hours before start working) till 4:30 pm (half an hour before the end of working hour). During lunch time, most split type air condition system would be turned off according to national energy conservation policy. Then, electrical consumption dropped between noon to 1:00 pm. Then, after working hour, people travel back to their residences turning on their split type air conditioning systems. Energy demand is still high constantly. Graphs still remained flat until 11:00 pm because of most split type air condition systems cool down indoor air, room elements (wall, ceiling, and floor), and all furniture. When all room components have their temperature close to indoor air temperature set point, cooling load has reduced. Therefore, consumption graphs dropped down until people weak up and sun rise again in the next day.

Comparison on Thursday November 7th and December 5th, 2019 (the national holiday) in Figure 2 (b) showed flat curve of December 5th and normal consumption curve on November 7th which is working day. Graph profile has shown the different electrical consumption between working and holiday demand. During night time and after working hours, the different between working day and holiday is about 1,000-2,000 MW. From 6:00 pm – 9:00 pm electrical consumption slightly increased since Thai people celebrating King Rama 9 Birthday (December 5th). Then, energy demand reduced. The different during working hours of working day and holiday started from 8:00 am till 5:00 pm which was about 3,000 MW. It can be analyzed that the amount of energy consumption from air condition system in office building has a lot more demand than residential systems. If we assumed than office use split type air conditioning system, it would be 250 million ton of split type or about 125 million ton of chill water air conditioning system.

Comparison on Friday November 8th and December 6th, 2019 in Figure 3 (a) showed the slightly parallel curves during working day. Graph profile in December 6th has lowest consumption on 0:00 -5:00 am because people began to turn off all resident air condition systems according to outside cool air temperature. It would take about 2 days for building materials cool down from cold weather since most building envelops are heavy with high mass and high heat capacity property such as masonry and reinforced concrete. Graph profiles during working hours are still the same shape with about 1,500 MW different. This can be analyzed that low outside ambient air temperature increased air conditioning efficiency and reduce all cooling load from hot air infiltration. Outside cool air has low enthalpy with low relative humidity (low grain of moisture also).

Comparison on Saturday November 9th and December 7th, 2019 in Figure 3 (b) showed the smoothly parallel curves during holiday. Graph profile illustrated the outside low enthalpy effected air conditioning load. Most resident air conditioning systems have been turned on according to city people behaviors. It rose up during 8:00 am till 5:00 pm and slightly consumed until midnight because of tomorrow is still another holiday. They do not have to hurry weak up to work. The electrical consumption has about 1,000 MW different.

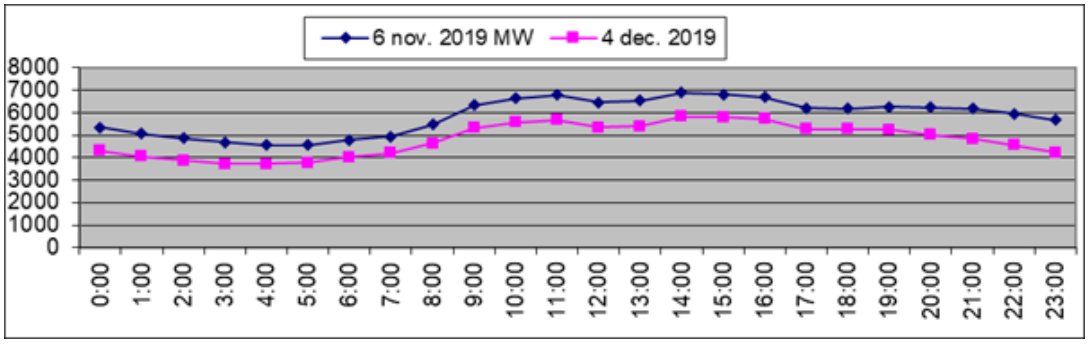
Comparison on Sunday November 10th and December 8th, 2019 in Figure 3 (c) also showed the smoothly parallel curves during holiday. Compared with Saturday in November, the peak load was about 5,000 MW while it was 4,000 MW on Sunday. It is 1,000 MW lower because of people stay home and relaxes. In December, peak load on Saturday was about 5,000 MW

while it was 4,000 MW on Sunday. It is also 1,000 MW different. People behavior remains the same between Saturday and Sunday activities. It can be analyzed that outside cool weather and low enthalpy reduce energy budget and cooling load at the same time.

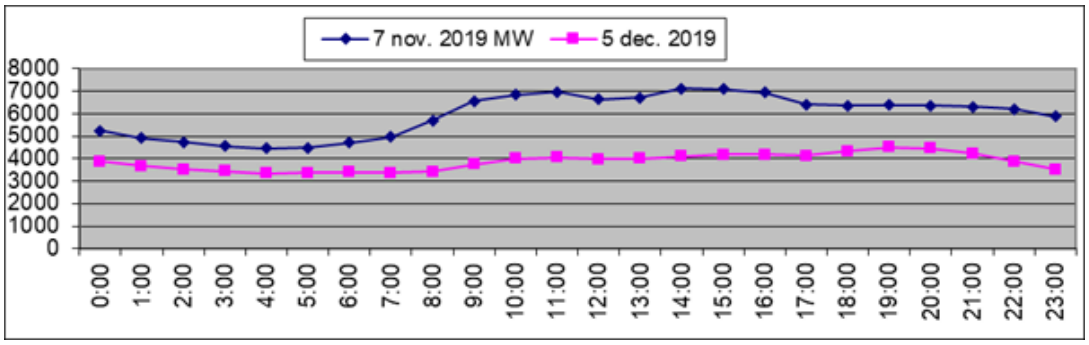
Comparison on Monday November 11th and December 9th, 2019 in Figure 3 (d) showed the similar curves during working day. It has closed to 7,000 MW peak load in November and 5,500 MW in December about 1,500 MW different. After office hours, the different was about 1,000 MW. In December, energy demand had rapidly reduced from 9:00 pm till 5:00 am since all people turned off all resident air conditioning systems.

Comparison on Tuesday November 12th and December 10th, 2019 in Figure 3 (e) also showed the similar curves during working day in November while it has lower curve in December. The different consumption during working hours was about 1,500 MW while it was 1,000 MW after working hours. All graphs are similar to Monday.

Electrical consumption from Metropolitan Electricity Authority (MEA, 2020) illustrated that 1,000 MW per hour roughly in average has been reduced during December 4th to 10th, 2019, compared to the same day in November 2019. December 4th, 6th, 9th, and 10th were working days. The electrical consumption was about 1,000 MW different in every hour (Figure 2 (a), Figure 3 (a), (d), (e)). December 5th, 7th and 8th were holidays. It was about 4,000 MW consumption average (Figure 2 (b), Figure 3 (b), (c)). Electrical consumption different was remain similar to those working days which is 1,000 MW hourly. Peak load ranged from 9:00 am till 9:00 pm which was about 5,000 MW consumption in working days. Then, peak load during day time in holi-

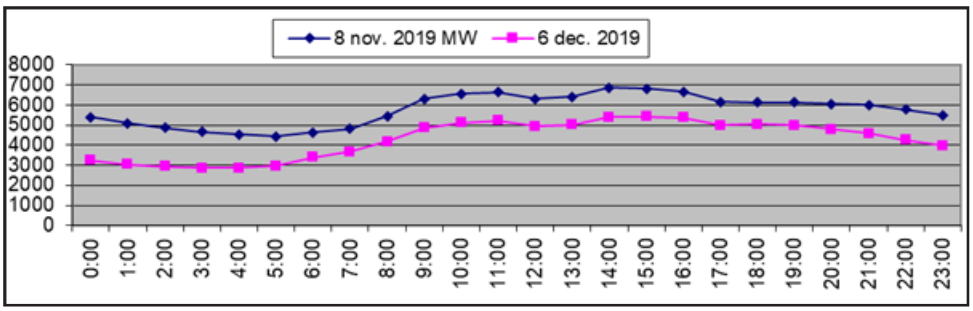


(a) Wednesday

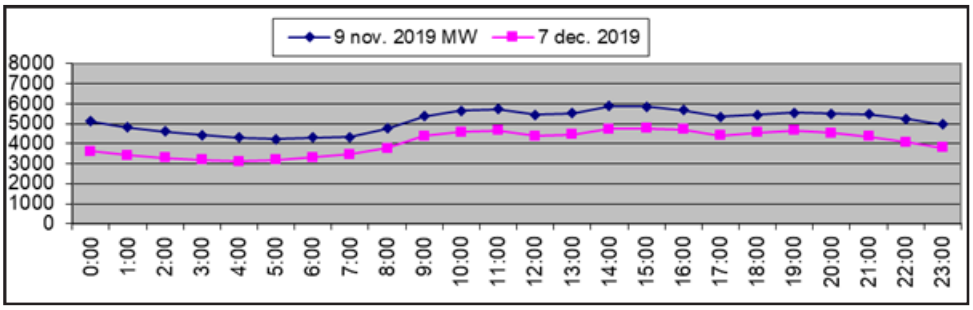


(b) Thursday

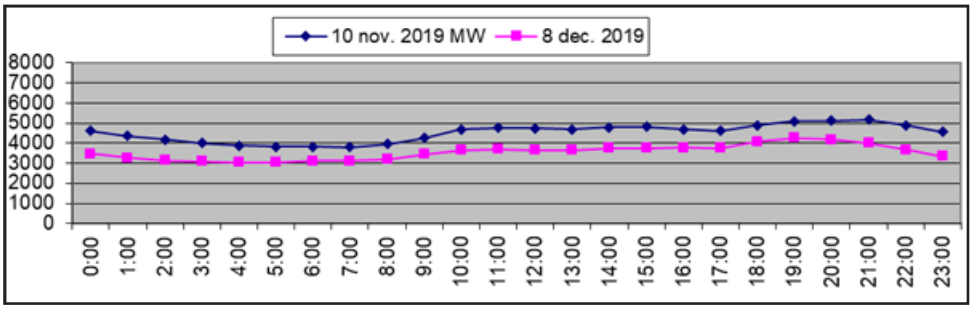
Figure 2. Electrical consumption in Bangkok area comparison between November 6th-7th (warm climate) and December 4th-5th (cold climate), 2019. During working days from Wednesday to Thursday have shown in (a) and (b).



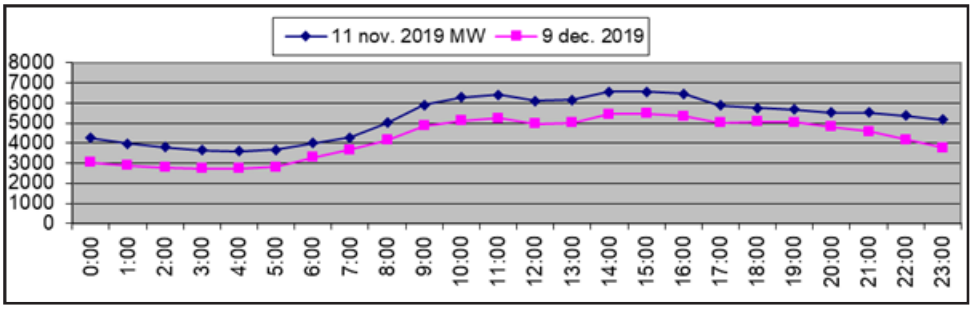
(a) Friday



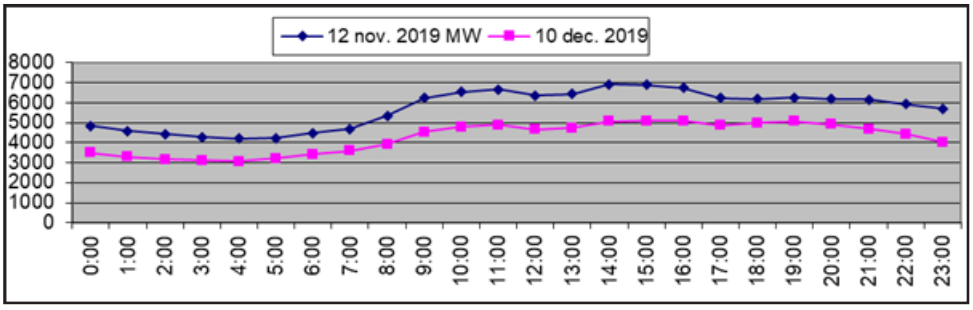
(b) Saturday



(c) Sunday



(d) Monday



(e) Tuesday

Figure 3. Electrical consumption in Bangkok area comparison between November 8th-12th (warm climate) and December 6th-10th (cold climate), 2019. During working days from Friday to Tuesday have shown in (a), (d), and (e) respectively, while Saturday and Sunday is (b) and (c).

Table 1 Electrical Consumption Summary During Cool Weather in December 2019 Compared to the Same Day with Normal Ambient Air Temperature in November 2019.

	2019 (2562)	MW different (hourly average)	Min. air temp.	Max. air temp.
Wednesday	6 nov. & 4 dec.	1,300	26 & 19 C	33 & 28 C
Thursday	7 nov. & 5 dec.	2,000	26 & 18 C	33 & 27 C
Friday	8 nov. & 6 dec.	2,000	25 & 18 C	32 & 28 C
Saturday	9 nov. & 7 dec.	1,300	24 & 17 C	31 & 27 C
Sunday	10 nov. & 8 dec.	1,000	20 & 19 C	31 & 27 C
Monday	11 nov. & 9 dec.	1,000	23 & 18 C	32 & 28 C
Tuesday	12 nov. & 10 dec.	1,000	23 & 18 C	33 & 29 C

days about 4,000 MW.

Conclusion and discussion

Air temperature in Bangkok in November 2019 was highest 31-33 degree Celsius while 27-28 degree Celsius highest in December (AccuWeather, 2019). It is 3-5 degree Celsius different. Outside air temperature in Bangkok in November 2019 was the lowest 23-26 degree Celsius while the lowest 18-19 degree Celsius in December 2019 was (TMD, 2019). It is 4-7 degree Celsius different. In December 2019, the outside air temperature was in comfort zone during the daytime while in the night time it was below thermal comfort. It was also rapidly cold, then people still got used to the previous experience of warm weather.

Calculate only electricity cost at 4.22 baht per kilowatt-hour (MEA, 2020) the energy reduced roughly about 1,000 MW per hour which cost about 4,220,000 baht hourly or 101,280,000 baht a day. It's worth 708.96 million baht a week. This is a significant number for urban planning, architect, engineer, designer, and MEA to recognize and draw actual plan to invest in environmental design reducing ambient air temperature. If we calculate back into cooling load for household using split-type air conditioning system turn on for 10 hours during night time and the rest turn on during office hours, it would be 1,000,000 ton of split-type air condition or 500,000 to of chilled water air condition system. Now we can estimate cooling load which is actual operate in Bangkok area regularly. If we renovated or replace those air conditioning systems and increase double efficiency, energy consumption will reduce in half. It would be 18,432.96 million baht saved annually. This number would help governors running economic model and its rapid payback to promote energy conservation regulation and loan funding.

To make urban area beautiful and rich nature, those amount of saving money can help to develop more green spaces in street furniture, city park, garden, open space, water pond, etc. many research results have been proposed to increase green area in urban area. If we balance green area as a surface to receive solar radiation rather than hard surfaces of construction, the ambient air temperature would reduce dramatically. It affects all cooling load in all buildings, consequently.

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