Demand Side Management and CO_2 Mitigation in Selected GMS Countries: The Household Sector

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Abstract

The rising of electricity demand in the selected Greater Mekong Sub-region (GMS) is an indicator for evaluation of improving social welfare and economic development. In recent years, the electricity demand in the region has increased significantly with an annual growth rate of 10%. The major electricity demand in the region is varying, based on the country perspective. In 2007, the household sector is the major electricity consumer in this region. It accounted for 50%, 60%, 21%, and 42% in Cambodia, Laos, Thailand, and Vietnam, respectively. To meet the forecasted electricity demand in the region, power expansion plans on the supply side would be developed. Otherwise, increasing the future supply capacity would emit more greenhouses gas (GHG) emissions that harm the global environment. In this context, to curb the high growth in electricity demand as well as to mitigate CO_2 emissions from the power sector in the selected GMS countries, the demand side management (DSM) options are applied to the end users. The Long-range Energy Alternative Planning system (LEAP) model is used to determine CO_2 emissions. Results reveal that implementing energy efficiency improvement in the DSM scenario for three types of appliances: lighting, air-conditioning, and refrigerating devices in the household sector could reduce installed capacity by 3000 MW and mitigate CO_2 emissions by about 14 million tons, compared to the business as usual (BAU) scenario in the selected GMS countries in 2030.

Keywords: DSM, CO_2 mitigation, GMS, LEAP, end-use model.

1. Introduction

Presently, concerned with huge capital investment in power expansion and the high fossil fuel price in the market, as well as the greenhouse gas (GHG) emissions, many countries seek to find out the best alternative choice in both demand side and supplies side to obtain sustainable and reliable supplies to serve consumers. To cope with this dilemma in modern power supply, the demand side management (DSM) through implementing the end use efficiency improvement, is introduced. Generally load management is composed of many strategies such as load clipping, valley filling, strategic conservation, and load shifting, etc [1]. In order to achieve the peak load reduction as well as to mitigate greenhouse gas (GHG) emission from the power sector, there are two approaches for implementing the DSM program: (1) cost investment solution, and (2) no cost investment solution. The cost investment solution depends on the size of DSM programs that all participants need to achieve. The simple and least cost investment solution is related to the lifestyle and behavior of using electrical appliances [2]. Another study confirmed that the power utility in Taiwan has sufficient load management through the cool storage air conditioning system by shifting the peak cooling demand period to the off peak period, by removing heat from a thermal storage medium during low cooling demand and low electric tariff in the nighttime. Then, the utility subsequently replaces the stored cooling at a later time to meet a peak cooling load and high tariff in the daytime. It showed that the electric utility got benefits from avoided capacity cost and avoided operating cost. Both are higher than expenses on the program with annual reduction of $58 per kW [3]. In addition, a DSM program in Nepal has provided a comprehensive analysis on the cost-effectiveness in three programs; namely (1) end-use power factor improvement, (2) efficiency improvement by replacing traditional lamps with efficient lamps in the household and commercial sectors, (3) intelligent motor controllers in industry. It indicated that the total potential of DSM programs in Nepal significantly reduced the peak demand to 450 MW by 2015 and recommended that Nepal can reduce imported power and delay investment in capacity expansion in two hydro power plants to around 173 MW [4]. In the early 1990s, Thailand became the first country in Asia in adoption of a nationwide DSM master plan. The DSM program has been implemented in all sectors, including (1) energy efficient fluorescent lamp program, known as thin tube program, (2) refrigerator efficiency labeling program, (3) air conditioner efficiency labeling program, (4) commercial building retrofit program, known as green buildings program, (5) high efficiency motor program, (6) energy efficient street lighting program using high pressure sodium vapors, (7) compact fluorescent lamp program, and (8) cool storage air conditioning program. All programs could save the power demand by over 270 MW. Otherwise, DSM reduces not only peak demand, but also CO_2 emission from the power sector [5].

The successful lesson of the DSM program has potential to curb partial peak demand and reduce the installed capacity, as well as to mitigate the GHG emissions from the power sector in many countries. From this concept, the DSM options under energy efficiency improvement in three end-use appliances are: lighting, air-conditioning, and refrigerating devices. These were introduced in the household sector in selected Greater Mekong Sub-region (GMS): Cambodia, Laos, Thailand and Vietnam. The implemented DSM in the individual country would reduce massive GHG emissions and avoid installed large capacity requirements in the region.

This paper is organized into 5 sections. Section 1 introduces general information from the successful implementation of a DSM program and effort of DSM in the electricity supply planning in the selected GMS countries, while Section 2 reviews the GMS power sector and indicators in the base year, 2007. Section 3 describes the methodology of analysis in the paper. Results and discussion are presented in Section 4, and the final Section is the conclusion.

2. GMS power sector

2.1 Electricity generation

In 2007, total electricity generation in the selected GMS countries reached 218 TWh within the total installed capacity of 43,000 MW. The share of fuel in electricity supply varies, depending on the indigenous capacity in each country, as presented in Fig 1. In the case of Cambodia, the electricity supply heavily relied on oil, steam, and diesel power plants, and it accounted for 90% of total installed capacity in the country while Laos, Thailand and Vietnam are less dependent on oil-based plants, and it accounted for 1.5%, 3.1% and 3.0%, respectively [6]. Among the selected GMS countries, Laos is the only country that has abundant hydropower supply. It accounted for 73% of the total electricity supply in the country with the total installed capacity of hydropower of 670.8 MW, and about 52% was developed by the independent power producer (IPP) for export purpose [7]. Vietnam is the second largest hydropower country that exploits more hydropower for the electricity supply. It accounted for 35% of total electricity supply in Vietnam [8]. Laos is the highest net electricity import country for domestic demand, compared to the other GMS members. In 2007, Laos imported about 25% of electricity for its domestic demand from Thailand and Vietnam. Thailand is the only country that consumed more natural gas for electricity generation up to 70% of the total electricity supply in the country [9]. Natural gas based plants supply about 31% in Vietnam while coal-based power plants supply about 25%, which is higher than any other GMS member.

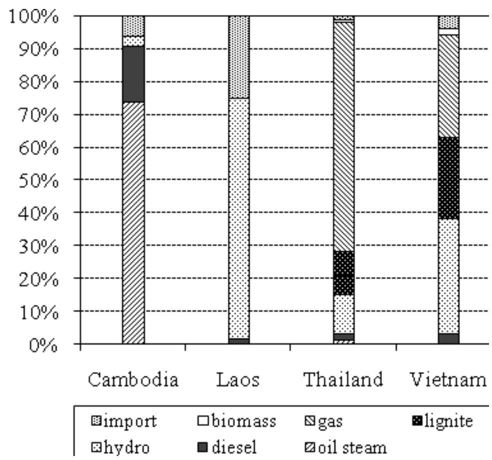

Figure 1 Fuel share in power generation of selected GMS countries in 2007.

2.2 Electricity demand

In 2007, the total electricity demand in the selected GMS countries increased to 200 TWh. The electricity demand was proportionally changed depending on the potential of economic development in each country. The household sector in Cambodia, Laos and Vietnam consumed 50%, 58.6%, and 42.5% of total consumption in each country, respectively, while in Thailand the household sector consumed about 20% of total consumption. The industrial sector was the major electricity consumer in Vietnam and Thailand. It accounted for 47.5% and 42.6%, respectively. Meanwhile, the Industrial sector consumed less electricity in Cambodia and Laos due to less economic development. It was 18.3% and 20%, respectively. The electricity in the commercial sector consumed more in Cambodia and Thailand, about 24.8%, and 24.6%, respectively, while Vietnam consumed lower in this sector, only 4.7% (see Fig 2).

2.3 Indicators of GMS Power Sector

The total population in the selected GSM countries was about 168 million in 2007. The highest population in the region is Vietnam, followed by Thailand. The total GDP of the regions was about 329,765 million USD [10].

In 2007, Thailand has the highest GDP and electricity per capita among selected GMS countries. Its GDP was about \$3,844 and electricity per capita was 2,180 kWh, followed by Vietnam with GDP of \$844.8 and electricity per capita of 695.4 kWh. On the other hand, among selected GMS countries, Cambodia has a low GDP of \$654.8 and low electricity consumption per capita of 98.6 kWh. Similarly, in 2007, the GDP and electricity per capita in Laos were \$717.9 and 225.8 kWh, respectively. In terms of electrification, Cambodia achieved 21%, Laos achieved 59.3%, and Vietnam achieved 84%, while the highest electrification was in Thailand with nearly 100% electrification, as presented in Fig 3.

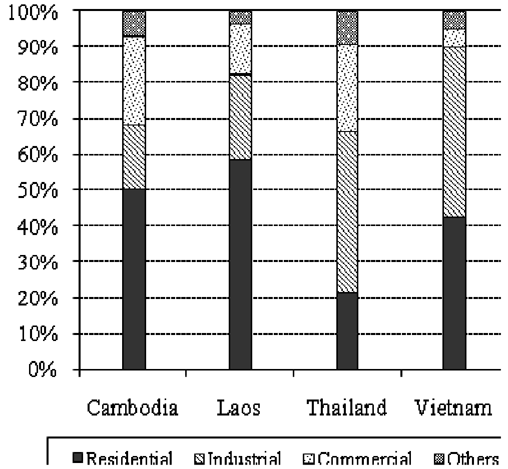

Figure 2 Electricity consumption by sector in selected GMS countries in 2007.

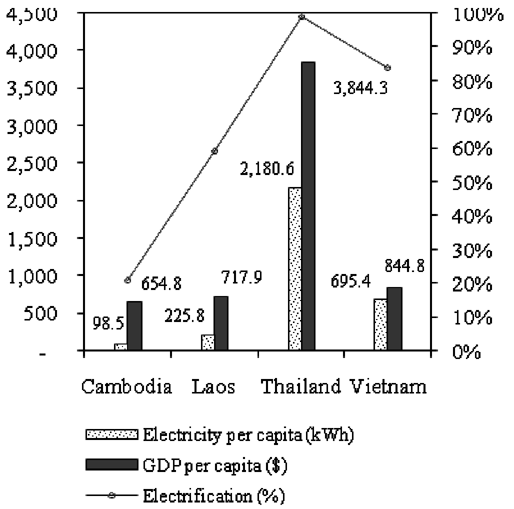

Figure 3 GDP, electricity per capita and electrification in 2007.

3. Methodology

3.1 LEAP modeling

This study uses a scenario based energy-environment model called Long-range Energy Alternative Planning system (LEAP) to forecast (a) the electricity demand and supply in the business as usual (BAU) scenario, (b) electricity demand and supply in the DSM scenario, (c) CO_2 emission mitigation from the power sector in the selected GMS countries. Originally LEAP was developed by Stockholm Environment Institute (SEI) [11]. LEAP uses a bottom-up approach to make projections on the future energy demand and examine a wide variety of technologies and strategies that best address environmental and energy issues. LEAP allows for analysis that is rich in technological specifications and end-use details and it incorporates a full range of energy systems. These are organized as well known energy carriers, with losses in the process, and through the final energy form to end users. Moreover, LEAP is easy to run on personal computers. Results include basic standard data of energy composition, energy contents, and emissions. For environmental assessment, LEAP can provide the results of pollution emission factors from each stage of fuel processing in power generation, including the cost of electricity generation and GHG emissions, extraction process, distribution, and the end-use activities [12]. In addition, the LEAP model could be used to simulate emission inventories and external costs of fossil electricity generation along with different future energy consumption patterns and pollution abatement policies under user-defined assumptions [13]. LEAP could be used for analysis in the economic sectors such as providing appropriate results of future energy demand of household consumers, in different income levels and economic perspectives in different areas between urban and rural, under scenarios of improvement in quality of livelihood [14].

3.2 Scenario Development

3.2.1 Business-as-Usual (BAU) scenario

The power expansion plan is derived from the power development plan (PDP) for each country. The acceleration of electricity demand varies due to the different perspectives of the economic development plan of each country. In this study, the planning period is 2007-2030.

The electricity demand forecast in GMS is based on the following criteria.

Population growth

The population would increase with an average of 1.8% per year in Cambodia, 1.7% in Laos, and 1.2% in Vietnam, while the lowest population growth rate of 0.5% is in Thailand [15]. In this study the population growth rates are assumed to follow the trends in each country during the planning period.

Urbanization and household size

The urbanization ratio is a factor that indicates the highest electricity demand because in these areas most people are living a high standard, materialistic, life-style and they consume more energy. In this study the urbanization of the country would increase steadily during the planning period. Based on the world development indicator [15], Cambodia and Laos are expected to increase urbanization to 30%, Vietnam would increase to 35% and Thailand is expected to increase to 45% by 2030.

In 2007, the household sizes are 5.2 in Cambodia, 6.1 in Laos, 3.8 in Thailand and 4.6 in Vietnam [15]. The household sizes are assumed to be constant up to 2030.

Electricity demand

The forecasted electricity demand growth in selected GMS countries is varying, depending on government plans and assumptions. In spite of electricity demand in the household sector, the electricity intensity in the household would increase from about 1,300 to 3,000 kWh per household for Cambodia and Laos. In addition Thailand would increase from 1,791 kWh to 3,500 kWh per household, while, Vietnam increases from 1,618 kWh to 4,000 kWh per household by 2030. The growth in electricity intensity in the household is based on the expectation of improving welfare and social economic development. However, the forecasted electricity demand in other sectors such as commercial, industrial, and other uses seem to increase with an annual growth rate of 12% in Cambodia, 11% in Laos, 5% in Thailand and 8.8% in Vietnam. The improvement of load factors in all countries is shown in Table 1.

Table 1: Expected electricity demand growth rates in the region.

GMS Countries	Household (kWh/yr/HH)	Commercial (%)	Industrial (%)	Others (%)	Load factor (%)
	2007 - 2030				2030
Cambodia	1,219 - 3,000	12	12	12	70
Laos	1,361 - 3,000	11	11	11	65
Thailand	1,791 - 3,500	5	5	5	75
Vietnam	1,618 - 4,000	8.8	8.8	8.8	68

Note: HH stands for household.

Table 2: Characteristics of power plants.

Plant type	Time life (years)	Capacity factor (%)	Efficiency (%)	Merit order[a]
Coal steam	40	80	30	1
Oil steam	30	80	100	2
Diesel oil CT	25	80	40	3
Natural gas CC	30	80	38	2
Hydro	30	60	43	1
Biomass IGCC	25	80	38	2
Wind	30	50	100	1

Table 2: Characteristics of power plants. (Cont.)

Plant type	Time life (years)	Capacity factor (%)	Efficiency (%)	Merit order[a]
Nuclear	30	90	100	1
Geothermal	40	80	80	1

Note: [a] Dispatched power plant based on load profile; (1) Base load, (2) Intermediate load, (3) Peak load.

Electrification

Based on the power development plans of the four GMS countries, the electrification in all countries would increase gradually. In case of Cambodia, the national electrification would increase to 70% by 2030. This ratio is still lower than Laos. Laos would increases up to 90% by 2030. Vietnam is expected to increase to 95% by 2030, while Thailand presently has very high access to electricity grid with electrification of 99%.

Transmission and distribution loss

Besides electrification, many countries in developing countries are facing the challenge of transmission and distribution (T&D) losses. In 2007, among selected GMS countries, Cambodia has the highest rate of transmission and distribution losses of about 16.75%. However, in the rural areas, the electricity loss is as high as 25% [17]. The power losses in Laos were about 16.41%, followed by Vietnam at 14.5% losses, while the electricity losses in Thailand are very small, at 5% only. However, the T&D loss would reduce significantly by improving technical standards with good management and administration. In this study, T&D losses in GMS countries are expected to reduce to 10% in Cambodia, Laos and Vietnam, except Thailand would keep constant at 5% until 2030.

Characteristics of Power Plants

In power system planning, the lifetime and efficiency of the power plant are very important. Furthermore, it is very important to reserve additional power capacity that can substitute for retired plants and fulfill forecasted demand. The efficiency of the power plants is presented in Table 2.

3.2.2 Demand side management (DSM) scenario

The demand side management (DSM) scenario in this study was focused on the efficiency improvement of three electric appliances: lighting, air-conditioning, and refrigerating devices in the household sector. The DSM would reduce the energy intensity in households.

Lighting devices

Lighting devices are major appliances which are widely used in both rural and urban areas. Improving efficiency in the lighting system would result in electricity reduction by substitution of compact fluorescent lamp (CFL) for incandescent bulb (IB), see Table 3. Thus, the introduction of lighting efficiency is based on this assumption and the penetration rate given in Table 4. An annual average lighting intensity of 350 kWh per household is used in the BAU scenario for all selected GMS countries [14]. Additionally, lighting is assumed to be turned on for five and a half hours per day.

Air-conditioning devices

The energy efficiency improvement in the air-conditioning systems is derived mainly from the replacement of inefficient air-conditioners and the penetration rates of replacement by highly efficient ones. The new air-conditioning systems are more efficient compared to the existing ones in the base year, as presented in Table 5.

Table 3: Basic lighting information.

Lighting devices	Rated power (W)	Life time (h)	Flux (Lumens)
Incandescent bulb (IB-40)	40	1,000	425
Incandescent bulb (IB-60)	60	1,000	720
Incandescent bulb (IB-100)	100	1,000	1,380
Fluorescent tube (FT-18)	18	6,000	970
Fluorescent tube (FT-20)	20	6,000	970
Fluorescent tube (FT-36)	36	6,000	2,450
Fluorescent tube (FT-40)	40	6,000	2,450
Compact fluorescent lamp (CFL-9)	11	10,000	900
Compact fluorescent lamp (CFL-12)	15	10,000	1,200
Compact fluorescent lamp (CFL-15)	18	10,000	1,500

Source: Balachandra P, 2001, [16]

Table 4: Efficient lighting scenario in households.

Propose Measurement	Period	Penetration rate (%)
Replace IB-40 by CFL-9 Replace IB-60 by CFL-12 Replace IB-100 by CFL-15	2007 - 2010	25%
Replace IB-40 by CFL-9 Replace IB-60 by CFL-12 Replace IB-100 by CFL-15	2011 - 2020	70%
Replace IB-40 by CFL-9 Replace IB-60 by CFL-12 Replace IB-100 by CFL-15	2021 - 2030	90%

Table 5: Improved efficiency of air-conditioning device.

	Energy (kWh/yr/HH)	Period	Penetration rate (%)
Air-conditioning	450[a]		
Air-conditioning	Improved efficiency of 10%	2007 - 2010	20%
Air-conditioning	Improved efficiency of 20%	2011 - 2020	50%
Air-conditioning	Improved efficiency of 30%	2021 - 2030	70%

Source: [a] Murata A, 2007, [18]

Refrigerating device

The replacement of inefficient refrigerators with highly efficient ones is proposed. The efficient refrigerators could significantly reduce electricity consumption in households. The penetration rates of efficient refrigerators are presented in Table 6.

Table 6: Improved efficiency of refrigerating device.

	Energy (kWh/yr/HH)	Period	Penetration rate (%)
Refrigerator	300[a]		
Refrigerator	Improved efficiency of 10%	2007 - 2010	20%
Refrigerator	Improved efficiency of 20%	2011 - 2020	50%
Refrigerator	Improved efficiency of 30%	2021 - 2030	70%

Source: [a] Tanatvanit S, 2003, [19]

4. Results and Discussion

The results are presented in three parts: (1) the electricity demand and supply composition in the BAU scenario, (2) the electricity demand and supply composition in the DSM scenario, and (3) CO_2 emission mitigation from the power sector.

4.1 BAU Scenario

Electricity demand in GMS

The electricity demand in the selected GMS countries is expected to increase from 202 TWh in the base year to 924.4 TWh in 2030 in the BAU scenario as presented in Fig 4. The industrial sector is the largest electricity consumer in the GMS region. The industrial sector accounted for 51.5%, and the household sector contributes 22.3% in total consumption. The commercial sector consumes about 16.7%, and other use accounts for 9.5%. The major of electricity consumers in Thailand and Vietnam are in the industrial sector. However, the household sector still remains the largest share of electricity consumption in Cambodia and Laos.

Electricity supply in GMS

To meet the forecasted electricity demand in the selected GMS countries, the power supply is developed. In the BAU scenario, the electricity supply in the region is likely to increase and depends on the conventional power plants. The total electricity supply in the region would increase from 219.1 TWh in 2007 to 1,002.1 TWh in 2030 (see Fig 5). In 2030, coal and natural gas combined cycle (NGCC) plants are the major contributors in the electricity supply, and account for 37.5% and 33.2% in total generation, respectively.

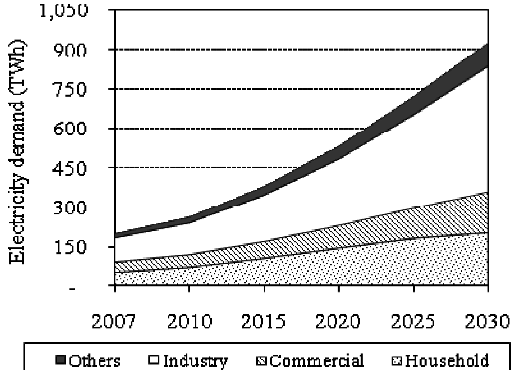

Figure 4 Electricity demand in the BAU scenario.

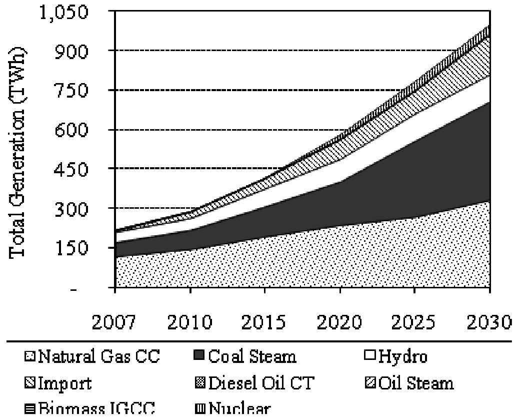

Figure 5 Electricity supply in selected GMS in the BAU scenario.

The electricity sector in the region is soaring. To fulfill the forecasted demand, besides the domestic supply, the imported electricity has to increase. The total imported electricity in the selected GMS countries would increase from 5.94 TWh in the base year to 152.75 TWh in 2030. The imported electricity would contribute to the power supply 15.2%, while the hydro power accounts for 10.4%, nuclear power provides 3.4%, and biomass contributes 0.3%. The region would increase the installed capacity from 33.7 GW in 2007 to 159.95 GW in 2030, as presented in Table 7.

Table 7: Power capacity requirements in the BAU scenario.

Supply sources	Capacity requirement (GW)					
	2007	2010	2015	2020	2025	2030
Coal steam	6.76	10.42	16.44	24.24	43.09	54.42
Oil CT	0.13	-	0.23	0.20	0.17	-
Diesel oil CT	0.49	-	0.41	0.37	0.54	0.20
Natural gas CC	19.77	24.60	32.33	40.95	47.71	60.49
Hydro	5.30	6.67	10.65	13.61	16.55	16.45
Biomass IGCC	0.44	0.43	0.41	0.42	0.44	0.44
Nuclear	-	-	-	2.33	4.90	4.90
Total	33.69	45.92	66.10	92.84	125.55	159.95

Notes: CT stands for Combustion Turbine.
IGCC stands for Integrated Gasification Combine Cycle.

GHG emissions

The increase in conventional fossil-based plants in the region results in production of massive GHG emissions in the power sector. The total emissions from the power sector in selected GMS countries increase gradually during the study period. In the BAU scenario, the total emission in the region increases from 102.61 million tons of CO_2 equivalent in 2007 to 541.19 million tons in 2030. The coal-based plant is the largest CO_2 emitter in the power sector, and accounts for 77.5% of total emission in 2030 as presented in Fig 6.

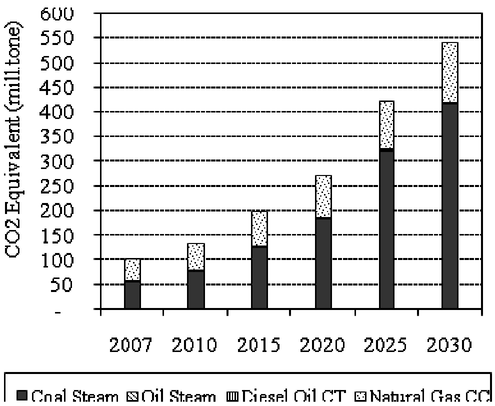

Figure 6 CO_2 emissions by plant type in selected GMS countries in the BAU.

In addition, among selected GMS countries, Thailand and Vietnam are the biggest GHG emitters. The emissions from both countries would increase roughly from 69.3 million tons and 32 million tons in the base year to 238.73 million tons and 295.69 million tons in 2030 for Thailand and Vietnam, respectively. (see Fig 7)

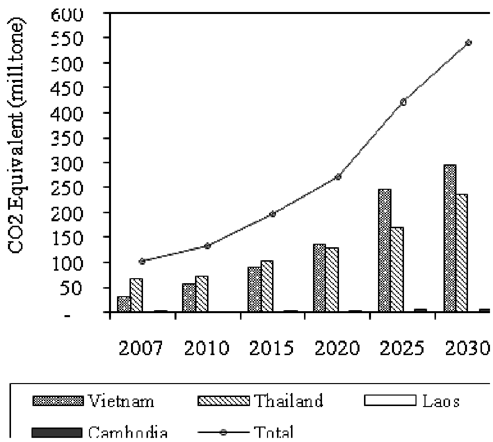

Figure 7 CO_2 emissions in the power sector in selected GMS countries in the BAU scenario.

4.2 Demand side management (DSM)

Electricity demand in GMS

The implementation of energy efficiency improvement on specific end-use appliances in the household sector through DSM options would reduce the electricity demand in the household sector from 205.9 TWh in the BAU scenario to 189 TWh. The potential of electricity demand reduction in selected GMS countries in the DSM scenario would be 8.2%, compared with the BAU scenario in 2030. In the DSM scenario, total electricity demand in the region decreases from 924.4 TWh in the BAU scenario to 907.6 TWh in 2030. (see Fig 8)

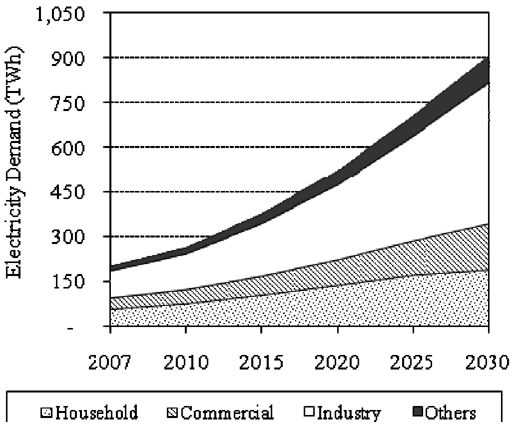

Figure 8 Electricity demand in selected GMS countries in the DSM scenario.

Electricity supply in GMS

Electricity demand reduction would affect directly the supply capacity requirement in the region. In the DSM scenario, the total power capacity requirement to meet the future demand is about 156.88 GW. The DSM saved about 3,000 MW or approximately 1.88% when compared to the BAU scenario in 2030, as shown in Table 8. Details of DSM options are presented in Table 9. In the DSM scenario, Vietnam has 60% or 1,863 MW, Thailand has 31% or 941 MW, Laos and Cambodia have 9% or 254 MW, in total avoided capacity in 2030.

Table 8: Supply capacity requirements in the DSM scenario.

Supply sources	Capacity requirement (GW)					
	2007	2010	2015	2020	2025	2030
Coal steam	6.76	10.04	15.98	23.36	42.27	52.74
Oil CT	0.13	0.07	0.23	0.20	0.18	-
Diesel oil CT	0.49	0.12	0.41	0.37	0.55	0.20
Natural gas CC	19.77	24.75	32.10	40.36	47.18	59.70
Hydro	5.30	6.62	10.54	13.38	16.40	16.25
Biomass IGCC	0.44	0.43	0.41	0.42	0.44	0.44
Nuclear	-	-	-	2.31	4.90	4.90
Total	33.69	45.84	65.27	91.01	123.86	156.88

Table 9: Comparison of supply capacity requirements in the BAU and DSM scenarios.

Unit: GW	2007				2030							
	CAM	LAO	THA	VN	CAM		LAO		THA		VN	
	BAU				BAU	DSM	BAU	DSM	BAU	DSM	BAU	DSM
Import	0.01	0.04	0.24	0.52	0.26	0.24	0.07	0.07	4.84	4.84	17.90	17.50
Coal steam	-	-	3.51	3.25	0.86	0.82	0.09	0.09	17.07	16.53	36.40	35.32
Oil CT	0.13	-	-	-	-	-	-	-	-	-	-	-
Diesel Oil CT	0.12	0.01	-	0.35	-	-	-	-	-	-	0.20	0.20
Natural Gas CC	-	-	16.35	3.43	-	-	-	-	37.96	37.56	22.53	22.14
Hydro	0.01	0.22	1.88	3.19	2.11	2.00	1.76	1.68	1.93	1.93	10.65	10.65
Biomass IGCC	-	-	0.23	0.21	-	-	-	-	0.23	0.23	0.21	0.21
Nuclear	-	-	-	-	-	-	-	-	1.70	1.70	3.20	3.20
Total	0.27	0.28	22.21	10.94	3.23	3.06	1.91	1.83	63.73	62.79	91.08	89.22

Note: CAM-Cambodia, LAO-Laos, THA-Thailand, VN-Vietnam.

GHG emissions

The total emissions from the power sector in selected GMS countries would increase during the study period. The CO_2 emission in the region increases from 102.61 million tons of CO_2 equivalent in 2007 to 541.19 million tons in 2030. The CO_2 emission in the region would be reduced significantly through DSM. The result reveals that three DSM options could mitigate CO_2 mission about 2.59% in 2030. Vietnam is the main contributor in CO_2 mitigation, and has about 57% in 2030. Thailand has 41%, Cambodia has 2% of CO_2 mitigation in 2030. While in Laos, it is no significance CO_2 mitigation under DSM options. The reason is that the major electricity supply in Laos is hydropower and imported electricity, which accounts for 93% of domestic supply, and the remainder is supplied from coal-based plants. The CO_2 emissions in the power sector of the selected GMS countries could be reduced from 541.19 million tons in the BAU to 527.19 million tons in the DSM scenario. (see Table 10)

Table 10: CO_2 emissions in the power sector

Years	GHG emissions (million tons)		
	BAU	DSM	Mitigation
2007	102.61	102.61	-
2010	133.24	131.64	1.60
2015	198.14	194.51	3.63
2020	271.52	263.63	7.89
2025	422.18	412.63	9.55
2030	541.19	527.19	14.00

5. Conclusion

Based on this study, the potential of three DSM options: efficient lighting, efficient air-conditioning, and efficient refrigerating devices in the household sector in the selected GMS countries, are very significant. In the DSM scenario, a supply capacity of 3000 MW has been saved. It accounts for 1.88% in total installed capacity in GMS. However, CO_2 emission in the power sector in GMS could be reduced from 541.19 million tons in the BAU to 527.19 million tons, and accounts for 2.59% reduction, in the DSM scenario in 2030. Finally, the selected GMS countries could avoid a capacity requirement of 3000 MW and CO_2 emissions of 14 million tons in 2030.

In addition, GMS countries are not included in Annex I Party to the United Nations Framework Convention on Climate Change (UNFCCC). The Annex I Party has to implement research on, and promote, develop and increase use of new and renewable forms of energy, CO sequestration technologies, and advanced innovative environmentally sound technologies, as indicated in the Kyoto Protocol. Other DSM options such as high efficiency electric devices, which have higher total cost in the BAU, would be used as certified emission reductions of Annex I Party through the clean development mechanism.

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