Provision of Services Related to Enabling Readiness for Up Scaling Investments in Building Energy Efficiency for Achieving NDC Goals in Thailand

Contract No.: UNEP/2020/252 (4700019197)

PROGRESS REPORT 5:

REPORT ON CONDUCT ENERGY AUDITS ON THE FIVE BUILDING TYPES (TASK 4)

Prepared for

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Leading the Transition to Clean Energy

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Acronyms

BEC	-	Building Energy Code
BESM	-	Building Energy Simulation Model
CBEEC	-	Commercial Building Energy Efficiency Information Center
CC	-	Cooling Capacity
COP	-	Coefficient of Performance
CTCN	-	Climate Technology Centre and Network
DEDE	-	Department of Alternative Energy Development and Efficiency
DPT	-	Department of Public Works and Town and Country Planning
ECON	-	Economic Building
EEP	-	Energy Efficiency Plan
EER	-	Energy Efficiency Ratio
EIA	-	Environment Impact Assessment
ENCON Act	-	Energy Conservation and Promotion Act
EnPI	-	Energy Performance Indicator
EPPO	-	Energy Policy and Planning Office (EPPO)
EUI	-	Energy Use Indicator
GGGI	-	Global Green Growth Institute
HEPS	-	High Energy Performance Standard
IIEC	-	International Institute for Energy Conservation
INDC	-	Intended Nationally Determined Contributions
KMUTT	-	King Mongkut University of Technology Thonburi
LAOs	-	Local Administration Organizations
LED	-	Lighting Emitting Diode
LPD	-	Lighting Power Density
MOE	-	Ministry of Energy
MOI	-	Ministry of Interior
MRV	-	Measurement, Report and Verification
NAMA	-	Nationally Appropriate Mitigation Actions
NCCC	-	National Committee on Climate Change Policy
NDC	-	Nationally Determined Contributions
NXPO	-	Office of National Higher Education Science Research and Innovation Policy Council
ONEP	-	Office of Natural Resources and Environmental Policy and Planning
OTTV	-	Overall Thermal Transfer Value
PEECB	-	Promoting Energy Efficiency in Commercial Buildings

RTTV	-	Roof Thermal Transfer Value
SEER	-	Seasonal Energy Efficiency Ratio
TBEED	-	Thailand Building Energy Efficiency Disclosures
TGO	-	Thailand Greenhouse Gas Management Organization
UNFCC	-	UN Framework Convention on Climate Change
UNEP	-	United Nations Environment Programme
ZEB	-	Zero Energy Building

EXECUTIVE SUMMARY

This report summarizes progress of the Contract No: UNEP/2020/252 (4700019197) for the provision of Services Related to Enabling Readiness for Up Scaling Investments in Building Energy Efficiency for Achieving NDC Goals in Thailand. The progress report specifically presents the completed project activities in the fifth reporting period of the project (September to December 2021).

This progress report shows the completed deliverable result of Task 4, activity 4.1 and 4.2. Key outcomes from the implementation of the project activities during the reporting period are as follows.

Activity 4.1: Conduct of Energy Audits of Building Sites

The continued COVID-19 pandemic had serious impacts on energy audit activities. The situations of each BEC building types from early months to October of the year 2021, the period when task 4 energy audit was planned. Realizing the above difficulty, the project team had to strategically plan on the recruitment of energy audit sites. The below channels were utilized for recruitment.

1. DEDE's Coordinating Center for Energy Conservation Building Design (BEC Center)

The project team was working closely with the BEC Center team from early April to October 2021 to identify and recruit potential building sites. The requests for energy audit were sent out via the BEC Center to many BEC buildings with expected success as most of these buildings have good cooperation with the Center. However only seven building accepted the requests to conduct the audit. Subsequently two offices declined the audit due to building closure and the selected hospital sites rejected because of management policy and overloaded activities of the hospital staff from the pandemic.

2. Networks of BEC building assessors and design consultants

In parallel the project team used network of BEC building assessors and building design consultants as an alternative channels to recruit more buildings to fill in the missing sites. After a few months of contact, no building accepted the audit requests because of the pandemic reason.

3. Previous customers of the project team

The energy audit recruitment was also done through contact of previous building customers of the project team. Despite the hard effort, the team was able to recruit only one more hospital and one more office building. However later on the management of the hospital decided not to continue the audit, so only one office remained.

Through the above recruiting channels and many months of recruiting efforts, the project team could come up with ten building sites including one office, one department store, two hotels and six condominiums.

Table: List of energy audit sites

No.	Building Name	Location	BEC Building Type	Status
1	Central Plaza Nakhon Ratchasima	Nakhon Ratchasima province	Department Store	Newly constructed building, In operation since 2017.
2	Grand Fortune Hotel Nakhon Si Thammarat	Nakhon Si Thammarat province	Hotel	Newly constructed building, In operation since 2020.
3	Fortune Saengchan Beach Hotel	Rayong province	Hotel	Newly constructed building, In operation since 2020.
4	The Courtyard Rayong	Rayong province	Condominium	Newly constructed building, In operation since 2020.

No.	Building Name	Location	BEC Building Type	Status
5	Supalai Oriental Sukhumvit 39	Bangkok	Condominium	Newly constructed building, In operation since 2020.
6	Supalai Loft @Khaerai Station	Nonthaburi province	Condominium	Newly constructed building, In operation since 2018
7	Supalai City Resort Chaeng Wattana	Nonthaburi province	Condominium	Newly constructed building, In operation since 2018.
8	LPN Mixx Thepharak-Srinakarin	Samutprakarn province	Condominium	Newly constructed building, In operation since 2017.
9	Lumpini Ville Sukhumvit 76 - Baering Station	Samutprakarn province	Condominium	Newly constructed building, In operation since 2017.
10	Lactasoy Office	Bangkok	Office	Construction completion with scheduled opening in early 2022.

To compliment with limited number of energy audit sites and unavailability of hospital buildings, the project team has conducted additional review of current design practices and potential technologies for BEC building types to confirm the validity of proposed technologies. BEC case examples recently published by DEDE are selected for this review.

Table: List of BEC case examples

No.	Building Name	Location	BEC Building Type	Status
1	Buriram Provincial Hall	Buriram Province	Office	Newly constructed, in operation
2	Office of the Attorney Building	No specified	Office	Design prototype
3	Dhanaphiphat Building	Bangkok	Office	Newly constructed, in operation
4	S Oasis	Bangkok	Department Store	Under construction
5	Red Planet Surawong	Bangkok	Hotel	Newly constructed, in operation
6	Siam@Siam Design Hotel	Pattaya	Hotel	Newly constructed, in operation
7	OPD and Emergency Building, Somdet Phra Sangharaja 19 Hospital	Kanchanaburi	Hospital	Newly constructed, in operation
8	Synphaet Medical Complex, Synphaet Ramintra Hospital	Bangkok	Hospital	Under construction
9	The Circle 2	Bangkok	Condominium	Newly constructed, in operation
10	The Cuvee Tiwanon	Nonthaburi	Condominium	Newly constructed, in operation

Energy audits were conducted by interview with persons involved with BEC during design and/or persons managing of current building operation. The interview results were noted on the data collection form thru on-site meeting, followed by walk-through surveys to collect actual building status and operational conditions. For the sites with limited physical accessibility, virtual conference were arranged for the interview together with fill-in forms and follow-on submission of energy consumption, building activity data and photos.

Data on the implementation of energy efficient technologies, building occupancy and operation, energy consumption and costs are collected for the evaluation of BEC impacts on energy savings. Information on building's energy management organizational structure, utilization of energy consumption data in monitoring and reporting are reviewed to assess data availability and possibility of building involvement in the future MRV

system. The outcomes of energy audit in this task 4 confirms the validity of technology and financial assessment results of task 3 and provides inputs for designing of MRV framework for BEC in task 5.

The detailed results and findings from the energy audits and review of BEC buildings are presented in Annex-1 and 2. Although ten buildings represent small portions of the whole BEC building population, they provide feedback on the technology study and confirm understanding of actual implementation and operational practices of the BEC buildings. Review of recent BEC case examples additionally check current building design and verify if identified technologies and assumptions are still applicable.

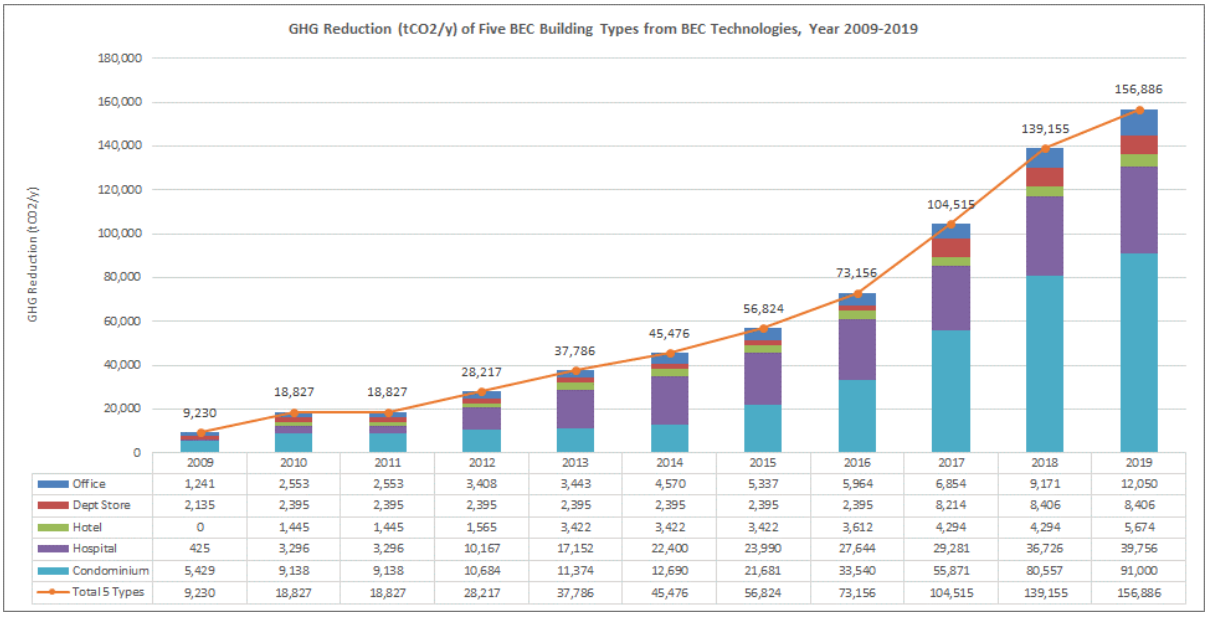
Activity 4.2: Develop Simulation Model for Energy and GHG Saving

The simulation model for estimation of energy saving and GHG reduction potential of the existing BEC buildings is built from the results of project tasks 1 to task 4.

- The result of task 1 provides insight analysis of 10-year BEC database. The database indicates population of BEC buildings, baseline technologies, design practices and baseline energy consumption.
- Task 2 technology assessment identifies and prioritizes the potential technologies to improve energy performance of the buildings. The study includes technologies for all five types of BEC buildings covered in this project.
- Task 3 financial assessment estimates energy savings of the prioritized technologies. The assessment analyzes how technologies applied to the five BEC building types and calculates how savings are achieved compared with baseline consumption from task 1. Assumptions on technology and building operation parameters are made based on reference information and practical knowledge from energy expert experiences.
- In Task 4, energy audits of the building samples together with the review of BEC building case examples confirm the validity on the application of identified technologies to the target buildings.

The simulation model collectively adds energy saving from the potential technologies for BEC components: building envelope, lighting, air conditioning, hot water generation and renewable energy utilization, which are applied to building population of five BEC building types to calculate the overall savings and GHG reductions.

The simulation shows GHG emission reduction potential in 2019 of 156,885 tCO_2/year from the energy saving of 249,289 MWh/year.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Office	1,241	2,553	2,553	3,408	3,443	4,570	5,337	5,964	6,854	9,171	12,050
Dept Store	2,135	2,395	2,395	2,395	2,395	2,395	2,395	2,395	8,214	8,406	8,406
Hotel	0	1,445	1,445	1,565	3,422	3,422	3,422	3,612	4,294	4,294	5,674
Hospital	425	3,296	3,296	10,167	17,152	22,400	23,990	27,644	29,281	36,726	39,756
Condominium	5,429	9,138	9,138	10,684	11,374	12,690	21,681	33,540	55,871	80,557	91,000
Total 5 Types	9,230	18,827	18,827	28,217	37,786	45,476	56,824	73,156	104,515	139,155	156,886

Figure: GHG emission reduction potential from implementing BEC technologies to five building types

The GHG emission for BEC reference baseline is 725,452 tCO_2/year in 2019. The emission of BAU design is 317,284 tCO_2/year and GHG emission from the implementation of BEC technologies is reduced to 160,398 tCO_2/year.

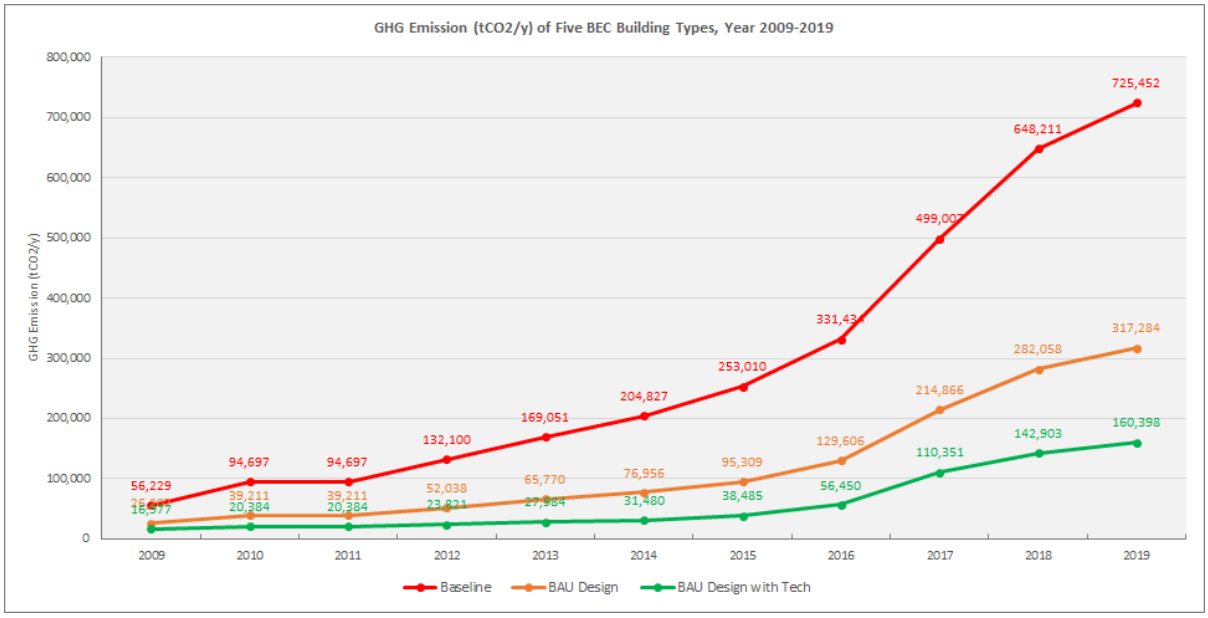


Figure: Benchmarking of GHG emission for three simulated scenarios

1 SUMMARY OF ACTIVITIES

This report summarizes the project's progress from September to December 2021 and deliverables under Task 4 (activity 4.1 and 4.2). The activities undertaken by the IIEC project team during this reporting period are summarized as follows.

- For activity 4.1, The IIEC project team conducts energy audits of ten representative sites. The audits consist of on-site data collection and interview with the team involved in building design and/or management of building operation to confirm the validity of technology and provide inputs for designing of MRV framework in task 5. Additional review of BEC case examples are added to compliment the energy audit results in technology validation.
- In activity 4.2, the simulation models are developed to estimate savings from the implementation of BEC technologies identified in task 2 and 3. Savings are calculated from the BAU design scenario derived from BEC pre-assessment of 10-year BEC database in task 1.
- Energy savings are converted into GHG emission reduction. GHG emission are benchmarked to compare the emission of reference BEC baseline, BAU design and BAU design with the implementation of BEC technologies.

2 PROGRESS BY TASK 4

This report provides the complete result of project task 4: Conduct Energy Audits on the Five Building Types. Ten buildings under five BEC building types covered in the project scope are selected as representative audit sites. The audits consist of on-site data collection and interview with the team involved in building design and/or management of building operation. Data on the implementation of energy efficient technologies, building occupancy and operation, energy consumption and costs are collected for the evaluation of BEC impacts on energy savings. Information on building's energy management organizational structure, utilization of energy consumption data in monitoring and reporting are reviewed to assess data availability and possibility of building involvement in the future MRV system. The outcomes of energy audit in this task 4 confirms the validity of technology and financial assessment results of task 3 and provides inputs for designing of MRV framework for BEC in task 5.

2.1 ACTIVITY 4.1: CONDUCT OF ENERGY AUDITS OF BUILDING SITES

2.1.1 Site recruitment

The continued COVID-19 pandemic had serious impacts on energy audit activities. The situations of each BEC building types from early months to October of the year 2021, the period when task 4 energy audit was planned, could be summarized as below.

Offices

Most office buildings were closed and some were opened only for critical businesses which required continuous operation and services. No visitor was allowed to enter the building except emergency case.

Department stores

Department stores during recruiting period were partially opened only to supermarket and food takeaways. Most areas were closed and low utilized. Exceptions were department stores whose areas were used as COVID-19 testing or vaccination centers.

Hotels

Most hotels were partly operated with very low occupancy. Only hotels being utilized as hospitel or quarantine facilities could run at moderate to high occupancy. However entry to these facilities were strictly controlled.

Hospitals

Hospitals were greatly affected by the pandemic. Hospitals were extremely strict in controlling access to the buildings to protect their patients and personnel. Many hospitals were overloaded with extra activities in servicing the infected patients. Any non-related activities to the main hospital functions were not allowed or postponed indefinitely.

Condominiums

Most condominiums were accessible with limitation to central and utility areas for privacy and pandemic prevention. Some condominiums limited only few visitors in a specified period. Meetings with management team or juristic person could be done but through virtual conference.

Realizing the above difficulty, the project team had to strategically plan on the recruitment of energy audit sites. The below channels were utilized for recruitment.

1. DEDE's Coordinating Center for Energy Conservation Building Design (BEC Center)

The BEC Center was considered as the most potential channel for site recruiting. The BEC Center was established by DEDE to drive the implementation of BEC. It has been operating by King Mongkut's Institute of Technology Ladkrabang (KMITL) under supervision of DEDE since 2010. With over 10 years of operation the center has developed BEC assessment tools and provided assessment services to over 850 buildings. The center is also the one-stop service center for technical advice, trainings and information dissemination to the relevant target groups including engineers, architects, project developers, and building owners.

Since early 2021 the project team was working closely with the BEC Center team to identify potential building sites. Around early April 2021 the requests for energy audit were sent out via the BEC Center to many BEC buildings with expected success as most of these buildings have good cooperation with the Center. However only seven building accepted the requests to conduct the audit. The initial list included two offices, one department stores, two hotels, one condominiums and one hospital. With the help of BEC Center the recruiting effort had continued until October 2021.

Unfortunately because of the increasing widespread of COVID-19 in the quarter 2 and 3 of the year 2021, the project team could only add five condominiums, one office and one hospital to the list. And finally two offices declined the audit due to building closure and the selected hospital sites rejected because of management policy and overloaded activities of the hospital staff from the pandemic.

2. Networks of BEC building assessors and design consultants

In parallel the project team used alternative channels to recruit more buildings to fill in the missing sites. These included the known network of BEC building assessors and building design consultants. With the close relationship of the assessors and consultants to the building owners, the project team again expected to obtain positive feedbacks on the audit requests. After a few months of contact, no building accepted the audit requests because of the pandemic reason.

3. Previous customers of the project team

The energy audit recruitment was also done through contact of previous building customers of the project team. Despite the hard effort, the team was able to recruit only one more hospital and one more office building. However later on the management of the hospital decided not to continue the audit, so only one office remained.

2.1.2 Energy audited sites and case examples

Through the above recruiting channels and many months of recruiting efforts, the project team could come up with ten building sites including one office, one department store, two hotels and six condominiums. And yet due to site situations and policies the energy audit approach was adjusted from normal practices.

Table 1: List of energy audit sites

No.	Building Name	Location	BEC Building Type	Status
1	Central Plaza Nakhon Ratchasima	Nakhon Ratchasima province	Department Store	Newly constructed building, In operation since 2017.
2	Grand Fortune Hotel Nakhon Si Thammarat	Nakhon Si Thammarat province	Hotel	Newly constructed building, In operation since 2020.
3	Fortune Saengchan Beach Hotel	Rayong province	Hotel	Newly constructed building, In operation since 2020.

No.	Building Name	Location	BEC Building Type	Status
4	The Courtyard Rayong	Rayong province	Condominium	Newly constructed building, In operation since 2020.
5	Supalai Oriental Sukhumvit 39	Bangkok	Condominium	Newly constructed building, In operation since 2020.
6	Supalai Loft @Khaerai Station	Nonthaburi province	Condominium	Newly constructed building, In operation since 2018
7	Supalai City Resort Chaeng Wattana	Nonthaburi province	Condominium	Newly constructed building, In operation since 2018.
8	LPN Mixx Thepharak-Srinakarin	Samutprakarn province	Condominium	Newly constructed building, In operation since 2017.
9	Lumpini Ville Sukhumvit 76 - Baering Station	Samutprakarn province	Condominium	Newly constructed building, In operation since 2017.
10	Lactasoy Office	Bangkok	Office	Construction completion with scheduled opening in early 2022.

To compliment with limited number of energy audit sites and unavailability of hospital buildings, the project team has conducted additional review of current design practices and potential technologies for BEC building types to confirm the validity of proposed technologies. BEC case examples recently published by DEDE are selected for this review.

Table 2: List of BEC case examples

No.	Building Name	Location	BEC Building Type	Status
1	Buriram Provincial Hall	Buriram Province	Office	Newly constructed, in operation
2	Office of the Attorney Building	No specified	Office	Design prototype
3	Dhanaphiphat Building	Bangkok	Office	Newly constructed, in operation
4	S Oasis	Bangkok	Department Store	Under construction
5	Red Planet Surawong	Bangkok	Hotel	Newly constructed, in operation
6	Siam@Siam Design Hotel	Pattaya	Hotel	Newly constructed, in operation
7	OPD and Emergency Building, Somdet Phra Sangharaja 19 Hospital	Kanchanaburi	Hospital	Newly constructed, in operation
8	Synphaet Medical Complex, Synphaet Ramintra Hospital	Bangkok	Hospital	Under construction
9	The Circle 2	Bangkok	Condominium	Newly constructed, in operation
10	The Cuvee Tiwanon	Nonthaburi	Condominium	Newly constructed, in operation

2.1.3 Energy audit approach

Energy audit of representative building sites were conducted by interview with persons involved with BEC during design and/or persons managing of current building operation. The interview results were noted on the data

collection form thru on-site meeting, followed by walk-through surveys to collect actual building status and operational conditions. For the sites with limited physical accessibility, virtual conference were arranged for the interview together with fill-in forms and follow-on submission of energy consumption, building activity data and photos.

Regardless of either on-site or virtual audit approach, the energy audits are structured to collect the following information.

Overall building status

Photo taking of current building exterior, space utilization, building envelope, air conditioning, lighting and other major energy consuming systems.

Building space utilization

Collection of actual utilization of building spaces including air conditioned areas, non-air conditioned areas, space occupancy, functional operation and operating hours. The collected information are compared with the design submitted for BEC assessment.

Building envelope and energy consuming systems

Data collection on the implementation of materials for building envelope, lighting, air conditioning, hot water generator, renewable energy utilization and other energy consuming equipment and systems. Comparisons of the collected data to submitted design for BEC assessment are made. The collected information are used to confirm the applicability of the key BEC technologies identified in task 3.

Energy consumption and related data

Collection of energy consumption data including electricity consumption over the past 12 months or more for building with more than one year of operation. The audit also checks the availability of energy metering and energy related data including area functions and utilization, building occupancy, which would be possibly used in the design of MRV.

Energy management system

Collection of energy management system being implemented to manage energy efficiency. Responsibility and reporting structure are reviewed.

Comments on BEC implementation

Collection of stakeholders' opinions on the implementation of BEC. Comments and concerns on BEC assessment, data submission and approval process, technology selection and installation to BEC requirements are collected. Recommendations for improvement or any BEC related issues are noted.

2.1.4 Energy audit and review results

The detailed results and findings from the energy audits and review of BEC buildings are presented in Annex-1 and 2. The results are summarized in three aspects: applicability of key BEC technologies, available energy data and reporting for MRV and recommendation and concerns on the implementation of BEC.

Although ten buildings represent small portions of the whole BEC building population, they provide feedback on the technology study and confirm understanding of actual implementation and operational practices of the BEC buildings. Review of recent BEC case examples additionally check current building design and verify if identified technologies and assumptions are still applicable.

Applicability of BEC technologies

Based on the findings of building materials and major energy consuming systems, the applicability of key technologies identified in task 3 is evaluated for each audited and case example sites, see table 3 and 4.

Table 3: Applicability of BEC technologies to energy audit sites

No.	Building Name	BEC Building Type/ Usable Area	Applicability of BEC Technologies					
			Envelope	High Eff LED Lamps	VRF A/C	Mag/High Eff Chillers	High Eff Split Type A/C	Rooftop Solar PV
1	Central Plaza Nakhon Ratchasima	Department Store 298,318 m^2	P	P	N	A	P	A
2	Grand Fortune Hotel Nakhon Si Thammarat	Hotel 24,500 m^2	P	P	N	A	P	P
3	Fortune Saengchan Beach Hotel, Rayong	Hotel 8,600 m^2	P	P	A	N	P	P
4	The Courtyard Rayong	Condominium 6,700 m^2	P	P	N	N	P	P
5	Supalai Oriental Sukhumvit 39, Bangkok	Condominium 23,283 m^2 x 2 31,331 m^2 x 2	P	P	N	N	P	P
6	Supalai Loft @Khaerai Station, Bangkok	Condominium 41, 780m^2	P	P	N	N	P	P
7	Supalai City Resort Chaeng Wattana, Nonthaburi	Condominium 56, 006m^2	P	P	N	N	P	P
8	LPN Mixx Thepharak-Srinakarin, Samutprakarn	Condominium 8 building-compound	P	P	N	N	P	P
9	Lumpini Ville Sukhumvit 76 - Baering Station, Samutprakarn	Condominium 4-building compound	P	P	N	N	P	P
10	Lactasoy Office, Bangkok	Office 8,300 m^2	A	P	A	A	P	P
Remarks								
A: Already implemented no more potential			1 / 10	0 /10	2 / 10	3 / 10	0 / 10	1 / 10
P: Potential to new or further implementation from existing			9 /10	10 /10	0 / 10	0 / 10	10 / 10	9 / 10
N: No potential due to irrelevant building type or size			0 /10	0 / 10	8 /10	7 / 10	0 / 10	0 / 10

Table 4: Applicability of BEC technologies to case examples

No.	Building Name	BEC Building Type/ Usable Area	Applicability of Key BEC Technologies					
			Envelope	High Eff LED Lamps	VRF A/C	Mag/High Eff Chillers	High Eff Split Type A/C	Rooftop Solar PV
1	Buriram Provincial Hall	Office 16,634 m2	P	P	P	N	P	P

No.	Building Name	BEC Building Type/ Usable Area	Applicability of Key BEC Technologies					
			Envelope	High Eff LED Lamps	VRF A/C	Mag/High Eff Chillers	High Eff Split Type A/C	Rooftop Solar PV
2	Office of the Attorney Building	Office 6,429 m^2	P	P	P	N	P	P
3	Dhanaphiphat Building	Office 4,630 m^2	A	P	N	N	N	A
4	S Oasis	Department Store 6,800 m^2	P	P	N	P	N	P
5	Red Planet Surawong	Hotel 5,700 m^2	P	P	P	P	N	P
6	Siam@Siam Design Hotel	Hotel 19,000 m^2	P	P	N	P	P	P
7	OPD and Emergency Building, Somdet Phra Sangharaja 19 Hospital	Hospital 9,178 m^2	P	P	N	P	P	P
8	Synphaet Medical Complex, Synphaet Ramintra Hospital	Hospital 43,000 m^2	P	P	N	P	P	P
9	The Circle 2	Condominium 58,000 m^2	P	P	N	N	P	P
10	The Cuvee Tiwanon	Condominium 23,189 m^2	P	P	P	P	P	P
Remarks								
A: Already implemented no more potential			1 / 10	0 /10	0 / 10	0 / 10	0 / 10	1 / 10
P: Potential to new or further implementation from existing			9 /10	10 /10	4 / 10	6 / 10	7 / 10	9 / 10
N: No potential due to irrelevant building type or size			0 /10	0 / 10	6 /10	4 / 10	3 / 10	0 / 10

The result confirms the relevance and validity of identified BEC technologies to the targeted building type as identified in task 3. This can be summarized for each technology below.

Building envelope

Although most buildings from the energy audits and case examples can pass the OTTV/RTTV criteria of BEC, there are still potentials for further improvement with building envelope technology.

High efficiency LED lamps

Further improvement on lighting energy efficiency still exists to all buildings whether LED lamps have been adopted. The potentials of higher efficacy (lumen per watt) than common LED lamps in the market are still high.

Air conditioning including VRF, magnetic, high efficiency chiller and high efficiency split type

Air conditioning together with building envelope technologies have the highest potential for energy saving for BEC. High efficiency systems are well-proven on the return on investment. Implementations have been realized from the audited sites and case examples.

Rooftop solar PV

Rooftop solar PV is still lowly implemented. It has great potential for energy saving from the grid with good return on investment for most BEC sites. A few buildings from the audited sites have started the implementation and many sites have considered to implement in the coming years.

Availability of energy data and reporting for MRV

Table 5 summarizes the findings on the availability of energy data and energy consumption report from each audit sites, which would support the implementation of MRV system for the BEC buildings in the future.

Table 5: Availability of energy consumption data and energy reporting to support MRV

No.	Building Name	Available Energy Data			Energy Reporting		
		Energy bill	Operation & Area Data	Manual /Automatic	Responsible team	Report Type	Reporting Channel
1	Central Plaza Nakhon Ratchasima	Yes	Yes	Manual	Energy management team	Energy expense / Annual energy management report	Internal / External to DEDE
2	Grand Fortune Hotel Nakhon Si Thammarat	Yes	Yes	Manual	Energy management team	Energy expense / Annual energy management report	Internal / External to DEDE
3	Fortune Saengchan Beach Hotel, Rayong	Yes	Yes	Manual	Energy management team	Energy expense / Annual energy management report	Internal / External to DEDE
4	The Courtyard Rayong	Yes Only central utility	Yes Only central utility	Manual	Juristic person	Energy expense	Internal
5	Supalai Oriental Sukhumvit 39, Bangkok	Yes Only central utility	Yes Only central utility	Manual	Juristic person	Energy expense	Internal
6	Supalai Loft @Khaerai Station, Bangkok	Yes Only central utility	Yes Only central utility	Manual	Juristic person	Energy expense	Internal
7	Supalai City Resort Chaeng Wattana, Nonthaburi	Yes Only central utility	Yes Only central utility	Manual	Juristic person	Energy expense	Internal
8	LPN Mixx Thepharak-Srinakarin, Samutprakarn	Yes Only central utility	Yes Only central utility	Manual	Juristic person	Energy expense	Internal
9	Lumpini Ville Sukhumvit 76 - Baering Station, Samutprakarn	Yes Only central utility	Yes Only central utility	Manual	Juristic person	Energy expense	Internal
10	Lactasoy Office, Bangkok	Yes	Yes	Manual	Energy management team	Energy expense	Internal

Comments from energy audit sites

Feedback comments on the implementation of BEC summarized from ten building sites are noted below.

1. Overall opinion on BEC participation

All building sees the benefits on BEC implementation in improving building design, reducing building energy costs and providing good business image to their target customers. However half of the sites expressed their concern if there is penalty applied on the non-compliance to BEC.

2. BEC impact to construction costs

Two sites expressed the effect of BEC criteria on building envelope design and material selection. One of the condominium concerned on higher construction cost which would result in the higher selling price and might lower their market competitiveness.

3. Improvement of BEC assessment process

One site addressed the complication of the BEC assessment process and five of the sites suggested the need to increase BEC's understanding of the Local Administrative Organization which directly involves in the approval of building design.

4. Technical and financial support request

One site suggested more technical and financial subsidy from DEDE on modern technology implementation. And most condominium sites requested supporting advice for Condominium juristic person to maintain and further improve energy efficiency of the buildings in the long term.

5. Education of BEC to the designer and auditor

The management of one audit site recommended inclusion of BEC trainings to professional associations including engineers and architects, university and education institutes. Also would like to see more BEC training courses for BEC auditors as current trainings are in high demanded and fully booked.

6. BEC regulation

One of the condominium group suggested to separate the assessment criteria for condominium buildings from hotels and hospitals because of the differences in area utilization and energy consumption characteristics. Also suggest involve the Property Management Association of Thailand (PMA) for inputs on the integration of BEC to the related residence building and condominium laws and regulations

2.2 ACTIVITY 4.2: DEVELOP SIMULATION MODEL FOR ENERGY AND GHG SAVING

This section presents the simulation of energy saving and GHG emission reduction from the implementation of BEC technologies to the existing buildings. Applying the simulation model from task 1 with the result of the technology and financial assessment of task 2 and 3 and energy audit findings from activity 4.1 energy saving and GHG reduction potential from the identified technologies are simulated.

2.2.1 Model development

The simulation model for estimation of energy saving and GHG reduction potential of the existing BEC buildings is built from the results of project tasks 1 to task 4.

- The result of task 1 provides insight analysis of 10-year BEC database. The database indicates population of BEC buildings, baseline technologies, design practices and baseline energy consumption.
- Task 2 technology assessment identifies and prioritizes the potential technologies to improve energy performance of the buildings. The study includes technologies for all five types of BEC buildings covered in this project.
- Task 3 financial assessment estimates energy savings of the prioritized technologies. The assessment analyzes how technologies applied to the five BEC building types and calculates how savings are achieved compared with baseline consumption from task 1. Assumptions on technology and building operation parameters are made based on reference information and practical knowledge from energy expert experiences.
- In Task 4, energy audits of the building samples together with the review of BEC building case examples confirm the validity on the application of identified technologies to the target buildings.

The simulation model collectively adds energy saving from the potential technologies for BEC components: building envelope, lighting, air conditioning, hot water generation and renewable energy utilization, which are applied to building population of five BEC building types to calculate the overall savings and GHG reductions.

2.2.2 Simulation scenarios

The analysis defines three scenarios for estimating energy saving and GHG reduction potentials from implementation of BEC technologies.

- **Baseline**

  This is the scenario should the BEC do not exist. The scenario takes the reference energy consumptions from BEC assessment program as the baseline. The reference energy consumptions for each BEC building type were established based on DEDE's study energy consumption of the building sector more than 10 years ago and have been used as the reference for BEC assessment since the launch of the BEC program.

  Another alternative realized during the conduct of this study is to use the SEC (specific energy consumption) result from DEDE' studies of specific energy consumption of various building sectors during the year 2004-2006 as baseline energy consumption. The SEC would provide more accurate baseline consumption as it allow adjustment of baseline energy consumption to parameters which vary over the years of operation.

  However calculation of baseline energy consumption from SEC requires building operation parameters and these parameters are not available from the existing BEC database. The SEC might be worth considered as the baseline for the calculation of energy savings for the MRV of the new BEC buildings provided that relevant parameter data are prepared and reported from the design to the operation phases of the buildings. (More details on the SEC approach for calculation of energy baseline and savings are proposed and explained in task 5.)

- **Business as usual (BAU) design**

  Similar to baseline scenario the BEC assessment database is utilized for business-as-usual analysis. The original building design submitted for BEC assessment (pre-assessment) is assumed to represent current building design and materials commonly implemented. Together with baseline, business as usual scenarios from the results of the benchmark analysis in task 1 are brought for the simulation.

- **BEC technology implementation**

  The scenario assumes that key technologies identified in task 3 are implemented by BEC buildings to improve energy performance and fully comply with the BEC criteria. The scenario are analyzed for each BEC building types, comprising office, department store, hotel, hospital and condominium in four groups of usable areas of 2,000-5,000, 5001-10,000, 10,001-20,000 and >20,000 m2. Energy savings from each building type are calculated and collectively added to calculate total potential energy savings and GHG emission reductions.

2.2.3 Energy saving and GHG reduction

Energy saving

Simulation of energy saving are based on the implementation of key technologies with applications and assumption given in task 3.

The following table 6 summarizes the typical savings from the technologies with target building groups. The saving percentage are matched to the building population derived from the BEC database. BAU design represents as baseline for saving calculation.

Table 6: Typical energy saving from BEC technologies

Building type	Type by usable area (m^2)	Energy saving percentage (%)					
		Envelope	High Eff LED Lamps	VRF A/C	Mag/High Eff Chillers	High Eff Split Type A/C	Rooftop Solar PV
Office	2000-5000	30.1%	47.4%	48.9%	53.1%	42.9%	5.0%
	5001-10000	30.9%	47.5%	48.9%	53.5%		5.0%
	10001-20000	31.2%	47.5%		27.6%		5.0%
	>20000	31.3%	47.5%		24.0%		5.0%
Department Store	2000-5000	32.3%	47.4%	48.9%	56.7%	42.9%	5.0%
	5001-10000	33.5%	47.5%	48.9%	57.1%		5.0%
	10001-20000	33.8%	47.5%		31.6%		5.0%
	>20000	34.0%	47.5%		28.1%		5.0%
Hotel	2000-5000	33.3%	47.4%	48.9%	58.5%	42.9%	5.0%
	5001-10000	34.7%	47.5%	48.9%	58.9%		5.0%
	10001-20000	35.1%	47.5%		32.1%		5.0%
	>20000	35.4%	47.5%		28.8%		5.0%
Hospital	2000-5000	33.3%	47.4%	48.9%	58.5%	42.9%	5.0%
	5001-10000	34.7%	47.5%	48.9%	58.9%		5.0%
	10001-20000	35.1%	47.5%		32.1%		5.0%
	>20000	35.4%	47.5%		28.8%		5.0%
Condominium	2000-5000	33.3%	47.4%			42.9%	5.0%
	5001-10000	34.7%	47.5%			42.9%	5.0%
	10001-20000	35.1%	47.5%			42.9%	5.0%
	>20000	35.4%	47.5%			42.9%	5.0%

Savings from technologies are calculated to energy saving per usable area for comparing to the EUI of BAU design.

Table 7: Energy saving per usable area of each building type

Building type	Type by usable area (m^2)	BAU (kWh/m2-y)	Envelope saving (kWh/m^2-y)	Air Cond saving (kWh/m^2-y)	Lighting saving (kWh/m^2-y)	Solar PV saving (kWh/m^2-y)
Office	2000-5000	41.7	5.1	5.2	2.6	2.1
	5001-10000	38.2	4.8	4.2	2.4	1.9
	10001-20000	36.8	6.8	4.1	2.0	1.8
	>20000	42.0	7.8	4.1	2.3	2.1
Department Store	2000-5000					
	5001-10000	90.1	15.7	17.2	7.5	4.5
	10001-20000	90.6	17.2	10.6	4.0	4.5
	>20000	46.1	8.8	4.8	2.0	2.3
Hotel	2000-5000	90.9	19.4	17.5	1.6	4.5
	5001-10000	124.4	27.6	21.7	2.2	6.2
	10001-20000	125.7	29.2	17.3	1.2	6.3
	>20000	129.8	30.3	15.9	1.2	6.5
Hospital	2000-5000	133.9	25.0	22.6	5.6	6.7
	5001-10000	108.0	21.0	16.5	4.5	5.4
	10001-20000	111.3	22.3	13.2	4.2	5.6
	>20000	106.6	21.5	11.3	4.1	5.3
Condominium	2000-5000	123.4	23.9	8.8	2.6	6.2
	5001-10000	113.6	22.8	7.9	2.4	5.7
	10001-20000	108.3	25.5	8.7	0.8	5.4
	>20000	95.6	22.7	7.6	0.7	4.8

With the 10-year record of building quantities and usable areas from the BEC database, energy saving from the scenario of implementing the BEC technologies to these existing BEC buildings can be quantified. The results are shown in figure 1.

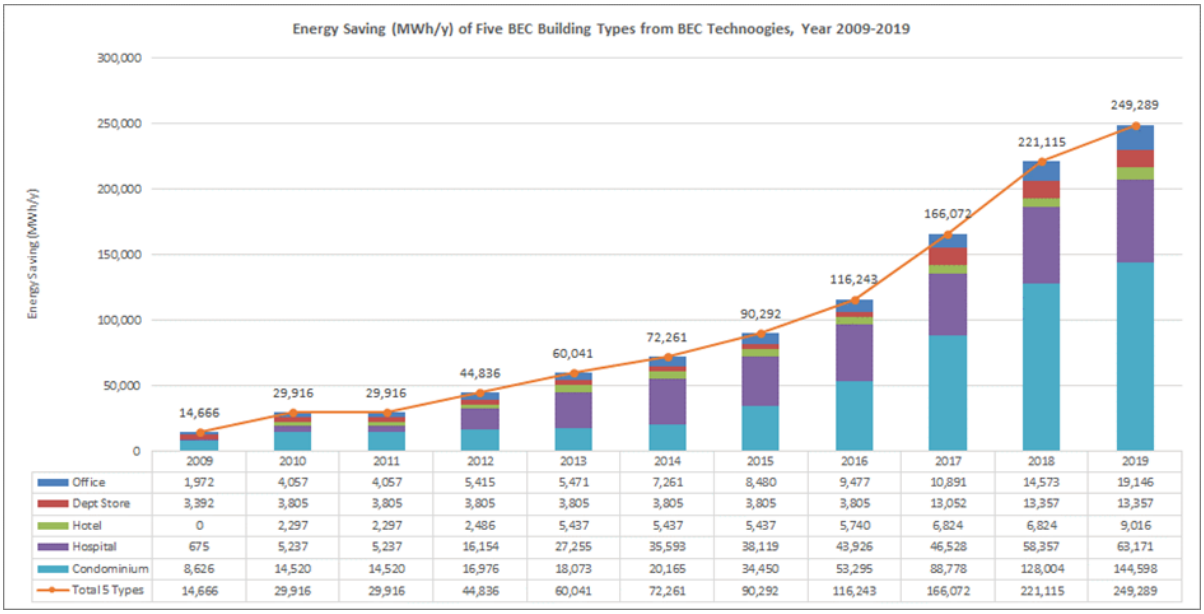
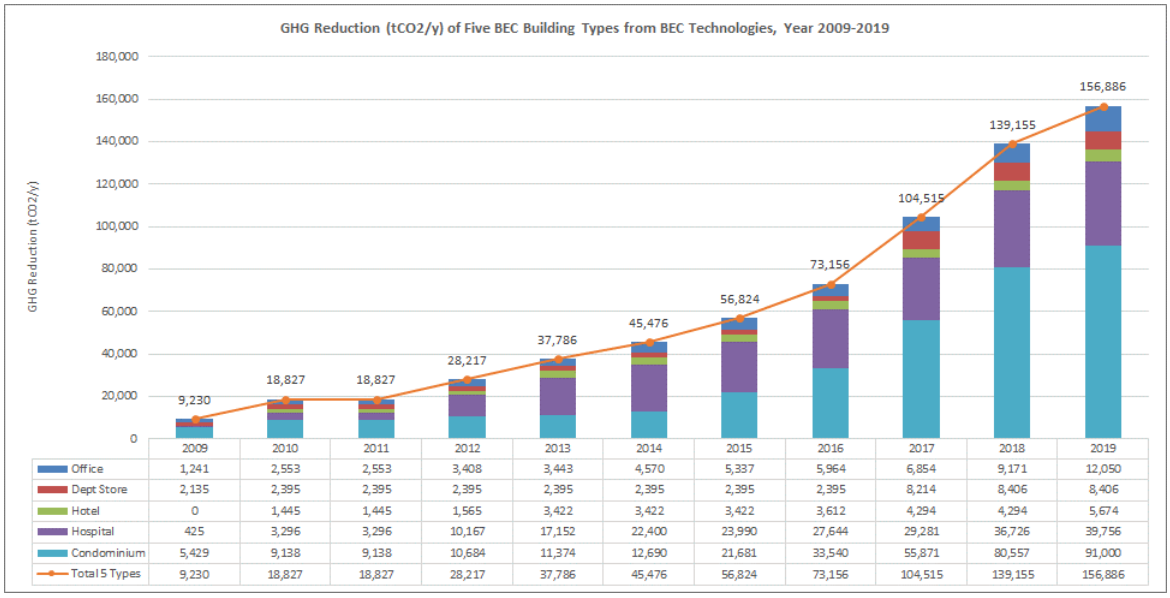


Figure 1: Energy saving potential from implementing BEC technologies to five building types

GHG emission reduction simulation

GHG emission reduction is calculated in ton CO_2 (tCO_2). The GHG emission factor of kg tCO_2 per kWh published by the Thailand Greenhouse Gas Management Organization (TGO) is used for conversion from energy consumption to GHG emission. The GHG emission reduction is determined by the avoided grid emission from the power generation incorporating 10% transmission and distribution losses. With the latest grid emission factor of 0.5664 kg CO_2/kWh (updated in year 2017), GHG emission factor used for the BEC saving is 0.6293 kg CO_2/kWh.

The following figure shows GHG emission reduction potential in 2019 of 156,885 tCO_2/year from the energy saving of 249,289 MWh/year.



	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Office	1,241	2,553	2,553	3,408	3,443	4,570	5,337	5,964	6,854	9,171	12,050
Dept Store	2,135	2,395	2,395	2,395	2,395	2,395	2,395	2,395	8,214	8,406	8,406
Hotel	0	1,445	1,445	1,565	3,422	3,422	3,422	3,612	4,294	4,294	5,674
Hospital	425	3,296	3,296	10,167	17,152	22,400	23,990	27,644	29,281	36,726	39,756
Condominium	5,429	9,138	9,138	10,684	11,374	12,690	21,681	33,540	55,871	80,557	91,000
Total 5 Types	9,230	18,827	18,827	28,217	37,786	45,476	56,824	73,156	104,515	139,155	156,886

Figure 2: GHG emission reduction potential from implementing BEC technologies to five building types

Technologies for saving building air conditioning consumption contribute to most proportion of GHG reduction. Building envelope technologies accounts for 56.2% and air conditioning technologies share 24.4% of total GHG reduction. Without the clear information on the roof areas, it is conservatively assumed solar PV generation at 5% of total electricity generation, which results in 13.2% portion of GHG reduction. The remaining small portion at 6.1% is from lighting technologies.

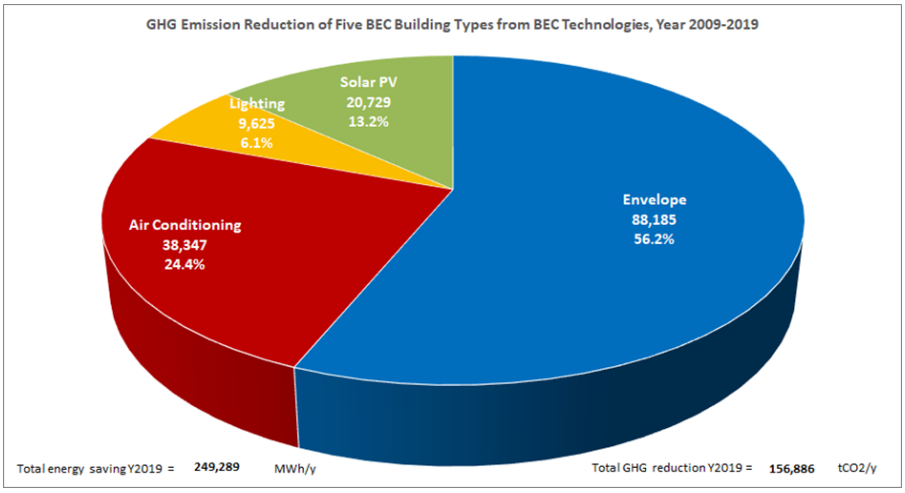


Figure 3: Proportion of GHG emission reduction from BEC technologies

GHG emission benchmarking

The following line graph visualizes GHG emissions for BEC reference baseline with 725,452 t CO_2/year in 2019, BAU design with 317,284 tCO_2/year and scenario with implementation of BEC technologies at 160,398 tCO_2/year.

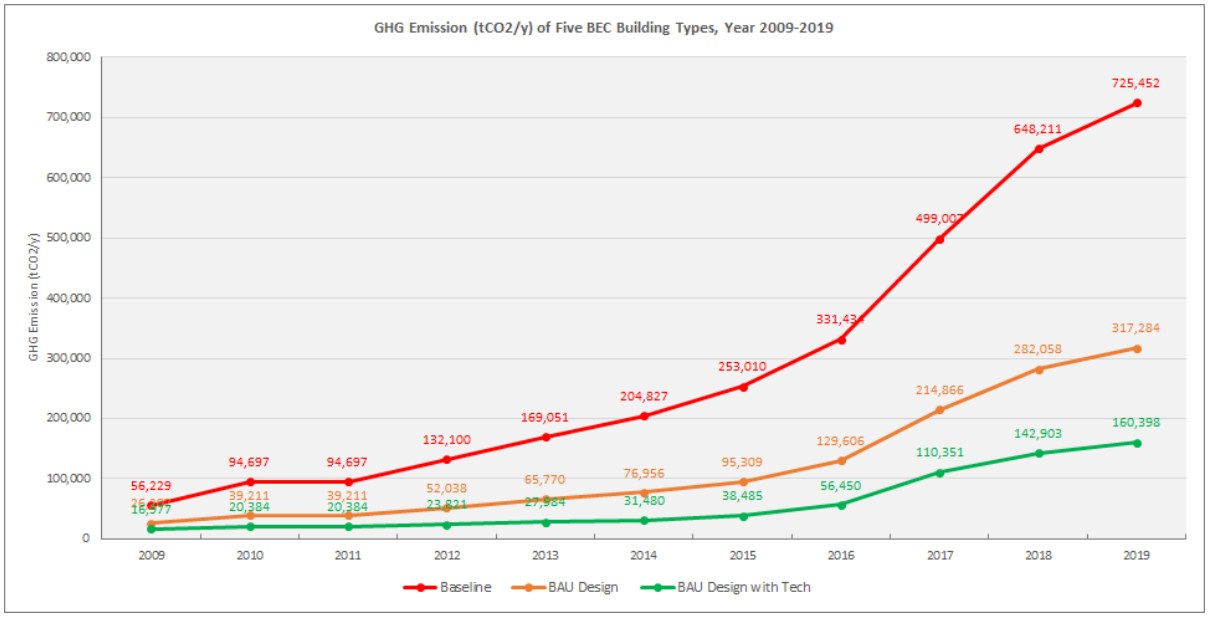


Figure 4: Benchmarking of GHG emission for three simulated scenarios

ANNEX-1 ENERGY AUDIT RESULTS OF THE TEN BUILDING SITES

1. Central Plaza Nakhon Ratchasima
2. Grand Fortune Hotel Nakhon Si Thammarat
3. Fortune Saengchan Beach Hotel
4. The Courtyard Rayong
5. Supalai Oriental Sukhumvit 39
6. Supalai Loft @Khaerai Station
7. Supalai City Resort Chaeng Wattana
8. LPN Mixx Thepharak-Srinakarin
9. Lumpini Ville Sukhumvit 76 - Baering Station
10. Lactasoy Office

SITE 1: CENTRAL PLAZA NAKHON RATCHASIMA

I. General Information

Building Name: **Central Plaza Nakhon Ratchasima**
Building Type: Department store and shopping mall
BEC Group 2-12Hr
Building Area: Total area 298,318.07 m^2
Total building utilization area 173,833.49 m^2
Air conditioning area 171,985 m^2
Non-air conditioning 1,848 m^2
Carpark 117,245 m^2
Number of floors: 5 floors included basement
Start Operation: 2017

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Design	Result
Option 1: By individual component			**Pass**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 40 W/ m^2	37.17	Pass
Roof Thermal Transfer Value (RTTV)	≤ 12 W/ m^2	5.12	Pass
Component 2: Lighting system			
Lighting Power Density (LPD), average of all utilization area	≤ 18 W/ m^2	1.81	Pass
Component 3: Air conditioning system			
Large air conditioning efficiency (Chiller): Centrifugal type	COP ≤ 0.62	0.56	Pass
Split type air conditioner efficiency:	COP ≥ 3.22	3.22	Pass

Assessment	Criteria	Design	Result
Component 4: Hot water generation			
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Solar photovoltaic system for internal self-consumption*	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 22,584,431.59	6,910,949.30	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Remark: * The building installed the solar photovoltaic system one year after the building construction was finished and operated. Therefore, the BEC calculation did not consider this renewable energy utilization to comply with the building construction licensing permit.

Comparison of Actual Construction to Building Design

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete with cement render, Metal sheet and Amplelite sheet.	Unchanged
Transparent wall/window	Clear laminated glass 10 mm for main entrance door and window. Clear low-E glass 10 mm for national lighting sky roof at hall area.	Unchanged
Window to wall ratio (WWR)	0.058	Unchanged
Roof	Concrete with fiber glass insulator , and metal sheet with fiber glass insulation	Unchanged
Component 2: Lighting system		
Lamp type 1	LED bulb 6-40 Watt	Unchanged
Lamp type 2	Tubular LED lamp 18-20 W for staff office and engineering area	Unchanged
Component 3: Air conditioning system		
Large air conditioning system: Water cooled chiller	Centrifugal Chiller 1000 TR x 4 units, COP 0.56 kW/TR	Unchanged
	Centrifugal Chiller 500 TR x 1 unit, COP 0.56 kW/TR	Changed to centrifugal chiller with VSD compressor 1,000 TR x 1 units, 0.54 kW/TR
Split type	Split type air conditioner with label no. 5, 30 units	Unchanged
Component 4: Hot water generation		
Air-source heat pump water heater	Not implemented	Not implemented
Hot water boiler	Not implemented	Not implemented
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Changed. The off-grid solar PV system has an installation capacity of 1 MW, and start operated in June 2021, one year after the building operation.
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		

Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

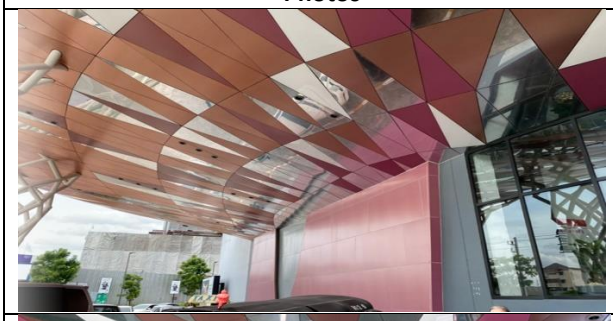
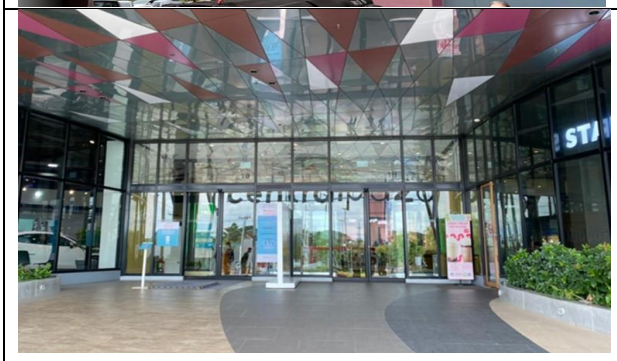
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Main shopping area: central service area, shopping center, and shops	10:30-21:00	10:00-21:00	10:00-21:00
Super market and Food court area	09:00-22:00	09:00-22:00	09:00-22:00
Business office areas	08:00-18:00	08:00-18:00	Partially opens for stand-by service duty
Engineering office	00:00-24:00	00:00-24:00	00:00-24:00

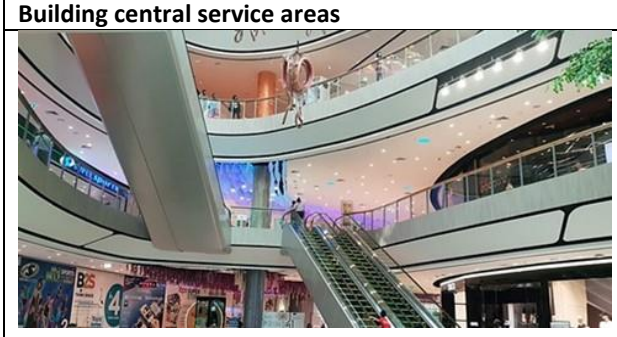
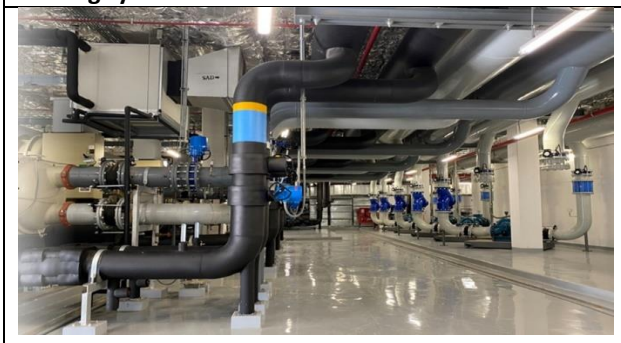
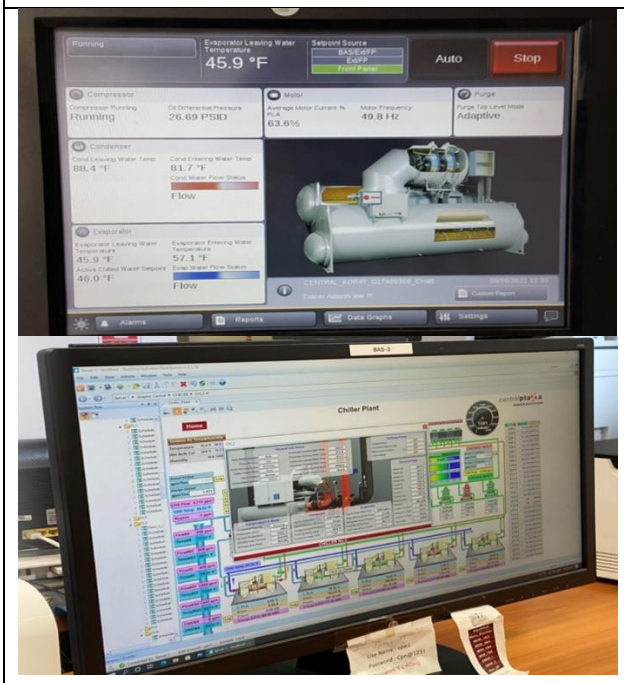
Building utilization

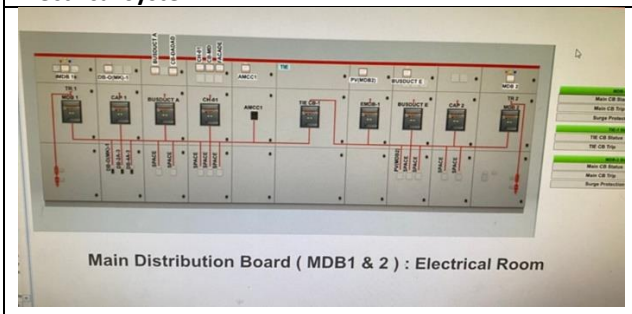
Building utilization level:	More than > 60-80%
Notes on shopping area, shops, main service hall utilization level:	In 2019-2020, during the COVID-19 pandemic, the building was opened and utilized as the vaccination service center; the utilization rate was about 60-80% of the total service area. However, the customer utilization rate in the shopping area and shops are about less than 50% of the normal operation.
Notes on chiller utilization level:	As of less than 50% of customer utilization rate, the chiller utilization level is only 50-60% of total four chillers unit installation, run only two chillers as maximum during COVID-19.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using light weight concrete with metal sheet and amplelite plate. • Windows and transparent wall using clear laminated glass 10 mm

Photos	Notes on the Photos
	• Closer look of opaque wall using light weight concrete with metal sheet and amplelite plate.
	• Closer look of windows and transparent wall using clear laminated glass 10 mm.
	•
	• Concrete roof and Insulation batts with fiber glass, no painted.
	• Metal sheet with fiber glass
	• Clear low-E glass 10 mm for national lighting sky roof at hall area.

Photos	Notes on the Photos
Building central service areas	
	Main shopping center and shops area showing: • Air conditioned with large chiller water cooled system, and concealed cool air duct supply. • Concealed downlight LED lamps, 6 to 18 Watt. • Lighting system in the shopping center and the shops are 100% LED.
	Shopping center and rental shops: • Concealed downlight LED lamps, 6 to 40 Watt for lighting. Installed lighting density for shopping area and shop is 1.81 W/m^2 • Lighting system in the shopping center and the shops (rental area) are 100% LED.
Cooling system	
	Main chilled water supply for cooling system for whole building: • The chiller was utilized only three units as maximum with one chiller stand-by for maintenance operation. • The chiller utilization level is about 50-60%. • The high efficiency chiller with VSD compressor is used to support the cooling load fluctuation.
	Based on the designed, three units of chiller utilization are sufficient to cope with the maximum building cooling load demand in summer; one unit is back up as a stand-by chiller for sequential maintenance. • Each individual chiller has chiller management control board, which linked and integrated the data to display in the overall chiller plant management system in the engineering division. • The overall chiller system is controlled with the chiller management system, and displayed in the monitoring system in the engineering room

Photos	Notes on the Photos
	Split-type air conditioners in the building office area and engineering zone will be used when the building is not in operation, and the shopping area is closed; the chiller system is not operated.
Electrical system	
	Main distribution board for electricity distribution • Metering cabinets installing electricity meters (analog kWh meters) for monitoring and recording of each major equipment, and integrated the data to display in the engineering division.
Renewable utilization	
	Solar photovoltaic power generation system • Off-grid solar PV system has an installation capacity of 1 MW, and start operated in June 2021, one year after the building operation.

IV. Current Energy Management Activities

Energy management structure

Management of electricity consumption of the whole building, including central shopping area, rental shops, central service hall, utilities, and the solar photovoltaic system is under the responsibility of the energy management and engineering team. The CPN headquarter has assigned a head-central of the energy management team to supervise and manage all 30 business subsidiary branches.

The energy management team will report of energy consumption to the center-headquarter energy management team, and submit the annual energy conservation report to DEDE. The building energy management procedure is implemented following the 8 steps of the designated building energy management structure of DEDE, which follows the ISO 50001 standard.

Energy management activities

The energy management team has implemented basic operation and maintenance measures to control the electricity consumption of the central shopping service areas and utilities. Examples of these measures include:

- The building has invested in the solar photovoltaic system one year after the building construction was finished and operated. It was designed as off-grid solar system. The electricity generation from the solar PV system is average 4,000 kWh/day. Total renewable electricity generation is about 1,524,782 kWh/yr. The electricity generated from the solar PV system is used for internal consumption to reduce the energy demand from the national grid.

- Prioritized and scheduled on-off chiller operation to control utility peak demand and matched with the cooling load demand. The overall energy efficiency (kW/Ton) of chiller plant is controlled with the chiller management system.
- The VSD Chiller is able to work in according to the fluctuation load varies, the VSD will reduced the functionality of the compressor to make energy saving up to 10-15%.
- Lighting system in the shopping center and the shops (rental area) are 100% LED.
- The lighting system inside the fire escape ladder and toilets are installed with a motion sensor system to save energy.
- Using a pull switch for each fluorescent lamp in the business office area (staff area)
- The escalator is installed a slow-speed system with a motion sensor detection. When there is no user, the motor will be reduced energy consumption, saving approximately 25% compared to the conventional escalator.
- Regular maintenance of equipment such as chiller, pump, cooling tower, AHU, lamps, lifts, water pumps and etc.

Interest or Plan for Energy Efficiency Improvement
The building is interested in implementing a motion sensor switch for the entire fire escape ladder area of the whole building. The building is also interested in installing the motion sensor in the indoor car park area to reduce unnecessary electricity energy consumption. The building will install a solar LED lighting system in the outdoor car park area and the stress lighting of all surrounding landscapes shortly. It is estimated that energy-saving around 10-15% of the actual lighting energy consumption.

V. Energy Consumption Information

Energy metering system
All energy meters are of digital AMR metering type. Metering of building energy consumption consists of two parts. The first part is the electricity supply to the building's central service area and utilities. The second part is the electricity to each rental shop.

For the rental shops, food restaurants, and food courts, the energy consumption depends on each shop's utilization. The building has a sub-metering for monitoring and billing charge for energy to the render. However, it requires manual reading for consumption data collection for individual rental shops zone.

The energy consumption in each shopping area and shops zone will be recorded in a daily log sheet for billing. The fuel consumption for food restaurants and catering services is monitored and recorded.

Energy data collection and reporting
The electricity consumption of central shopping service areas and utilities is regularly monitored and reported monthly as part of internal operational expense control by the energy management team. The monthly energy consumption and expenditure is reported to the headquarters' accounting business unit center as regular business management.

Energy consumption
The electricity consumption of the whole building and utilities in the year 2020 is 20,239,200 kWh/year. The whole building's total electricity bill is included the energy consumption of all the rental shops in the building. However, it is noted that the BEC calculation did not consider all the electric appliance's energy consumption installed by each rental shop and food restaurant, e.g., decorated lighting, refrigerators and freezer, electric ovens, and cooking devices.

Based on the energy balance recorded by the energy management team, it was reported that the energy balance for the rental shops and shopping area is about 60% of the total energy consumption bill, 30% chiller plant, and lighting and others 10%.

VI. Opinions on BEC Implementation

Benefits from the BEC

The building sees the following benefits on BEC implementation.

1. Helping improve building design and selection of good materials, which benefits to reduce building energy costs
2. Providing good business reputation to the customers and climate friendly.

Problem and obstacles on BEC implementation

Following the BEC compliance criteria design, a higher capital investment cost is required than the typical construction cost; e.g., investment in high efficiency VSD chiller with VSD pump, and LED lighting lamps, it will need an additional investment cost. However, the management considered that it would help save on the energy expenditures cost in the long term.

It is noted that the solar photovoltaic generation system is not designed to comply with BEC compliance during the construction phase, the problem caused by the system design, and supplier selection in the bidding process. Therefore, the solar PV system is installed and operated one year later.

Suggestions

Need the government (DEDE) to support modern technologies' information and subsidy for investment in high-efficiency technologies.

SITE 2: THE GRAND FORTUNE HOTEL NAKHON SI THAMMARAT

I. General Information

Building Name: **The Grand Fortune Hotel Nakhon Si Thammarat**
Building Type: Hotel
BEC Group 3-24Hr
Building Area: Total area 24,500 m^2
Air conditioning area 14,642 m^2
Number of floors: 18 floors, 316 guest rooms
Start Operation by: 2020

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Design	Result
Option 1: By individual component			**Pass**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/ m^2	26.38	Pass
Roof Thermal Transfer Value (RTTV)	≤ 10 W/ m^2	4.86	Pass
Component 2: Lighting system			
Lighting Power Density (LPD), average of all utilization area	≤ 12 W/ m^2	1.55	Pass
Component 3: Air conditioning system			
Large air conditioning efficiency (Chiller): Centrifugal type	COP ≤ 0.76	0.65	Pass

Assessment	Criteria	Design	Result
Large air conditioning efficiency (Chiller): Screw type	COP ≤ 0.78	0.70	Pass
Component 4: Hot water generation			
Air-source heat pump water heater	COP ≥ 0.30	3.48	Pass
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 4,766,736.09 kWh/y	3,127,301.02 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Comparison of Actual Construction to Building Design

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Double laminated green tinted glass 6-6 mm	Unchanged
Window to wall ratio (WWR)	0.28	Unchanged
Roof	Concrete with fiber glass insulator for the roof over air conditioned areas	Unchanged
Component 2: Lighting system		
Lamp type 1	LED bulb 6-18 W	Unchanged
Lamp type 2	Tubular LED lamp 18 W for staff office and engineering area	Unchanged
Component 3: Air conditioning system		
Large air conditioning system: Water cooled chiller	Screw Chiller 350 TR x 1 unit, 0.70 kW/TR	Changed to VSD Screw Chiller 350 TR x 1 unit, 0.65-0.70 kW/TR
	Centrifugal Chiller 350 TR x 2 units, 0.65 kW/TR	Changed to be Magnetic Oil Free Chiller 350 TR x 2 units, 0.65 kW/TR
Split type	Cooing supply from heat pump unit	Changed
Component 4: Hot water generation		
Air-source heat pump water heater	Heating capacity 36,000 watt Cooling capacity 90,077 Btu/hr x 2 units for swimming pool and hotel service area	Unchanged
	Electric water heater for all guest rooms (316 rooms)	Changed
Hot water boiler	Not implemented	Not implemented
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

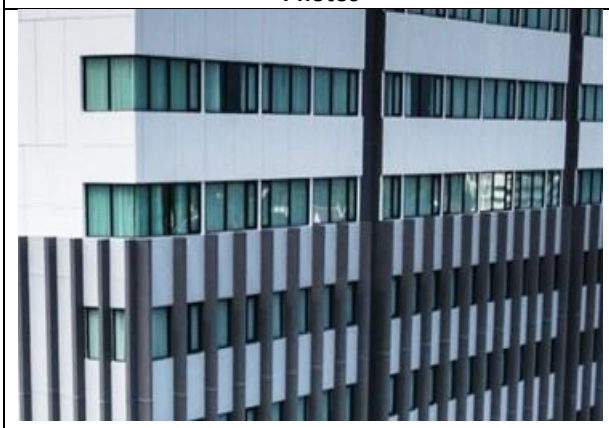
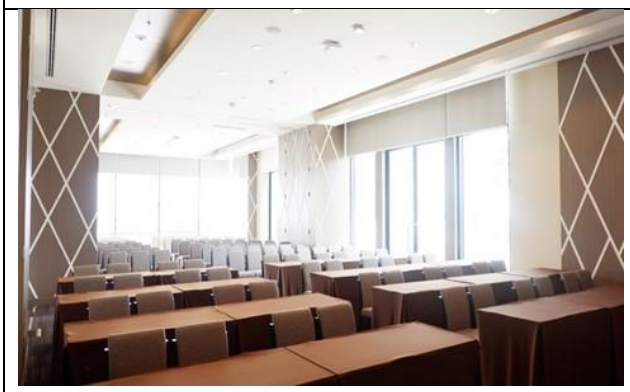
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Guest rooms	00:00-24:00 Depending on occupancy	00:00-24:00 Depending on occupancy	00:00-24:00 Depending on occupancy
Central area: hall way, main lobby, lift	00:00-24:00	00:00-24:00	00:00-24:00
Functional area	Depending on occupancy	Depending on occupancy	Depending on occupancy
Business office areas	08:00-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty
Engineering office	00:00-24:00	00:00-24:00	00:00-24:00

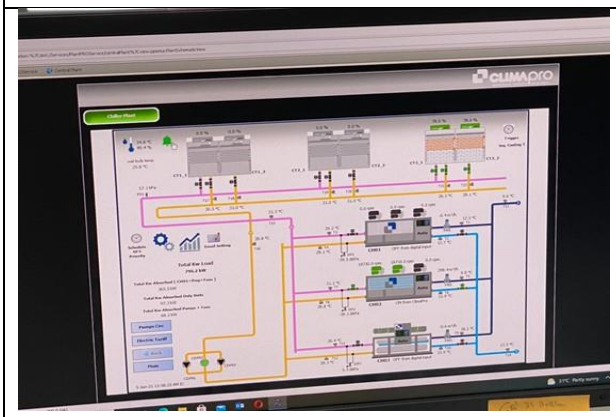
Building utilization

Building utilization level:	Very low <25%
Notes on guest rooms and function rooms utilization level:	In 2020-2021, due to the COVID-19 pandemic, the guest occupancy rate was less than 40-50% of 316 units. Most of the functional room units are partially operated with less than a 10% utilization rate.
Notes on chiller utilization level:	As of less than 50% guest occupancy rate, the chiller utilization level is run less than 50%-60% of total three units installation.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using light weight concrete with mixing of dark and light color. • Windows and transparent wall using double laminated tinted glass (green) 6 mm, 2 layers.

Photos	Notes on the Photos
	• Closer look of windows and transparent wall using double laminated tinted glass.
	• Concrete roof and Insulation batts with fiber glass, no painted.
Building central service areas	
	Main lobby area showing: • Air conditioned with large chiller water cooled system, and concealed cool air duct supply. • Concealed downlight LED lamps, 6 to 18 Watt. • Natural light from transparent wall and windows. •
	Function room area: • Opens from 0800 AM to 12.00 PM. Partially operated or fully operated depend on customer occupancy rate. • Air conditioned with large chiller water cooled system, and concealed cool air duct supply. • Normally the chilled water supply to the function area is not operated, if no events. • Concealed downlight LED lamps, 6 to 18 Watt for lighting. Installed lighting density for function room is 7.09 W/m^2

Photos	Notes on the Photos
Guest rooms	
	Typical interior from the show room of the guest room units showing: • Concealed downlight LED lamps. • Split-type air conditioning units. • Electric appliances including refrigerator, TV, electric kettle. All electric appliances are energy efficiency No.5 label products. • Hot water supplies by air-source heat pump water heater system.
	Hall way and lift area to guest room in each floor: • Hall way areas are non-air conditioned. • Concealed downlight LED lamps. • Utilize of natural light from transparent wall and windows. • Opens 24 hours on floors with guest occupancy, but turns off lighting and cooled air supplied in the floor that no guest occupies.
Cooling system	
	Main chilled water supply for cooling system for whole building: • The chiller was utilized only two units as maximum with one chiller unit run in full-load operation, and one chiller runs in part load. • The chiller utilization level is about 50%-60%. as of less than 50% guest occupancy rate.
	The overall chiller system is controlled with the chiller management system (Climo Pro) with variable speed drive (VSD) pumps.

Photos	Notes on the Photos
Hot Water Generation System	
	Air-source heat pump water heater system: • Original designed 2 units of air source heat pump for swimming pool and hotel service area • Changed from electric water heater for guest rooms to air-source heat pump water heater during the construction phase, with heating capacity 36,000 watts and a cooling capacity 90,077 Btu/hr x 3 units • These additional 3 units of heat pump water heater supply hot water for all guest rooms (316 rooms)
Electrical system	
	Main distribution board for electricity distribution • Metering cabinets installing electricity meters (analog kWh meters) for recording and electricity billing of each major equipment and to main distribution board to each floor.

IV. Current Energy Management Activities

Energy management structure

Management of electricity consumption of the whole building, including guest rooms, central service areas and utilities is under the responsibility of the energy management and engineering team.

Under the Energy Conservation Act, the building energy management procedure is implemented following the 8 steps of the designated building energy management procedure, following ISO 50001. The energy management team will report of energy consumption to the company headquarter, and submit the annual energy conservation report to DEDE.

Energy management activities

The energy management team has implemented basic operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Prioritized and scheduled on-off chiller operation to control utility peak demand and matched with the cooling load demand.
- Use the chiller management system (Climo Pro) to control and manage the three chiller's on-off operations. The most efficient magnetic oil-free chiller is the central unit running as a based load chiller.
- Usually, two units of chiller utilization are sufficient to cope with the building cooling load demand; one unit is back up as a stand-by chiller for sequential maintenance.
- Scheduled on-off operation of lighting in service areas such as lobby, fitness room, hallways.
- Regular maintenance of equipment such as chiller, pump, cooling tower, AHU, lamps, lifts, water pumps and etc.

Interest or Plan for Energy Efficiency Improvement

The building is interested in implementing rooftop solar PV for reduction of energy costs in the near future. The plan is in the business pipeline in the next 3-5 years. However, it is subject to the investment cost and return on investment feasibility and the building owner's approval of the implementation budget.

V. Energy Consumption Information

Energy metering system
Metering of building energy consumption consist of two parts. The first part is the electricity supply to the building's central service area and utilities. The second part is the electricity to each individual residence units. The central area supply and each residence units are all independently operated under separated PEA electricity consumer's contracts. All meters are of analog type and require manual reading for consumption data collection.

Energy data collection and reporting
The electricity consumption of central service areas and utilities is regularly monitored and reported on a monthly basis as part of internal operational expense control by the energy management team. The fuel consumption for food restaurants and catering services is monitored and reported.

The monthly energy consumption and expenditure is reported to the headquarters' accounting business unit center of the company as normal business management.

Energy consumption
The electricity consumption of the whole building and utilities in the year 2020 is 2,435,160 kWh/year. The whole building's total energy consumption is less than the BEC energy consumption baseline estimated. However, it is noted that due to the COVID-19 pandemic in the year 2020 to 2021, the guest occupancy rate was less than 50% of business usual, and most of the functional room units are partially operated with less than a 10% utilization rate. Therefore, the annual electricity consumption in 2020-201 seems to be less than business as usual.

It is acceptable that the monthly energy consumption could fluctuate depending on the guest occupancy rate percentage. However, energy cost per guest room will be monitored and managed within the range of business standard cost ratio per guest room. The standard business cost ratio of energy expenditure is set at 10% of the total business revenue as the maximum ratio.

Energy consumption is estimated at 2,947,000 kWh/hr as BAU by the building management team. The energy utilization index (EUI) is calculated at 26.06 kWh/m3 of total utilization area, and 42.26 kWh/ m^2 for the total air-conditioning services area.

VI. Opinions on BEC Implementation

Benefits from the BEC
The building sees the following benefits on BEC implementation.
1. Helping improve building design and selection of good materials.
2. Benefits of reducing building energy costs
3. Providing good business reputation to the hotel customers with good standard design and climate friendly.

Problem and obstacles on BEC implementation
None.
It is noted that the current energy management teams are not involved in BEC design and implementation during the construction phase.

Suggestions
1. Concern if there is penalty applied on non-compliance to the BEC.
2. Need to increase understanding of BEC to the Local Administrative Organization which involves in review and approval of building construction.

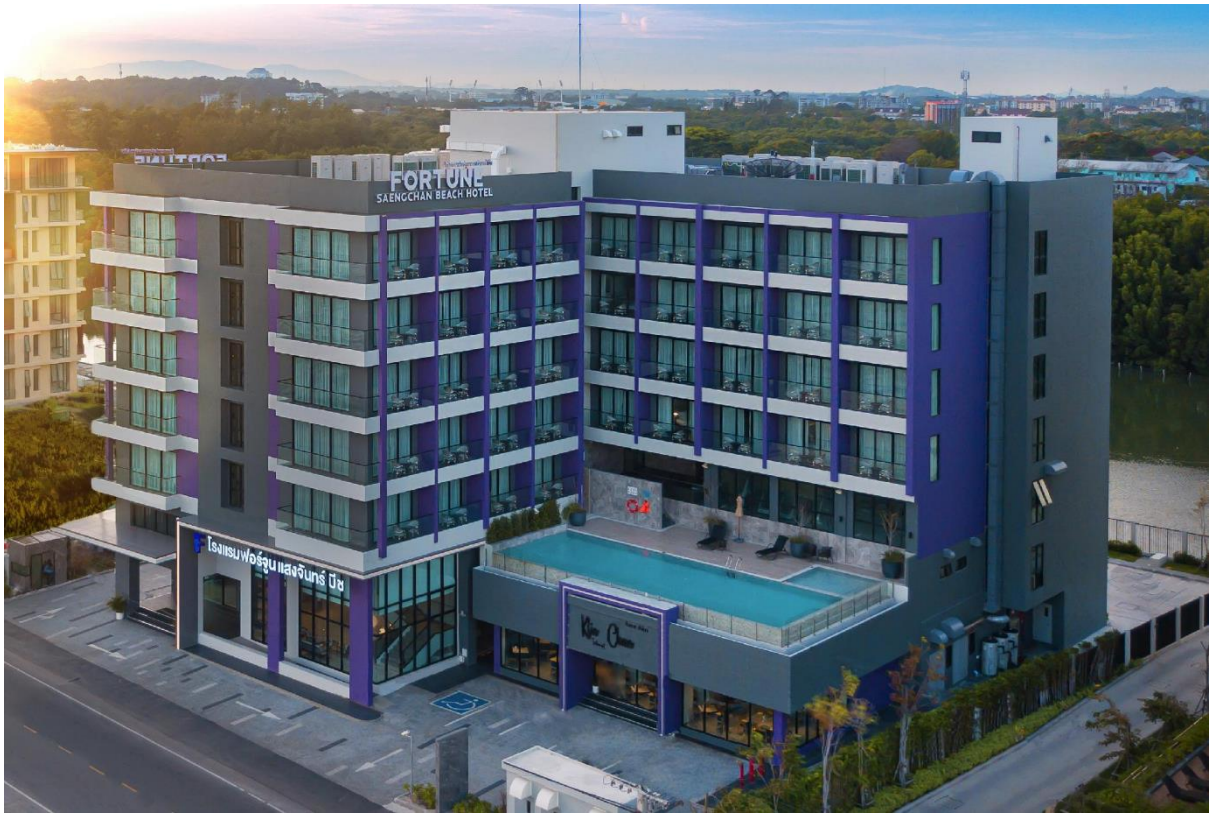
3. Property Management Association of Thailand (PMA) could provide good inputs on the implementation and integration of BEC to the related residence building and condominium laws and regulations

SITE 3: FORTUNE SAENG CHAN BEACH HOTEL, RAYONG

I. General Information

Building Name: **Fortune Saeng Chan Beach Hotel, Rayong**
Building Type: Hotel
Total Floor Area: 8,600 m^2
Number of floors: 7 floors, 107 guest rooms

Overall Photo



II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/ m^2	55.01	Fail
Roof Thermal Transfer Value (RTTV)	≤ 6 W/ m^2	4.91	Pass
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/ m^2	2.07	Pass
Component 3: Air conditioning system			
VRF air conditioning system	≤ 1.12 kW/RT COP ≥ 3.14	0.88 kW/RT COP = 4.0	Pass
Component 4: Hot water generation			
Electric hot water heater	NA	NA	NA

Assessment	Criteria	Design	Result
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 1,469,581.35 kWh/y	840,779.61 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Comparison of Actual Construction to Building Design

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated tinted glass 8 mm	Unchanged
Window to wall ratio (WWR)	0.44	Unchanged
Roof	Concrete with fiber glass insulator for the roof over air conditioned areas4	Unchanged
Component 2: Lighting system		
Lamp type 1	Tubular LED lamp	Unchanged
Lamp type 2	LED bulb	Unchanged
Component 3: Air conditioning system		
Central air conditioning system	VRF air conditioning system	Unchanged
Component 4: Hot water generation		
Hot water boiler	Electric hot water heater	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

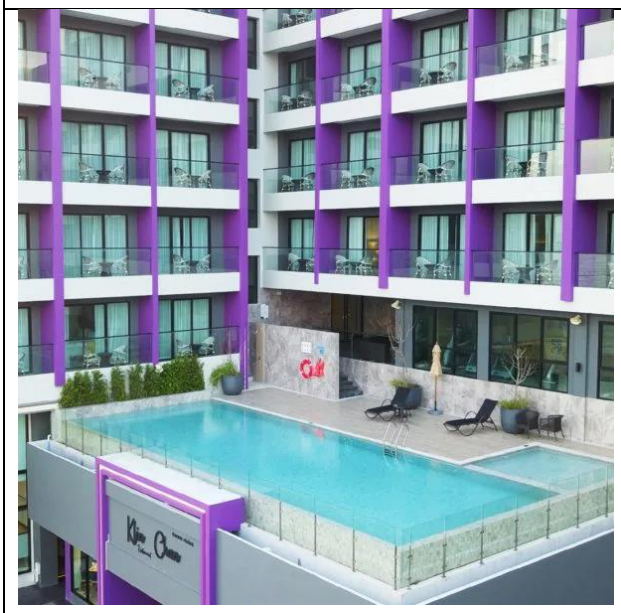
Main building areas and operating hours

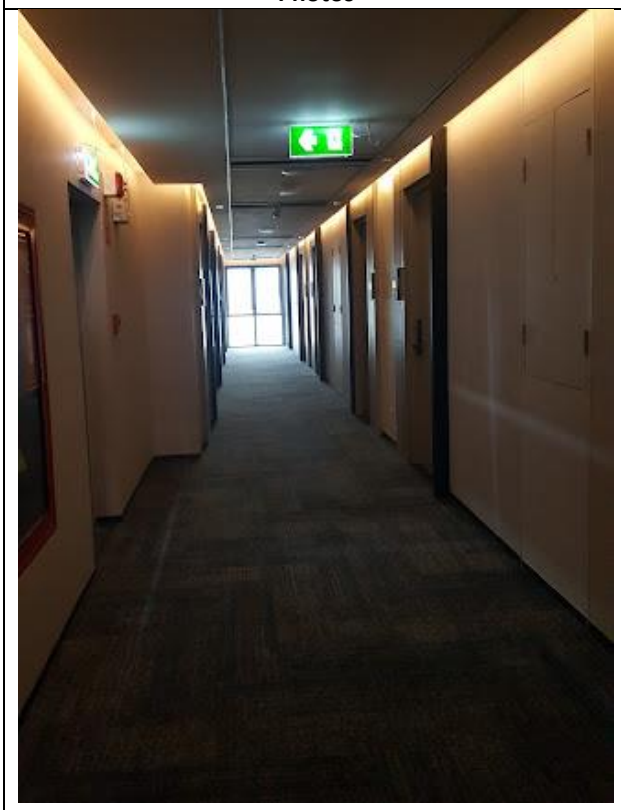
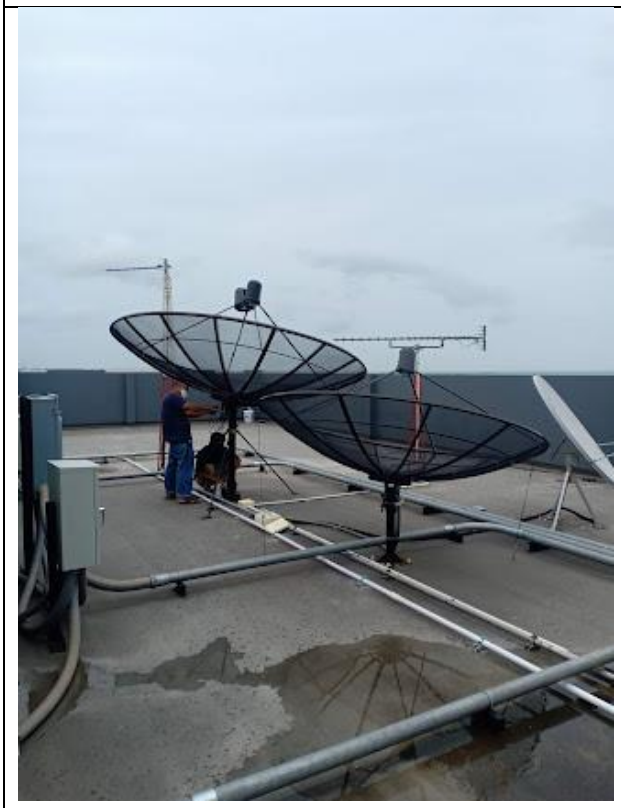
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Guest rooms	Depending on occupancy	Depending on occupancy	Depending on occupancy
Central area: main lobby, lift, corridors	00:00-24:00	00:00-24:00	00:00-24:00
Meeting rooms	Depending on activities	Depending on activities	Depending on activities
Dining rooms	06:00-10:00/11:00-22:00	06:00-10:00/11:00-22:00	06:00-10:00/11:00-22:00
Fitness center	08:00-22:00	08:00-22:00	08:00-22:00
Swimming pool	08:00-22:00	08:00-22:00	08:00-22:00
Hotel administration office	08:00-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty

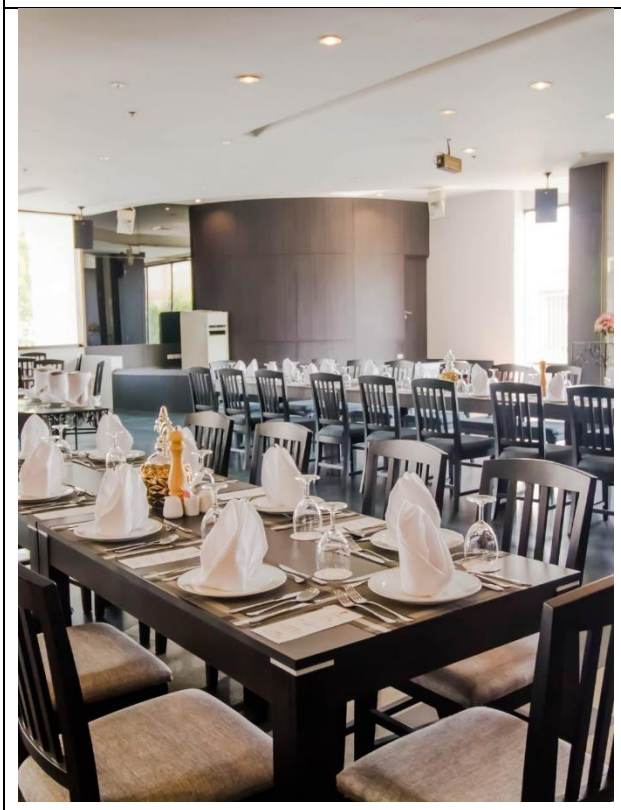
Building utilization

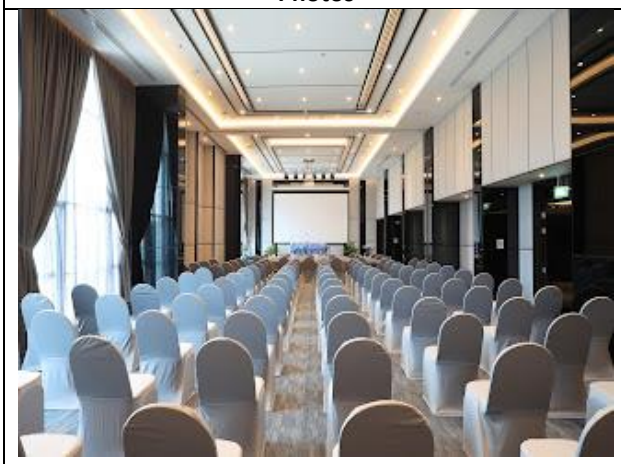
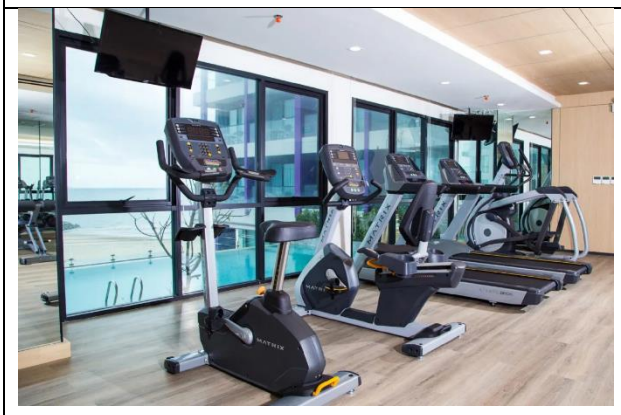
Building utilization level:	Moderate with 60-70% occupancy
Notes on utilization level:	The hotel is being used for COVID-19 quarantine for the private company. Guest rooms are partially occupied and usages of other facilities such as fitness center, meeting rooms and dining rooms are limited.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using light weight concrete. • Windows and transparent walls using laminated tinted glass.
	• Closer look of transparent walls with laminated tinted glass and some shading by the balcony in each room.

Photos	Notes on the Photos
	• Hotel corridor to guest rooms with concealed tubular LED lamps.
	• Concrete roof with water prevention coating.
Building areas	

Photos	Notes on the Photos
	• Main lobby with decorated LED lamps.
	• Dining room with concealed downlight LED lamps.
	• Meeting room with concealed downlight LED lamps and transparent wall with day lighting.

Photos	Notes on the Photos
	
	• Fitness center with concealed downlight LED lamps and transparent walls.
 	Typical interior of guest rooms showing: • Concealed downlight LED lamps. • Concealed fan coil of the VRF air conditioning system. • Electric appliances including LED TV and refrigerator.

Photos	Notes on the Photos
 	• View from the luxury guest rooms with transparent walls for sea view and daylighting.
Building Utilities	
Electrical system	
	• 1250 kVA PEA transformer for electricity supply to the building

Photos	Notes on the Photos
	• 275 kVA backup diesel generator.
Air conditioning system	
 	• Condensing units of the VRF air conditioning system for the whole building.
Hot water generation system	

Photos	Notes on the Photos
	• 3 units of electric hot water heaters for central production of hot water.

IV. Current Energy Management Activities

Energy management structure

The hotel is the designated building under the Energy Conservation Act. The hotel has formed the energy management working committee for driving hotel's energy efficiency and complying with related energy management regulations. The hotel implements the energy management system according to DEDE's regulation for designated buildings.

In addition the hotel energy management committee has strong support from the hotel group's facility management and central engineering company in design and implementation of energy efficiency technologies. Energy efficiency and renewable energy is set as the corporate policy and implemented in all facilities in the group company.

Energy management activities

The hotel implements operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Scheduled on-off operation to reduced unnecessary energy waste.
- Regular maintenance of equipment such as air conditioning system, lamps, lifts, water pumps and etc.

Interest or Plan for Energy Efficiency Improvement

1. Energy-efficient glass

The BEC team recommends changing of glass on transparent walls from 8 mm laminated to 8 mm reflective glass to reduce air conditioning heat gain. From the web-based BEC calculation OTTV could be reduced from 55.01 W/ m^2 to 28.75 W/m^2.

2. Rooftop Solar PV

The hotel is planning to install roof top solar PV within the next 6 months to reduce energy supply from PEA.

3. Smart building system

The hotel is interested in implementing smart technology for automatic real-time monitoring of electricity and fuel consumption.

V. Energy Consumption Information

Energy metering system
Metering of building energy consumption is done by the AMR meter installed by PEA to record total electricity consumption for electricity billing of the hotel. PEA provides the internet system to track daily load profile and consumption.

Energy data collection and reporting
Through the energy management system building energy consumption is regularly monitored and reported on a monthly basis. The energy reports are generated to the energy reporting format for designated buildings for internally use and submission to DEDE.

Energy consumption
The electricity consumption since the opening of the hotel in June 2020 is estimated around 873,971 kWh/year.

VI. Opinions on BEC Implementation

Benefits from the BEC
The building sees benefits of BEC in providing good image to the customers.

Problem and obstacles on BEC implementation
1. The selection of materials to meet BEC criteria affects building envelope outlook and design.
2. The BEC assessment process is rather complicated.

Suggestions
1. Concern if there is penalty applied on non-compliance to the BEC.
2. It would be good if the web-based BEC program could be utilized for analysis of energy conservation measures.

SITE 4: THE COURTYARD RAYONG

I. General Information

Building Name: **The Courtyard Rayong**
Building Type: Condominium
Total Building Area: 6,700 m^2
Number of floors: 7 floors, 137 residence units

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	48.84	Fail
Roof Thermal Transfer Value (RTTV)	≤ 6 W/m^2	4.89	Pass
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	1.52	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			

Assessment	Criteria	Design	Result
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 956,268.21 kWh/y	598,910.95 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Comparison of Actual Construction to Building Design

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Ocean green tinted glass 8 mm	Unchanged
Window to wall ratio (WWR)	0.55	Unchanged
Roof	Concrete with fiber glass insulator for the roof over air conditioned areas4	Unchanged
Component 2: Lighting system		
Lamp type 1	Tubular LED lamp 18 W	Unchanged
Lamp type 2	LED bulb 7 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

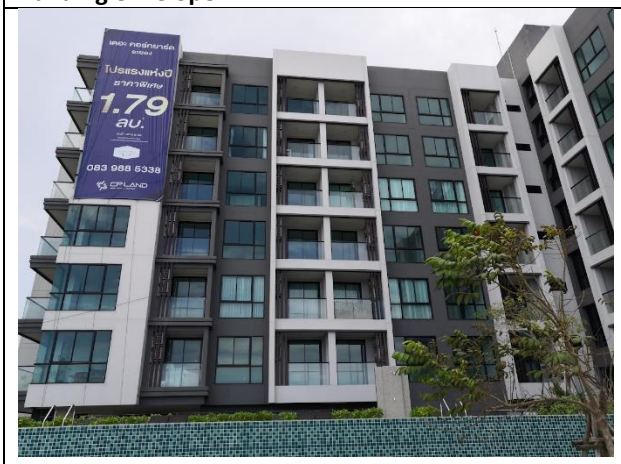
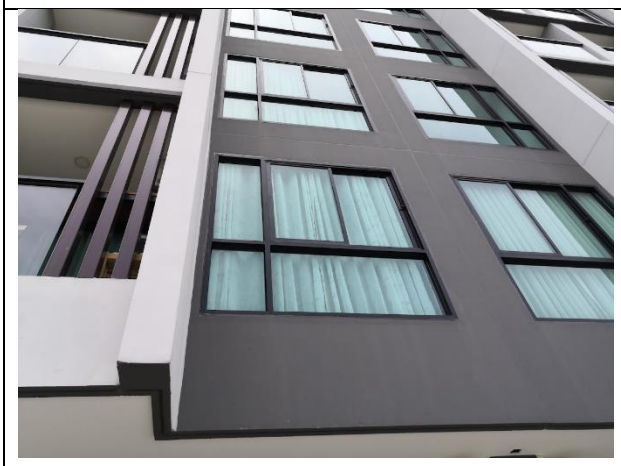
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Residence units	Depending on occupancy	Depending on occupancy	Depending on occupancy
Central areas: corridors, main lobby, lift	00:00-24:00	00:00-24:00	00:00-24:00
Fitness center	06:00-22:00	06:00-22:00	06:00-22:00
Condominium Juristic person office	08:00-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty

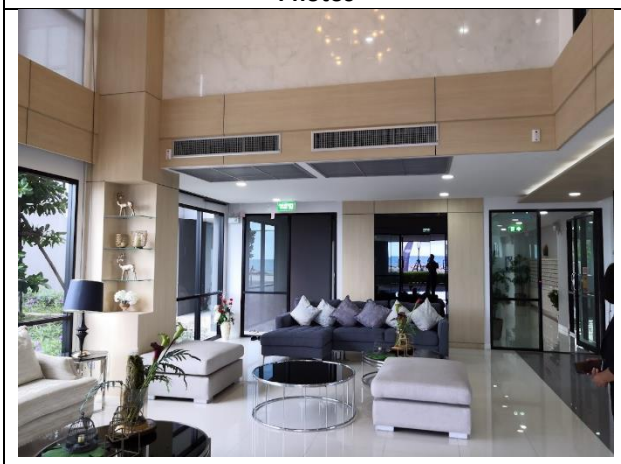
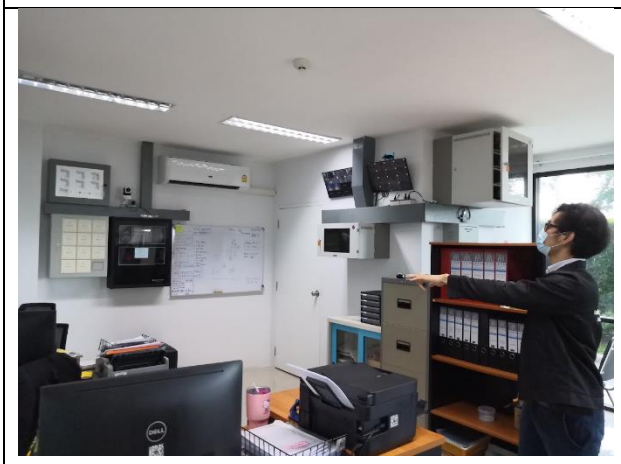
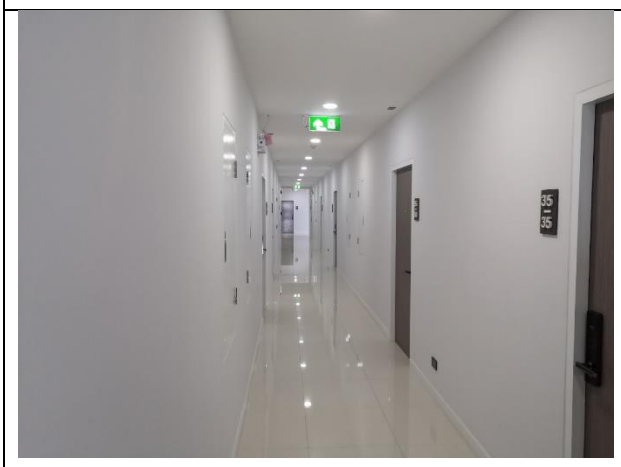
Building utilization

Building utilization level:	Very low <25%

Notes on utilization level:	Only 26 units out of 137 units have completed transfer of ownership. Most of the residence unit occupancies occur during weekends and holidays.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using light weight concrete with mixing of dark and light color. • Windows and transparent wall using ocean green tinted glass.
	• Closer look of windows and transparent wall using ocean green tinted glass.
	• Concrete roof with water prevention coating.
Building central service areas	

Photos	Notes on the Photos
	Main lobby area showing: • Concealed split type air conditioner, 24,000 Btu/h capacity. Normally not operated. Only operated during hot days with high occupancy. • Concealed downlight LED lamps. • Natural light from transparent wall and windows.
	Juris person office: • Opens from 0800-1800 weekday • Partial opens 24 hours for stand-by maintenance duty. • Air conditioned with split type air conditioners. • Tubular LED lamps for lighting.
	Corridor to residence units in each floor: • Corridors are non-air conditioned. • Concealed downlight LED lamps. • Opens 24 hours on floors with residence occupancy.
Residence units	

Photos	Notes on the Photos
 	Typical interior from the sample room of the residence units showing: • Concealed downlight LED lamps. • Split-type air conditioning units. • Electric appliances including refrigerator, microwave and exhaust hood.
	• Split-type air conditioning units for residence units.

Photos	Notes on the Photos
	
Electrical system	
	• Main distribution board for electricity distribution to residence units on each floor.
	• Metering cabinets installing electricity meters (analog kWh meters) for recording and electricity billing of each residence unit.

IV. Current Energy Management Activities

Energy management structure

Management of electricity consumption of the building's central service areas and utilities is under the responsibility of condominium juristic person. Energy consumption of the residence units are individually managed by their tenants.

Energy management activities
Juristic person management team has implemented basic operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Scheduled on-off operation of lighting in service areas such as lobby, fitness room, hallways.
- Regular maintenance of equipment such as split-type air conditioners, lamps, lifts, water pumps and etc.

There is no evidence of energy efficient measure implementation on the residence units as they are individually owned and out of Juristic person scope of responsibility.

Interest or Plan for Energy Efficiency Improvement
Juristic person is interested in implementing rooftop solar PV for reduction of energy costs in the near future. However it is subject to the Condominium juristic person committee's opinions and approval on the implementation budget.

V. Energy Consumption Information

Energy metering system
Metering of building energy consumption consist of two parts.

- Electricity supply to the building's central service area and utilities, and
- Electricity supply to each individual residence units.

Both parts are all independently operated under separated PEA electricity consumer's contracts. All meters are of analog type and require manual reading for consumption data collection.

Energy data collection and reporting
Only electricity consumption of central service areas and utilities is regularly monitored and reported on a monthly basis as part of internal operational expense control by juristic person management team.

Energy consumption
The electricity consumption of the building service areas and utilities in year 2020 is 102,884 kWh/year. However this is only small portion of the whole buildings as the consumption of all residence units are not included in the report.

VI. Opinions on BEC Implementation

Benefits from the BEC
The building sees the following benefits on BEC implementation.

1. Helping improve building design and selection of good materials.
2. Providing good marketing outlook to the customers with good standard design.

Problem and obstacles on BEC implementation
None.

Suggestions

1. Concern if there is penalty applied on non-compliance to the BEC.
2. Need to increase understanding of BEC to the Local Administrative Organization which involves in review and approval of building construction.
3. Property Management Association of Thailand (PMA) could provide good inputs on the implementation and integration of BEC to the related residence building and condominium laws and regulations

SITE 5: SUPALAI ORIENTAL SUKHUMVIT 39, BANGKOK

I. General Information

Building Name: **Supalai Oriental Sukhumvit 39, Bangkok**
Building Type: Condominium
Total No. of Buildings: 4 buildings (A, B, C, D)
Total No. of Residence units: 1,046 residence units
Building A and B: Total area 23,283 m^2, 25 floors
Building C and D: Total area 31,331 m^2, 35 floors

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Building A and B

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	A: 42.07 W/m^2 B: 42.28 W/m^2	Fail
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2 (see note 1)	7.74 W/m^2	Pass (see note 2)
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	A: 3.60 W/m^2	Pass

Assessment	Criteria	Design	Result
		B: 3.59 W/m^2	
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	A: ≤ 4,694,730.18 kWh/y B: ≤ 4,699,755.94 kWh/y	A: 2,805,676.23 kWh/y B: 2,810,760.35 kWh/y	Pass
Overall BEC compliance	**Building A: Comply by Option 2** **Building B: Comply by Option 2**		**Pass**

Building C and D

Assessment	Criteria	Design	Result
Option 1: By individual component			**C: Pass** **D: Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	C: 26.01 W/m^2 D: 41.43 W/m^2	C: Pass D: Fail
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2 (See note 1)	6.68 W/m^2	Pass (See note 2)
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	C: 3.29 W/m^2 D: 4.11 W/m^2	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.41	Pass
Component 4: Hot water generation			
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	A: ≤ 5,546,612.54 kWh/y B: ≤ 5,544,311.81 kWh/y	A: 2,629,652.01 kWh/y B: 2,998,950.05 kWh/y	Pass
Overall BEC compliance	**Building C: Comply by Option 1 and 2** **Building D: Comply by Option 2**		**Pass**

Notes:

1. The BEC criteria applied in assessment of the building design is BEC 2009 version, which set the RTTV limit for condominium at 10 W/m^2. Current BEC has revised the RTTV to 6 W/m^2.
2. Appling current BEC, these buildings would fail on the RTTV limit of 6 W/m^2.

Comparison of Actual Construction to Building Design

Building A and B

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated tinted glass 8 mm	Unchanged
Window to wall ratio (WWR)	0.54	Unchanged
Roof	Concrete roof covering by green roof garden	Unchanged
Component 2: Lighting system		
Lamp type	Tubular LED lamp and LED bulb 18-32 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

Building C and D

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated tinted glass 6 mm	Unchanged
Window to wall ratio (WWR)	0.61	Unchanged
Roof	Concrete roof covering by green roof garden	Unchanged
Component 2: Lighting system		
Lamp type	Tubular LED lamp and LED bulb 18-32 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

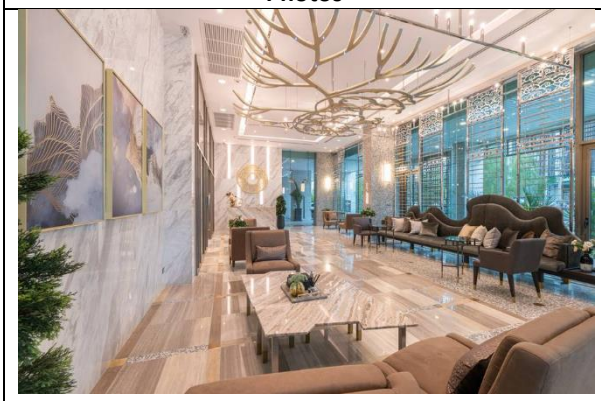
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Residence units	Depending on occupancy	Depending on occupancy	Depending on occupancy
Central areas: corridors, main lobby, lift	00:00-24:00	00:00-24:00	00:00-24:00
Fitness center, swimming pool	06:00-22:00	06:00-22:00	06:00-22:00
Condominium Juristic person office	08:00-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty

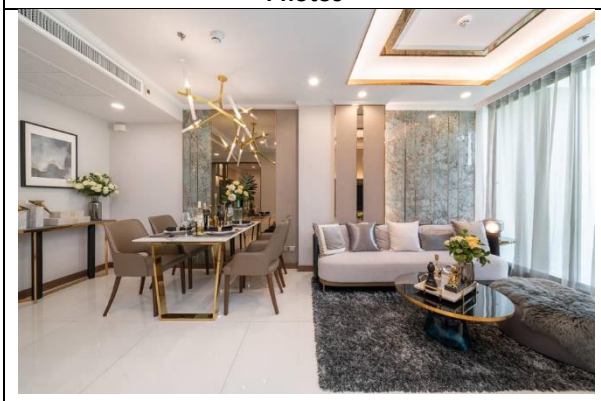
Building utilization

Building utilization level:	Very low <5%
Notes on utilization level:	Just opened in 2020, the condominium has average occupancy only 1-4%.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using precast concrete with light color. • Windows and transparent wall using mainly laminated tinted glass.
	• Windows and transparent wall using ocean green laminated tinted glass. • Green roof with plantation over concrete roof for space utilization and heat protection.
Building central service areas	

Photos	Notes on the Photos
	Main lobby area showing: • Concealed split type air conditioner. • Decorated and tubular LED lamps. • Transparent walls for natural light and external view.
	Resting area showing: • Decorated and concealed downlight LED lamps. • Transparent walls for natural light and external view.
Residence units	
	Interior of the bedroom of the small sample residence unit showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning units.
	Interior of the bedroom of the small sample residence unit showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning units.

Photos	Notes on the Photos
	Interior of the integrated dining and living room of the medium-sized sample residence unit showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning units.
	• Interior of the bathroom with downlight LED lamps and small window for ventilation.

IV. Current Energy Management Activities

Energy management structure

Management of electricity consumption of the building's central service areas and utilities is under the responsibility of condominium juristic person. Energy consumption of the residence units are individually managed by their tenants.

Energy management activities

Juristic person management team has implemented basic operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Scheduled on-off operation of lighting in service areas such as lobby, fitness room, hallways.
- Regular maintenance of equipment such as split-type air conditioners, lamps, lifts, water pumps and etc.
- Offering 2-year free cleaning of air conditioners after the ownership transfer of each residence unit.

There is no evidence of energy efficient measure implementation on the residence units as they are individually owned and out of Juristic person scope of responsibility.

Interest or Plan for Energy Efficiency Improvement

The BEC team has recommended to change the glass of the top floor from laminated to reflective glass to reduce heat gain through transparent walls and windows.

V. Energy Consumption Information

Energy metering system

Metering of building energy consumption consist of two parts.

- Electricity supply to the building's central service area and utilities, and
- Electricity supply to each individual residence units.

Both parts are all independently operated under separated MEA electricity consumer's contracts. All meters are of analog type and require manual reading for consumption data collection.

Energy data collection and reporting
Electricity consumptions of central service areas and utilities are collected daily. Consumption data are summarized and reported on a monthly basis as part of internal operational expense control by juristic person management team.

Energy consumption
The electricity consumption of the building service areas and utilities in year 2020-2021 is estimated at 2,064,960 kWh/year. However this is only small portion of the whole buildings as the consumption of all residence units are not included in the report.

VI. Opinions on BEC Implementation

Benefits from the BEC
The building management team see the following benefits of BEC implementation.

1. Helping reduce building operation costs.
2. Good response to national policy on energy efficiency and GHG emission reduction.
3. Providing good marketing outlook to the customers with good standard design.

Problem and obstacles on BEC implementation
None.

Suggestions

1. Request supporting advice for Condominium juristic person to maintain and further improve energy efficiency of the buildings in the long term.

SITE 6: SUPALAI LOFT @KHAERAI STATION, NONTHABURI

I. General Information

Building name:	**Supalai Loft @Khaerai Station, Nonthaburi**
Building type:	Condominium
Total No. of buildings:	1 building
Total floor area:	41,780 m^2
Total no. of floors:	33 floors, 424 residence units

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	31.96 W/m^2	Fail
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2 (see note 1)	3.98 W/m^2	Pass (see note 2)
Component 2: Lighting system			

Assessment	Criteria	Design	Result
Lighting Power Density (LPD)	≤ 12 W/m^2	2.07 W/m^2	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	4,956,833.06 kWh/y	2,156,380.23 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Notes:

1. The BEC criteria applied in assessment of the building design is BEC 2009 version, which set the RTTV limit for condominium at 10 W/m^2. Current BEC has revised the RTTV to 6 W/m^2.
2. Appling current BEC, these buildings would fail on the RTTV limit of 6 W/m^2.

Comparison of Actual Construction to Building Design

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated tinted glass 6 & 8 mm	Unchanged
Window to wall ratio (WWR)	0.22	Unchanged
Roof	Concrete roof covering by green roof garden	Unchanged
Component 2: Lighting system		
Lamp type	LED bulb 11 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

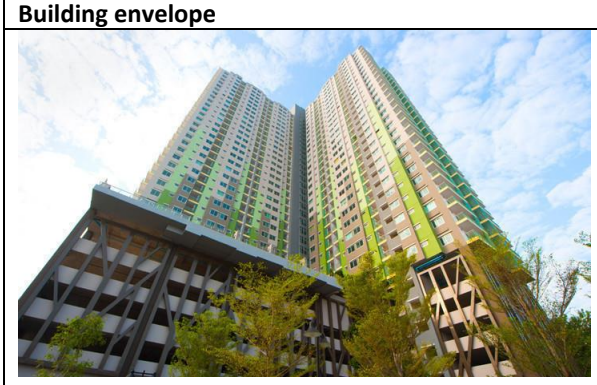
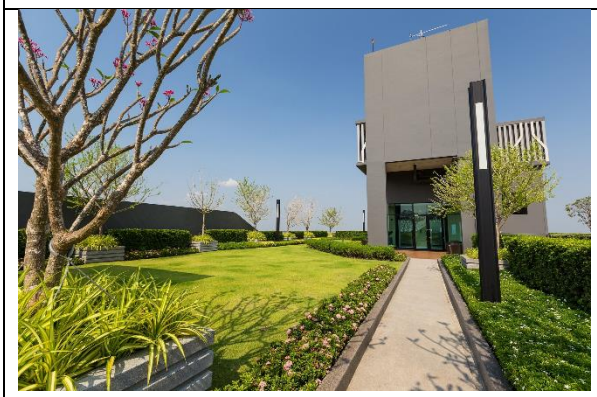
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Residence units	Depending on occupancy	Depending on occupancy	Depending on occupancy
Central areas: corridors, main lobby, lift	00:00-24:00	00:00-24:00	00:00-24:00

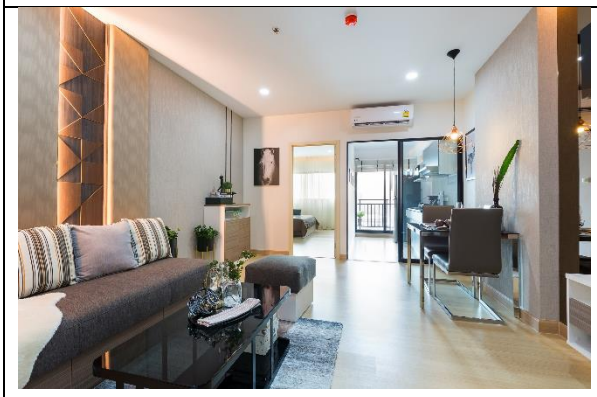
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Fitness center, swimming pool	06:00-22:00	06:00-22:00	06:00-22:00
Condominium Juristic person office	08:00-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty

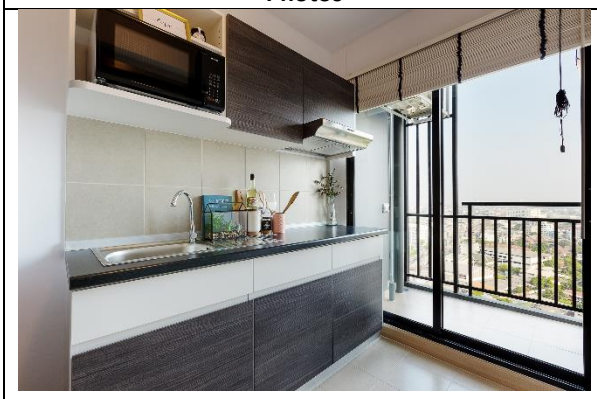
Building utilization

Building utilization level:	Moderate around 50%
Notes on utilization level:	Since its opening in 2018, 50% of the residence units have been sold and occupied.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using light weight concrete and light brown and green colors. • Windows and transparent wall using mainly laminated tinted glass.
	• Green roof with plantation over concrete roof for space utilization and heat protection.
Building central service areas	
	• Main lobby area showing decorated and tubular LED lamps.

Photos	Notes on the Photos
	• Lift hall and mail box areas with concealed downlight LED lamps.
	Fitness room showing: • Transparent walls for natural lighting. • Decorated and concealed downlight LED lamps. • Concealed air conditioning units.
Residence units	
	Interior of the living room of the sample residence unit showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning unit.
	Interior of the bedroom of the sample residence unit showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning unit.

Photos	Notes on the Photos
	Interior of the kitchen of the sample residence unit showing: • Transparent wall for natural lighting. • Verandah for outdoor atmosphere and shading to the transparent wall.

IV. Current Energy Management Activities

Energy management structure

Management of electricity consumption of the building's central service areas and utilities is under the responsibility of condominium juristic person. Energy consumption of the residence units are individually managed by their tenants.

Energy management activities

Juristic person management team has implemented basic operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Scheduled on-off operation of lighting in service areas such as lobby, fitness room, hallways.
- Regular maintenance of equipment such as split-type air conditioners, lamps, lifts, water pumps and etc.

There is no evidence of energy efficient measure implementation on the residence units as they are individually owned and out of Juristic person scope of responsibility.

Interest or Plan for Energy Efficiency Improvement

The BEC team has recommended adding of insulation and gypsum board to the opaque walls of the air conditioning areas.

V. Energy Consumption Information

Energy metering system

Metering of building energy consumption consist of two parts.

- Electricity supply to the building's central service area and utilities, and
- Electricity supply to each individual residence units.

Both parts are all independently operated under separated MEA electricity consumer's contracts. All meters are of analog type and require manual reading for consumption data collection.

Energy data collection and reporting

Electricity consumptions of central service areas and utilities are collected daily. Consumption data are summarized and reported on a monthly basis as part of internal operational expense control by juristic person management team.

Energy consumption

The electricity consumption of the building service areas and utilities in year 2020 is 279,508 kWh/year. However this is only small portion of the whole buildings as the consumption of all residence units are not included in the report.

VI. Opinions on BEC Implementation

Benefits from the BEC

The building management team see the following benefits of BEC implementation.

1. Helping reduce building operation costs.
2. Good response to national policy on energy efficiency and GHG emission reduction.
3. Providing good marketing outlook to the customers with good standard design.

Problem and obstacles on BEC implementation

None.

Suggestions

1. Request supporting advice for Condominium juristic person to maintain and further improve energy efficiency of the buildings in the long term.

SITE 7: SUPALAI CITY RESORT CHAENG WATTANA, NONTHABURI

I. General Information

Building name: **Supalai City Resort Chaeng Wattana, Nonthaburi**
Building type: Condominium
Total No. of buildings: 1 building
Total floor area: 56,006 m^2
Total no. of floors: 24 floors, 758 residence units

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	33.83 W/m^2	Fail
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2 (see note 1)	5.06 W/m^2	Pass (see note 2)
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	1.87 W/m^2	Pass
Component 3: Air conditioning system			

Assessment	Criteria	Design	Result
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	9,176,541.00 kWh/y	3,309,334.73 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Notes:
1. The BEC criteria applied in assessment of the building design is BEC 2009 version, which set the RTTV limit for condominium at 10 W/m^2. Current BEC has revised the RTTV to 6 W/m^2.
2. Appling current BEC, these buildings would fail on the RTTV limit of 6 W/m^2.

Comparison of Actual Construction to Building Design

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated tinted glass 6 mm	Unchanged
Window to wall ratio (WWR)	0.43	Unchanged
Roof	Concrete roof covering by green roof garden and outdoor lounge	Unchanged
Component 2: Lighting system		
Lamp type	Tubular LED and LED bulb 18 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

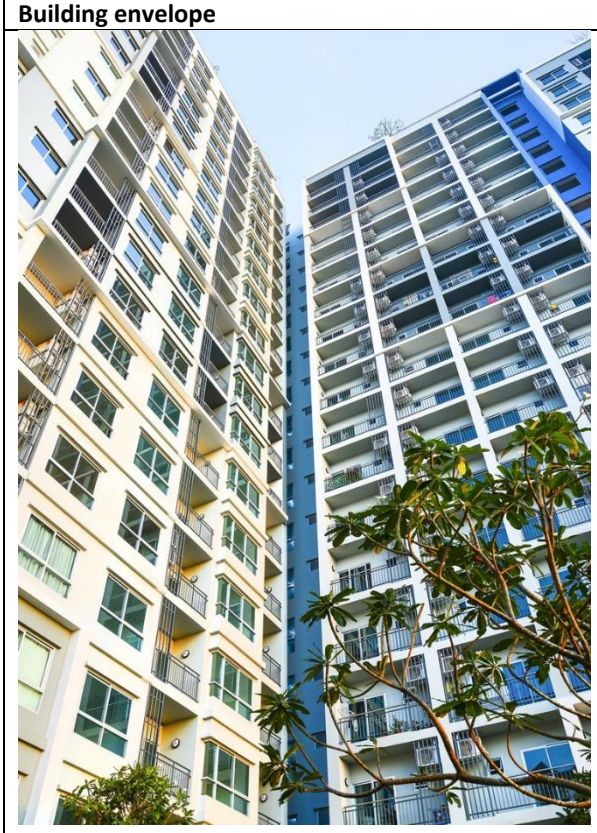
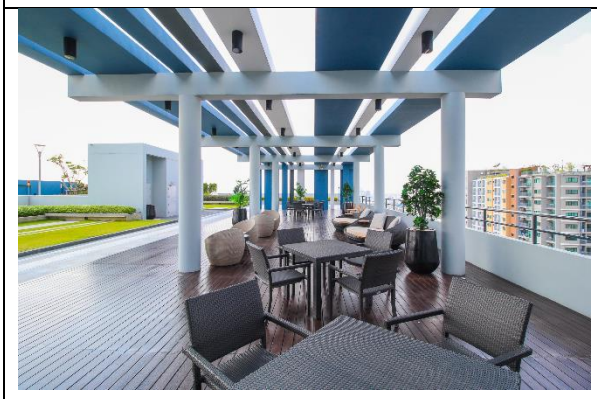
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Residence units	Depending on occupancy	Depending on occupancy	Depending on occupancy
Central areas: corridors, main lobby, lift	00:00-24:00	00:00-24:00	00:00-24:00
Fitness center, swimming pool	06:00-22:00	06:00-22:00	06:00-22:00

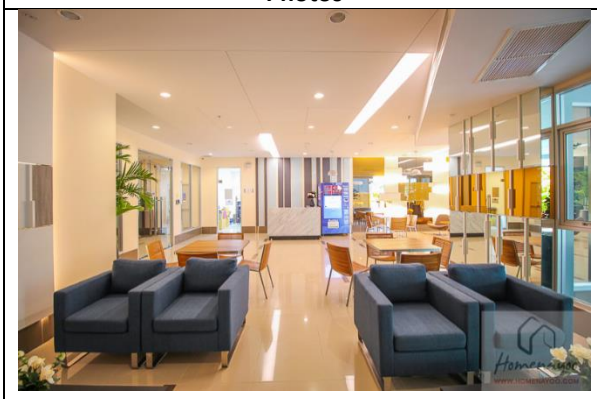
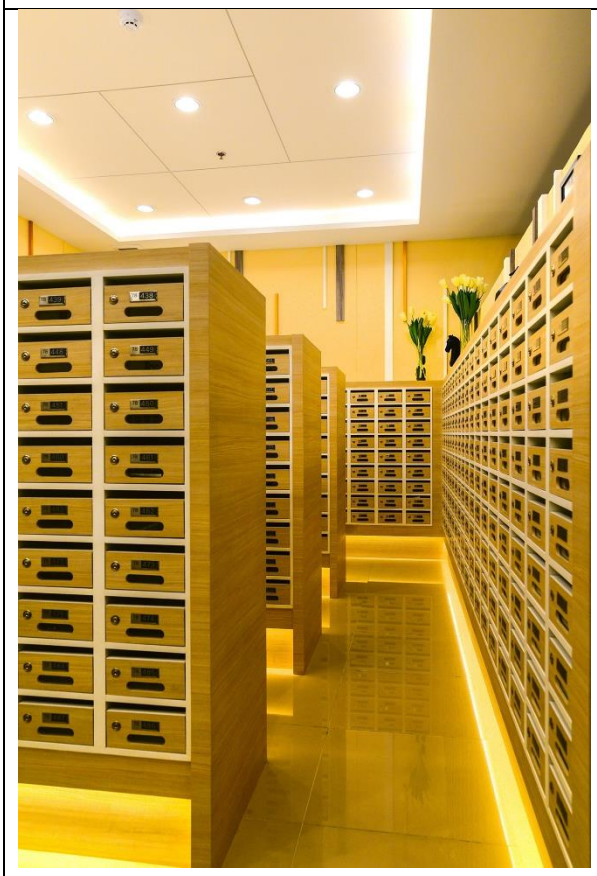
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Condominium Juristic person office	08:00-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty

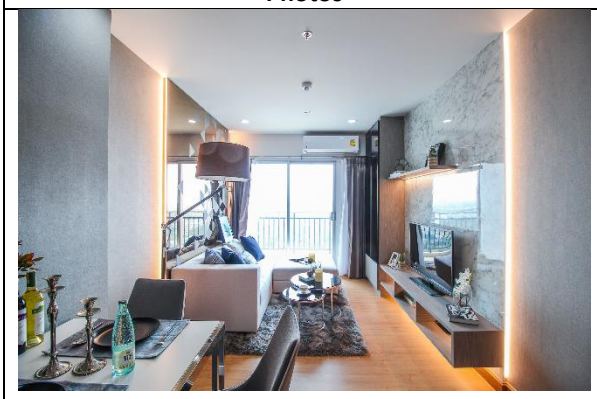
Building utilization

Building utilization level:	Moderate around 60%
Notes on utilization level:	Since its opening in 2018, 60% of the residence units have been sold and occupied.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using light weight concrete and light colors. • Windows and transparent wall using laminated tinted glass.
	• Concrete roof being covered by garden and outdoor lounge.
Building central service areas	

Photos	Notes on the Photos
	Main lobby area showing: • Tubular LED and concealed downlight LED lamps. • Concealed air conditioning unit.
	• Lift hall and mail box areas with concealed downlight and decorated LED lamps.
	Fitness room showing: • Transparent walls for natural lighting. • Decorated and concealed downlight LED lamps. • Concealed air conditioning units.
Residence units	

Photos	Notes on the Photos
	Interior of the living room of the sample residence unit showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning unit.
	Interior of the bedroom of the sample residence unit showing: • Transparent walls for natural lighting. • Verandah for outdoor atmosphere and shading provision to the transparent wall. • Concealed downlight LED lamps. • Split-type air conditioning unit.

IV. Current Energy Management Activities

Energy management structure

Management of electricity consumption of the building's central service areas and utilities is under the responsibility of condominium juristic person. Energy consumption of the residence units are individually managed by their tenants.

Energy management activities

Juristic person management team has implemented basic operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Scheduled on-off operation of lighting in service areas such as lobby, fitness room, hallways.
- Regular maintenance of equipment such as split-type air conditioners, lamps, lifts, water pumps and etc.

There is no evidence of energy efficient measure implementation on the residence units as they are individually owned and out of Juristic person scope of responsibility.

Interest or Plan for Energy Efficiency Improvement

The BEC team has recommended changing of glass types for transparent walls of the air conditioned areas from 6 mm laminated tinted glass to 6mm reflective glass.

V. Energy Consumption Information

Energy metering system

Metering of building energy consumption consist of two parts.

- Electricity supply to the building's central service area and utilities, and

- Electricity supply to each individual residence units.

Both parts are all independently operated under separated MEA electricity consumer's contracts. All meters are of analog type and require manual reading for consumption data collection.

Energy data collection and reporting
Electricity consumptions of central service areas and utilities are collected daily. Consumption data are summarized and reported on a monthly basis as part of internal operational expense control by juristic person management team.

Energy consumption
The electricity consumption of the building service areas and utilities in year 2020 is 617,240 kWh/year. However this is only small portion of the whole buildings as the consumption of all residence units are not included in the report.

VI. Opinions on BEC Implementation

Benefits from the BEC
The building management team see the following benefits of BEC implementation.

1. Helping reduce building operation costs.
2. Good response to national policy on energy efficiency and GHG emission reduction.
3. Providing good marketing outlook to the customers with good standard design.

Problem and obstacles on BEC implementation
None.

Suggestions

1. Request supporting advice for Condominium juristic person to maintain and further improve energy efficiency of the buildings in the long term.

SITE 8: LUMPINI MIXX THEPHARAK-SRINAKARIN, SAMUTPRAKARN

I. General Information

Building name: **Lumpini Mixx Thepharak-Srinakarin, Samutprakarn**
Building type: Condominium
Total No. of buildings: 7 buildings (A1-A3, B1-B4)
Total No. of residence units: 2,041 residence units
Building A1-A3: 8 floors
Building B1-B4: 8 floors

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Building A1-A3

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	51.32 W/m^2	Fail
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2 (see note 1)	4.19 W/m^2	Pass (see note 2)
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	3.65 W/m^2	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 1,743,972.95 kWh/y	1,038,083.80 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Building B1-B4

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	39.97 W/m^2	Fail
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2 (See note 1)	4.56 W/m^2	Pass (See note 2)
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	3.96 W/m^2	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 1,830,868.71 kWh/y	1,104,415.82 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Notes:

1. The BEC criteria applied in assessment of the building design is BEC 2009 version, which set the RTTV limit for condominium at 10 W/m^2. Current BEC has revised the RTTV to 6 W/m^2.
2. Appling current BEC, these buildings would fail on the RTTV limit of 6 W/m^2.

Comparison of Actual Construction to Building Design

Building A1-A3

Component	Design	Actual Construction
Component 1: Building envelope		

Component	Design	Actual Construction
Opaque wall	Precast concrete	Unchanged
Transparent wall/window	Tinted glass 5 & 6 mm	Unchanged
Window to wall ratio (WWR)	0.41-0.48	Unchanged
Roof	Concrete roof with insulation	Unchanged
Component 2: Lighting system		
Lamp type	Fluorescent lamp 18-36 W	Changed to LED lamps after operation
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

Building B1-B4

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Precast concrete	Unchanged
Transparent wall/window	Tinted glass 5 mm	Unchanged
Window to wall ratio (WWR)	0.11-0.14	Unchanged
Roof	Concrete roof with insulation	Unchanged
Component 2: Lighting system		
Lamp type	Fluorescent lamp 32-36 W	Changed to LED lamps after operation
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Residence units	Depending on occupancy	Depending on occupancy	Depending on occupancy

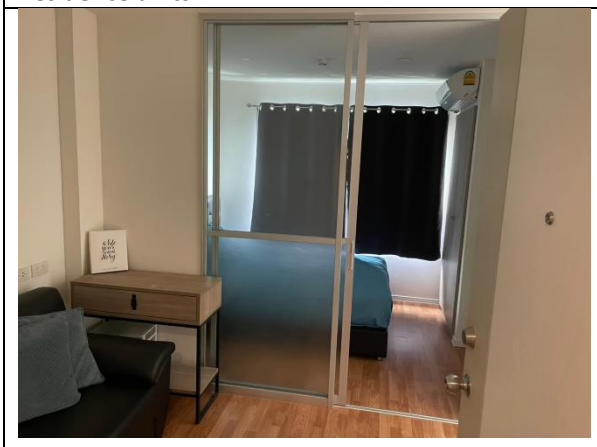
Central areas: corridors, main lobby, lift	00:00-24:00	00:00-24:00	00:00-24:00
Fitness center, swimming pool	06:00-22:00	06:00-22:00	06:00-22:00
Condominium Juristic person office	08:30-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty

Building utilization

Building utilization level:	High 80%
Notes on utilization level:	The residence units are mostly sold with average occupancy around 80%.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using precast concrete with light color. • Windows and transparent wall using tinted glass.
	• Roof made of concrete slab.
Building central service areas	

Photos	Notes on the Photos
	Library room showing: • Concealed split type air conditioner. • Concealed downlight LED lamps. • Transparent walls for natural lighting.
Residence units	
	Interior of the example bedroom in small residence units showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning units.
 	• Split-type air conditioner for the residence unit.

Photos	Notes on the Photos
Electrical system	
	• Floor power distribution board and analog electricity meters for measuring electricity consumption and billing of each residence unit.

IV. Current Energy Management Activities

Energy management structure
Management of electricity consumption of the building's central service areas and utilities is under the responsibility of condominium juristic person. Energy consumption of the residence units are individually managed by their tenants.

Energy management activities
Juristic person management team has implemented basic operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Scheduled on-off operation of lighting in service areas such as lobby, fitness room, hallways.
- Regular maintenance of equipment such as split-type air conditioners, lamps, lifts, water pumps and etc.

The juristic persons of all condominiums under the LPN group follow standard practice of LPN green community management in saving energy and maintaining good environment.

There is no evidence of energy efficient measure implementation on the residence units as they are individually owned and out of Juristic person scope of responsibility.

Interest or Plan for Energy Efficiency Improvement
The BEC team has recommended to change the glass of the air conditioned areas from tinted glass to reflective glass to reduce heat gain through transparent walls and windows.

V. Energy Consumption Information

Energy metering system
Metering of building energy consumption consist of two parts.

- Electricity supply to the building's central service area and utilities, and
- Electricity supply to each individual residence units.

Both parts are all independently operated under separated MEA electricity consumer's contracts. All meters are of analog type and require manual reading for consumption data collection.

Energy data collection and reporting

Electricity consumptions of central service areas and utilities are collected daily. Consumption data are summarized and reported on a monthly basis as part of internal operational expense control by juristic person management team.

Energy consumption

The electricity consumption of the building service areas and utilities in year 2020 is 680,271 kWh/year. However this is only small portion of the whole buildings as the consumption of all residence units are not included in the report.

VI. Opinions on BEC Implementation

Benefits from the BEC

The building management team see the following benefits of BEC implementation.

1. Helping reduce building operation costs.
2. Good response to national policy on energy efficiency and GHG emission reduction.
3. Providing good marketing outlook to the customers with good standard design.

Problem and obstacles on BEC implementation

Passing of the OTTV criteria for condominium could result in very high investment cost causing high unit selling prices and affecting the customer target groups of medium to low priced condominiums.

Suggestions

1. Suggest separation of BEC assessment criteria for condominium buildings as condominiums have different area utilization and energy consumption characteristics from hotels and hospitals which are in the same group of 24 hour operation.

SITE 9: LUMPINI VILLE SUKHUMVIT 76, SAMUTPRAKARN

I. General Information

Building name: **Lumpini Ville Sukhumvit 76-Baering Station, Samutprakarn**
Building type: Condominium
Total No. of buildings: 4 buildings (A, B, C, D)
Total No. of floors: 8 floors

Overall Photo

II. BEC Assessment of Design Documents

BEC Assessment Result

Building A, B, C, D

Assessment	Criteria	Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	45.76 W/m^2	Fail
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2 (see note 1)	5.05 W/m^2	Pass (see note 2)
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	4.08 W/m^2	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			

Assessment	Criteria	Design	Result
Not Installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 1,777,349.32 kWh/y	1,144,489.05 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Notes:

1. The BEC criteria applied in assessment of the building design is BEC 2009 version, which set the RTTV limit for condominium at 10 W/m^2. Current BEC has revised the RTTV to 6 W/m^2.
2. Appling current BEC, these buildings would fail on the RTTV limit of 6 W/m^2.

Comparison of Actual Construction to Building Design

Building A, B, C, D

Component	Design	Actual Construction
Component 1: Building envelope		
Opaque wall	Precast concrete	Unchanged
Transparent wall/window	Tinted glass and clear glass 5 mm	Unchanged
Window to wall ratio (WWR)	0.23-0.79	Unchanged
Roof	Concrete roof with insulation	Unchanged
Component 2: Lighting system		
Lamp type	Fluorescent lamp 18-36 W	Changed to LED lamps after operation
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

III. Current Building Operation Status

Main building areas and operating hours

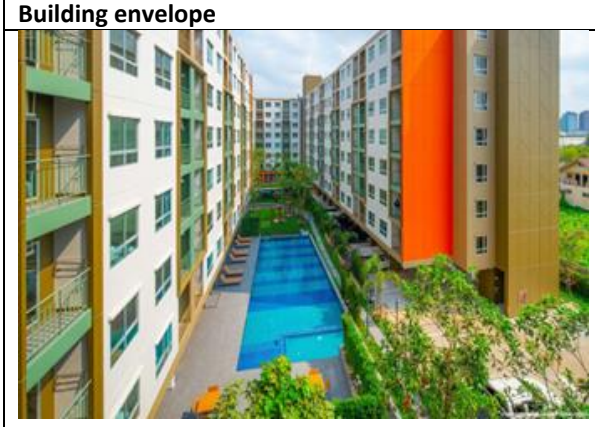
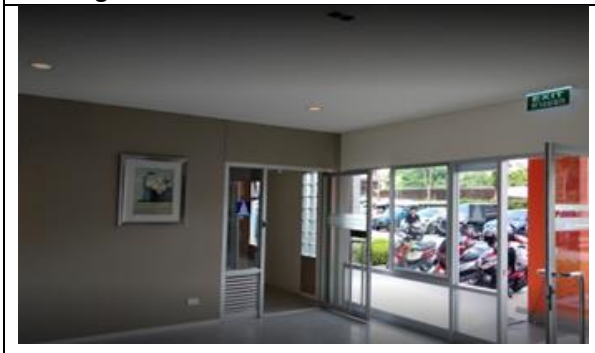
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Residence units	Depending on occupancy	Depending on occupancy	Depending on occupancy
Central areas: corridors, main lobby, lift	00:00-24:00	00:00-24:00	00:00-24:00
Fitness center, swimming pool	06:00-22:00	06:00-22:00	06:00-22:00

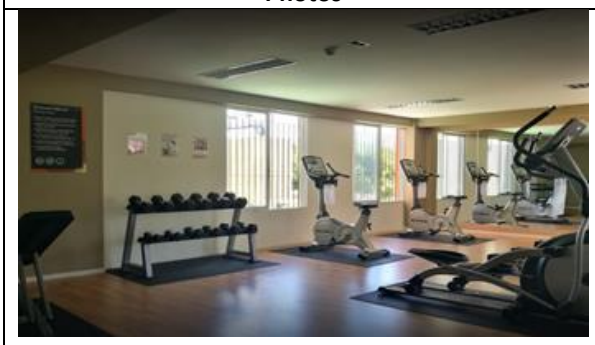
Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Condominium Juristic person office	08:30-18:00	Partially opens for stand-by maintenance duty	Partially opens for stand-by maintenance duty

Building utilization

Building utilization level:	High 90%
Notes on utilization level:	The residence units are mostly sold with average occupancy around 90%.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	
	Showing building envelope comprising: • Opaque wall using precast concrete with mixing of light and bright colors. • Windows and transparent wall using tinted glass.
	• Roof made of concrete slab.
Building central service areas	
	Main entrance area showing: • Concealed downlight LED lamps. • Transparent walls for natural lighting.

Photos	Notes on the Photos
	Fitness room showing: • Concealed tubular fluorescent lamps. • Transparent walls for natural lighting
Residence units	
 	Interior of the bedroom of the sample residence unit showing: • Transparent walls for natural lighting. • Concealed downlight LED lamps. • Split-type air conditioning units.
Electrical system	
	• Floor power distribution board and analog electricity meters for measuring electricity consumption and billing of each residence unit.

IV. Current Energy Management Activities

Energy management structure

Management of electricity consumption of the building's central service areas and utilities is under the responsibility of condominium juristic person. Energy consumption of the residence units are individually managed by their tenants.

Energy management activities
Juristic person management team has implemented basic operation and maintenance measures to control the electricity consumption of the central service areas and utilities. Examples of these measures include:

- Scheduled on-off operation of lighting in service areas such as lobby, fitness room, hallways.
- Regular maintenance of equipment such as split-type air conditioners, lamps, lifts, water pumps and etc.

The juristic persons of all condominiums under the LPN group follow standard practice of LPN green community management in saving energy and maintaining good environment.

There is no evidence of energy efficient measure implementation on the residence units as they are individually owned and out of Juristic person scope of responsibility.

Interest or Plan for Energy Efficiency Improvement
The BEC team has recommended to change the glass of the air conditioned areas from tinted glass to reflective glass to reduce heat gain through transparent walls and windows.

V. Energy Consumption Information

Energy metering system
Metering of building energy consumption consist of two parts.

- Electricity supply to the building's central service area and utilities, and
- Electricity supply to each individual residence units.

Both parts are all independently operated under separated MEA electricity consumer's contracts. All meters are of analog type and require manual reading for consumption data collection.

Energy data collection and reporting
Electricity consumptions of central service areas and utilities are collected daily. Consumption data are summarized and reported on a monthly basis as part of internal operational expense control by juristic person management team.

Energy consumption
The electricity consumption of the building service areas and utilities in year 2020 is 382,971 kWh/year. However this is only small portion of the whole buildings as the consumption of all residence units are not included in the report.

VI. Opinions on BEC Implementation

Benefits from the BEC
The building management team see the following benefits of BEC implementation.

1. Helping reduce building operation costs.
2. Good response to national policy on energy efficiency and GHG emission reduction.
3. Providing good marketing outlook to the customers with good standard design.

Problem and obstacles on BEC implementation
Passing of the OTTV criteria for condominium could result in very high investment cost causing high unit selling prices and affecting the customer target groups of medium to low priced condominiums.

Suggestions

1. Suggest separation of BEC assessment criteria for condominium buildings as condominiums have different area utilization and energy consumption characteristics from hotels and hospitals which are in the same group of 24 hour operation.

SITE 10: LACTASOY NEW OFFICE BUILDING, BANGKOK

I. General Information

Building name:	**Lactasoy New Office Building, Bangkok**
Building type:	Office
Total no. of buildings:	1 buildings
Total floor areas:	8,300 m^2, 3 floors with mezzanine

Overall Photo

II. Energy Efficiency Design in relevant to BEC

This building was previously used as factory. The building was bought by the current owner and modified to 3-stoery modernized office. The redesign of the building incorporates high-end building envelope materials and implements advanced energy-efficient building systems and controls. With no BEC enforcement on the retrofitted building, the design of this building was not fully assessed by the BEC program. However the building has participated and received the financial subsidy from DEDE on the implementation of the air conditioning, lighting technologies which are better than the BEC requirements.

Opaque walls

Most of the opaque wall portions of the building envelope are enclosed with the wall insulator and aluminum composite exterior to prevent heat transfer to the air conditioned areas.

Transparent walls
The building is designed to with high window-to-wall ration for high levels of natural light. To limit the heat gain, the heat stop low-e glass with very low solar heat gain (SHGC) of 0.19 is implemented to all transparent walls.

Roof
All roof areas are provided with insulation and air gap to minimize heat gain through roof.

Air conditioning system
Building utilizes two air conditioning systems for optimize the air conditioning to the area usage.
1. 200RT of Oil free magnetic bearing chiller system is used for air conditioning supply to most of the building areas.
2. VRF system provides air conditioning for management and server rooms to with flexibility of usage and high efficiency at low cooling loads. The VRF avoids energy waste from using chiller system to supply occasional cooling loads or small areas after normal office hours.

Building automation
The building implements building automation system for optimized control of the building functions and securities. Most of the lightings are automatically switched to the set schedule while room temperatures are zoning controlled. Digital power meters are installed for online tracking of energy consumption of the major electricity consuming loads.

III. Current Building Operation Status

Main building areas and operating hours

Main Areas	Monday-Friday	Saturday-Sunday	Holidays
Office areas	08:00-18:00	08:00-18:00	Closed
Management rooms and meetings	08:00-18:00 Occasional	08:00-18:00 Occasional	Occasional
Server room	00:00-24:00	00:00-24:00	00:00-24:00

Building utilization

Building utilization level:	Around 50%
Notes on utilization level:	At the initial opening half of the space will be utilized for office, and the remaining will be used for warehouse and future office expansion.

Photos taken from the Building

Photos	Notes on the Photos
Building envelope	

Photos	Notes on the Photos
	• Opaque wall with insulation and aluminium composite.
	• Transparent walls with heat stop low-e insulating glass and vertical blinds for shading.
	• Transparent walls providing high amount of natural light to the office areas and walk ways.

IV. Current Energy Management Activities

Energy management structure

Following the company policy, the energy consumption of the building is managed under the dedicated department. Energy efficiency is closely monitored and reported to the responsible persons. The overall efficiency and energy costs are overseen by top management.

Energy management activities

The dedicated energy management team has implemented basic operation and maintenance measures to control the electricity consumption of the buildings. Regular maintenance of equipment are executed regularly for maintain their best efficiency and working conditions.

Interest or Plan for Energy Efficiency Improvement
Energy efficiency is part of the continual improvement company policy. External consultants and technology expertise will be contracted to support the internal team in exploring new technologies for further implementation.

V. Energy Consumption Information

Energy metering system
Most of the energy consuming equipment and system are installed with digital meters for automatically record the consumption and real-time monitoring.

VI. Opinions on BEC Implementation

Benefits from the BEC
The building management team see the following benefits of BEC implementation.

1. Helping reduce building operation costs.
2. Good support to national policy on energy efficiency and GHG emission reduction.

Problem and obstacles on BEC implementation
The unclear scope explanation and complication faced during the submission of design documents for subsidy application. Most of the problems could be avoided if the proper application forms are designed and deployed.

Suggestions

1. Include BEC trainings to all related professional associations including engineers and architects.
2. Incorporate BEC to the university and education institutes.
3. Conduct more BEC training courses for BEC auditors. Current trainings are in high demanded and fully booked quickly.

ANNEX-2 BEC CASE EXAMPLES

1. Buriram Provincial Hall
2. Office of the Attorney Building
3. Dhanaphiphat Building
4. S Oasis
5. Red Planet Surawong
6. Siam@Siam Design Hotel
7. OPD and Emergency Building, Somdet Phra Sangharaja 19 Hospital
8. Synphaet Medical Complex, Synphaet Ramintra Hospital
9. The Circle 2
10. The Cuvee Tiwanon

CASE NO.1: BURIRAM PROVINCIAL HALL, BURIRAM

I. General Information

Building Name: **Buriram Provincial Hall, Buriram Province**
Building Type: Office
Total Floor Area: 16,634 m^2
Air Conditioned Area: 11,113 m^2
Number of Floors: 4 floors
Current Status: In operation

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 50 W/m^2	49.63	Pass
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2	14.19	Fail
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 10 W/m^2	5.77	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			

Assessment	Criteria	Final Design	Result
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 977,000 kWh/y	600,634 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Comparison of Actual Construction to Building Design

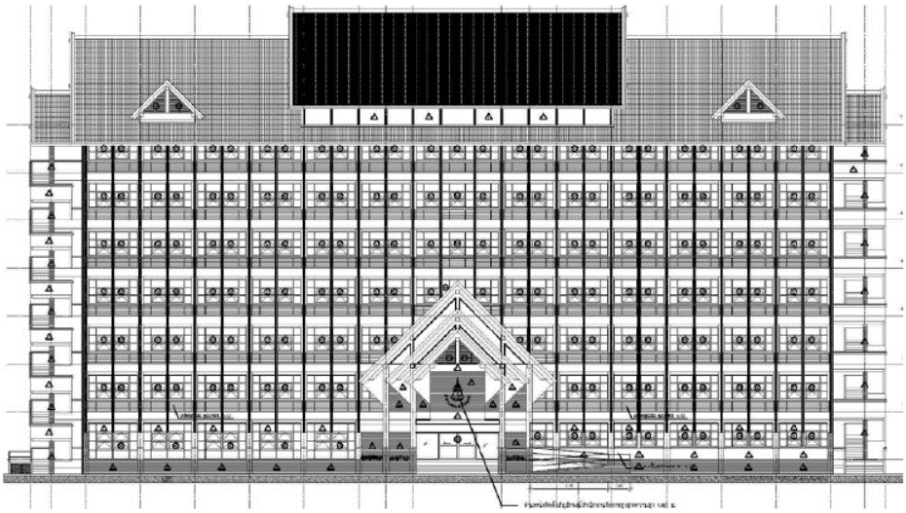
Component	Original Design	Final Design after Assessment
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated tinted glass 6 mm	Unchanged
Window to wall ratio (WWR)	0.25	Unchanged
Roof	Concrete roof tile with 3 m air gap and 9 mm gypsum board	Concrete roof tile with aluminum foil, 3 m air gap and 9 mm gypsum board
Energy efficient features	• Terrace for air conditioner installation and window shading. • High-pitched gable roof for heat ventilation.	Unchanged
Component 2: Lighting system		
Lamp type	Fluorescent lamps 14-28 W	LED lamps 9-20 W
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

CASE NO.2: OFFICE OF THE ATTORNEY BUILDING

I. General Information

Building Name:	**Office of the Attorney Building**
Building Type:	Government Office
Total Floor Area:	6,429 m^2
Air Conditioned Area:	2,656 m^2
Number of Floors:	7 floors
Current Status:	Design prototype

Photo/Picture



II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 50 W/m^2	44.26	Pass
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2	14.85	Fail
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 10 W/m^2	4.92	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 323,255 kWh/y	169,024 kWh/y	Pass

Assessment	Criteria	Final Design	Result
Overall BEC compliance	**Comply by Option 2**		**Pass**

Comparison of Actual Construction to Building Design

Component	Original Design	Final Design after Assessment
Component 1: Building envelope		
Opaque wall	Masonry brick with cement render	Light weight concrete
Transparent wall/window	Laminated clear glass 6 mm	Laminated tinted glass 6 mm
Window to wall ratio (WWR)	0.45	Unchanged
Roof	Concrete roof tile with 3.5 m air gap and 9 mm gypsum board	Concrete roof tile with aluminum foil, 3.5 m air gap and 9 mm gypsum board
Energy efficient features	• Walking terrace and shading devices for window shading. • High-pitched gable roof for heat ventilation.	Unchanged
Component 2: Lighting system		
Lamp type	LED lamps 1-20 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

CASE NO.3: DHANAPHIPHAT BUILDING, BANGKOK

I. General Information

Building Name:	**Dhanaphiphat Building, Bangkok**
Building Type:	Office
Total Floor Area:	4,630 m^2
Number of Floors:	3 floors
Current Status:	In operation

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Pass**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 50 W/m^2	37.44	Pass
Roof Thermal Transfer Value (RTTV)	≤ 10 W/m^2	1.99	Pass
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 10 W/m^2	5.62	Pass
Component 3: Air conditioning system			

Assessment	Criteria	Final Design	Result
Air condition efficiency: district cooling	NA	NA	NA
Component 4: Hot water generation			
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Solar PV roof	NA	129.31 kW	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	NA	20,736 kWh/y	Pass
Overall BEC compliance	**Comply by Option 1**		**Pass**

Comparison of Actual Construction to Building Design

Component	Original Design	Final Design after Assessment
Component 1: Building envelope		
Opaque wall	Light weight concrete with insulation	Unchanged
Transparent wall/window	Double glazing reflective tinted glass 6 mm	Unchanged
Window to wall ratio (WWR)	0.57	Unchanged
Roof	Metal sheet with fiberglass insulator enclosed in aluminum foil	Unchanged
Component 2: Lighting system		
Lamp type	LED lamps 7-29 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Not implemented	Unchanged
Central air conditioning system	District cooling	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Solar PV roof 129.31 kW	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

CASE NO.4: S OASIS, BANGKOK

I. General Information

Building Name:	**S Oasis, Bangkok**
Building Type:	Department store
Total Floor Area:	6,800 m^2
Number of Floors:	3 floors
Current Status:	Under construction

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Pass**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 40 W/m^2	37.45	Pass
Roof Thermal Transfer Value (RTTV)	≤ 8 W/m^2	8.27	Pass
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 11 W/m^2	8.39	Pass
Component 3: Air conditioning system			
Air condition efficiency: air-cooled centrifugal chiller > 300 TR	≤ 0.61 kW/TR	≤ 0.61 kW/TR	Pass
Component 4: Hot water generation			
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA

Assessment	Criteria	Final Design	Result
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	NA	461,187 kWh/y	Pass
Overall BEC compliance	**Comply by Option 1**		**Pass**

Comparison of Actual Construction to Building Design

Component	Original Design	Final Design after Assessment
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Double glazing laminated tinted glass 6 mm	Unchanged
Window to wall ratio (WWR)	0.68	Unchanged
Roof	Reinforced concrete with fiberglass insulator enclosed in aluminum foil	Unchanged
Component 2: Lighting system		
Lamp type	LED lamps 4-38 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Not implemented	Unchanged
Central air conditioning system	Air-cooled centrifugal chiller	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

CASE NO.5: RED PLANET SURAWONG, BANGKOK

I. General Information

Building Name: **Red Planet Surawong, Bangkok**
Building Type: Hotel
Total Floor Area: 5,700 m^2
Air Conditioned Area: 3,200 m^2
Number of Floors: 7 floors
Current Status: In operation

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	29.97	Pass
Window to Wall Ratio (WWR)	NA	0.55	
Roof Thermal Transfer Value (RTTV)	≤ 6 W/m^2	7.23	Fail
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	5.18	Pass
Component 3: Air conditioning system			
No information	NA	NA	Pass
Component 4: Hot water generation			

Assessment	Criteria	Final Design	Result
No information	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 1,166,000 kWh/y	706,700 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

CASE NO.6: SIAM@SIAM DESIGN HOTEL, PATTAYA

I. General Information

Building Name: **Siam@Siam Design Hotel, Pattaya**
Building Type: Hotel
Total Floor Area: 19,000 m^2
Air Conditioned Area: 12,000 m^2
Number of Floors: 23 floors
Current Status: In operation

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	29.80	Pass
Window to Wall Ratio (WWR)	NA	0.46	
Roof Thermal Transfer Value (RTTV)	≤ 6 W/m^2	7.33	Fail
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	10.82	Pass
Component 3: Air conditioning system			

Assessment	Criteria	Final Design	Result
No information	NA	NA	Pass
Component 4: Hot water generation			
No information	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 3,674,792 kWh/y	3,470,162 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

CASE NO.7: OPD AND EMERGENCY BUILDING, KANCHANABURI

I. General Information

Building Name:	**OPD and Emergency Building, Somdet Phra Sangharaja 19 Hospital, Kanchanaburi**
Building Type:	Hospital
Total Floor Area:	9,178 m^2
Air Conditioned Area:	3,555 m^2
Number of Floors:	4 floors
Current Status:	In operation

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	29.34	Pass
Roof Thermal Transfer Value (RTTV)	≤ 6 W/m^2	6.40	Fail
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	3.60	Pass
Component 3: Air conditioning system			
Air condition efficiency: Chiller	No information	No information	Pass

Assessment	Criteria	Final Design	Result
Component 4: Hot water generation			
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 1,650,449 kWh/y	845,074 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

Comparison of Actual Construction to Building Design

Component	Original Design	Final Design after Assessment
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated clear glass 6 mm	Laminated tinted glass 6 mm
Window to wall ratio (WWR)	0.20	Unchanged
Roof	Concrete roof tile with 0.3 m air gap and 9 mm gypsum board	Concrete roof tile with aluminum foil, 0.3 m air gap and 9 mm gypsum board
Energy efficient features	• Building orientation. • Window shading from walking terrace. • Air gap under roof.	Unchanged
Component 2: Lighting system		
Lamp type	Fluorescent lamps 9-36 W	LED lamps 7-20 W
Component 3: Air conditioning system		
Split type air conditioner	Not implemented	Unchanged
Central air conditioning system	Chilled water system	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged

CASE NO.8: SYNPHAET MEDICAL COMPLEX, BANGKOK

I. General Information

Building Name:	**Synphaet Medical Complex, Synphaet Ramintra Hospital, Bangkok**
Building Type:	Hospital
Total Floor Area:	43,000 m^2
Air Conditioned Area:	22,660 m^2
Number of Floors:	No information
Current Status:	Under construction

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	27.03	Pass

Assessment	Criteria	Final Design	Result
Window to Wall Ratio (WWR)	NA	0.47	
Roof Thermal Transfer Value (RTTV)	≤ 6 W/m^2	7.68	Fail
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	5.03	Pass
Component 3: Air conditioning system			
No information	NA	NA	Pass
Component 4: Hot water generation			
No information	NA	NA	NA
Component 5: Renewable energy utilization			
No information	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	≤ 22,357,500 kWh/y	6,916,800 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

CASE NO.9: THE CIRCLE 2, BANGKOK

I. General Information

Building Name:	**The Circle 2, Bangkok**
Building Type:	Condominium
Total Floor Area:	58,000 m^2
Air Conditioned Area:	41,000 m^2
Number of Floors:	53 floors
Current Status:	In operation

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Fail**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	29.93	Pass
Roof Thermal Transfer Value (RTTV)	≤ 6 W/m^2	7.45	Fail
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	4.29	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass
Component 4: Hot water generation			
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	16,975,000 kWh/y	11,132,000 kWh/y	Pass
Overall BEC compliance	**Comply by Option 2**		**Pass**

CASE NO.10: THE CUVEE TIWANON, NONTHABURI

I. General Information

Building Name: **The Cuvee Tiwanon, Nonthaburi**
Building Type: Condominium
Total Floor Area: 23,189 m^2
Number of Floors: 33 floors
Current Status: In operation

Photo/Picture

II. BEC Assessment of Design Documents

BEC Assessment Result

Assessment	Criteria	Final Design	Result
Option 1: By individual component			**Pass**
Component 1: Building envelope			
Overall Thermal Transfer Value of Walls (OTTV)	≤ 30 W/m^2	29.47	Pass
Roof Thermal Transfer Value (RTTV)	≤ 6 W/m^2	4.76	Pass
Component 2: Lighting system			
Lighting Power Density (LPD)	≤ 12 W/m^2	1.43	Pass
Component 3: Air conditioning system			
Air condition efficiency: split type air conditioner	COP ≥ 3.22	3.22	Pass

Assessment	Criteria	Final Design	Result
Component 4: Hot water generation			
Not installed	NA	NA	NA
Component 5: Renewable energy utilization			
Not installed	NA	NA	NA
Option 2: Whole energy performance			**Pass**
Component 6: Whole energy performance			
Total energy consumption	NA	1,818,401 kWh/y	Pass
Overall BEC compliance	**Comply by Option 1**		**Pass**

Comparison of Actual Construction to Building Design

Component	Original Design	Final Design after Assessment
Component 1: Building envelope		
Opaque wall	Light weight concrete	Unchanged
Transparent wall/window	Laminated tinted glass 6 mm	Unchanged
Window to wall ratio (WWR)	0.44	Unchanged
Roof	Reinforced concrete with fiberglass insulator enclosed in aluminum foil	Unchanged
Component 2: Lighting system		
Lamp type	LED lamps 9-16 W	Unchanged
Component 3: Air conditioning system		
Split type air conditioner	Fixed speed split type air conditioner, label no.5	Unchanged
Central air conditioning system	Not implemented	Unchanged
Component 4: Hot water generation		
Hot water boiler	Not implemented	Unchanged
Component 5: Renewable energy utilization		
Electricity generation from renewable energy source	Not implemented	Unchanged
Thermal energy generation from renewable energy source	Not implemented	Unchanged
Component 6: Whole energy performance		
Integrated energy system	Not implemented	Unchanged