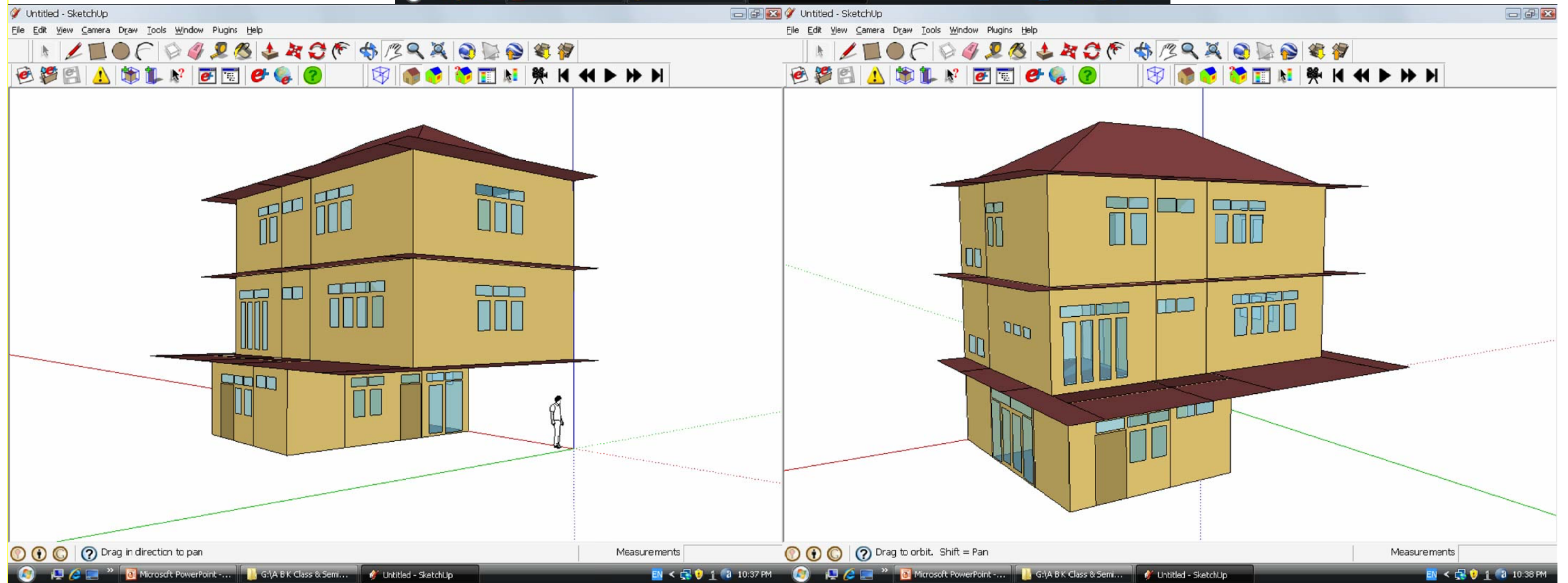
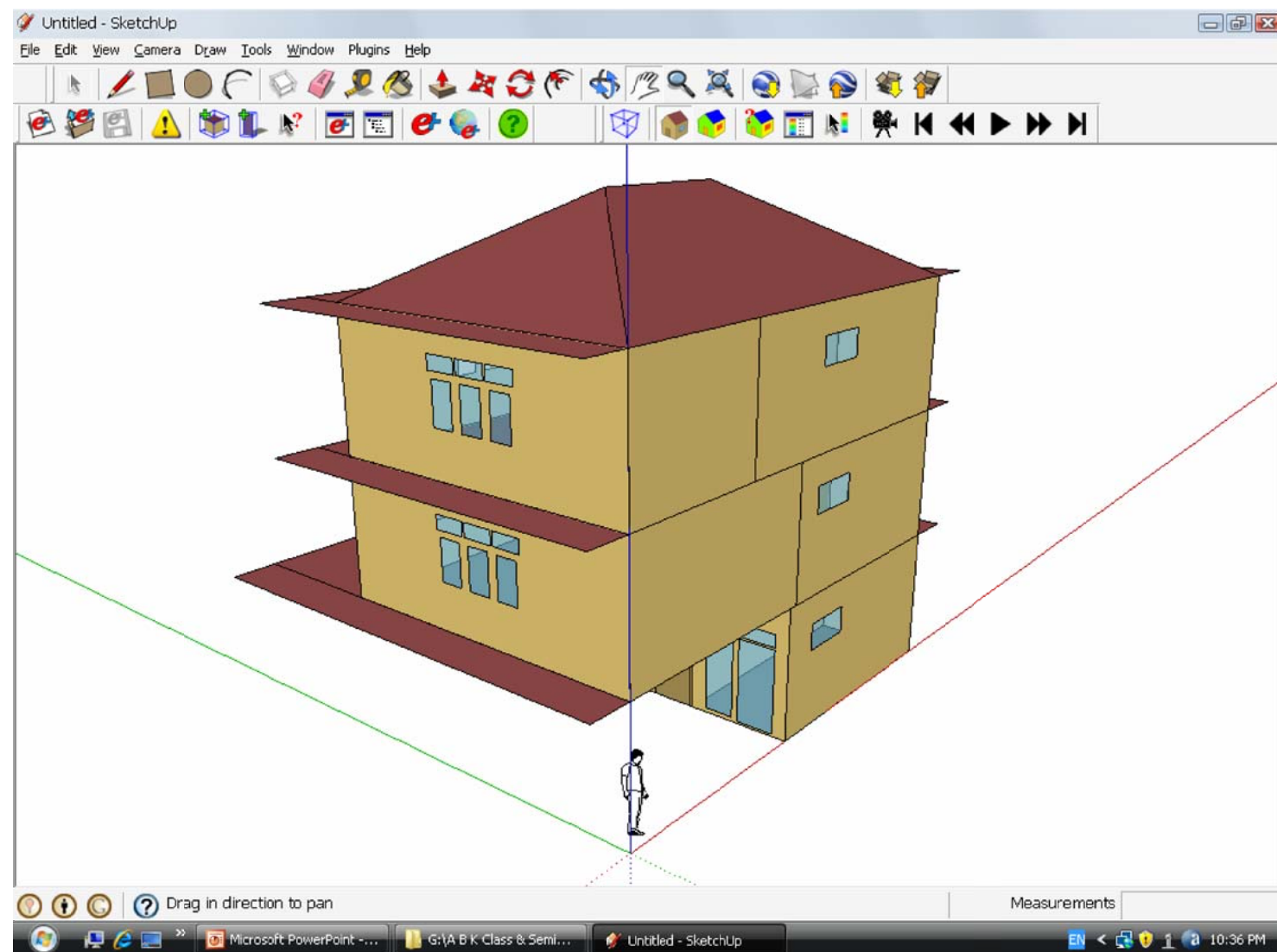
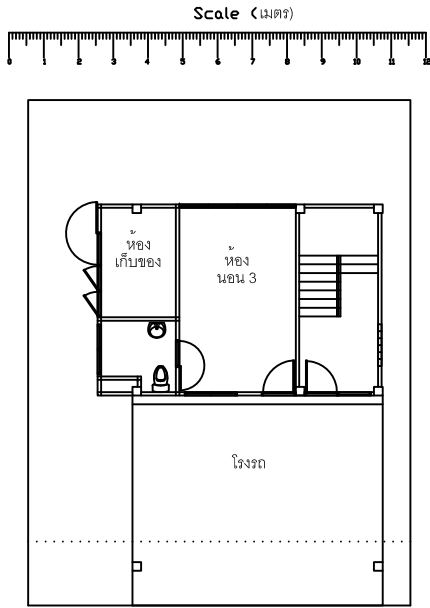


**Exercise  
on  
Cooling Load Calculations  
by**

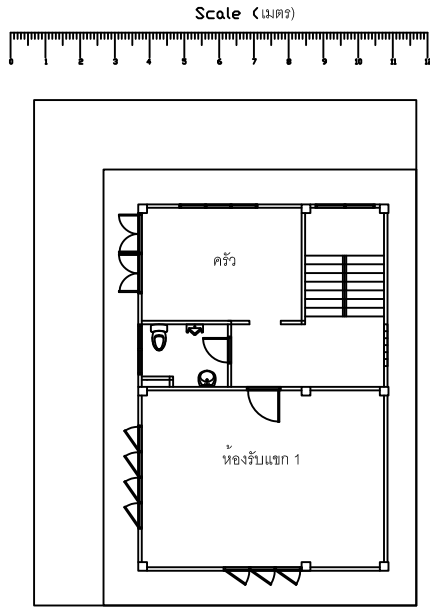
**Assist. Prof. Dr. Tul Manewattana.  
Chulalongkorn University  
Bangkok, THAILAND**



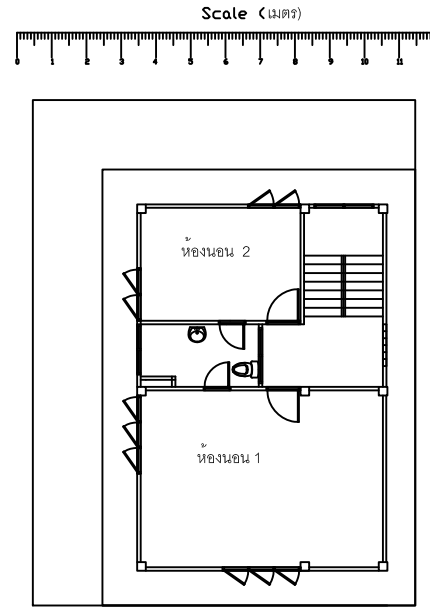




N แปลนพื้นที่ชั้นกลาง (ชั้น 1) 1:100



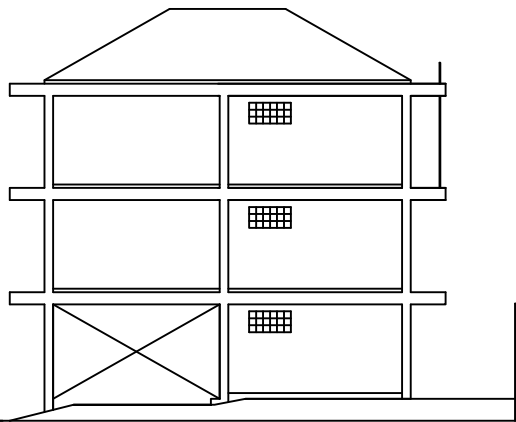
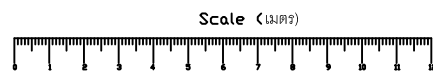
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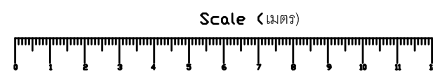
N แปลนพื้นที่ชั้น 3 1:100



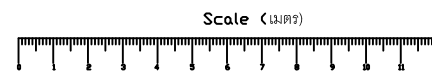
รูปด้านทิศเหนือ 1:100



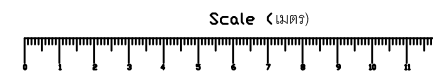
รูปด้านทิศใต้ 1:100



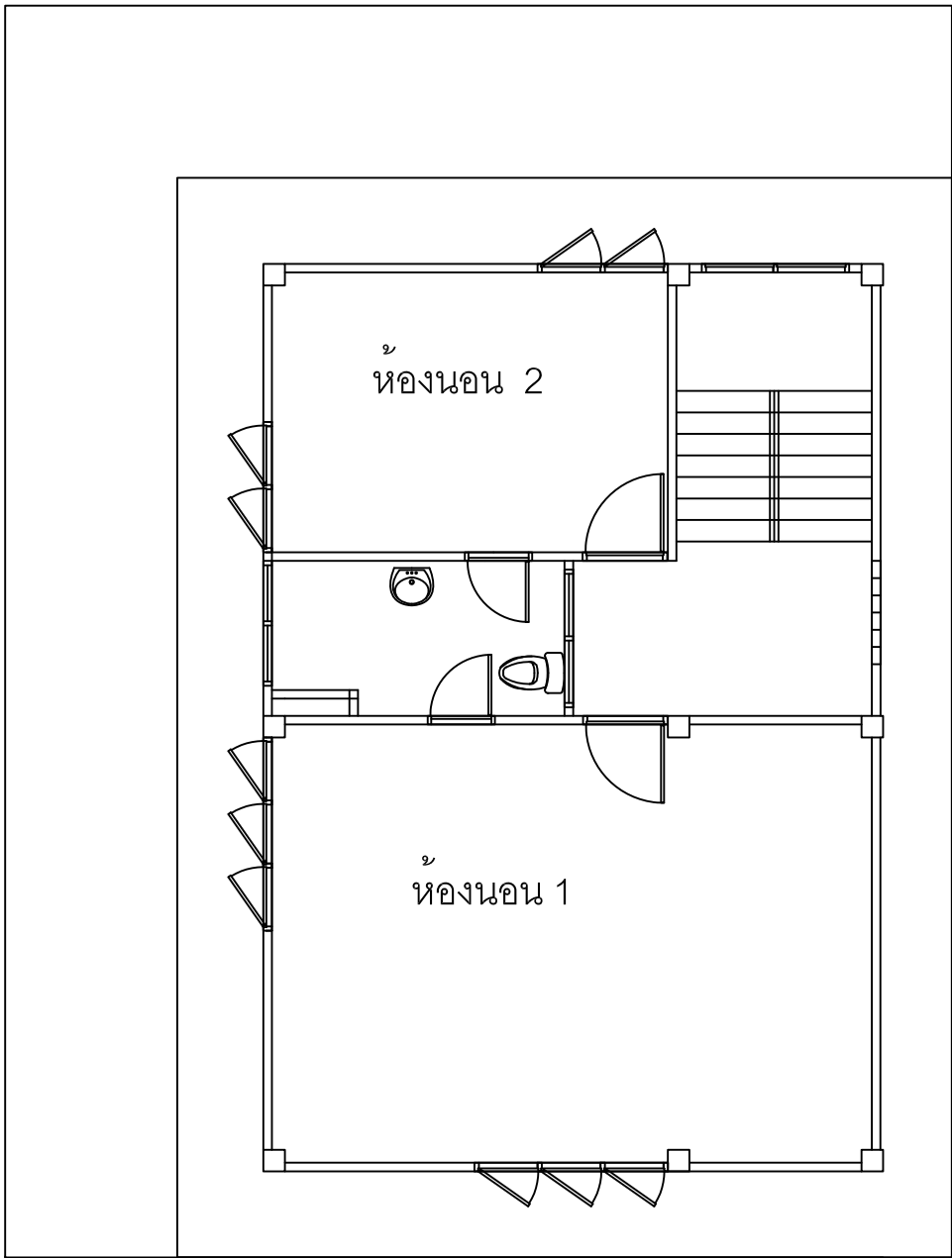
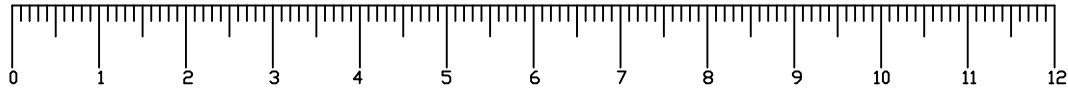
รูปด้านทิศตะวันตก 1:100



รูปด้านทิศตะวันออก 1:100



Scale (เมตร)

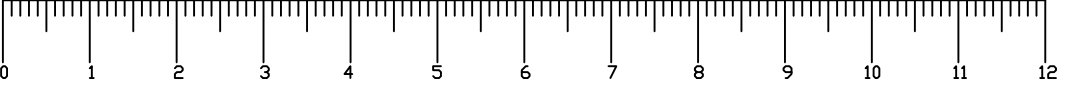


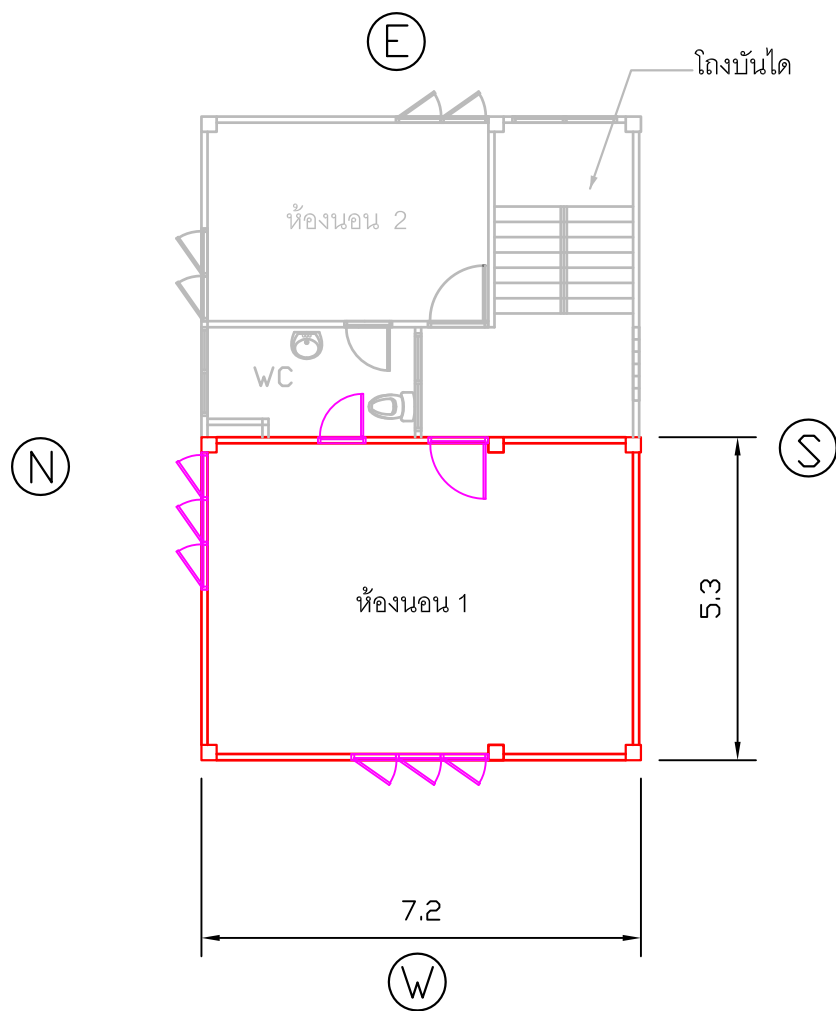
แปลนพื้นที่ 3 1:100




รูปด้านทิศตะวันตก 1:100

Scale (เมตร)



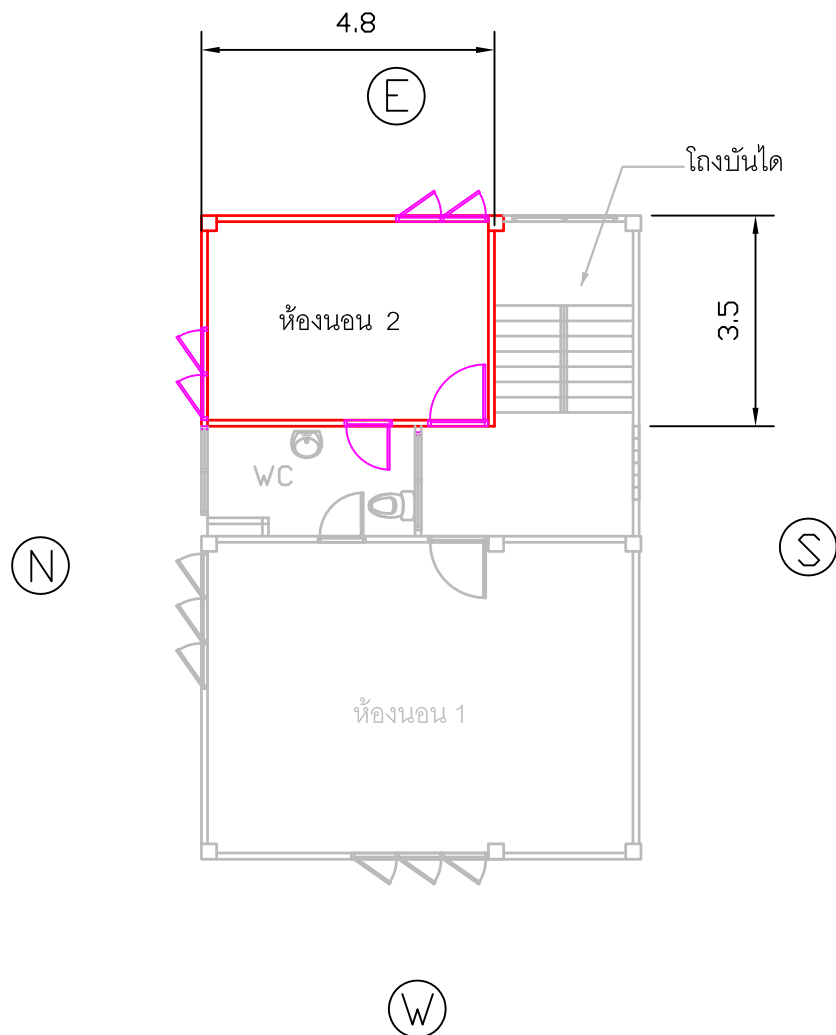



N  แปลนพื้นที่ 3 1:100

พื้นที่ห้อง	38.2 ม.
ความสูง	2.6 ม.

พื้นที่ผนัง		
ทิศ	ตรม.	หมายเหตุ
N	11.0	
S	13.8	
E	18.7	Partition
W	15.9	

พื้นที่กระจก		
ทิศ	ตรม.	หมายเหตุ
N	2.8	
S	0	
E	0	
W	2.8	

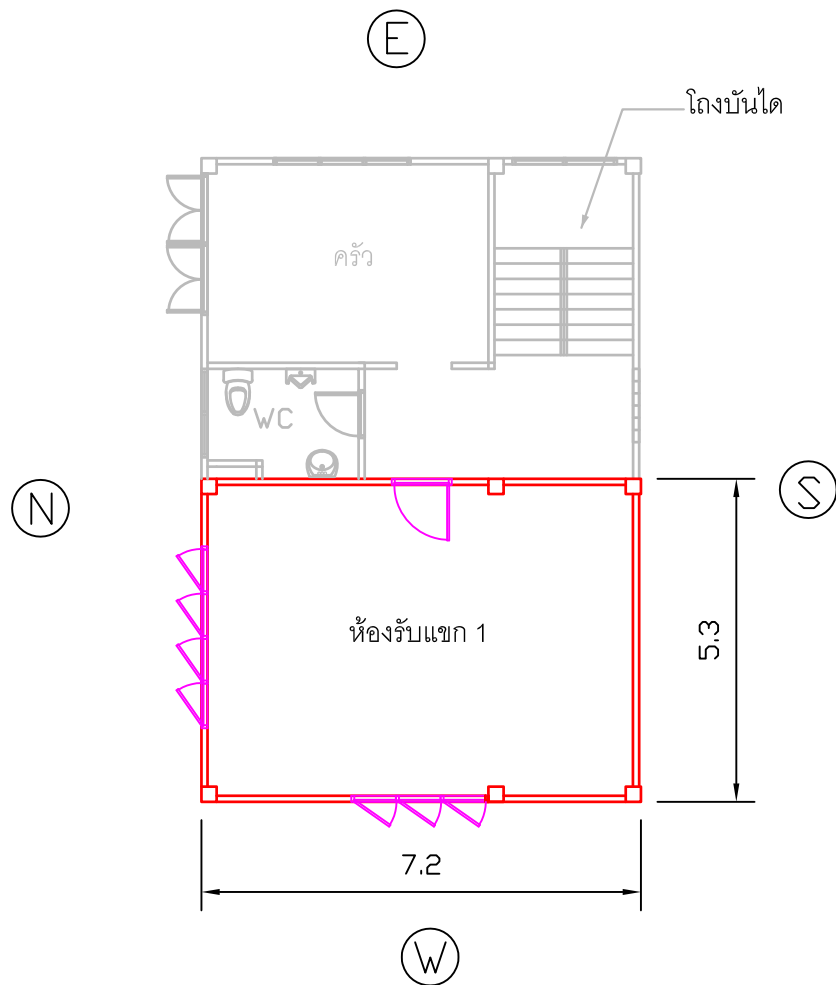



N  แปลนพื้นที่ชั้น 3 1:100

พื้นที่ห้อง	16.8 ตรม.
ความสูง	2.6 ม.

พื้นที่ผนัง		
ทิศ	ตรม.	หมายเหตุ
N	7.2	
S	9.1	Partition
E	10.6	
W	12.5	Partition

พื้นที่กระจก		
ทิศ	ตรม.	หมายเหตุ
N	1.9	
S	0	
E	1.9	
W	0	



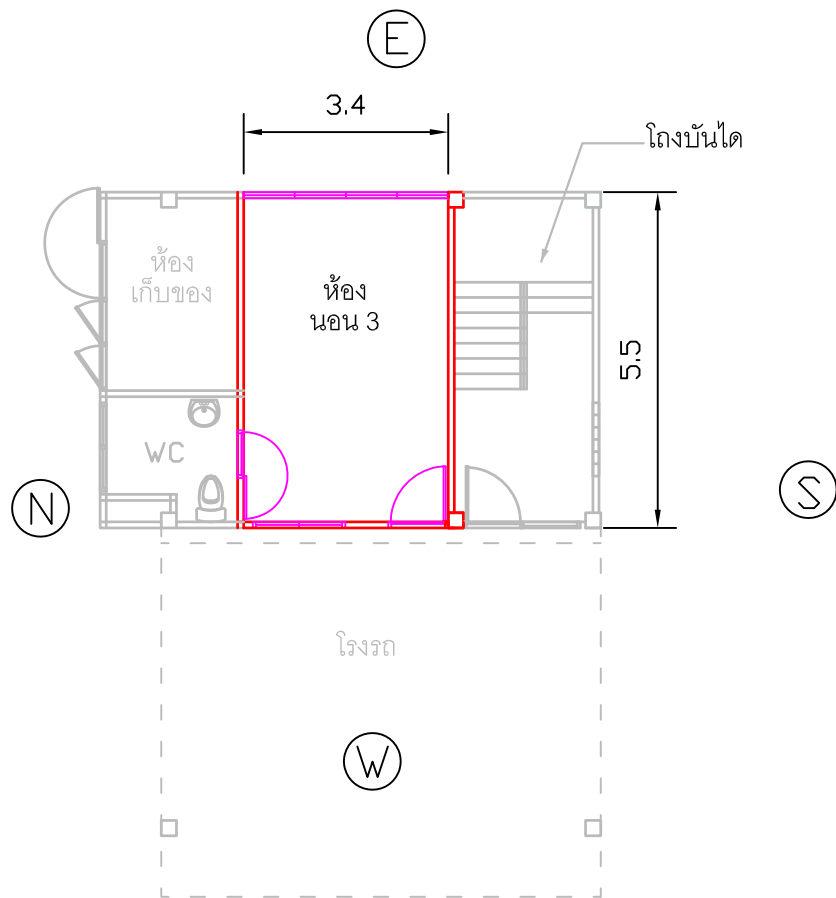
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พื้นที่ห้อง	38.2 ตรม.
ความสูง	2.6 ม.

พื้นที่ผนัง		
ทิศ	ตรม.	หมายเหตุ
N	10.1	
S	13.8	
E	18.7	Partition
W	15.9	

พื้นที่กระจก		
ทิศ	ตรม.	หมายเหตุ
N	3.7	
S	0	
E	0	
W	2.8	



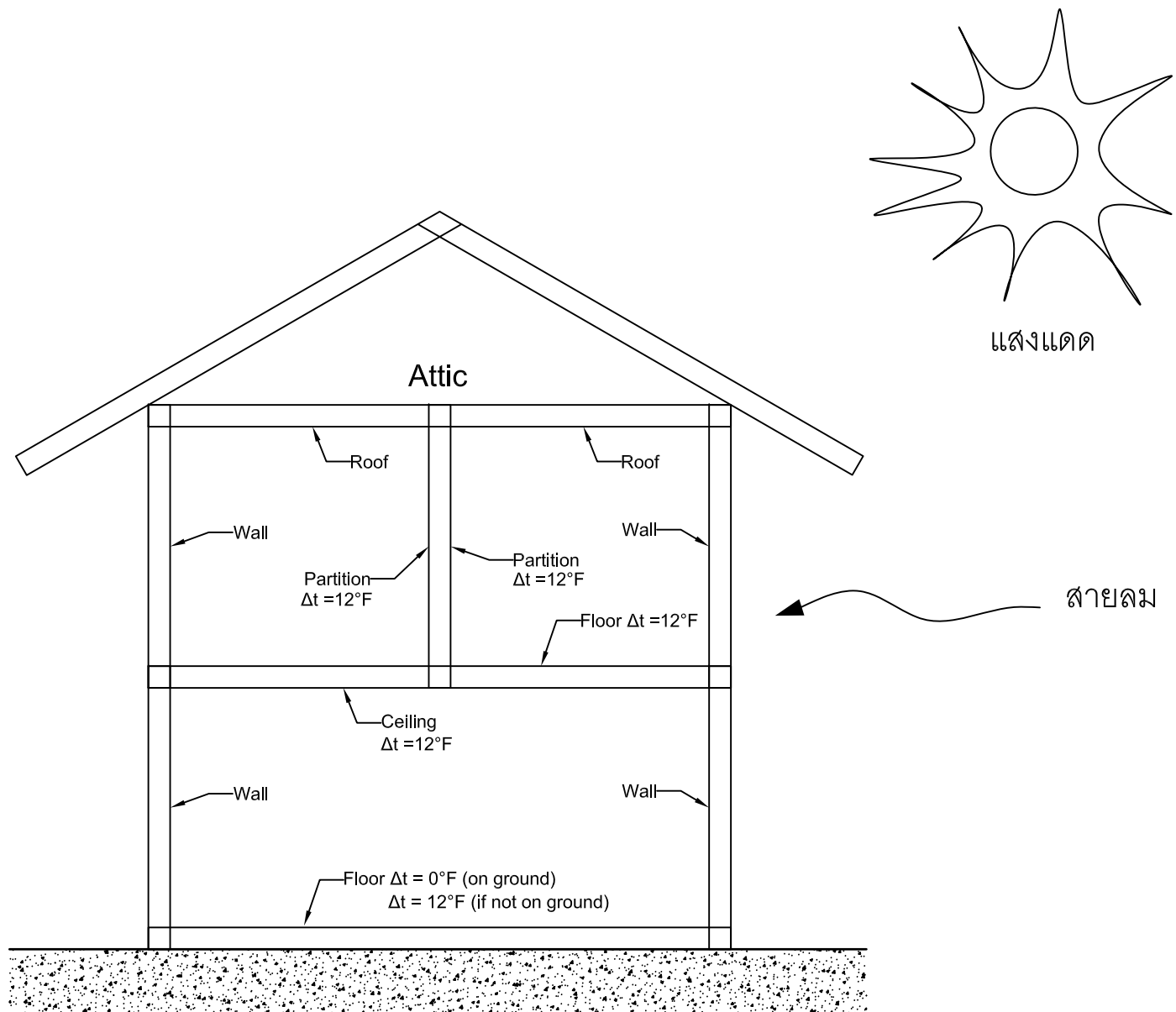


N  แปลนพื้นที่ชั้นล่าง 1:100

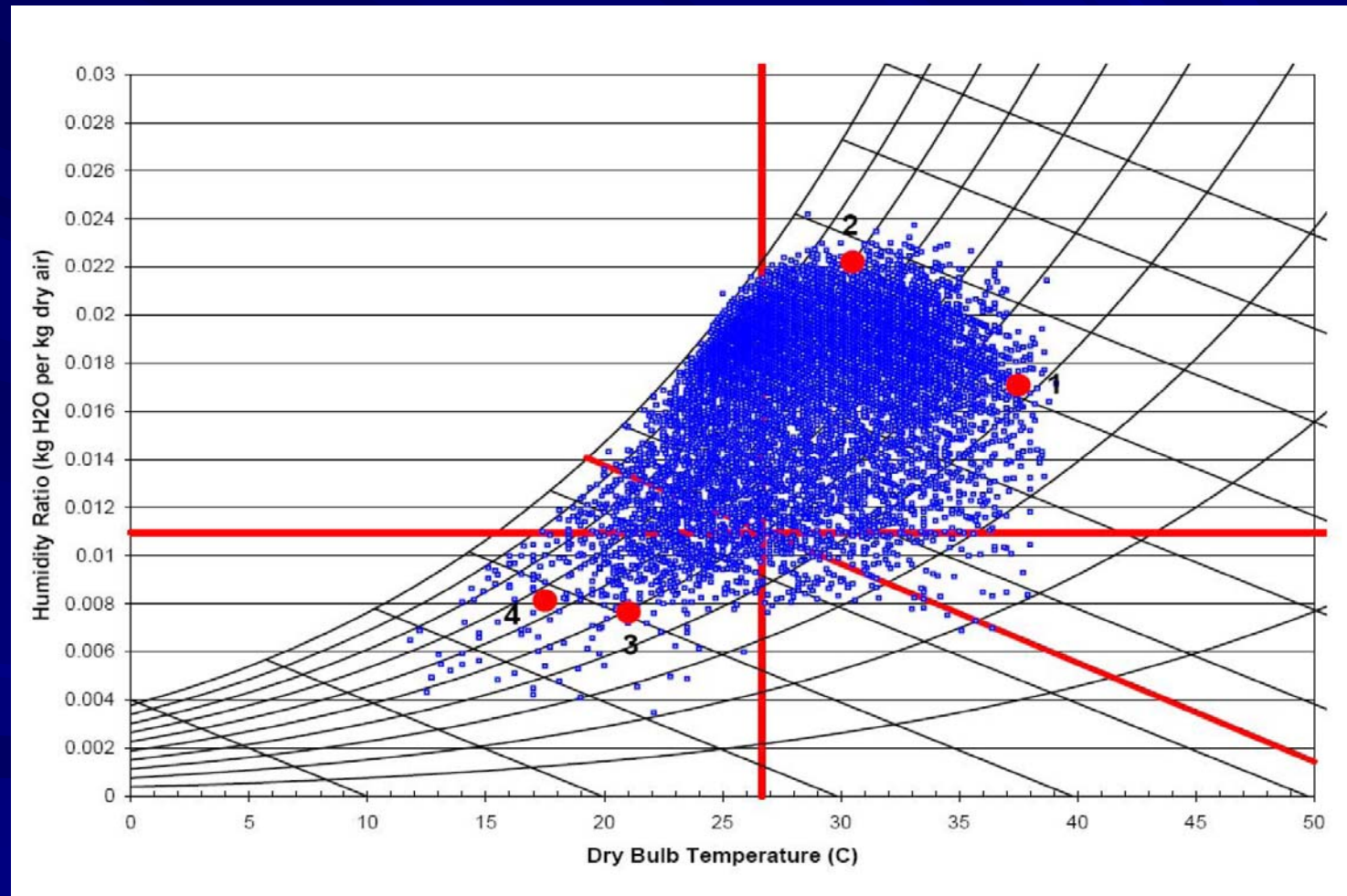
พื้นที่ห้อง	18.7 ตรม.
ความสูง	2.6 ม.

พื้นที่ผนัง		
ทิศ	ตรม.	หมายเหตุ
N	14.3	Partition
S	14.3	Partition
E	4.4	
W	7.0	Shaded

พื้นที่กระจก		
ทิศ	ตรม.	หมายเหตุ
N	0	
S	0	
E	4.4	
W	1.8	Shaded



# Outdoor Design Conditions



## Design conditions for BANGKOK, Thailand

## Station Information

Station name	WMO#	Lat	Long	Elev	StdP	Hours +/- UTC	Time zone code	Period
1a	1b	1c	1d	1e	1f	1g	1h	1i
BANGKOK	484550	13.73N	100.57E	20	101.08	7.00	SEA	8201

## Annual Heating and Humidification Design Conditions

Coldest month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
			99.6%			99%			0.4%		1%			
	99.6%	99%	DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
2	3a	3b	4a	4b	4c	4d	4e	4f	5a	5b	5c	5d	6a	6b
12	18.7	20.3	11.7	8.6	23.0	13.3	9.5	23.7	6.8	27.4	5.6	27.8	1.0	N/A

## Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest month	Hottest month DB range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
7	8	9a	9b	9c	9d	9e	9f	10a	10b	10c	10d	10e	10f	11a	11b
4	7.1	35.7	26.4	35.0	26.4	34.4	26.2	28.0	33.0	27.6	32.4	27.2	31.8	2.9	N/A

Dehumidification DP/MCDB and HR									Enthalpy/MCDB					
0.4%			1%			2%			0.4%		1%		2%	
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB
12a	12b	12c	12d	12e	12f	12g	12h	12i	13a	13b	13c	13d	13e	13f
26.7	22.4	30.2	26.4	21.9	29.9	26.1	21.6	29.7	89.5	33.0	87.9	32.8	86.4	32.1

## Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%		Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
14a	14b	14c	15	16a	16b	16c	16d	17a	17b	17c	17d	17e	17f	17g	17h
6.4	5.7	5.1	33.2	37.4	16.3	0.8	2.4	38.0	14.6	38.4	13.2	38.9	11.8	39.5	10.1

## Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18a	18b	18c	18d	18e	18f	18g	18h	18i	18j	18k	18l
0.4%	33.9	24.3	34.6	24.4	35.8	24.7	36.7	25.9	36.7	26.7	35.2	26.5
1%	33.5	24.3	34.0	24.8	35.2	25.1	36.2	26.3	36.2	26.9	34.8	26.4
2%	33.0	24.3	33.5	24.9	34.7	25.4	35.8	26.5	35.7	26.9	34.2	26.4

%	Jul		Aug		Sep		Oct		Nov		Dec	
	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB	DB	MCWB
	18m	18n	18o	18p	18q	18r	18s	18t	18u	18v	18w	18x
0.4%	34.8	26.3	34.3	26.3	34.0	26.2	33.8	26.2	34.0	25.3	33.9	24.5
1%	34.3	26.2	33.8	26.1	33.6	26.1	33.3	26.1	33.5	25.2	33.3	24.3
2%	33.9	26.1	33.3	25.9	33.1	26.1	32.9	26.1	33.1	25.1	32.9	24.1

## Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures

%	Jan		Feb		Mar		Apr		May		Jun	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19a	19b	19c	19d	19e	19f	19g	19h	19i	19j	19k	19l
0.4%	26.8	30.5	27.7	32.4	27.7	32.8	28.6	34.1	28.2	33.6	27.7	32.3
1%	26.4	30.3	27.2	31.5	27.4	32.4	28.2	33.4	28.0	33.4	27.6	32.1
2%	26.1	30.2	26.9	31.0	27.2	32.0	28.1	33.1	27.7	32.9	27.3	31.7

%	Jul		Aug		Sep		Oct		Nov		Dec	
	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB	WB	MCDB
	19m	19n	19o	19p	19q	19r	19s	19t	19u	19v	19w	19x
0.4%	27.6	32.3	27.2	31.7	27.5	31.2	27.5	31.7	26.9	31.4	26.4	30.6
1%	27.2	31.7	27.0	31.5	27.2	31.1	27.2	31.3	26.6	31.0	25.9	30.0
2%	27.0	31.4	26.7	31.1	26.9	30.9	26.9	30.9	26.2	30.7	25.5	30.0

## Monthly Mean Daily Temperature Range

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
20a	20b	20c	20d	20e	20f	20g	20h	20i	20j	20k	20l
8.9	7.8	7.3	7.1	6.8	6.1	6.1	6.0	6.4	6.4	7.3	8.8

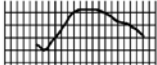
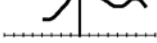
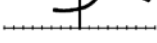
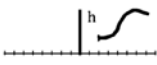

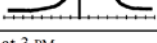
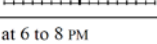

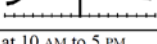
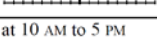
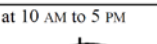
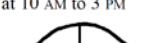

WMO#	World Meteorological Organization number	Lat	Latitude, °	Long	Longitude, °
Elev	Elevation, m	StdP	Standard pressure at station elevation, kPa		
DB	Dry bulb temperature, °C	DP	Dew point temperature, °C	WB	Wet bulb temperature, °C
WS	Wind speed, m/s	Enth	Enthalpy, kJ/kg	HR	Humidity ratio, grams of moisture per kilogram of dry air
MCDB	Mean coincident dry bulb temperature, °C	MCDP	Mean coincident dew point temperature, °C	MCWB	Mean coincident wet bulb temperature, °C
MCWS	Mean coincident wind speed, m/s	PCWD	Prevailing coincident wind direction, °, 0 = North, 90 = East		

Percent	Percent	DB°C	WB°C	RH%	W	TDP°C
0.30%	99.71%	37.70	26.00	39	0.01618	21.25
0.30%	99.70%	37.70	25.50	37	0.01533	20.48
0.31%	99.70%	37.70	24.90	35	0.01433	19.52
0.32%	99.69%	37.70	21.60	23	0.00929	13.30
0.32%	99.68%	37.60	26.40	41	0.01691	21.89
0.33%	99.68%	37.60	26.00	40	0.01622	21.29
0.34%	99.67%	37.60	26.00	40	0.01622	21.29
0.34%	99.66%	37.60	25.60	38	0.01554	20.68
0.35%	99.66%	37.60	25.40	37	0.01520	20.37
0.36%	99.65%	37.60	24.70	35	0.01405	19.24
0.36%	99.64%	37.60	24.50	34	0.01372	18.91
0.37%	99.64%	37.50	27.70	47	0.01930	23.76
0.38%	99.63%	37.50	27.30	46	0.01857	23.21
0.39%	99.62%	37.50	26.80	43	0.01767	22.51
0.39%	99.61%	37.50	26.70	43	0.01749	22.36
0.40%	99.61%	37.50	26.60	43	0.01731	22.22
0.41%	99.60%	37.50	26.60	43	0.01731	22.22
0.41%	99.59%	37.50	26.50	42	0.01713	22.07
0.42%	99.59%	37.50	26.30	41	0.01678	21.78
0.43%	99.58%	37.50	26.10	40	0.01644	21.48
0.43%	99.57%	37.50	26.00	40	0.01626	21.33
0.44%	99.57%	37.50	26.00	40	0.01626	21.33
0.45%	99.56%	37.50	25.90	40	0.01609	21.18
0.45%	99.55%	37.50	24.80	35	0.01425	19.45
0.46%	99.55%	37.50	24.70	35	0.01409	19.28
0.47%	99.54%	37.40	27.40	46	0.01879	23.39
0.47%	99.53%	37.40	27.00	45	0.01807	22.83
0.48%	99.53%	37.40	26.20	41	0.01665	21.67
0.49%	99.52%	37.40	26.10	41	0.01648	21.52
0.50%	99.51%	37.40	26.00	40	0.01631	21.37
0.50%	99.50%	37.40	25.70	39	0.01580	20.91
0.51%	99.50%	37.30	26.60	43	0.01740	22.29
0.52%	99.49%	37.30	25.20	37	0.01500	20.18
0.52%	99.48%	37.30	24.10	33	0.01321	18.36
0.53%	99.48%	37.20	27.20	46	0.01852	23.17

Table 1 General Design Criteria<sup>a, b</sup>

General Category	Specific Category	Inside Design Conditions		Air Movement	Circulation, air changes per hour
		Winter	Summer		
Dining and Entertainment Centers	Cafeterias and Luncheonettes	21 to 23°C 20 to 30% rh	26°C <sup>d</sup> 50% rh	0.25 m/s at 1.8 m above floor	12 to 15
	Restaurants	21 to 23°C 20 to 30% rh	23 to 26°C 55 to 60% rh	0.13 to 0.15 m/s	8 to 12
	Bars	21 to 23°C 20 to 30% rh	23 to 26°C 50 to 60% rh	0.15 m/s at 1.8 m above floor	15 to 20
	Nightclubs and Casinos	21 to 23°C 20 to 30% rh	23 to 26°C 50 to 60% rh	below 0.13 m/s at 1.5 m above floor	20 to 30
	Kitchens	21 to 23°C	29 to 31°C	0.15 to 0.25 m/s	12 to 15 <sup>g</sup>
Office Buildings		21 to 23°C 20 to 30% rh	23 to 26°C 50 to 60% rh	0.13 to 0.23 m/s 4 to 10 L/(s·m <sup>2</sup> )	4 to 10
Museums, Galleries, Libraries and Archives	Average	20 to 22°C 40 to 55% rh		below 0.13 m/s	8 to 12
	Archival	See <a href="#">Chapter 21</a>		below 0.13 m/s	8 to 12
Bowling Centers		21 to 23°C 20 to 30% rh	24 to 26°C 50 to 55% rh	0.25 m/s at 1.8 m above floor	10 to 15
Communication Centers	Telephone Terminal Rooms	22 to 26°C 40 to 50% rh	22 to 26°C 40 to 50% rh	0.13 to 0.15 m/s	8 to 20
	Radio and Television Studios	21 to 23°C 40 to 50% rh	23 to 26°C 45 to 55% rh	0.13 to 0.15 m/s	15 to 40
Transportation Centers (also see <a href="#">Chapter 13</a> )	Airport Terminals	23 to 26°C 30 to 40% rh	23 to 26°C 40 to 55% rh	below 0.13 m/s at 3.7 m above floor	8 to 12
	Ship Docks	21 to 23°C 20 to 30% rh	23 to 26°C 50 to 60% rh	0.13 to 0.15 m/s at 1.8 m above floor	8 to 12
	Bus Terminals	21 to 23°C 20 to 30% rh	23 to 26°C 50 to 60% rh	0.13 to 0.15 m/s at 1.8 m above floor	8 to 12
	Garages <sup>j</sup>	4 to 13°C	27 to 38°C	0.15 to 0.38 m/s	4 to 6 Refer to NFPA
Warehouses		Inside design temperatures for warehouses often depend on the materials stored.			1 to 4

Table 1 General Design Criteria<sup>a, b</sup> (Concluded)

Noise <sup>c</sup>	Filtering Efficiencies (ASHRAE Standard 52.1)	Load Profile	Comments
NC 40 to 50 <sup>e</sup>	35% or better	Peak at 1 to 2 PM 	Prevent draft discomfort for patrons waiting in serving lines
NC 35 to 40	35% or better	Peak at 1 to 2 PM 	
NC 35 to 50	Use charcoal for odor control with manual purge control for 100% outside air to exhaust $\pm 35\%$ prefilters	Peak at 5 to 7 PM 	
NC 35 to 45 <sup>f</sup>	Use charcoal for odor control with manual purge control for 100% outside air to exhaust $\pm 35\%$ prefilters	Nightclubs peak at 8 PM to 2 AM Casinos peak at 4 PM to 2 AM Equipment, 24 h/day	Provide good air movement but prevent cold draft discomfort for patrons
NC 40 to 50	10 to 15% or better		Negative air pressure required for odor control (also see <a href="#">Chapter 31</a> )
NC 30 to 45	35 to 60% or better	Peak at 4 PM 	
NC 35 to 40	35 to 60% or better	Peak at 3 PM 	
NC 35	35% prefilters plus charcoal filters 85 to 95% final <sup>1</sup>	Peak at 3 PM 	
NC 40 to 50	10 to 15%	Peak at 6 to 8 PM 	
to NC 60	85% or better	Varies with location and use	Constant temperature and humidity required
NC 15 to 25	35% or better	Varies widely because of changes in lighting and people	Constant temperature and humidity required
NC 35 to 50	35% or better and charcoal filters	Peak at 10 AM to 9 PM 	Positive air pressure required in terminal
NC 35 to 50	10 to 15%	Peak at 10 AM to 5 PM 	Positive air pressure required in waiting area
NC 35 to 50	35% with exfiltration	Peak at 10 AM to 5 PM 	Positive air pressure required in terminal
NC 35 to 50	10 to 15%	Peak at 10 AM to 5 PM 	Negative air pressure required to remove fumes; positive air in pressure adjacent occupied spaces
to NC 75	10 to 35%	Peak at 10 AM to 3 PM 	



**TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE**  
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate		Area Outdoor Air Rate		Notes	Default Values			Air Class
	$R_p$		$R_a$			Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s/person	cfm/ft <sup>2</sup>	L/s·m <sup>2</sup>		#/1000 ft <sup>2</sup> or #/100 m <sup>2</sup>	cfm/person	L/s/person	
Correctional Facilities									
Cell	5	2.5	0.12	0.6		25	10	4.9	2
Dayroom	5	2.5	0.06	0.3		30	7	3.5	1
Guard stations	5	2.5	0.06	0.3		15	9	4.5	1
Booking/waiting	7.5	3.8	0.06	0.3		50	9	4.4	2
Educational Facilities									
Daycare (through age 4)	10	5	0.18	0.9		25	17	8.6	2
Daycare sickroom	10	5	0.18	0.9		25	17	8.6	3
Classrooms (ages 5–8)	10	5	0.12	0.6		25	15	7.4	1
Classrooms (age 9 plus)	10	5	0.12	0.6		35	13	6.7	1
Lecture classroom	7.5	3.8	0.06	0.3		65	8	4.3	1
Lecture hall (fixed seats)	7.5	3.8	0.06	0.3		150	8	4.0	1
Art classroom	10	5	0.18	0.9		20	19	9.5	2
Science laboratories	10	5	0.18	0.9		25	17	8.6	2
University/college laboratories	10	5	0.18	0.9		25	17	8.6	2
Wood/metal shop	10	5	0.18	0.9		20	19	9.5	2
Computer lab	10	5	0.12	0.6		25	15	7.4	1
Media center	10	5	0.12	0.6	A	25	15	7.4	1
Music/theater/dance	10	5	0.06	0.3		35	12	5.9	1
Multi-use assembly	7.5	3.8	0.06	0.3		100	8	4.1	1
Food and Beverage Service									
Restaurant dining rooms	7.5	3.8	0.18	0.9		70	10	5.1	2
Cafeteria/fast-food dining	7.5	3.8	0.18	0.9		100	9	4.7	2
Bars, cocktail lounges	7.5	3.8	0.18	0.9		100	9	4.7	2
Kitchen (cooking)	7.5	3.8	0.12	0.6		20	14	7.0	2
General									
Break rooms	5	2.5	0.06	0.3		25	10	5.1	1
Coffee stations	5	2.5	0.06	0.3		20	11	5.5	1
Conference/meeting	5	2.5	0.06	0.3		50	6	3.1	1
Corridors	—	—	0.06	0.3		—			1
Occupiable storage rooms for liquids or gels	5	2.5	0.12	0.6	B	2	65	32.5	2
Hotels, Motels, Resorts, Dormitories									
Bedroom/living room	5	2.5	0.06	0.3		10	11	5.5	1
Barracks sleeping areas	5	2.5	0.06	0.3		20	8	4.0	1
Laundry rooms, central	5	2.5	0.12	0.6		10	17	8.5	2
Laundry rooms within dwelling units	5	2.5	0.12	0.6		10	17	8.5	1
Lobbies/prefunction	7.5	3.8	0.06	0.3		30	10	4.8	1
Multipurpose assembly	5	2.5	0.06	0.3		120	6	2.8	1



**TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE (Continued)**  
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate $R_p$		Area Outdoor Air Rate $R_a$		Notes	Default Values			Air Class
						Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s·person	cfm/ft <sup>2</sup>	L/s·m <sup>2</sup>		#/1000 ft <sup>2</sup> or #/100 m <sup>2</sup>	cfm/person	L/s·person	
Office Buildings									
Breakrooms	5	2.5	0.12	0.6		50	7	3.5	1
Main entry lobbies	5	2.5	0.06	0.3		10	11	5.5	1
Occupiable storage rooms for dry materials	5	2.5	0.06	0.3		2	35	17.5	1
Office space	5	2.5	0.06	0.3		5	17	8.5	1
Reception areas	5	2.5	0.06	0.3		30	7	3.5	1
Telephone/data entry	5	2.5	0.06	0.3		60	6	3.0	1
Miscellaneous Spaces									
Bank vaults/safe deposit	5	2.5	0.06	0.3		5	17	8.5	2
Banks or bank lobbies	7.5	3.8	0.06	0.3		15	12	6.0	1
Computer (not printing)	5	2.5	0.06	0.3		4	20	10.0	1
General manufacturing (excludes heavy industrial and processes using chemicals)	10	5.0	0.18	0.9		7	36	18	3
Pharmacy (prep. area)	5	2.5	0.18	0.9		10	23	11.5	2
Photo studios	5	2.5	0.12	0.6		10	17	8.5	1
Shipping/receiving	10	5	0.12	0.6	B	2	70	35	2
Sorting, packing, light assembly	7.5	3.8	0.12	0.6		7	25	12.5	2
Telephone closets	—	—	0.00	0.0		—			1
Transportation waiting	7.5	3.8	0.06	0.3		100	8	4.1	1
Warehouses	10	5	0.06	0.3	B	—			2
Public Assembly Spaces									
Auditorium seating area	5	2.5	0.06	0.3		150	5	2.7	1
Places of religious worship	5	2.5	0.06	0.3		120	6	2.8	1
Courtrooms	5	2.5	0.06	0.3		70	6	2.9	1
Legislative chambers	5	2.5	0.06	0.3		50	6	3.1	1
Libraries	5	2.5	0.12	0.6		10	17	8.5	1
Lobbies	5	2.5	0.06	0.3		150	5	2.7	1
Museums (children's)	7.5	3.8	0.12	0.6		40	11	5.3	1
Museums/galleries	7.5	3.8	0.06	0.3		40	9	4.6	1
Residential									
Dwelling unit	5	2.5	0.06	0.3	F,G	F			1
Common corridors	—	—	0.06	0.3					1
Retail									
Sales (except as below)	7.5	3.8	0.12	0.6		15	16	7.8	2
Mall common areas	7.5	3.8	0.06	0.3		40	9	4.6	1
Barbershop	7.5	3.8	0.06	0.3		25	10	5.0	2

**TABLE 6-1 MINIMUM VENTILATION RATES IN BREATHING ZONE (Continued)**  
(This table is not valid in isolation; it must be used in conjunction with the accompanying notes.)

Occupancy Category	People Outdoor Air Rate		Area Outdoor Air Rate		Notes	Default Values			Air Class
	$R_p$		$R_a$			Occupant Density (see Note 4)	Combined Outdoor Air Rate (see Note 5)		
	cfm/person	L/s-person	cfm/ft <sup>2</sup>	L/s·m <sup>2</sup>		#/1000 ft <sup>2</sup> or #/100 m <sup>2</sup>	cfm/person	L/s-person	
Beauty and nail salons	20	10	0.12	0.6		25	25	12.4	2
Pet shops (animal areas)	7.5	3.8	0.18	0.9		10	26	12.8	2
Supermarket	7.5	3.8	0.06	0.3		8	15	7.6	1
Coin-operated laundries	7.5	3.8	0.12	0.6		20	14	7.0	2
<b>Sports and Entertainment</b>									
Sports arena (play area)	—	—	0.30	1.5	E	—			1
Gym, stadium (play area)	—	—	0.30	1.5		30			2
Spectator areas	7.5	3.8	0.06	0.3		150	8	4.0	1
Swimming (pool & deck)	—	—	0.48	2.4	C	—			2
Disco/dance floors	20	10	0.06	0.3		100	21	10.3	2
Health club/aerobics room	20	10	0.06	0.3		40	22	10.8	2
Health club/weight rooms	20	10	0.06	0.3		10	26	13.0	2
Bowling alley (seating)	10	5	0.12	0.6		40	13	6.5	1
Gambling casinos	7.5	3.8	0.18	0.9		120	9	4.6	1
Game arcades	7.5	3.8	0.18	0.9		20	17	8.3	1
Stages, studios	10	5	0.06	0.3	D	70	11	5.4	1

**GENERAL NOTES FOR TABLE 6-1**

- Related requirements:** The rates in this table are based on all other applicable requirements of this standard being met.
- Environmental Tobacco Smoke:** This table applies to ETS-free areas. Refer to Section 5.17 for requirements for buildings containing ETS areas and ETS-free areas.
- Air density:** Volumetric airflow rates are based on an air density of 0.075 lb<sub>da</sub>/ft<sup>3</sup> (1.2 kg<sub>da</sub>/m<sup>3</sup>), which corresponds to dry air at a barometric pressure of 1 atm (101.3 kPa) and an air temperature of 70°F (21°C). Rates may be adjusted for actual density but such adjustment is not required for compliance with this standard.
- Default occupant density:** The default occupant density shall be used when actual occupant density is not known.
- Default combined outdoor air rate (per person):** This rate is based on the default occupant density.
- Unlisted occupancies:** If the occupancy category for a proposed space or zone is not listed, the requirements for the listed occupancy category that is most similar in terms of occupant density, activities and building construction shall be used.

**ITEM-SPECIFIC NOTES FOR TABLE 6-1**

- For high school and college libraries, use values shown for Public Assembly Spaces—Libraries.
- Rate may not be sufficient when stored materials include those having potentially harmful emissions.
- Rate does not allow for humidity control. Additional ventilation or dehumidification may be required to remove moisture. "Deck area" refers to the area surrounding the pool that would be expected to be wetted during normal pool use, i.e., when the pool is occupied. Deck area that is not expected to be wetted shall be designated as a space type (for example, "spectator area").
- Rate does not include special exhaust for stage effects, e.g., dry ice vapors, smoke.
- When combustion equipment is intended to be used on the playing surface, additional dilution ventilation and/or source control shall be provided.
- Default occupancy for dwelling units shall be two persons for studio and one-bedroom units, with one additional person for each additional bedroom.
- Air from one residential dwelling shall not be recirculated or transferred to any other space outside of that dwelling.

different sources can be applied to any other aspect of indoor air quality.

**6.2.2.1.1 Design Zone Population.** Design zone population ( $P_z$ ) shall equal the largest (peak) number of people expected to occupy the *ventilation zone* during typical usage.

**Exceptions:**

- If the number of people expected to occupy the *ventilation zone* fluctuates, zone population equal to the average number of people shall be permitted, provided such average is determined in accordance with Section 6.2.6.2.

- If the largest or average number of people expected to occupy the *ventilation zone* cannot be established for a specific design, an estimated value for zone population shall be permitted, provided such value is the product of the *net occupiable area* of the *ventilation zone* and the default occupant density listed in Table 6-1.

**6.2.2.2 Zone Air Distribution Effectiveness.** The zone air distribution effectiveness ( $E_z$ ) shall be no greater than the default value determined using Table 6-2.

**Note:** For some configurations, the default value depends upon space and supply air temperature.



**6.2.2.3 Zone Outdoor Airflow.** The zone outdoor airflow ( $V_{oz}$ ), i.e., the outdoor airflow rate that must be provided to the *ventilation zone* by the supply air distribution system, shall be determined in accordance with Equation 6-2.

$$V_{oz} = V_{bz}/E_z \quad (6-2)$$

**6.2.3 Single-Zone Systems.** For ventilation systems wherein one or more air handlers supply a mixture of *outdoor air* and *recirculated air* to only one *ventilation zone*, the outdoor air intake flow ( $V_{ot}$ ) shall be determined in accordance with Equation 6-3.

$$V_{ot} = V_{oz} \quad (6-3)$$

**6.2.4 100% Outdoor Air Systems.** For ventilation systems wherein one or more air handlers supply only *outdoor air* to one or more *ventilation zones*, the outdoor air intake flow ( $V_{ot}$ ) shall be determined in accordance with Equation 6-4.

$$V_{ot} = \sum_{all\ zones} V_{oz} \quad (6-4)$$

**6.2.5 Multiple-Zone Recirculating Systems.** For ventilation systems wherein one or more air handlers supply a mixture of *outdoor air* and *recirculated air* to more than one *ventilation zone*, the outdoor air intake flow ( $V_{ot}$ ) shall be determined in accordance with Sections 6.2.5.1 through 6.2.5.4.

**6.2.5.1 Primary Outdoor Air Fraction.** Primary outdoor air fraction ( $Z_{pz}$ ) shall be determined for *ventilation zones* in accordance with Equation 6-5.

$$Z_{pz} = V_{oz}/V_{pz} \quad (6-5)$$

where  $V_{pz}$  is the zone primary airflow, i.e., the primary airflow rate to the *ventilation zone* from the air handler, including outdoor air and recirculated air.

**Note:** For VAV-system design purposes,  $V_{pz}$  is the lowest zone primary airflow value expected at the design condition analyzed.

**Note:** In some cases it is acceptable to determine these parameters for only selected zones as outlined in Normative Appendix A.

**6.2.5.2 System Ventilation Efficiency.** The system ventilation efficiency ( $E_v$ ) shall be determined in accordance with Table 6-3 or Normative Appendix A.

**6.2.5.3 Uncorrected Outdoor Air Intake.** The uncorrected outdoor air intake ( $V_{ou}$ ) flow shall be determined in accordance with Equation 6-6.

$$V_{ou} = D \sum_{all\ zones} (R_p \cdot P_z) + \sum_{all\ zones} (R_a \cdot A_z) \quad (6-6)$$

**6.2.5.3.1 Occupant Diversity.** The occupant diversity ratio ( $D$ ) shall be determined in accordance with Equation 6-7 to account for variations in population within the *ventilation zones* served by the system.

$$D = P_s / \sum_{all\ zones} P_z, \quad (6-7)$$

where the system population ( $P_s$ ) is the total population in the area served by the system.

**Exception:** Alternative methods to account for occupant diversity shall be permitted, provided that the result-

**TABLE 6-2 Zone Air Distribution Effectiveness**

Air Distribution Configuration	$E_z$
Ceiling supply of cool air.	1.0
Ceiling supply of warm air and floor return.	1.0
Ceiling supply of warm air 15°F (8°C) or more above space temperature and ceiling return.	0.8
Ceiling supply of warm air less than 15°F (8°C) above space temperature and ceiling return provided that the 150 fpm (0.8 m/s) supply air jet reaches to within 4.5 ft (1.4 m) of floor level. <b>Note:</b> For lower velocity supply air, $E_z = 0.8$ .	1.0
Floor supply of cool air and ceiling return provided that the 150 fpm (0.8 m/s) supply jet reaches 4.5 ft (1.4 m) or more above the floor. <b>Note:</b> Most underfloor air distribution systems comply with this proviso.	1.0
Floor supply of cool air and ceiling return, provided low-velocity displacement ventilation achieves unidirectional flow and thermal stratification.	1.2
Floor supply of warm air and floor return.	1.0
Floor supply of warm air and ceiling return.	0.7
Makeup supply drawn in on the opposite side of the room from the exhaust and/or return.	0.8
Makeup supply drawn in near to the exhaust and/or return location.	0.5

1. "Cool air" is air cooler than space temperature.
2. "Warm air" is air warmer than space temperature.
3. "Ceiling" includes any point above the *breathing zone*.
4. "Floor" includes any point below the *breathing zone*.
5. As an alternative to using the above values,  $E_z$  may be regarded as equal to air change effectiveness determined in accordance with ANSI/ASHRAE Standard 129<sup>17</sup> for all air distribution configurations except unidirectional flow.

**TABLE 6-3 System Ventilation Efficiency**

Max ( $Z_p$ )	$E_v$
≤0.15	1.0
≤0.25	0.9
≤0.35	0.8
≤0.45	0.7
≤0.55	0.6
>0.55	Use Appendix A

1. "Max ( $Z_p$ )" refers to the largest value of  $Z_{pz}$ , calculated using Equation 6-5, among all the *ventilation zones* served by the system.
2. For values of Max ( $Z_p$ ) between 0.15 and 0.55, the corresponding value of  $E_v$  may be determined by interpolating the values in the table.
3. The values of  $E_v$  in this table are based on a 0.15 average outdoor air fraction for the system (i.e., the ratio of the uncorrected outdoor air intake ( $V_{ou}$ ) to the total zone primary airflow for all the zones served by the air handler). For systems with higher values of the average outdoor air fraction, this table may result in unrealistically low values of  $E_v$  and the use of Appendix A may yield more practical results.

ing  $V_{ou}$  value is no less than that determined using Equation 6-6.

**Note:** The uncorrected outdoor air intake ( $V_{ou}$ ) is adjusted for occupant diversity, but it is not corrected for system ventilation efficiency.

**6.2.5.3.2 Design System Population.** Design system population ( $P_s$ ) shall equal the largest (peak) number of

or portions of rooms, without direct openings to the outdoors are ventilated through adjoining rooms, the opening between rooms shall be permanently unobstructed and have a free area of not less than 8% of the area of the interior room nor less than 25 ft<sup>2</sup> (2.3 m<sup>2</sup>).

**6.4.3 Control and Accessibility.** The means to open required operable openings shall be readily accessible to building occupants whenever the space is occupied. Controls shall be designed to properly coordinate operation of the natural and mechanical ventilation systems.

**6.5 Exhaust Ventilation.** The design exhaust airflow shall be determined in accordance with the requirements in Table 6-4. Exhaust makeup air may be any combination of outdoor air, recirculated air, and transfer air.

**6.6 Design Documentation Procedures.** Design criteria and assumptions shall be documented and should be made available for operation of the system within a reasonable time after installation. See Sections 4.3, 5.1.3, 5.16.4, 6.2.7.1.5, and 6.3.6 regarding assumptions that should be detailed in the documentation.

## 7. CONSTRUCTION AND SYSTEM START-UP

### 7.1 Construction Phase

**7.1.1 Application.** The requirements of this section apply to ventilation systems and the spaces they serve in new buildings and additions to or alterations in existing buildings.

**7.1.2 Filters.** Systems designed with particle filters shall not be operated without filters in place.

**TABLE 6-4 Minimum Exhaust Rates**

Occupancy Category	Exhaust Rate, cfm/unit	Exhaust Rate, cfm/ft <sup>2</sup>	Notes	Exhaust Rate, L/s·unit	Exhaust Rate, L/s·m <sup>2</sup>	Air Class
Arenas	—	0.50	B	—	—	1
Art classrooms	—	0.70		—	3.5	2
Auto repair rooms	—	1.50	A	—	7.5	2
Barber shops	—	0.50		—	2.5	2
Beauty and nail salons	—	0.60		—	3.0	2
Cells with toilet	—	1.00		—	5.0	2
Copy, printing rooms	—	0.50		—	2.5	2
Darkrooms	—	1.00		—	5.0	2
Educational science laboratories	—	1.00		—	5.0	2
Janitor closets, trash rooms, recycling	—	1.00		—	5.0	3
Kitchenettes	—	0.30		—	1.5	2
Kitchens—commercial	—	0.70		—	3.5	2
Locker/dressing rooms	—	0.25		—	1.25	2
Locker rooms	—	0.50		—	2.5	2
Paint spray booths	—	—	F	—	—	4
Parking garages	—	0.75	C	—	3.7	2
Pet shops (animal areas)	—	0.90		—	4.5	2
Refrigerating machinery rooms	—	—	F	—	—	3
Residential kitchens	50/100	—	G	25/50	—	2
Soiled laundry storage rooms	—	1.00	F	—	5.0	3
Storage rooms, chemical	—	1.50	F	—	7.5	4
Toilets—private	25/50	—	E	12.5/25	—	2
Toilets—public	50/70	—	D	25/35	—	2
Woodwork shop/classrooms	—	0.50		—	2.5	2

A Stands where engines are run shall have exhaust systems that directly connect to the engine exhaust and prevent escape of fumes.

B When combustion equipment is intended to be used on the playing surface additional dilution ventilation and/or source control shall be provided.

C Exhaust not required if two or more sides comprise walls that are at least 50% open to the outside.

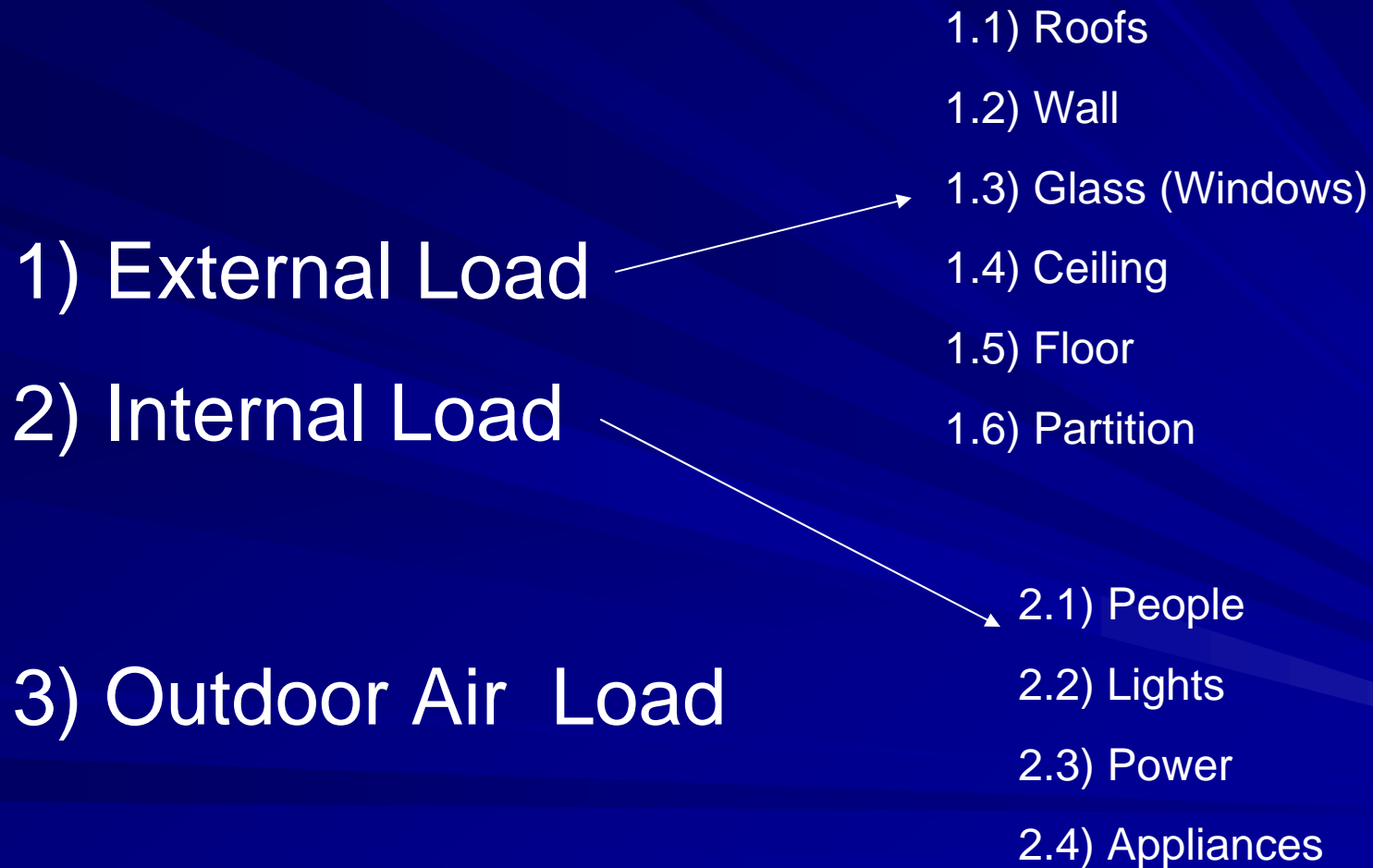
D Rate is per water closet and/or urinal. Provide the higher rate where periods of heavy use are expected to occur, e.g., toilets in theatres, schools, and sports facilities. The lower rate may be used otherwise.

E Rate is for a toilet room intended to be occupied by one person at a time. For continuous system operation during normal hours of use, the lower rate may be used. Otherwise use the higher rate.

F See other applicable standards for exhaust rate.

G For continuous system operation, the lower rate may be used. Otherwise use the higher rate.

# Components of Cooling Load

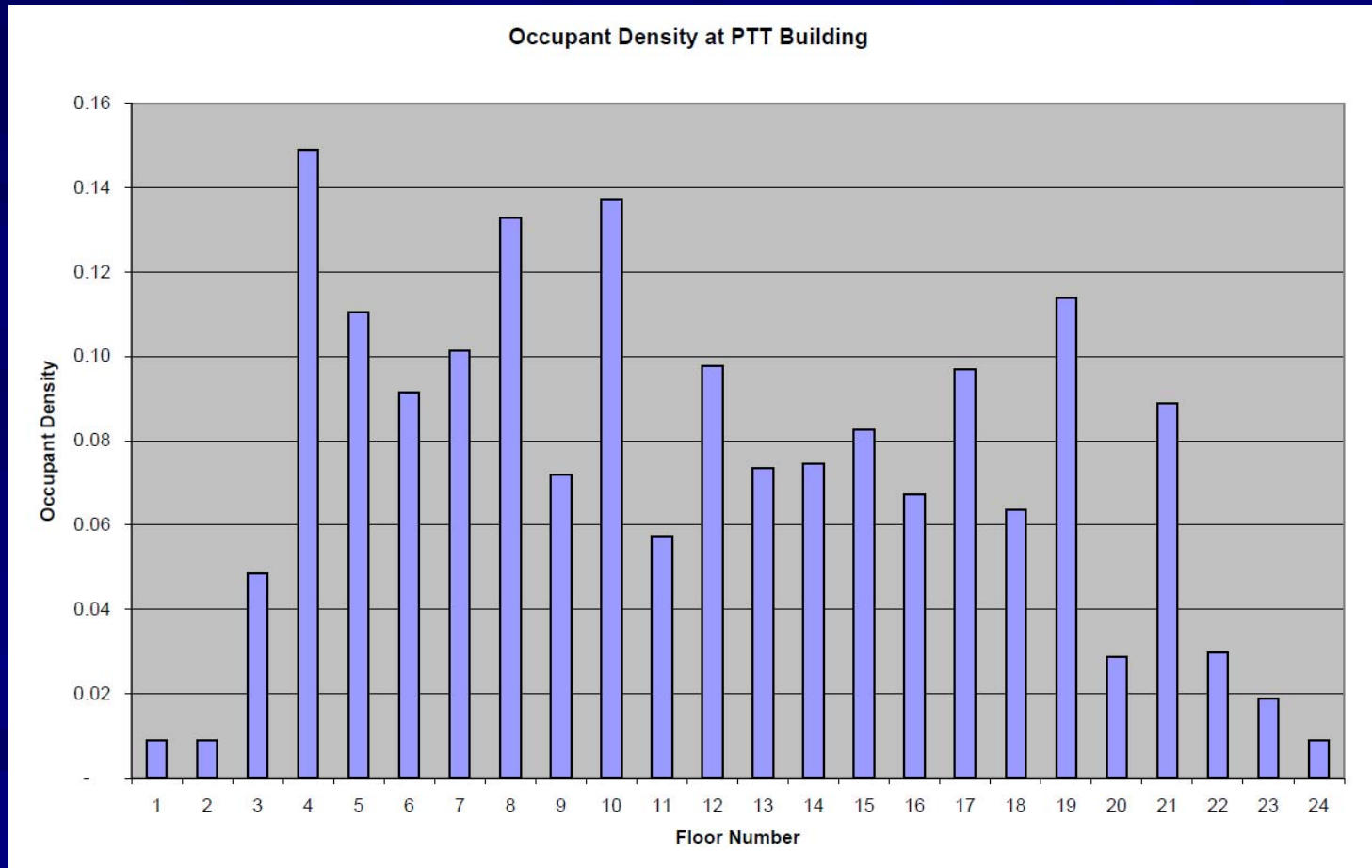




# Approximate Watt/Sq.m

Activity	Illumination (lux, lumen/m <sup>2</sup> )	Watt/Sq.m (Assume Eff. = 40 lu/Watt)
Warehouses, Homes, Theaters, Archives	150	3.75
Easy Office Work, Classes	250	6.25
Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories	500	12.5
Supermarkets, Mechanical Workshops, Office Landscapes	750	18.75
Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres	1,000	25
Detailed Drawing Work, Very Detailed Mechanical Works	1,500 - 2,000	37.5 - 50

# Occupant Density (PTT Bld.)



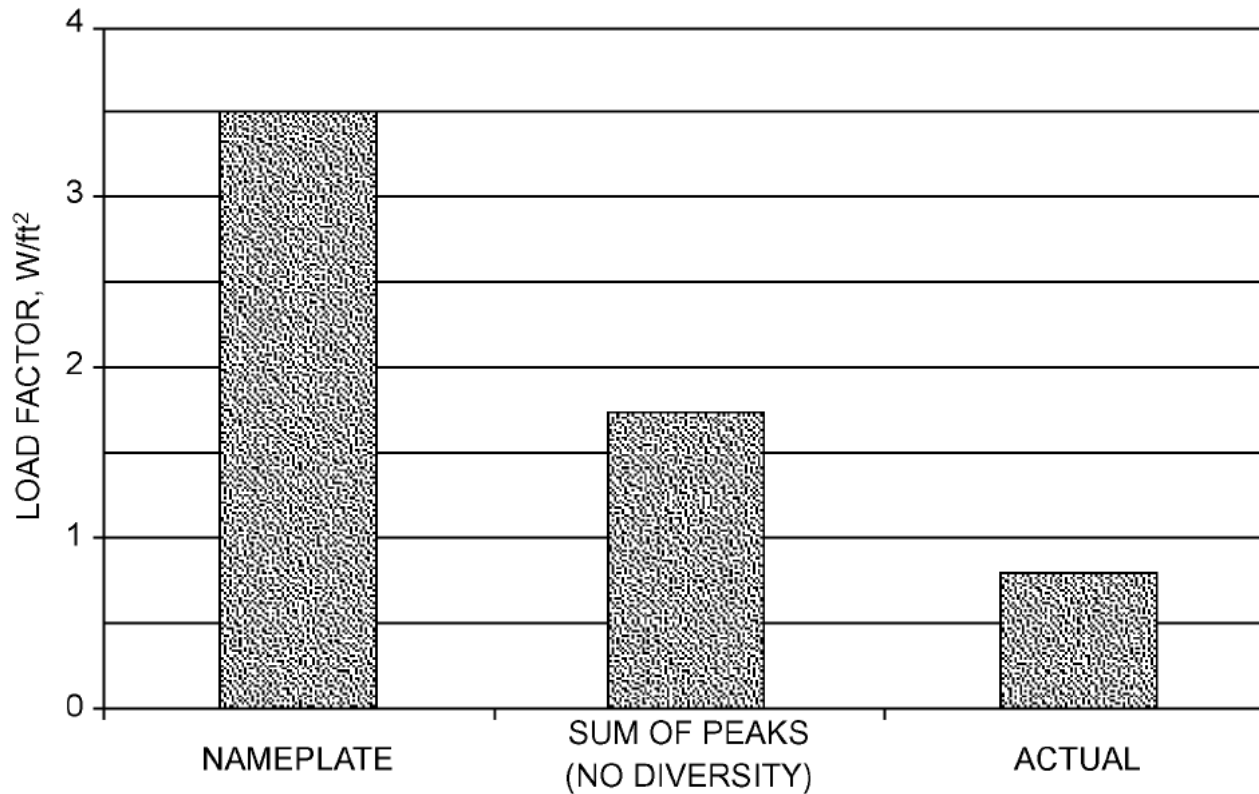
# Office Equipment Load Factor

**Table 11 Recommended Load Factors for Various Types of Offices**

<b>Load Density of Office</b>	<b>Load Factor, W/m<sup>2</sup></b>	<b>Description</b>
Light	5.4	Assumes 15.5 m <sup>2</sup> /workstation (6.5 workstations per 100 m <sup>2</sup> ) with computer and monitor at each plus printer and fax. Computer, monitor, and fax diversity 0.67, printer diversity 0.33.
Medium	10.8	Assumes 11.6 m <sup>2</sup> /workstation (8.5 workstations per 100 m <sup>2</sup> ) with computer and monitor at each plus printer and fax. Computer, monitor, and fax diversity 0.75, printer diversity 0.50.
Medium/ Heavy	16.1	Assumes 9.3 m <sup>2</sup> /workstation (11 workstations per 100 m <sup>2</sup> ) with computer and monitor at each plus printer and fax. Computer and monitor diversity 0.75, printer and fax diversity 0.50.
Heavy	21.5	Assumes 7.8 m <sup>2</sup> /workstation (13 workstations per 100 m <sup>2</sup> ) with computer and monitor at each plus printer and fax. Computer and monitor diversity 1.0, printer and fax diversity 0.50.



# Actual Load Factor



**Fig. 4 Office Equipment Load Factor Comparison**  
(Wilkins and McGaffin 1994)



# Duct Heat Gain & Leak Loss

Duct Heat Gain in % of RSH

- Supply Duct 1.5% (Typical Value)
- Return Duct 1.5% (Typical Value)

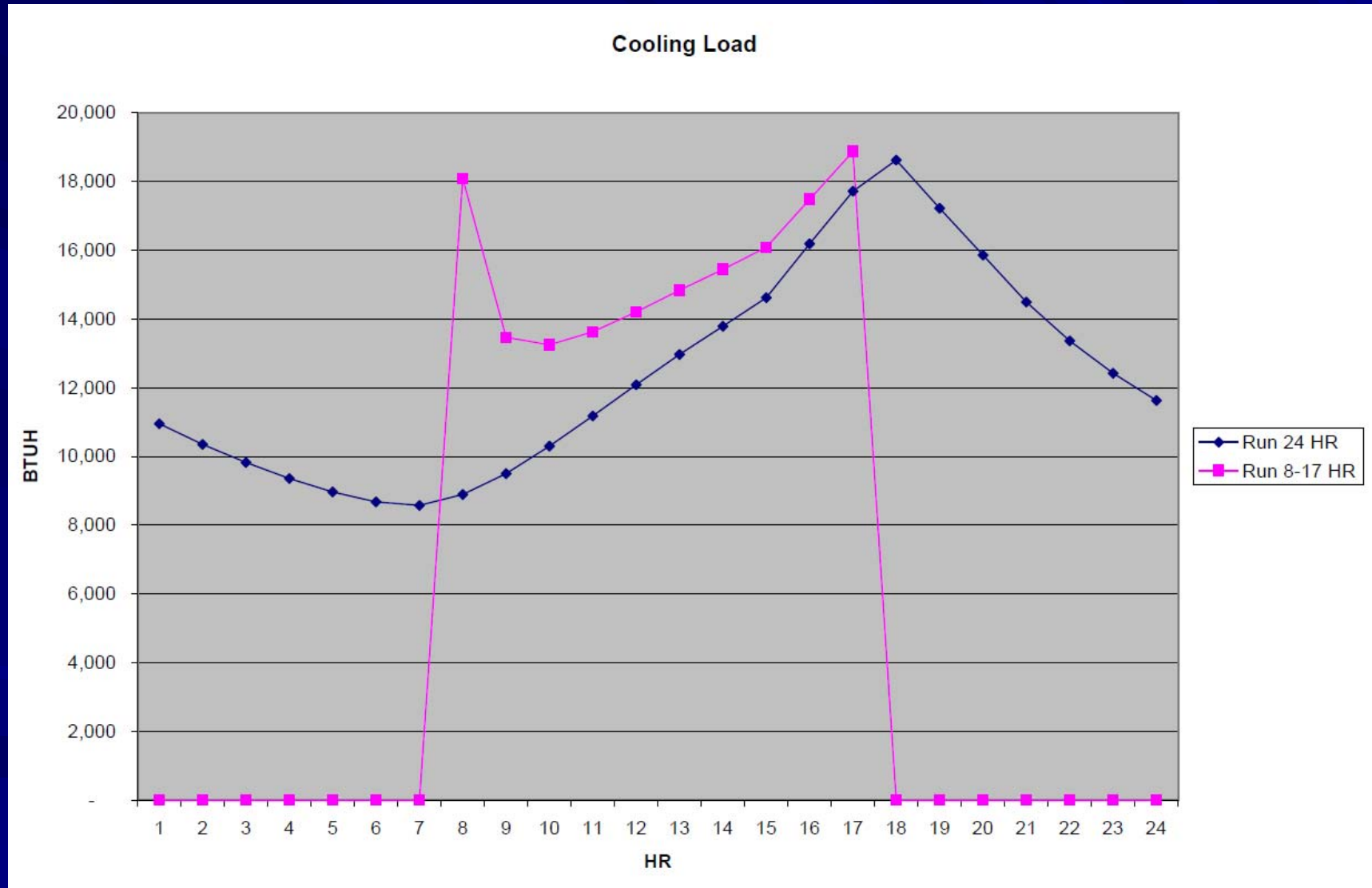
Duct Leakage in % of Total Air Supply

- Supply Duct 3% (Typical Value)
- Return Duct 0% (Typical Value)

Note that these value are only approximated.

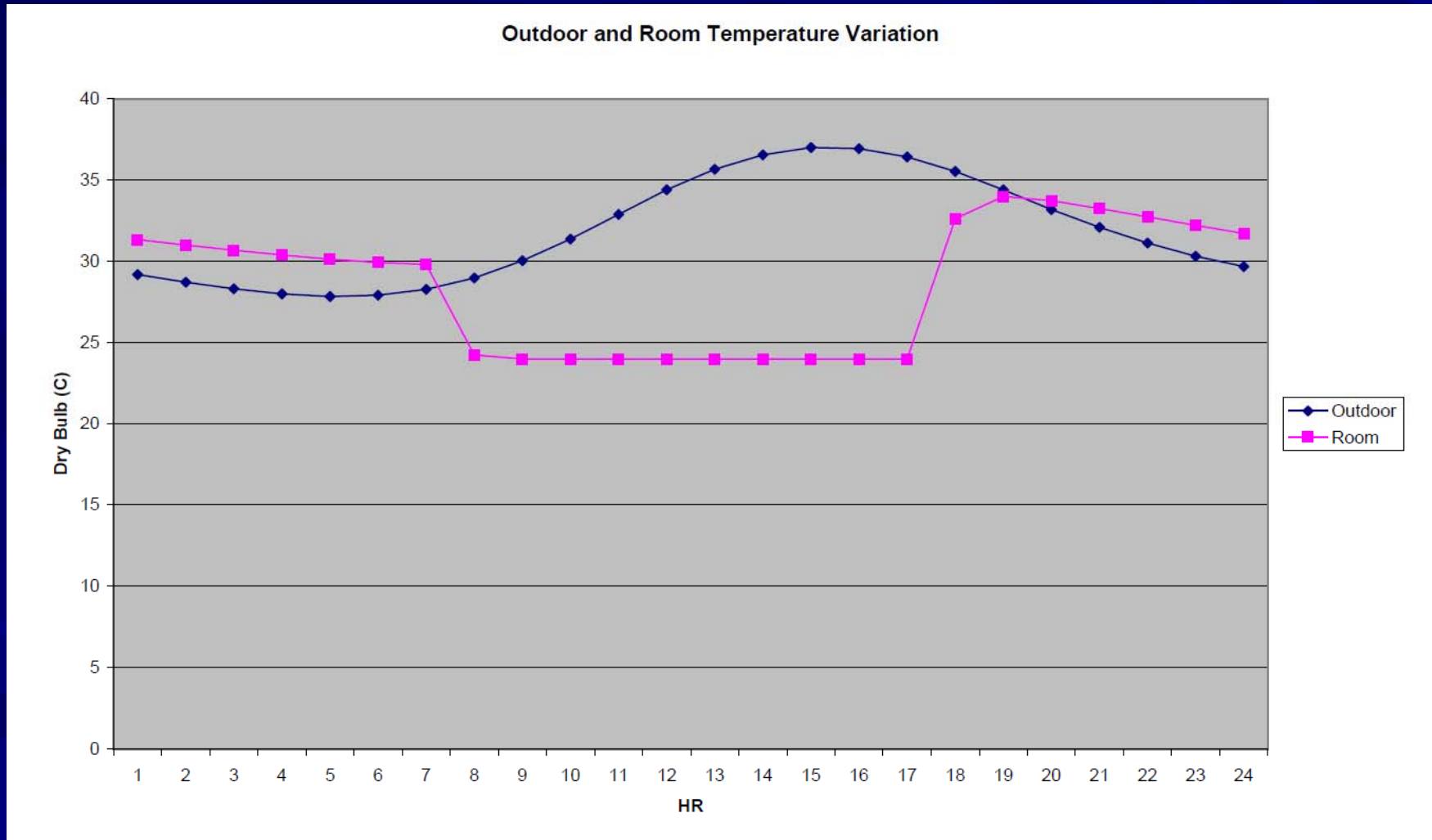


# Effect of Internal Mass





# Room Temperature Variation



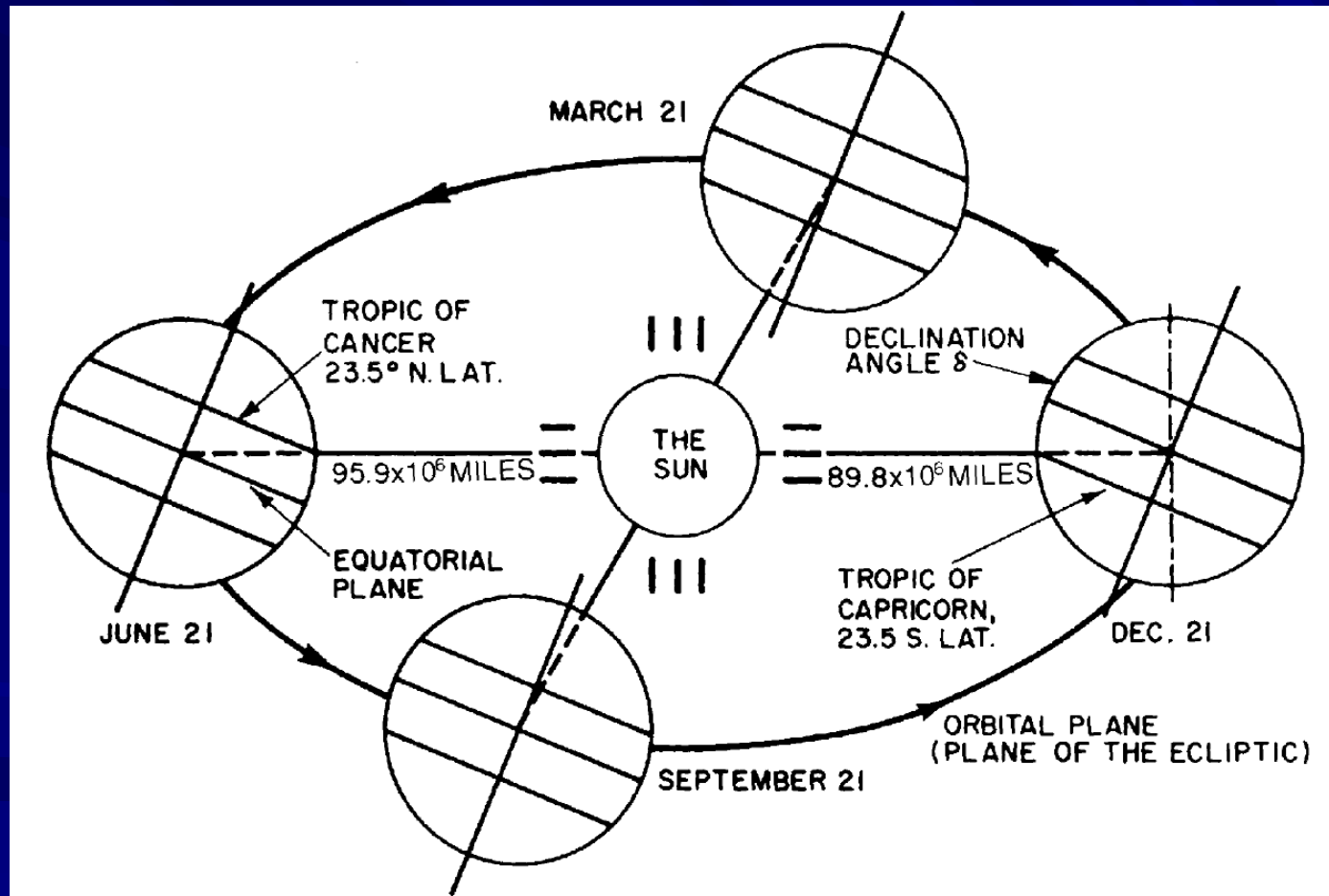
# Diversity Factor & Block Load

TABLE 14-TYPICAL DIVERSITY FACTORS  
FOR LARGE BUILDINGS

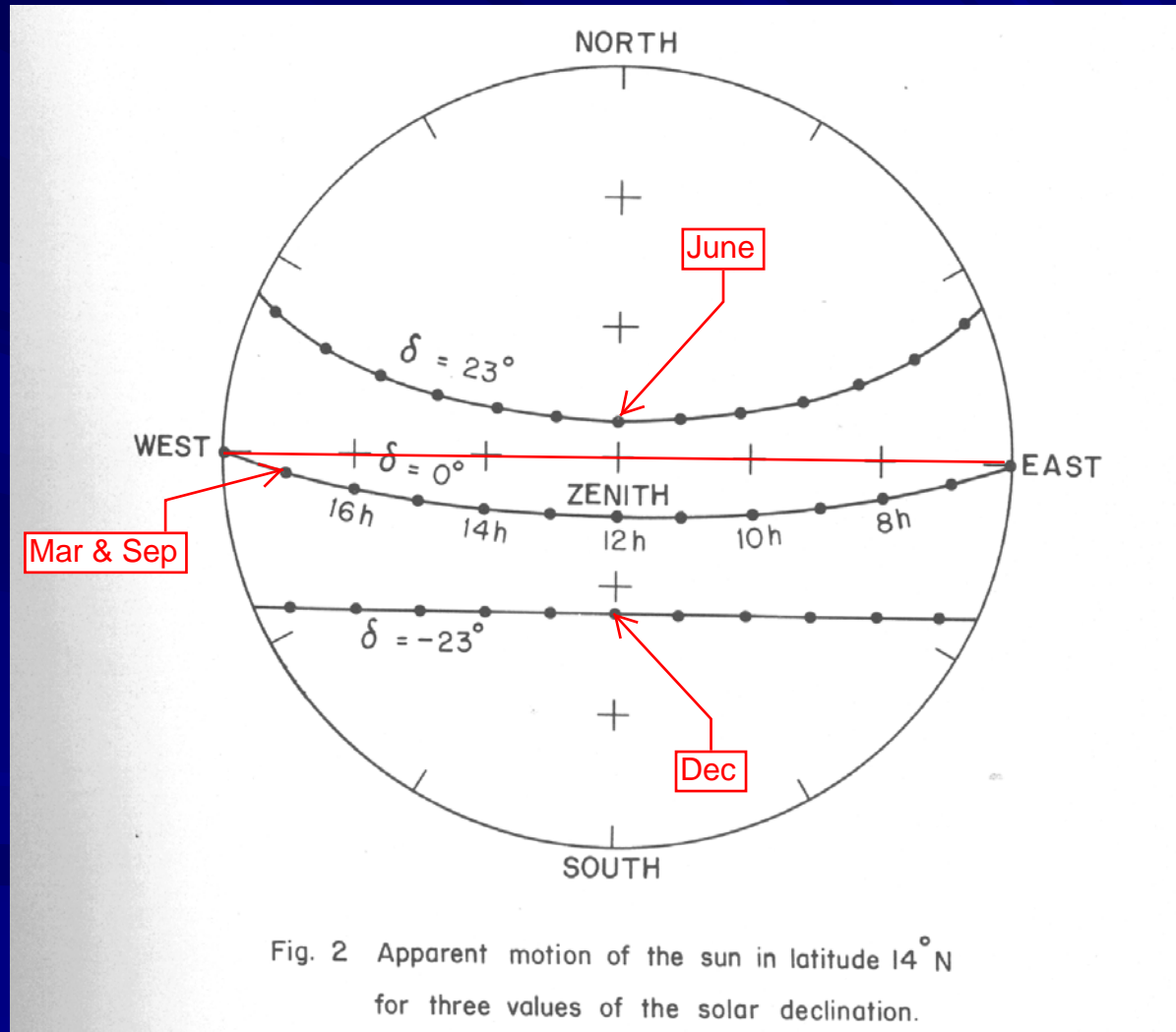
(Apply to Refrigeration Capacity)

TYPE OF APPLICATION	DIVERSITY FACTOR	
	People	Lights
Office	.75 to .90	.70 to .85
Apartment, Hotel	.40 to .60	.30 to .50
Department Store	.80 to .90	.90 to 1.0
Industrial*	.85 to .95	.80 to .90

# Earth Orbit



# Declination



Standard Sizing Step	Average No of People	Average No of Person Per Sq.m	Average Ventilation CFM	Average Ventilation ACH	Average Lighting Power Density (LPD) W/Sq.m	Average Plug Power Density (PPD) W/Sq.m
1 (14)	1.9	0.06	35	0.6	9.6	3.1
2 (19)	6.1	0.17	72	1.3	11.9	5.0
3 (17)	11.6	0.33	147	2.6	12.9	6.9
4 (12)	13.2	0.38	191	3.4	14.1	5.2
5 ( 5)	13.6	0.39	308	5.5	15.0	1.7
6 ( 9)	36.0	1.03	278	5.0	12.9	2.7
7 ( 5)	44.0	1.26	372	6.7	10.7	6.4
8 ( 1)	36.0	1.03	743	13.4	26.2	2.7
Standard Sizing Step	Average Total EE Power Density (TPD) W/Sq.m	Average Calculated BTU/H/Sq.m	Average Calculated BTU/H/Sq.m	Average Calculated Supply Air CFM	Average Supply Air ACH	Recommended Standard A/C Size BTU/H
1 (14)	12.7	22,071	631	1,079	19.4	24,000
2 (19)	16.9	26,696	763	1,142	20.5	30,000
3 (17)	19.9	33,543	958	1,215	21.9	36,000
4 (12)	19.3	38,416	1,098	1,265	22.7	42,000
5 ( 5)	16.8	45,643	1,304	1,236	22.2	48,000
6 ( 9)	15.6	55,200	1,577	1,407	25.3	60,000
7 ( 5)	17.1	66,355	1,896	1,437	25.8	90,000
8 ( 1)	28.9	98,427	2,812	1,519	27.3	120,000

Help on Person/Sq.m

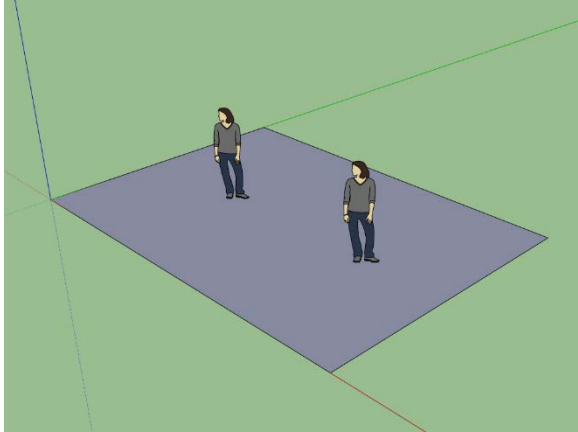
Help on LPD

Help on PPD

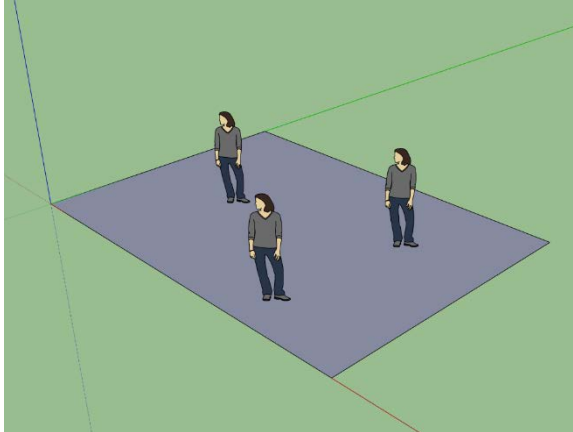
Click on Any Row to see the Example of Applications (Based on GOOD Ventilation)



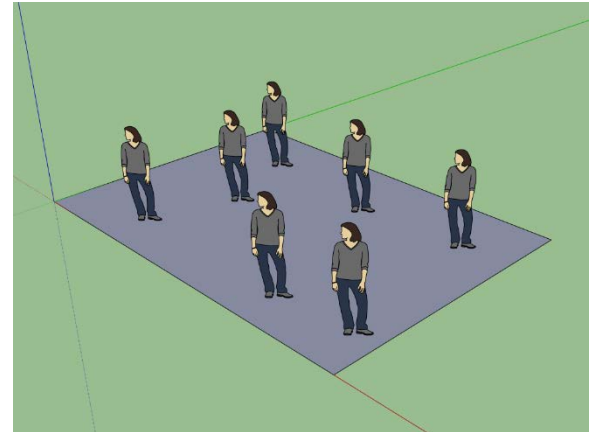
# จำนวนคน/ตรม



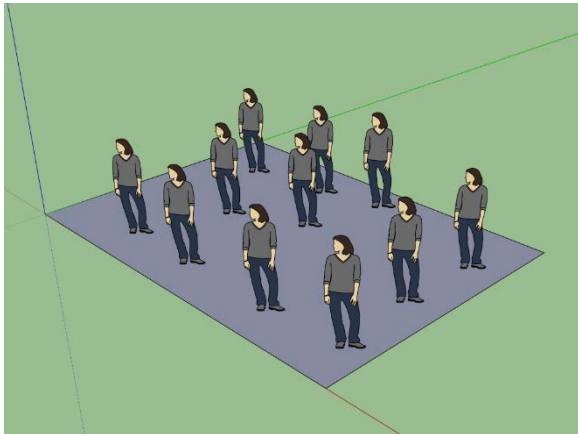
**0.06**



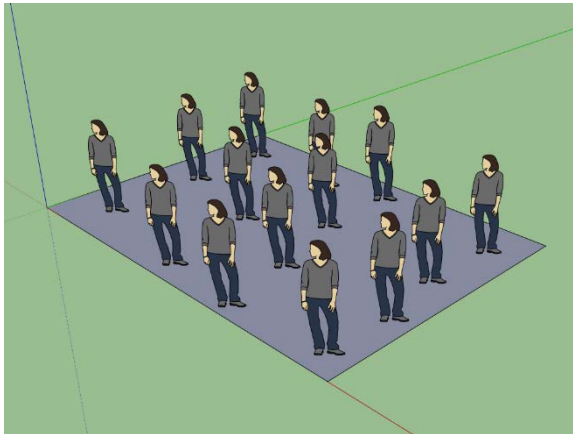
**0.09**



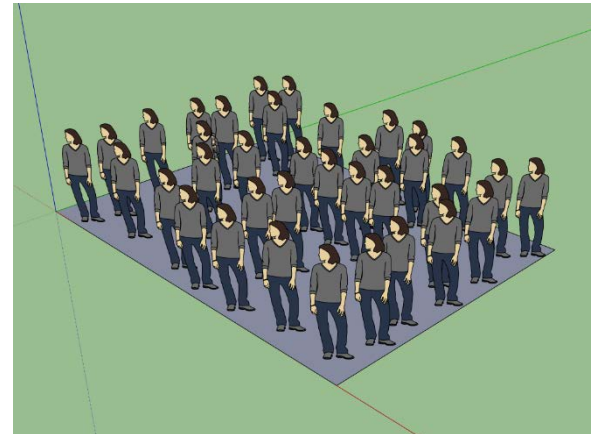
**0.20**



**0.31**



**0.40**



**1.03**

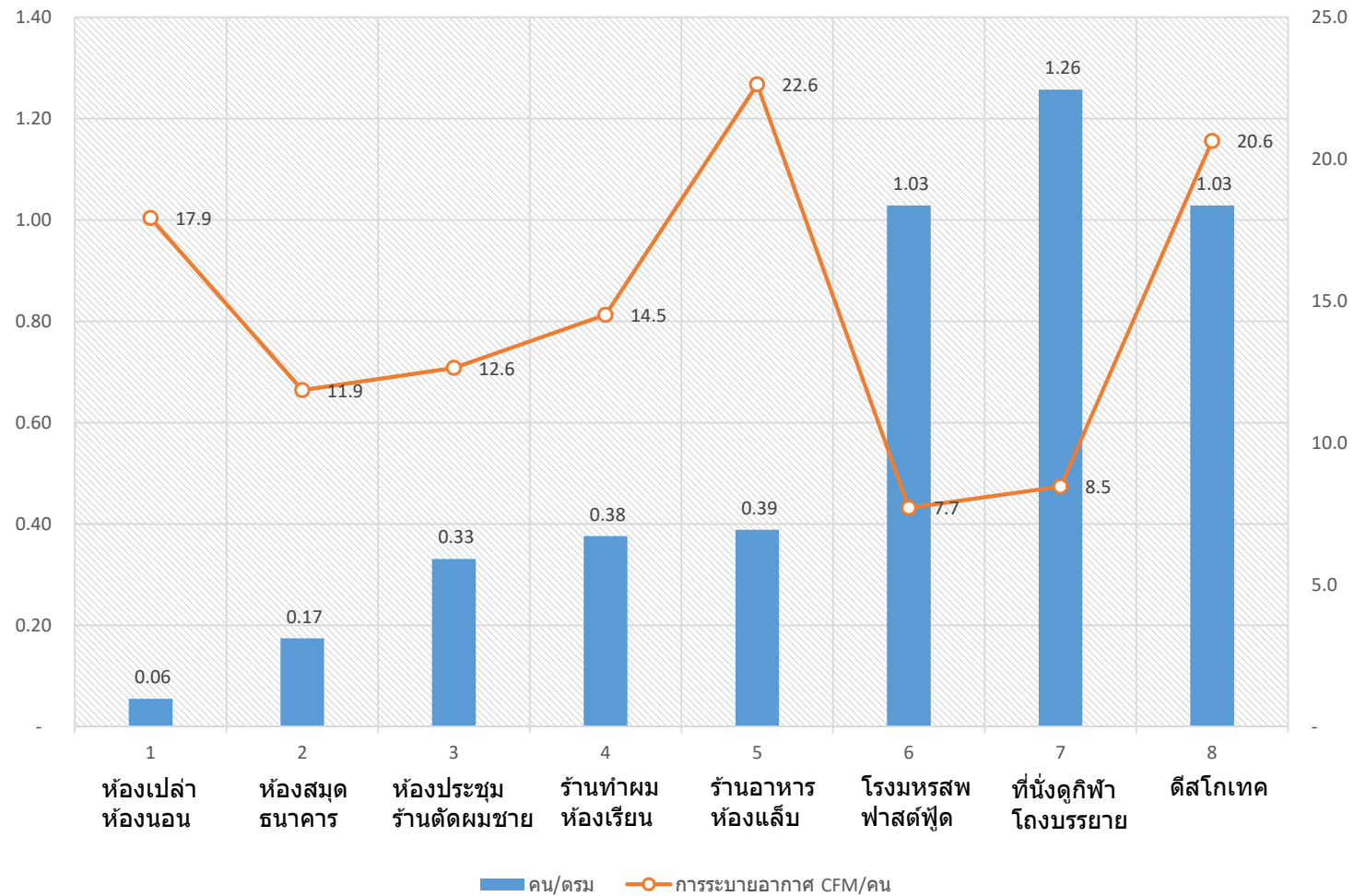
### การประยุกต์ใช้ Standard Sizing Step

จำนวนคน	การระบายอากาศต่อคน	Sizing Step	บีทียู/ตรม.	ตัวอย่างลักษณะการใช้งาน
น้อยมาก	ปานกลาง	1	631	ห้องเปล่า ห้องนอน
น้อย	น้อย	2	763	ห้องสมุด ธนาคาร
ปานกลาง	น้อย	3	958	ห้องประชุม ร้านตัดผมชาย
ปานกลาง	ปานกลาง	4	1,098	ร้านทำผม ห้องเรียน
ปานกลาง	มาก	5	1,304	ร้านอาหาร ห้องแล็บ
มาก	น้อย	6	1,577	โรงมหรสพ ฟาสต์ฟู้ด
มาก	น้อย	7	1,896	ที่นั่งดูกีฬา โถงบรรยาย
มาก	เยอะมาก	8	2,812	ดีสโกเทค

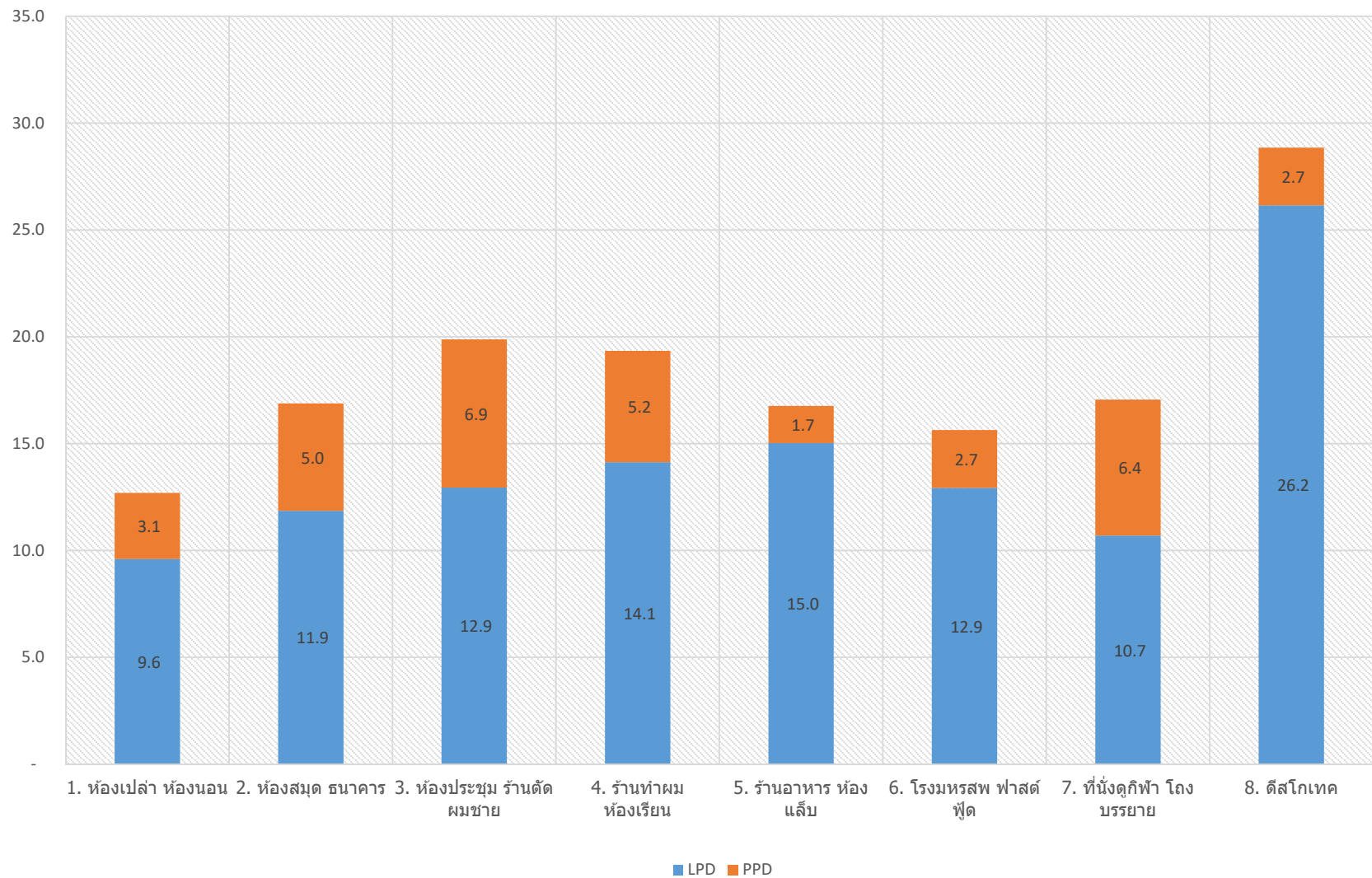
ตัวอย่างเช่น

- ถ้าเป็นห้องประชุมก็เลือกเครื่องขนาดที่ Sizing Step 3 เลยกก็ได้ เป็นต้น
- หรือดูจำนวนคนกับปริมาณการระบายอากาศต่อคน เพื่อเลือก Sizing Step ที่เหมาะสมเลยก็ได้

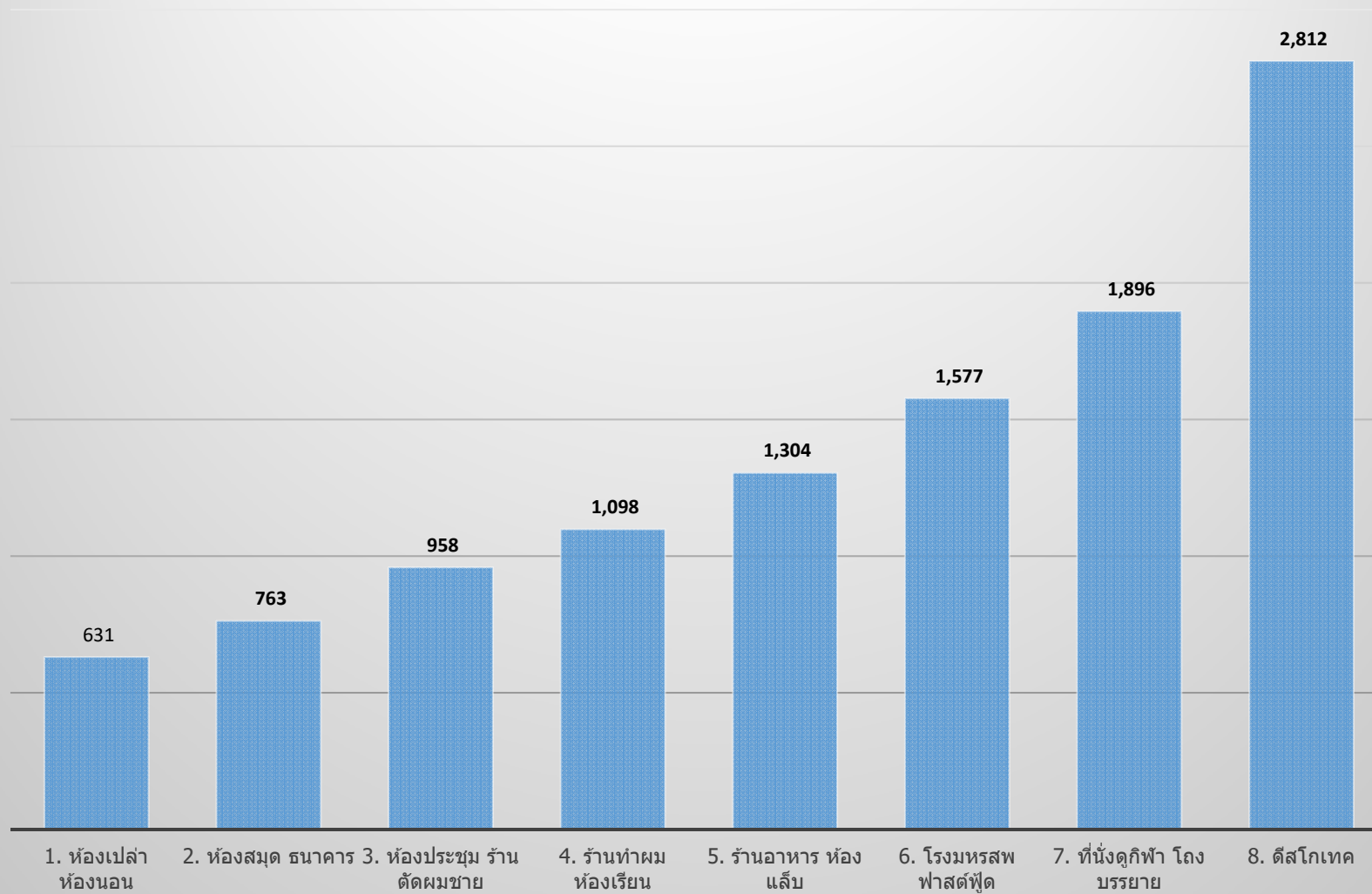
## คนและการระบายอากาศ



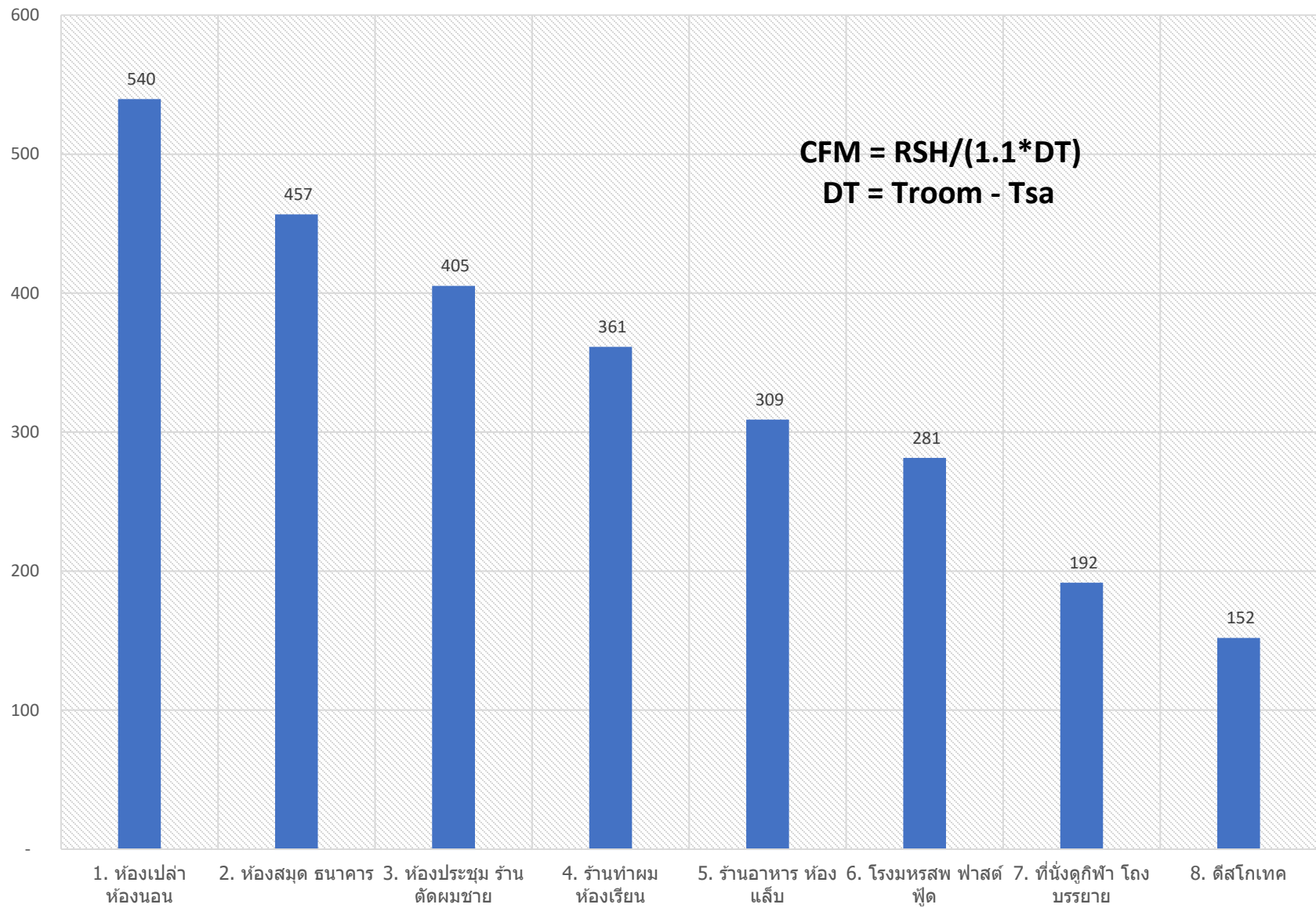
## การใช้ไฟฟ้าและแสงสว่าง



## BTUH/ตรม



## ปริมาณลมจ่าย CFM/Ton



# TMW-CL1 Summary of Cooling Load Calculations



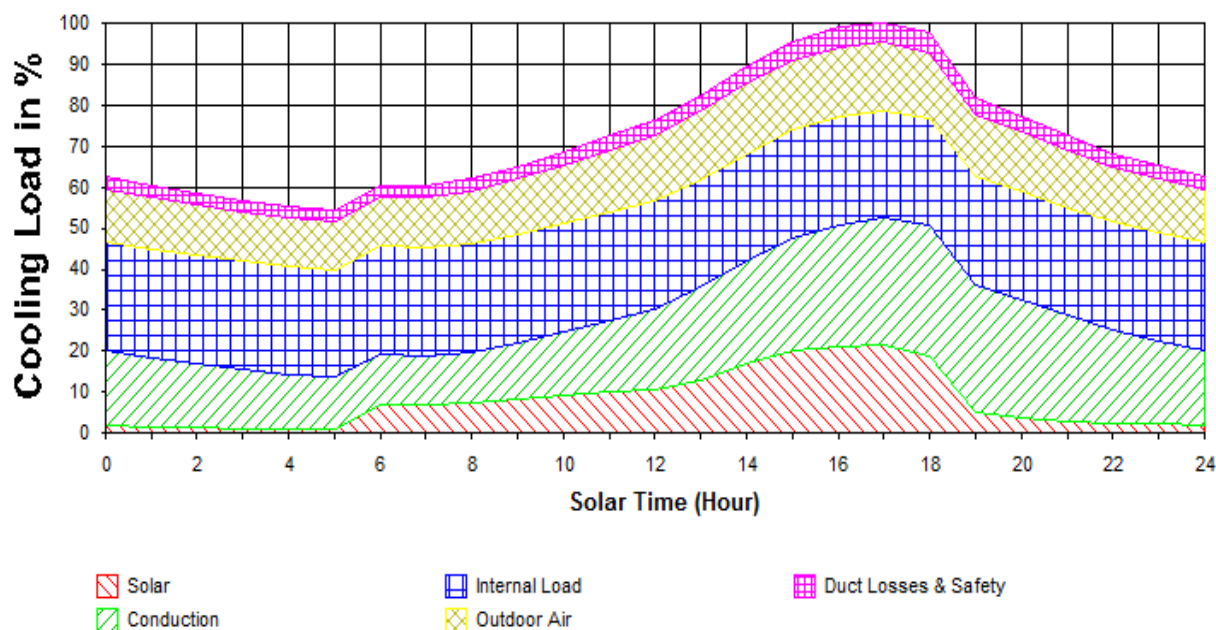
**Project :** My House

**Calculated by :** Tul Manewattana

**Zone :** Living room

**Date :** 6-March-2015

**Cooling Load Curve**



Total Cooling Load & Peak Hour		Load Components in Btu/h		Total Load Components in Btu/h	
Total Cooling Load (Btu/h)	38,077	Roof	0	Total Conduction Heat Gain	11,812
Sensible Heat Ratio	0.81	Walls	6,170	Total Solar Heat Gain	8,120
Peak HR	17	Glass	1,379	Total Internal Heat Gain	10,045
<b>Check Figures</b>		Partitions	1,123	Total Outdoor Air Load	6,286
Total Btu/h/sq.m.	1,088	Ceilings	565	Total Duct Loss & Safety	1,813
External Btu/h/sq.m.	569	Floors	2,576	<b>Important Input Parameters</b>	
Internal Btu/h/sq.m.	287	Solar	8,120	Latitude (Degree-N)	13.73
Outdoor Air Btu/h/sq.m.	180	Lighting	3,340	DB Range (F)	18.0
Loss & Safety Btu/h/sq.m.	52	People - Sensible	2,550	Outside DB (F)	95.0
<b>Supply Air</b>		People - Latent	2,550	Outside WB (F)	82.0
Supply Air (cfm)	1,515	Appliance - Sensible	0	Inside DB (F)	78.0
Cfm/Ton	477	Appliance - Latent	0	Inside RH %	55
Cfm/sq.m.	43.3	FCU/AHU Fan Motor	1,604	Floor Area (sq.m.)	35.00
<b>Input Filename &amp; Type of Area</b>		Outdoor Air - Sensible	1,782	Height (m.)	2.70
Room Filename	room2.zon	Outdoor Air - Latent	4,504	No. of People	10
Type of Area	Office	Duct Losses	0	Max. Ventilation Rate (cfm)	100

# Load Calculation Programs

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**Simple: TMW-CL1**

**Complex: EnergyPlus with Legacy  
OpenStudio Plug-in for Google SketchUp**











				People					Ventilation					Light		Equipment			Equipment		
Floor	Room Name	Area	Hight	พื้นที่เป็นหลัก		จำนวนคนเป็นหลัก		Conclude	People		Area			W/m2	(W)	W/m2	(W)	BTUH	Sensible Heat	Latent Heat	Hood Factor
				คน/m2	(คน)	(คน)	คน/m2		cfm /คน	cfm	cfm / ft2	cfm	total cfm								
1	Meeting Room	27	2.8	0.50	14	12	0.44	14	5.0	70	0.06	17	109	12.50	338	10.8	292	995			
1	Lobby	34	2.8	0.30	10	10	0.29	10	8	75	0.06	22	121	6.25	213	5.4	184	626			
1	Office	128	2.8	0.25	32	26	0.20	32	5.0	160	0.06	83	303	12.50	1,600	10.8	1,382	4,717			
1	Manager Room	12.5	2.8	0.30	4	2	0.16	2	5.0	10	0.06	8	23	12.50	156	5.4	68	230			
2	Conference	72	2.8	0.50	36	36	0.50	36	5.0	180	0.06	46	283	12.50	900	10.8	778	2,653			
2	Office	84	2.8	0.25	21	21	0.25	21	5.0	105	0.06	54	199	12.50	1,050	10.8	907	3,095			
2	Foyer	48	2.8	0.20	10	14	0.29	10	8	75	0.06	31	132	6.25	300	5.4	259	884			
2	Manager Room	12.5	2.8	0.30	4	2	0.16	2	5.0	10	0.06	8	23	12.50	156	5.4	68	230			
3	Reception Room	28	2.9	0.50	14	8	0.29	14	8	105	0.06	18	154	6.25	175	5.4	151	516			
3	Foyer	49	2.9	0.10	5	12	0.24	5	8	38	0.06	32	86	6.25	306	5.4	265	903			
3	Conference	113	4	0.50	57	50	0.44	57	5.0	285	0.06	73	447	12.50	1,413	10.8	1,220	4,164			