PT. SIGMATECH TATAKARSA
Mechanical & Electrical Engineers

DAIKIN

TALKSHOW AND WORKSHOP
HOSPITAL **HVAC** SYSTEM
DURING **ENDEMIC** COVID-19

Design dan Implementasi Sistem Tata Udara di Berbagai Ruangan Rumah Sakit

Dr. Ery Djunaedy, GP, CPMP
Direktur Pengembangan, Sigmatech Tatakarsa

Indonesian Association of Hospital Engineering
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Design dan Implementasi Sistem Tata Udara di Berbagai Ruangan Rumah Sakit

OUTLINE

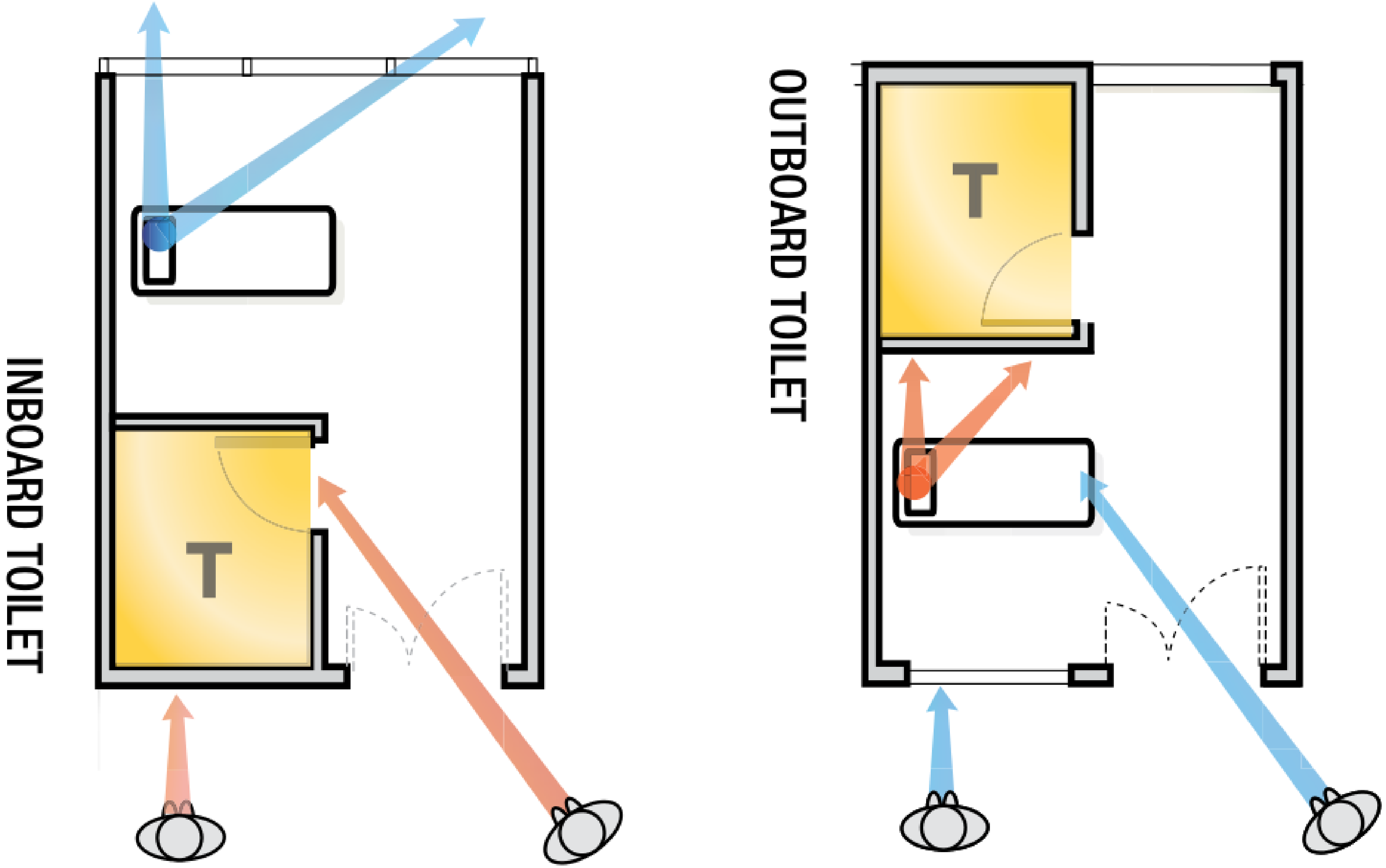
1 Kinerja Bangunan

Konsep Perancangan Kinerja Bangunan untuk RS

Toilet di Rumah Sakit

Apa yang salah dengan rancangan ini?

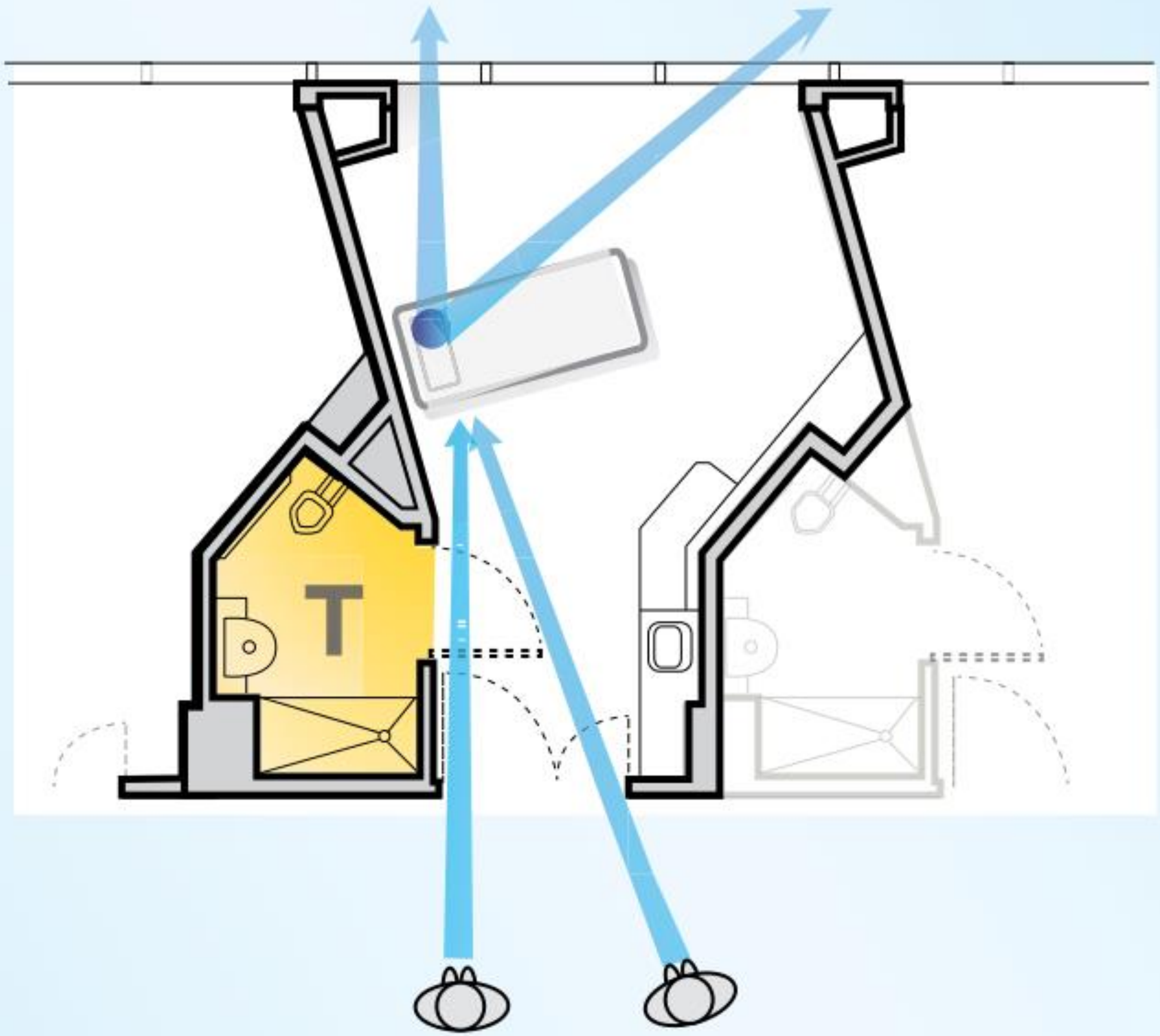
Toilet di Rumah Sakit



- Outboard vs inboard
- Patient vs nurse

Untuk ilustrasi saja, abaikan arah bukaan pintu

Toilet di Rumah Sakit



Toilet di Rumah Sakit

Both,
not either or


907

Toilet di Rumah Sakit

Miami Valley Patient Room

Conventional Patient Room

Move

Safety

Untuk ilustrasi saja, abaikan arah bukaan pintu toilet

Toilet di Rumah Sakit

- Ada aspek kinerja yang dipengaruhi oleh desain:
  - Jumlah langkah suster ketika keliling
  - Pandangan pasien ke luar jendela
  - Pandangan suster ke dalam kamar pasien
  - Kecepatan manuver tempat tidur
  - Berapa tikungan yang harus dilakukan oleh pasien untuk ke kamar mandi
- Desain harus berubah untuk mengakomodasi kinerja-kinerja ini

Toilet di Rumah Sakit

- Ada aspek kinerja yang dipengaruhi oleh desain:
  - Jumlah langkah suster ketika keliling
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- Desain harus berubah untuk mengakomodasi kinerja-kinerja ini

Kinerja Bangunan

- The common understanding of building performance across these publications is that of **a concept that allows to compare and contrast user needs with behaviour of a specific building**, or, in other words, **a concept that allows to quantify how well a building fulfils its functions**. (de Wilde, 2019)

- Sebuah konsep yang membuat kita bisa membandingan antara kebutuhan penghuni dengan perilaku bangunan

- Sebuah konsep yang membuat kita bisa mengkuantifikasi sebaik apa bangunan berfungsi

Kinerja Bangunan

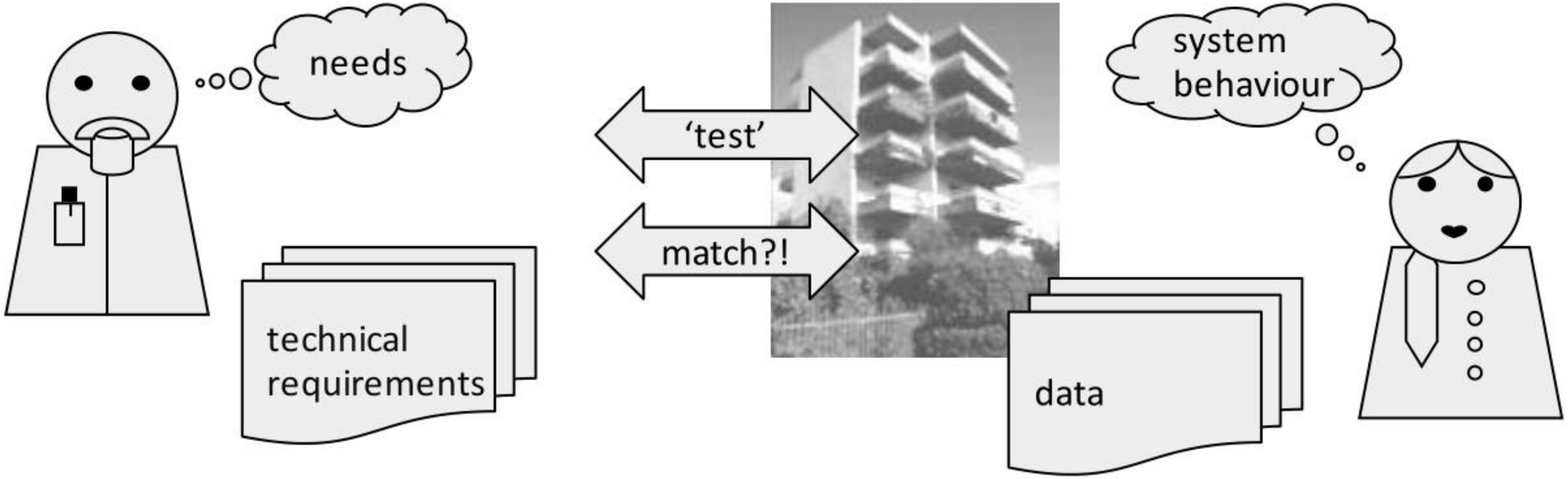

Figure 1: building performance as the test of how stakeholder needs meet observed behaviour

A closer view notes the need to redevelop the more general ‘user needs’ into ‘technical performance requirements’, whereas ‘building behaviour’ is something that emerges from building systems being subject to some form of excitation or stress, which leads to observable states.

Definisi Bangunan

- Amerika (Energy Independence and Security Act 2007 401 PL 110-140)
  - **Bangunan Berkinerja Tinggi** (High Performance Building): Bangunan yang memadukan dan mengoptimisasi dalam level siklus hidup **semua atribut utama kinerja tinggi**, termasuk konservasi energi [dan air], serta pertimbangan lingkungan, keselamatan, keamanan, ketahanan, keterjangkauan, biaya-manfaat, produktivitas, keberlanjutan, fungsionalitas, dan operasional.
- Indonesia (PermenPUPR 02/2015)
  - **Bangunan Gedung Hijau** adalah bangunan gedung yang memenuhi persyaratan bangunan gedung dan memiliki **kinerja** terukur secara signifikan dalam **penghematan energi, air, dan sumber daya lainnya** melalui penerapan prinsip bangunan gedung hijau sesuai dengan fungsi dan klasifikasi dalam setiap tahapan penyelenggaraannya.

Bukan hanya kinerja energi

Bukan hanya
kinerja energi

2

ASHRAE Standard 170

Perancangan Perancangan Sistem Tata Udara dengan Menggunakan Persyaratan ASHRAE Standard 170

ANSI/ASHRAE/ASHE Standard 170-2021
Ventilation of Health Care Facilities

SECTION

STANDARD

ANSI/ASHRAE/ASHE Standard 170-2021
(Supersedes ANSI/ASHRAE/ASHE Standard 170-2017)
Includes ANSI/ASHRAE/ASHE addenda listed in Appendix F

Ventilation of Health Care Facilities

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, the ASHE Board of Directors, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (https://www.ashrae.org/continuous-maintenance).

The latest edition of an ASHRAE Standard may be purchased from the ASHRAE website (www.ashrae.org) or from ASHRAE Customer Service, 180 Technology Parkway NW, Peachtree Corners, GA 30092. E-mail: orders@ashrae.org. Fax: 678-539-2129. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada). For reprint permission, go to www.ashrae.org/permissions.

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ASHRAE ASHE Optimizing health care facilities Approved American National Standard ANSI www.ansi.org

1. PURPOSE

The purpose of this standard is to define ventilation system design requirements that provide environmental control in health care facilities.

2. SCOPE

2.1 The requirements in this standard apply to patient care areas, resident care areas, and related support areas within health care facilities.

2.2 This standard applies to new buildings, additions to existing buildings, and those alterations to existing buildings that are identified within this standard.

2.3 This standard considers chemical, physical, and biological contaminants that can affect the delivery of medical care to patients and residents; the convalescence of patients and residents; and the safety of patients, residents, health care workers, and visitors.

2.4 This standard establishes design requirements for temperature and humidity.

2.5 This standard establishes design requirements for odor control and asepsis.

2.6 This standard establishes design requirements for ventilation rates, including, but not limited to, outdoor air to serve health care facilities.

2.7 This standard does not establish comprehensive thermal comfort design requirements.

Sistem Ventilasi

Ini **berbeda** dengan sistem pendinginan

Sistem Pendinginan ➔ untuk kenyamanan termal

Sistem Ventilasi ➔ untuk bernafas

4. COMPLIANCE

4.1 Compliance Requirements

4.1.1 New Buildings. New buildings shall comply with the provisions of this standard.

4.1.2 Existing Buildings

4.1.2.1 Additions to Existing Buildings. Additions shall comply with the provisions of this standard.

4.1.2.2 Alterations to Existing Buildings. Portions of a heating, ventilating, and air-conditioning system and other systems and equipment that are being altered shall comply with the applicable requirements of this standard.

4.1.2.2.1 Heating, Ventilation, and Air-Conditioning System Alterations. Alterations to mechanical systems serving the building heating, cooling, or ventilating needs shall comply with the requirements of Section 6, "Systems and Equipment," applicable to those specific portions of the building and its systems that are being altered. Any new mechanical equipment installed in conjunction with the alteration as a direct replacement of existing mechanical equipment shall comply with the provisions of Sections 6.2, 6.4, 6.5, and 6.6.

4.1.2.2.2 Space Alterations. Alterations to spaces listed in Tables 7-1, 8-1, 8-2, and 9-1 shall comply with the requirements of Sections 6.7, 7, 8, and 9, applicable to those specific portions of the building and its systems that are being altered. Any alteration to existing patient or resident care space in a building that will continue to treat patients during construction shall comply with Sections 5.4, 5.5, 10.1, 10.2.5.

Cakupan kepatuhan (compliance)

- Bangunan baru
- Bangunan eksisting yang mengalami renovasi

5. PLANNING

5.1 General. Space programming and planning details that impact the HVAC design shall be identified and addressed in the planning phase of design.

a. Facilities without operating rooms, that consist of spaces designed solely for outpatient or residential health, care, and support use, need only comply with Sections 5.2, 5.3, and 5.4.

5.2 Owner Requirements. Owners/managers of health care facilities shall do the following:

a. **Space Program.** Prepare a space program, including the clinical service expected in each space and specific user equipment to be used. The program shall include space names and paragraph numbering references from the applicable version of the relevant FGI Guidelines for each space noted within the program (***Informative Note:*** see FGI [2018a, 2018b, and 2018c] in Informative Appendix E). Specify needs for temperature, humidity, air filtration, localized and general exhaust, and pressure control that are not covered or are different than the requirements in this standard.

b. **Medical/Clinical Organizations.** Provide specific medical and clinical requirements that are different than the requirements in this standard.

c. **Facility Operational Plan.** Provide an operational plan in event of extended power or fuel outage. See Sections 6.1.2.1 and 6.1.2.2.

Owner’s requirements

Space programming:

- Ini ranah ARSITEK
- Sangat sulit meminta arsitek untuk mengeluarkan tabel berisi daftar ruangan beserta persyaratannya
- Ini harus ada dalam kontrak sebagai bagian dari deliverable arsitek

Contoh Space Programming
RS Salman “JIH” Bandung

1	ROOM NO	ROOM NAME	ZONE	LUAS	EQ		PENGHUNI		OUTDOOR AIR				EXHAUST		COOLING CAPACITY	INDOOR UNIT				RETURN AIR GRILLE		FRESH AIR GRILLE		EXHAUST AIR	
2									ACH	PER ORANG	PER M2	TOTAL	ACH	TOTAL		TYPE	QTY	CAPACITY	FLOW RATE	FLOW RATE	DIMENSION	FLOW RATE	DIMENSION	FLOW RATE	DI
3															kW										
4	1A01	MAIN LOBBY	1A	426.9	20	860	10.0	43	2			2391		0	45.6	CC	3	16	0			2391	600 x 400		
5	1A02	TOILET DIFABLE	1A	5.6	0	0	0.0	0				0	10	157					0					157	2
6	1A03	TOILET WANITA	1A	13.8	0	0	0.0	0				0	10	387					0					387	3
7	1A04	TOILET PRIA	1A	10.0	0	0	0.0	0				0	10	280					0					280	2
8	1A05	CUSTOMER SERVICE	1A	11.2	50	100	5.0	2		8.5	1	29		0	1.9	CC	1	2.2	0			29	150 x 100		
9	1A06	MEDICAL RECORD	1A	26.0	100	500	5.0	5		8.5	1	69		0	1.9	CC	1	2.2	0			69	150 x 100		
10	1A07	KORIDOR	1A	69.5	0	0	10.0	7				0		0	2.1	CC	1	2.2	0						
11	1A08	PANTRY	1A	3.2	0	0	3.0	1				0	4	36					0					36	1

- Tabel ini dibuat oleh konsultan MEP, sehingga berisi informasi sistem ventilasi dan pendinginan saja
- Seharusnya tabel ini (awalnya) dibuat oleh arsitek, konsultan MEP tinggal melanjutkan saja dengan kolom baru
- Persyaratan ruangan ➔ arsitek, dibantu engineers
- Misalnya:
  - Luas ruangan ➔ bukan pekerjaan MEP untuk menghitung luasan ruangan dari gambar
  - Ruangan itu mau terang benderang (flood light) atau temaram
  - Ada berapa orang yang harus ada di situ
  - Aktivitas apa yang dilakukan orang di situ

5.3 Planning for HVAC Services in a New Facility. Design documents for new construction shall meet the following requirements:

a. **Mechanical Equipment**

1. Locate mechanical rooms to avoid the intrusion of maintenance personnel into surgical, critical-care-patient, or other patient- or medical-staff-sensitive areas.
2. Provide sufficient space to comply with HVAC equipment manufacturers' minimum required access for operation, maintenance, and replacement.
3. Provide safe and practical means of accessing equipment.
4. Floors in mechanical rooms shall be sealed—including sealing around all penetrations—when they are above surgical suites and critical care spaces.

b. **Space Allocation for HVAC Distribution Systems**

1. **HVAC Distribution Systems.** Coordinate ceiling plenum height, underfloor, and other areas where HVAC distribution systems are intended to be installed to allow for installation, inspection, and maintenance.
2. **Mechanical Shafts.** Allow for needed access for damper installation (if required), inspection, and service. Access doors shall be sized to meet code minimum for service requirements.

Ranah konsultan MEP

Ranah arsitek, atas permintaan MEP

5.4 Planning for the HVAC Services in an Existing Facility. If any existing air-handling, cooling, or heating equipment is to be reused, the designer shall evaluate the capacity of the equipment to determine whether it will meet the requirements of this standard for the remodeled space.

5.5 Planning for Infection Control During Remodeling of an Existing Facility. Where required, prior to beginning modifications or remodeling of HVAC systems in an existing facility, an owner shall conduct an infection control risk assessment (ICRA). The ICRA shall establish those procedures required to minimize the disruption of facility operation and the distribution of dust, odors, and particulates.

5.6 Planning for HVAC Systems Operating During Construction. Owner and design team shall determine if, and under what conditions, the permanent HVAC systems can be used for providing temporary heating, cooling, and/or dehumidifying during construction. Refer to Section 10.1.4.3(b).

Beberapa kasus khusus

6.1 Utilities

6.1.1 Ventilation Upon Loss of Electrical Power. The space ventilation and pressure relationship requirements of Tables 7-1, 8-1, and 9-1 shall be maintained for the following spaces, even in the event of loss of normal electrical power:

a. All rooms
b. Protective environment (PE) rooms (inpatient only)
c. Operating rooms (ORs), including delivery rooms (Caesarean) (inpatient and outpatient only)

Exception to 6.1.1: When an essential power system is not provided or required, operation of space ventilation and pressure relationships is not required.

Informative Note: For further information, see NFPA 99 (2021) in Informative Appendix E.

6.1.2 Heating and Cooling Sources

6.1.2.1 Provide heat sources and essential accessories in number and arrangement sufficient to accommodate the facility needs (reserve capacity), even when any one of the heat sources or essential accessories is not operating due to a breakdown or routine maintenance. The capacity of the remaining source or sources shall be sufficient to provide for domestic hot water, sterilization, and dietary purposes and to provide heating for operating, delivery, birthing, labor, recovery, emergency, intensive care, nursery, and resident care areas and inpatient/resident rooms. Fuel sufficient to support the owner's facility operation plan upon loss of fuel service shall be provided on site.

Exception to 6.1.2.1: Reserve capacity is not required if the ASHRAE 99% heating dry-bulb temperature for the facility is greater than or equal to 25°F (–4°C).

6.1.2.2 Inpatient and Residential Health Care Spaces. For central cooling systems greater than 400 tons (1407 kW) peak cooling load, the number and arrangement of cooling sources and essential accessories shall be sufficient to support the owner's facility operation plan upon a breakdown or routine maintenance of any one of the cooling sources.

Asumsi dalam perancangan sistem ventilasi:

- Power suplai tersedia
- Sistem pendinginan tersedia

6.2 Air-Handling Unit (AHU) Design

6.2.1 AHU Casing. The casing of the AHU shall be designed to prevent water intrusion, resist corrosion, and permit access for inspection and maintenance. All airstream surfaces of AHUs shall comply with ASHRAE Standard 62.1 [1], Section 5.4.

6.3 Outdoor Air Intakes and Exhaust Discharges

6.3.1 Outdoor Air Intakes

6.3.1.1 General. Outdoor air intakes for AHUs shall be located such that the shortest distance from the intake to any specific potential outdoor contaminant source shall be equal to or greater than the separation distance listed in Table 6-1 and comply with all other requirements of this section. New facilities with moderate-to-high risk of natural or man-made extraordinary incidents shall locate air intakes away from public access. All intakes shall be designed to prevent the entrainment of wind-driven rain, shall contain features for draining away precipitation, and shall be equipped with a birdscreen of mesh no smaller than 0.5 in. (13 mm).

Table 6-1 Air Intake Minimum Separation Distance

Potential Outdoor Contaminant Source	Minimum Distance, ft (m)
Class 2 air outlet	10 (3)
Required exhaust from ASHRAE Standard 62.1, Table 6-2, or other codes	25 (7.5)
Required exhaust from Table 7-1, 8-1, 8-2, or 9-1 or Class 3 air exhaust outlet	25 (7.5)
Required exhaust from Section 6.3.2.2 or Class 4 air exhaust outlet	30 (10)
Plumbing vents	25 (7.5)
Vents, chimneys, and flues from combustion appliances and equipment	25(7.5)
Garage entry, automobile loading area, or drive-in queue	See Note 1
Truck loading area or dock, bus parking/idling area	See Note 1
Driveway, landscaped grade, sidewalk, street, or parking place directly below intake	5 (1.6)
Thoroughfare with high vehicle traffic volume	See Note 1
Roof or other above-grade surface directly below intake	3 (1)
Garbage storage/pick-up area, dumpsters	See Note 1
Cooling tower exhaust, intake, or basin	25 (7.5)

Note 1: Refer to ASHRAE Standard 62.1 [1], Table 5-1.

Informative Note: Classifications in Tables 6-1, 6-2, and 6-3 are based on relative contaminant concentration using the following subjective criteria:

1. Class 1: Air with low contaminant concentration, low sensory-irritation intensity, and inoffensive odor.
2. Class 2: Air with moderate contaminant concentration, mild sensory-irritation intensity, or mildly offensive odors. (Class 2 air also includes air that is not necessarily harmful or objectionable but that is inappropriate for transfer or recirculation to spaces used for different purposes.)
3. Class 3: Air with significant contaminant concentration, significant sensory-irritation intensity, or offensive odor.
4. Class 4: Air with highly objectionable fumes or gases or with potentially dangerous particles, bioaerosols, or gases, at concentrations high enough to be considered as harmful.

Table 6-3 Airstreams or Sources

Description	Air Class
Commercial kitchen grease hoods	4
Commercial kitchen hoods other than grease	3
Diazo printing equipment discharge	4
Hydraulic elevator machine room	2
Laboratory hoods	4
Paint spray booths	4
Refrigerating machinery rooms	3
Residential kitchen hoods in transient occupancy	3

Table 5-1 Air Intake Minimum Separation Distance

Object	Minimum Distance, ft (m)
Class 2 air exhaust/relief outlet	10 (3)
Class 3 air exhaust/relief outlet	15 (5)
Class 4 air exhaust/relief outlet	30 (10)
Cooling tower exhaust	25 (7.5)
Cooling tower intake or basin	15 (5)
Driveway, street, or parking place	5 (1.5)
Garage entry, automobile loading area, or drive-in queue	15 (5)
Garbage storage/pick-up area, dumpsters	15 (5)
Plumbing vents terminating at least 3 ft (1 m) above the level of the outdoor air intake	3 (1)
Plumbing vents terminating less than 3 ft (1 m) above the level of the outdoor air intake	10 (3)
Roof, landscaped grade, or other surface directly below intake	1 (0.30)
Thoroughfare with high traffic volume	25 (7.5)
Truck loading area or dock, bus parking/idling area	25 (7.5)
Vents, chimneys, and flues from combustion appliances and equipment	15 (5)

6.3 Outdoor Air Intakes and Exhaust Discharges

6.3.1 Outdoor Air Intakes

6.3.1.1 General. Outdoor air intakes for AHUs shall be located such that the shortest distance from the intake to any specific potential outdoor contaminant source shall be equal to or greater than the separation distance listed in Table 6-1 and comply with all other requirements of this section. New facilities with moderate-to-high risk of natural or man-made extraordinary incidents shall locate air intakes away from public access. All intakes shall be designed to prevent the entrainment of wind-driven rain, shall contain features for draining away precipitation, and shall be equipped with a birdscreen of mesh no smaller than 0.5 in. (13 mm).

Exception to 6.3.1.1:

1. For gas-fired, packaged rooftop units, the separation distance of the unit's outdoor air intake from its flue may be less than 25 ft (8 m). The separation distance shall be greater than or equal to the distance prescribed in ASHRAE Standard 62.1 [1], Table 5-1, "Air Intake Minimum Separation Distance."
2. For plumbing vents terminating with stack-type air admittance valves installed less than 3 ft (1m) above the level of the outdoor air intake, the minimum separation distance may be 10 ft (3 m). For plumbing vents terminating with stack-type air admittance valves installed at least 3 ft (1m) above the level of the outdoor air intake, the minimum separation distance may be 3 ft (1 m).
3. If permitted by the AHJ, based on an engineering analysis of reentrainment, separation distances may be decreased below Table 6-1 values for cooling towers and exhaust and vent discharges, and an alternate location may be used. The submitted reentrainment analysis shall demonstrate that an exhaust discharge outlet located at a distance less than required by Table 6-1 provides a lower concentration of reentrainment than all the areas located at a distance greater than required by Table 6-1 on the roof level where the exhaust discharge is located. (***Informative Note:*** For example, located adjacent to an air intake but with the exhaust discharge point above the top of the air intake.)

6.3.2 Exhaust Discharges

6.3.2.1 General. Exhaust discharge outlets that discharge air from AII rooms, bronchoscopy and sputum collection and pentamidine administration rooms, emergency department public waiting areas, nuclear medicine hot labs, radiology waiting rooms programmed to hold patients who are waiting for chest x-rays for diagnosis of respiratory disease, pharmacy hazardous-drug exhausted enclosures, and laboratory work area chemical fume hoods shall

a. be designed so that all ductwork within the building is under negative pressure.

   Exception to 6.3.2.1(a): Ductwork located within mechanical equipment rooms. Positive-pressure exhaust ductwork located within mechanical equipment rooms shall be sealed in accordance with SMACNA duct leakage Seal Class A [2].

b. be located such that they reduce the potential for the recirculation of exhausted air back into the building.

6.3.2.2 Additional Requirements

a. Exhaust discharge outlets from AII rooms, bronchoscopy and sputum collection exhaust, pharmacy hazardous-drug exhausted enclosures, and laboratory work area chemical fume hoods shall additionally be arranged to discharge to the atmosphere in a vertical direction (with no rain cap or other device to impede the vertical momentum) and at least 10 ft (3 m) above the adjoining roof level.

Exception to 6.3.2.2(a): AII room exhaust that first passes through a high-efficiency particulate air (HEPA) filter.

b. Exhaust discharge outlets from laboratory work area chemical fume hoods shall discharge with a stack velocity of at least 3000 fpm (15.24 L/s).

Exception to 6.3.2.2(b): Lower discharge velocity may be permitted when an engineering analysis can demonstrate that the specific design meets the dilution criteria necessary to reduce concentration of hazardous materials in the exhaust to safe levels at all potential receptors. (See ANSI/AIAH Z9.5 [3], Section 2.1.)

c. Exhaust discharge outlets from AII rooms, bronchoscopy and sputum collection exhaust, and laboratory work area chemical fume hoods shall be located not less than 25 ft (8 m) horizontally from outdoor air intakes, openable windows/doors, and areas that are normally accessible to the public.

Exception to 6.3.2.2(c): If permitted by the AHJ, an alternate location may be used (***Informative Note:*** e.g., located adjacent to an air intake but with the exhaust discharge point above the top of the air intake). The submitted reentrainment analysis shall demonstrate that an exhaust discharge outlet located at a distance less than 25 ft (8 m) horizontally provides a lower concentration of reentrainment than all the areas located at a distance greater than 25 ft (8 m) horizontally on the roof level where the exhaust discharge is located.

6.4 Filtration. Filtration of mechanically supplied air shall be provided as follows:

a. Particulate matter filters, minimum MERV-8, shall be provided upstream of the first heat exchanger surface of any air-conditioning system that combines return air from multiple rooms or introduces outdoor air.
b. Outdoor air shall be filtered in accordance with Table 7-1, 8-1, 8-2, or 9-1.
c. Air supplied from equipment serving multiple or different spaces shall be filtered in accordance with Table 7-1, 8-1, 8-2, or 9-1.
d. Air recirculated within a room shall be filtered in accordance with Table 7-1, 8-1, 8-2, or 9-1, or Section 7.1(a)(5), 8.1(a)(5), 8.2(a)(5), or 9.1(a)(5).
e. The design shall include all necessary provisions to prevent moisture accumulating on filters located downstream of cooling coils and humidifiers.
f. Minimum filter requirements shall meet the equivalent MERV rating when tested in accordance with ASHRAE Standard 52.2 [4].
g. Any HEPA filter or filter MERV-14 or higher shall have sealing interface surfaces. ***(Informative Note:*** HEPA filters are those filters that remove at least 99.97% of 0.3 micron sized particles at the rated flow in accordance with the testing methods of IEST RP CC001.3 [2005] in Informative Appendix E).
h. For spaces that do not permit air recirculated by means of room units and have a minimum filter efficiency of MERV-14, MERV-16, or HEPA in accordance with Table 7-1, 8-1, or 8-2, the minimum filter requirement listed in Table 7-1, 8-1, or 8-2 shall be installed downstream of all wet-air cooling coils and the supply fan.

6.7 Air Distribution Systems

6.7.1 General. Maintain the pressure relationships required in Tables 7-1, 8-1, 8-2, and 9-1 in all modes of HVAC system operation, except as noted in the tables. Spaces that have required pressure relationships shall be served by fully ducted return systems or fully ducted exhaust systems. The following additional surgery and critical-care patient care areas that do not require a pressure relationship to adjacent areas shall also be served by fully ducted return or exhaust systems: recovery rooms, critical and intensive care areas, intermediate care areas, and wound intensive care units (burn units). In inpatient facilities, patient care areas shall use ducted systems for return and exhaust air. Where space pressure relationships are required, the air distribution system design shall maintain them, taking into account recommended maximum filter loading, heating-season lower airflow operation, and cooling-season higher airflow operation. Airstream surfaces of the air distribution system shall comply with ASHRAE Standard 62.1 [1], Section 5.4. The air distribution system shall be provided with access doors, panels, or other means to allow convenient access for inspection and cleaning.

6.7.2 Air Distribution Devices. All air distribution devices shall meet the following requirements:

a. Surfaces of air distribution devices shall be suitable for cleaning. Supply air outlets in accordance with Table 6-2 shall be used.

b. The supply diffusers in ORs shall be designed and installed to allow for internal cleaning.

c. Psychiatric, seclusion, and holding patient rooms shall be designed with security diffusers, grilles, and registers.

Table 6-2 Supply Air Outlets

Space Designation (According to Function)	Supply Air Outlet Classification [a]
Operating rooms [b], procedure rooms	Supply diffusers within the primary supply diffuser array: Group E, nonaspirating; Additional supply diffusers within the room: Group E
Protective environment rooms	Group E, nonaspirating
Wound intensive care units (burn units)	Group E, nonaspirating
Trauma rooms (crisis or shock)	Group E, nonaspirating
AII rooms	Group A or Group E
Single-bed patient or resident rooms [c]	Group A, Group D, or Group E
All other patient care or resident care spaces	Group A or Group E
All other spaces	No requirement

a. ***Informative Note:*** Refer to 2017 *ASHRAE Handbook—Fundamentals*, Chapter 20 (ASHRAE [2017b]), for definitions related to outlet classification and performance.

b. Surgeons may require alternate air distribution systems for some specialized surgeries. Such systems shall be considered acceptable if they meet or exceed the requirements of this standard.

c. Air distribution systems using Group D diffusers shall meet the following requirements:

1. The system shall be designed according to "Design Guidelines" in *System Performance Evaluation and Design Guidelines for Displacement Ventilation* [6], Chapter 7.
2. The supply diffuser shall be located where it cannot be permanently blocked (***Informative Note:*** e.g., opposite the foot of the bed).
3. The room return/exhaust grille shall be located in the ceiling, approximately above the head of the patient or resident bed.
4. The transfer grille to the toilet room shall be located above the occupied zone.

Outlet Types and Characteristics

Straub and Chen (1957) and Straub et al. (1956) classified outlets into five major groups (the subgrouping was added in 2017 and was not part of the original research):

Group A1. Outlets mounted in or near the ceiling that discharge air horizontally (Figures 2 and 3).

Group A2. Outlets discharging horizontally that are not influenced by an adjacent surface (free jet; Figure 4).

Group B. Outlets mounted in or near the floor that discharge air vertically in a linear jet (Figure 5).

Group C. Outlets mounted in or near the floor that discharge air vertically in a spreading jet (Figure 6).

Group D. Outlets mounted in or near the floor that discharge air horizontally (Figure 7 and 8). When used in fully stratified systems (TDV), these outlets use low discharge velocities; in mixed systems, they use higher discharge velocities.

Group E. Outlets that project supply air vertically downward (Figures 9 and 10). These outlets When used in partially stratified systems (e.g., laminar flow outlets, TDV), these outlets use low discharge velocities; in mixed systems (e.g., air curtain units, other downward directed ceiling devices, etc.), they use higher discharge velocities.

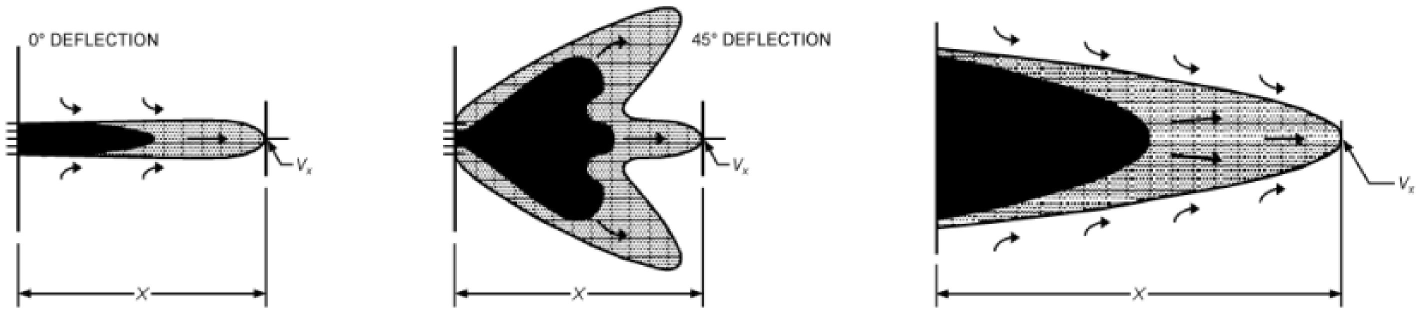


Fig. 4 Example Airflow Patterns (Isothermal) of Outlet Group A2

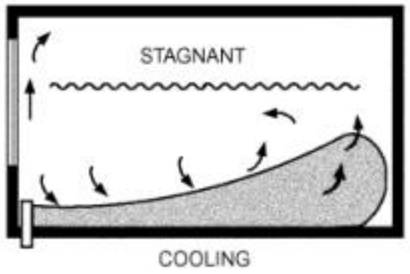


Fig. 7 Example Airflow Patterns (Nonisothermal) of Outlet Group D (High Velocity)

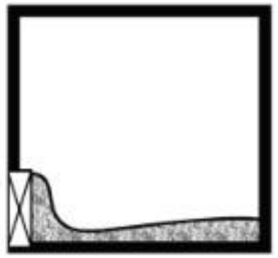


Fig. 8 Example Airflow Patterns (Nonisothermal) of Outlet Group D (Low Velocity)

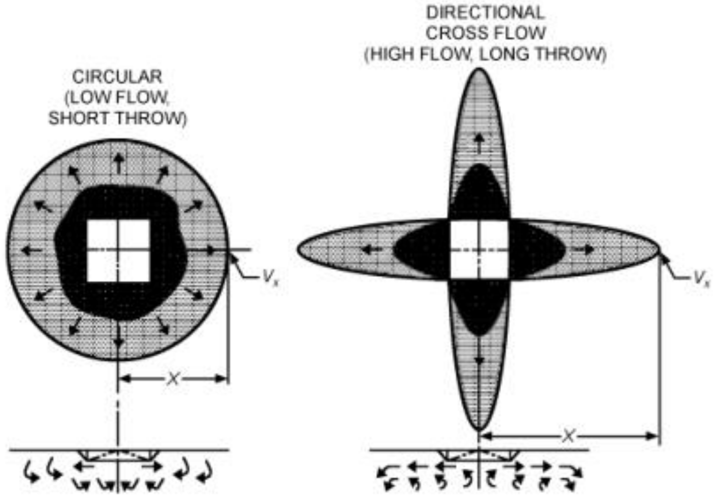


Fig. 2 Example Airflow Patterns of Outlet Group A1

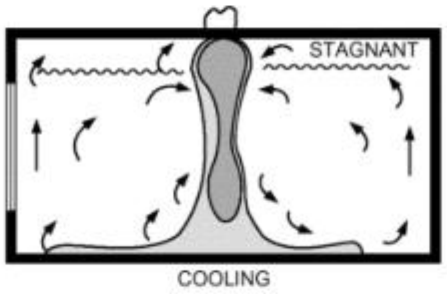


Fig. 9 Example Airflow Patterns (Nonisothermal) of Outlet Group E (High Velocity)

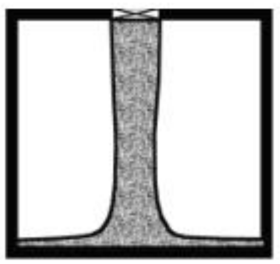


Fig. 10 Example Airflow Patterns (Nonisothermal) of Outlet Group E (Low Velocity)

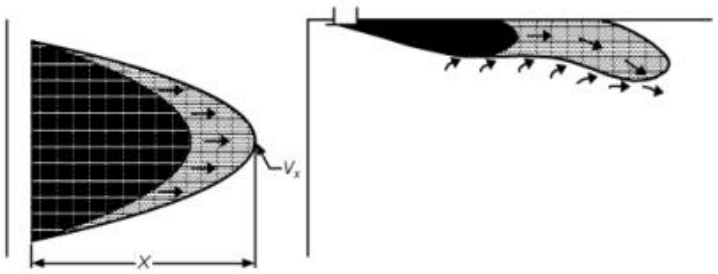


Fig. 3 Example Airflow Patterns (Nonisothermal) of Outlet Group A1

Function of Space (ee)	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated by Means of Room Units (a)	Unoccupied Turndown	Minimum Filter Efficiencies (cc)	Design Relative Humidity (k), %	Design Temperature (l), °F/°C
NURSING UNITS AND OTH & ER PATIENT CARE AREAS									
AII anteroom *(FGI 2.1–2.4.2.3)* (u)	(e)	NR	10	Yes	No	Yes	MERV-8	NR	NR
AII room *(FGI 2.1–2.4.2)* (u)	Negative	2	12	Yes	No	Yes	MERV-14	Max 60	70–75/21–24
Cesarean Delivery room *(FGI 2.2–2.9.11.1)* (m), (o)	Positive	4	20	NR	No	Yes	MERV-16	20–60	68–75/20–24
Combination AII/PE anteroom *(FGI 2.2–2.2.4.5)*	(e)	NR	10	Yes	No	No	HEPA	NR	NR
Combination AII/PE room *(FGI 2.2–2.2.4.5)*	Positive	2	12	Yes	No	No	HEPA	Max 60	70-75/21-24
Continued care nursery *(FGI 2.2–2.10.3.2)*	N/R	2	6	N/R	No	Yes	MERV-14	30–60	72–78/22–26
Critical care patient care station *(FGI 2.2–2.6.2)*	NR	2	6	NR	No	Yes	MERV-14	30–60	70–75/21–24
Emergency department exam/treatment room *(FGI 2.2–3.1.2.6 & 2.2–3.1.3.6)* (p)	NR	2	6	NR	NR	Yes (ff)	MERV-14	Max 60	70–75/21–24
Emergency department human decontamination *(FGI 2.2–3.1.3.6[8])*	Negative	2	12	Yes	No	Yes (ff)	MERV-14	NR	NR
Emergency department public waiting area *(FGI 2.2–3.1.2.4 & 2.2-3.1.3.4)*	Negative	2	12	Yes (q)	NR	Yes (ff)	MERV-8	Max 65	70–75/21–24
Emergency department trauma/resuscitation room *(FGI 2.2–3.1.3.6[4])* (c)	Positive	3	15	NR	No	Yes	MERV-14	20–60	70–75/21–24
Emergency service triage area *(FGI 2.2–3.1.3.3)*	Negative	2	12	Yes (q)	NR	Yes (ff)	MERV-8	Max 60	70–75/21–24
Intermediate care patient room *(FGI 2.2–2.5)* (s)	NR	2	6	NR	NR	Yes	MERV-14	Max 60	70–75/21–24
Labor/delivery/recovery (LDR) *(FGI 2.2–2.9.3)* (s)	NR	2	6	NR	NR	Yes	MERV-14	Max 60	70–75/21–24
Labor/delivery/recovery/postpartum (LDRP) *(FGI 2.2–2.9.3)* (s)	NR	2	6	NR	NR	Yes	MERV-14	Max 60	70–75/21–24
Laser eye room *(FGI Table T2.2-1)*	Positive	3	15	NR	No	Yes	MERV-14	20–60	70–75/21–24
Neonatal intensive care *(FGI 2.2–2.8)*	Positive	2	6	NR	No	Yes	MERV-14	30–60	72–78/22–26
Newborn nursery *(FGI 2.2–2.10.3.1)*	NR	2	6	NR	No	Yes	MERV-14	30–60	72–78/22–26
Nourishment area or room *(FGI 2.1–2.8.9)*	NR	NR	2	NR	NR	Yes	MERV-8	NR	NR
Nursery workroom *(FGI 2.2–2.10.8.5)*	NR	2	6	NR	No	Yes	MERV-8	Max 60	72–78/22–26
Operating room *(FGI 2.2–3.3.3)* (m), (o)	Positive	4	20	NR	No	Yes	MERV-16 (hh)	20–60	68–75/20–24

Informative Notes: (1) NR = no requirement; (2) FGI paragraph numbers are shown in parentheses in the “Function of Space” column.

Function of Space (f)	Pressure Relationship to Adjacent Areas (n)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (j)	Air Recirculated by Means of Room Units (a)	Minimum Filter Efficiencies (c)	Design Relative Humidity (k), %	Design Temperature (l), °F/°C
SURGERY AND EMERGENCY DEPARTMENT (ED)								
Delivery (Caesarean) *(FGI 2.1–3.2.3)* (m), (o), (v), (gg)	Positive	4	20	NR	No	MERV-16 (dd)	20–60	68–75/20–24
ED human decontamination *(FGI 2.8–3.4.8)*	Negative	2	12	Yes	No	MERV-14 (cc)	NR	NR
ED exam/treatment room *(FGI 2.8–3.4.2)* (p)	NR	2	6	NR	NR	MERV-14 (cc)	Max 60	70–75/21–24
ED public waiting area *(FGI 2.8–6.2.3)*	Negative	2	12	Yes (q)	NR	MERV-8	Max 65	70–75/21–24
Operating room *(FGI 2.1–3.2.3)* (m), (o), (v), (gg)	Positive	4	20	NR	No	MERV-16 (dd)	20–60	68–75/20–24
Procedure room *(FGI 2.1–3.2.2)* (d), (o), (p)	Positive	3	15	NR	No	MERV-14	20–60	70–75/21–24
Phase I recovery (PACU) *(FGI 2.1–3.7.4)*	NR	2	6	NR	No	MERV-8	Max 60	70–75/21–24
Phase II recovery *(FGI 2.1–3.7.5)* (u)	NR	2	2	NR	NR	MERV-8	Max 60	70–75/21–24
Pre-procedure patient care *(FGI 2.1–3.7.3)* (t)	NR	2	2	NR	NR	MERV-8	Max 60	70–75/21–24
Trauma room (crisis or shock) *(FGI 2.8–3.4.4)* (bb)	Positive	3	15	NR	No	MERV-14	20–60	70–75/21–24
Triage *(FGI 2.8–6.2.2.2 & 6.2.2.3)*	Negative	2	12	Yes (q)	NR	MERV-8	Max 60	70–75/21–24
DIAGNOSTIC AND TREATMENT								
Class 1 imaging room *(FGI 2.1–3.5.2.4[1][b][i])* (ff)	NR	2	6	NR	NR	MERV-8	Max 60	72–78/22–26
Class 2 imaging room *(FGI 2.1–3.5.2.4[1][b][ii])* (d), (p), (ff)	Positive	3	15	NR	No	MERV-14	20–60	70–75/21–24
Class 3 imaging room *(FGI 2.1–3.5.2.4[1][b][ii])* (m), (o), (ff)	Positive	4	20	NR	No	MERV-16 (dd)	20–60	68–75/20–24
Diagnostic imaging waiting *(FGI 2.1–3.5.10.4)* (g)	Negative	2	12	Yes (q), (r)	NR	MERV-8	Max 60	70–75/21–24
AII anteroom *(FGI 2.1–3.3.2.3)* (i)	(e)	NR	10	Yes	No	MERV-8	NR	NR
AII room *(FGI 2.1–3.3.2)* (i)	Negative	2	12	Yes	No	MERV-8	Max 60	70–75/21–24
PE anteroom *(FGI 1.2–4.2.2.1[1])* (n) (w)	(e)	NR	10	NR	No	HEPA	NR	NR
Protective environment room *(FGI 1.2–4.2.2.1[1])* (n) (w)	Positive	2	12	NR	No	HEPA	Max 60	70–75/21–24
Cancer treatment area *(FGI 2.6–3.1)*	NR	2	6	NR	NR	MERV-8	Max 60	70–75/21–24
Dialysis treatment area *(FGI 2.10–3.2)*	NR	2	6	NR	NR	MERV-8	NR	72–78/22–26
Dialyzer reprocessing room *(FGI 2.10–3.8.12)*	Negative	NR	10	Yes	No	MERV-8	NR	NR
Bronchoscopy *(FGI 2.1–3.2.2.1)* (n) (x)	Negative	2	12	Yes	No	MERV-14	NR	68–73/20–23
Instrument processing room *(FGI 2.1–4.3.2.3)*	Negative	2	10	Yes	No	MERV-8 (s)	NR	NR
Endoscopy procedure room *(FGI 2.9–3.2)* (h)	NR	2	6	NR	No	MERV-8	Max 60	68–73/20–23

Informative Note: NR = no requirement

Function of Space (l)	Pressure Relationship to Adjacent Areas (d)	Minimum Outdoor ach	Minimum Total ach	All Room Air Exhausted Directly to Outdoors (f)	Air Recirculated by Means of Room Units (a)	Unoccupied Turndown	Minimum Filter Efficiencies (i)	Design Relative Humidity (g), %	Design Temperature (h), °F/°C
RESIDENTIAL HEALTH									
NURSING HOMES									
AII room *(FGI 3.1–2.2.4.1)* (b)	Negative	2	12	Yes	No	Yes	MERV-14	Max 60	70–78/21–29
AII anteroom *(FGI 3.1–2.2.4.1)* (b)	Negative	NR	10	Yes	No	Yes	MERV-14	Max 60	70–78/21–29
Occupational therapy *(FGI 3.1–3.3.3)*	NR	2	6	NR	NR	Yes	MERV-14	NR	70–78/21–29
Physical therapy *(FGI 3.1–3.3.2)*	Negative	2	6	NR	NR	Yes	MERV-14	NR	70–78/21–29
Resident living/activity/dining *(FGI 3.1–2.3.3)*	NR	4	4	NR	NR	Yes	MERV-14	Max 60	70–78/21–29
Resident room *(FGI 3.1–2.2.2)*	NR	2	2	NR	NR	Yes	MERV-14	Max 60	70–78/21–29
Resident corridor *(FGI 2.4–2.2.2)*	NR	NR	4	NR	NR	Yes	MERV-14	NR	70–78/21–29
Toilet/bathing room *(FGI 3.1–2.2.2.6)*	Negative	NR	10	Yes	No	No	MERV-14	NR	70–78/21–29
HOSPICE FACILITIES									
AII room *(FGI 3.2–2.2.3.1)* (c)	Negative	2	12	Yes	No	Yes	MERV-14	Max 60	70–75/21–24
AII anteroom *(FGI 3.2–2.2.3.1)* (c)	(e)	NR	10	Yes	No	Yes	MERV-8	Max 60	NR
Resident room *(FGI 3.2–2.2.2)*	NR	2	2	NR	NR	Yes	MERV-8	Max 60	70–75/21–24
Resident corridor *(FGI 2.4–2.2.2)*	NR	NR	4	NR	NR	Yes	MERV-8	NR	NR
Toilet/bathing room *(FGI 3.2–2.2.2.6)*	Negative	NR	10	Yes	No	Yes	MERV-8	NR	70–75/21–24
RESIDENTIAL CARE AND SUPPORT									
ASSISTED LIVING FACILITIES									
Resident living/activity/dining *(FGI 4.1–2.3.3)*	NR	NR	NR	NR	NR	Yes	MERV-8	NR	NR
Resident room *(FGI 4.1–2.2.2)*	NR	NR	NR	NR	NR	Yes	MERV-8	NR	70–78/21–29
Resident corridor *(FGI 2.4–2.2.2)*	NR	NR	NR	NR	NR	Yes	MERV-8	NR	NR
Toilet/bathing room *(FGI 4.1–2.2.2.7)*	NR	NR	NR	NR	NR	Yes	MERV-8	NR	NR
SERVICE									
Clean linen storage *(FGI 2.3–4.6)*	Positive	NR	2	NR	NR	No	MERV-8	NR	72–78/22–26
Dietary storage *(FGI 2.3–4.5)*	NR	NR	2	NR	No	No	MERV-8	NR	72–78/22–26
Food preparation center *(FGI 2.3–4.5.3.3)* (e)	NR	2	10	NR	No	Yes	MERV-8	NR	72–78/22–26
Hair salon *(FGI 2.3–2.3.5 & 4.1–2.3.5)*	Negative	NR	10	Yes	NR	Yes	MERV-8	NR	70–78/21–29
Laundry, central and personal *(FGI 2.3–4.2.7)*	Negative	2	10	Yes	No	No	MERV-8	NR	NR
Linen and trash chute room *(FGI 2.3–4.6 & 2.3–4.9)*	Negative	NR	10	Yes	No	No	MERV-8	NR	NR
Medication room *(FGI 2.3–4.2.2.2)*	NR	2	4	NR	NR	Yes	MERV-8	Max 60	70–75/21–24
Soiled linen sorting and storage *(FGI 2.3–4.6)*	Negative	NR	10	Yes	No	No	MERV-8	NR	NR
Warewashing *(FGI 2.3–4.5.3.6)*	Negative	NR	10	Yes	No	Yes	MERV-8	NR	NR
SUPPORT SPACE									
Clean utility *(FGI 2.3–4.2.5)*	Positive	2	4	NR	NR	No	MERV-8 (k)	NR	NR
Environmental services room *(FGI 2.3–4.9)* (j)	Negative	NR	10	Yes	NR	No	MERV-8	NR	NR
Hazardous waste storage *(FGI 2.3–4.8)*	Negative	2	10	Yes	No	No	MERV-8	NR	NR
Soiled utility or soiled holding *(FGI 2.3–4.2.6)*	Negative	2	10	Yes	No	No	MERV-8	NR	NR

Informative Note: NR = No requirement

10.2 System Start-Up

10.2.1 Application. This section applies to HVAC equipment and systems designed and installed to meet the requirements of this standard.

10.2.2 Testing, Adjusting, and Balancing (TAB). HVAC systems shall be balanced in accordance with one of the following national standards: ASHRAE Standard 111 [19], AABC, NEBB, or TABB for airflows, water flows, and relative room air pressurization.

10.2.3 Testing of Drain Pans. To minimize conditions of water stagnation that may result in microbial growth, inspect drain pans to verify proper drainage under operating conditions.

10.2.4 Manufactured Equipment Start-Up. For all manufactured HVAC equipment components, follow manufacturer's start-up recommendations and requirements. All equipment and air distribution systems shall be clean of dirt and debris.

10.2.5 Documentation of New or Remodeled HVAC Systems. Owners shall retain an acceptance testing report for their files. In addition, the design shall include requirements for operations and maintenance (O&M) staff training that is sufficient for the staff to keep all HVAC equipment in a condition that will maintain the original design intent for ventilation. Training of operating staff shall include an explanation of the design intent. The training materials shall include, at a minimum, the following:

a. O&M procedures
b. Temperature and pressure control operation in all modes
c. Acceptable tolerances for system temperatures and pressures
d. Procedures for operations under emergency power or other abnormal conditions that have been considered in the facility design

Table D-1 Recommended Filter Efficiencies by Space Type

Level	Space Category	Filter Efficiency Recommendations [a,b]
I	• Primarily exhausted space (e.g., restrooms, janitor's rooms) • Any human-occupied space • Any room, inpatient or outpatient, where a patient stays less than 6 hours including waiting rooms • Laboratories • Resident rooms in assisted living or hospice • Storage of packaged sterile material, clean linen, or pharmaceuticals [c] • Treatment rooms, endoscopy procedure room • Dirty side of decontamination process	MERV 8 (equivalent to ASHRAE 62.1 or Standard 62.2)
II	• Inpatient spaces, including medical-surgical, airborne isolation [d] • Special exam room for suspect airborne cases, emergency department exam rooms [e] • Resident room in a skilled nursing area • Workroom for packing of sterile materials • CT or MRI procedure, interventional radiology (including biopsy), or bronchoscopy • ER procedure or trauma room	MERV14 [f,g]
III	• Operating room [h]	MERV16 [f]
IV	• Operating room designated for orthopedic, transplants, neurosurgery, or dedicated burn unit procedures • Protective environments, including burn units	HEPA

Notes:

a. Where listed, MERV rating is assumed to be nondegrading.
b. Transfer air due to differences in pressure between spaces may be unfiltered.
c. Pharmacy compounding spaces are not covered in this table. Follow USP 795, USP 797, or USP 800, as applicable (see Section 11 references).
d. Does not include recirculated air. Air recirculated in an AII room requires HEPA filters.
e. Air from spaces where suspected airborne cases may be treated or examined should be filtered at level II prior to recirculation to other spaces. If exhausted, supply air filtration may be level I.
f. Minimum MERV rating of the highest efficiency filter in the airstream.
g. Filter efficiency if supply air is used; not intended to exclude natural ventilation if otherwise allowed.
h. An optional risk assessment, conducted with the user group, may indicate a need to increase from Level III to Level IV.

A1. O&M IN HEALTH CARE FACILITIES

The following operations and maintenance (O&M) procedures are recommended for health care facilities.

A1.1 Operating Rooms (ORs)

a. Each OR should be tested for positive pressure semiannually or on an effective preventative maintenance schedule.

b. Operating and Caesarean delivery room ventilation systems shall operate at all times, except during maintenance and during conditions requiring shutdown by the building's fire alarm system.

A1.2 Protective Environment (PE) Rooms. PE rooms should remain under positive pressure with respect to all adjoining rooms whenever an immunocompromised patient is present. PE rooms should be tested for positive pressure daily when an immunocompromised patient is present.

A1.3 Airborne Infection Isolation (AII) Rooms. AII rooms should remain under negative pressure, relative to all adjoining rooms, whenever an infectious patient is present. They should be tested for negative pressure daily whenever an infectious patient is present.

A1.4 Filters. Filters and filter frames should be visually inspected for pressure drop and for bypass monthly. All filters and air cleaning devices shall be replaced or maintained per manufacturer recommendations.

A1.5 Unoccupied Turndown. When unoccupied turndown is implemented for a space, control and operate the turndown mode such that a relative humidity of 60% is not exceeded in the space.

Prinsip O&M di RS

INFORMATIVE APPENDIX B
THERMAL COMFORT

a. Section 2.7 was added to the scope of Standard 170 to better communicate that compliance with Standard 170 does not ensure compliance with ASHRAE Standard 55 (2017).

b. ASHRAE Standard 55 specifies the combination of environmental factors (temperature, thermal radiation, humidity, air speed) and personal factors (activity level and clothing) that will produce thermal conditions acceptable to the majority of healthy occupants. However, there are scenarios and spaces within health care facilities where Standard 55 does not apply or where deviations from Standard 55 are required.

c. Standard 170 provides HVAC design temperature and humidity ranges that, while potentially affecting occupant comfort, are also provided in support of therapeutic patient outcomes, aseptic practices, and worker protection.

Bagaimana dengan kenyamanan termal?

- Ini BUKAN tanggung jawab sistem ventilasi
- Aturan sistem ventilasi bisa menyebabkan kondisi tidak nyaman, bila pendinginan tidak cukup

Table D-1 Recommended Filter Efficiencies by Space Type

Level	Space Category	Filter Efficiency Recommendations [a,b]
I	• Primarily exhausted space (e.g., restrooms, janitor's rooms) • Any human-occupied space • Any room, inpatient or outpatient, where a patient stays less than 6 hours including waiting rooms • Laboratories • Resident rooms in assisted living or hospice • Storage of packaged sterile material, clean linen, or pharmaceuticals [c] • Treatment rooms, endoscopy procedure room • Dirty side of decontamination process	MERV 8 (equivalent to ASHRAE 62.1 or Standard 62.2)
II	• Inpatient spaces, including medical-surgical, airborne isolation [d] • Special exam room for suspect airborne cases, emergency department exam rooms [e] • Resident room in a skilled nursing area • Workroom for packing of sterile materials • CT or MRI procedure, interventional radiology (including biopsy), or bronchoscopy • ER procedure or trauma room	MERV14 [f,g]
III	• Operating room [h]	MERV16 [f]
IV	• Operating room designated for orthopedic, transplants, neurosurgery, or dedicated burn unit procedures • Protective environments, including burn units	HEPA

Notes:

a. Where listed, MERV rating is assumed to be nondegrading.
b. Transfer air due to differences in pressure between spaces may be unfiltered.
c. Pharmacy compounding spaces are not covered in this table. Follow USP 795, USP 797, or USP 800, as applicable (see Section 11 references).
d. Does not include recirculated air. Air recirculated in an AII room requires HEPA filters.
e. Air from spaces where suspected airborne cases may be treated or examined should be filtered at level II prior to recirculation to other spaces. If exhausted, supply air filtration may be level I.
f. Minimum MERV rating of the highest efficiency filter in the airstream.
g. Filter efficiency if supply air is used; not intended to exclude natural ventilation if otherwise allowed.
h. An optional risk assessment, conducted with the user group, may indicate a need to increase from Level III to Level IV.

3

Fail to Comply

Apa Konsekuensi Bila Tidak Patuh?

Kondisi yang Dirancang

Enam parameter yang wajib dicapai:

- a. Temperatur
- b. Kelembaban udara relatif.
- c. Kelas kebersihan
- d. Jumlah udara ventilasi
- e. Tekanan udara
- f. Distribusi udara di dalam ruangan.

Dari Tabel Peraturan (Draft Permen)

- Tidak semua zone/ruangan memiliki kriteria untuk keenam parameter.
- Ada zone/ruangan yang diberi "pilihan" untuk menetapkan sendiri kriterianya.
- Hanya ada satu kriteria (Temperatur) yang diberlakukan secara ketat di seluruh zone/ruangan di RS, itupun tidak termasuk area dapur dan laundry.
- Kriteria lainnya diberlakukan secara selektif di zone/ruangan tertentu saja.

Enam parameter yang wajib dicapai:

1. Temperatur
2. Kelembaban udara relatif
3. Kelas kebersihan
4. Jumlah udara ventilasi
5. Tekanan udara
6. Distribusi udara di dalam ruangan.

Distribusi udara adalah arah aliran udara dalam ruangan yang arahnya dari area bersih ke area kotor, ditentukan sesuai fungsi ruangan.

Tidak menggunakan sistem AC yang mensirkulasi udara di dalam ruangan

Aturan tambahan

Fungsi Ruang	Temperatur (°C)	Kelembaban Udara Relatif (%)	Kelas Kebersihan	Hubungan Tekanan Terhadap Area Bersebelahan	Pertukaran Udara Dari Luar Per Jam (Min)	Total Pertukaran Udara Per Jam (Min)	Seluruh Udara Di Buang Langsung Ke Luar Bangunan	Resirkulasi Udara Di Dalam Unit Ruangan
PERAWATAN BEDAH DAN KRITIS								
Ruangan Operasi Khusus	22±2	maks. 60%	Di atas meja operasi: Kelas 1.000 (ISO-6) Ruangan: Kelas 10.000 (ISO-7)	P(*min Δ 2,5 Pa)*	4-5	25-30	Pilihan	Tidak
Ruangan Operasi Umum	22±2	maks. 60%	Di atas meja operasi: Kelas 1.000 (ISO-6) Ruangan: Kelas 10.000 (ISO-7)	P(*min Δ 2,5 Pa)*	3-4	20-25	Pilihan	Tidak
Ruangan Operasi Minor	22±2	maks. 60%	Di atas meja operasi: Kelas 10.000 (ISO-7) Ruangan: Kelas 10.000 (ISO-7)	P(*min Δ 2,5 Pa)*	3-4	15-20	Pilihan	Tidak
Ruangan Operasi Infeksi	22±2	maks. 60%	Di atas meja operasi: Kelas	P(*min Δ 2,5 Pa)*	3-4	20-25	Pilihan (direkomendas	Tidak

Distribusi udara di dalam ruangan

Ada dua pengertian:

- Distribusi udara adalah arah aliran udara dalam ruangan yang arahnya dari area bersih ke area kotor, ditentukan sesuai fungsi ruangan.
  - Di ruang isolasi, exhaust di sekitar kepala pasien
  - Di ruang operasi, tidak ada yang resirkulasi ke meja operasi.
- Tidak menggunakan sistem AC yang mensirkulasi udara di dalam ruangan

Either way, compliance (kepatuhan) mudah dilakukan, dan tidak mengandung potensi kenaikan biaya.

Tekanan udara

- Compliance mudah dilakukan, dan ini tidak ada tawar-menawar, karena berurusan dengan masalah keselamatan
- Penyebab non-performance (kenapa tekanan udara tidak mencapai kriteria):
  - Bocor (infiltrasi atau exfiltrasi) ➔ melalui berbagai celah/lubang
    - Celah pintu, celah kusen/jendela, lubang colokan listrik
    - Kebocoran ducting
  - Aliran udara tidak sesuai perancangan ➔ masalah balancing
- Harus ada benchmark energi fan ➔ W/cfm
- Cara pembuktian: bacaan manometer

Kelas Kebersihan

- Compliance mudah dilakukan, dan ini tidak ada tawar-menawar, karena berurusan dengan masalah keselamatan
- Penyebab non-performance (kenapa tekanan udara tidak mencapai kriteria):
  - Filter yang tidak rapat: ada udara by-pass yang tidak melalui filter
  - Filter yang tidak sesuai spesifikasi
- Harus ada benchmark energi fan → W/cfm
- Cara pembuktian: pengukuran di beberapa titik

Kelas Kebersihan

- Compliance mudah dilakukan, dan ini tidak ada tawar-menawar, karena berurusan dengan masalah keselamatan
- Penyebab non-performance (kenapa jumlah partikel melebihi kriteria):
  - Filter yang tidak rapat: ada udara by-pass yang tidak melalui filter
  - Filter yang tidak sesuai spesifikasi
- Harus ada benchmark energi fan ➔ W/cfm
- Cara pembuktian: pengukuran di beberapa titik

Jumlah Udara Ventilasi

- Biasanya diabaikan di berbagai zone/ruangan: harus mulai ditegakkan kepatuhan terhadap peraturan ini
- Penyebab non-performance (kenapa suplai udara luar tidak terjadi?):
  - Bocor ➔ ducting
  - Balancing tidak sesuai
- Cara pembuktian:
  - Pengukuran flowrate udara suplai di ducting
  - Pengukuran CO_2 di ruangan

Temperatur dan Kelembaban Relatif

- Aspek paling penting dari keenam parameter
- Paling sulit ditegakkan kepatuhannya
- Mudah terjadi non-compliance (kenapa?)

Kebijakan Kemenkes membuat ruangan RS naik kelas

Class I
• Temperature Moderated • Vapor Pressure Uncontrolled • Air Pressure Uncontrolled
Class II
• Temperature Controlled • Vapor Pressure Moderated • Air Pressure Moderated
Class III
• Temperature Controlled • Vapor Pressure Controlled • Air Pressure Controlled

Table 1: Interior climate classes.

Tabel 1 – Kondisi perencanaan udara luar ruang untuk sistem tata udara (3 dari 7)

Lokasi			*Cooling* DB/MCWB (°C)						*Evaporation* WB/MCDB (°C)						*Dehumidification* DP/MCDB dan HR (°C dan $g_{cairan}/kg_{udara\ kering}$)								
			0.4%		1%		2%		0.4%		1%		2%		0.4%			1%			2%		
Kabupaten/ Kota	Koordinat	Stasiun Cuaca	DB	MC WB	DB	MC WB	DB	MC WB	WB	MC DB	WB	MC DB	WB	MC DB	DP	HR	MC DB	DP	HR	MC DB	DP	HR	MC DB
Jakarta Pusat	6.183S, 106.833E	Jakarta Observatory	34,2	25,7	33,7	25,7	33,3	25,7	27,2	32,3	26,9	32,0	26,7	31,6	25,7	21,0	30,2	25,5	20,7	29,9	25,2	20,4	29,6
Jakarta Utara	6.100S, 106.867E	Jakarta Tanjung Priok	33,8	25,8	33,2	25,8	32,9	25,8	27,2	32,0	27,1	31,8	26,8	31,4	26,0	21,3	30,2	25,7	21,0	30,0	25,5	20,7	29,8
Jambi	1.638S, 103.644E	Thaha	33,2	25,6	32,7	25,6	32,4	25,5	27,1	30,8	26,7	30,5	26,5	30,3	26,1	21,5	29,0	25,7	21,0	28,7	25,5	20,7	28,5
Kabupaten Jayapura	2.577S, 140.516E	Sentani	33,6	26,0	33,1	26,0	32,8	25,9	27,5	31,6	27,1	31,4	26,8	31,0	26,2	21,9	30,2	25,9	21,5	29,8	25,6	21,1	29,3
Kepulauan Tanimbar	7.983S, 131.300E	Saumlaki	33,2	26,9	32,7	26,8	32,2	26,6	27,7	31,6	27,4	31,2	27,2	30,8	26,6	22,2	29,9	26,3	21,8	29,4	26,1	21,6	29,2
Kotawaringin Barat	2.705S, 111.673E	Iskandar	33,2	27,4	32,7	27,3	32,2	27,1	28,7	32,0	28,2	31,6	28,0	31,4	27,7	23,8	31,4	27,2	23,1	30,9	27,0	22,8	30,7
Kubu Raya	0.151S, 109.404E	Supadio Intl	34,1	26,3	33,7	26,3	33,2	26,2	27,7	31,8	27,4	31,5	27,1	31,2	26,7	22,2	30,2	26,2	21,6	29,5	26,1	21,4	29,3
Kupang	10.172S, 123.671E	El Tari	34,6	24,9	33,8	25,0	33,1	25,0	28,1	31,2	27,7	30,9	27,2	30,6	27,2	23,2	30,3	26,8	22,7	30,0	26,3	22,0	29,4
Lingga	0.479S, 104.579E	Dabo	32,7	27,0	32,3	26,9	32,0	26,8	28,1	31,5	27,7	31,3	27,4	31,0	27,1	23,0	30,8	26,7	22,4	30,4	26,4	21,9	30,0

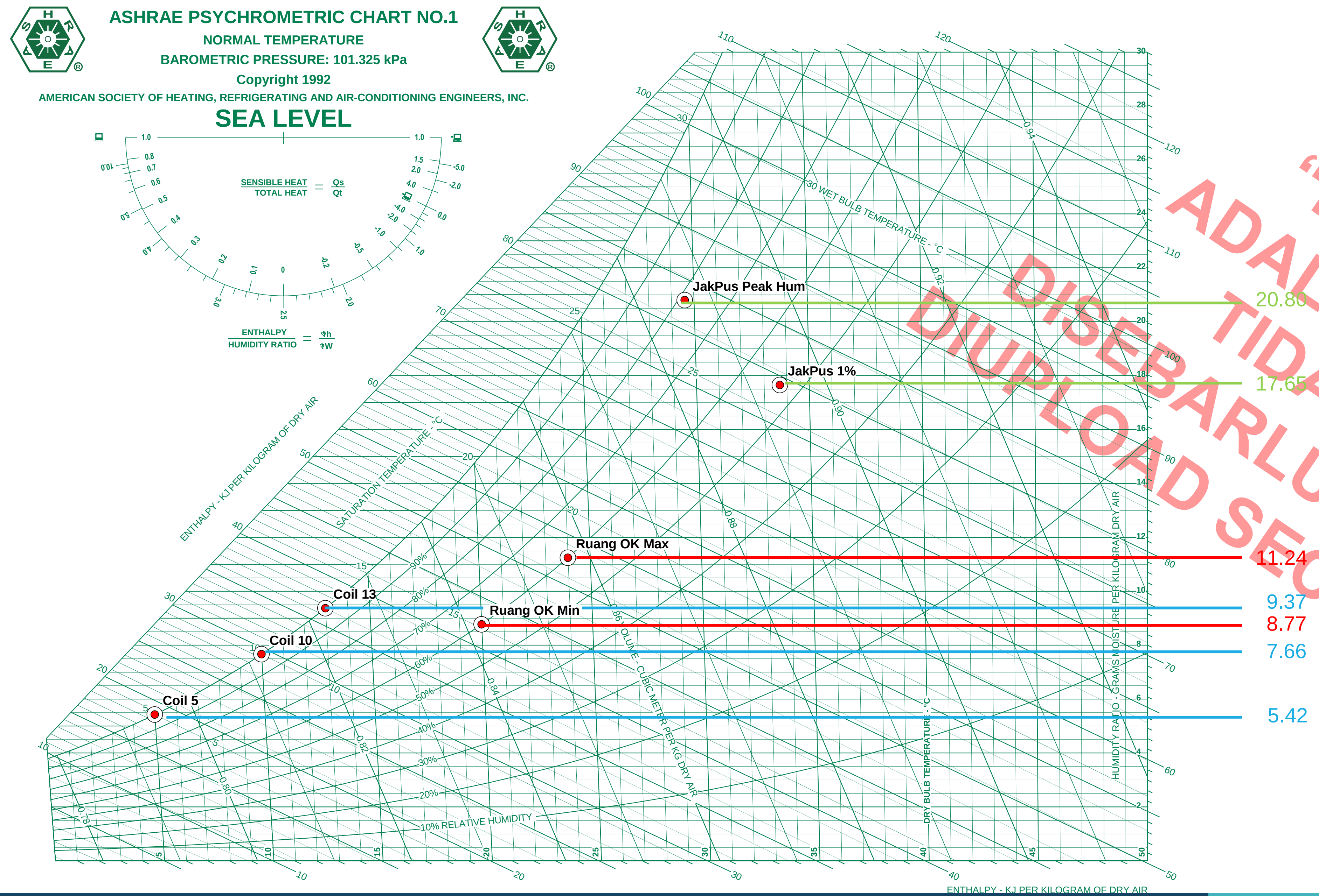
Lokasi			*Cooling* DB/MCWB (°C)						*Evaporation* WB/MCDB (°C)						*Dehumidification* DP/MCDB dan HR (°C dan $g_{cairan}/kg_{udara\ kering}$)								
			0.4%		1%		2%		0.4%		1%		2%		0.4%			1%			2%		
Kabupaten/ Kota	Koordinat	Stasiun Cuaca	DB	MC WB	DB	MC WB	DB	MC WB	WB	MC DB	WB	MC DB	WB	MC DB	DP	HR	MC DB	DP	HR	MC DB	DP	HR	MC DB
Jakarta Pusat	6.183S, 106.833E	Jakarta Observatory	34,2	25,7	33,7	25,7	33,3	25,7	27,2	32,3	26,9	32,0	26,7	31,6	25,7	21,0	30,2	25,5	20,7	29,9	25,2	20,4	29,6

Design Condition Jakarta Pusat (1%) = 33.7 DB / 25.7 WB ➔ RH = 53.2% w=17.65

Kelembaban Puncak Jakarta Pusat (1%) = 25.5 DP / 29.6 DB ➔ RH = 78.7 w= 20.8

Fungsi Ruang	Temperatur (°C)	Kelembaban Udara Relatif (%)	Kelas Kebersihan	Hubungan Tekanan Terhadap Area Bersebelahan	Pertukaran Udara Dari Luar Per Jam (Min)	Total Pertukaran Udara Per Jam (Min)	Seluruh Udara Di Buang Langsung Ke Luar Bangunan	Resirkulasi Udara Di Dalam Unit Ruangan
PERAWATAN BEDAH DAN KRITIS								
Ruangan Operasi Khusus	22±2	maks. 60%	Di atas meja operasi: Kelas 1.000 (ISO-6) Ruangan: Kelas 10.000 (ISO-7)	P*(min Δ 2,5 Pa)*	4-5	25-30	Pilihan	Tidak

Min = 20 DB 60% RH ➔ w = 8.77
Max = 24 DB 60% RH ➔ w = 11.24


ASHRAE PSYCHROMETRIC CHART NO.1
NORMAL TEMPERATURE
BAROMETRIC PRESSURE: 101.325 kPa
Copyright 1992
AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
SEA LEVEL
SENSIBLE HEAT / TOTAL HEAT = Qs / Qt
ENTHALPY / HUMIDITY RATIO = Δh / ΔW
ENTHALPY - KJ PER KILOGRAM OF DRY AIR
SATURATION TEMPERATURE - °C
30 WET BULB TEMPERATURE - °C
VOLUME - CUBIC METER PER KG DRY AIR
10% RELATIVE HUMIDITY
DRY BULB TEMPERATURE - °C
HUMIDITY RATIO - GRAMS MOISTURE PER KILOGRAM DRY AIR
JakPus Peak Hum
20.80
JakPus 1%
17.65
Ruang OK Max
11.24
Coil 13
9.37
Ruang OK Min
8.77
Coil 10
7.66
Coil 5
5.42

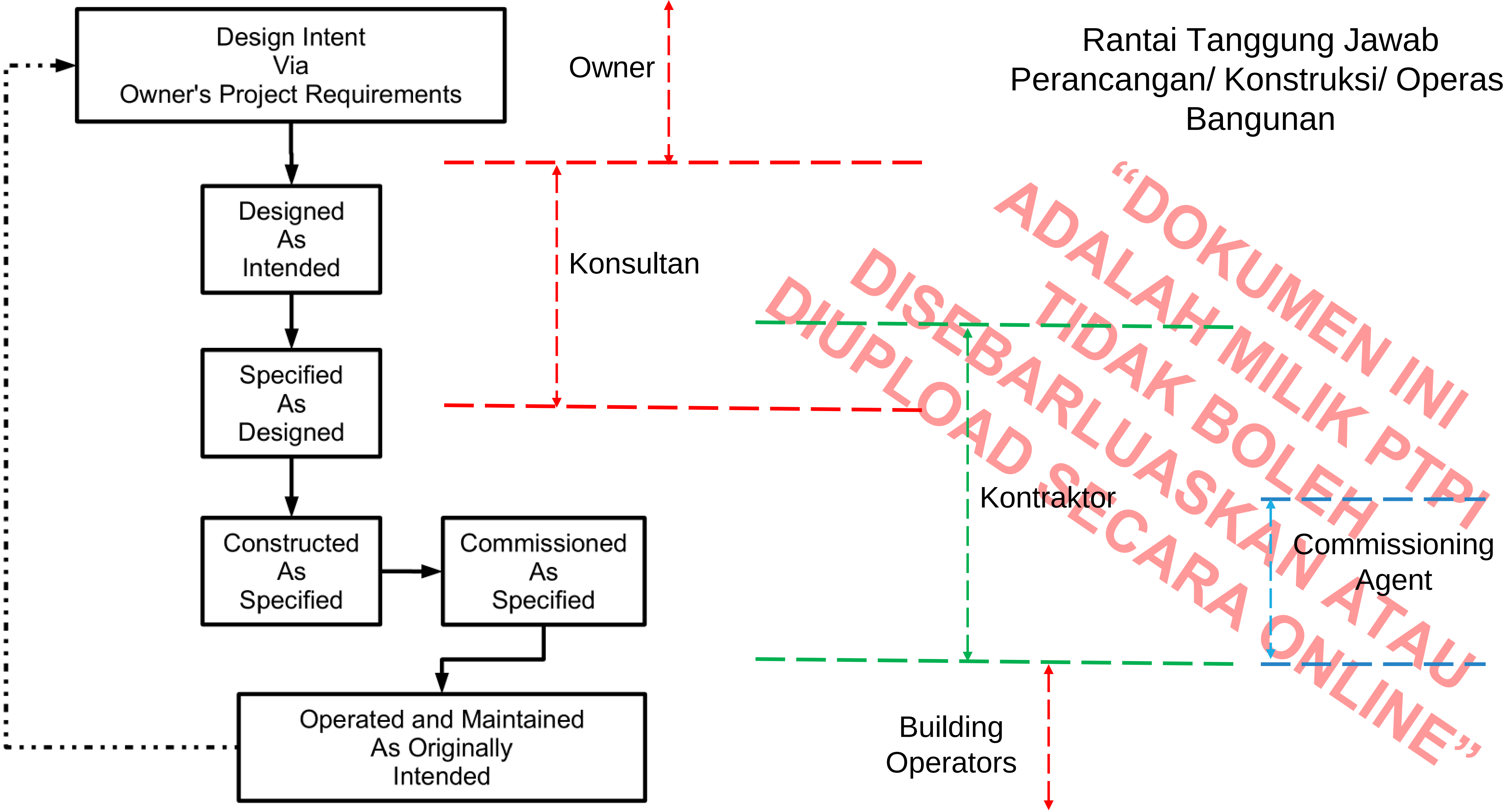
No.	Deskripsi	Water Cooled Chiller	Air Cooled Chiller	Air Cooled VRF & Non VRF-
1	Komponen Sistem	- Water Cooled Chiller (Screw VSD Compressor Type) - Cooling Tower - Condenser Water Pump - Chilled water Pump - Air Handling Unit (AHU)	- Air Cooled Chiller (Screw VSD Compressor Type) - Chilled water Pump - Air Handling Unit (AHU)	- Air Cooled Outdoor unit Inverter (untuk Zona Critical & Semi Steril) - Air Cooled Outdoor unit Non (untuk Zona Public) - Air Handling Unit (AHU) DX
2	Konfigurasi			
	Cooling Plant System	Tersentral, berupa Chiller Water Cooled - Screw compressor, 3 x 175 TR	Tersentral, berupa Air Chiller Cooled - Screw compressor, 3 x 175 TR	Invididual system, dedicated antara oudoor dan Indoor Namun untuk membatasi ukuran Indoor unit (max 1200 mm) maka kapasitas Outdoor dibatasi 15 TR
	Terminal unit (Air Handling Unit)	AHU untuk Zona Critical max 16 HP (Filter G4, F8 dan HEPA di Diffuser, dengan control RH) AHU untuk Zona Semi Steril max 20 HP (Filter G4, F8, dan Option HEPA Filter di Unit AHU nya, dengan Control RH) AHU untuk zona Public, max 20 HP (Filter G4, F8, tanpa control RH)	AHU untuk Zona Critical max 16 HP (Filter G4, F8 dan HEPA di Diffuser, dengan control RH) AHU untuk Zona Semi Steril max 20 HP (Filter G4, F8, dan Option HEPA Filter di Unit AHU nya, dengan Control RH) AHU untuk zona Public, max 20 HP (Filter G4, F8, tanpa control RH)	AHU DX untuk Zona Critical max 16 HP (Filter G4, F8 dan HEPA Diffuser, dengan control RH) AHU untuk Zona Semi Steril max 20 HP (Filter G4, F8, dan Option HEPA Filter di Unit AHU nya, dengan Control RH) AHU DX untuk zona Public, max 20 HP (Filter G4, F8, tanpa control RH)
3	Keuntungan / Kerugian	Life Time 15 ~ 20 Tahun Sistem Chiller tersentral, dengan demikian ada back-up di chiller plant	Life Time 10 ~ 15 Tahun Air cooled chiller sudah lebih dikenal oleh operator saat ini Sistem Chiller tersentral, dengan demikian ada back-up di chiiler plant	Life Time 7 ~ 10 Tahun Sistem individual, jadi tidak ada back-up nya
4	Konsumsi daya elektrik Cooling Plant	Beban penuh : kW/TR = 0,58 (Chiller) kW/TR = 0,075 (CHWP) kW/TR = 0,075 (CWP) kW/TR = 0,025 (CT) Total = 0,755 kW/TR	Beban penuh : kW/TR = 1,1 (Chiller) kW/TR = 0,075 (CHWP) Total = 1,175 kW/TR	Beban penuh : kW/TR = 1.08 - 1.18 (diambil rata-rata di 1.1 KW/TR)
	Air Side/Terminal Unit	Konsumsi daya elektrik: AHU Critical : 0.38 KW/TR, Heater 24 AHU Semi Steril: 0.34 KW/TR, Heater 22KW AHU Public: 0.29 KW/TR, tanpa Heater	Konsumsi daya elektrik: AHU Critical : 0.38 KW/TR, Heater 24 AHU Semi Steril: 0.34 KW/TR, Heater 22KW AHU Public: 0.29 KW/TR, tanpa Heater	Konsumsi daya elektrik: AHU DX Critical : 0.38 KW/TR, Heater AHU DX Semi Steril: 0.34 KW/TR, Heater 22KW AHU DX Public: 0.29 KW/TR, tanpa

Rancangan:
Sigmatech Tatakarsa

Temperatur dan Kelembaban Relatif

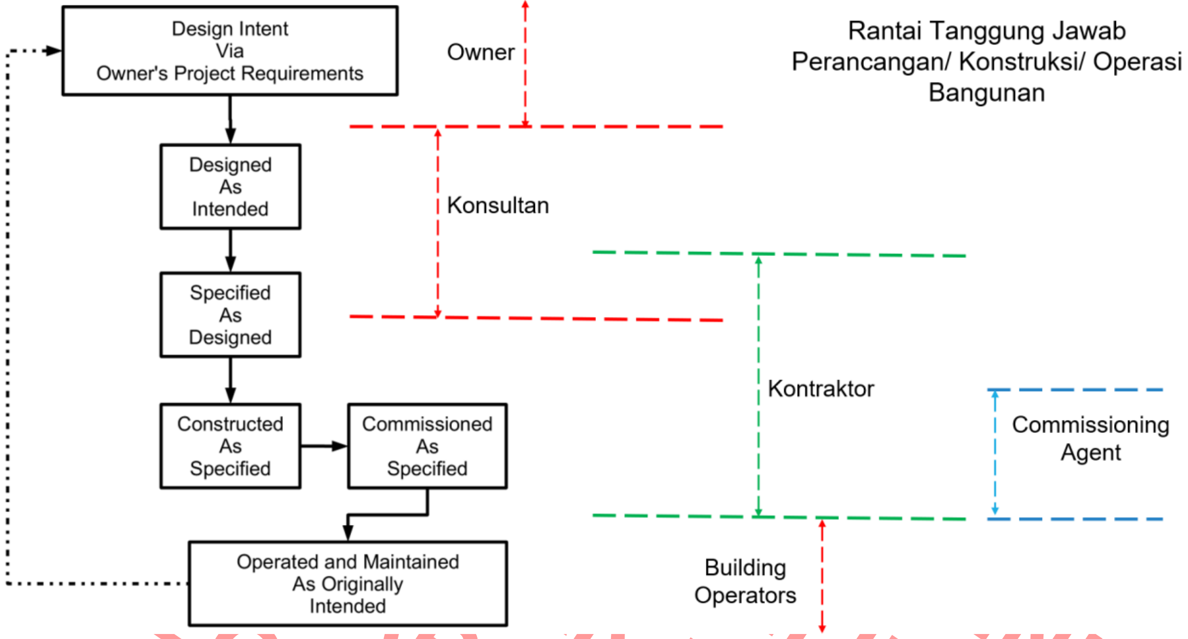
- Kesimpulan:
  - Pengaturan RH bisa dilakukan ➔ ada implikasi biayanya
  - Perancangan AC konvensional tidak bisa mencapai kriteria ini. Konsultan pun perlu diberi tambahan pemahaman.
  - Ada beberapa teknik/strategi yang bisa digunakan untuk menurunkan biaya operasional.

Rantai Tanggung Jawab Perancangan/ Konstruksi/ Operasi Bangunan



Performance Criteria

- Siapa yang menjamin tercapainya “performance criteria”?
  - Shared Responsibility ➔ setiap stakeholder punya tanggung jawab
  - Setiap non-performance harus ditentukan:
    - Salah rancang
    - Salah pilih
    - Salah pasang
    - Salah urus



Contoh: Temperatur/ RH

- Salah rancang: salah menentukan coil ADP
- Salah pilih: memesan unit yang salah
- Salah pasang: ada sensor yang tidak terpasang, (bisa arsitektural?)
- Salah urus: pola operasional yang berbeda dengan perancangan (jumlah orang, buka/tutup pintu)

4

Drivers to Energy Consumtion

Apa Sajakah Faktor-Faktor Pendorong Konsumsi Energy di Rumah Sakit?

Drivers of Hospital Energy Consumption

- Kita semua diminta untuk menghemat energi
- Pertanyaannya:
  - Menghemat dari berapa? ➔ kebanyakan tidak tahu
  - Menjadi berapa? ➔ ini lebih tidak tahu lagi, karena menyangkut efisiensi
  - Yang dihemat apa? ➔ Energi (kWh) atau biaya (Rp)?
  - Bagaimana caranya? ➔ Lebih puyeng lagi, karena pertanyaannya di atas belum terjawab

Drivers of Hospital Energy Consumption

- Pertanyaannya:
  - Yang dihemat apa? ➔ Energi (kWh) atau biaya (Rp)?
  - Harus ada kebulatan tekad: kita harus menghemat **energi** (kWh), berapapun **biayanya** (Rp).
  - Bisakah menghemat biaya tanpa menghemat energi?
    - Bisa ➔ Net-Zero Building (akal-akalan): bangunan **boros**, dipasangi solar PV
    - Seharusnya ➔ Net-Zero Building (official): bangunan **hemat**, dipasangi solar PV
  - Jangan lupakan pertanyaan eksistensial ini:
    - Apakah kalau sesuatu itu gratis, maka kita boleh boros? TIDAK BOLEH
    - Orang boros itu saudara setan, regardless yang diboroskan itu bayar atau tidak
    - Contoh: air

Drivers of Hospital Energy Consumption

- Pertanyaannya:
  - Menghemat dari berapa? ➔ kebanyakan tidak tahu
  - Sebagian besar top management TIDAK HAFAL angka konsumsi energi.
    - Dari sample kecil top management RS yang saya kenal
    - Kalau ditanya: kebanyakan tidak tahu.
  - Sebagian kecil yang tahu: hanya nilai rupiahnya (Rp.)
    - Tidak tahu konsumsi energinya (dalam kWh per bulan atau per tahun)
  - Apakah regulator tahu angka ini?
  - IKE = intensitas konsumsi energi (kWh/m2) ➔ Angka ini WAJIB dihafalkan oleh SEMUA manajer dan direksi RS
    - kWh = tagihan listrik setahun (dalam kWh, bukan Rp.)
    - m2 = luas lantai RS (AC vs non-AC)

Drivers of Hospital Energy Consumption

- Pertanyaannya:
  - Menjadi berapa? ➔ ini lebih tidak tahu lagi, karena menyangkut efisiensi
  - Konsumsi vs efisiensi: ➔ Tidak tahu Drivers of Energy Consumption
    - Kita biasanya tahu konsumsinya berapa
    - Tapi tidak tahu apakah konsumsi segitu hemat atau boros?
  - Ini terjadi di seluruh sektor bangunan bukan saja rumah sakit:
    - Rumah Sakit
    - Shopping Mall
    - Airport

Drivers of Hospital Energy Consumption

- Pertanyaannya:
  - Bagaimana caranya? ➔ Lebih puyeng lagi, karena pertanyaannya di atas belum terjawab
  - Pertanyaan ini harus dijawab kasus per kasus ➔ setiap bangunan unik
  - PR nasional: kita perlu benchmark
    - BENCHMARK: standard/metodologi yang bisa dipakai untuk menyimpulkan bahwa sebuah rumah sakit itu hemat atau boros.

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Energy Star based benchmarking model for Malaysian Government hospitals - A qualitative and quantitative approach to assess energy performances

Nofri Yenita Dahlan [a,b,*], Hassan Mohamed [c], Khairul Azmy Kamaluddin [d], Noor Muhammad Abd Rahman [d], Gregers Reimann [e], Joshua Chia [e], Nur Iqtiyani Ilham [f]

[a] *Solar Research Institute (SRI), Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia*
[b] *School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia*
[c] *Institute of Sustainable Energy, Universiti Tenaga Nasional, 43000, Kajang, Selangor, Malaysia*
[d] *Engineering Services Division, Ministry of Health Malaysia, Putrajaya, Malaysia*
[e] *IEN Consultants Sdn Bhd, Syed Kechik Building, 8th floor, Jalan Kapas, Bangsar, 59100, Kuala Lumpur, Malaysia*
[f] *School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Cawangan Pasir Gudang, Masai, Johor, Malaysia*

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Contoh dari Malaysia

Table 2
List of initial 31 parameters considered for the analysis.

No.	Variables	No.	Variables
1	GFA, m^2	17	Mortuary Area, m^2
2	ACA, m^2	18	Non-Air Conditioned (AC) Ward Area, m^2
3	No. of OT Room	19	Air-Conditioned (AC) Ward Area, m^2
4	No. of Major OT	20	No. of Bed Capacity
5	No. of Minor OT	21	Cooling Degree Days (CDD)
6	No. of Labor Room	22	Average Monthly Bed Occupancy Rate (BOR)
7	No. of Bed in ICU/CCU	23	Average Annual (yearly) No. of In-Patient
8	No. of Bed in HDU	24	Average Annual (yearly) No. of Day-Care
9	Accommodation Area, m^2	25	Average Annual (yearly) No. of Out-Patient
10	OT Area, m^2	26	Average Accommodation Energy Usage
11	Maternity Area, m^2	27	Total Design Cooling Load (RT)
12	No. of Bed in Maternity	28	No. of Light Fixtures
13	Imaging Department Area, m^2	29	Total Installed Power of Lighting (kW)
14	Centralised Sterile Service Department Area, m^2	30	Average Annual (yearly) Total lighting Energy Consumption (kWh)
15	Accident & Emergency (A&E) Area, m^2	31	No. of High-Energy Medical Machines
16	Laboratory Area, m^2		

- Sample dari 84 rumah sakit pemerintah
- Dikumpulkan data yang mengandung 31 parameter

- 31 parameter ini adalah parameter yang potensial menjadi Driver of Energy Consumption

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Table 5
Simple linear regression results.

No.	Variables	R^2	No.	Variables	R^2
1	GFA, m^2	0.8314	17	Mortuary Area, m^2	0.2622
2	ACA, m^2	0.7414	18	Non-Air Conditioned (AC) Ward Area, m^2	0.7040
3	No. of OT Room	NA	19	AC Ward Area, m^2	0.3481
4	No. of Major OT	NA	20	No. of Bed Capacity	0.7625
5	No. of Minor OT	NA	21	Cooling Degree Days (CDD)	0.0131
6	No. of Labour Room	NA	22	Average Monthly Bed Occupancy Rate (BOR)	0.1618
7	No. of Bed in ICU/ CCU	NA	23	Average Annual (yearly) No. of In-Patient	0.2429
8	No. of Bed in HDU	NA	24	Average Annual (yearly) No. of Day-Care	0.0976
9	Accommodation Area, m^2	0.0000	25	Average Annual (yearly) No. of Out-Patient	0.3403
10	OT Area, m^2	0.6789	26	Average Accommodation Energy Usage	0.0102
11	Maternity Area, m^2	0.5957	27	Total Design Cooling Load (RT)	0.5135
12	No. of Bed in Maternity	NA	28	No. of Light Fixtures	0.3954
13	Imaging Department Area, m^2	0.6237	29	Total Installed Power of Lighting (kW)	0.0225
14	Centralized Sterile Service Department Area, m^2	0.0000	30	Average Annual (yearly) Total lighting Energy Consumption (kWh)	0.6956
15	Accident & Emergency (A&E) Area, m^2	0.2567	31	No. of High-Energy Medical Machines	0.6826
16	Laboratory Area, m^2	0.0405			

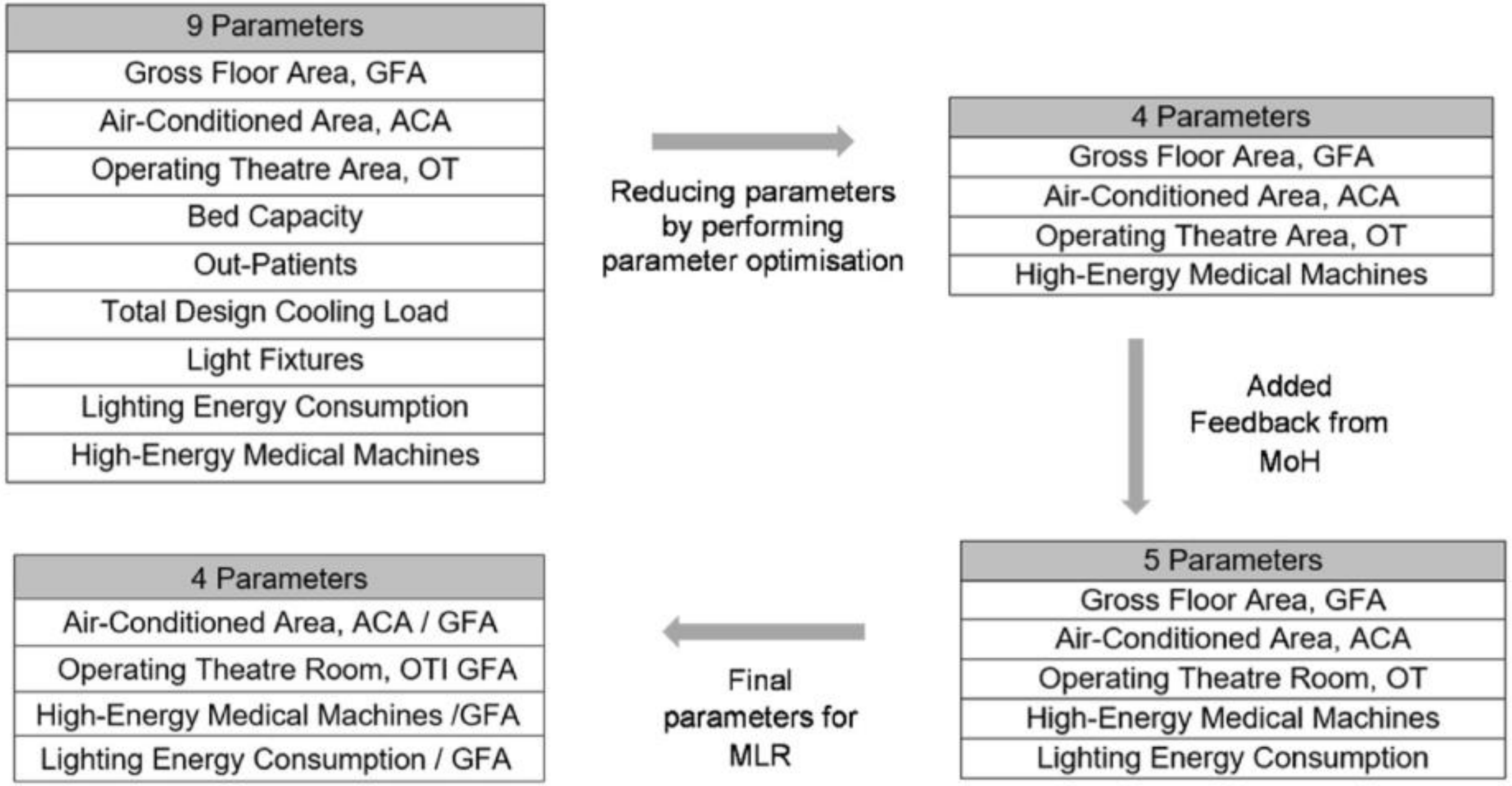

Fig. 3. Hospitals' parameters sequence changing.

- Dilakukan analisis dan pembobotan terhadap 31 parameter tersebut
- Dari 31 dipilih 9, kemudian 4, kemudian 5, kemudian 4 parameter

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$$Y = 72.54X_1 + 127,697X_2 + 79,883X_3 + 2.2X_4 + 23.94 \quad (6)$$

whereby:

Y = Energy Use Intensity, EUI (kWh/m^2 year)
X_1 = Air-conditioned Area, ACA (m^2)/GFA (m^2)
X_2 = Number of Operating Theatre (OT) rooms (nos.)/GFA (m^2)
X_3 = Number of High-Energy Medical Equipment (nos.)/GFA (m^2)
X_4 = Lighting Energy Consumption (kWh/year)/GFA (m^2)

Drivers of Energy Consumption in Hospitals
For Malaysia

- Kalau kita tahu 4 parameter ini, maka kita bisa menilai apakah sebuah RS di Malaysia hemat atau boros

- Apakah model/persamaan ini bisa kita pakai di Indonesia? TIDAK
- Kita **HARUS** membuat model kita sendiri ➔ PR Nasional

- Saya (SIGMATECH) siap mengerjakan proyek ini untuk Indonesia secara PRO BONO: kalau semua data disediakan

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Proses Benchmarking

Input

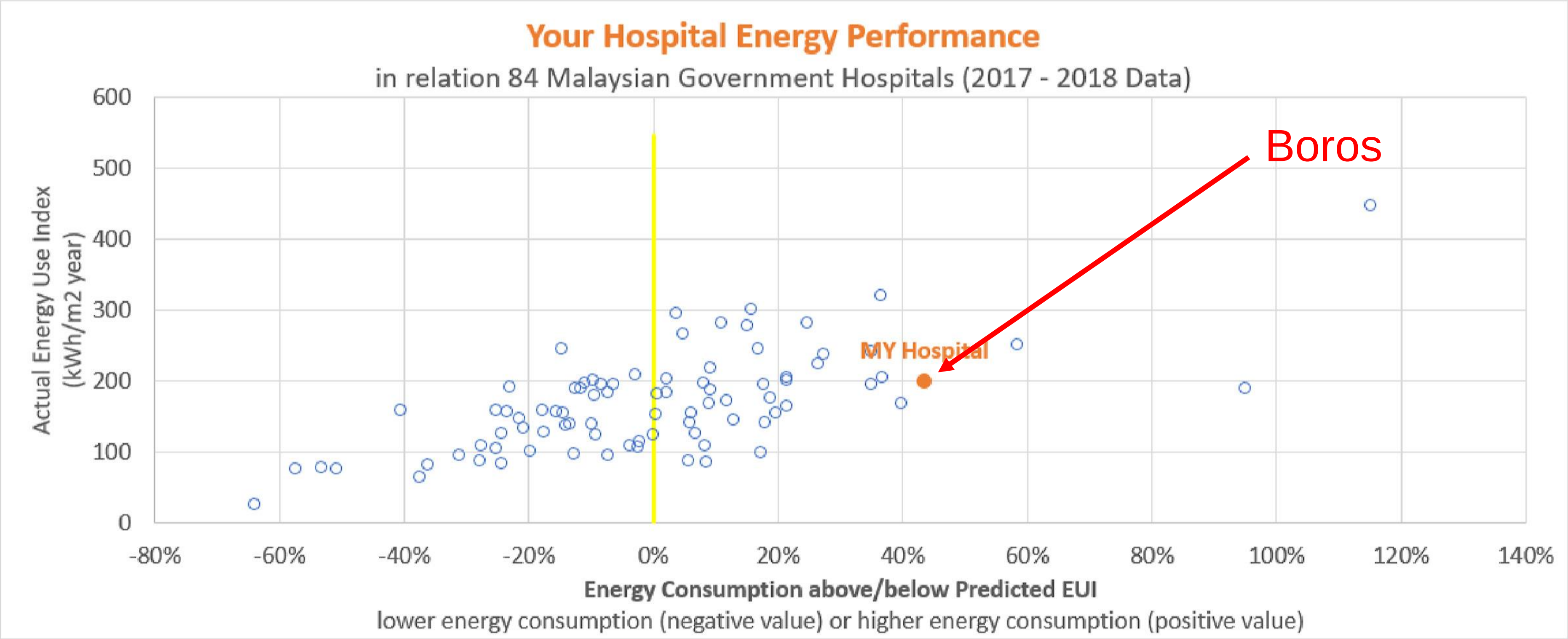
Enter these values

Hospital Name	MY Hospital
Hospital type (non-specialist or other):	Non-Specialist
Gross Floor Area, GFA (m2):	20,000
Air-Conditioned Area, ACA (m2):	10,000
Annual Electric Consumption (kWh/year):	4,000,000
Annual Lighting Energy Consumption (kWh/year):	350,000
Number of OT rooms (nos.):	2
Number of High-Energy Medical Equipment (nos.):	7
Scoring Table Type	Single Formula, All

Output

Calculated values

Actual Energy Use Index, EUI (kWh/m2 year):	200.0	
Predicted Energy Use Index, EUI (kWh/m2 year)	139.4	
Actual EUI / Predicted EUI:	1.43	
Energy Consumption (above/below) Predicted EUI	43%	Higher
Energy Label (1-5 Stars)	1	Stars
Energy Score (1-100)	8	



Proses Benchmarking

Input

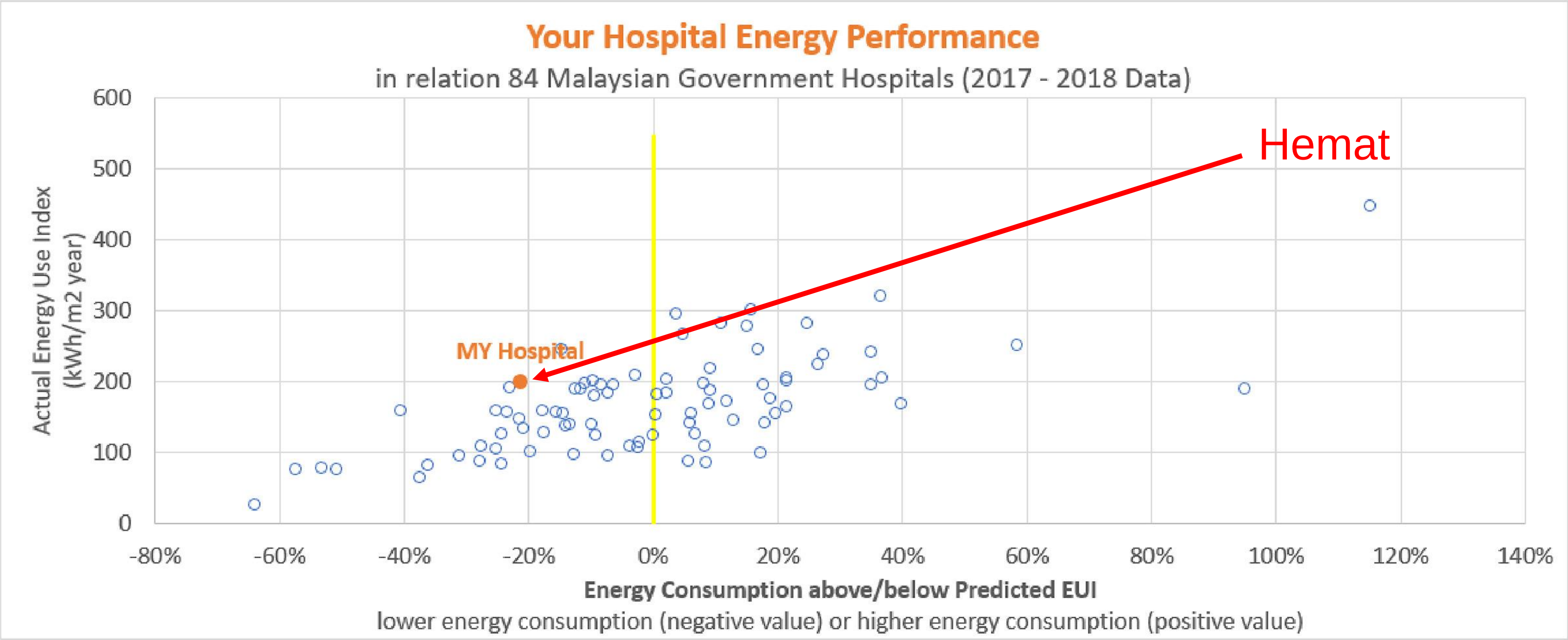
Enter these values

Hospital Name	**MY Hospital**
Hospital type (non-specialist or other):	Non-Specialist
Gross Floor Area, GFA (m2):	20,000
Air-Conditioned Area, ACA (m2):	10,000
Annual Electric Consumption (kWh/year):	4,000,000
Annual Lighting Energy Consumption (kWh/year):	350,000
Number of OT rooms (nos.):	20
Number of High-Energy Medical Equipment (nos.):	7
Scoring Table Type	Single Formula, All

Output

Calculated values

Actual Energy Use Index, EUI (kWh/m2 year):	**200.0**	
Predicted Energy Use Index, EUI (kWh/m2 year)	**254.3**	
Actual EUI / Predicted EUI:	**0.79**	
Energy Consumption (above/below) Predicted EUI	**-21%**	Lower
Energy Label (1-5 Stars)	**4**	Stars
Energy Score (1-100)	**77**	



Appendix B. Energy Ranking Label for all 84 hospitals

IKE Aktual

IKE dari benchmark

Energy label	No.	Hospital	State	Type of hospital	Actual EUI (kWh/GFA)	Predicted EUI (kWh/GFA)	EER	Percentile (%)	Score
5 STARS most energy efficient	1	NS1	Perak	Non-Specialist	23.77	65.92	0.36	1.19%	100
	2	NS2	Selangor	Non-Specialist	74.09	173.80	0.43	2.38%	100
	3	NS3	Pahang	Non-Specialist	76.81	163.99	0.47	3.57%	99
	4	NS4	Sarawak	Non-Specialist	74.45	151.02	0.49	4.76%	99
	5	NS5	Kelantan	Non-Specialist	157.40	264.48	0.60	5.95%	95
	6	NS6	Pahang	Non-Specialist	62.19	99.29	0.63	7.14%	93
	7	NS7	Perak	Non-Specialist	79.78	125.09	0.64	8.33%	92
	8	NS8	Perak	Non-Specialist	94.41	136.91	0.69	9.52%	88
	9	NS9	Pahang	Non-Specialist	85.70	118.93	0.72	10.71%	85
	10	NS10	Kedah	Non-Specialist	107.02	147.77	0.72	11.90%	84
	11	NS11	Perak	Non-Specialist	103.51	138.46	0.75	13.10%	81
	12	NS12	Kelantan	Non-Specialist	158.27	211.38	0.75	14.29%	81
	13	NS13	Sabah	Non-Specialist	82.04	108.49	0.76	15.48%	80
	14	NS14	Pahang	Non-Specialist	125.48	165.66	0.76	16.67%	80
	15	NS15	Kelantan	Non-Specialist	154.64	202.34	0.76	17.86%	79
	16	SG1	Johor	State/General	189.43	246.13	0.77	19.05%	79
1 STAR most energy inefficient	68	MJ12	Perak	Major Specialist	140.46	119.29	1.18	80.95%	25
	69	NS37	Sabah	Non-Specialist	174.94	147.48	1.19	82.14%	24
	70	MJ13	Negeri Sembilan	Major Specialist	153.61	128.53	1.20	83.33%	23
	71	MJ14	Selangor	Major Specialist	198.95	164.12	1.21	84.52%	22
	72	SG9	Negeri Sembilan	State/General	202.90	167.30	1.21	85.71%	22
	73	MJ15	Sabah	Major Specialist	163.64	134.76	1.21	86.90%	21
	74	MN13	Johor	Minor Specialist	280.92	225.57	1.25	88.10%	19
	75	SG10	Wilayah Persekutuan	State/General	222.43	176.01	1.26	89.29%	17
	76	MJ16	Kedah	Major Specialist	235.89	185.33	1.27	90.48%	17
	77	SG11	Perak	State/General	193.36	143.43	1.35	91.67%	12
	78	MN14	Perak	Minor Specialist	239.99	177.91	1.35	92.86%	12
	79	MJ17	Selangor	Major Specialist	318.28	233.38	1.36	94.05%	11
	80	MN15	Pulau Pinang	Minor Specialist	203.99	149.27	1.37	95.24%	11
	81	NS38	Terengganu	Non-Specialist	166.28	119.06	1.40	96.43%	9
	82	NS39	Pahang	Non-Specialist	249.63	157.75	1.58	97.62%	4
	83	NS40	Kelantan	Non-Specialist	187.87	96.49	1.95	98.81%	1
	84	NS41	Pahang	Non-Specialist	445.77	207.48	2.15	100.00%	1

RS Hemat
IKE Aktual < IKE Benchmark

RS Boros
IKE Aktual > IKE Benchmark

Dahlan, Nofri Yenita, Hassan Mohamed, Khairul Azmy Kamaluddin, Noor Muhammad Abd Rahman, Gregers Reimann, Joshua Chia, and Nur Iqtiyani Ilham. "Energy Star Based Benchmarking Model for Malaysian Government Hospitals - A Qualitative and Quantitative Approach to Assess Energy Performances." *Journal of Building Engineering* 45 (January 1, 2022): 103460. https://doi.org/10.1016/j.jobe.2021.103460.

CONCLUSION

- Kita harus mulai terbiasa untuk menyatakan kinerja bangunan dalam spesifikasi teknis
- Ini sudah dimulai dengan kebijakan Kemenkes untuk “menjamin” tercapainya enam parameter yang dibahas di workshop ini
- Kalau kita “menjamin” tercapainya keenam parameter tersebut, maka akan terjadi kenaikan konsumsi energi. **Kenaikan** konsumsi energi ini harus dipastikan **hemat**.
- SEMUA bangunan harus memiliki target IKE sejak dari perancangan

- Kita belum punya benchmark untuk menilai sebuah RS itu boros atau hemat
- Ini seharusnya menjadi prioritas nasional dalam kebijakan RS

Thank You


TALKSHOW AND WORKSHOP
HOSPITAL HVAC SYSTEM
DURING ENDEMIC COVID-19