Green Hospital, Energy Efficiency in Hospitals

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1. The Percentage of GHG(Greenhouse Gas) related to Construction and operation of buildings

1) U.S.A

Accounts for 48% of GHG (GrConstruction and operation of buildings eenhouse Gas) emissions. 9% of that comes form hospitals.

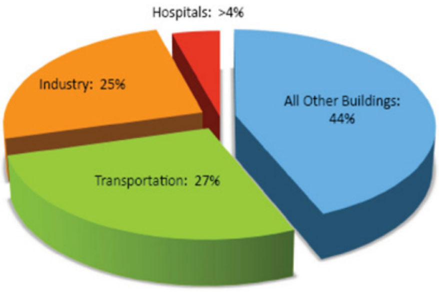


그림 1 GHG (greenhouse gas) emission sources, U.S.A

2) England

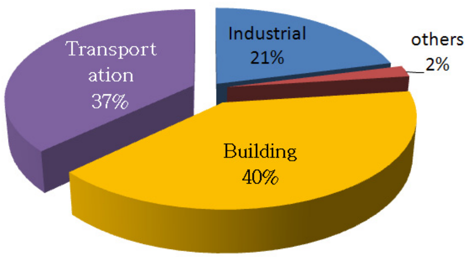


그림 2 GHG (greenhouse gas) emission sources, England

3) Korea

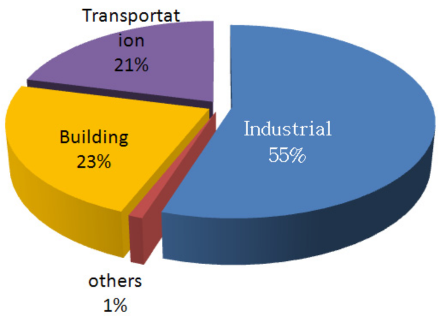


그림 3 GHG (greenhouse gas) emission sources, Korea

2. Resource Exhaustion

"In year 2030 , we need one more earth"

- World Wildlife Fund's biannual 'Living Planet' reported that in year 2010 had twice more energy consumption than year 1961. In year 2007, we had energy consumption more than 1.5 times of our earth can provide.

1) Fossil fuel exhaustion - Estimated amount of Fossil fuel deposits

- Oil : 41 yrs
- Gas : 63 yrs
- Coal : 218 yrs

2) Carbon-neutral in 2030

All new buildings, developments and major renovations

1) Professor, Ajor Vriuersitu
2) Managmg Director Samoo Arebiteets & Engineer
3) Vice Principal Samoo Arebiteets & Engineer

shall be designed to meet a fossil fuel, GHG-emitting, energy consumption performance standard of 50% of the regional (or country) average for that building type today.

The fossil fuel reduction standard for all new buildings shall be increased to:

- 60% in 2010
- 70% in 2015
- 80% in 2020
- 90% in 2025
- Carbon-neutral in 2030 : means using no fossil fuel GHG emitting energy to operate

3. Minimize environmental pollution through energy and natural resources conservation

1) Energy conservation & New Regeneration Energy

(1) Building Energy conservation

- Energy efficient plan (Optimum orientation / Mass / Exterior design)
- Insulation build-up (Building insulation, tighten exterior openings)
- High efficient mechanical system and operation (BEMS)

(2) New generation energy

- New generation energy : Fuel cell, Coal liquefaction, Hydrogen energy
- Renewable energy : Solar, Bio, Wind power, Hydrological, Geothermal

2) Building Form and Orientation

- Advantageous Mass design for natural ventilation and lighting
- Optimum orientation
- Exterior Design : Building skin concept change, Minimize Building skin area, Increase solid area, reduce opening, Adopt functional Building skin system

3) High efficient equipment / Efficient management system

- BEMS – Building Energy Management System

4. Energy Strategy

1) Process

- Reduce Loads
- Passive Strategies
- Active Strategies
- Recover Energy
- On Site Generation
- Offsetting

2) Sustainable Healthcare Design Strategies

- Energy
- Water
- On-site Renewable Energy
- Material & Indoor Environment Quality
- Landscape

3) Energy - Mechanical System - Strategies

- Unoccupied mode (lower ACH) setback
- Each patient room as individual zone.
- Provide VFD on all motors >= 3HP (*VFD = Variable Voltage Variable Frequency)
- Thermal Energy Storage (in central plant?).
- Pulse water treatment system (Dolphin) for condenser water.
- Fan Wall Technology (redundancy and acoustic)
- Use recirculating type hoods or VAV hoods in labs and IV Prep Rooms.
- Heat recovery chillier
- Solar hot water system
- Demand Control
- Heat Recovery
- Therapy pool
- Condenser heat recovery system to therapy pool water heating.
- Ozone pool water treatment system instead of chlorine based water treatment system.

- Study cost benefits of air economizer.

4) Energy - Electrical System - Strategies

- High efficiency transformers. (Direct energy cost savings under EAc1 Optimize Energy
- Performance. The high efficiency transformers have quick payback from experience)
- Circuit electrical and lighting load separately for easy metering
- Active Harmonic Filter
- Power Factor Correction Equipment
- Low Loss Cable
- High Efficiency Motor

5) Energy - Lighting System - Strategies

- Use day lighting in all patient rooms and whenever possible
- Daylight control
- Use light shelves and/or atrium to direct lights to interior of the building
- Use light sensor whenever possible at atrium, and the perimeter zones
- Bi-level lighting in patient corridors
- Reduced background lighting and provide task lighting at offices
- Dimmable lighting at nurse stations
- Occupant sensors in public restrooms, open offices, study rooms, etc.
- LED lighting
- Compact Fluorescent Lighting with reduced mercury.
- Site and exterior lighting: avoid light spills
- Optimize lighting density through lighting modeling

6) Water Strategies

- Low-flow water fixture:
- Sensor operated fixtures, soap machine, and paper towel machine - also helps on minimizing risk of bacteria/virus transfer through contact.
- On-site rain water harvesting.
- Reclaim cooling tower blow-down water for irrigation.
- Plant native and drought-tolerant plants
- BIOREACTOR + UV TREATMENT + OZONATION =
  - ✓ POTENTIAL FOR POTABLE WATER REDUCTION FOR TOILETS, COOLING TOWER SUPPLY, IRRIGATION DEMAND
  - ✓ CLEAN EFFLUENT FROM ALL BLACKWATER FLOW
- Use of reclaim water in restroom needs careful studies as this can be potential risk of infection to patients.
- PRECEDENT: Center for Health and Healing at Oregon Health and Science University (MOB)

5. On-site Renewable Energy Strategies

1) Biofuel

2) Biomass

3) Geothermal

- Technologies in use include dry steam power plants, flash steam power plants and binary cycle power plants. Geothermal electricity generation is currently used in 24 countries while geothermal heating is in use in 70 countries.
- Estimates of the electricity generating potential of geothermal energy vary from 35 to 2000 GW. Current worldwide installed capacity is 10,715 megawatts (MW), with the largest capacity in the United States (3,086 MW),[3] Philippines, and Indonesia.
- Geothermal power is considered to be sustainable because the heat extraction is small compared with the Earth's heat content. The emission intensity of existing geothermal electric plants is on average 122 kg of CO_2 per megawatt-hour (MW·h) of electricity, about one-eighth of a conventional coal-fired plant.

4) Hydroelectricity

5) Solar energy

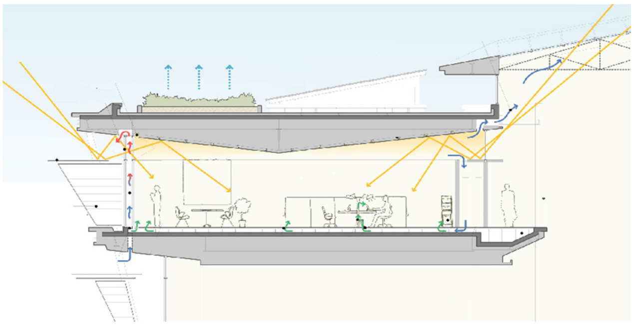


그림 4 Passive Solar System - Light Ceiling, IGES, Japan

6) Tidal power

7) Wave power

8) Wind power

9) Fuel Cell

- A fuel cell is a device that converts the chemical energy from a fuel into electricity through a chemical reaction with oxygen or another oxidizing agent
- CO_2 reduction vs. grid = 34%
- Building Electrical consumption = 1,752,000 kWh.
- Fuel Cell Generation = 300 kWh (1.7% of total energy estimated use)
- Operates 24/7, export to grid during nighttime

6. Material & Indoor Environment Quality Strategies

1) Hospital Acquired Infection (HAI) Control

Infections occur – patient to patient and staff to patient

Use CFD (Computational Fluid Dynamics):

- Air borne transmission routes
- Ventilation strategies to reduce infection transfer

2) Day lighting:

- Appropriate solar control device to bring low energy daylight
- Appropriate thermal insulated glazing
- Shading devices
- Glare precaution
- Reduce electricity of artificial lighting

3) Considerations for design of solar control:

- Create the best possible ENERGY BALANCE
- Effective passive and/or active solar control device
- Encompass with architectural design
- Incorporate landscape for spot cooling
- Maximise diffuse sunlight access
- Minimise the direct sunlight access
- Re-direct direct sunlight by reflection
- Reduce adverse impacts to surroundings

4) Artificial Lighting Control System:

- Fluorescent lamp dimming control system
- Using of electrical ballasts cooperating with the Digital Addressable Lighting Interface (DALI) controller and photocell
- Energy saving in electric lighting system which incorporated with the daylighting design
- Proper lighting wiring connection for dimming
- Use of T5 fluorescent tube
- Proper window size and dimension for daylight transmission
- Occupant sensor

5) Indoor Air Quality:

- Provide thermal comfort by adopting suitable natural and mechanical ventilation strategies. When using mechanical ventilation, maximize the degree of personal control over temperature and airflow;
- Supply adequate levels of ventilation and outside air to ensure indoor air quality;
- Avoid the use of materials that are high in volatile organic compounds (VOCs) emissions;
- Control odors through contaminant isolation

6) Acoustic Environment*:

- Research shows good acoustic environment improves patient recovery rate.

7) Material and Indoor Environment Quality:

- MRc4.1–4.4: Low–VOC paints and sealants, green carpet tiles, etc.
- UVGI (Ultraviolet Germicidal Irradiation) at Air Handling Units
- Provide HEPA filter at fresh air intake.
- Higher fresh air ventilation rate.
- Controllability of systems – Lighting and Thermal Comfort – each patient room shall be an individual zone for patient's comfort.

7. Landscape Strategies

- Maximize open spaces for patients and staffs
- Carefully planned landscapes
- Healing Gardens
- Green Roofs
- Reduce heating/cooling loads
- Achieve LEED➋ SSc5.2
- Water efficient irrigation system
- Native, drought resistant plants

8. LEED for Healthcare 2009 - Released on 8 APR 2011

1) Different from LEED NC - recognizes the unique nature of healthcare facilities

- regulatory requirements
- 24/7 operations
- specific programmatic demands

2) Designed to meet the unique needs of healthcare market

- Inpatient Care
- Licensed Outpatient Care
- Licensed Long Term Care
- Medical Offices
- Assisted Living

3) Most of the Indoor Environmental Quality credits (IEQ) have been modified to align the need for infection control, to protect patients from contaminants, and the strict code regulations on ventilation with green building strategies

9. Hospital Design Functional Requirements

1) Reliability

- 24x7 operation – Reliability is the most critical concern!
- Zero downtime allowed for life–essential operations
- e.g. backup power to breathing machines, oxygen supply, biobank, etc.
- Backup mechanical and electrical systems

2) Efficient Operation

- Effective transportation and communication systems
- Safety for patients, visitors, and staffs
- Flexibility for future expansion
- Easy maintenance access
- Minimize interruption on maintenance

3) Infection Controls

- Airborne infection and infection through physical contacts
- Pressurization control and monitoring
- Prevent cross contamination, control on infectious sources

4) Sustainability

- Energy Conservation – Optimize MEP systems design
- Renewable energy to offset energy use
- Water Conservation and reuse
- Transportation

5) IEQ

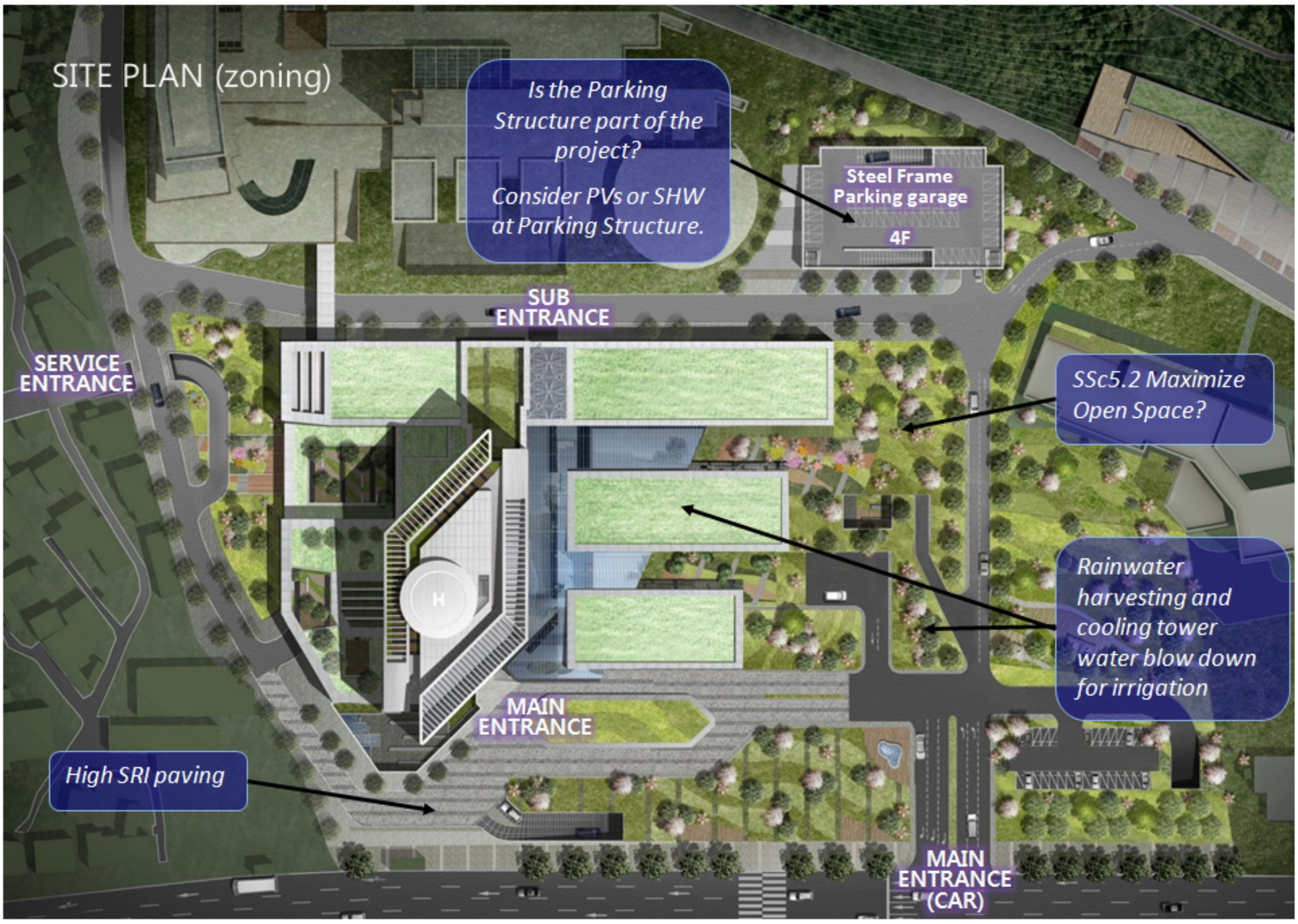
- Good Air Quality – efficient air distribution and filtration systems
- Improved acoustic for better patients and staffs comfort
- Controllability of lighting and thermal conditions

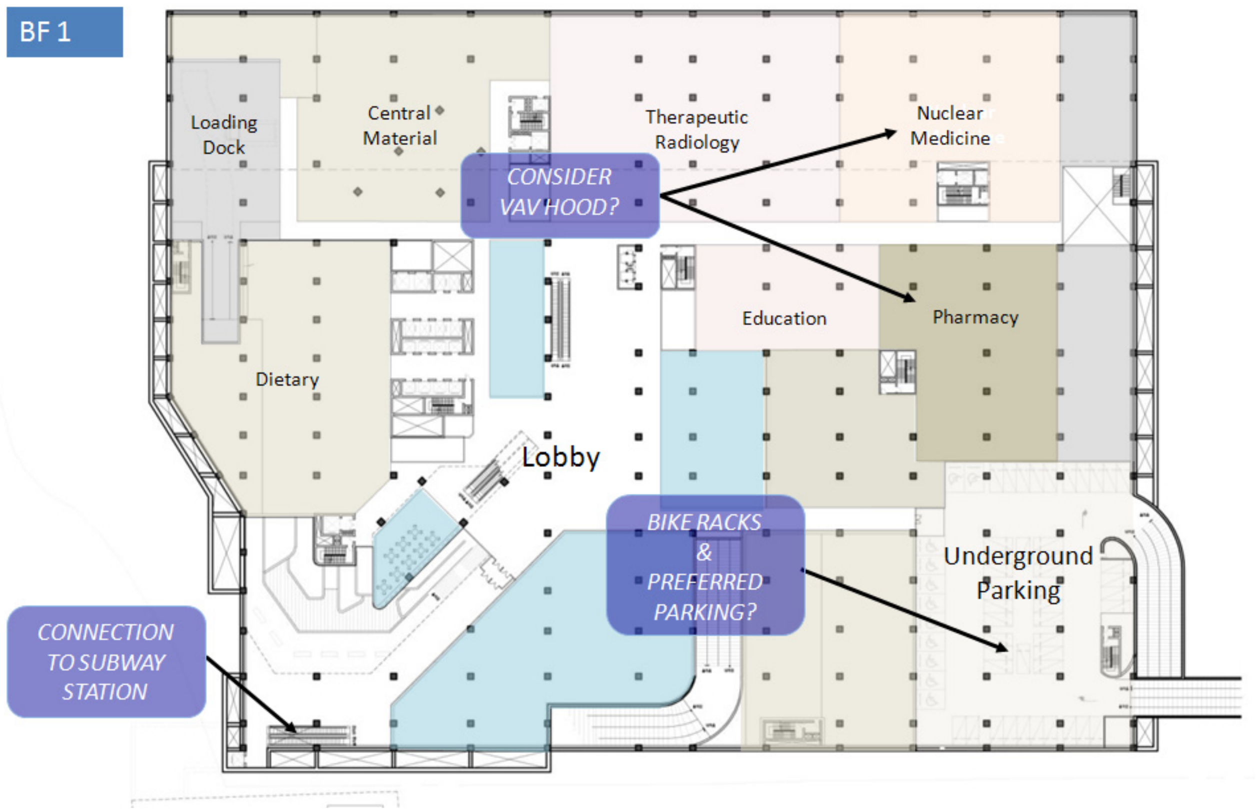
- Increase patient comfort
- More outside view and daylight

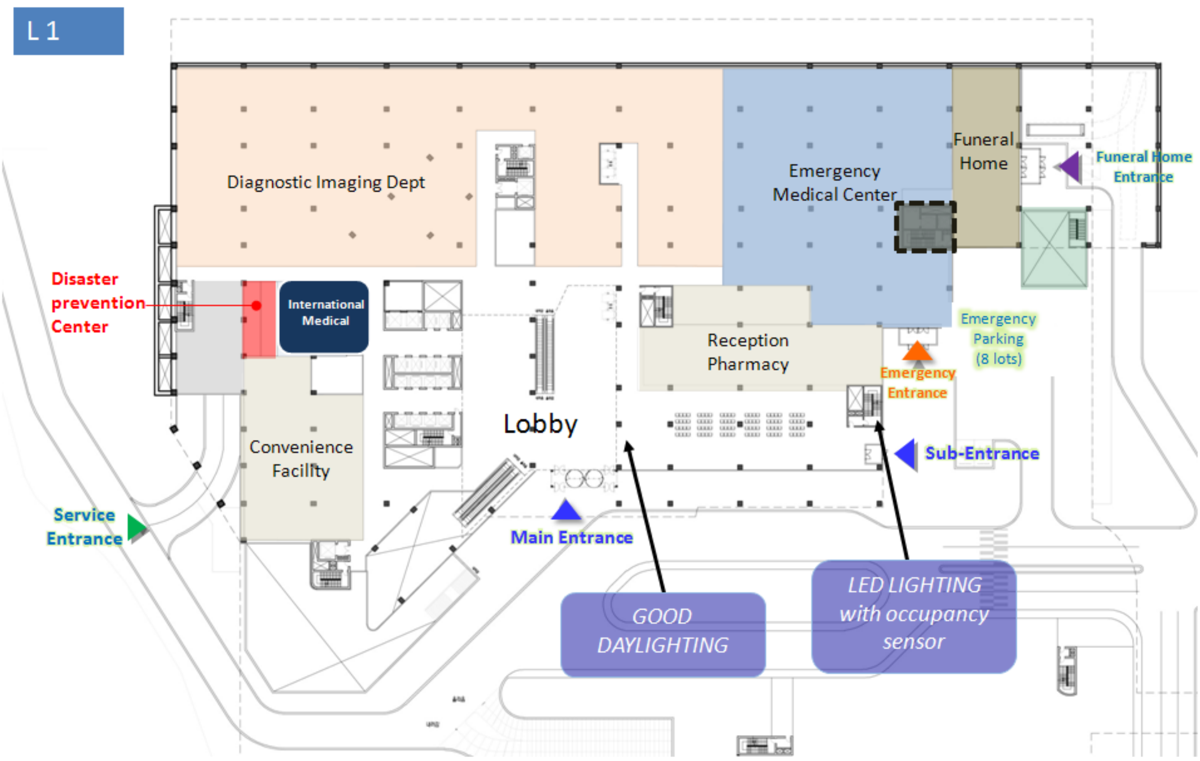
6) Patients Recovery

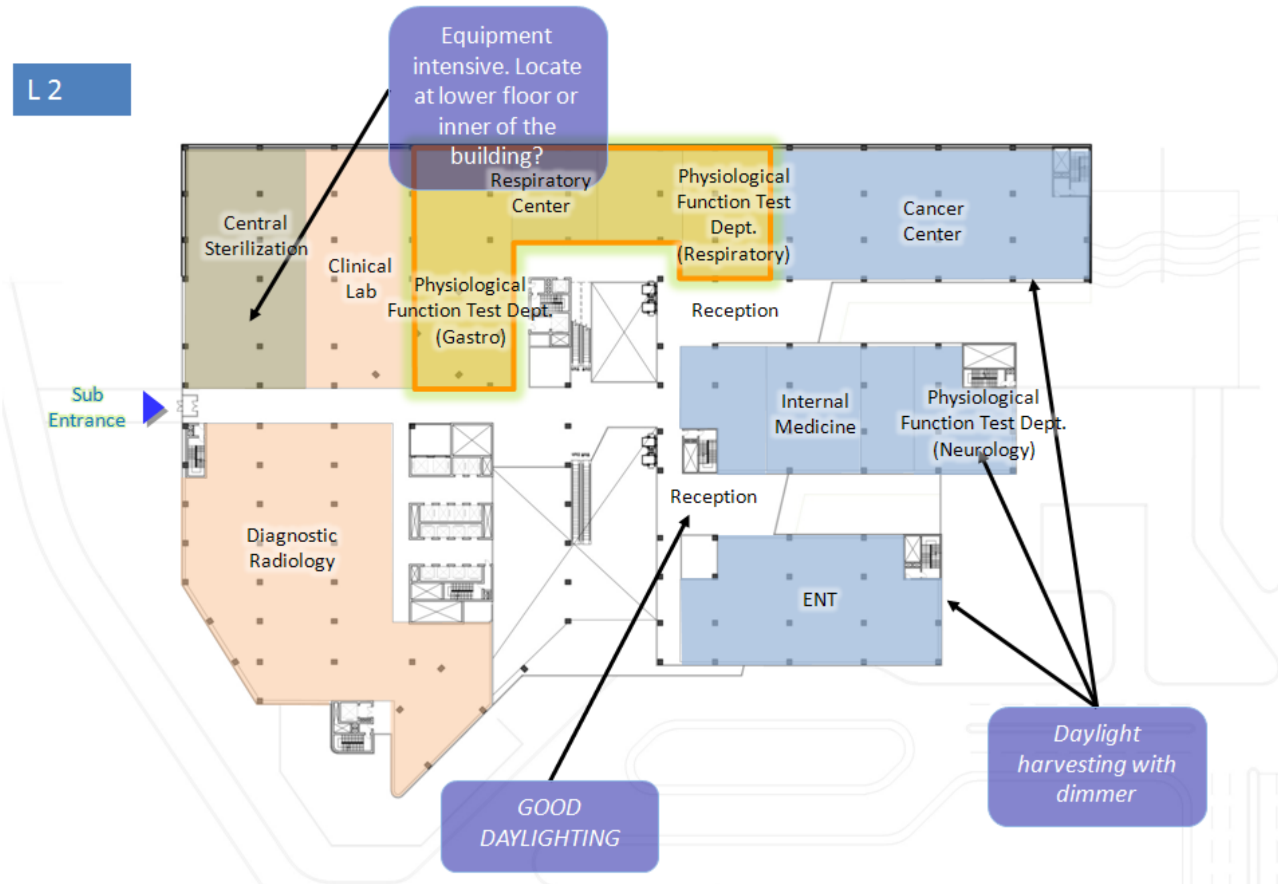
- Closely connected to the environment
- Communications with nurses/doctors
- Patient Comfort
- Acoustics impact recovery rates

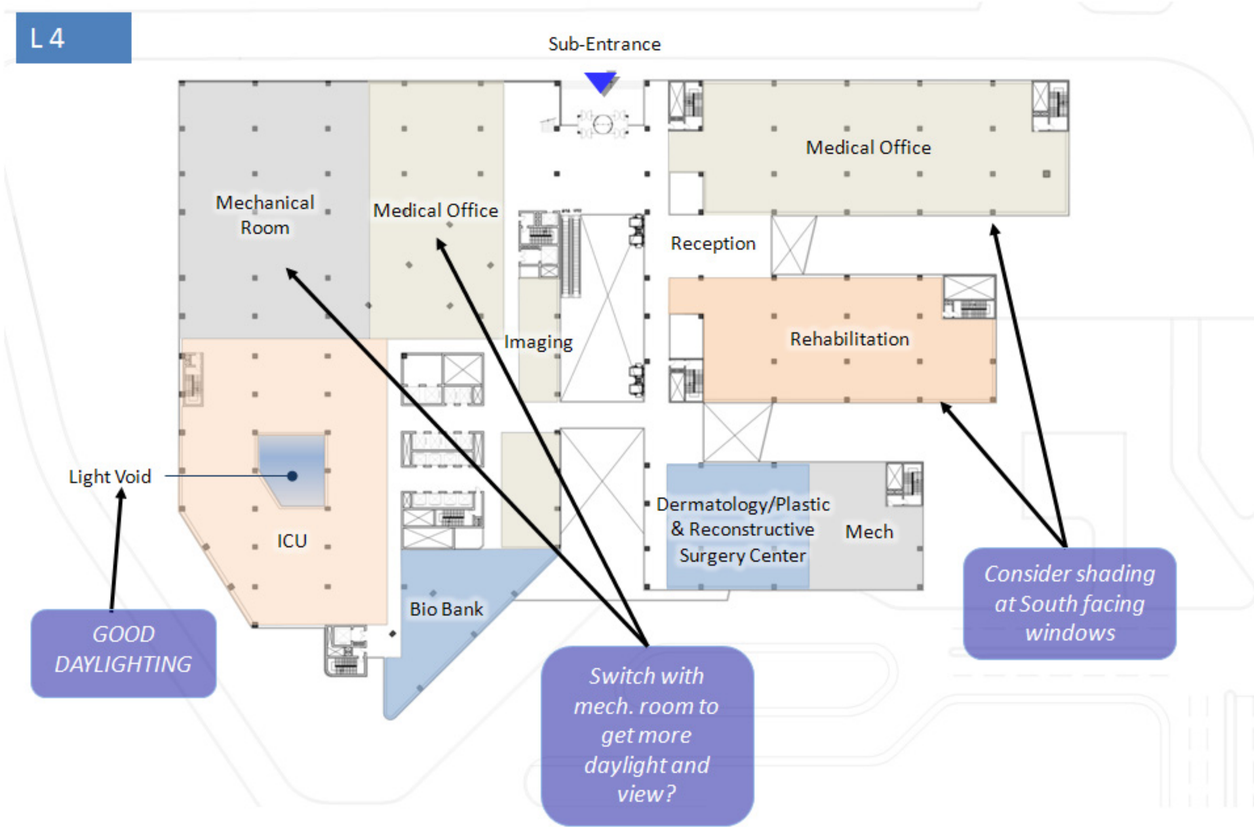
10. Example



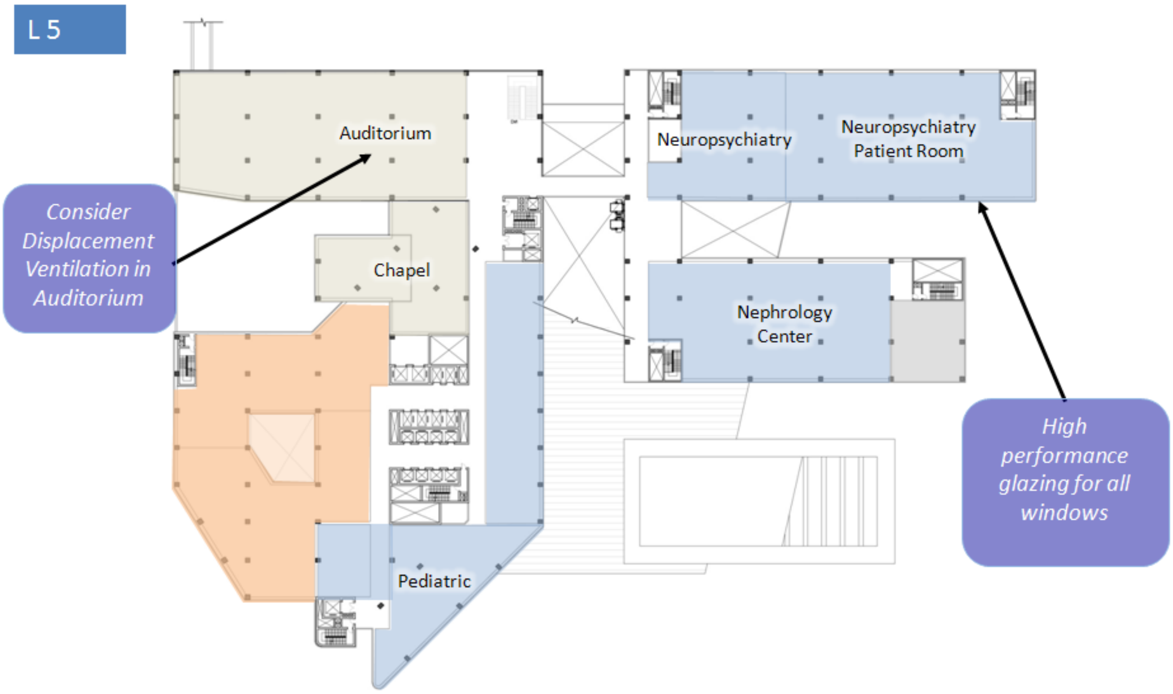

BF 1
Loading Dock
Central Material
Therapeutic Radiology
Nuclear Medicine
CONSIDER VAV HOOD?
Education
Pharmacy
Dietary
Lobby
BIKE RACKS & PREFERRED PARKING?
Underground Parking
CONNECTION TO SUBWAY STATION


L 1
Diagnostic Imaging Dept
Emergency Medical Center
Funeral Home
Funeral Home Entrance
Disaster prevention Center
International Medical
Reception Pharmacy
Emergency Parking (8 lots)
Emergency Entrance
Lobby
Sub-Entrance
Convenience Facility
Service Entrance
Main Entrance
GOOD DAYLIGHTING
LED LIGHTING with occupancy sensor

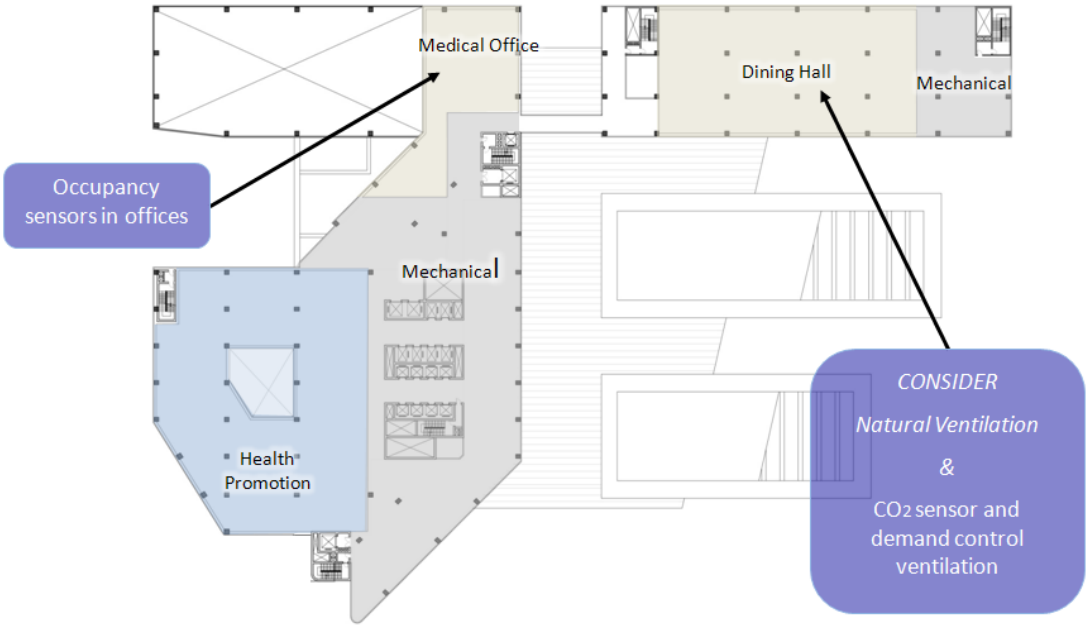

L 2
Equipment intensive. Locate at lower floor or inner of the building?
Central Sterilization
Clinical Lab
Respiratory Center
Physiological Function Test Dept. (Respiratory)
Cancer Center
Physiological Function Test Dept. (Gastro)
Reception
Sub Entrance
Internal Medicine
Physiological Function Test Dept. (Neurology)
Reception
Diagnostic Radiology
ENT
Daylight harvesting with dimmer
GOOD DAYLIGHTING

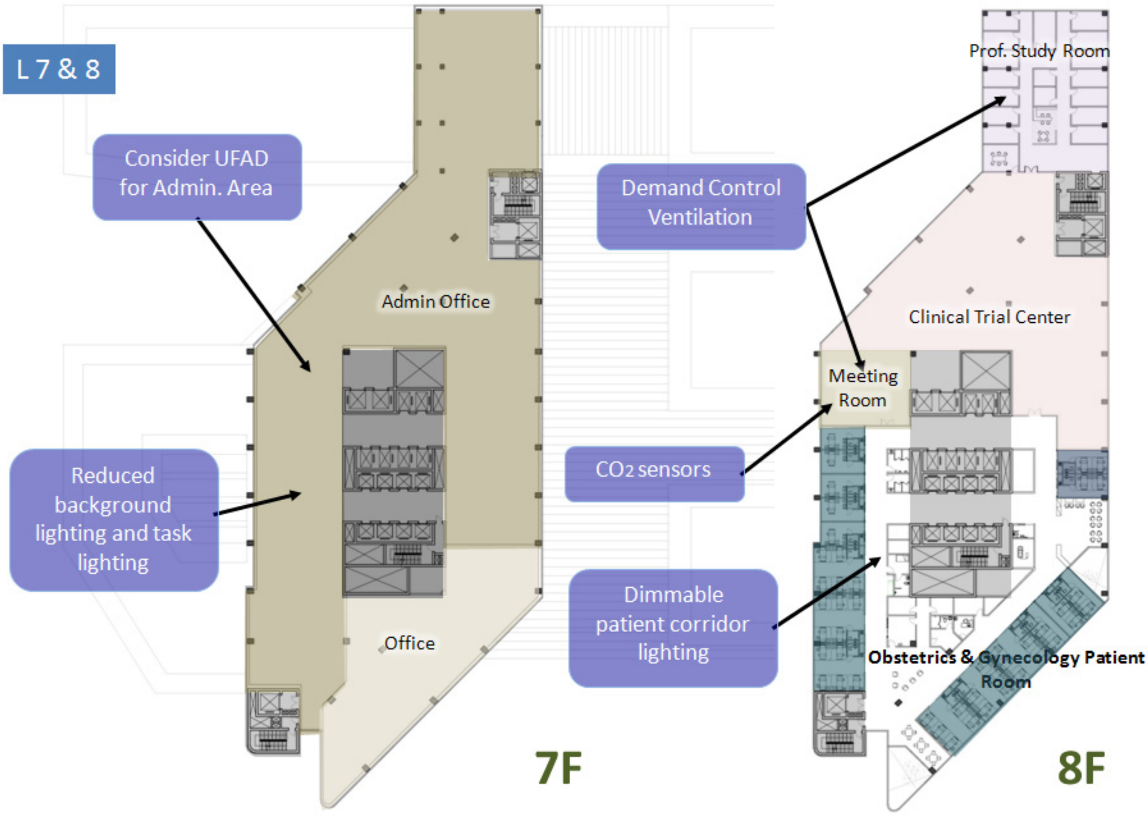

L 4
Sub-Entrance
Medical Office
Mechanical Room
Medical Office
Reception
Imaging
Rehabilitation
Light Void
ICU
Dermatology/Plastic & Reconstructive Surgery Center
Mech
Bio Bank
GOOD DAYLIGHTING
Switch with mech. room to get more daylight and view?
Consider shading at South facing windows

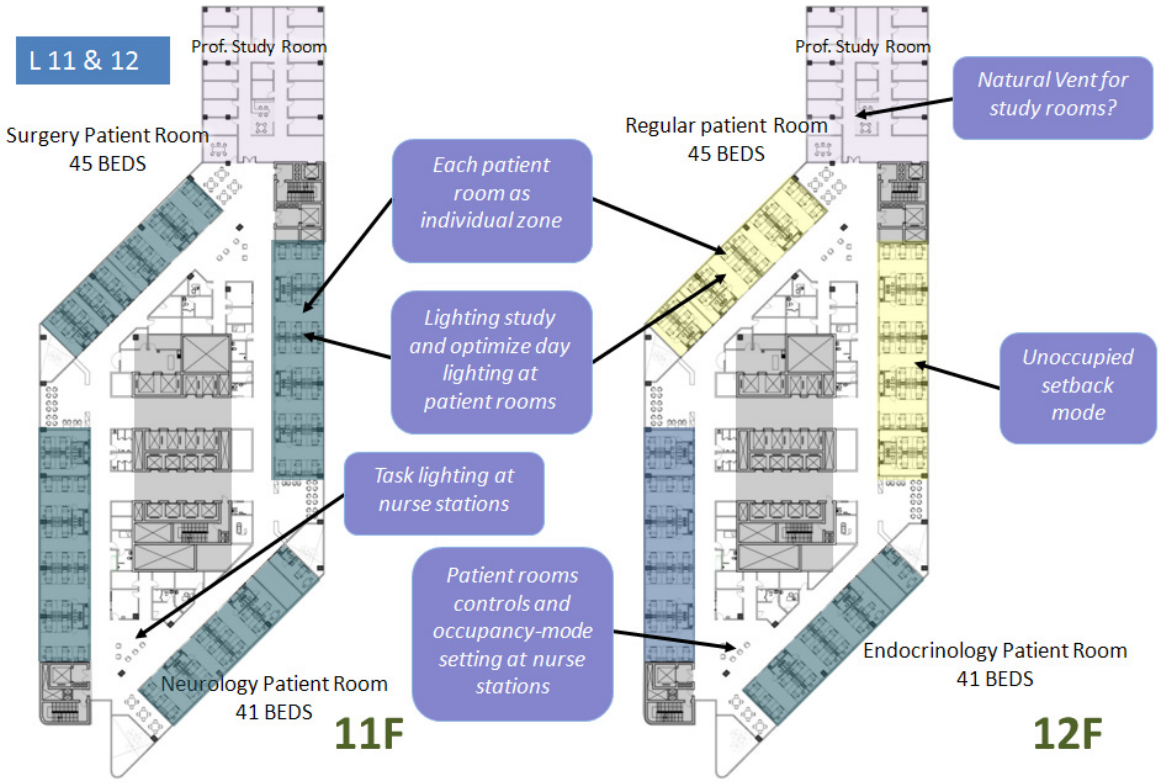
L 5


Auditorium
Consider Displacement Ventilation in Auditorium
Chapel
Neuropsychiatry
Neuropsychiatry Patient Room
Nephrology Center
High performance glazing for all windows
Pediatric

L 6


Medical Office
Dining Hall
Mechanical
Occupancy sensors in offices
Mechanical
Health Promotion
CONSIDER
Natural Ventilation
&
CO2 sensor and demand control ventilation





TYPICAL PATIENT FLOOR

References

1. 김강수, 이승복, 정대업 공저, 건축환경학, 문운당, 2002
2. 김성완, 건물의 외단열과 내단열, 대한건축학회 36권 6호, 1992
3. 김원 외, 친환경건축설계 가이드북, 발언, 2009
4. 나카타니 요시노리 편저, 친환경건축물 요소기술과 설계기법, 삼우종합건축사사무소, 2008
5. 오니시 마사노리 저, 박헌주 역, 환경건축・환경도시, 기문당, 2007
6. 이승복, 통합외피시스템의 계획방향, 설비「통권 292」, 2009
7. 함정도・노정선 공저, 친환경건축의 이해, 기문당, 2003
8. Catherine Slessor, Eco-Tech, Thames and Hudson, 1997
9. Daniel D. Chiras, The Natural House, Chelsea Green Publishing Company, 2000
10. Edward Harland, Eco-Renovation, Chelsea Green Publishing Company, 1999
11. James Steele, Sustainable Architecture, McGraw-Hill, 1997
12. Nick Hollo, Warm house Cool house, Choicebooks, 2003
13. Steven Winter Associates, The Passive Solar Design and Construction Handbook, John Wiley & Sons, Inc., 1998
14. Tom Woolley and Sam Kimmins, Green Building Handbook, Spon Press, 2002