

FIVE ENERGY EFFICIENCY STRATEGY



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FIVE ENERGY EFFICIENCY STRATEGY

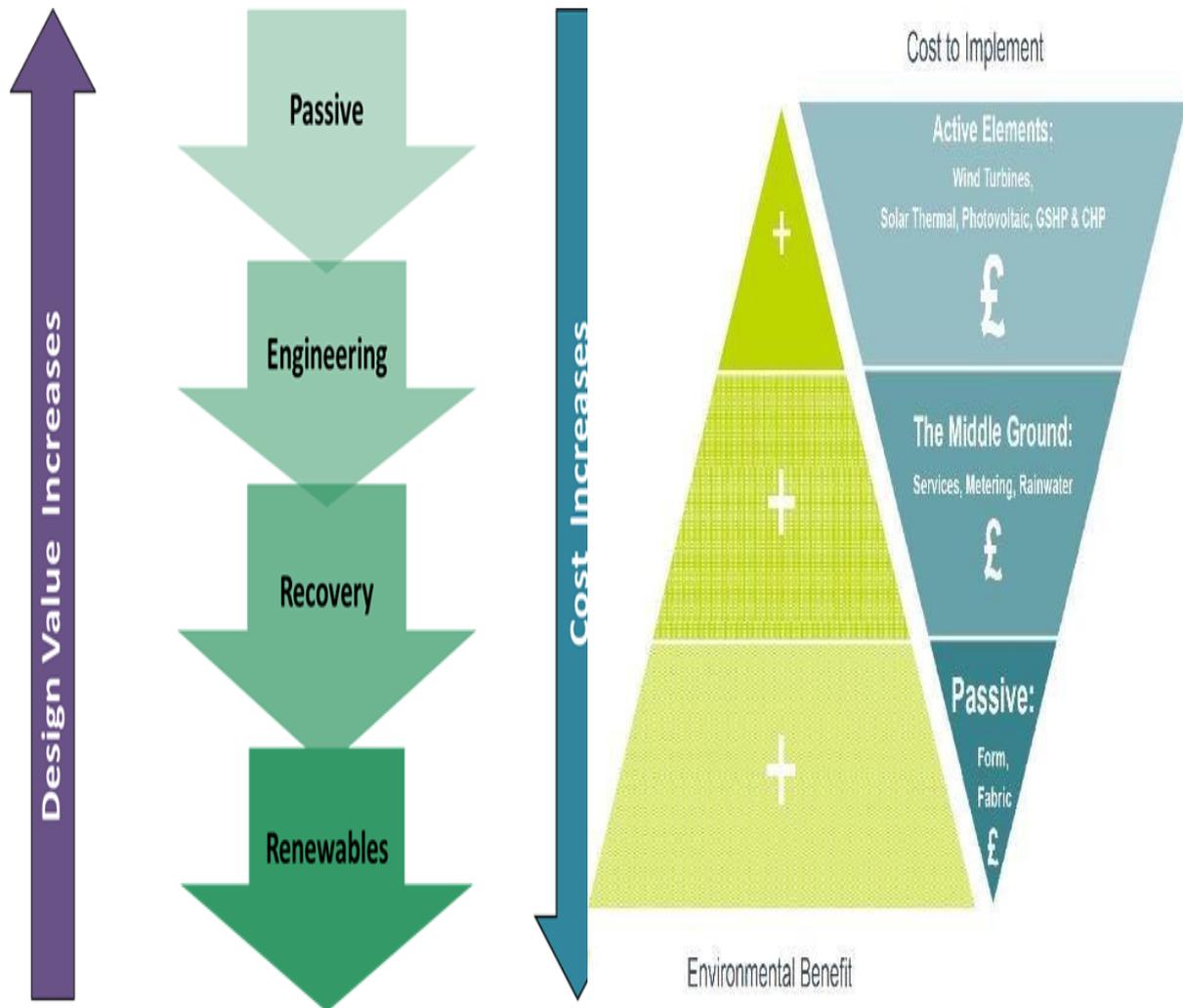
FIVE strives to operate its business in an energy efficient and environmentally responsible manner in accordance with the highest international standards. The current activities of the company involve owning and operating luxury hospitality properties and residential buildings in several countries. FIVE also undertakes several new projects that require new construction or major renovation of existing properties which are acquired as part of its growth strategies. The Nature and Scale of project always offers new opportunities for energy savings based on whether it is a new construction, existing operating building, or a major retrofit renovation project. With the advent of new technologies additional energy improvements are always possible and on top of that the commitment to Climate change further requires a close synergy of asset and all energy improvement measures.

The Existing building energy savings normally begins with an energy Audit which may include ASHRAE Level 1, ASHRAE Level 2 ASHRAE Level 3 that identifies the energy improvement opportunities through energy conservation measures. There are ASHRAE standard equivalents available for different geographic regions that the projects can use for optimizing energy consumption of existing assets. On the other hand, New Construction projects have higher level of energy savings opportunities through better design beginning with passive energy savings measures, building orientation, followed by energy efficiency fixtures, recovery of waste energy and renewable energy. The existing assets of the group will undergo continuous benchmarking of energy performance. The assets of the company are ISO 50001 certified demonstrating its commitment continuous improvement in Energy Management

For a New Construction Project, the continual development of the design solution follows a simple four stage process that occurs in parallel through the whole design.

- Add passive.
- Engineering
- Recovery
- Renewables diagram

Energy performance efficiency are maximized in the first instance by reducing the loads on the building through passive design, while the active systems are designed to be as energy and water efficient as possible. Finally renewable energy systems are employed, where practical and possible, to provide some of the energy needs.



A number of Building elements and Energy related systems are critically responsible for making a building energy efficient and improve continually.

Energy performance of projects will meet minimum ASHRAE 90.1 2010 requirements.

External Walls	Base Line U-Value - 0.365 w/m ² -°k
Roof	Insulation Entirely Above Deck U-Value - 0.273 w/m ² -°k SRI 78
Floors & Partitions	U-Value- 0.42 w/m ² -°k
Slab (On Grade)	F-Factor: 0.935 W/m-K (unheated) U Value - 1.489
Glazing	U Value - 3.12 w/m ² -°k
	SHGC - 0.46
	VLT - 50%
WWR(Window to Wall ratio)	Maximum 40%
HVAC Type	Packaged terminal AC
Efficiency at ARI Condition	> 11.9 EER
Internal Lighting Load	
Café	15 LPD W/m ²
Corridors	5 LPD W/m ²
Electrical / Mechanical	16 LPD W/m ²
Lobby	14 LPD W/m ²
Reception Areas	14 LPD W/m ²
Retail / F&B Outlets	18 LPD W/m ²
Store Rooms	9 LPD W/m ²
Toilets	10 LPD W/m ²
Office Areas	12 LPD W/m ²
Children Room	14 LPD W/m ²
Gym	10 LPD W/m ²
Meeting Rooms	14 LPD W/m ²
Hotel Guest Rooms	12 LPD W/m ²
Maid Rooms	12 LPD W/m ²
Residential Apartments	12 LPD W/m ²
Stairs	6 LPD W/m ²

Recommended Lighting Level

RESIDENTIAL AREA	
Area	Recommended Lighting Level
Bedrooms	100 lux
Bathrooms	150 lux
Toilets	100 lux
Kitchens	200 lux
External Lightings (Path- ways & Car parking)	10 lux
Stairs & Lobbies	100 lux
Corridor	100 lux
Corridor at Night	20 lux
Entrances	200 lux

RESTAURANTS & HOTELS	
Area	Recommended Lighting Level
Food Storage Areas	150 lux
Wash Up & Vegetable Preparation	300 lux
Food Preparation & Cooking	500 lux
Entrance Halls	100 lux
Reception Desk	300 lux
Bar, Restaurant or Lounge	50-200 lux
Bedrooms	50-100 lux

OFFICES	
Area	Recommended Lighting Level
General Offices	500 lux
Drawing Offices	500 lux
Executive Offices	300-500 lux
Computer Workstations	300-500 lux
Filing Rooms	300 lux
Print Rooms	300 lux
CAD Design Areas	300-500 lux
Drawing Boards	750 lux

Recommended Appliance and Process Water Use

Appliances, equipment, and processes within the project scope to meet the requirements listed in the tables below.

Standards for appliances	
Appliance	Requirement
Residential clothes washers	ENERGY STAR or performance equivalent
Commercial clothes washers	CEE Tier 3A
Residential dishwashers (standard and compact)	ENERGY STAR or performance equivalent
Prerinse spray valves	≤ 1.3 gpm (4.9 lpm)
Ice machine	ENERGY STAR or performance equivalent and use either air-cooled or closed-loop cooling, such as chilled or condenser water system

gpm = gallons per minute lpm = liters per minute

Standards for processes	
Process	Requirement
Heat rejection and cooling	No once-through cooling with potable water for any equipment or appliances that reject heat
Cooling towers and evaporative condensers	Equip with <ul style="list-style-type: none"> • makeup water meters • conductivity controllers and overflow alarms • efficient drift eliminators that reduce drift to maximum of 0.002% of recirculated water volume for counterflow towers and 0.005% of recirculated water flow for cross-flow towers

gpm = gallons per minute lpm = liters per minute

Recommended Retail and Hospitality Only- Assets

In addition, water-consuming appliances, equipment, and processes must meet the requirements listed in

Kitchen Equipment		Requirement (IP units)	Requirement (SI units)
Dishwasher	Undercounter	≤ 1.6 gal/rack	≤ 6.0 liters/rack
	Stationary, single tank, door	≤ 1.4 gal/rack	≤ 5.3 liters/rack
	Single tank, conveyor	≤ 1.0 gal/rack	≤ 3.8 liters/rack
	Multiple tank, conveyor	≤ 0.9 gal/rack	≤ 3.4 liters/rack
	Flight machine	≤ 180 gal/hour	≤ 680 liters/hour
Food Steamer	Batch	≤ 6 gal/hour/pan	≤ 23 liters/hour/pan
	Cook-to-order	≤ 10 gal/hour/pan	≤ 38 liters/hour/pan
Combination Oven	Countertop or stand	≤ 3.5 gal/hour/pan	≤ 13 liters/hour/pan
	Roll-in	≤ 3.5 gal/hour/pan	≤ 13 liters/hour/pan

Process requirements	
Process	Requirement
Discharge water temperature tempering	Where local requirements limit discharge temperature of fluids into drainage system, use tempering device that runs water only when equipment discharges hot water OR Provide thermal recovery heat exchanger that cools drained discharge water below code-required maximum discharge temperatures while simultaneously preheating inlet makeup water OR If fluid is steam condensate, return it to boiler
Venturi-type flow-through vacuum generators or aspirators	Use no device that generates vacuum by means of water flow through device into drain

1 Energy Policy

1.1 Objectives

The objective is to meet the vision for the FIVE Group, which is to create sustainable assets with the low environmental footprint with lower Green House Gas (GHG) emissions. FIVE has established measurable goals that support the vision including: Sustainability, Renewable Natural Resources and Innovation.

It is also understood that in addition to its 100% LEED Platinum operational hotels as of April 2023, FIVE’s future projects aim to achieve LEED Platinum or an equivalent Sustainability rating that requires a number of mandatory and optional credits required to be included in Design and Construction process.

1.2 Information References

Project Design will follow High Performance Building Code ASHRAE 189.1.2009 and Energy Code ASHARE 90.1.2010 or equivalent local standard

1.3 Report Analyses

1.3.1 Energy Design Guideline

The FIVE Group is inspired by internationally adopted Building Energy codes and standards such as ASHRAE, IESNA, ICC etc. and Green Building rating systems

such as LEED and BREEAM etc. FIVE particularly emphasizes on ASHRAE 90.1 and ASHRAE 189.1 standards.

There are two compliance methodologies available to follow:

- 1) Prescriptive Methodology: The project needs to meet with minimum required design parameters and all mandatory requirements.
- 2) Model-Based Methodology: In addition to the minimum mandatory requirements, the proposed buildings need to be modeled in an energy software package and compared to a reference model to ensure compliance with the Energy Guidelines. This can be achieved in two methods:
 - a) Compliance Model Path – Demonstrate performance improvement based on reduction in annual energy.
 - b) Alternative Compliance Model Path - Demonstrate performance improvement based on reduction in annual energy consumption relative to ASHRAE 90.1-2010 by 30% (recommended option).

The building Compliance Model Path is an alternative to the prescriptive provisions of this guideline for buildings below 2,000 m² and mandatory for buildings above this size. We would highly recommend following the Alternative Compliance Model Path to achieve sustainable targets using Energy Plus, DOE-2, IES ,HAP, eQuest or another hourly load and energy modeling software tool.

FIVE also has set the ambition for all projects to achieve energy efficiency KPI of 30% better than ASHRAE 90.1.2010

The Energy Guideline applies to all building typologies and prescribes the minimum requirements or Energy Design Guidelines under the following categories:

- Building Envelope
- Heating, Ventilating, and Air Conditioning
- Service Water Heating
- Building Lighting Systems
- Electric Power, Motors and Energy Management systems
- Renewable Energy use or alternatively REC(Renewable Energy Certificates) use

A brief description of the Mandatory requirements under each category is described below.

1.3.2 Building Envelope

- The building envelope shall comply with ANSI/ASHRAE/IESNA Standard 90.1-2010
- Air leakage rate of the building envelope does not exceed 3.0 m³/hour.m² of the envelope area of the building, under a pressure differential of 50 Pa in accordance with ASTM E 779 *EN 13829* or an equivalent approved method.

- The entire roof must have a minimum initial SRI of 78 for a low-sloped roof (a slope less than or equal to 2:12) and a minimum initial SRI of 29 for a steep-sloped roof (a slope of more than 2:12).
- The total vertical fenestration for conditioned spaces shall not exceed 40% of the gross wall area for Residential buildings and 35% of the gross wall area for all other building types.
- The vertical fenestration on the west, south, and east shall be shaded by permanent overhang having an area-weighted average Projection Factor (PF) of not less than 0.50.
- The ratio of VLT over SHGC for all glazing should be at least 1.8.
- Operable windows must be equipped with interlocking controls.

Table 2.1.3 – Building Envelope Requirements for all Building Types

Opaque Building Element	All Building Types Excluding Residential		Residential Buildings	
	Assembly Maximum U-Value W/m ² -K		Assembly Maximum U-Value W/m ² -K	
Roofs	0.20 W/m ² -K		0.20 W/m ² -K	
Above-Grade Walls	0.28 W/m ² -K		0.28 W/m ² -K	
Below-Grade Walls	No specific requirement		No specific requirement	
Floors (adjacent to non-conditioned zones)	0.50 W/m ² -K		0.50 W/m ² -K	
Partitions (adjacent to non-conditioned zones)	0.50 W/m ² -K		0.50 W/m ² -K	
Slab-On-Grade Floors	F-Factor: 3.00 W/m-K		F-Factor: 3.00 W/m-K	
Opaque <i>Swinging</i> Doors	3.00 W/m ² -K		3.00 W/m ² -K	
Opaque <i>Non-Swinging</i> Doors	2.50 W/m ² -K		2.50 W/m ² -K	
Fenestration	All Building Types Excluding Residential		Residential Buildings	
	Assembly Max. U-Value W/m ² -K	Assembly Max. SHGC	Assembly Max. U-Value W/m ² -K	Assembly Max. SHGC
Vertical Fenestration	1.60	0.25	1.80	0.25
Skylights	2.00	0.20	2.00	0.20

1.3.3 Heating, Ventilating, and Air Conditioning

- The HVAC systems shall comply with ANSI/ASHRAE/IESNA Standard 90.1-2010
- Demand Control Ventilation (DCV) is required for densely occupied spaces with a design occupant density greater than or equal to 25 people per 100 m² and where occupancy is variable and unpredictable.
- In hotels and motels, the lighting switched outlets, television, and HVAC equipment serving each guest room shall be automatically controlled such that the lighting, switched outlets, and televisions will be turned off and the AC set point raised at least 3°C in the cooling mode whenever the guest room is unoccupied.
- In residential units, the operation of exhaust and lighting systems serving each toilet and kitchen shall be directly related to occupancy in each of these spaces in the most effective manner, and the outdoor air supply to the living areas shall also be responsive to these controls to comply with the requirements of ANSI/ASHRAE Standard 62.1-2010 and to maintain an adequate air balance within the residential unit.
- Operable windows must include interlocking controls with the building HVAC system to disengage the HVAC system when windows are opened, such that there shall be no space conditioning and no air supply from HVAC systems if and when windows are open.
- The supply of cooling energy to each zone shall be individually controlled by communicating programmable thermostats responding to temperature within the zone.

1.3.4 Service Water Heating

- 50% of annual service hot water requirements for the building shall be met via local solar thermal generation methods

1.3.5 Building Lighting Systems

- The building lighting systems including interior spaces of building; exterior building features, including facades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies; and exterior building grounds lighting provided through the building's electrical service shall comply with ANSI/ASHRAE/IESNA Standard 90.1-2010.
- High efficacy lamps should be used for all interior and exterior lighting, with a minimum efficacy of 110 lumens/Watt.
- For lighting of building facades, and canopies, automatic controls shall be installed to reduce the sum of all lighting power (in watts) by a minimum of 50% one hour after normal business closing and to turn off outdoor lighting within 30 minutes after sunrise.

1.3.6 Electric Power, Motors and Energy Management systems

- The power distribution systems and all equipment shall comply with ANSI/ASHRAE/IESNA Standard 90.1-2010.
- Building projects shall provide for the future installation of on-site renewable energy systems with a minimum rating of 40 W/m² multiplied by the total roof area in m². Building projects design shall show allocated space and pathways for installation of on-site renewable energy systems and associated infrastructure.
- The proposed design shall have the same or less peak electrical demand than the Baseline building design. In addition, the proposed design shall have a minimum electrical annual load factor of 0.25

2 Basis of Design

Our BOD is summarized under the following headings which would influence design principles:

- Thermal Comfort
- Energy
- Air Quality

2.1 Thermal Comfort

One of driving design principles is to improve outdoor thermal comfort and extend the duration of comfort throughout the year for occupants by appropriate planning and other passive strategies. Design guidelines and recommendations outlined throughout the Basis of Design recommend improving the outdoor wind and thermal comfort.

Factors

- Predicted Mean Vote (PMV) is one of the most widely used thermal comfort indices. Standard PMV (SPMV) value of +2.5 (or 35oC PET) is an acceptable threshold for projects.
- For any outdoor pedestrian area, the SPMV value should be lower than +2.5 for at least 80% of the time when frequent use of the area is anticipated. This value is a threshold for acceptability and not a threshold for comfort.

Table 3-1 Thermal Sensation, Physiological Stress and Reference Temperature

<i>SPMV*</i>	<i>Thermal Sensation</i>	<i>Physiological Stress</i>	<i>Equivalent PET (°C) (for reference use only)</i>
	very cold	extreme cold stress	
- 3.5			4
	cold	strong cold stress	
- 2.5			8
	cool	moderate cold stress	
- 1.5			13
	slightly cool	slight cold stress	
- 0.5			18
	comfortable	no thermal stress	
+ 0.5			23
	slightly warm	slight heat stress	
+ 1.5			29
	warm	moderate heat stress	
+ 2.5			35
	hot	strong heat stress	
+ 3.5			41
	very hot	extreme heat stress	

- Walkability and public transportation are to be promoted in the project.

Design Guidelines/ Principles

- Thermal comfort can be improved by increasing shading and by encouraging air movement. Shading is more critical for the afternoon hours, and wind flows should be encouraged in the morning and evening hours.
- Orient and place buildings to provide maximum shade in order to increase thermal comfort.
- Appropriate use of building material selection is important to reduce potential increases in solar insolation levels due to this design direction.
- Open public spaces can be placed in these north, east and west areas to take advantage of additional shade and should be avoided in regard to the placement of solar panels(in future).
- Streets and public spaces that are narrow in relation to building height (i.e., tighter building spacing) generally have more shading than spaces that are wide in relation to building height.
- A typical residential courtyard would require additional shading elements such as trees etc. in addition to the large shading elements placed over the courtyard and the proximity of the surrounding building walls.
- Ways to determine the required shading area for city centre streets, walkway and for an open space/ courtyard / roof terrace are discussed in the BOD. follow
- Shading strategies to be encouraged include using the built form, landscaping and use of active means such as bridges, shades, buildings etc.

2.2 Air Quality

Both indoor and outdoor air quality comfort is of prime importance which closely relate to ventilation, dispersion of air pollution and protection from dust and sand.

Factors

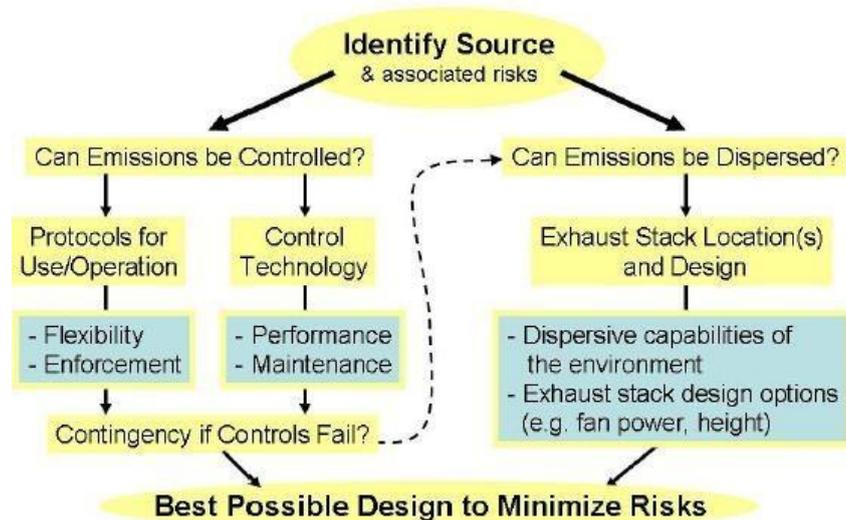


Table 4 – Examples of Air Quality Standards and Guidelines

Pollutant	Organization	Time Average	Value [$\mu\text{g}/\text{m}^3$]
PM ₁₀	WHO	24-hr	50
	USNAAQS	24-hr	150
	EU	24-hr	50
	UAE	24-hr	70

Acronyms: WHO – World Health Organization
 USNAAQS – United States National Ambient Air Quality Standards
 EU – European Union
 UAE – United Arab Emirates

Design Guidelines/ Principles

- Nearby exhaust sources should be designed to avoid exhaust impingement not only on building air intakes, but also outdoor amenity spaces.
- Many building rooftops will include exhaust stacks, and these exhaust stacks should extend above the height of the tallest adjacent roofline. Rooftop exhaust stacks should have a minimum discharge height of 3 m above the tallest nearby rooftop structure and/or recirculation regions.
- Caution should be observed when locating any rooftop exhausts within 40 m from a city edge.
- It is advantageous to collect several exhausts together and discharge them as one plume, with as much upward momentum (i.e., exit velocity) as possible.

- In order to reduce significant amounts of dust being scoured and blown off rooftops and canopies onto the spaces below, they should be designed to include a small parapet
- The closer an exhaust stack is located to a wind tower (if considered in design), the higher the potential for re-entrainment to occur at undesirable levels. Should exhaust stacks be located on the tops of the wind towers themselves, dispersion may be subject to the aerodynamic effects of the tower massing.
- A minimum setback distance of 150 m is required from any dedicated car parks. All measures should be taken to both reduce traffic and produce efficient traffic flows during peak hours. Promote carpooling, bus services and other modes to reduce car travel.
- Dust can be controlled during construction, and operation of the City with low, dense plantings, porous wind/sand screens, sand fences, etc. Include vestibules, properly seal openings to keep dust out. Periodic cleaning of facades is required to remove dust. Includes grilles or carpets at pedestrian entrances to reduce dust, doors at the entrances and vacuum trucks rather than sweepers.
- The exhausts serving odorous areas should discharge above roof level. Avoid exhaust impingement not only on building air intakes, but also outdoor amenity spaces, natural ventilation openings, and wind towers.
- Odorous facilities should be engineered to meet a 1 odor unit threshold over a 10 minute averaging time at sensitive receptors (such as outdoor amenity areas, operable windows, etc.).
- Mechanical Biological Treatment Facility and the Sewage Treatment plant are to be located at least 250 m from the nearest sensitive receptor to avoid air quality and/or odor impacts.
- Air intakes should be located on building sidewalls rather than on rooftops where possible. Air handling systems should be designed to have an “emergency dust mode” that includes highly filtered supply air and minimal exhaust air in order to maintain net positive pressure within the building. Employ a strategy whereby certain air handling units are shut down, or cycle on/off during dust storms and events, depending on the requirements and sensitivity of the space.
- High performance air filters should be used. Electrostatic air cleaning device to charge and capture particulate in the incoming air stream can be used.
- Cooling towers should be located at roof level. If possible, the cooling tower exhausts should extend above the photo-voltaic panels (if used), in order to allow for better dispersion. To reduce odors from water treatment chemicals in the cooling towers, use low-odor, low-toxicity chemical. Control the growth of Legionella bacteria by following ASHRAE and the Cooling Technology Institute for all cooling towers guidelines.
- All kitchen/cooking rooftop exhausts be located on rooftops, as opposed to grade-level or sidewall exhausts. The exhausts should be designed as vertical, uncapped stacks, with the highest possible exit velocity (minimum 7.6 m/s) and a minimum height of 3 m above the tallest rooftop obstructions or recirculation

regions. Grease extraction systems and odor control technology should be considered for large/commercial kitchen exhausts.

- All laboratory/chemical exhausts have a minimum exit velocity of 15 m/s, in accordance with the ANSI Z9.5 Guidelines for rooftop worker safety. All exhausts should be routed to roof level, with a discharge height well above any rooftop obstructions.
- Specify generator units with the lowest NO_x emissions possible (4.5 g/bhp-hr or less). Control technology such as a selective catalytic reduction (SCR) system could be utilized to reduce NO_x emissions from generators. For diesel generators, roof-level exhaust stacks should discharge vertically, with a minimum exit velocity of 40 m/s. Selection of natural gas units would eliminate diesel odour concerns. If natural gas units are selected, low-NO_x units are advantageous.

2.3 Energy

The project needs to focus on the design and development energy conservation strategies through demand reduction and efficient generation and distribution, while making informed decisions about the implications of renewable energy strategies.

Design Guidelines/ Principles

- It is suggested to carryout Window shading study, energy modeling and daylight modeling for internal spaces to meet design and Estidama targets.
- Only enough shading to block direct solar from intercepting a window is required. North facing windows need not have shading devices. Recessed windows may offer an equivalent level of shading. The cumulative impact of multiple shading devices acting on a single window needs consideration.
- Window centre of glass U-value should be < 1.6 W/m²K
- Window to wall ratio in residential units should be between 30 – 40%. If the WWR < 10%, any window height to width ratio between 1:1 and 1:5 is acceptable. If the WWR > 10%, the effective aspect ratio must be at least 1:3. Shading must be used for windows in this residential unit.
- Façade should minimize the reflection of solar heat into the street space with either reflecting the heat back up to the sky or diffuse the radiation so that the intensity reaching the ground is less or alternatively absorb the heat and then release it during the cooling evening hours.
- Place higher thermal mass facades in the streetscape and take advantage of the thermal lag they afford to provide additional cooling to people during certain periods of the day.
- Optimal tilt angles for Solar Thermal/ PV (if used) will depend on size, spacing, and other factors, but in general the recommended tilt angle is rather low. Panel height for a rooftop garden area should have a minimum clearance for people below (perhaps 2.5 m), plus the distance to the solar thermal/PV panel (1.5 m).

- Overhanging the roof beyond the extent of the building (maximum 1.5 m offset from the centre line of the street) will provide additional shading; reduce wind penetration to the street level; and reduce visibility to sky impacting pedestrian experience and potential for night sky radiative cooling.
- Passive strategies suggested in the BOD are wind towers, evaporative cooling and solar chimney which typically work well in the Middle East.
- Evaporative cooling is a strategy that can be employed to assist with improving comfort albeit at a cost of water consumption and needs to be carefully implemented. Strategies recommend are, to use clean treated water; For both indoor and outdoor spaces, limit the ventilation air supply to essential air flow only – generate additional air movement through the use of fans; Use as fine a mist spray as possible to ensure complete evaporation; anticipate using evaporative cooling to reduce the daily temperature peaks only during the shoulder seasons – the effectiveness of evaporative cooling during the summer would be less beneficial.
- A solar chimney is another device that is used to generate air movement in a space by harnessing energy from the environment. Following design consideration should be implemented while incorporating a solar chimney: should be as tall as possible; top of the chimney must be designed so that any wind conditions provides at least a benign impact on the ventilation; occupied space connected to the solar chimney must be configured in such a manner that the air entering the chimney passes over the occupants; can be coupled with a wind tower where the solar chimney would act as an exhaust; could be used as a common location for multiple buildings to release benign exhaust that ideally should be released over the city but for which individual exhaust stacks would be economically unfeasible; reduce the potential shading impact of solar chimneys (and wind towers) they should be located either along the south sides of roads or alternatively in the centre of courtyards.

3 Design Consideration

- Building Design must exceed ASHRAE 90.1-2010 and ASHRAE 189.1-2009 requirements to attain 30 % Energy savings
- Envelope Parameters, LPD and Other ECM's must be finalized after Energy Modeling for a building
- COP of Chillers must be +6.5 to meet Energy Modeling

Parameters	Proposed Case (To meet ASHRAE 90.1-2007 with 40% Energy Savings)
Building Envelope	
Above Grade Wall construction	U factor <= 0.049 Btu/hr.ft ² .°F(0.28 W/m ² -K)
Roof Construction	Roof with over deck insulation U value < 0.035 Btu/hr.ft ² .°F (0.20 W/m ² -K) & with roof reflective Coating with SRI > 90
Window to Wall Ratio	Between 35% to 40%
Fenestration Type	Assembly U-Value < 0.266 Btu/hr.ft ² .°F(1.6 W/m ² -K) SHGC < 0.25 VLT > 45%
External Shading Devices	Yes
Parameters	Proposed Case
Electrical Systems	
Lighting Power Density (Building Area Method)	LPD < 5 - 7 W/M ²
Lighting Occupant sensor control	Yes
Day lighting Controls	Yes
Parameters	Proposed Case
Mechanical Systems	
HVAC System Types	Variable Air Volume System

Design Supply Air temperature	24 deg. C
Economizer	Yes
Demand Control Ventilation	Yes
Enthalpy Wheels	Yes
CO monitoring based ventilation in basement parking	Yes
HVAC Plant (Part of Central Utilities)	
Chiller Type	Water cooled
COP at ARI Condition	COP > 6.5
Cooling Tower	With VFD

4 Building Energy Target Comparison

4.1 Lighting

Lighting accounts for 25% of the electricity used. If advanced lighting technologies and designs were implemented, electricity use for lighting would be cut by more than 50%, electrical demand dramatically reduced, and working environments significantly improved. Lighting power densities can be reduced to in new buildings by:

- 1) maximizing daylight
- 2) using energy efficient lamps and fittings
- 3) use of lighting control and management systems

4.1.1 Maximizing daylight

Natural daylight in a building is of great benefit to the occupants, mainly because it provides a high quality light covering a broader spectrum than the cool white light of fluorescent luminaires, and it changes over the day. This light quality improves vitality and also quality of sleep.

While daylighting has many benefits on the indoor environment, one of its side effects is glare, which can cause discomfort and annoyance. This can lead to occupants pulling the blinds down or the curtains shut on large glazed areas, resulting in the need to switch on artificial lighting during the daytime. Glare however can be prevented in a number of ways, through the use of external and internal blinds and shades, and through high performance glazing with a low shading coefficient.

Methods and technologies that maximize the amount of natural light entering the building therefore reducing the need for artificial lighting and thus lowering the amount of power consumed.

Table below shows a number of methods of maximizing natural daylight within a building.

METHOD	DESCRIPTION	ADVANTAGES
Sun pipes	The Sunpipe is a way to transfer natural daylight into a building. It is a hollow silverised mirror finished pipe that actively channels light from the roof to exactly where it is needed.	<ul style="list-style-type: none"> ▪ Reduces need for artificial lighting therefore reducing energy demand. ▪ Improves natural lighting ▪ Reduces electricity costs. ▪ Maintenance-free ▪ Natural daylight 'harvesting' can make people happier, healthier, and more productive
Skylights	Glass panels in the roof.	
Glazing with high visible light transmission	For daylight applications, high visible transmission values are important to deliver as much daylight as possible. VLT (Visible Light Transmission) indicates the percentage of visible light that is transmitted through the window.	

4.1.2 Energy efficient lamps and fittings

METHOD	DESCRIPTION	ADVANTAGES
Efficient Lamps	Installing modern, efficient luminaries Replacing incandescent lamps with compact fluorescent lamps (CFLs) and LED's; Implementing task lighting strategies	Reduces electricity costs.
Efficient fittings	Replacing ballasts and lamps with modern components	Reduces maintenance. Reduces Operation costs

4.1.3 Lighting control and management systems

Systems that manage and control lighting within a building to ensure that lights are only switched on when required and that an optimum level of brightness is maintained. This prevents energy been wasted unnecessarily

Table below shows a number of lighting control methods that can be used to ensure artificial lighting is used efficiently.

METHOD	DESCRIPTION	ADVANTAGES
Zones	Lights are zoned in small groups that correspond to daylight distribution and patterns of occupancy	Lights are only switched on corresponding to the use and layout of the lit areas. Avoids lighting a large area if only a small part of it is needed
Time control	Lights turn on and off automatically in each zone, to a present schedule of light use.	Lights are only switched on when they are needed.
Passive Infra-Red (PIR) Occupancy sensing	PIR systems switch off the lights after a period of time when no movement has been detected.	Prevents lights been on unnecessarily when the room/area is not occupied. They detect when a working area is unoccupied, and can dim or switch off the lights. When a person enters the room, lighting is brought back up to the required level
Light level monitoring:	Use photoelectric sensors to monitor the brightness of light in a room/area. The luminance control system then switches or dims the artificial light to maintain a pre determined light level.	Prevents lights being on when they are not needed Dimming controls save more energy than on/off controls and can reduce annual energy bill by as much as 60%.
Sensor lights	Sensor lights contain a built-in infra-red sensor which automatically switches the light on at dusk and off at dawn.	Last about 15 times longer than a conventional light bulb. Uses about 80% less electricity. No need to remember to switch the light on and off. Provides constant, economical light but only when needed

5 Natural Ventilation

5.1 Overview

Natural ventilation systems are intended to provide sufficient outside air to achieve appropriate standards of air quality and to provide cooling when needed. Naturally ventilated buildings do not aim to achieve constant environmental conditions, but take advantage of dynamics to provide comfortable, controllable conditions for the occupants. The most appropriate strategy depends on the type of space and whether wind or buoyancy forces are likely to predominate. This section aims to provide a conceptual understanding of natural ventilation and how the various system concepts apply to the proposed schematic plan drawings for typical office, hotel and apartment spaces.

Climatic Analysis

One of the most important issues in determining the potential of natural ventilation systems is the suitability of the climate.

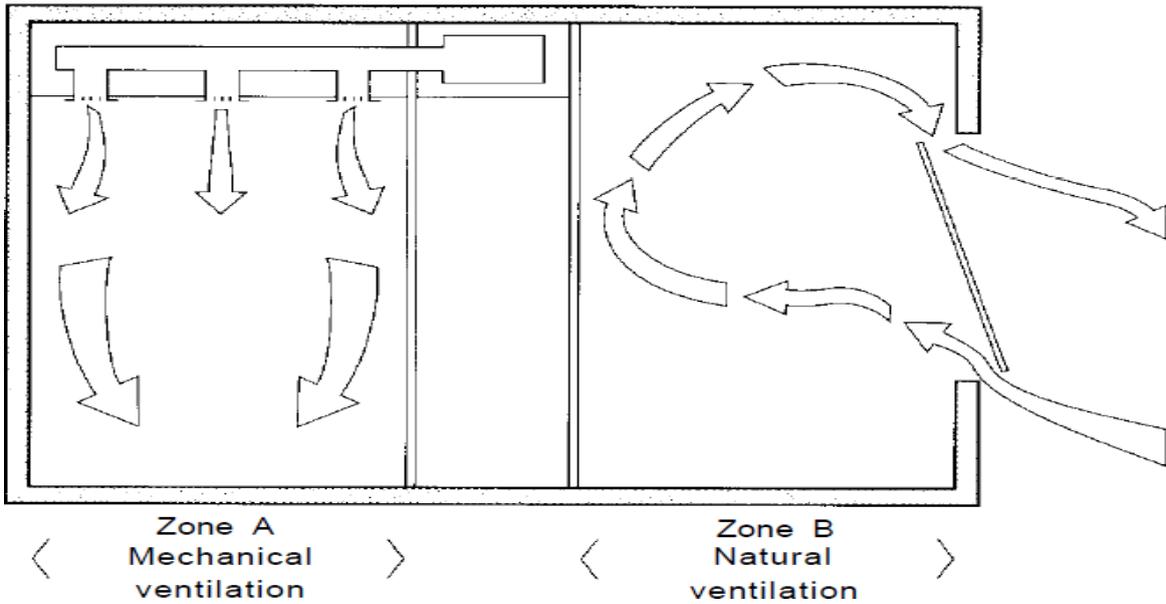
Daily mean maximum temperatures are typically below comfort levels (20 to 26 deg.C) from January to April and from November to December. It is above comfort levels from June to October. This gives us approximately 20% hours in a year.

Natural Ventilation Strategies

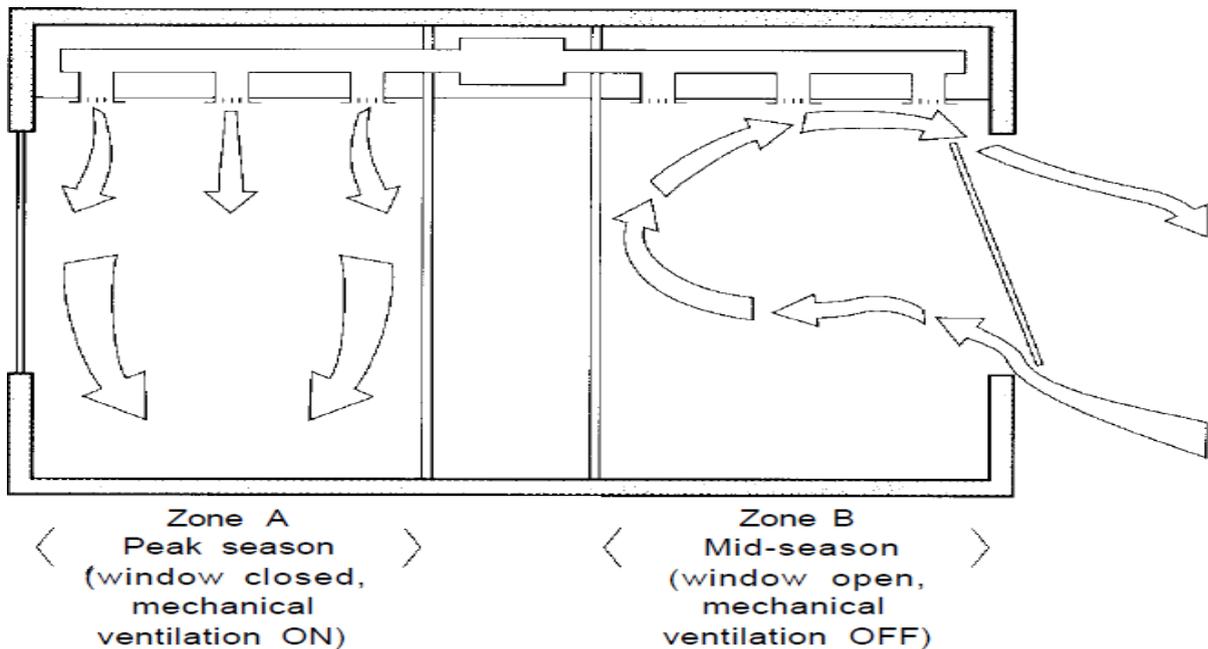
It should be recognized that natural ventilation provides limited cooling capacity available. Great care must be taken at the design stage to control the heat gains into the occupied space. Considering this in proposed typical office layout as shown below, a combination of natural ventilation and mechanical ventilation and/or air conditioning is the best approach to maintain comfort conditions. Such combinations are known as 'mixed-mode' systems.

A number of mixed-mode strategies can be employed, the two main strategies being the following:

- Zonal mixed-mode. Different parts of a building are serviced in different ways to cater for different uses of the space. This allows additional servicing to be provided to those parts of the building which have the more demanding environmental requirements.

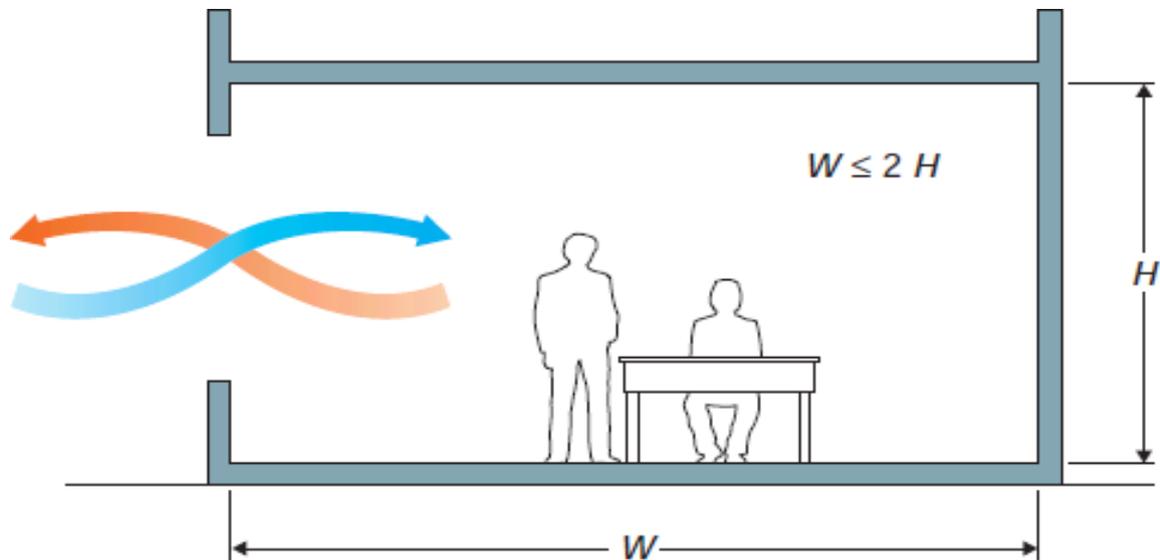


- Seasonal mixed-mode. Both natural and mechanical ventilation systems are installed to service a particular zone, the alternative systems being used at different times of the year. Usually the mechanical ventilation is run in winter and peak summer and natural ventilation being employed in mid-season.



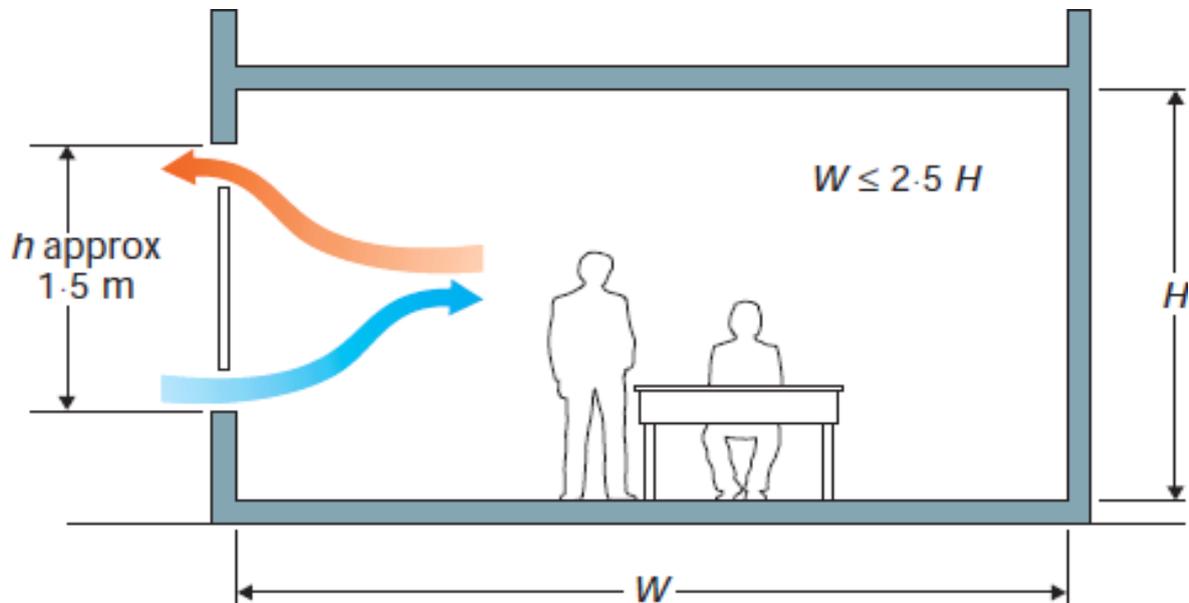
The proposed office layout is a cellular building type with opening windows on one side and closed internal doors on the other side. In this type of building concept, single sided ventilation is the best approach to apply natural ventilation. This strategy relies on opening(s) on one side only of the ventilated enclosure. There are two ways to apply this.

First is with a single ventilation opening.



In summer the main driving force for natural ventilation is wind turbulence. Relative to the other strategies, lower ventilation rates are generated and the ventilating air penetrates a smaller distance into the space. As a rule of thumb, the limiting depth for effective ventilation is about twice the floor-to-ceiling height. It is also possible to get buoyancy driven exchanges through a single opening provided the opening is reasonably large in the vertical dimension.

Second is a with a multiple ventilation opening.



Multiple ventilation openings are provided at different heights within the façade. Then the ventilation rate can be enhanced due to the stack effect. The stack induced flows increase with the vertical separation of the openings and with the inside to outside temperature difference. As well as enhancing the ventilation rate, the double opening increases the depth of penetration of the fresh air into the space. As a rule of thumb, the limiting depth for effective ventilation is about 2.5 times the floor-to-ceiling height.

These strategies are also applied to the proposed layout for hotel and apartment, since it has the same concept as shown below - opening windows on one side and closed internal doors on the other side.

6. SUMMARY OF STRATEGIES FOR ENERGY

	STRATEGY	DESCRIPTION	CONSUMPTION	% COMPARED TO BENCHMARK	LIFE-CYCLE COST
1	Daylighting	Daylight Analysis from current design.	As described in various models and configurations above.	18.5%-24.5% reduction	Medium
2	Energy Efficient Lamps and Fittings				
	LED	100% lights to be specified as LED	Entire lighting design for the project including interior, exterior and landscape lighting.	85% savings compared to Incandescent lights.	Low LCC due to low energy consumption and very high durability.
3	Lighting Control & Management Systems	Daylight Sensors Occupancy Sensors	To be specified for the office and hotel components.	Reduces energy by 0.5-1%	Low
4	Building Envelope	Glazing options discussed above.	As described in various models and configurations above.	18.5%-24.5% reduction	Medium
5	Vertical Transportation				
	Regenerative Lifts	Generates power when the lift motor is braking.	To be specified for all VT and further studied by VT consultant.	VT consumes approximately 5% of building's energy and 15-20% reductions could be achieved.	Low
6	Natural Ventilation	Ventilation openings discussed above.	-	-	Low
7	Air-conditioning Cooling	Provide indirect adiabatic cooling during moderate weather periods, and supplement the indirect adiabatic cooling with vapour absorption refrigeration when required.	-	-	Low

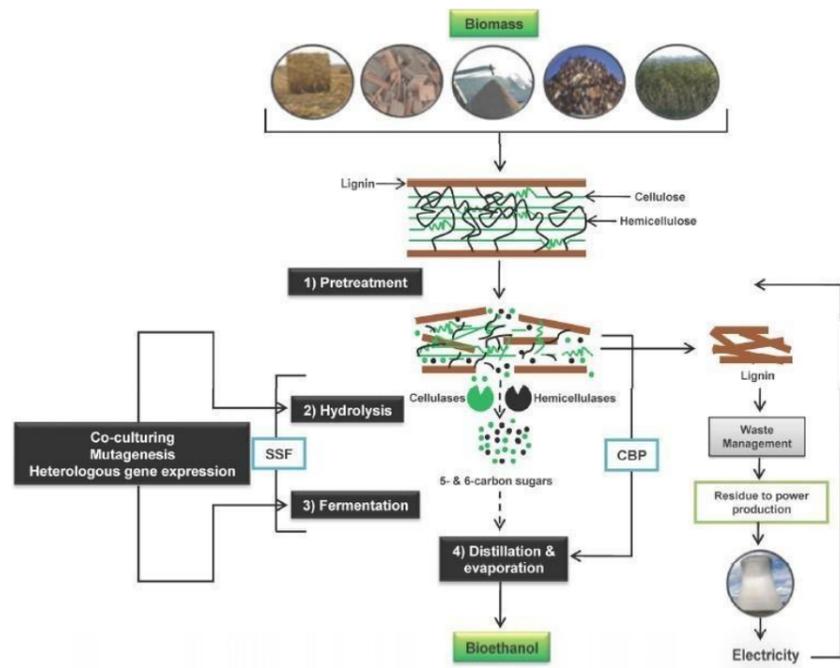
CATEGORY	BASELINE	STRATEGY BEING EMPLOYED	PROPOSED DESIGN VALUE	% COMPARED TO BENCHMARK
Building Envelope				
External Walls	Steel Framed U-Value - 0.365 w/m ² -°k	Thermal block and insulation in spandrel panels to achieve desired U value.	Plaster + 200mm AAC Block + 100mm thick Polystyrene Insulation + External Cladding U-Value 0.20 w/m ² -°k	2.10 % energy savings
Roof	Insulation Entirely Above Deck U-Value - 0.273 w/m ² -°k SRI □ 78	Thermal insulation to achieve de- sired U value.	Inside Surface Resistant + 100mm Polystyrene Insulation + RCC Slab + 50mm Screed + Waterproofing Membrane + Geotextile Sheet + Reinforced Screed + Tiles U-Value 0.23 w/m ² -°k SRI □ 90	
Glazing	U Value - 3.12 w/m ² -°k SC - 0.46 VLT - 50%	Glazing Typologies of Building Envelop	Case-1: Clear Glass; U-value 1.0w/m ² -k; SC 0.39; VLT 62.4%	19.45% energy savings
			Case 2: Clear Glass; U-value 1.6w/m ² -k; SC 0.44; VLT 68%	18.67% energy savings
			Case 3: Clear Glass + Frit Glass with 50% dots; 1/2 module in 2 modules (U-value 1.3w/m ² -k; SC 0.31; VLT41.4%)	20.53% energy savings
			Case 4: PV Panels (U-value 1.08w/m ² -k; SC 0.20; VLT30%)	24.58% energy savings
			Case 5: Clear Glass + Solid Panels w/ PPE Finish; 1/2 module for every 2 modules (U-value 1.09w/m ² -k)	25.01% energy savings
WWR	Maximum 40%	-	83%	-
HVAC Type	As per ASHRAE 90.1.2010 - Appendix G	Efficient HVAC systems as pro- posed.	Variable Air Volume System; Fan Coil Units	Approximately 30% reduction in Heating and 45% reduction in Cooling.
Efficiency at ARI Condition	> 11.9 EER		> 6.5 COP, Chiller Plant COP = 4.0	
Chiller Type	No		Yes	
Cooling Tower	No requirement		with VFD	

	CATEGORY	BASELINE	STRATEGY BEING EMPLOYED	PROPOSED DESIGN VALUE	% COMPARED TO BENCHMARK
	Electrical Systems				
	Lighting Power Density	15 LPD W/m2	As discussed in Lighting section above.	6.8 LPD W/m2	Approx. 45% reduction in LPD
	Internal Lighting Load				
	Café Corridors Electrical / Mechanical Rooms Lobby Reception Areas Retail / F&B Outlets Store Rooms Toilets Office Areas Children Room Gym Meeting Rooms Hotel Guest Rooms Maid Rooms Residential Apartments Stairs	15 LPD W/m2 5 LPD W/m2 16 LPD W/m2 14 LPD W/m2 14 LPD W/m2 18 LPD W/m2 9 LPD W/m2 10 LPD W/m2 12 LPD W/m2 14 LPD W/m2 10 LPD W/m2 14 LPD W/m2 12 LPD W/m2 12 LPD W/m2 12 LPD W/m2 6 LPD W/m2	As discussed in Lighting section above.	8 LPD W/m2 4 LPD W/m2 5 LPD W/m2 8 LPD W/m2 8 LPD W/m2 10 LPD W/m2 6 LPD W/m2 10 LPD W/m2 8 LPD W/m2 8 LPD W/m2 10 LPD W/m2 8 LPD W/m2 8 LPD W/m2 7 LPD W/m2 7 LPD W/m2 7 LPD W/m2 3 LPD W/m2	Approx. 40% reduction in lighting load values.

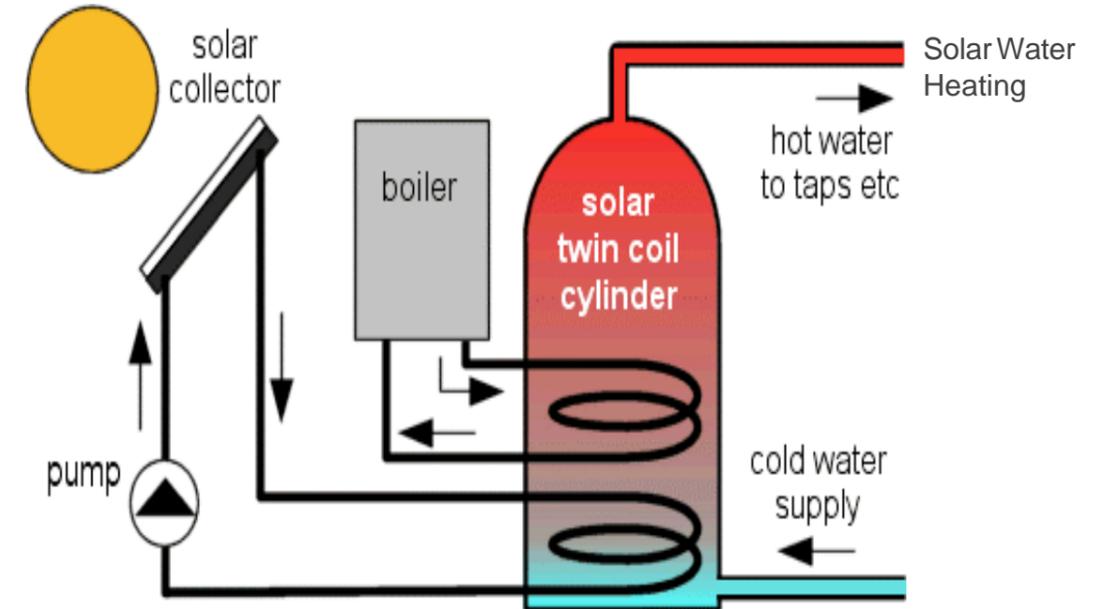
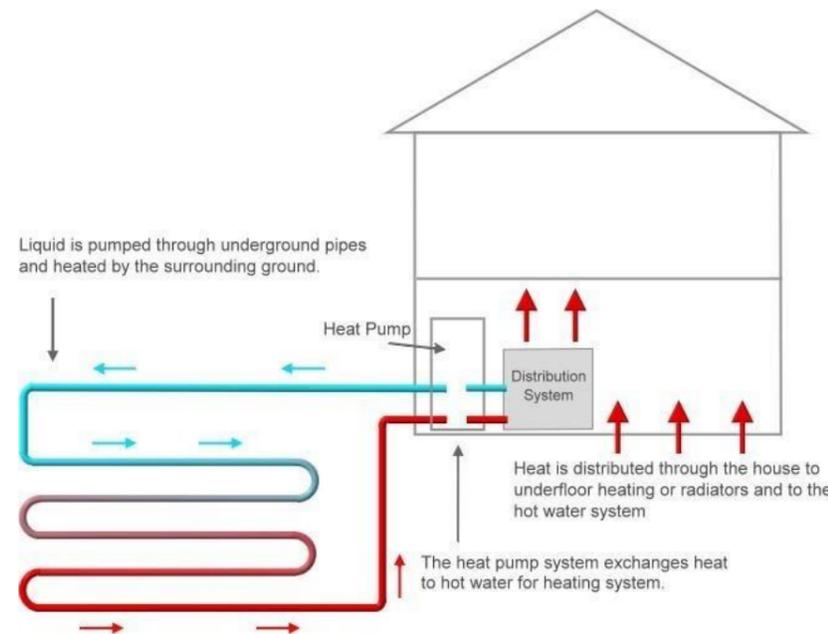
7. RENEWABLE ENERGY - RECOMMENDED SUMMARY OF STRATEGIES FOR ENERGY

TECHNOLOGY	CHARACTERISTICS	FUNCTIONALITY	COST EFFECTIVENESS	RELIABILITY	MAINTENANCE REQUIREMENT	CO2 SAVING
Biomass	Uses plant-derived organic material (relatively carbon neutral). Can produce heat or biogas depending on the type of technology	High. Direct combustion systems can replace gas/ oil-fired boilers. Requires large fuel storage facility	Medium. More expensive than conventional boilers	High for direct combustion systems. Anaerobic digestion and gasification systems can be problematic	Medium. Direct combustion systems are partially self cleaning	High
Geothermal	Uses heat from the ground to pre-condition the supply air to a building	High. Can be pre-cool air in summer and pre-heat it in winter	Medium. Depends on cost drilling or excavation to install pipes	High. No moving parts	Low. Providing steps are taken to pre-filter air and avoid water ingress	Medium
Solar water heating	Solar energy used to heat water, usually for domestic hot water purposes	Medium. Proven technology with a range of collectors for different operational requirements	Medium	Medium - high. Circulation pump and valves are relatively reliable	Low	Medium. Circulating pumps can be PV powered

Biomass Energy



Geothermal Energy - Ground source Heat Pump



8. RENEWABLE ENERGY - BUILDING INTEGRATED PHOTOVOLTAIC SUMMARY OF STRATEGIES FOR ENERGY

TECHNOLOGY	CHARACTERISTICS	FUNCTIONALITY	COST EFFECTIVENESS	RELIABILITY	MAINTENANCE REQUIREMENT	CO2 SAVING
Solar - Photovoltaic Building Integrated Photovoltaic	Converts sunlight directly to DC electrical power. Requires inverter to convert to AC	Medium. Requires careful positioning for optimum performance. Wide range of installation options	High. However, costs are predicted to improve.	Medium. Associated inverters can cause problems	Low, but specialist	Low. Relative to high cost

Example: Varies Based on Climate Zone

GL.01_Vision glass:

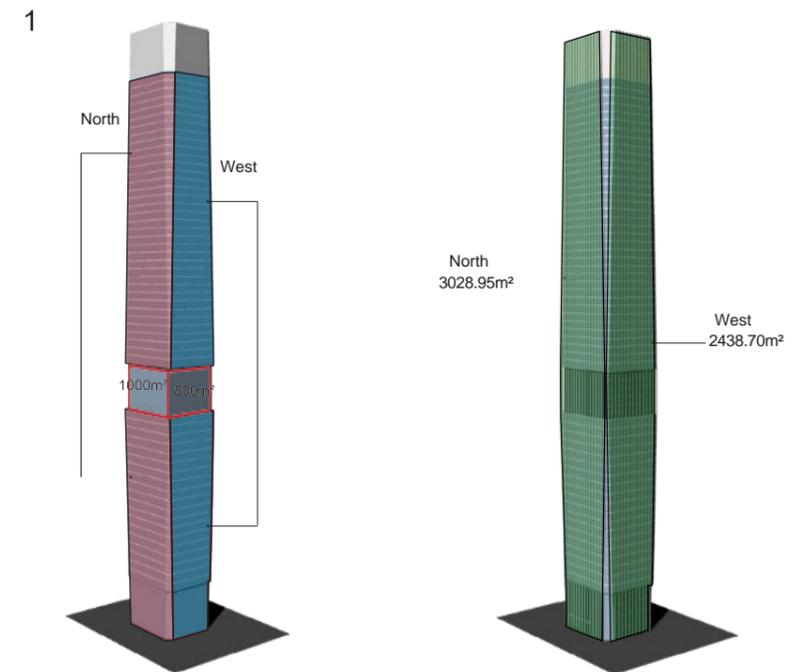
30% transparency amorphous Si with configuration 6+3+6/16 argon/6T mm. Total integration area 35176 sqm

Installed power 977 kwp and energy generation 611431 kwh per year.

GL.02_Spandrel glass

Opac standard crystalline with configuration 6+6/16 argon/6T mm. Total integration area 10931 sqm.

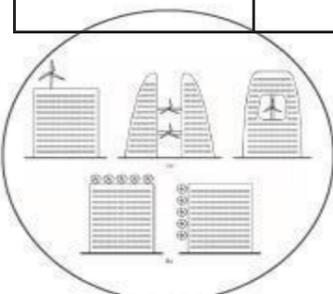
Installed power 1549 kwp and energy generation 969403 kwh per year.



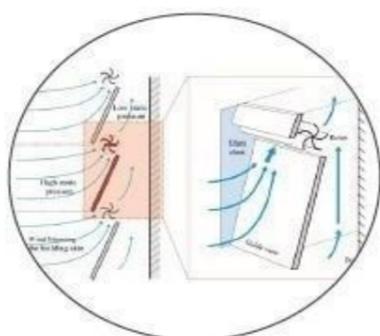
9. RENEWABLE ENERGY - BUILDING INTEGRATED TURBINES SUMMARY OF STRATEGIES FOR ENERGY

TECHNOLOGY	CHARACTERISTICS	FUNCTIONALITY	COST EFFECTIVENESS	RELIABILITY	MAINTENANCE REQUIREMENT	CO2 SAVING
Wind Building Integrated Turbines	Turbine/ generator converts wind energy to electrical power	Best performance in open, non-urban locations. Can be installed on, or integrated into, a building	Low. Depends greatly on available wind conditions. Actual power output likely to be much less than the rated output	Medium. Turbulent air conditions associated with urban locations may reduce lifespan of components	Medium. Requires regular maintenance. Access may be an issue	Low - medium. Large sized turbines in non-urban or off- shore locations will be more effective

A New Building-Integrated Wind Turbine System Utilizing the Building

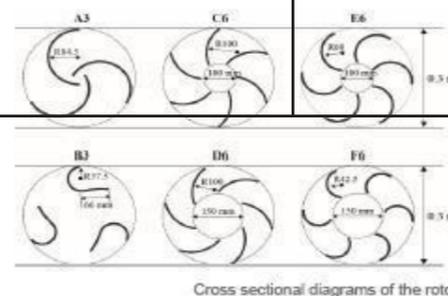


Building-integrated wind turbine system using wind turbines: (a) three possible installation locations of large-size wind turbines; and (b) two possible installation locations of small-size wind turbines.

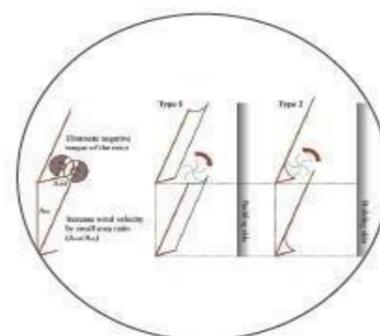


The right picture depicts a unit module consisting of a guide vane and a rotor. In the unit module, the guide vane is the key composition that changes according to approaching wind conditions, such as low velocity or high static pressure, to be appropriate for rotor operation

Several types of Savonius rotors with different shapes and numbers of blades from previous studies and performed CFD analyses to compare their performances. The schematics of the rotor models shown in Figure 9. All rotors were assumed to have a diameter of 30 cm and a thickness of 2 mm considering the manufacturable size of a rotor. Rotor A has three blades with over gap, which is known as one of the models showing the highest performance for open space. Rotor B has three particular-shaped blades and it is a merchandised model called GWE-200B1 by Goldwind Energy in South Korea. Rotors C to F are not merchandised models but the shapes of the blades.



Cross sectional diagrams of the rotors



Various design for the shape of the guide vane.

The noise generated during operation, one of the biggest issues for application in residential environments, can be reduced using a Savonius rotor, which has a lower noise level and lower cut-in speed compared to other types, especially horizontal axis. In addition, it reduces emissive noise around the building because the rotor is concealed by the guide vane.

Experimental Evaluation of Rotor Performance

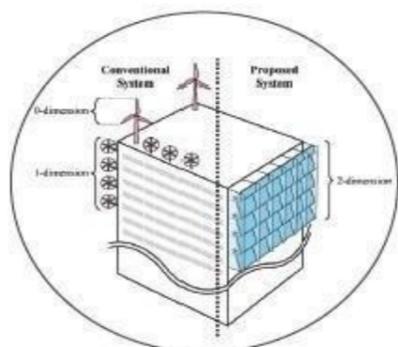
A prototype was manufactured to examine the performance of the rotor. The width and height of one module were 1 m and the distance from the building skin to the module was also 1 m.

(a) Prototype model of the rotor and the guide vane and (b) assembly diagrams.



Parameters of the rotor.

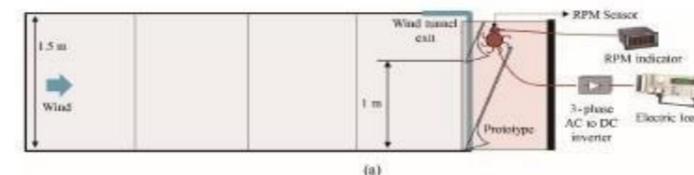
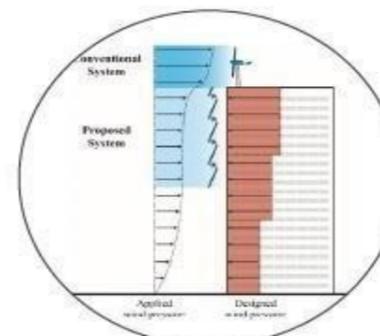
Parameter	Value	Parameter	Value
Diameter (m)	0.30	Number of blades	8
Length (m)	0.793	Weight (kg)	4.79
Material	AL 5052		



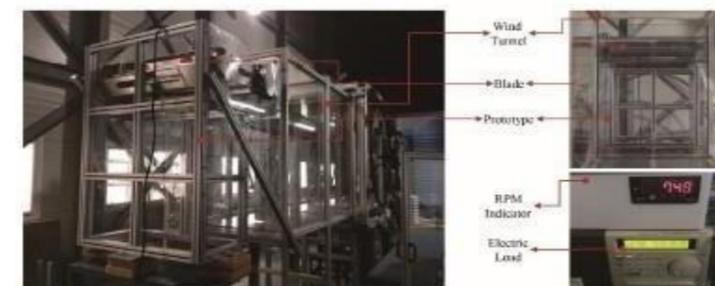
Comparison of the installation area between the proposed system and the conventional ones.

The conventional BIWT systems generally consist of one or a few large-size turbines or aligned small-size turbines following the edge, so they can be considered as 0- or 1-dimensional deployment. As a countermeasure, the proposed BIWT system consisting of many unit modules is designed to be installable on the building skin (or an exterior wall of a building), which is a previously unused and unavailable large area

The proposed system is able to utilize the wind pressure acting on the building wall, so structural strengthening or modification is not necessary because this wind pressure is already considered in the building design stage as shown. The only important consideration is a structurally solid connection between the modules and the building skin for the system to satisfy the standard as a cladding.



(a)

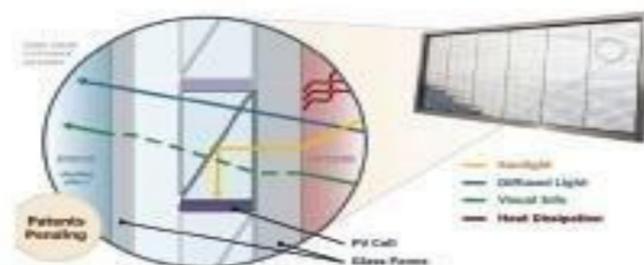


(b)

10. RENEWABLE ENERGY - BUILDING INTEGRATED PHOTOVOLTAIC SUMMARY OF STRATEGIES FOR ENERGY

Photovoltaic Glass

Photovoltaic glass (PV glass) is a technology that enables the conversion of light into electricity. The glass incorporates transparent semiconductor-based photovoltaic cells, which are also known as solar cells. The cells are sandwiched between two sheets of glass. Photovoltaic glass is not perfectly transparent but allows some of the available light through.



-Infinite combinations of photovoltaic glass: choose your color, pattern, transparency degree, thickness and size.

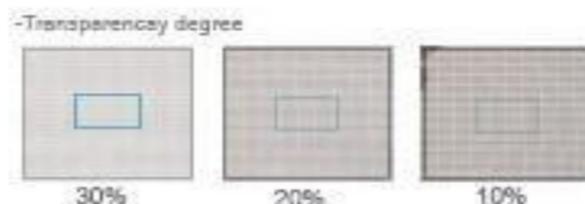
-photovoltaic glass can be incorporated in any type of building: Curtain walls, façades, brise soleil, skylights

Advantages

- allow the entrance of the sunlight, avoiding UV radiation and infrared radiation, and seeing through the glass at the same time.
- choose between 10%, 20% or 30% of transparency degree, depending on the luminosity required and enjoy your views.
- Through laser cutting technology, the active area of the glass can be modified in order to get different patterns and 100% customized designs, leading to spectacular shapes and semi-transparency effects
- energy cost savings, potential
- considered green or clean electricity because its source is renewable and it does not cause pollution.

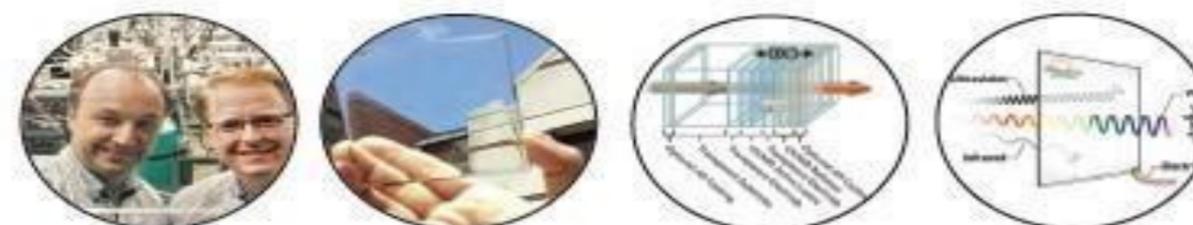
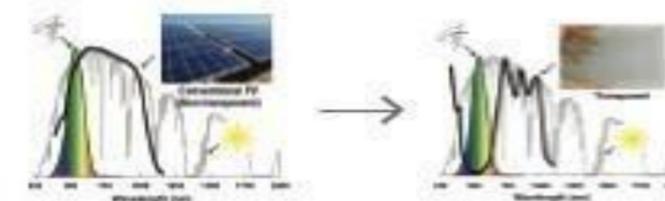
Disadvantages

- Depending on the selected pattern or design, and the degree of semi-transparency, peak power could decrease and therefore the efficiency.
- This system obscures the look of the underlying material, as it is not 100% transparent.
- can not optimize efficiency and aesthetics at the same time.



Transparent solar cells

True transparency is achieved by selectively transmitting light visible to the human eye, while converting invisible ultraviolet and near-infrared light into electricity. The coating could easily be deposited on one of the inner surfaces of double-paned windows, along with standard low-emittance or solar-control coatings.



-MIT Engineering group: Richard Lunt, Vladimir Bulovic, Miles Barr

Advantages

- Invisible: up to 90% visible light transmitted; absorbs only ultraviolet and infrared
- Efficient: over 10% achievable; optimization is independent of transparency
- Low cost: low-cost, non-toxic materials; industry standard deposition equipment
- Thin and light: film is less than 1/1000th of a millimeter thick
- Ubiquitous: ClearView Power™ can generate electricity on any surface or device without aesthetic impact

Disadvantages

- the efficiency of the panels which are only able to capture some where around 1% of the light that passes through them.
- By contrast, the most efficient solar panels are able to capture upwards of 40% of light that hits it.

11. CONCLUSION

CATEGORY	BASELINE	STRATEGY BEING EMPLOYED	PROPOSED DESIGN VALUE	% COMPARED TO ENERGY BASELINE
HVAC Type				
Economizer	No		Yes	0.5%
Demand Control Ventilation	No		Yes	1-2% energy reduction
Heat Recovery Wheels	No		Yes	1-2% energy reduction
Co Monitoring in Basements	No		Yes	0.5%
Renewable Energy				
Biomass	No	Biomass for power generation to be studied. The methane produced by the sewerage would be used to run methane driven engines to power the electric generators. This power will be supplemented by the electric power generated from the solar panels. Additional biomass such as cornstalk can be added to generate more energy.	Yes	1-2% energy reduction
Geothermal	No	Used to preheat cold air prior to supplying air to the building. Provide Geothermal heating supplemented by hot water from the methane driven engine of the electric generator. The hot water for domestic consumption would be from the engine jacket water, whilst the heat from exhaust flue would be for building heating hot water	Yes	1-2% energy reduction
Solar Photostatic (BIPV)	No	Photovoltaic Thin Film type can be installed as Build- ing Integrated Photovoltaic (BIPV) which generates at 5-10% efficiency. Building south and west façade will be preferred location.	Yes	Approximately 4% energy reduction.
Solar Water Heater	No	Evacuated Ejector Tube: Renewable Energy - Solar Thermal Solar Hot water can meet the hot water requirement for Residential and Hotel occupants. Electric hot water system will be standby.	Yes	1-2% energy reduction
Building Integrated Wind Turbine	No	Installable on building skin in a unit module with guide vane and motors.	Yes	Approximately 6% energy reduction.