ASHRAE Hong Kong Chapter Annual General Meeting
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Zero Energy Building: What Does It Mean?

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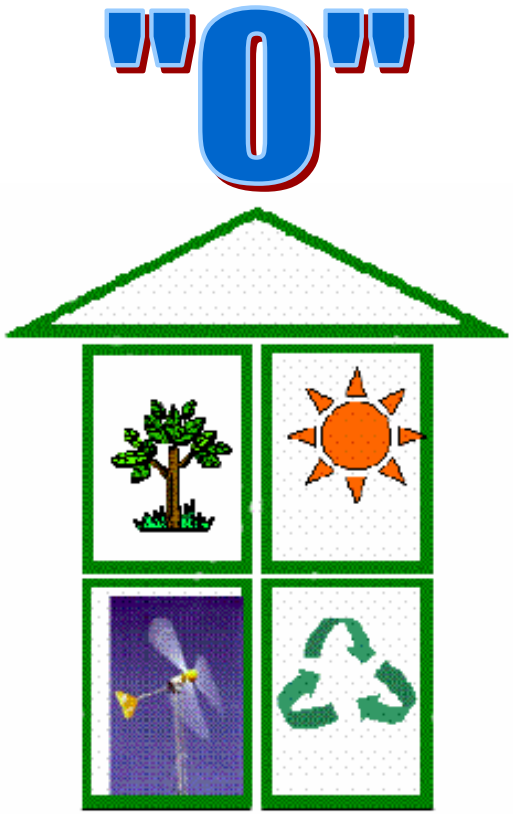
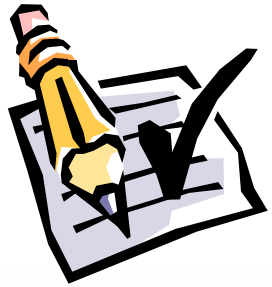
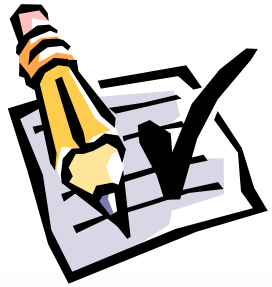


Define Zero Energy Building



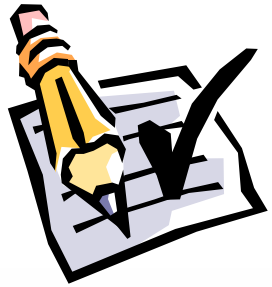
- Zero energy building (ZEB)
  - A building that produces as much energy on-site as it consumes on an annual basis
  - "Net" zero energy building
- Benefits of ZEB:
  - Reduce energy consumption and costs
  - Reduce carbon emissions
  - Reduce dependence on fossil fuels

Define Zero Energy Building



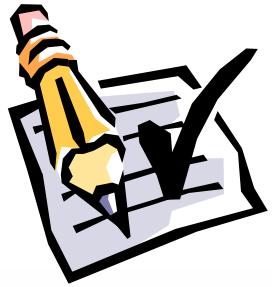
- A building approaching zero energy is called
  - Near-zero energy building
  - Ultra low energy building
- Low energy building (LEB)
  - Building developments that facilitate or use low levels of energy (than regular buildings)
- Energy-plus/-positive building (E+B)
  - That produces a surplus of energy during a year

Define Zero Energy Building



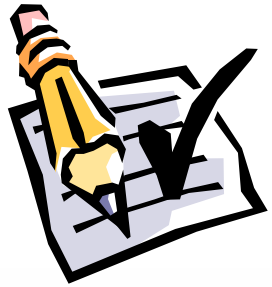
- Net zero site energy (site ZEB)
  - Amount of energy provided by on-site renewable energy sources is equal to the amount of energy used by the building
- Net off-site zero energy (off-site ZEB)
  - Similar to previous one, but consider purchasing of energy off-site from 100% renewable energy sources

Define Zero Energy Building



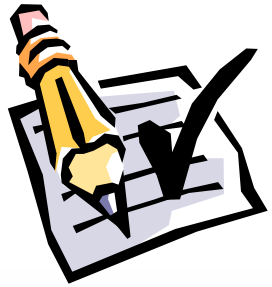
- Net zero source/primary energy (source ZEB)
  - It produces as much energy as it uses in a year, when accounted for the source
  - For electricity, only around 35% of the energy used in a fossil fuel power plant is converted to useful electricity and delivered
  - Site-to-source conversion multipliers are used to calculate a building's total source energy

Define Zero Energy Building



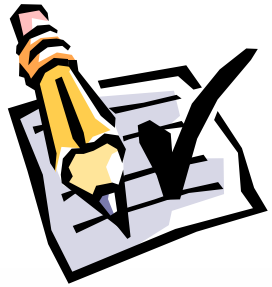
- Net zero energy costs (cost ZEB)
  - The cost of purchasing energy is balanced by income from sales of electricity to the grid of electricity generated on-site
- Net zero energy emissions
  - Zero carbon building or zero emission building
  - The carbon emissions generated from the on-site or off-site fossil fuel use are balanced by the amount of on-site renewable energy production

Define Zero Energy Building



- Other related terms
  - Off-the grid building: completely self-sufficient stand-alone ZEB that is not connected to an off-site energy utility facility
    - It requires distributed renewable energy sources AND energy storage capability
  - Autonomous or self-sufficient building: a building designed to be operated independently from infrastructural support services e.g. electricity grid, municipal water systems, sewage treatment systems, storm drains, communication services

Define Zero Energy Building



- Other related terms (cont'd)
  - Passive (energy) building:
    - Passive house (passivhaus in German); passive solar building; ultra low energy, through passive design; does not include active systems e.g. mechanical ventilation or photovoltaics
  - Green building:
    - Reduce the environmental impact while improving environmental sustainability
    - Most ZEBs are very "green"; very few green buildings use zero energy

Examples of ZEB

- Selected examples of ZEB:
  - Germany
  - U.K.
  - Singapore
  - Guangdong, China
  - Malaysia

Self-sufficient solar house in Freiburg, Germany

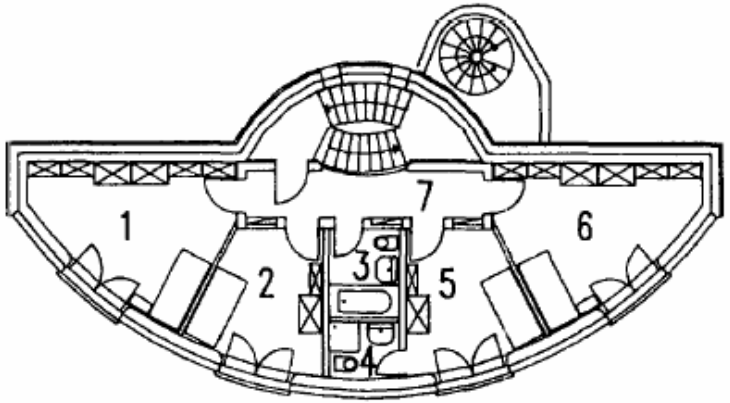
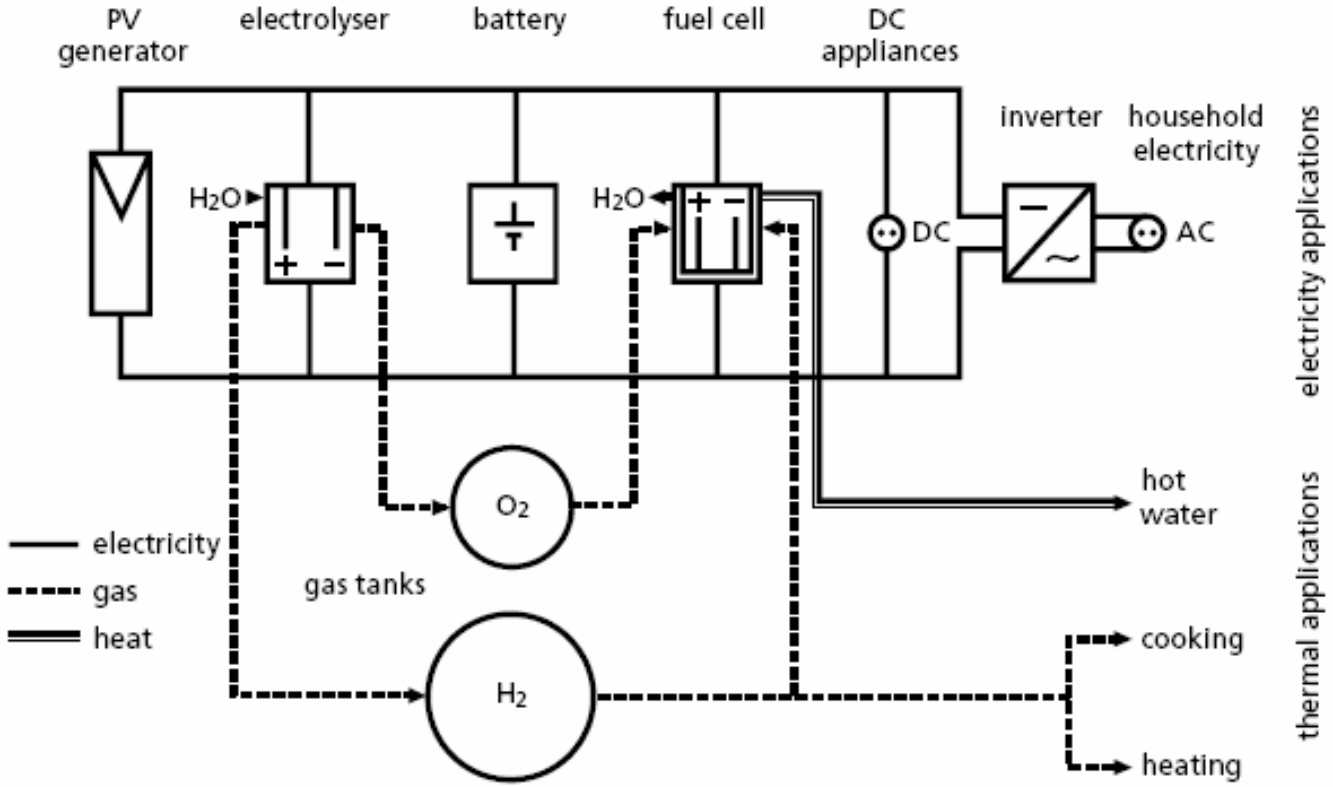


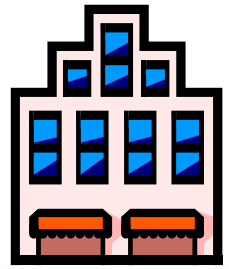
Fig. 3. The first floor of the SSSH

1: room 1, 2: room 2, 3: bath/toilet, 4: shower/toilet, 5: room 3, 6: room 4, 7: dor.



(Source: www.ise.fhg.de)

Examples of ZEB



- Low-energy buildings in Germany
  - Determined by heating needs in kWh/m^2/year
    - Existing buildings (depending on insulation): 80 – 300 kWh/m^2/year
    - Low-energy building: 40 – 79 kWh/m^2/year
    - Three-litre-building: 16 – 39 kWh/m^2/year
    - Passive energy building: max. 15 kWh/m^2/year
    - Zero-energy building: 0 kWh/m^2/year
    - Energy-producing building or energy surplus: (-ve) kWh/m^2/year

(Source: www. solarserver.de)

Beddington Zero Energy Development (BedZED), UK

Energy design features:
- Triple glazed
- High thermal insulation
- 777 m² of solar panels
- Co-generation
- District heating & electricity

Wind catcher

Singapore zero energy building – Building and Construction Authority (BCA) Academy (completed in 2009)

(Source: www.channelnewsasia.com)

Zero energy office building in Guangdong, China (Pearl River Tower, for Guangdong Tobacco Company)

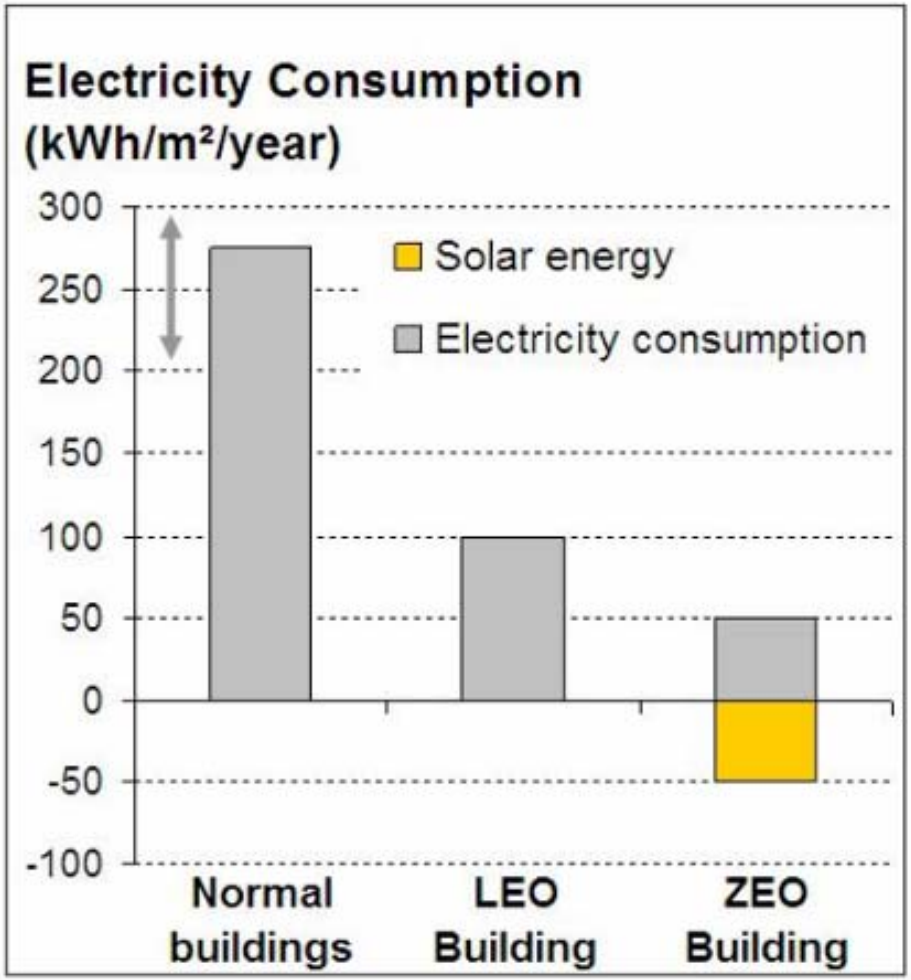
(completed in 2009)

Main features:

- Orientation of the building
- Low-E-glass
- Double-layer curtain-wall
- Chilled slab concrete ceilings
- Lighting efficiency
- Geothermal heat sink
- Energy storage
- Wind
- Integrated photovoltaics
- Microturbines

(Source: sustainabledesignupdate.com)

Malaysia low energy building and zero energy building

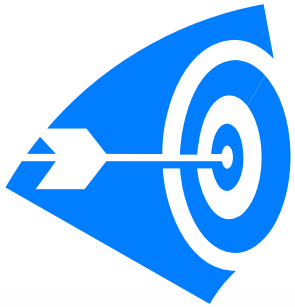


0-energy
(Zero Energy Office)

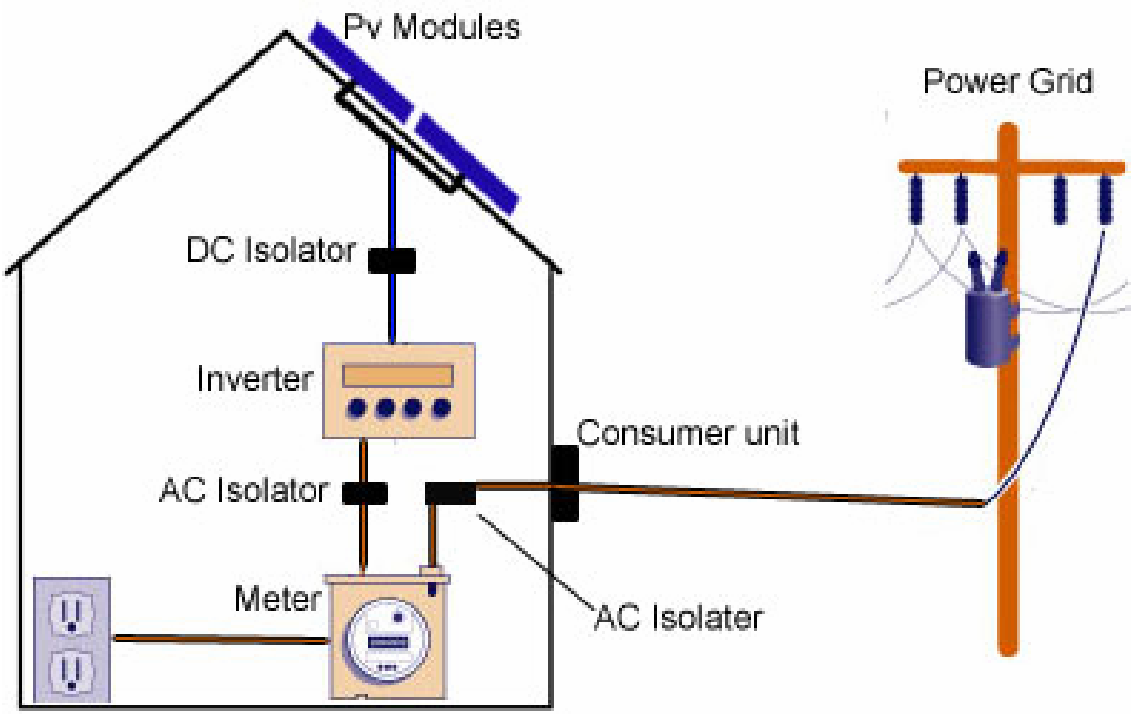
(Source: www.ptm.org.my/PTM_Building)

Zero Energy Office (ZEO) Building in Malaysia
Video Presentation (7 min.)

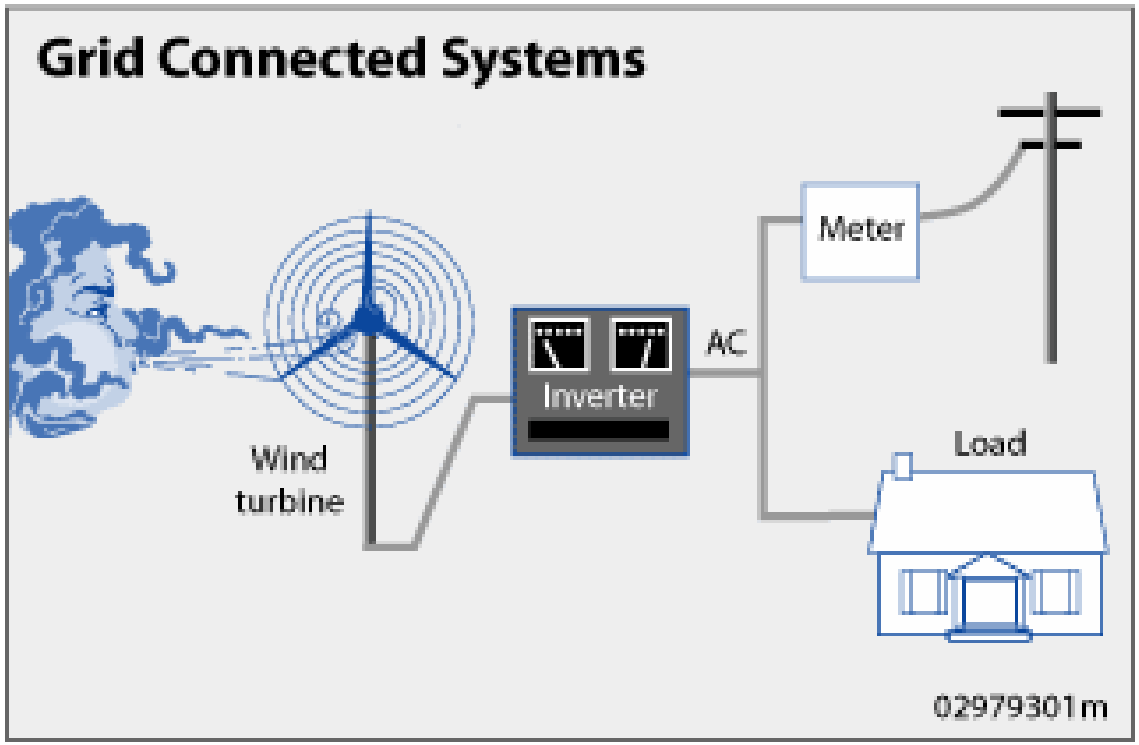
Critical Issues



- For energy balances in ZEB, usually grid connection is allowed and necessary
  - Excess production to offset later energy use
- Achieving a ZEB w/o the grid is very difficult, as current storage technologies is limited
  - Off-grid buildings cannot feed their excess energy production back onto the grid to offset other energy uses

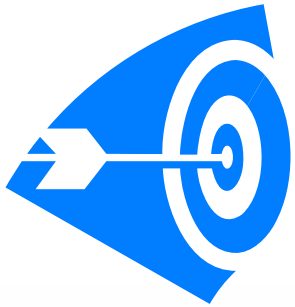


Grid connected PV systems



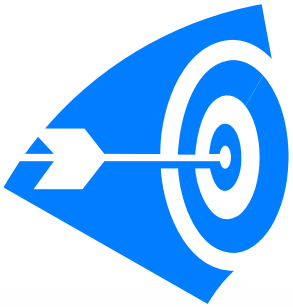
Grid connected wind energy systems

Critical Issues



- Usually, the goal of ZEB designers is to:
  - Design a building that uses zero energy, and produces zero emission
  - Also, minimize all energy use and damage to the environment
- Passive solar design is often more cost effective than adding expensive PV to a conventional inefficient building

Critical Issues



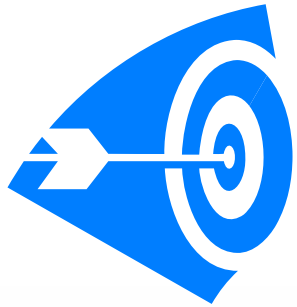
- Balance between energy conservation and energy generation
  - A good ZEB should first encourage energy efficiency, and then use renewable energy sources available on site
- ZEB supply options strategy:
  - i. Reduce site energy use
  - ii. On-site supply
  - iii. Off-site supply

Table 1. ZEB Renewable Energy Supply Option Hierarchy

Option Number	ZEB Supply-Side Options	Examples
0	Reduce site energy use through low-energy building technologies	Daylighting, high-efficiency HVAC equipment, natural ventilation, evaporative cooling, etc.
	On-Site Supply Options	
1	Use renewable energy sources available within the building's footprint	PV, solar hot water, and wind located on the building.
2	Use renewable energy sources available at the site	PV, solar hot water, low-impact hydro, and wind located on-site, but not on the building.
	Off-Site Supply Options	
3	Use renewable energy sources available off site to generate energy on site	Biomass, wood pellets, ethanol, or biodiesel that can be imported from off site, or waste streams from on-site processes that can be used on-site to generate electricity and heat.
4	Purchase off-site renewable energy sources	Utility-based wind, PV, emissions credits, or other "green" purchasing options. Hydroelectric is sometimes considered.

(Source: National Renewable Energy Laboratory)

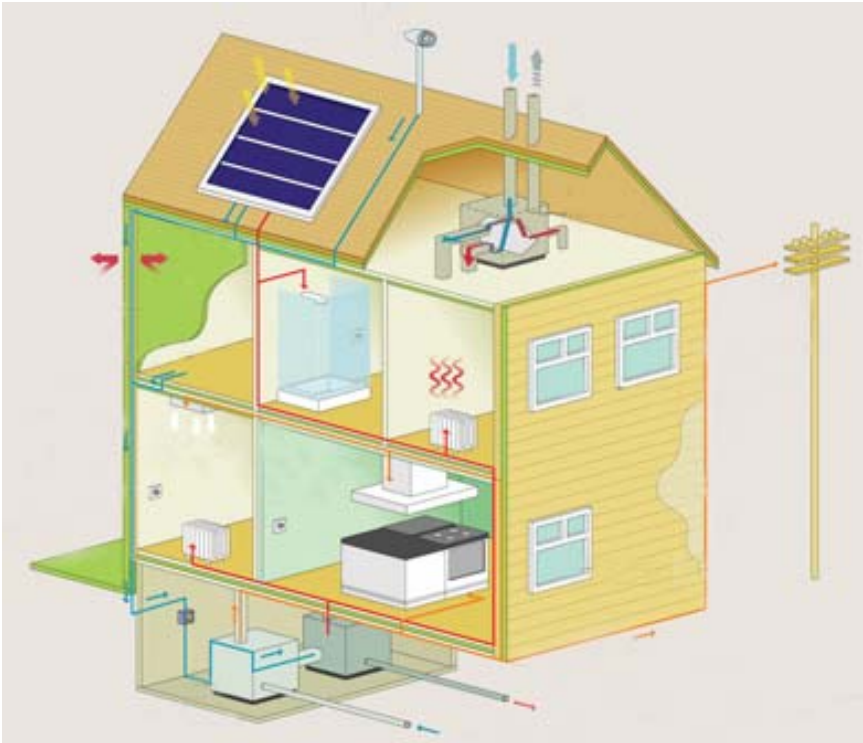
Critical Issues



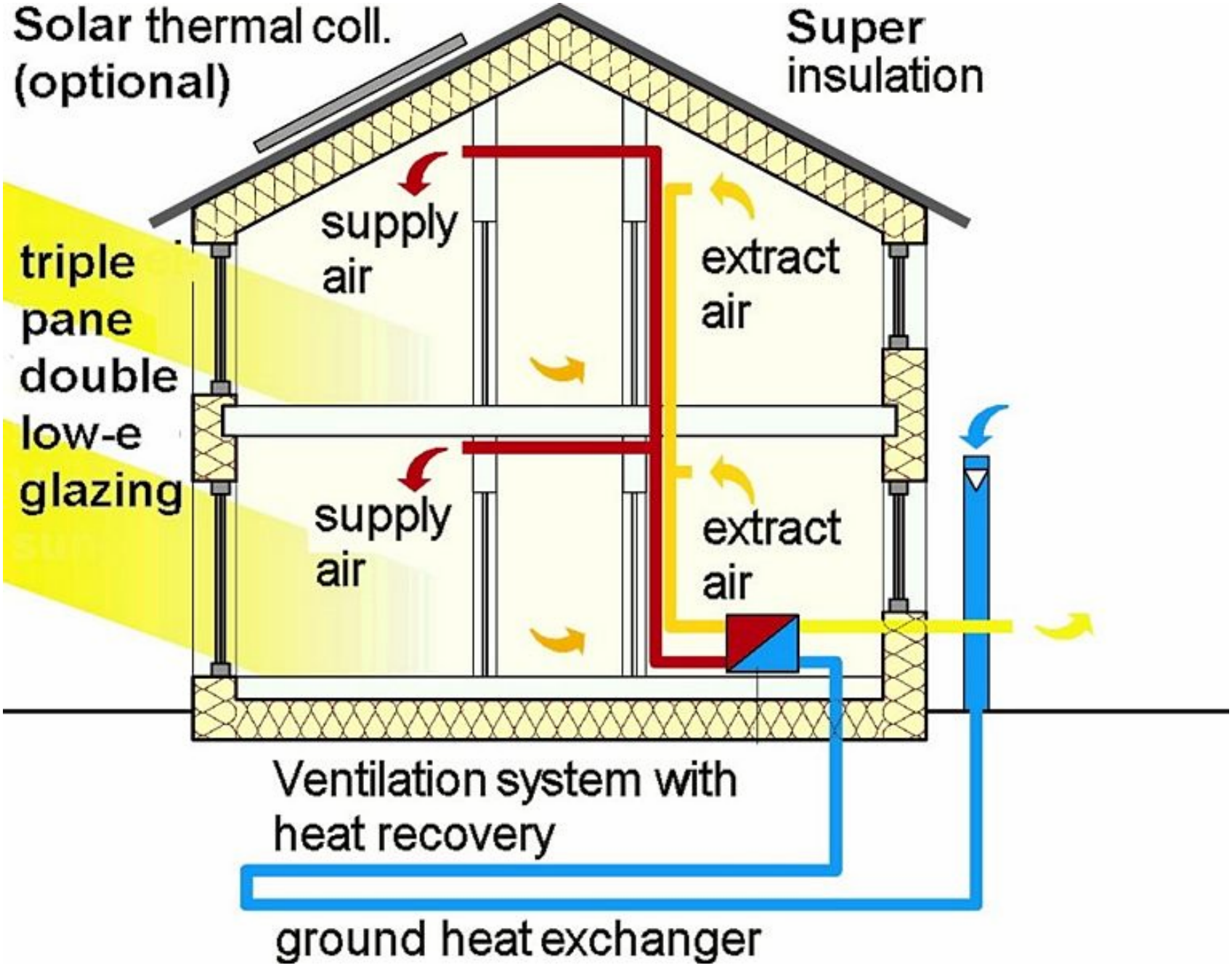
- ZEB is not a single product or technology; but rather a combination of closely-integrated evolving technologies
  - Whole-building energy-consumption system integration
  - Requires careful planning and computer modelling to make all the subcomponent parts work together cost effectively

Critical Issues

- Common energy efficiency (EE) features:
  - Daylighting
  - EE lighting
  - EE office equipment
  - EE ventilation
  - Controls & Sensors
  - Orientation
  - Insulation
  - Energy management

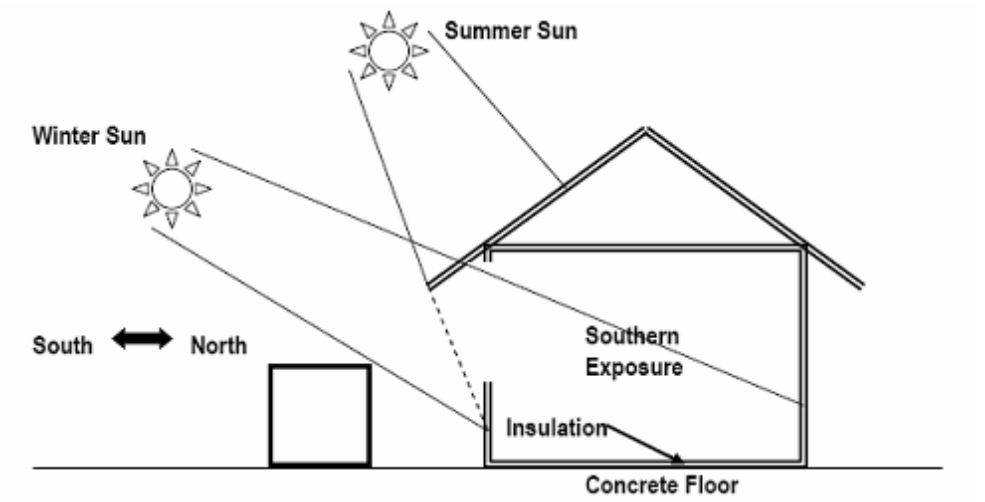


Typical techniques for passive house

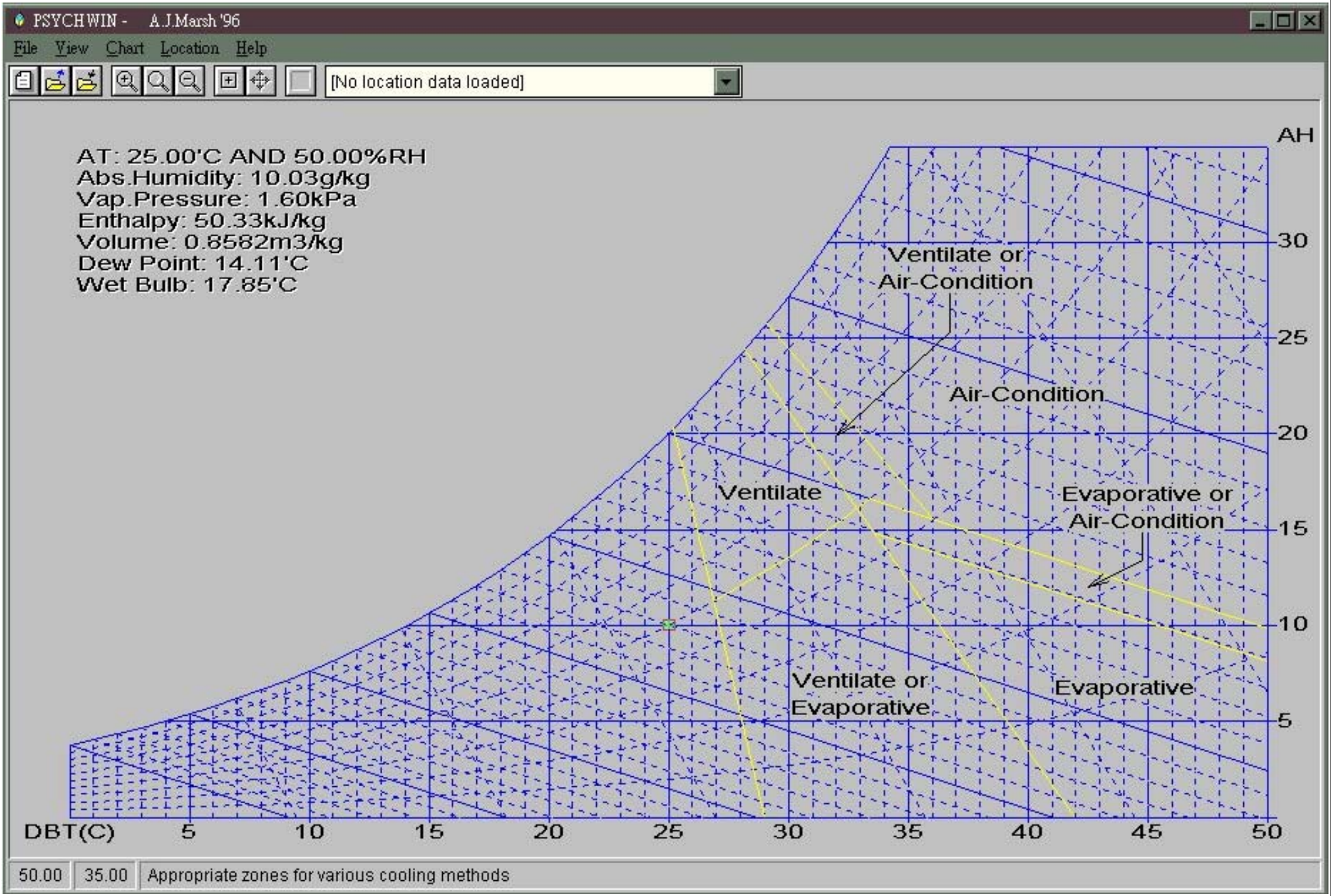


Critical Issues

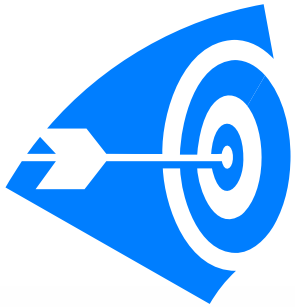
- Passive solar buildings
  - Aim to maintain interior thermal comfort whilst reducing the requirement for active cooling and heating systems
- 4 passive solar energy configurations:
  - Direct solar gain
  - Indirect solar gain
  - Isolated solar gain
  - Passive cooling



Analysis of cooling strategies on a psychrometric chart

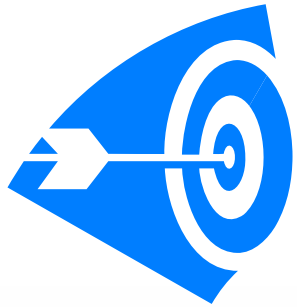


Critical Issues



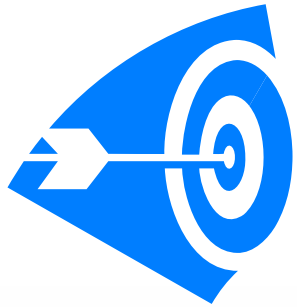
- Total energy approach (depend on size & site)
  - Combined heat, cooling and power
  - Distributed generation schemes
  - District cooling/heating
  - Shared wind turbines
- Better use of heat energy
  - Heat recovery ventilation
  - Heat pump system (e.g. for heating hot water)
  - Thermal mass of structure (stablize indoor temp.)

Critical Issues



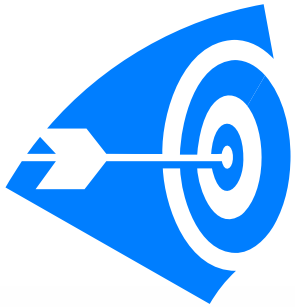
- Design of ZEB
  - Need to evaluate future consequences on energy demand using life cycle energy analysis
    - Find out cost-effective ways to reduce energy use
    - Balance initial construction costs with operating costs
  - Model economic and financial implications
    - Such as tariff structures, investment strategies
    - May change with increase of conventional energy (oil price now goes up to US$135 per barrel!!)

Critical Issues



- Design of ZEB (cont'd)
  - Methods to evaluate building energy use
    - No standards available in HK at present
    - May use the performance-based building energy code as a reference (simulation approach)
  - Use simulation to predict how the building will perform before it is built
    - Calculate likely energy use & thermal loads
    - Form the basis for determining "zero" energy use

Critical Issues



- ZEB vs Green Building (GB)
  - Many similarities between the goals of ZEB & GB
    - Reduce or eliminate energy bills & greenhouse gas emission
    - Achieve high-performance energy-efficient buildings
- But, ZEB does not consider the followings:
  - Embodied energy of the structure
  - Energy for construction of the building
  - Energy for transport or commuting

ASHRAE Design Tools

- Advanced Energy Design Guides
  - Developed by ASHRAE, USGBC, AIA
  - Free for download at www.ashrae.org/freeaedg
    - Small warehouses and self-storage buildings
    - Small office buildings
    - Small retail buildings
    - K-12 school buildings
  - Energy savings target of 30% (the first step in the process toward achieving a ZEB)

Advanced Energy Design Guides

www.ashrae.org/freeaedg

ASHRAE Design Tools

- Useful ASHRAE Standards
  - Standard 55 – thermal comfort
  - Standard 62 – indoor air quality
  - Standard 90.1 – energy standard for buildings
  - Standard 100 – energy conservation in existing buildings
  - Standard 105 – measuring & expressing building energy performance
  - Standard 140 – test for evaluation of building energy analysis computer programs

ASHRAE Design Tools

- Video presentation (2 min.)
  - Achieving net zero energy buildings
    - Typical 2-story building
    - Building envelope measures
    - HVAC, service water heating and lighting measures
    - Renewable energy measures

THANK YOU