Solar and Energy Efficient Buildings – Potential and Technologies

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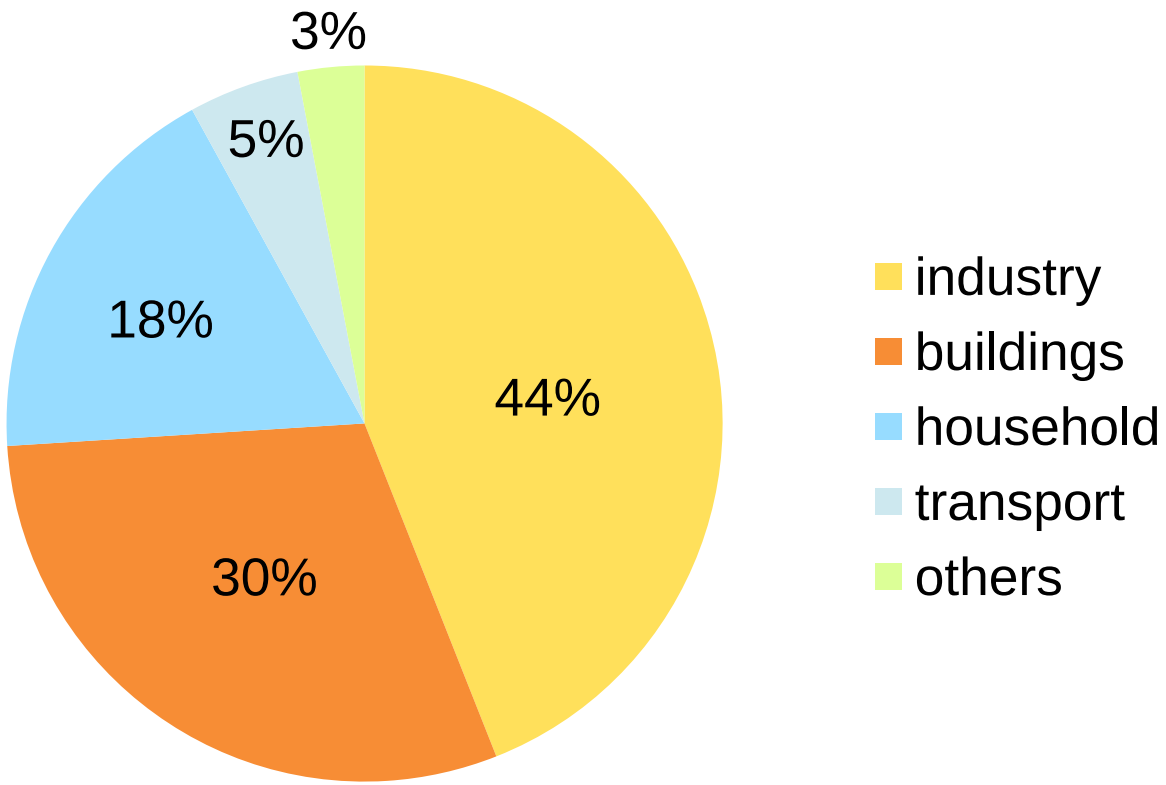
Electricity consumption in Singapore,

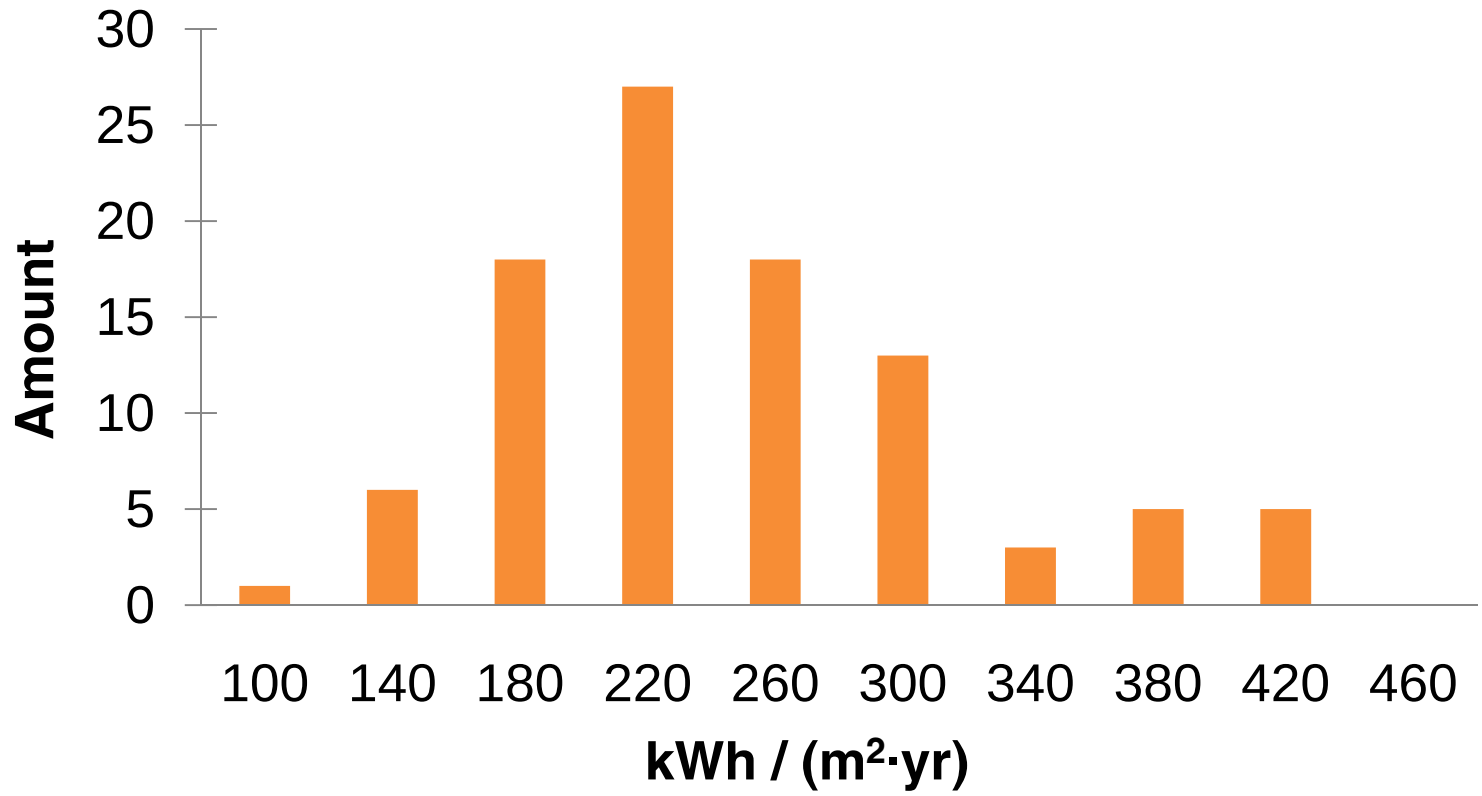
Importance of the building sector



Sources: BCA, SEAS, 2007

Electricity consumption - offices

Electricity consumption of office buildings in Singapore



Sources: NUS Energy Sustainability Unit (ESU), based on energy auditing on 104 office buildings

Energy consumption office buildings

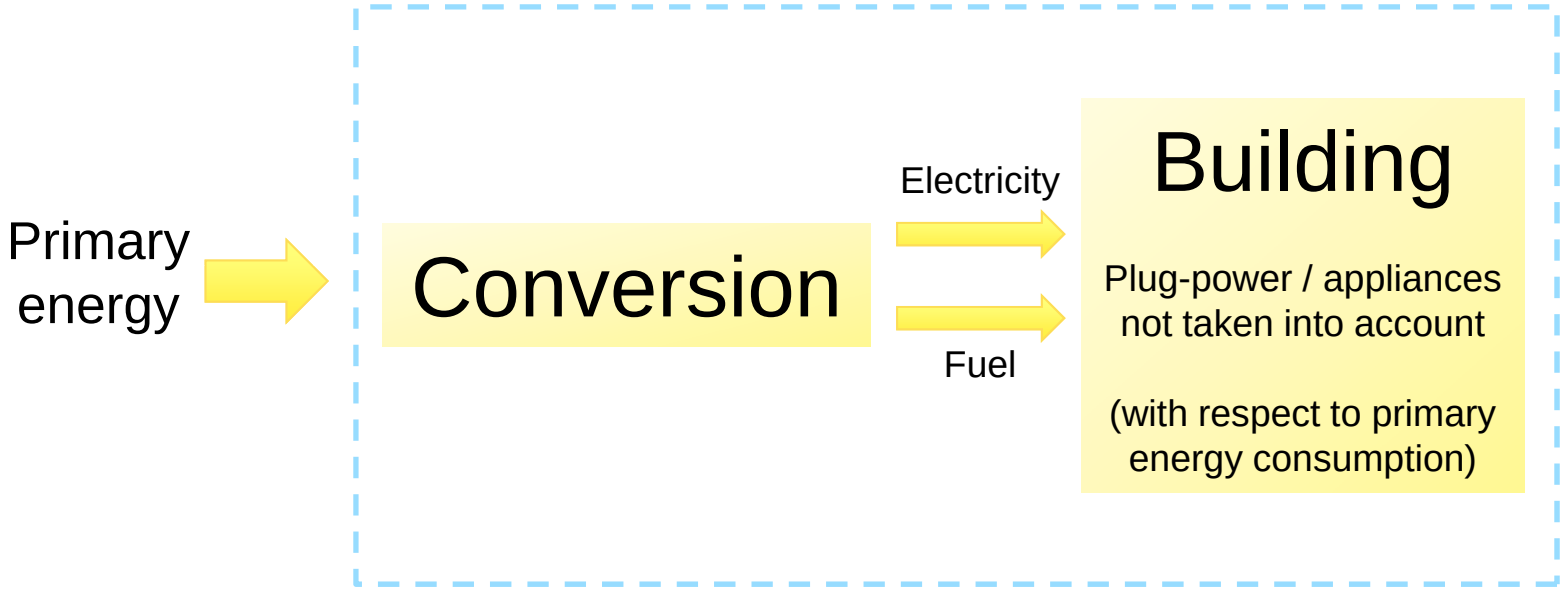
Comparison Singapore - Germany

	Electricity kWh / (m^2·yr)	Primary energy kWh / (m^2·yr)
Singapore building stock	230	605
Germany building stock		300
Highly efficient office building in Singapore	~ 100	~ 260
Highly efficient office building in Germany		~ 60

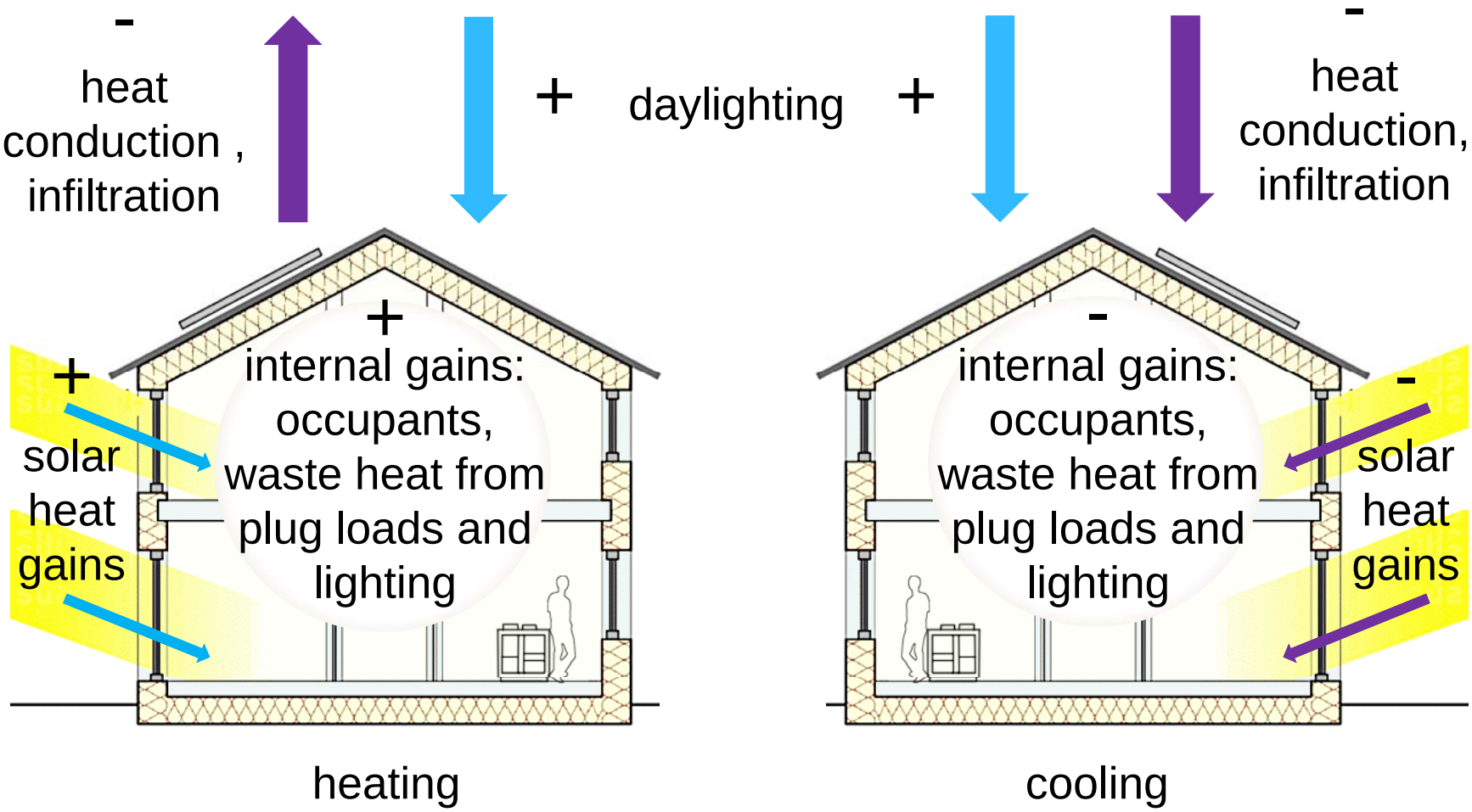
conversion : 38% primary energy = electric energy

Building energy consumption

Primary energy consumption as a figure of merit for buildings: energy security and CO2 emission (European directive)



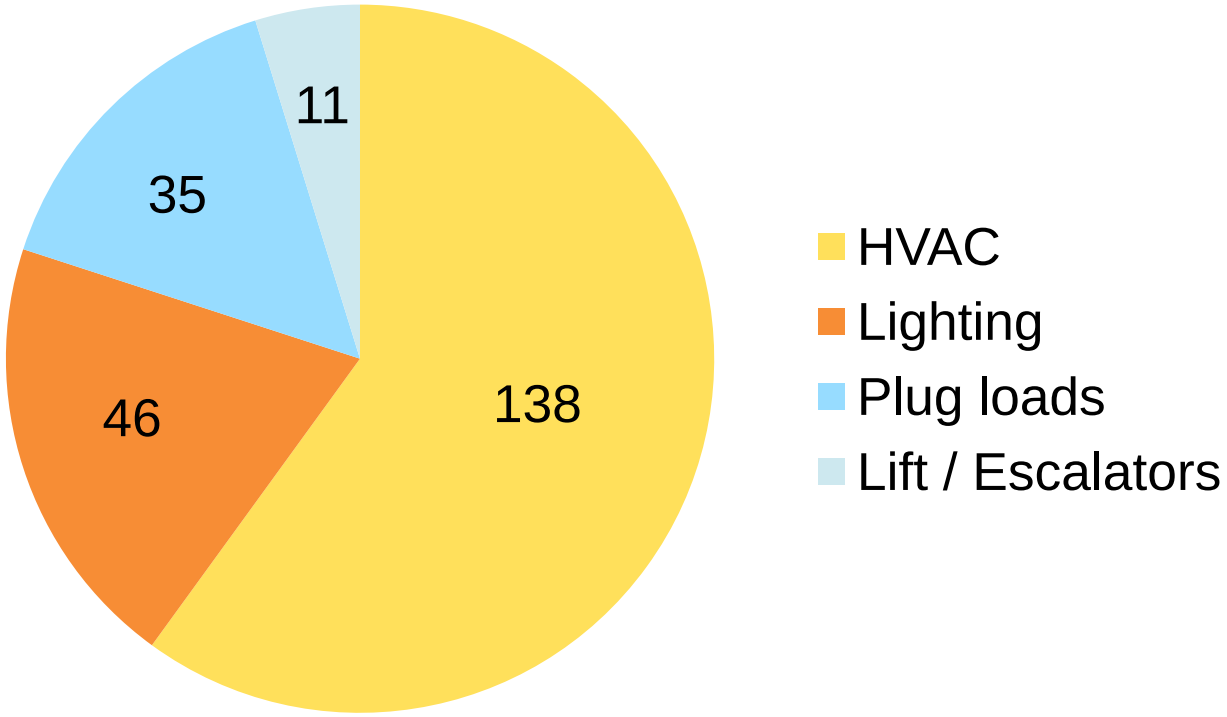
Cooling vs. heating



Electricity consumption in buildings,

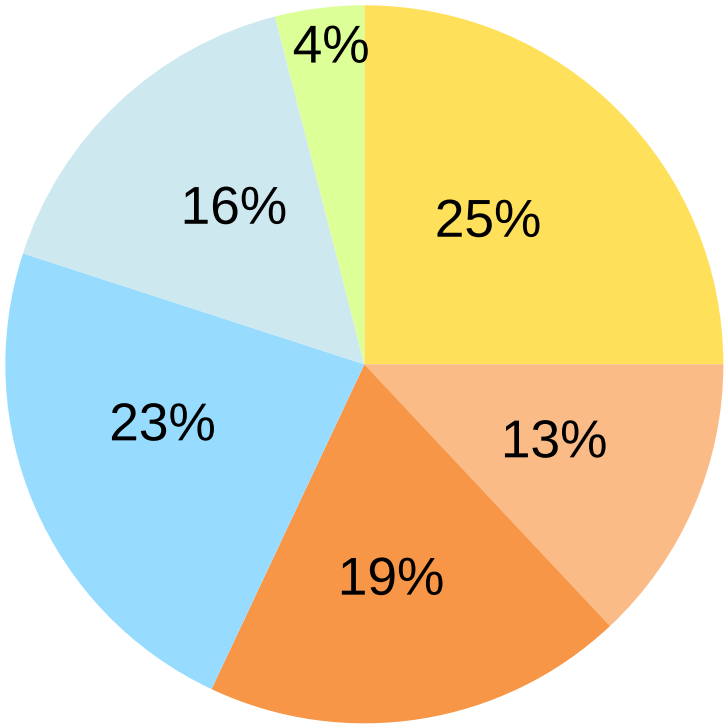
Importance of air-conditioning in Singapore

consumption in kWh/(m^2·yr), Singapore, gross floor area



Sources: NUS Energy Sustainability Unit (ESU), based on energy auditing on 104 office buildings

Thermal cooling loads in buildings



- Heat input via solar radiation
- Wall / glass conduction
- Ventilation / infiltration
- Lighting
- Occupants
- Others, including plug loads

Source: SK Chou. Large building cooling load.
In: International Journal of Energy Research 1997

Where can we improve

Building envelope

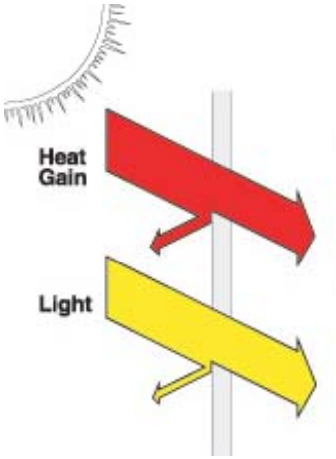
National Library Building
Singapore

- Better windows for lower thermal transmission of solar radiation, reduced heat conduction and infiltration/ventilation
- Better walls and roofs for reduced heat conduction
- Use of daylight for reduction of electrical lighting
- Building integrated photovoltaics harnessing solar energy

Windows

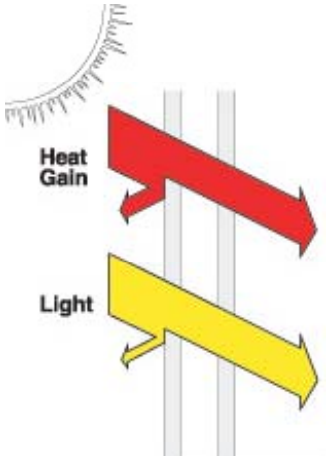
Potential for improved performance

Single glazing



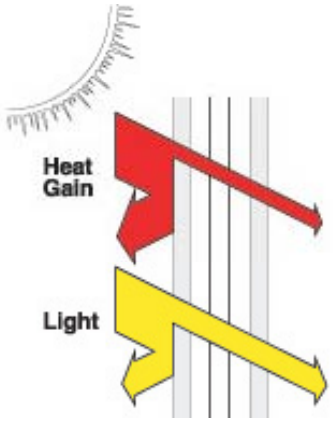
G-value: 0.8 – 0.9
T-value: 0.9
U-value: 5 - 7

Double glazing



G-value: 0.3 – 0.5
T-value: 0.5 – 0.8
U-value: 2 - 3

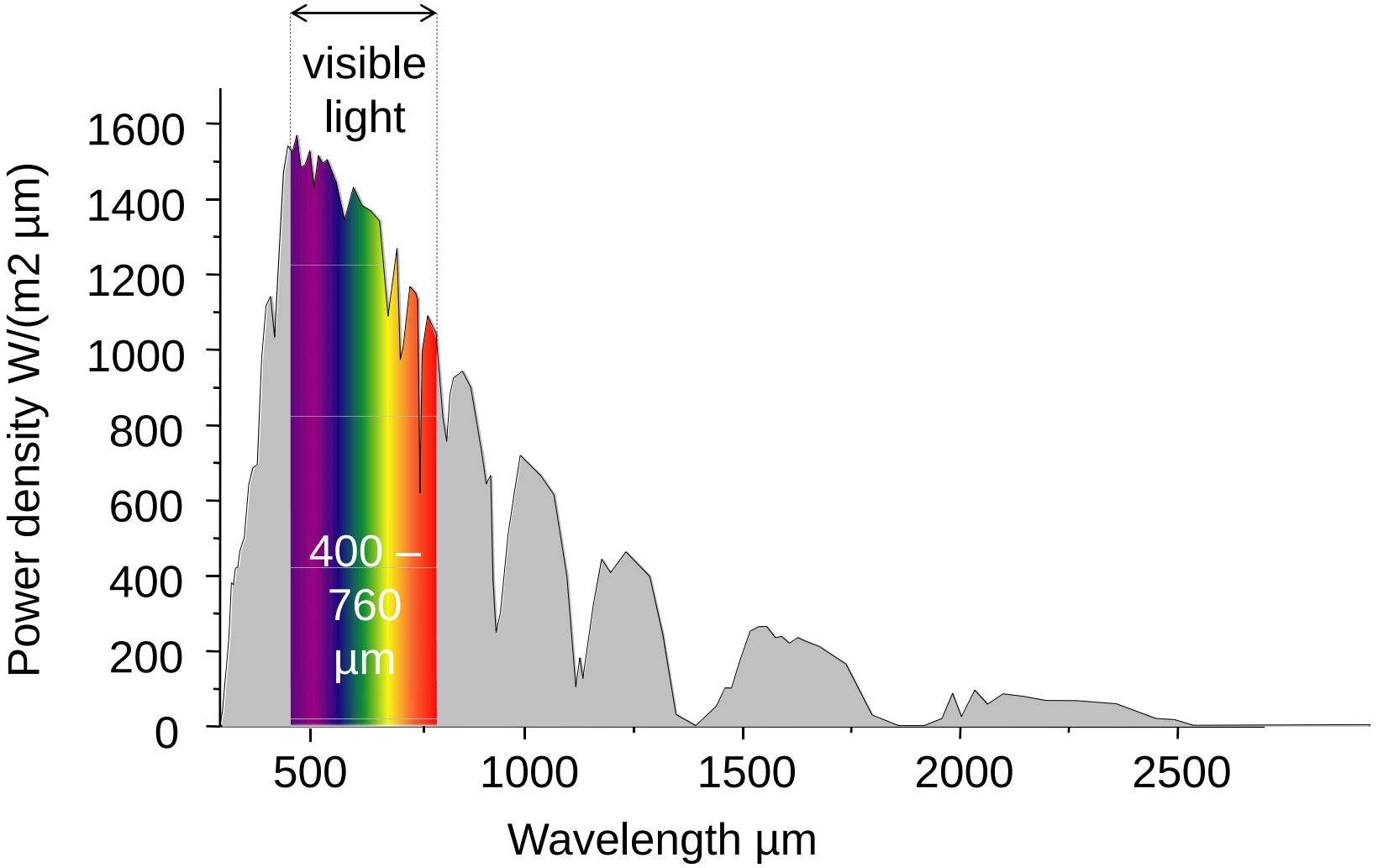
Super - triple glazing



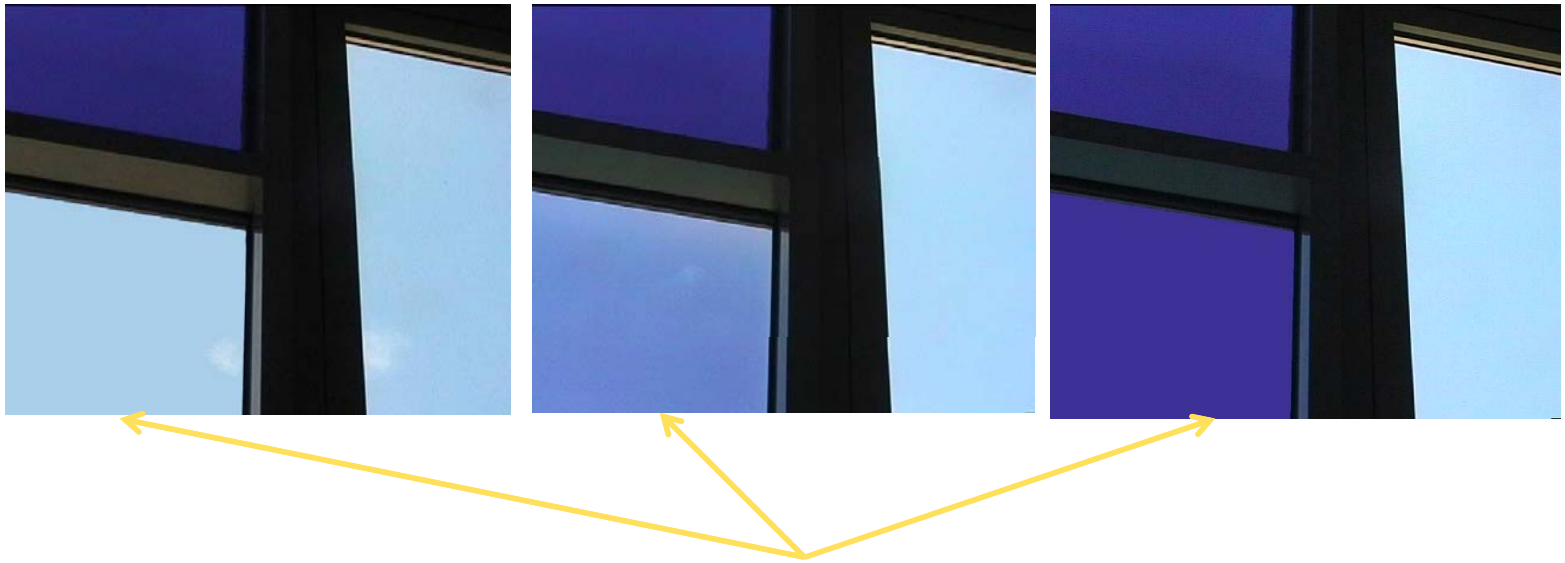
G-value: 0.1 – 0.5
T-value: 0.5 – 0.7
U-value: 0.5 - 0.7

G-value measures solar heat gain, T-value visible light transmission, U-value thermal conduction (W/m^2K)

Energy distribution in the solar spectrum



Optically switchable windows

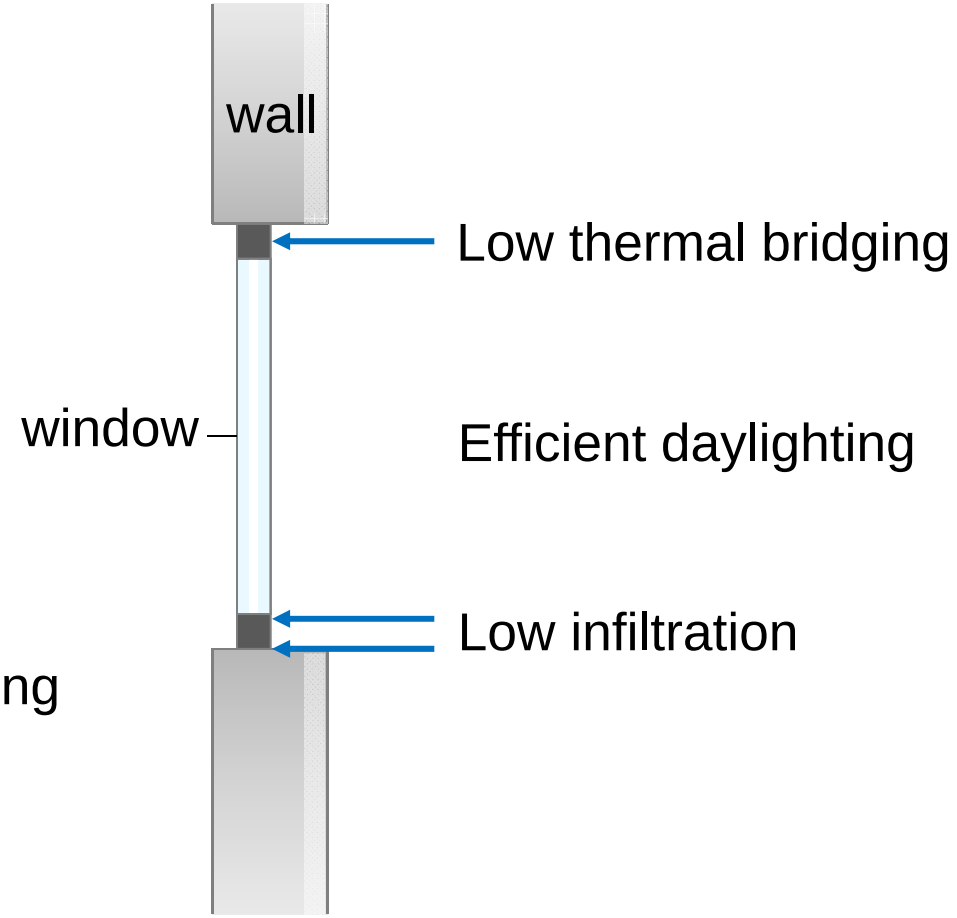


Switching glazing

Efficient fenestration

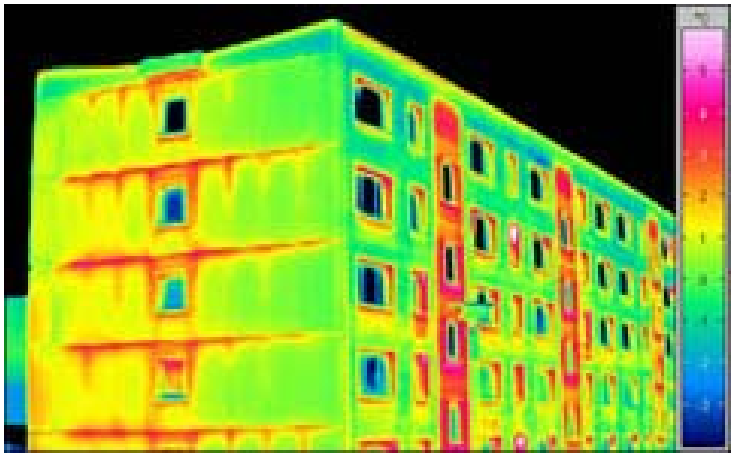
Fenestration:
Low U-value
Low g-value
High T* value

* Optically switching



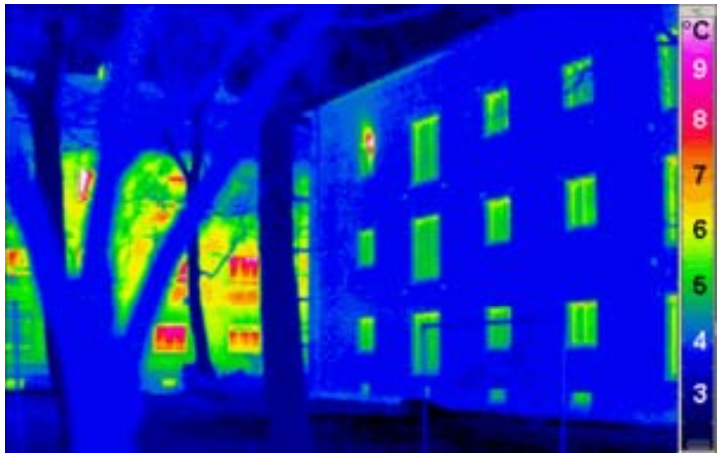
Potential for wall performance

Building Stock in Singapore
Concrete wall



U-values
0.5 - 2.5 (Office buildings)
1.2 -4.5 (Public housing)

"Passiv Haus"
super insulated wall

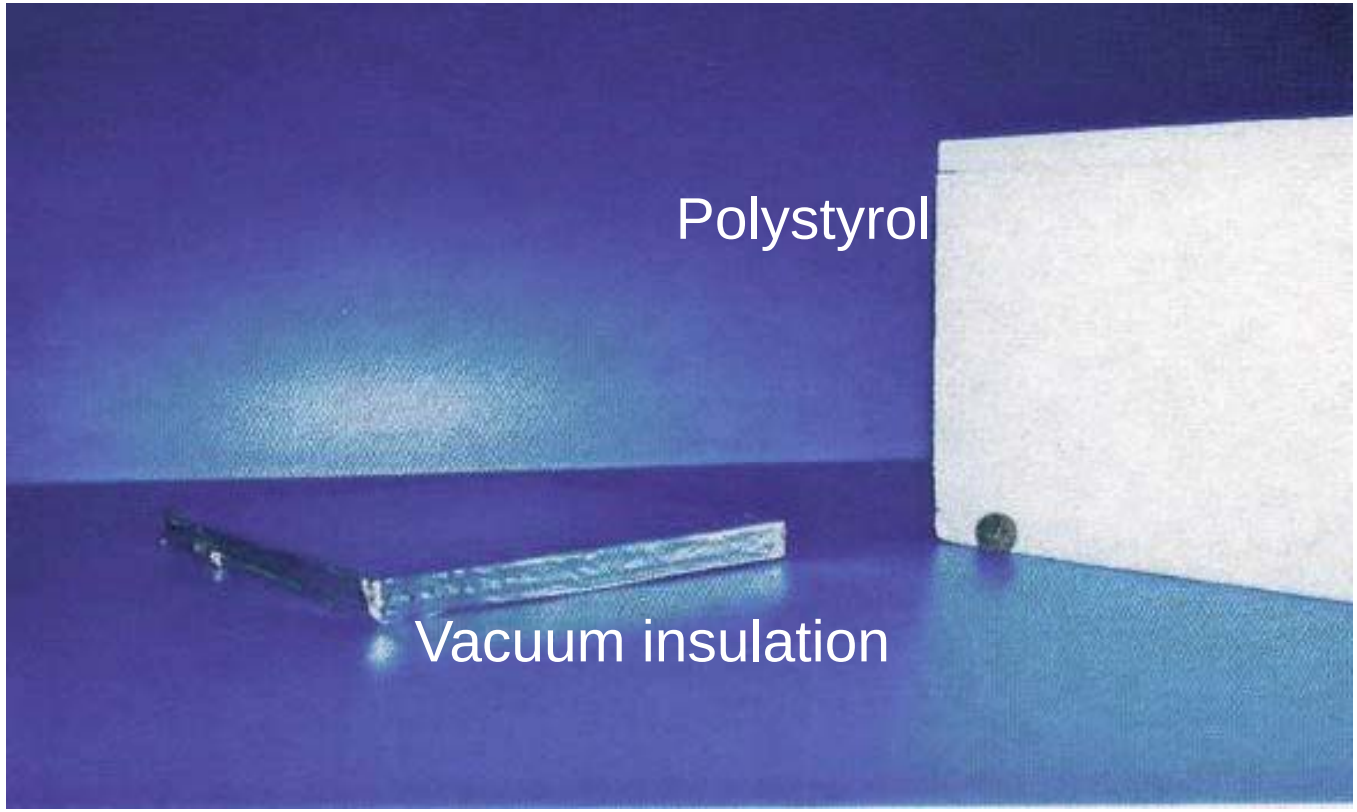


U-values
U < 0.45 (German building code)
U < 0.15 ("Passiv Haus")

U-value measures thermal conduction (W/m^2K)

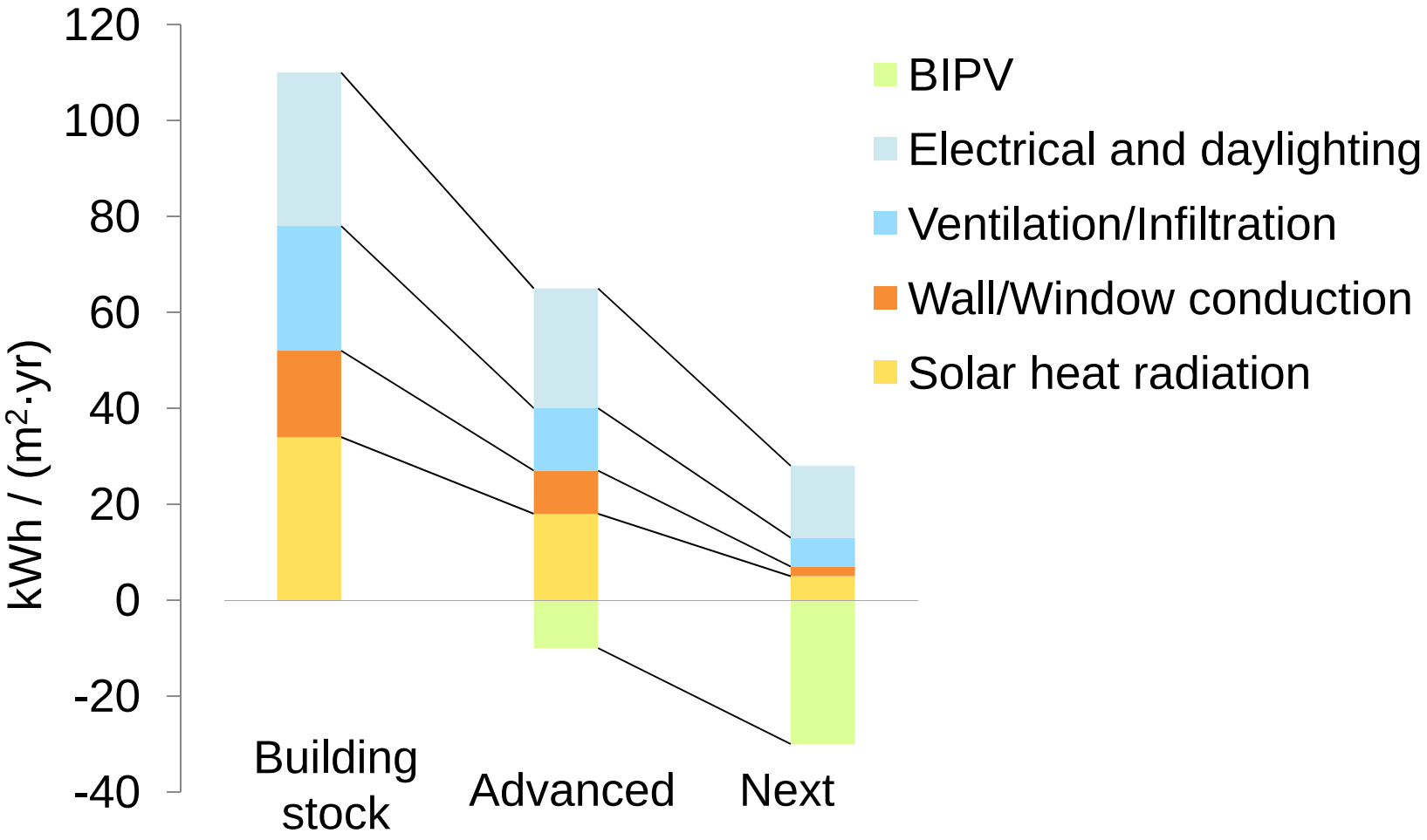
Thermal insulation of building walls,

new technologies



Possible Improvements

Envelope dependent negative and positive gains

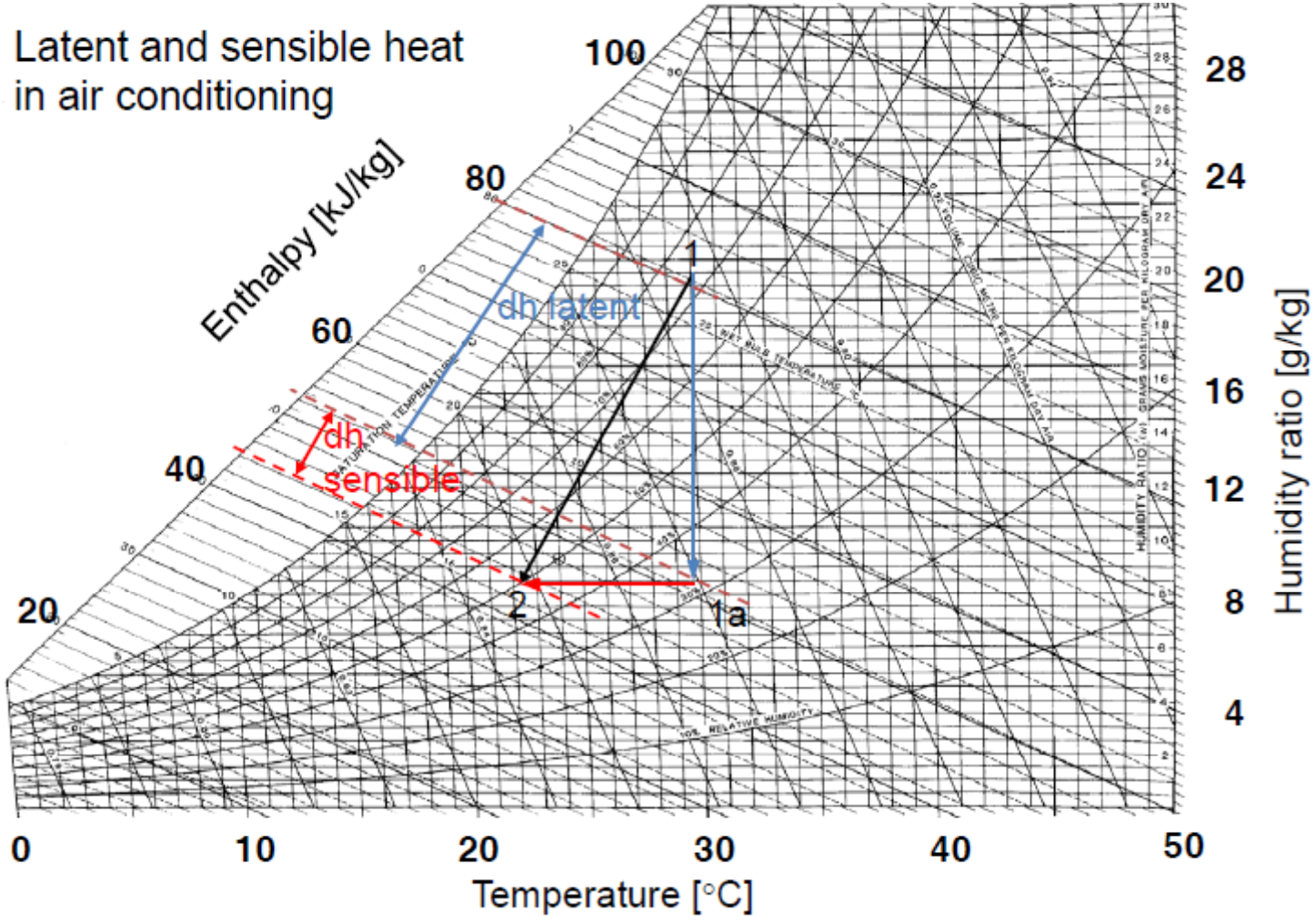


Where can we improve

Building services

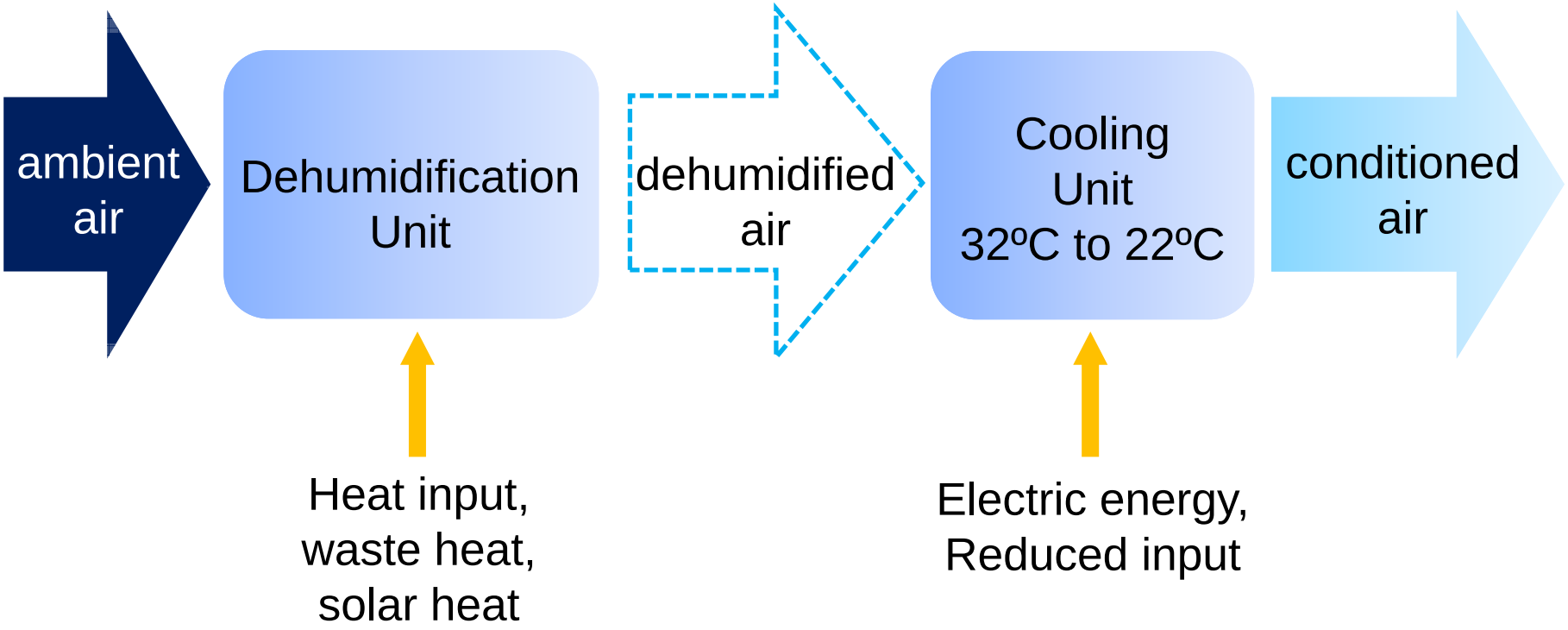
- Energy efficient HVAC
- Energy efficient equipment
- Energy efficient lighting
- Building operation
- Combined heat/air-conditioning and power units

Air-conditioning



Heat powered air-conditioning,

Dehumidification of ambient air



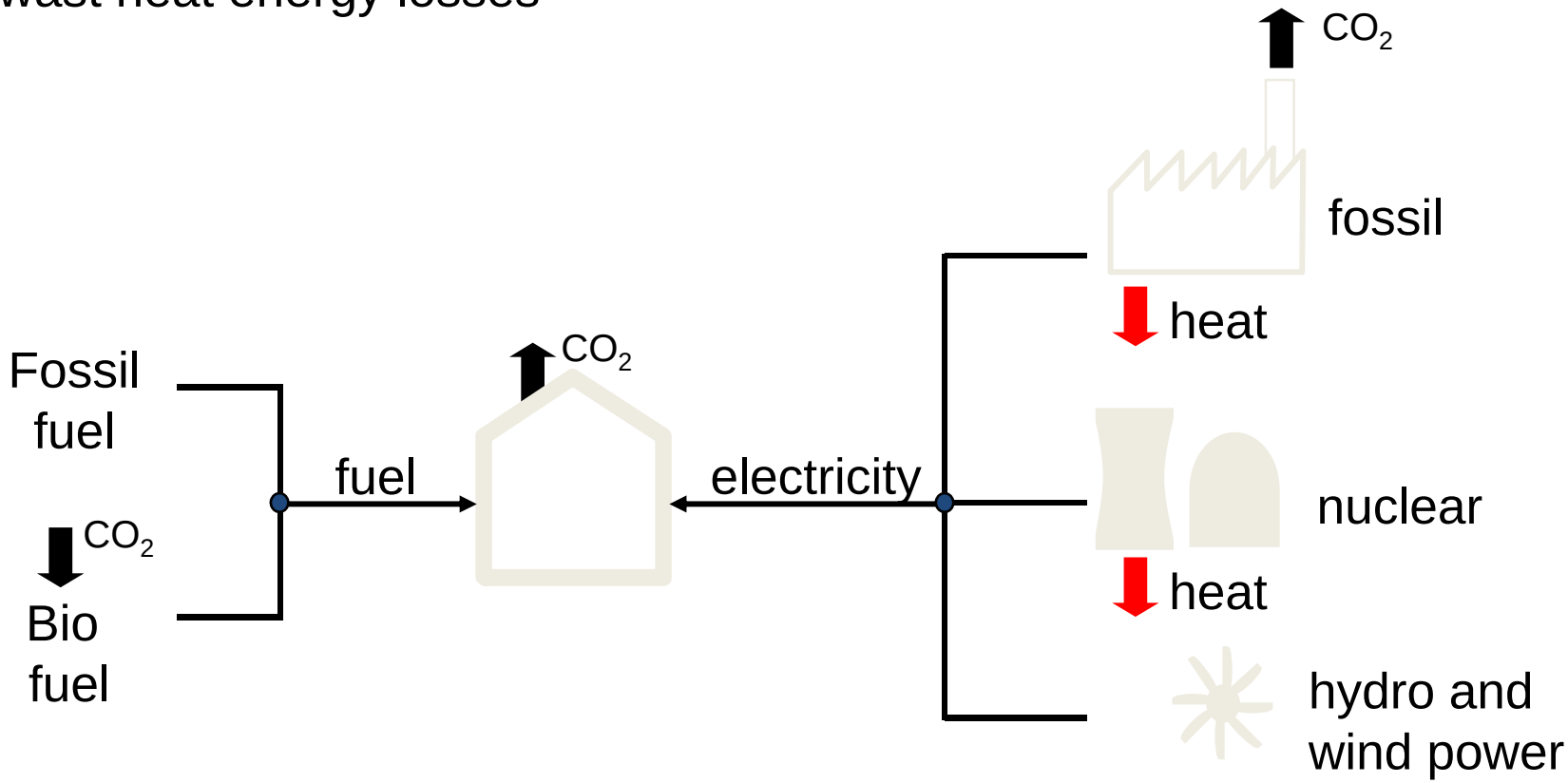
Solar thermal collectors

Flat plate collectors

Vacuum tube collectors

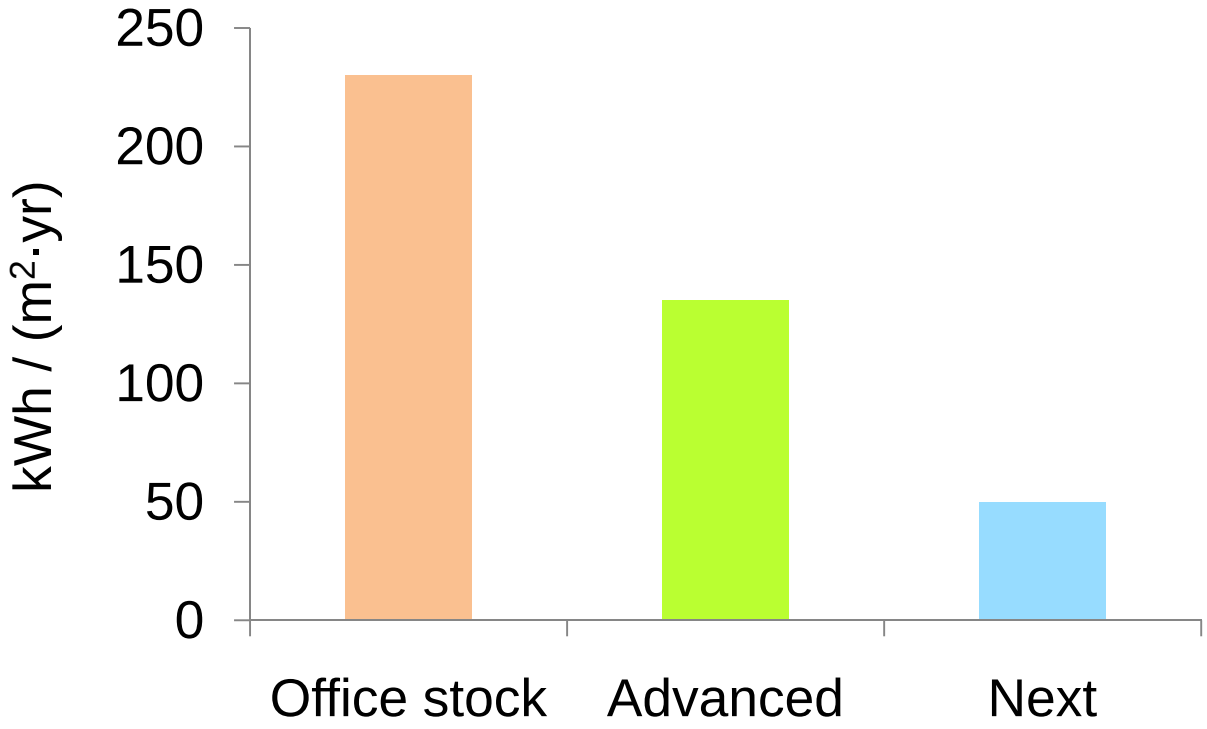
Centralised electricity generation,

wast heat energy losses



Electricity consumption

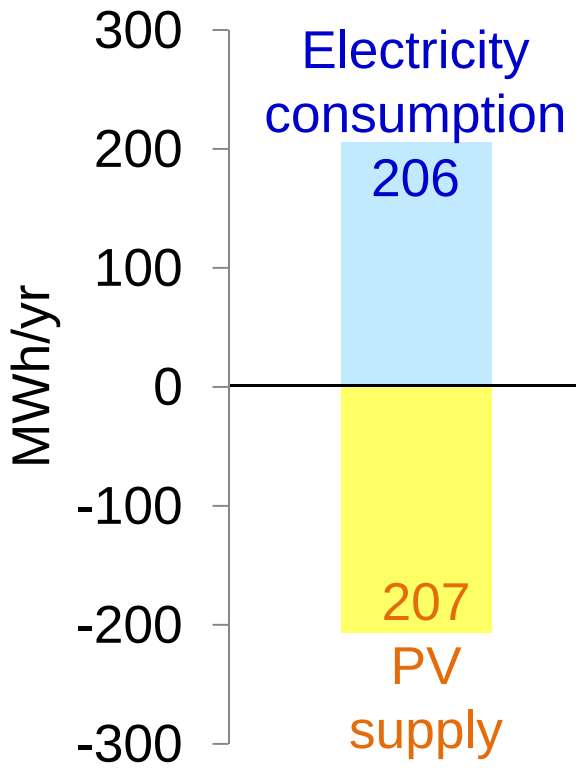
Office buildings in Singapore, gross assessment



- Plug-loads / appliances not included
- PV generation not included

PV electricity harvesting

Net Zero-Energy Building (ZEB) at Building & Construction Authority Academy



Sustainable energy supply

Conditions that have to be met simultaneously

Ecologically sustainable

Socially sustainable

Economically sustainable

Security of energy supply

Information on SERIS,

the Solar Energy Research Institute of Singapore

www.seris.sg