“Green” Design

Resource & Environmental Management

Integrated Design

Optimal use of natural resources available combined with technology.

Allows cost and environmental benefits of green building design to be realised

Considers:

- Is a new building actually necessary?
- Can simple renovation save time, money and resources?
- Will current location of existing building use infrastructure and services which are already in place thus negating the need for new systems?

Integrated Design

- Comprehensive, holistic
- Many specialists working closely
- Shared focus, attention to detailed, early commitment.
- Design charette, Human-centred design
- Innovative technology e.g. BIM, LCA energy modelling

https://www.youtube.com/watch?v=5eYVKNX37lk

Green?

Green or sustainable design is a well-established design-build model with a proven history.

https://www.youtube.com/watch?v=g1YcZ1J4oIc

ACROS Fukuoka Foundation Building in Fukuoka, Japan

Parthenon

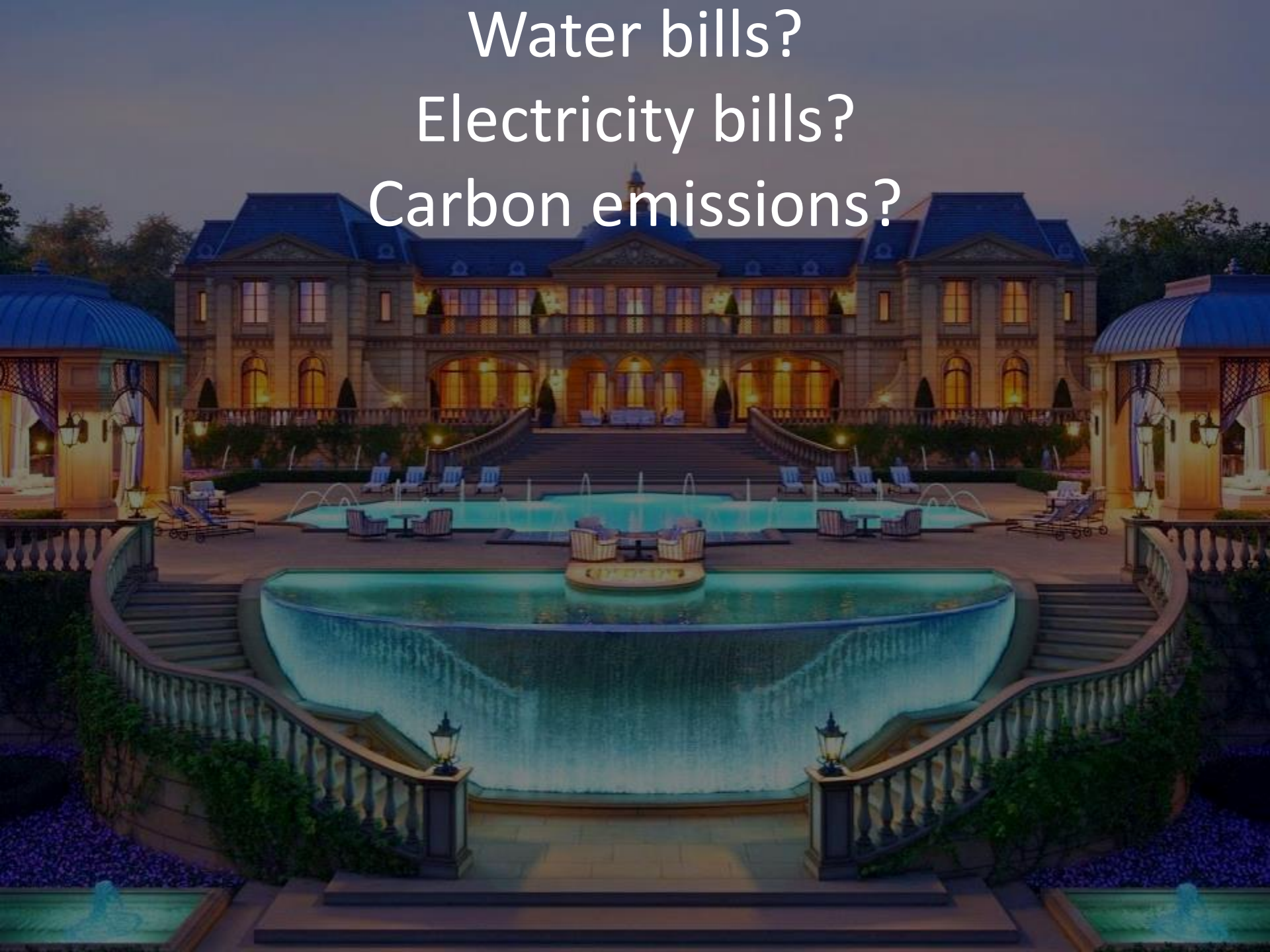
> *"Now in houses with a south aspect, the sun's rays penetrate into the porticos in winter, but in the summer the path of the sun is right over our heads and above the roof, so that there is shade. If, then, this is the best arrangement, we should build the south side loftier to get the winter sun and the north side lower to keep out the winter winds."*

In Book III, Chapter VIII, of Xenophon's Memorabilia of Socrates

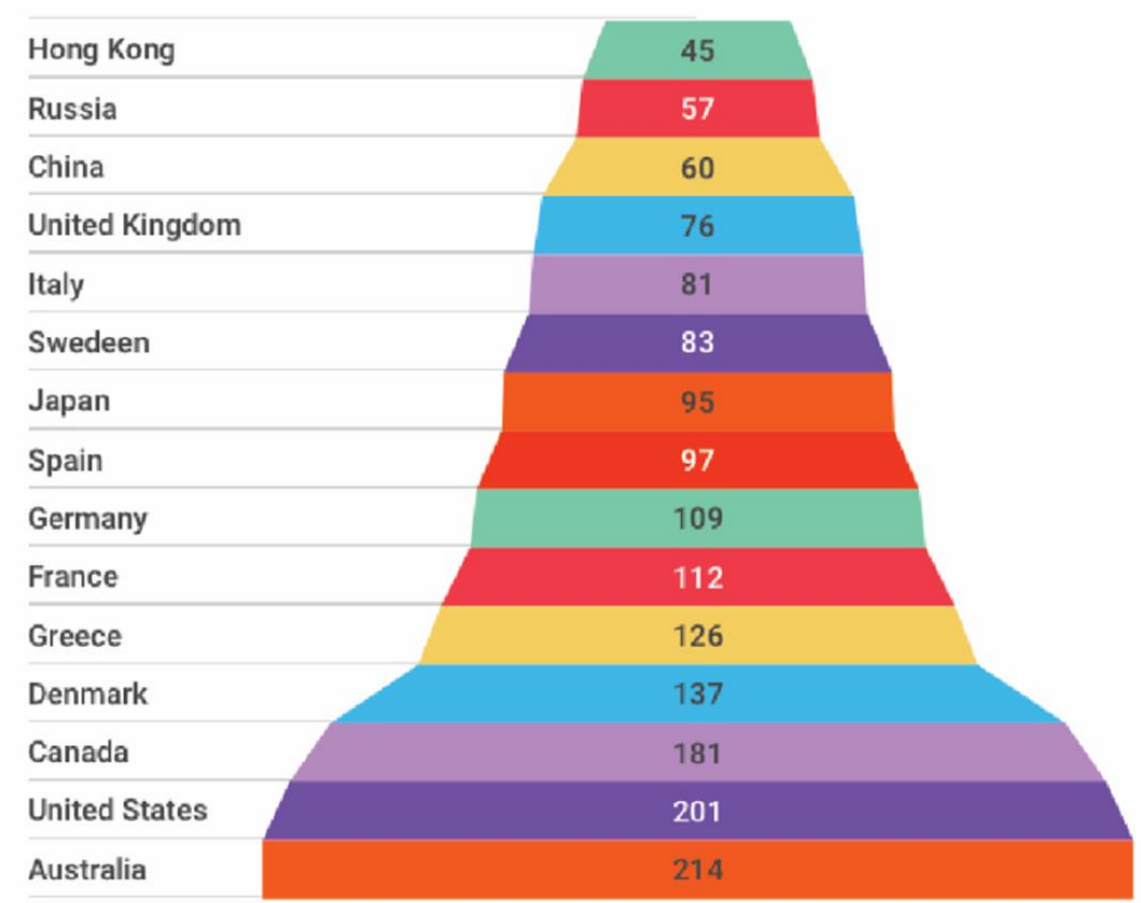
Cliff Palace, Colorado

Passive Solar and Thermal Mass

How big is your Dream House?


Water bills?
Electricity bills?
Carbon emissions?

House Sizes around the world (m^2)

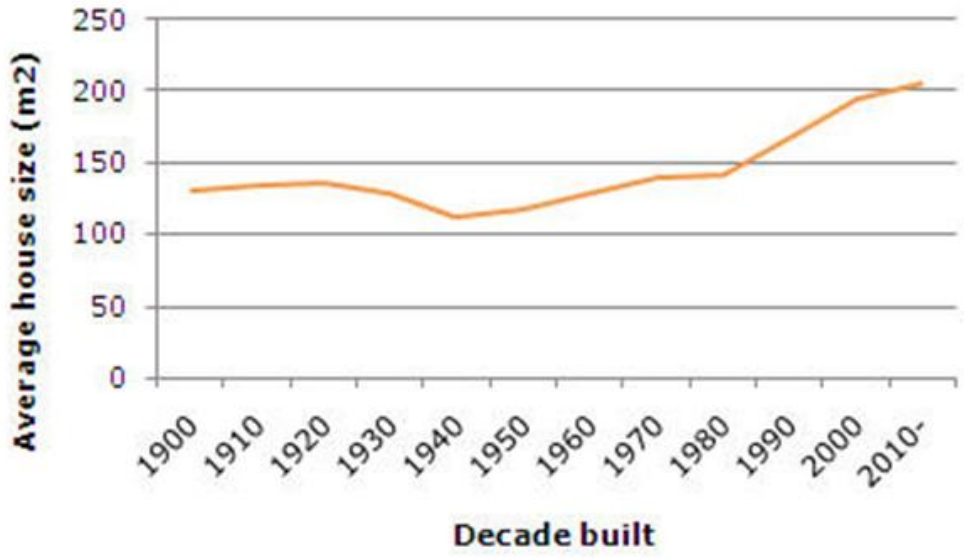


Is Bigger Still Better?

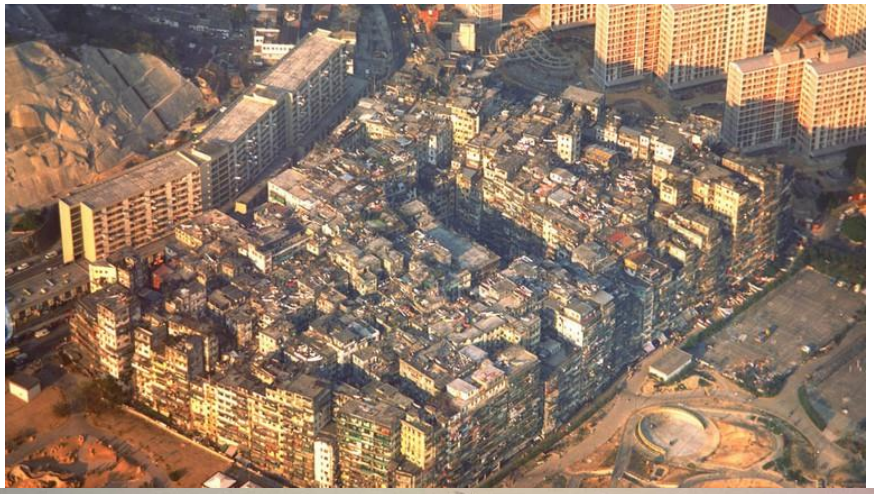
Average NZ house 149 m2

- 1900 = 132m^2
- 2010 = 205m^2
- 2017 =176m^2

Decade built	Average size (m2)
1900	131.7
1910	135.3
1920	136.7
1930	129.8
1940	112.7
1950	117.5
1960	128.2
1970	140.2
1980	142.4
1990	166.4
2000	194.2
2010-	205.3

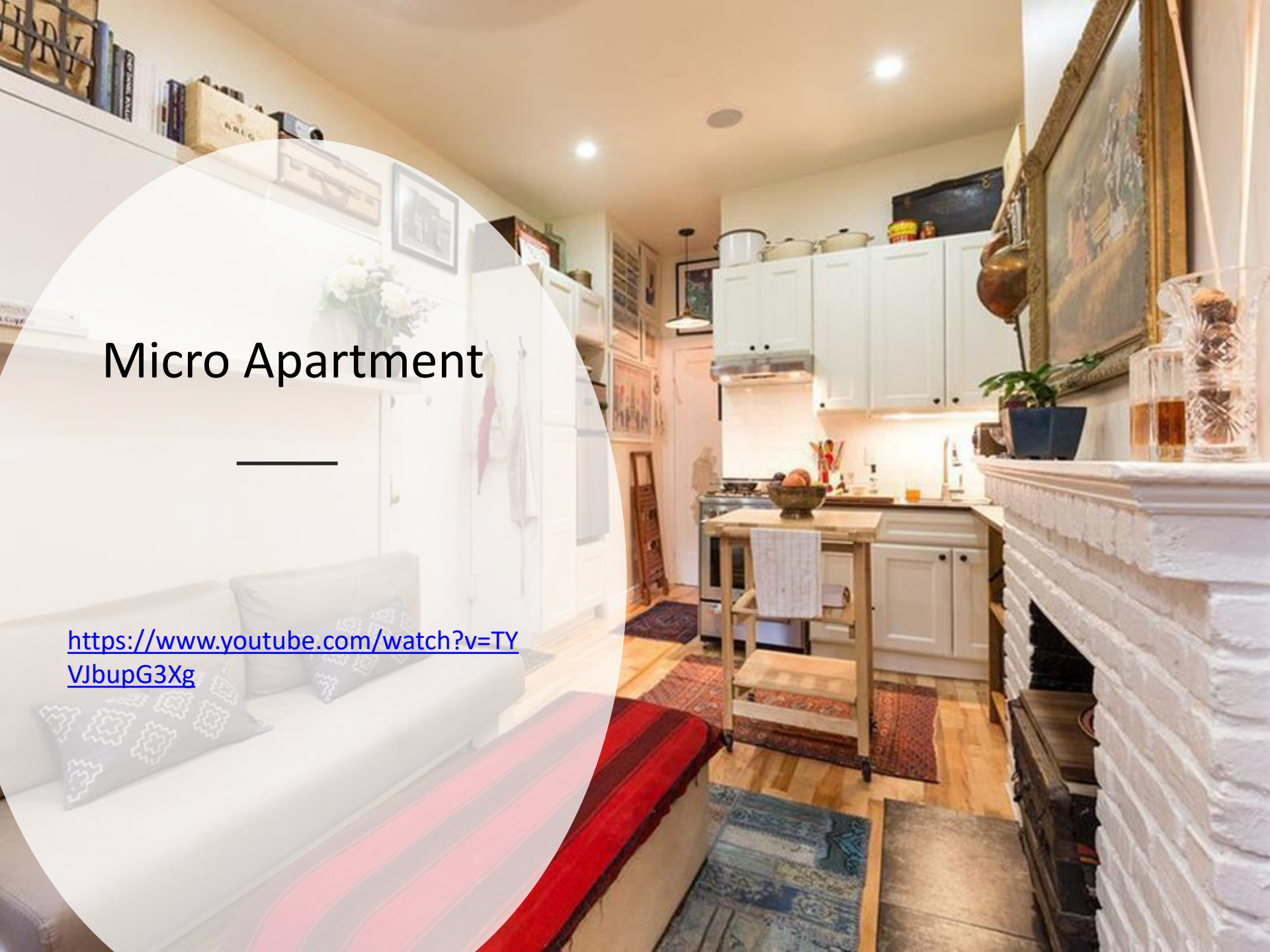


Hong Kong buildings



Kowloon walled city

“Monster building”



Micro Apartment

https://www.youtube.com/watch?v=TYVJbupG3Xg

Tiny house

- Rapidly growing social movement
- Simplicity, style, function
- Living with less = freedom
- Minimise debt / economic freedom

Building Size

- Low footprint
- How small can you go?
- Waste-free living?
- https://www.youtube.com/watch?v=1FR0fSI_mEI

AROUND

38,800 GWh

OF ELECTRICITY WAS CONSUMED IN 2017

RESIDENTIAL CONSUMERS

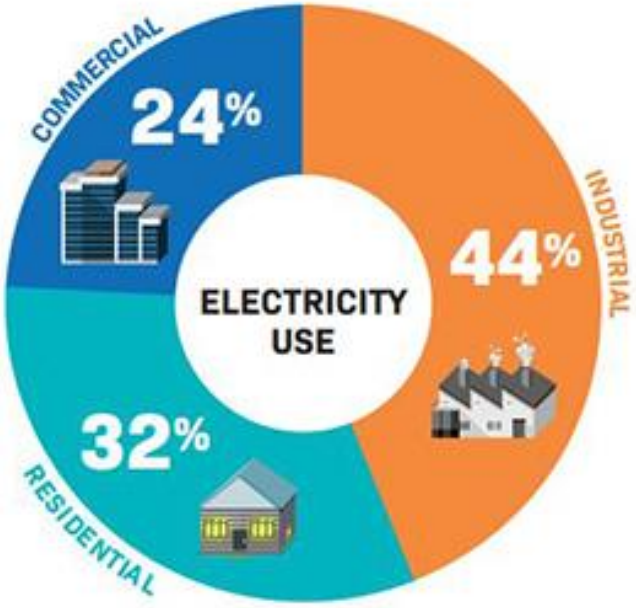
1,720,000

COMMERCIAL CONSUMERS

175,000

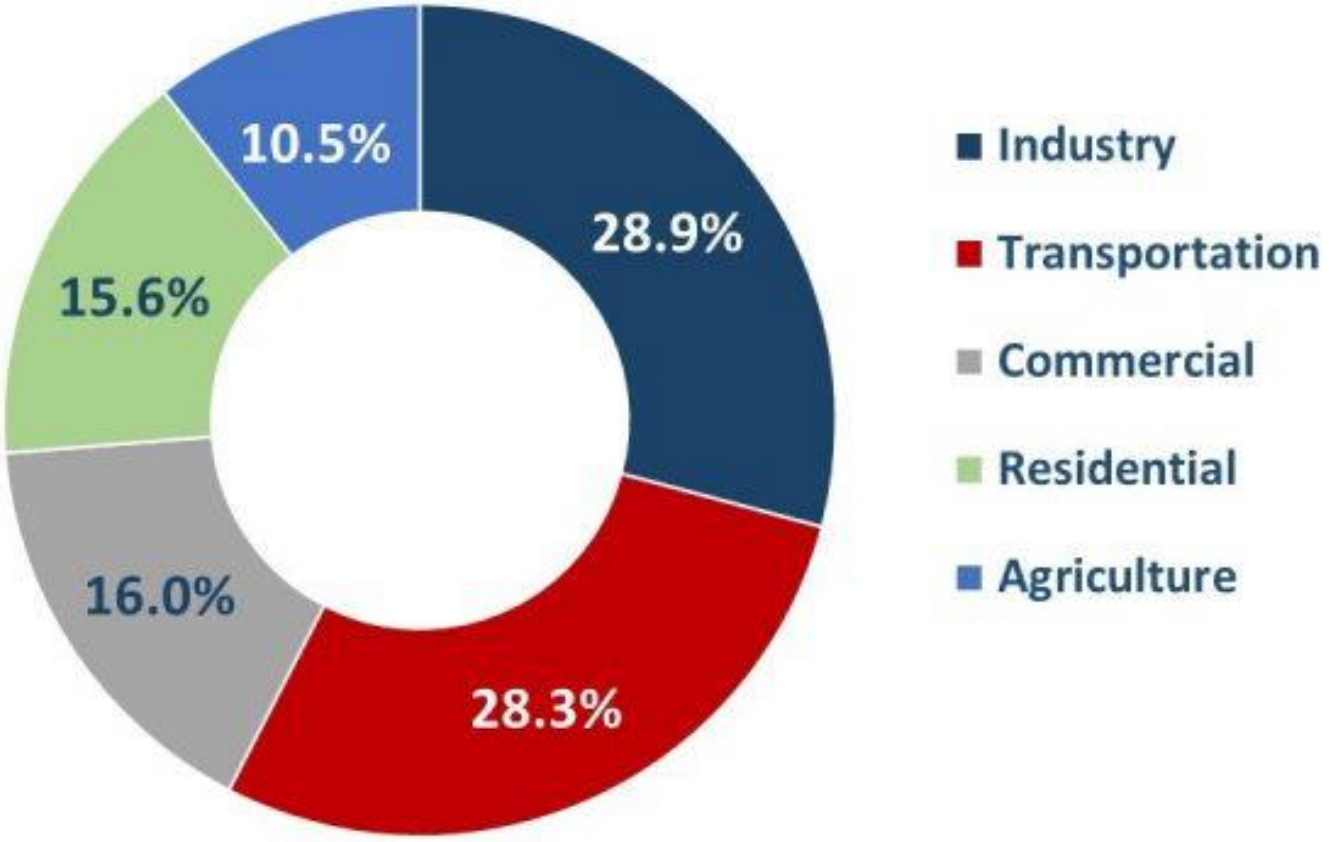
INDUSTRIAL CONSUMERS

123,000



Source: Ministry of Business Innovation and Employment as at 25 May 2018

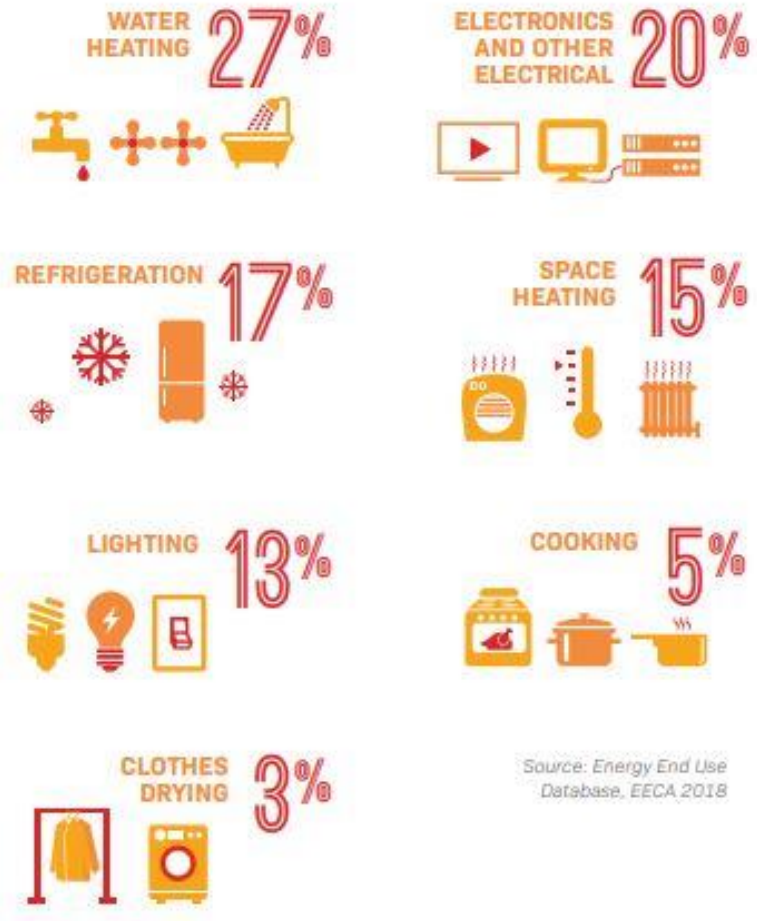
US Greenhouse Gas Emissions, 2018 (MMT CO_2 Eq)



Source: "Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2018", EPA

TYPICAL HOUSEHOLD

ELECTRICITY USAGE



Source: Energy End Use Database, EECA 2018

BOOST INSULATION

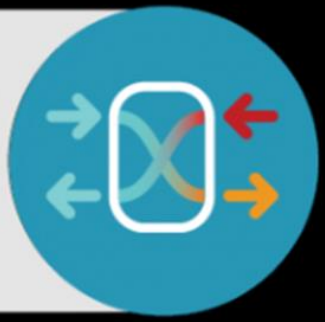
To reduce heat loss, increase insulation in walls, floors, roof, and foundation.

BAN BRIDGES

A break in your insulation acts like a bridge that carries heat straight out of the house. Take care with corners, junctions, gaps and studs!

VENTILATE SMARTLY

Bring plenty of fresh air into the home and recover heat from the exhaust air leaving the building.



SEAL IT UP

Air leaks are heat leaks. Wrap the home tightly, taking care to seal around ducts, pipes, fixtures, and wires that pass through walls, ceilings, and roof.

MIND YOUR MACHINES

Specify efficient appliances, and ensure your heating system will meet – but not exceed – the home's needs.

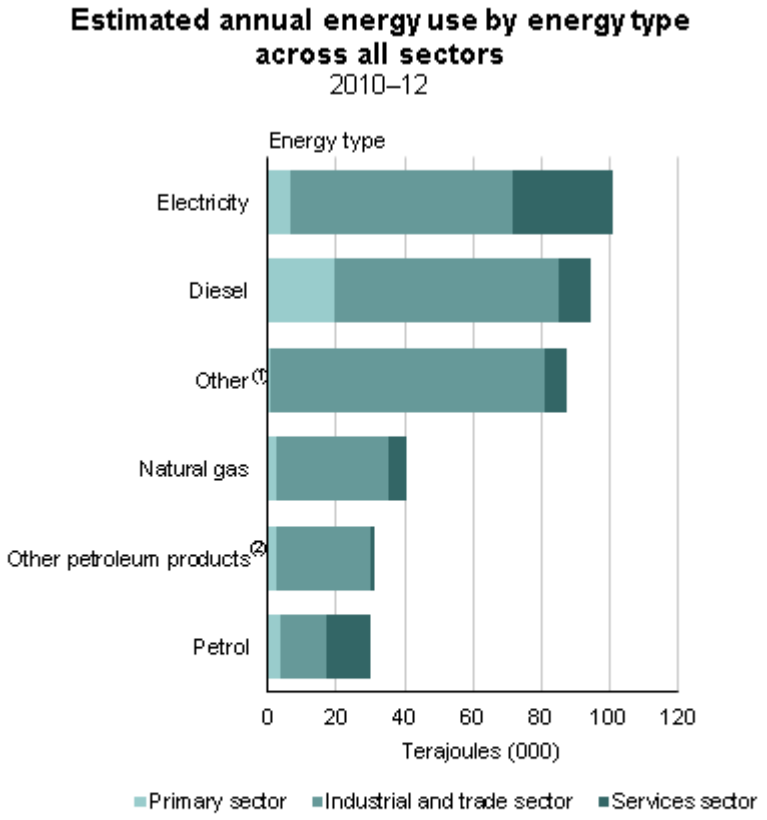
THINK ABOUT DOORS & WINDOWS

Carefully consider their energy performance, size, and location.

Efficiency Drivers

Commercial buildings could save $280 million – what about residential?

Save money, resources. Reduce pollution and CO_2 in atmosphere



1. Includes other fuels not captured elsewhere; eg coal, wood, steam, and waste oil
2. Includes other petroleum products not captured elsewhere; eg fuel oil, LPG, and aviation fuel.

Source: Statistics New Zealand

Low Energy Living

- Planning
- Design
  - Location
  - climate
- Savings up to 40%

Other Features

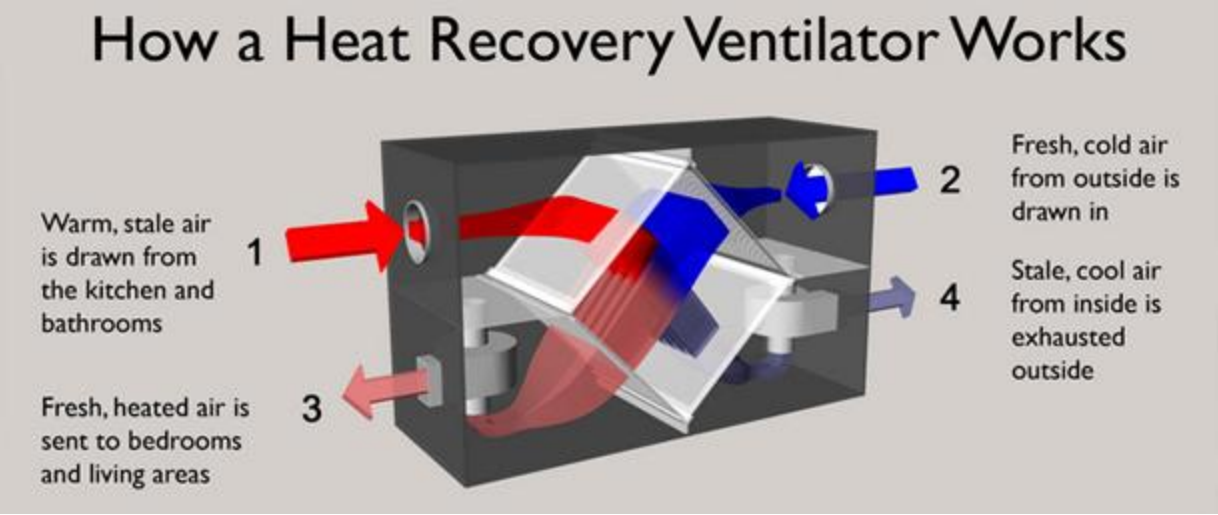
Attention to:

- external walls
- roof
- windows

include optimal sealing, insulation and radiant barriers

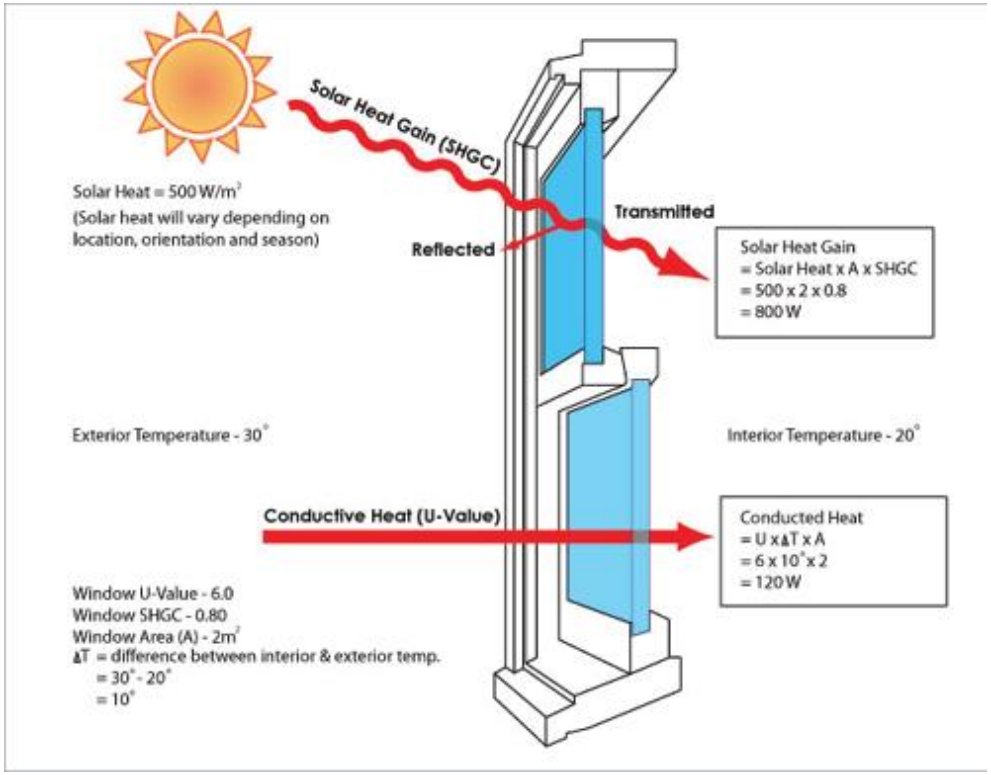
- HRV

Heat Recovery Ventilation



https://www.youtube.com/watch?v=Ut9wQmbUY7I

Solar Radiation and Materials

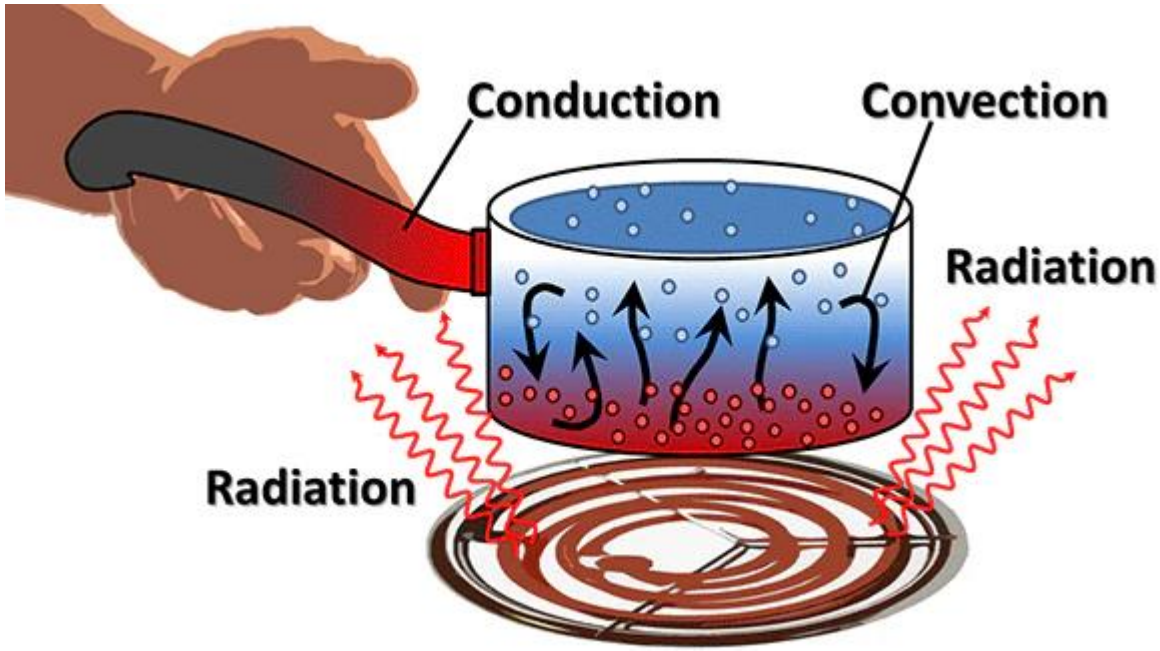


- **Reflect**
- **Absorb**
- **Transition**

Reflection of solar Radiation

Unwanted Heat Transfer

- **Radiation**
- **Convection**
- **Conduction**



Convection

Prevention methods:

- Air barriers
- Sealing gaps around windows, doors and any other openings to the exterior.
- Air-lock entrances
- Heat recovery ventilators

Conduction

The conductivity of a material (U-value) is the inverse of its resistance (R-value).

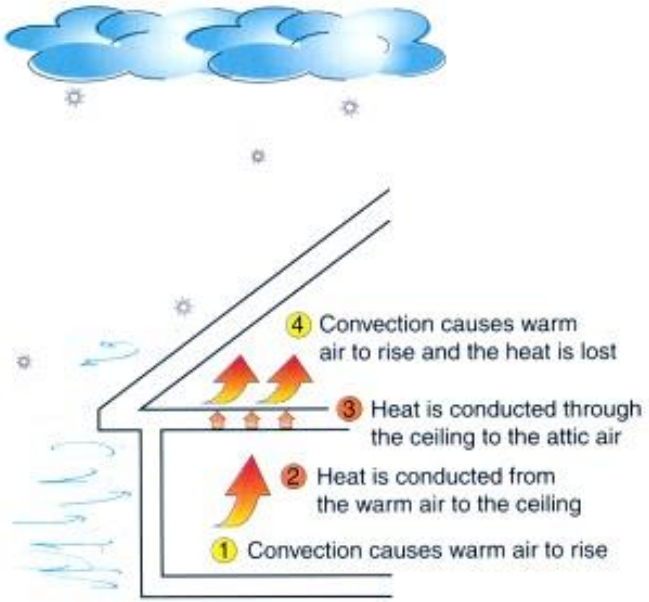
Insulating materials have a high R-value and are important for the prevention of heat transfer by conduction.

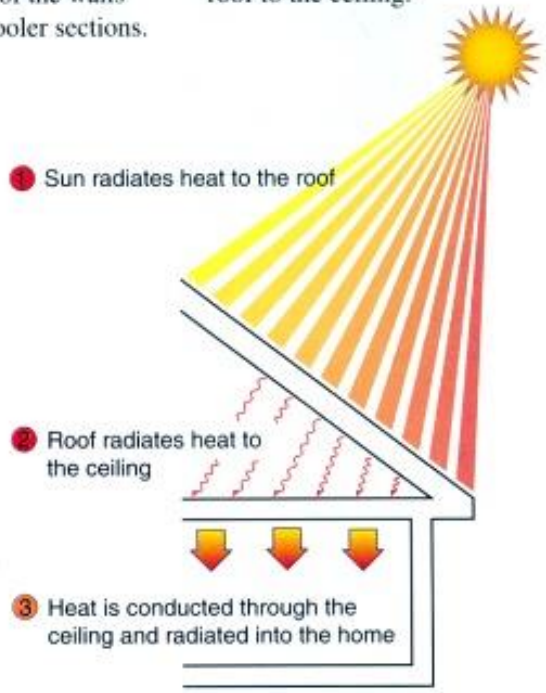
Amount of insulation and benefits of insulation increase in climates which have significant temperature differences between indoor and outdoors.

Heat Loss & Gain

Your Home Loses and Gains Heat in 3 Ways

	Convection	Conduction	Radiation
Definition:	The transfer of heat by moving air.	The transfer of heat through a solid material.	The transfer of heat in the form of electromagnetic waves.
Example:	Warm air rises and transfers heat to the ceiling	Heat is transferred from warmer sections of the walls and ceilings to cooler sections.	Heat is transferred from the roof to the ceiling.





Lighting

Efficient lighting benefits:

- Less energy consumption
- Reduced cooling load from unwanted heat energy

Daylighting

Other benefits:

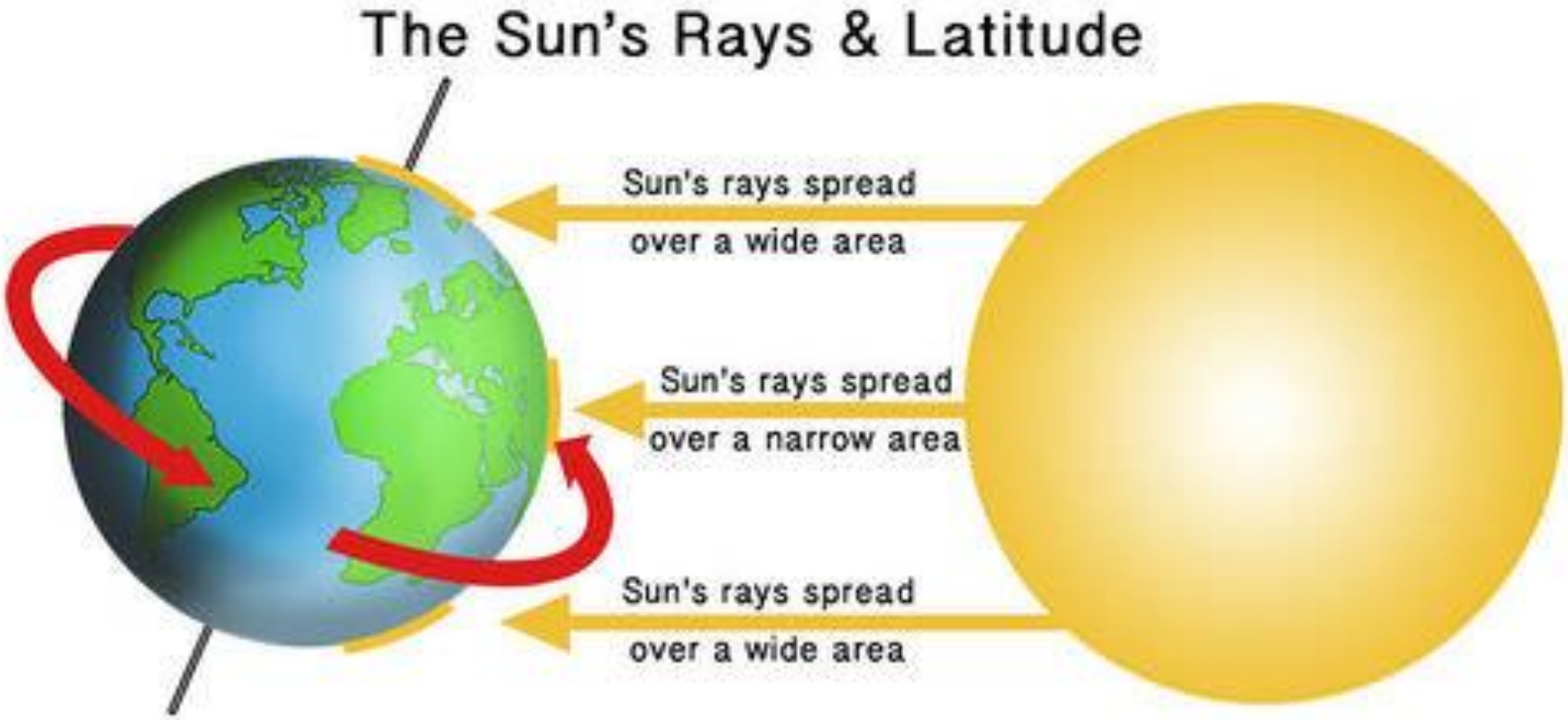
- Improved visual amenity
- Enhanced productivity and well being
- Connection to nature
- https://www.youtube.com/watch?v=hPXjzsXJ1Y0

Solar Energy

1 day sunlight = 27 years demand

Two main types of solar heating:

Passive and **Active**



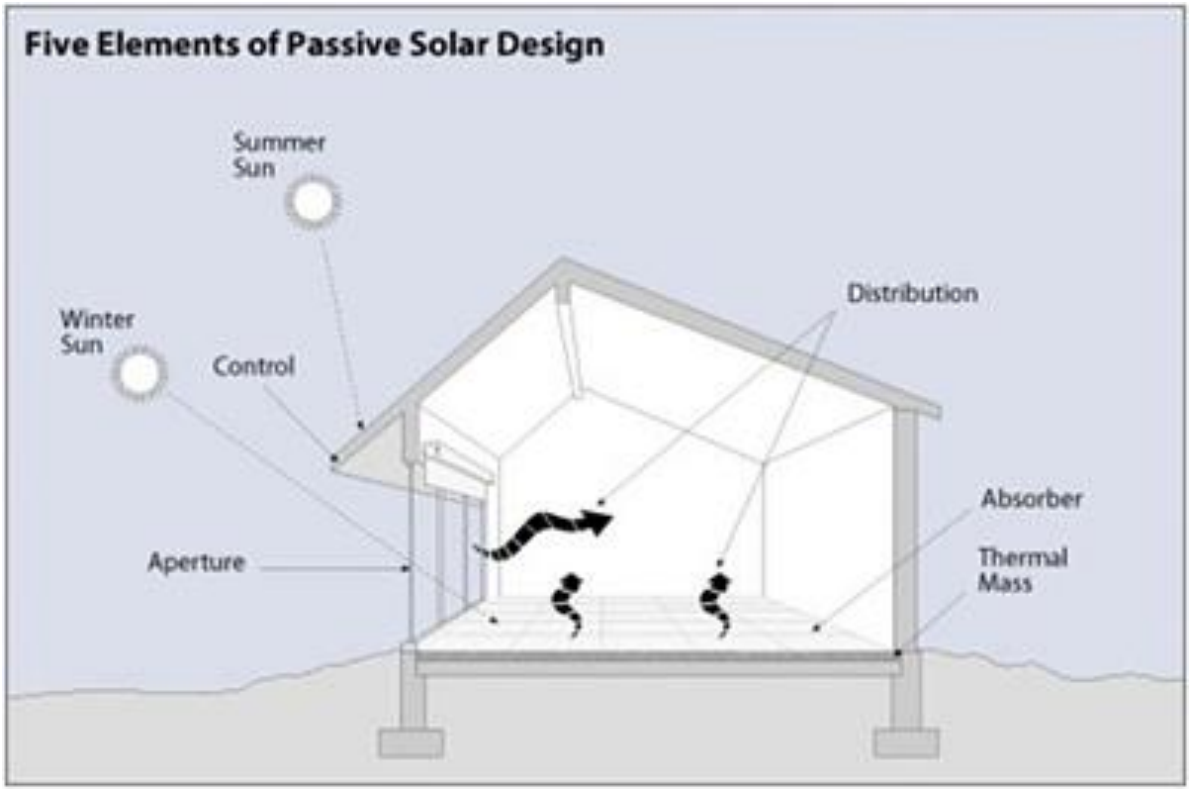
Passive Solar

Collection, storage and distribution

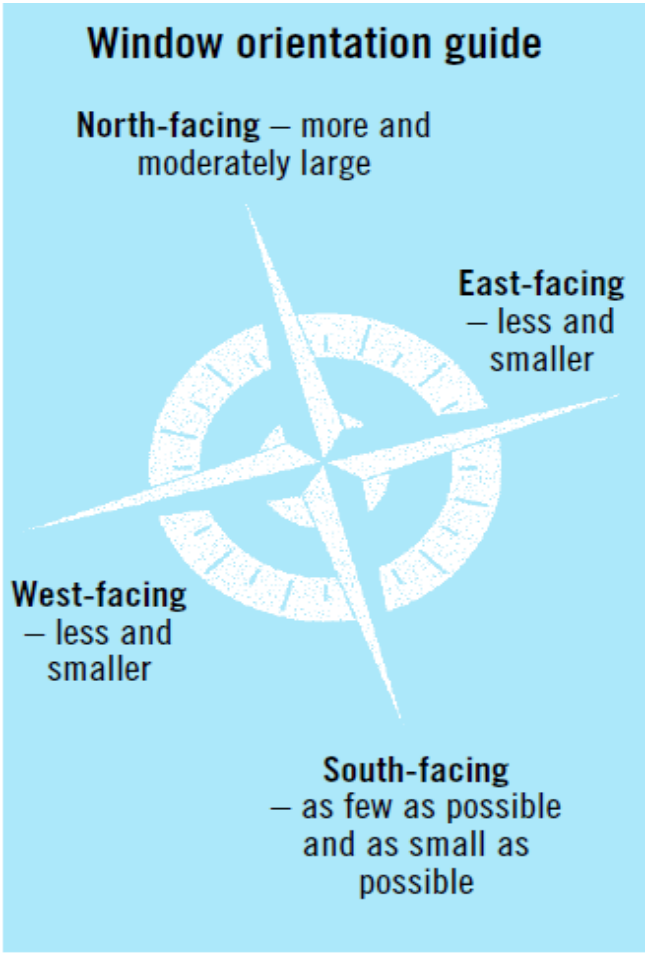
Windows, walls, floors

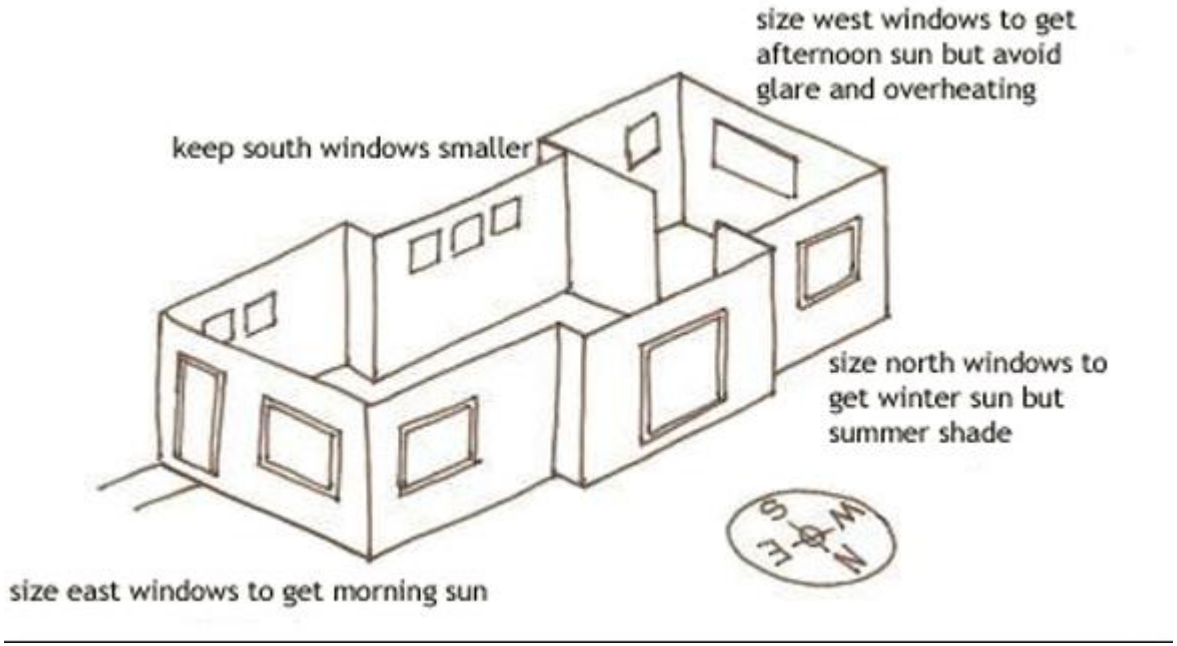
https://www.youtube.com/watch?v=YylmeMilok8

Five Elements

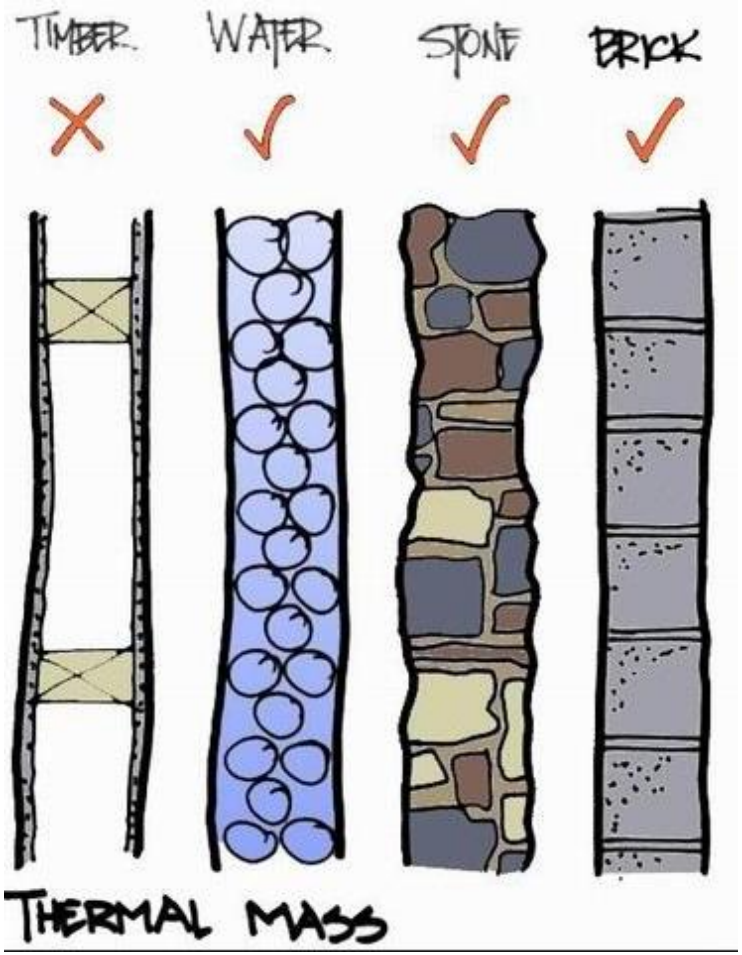


Window orientation





Thermal mass



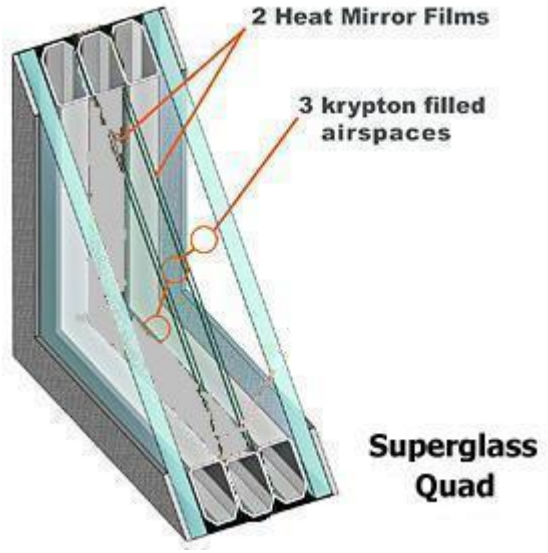
Material	Density(Kg/m3)	Specific heat(kJ/kg.K)	Thermal mass (kJ/m3.K)
Water	1000	4.186	4186
Concrete	2240	0.920	2060
AAC	500	1.100	550
Brick	1700	0.920	1360
Stone (Sandstone)	2000	0.900	1800
FC Sheet (compressed)	1700	0.900	1530
Earth Wall (Adobe)	1550	0.837	1300
Rammed Earth	2000	0.837	1673
Compressed Earth Blocks	2080	0.837	1740

Windows

Consider climate, solar orientation and building use.

High performance windows:

- Lower temperature differential near window space
- Smaller HVAC
- Less fading from UV light
- Less noise transfer
- Less condensation
- Better daylighting

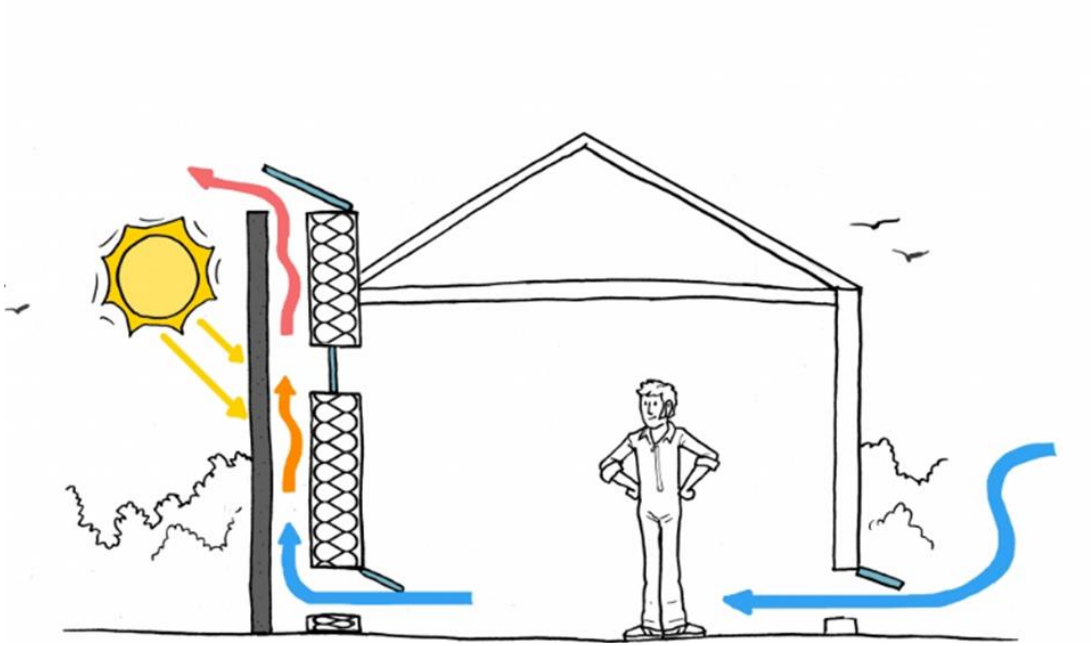


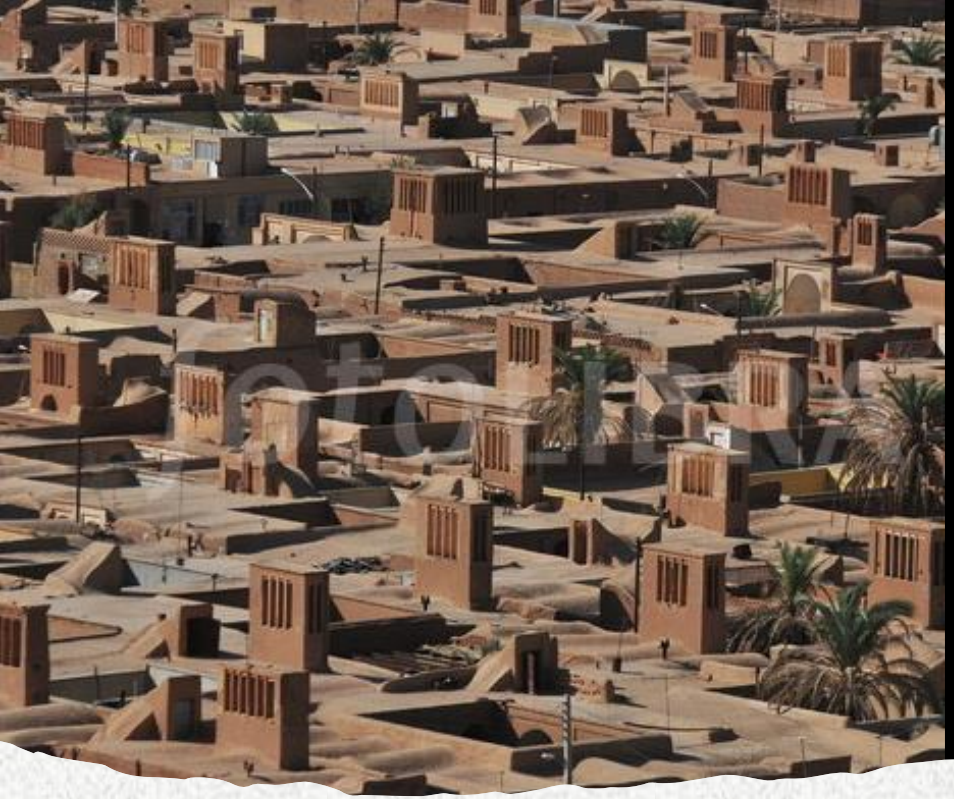
Cooling

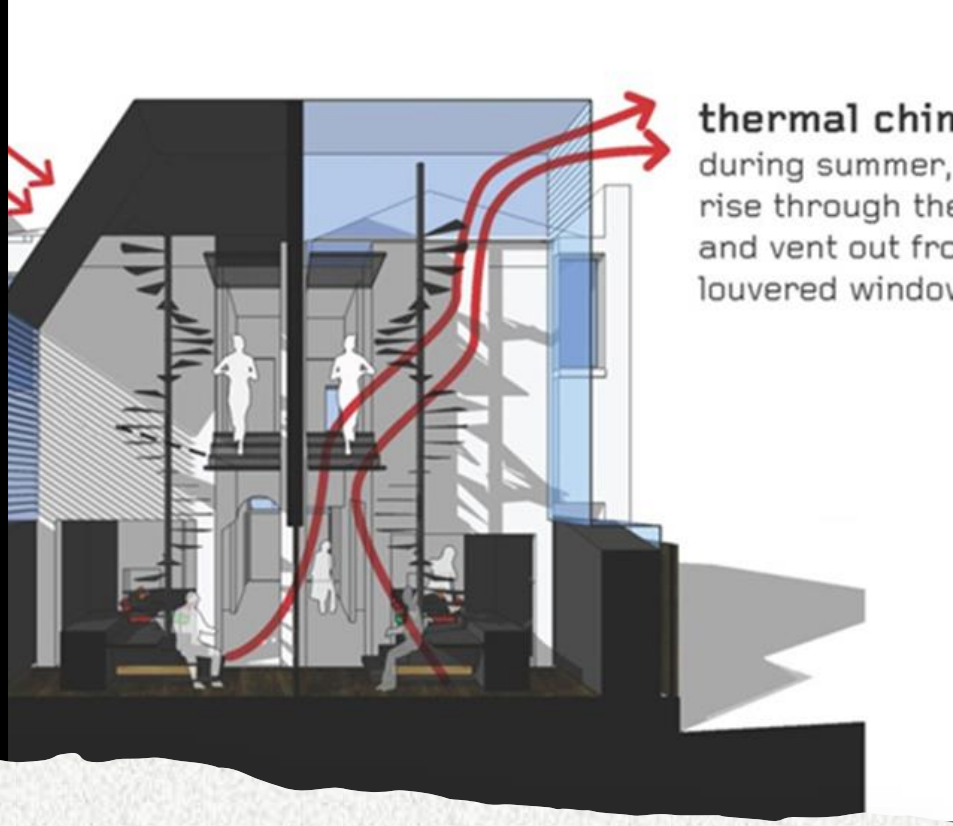
Effectiveness depends on climate

Hot, dry climates:

- Thermal chimneys
- Evaporative cooling
- Earth sheltering and Earth coupling techniques







Thermal Chimneys

https://www.youtube.com/watch?v=g4c2Nl7fHL8

Earth Sheltering & Coupling

Use ground as thermal mass

Sheltering also protects from severe weather

Coober Pedy, South Australia

- Underground homes
- 80% population
- Outside 50 ^{o}C
- Inside 23-25 ^{o}C

https://www.youtube.com/watch?v=-1XSKu3pK8A

Temperate climates

Thermal mass cooling may be used in climates with a large diurnal swing.

A large indoor building mass absorbs heat during the day (and releases during the night).

Humid Climates

Lowering humidity can make warmer temperatures more tolerable.

Radiant cooling - not a passive technology but is very efficient.

This often involves running cool water through floor slabs, walls or ceilings.