2013 Solar Decathalon international sustainable housing competition entry by Wollongong Uni students

Key Issues for Building Healthy, Safe Homes that offer Affordable Living

Building energy-efficient houses that save money and help the environment Webinar

• Cobargo and Region Energy Transition Group •SouthCoast Health and Sustainability Alliance (SHASA)

•Clean Energy for Eternity, Bermagui (CEFE)

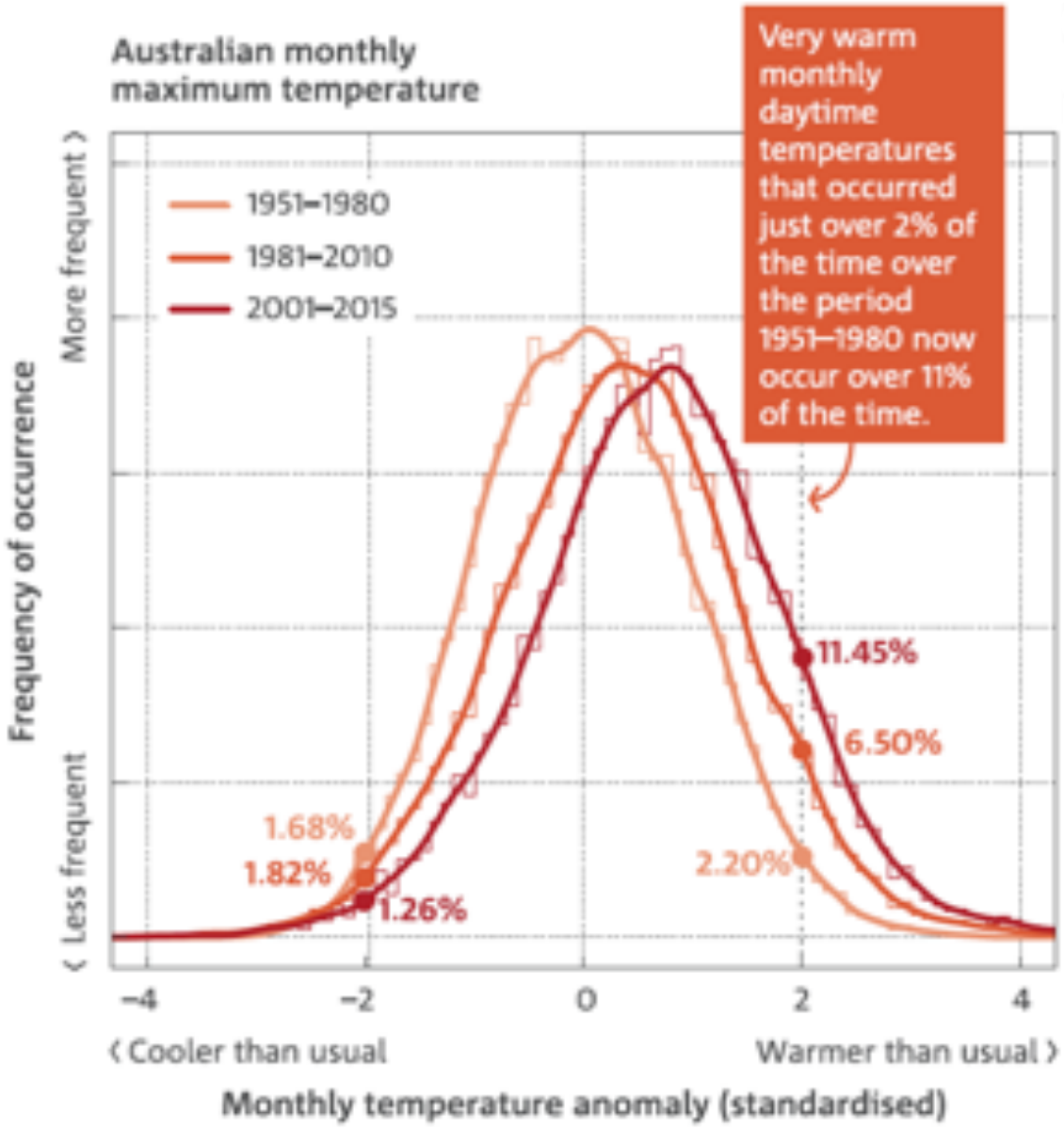
Alan Pears AM

Senior Industry Fellow, RMIT, Fellow, University of Melbourne Climate and Energy College

26 August 2020

Issues for this region

- Climate: varies from mild coastal to more extreme inland areas – and climate is changing!
- Trauma, financial, insurance, rebuilding, adjustment after fires
- Increasing fire risk, beach erosion, flooding
- Central energy supply resilience and reliability in decline? And desire for energy independence?
- Focus on ‘Beyond Zero Carbon’ society
- Exciting innovation is emerging from many directions
- ???



State of the Climate 2016, BoM

Climate change is driving serious changes we must factor into building design:

- More extreme temperatures with longer hot spells, warmer, more humid nights and higher winds
- Increasing bushfire risk, more areas affected and shifting – need to upgrade fire performance or relocate?
- Increasing risk of flooding, inundation, overloading of stormwater pipes and drains due to:
  - higher peak rainfall– each degree of temp rise increases air's capacity to hold water vapour by 7%
  - Rising sea levels, storm surges
- Increasing risk of failures of infrastructure – energy supply, water, transport, cooling equipment
- Financial impacts on owners of land, assets and businesses impacted by changes
- Psychological impacts of uncertainty and increasing frequency of 'natural' disasters
- Impacts on supply chain businesses of changes in policies, regulations and consumer expectations

A strategy helps planning

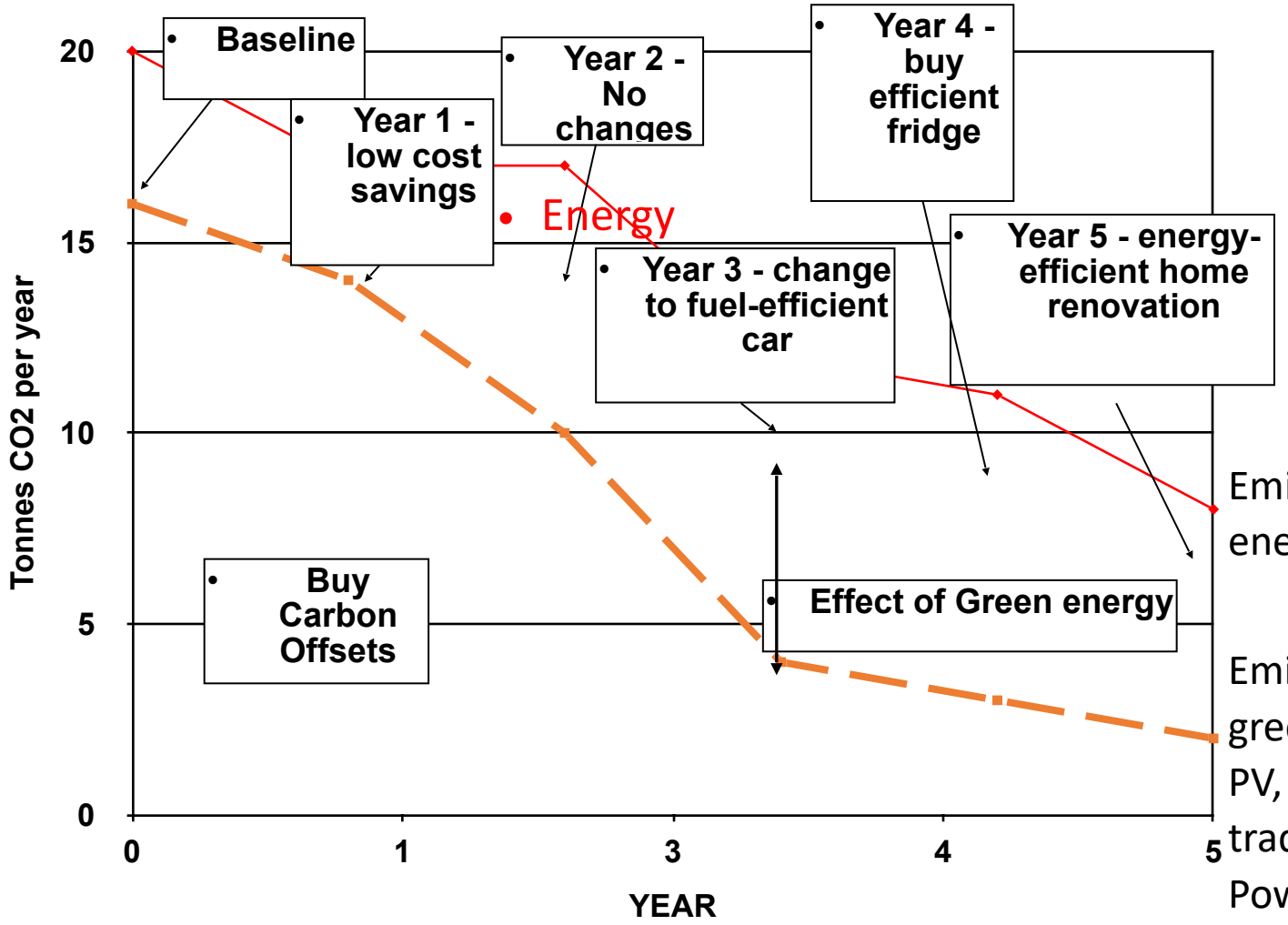
Example of a personal zero emission strategy for household energy-related emissions – some or all of remaining emissions can be offset each year. Plan ahead to empower and avoid crises

To estimate base year and ongoing emissions:

ENERGY/fuel: use billing data and emission factors from **National Greenhouse Accounts Factors - August 2019** or options below ENERGY, FOOD, WASTE, GOODS, etc: NGAF (above), https://www.climateactive.org.au/

EPA Vic calculator (till Dec 2020) https://apps.epa.vic.gov.au/AGC/home.html only works with Internet Explorer or if Flash enabled); https://www.carbonfootprint.com/calculator.aspx (US EPA); https://carbonneutral.com.au/carbon-calculator/ (log-in for detail)

Also consider your emissions from

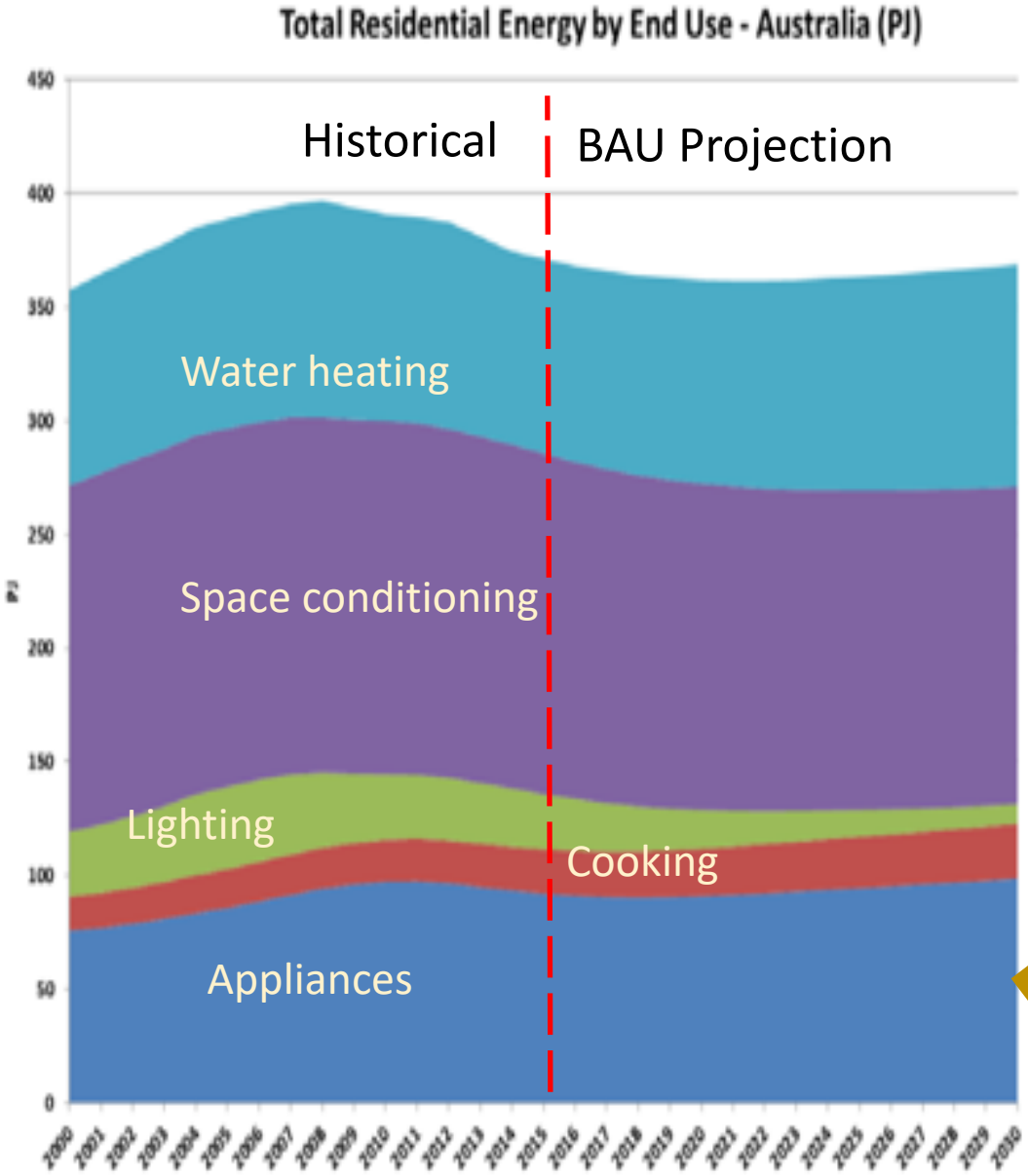


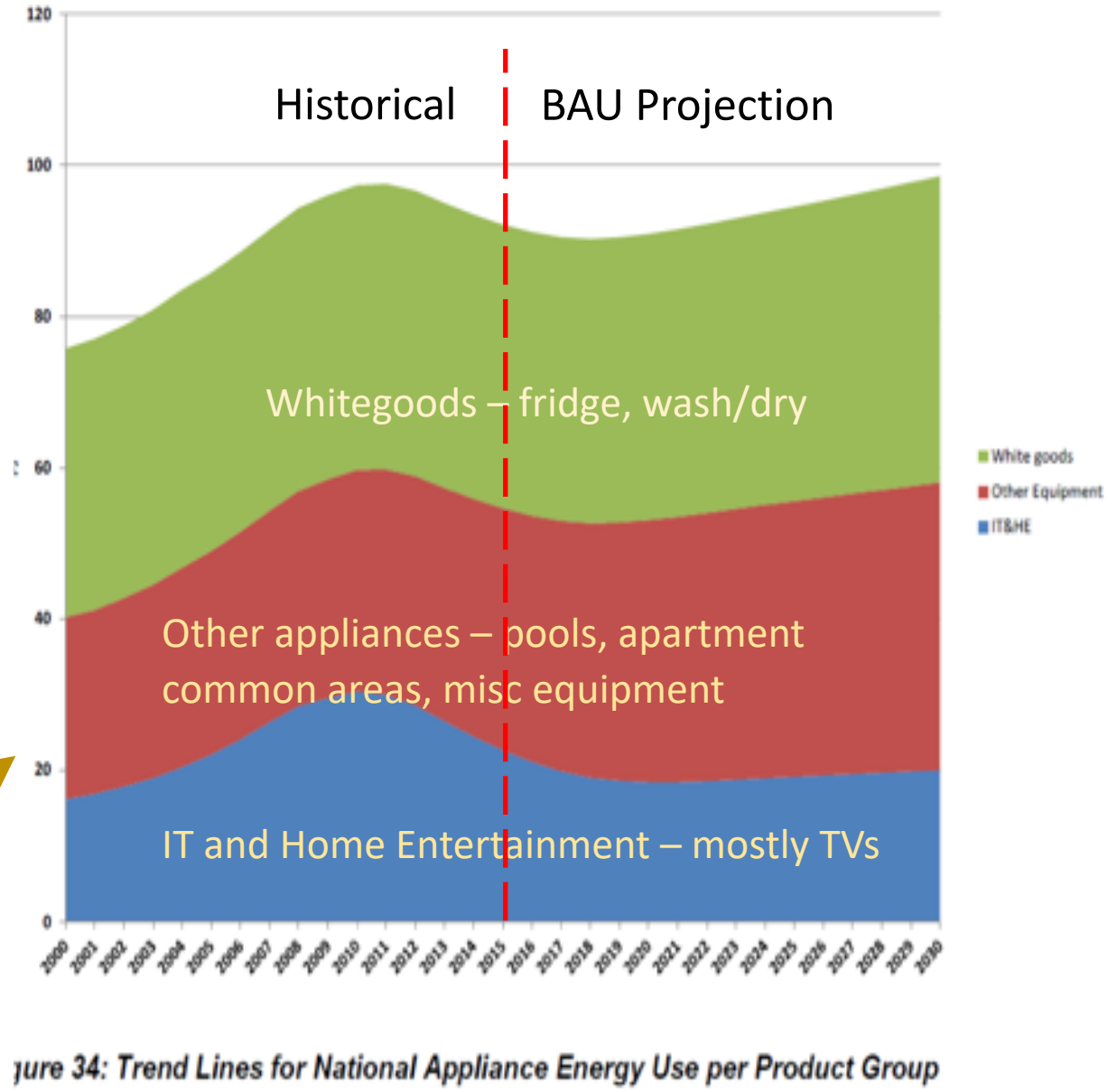
Emissions after cutting energy waste

Emissions after using green energy – on-site PV, buy RE, micro-grid, trading, buy Green Power etc

Australian Residential BAU final energy trends 2000 to 2030

(Residential Baseline Study 2015, EnergyConsult)





ure 34: Trend Lines for National Appliance Energy Use per Product Group

Making decisions: costs, benefits and opportunities

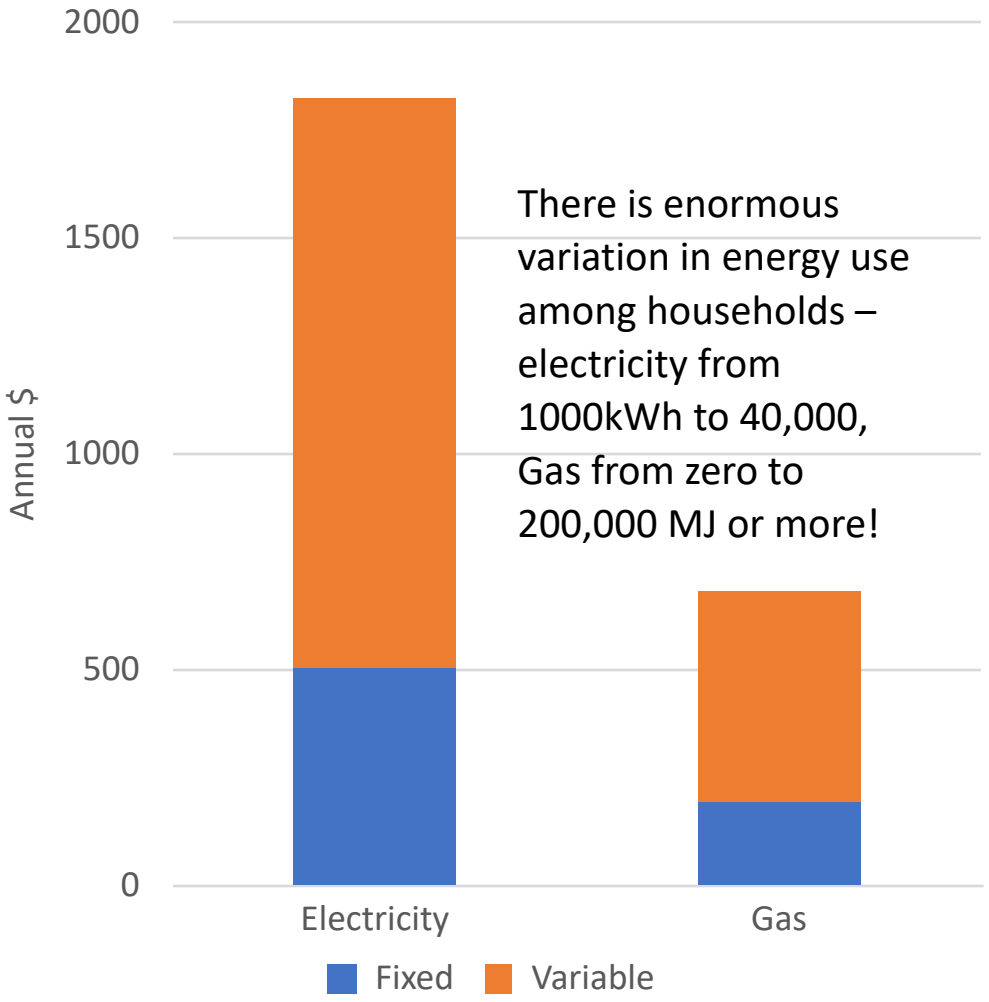
Making building-related decisions is difficult. Issues include:

- Access to capital, its cost and repayment period
- Uncertainty about returns, implementation risks, equipment reliability, future maintenance…..
- ‘Lock-in’ impacts on future living costs and behaviour
- Factoring in ‘multiple benefits’, eg health, comfort, noise, maintenance, durability, capital/operating cost of other elements

Approaches to financial analysis:

- Payback period – psychologically negative and very conservative
- Cash flow: if borrowing some or all of $, do savings offset repayments?
- Rate of return on investment compared with ‘cost of capital’/ return from other investments
- Lifetime cost – capital, operation, maintenance, disposal
- Risk of existing equipment failing

www.energymadeeasy.gov.au/ using prices from Globird

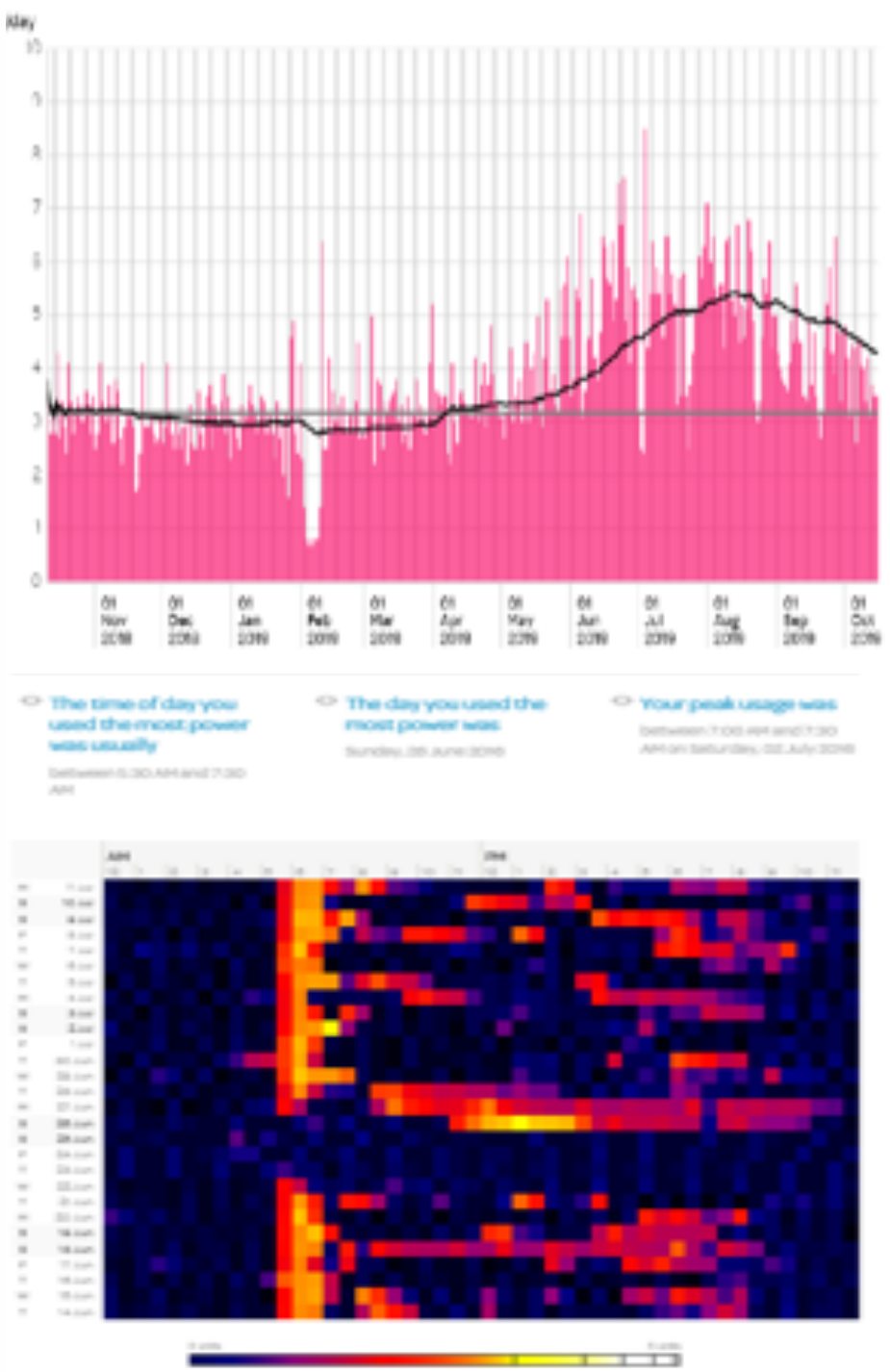


There is enormous variation in energy use among households – electricity from 1000kWh to 40,000, Gas from zero to 200,000 MJ or more!

- Elect fixed charge $501.88/y first 912.5 kwh/month 23.98c - $218.82, then 27.5c 2-3 people ave elect use 15.1 kWh/d 5512 kwh/y, 4-5 pple 19.7 kWh/d 7191 kwh/y
- Gas $192.72 pricing first 629 MJ/month 3.19c $20.07 then 2.26c/MJ 2-3 people ave gas use 50.8 MJ/d 18542 MJ/y, 4-5 pple 59.4 MJ/d 21681 MJ/y

Information empowers

From https://www.agl.com.au/yourenergyinsights



All new home and replacement meters now are ‘smart’ electricity meters that collect half-hourly usage data – available next day from retailer or network operator – real time data more useful, eg PowerPal, PV data.

Most retailers and network operators offer tools to analyse usage. Many solar systems provide useful data. Energy advisers can interpret this if you or a friend can’t

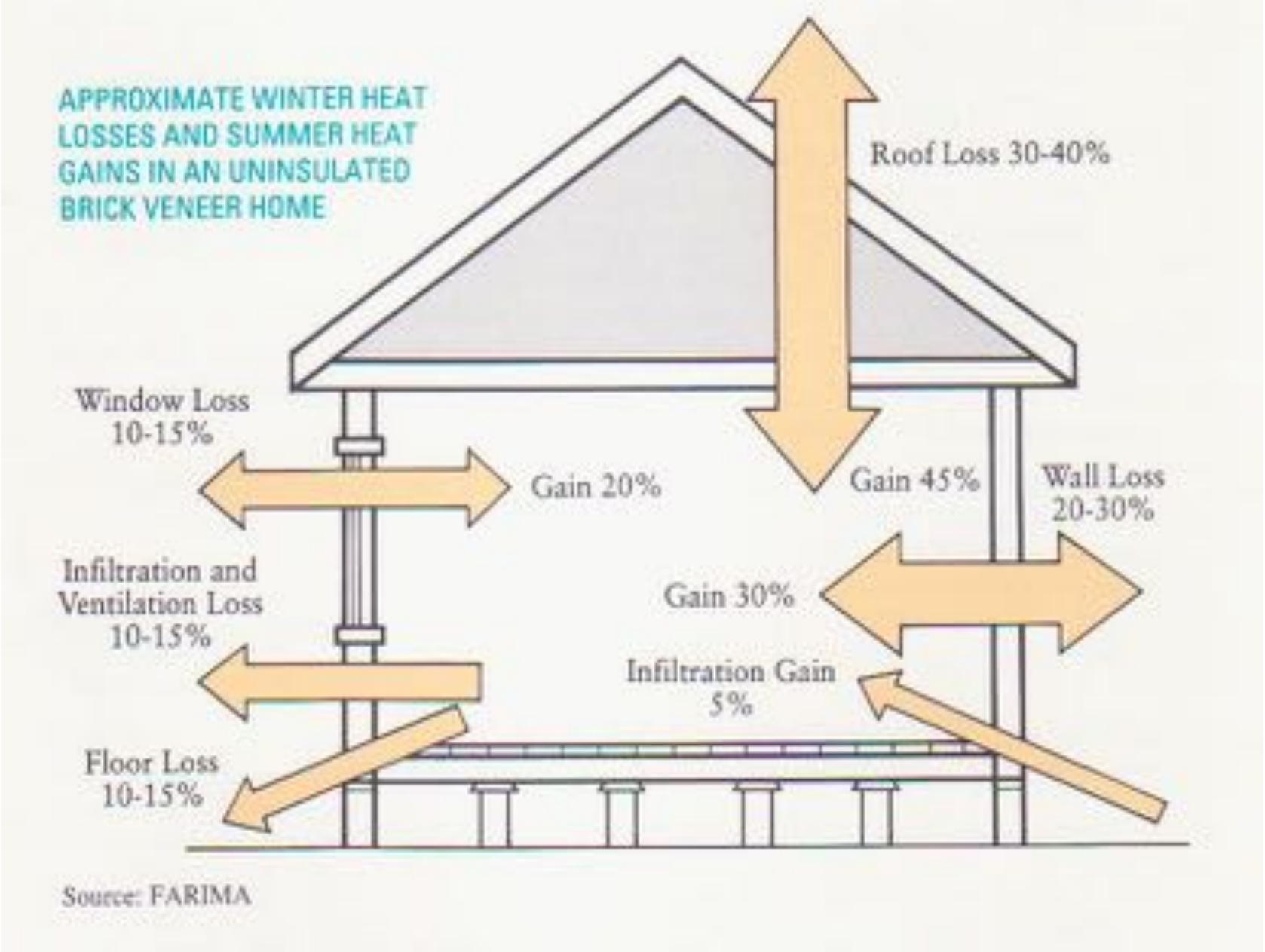
For a time (eg a week) keep a diary of activities and match against usage

Increasing use of data analytics to provide personalised, activity-level insights, identify faults. Soon we will have adapters for gas, water and older electricity meters to talk to the ‘cloud’ with real time data

Building energy issues

Location	Transport energy – access to services Climate Access to energy sources (eg gas)
Site	Solar access Exposure to wind, microclimate Impacts on neighbours - shading
Building orientation and position	Utilisation, protection of solar access potential Amenity (eg outdoor spaces) Impacts on neighbours – and theirs on us
Building envelope design	Floor area/size Fuel/energy source selection - solar Envelope energy efficiency, peak demand Embodied energy and emissions of materials
Equipment and systems in building	Energy efficiency, energy sources Range of equipment installed Lifecycle impacts of materials, management, lock-in

Building Fabric – the basic issues



Roof: insulate; foil and/or light roof colour for summer

Walls: insulate, light colours or shade on west

Floor: slab-on-ground; insulated suspended floors

Windows: orientation, size, low-emissivity double glazing; adjustable, light-coloured shading (shade ground as well as window)

Air leakage: seal leaks, install energy recovery ventilation (eg passivhaus approach) – use plastic film draped over coat hanger on windy day to detect leaks

But there are many subtleties!

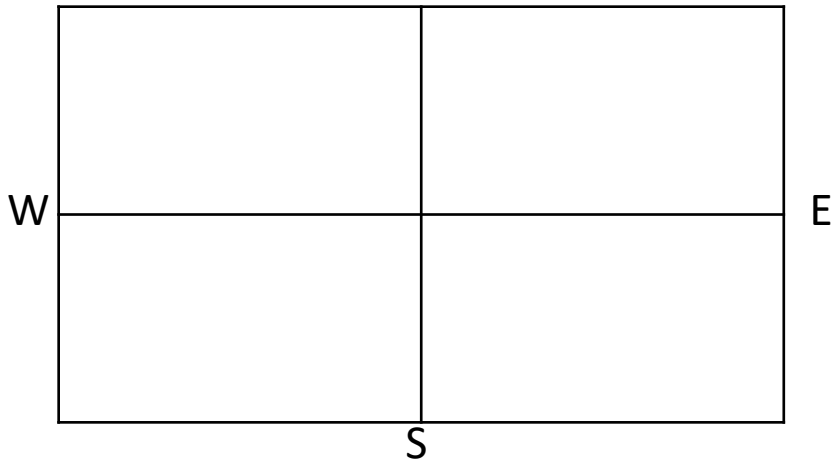
Orientation issues

Differently oriented rooms behave differently

Low winter sun – obstructions may limit solar gain
Large windows mean high winter solar gains but large heat loss when cloud or no sun: advanced glazing cuts heat loss.
High summer heat gain
Fixed shading good in Dec-Jan but not in hot March: need adjustable shading of windows AND ground

Sun symbols show where sun rises and sets, and that it is high in the sky at midday in mid-summer, but low in the sky in mid-winter

Afternoon winter sun (good for bedrooms)
Needs protection from afternoon summer sun
Hot summer afternoon micro-climate unless extensive shading
If advanced glazing used, can provide net winter energy benefit
NW facing PV generates more during afternoon peak periods



Cooler all year round
No direct sun for much of year
Cold winter winds

North-east glazing can work well if shaded in summer
Morning winter sun (good for living areas)
Needs protection from summer morning sun: well-placed vertical shading can be good
Building and outdoor areas protected from afternoon summer sun
If advanced glazing used, can provide net winter energy benefit

Residential contribution to summer and winter system peak demand

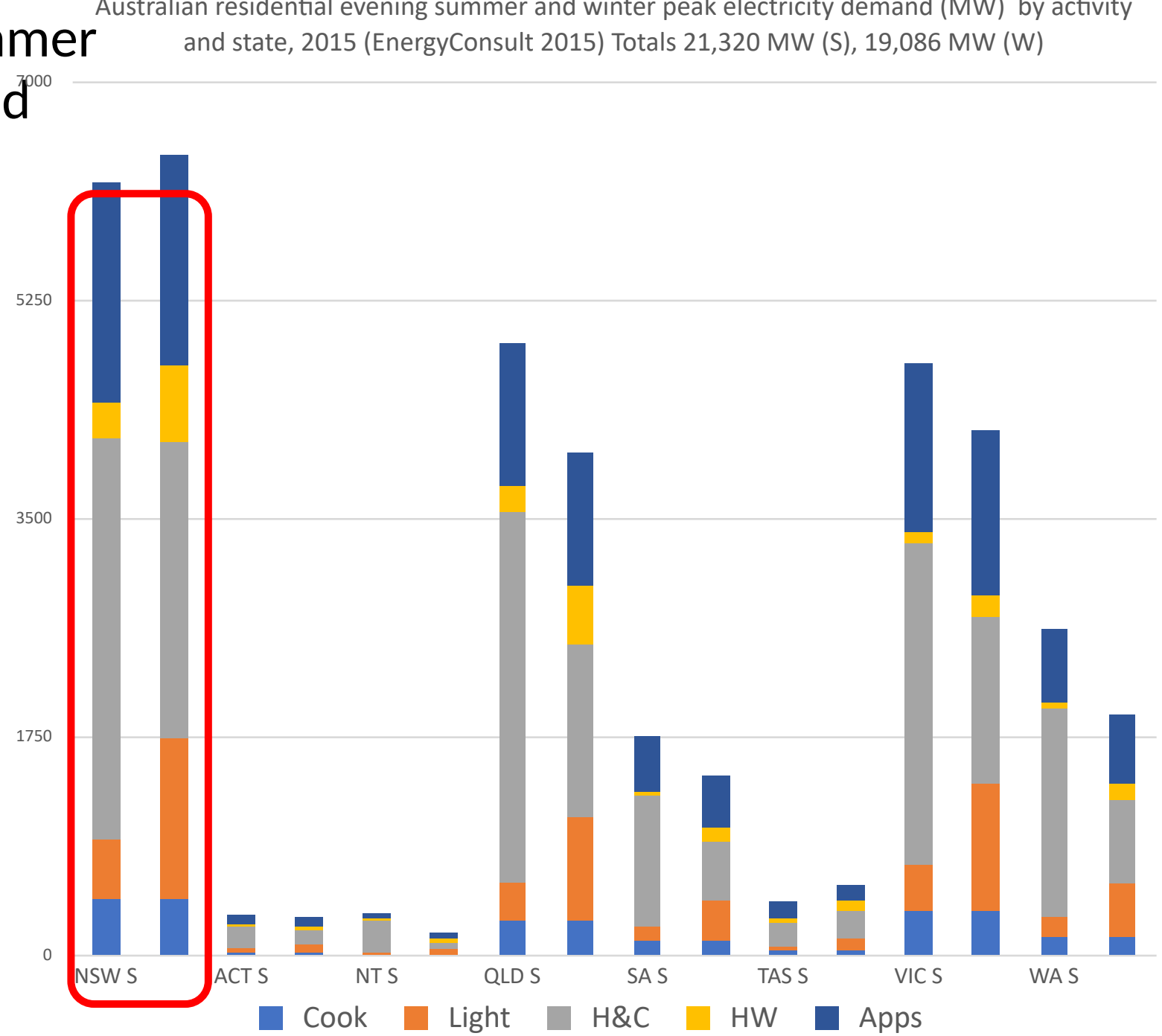
Cooking S&W – will increase if many switch from gas – unless more efficient, smarter, manage peak demand

Lighting W but some summer – LEDs (increasing efficiency), smart controls and ‘sensible’ numbers installed, behaviour

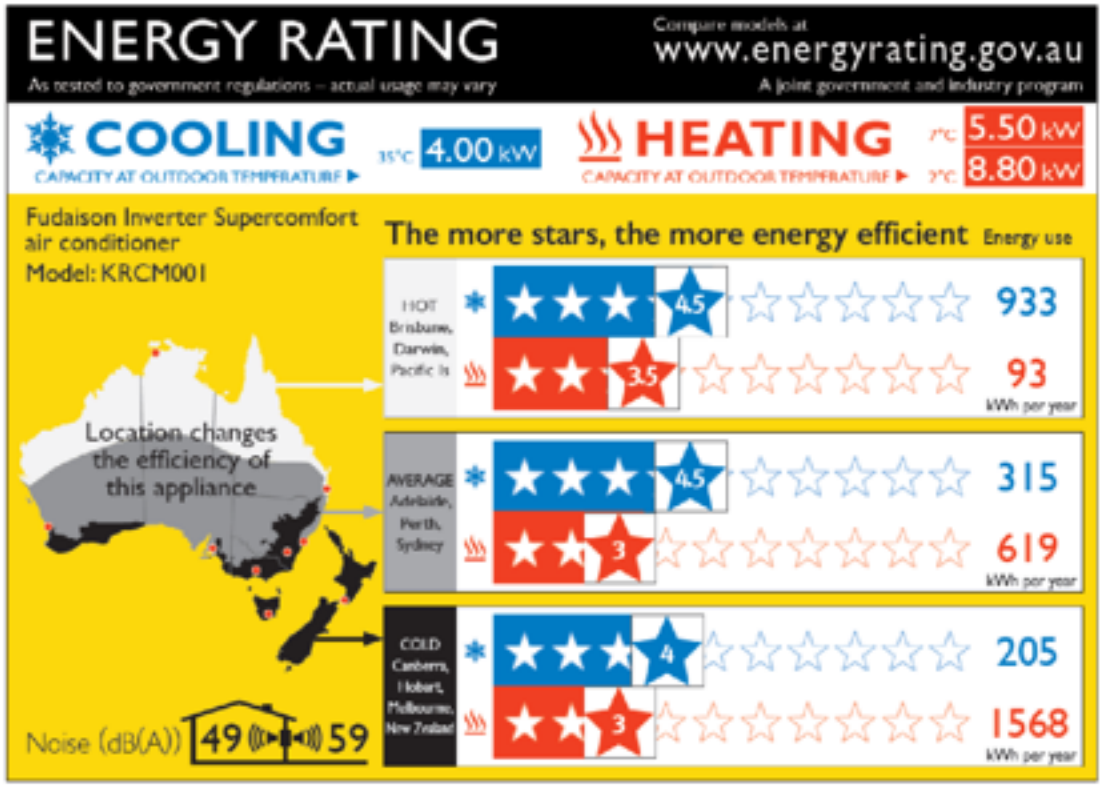
H&C S&W with W increase as many switch from gas and in S with climate change – unless high eff homes, high eff Rev Cycle a/c, zoning, behaviour, storage

Hot Water W but some summer – smart controlled heat pumps, water efficiency

Appliances S&W – TVs, IT big but big eff potential; high eff fridges; smart high eff pool pumps; DW&CW time managed+ high eff; misc cut standby+eff.



‘Best on market’ appliances typically use 50-80% LESS energy than worst available: an extra star means 15-30% energy saving



Appliance efficiency programs are saving an average Australian household $300 each year on energy bills.

Product lists are at www.energyrating.gov.au and an ‘app’ is now available.

Labelled products include:

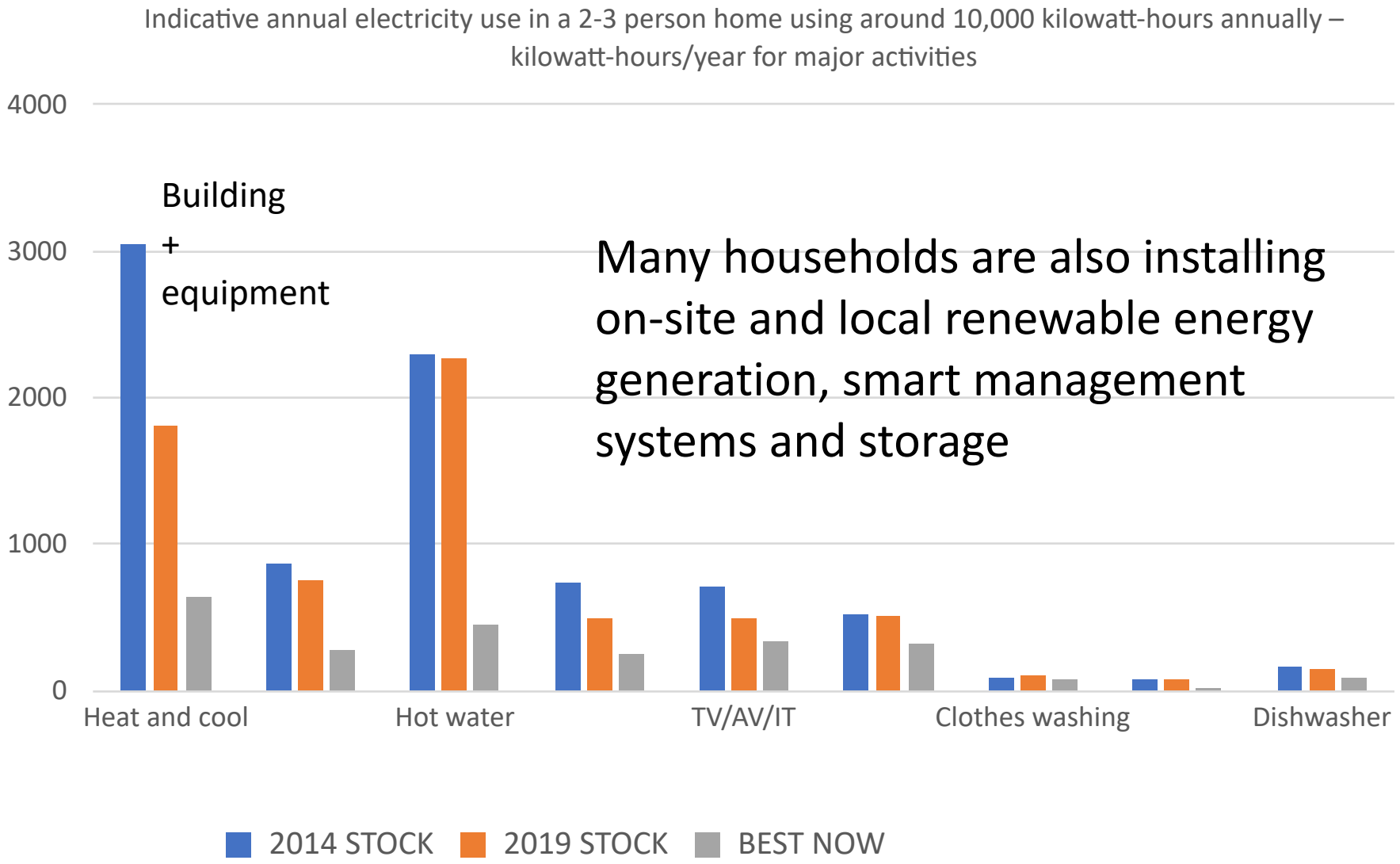
* TVs,
* fridges and freezers,
* dishwashers,
* clothes washers,
* clothes dryers
* Pool filter pumps
* airconditioners – new ‘climate zoned’ label being phased in

Residential: Technology transformation to cut energy use

(Based on Pears presentation to Sydney A2SE Workshop, April 2014, updated 2019, 2014 and 2019 stock energy use based on data from 2015 *Residential Baseline Study Worksheets* www.energyrating.gov.au)

Best practice features:

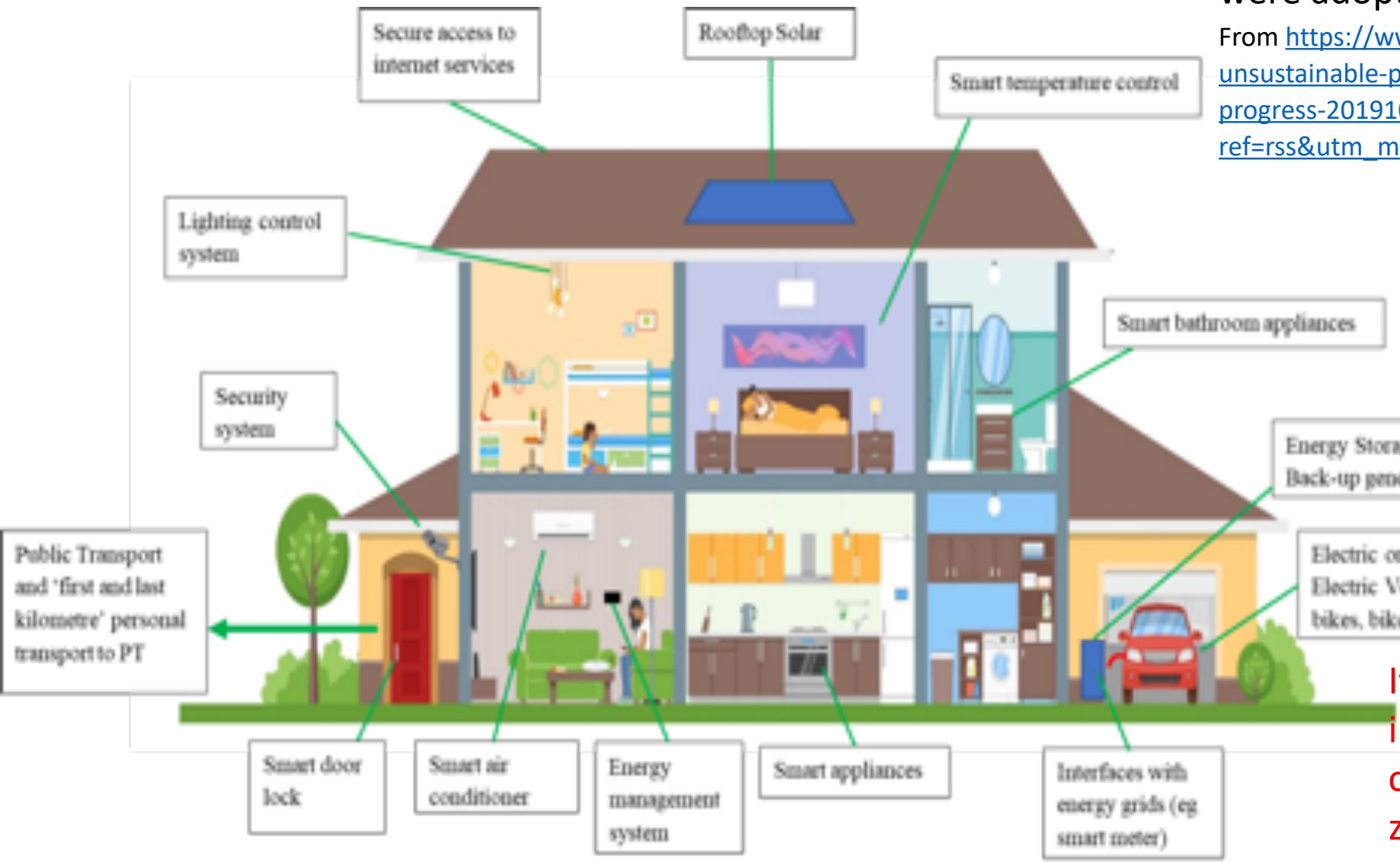
- Building: 8+stars with good summer and winter performance
- Heating/cooling: 5+star split-system reverse cycle airconditioner(s)
- Refrigeration: lowest annual consumption for size range
- Hot water: CO2 heat pump with user-friendly interface to program operating times
- Lighting: LEDs, lighting controls
- TV etc: 7+star TV, tablet or laptop computers, efficient monitors, modem/router
- Cooking: induction, careful cooking techniques, good management of range hood, efficient oven (www.topten.eu)
- Clothes wash: front loader, high spin speed
- Clothes dryer: 8 star heat pump
- Dishwasher: 4.5 star run when full



Many households are also installing on-site and local renewable energy generation, smart management systems and storage

Future home? Smart, connected, efficient and renewable

(from Pears and Moore chapter in *Decarbonising the Built Environment* Newton P et al, 2019, Palgrave Macmillan)



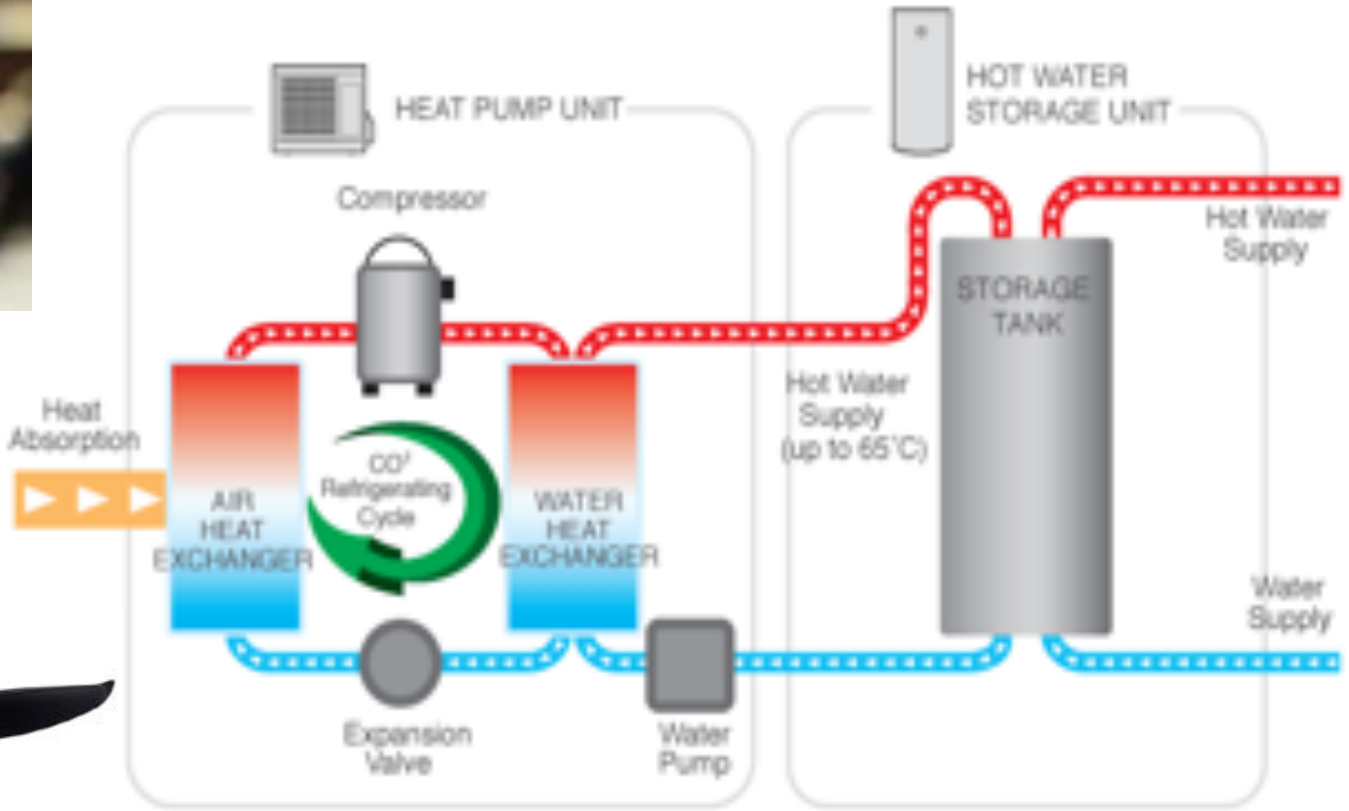
Mr Tricoire [CEO of Schneider Electric] said digitally-enabled energy-measures could assist in driving a 50 per cent reduction of carbon dioxide emissions by 2040 if they were adopted in half of existing buildings.

From https://www.smh.com.au/business/the-economy/unsustainable-path-energy-leaders-warn-on-lagging-climate-progress-20191013-p53066.html?ref=rss&utm_medium=rss&utm_source=rss_business

Integrating information from multiple data streams opens up many possibilities!

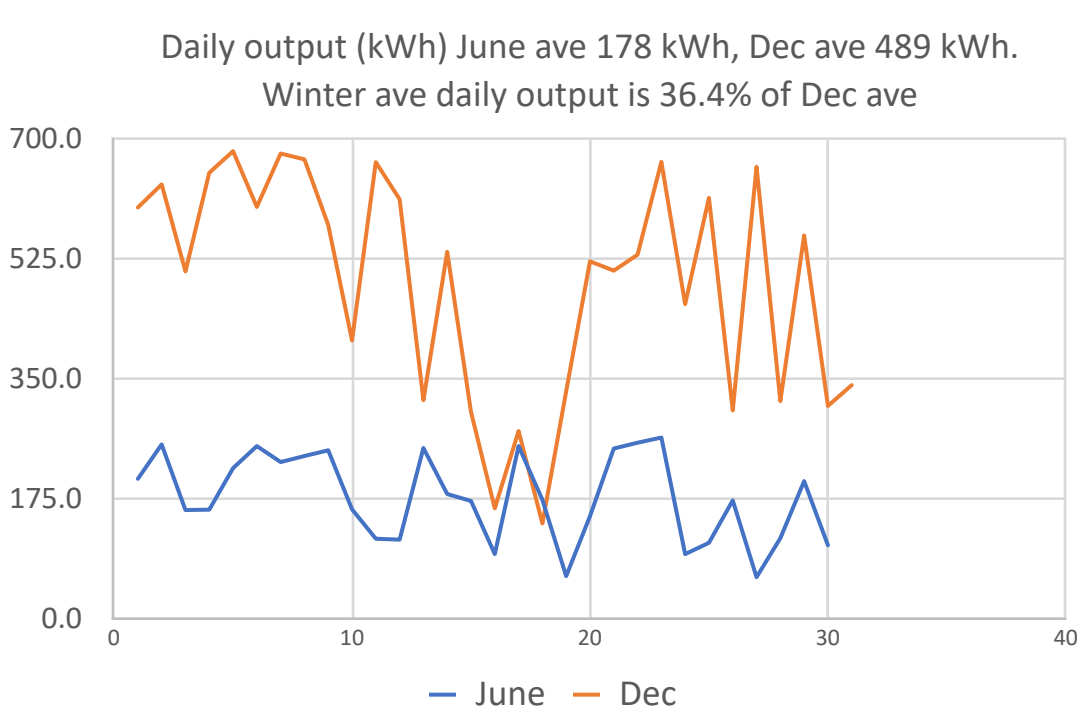
If up-front incremental cost built-into mortgage, potentially net cash-flow positive from day 1 – zero net energy/fuel cost

THE END - DISCUSSION



Integrated approach offers best outcome:

* Energy efficient, flexible, smart, connected equipment and systems to provide services
* Smart demand response and management
* Energy storage (electric, thermal, gravity etc)
* Energy production on-site, local
* Review energy tariffs/contracts to maximise benefit from above
* Trading energy, demand response and other services, Power Purchase Agreements, etc



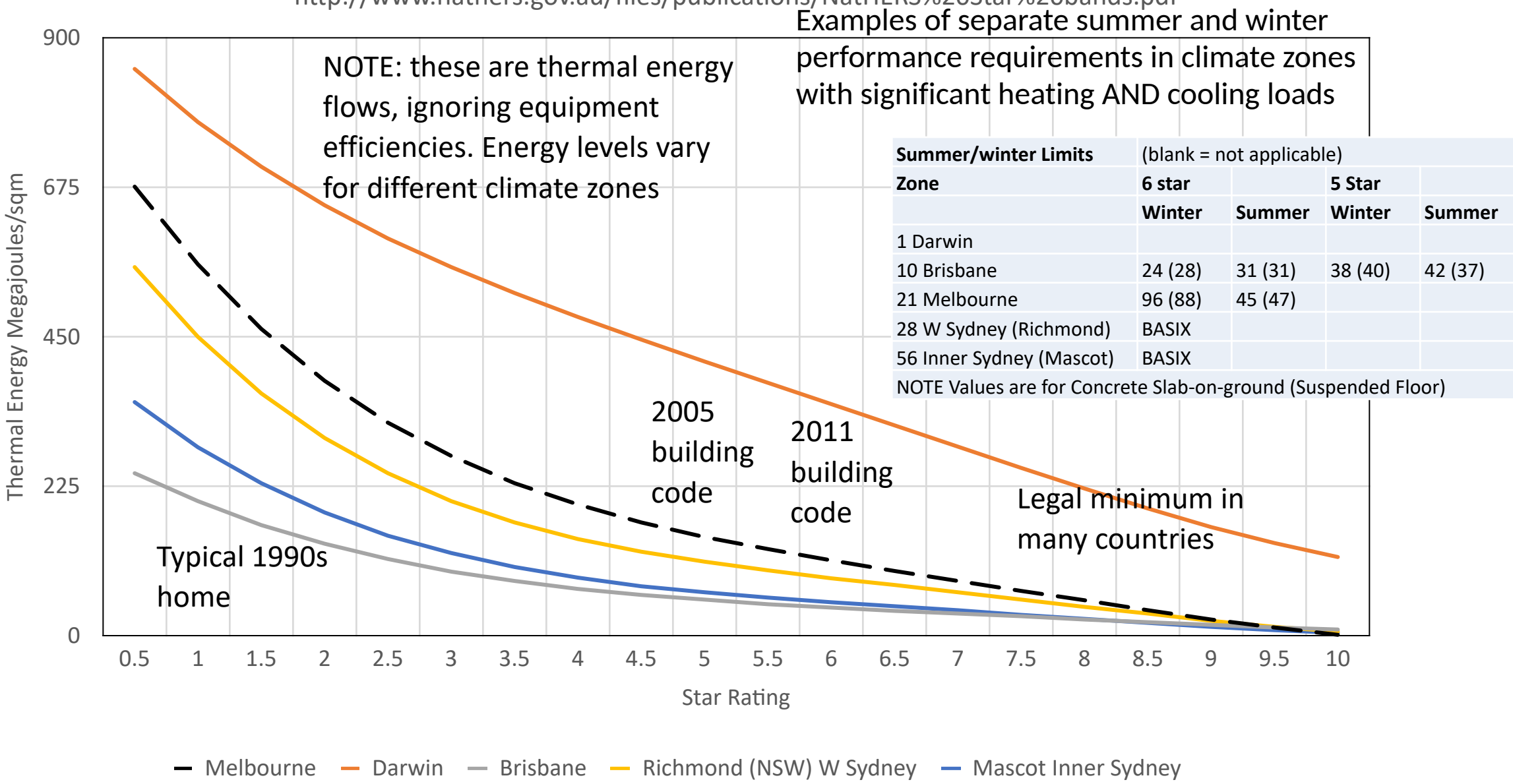
Energy efficiency and demand management can 'help' supply:

- Reduce energy consumption
- Reduce supply system losses
- Often reduce peak demand
- Reduce capacity of energy supply and storage required
- Reduce impacts of supply disruptions
- Reduce overall costs
- And more…… smaller capacity, often simpler and cheaper end use equipment

The Sunulator (at https://renew.org.au/resources/sunulator/ is a free analysis tool for grid-connected PV evaluation. https://pvwatts.nrel.gov/ is also useful.

In this thermal imaging photo, the areas in red show where a house loses the most energy

Examples of NatHERS residential building star rating annual thermal energy (megajoules/square metre) from http://www.nathers.gov.au/files/publications/NatHERS%20Star%20bands.pdf



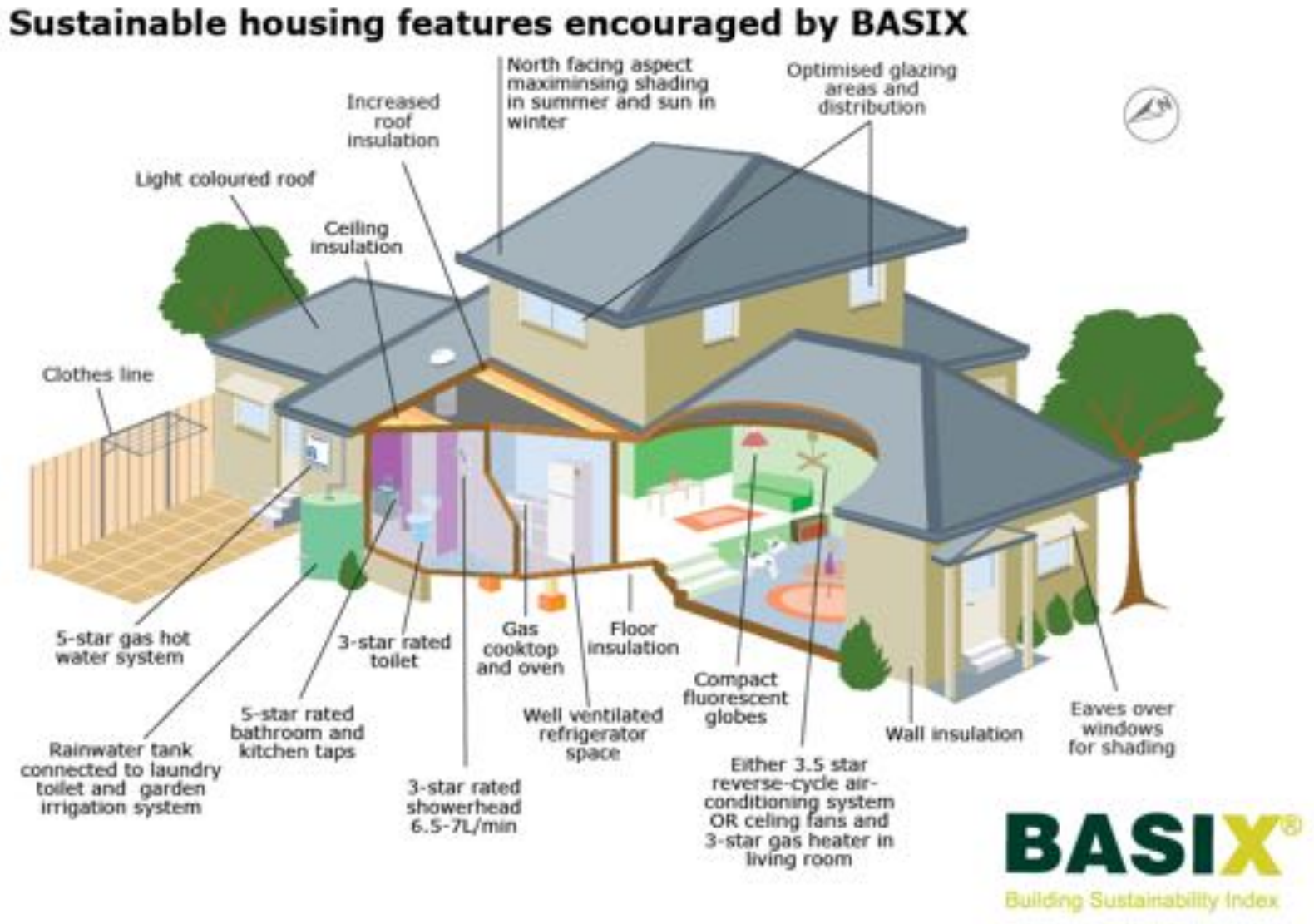
BASIX rating scheme is used for new homes in NSW

BASIX requirements are moderate, but rating and scoring process can be used to aim for higher performance outcomes

It rates:
Energy: scored relative to overall benchmark for
Hot water system
Heating and cooling (building+equipment)
Ventilation
Lighting
Pools and spas
Alternative energy sources
Energy use by other major appliances
Central systems (apartments)

Thermal comfort: uses NatHERS rating tools to simulate hourly building performance: must pass separate summer and winter thermal energy requirements while maintaining reasonable comfort

Water use
Water efficiency, rainwater use, etc



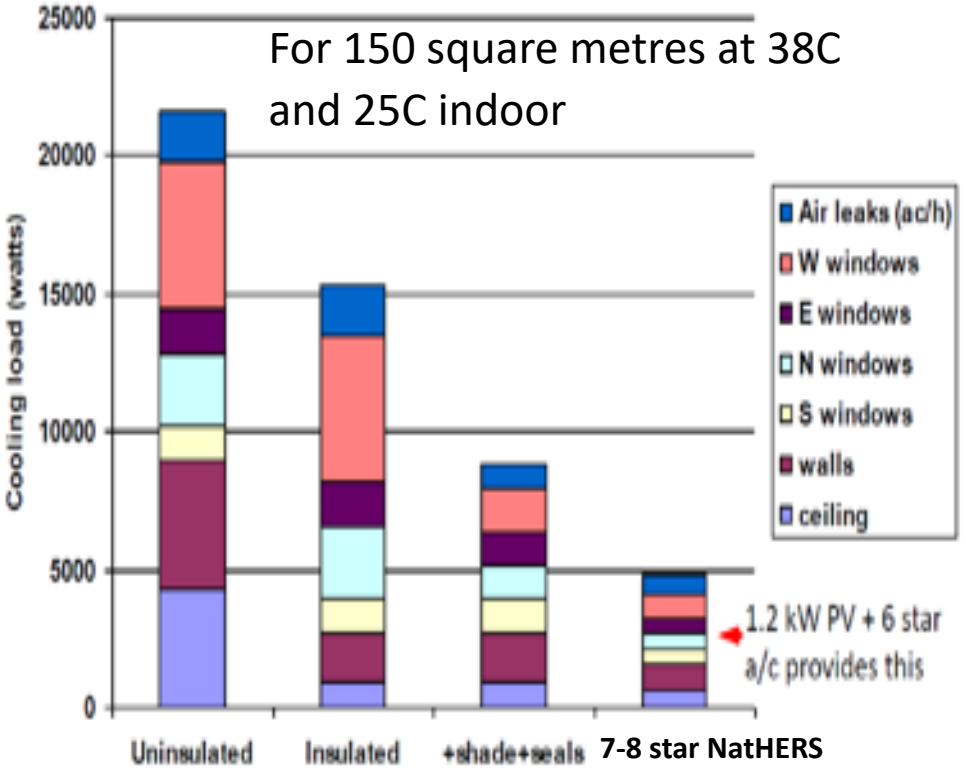
Source: https://basix.nsw.gov.au/iframe/images/BASIXhouse50_large.png

Comfort, health (heating/cooling)

- **Peak energy demand**:
  - High performance building fabric, ventilation energy recovery. Include natural venting BUT scope to seal up
  - Exposure of glazing to sun is a critical summer issue: light coloured adjustable shading, external roller shutters, etc
  - Access to winter morning-daytime sun most useful – but manage solar radiation for increasing proportion of year
- C**onsumption**:
  - As for peak demand
  - Highest heating load occurs when PV output is lowest
  - Highest cooling load is major driver of system peak load
- **Building** design and **appliance/equipment** selection:
  - Locks in future consumption and demand
  - Building performance locks-in comfort, health, size/cost of H&C equipment, 'resilience' if active equipment or grid fails, extent of 'intervention' needed
- **Behaviour** has big impact on consumption, peak demand
  - Eg permanently open windows extract air and can grow mould

Heat flows in Summer	insulated wall	uninsulated wall	Triple Low-e Argon filled glazing	Single clear glazing
Thermal resistance	R3	R0.5	R1	R0.17
Conducted heat Watts/ m2	5	30	15	88
radiant heat@ 500W/m2	varies with external colour, insulation		105	400
Light transmission %			49	80
Solar Heat Gain Factor			0.21	0.8

Advanced glazing data from www.wers.net.au
Single glazed data from http://yourhome.gov.au/passive-design/glazing



Evaporative coolers without automatic seals dump a lot of air

Many homes have 2 or more airchanges/hour

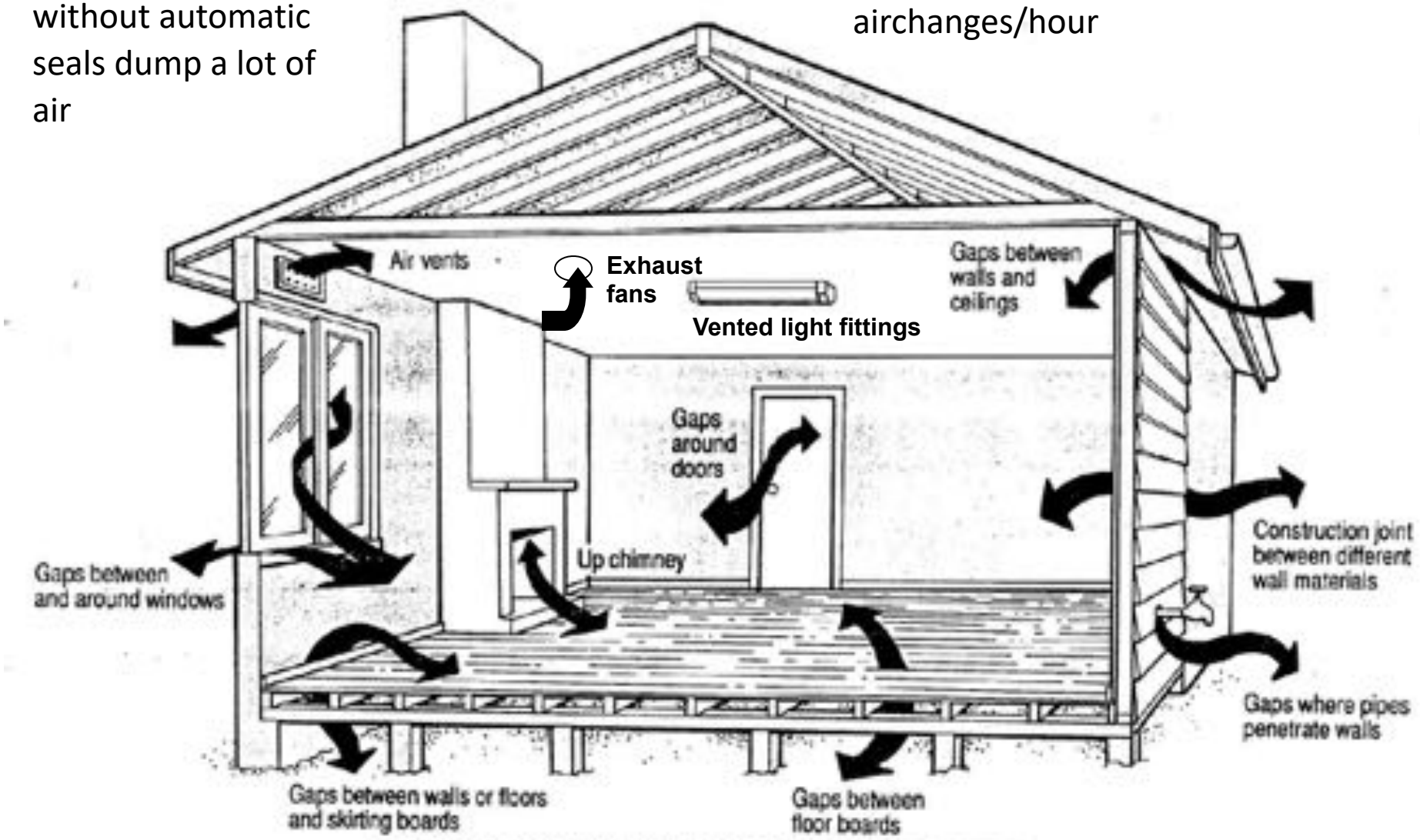
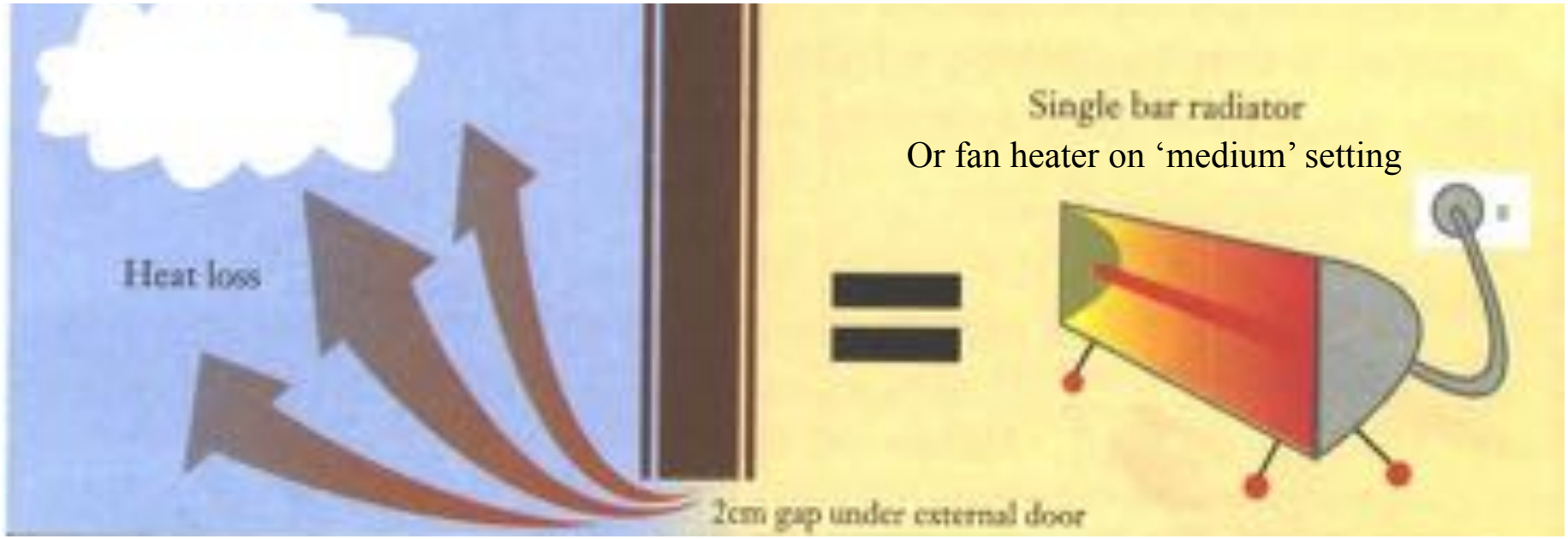


DIAGRAM 1: MAJOR SOURCES OF HEAT LEAKS AND DRAUGHTS.

If central heating, 1 airchange/hour loses approx 2 kW, costs approx $150-400 per year – well-sealed home has 0.5 airchanges/hour.

Significance of gaps – and losses through gaps increase with wind speed and temperature difference



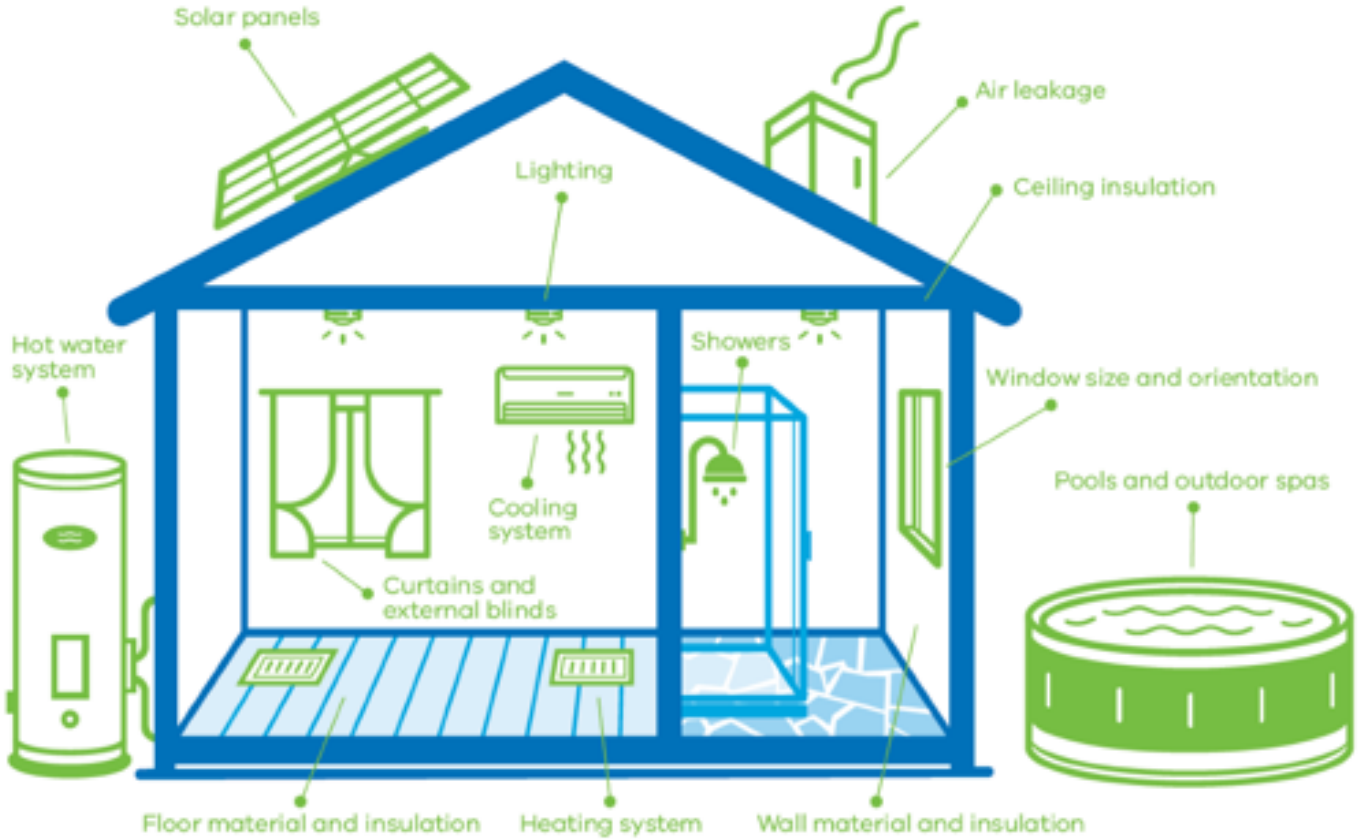
Indoor air quality is not just about opening windows and more ventilation!

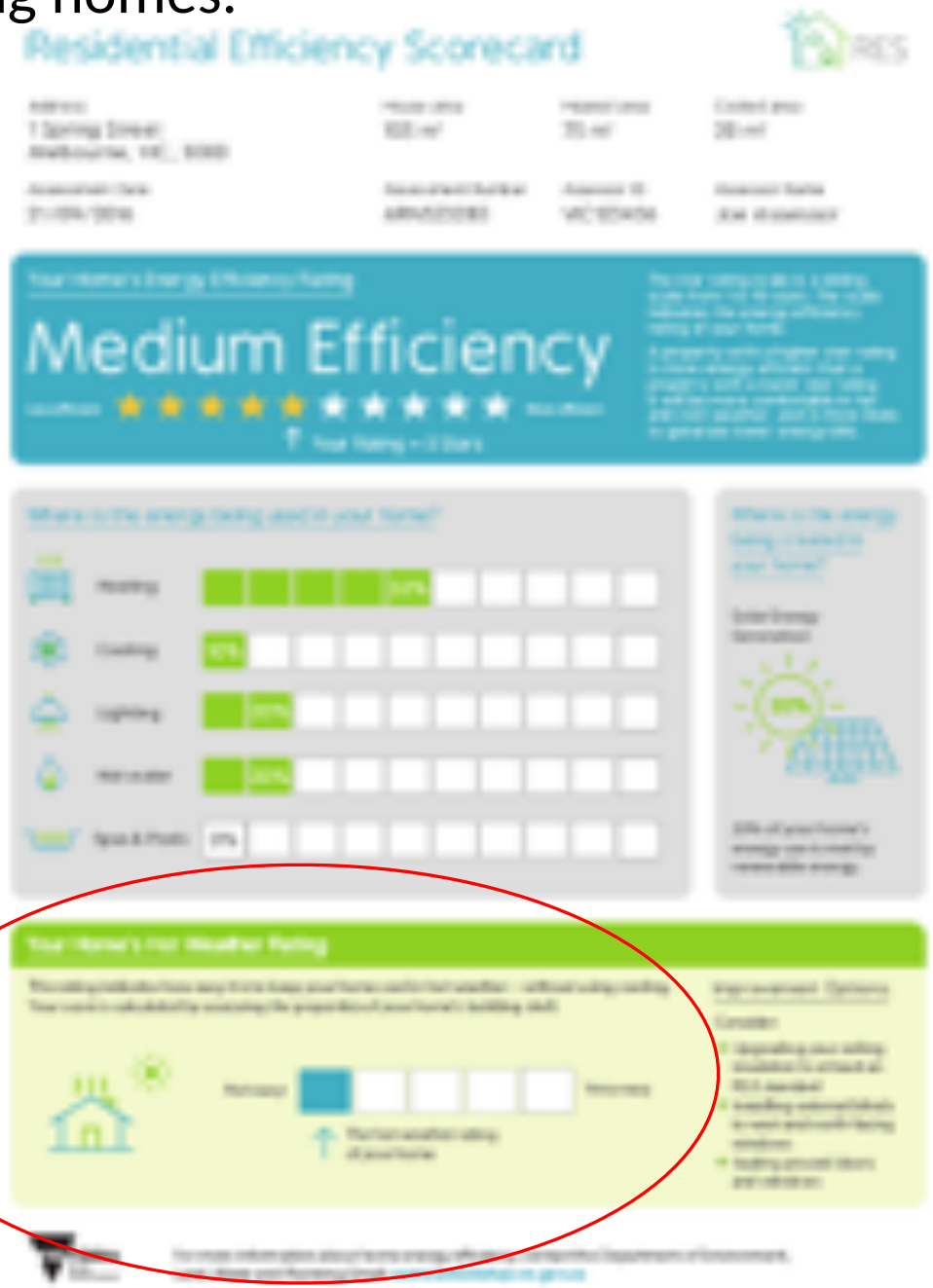
Mould caused when warm, moist air meets cold air and condensation occurs

Heat recovery ventilator cuts air leakage but beware energy use! Lunos uses only 1.4 watts at 15 m3/hour and over 80% efficiency

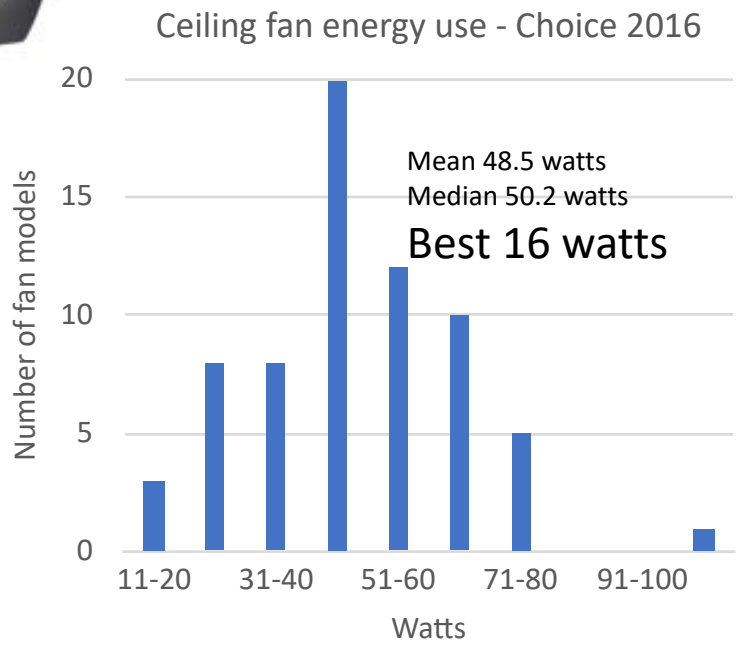
Maintenance is important!

Victorian Residential Efficiency Scorecard – focus on existing homes.
Being extended nationally
Voluntary but expected to be phased towards mandatory
https://www.victorianenergysaver.vic.gov.au/scorecard





How to manage the heat problem?



Most efficient air conditioner on market: 7.1 star 5.8 annual EER cooling; can also supply dehumidified, filtered outdoor air. Mandated Standard EER is 3.1

- Manage heat gain through glazing:
  - Area, orientation
  - Shading, insulated blinds (adjustable? automated?)
  - Advanced glazing?
  - Other daylighting options, eg aerogels, light shelves
- Manage internal heat generation:
  - Lights, appliances
  - Cooking (but beware, exhaust fan draws hot outdoor air into home!) – induction heats much less than gas
- Outdoor air:
  - Manage uncontrolled air leakage (including open windows, especially on windy days!)
  - ‘Smart’ ventilation at appropriate times
  - Heat/coolth recovery ventilation
- Thermally efficient envelope, ‘retreat’ room?
- Vegetation, light coloured permeable paving
- Efficient active cooling – fans, air con etc
- Thermal or electricity storage, ‘smarts’?
- Appropriate clothing, ‘cool’ clothing?
- Educate occupants/operators?
- ????

Cooking

- **Peak energy demand**:
  - 'Heat-up' with induction cooktop can have high peak demand, eg to heat up 1kg steel +1.5kg water equivalent in 4 minutes, peak demand 4 kW but consumes less than 0.3 kWh
  - Most efficient electric oven uses ~0.8 kWh to heat up, then cook for an hour – 30% of this is to heat up oven materials, using about 2 kilowatts
- **Consumption:**
  - Induction cooker most efficient – least waste heat: gas 4x as much waste heat+ indoor air pollution
  - *Insulated* pots and lids (evaporating 1.5 litres/hour adds 1.2 kW, creates condensation and even mould issues)
  - Range hood extracts air from room – 2-3 kW of cold/ hot air enter house in extreme weather
- **Appliance/equipment** selection:
  - Creative solution: 2 kW mains supply+ small battery or super-capacitor+ smarts could manage peak cooking loads without requiring wiring and/or inverter upgrade
  - In principle, precision controlled resistive electric element within insulation of an insulated pot with lid is most efficient…..
  - Highly insulated, lightweight oven using exhaust to pre-heat inlet air
- **Behaviour**
  - Cook in bulk, use efficient cooking practices, recipes, freeze then defrost in fridge+microwave. Defrost before cooking!

Induction cooktops don't heat up – so insulated pots can be used to cut heat loss

Induction for boiling kettle in traditional Chinese tea ceremony, Beijing