AUSTRALIAN MODERN BUILDING ALLIANCE

Safe and sustainable construction with polymers

Energy Efficient Light Weight Timber Frame Construction

Thinking Outside of the Box

Chemistry Australia

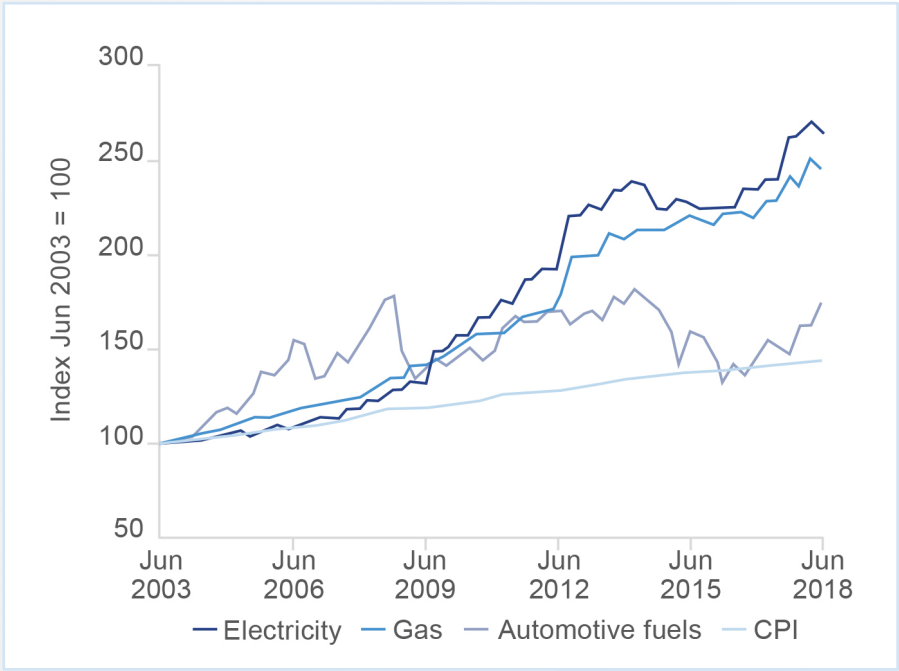
The Business of Chemistry Essential for Life

AMBA is an interest group of companies within Chemistry Australia representing the use of polymers in the Australian building and construction industries.

Australia Lags in Energy Efficiency

AUSTRALIAN ENERGY PRICES THE HIGHEST IN THE WORLD …

- Australian energy prices are the highest in the world: 2-3 x those of the USA (Grattan Institute).
- Adopting leading international practices in energy efficiency (Energy Efficiency Council) would:
  - slash the energy bills of households and businesses by $7.7 billion a year,
  - create 120,000 extra jobs, and
  - meet over half of Australia's commitment to reduce emissions by 26-28% by 2030 and support the transition to renewable energy and electric vehicles.

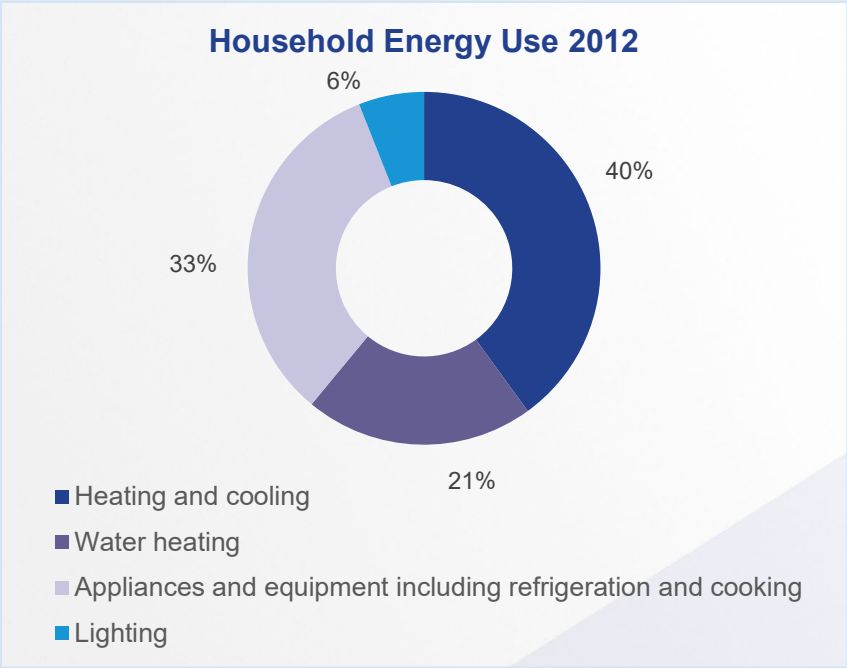


Quarterly Household Energy Price Index [Australian Bureau of Statistics (2018c) Consumer Price Index, Australia, June 2018, 640.1

Australia Lags in Building Energy Efficiency

YET AUSTRALIAN BUILDINGS ARE NOT OPTIMISED FOR ENERGY EFFICIENCY.

- Australian buildings account for 19% of the total energy used in Australia and 18% of the total greenhouse gas emissions (Dept. of the Environment and Energy).
- Insulating buildings is the most cost-effective way of reducing energy consumption and GHG emissions (NSW Greenhouse Office).
- “Implementing cost-effective building and appliance upgrades could reduce buildings energy consumption by over 25% by 2030, reducing household and business energy bills by a cumulative $20 billion over 15 years” (ABSEC).



Energy Use in the Australian Residential Sector 1986-2020, Department of the Environment, Water, Heritage and the Arts.

The Problem: “As Built” ≠ “As Designed”

CSIRO INVESTIGATION 2013 & 2015 IMPLICATED EXCESSIVE AIR LEAKAGE

- **CSIRO Study 1 on 5-star vs 4-star houses:** used less energy in winter (Melbourne, Adelaide & Brisbane) but more energy in summer (Melbourne & Brisbane)!
- **CSIRO Study 2:** 50% of houses had $ACH_{50} \geq 15$ & only 30% of houses had a “good rating” for ceiling and wall insulation installation respectively.

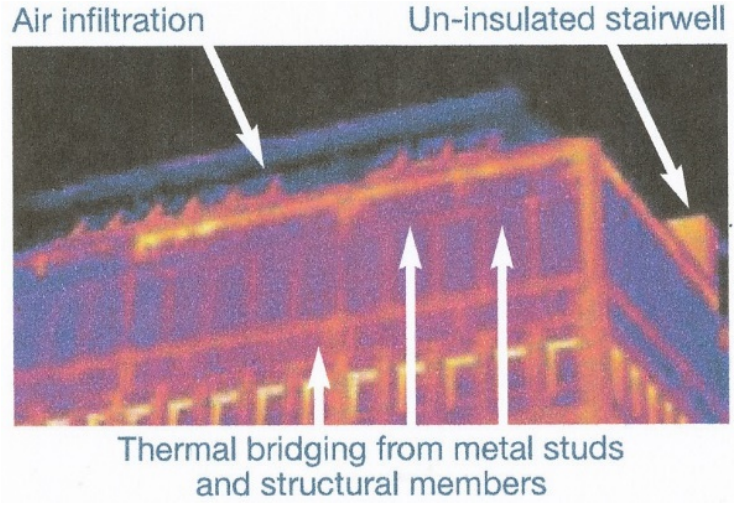


Photo courtesy of Huntsman Polyurethanes

The Problem: “As Built” ≠ “As Designed”

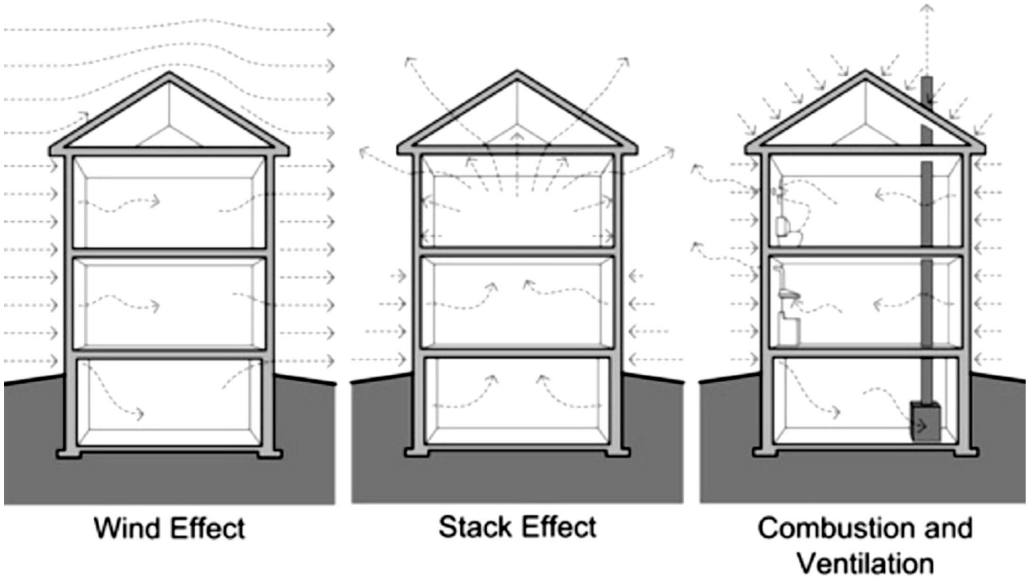
OTHER INVESTIGATIONS CONFIRMED EXCESSIVE AIR LEAKAGE & WORKMANSHIP

- **LCLCRC 2019:** Identified the root causes as workmanship (excessive air leakage and poorly installed insulation) plus “trade-offs” on the thermal performance of one building component against another (e.g. windows versus walls).
- **DRET 2013:** Uncontrolled air infiltration
  can reduce the NatHERS star rating by over
  1-star. Together with poor insulation installation and the rating can be reduced by over 1.7 stars.

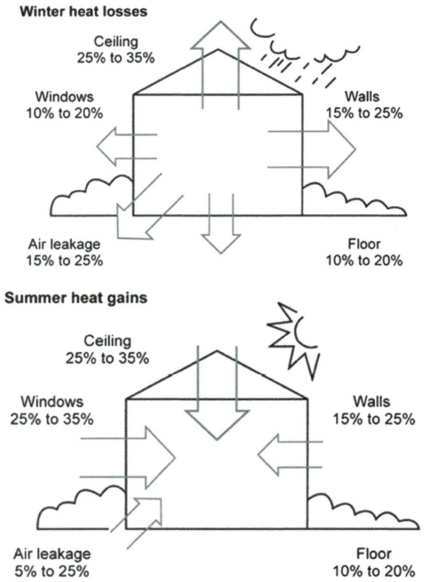
- **NatHERS 7-star Case Study 2008:**
  - Target maximum heating /cooling energy usage = 83 MJ/m^2/year.
  - Actual heating /cooling energy usage = 293 MJ/m^2/year (about a 2.5-star performance).
  - Measured air-leakage ACH_{50} = 26.8.
  - It was estimated by the builder to cost around $5,000 to remedy the air-leakage post construction versus $600 during construction.

So How Do We Address Air Leakage?

FIRST, UNDERSTAND THE MECHANISMS OF AIR LEAKAGE



Building Science Corporation, www.buildingscience.com

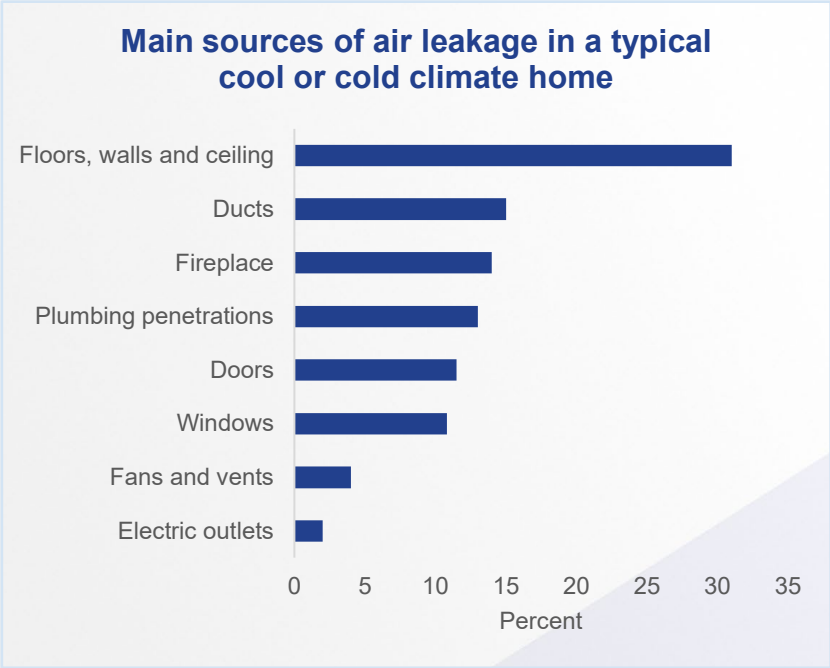


Sustainable Energy Authority of Victoria 2002

So How Do We Address Air Leakage?

SECOND, UNDERSTAND THE MAIN LEAKAGE POINTS

- **Design Stage**
  - Avoid open vented in-ceiling downlights
  - Use exhaust fans that have non-return baffles and are ducted to the outside of the building
  - Use and efficient building envelope air-barrier
- **Post Occupancy Stage (weatherisation):**
  - Fit draught-proofing strips to windows and doors
- **Construction Stage:**
  - Gaps around wall penetrations such as pipes and ducting
  - Gaps at building envelope junctions such as floor-wall and wall-ceiling
  - Seal between the building frame and windows/door frames

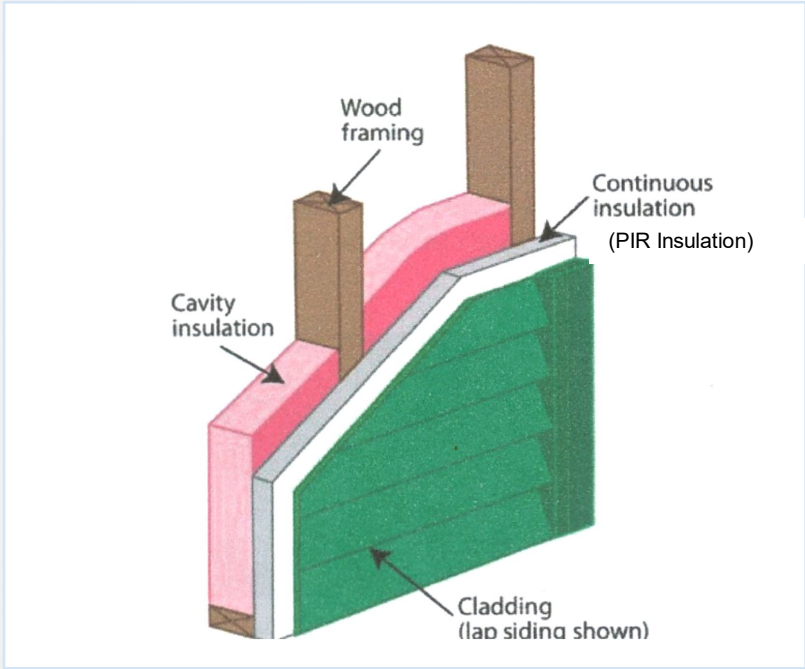


Sustainable Energy Authority Victoria

So How Do We Address Air Leakage?

THIRD, THINK OUTSIDE OF THE BOX AND USE CONTINUOUS INSULATION (OR INSULATED SHEATHING)

- **Continuous insulation** is defined as “insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior [or] exterior, or is integral to any opaque surface of the building envelope.” ASHRAE 90.1-2007.
- **Foil faced polyisocyanurate insulation board:**
  - Building envelope insulation – high wall R-value
  - Air-barrier
  - Water-resistive barrier
  - Thermal break – prevention of frame thermal bridges



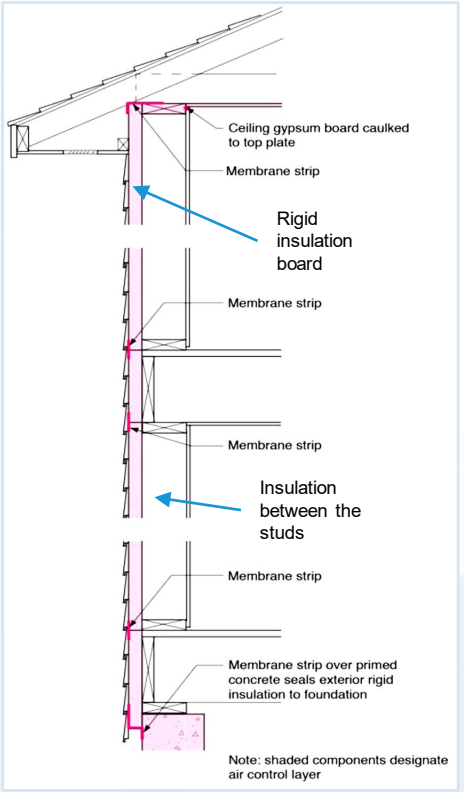
PIMA Technical Bulletin #403: Continuous Insulation Using Polyiso Wall Sheathing

Exterior Insulated Sheathing

ADVANTAGES OF CONTINUOUS INSULATION:

- Used with insulation between the studs to achieve a high total wall R-value – reduce thermal bridging due to the framing.
- Simplifies meeting air-tightness standards by moving the air barrier to the exterior.
- Better productivity and less waste by using one product for four functions.
- Applicable to any climate by varying the thickness of the exterior rigid insulation board (IECC 2012 or ASHRAE 90.1).

USA Climate Zone	2” x 4” Wall	2” x 6” Wall
4	R-value ≥ 0.44	R-value ≥ 0.66
5	R-value ≥ 0.88	R-value ≥ 1.32
6	R-value ≥ 1.32	R-value ≥ 1.98
7 & 8	R-value ≥ 1.76	R-value ≥ 2.64



Joseph W. Lstiburek, Building Science Corporation, Insight 084 Forty Years of Air Barriers, February 2015.

Changes to the NCC 2019 a Good Start

AUSTRALIA NCC 2019 CHANGES RELATED TO RESIDENTIAL WALLS ENERGY EFFICIENCY

- **Airtightness**: the building *envelope* is to have an air permeability ≤ 10 $m^3/hr.m^2$ (broadly equivalent to 10 ACH_{50}) or there is a *deemed-to satisfy* "airtight drywall" solution.
- **Thermal breaks** are required on metal framed buildings with lightweight external cladding if it does not have a wall lining or the wall lining is fixed directly to the metal frame. The thermal break must have a *R-value* ≥ 0.2.
- **Condensation control**: "Risks associated with water vapour and *condensation* must be managed to minimise their impact on the health of occupants". A *deemed to-satisfy* solution using a pliable membrane for fibrous insul;ation is provided.

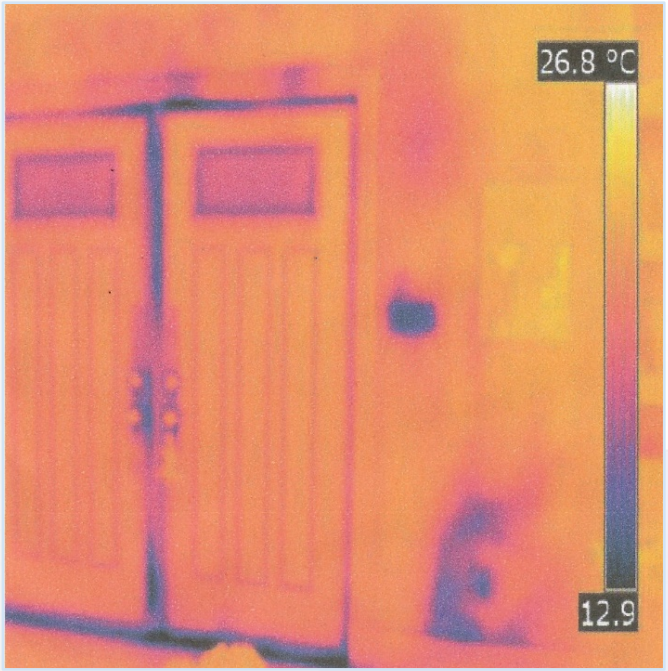


Photo courtesy of Demilec Inc.

Infrared photo showing effect of air leakage – external door, missing insulation & switch

Australia Compared to California

2019 CALIFORNIA TITLE 24 ENERGY CODE

✓	**Zero net energy by 2020.**
✓	**High levels of insulation** e.g. San Francisco wall U-value = 0.27 W/m^{2}K or R-value = 3.70 m^{2}K/W (between the studs) plus R=1.06 m^{2}K/W of exterior rigid insulation. **Total wall R-value = 4.76.**
✓	The exterior rigid insulation doubles as the **thermal break;** R-value = 1.06 m^{2}K/W.
✓	**Airtightness** ≤ 5 or 3 ACH_{50} for the warmer and colder parts of California respectively.
✓	**Mandatory inspections** of insulation and air barrier during construction (CF2R-ENV-02-E).
✓	***Deemed-to-satisfy* air tightness solutions:** • **Continuous (polyiso) insulation** external to the frame, or • **Polyurethane sprayfoam** used between the studs do not require a separate air barrier.

CA has 3 paths to compliance: Prescriptive, U-factor & Total U-factor Analysis.
The latter two both require thermal and hygrothermal analysis (e.g. WUFI).

AUSTRALIA NCC 2019

✗	**No trajectory to "low energy buildings"**
✗	**Low levels of insulation** e.g. Melbourne wall U-value = 0.36 W/m^{2}K or R-value = 2.8 m^{2}K/W.
✗	**Thermal break requirements** only for steel frame buildings R-value ≥ 0.2 m^{2}K/W.
✗	**Airtightness** ≤ 10 ACH_{50}
✗	**Over reliance on modelling (NatHERS):** • Air-leakage may not be able to be modelled • No quality control of insulation or air barrier installation during construction.

Suggested Changes to the NCC 2022

ADOPT THE CONTINUOUS INSULATION PRINCIPLE ➡ DECREASE AIR LEAKAGE & THERMAL BRIDGING WHILE INCREASING OVERALL INSULATION THICKNESS

- Trajectory to “low energy buildings”.
- Adopt the continuous insulation principle by mandating a minimum exterior rigid insulation wall R-value of 1.06.
- Reduce the airtightness target to ACH50 ≤ 5.
- Introduce insulation/air barrier quality checks:
  - Mandatory blower door test, or
  - Increased “deemed-to-satisfy” provisions and independent quality inspection at the construction stage?

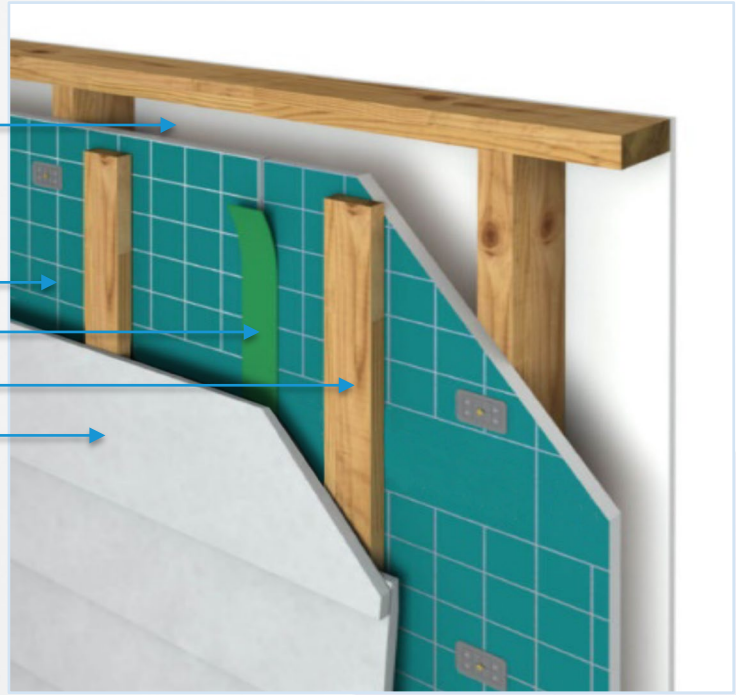
Photos courtesy of Polyurethane Consulting Service P/L

Practical Implementations of CA Title 24 Codes

GENERIC OPTIONS BASED ON RECOMMENDATIONS BY JOHNS MANVILLE FOR TIMBER FRAMED LIGHTWEIGHT CONSTRUCTION WITH CLADDING

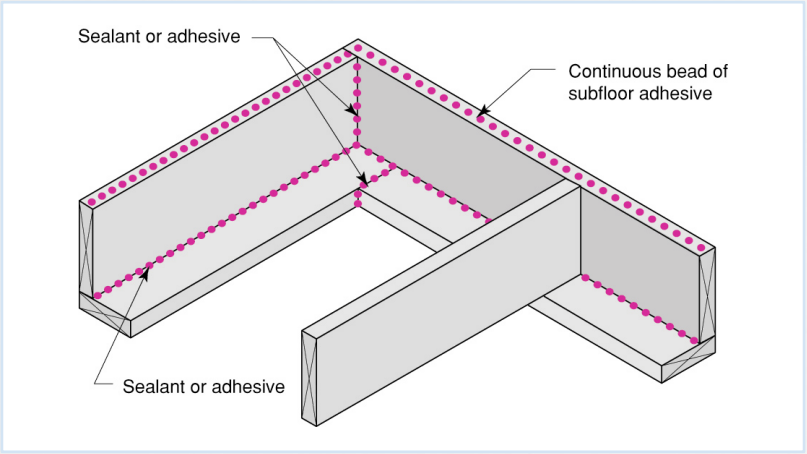
California climate zones 1-5 & 8:

- Cavity insulation:
  - Sprayfoam (ocSPF or ccSPF),
  - Fibreglass
- Polyisocyanurate insulation board with foil facings
  - Sealing tape
  - Furring to provide an air gap
  - Cladding



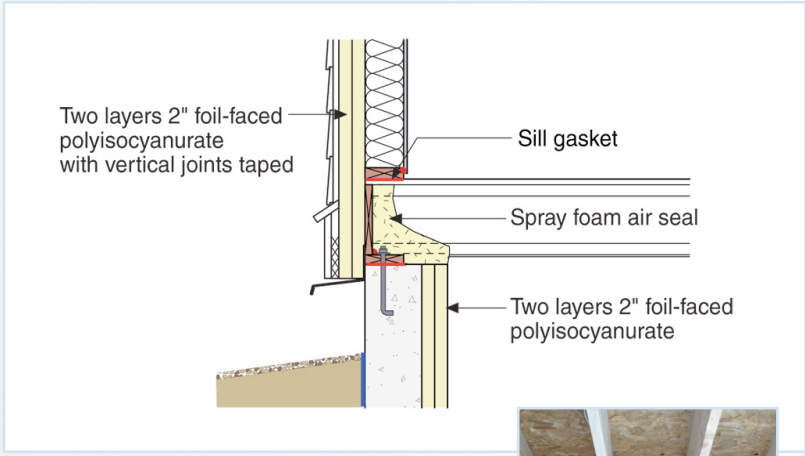
Continuous Insulation

FIBROUS INSULATION IN CAVITY REQUIRES MORE ATTENTION TO DETAIL FOR AIR SEALING



Use of adhesive and sealant:

- Highly sensitive to workmanship
- Labour intensive



Sprayfoam (SPF) simplifies the sealing process and reduces labour.

Building Science Corporation, Information Sheet 408 Critical Seal (Sprayfoam at Rim Joist) for All Climates

Polyisocyanurate insulation (PIR)

CONTINUOUS INSULATION, AIR BARRIER AND MOISTURE BARRIER WHEN TAPED

Property	Polyiso (Foil Faced)
Thermal conductivity (W/mK)	0.020
R-value at 25mm (m^2K/W)	1.25
Emittance	E 0.03 (silver foil face)
Water Vapour Permeance ($ng/Pa.s.m^2$)	1.72
Water Vapour Resistivity (MNs/gm)	> 100 (ASTM E96)
Air Permeance ($L/s.m^2$@75Pa)	≤ 0.02
Water absorption (% vol/vol)	≤ 0.1 (ASTM C1289)
Compressive strength (kPa)	≈ 172 (AS 2498.3)
Thermoset plastic	Chars & burns similar to timber
External Wall Classification	EW (AS 5113:2016)

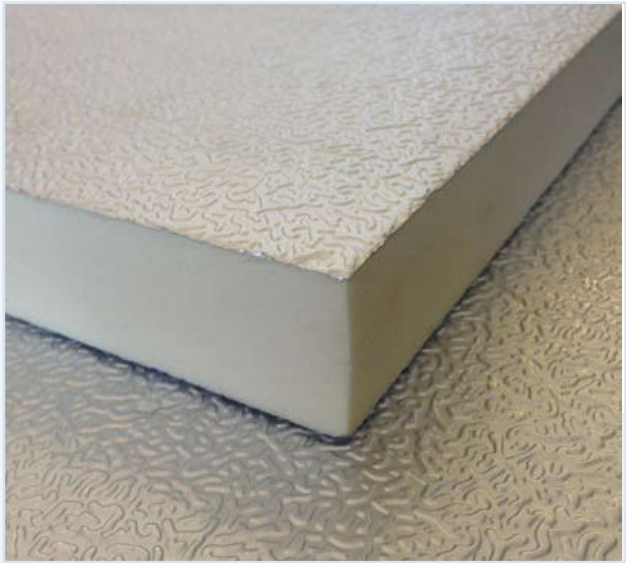


Photo courtesy of PIRMAX P/L

Polyurethane Sprayfoam (SPF)

CONTINUOUS INSULATION, AIR BARRIER AND MOISTURE BARRIER

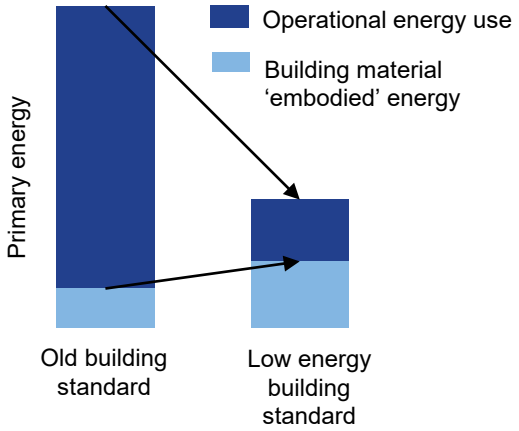
Insulant	Fiberglass Batts	Cellulose	ocSPF	ccSPF
Thermal conductivity (W/mK)	0.038	0.036	0.038	0.021
R-value @ 25mm (m^2K/W)	0.65	0.70	0.67	1.25
Air Barrier	✗	✗	✓	✓
Water vapor retarder	✗	✗	✓	✓
Continuous Insulation	✗	✗	✓	✓
Waterproofing	✗	✗	✗	✓
Structural strength	✗	✗	✗	✓
Durability	✗	✗	✓	✓
Thermoset	✗	✗	✓	✓

Photo courtesy of Huntsman Polyurethanes

Sustainability of Insulation

STEP 1: Optimise building energy use

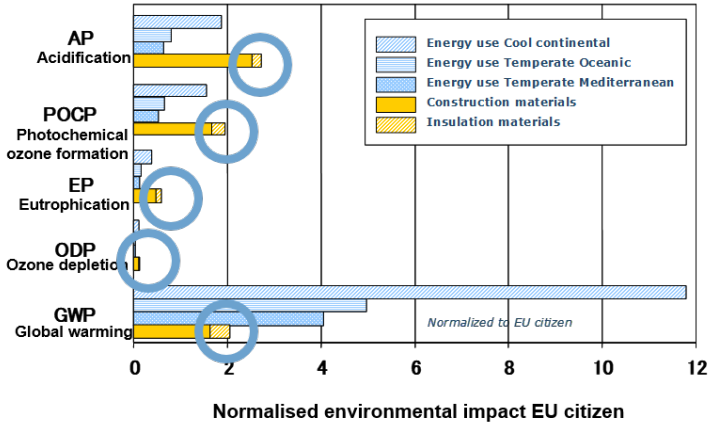
Designing for low energy increases the relative embodied energy but:……



"Insulation for Sustainability – A Guide" A study by XCO^2 for BING, 2000

STEP 2: reduce embodied impact if it does not compromise in-use performance

Insulation choice has limited impact on the building embodied energy.



PU Europe, Fact Sheet No 15, Feb 2014.

Conclusion

THINK OUTSIDE OF THE BOX AND USE EXTERIOR INSULATED SHEATHING TO SIMPLIFY BUILDING ENERGY EFFICIENT LIGHTWEIGHT FRAMED BUILDINGS

 **MAXIMISE SOLAR GAINS**	NOT DISCUSSED IN THIS PRESENTATION
 **SPECIFY HIGH INSULATION LEVELS**	• **EXTERIOR INSULATED SHEATHING (eg PIR Insulation Board) PROVIDES A CONTINUOUS LAYER OF INSULATION, MINIMISES THERMAL BRIDGING AND PROVIDES A AIR BARRIER AND RAIN BARRIER ALL IN ONE PRODUCT.** • **SPRAYFOAM USED BETWEEN THE STUDS MAXIMISES THE INSULATION VALUE AND PROVIDES A COMPLETE AIRSEAL** • **OCF SIMPLIFIES AIR SEALING**
 **AIRTIGHTNESS**	
 **CONTROLLED VENTILATION**	**“BUILD TIGHT AND VENTILATE RIGHT”**
 **ENERGY EFFICIENT APPLIANCES**	NOT DISCUSSED IN THIS PRESENTATION - ADDRESS THROUGH THE GEMS PROGRAM
 **RENEWABLE ENERGY**	NOT DISCUSSED IN THIS PRESENTATION - ADOPT THE ENERGY EFFIENCY FIRST PRINCIPLE TO AVOID OVER INVESTMENT IN RENEWABLES

Australian Modern Building Alliance

This presentation was presented by Dr David A C Evans from *Polyurethane Consulting Services* on behalf of AMBA.

AMBA is an interest group within Chemistry Australia with a purpose to promote the safe and sustainable use of polymers in the built environment. AMBA membership includes the leading suppliers of polymer materials to Australia's building and construction industries.

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