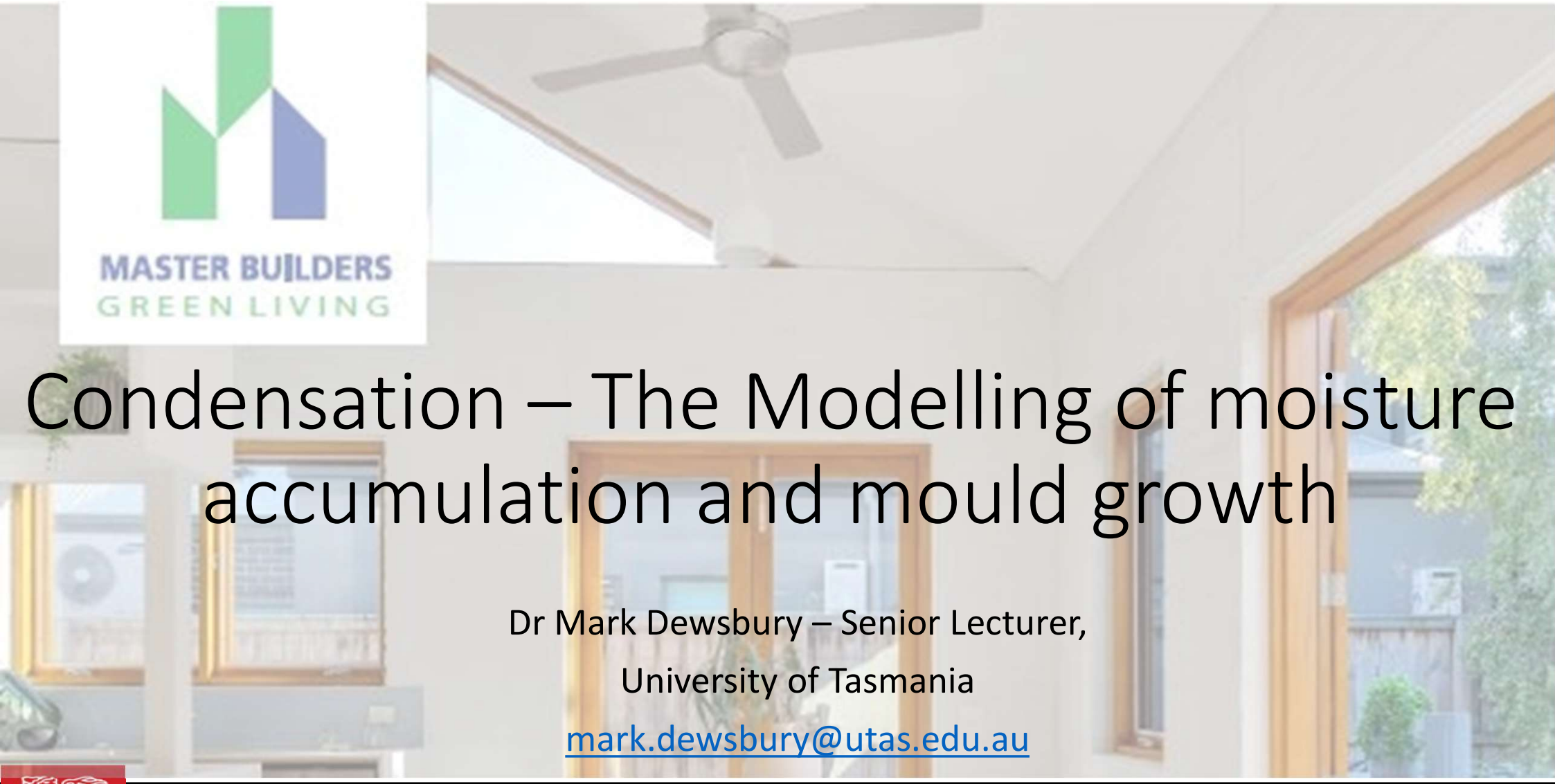

Condensation – The Modelling of moisture accumulation and mould growth

Dr Mark Dewsbury – Senior Lecturer,

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Our expectations have changed – Class 1

Comfort
Wealth
Materials

Our expectations have changed – Class 2

Comfort
Wealth
Materials

What causes condensation?

1. Heat
2. Moisture (water vapour in the air and materials)
3. Thermal bridging

How might we manage condensation?

1. Heat – fully separate hot and cold elements

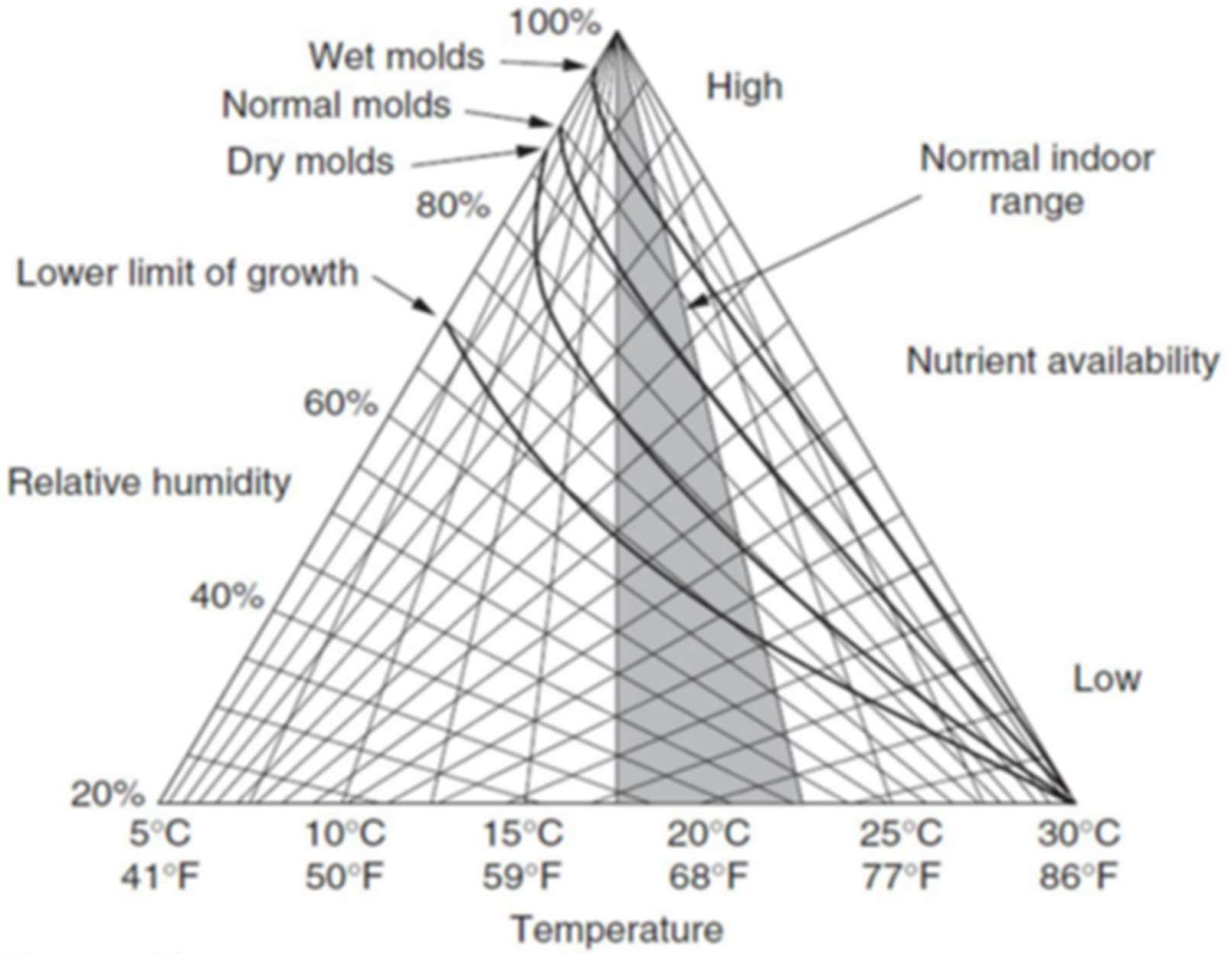
2. Moisture – control the amount of water vapour in the air and control where and how water vapour moves

Can we stop condensation

1. NO

2. We need to understand
   - where it forms
   - manage how much may form, and
   - design in ‘drying potential’

What does mould need to grow



How might we limit mould to the microscopic level?

1. Control the amount of water vapour in the air
2. Control where and how water vapour moves
3. Fully separate hot and cold elements

Can we stop Mould growth?

1. Mould is every where but at the optical microscopic level. In essence it is in equilibrium with other elements in the environment.

2. We want to design the built fabric such that mould does not become out of balance (become optically visible)

The International hygrothermal journey

- BS 5250 – 1975
- DIN 4108 - 1952, DIN 4108-3 - 1981, DIN 4108-4 - 1981
- ASHRAE 160 - 2009
- Canada Condo Crisis – 1980's and 1990's
- New Zealand Leaky Buildings 1990's ….. NZ$46 B
- Australia 2019 …..

The Australian hygrothermal journey

- But are these problems new?
- Since the 1960's, the focus has been to blame how the occupants live and not the building
- 1964… revised 1974 NBTC NSB 32: House design for Australian cold-winter climates
- 1964 … revised 1970 NBTC NSB 61: Condensation in dwellings
- 1964 NBTC NSB 78: Some condensation problems
- BUT occupant expectations in Australia have been quite low. Until very recently there was no Australian discussion regarding how Mould affects human health.

NCC 2019

- In 2019 we gained some climate type limited regulations regarding condensation and mould in Australian homes.
- Permeability and ventilation
- For many Australian climate zones, we are now required to consider roof space ventilation, permeable membranes in external walls and some forms of exhaust ventilation.

P2.4.7 Condensation and water vapour management

Risks associated with water vapour and *condensation* must be managed to minimise their impact on the health of occupants.

Application:
P2.4.7 only applies to a Class 1 building.

3.8.7.2 Pliable building membrane

(a) Where a *pliable building membrane* is installed in an *external wall*, it must—
(i) compl
(ii) be ins
(iii) be a v
(iv) be loc of a bu

(b) Except for *external wa*

3.8.7.3 Flow rate and discharge of exhaust systems

(a) An exhaust system installed in a kitchen, bathroom, *sanitary compartment* or laundry mu rate of—
(i)
(ii)
(b) Exha
(i)
(ii)

3.8.7.4 Ventilation of roof spaces

(a) Where an exhaust system covered by 3.8.7.3 discharges into a roof space, th *outdoor air* through evenly distributed openings.

(b) Openings *required* by (a) must have a total unobstructed area of 1/300 of the respective ceiling area if the roof pitch is more than 22°, or 1/150 of the respective ceiling area if the roof pitch is not more than 22°.

V2.4.7 Verification of condensation management

Compliance with P2.4.7 is verified when modelling that assesses the effects of—

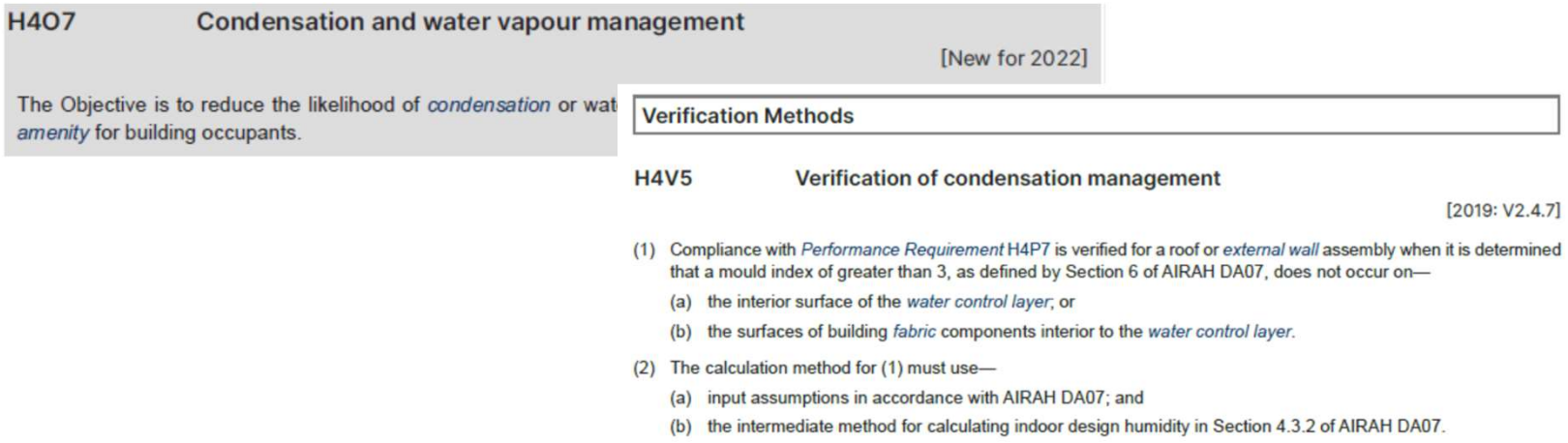
(a) indoor and outdoor temperature and humidity conditions; and
(b) heating and cooling set points; and
(c) rain absorption; and
(d) wind pressure; and
(e) solar radiation; and
(f) material hygrothermal properties,

determines that moisture will not accumulate—

(g) interior to the primary *water control layer* within a building envelope; or
(h) on the interior surface of the *water control layer*.

NCC 2022

- Mould index of 3
- In 2022 we gained some more climate type limited regulations regarding condensation and mould in Australian homes.
- For more Australian climate zones, we are now required to consider roof space ventilation, permeable membranes in external walls and some forms of exhaust ventilation.



H4O7 Condensation and water vapour management

[New for 2022]

The Objective is to reduce the likelihood of *condensation* or wat
amenity for building occupants.

Verification Methods

H4V5 Verification of condensation management

[2019: V2.4.7]

(1) Compliance with *Performance Requirement* H4P7 is verified for a roof or *external wall* assembly when it is determined that a mould index of greater than 3, as defined by Section 6 of AIRAH DA07, does not occur on—

(a) the interior surface of the *water control layer*; or

(b) the surfaces of building *fabric* components interior to the *water control layer*.

(2) The calculation method for (1) must use—

(a) input assumptions in accordance with AIRAH DA07; and

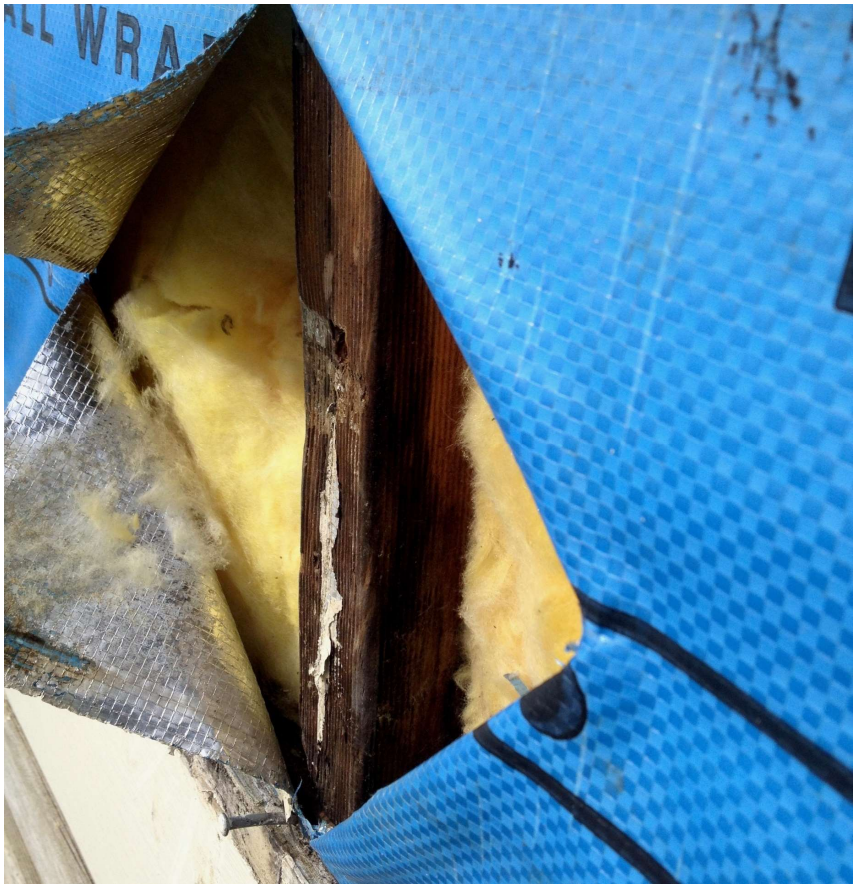
(b) the intermediate method for calculating indoor design humidity in Section 4.3.2 of AIRAH DA07.

What is this mould index

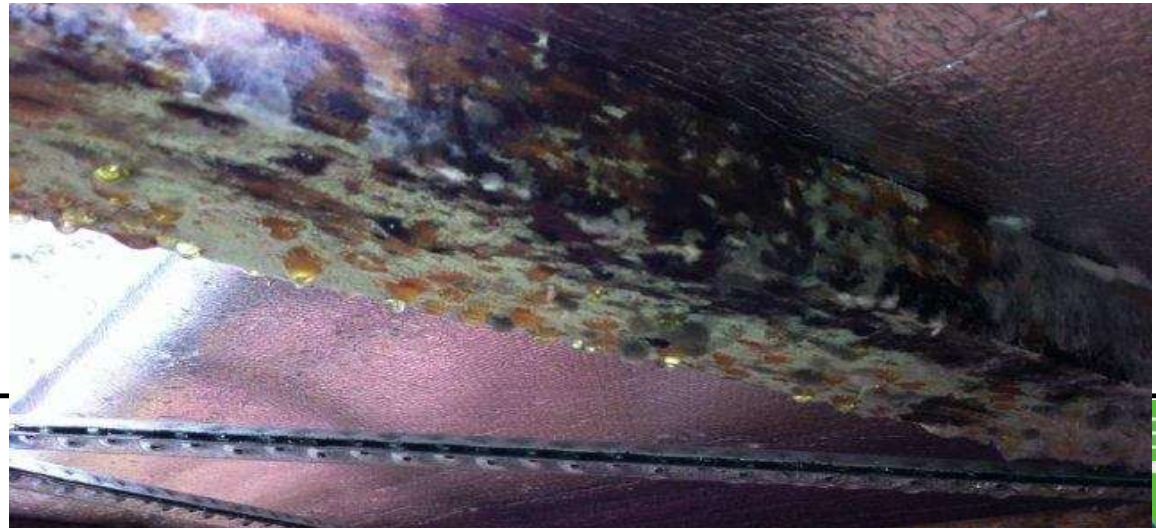
Index (MI)	Growth rate	Description
0	No growth	Spores not activated
1	Small amounts of mould on surface (microscope)	Initial stages of growth
2	<10% coverage of mould on surface (microscope)	Initial stages of growth
3	10%–30% coverage of mould on surface (visual)	New spores produced
4	30%–70% coverage of mould on surface (visual)	Moderate growth
5	>70% coverage of mould on surface (visual)	Plenty of growth
6	Very heavy and tight growth	Coverage around 100%

Mould on walls

Mould in walls



Mould in Roof spaces



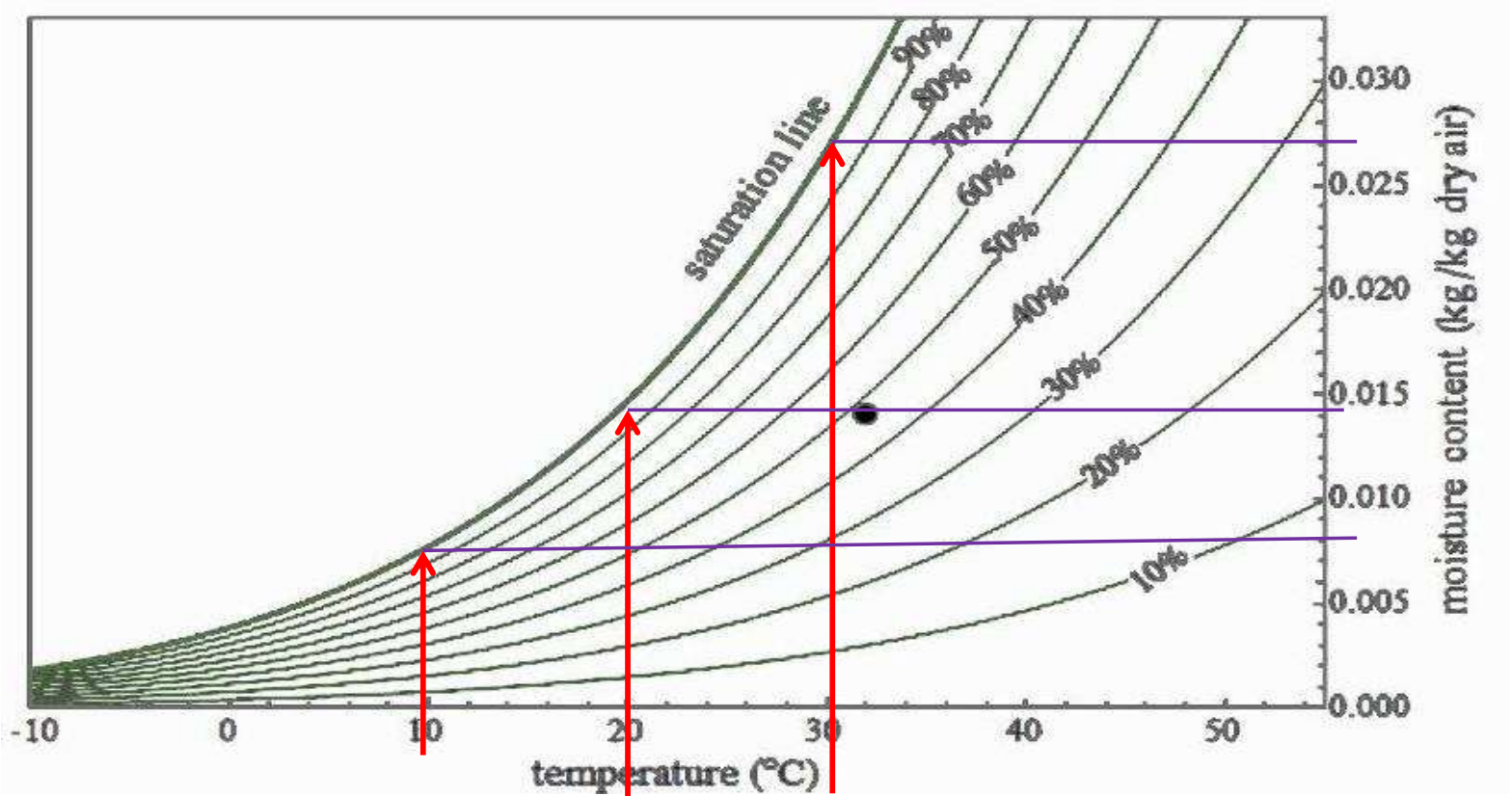
School of Architecture & Design
Science, Engineering & Technology

Dr Mark Dewsbury

Mould in subfloors

Is this linked to energy efficiency

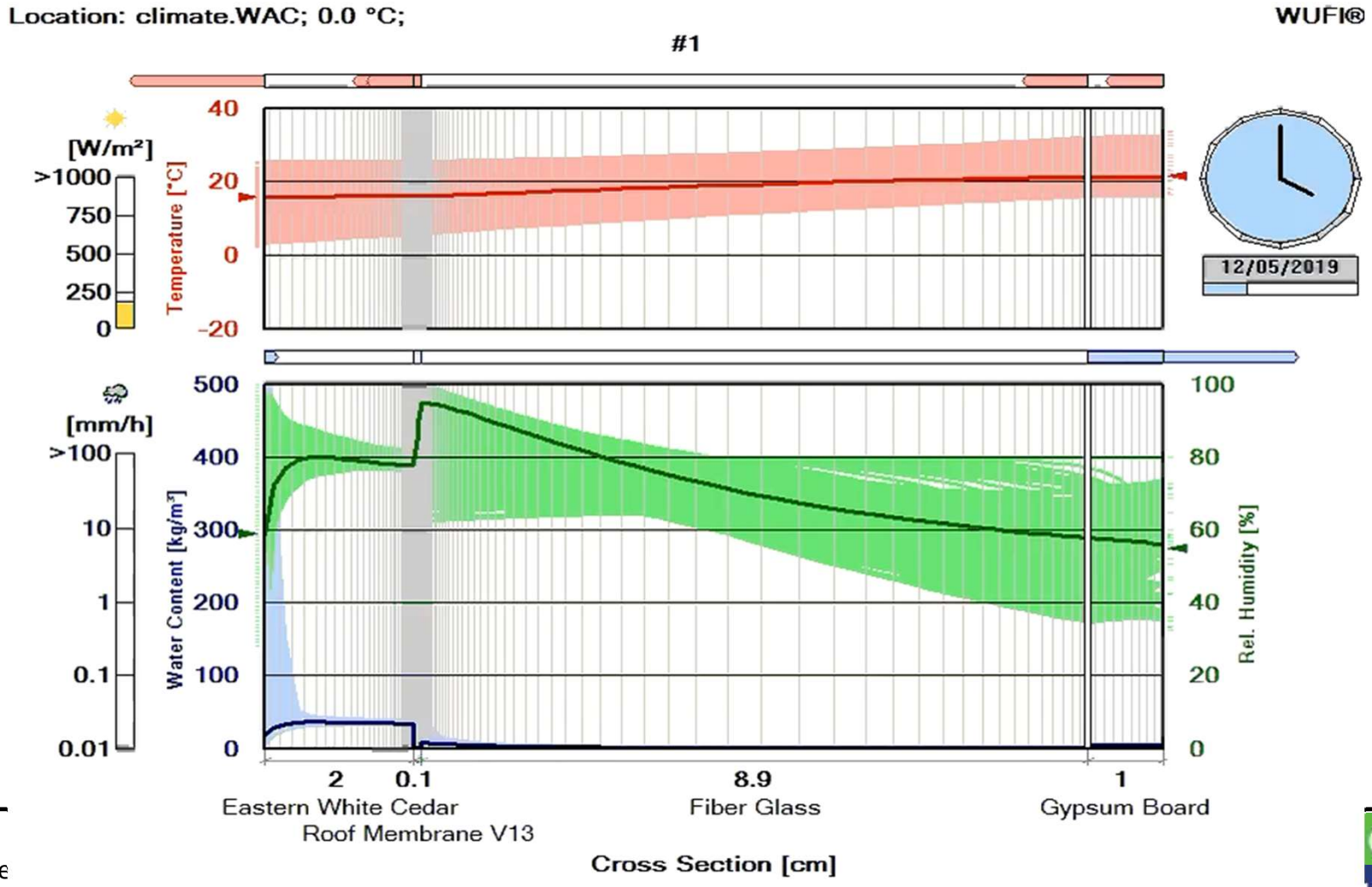
Psychrometric chart



Is this linked to energy efficiency

Air Temperature (°C)	Relative Humidity (%)	Dewpoint Temperature (°C)	Water Vapour Pressure (PA)
21	60	13	1496
21	70	15	1703
21	80	17	1935
23	70	17	1935
23	80	19	2194
24	70	18	2061
16	55	7	1001
10	65	3	758

Heat and moisture simulation



6 Stars >> 7 Stars

NatHERS Climates	21	22	27	60	61	63	64 (&62)	66
7 Star 27% glass to floor area	R2.7 wall batts	R2.7 wall batts	R3.5 wall batts	R3.5 wall batts	R3.5 wall batts	R3.2 wall batts	R3.2 wall batts	R3.2 wall batts
	R6.0 Ceiling batt	R6.0 Ceiling batt	R6.0 Ceiling batt	R6.0 Ceiling batt	R6.0 Ceiling batt	R8.0 Ceiling batt	R6.0 Ceiling batt	R6.0 Ceiling batt
	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living
	Habitable AL DG 4/10Ar/4EA U = 3.5, SHGC = 0.53	Habitable AL DG 4/10Ar/4EA U = 3.5, SHGC = 0.53	Habitable AL DG 4-12Ar-4ET U = 3.1, SHGC = 0.49	Habitable AL DG 4-12Ar-4ET U = 3.1, SHGC = 0.49	Habitable AL DG 4/10/4EA U = 3.7, SHGC = 0.53	Habitable AL DG 4/16Ar/4 U = 3.2, SHGC = 0.53	Habitable AL DG 4/16Ar/4 U = 3.2, SHGC = 0.53	Habitable AL DG 4-12Ar-4ET U = 3.1, SHGC = 0.49
	Non-habitable AL SG U = 5.4, SHGC = 0.58	Non-habitable AL SG U = 5.4, SHGC = 0.58	Non-habitable AL SG U = 5.4, SHGC = 0.58	Non-habitable AL SG U = 5.4, SHGC = 0.58	Non-habitable AL SG U = 5.4, SHGC = 0.58	Non-habitable AL SG U = 5.4, SHGC = 0.58	Non-habitable AL SG U = 5.4, SHGC = 0.58	Non-habitable AL SG U = 5.4, SHGC = 0.58
7 Star 21% glass to floor area	R2.7 wall batts	R2.7 wall batts	R2.0 wall battsl	R2.0 batts in wall	R2.5 batts in wall	R2.7 batts in wall	R2.7 batts in wall	R2.7 batts in wall
	R4.2 Ceiling batt	R4.2 Ceiling batt	R5.0 Ceiling batt	R5.0 Ceiling batt	R6.0 Ceiling batt	R6.0 Ceiling batt	R6.0 Ceiling batt	R6.0 Ceiling batt
	Insulated Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living	Insul Partition Garage/Living Laundry/Living
	Habitable AL DG 4/10Ar/4EA U = 3.5, SHGC = 0.53	Habitable AL DG 4/10Ar/4EA U = 3.5, SHGC = 0.53	Habitable AL DG 4-12Ar-4ET U = 3.1, SHGC = 0.49	Habitable Al DG 4/10Ar/4EA U = 3.5, SHGC = 0.53	Living AL DG 4/10Ar/4EA U = 3.5, SHGC = 0.53	Living AL DG 4/16Ar/4 U = 3.2, SHGC = 0.53	Habitable AL DG 4/16Ar/4 U = 3.2, SHGC = 0.53	Habitable AL DG 4/10Ar/4EA U = 3.5, SHGC = 0.53
	Non habitable AL SG 3Clr U = 6.5, SHGC = 0.66	Non habitable AL SG 3Clr U = 6.5, SHGC = 0.66	Non habitable AL SG 3Clr U = 6.5, SHGC = 0.66	Non habitable AL SG 3Clr U = 6.5, SHGC = 0.66	Beds AL DG 4/10/4 U = 4.2, SHGC = 0.57	Beds AL DG 4/10Ar/4 U = 4.1, SHGC = 0.57	Non habitable AL SG 3Clr U = 6.5, SHGC = 0.66	Non-habitable AL SG U = 5.4, SHGC = 0.58
					Non habitable AL SG 3Clr U = 6.5, SHGC = 0.66	Non habitable AL DG 4/10/4 U = 4.2, SHGC = 0.57		

The membrane effect

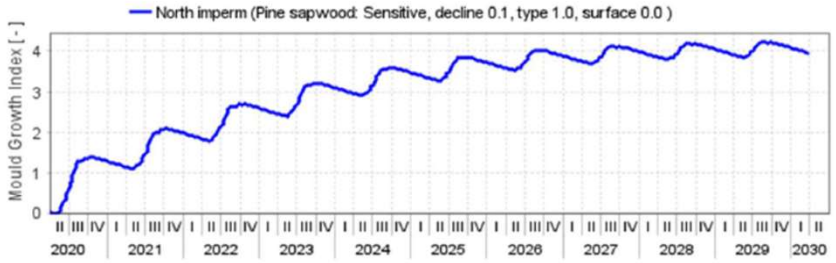


Figure 16: Timber clad wall, northern orientation, NatHERS CZ66, impermeable building membrane

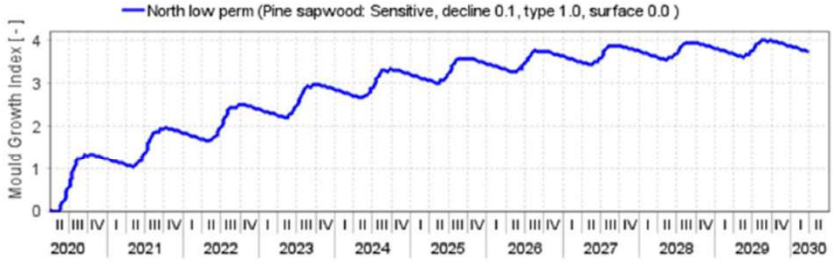


Figure 17: Timber clad wall, northern orientation, NatHERS CZ66, AS4200 Class 3 building membrane

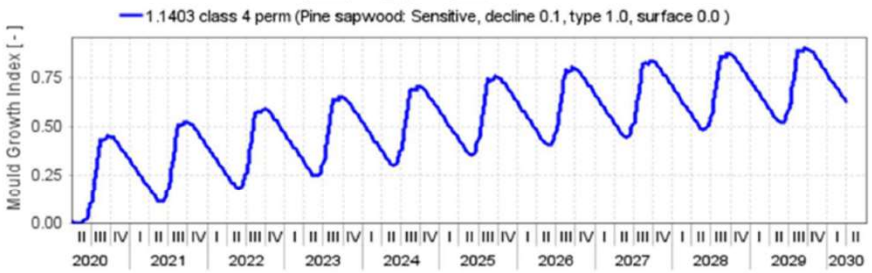
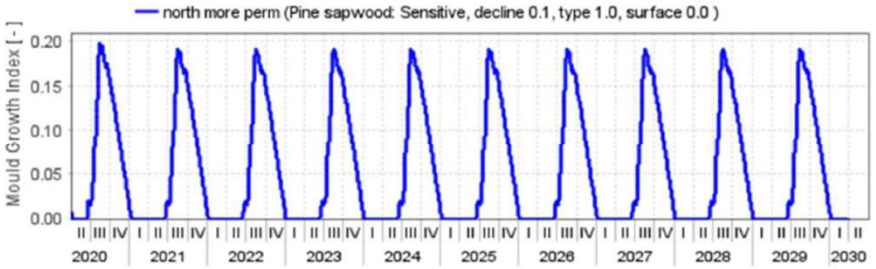
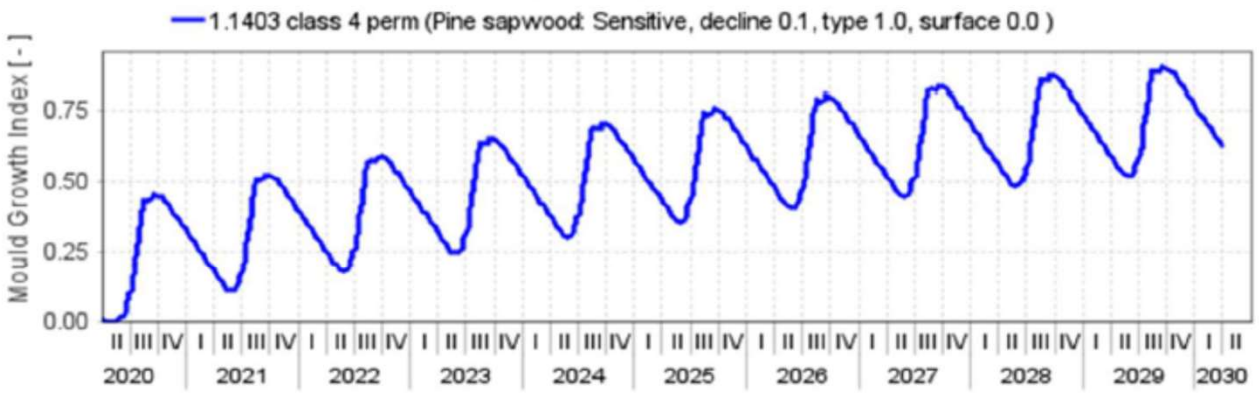


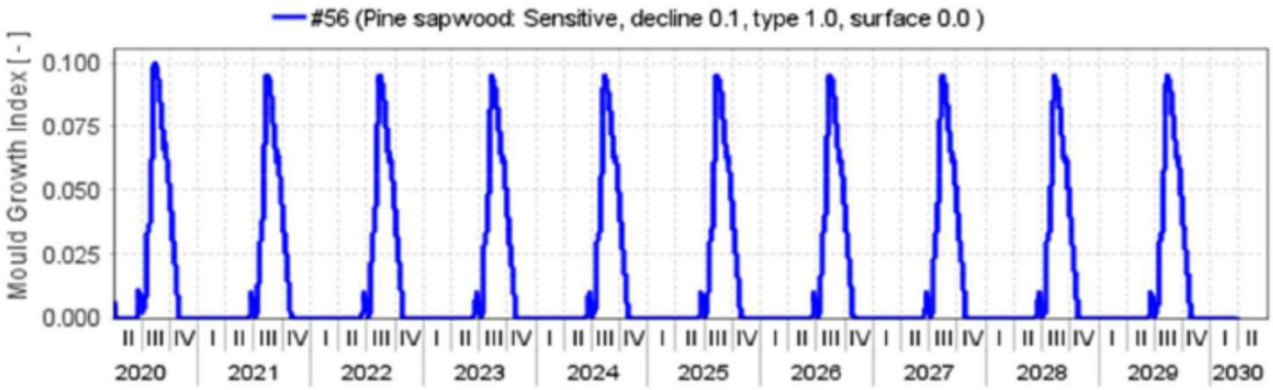
Figure 18: Timber clad wall, northern orientation, NatHERS CZ66, AS4200 Class 4 building membrane (1.1403 ug/N.s)



The cavity effect



igure 20: Timber clad wall, northern orientation, N
membrane (1.1



The airtightness effect

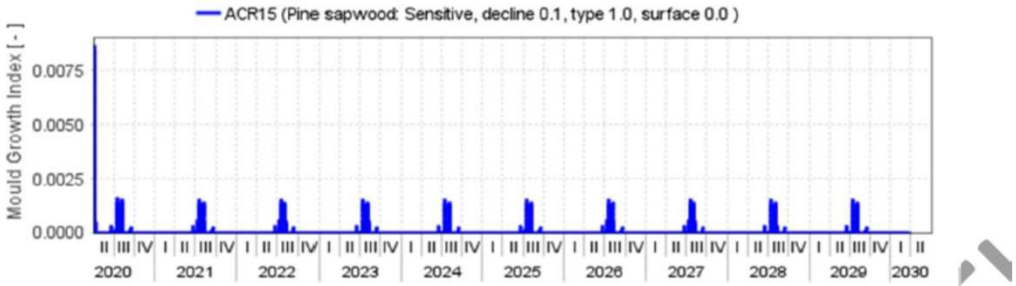


Figure 22: Timber clad wall, northern orientation, NatHERS CZ66, AS4200 Class 4 permeable building membrane (1.1403 ug/N.s) ACR 15

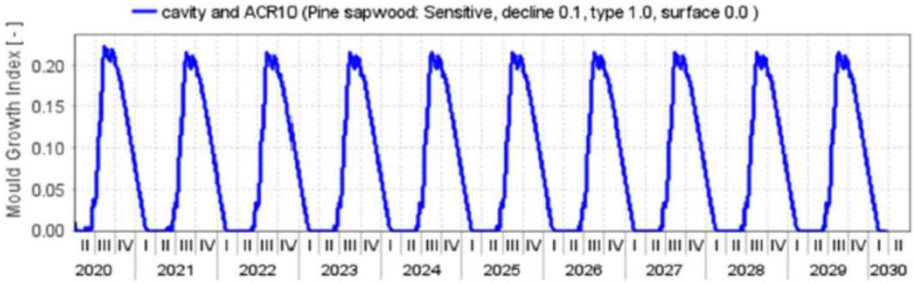


Figure 23: Timber clad wall, northern orientation, NatHERS CZ66, AS4200 Class 4 permeable building membrane (1.1403 ug/N.s) ACR 10

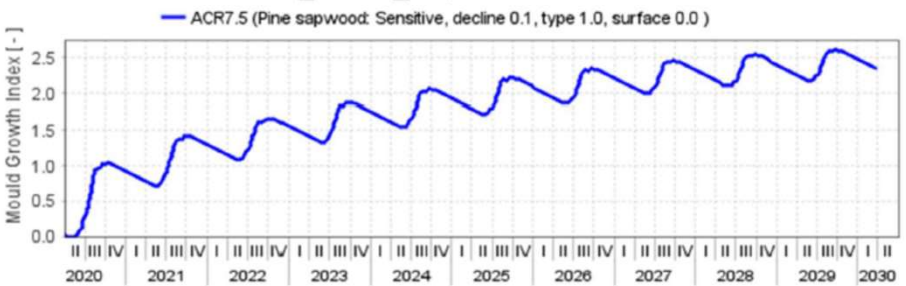


Figure 24: Timber clad wall, northern orientation, NatHERS CZ66, AS4200 Class 4 permeable building membrane (1.1403 ug/N.s) ACR 7.5

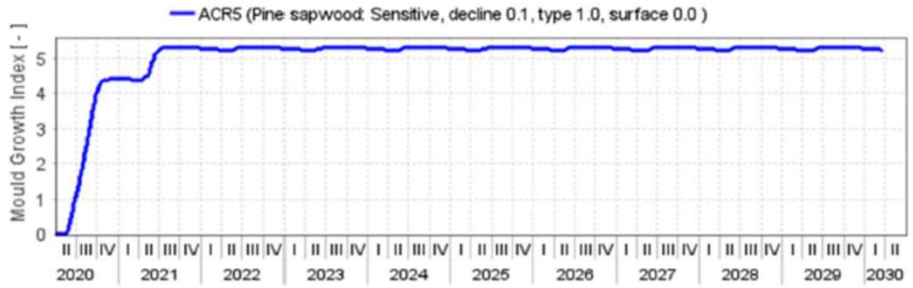
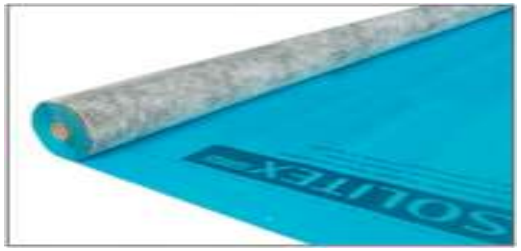


Figure 25: Timber clad wall, northern orientation, NatHERS CZ66, AS4200 Class 4 permeable building membrane (1.1403 ug/N.s) ACR 5.0

Possible strategies – More permeable



Technical Details

water vapour transmission resistance	less than 0,10m
Permeance	more than 33 US perms
Mvtr	less than 0,5MNs/g
water-resistance:rainproof	Water column more than 2500mm
surface weight:	170g/m2
diffusion ability:	more than 400g/m2 24h
UV stability and outdoor exposure:	3 months
fire rating:	B2
tear-resistance:	more than 390N/5cm
resistance to nails tearing out:	more than 300N
cover-fleece:	polypropylene microfibre
membrane:	monolithic TEEE film
non-woven fabric:	polypropylene microfibre
reinforcement:	polypropylene fabric
temperature resistance:	-40˚C to +100˚C
colour:	light-blue

DuPont™ Tyvek® HomeWrap®

PHYSICAL PROPERTIES DATA SHEET

Properties Australian Building Code and AS/NZS4200	Test Method	Requirement	DuPont™ Tyvek® HomeWrap® (1055B)
Duty Classification	Table 1, AS/NZS 4200.1:2017	Light wall	Light wall
Vapour Permeance	ASTM E96 – B	>1.14µg/N.s	> 2.0µg/N.s
Vapour Resistance	ASTM E96 – B	<0.88MN.s/g	<0.5MN.s/g
Vapour Control Classification	AS/NZS 4200.1:2017 Table 4	Class 4	Class 4 (low)
Emittance Classification	AS/NZS 4201.5	Non-Reflective	Non-Reflective
Mechanical Strength			

It is good practice for Enviroseal™ ProctorWrap™ RW to be separated from the exterior cladding by a cavity to allow for the drainage of any moisture that has penetrated the exterior cladding or condensation that may form on the rear face of the cladding. Adequate provision for the drainage, absorption or diffusion of moisture is required exterior to the membrane to ensure that moisture is not left trapped between the Enviroseal™ ProctorWrap™ RW and the external cladding. This is especially important for vapour tight or non-absorbent claddings such as steel.

Care should be taken when installing insulation so that this does not restrict drainage within the cavity.

CLASSIFICATIONS

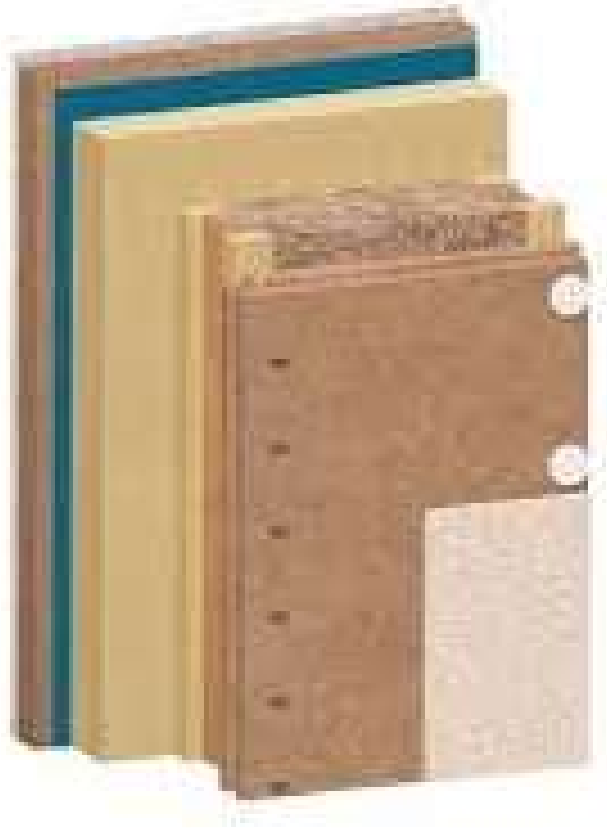
CRITERIA	REFERENCE	RESULT
DUTY CLASSIFICATION	Table 1 AS/NZS 4200.1:1994	Light*
VAPOUR PERMEABILITY	ASTM E96	4.5µg/N.s
VAPOUR RESISTANCE	ASTM E96	0.22MN.s/g
VAPOUR BARRIER CLASSIFICATION	ASTM E96	Low
EMITTANCE	AS/NZS 4201.5	Non-reflective
WATER BARRIER	AS/NZS 4201.4	High

Possible strategies – Interior membranes

Figure 10.68: Installation of INTELLO® PLUS at wall sections

Figure 10.69: Stapling of INTELLO® PLUS. Photo courtesy of Bright Haus

Possible strategies – EIFS



Canadian Code: Part - 9.36.5.3. Compliance stresses that it is not the occupant's role to manage vapour and condensation but the built fabric, & **is not dependent on occupant interaction**

$$Td = T - ((100-RH)/5)$$

Condensation – The Modelling of moisture accumulation and mould growth

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