Quantifying the potential of ultra-efficient houses to reduce seasonal electricity demand and enable greater renewable supply

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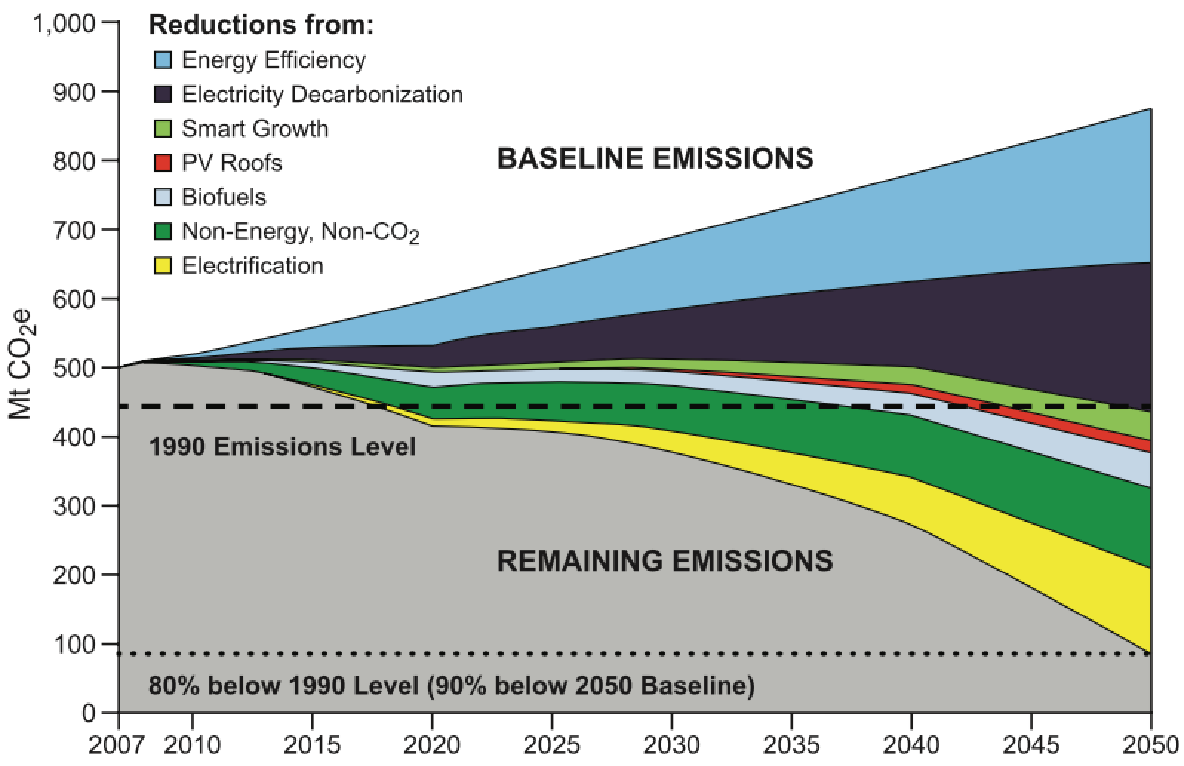
Can ultra-efficient houses keep us warm and healthy *and* solve the “dry-year problem”?

Low Energy & Passivhaus Retrofit

Energy efficiency + electrification = Decarbonization

Technology Path for California



Williams et al. Science, 335, 53 (2012)

Preferred pathway for New Zealand Interim Climate Change Committee (ICCC) *

"Three-step" plan

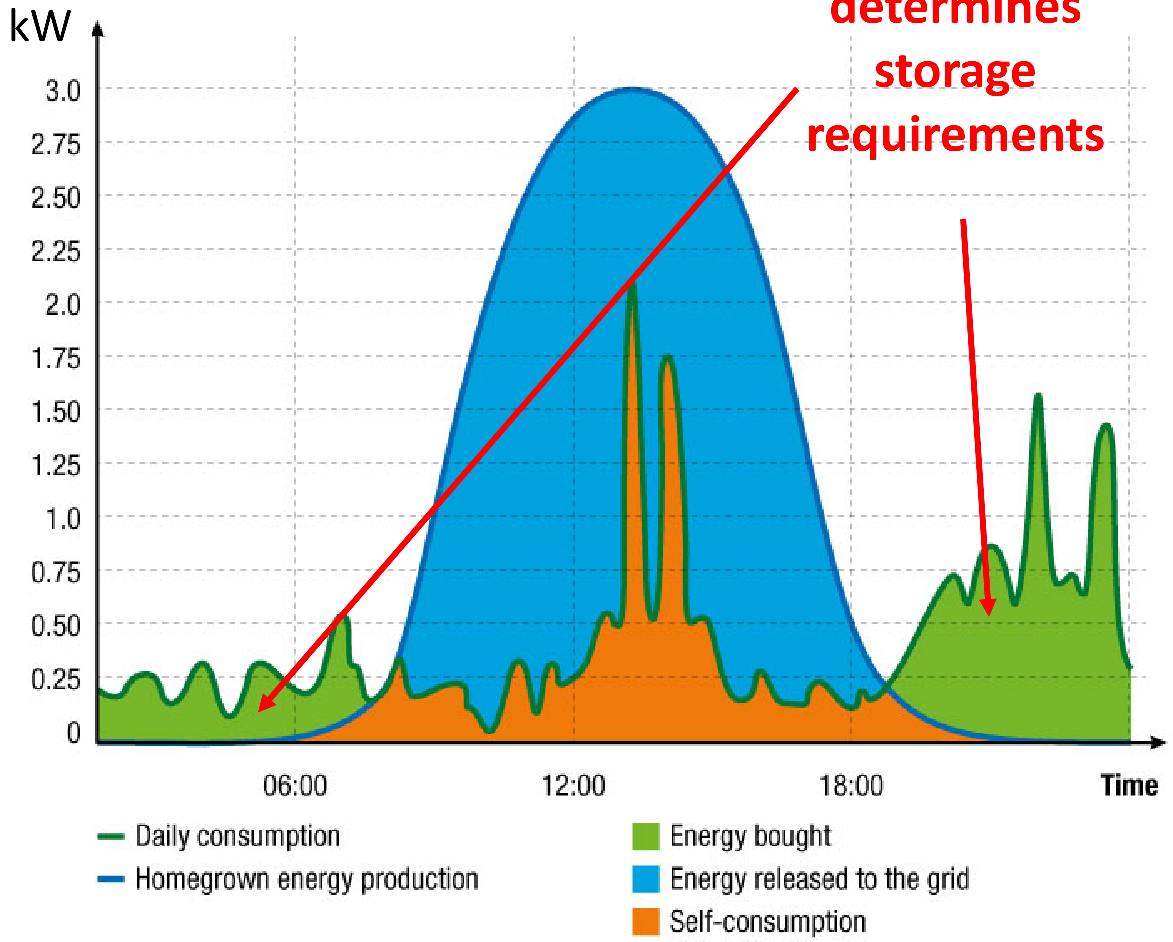
1. Reduce energy demand
2. Increase % of renewable electricity
3. Electrify heating and transport (e.g. EVs)

*Accelerated Electrification report 2019

Renewable electricity: Variability challenges

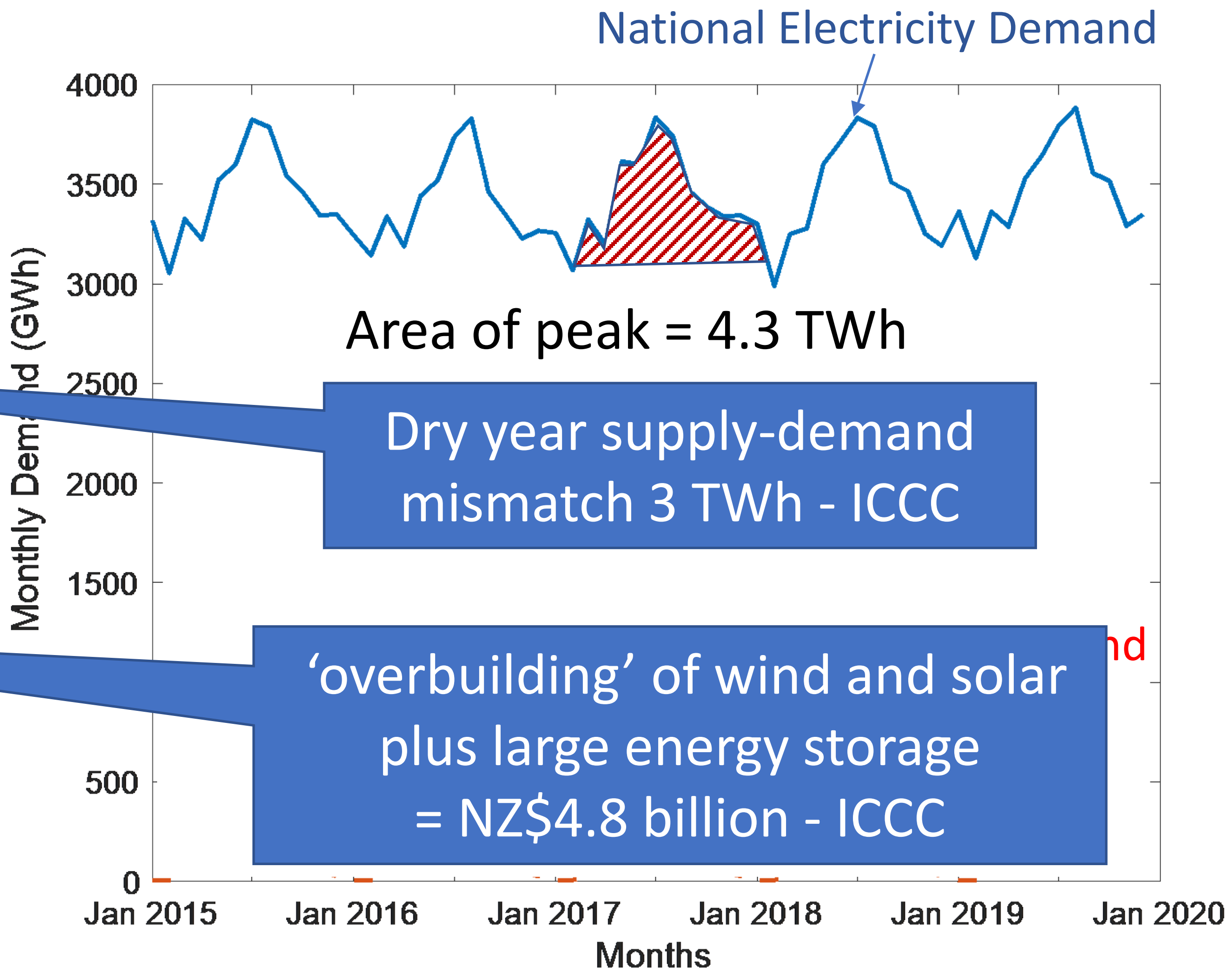
- Most renewable resources are “non-dispatchable” resulting in a temporal mismatch between supply and demand
- Energy storage can be used to bridge short-duration (<2 weeks) mismatches
- Economic solutions for longer supply-demand mismatches currently *do not exist*

Area under curve determines storage requirements

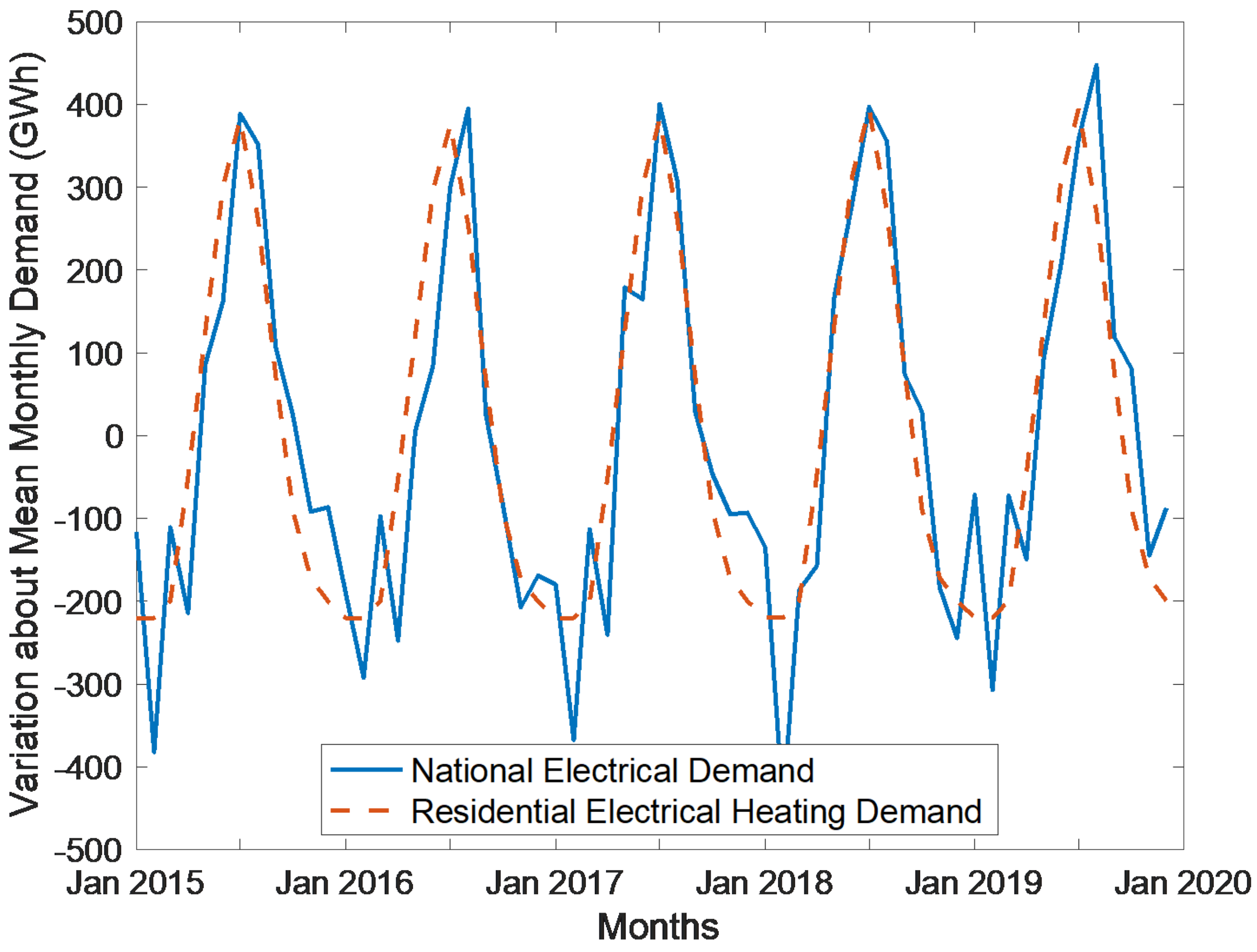


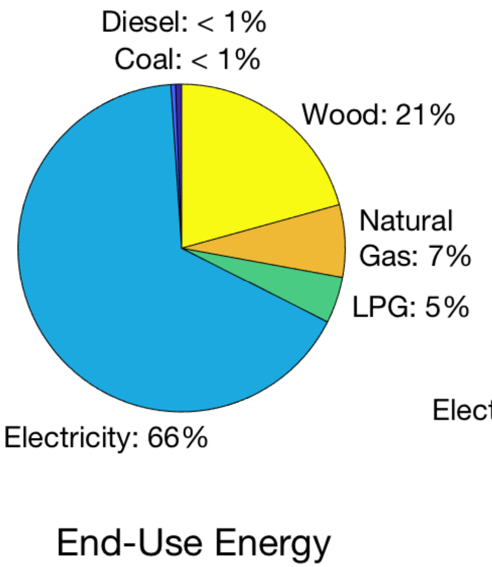
Seasonal supply-demand mismatch & the 'dry year problem'

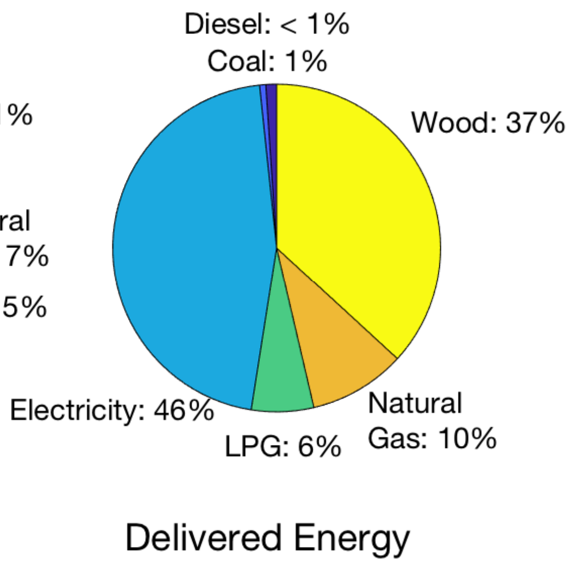
- New Zealand has a significant winter peak in electricity demand
- In dry, calm years this results in a significant seasonal supply-demand mismatch
- Solar PV likely to make this worse
- Supply-side and storage solutions are very expensive
- Argument for *not* pursuing 100% renewable electricity - ICCC
- But… what causes this winter peak in demand?



Residential Heating Causes Winter Peak







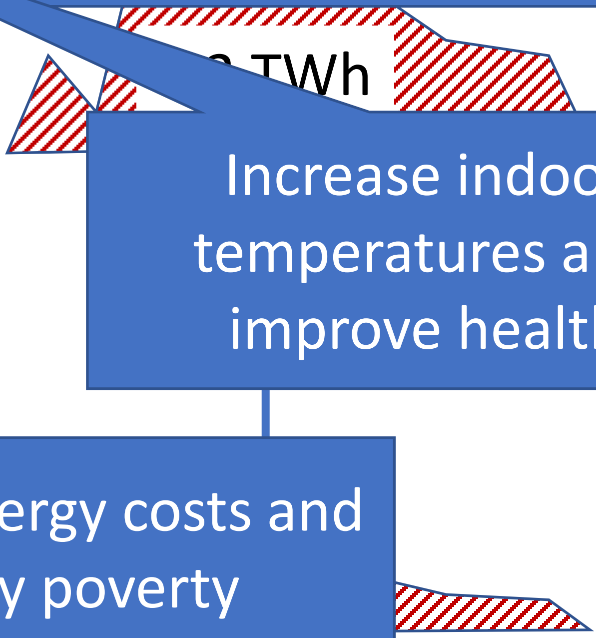
Can energy-efficient buildings reduce the supply-demand mismatch?

- Energy-efficient housing has been demonstrated to have multiple benefits
- Could energy-efficient housing also reduce the seasonal supply-demand mismatch?
- Key Considerations:
  - Need long-term perspective – houses often exist for 100 years
  - Future trends – population, building technologies, house size, etc…
  - Current state of NZ's housing stock

Reduce Space heating energy use (by 80%) and associated Greenhouse Gas Emissions

Increase indoor temperatures and improve health

Reduce energy costs and energy poverty



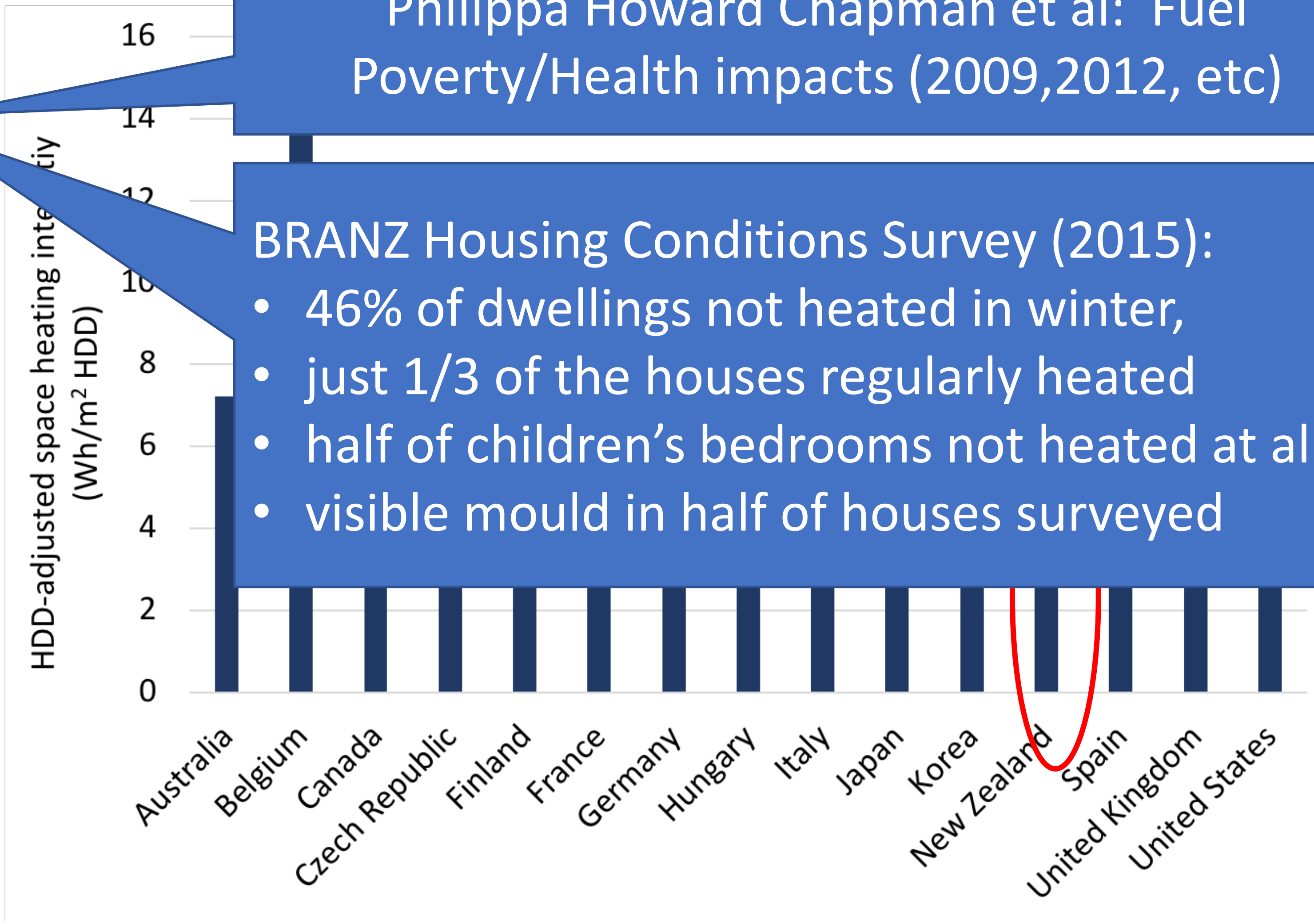
We do not heat our houses enough

- Much has been written about the poor state of NZ housing
- NZ has lowest space heating intensity of selected OECD countries (IEA)
- True even when adjusted for different climates (divided by Heating Degree Day)

Philippa Howard Chapman et al: Fuel Poverty/Health impacts (2009,2012, etc)

BRANZ Housing Conditions Survey (2015):

- 46% of dwellings not heated in winter,
- just 1/3 of the houses regularly heated
- half of children’s bedrooms not heated at all
- visible mould in half of houses surveyed

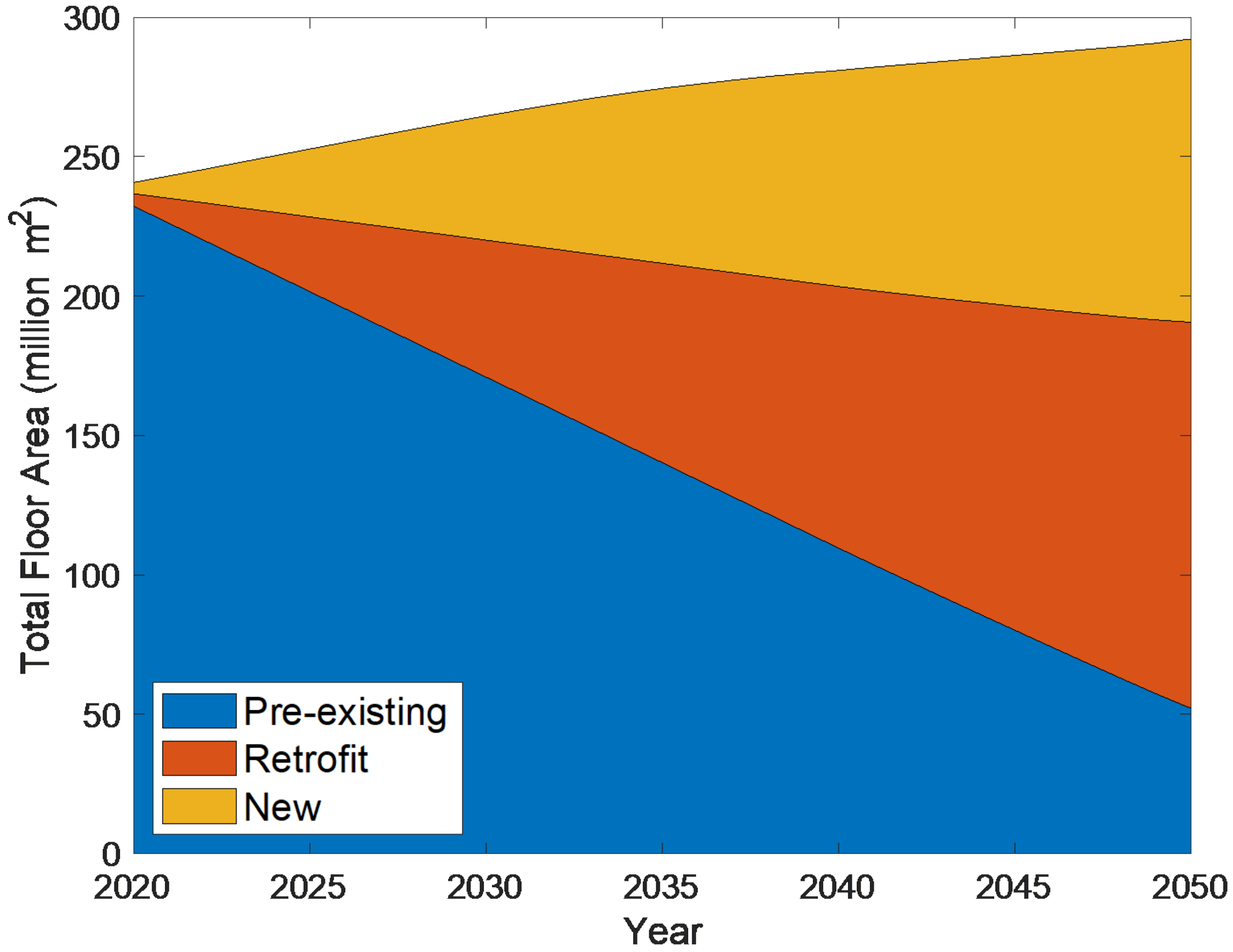


Future Residential Heating Scenarios

- Time period: 2020 to 2050 (align with Net Zero carbon aspirations)
- Focus on detached houses (>90% of dwellings by floor area)
- Range of space heating possibilities – based on different building standards
- Assume all houses heated to 20 deg C as baseline
- Regional break down using climate data

Annual space heating energy demand = Floor area model x Space heating demand per m^2 (determined by each building standard scenario)

Future Detached-House Floor Area Model



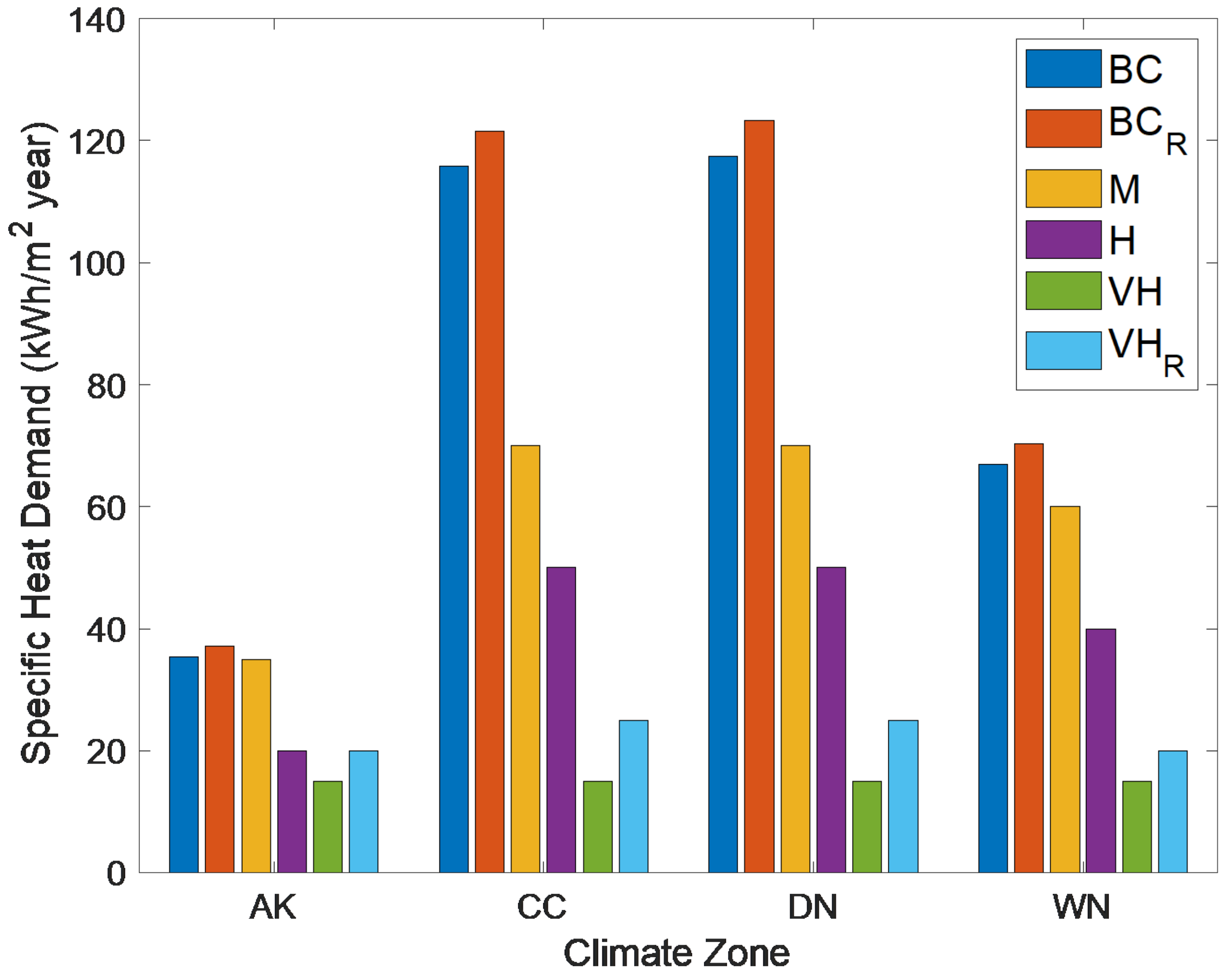
Assumptions:

1. Demolition of pre-existing houses at a rate of 0.7% per year(Coleman 2018)
2. Population growth 2020: 1.2%/year, 2050: 0.5%/ year
3. New builds increase at a linear rate based on recent consents then slow to 60% of this by 2050 (Stats NZ)
4. 30,000 energy efficient retrofits per year

Future energy heating scenarios

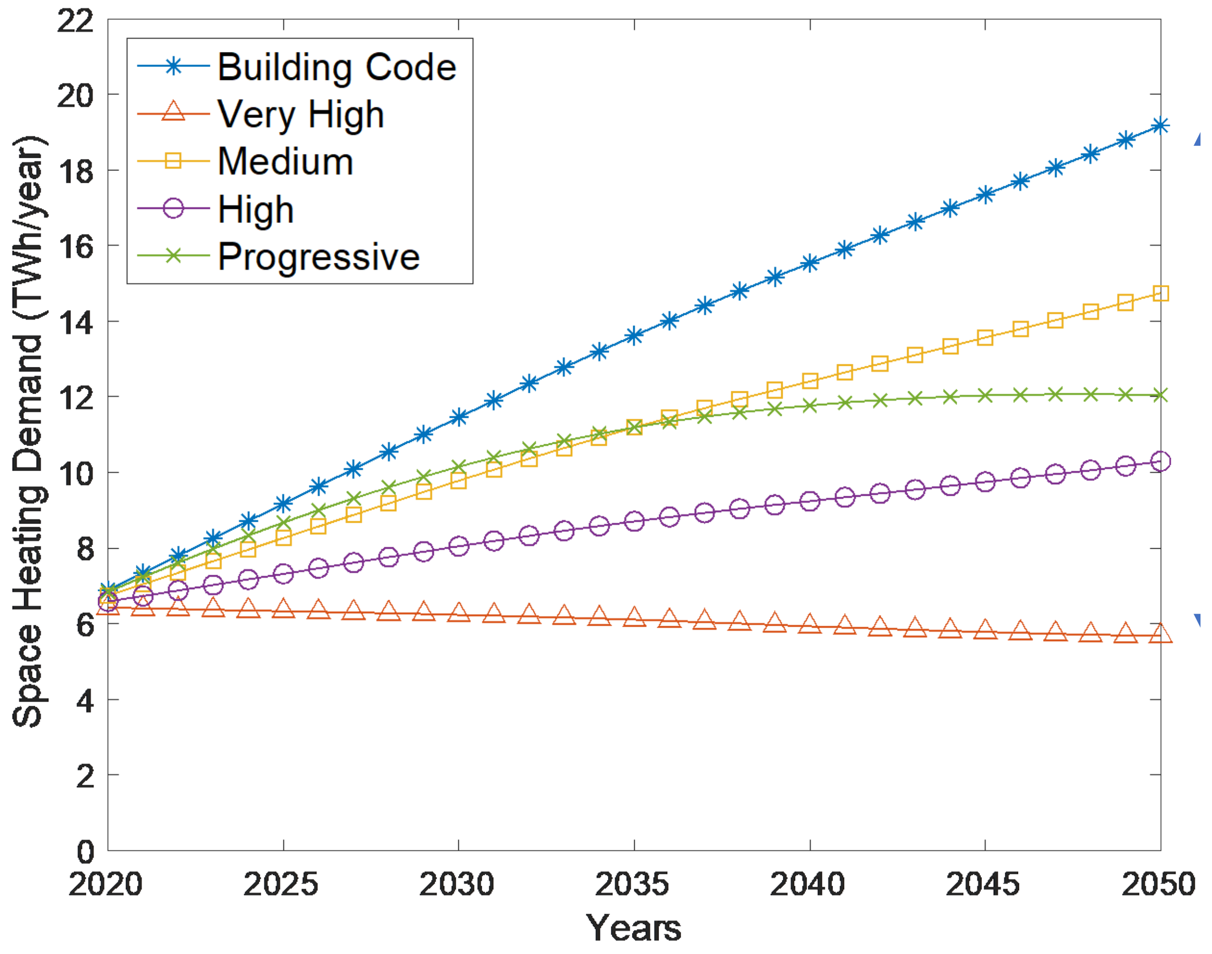
- **NZ Building Code (BC)**
  - New and Retrofits built to BC – based on Building Performance Index
- **Medium (M)**
  - New and Retrofits built to Homestar 6 Standard
- **High (H)**
  - New and Retrofits built to Homestar 7 Standard
- **Very High (VH)**
  - New Builds and Retrofits built to Passive House Standard
- **Progressive (P)**
  - Progressively move to Passive House Standard from BC

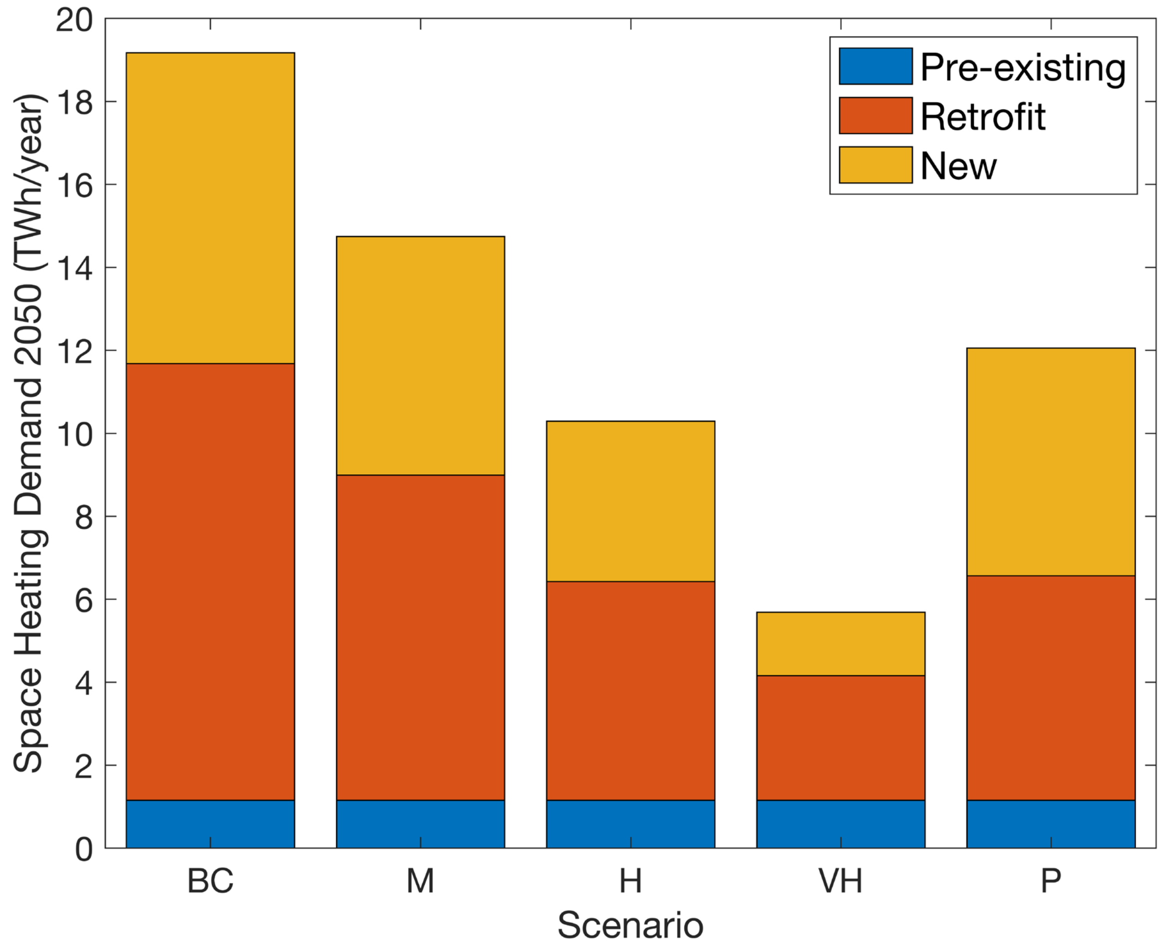
Results - Specific Heat Demand (kWh/m^2)



Zone	$\bar{T}_{\text{July}}$	$\bar{T}_{\text{Jan}}$	Territorial authority
AK	11.3	19.2	Thames-Coromandel District, Auckland
WN	9.0	17.0	Porirua City, Lower Hutt City, Wellington City
CC	5.1	16.2	Hurunui District, Waimakariri District, Christchurch City, Selwyn District, Ashburton District, Timaru District, Waimate District
DN	7.0	14.2	Waitaki District, Dunedin City, Clutha District

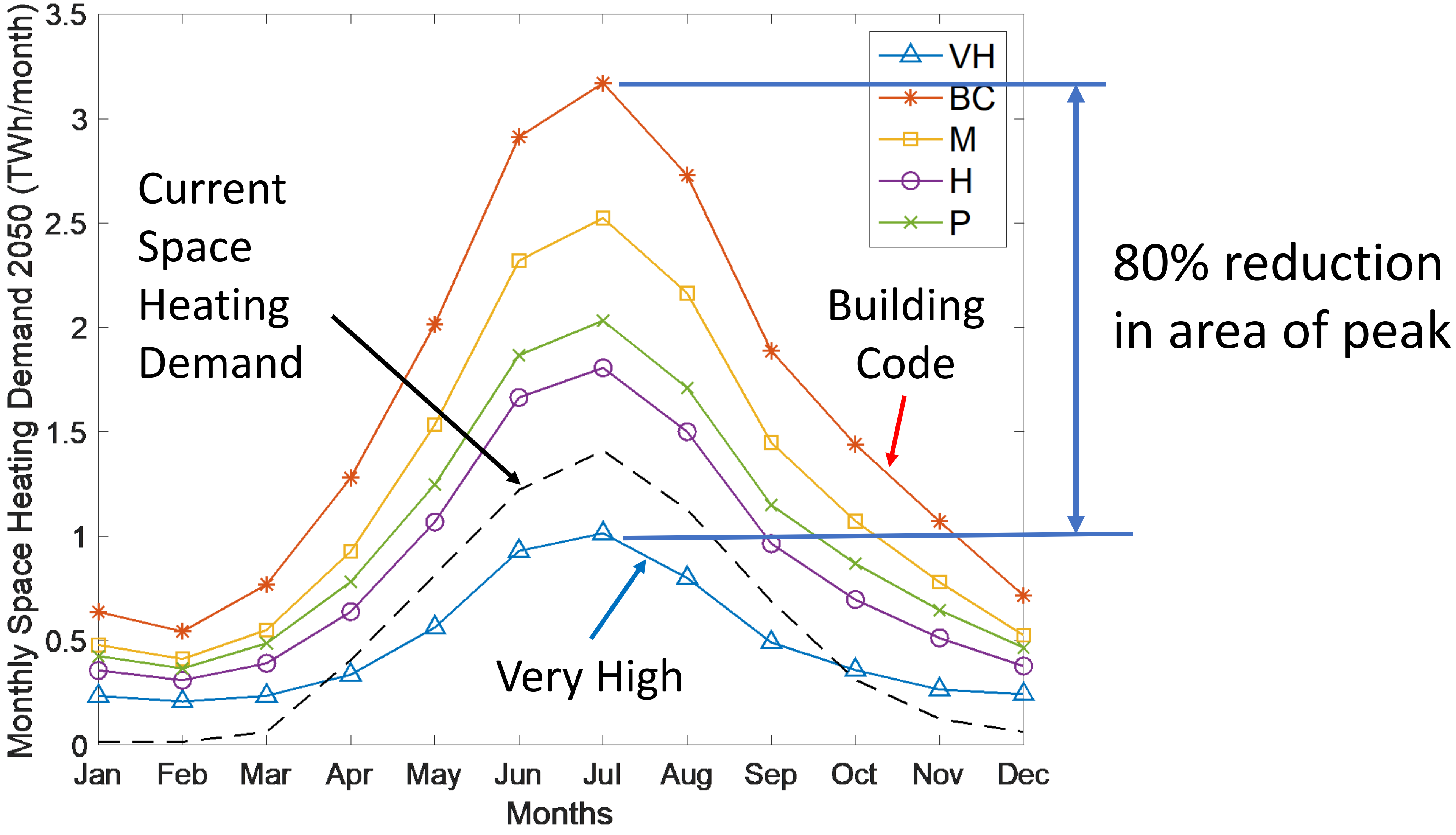
Results - Annual Space Heating Demand





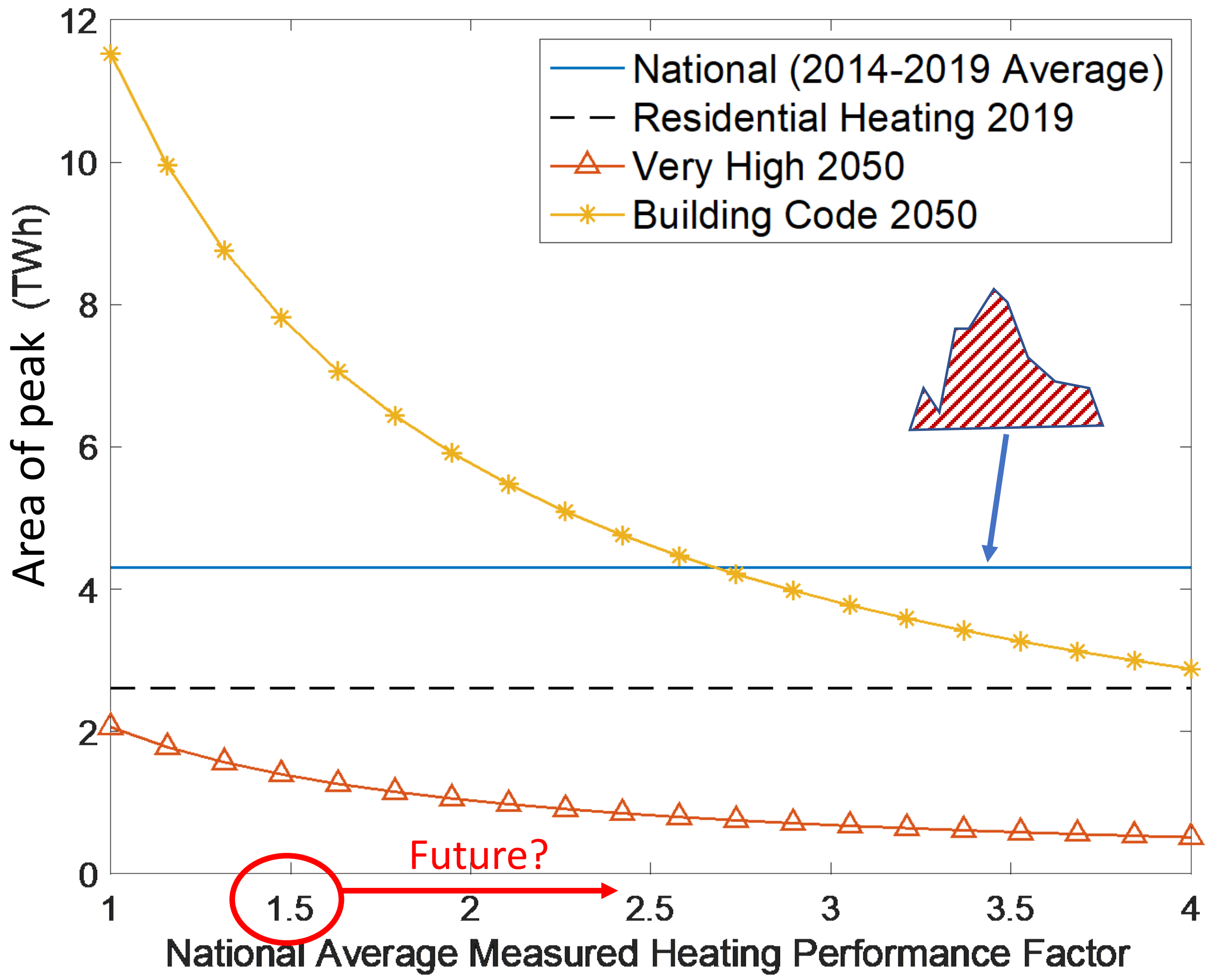
Note Progressive Scenario <50% reduction by 2050

Results - Monthly Space Heating Demand 2050



What does this mean for winter peak reduction?

- Impact on electricity demand depends on efficiency of electrical heating:
  - Measured Heating Performance Factor (MHPF)
- Current average MHPF ~ 1.5
  - c.f. Heat pump Coefficient of Performance ~2-3
- Building Code Scenario “area of peak” is greater than current for residential heating for MHPF<4
- For Very High Scenario “area of peak” in 2050 is ½ of current for MHPF = 1.5



Summary

- Currently-achievable best practice standards could red
  - annual electricity demand to 1/3 of BAU by 2050
  - difference between winter and summer demand to 1/ BAU
- This will help decarbonisation of the New Zealand electri y system and thus overall energy system.
- Slower implementation will significantly delay benefits
- Retrofits critical
- Need cross-sector policies that mandate energy efficient residential buildings based on their wide-ranging **health**, **efficiency** and **energy affordability** benefits *and* their role in **decarbonisation.**

In contrast recent MBIE report suggests staged implementation*.

Missing from MBIE report.

**Building for Climate Change: Transforming operational efficiency consultation report 2(020)*

Some quick calculations

Value of Building to VH Standard

Zone	Savings per year ($/m²)	NPV of savings (3%)	NPV of savings (6%)	NPV of savings as percentage of building costs (3%)	NPV of savings as percentage of building costs (6%)
AK	$ 3.07	$ 60.09	$ 42.20	2%	1%
WN	$ 7.80	$ 152.87	$ 107.36	5%	4%
CC	$ 15.12	$ 296.27	$ 208.06	10%	7%
DN	$ 15.37	$ 301.34	$ 211.63	10%	7%

Assumptions:

- 30 year lifetime
- Building cost $3,000/m^2
- Space heating energy cost $0.15/kWh

Value to NZ of reducing peak

$4.3 Bn/3 TWh = $1.6 Bn/TWh