

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

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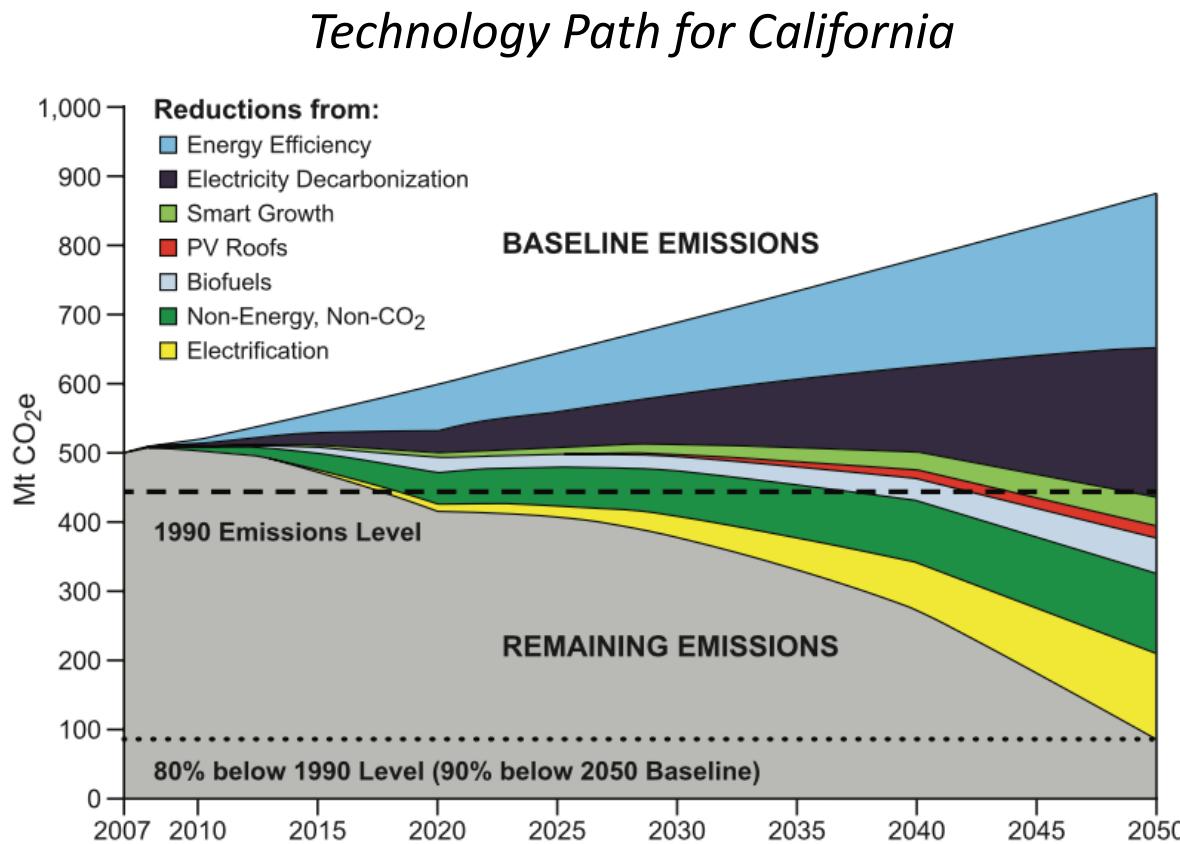
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Can ultra-efficient
houses keep us warm
and healthy *and* solve
the “dry-year problem”?



Low Energy & Passivhaus Retrofit

Energy efficiency + electrification = Decarbonization



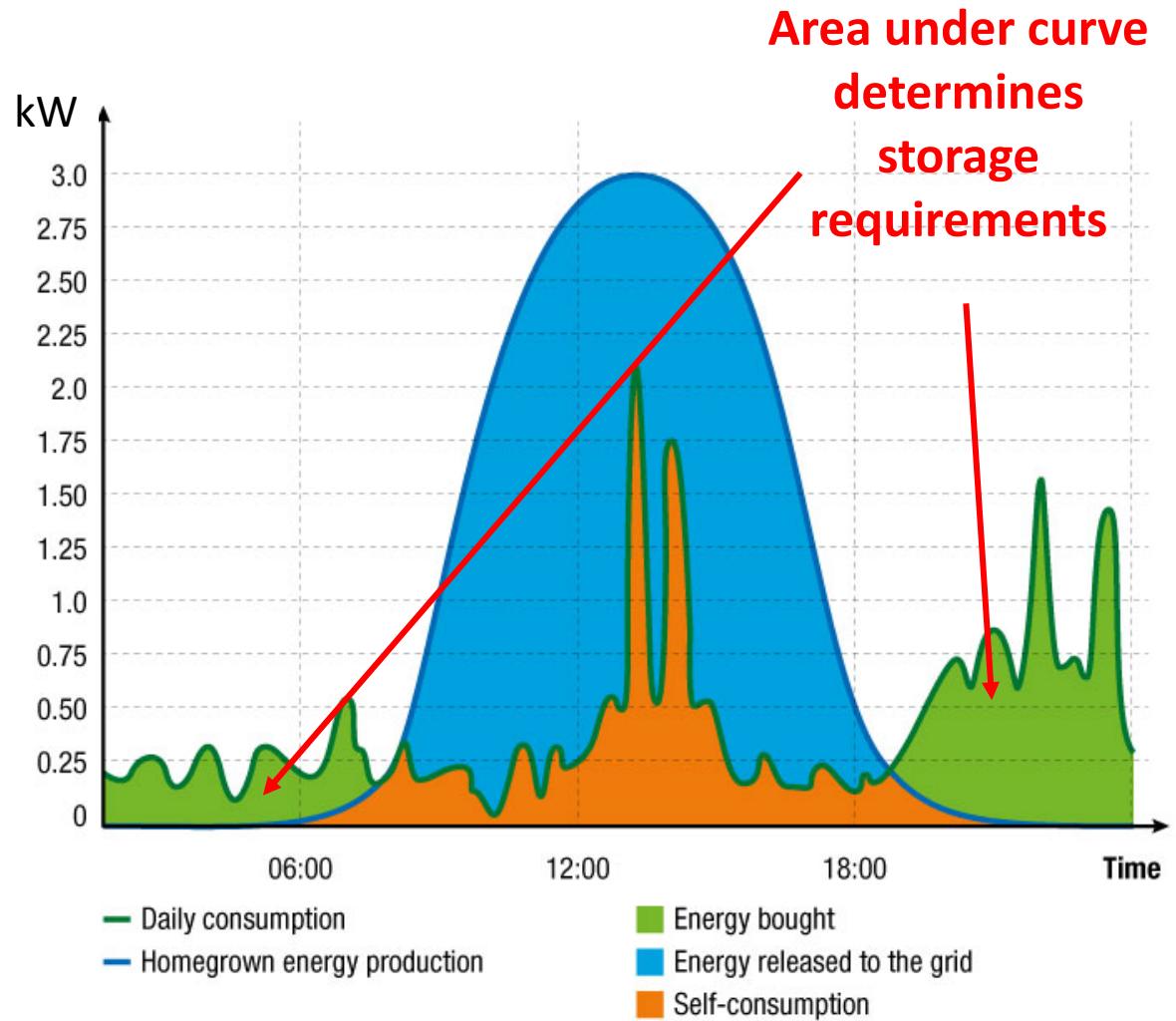
Preferred pathway for New Zealand
Interim Climate Change Committee
(ICCC) *

“Three-step” plan

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

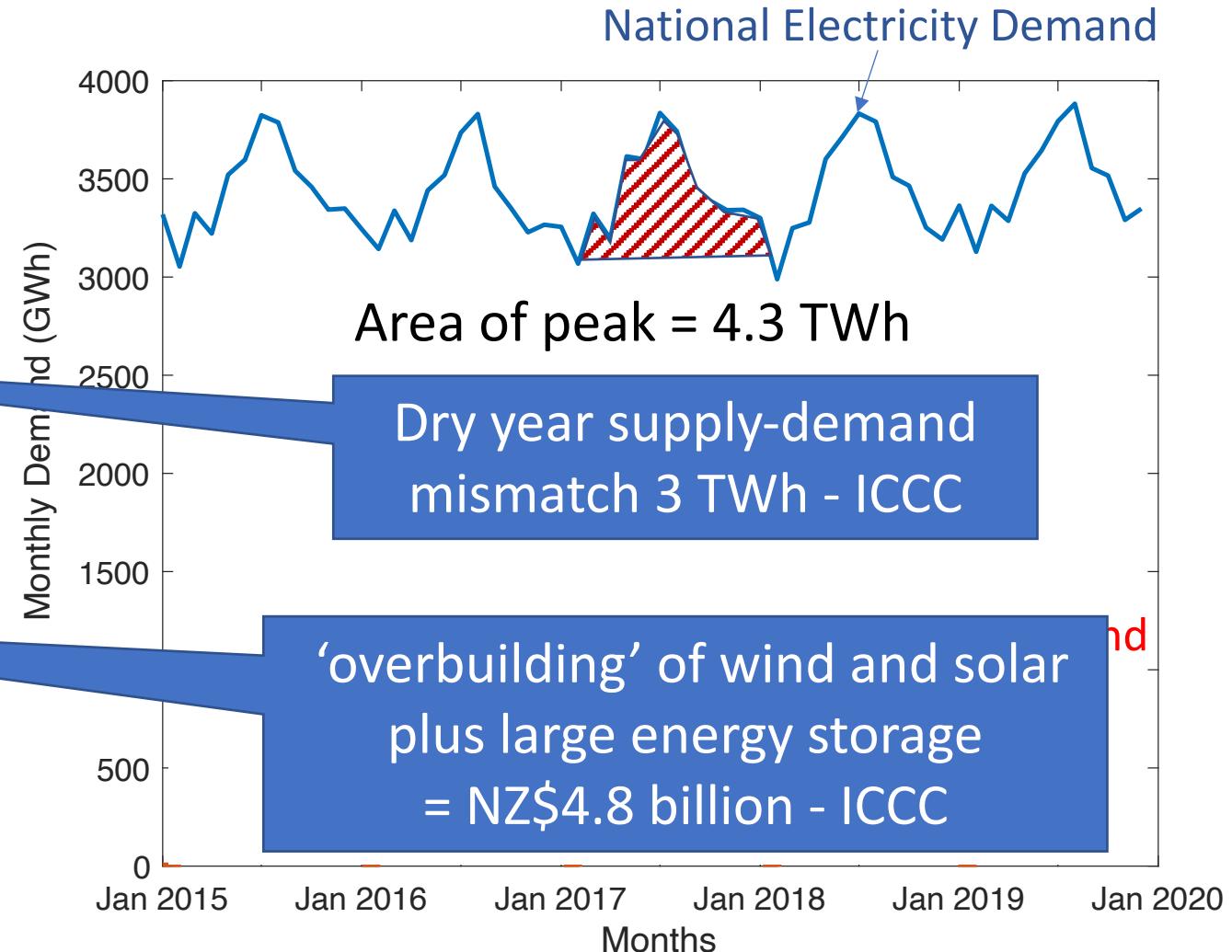
Renewable electricity: Variability challenges

- 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*

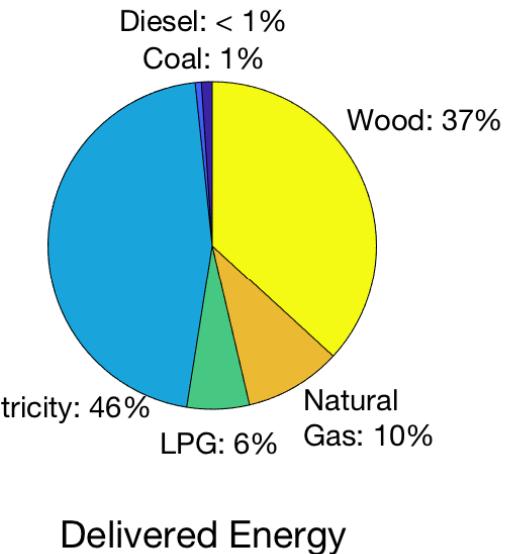
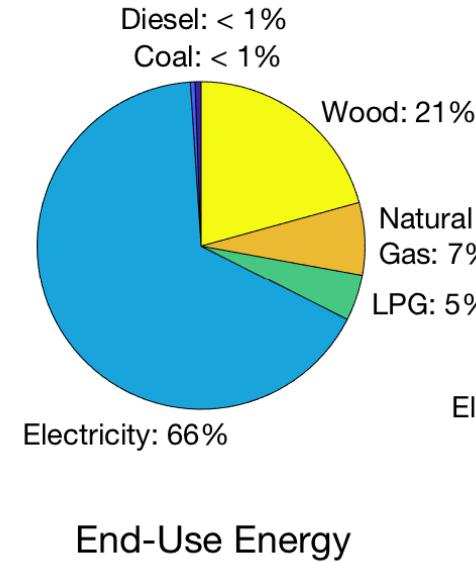
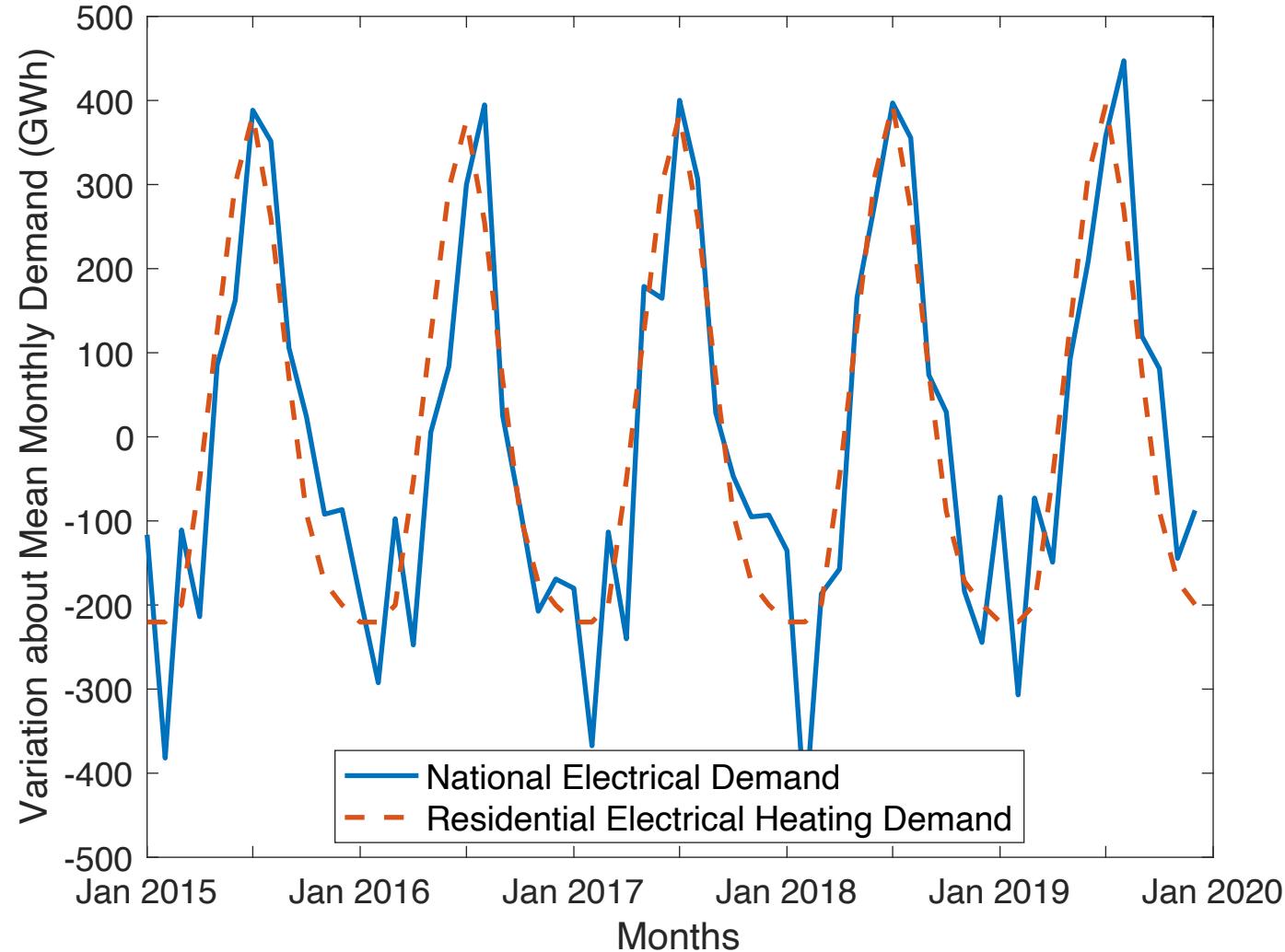


Seasonal supply-demand mismatch & the 'dry year problem'

- 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?

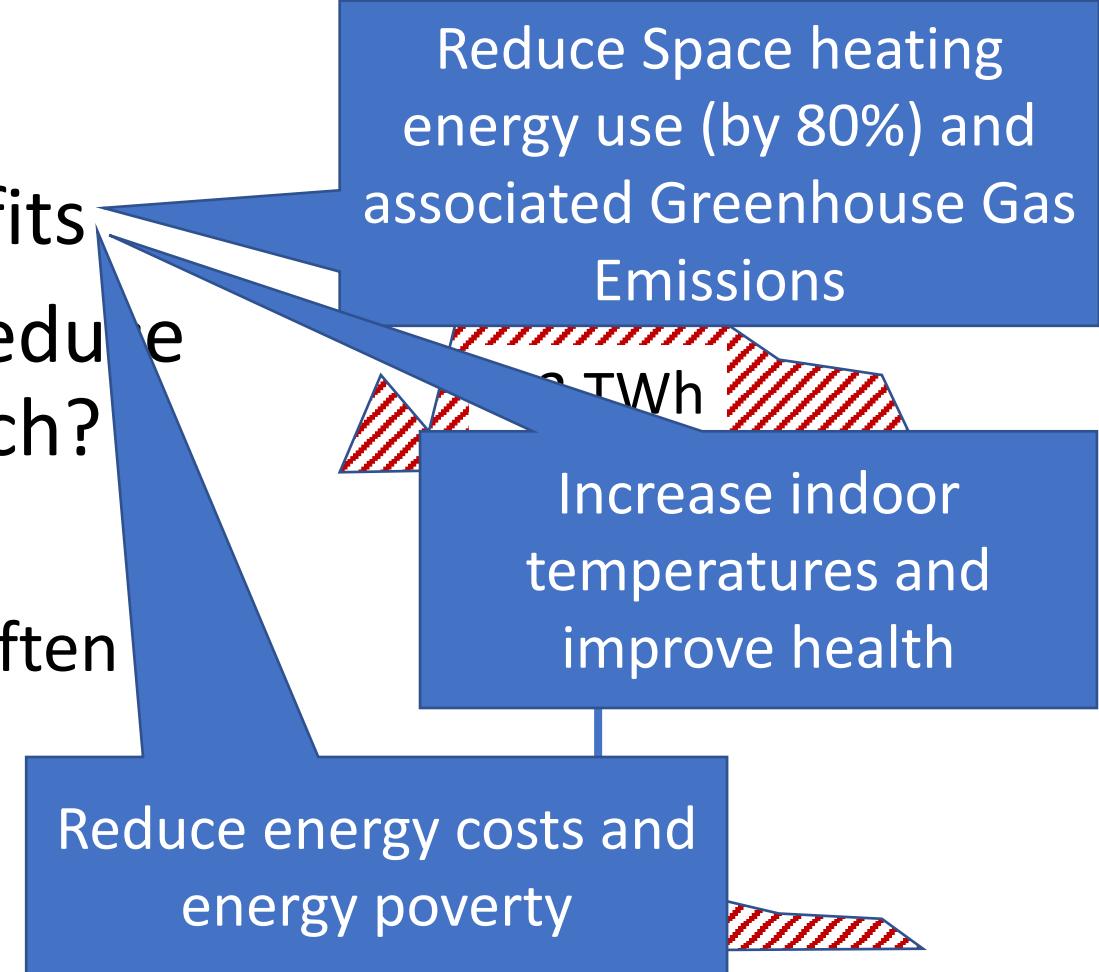


Residential Heating Causes Winter Peak



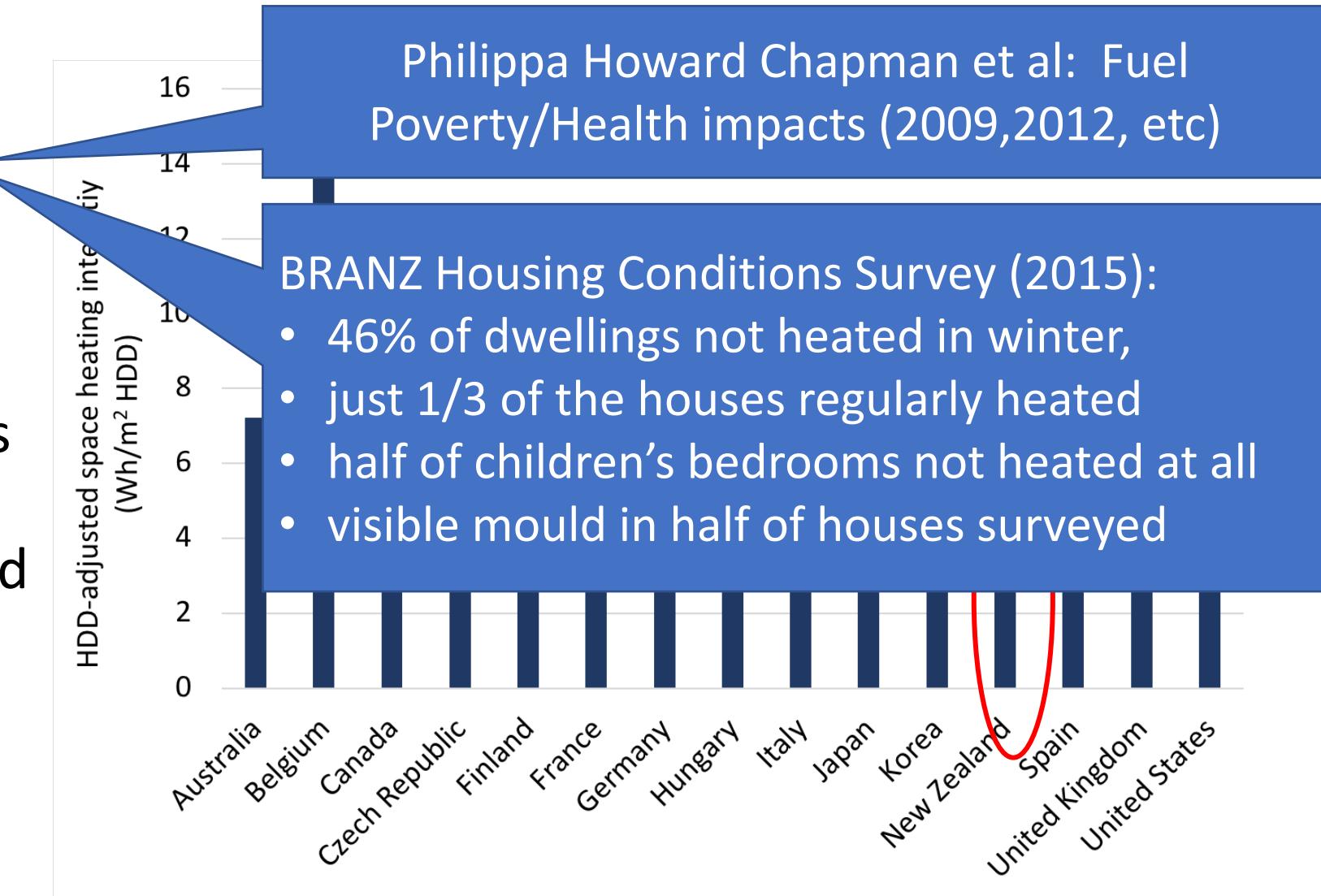
Can energy-efficient buildings reduce the supply-demand mismatch?

- 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



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)

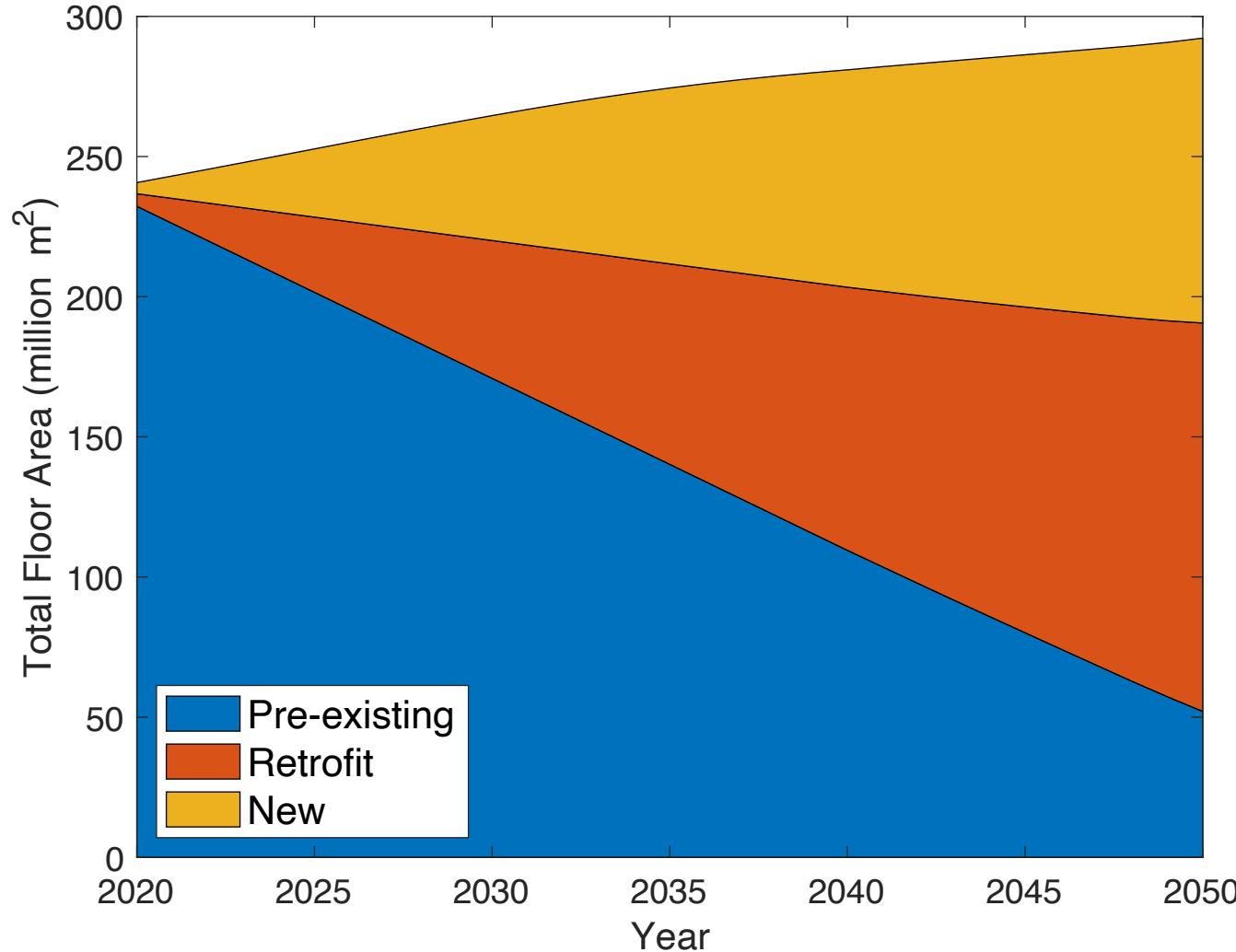


Future Residential Heating Scenarios

- 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

$$\text{Annual space heating energy demand} = \text{Floor area model} \times \text{Space heating demand per m}^2 \text{ (determined by each building standard scenario)}$$

Future Detached-House Floor Area Model



Assumptions:

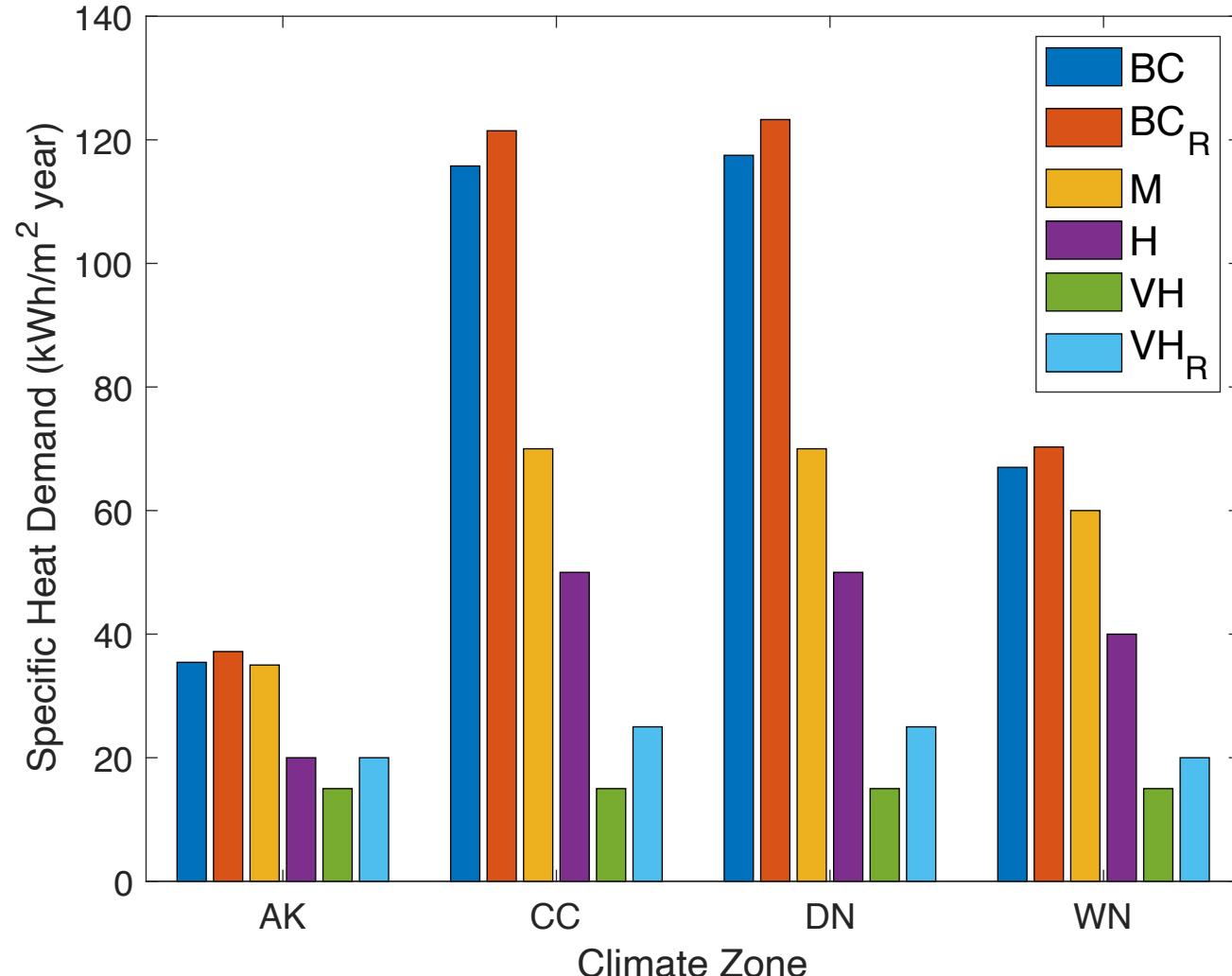
1. Demolition of pre-existing houses at a rate of 0.7% per year (Coleman 2018)
2. Population growth 2020: 1.2%/year, 2050: 0.5% / year
3. New builds increase at a linear rate based on recent consents then slow to 60% of this by 2050 (Stats NZ)
4. 30,000 energy efficient retrofits per year

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

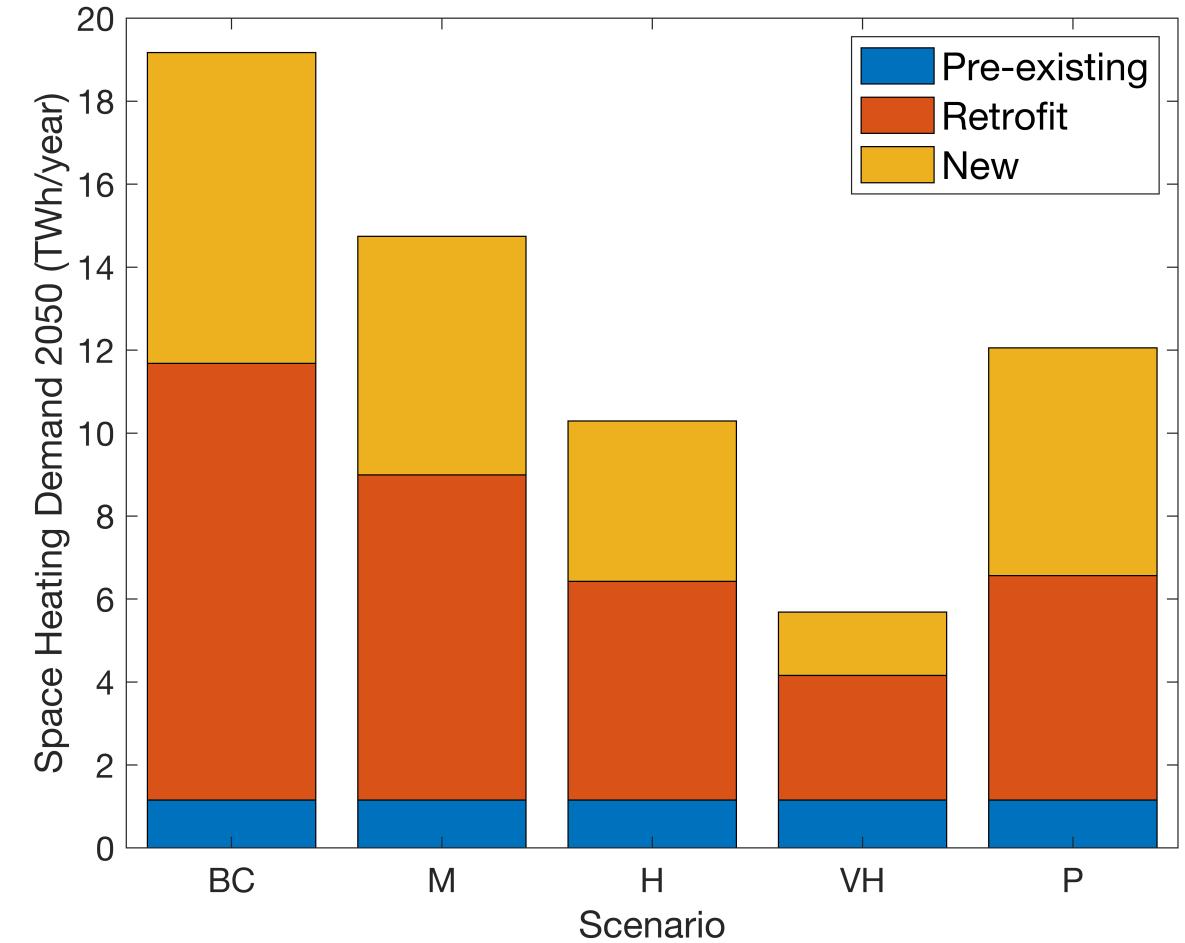
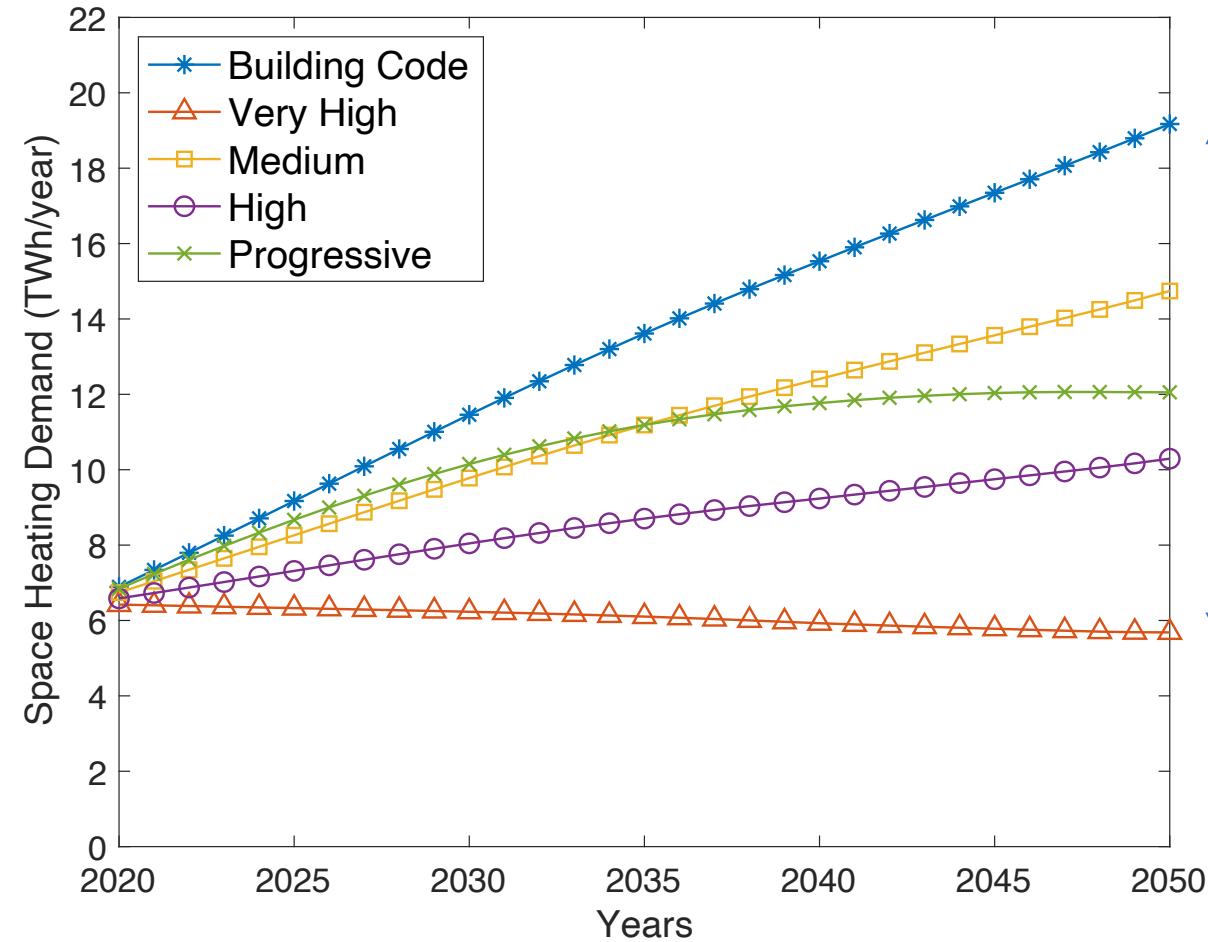


Results - Specific Heat Demand (kWh/m²)



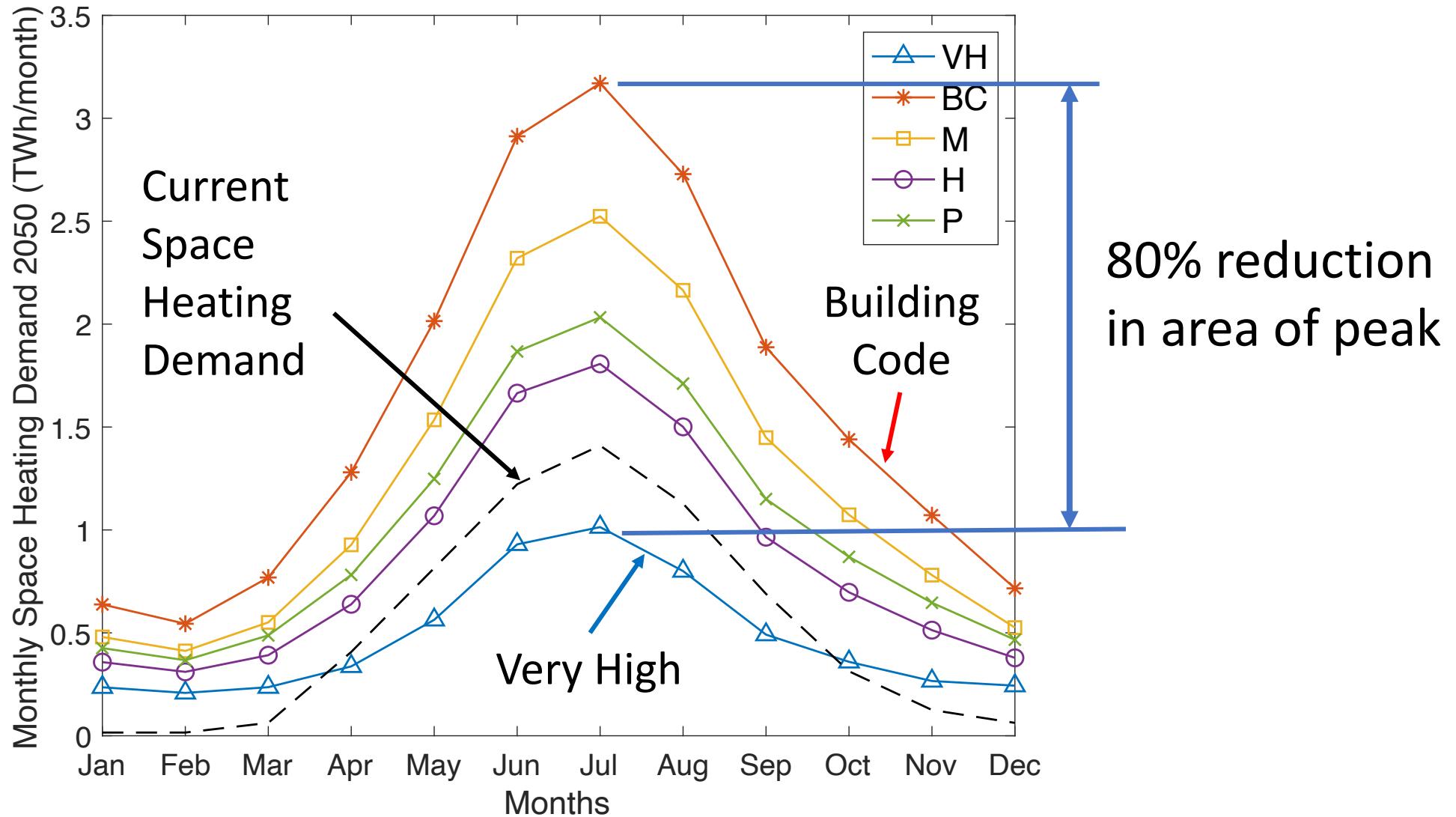
Zone	\bar{T}_{July}	\bar{T}_{Jan}	Territorial authority	
AK	11.3	19.2	Thames-Coromandel District, Auckland	
WN	9.0	17.0	Porirua City, Lower Hutt City, Wellington City	
CC	5.1	16.2	Hurunui District, Waimakariri District, Christchurch City, Sel- wyn District, Ashburton District, Timaru District, Waimate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

Results - Annual Space Heating Demand



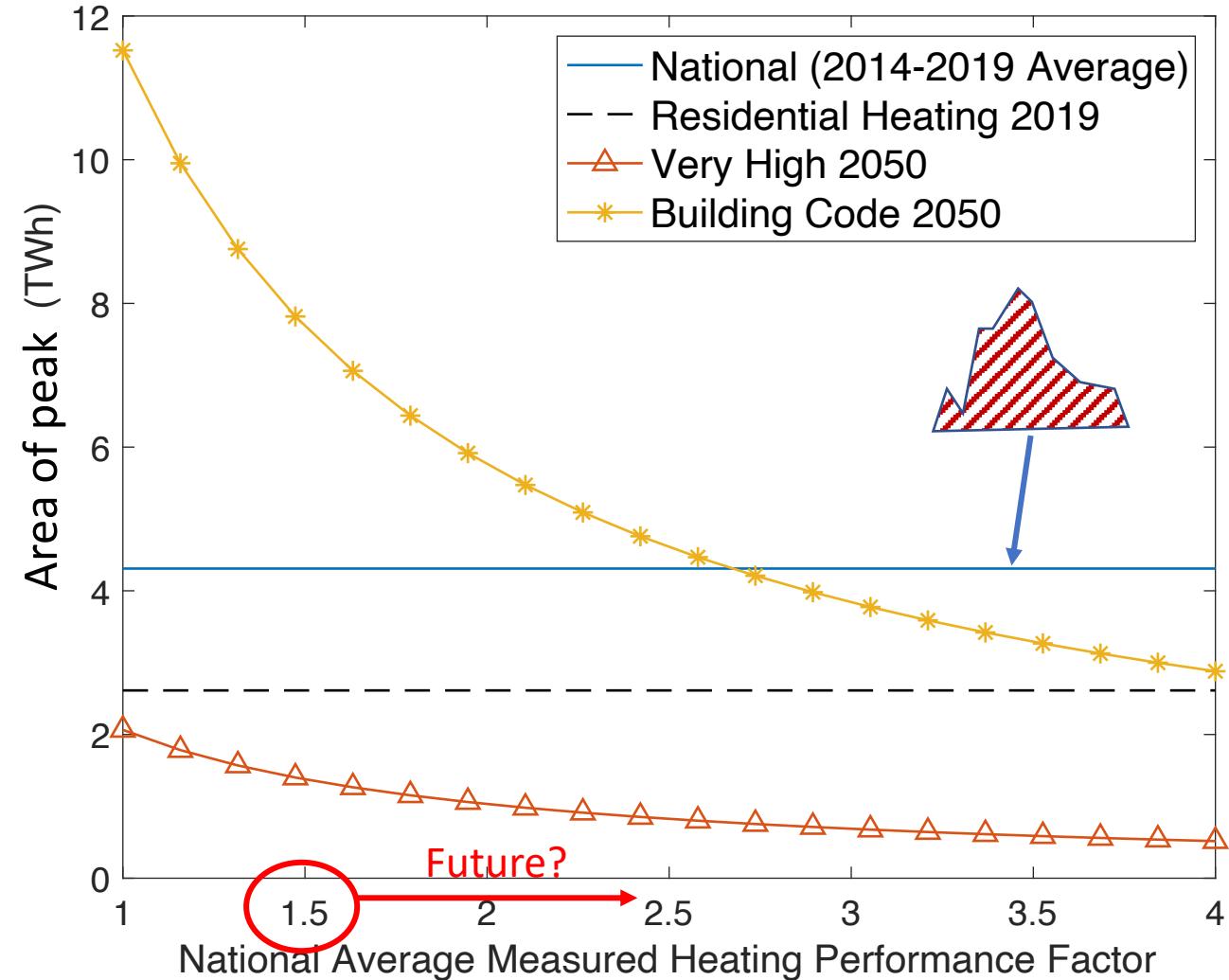
Note Progressive Scenario <50% reduction by 2050

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 $\sim 2-3$
- 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 $\frac{1}{2}$ of current for MHPF = 1.5



Summary

- Currently-achievable best practice standards could reduce:
 - annual electricity demand to 1/3 of BAU by 2050
 - difference between winter and summer demand to 1/3 of BAU
- This will help decarbonisation of the New Zealand electricity 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 (\$/m ²)	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/m²
- Space heating energy cost \$0.15/kWh

Value to NZ of reducing peak

$$\$4.3 \text{ Bn} / 3 \text{ TWh} = \$1.6 \text{ Bn/TWh}$$