Will net-zero energy buildings break the electricity grid?

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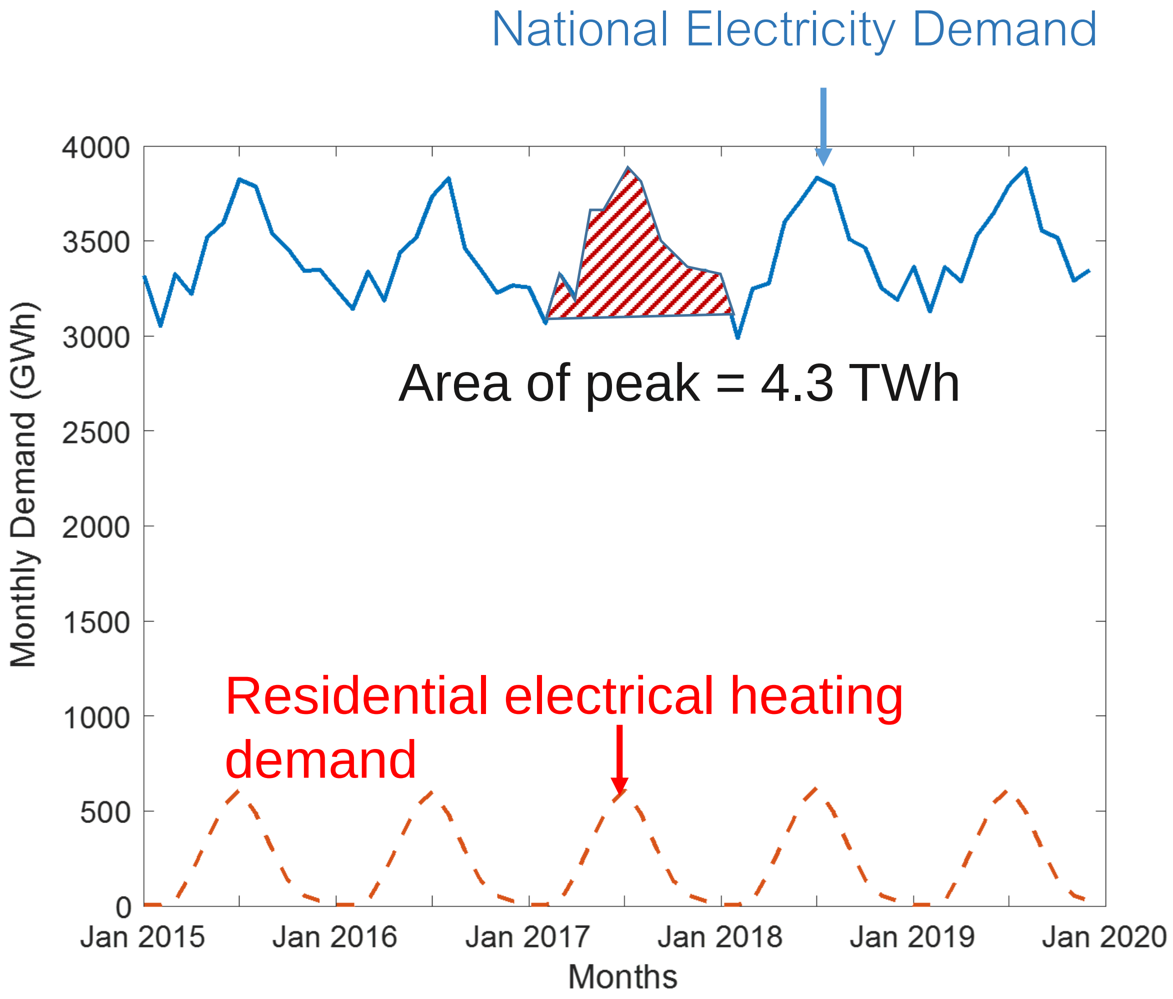
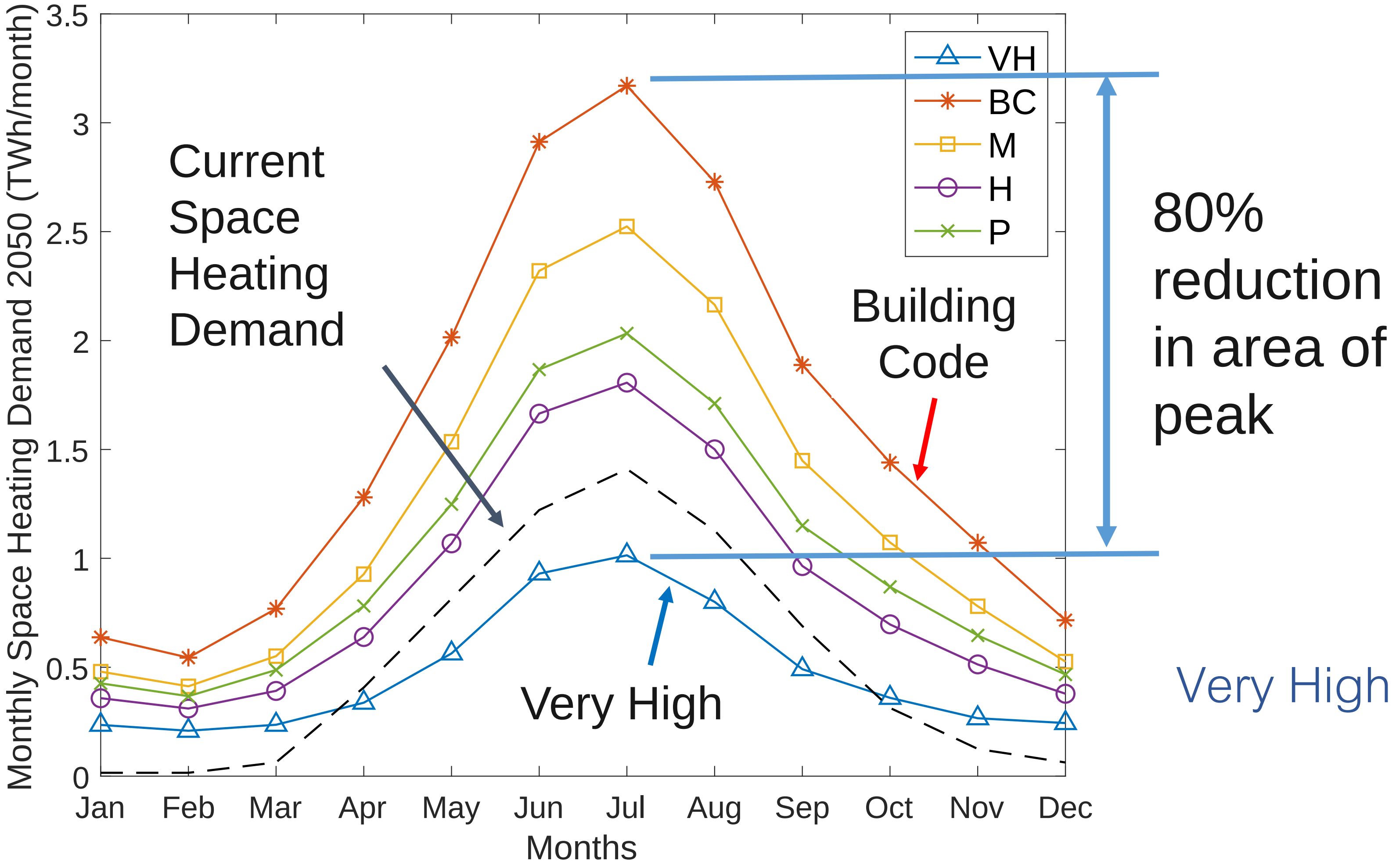
Residential heating causes winter peak



What will this look like in 2050, if we keep building as we do and also decide to heat our houses to healthy temperatures?

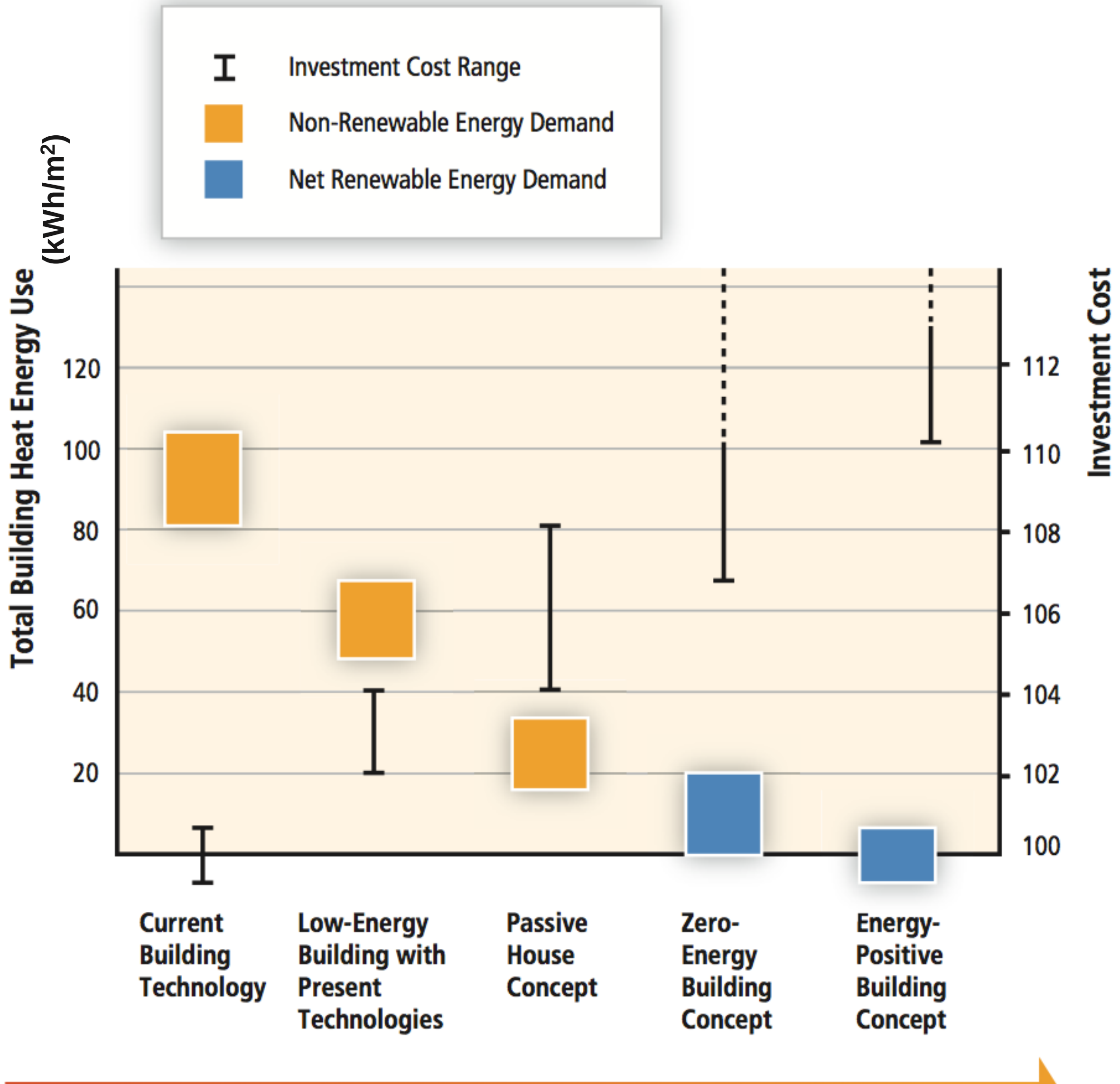
Efficient buildings reduce winter peak in 2050



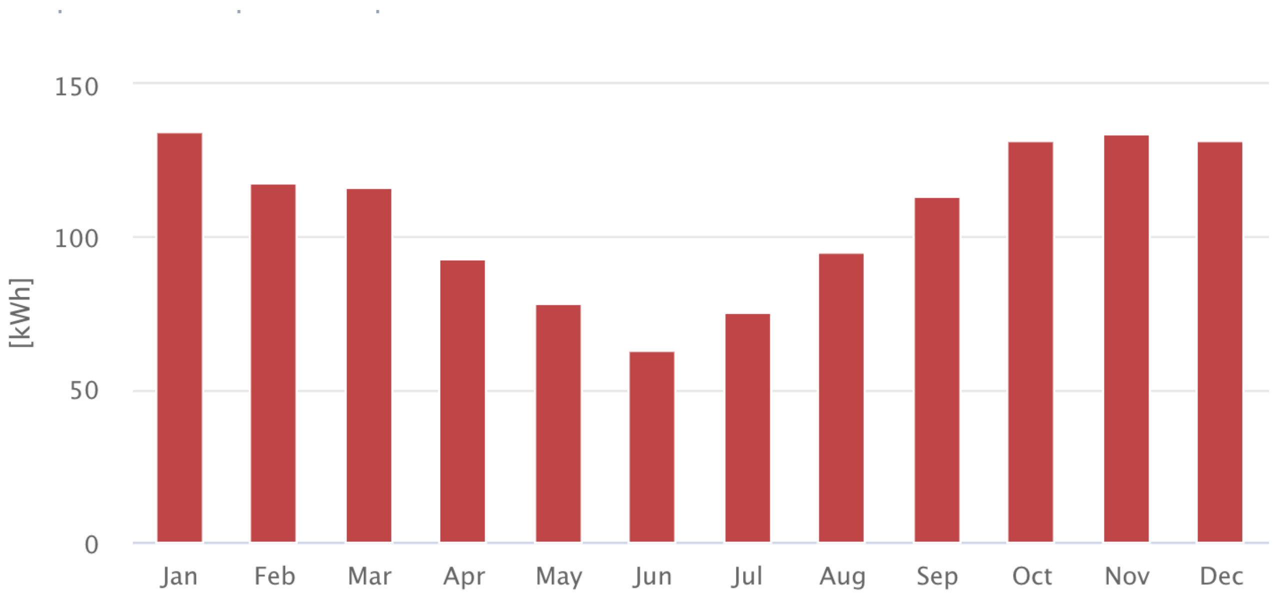
Very High = Passive house standard

Jack, M. W, Mirfin, A., and Anderson, B. *The role of highly energy-efficient dwellings in enabling 100% renewable electricity*, Energy Policy **158**,112565, (2021)

What about Net-Zero Energy Buildings?



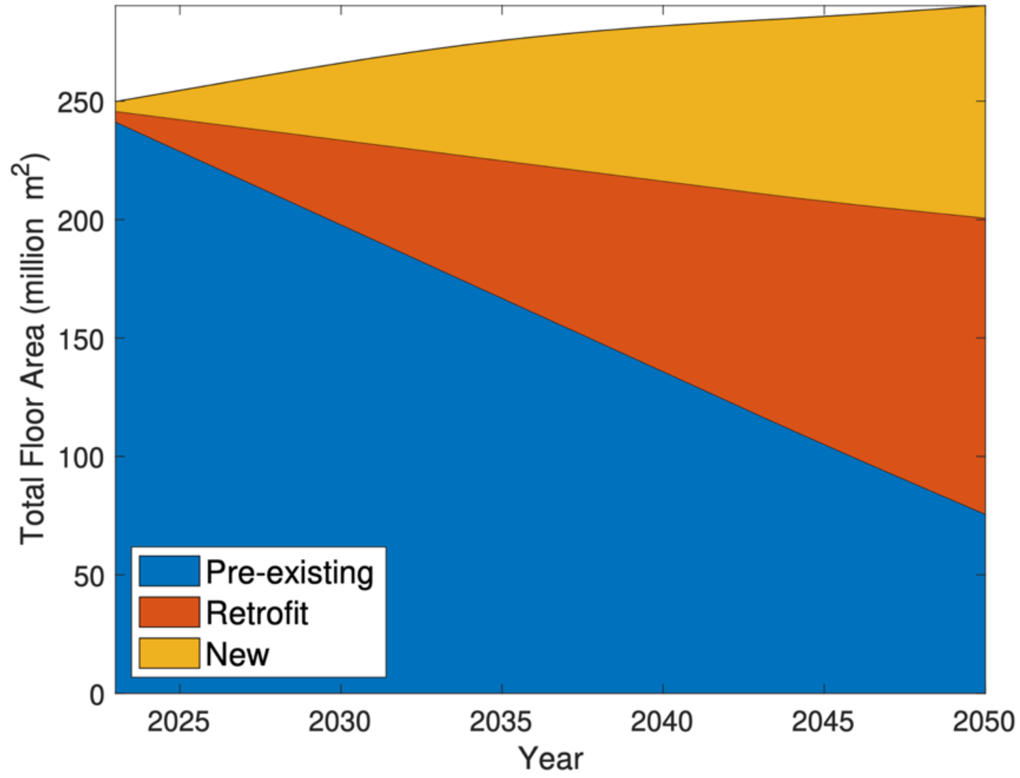
Seasonal Variation in Solar PV output



Christchurch (1kW panel tilted to latitude)

Future residential demand scenarios

- Time period: 2023 to 2050
- Stock model of new and retrofit detached houses (>90% by floor area).
- 18 Climate zones, 66 territorial authorities
- Assume electric heating and cooling to healthy temperatures (national average COP)
- A range of building code and self-generation scenarios for new builds and retrofits



NZ Building Code (BC)

Very High (VH)

Certified Passive House
Passive House Institute
classic | plus | premium

EnerPHit
Certified Retrofit
Passive House Institute
classic | plus | premium

Scenarios $T_{set}^{H}: \sigma: \lambda$ ← Self generation scenario

σ = VH – Passive house

σ = BC – Building code

Self-generation scenarios

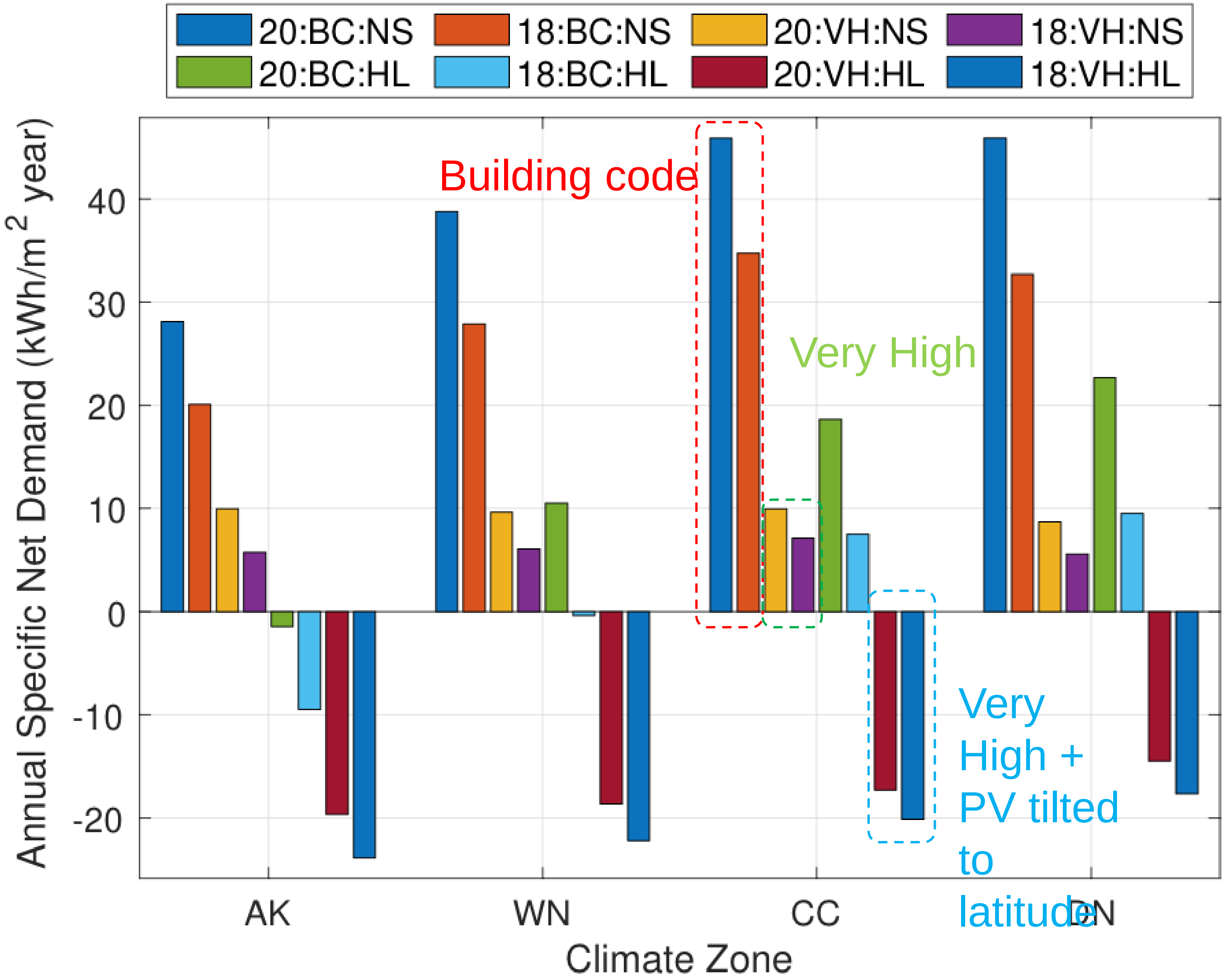
Solar PV penetration factor: ratio of panel area to floor area

Solar panel tilt angle

λ	Description	κ_r^λ	θ_n^λ
NS	No solar	0	-
LS	Low penetration, shallow tilt angle	0.125/3	$\theta_n^\lambda = 15°$
HS	High penetration, shallow tilt angle	0.125	$\theta_n^\lambda = 15°$
LL	Low penetration, tilt angle equals latitude	0.125/3	$\theta_n^\lambda =$latitude
HL	High penetration, tilt angle equals latitude	0.125	$\theta_n^\lambda =$latitude
LO	Low penetration, tilt angles where $\delta_n^{\sigma,\lambda} < \delta_{\text{thres}}$	0.125/3	$50° \leq \theta_n^{\text{opt}} \leq 90°$
HO	High penetration, tilt angles where $\delta_n^{\sigma,\lambda} < \delta_{\text{thres}}$	0.125	$50° \leq \theta_n^{\text{opt}} \leq 90°$

$\kappa = 0.125$: 8kW(6kW) rated solar system on 50% of the new(retrofitted) houses

Results: Specific net energy demand

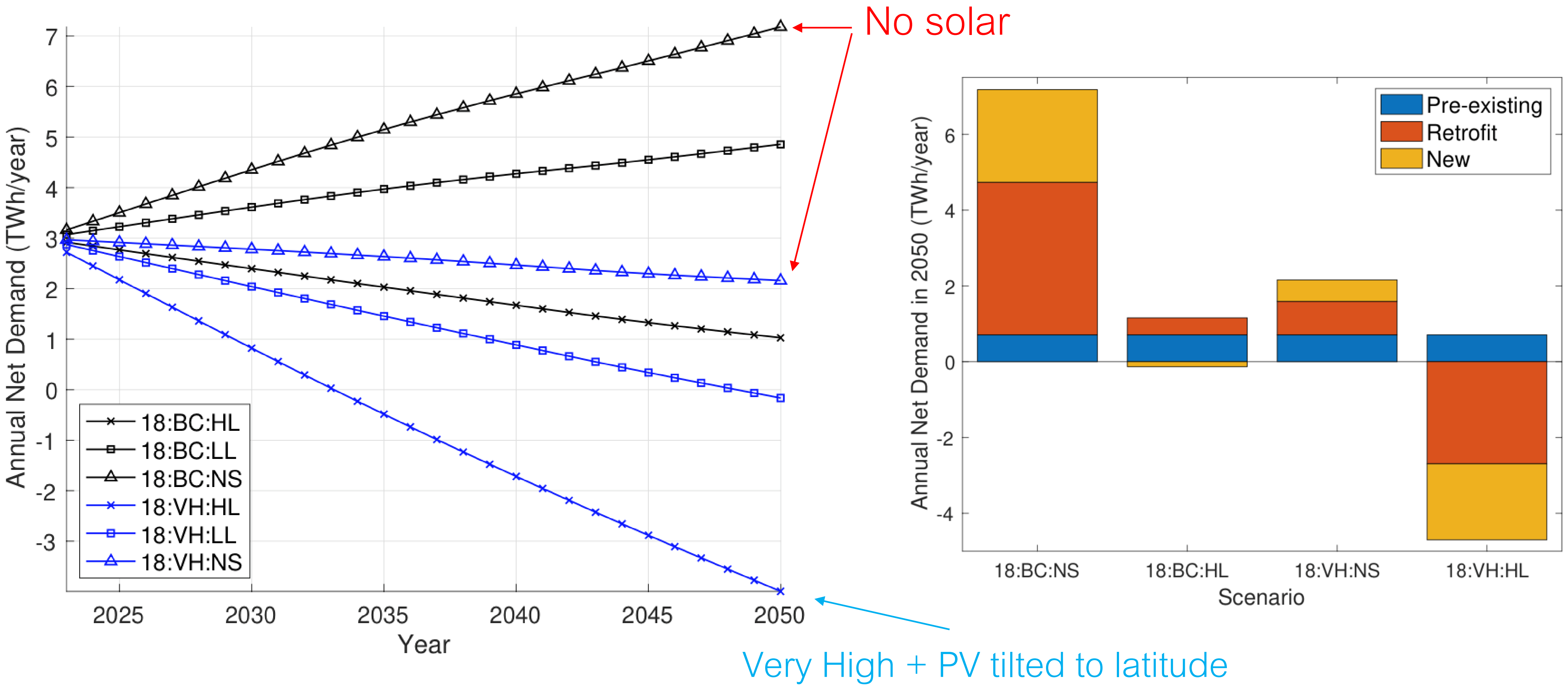


Scenarios $T^{H}_{\text{set}}: \sigma: \lambda$

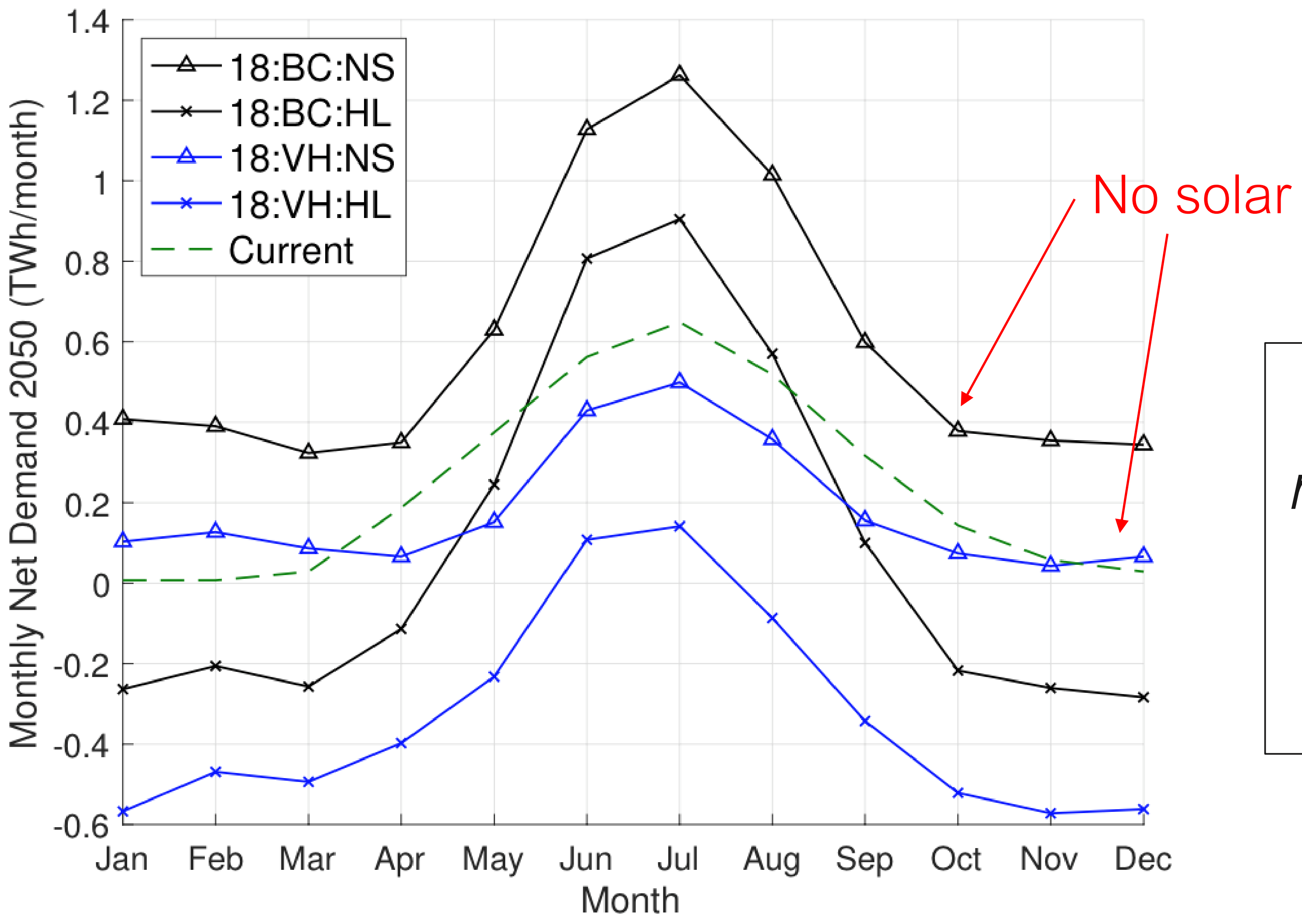
σ = VH – Passive house

σ = BC – Building code

Annual net electricity demand

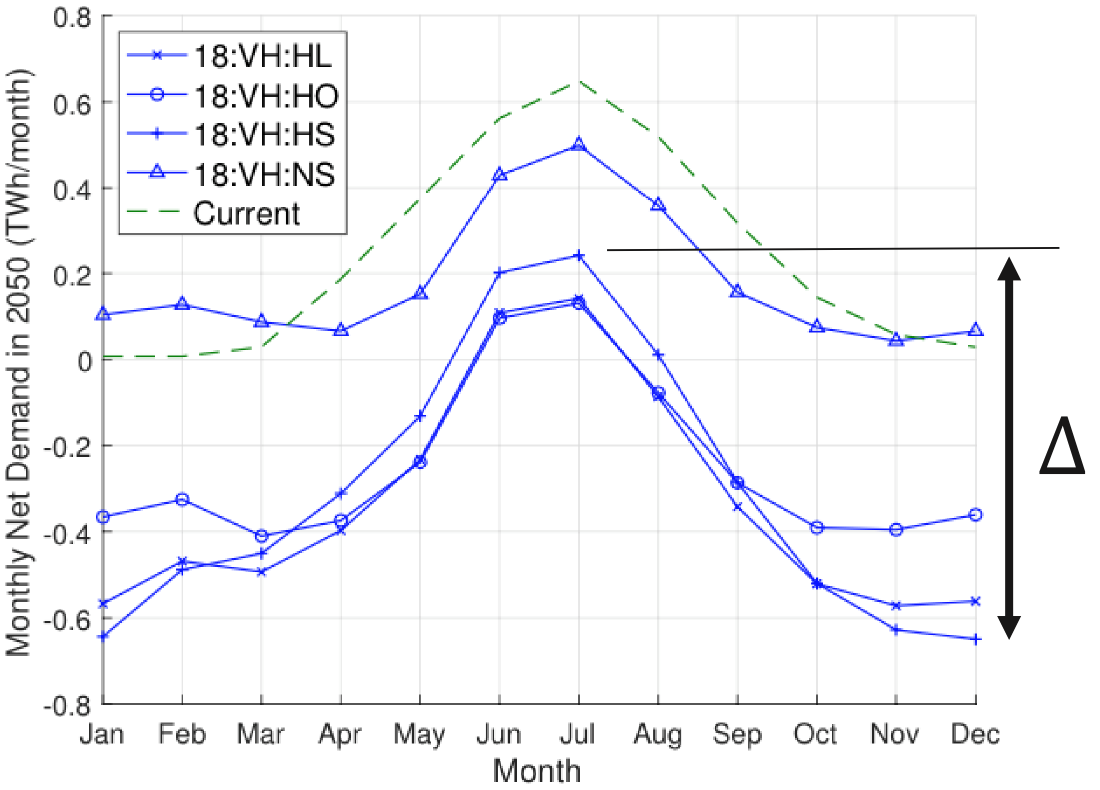


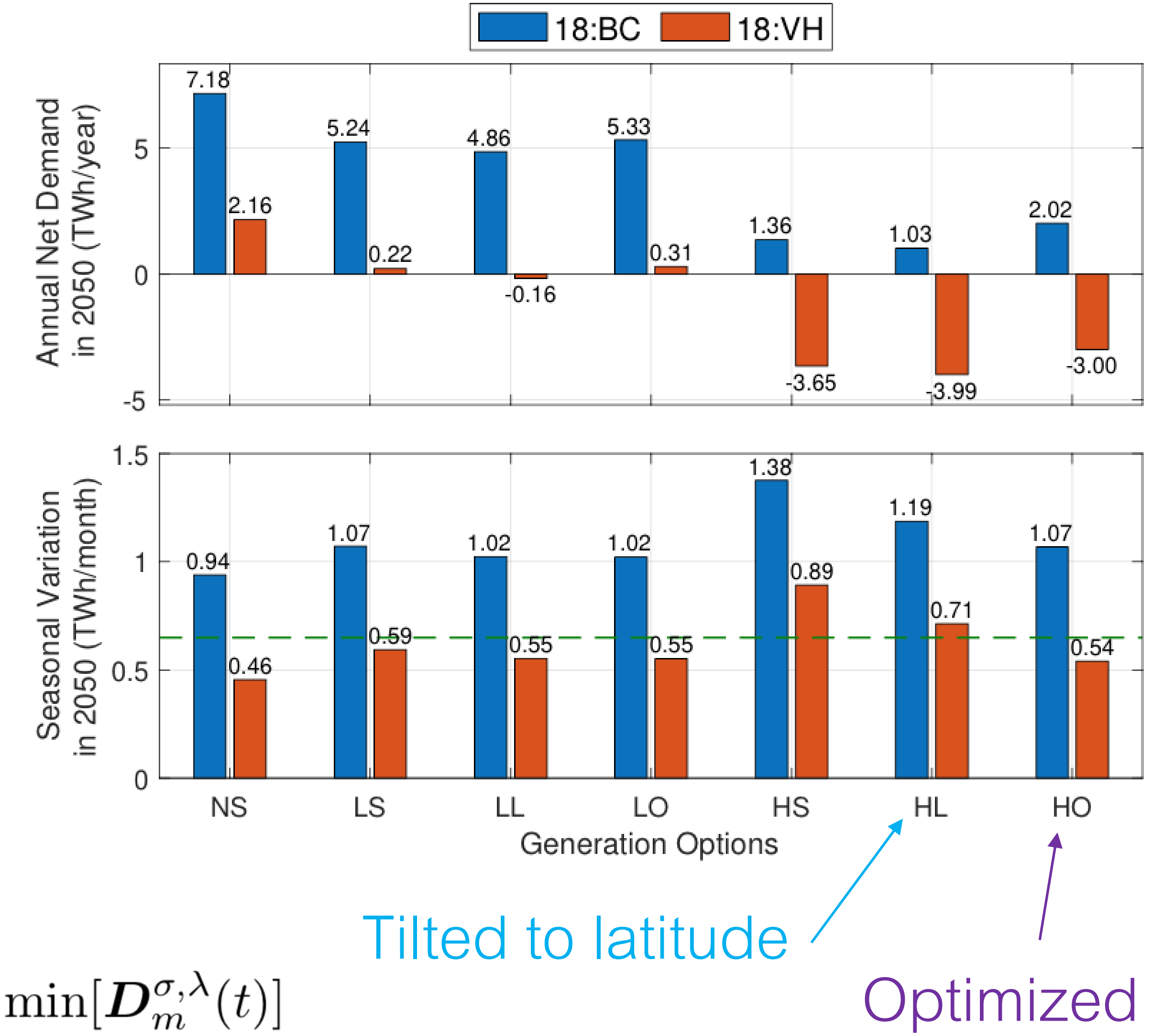
Monthly net electricity demand



Solar PV reduces *net annual demand* but increases *seasonal variation*

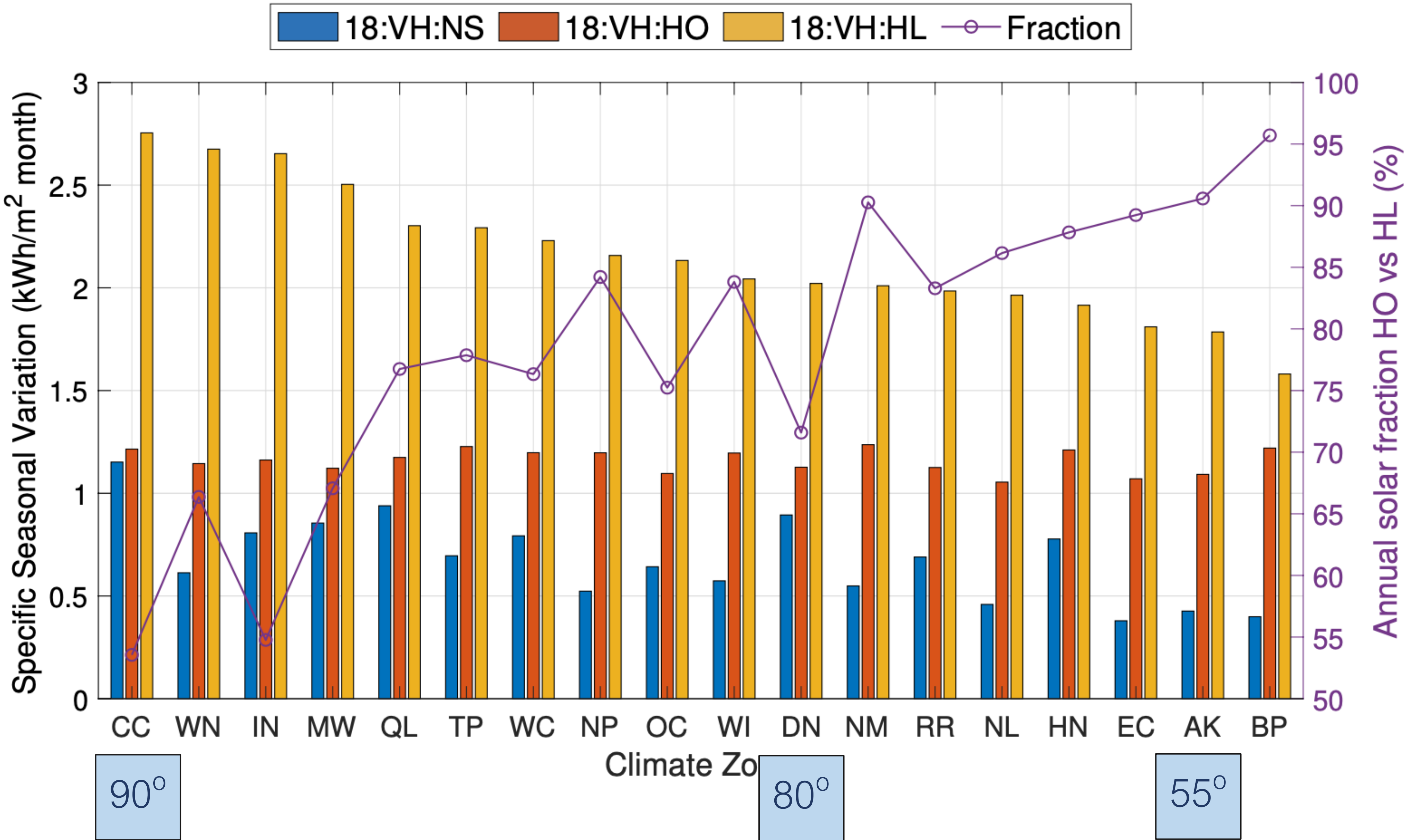
Rooftop solar options





Seasonal Variation: $\Delta^{\sigma,\lambda}(t) = \max[\boldsymbol{D}_m^{\sigma,\lambda}(t)] - \min[\boldsymbol{D}_m^{\sigma,\lambda}(t)]$

Regional impact – Optimized tilt scenario



Conclusions

- High efficiency buildings can significantly reduce winter demand and seasonal variability – retrofits important
- Pursuing solar PV net zero energy houses without increasing efficiency, will lead to significant seasonal variation
- Very efficient houses with integrated solar PV can significantly reduce annual demand and demand across all seasons (and offset the growing cooling demand), but increases seasonal variability.
- Potential solution: Install solar PV at very high tilts in some low solar regions