Optimising Weather Data Reference Periods

Enhancing Building Simulation Climate Data in a Changing Climate

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Climate Files for Building Simulations

- Typical climate files consist of one year's worth (8,760 values) of various meteorological parameters, e.g. air temperature, humidity, solar radiation
- Reference Meteorological Year (RMY) data is built by concatenating the most typical historical months. Importantly, this requires selecting an appropriate reference period
  - Reference periods are typically at least 10 years
  - World Meteorological Organization uses a 30 year reference period[1]
  - CSIRO uses a 25 year reference period (1990 to 2015)

[1] Trewin, B, 2007, '*The Role of Climatological Normals in a Changing Climate*', World Meteorological Organization.

Climate Change

- Long-term global warming trend
  - 2015 to 2022 are the eight warmest years on record
  - 2023 expected to be the warmest year yet
  - Shifts in temperature and precipitation, and greater incidence of extreme weather events
- To what extent can historical weather data represent future climate?
- Within the context of a warming climate, conventional reference periods might no longer accurately represent the future climate at a given location
  - In this work, we considered shorter, more recent reference periods constituting the past 15 full years (2008-2022)

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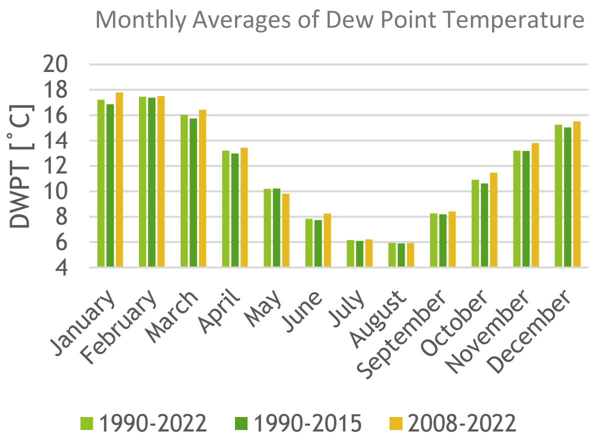
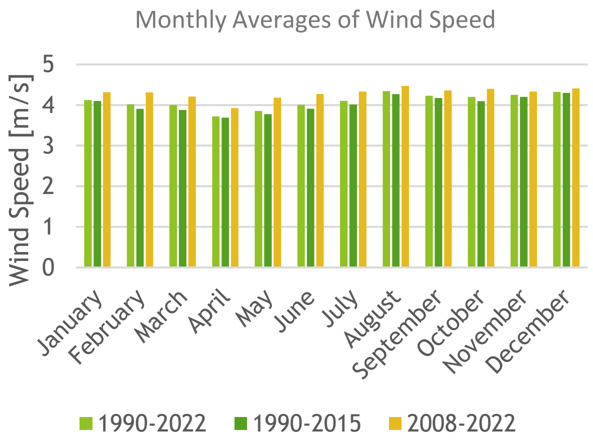
Temporal Analysis - Methodology

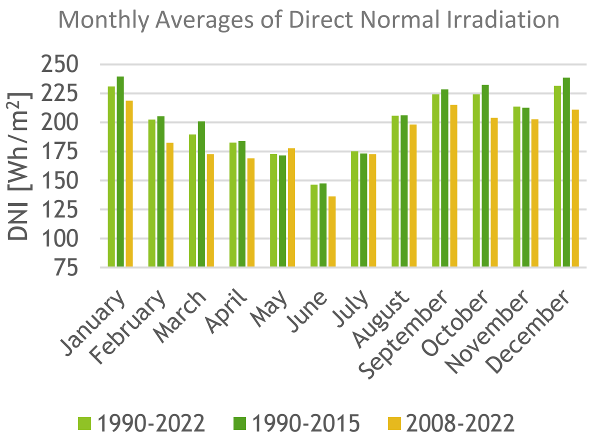
- Considered dry bulb temperature, dew point temperature, relative humidity, wind speed, GHI, and DNI
- Took monthly averages for each parameter using reference periods of 1990-2022 (33 years), 2008-2022 (15 years), 1990-2015 (CSIRO - 25 years)

Temporal Analysis – Results (Sydney)

- Most notable differences observed for dew point temperature, wind speed, and DNI
  - 1990-2015 vs 2008-2022 annual averages: rise in dew point temperature of 0.38°C, rise in wind speed of 6.64%, and decrease in DNI of 7.36%
  - 1990-2022 vs 2008-2022 annual averages: rise in dew point temperature of 0.24°C, rise in wind speed of 5.77%, and decrease in DNI of 5.78%

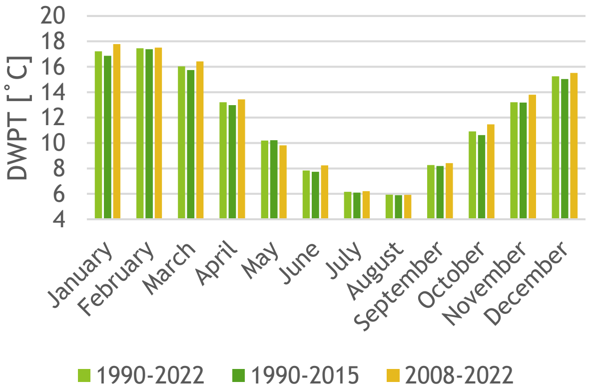


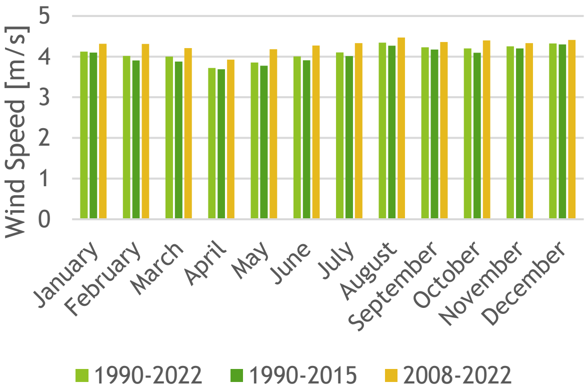


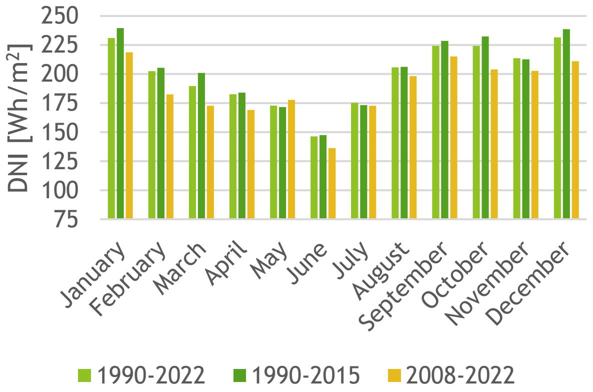


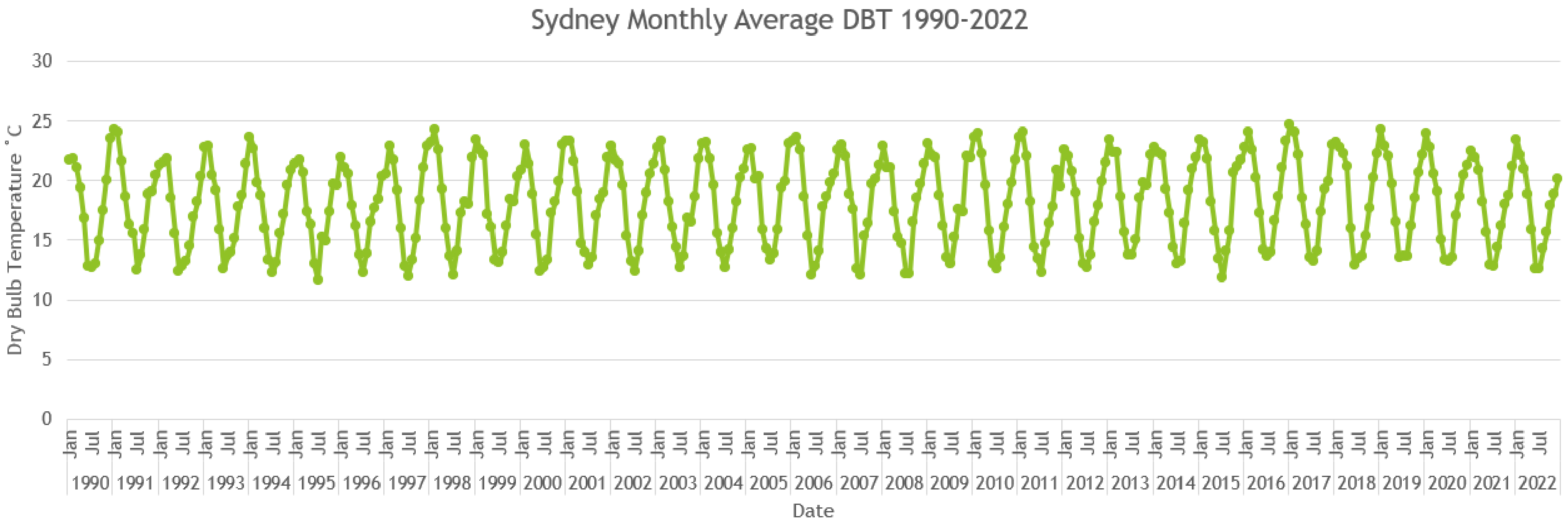
Temporal Analysis – Results (Sydney)

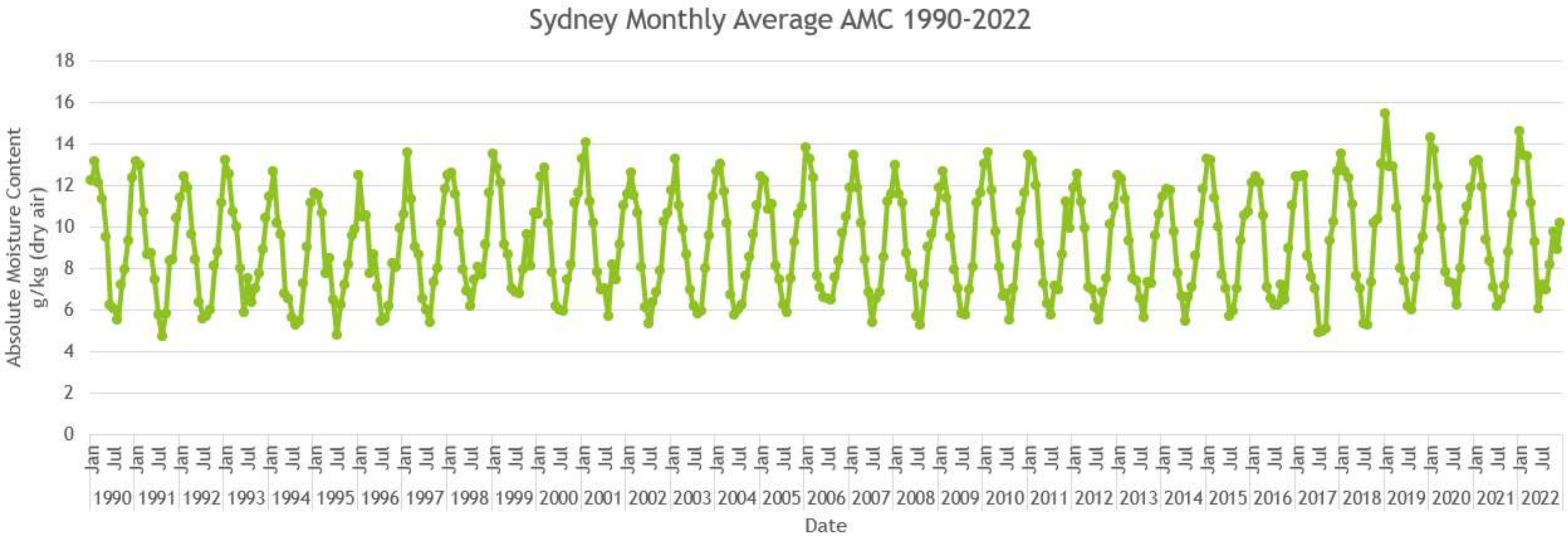
- Differences in dew point temperature, wind speed, and DNI for 2008-2022 vs other reference periods were notable for most months
- Slight increases in 2008-2022 dry bulb temperature and relative humidity, and a decrease in GHI compared to other reference periods
  - Differences tended to be greater for Summer and Spring months





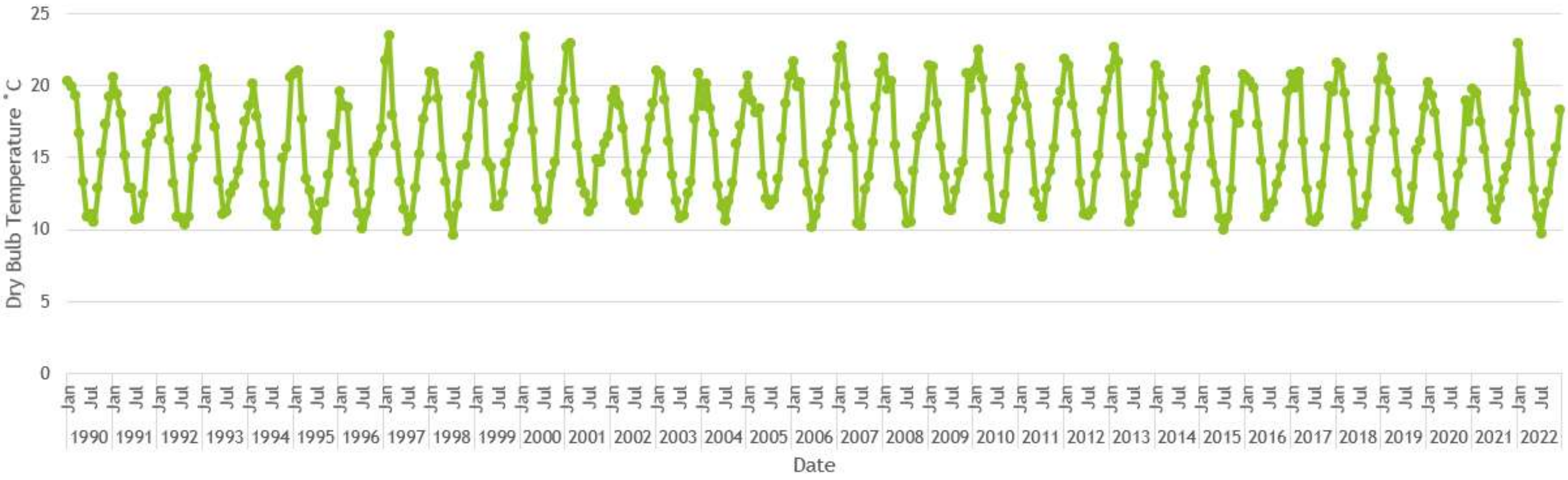


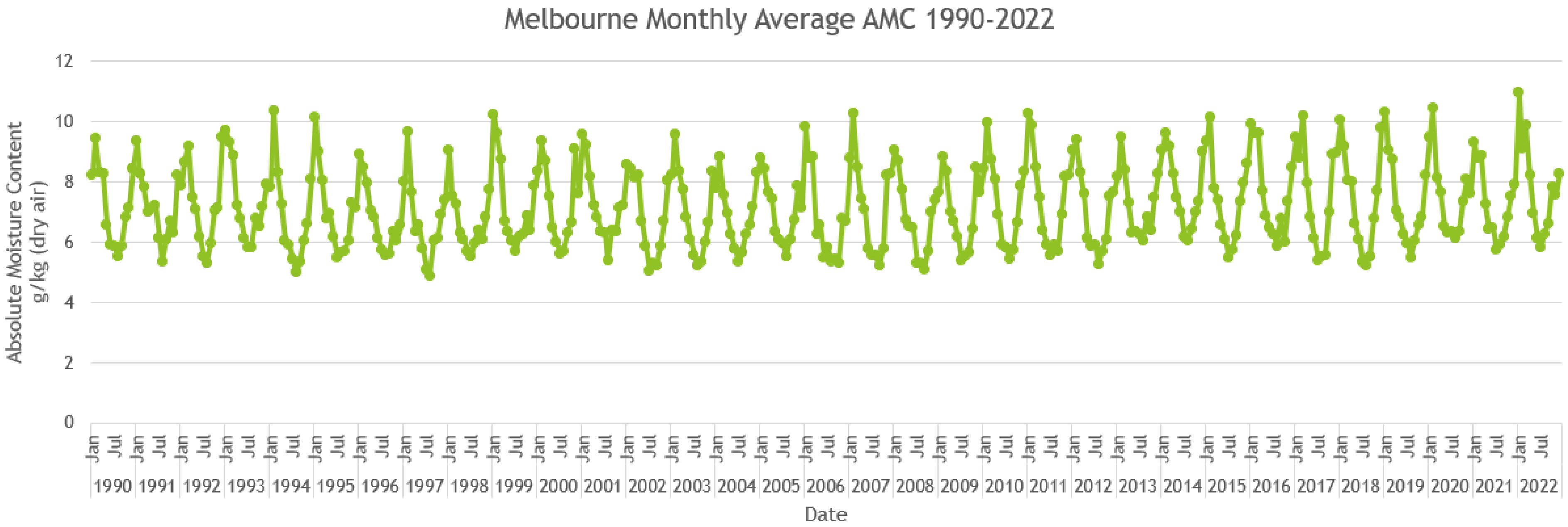

Sydney Monthly Average DBT 1990-2022
Dry Bulb Temperature ˚C
30
25
20
15
10
5
0
Jan
Jul
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
Date



Sydney Monthly Average AMC 1990-2022
Absolute Moisture Content g/kg (dry air)
18
16
14
12
10
8
6
4
2
0
Jan
Jul
1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 2022
Date

Melbourne Monthly Average DBT 1990-2022




Melbourne Monthly Average AMC 1990-2022
Absolute Moisture Content g/kg (dry air)
12
10
8
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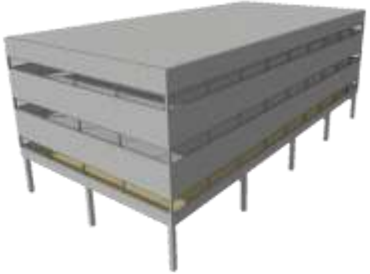
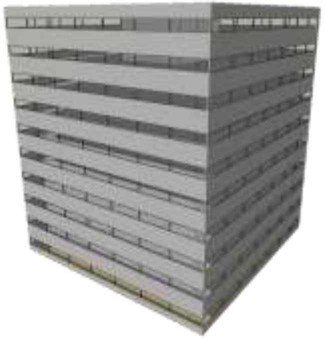
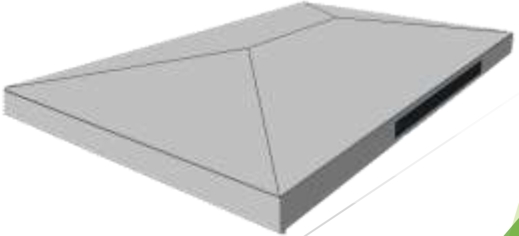
Date

Examining HVAC Energy Consumption - Methodology

- Sydney weather data (1990-2022) from BOM processed in in-house software *ClimateCypher*
- Considered 3 archetypical buildings, compliant with the current NCC: a 3-storey office building, a 10-storey office building, and a ground-level supermarket
- Analysed HVAC heating, cooling, and total energy consumption by simulating the processed data and building models in EnergyPlus







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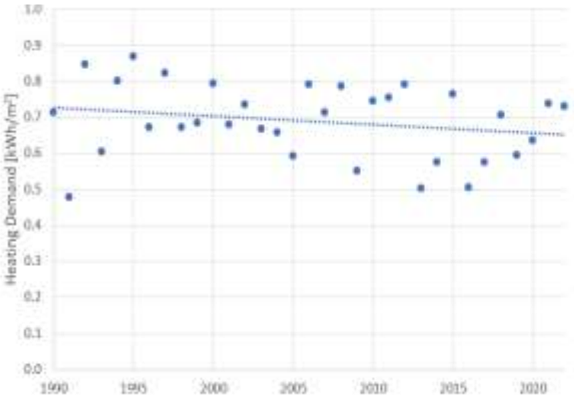
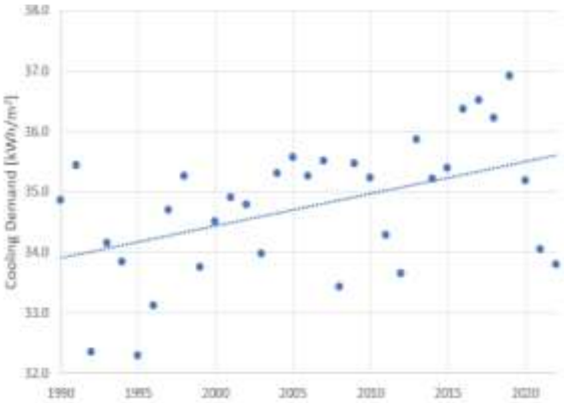
Examining HVAC Energy Consumption - Results

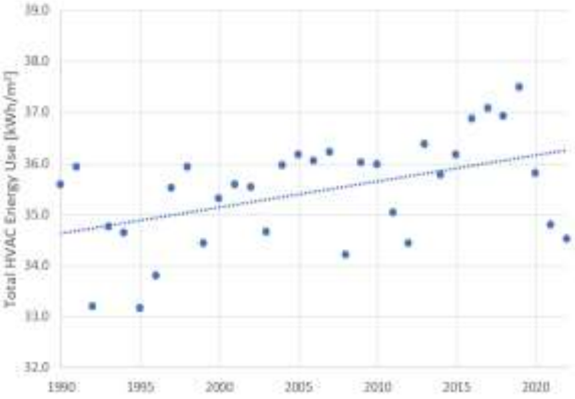
Annual Energy Consumption for Heating of Three Building Archetypes in Sydney (1990-2022)



Annual Energy Consumption for Cooling of Three Building Archetypes in Sydney (1990-2022)



Annual Total HVAC Energy Consumption of Three Building Archetypes in Sydney (1990-2022)



- Trend of decreasing heating demand
- Trend of rising annual average cooling demand and total HVAC energy usage
- Cooling demand from 2015-2019 was relatively high, but there is a notable 8.79% reduction from 2019-2022

Examining HVAC Energy Consumption - Results

Average Consumption		
1990-2022	**1990-2008**	**2008-2022**
398,400 kWh	396,400 kWh	400,400 kWh

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Conclusions

- Notable differences in critical meteorological elements within the recent 2008-2022 period compared to the older 1990-2022 and 1990-2015 reference periods
- Shifts in building cooling and heating demand observed over the past decades
- Traditional reference periods may fail to adequately represent the changing climate
- Need for reliable and up-to-date weather data that more accurately characterises the climate in which buildings will operate
  - Achievable through frequent updates and/or a shorter measurement period.

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Proposed Next Steps

- Urgent updates to the de facto “industry standard” RMY datasets
- Continued monitoring of climate trends
- Investigation of the annual variations and timing of peak cooling loads, and how these may vary with climate change
- RMYs for deep-plan & shallow-plan buildings, solar PV, moisture management…
- eXtreme Meteorological Year (XMY) climate files
  - P01, P10, P90, and P99 data → weather that would be expected 1%, 10%, 90% and 99% of the time in a given period
  - Understanding building energy performance in an extreme year
  - Consider that the reference period for XMY (extremes) might differ from RMY (norms)

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Thank You!

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