Is climate data given sufficient consideration in building design?

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Typically ….

… users pick default weather data; no questions asked

… they assume it is representative & appropriate for the task

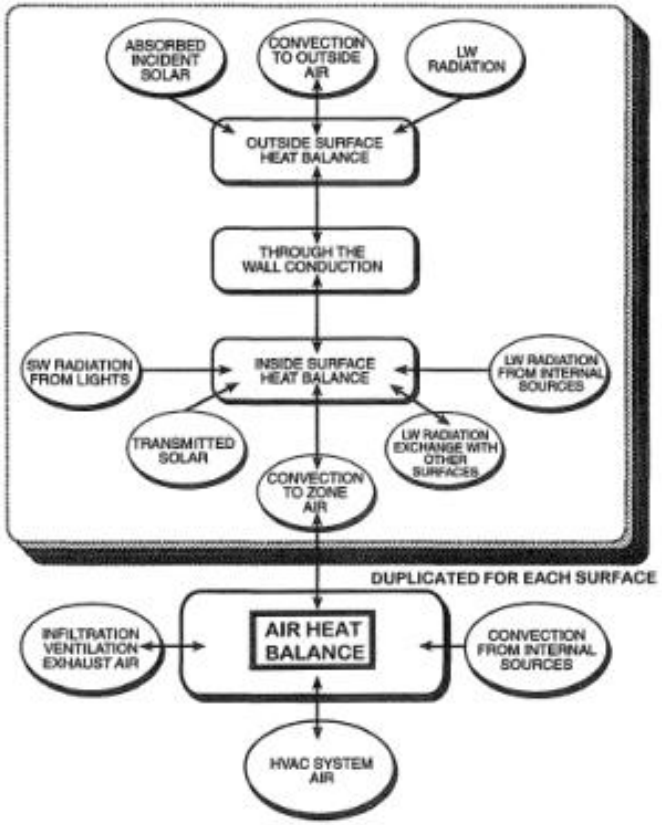
… they do not consider weather data file variability nor sensitivity to climate change

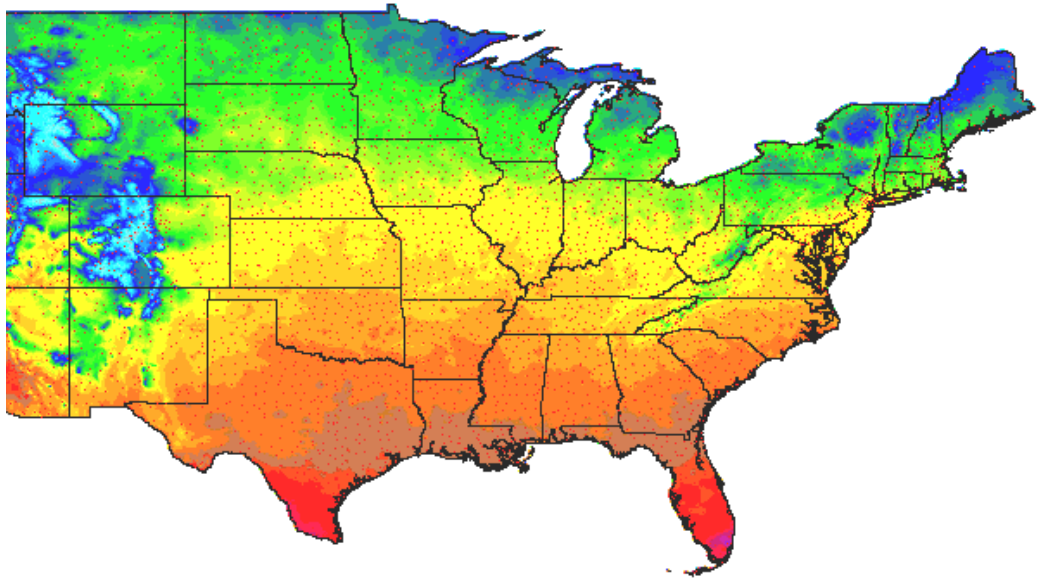
25 years ago ….

	Summer ºC	Winter ºC
San Francisco	28/18	3
London	28/20	-4
Singapore	33/28	22

1kB

15 years ago ….





http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_simulation.cfm

ASHRAE heat balance method

100kB

12 years ago ....


```
LOCATION,Cadiz,-,ESP,SWEC,084520,36.50,-6.26,1.0,82.0
DESIGN CONDITIONS,0
TYPICAL/EXTREME PERIODS,6,Summer - Week Nearest Max Temperature For Period,Extreme,7/22,7/28,Summer - Week Nearest Average Temperature For Period,Typical,7/ 8,7/14,Winter - \
GROUND TEMPERATURES,3,.5,,,,13.42,12.95,13.79,15.11,18.55,21.21,23.00,23.55,22.62,20.56,17.80,15.24,2,,,,15.17,14.32,14.50,15.20,17.50,19.59,21.25,22.15,21.96,20.79,18.89,16.87,4,,,,16.62,15.
HOLIDAYS/DAYLIGHT SAVINGS,No,0,0,0
COMMENTS 1,Spanish Weather for Energy Calculations (SWEC) created by Prof Pérez-Lombard Escuela Superior de Ingeneiros Sevilla for 52 Spanish provincial capitals.; Synthetically generat
COMMENTS 2, -- Ground temps produced with a standard soil diffusivity of 2.3225760E-03 {m**2/day}
DATA PERIODS,1,1,Data,Sunday, 1/ 1,12/31
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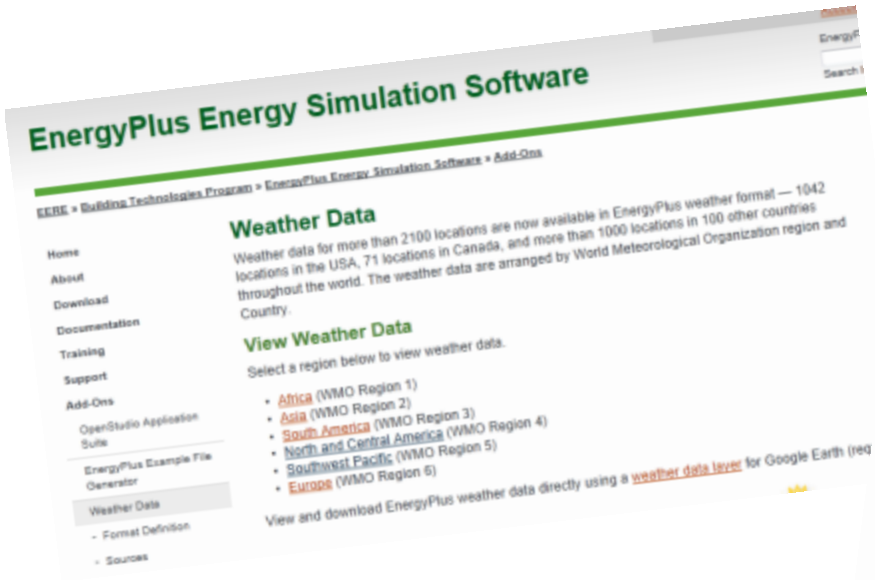
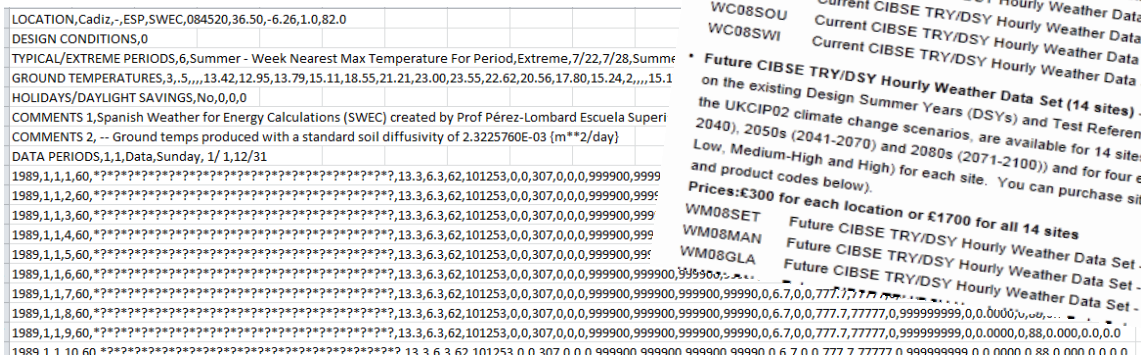
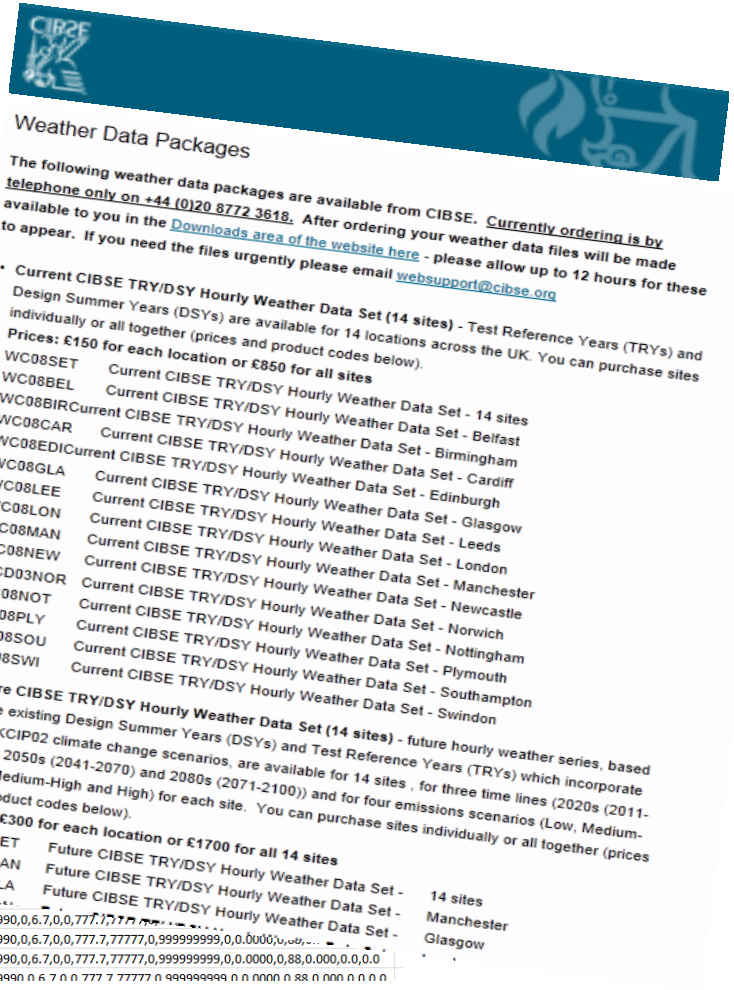
Legacy issues !

1600kB

Now …







http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_sources.cfm

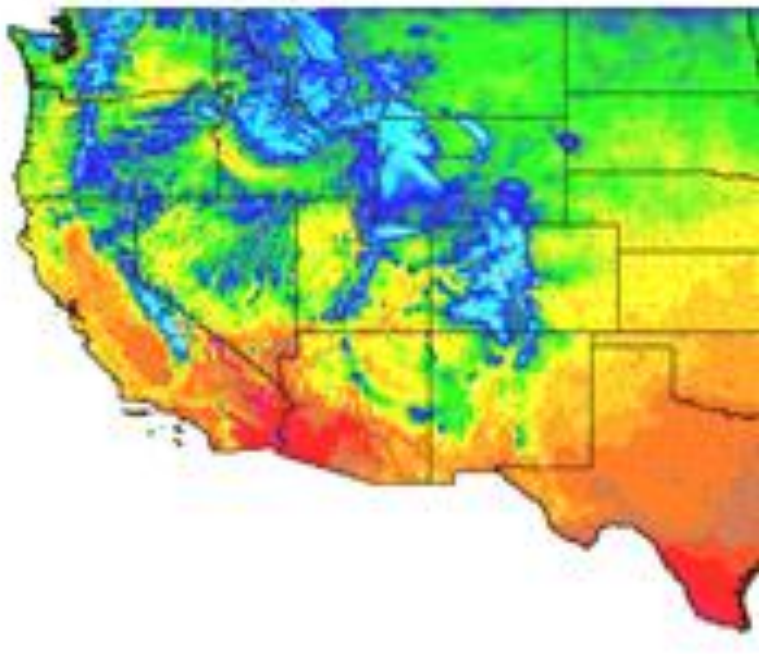
Questions to ask

Compare metrics

Look for typical / atypical data

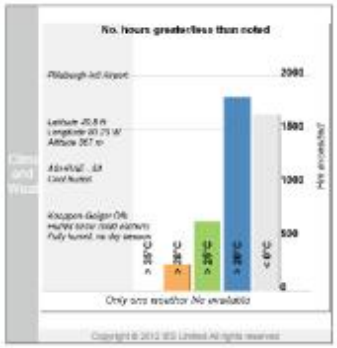
Check what was it created for

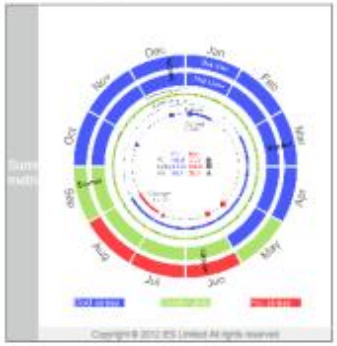
Check how it was created

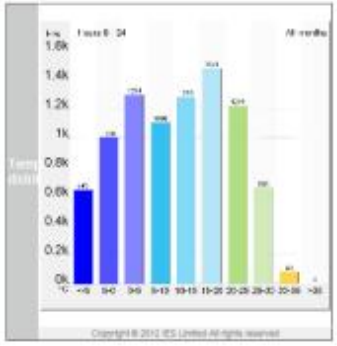


http://apps1.eere.energy.gov/buildings/energyplus/weatherdata_simulation.cfm

Metrics…







Pittsburgh Intl Airport

ASHRAE 90.1[1]: 5A Cool humid
Koeppen-Geiger[1]: Dfb Humid snow (cold winters). Fully humid; no dry season. Warm summer (marine).
Chosen weather file is USA_PA_Pittsburgh_TMY2.epw
Rainfall location: Pittsburgh, USA
Winter is potentially most dominant - the design must minimise heating energy
Latitude is mid - solar radiation on south/east/west walls is significant. Solar radiation on roofs is significant.
Summer is warm. Summer also has a large diurnal range
Summer also has cool summer nights
Winter is cold
Winter prevailing winds typically from the north. Summer prevailing winds typically from the south. Wind patterns: Typically westerly winds.
Annual cloud cover is high (affects access to solar energy).

Temperature[3]:

Warmest month Aug
Max annual temperature (Jun) 33.3 °C
Warmest six months Aug Jul Jun Sep May Oct
Coldest month Jan
Min annual temperature (Jan) -18.9 °C
Coldest six months Jan Feb Dec Nov Mar Apr
Number of months warmer than 10.0°C mean = 6

Diurnal temperature swing[3]:

0 months swing > 20 °C, of which 0 are in the warmest 6M
0 months swing 15 to 20 °C, of which 0 are in the warmest 6M
8 months swing 10 to 15 °C, of which 6 are in the warmest 6M
4 months swing 5 to 10 °C, of which 0 are in the warmest 6M
0 months swing < 5 °C

Moisture and humidity[4]:

Max. moisture content 0.022 kg/kg
Min. moisture content 0.000 kg/kg
Mean moisture content 0.006 kg/kg
Mean relative humidity 67.3 %

Wind[5]:

Annual mean speed 3.9 m/s
Annual mean direction E of N -100.3°

Precipitation[6]:

Annual rainfall 935.9 mm
Driest month Oct with 59.9 mm rainfall
Wettest month Jul with 95.3 mm rainfall
Wettest summer month Jul
Wettest winter month Mar
Driest summer month Oct
Driest winter month Feb
Wettest six months Jul Jun May Mar Aug Apr

Solar energy[7]:

Annual hourly mean global radiation(a) 157.4 W/m²
Mean daily global radiation(b) 3771.3 Wh/m²
Annual solar resource(c) 1378.7 kWh/m².yr
Annual mean cloud cover(d) 6.5 oktas

Degree days[8]:

HDD(18.0) = 3371.3
CDD(10.0) = 1716.1

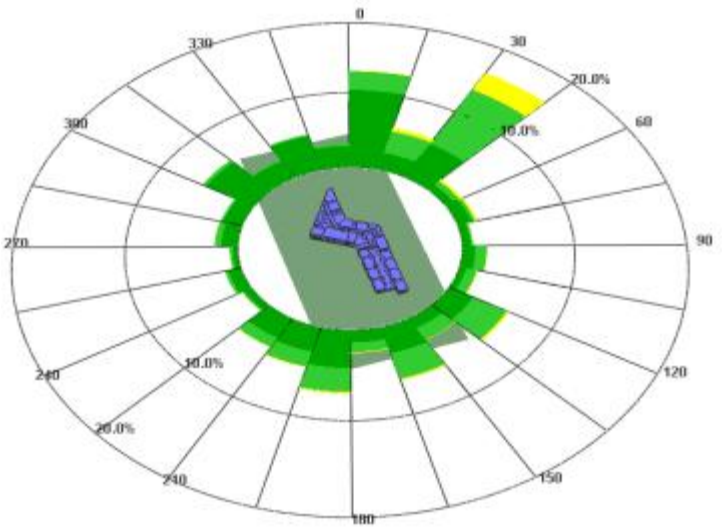
Numbers …

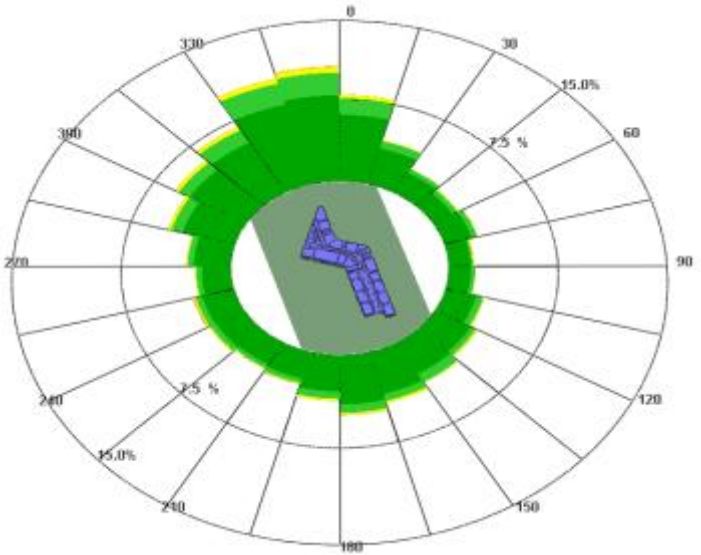
Minima / maxima
Cumulative; solar
Hours thresholds exceeded
Peak months etc

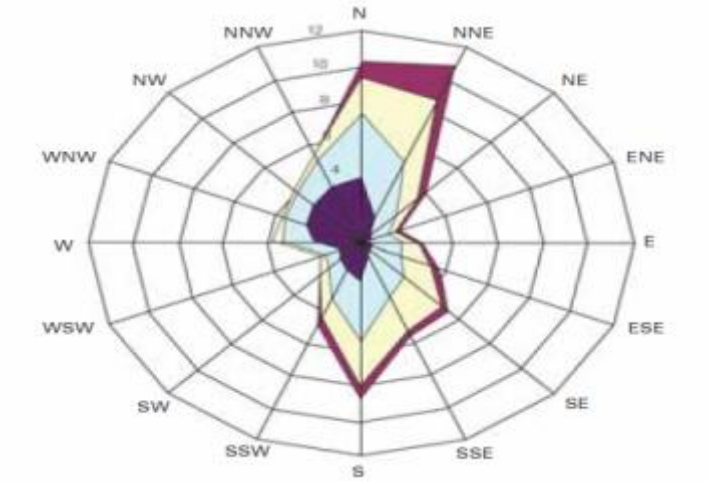
Derived …

Climate type
Diurnal range
Degree days
…..

Atypical … Singapore wind



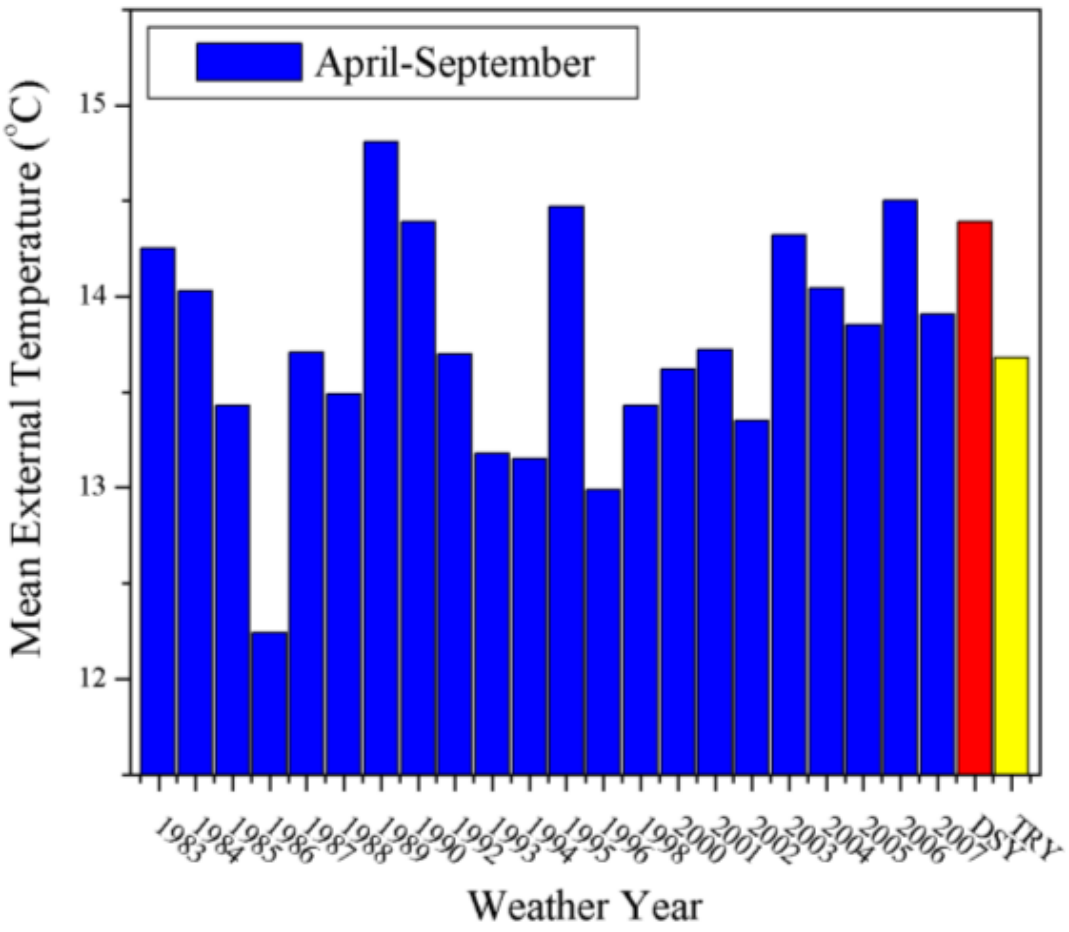




Try to use period based real data !

http://meteonorm.com/products/mete

What it was created for …

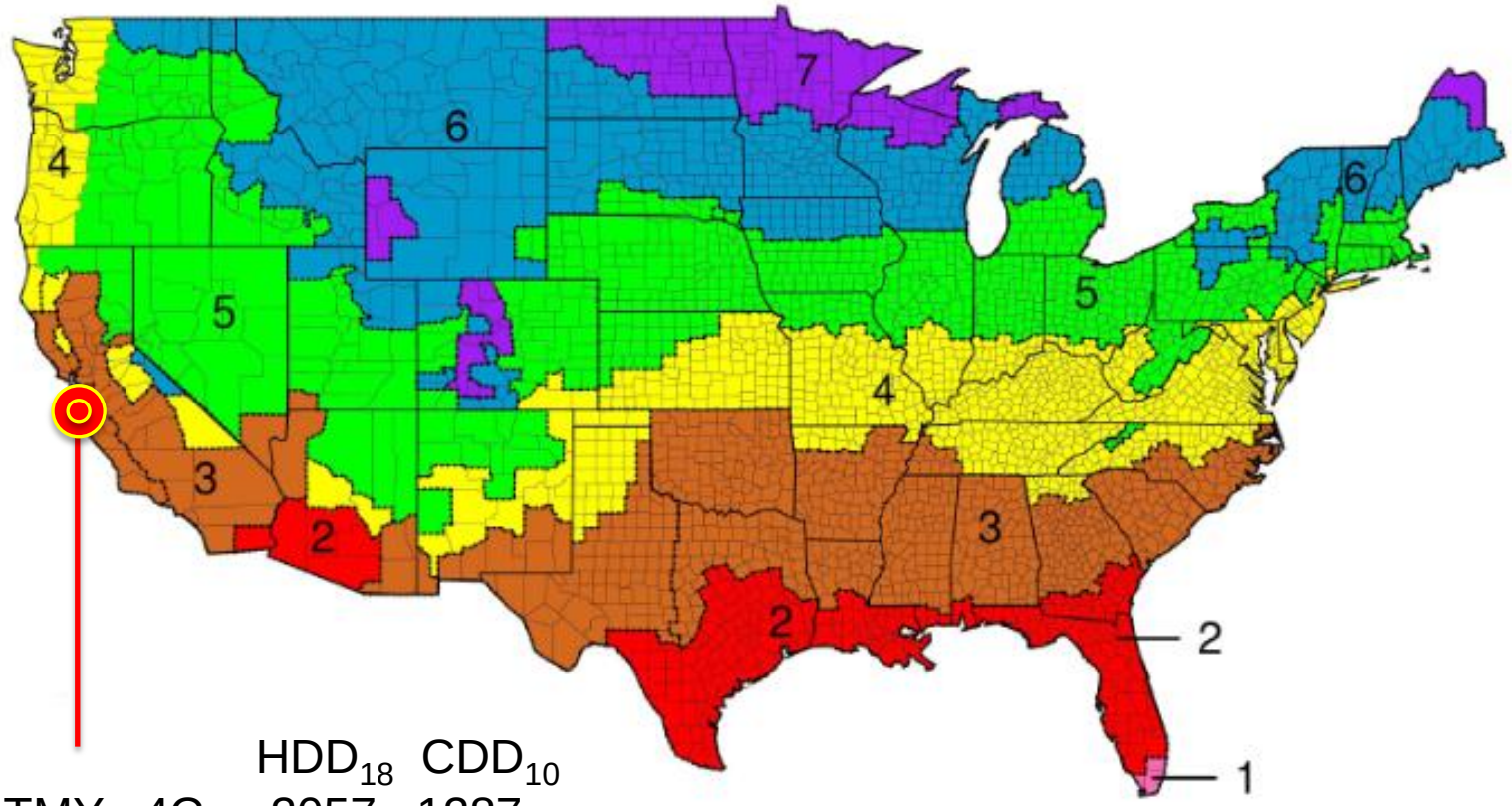


TRY *5A* *HDD 3166* / *CDD 844*
TRY 05 *4A* *HDD 2650* / *CDD 1150*
9697 *4A* *HDD 2599* / *CDD 1163*
DSY 05 *4A* *HDD 2535* / *CDD 1332*

20% spread for HDD
37% spread for CDD

Try to use period based real data (TMY)
Use single years for specific purposes only

Climate zone issues … shift …

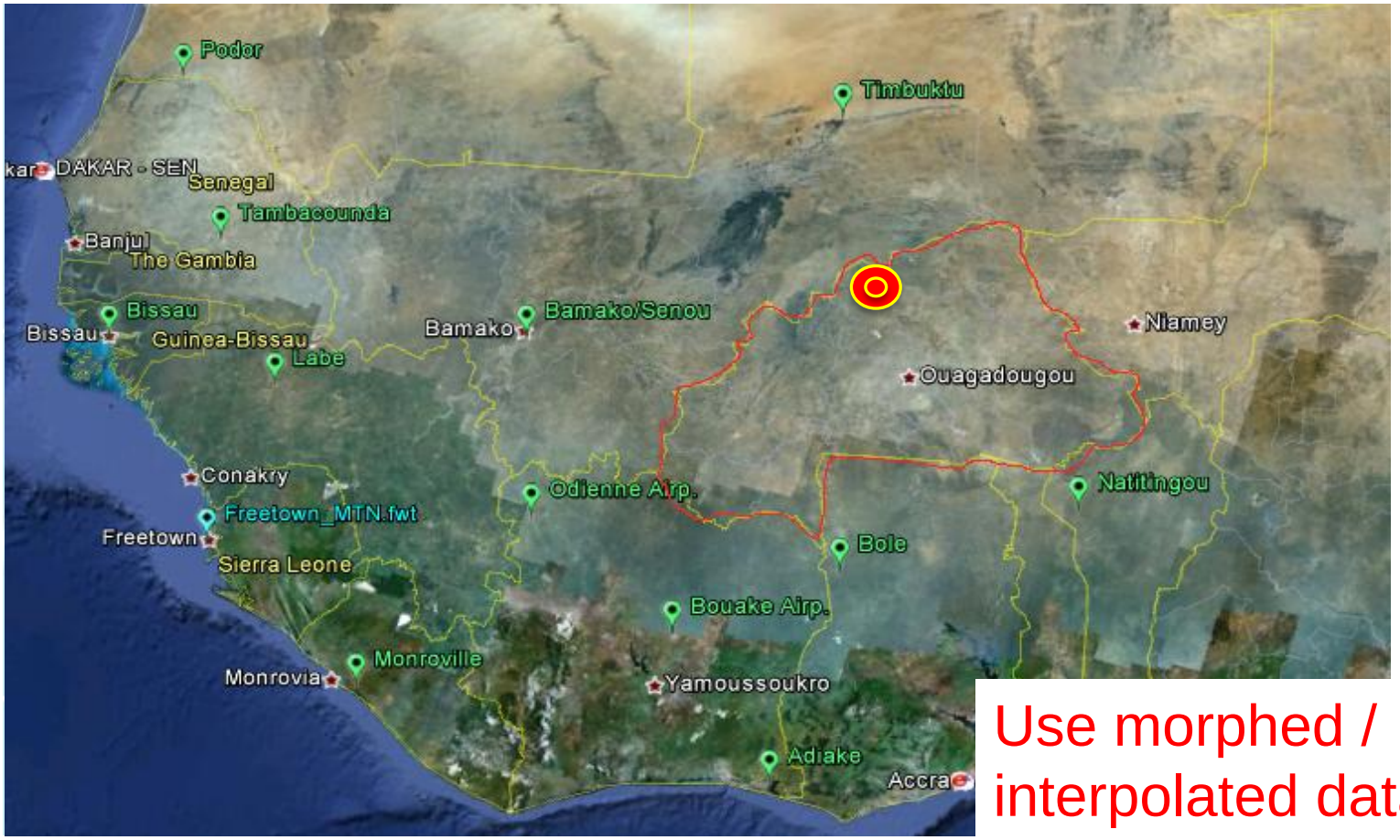


SFO

		HDD_{18}	CDD_{10}
TMY	4C	2057	1287
TMY2	4C	2025	1299
TMY3	3C	1773	1479

Pick representative weather data

How it was created … interpolated



Use morphed / interpolated data very carefully

Acknowledgement: Meteonorm

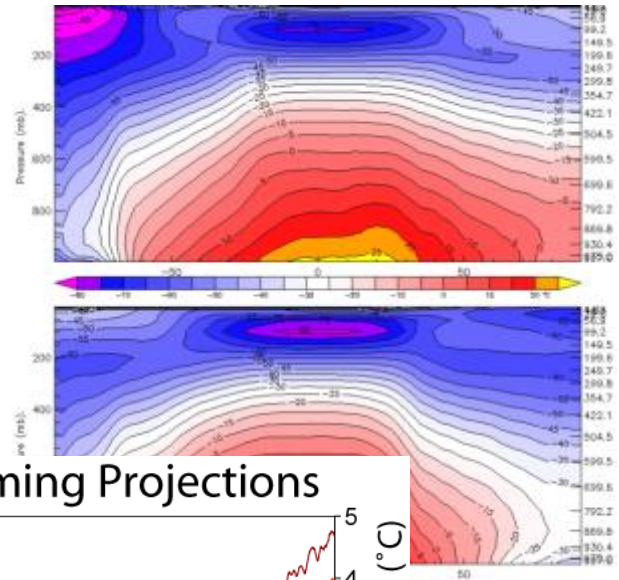
http://www.antherm.eu/meteonorm/EN/

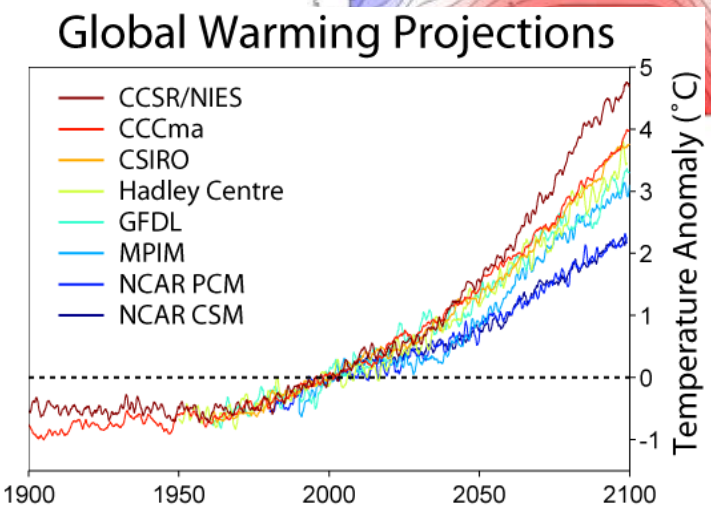
Climate change

Hadley centre models:

Used in ….
IPCC 2001 assessment
UKCP02 projections

More recently ….
IPCC 2007 assessment
UKCP09

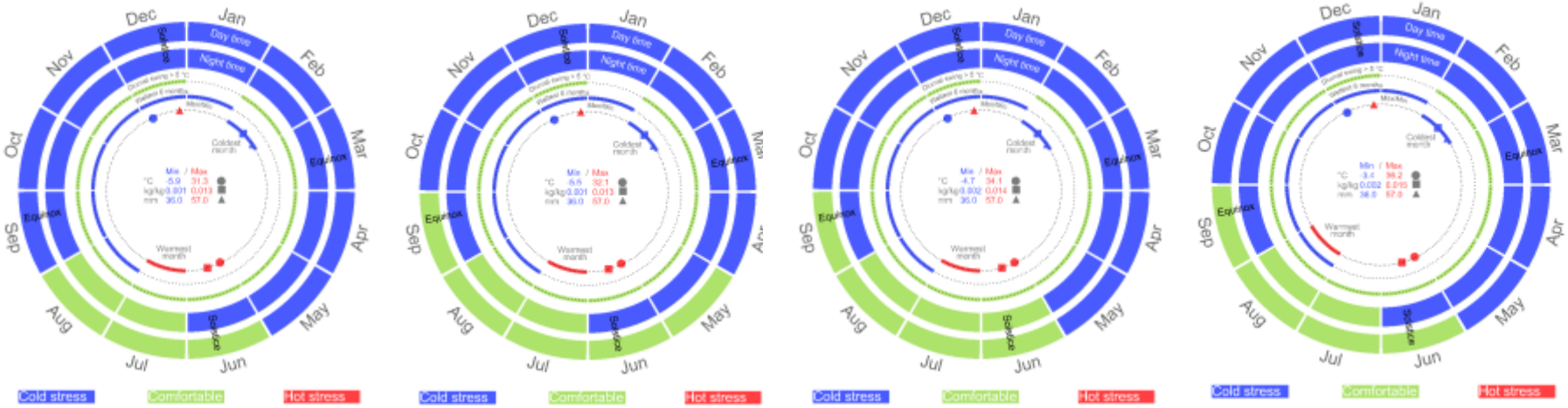




HadCM3 A2 morphed data (circa 2001)

London:

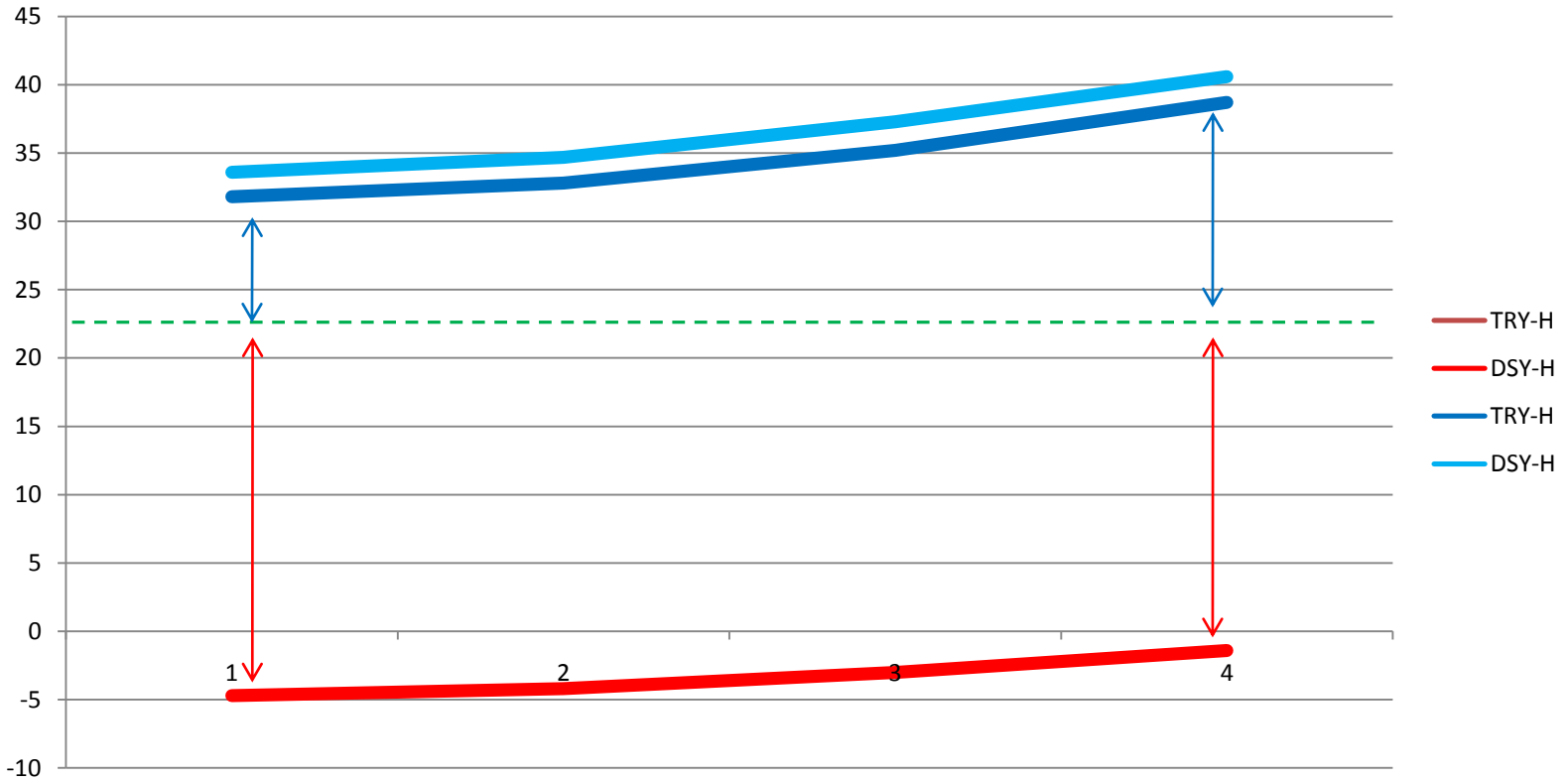
Current epw | epw 2020 | epw 2050 | epw 2080



90.1	5A	4A	4A	4A	
KG	Cfb	Cfb	Cfb	Cfb	
HDD	3063	2819	2497	2075	-33%
CDD	926	1088	1365	1774	+92%

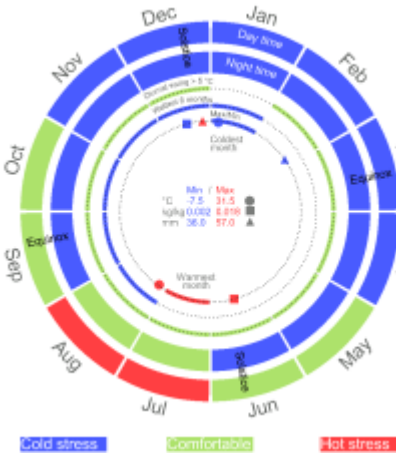
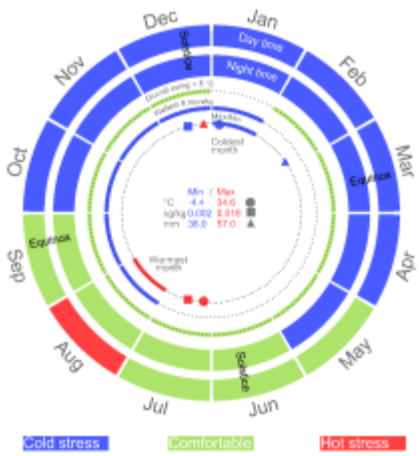
Effect on plant sizing

Peak ext design temperatures:



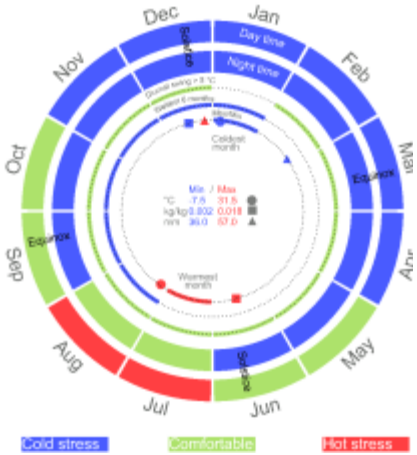
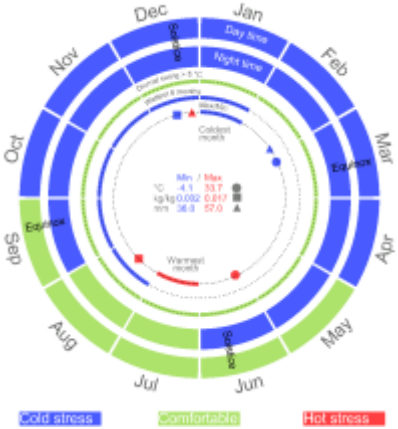
UKCIP 09 50%

London: energy sims

Current TRY05	TRY 2030	TRY 2050	TRY 2080	
				
90.1	4A	4A	4A	4A	
KG	Cfb	Cfb	Cfb	Cfb	
HDD	2650	2418	2245	2022	-24%
CDD	1150	1507	1678	1906	+66%

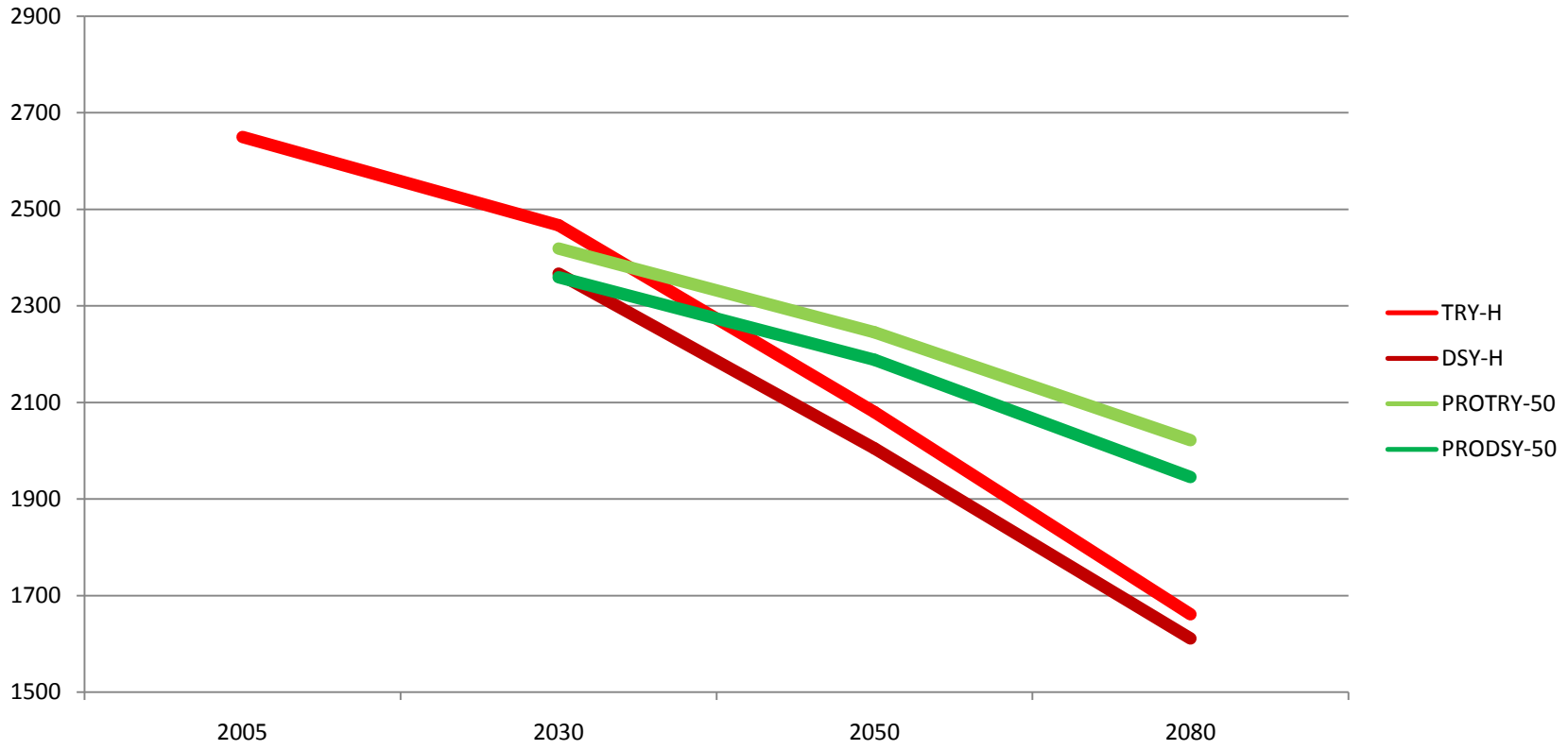
UKCIP 09 50%

London: worst case year

Current DSY05	DSY 2030	DSY 2050	DSY 2080	
				
90.1	4A	4A	4A	3C	
KG	Cfb	Cfb	Cfb	Cfa	
HDD	2535	2418	2188	1945	-23%
CDD	1332	1507	1765	1990	+49%

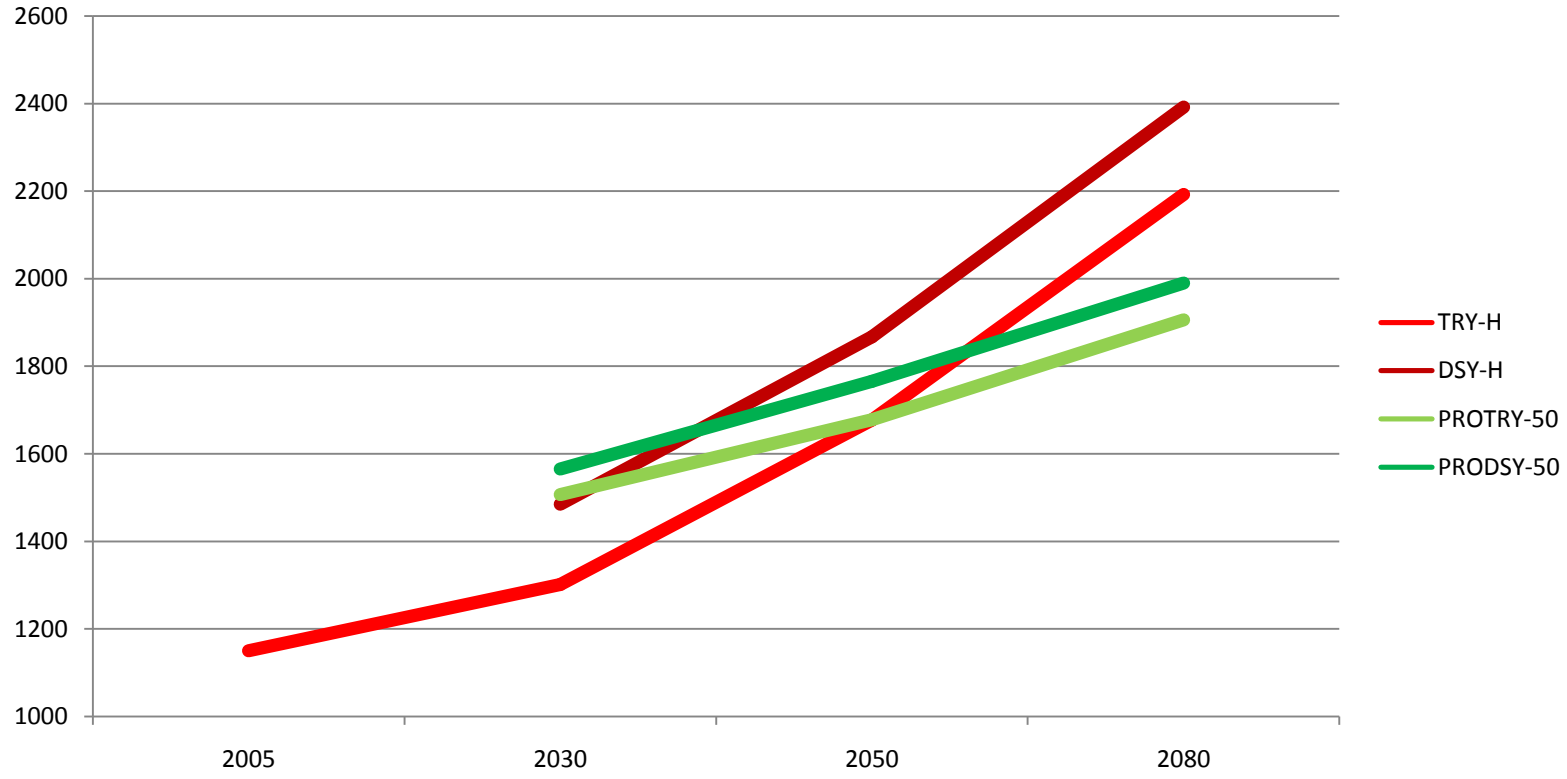
HDD

Heating degree days…



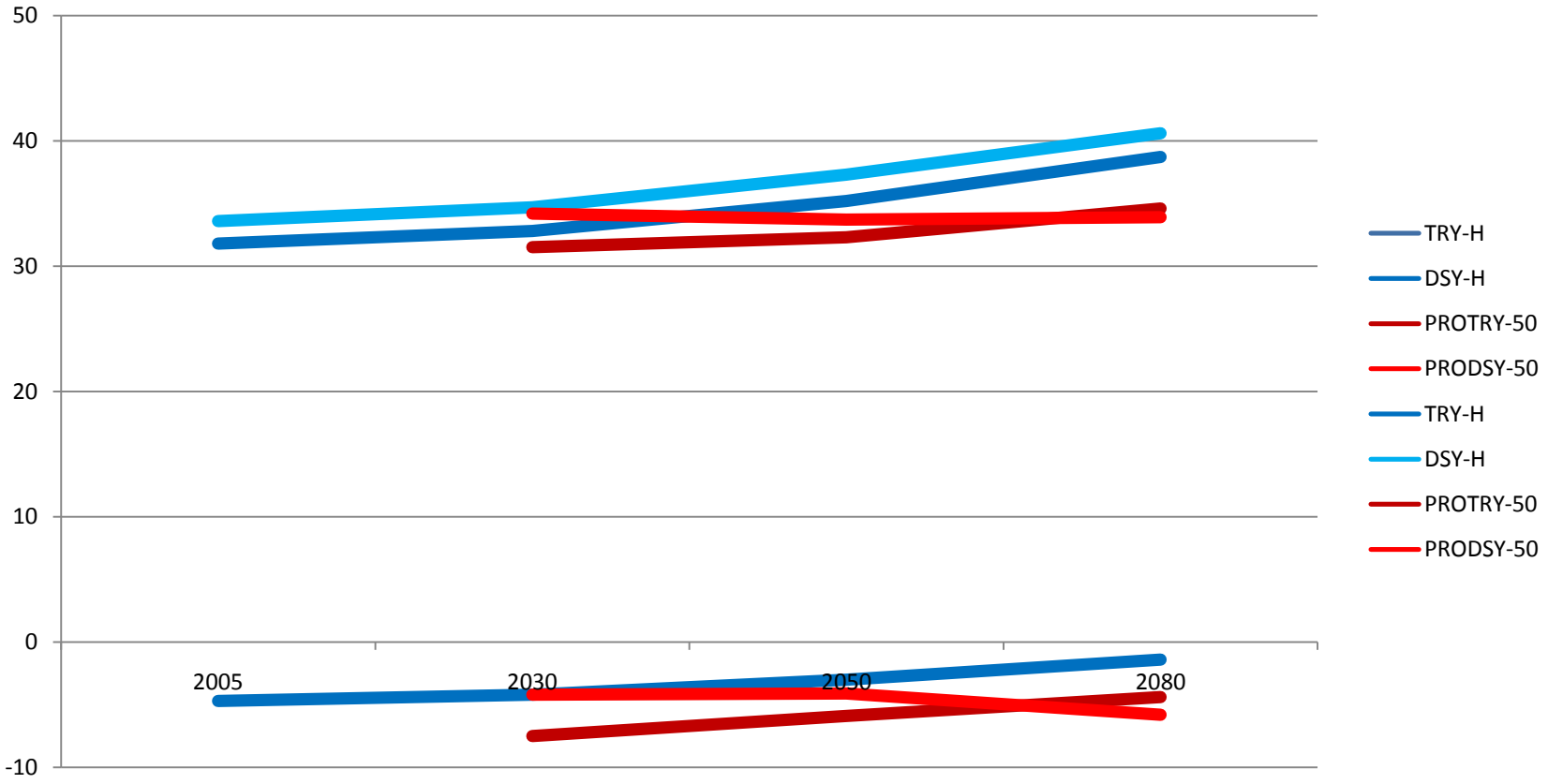
CDD

Cooling degree days…



Effect on plant sizing

Peak temperature …



Conclusions …

Earlier climate model over-estimated peaks but peak change is still significant

Plant run hours changes HVAC economics & carbon balance … plant efficiency even more critical than now

2030 data for design yes

2050/80 data for adaption strategy / risk only!

Questions?

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