COPSE

DESIGNING WITH FUTURE WEATHER DATA

Adapting Our Built Environment:
ARCC Contributions and Challenges

St Catherine's College,
University of Oxford

6-7 April 2011

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CO-INCIDENT PROBABILISTIC CLIMATE CHANGE WEATHER DATA FOR A SUSTAINABLE BUILT ENVIRONMENT (COPSE)

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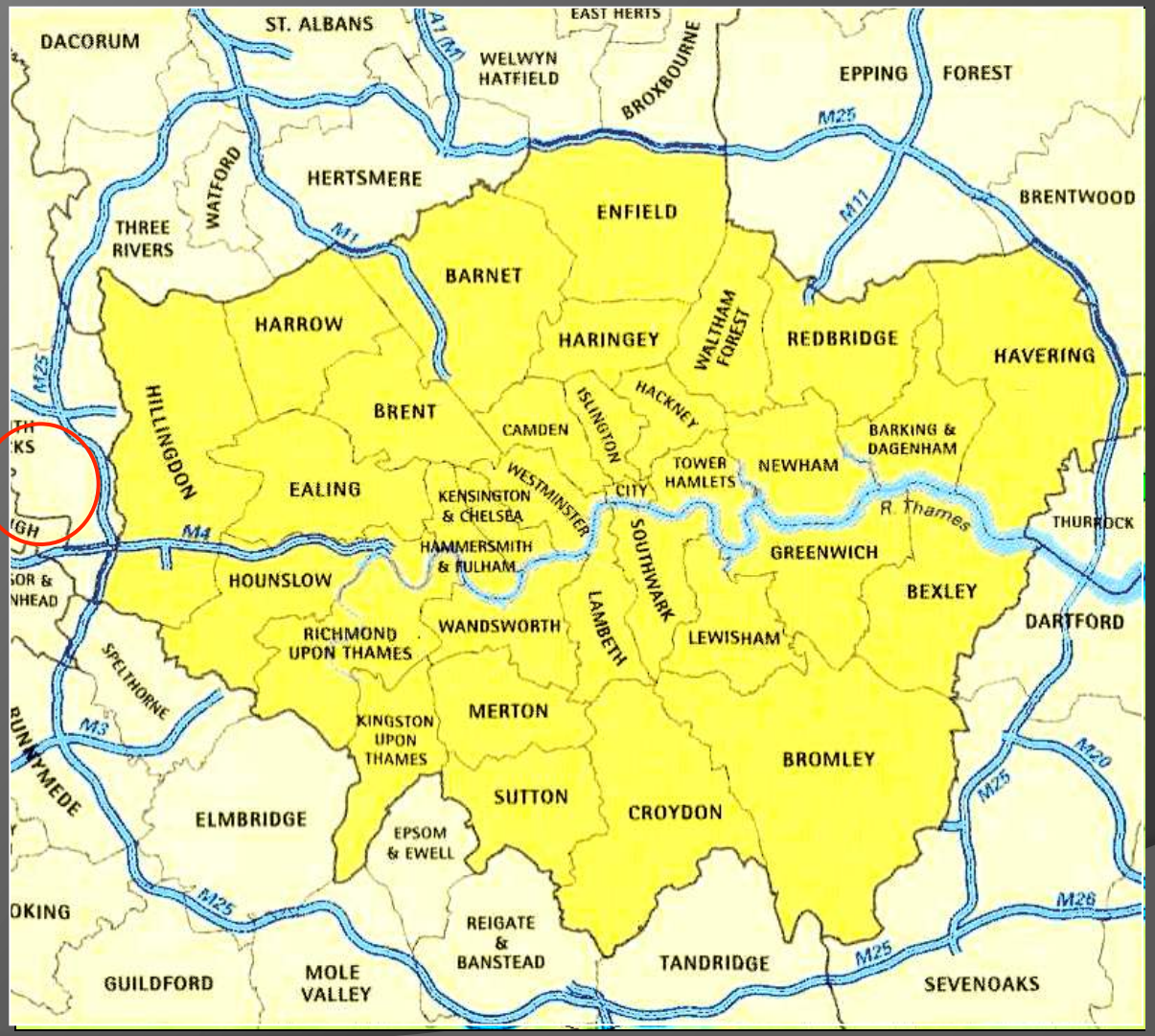
MAIN AIMS OF COPSE

1. Transform CP09-based probabilistic data into building design data for practitioners.
2. New Design Reference Year (DRY).
3. Modify the data to reflect Urban Heat Island (UHI) effects.
4. Examine natural ventilation and noise issues.
5. Comfort and adapting to higher temperatures.
6. Produce case studies of new-build and refurbishment projects to assess adaptation potential for carbon emission reduction.
7. Examine the solar data in CP09 and its effects on renewable energy use.

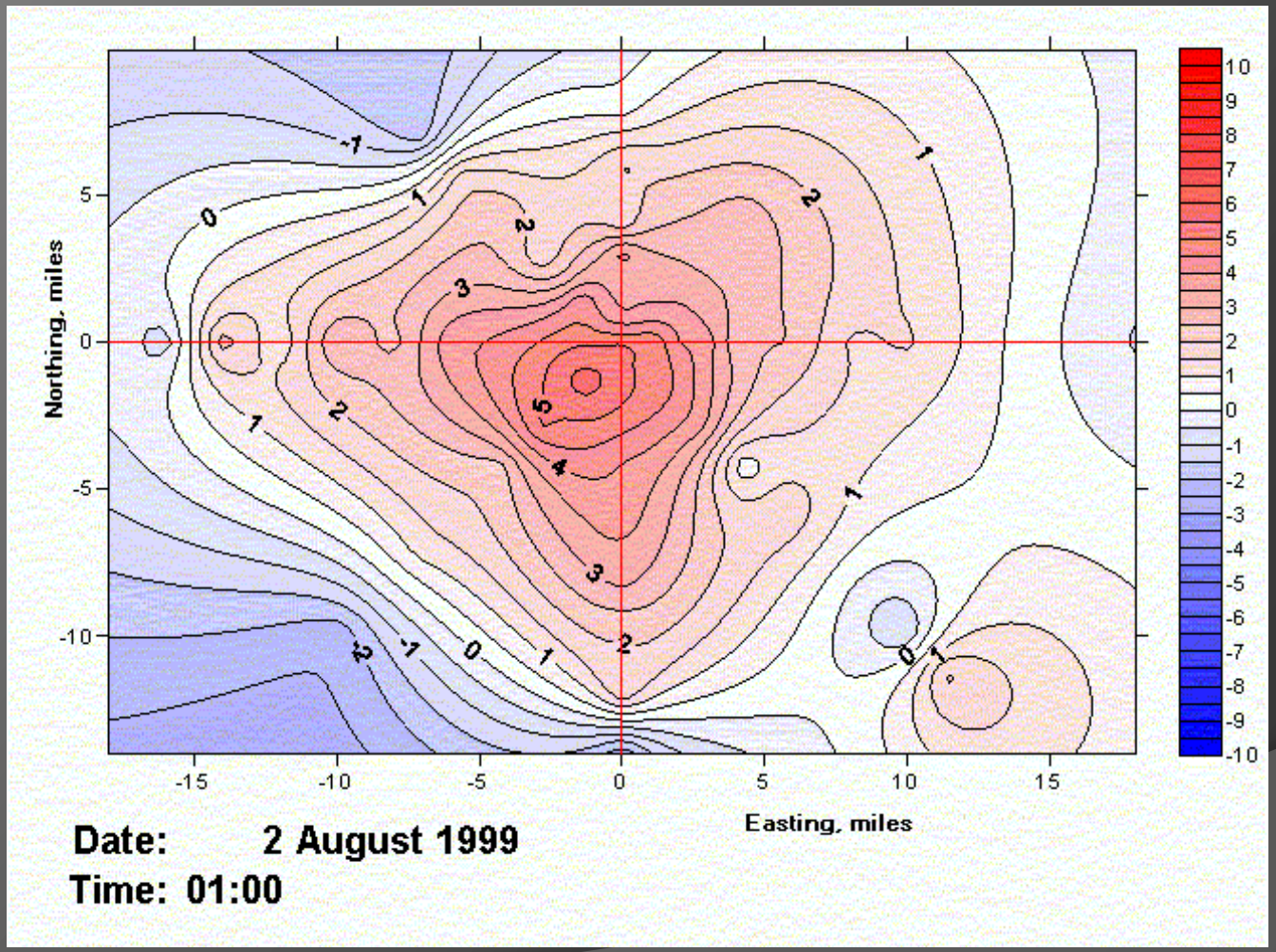
URBAN HEAT ISLAND EFFECTS

1. Higher mean temperatures
2. Lower mean air speeds
3. Time shifting of peak temperatures
4. Increased cooling load & decreased heating load

URBAN HEAT ISLAND EFFECTS

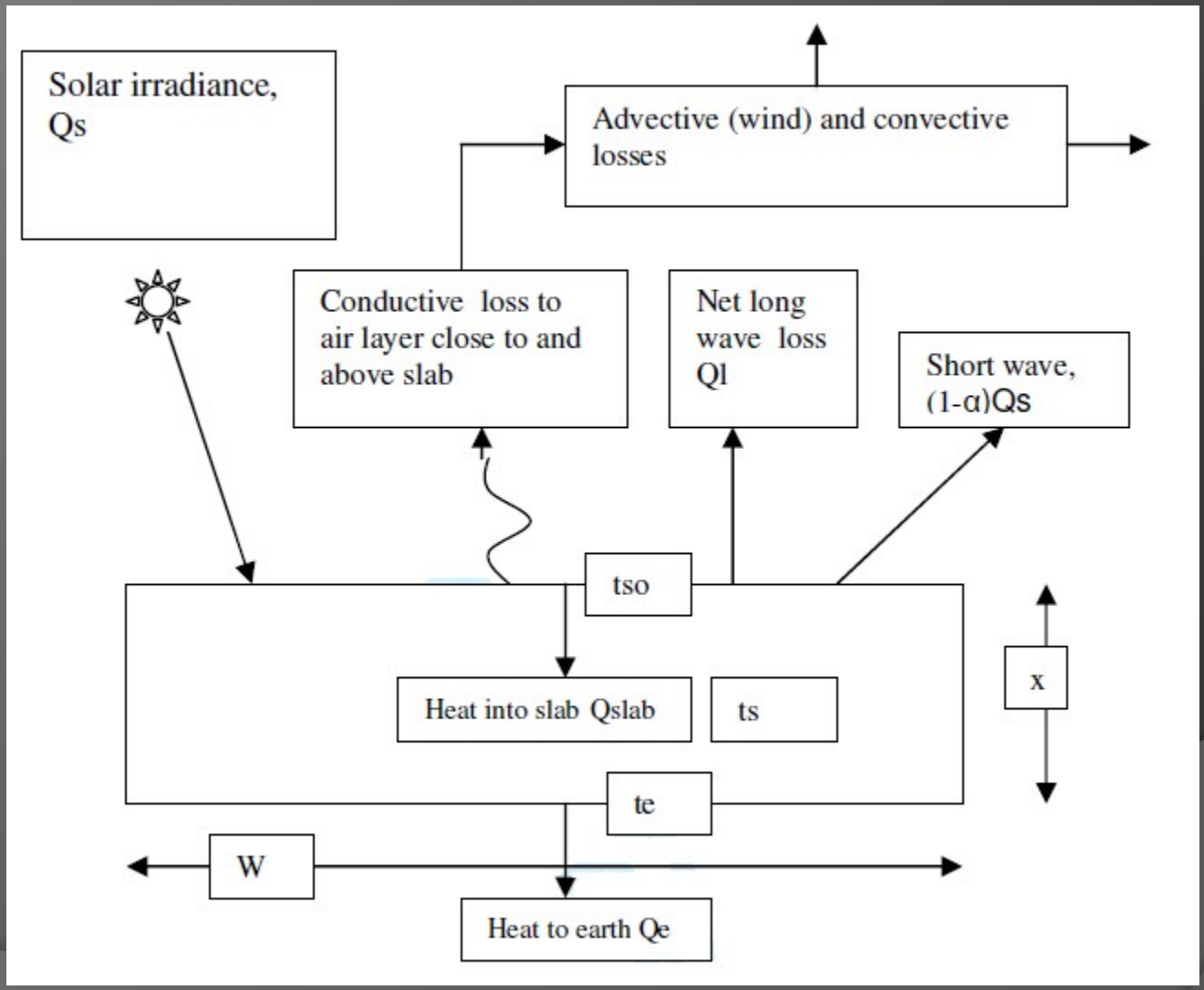


URBAN HEAT ISLAND EFFECTS

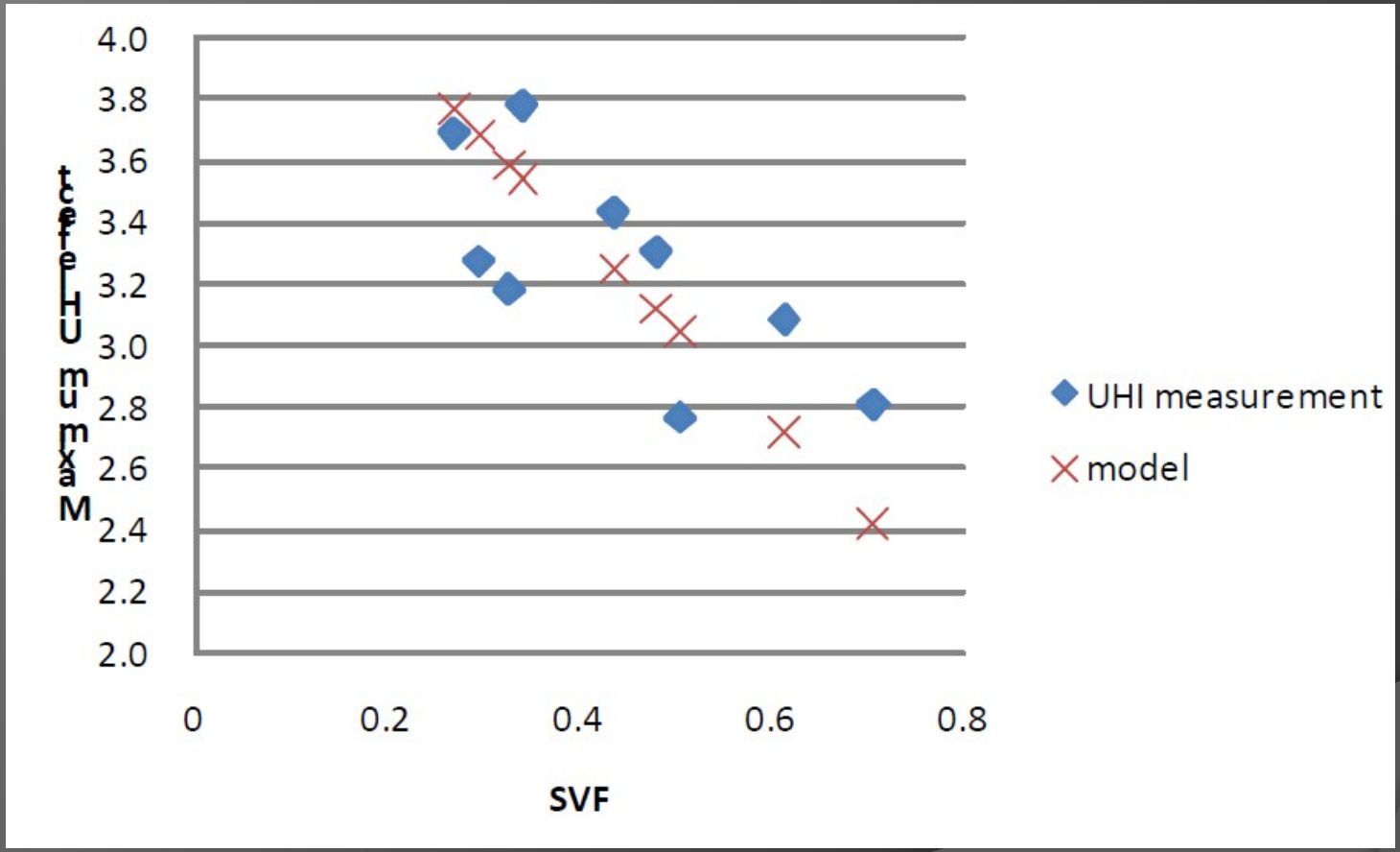


URBAN HEAT ISLAND EFFECTS

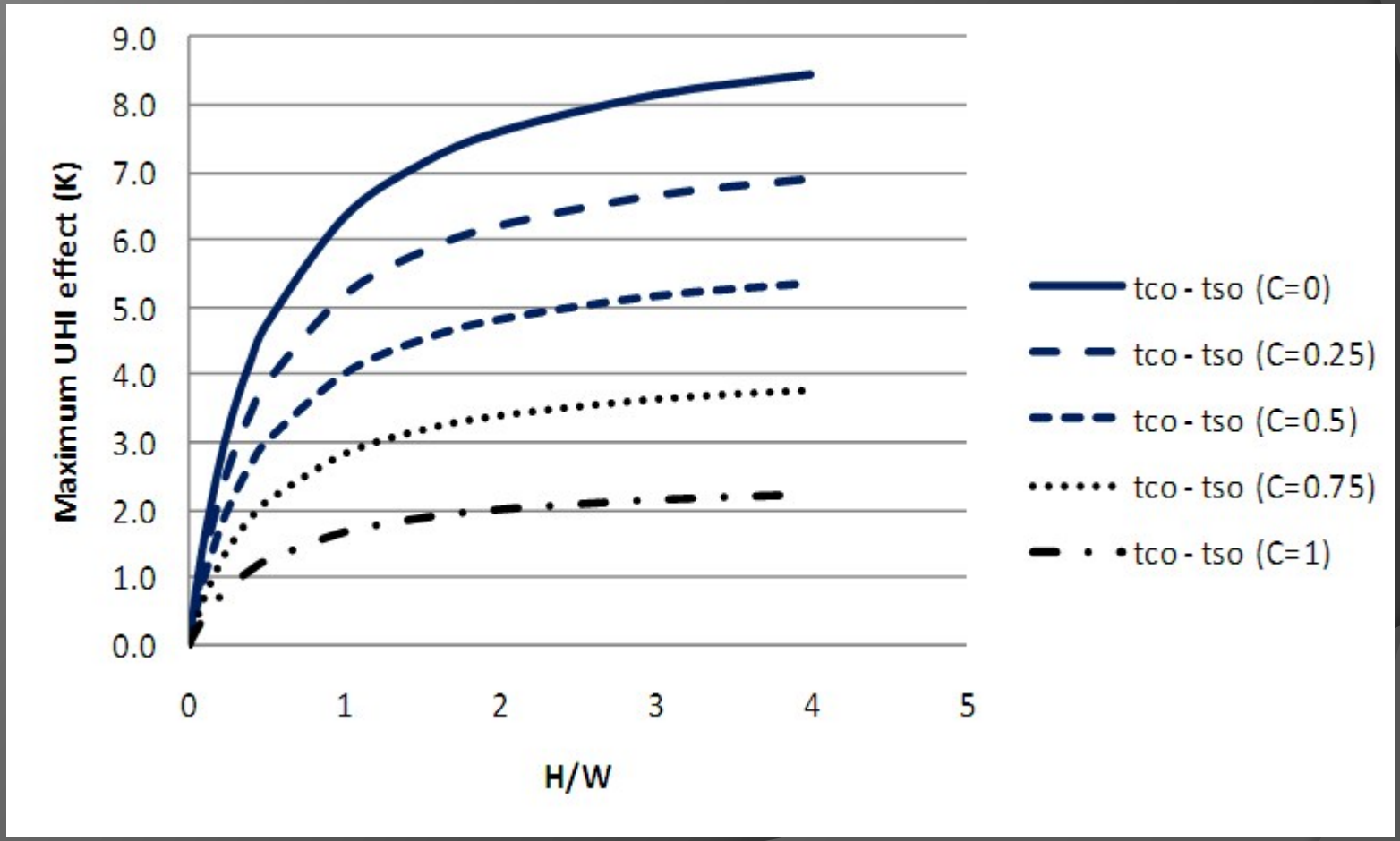
URBAN HEAT ISLAND EFFECTS MODEL



URBAN HEAT ISLAND EFFECTS



URBAN HEAT ISLAND EFFECTS



URBAN HEAT ISLAND EFFECTS

This gives us a tool to modify CP09 weather data for local context.

TEST REFERENCE YEARS & DESIGN REFERENCE YEARS

We need weather data for design:

TRYs

DSYs

DRYs

TRYS FROM CP09 DATA

- We want weather that avoids extremes.
- UKCIP gives 3000 years of possible future weather.
- For any given month (Jan-Dec), we determine the month which has the most typical weather.
- We do this for all 12 months and join the data together .

TRYS FROM CP09 DATA

- We also want to ensure that other weather parameters are not extreme: solar irradiance and humidity.
- In practice, we combine these requirements .
- This method is a standard method (ISO) that is very robust, well-defined, and reproducible. A very similar approach is used to provide the current CIBSE TRYs for the UK.

EXAMPLE TRY FROM CP09 DATA (HEATHROW 2080H)

Heathrow 2080H CIBSE_TRY.txt - Notepad

File Edit Format View Help

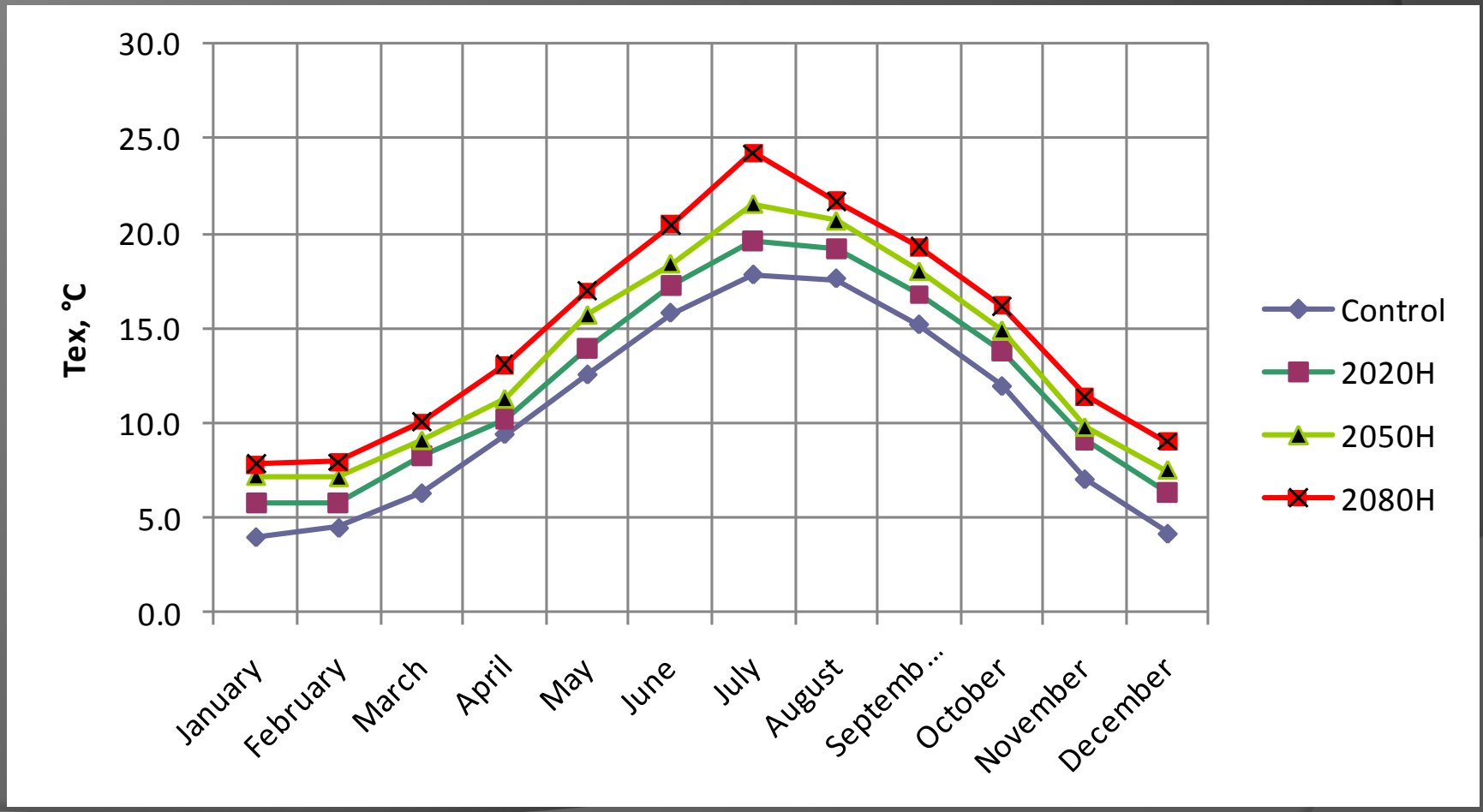
```
Test reference Year TRY for: London    Heathrow
Start Year = 3001.    End Year = 3012.
Latitude = 51.48N. Longitude = 0.45W. Altitude = 25m.

Selection using FS method with equal weighting for Solar, DryT and RH
Selected years for each month are:
January:   3001
February:  3002
March:     3003
April:     3004
May:       3005
June:      3006
July:      3007
August:    3008
September: 3009
October:   3010
November:  3011
December:  3012

Notation and units:
ID         = Station Identifier
PWC        = Present Weather Code
Cloud      = Cloud amount              1/8
DryT       = Dry Bulb Temperature      degrees C
WetT       = Wet Bulb Temperature      degrees C
Press      = Mean Sea Level Pressure   hPa
WD         = Wind Direction            degrees
WS         = Wind Speed                knots
GlRad      = Global radiation          Watts per sq. metre
DiRad      = Diffuse radiation         Watts per sq. metre

  ID    Year  Month  Day Hour  PWC Cloud  DryT   WetT    Press     WD    WS  GlRad  DiRad
  0000  3001    1     1    0    -1    8    6.9    4.7   1013.0    100    13     0      0
  0000  3001    1     1  100    -1    8    6.7    4.8   1013.0    280    12     0      0
  0000  3001    1     1  200    -1    8    6.6    4.9   1013.0    230    11     0      0
  0000  3001    1     1  300    -1    8    6.4    5.0   1013.0    190    12     0      0
  0000  3001    1     1  400    -1    8    6.3    5.1   1013.0    170    13     0      0
```

TRYS FOR HEATHROW (CONTROL, 2020, 2040, 2080) WITH HIGH EMISSIONS MONTHLY MEAN TEMPERATURES

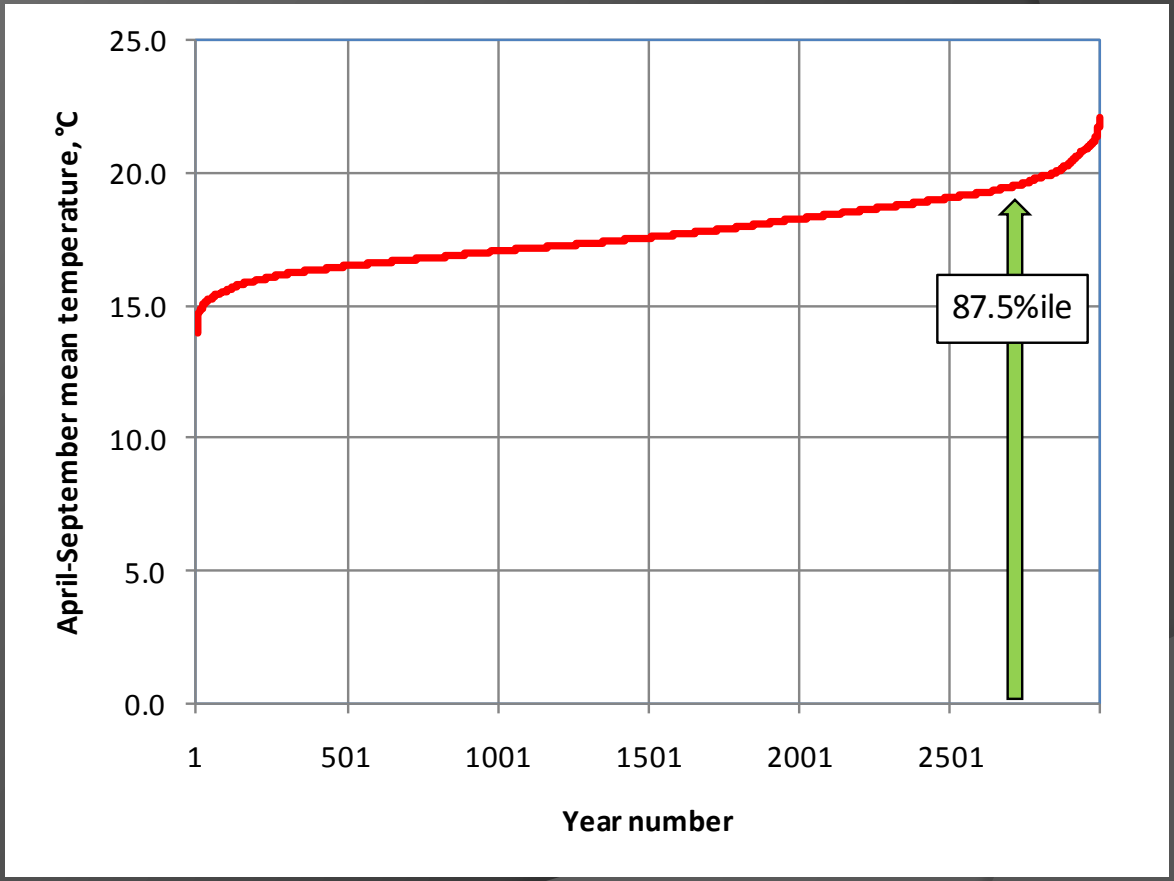


DESIGN SUMMER YEARS (DSYS)

3000 years‘ data

Tex April-Sep

87.5%ile year chosen

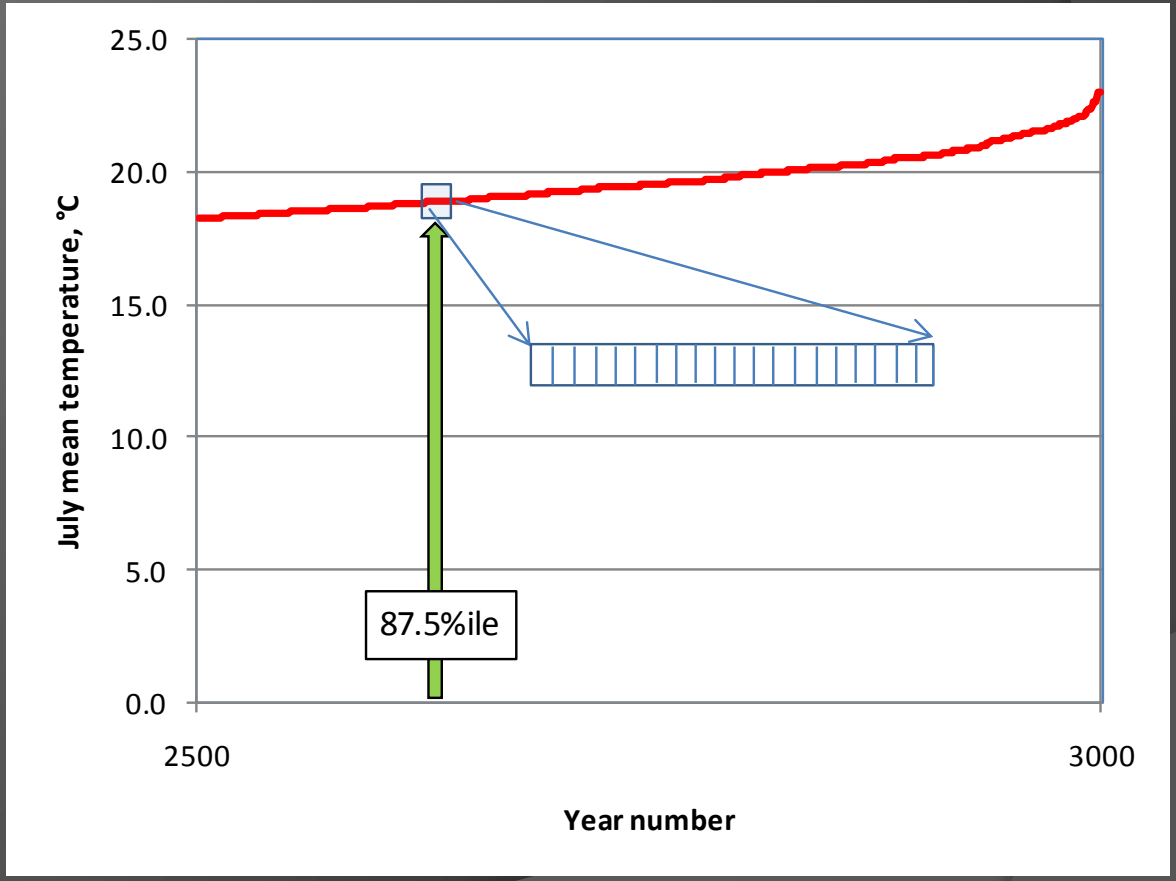


DESIGN REFERENCE YEARS (DRYS)

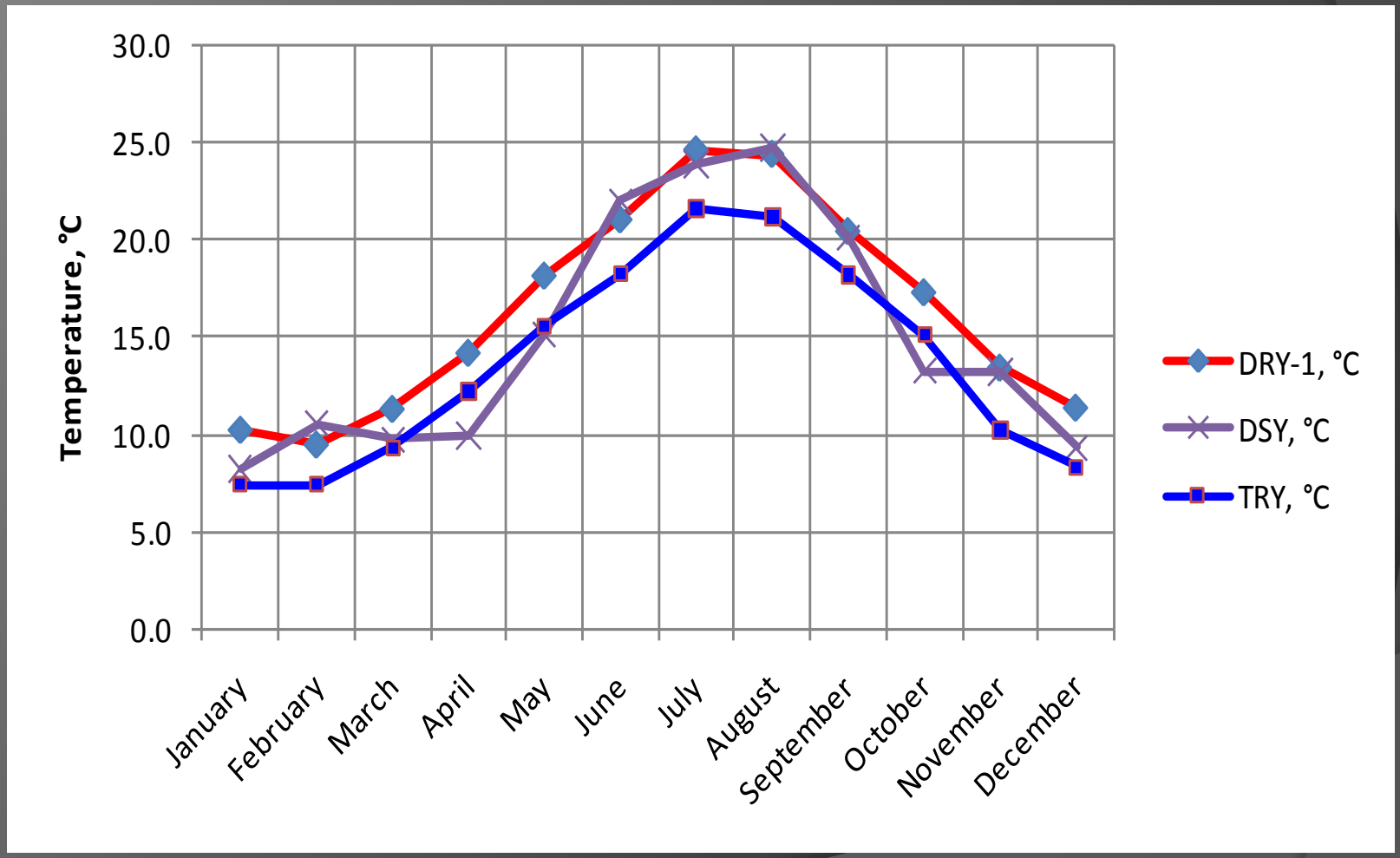
- To provide more testing weather: we want it to be warmer AND sunnier. But not too extreme, and not too coincident in warmth and sun.
- We assume a critical month . This month can be identified from running a building using the TRY.

DESIGN REFERENCE YEARS (DRYS)

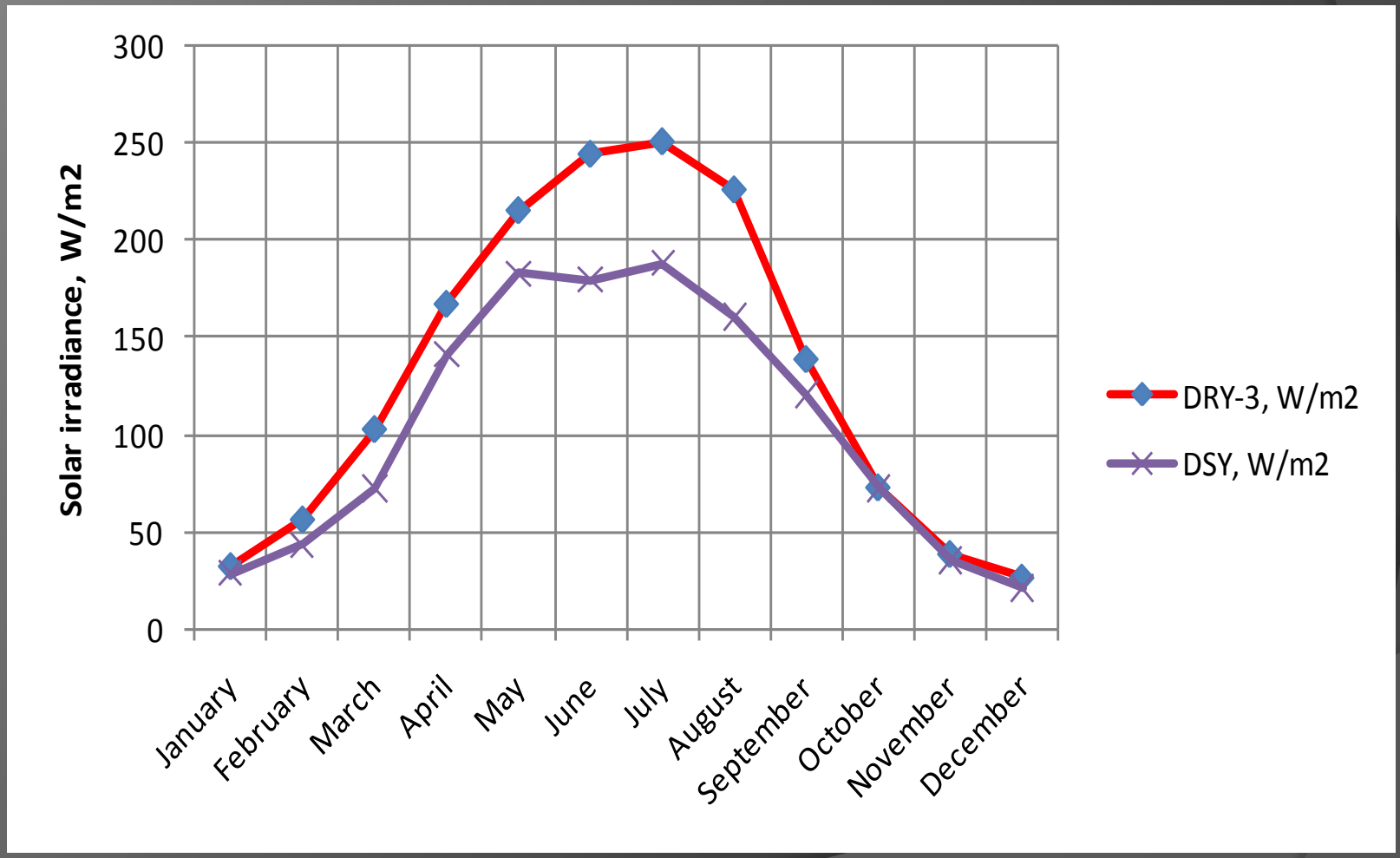
- 3000 years‘ data
- Tex/RH/Solar
- 87.5%ile sampling point chosen
- 20 years analysed using FS-stat, with Tex, Solar, RH
- Most typical month is the DRY month



COMPARING EXTERNAL TEMPERATURE FOR DSY AND DRY



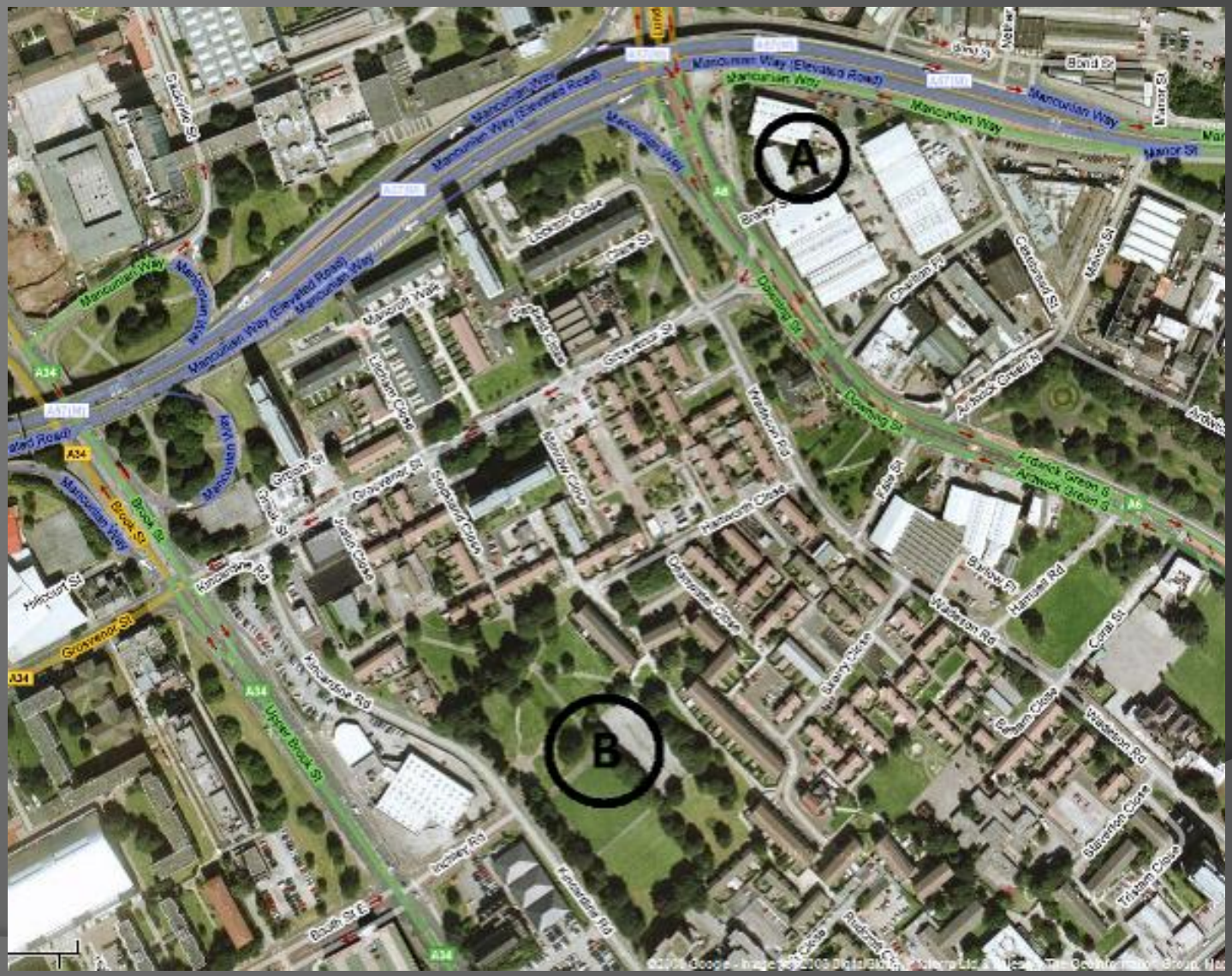
COMPARING SOLAR IRRADIANCE FOR DSY AND DRY



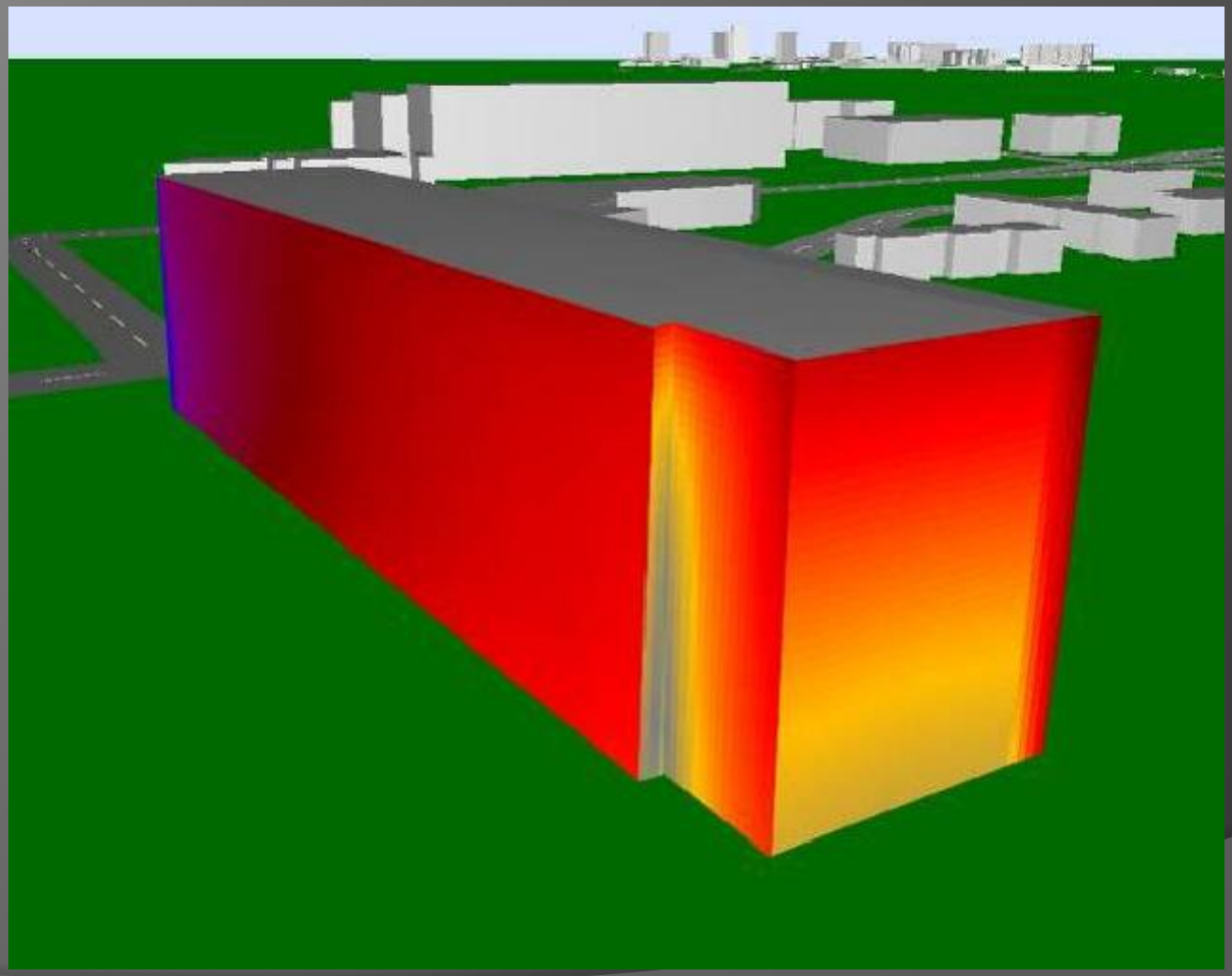
INTEGRATING ACOUSTIC AND NATURAL VENTILATION PERFORMANCE

- Consider a building with mixed mode ventilation
- Noise levels over façade from CadnaA Noise mapping software
- Window opening is adjusted so that noise ingress is as close to tolerated noise level as possible
- Mixed mode cooling energy
- Compared to changes due to climate change

MAPPED AREA OF MANCHESTER



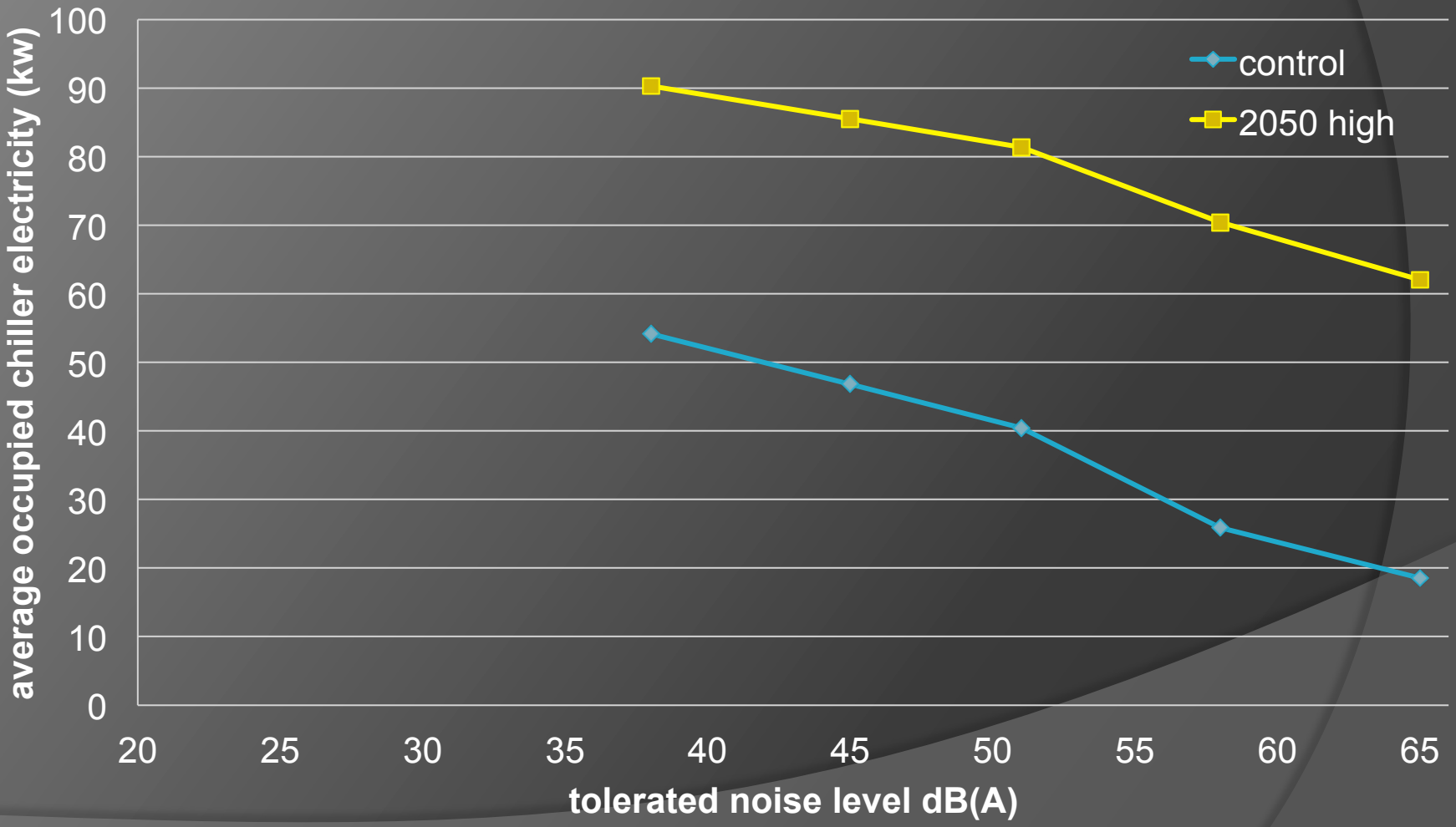
BUILDING FAÇADE NOISE LEVELS FOR POSITION B



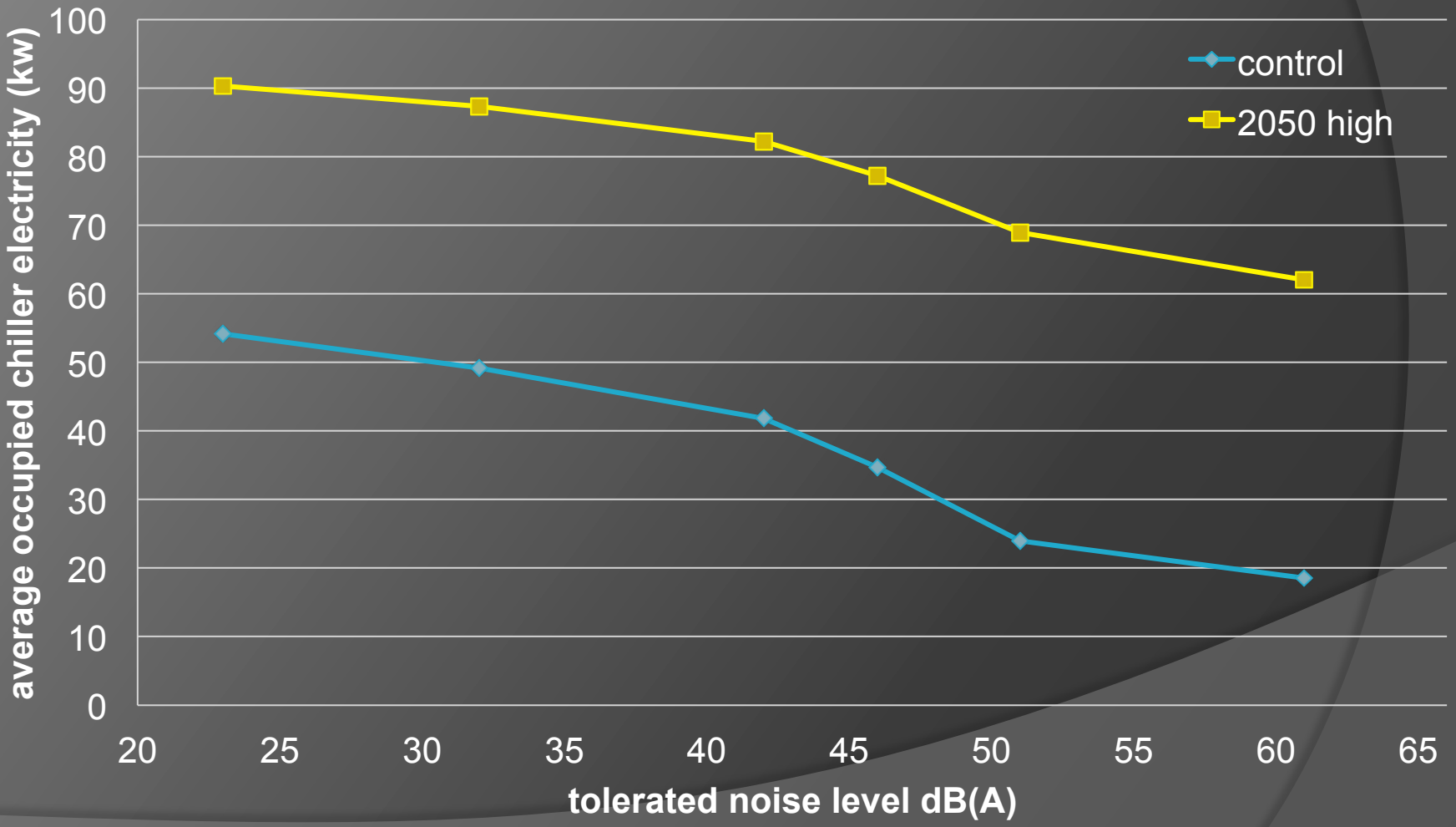
Noise levels dB(A)

	if >	-99.0
	if >	35.0
	if >	40.0
	if >	45.0
	if >	50.0
	if >	55.0
	if >	60.0
	if >	65.0
	if >	70.0
	if >	75.0
	if >	80.0
	if >	85.0

BUILDING IN POSITION A



BUILDING IN POSITION B

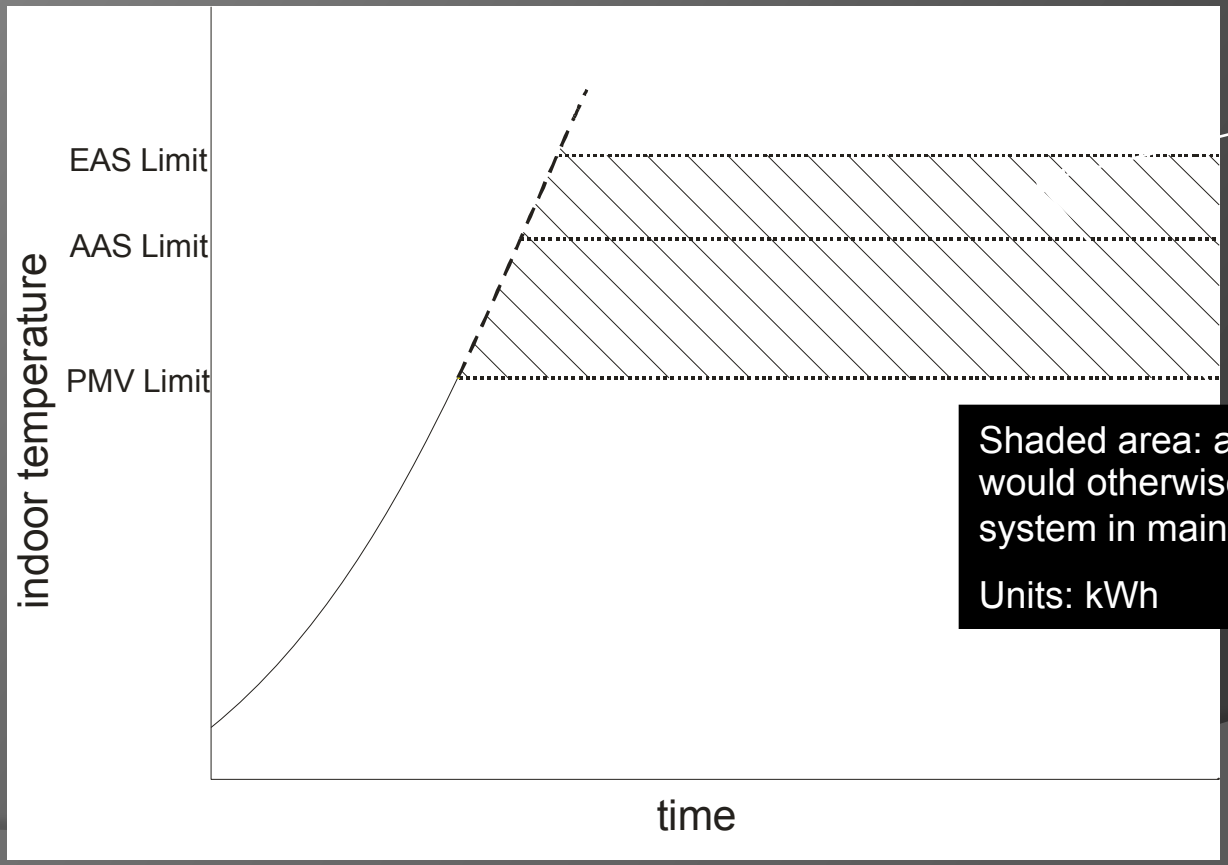


COMFORT AND ADAPTING TO HIGHER TEMPERATURES

ADAPTIVE COMFORT DEGREE-DAYS (ACDD)

Metric to compare future energy savings for Adaptive Comfort standards

- EN15251 (Category II) (EAS)
- ASHRAE 55 (80% acceptability) (AAS)



Shaded area: can be described in terms of a novel temp diff-time composite metric (based on upper limit of thermal comfort zone for EAS or AAS)

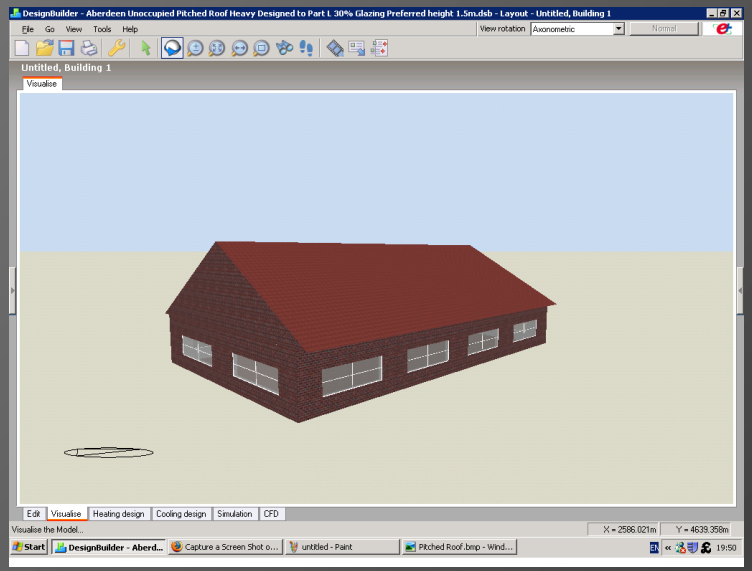
Units: ACDD

Shaded area: also proportional to energy which would otherwise be consumed by an A/C system in maintaining indoor temp at PMV limit

Units: kWh

ADAPTIVE COMFORT DEGREE-DAYS

Aim: Investigate whether Qc α ~ ACDDs over wide range of solar radiation levels. (indoor temp = 26°C, fan coil units)



5 LEVELS OF GLAZING

10%, 30%, 50%, 70%, 90%

5 CONSTRUCTION TYPES

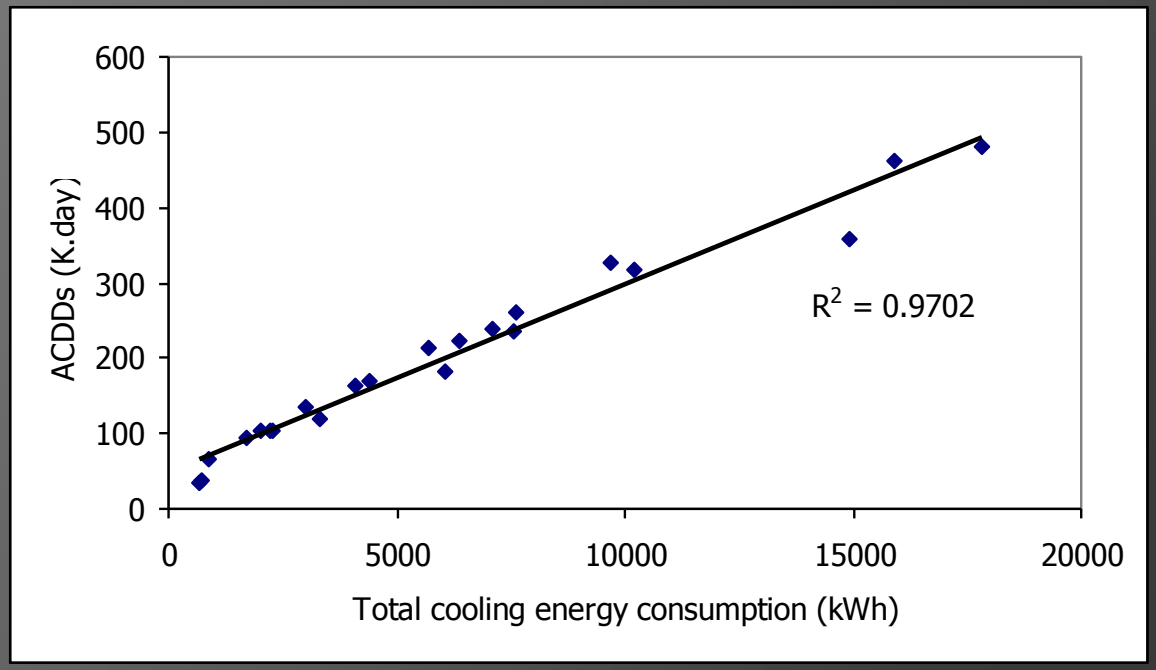
- LIGHTWEIGHT, FLAT ROOF (LIGHT)
- MEDIUM/HEAVY WEIGHT, FLAT ROOF (MEDIUM)
- MEDIUM/HEAVYWEIGHT- HIGHLY INSULATED, FLAT ROOF (HEAVY)
- MEDIUM/HEAVYWEIGHT, PITCHED ROOF WITH EAVES (PITCHED)
- SOLID WALL , SOLID FLAT ROOF (SOLID)

	Dry Bulb Temp (°C)	Direct Normal (kWh/m²)	Annual Solar Gains-Window (kWh)*
Aberdeen	13.3	483	21568
Oban	13.5	588	21209
Aughton	14.7	600	22376
Hemsby	15.3	690	24411
Finningley	15.6	597	22622
Brest	15.6	661	24570
Birmingham	15.9	627	24184
Jersey	16.2	891	26499
Gatwick	16.3	743	23803
Cologne	17.1	564	22503
Brussels	17.1	509	21352
Nancy	17.8	729	24637
Frankfurt	18.2	723	23866
Nantes	18.4	885	27090
Paris	18.6	679	24282
Dijon	19.1	812	26257
Mannheim	19.2	727	24255
Bordeaux	20.2	930	28631
Odessa	21.1	831	26659
Turin	21.5	1035	28648
Montpellier	22.7	1320	32531
Marseille	23.3	1504	33737

Direct Normal Coefficient of Variation (annual)	**31.4%**	**12.7%**
Direct Normal Coefficient of Variation (summer)		**6.7%**

**MEDIUM construction, 30% glazing*

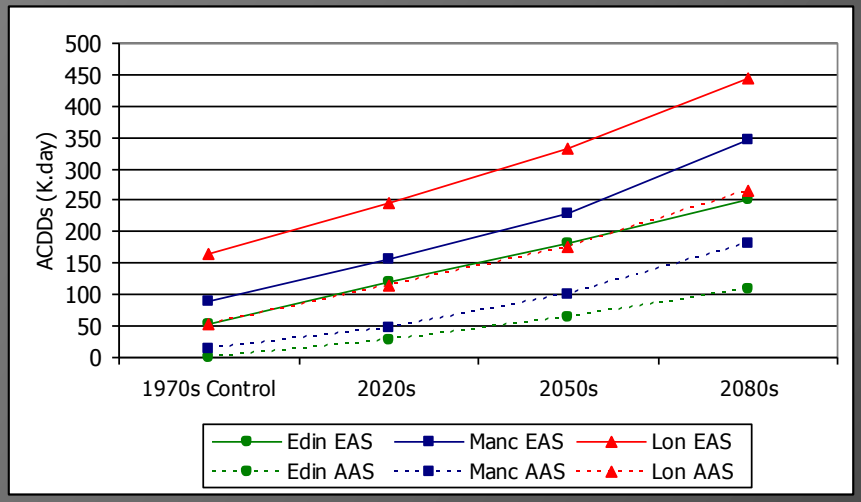
ADAPTIVE COMFORT DEGREE-DAYS



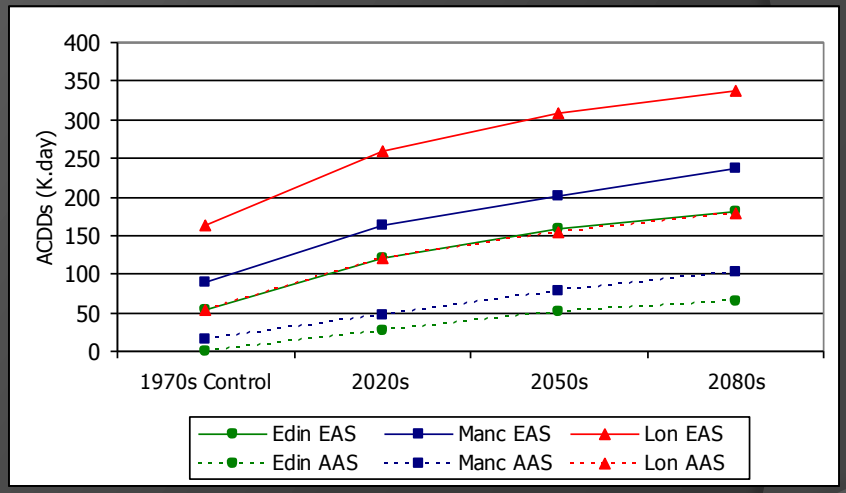
Correlation between annual number of cooling EAS ACDDs and total annual cooling energy consumption for the MEDIUM building with 30% glazing

ADAPTIVE COMFORT DEGREE-DAYS

Edinburgh (Turnhouse), Manchester (Ringway) and London (Heathrow) for the 2020s, 2050s and 2080s



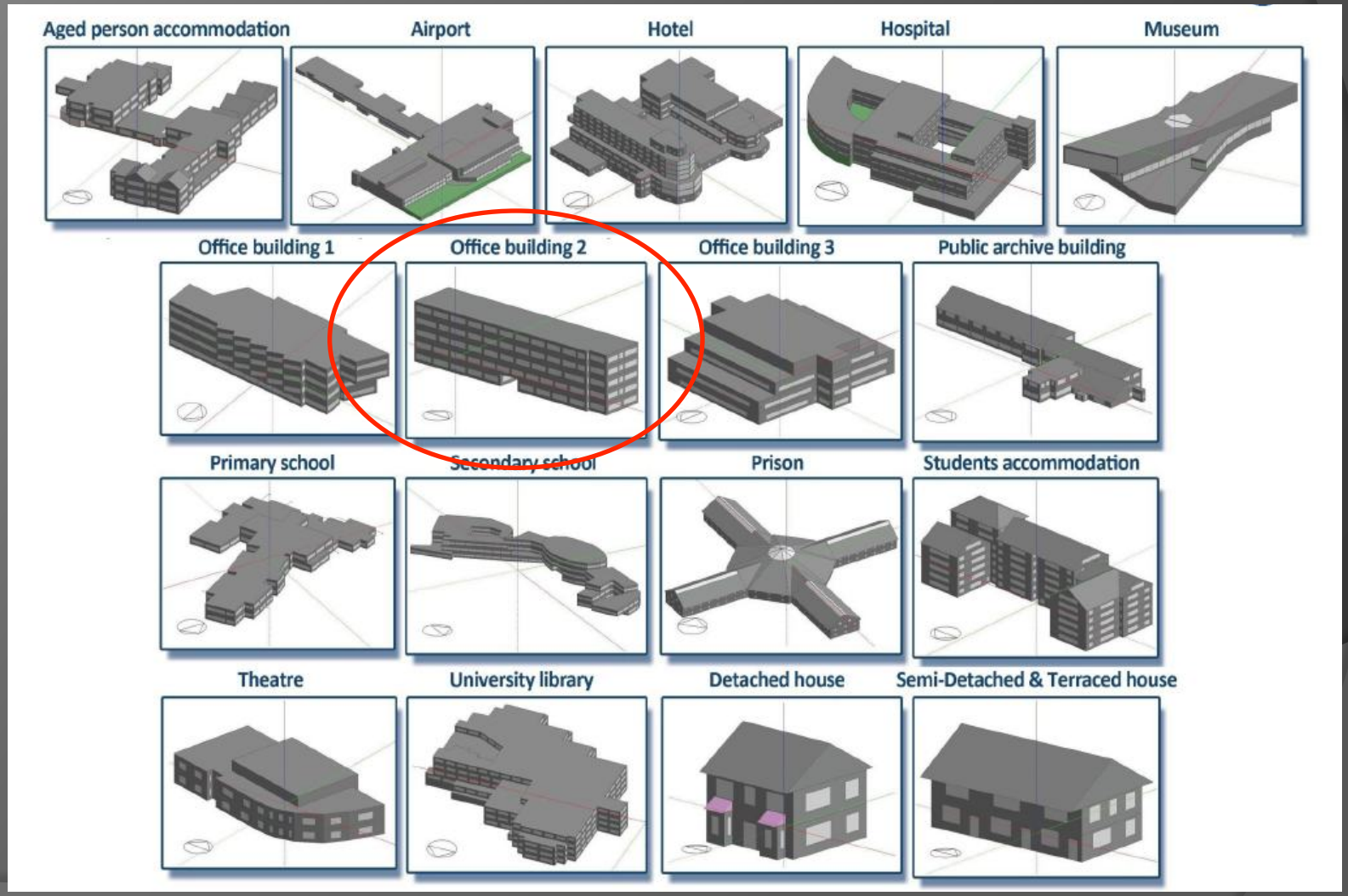
(a) high emissions scenarios



(b) low emissions scenarios

Annual number of cooling ACDDs following implementation of the AAS and the EAS using TRY data

SIMULATION MODELLING USING TRYS FROM CP09 DATA

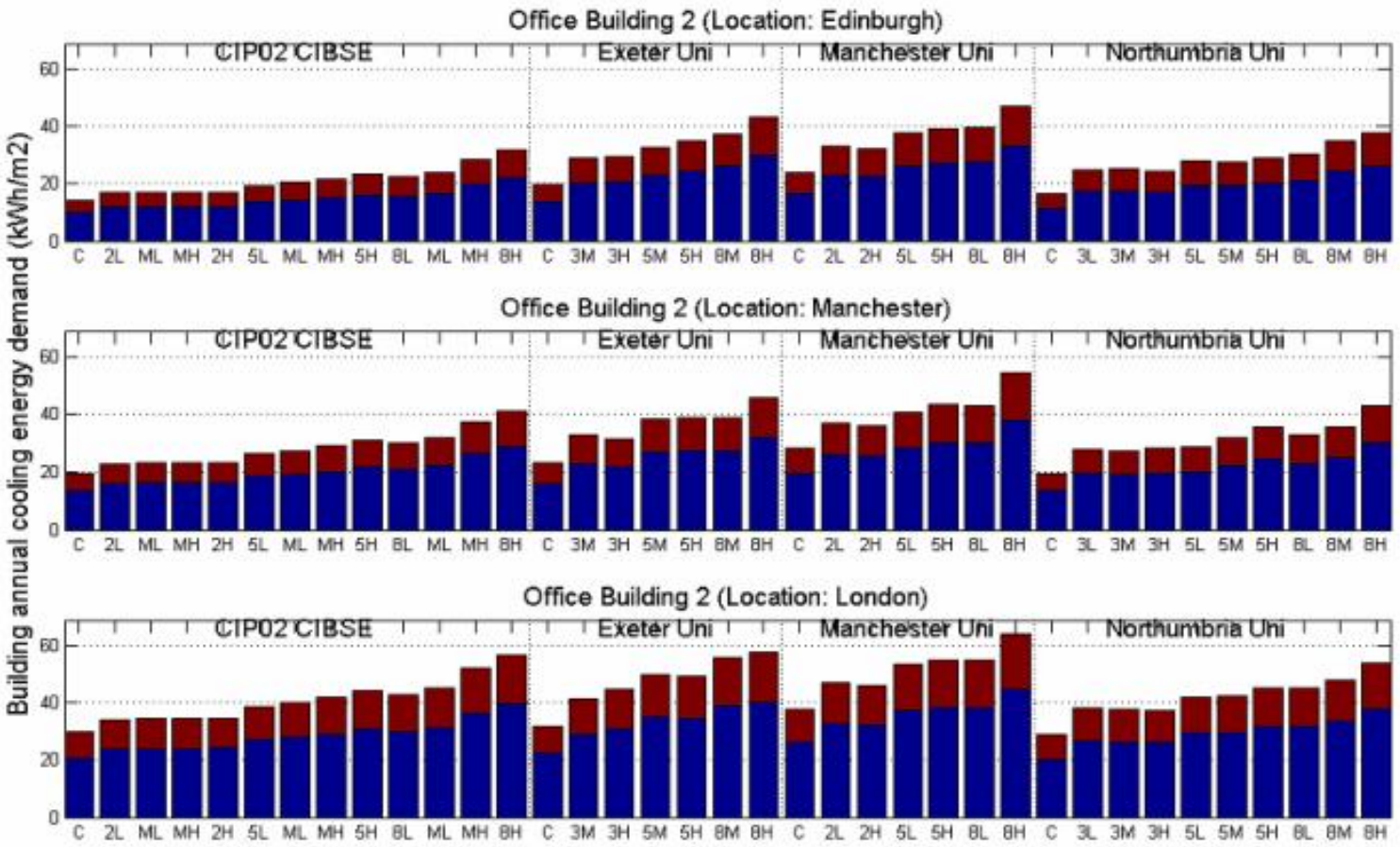


SIMULATION MODELLING USING TRYS FROM CP09 DATA

Compare weather files (TRYs) from:

- CIBSE morphed data (UKCIP02) TRYs
- Manchester & Northumbria TRYs (CP09)
- Exeter TRYs (CP09)

SIMULATION MODELLING USING TRYS FROM CP09 DATA



SIMULATION MODELLING USING TRYS FROM CP09 DATA

Results:

- Good agreement between Exeter, Manchester & Northumbria
- The mean summer indoor temperature from CP09 data is about 1°C higher than for CIBSE morphed data – in EDINBURGH.
- For LONDON, CP09 and CIBSE morphed data give similar results.
- Similar results are found for: %occupied hours over 28°C, heating energy and cooling energy.

SUMMARY

- Methods for producing: TRYs, DRYs and DSYs
- Tool for modifying CP09 data for the UHI.
- Extensive modelling work to quantify the effects of future weather.
- Impact of warmer conditions on ventilation potential allowing for noise.
- Comfort criteria re-appraisal to allow for adapting to warmer weather.
- Solar radiation data in CP09 assessed leading to a revision.

STAKEHOLDERS

Designers and clients are providing information on their choice and use of risk criteria and applying the weather files.

Stakeholders include:

- IES
- EDSL
- Designbuilder Software Ltd
- Derrick Braham Associates Ltd
- Bristol City Council
- 3DReid
- AECOM
- Aedas Architects Ltd
- Feilden Clegg Bradley
- Hoare Lea Research & Development
- King Shaw Associates
- Roger Preston Environmental
- UKCIP
- CIBSE