A proposed new UK framework for the sizing of domestic hot and cold water systems for medium-large scale residential buildings

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Primary Objective

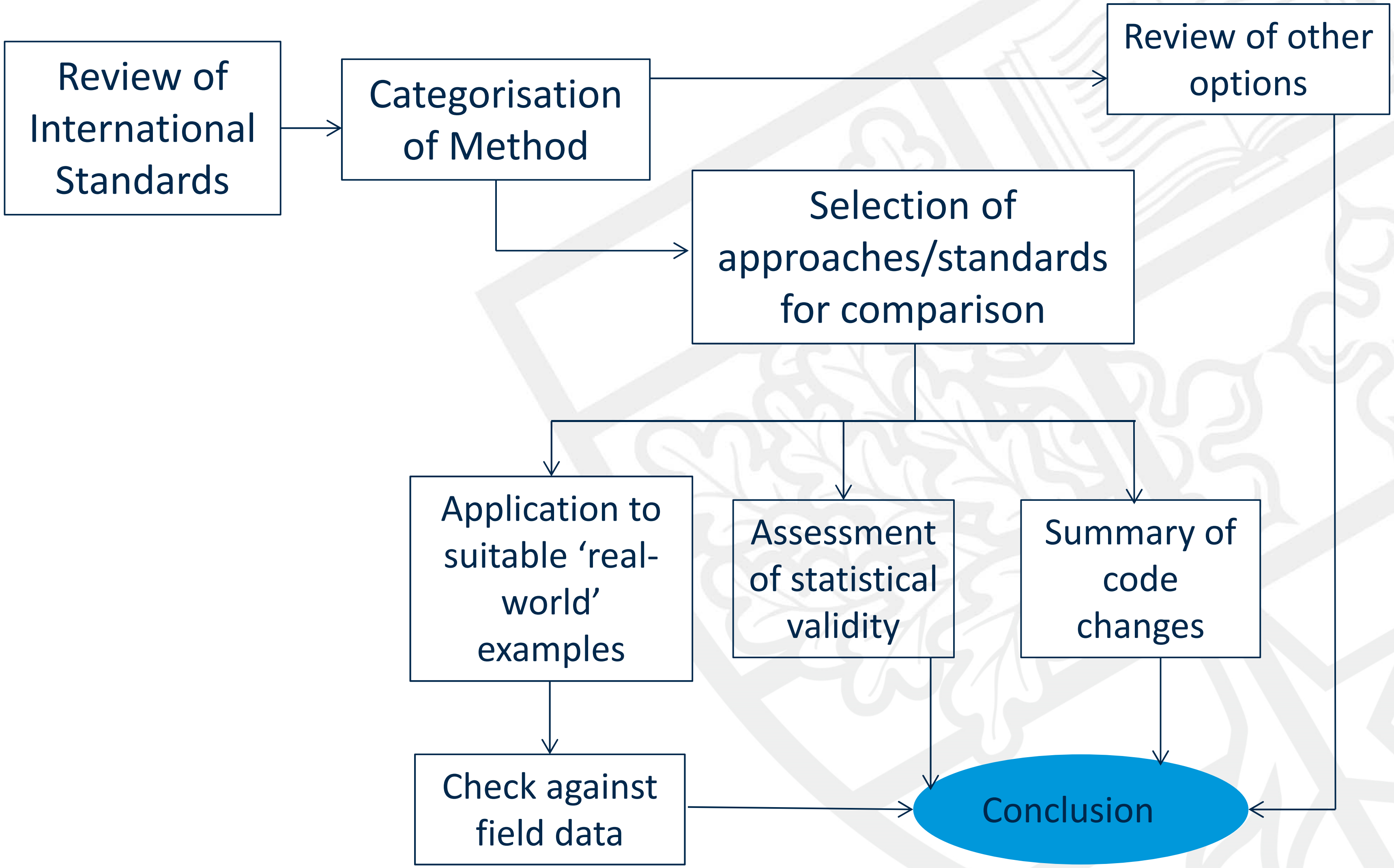
UK perspective…..growing concern about oversizing

Recommendation for framework/methodology for the sizing of domestic hot and cold water for new national standard

Clarity on whether the existing Loading Units methodology should be retained and re-worked, or whether an alternative method is more suitable

Primary focus for methodological re-work - medium/large-scale dwellings

Investigative method adopted



Review of international standards

Not an international review……..

BSEN806
BS6700
Guide G/CIPHE (IOP)

} UK

USA, IPC/UPC/NSPC
Netherlands, ISSO55
South Africa, SANS10252
Spain, UNE149201
Germany, DIN1988
Denmark DS439
Russia SNiP 2.04.01-85

Categorisation of Method

Code	Statistical Method	Comments
BSEN806	Probability	1% Exceedance
BS6700	Probability	1% Exceedance
Guide G	Probability	1% Exceedance
IPC/UPC	Probability	1% Exceedance
ISSO55	Empirical	Code version
ISSO55	Stochastic	Via SIMDEUM
SANS10252	Empirical	Applicable to ten building types
(UNE)149201	Empirical	Applicable to six building types
DIN1988	Empirical	Applicable to seven building types
DS439	Empirical	
Russia	Empirical	

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Selected for comparison

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Application to real-world examples

1. *A large, high-end private house of 5 upper ground floors and 2 basement floors (inc. sprinklers, rainwater harvesting system, pool)*

2. 9 high-end apartment scheme (mainly 2 apartment layouts with 1 or 2 bathrooms)

3. A 101 basic apartment scheme:16 apartments on level 1 and 17 apartments on each of other 5 floors. Bathroom provision varied across apartments

4. A 165 apartment scheme, inc rainwater harvesting tank and energy centre. Cores 1, 2 and 3 have 27, 91 and 47 apartments respectively spanning 10 floors

5. A 289 apartment scheme; 8 blocks of different sizes spanning lower ground to 10th floor. The number of apartments and appliance settings vary

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Assumptions

Total variables LU, qf and VR calculated by adding hot and cold water
ISSO55 - results for cold and hot water flow rates added
Omitted – sprinklers, pools, district heating
In some cases, washing machine and dishwasher loads have been added to allow comparability with ISSO55
Russian code - number of persons per apartment was assumed as:

Apartment type	Number of persons
En-suite	1
1 bedroom	2
2 bedroom	4
3 bedroom	6

Not every code application directly comparable

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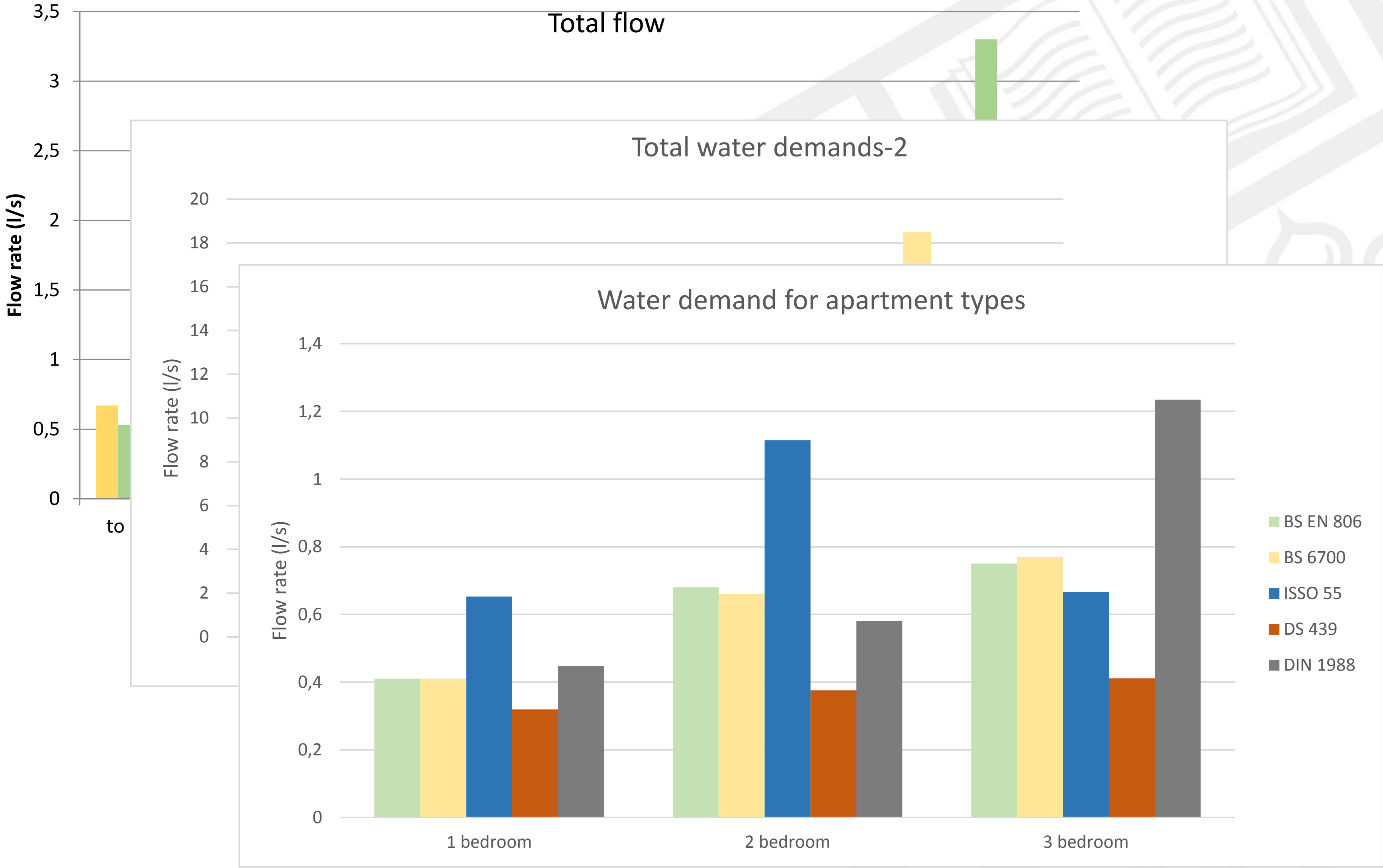
Examples for initial comparison



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Check against field data

Statistical frameworks are predictive

Measured data required to provide benchmark against actual

Data provided by Tindall/AquaTech

Compared peak flows with flows suggested by UK codes.

Found an average oversizing of x5

BSEN806 most accurate of BSEN806, BS6700 and CIPHE/IOP (IOP; low)

Recorded domestic cold water incoming flow rates in two multi-storey blocks

Used secondary data to validate measured

Check against field data

Building 1

- built 1966, recently renovated
- 26 storeys
- 125 two-bedroom flats
- residents restricted to over-55s
- Flats each have: Shower, WC, Wash hand basin, Bath, Kitchen sink

Building 2

- 60 two-bedroom flats plus 30 single residences
- built 1961, recently renovated
- occupant profile mixed (employed and unemployed)
- Flats each have: Shower, WC, Wash hand basin, Bath, Kitchen sink

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Data for cases VI- XIV

Case No	Flats	DCWS outlet types for all methods (except ISSO 55)	Notes for ISSO 55
Case VI	125 2-bed	whb, wc, bath, shower	2 bed flats- senior citizen
Case VII	30 1-bed	whb, wc, bath, shower	1 bed flats
	60 2-bed	whb, wc, bath, shower	2 bed flats
Case VIII	22 2-bed	whb & wc x2, bath, shower, kitchen sink, wm, dw	2 bed flats
Case IX	24 2-bed	whb & wc x2, bath, shower, kitchen sink, wm, dw	2 bed flats
	3 2-bed	whb & wc , bath, shower, kitchen sink, wm, dw	2 bed flats
Case X	33 2-bed	whb & wc x2, bath, shower, kitchen sink, wm	2 bed flats
Case XI	45 2-bed	whb, wc , bath, shower, kitchen sink, wm	2 bed flats
Case XII	140 2-bed	whb & wc x2, bath, shower, kitchen sink, wm, dw	2 bed flats
	14 2-bed	whb & wc x2, bath x2, shower x2, kitchen sink, wm, dw	2 bed flats
	12 3-bed	whb & wc x3, bath, shower, kitchen sink, wm, dw	3 bed flats
Case XIII	50 1-bed	whb, wc , bath, kitchen sink, wm	1 bed flats
	130 2-bed	whb & wc x2, bath, shower, kitchen sink, wm, dw	2 bed flats
Case XIV	255 1-bed	whb, wc , shower, kitchen sink	1 bed flats

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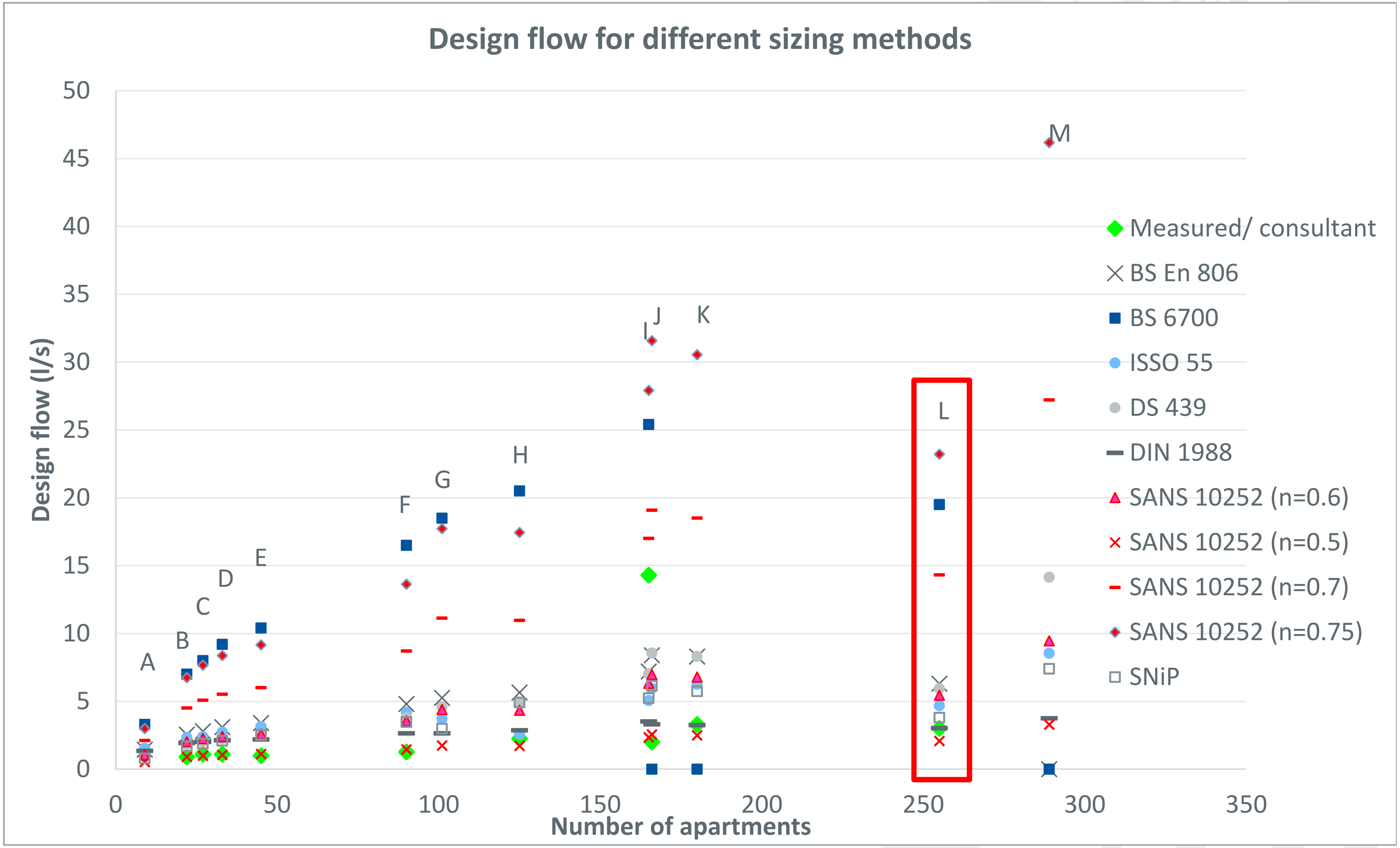
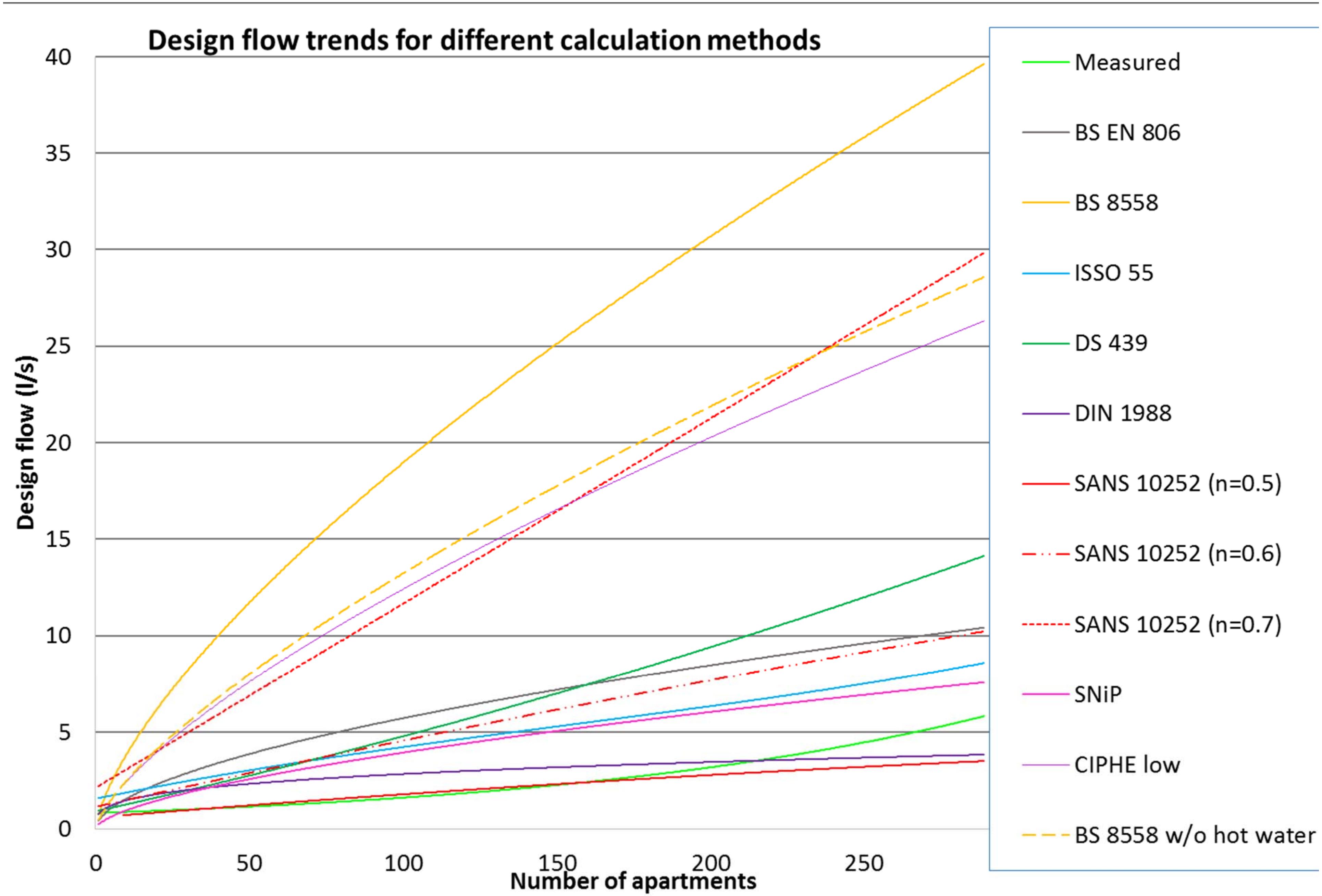
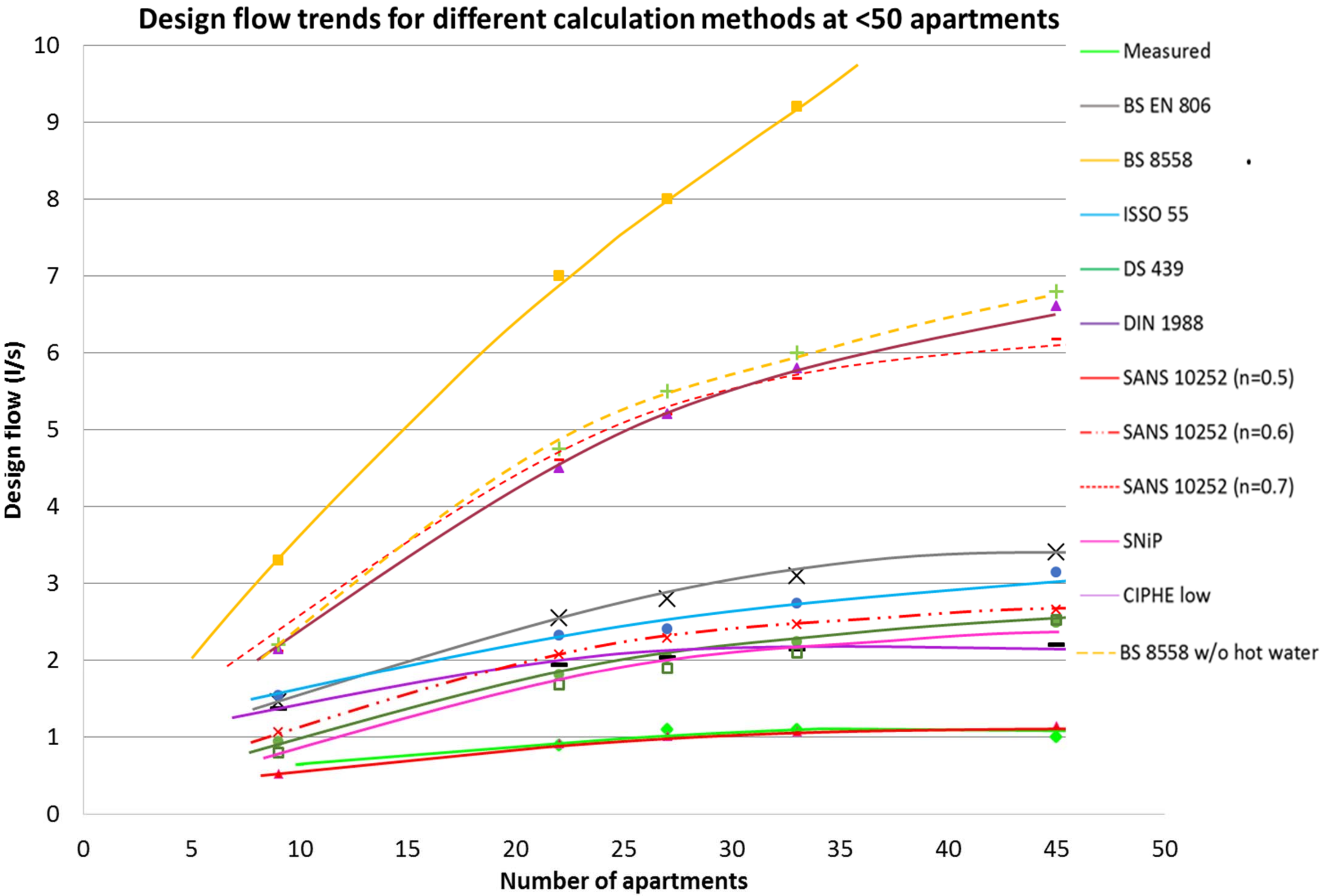
Results - data




Design flow trends for different calculation methods
Design flow (l/s)
Number of apartments
0
5
10
15
20
25
30
35
40
0
50
100
150
200
250
Measured
BS EN 806
BS 8558
ISSO 55
DS 439
DIN 1988
SANS 10252 (n=0.5)
SANS 10252 (n=0.6)
SANS 10252 (n=0.7)
SNiP
CIPHE low
BS 8558 w/o hot water



Design flow trends for different calculation methods at <50 apartments
Design flow (l/s)
Number of apartments
0
1
2
3
4
5
6
7
8
9
10
0
5
10
15
20
25
30
35
40
45
50
Measured
BS EN 806
BS 8558
ISSO 55
DS 439
DIN 1988
SANS 10252 (n=0.5)
SANS 10252 (n=0.6)
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SNiP
CIPHE low
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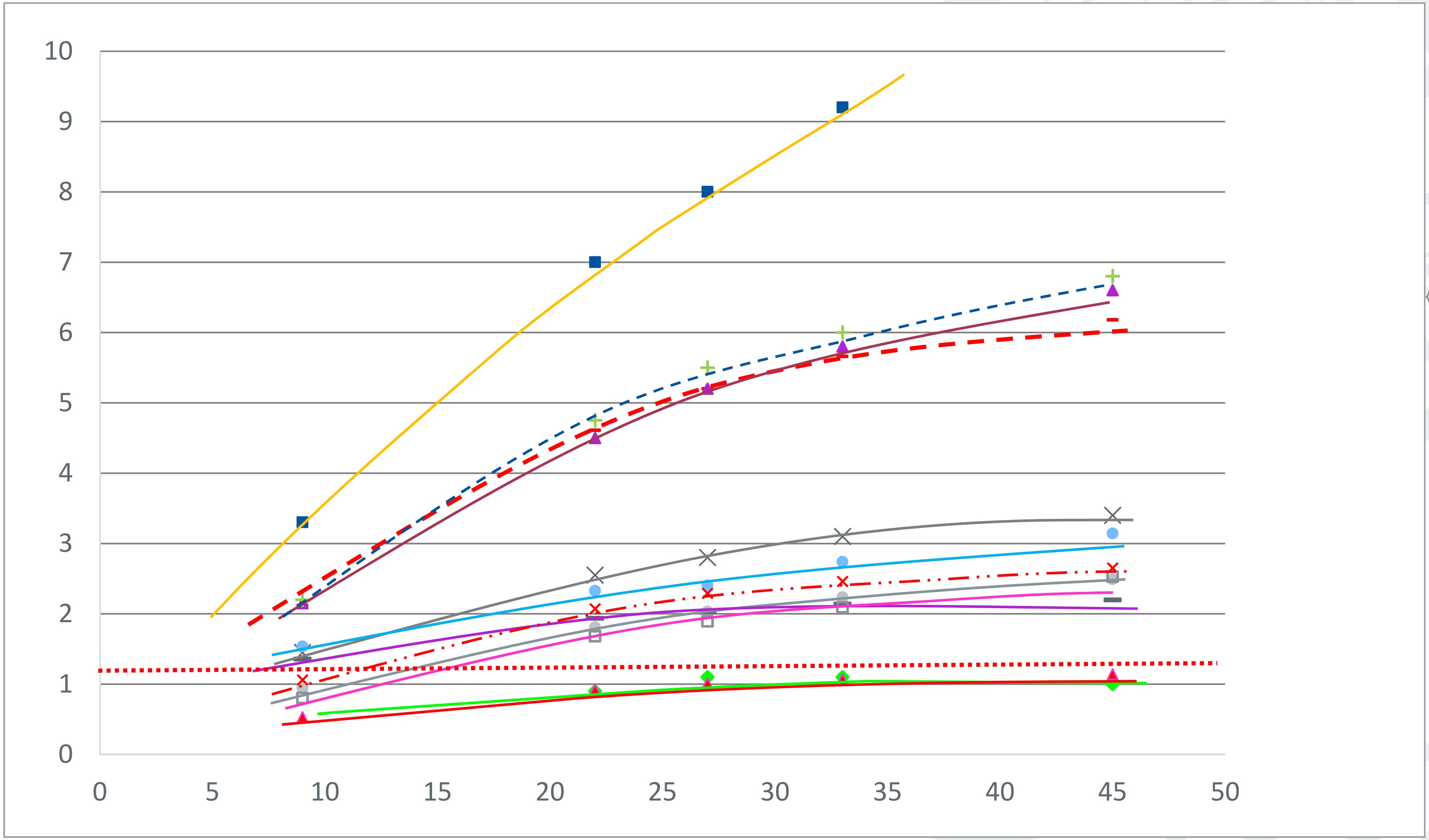
Results – reduced scale



Defining lower threshold

Design flow (l/sec)	Number of apartments
5	25
4	18
3	12

Code Conclusions - generalised

Codes give varying outcomes

UK codes give varying outcomes

At apartment scale – difficult to draw conclusions; no identifiable trends

BS6700 almost always over estimates except in certain situations BS6700 get progressively worse, the bigger the building

DIN1988, BSEN806 on a par at smaller scale but DIN1988 notably lower for bigger buildings

DS439 generally lower than both DIN1988 and BSEN806, although DIN1988 and DS439 close at larger scale. As scale increases, DIN1988 is smaller cf DS439

Code Conclusions - generalised

In general, **DIN1988** seems to most closely estimate peak demand (except for the lower boundary of South African method (n=0.5)). Overall, the German method slightly overestimates demand, but there is a possible underestimation in the higher range

The **Russian** code estimates demand better (than the German code) up to around 30 flats. Above 30, the Russian code slightly overestimates

Overall the **Dutch** method overestimates, but does better predict demand (with the exception of DIN1988 and SANS) as number of flats increases

Code Conclusions - generalised

The **Danish** code slightly overestimates at <100 flats and overestimates, more so than BS EN806 above 100 flats

South African code:
For less than 150 flats, n=0.5 yields comparable values to measured data (but slightly underestimates when the number of flats is < 50). For >150 flats, the code slightly underestimates (although some uncertainty).

For n=0.6, the code slightly overestimates and is comparable to DIN1988 for <50 flats. For>100 flats, the code overestimates. For n=0.7 and n=0.75, demand is notably overestimated (with results comparable to BS6700 for n=0.75 for >120 flats)

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Statistical Validity - Probabilistic models

Classically used (variant of Hunter) but increasingly replaced by empirical

Model is based on replicating simultaneous use of same type of appliance and then adapted using LUs

Provides flexibility to user to select desired design criteria (ie exceedance)

Provides good level of ‘safety’ but consequently, does overestimate

Model is based on underlying assumptions on flow equivalency

Model does not account for factors such as building type, users/behaviour

Could be improved by joint /conditional probability, but these are complex

Most models don’t provide information on the core development data. Also, no information on how robustly models have been validated

Models are highly sensitive to extreme values

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Statistical Validity - Empirical/deterministic

In general, most are based on two basic types of modelling scheme:

a) Power law models;
b) Square root models.

These models are technically much simpler to set up and to apply

Model generates one possible solution for a given set of parameters

Sensitive to some outliers

Generally, no confidence levels are attached to model outcomes

No/limited information is available on type, quality and quantity of data used to establish various empirical models, or on validation/goodness of fit

Generally, models account for different building types but not user/behavioural information

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Statistical Validity - Stochastic

Use statistical probabilities to predict the probability of outcome

Can generate most realistic scenario of the dynamic behaviour

Most effective for factoring in uncertainty

Model sensitivity is less problematic

Structurally complex and could demand significant amount of data/information to generate input probability distribution files.

Requires complex algorithms; comparatively difficult to calibrate.

Model results in a range of possible solution/outcome ; often requires development of additional tools

Best options for handling extreme events

Can readily account for building/appliance type, number of users, behavioural aspects, peak time

Outcome options

Re-cast Loading Units so as to better represent loading, and retain the existing method

Recommend an alternative methodology based on an critique of appropriate options

Stochastic/Empirical

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Thank you for your attention