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How is building airtightness factored into the energy performance assessment of homes in the UK?

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Outline

Energy impact of building airtightness

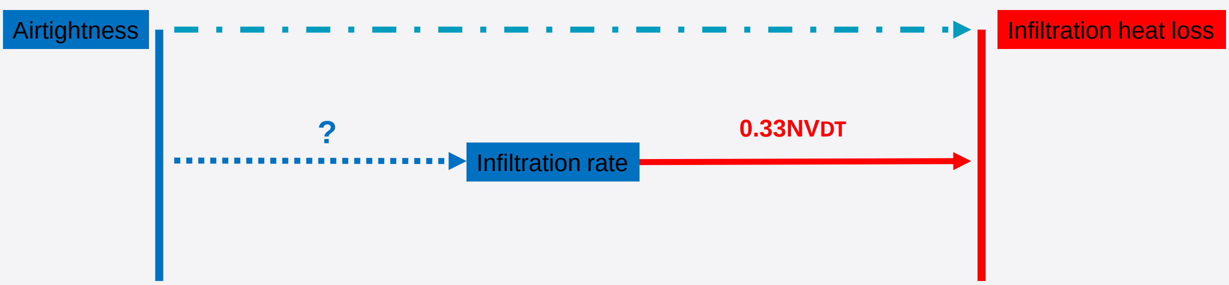
UK adaptation

Inclusion of Pulse in SAP 10.2

Space for improvement

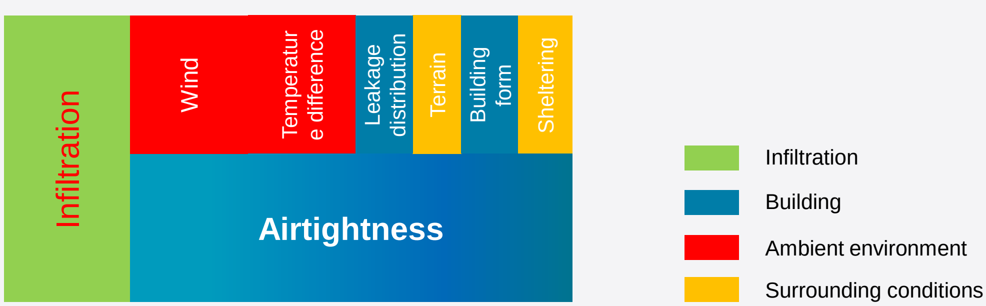
2

Energy impact of airtightness

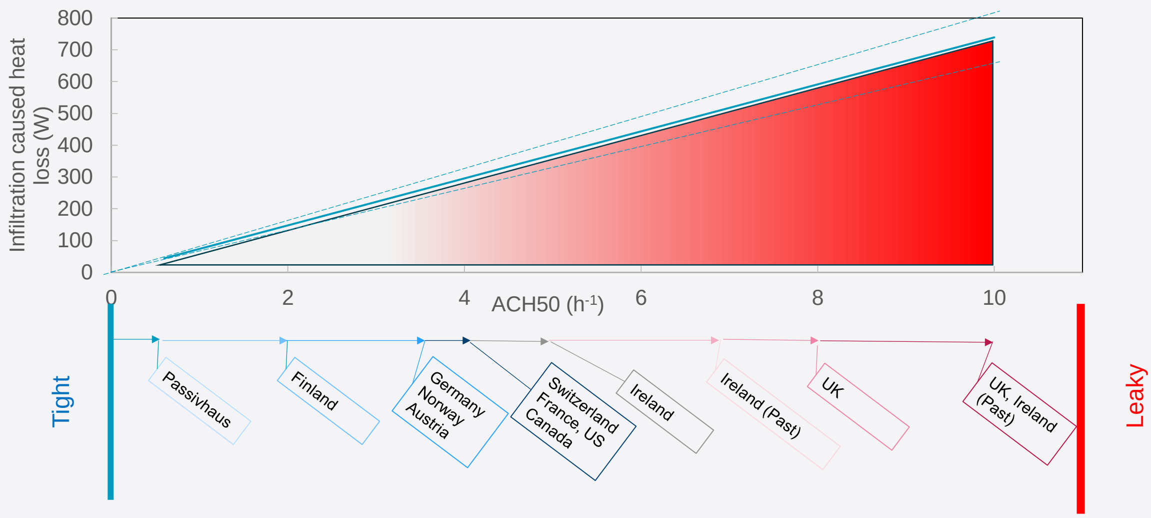


Correlation between air leakage and infiltration

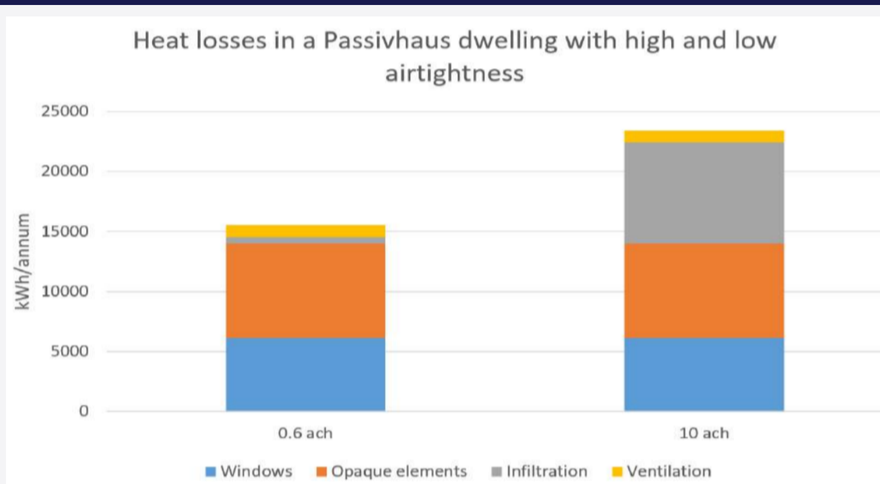
Infiltration: air movement through cracks and gaps in the building thermal envelope, driven by the wind and buoyancy effect.



Energy impact of airtightness



Energy impact of airtightness



Source: Good practice guide to airtightness by Passivhaus Trust

Energy impact of airtightness

Future scenario



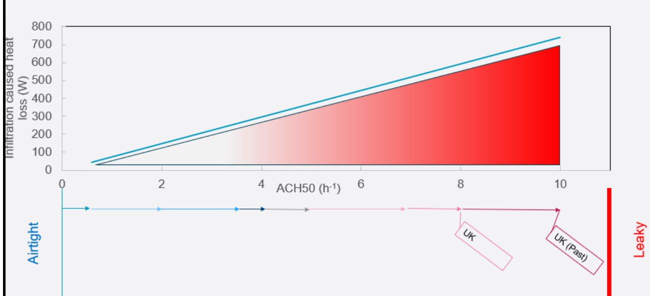
Source: Secret Bunker, New York Time, Web Urbanist

Is highly airtight and mechanical ventilated home the future?

The growing demand for low-carbon buildings highlights the need for highly airtight homes with mechanical ventilation systems in the future. However, concerns have been raised about the dependency of super-airtight buildings on the proper functioning of ventilation systems, which could pose risks under certain circumstances.[1]

[1]. D. Etheridge **A perspective on fifty years of natural ventilation research**
Building and Environment. Volume 91, September 2015, Pages 51-60

Energy impact of airtightness in the UK



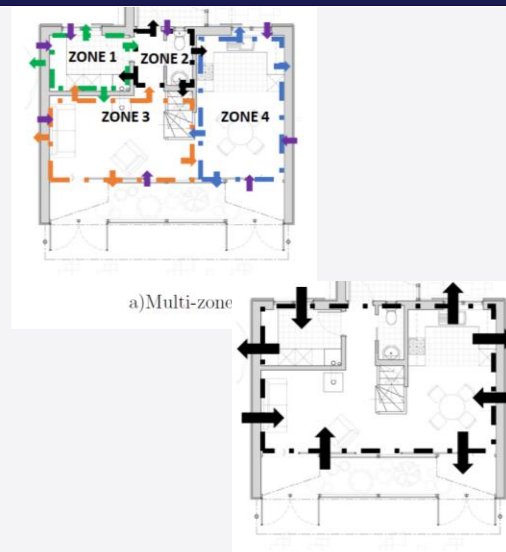
Given the fact UK building regulations are unlikely to impose highly stringent airtightness requirements in the foreseeable future. Relatively leaky homes remain prevalent, which highlights the importance of gaining a deeper understanding of the energy impact of building airtightness in the UK context.

Infiltration models

International context

Table 1 Summary of infiltration predicting models

Model	Complexity	Main use	Zonal definition	Valida-tion
LBL	Simplified	Infiltration prediction	Single	Yes
AIM-2	Simplified	Infiltration prediction	Single	Yes
AIDA	Complex	Infiltration prediction	Single	
CONTAM	Complex	Pollutant transport	Multi-zone	Yes
DOMVENT3D	Complex	Stock modelling	Single	No



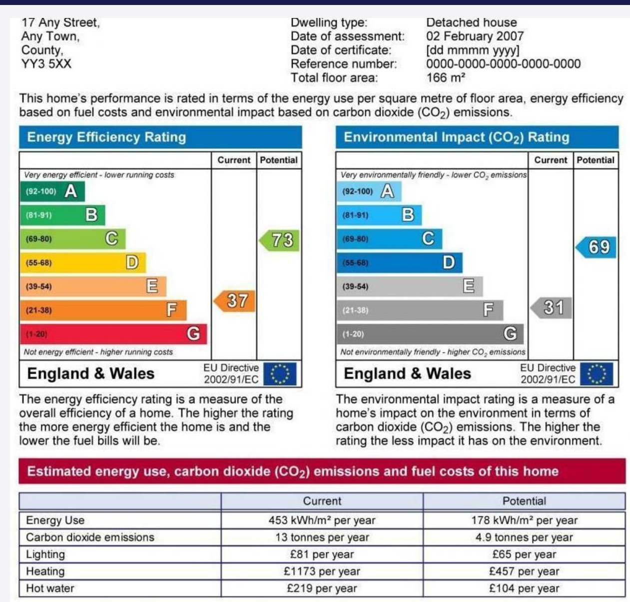
a)Multi-zone

b)Single zone

Standard Assessment Procedure (SAP)

SAP explained

- The calculation is based on the energy balance, taking into account a range of factors that contribute to energy efficiency:
  - materials used for construction of the dwelling
  - thermal insulation of the building fabric
  - **air leakage**, ventilation characteristics of the dwelling, and ventilation equipment
  - efficiency and control of the heating system(s)
  - solar gains through openings of the dwelling
  - the fuel used to provide space and water heating, ventilation and lighting
  - energy for space cooling, if applicable
  - renewable energy technologies


17 Any Street,
Any Town,
County,
YY3 5XX

Dwelling type: Detached house
Date of assessment: 02 February 2007
Date of certificate: [dd mmmm yyyy]
Reference number: 0000-0000-0000-0000-0000
Total floor area: 166 m²

This home's performance is rated in terms of the energy use per square metre of floor area, energy efficiency based on fuel costs and environmental impact based on carbon dioxide (CO_2) emissions.

The energy efficiency rating is a measure of the overall efficiency of a home. The higher the rating the more energy efficient the home is and the lower the fuel bills will be.

The environmental impact rating is a measure of a home's impact on the environment in terms of carbon dioxide (CO_2) emissions. The higher the rating the less impact it has on the environment.

Estimated energy use, carbon dioxide (CO_2) emissions and fuel costs of this home

	Current	Potential
Energy Use	453 kWh/m² per year	178 kWh/m² per year
Carbon dioxide emissions	13 tonnes per year	4.9 tonnes per year
Lighting	£81 per year	£65 per year
Heating	£1173 per year	£457 per year
Hot water	£219 per year	£104 per year

UK adaptation-SAP 10.2

Consideration of airtightness in SAP 10.2

No measurement

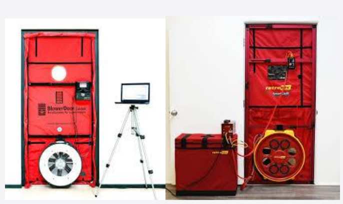
Infiltration rate
1. Additional infiltration due to storeys in the dwellings
2. Structural infiltration
3. Ground floor construction
4. Draught lobby
5. Percentage of windows and doors draught proofed

UK adaptation-SAP 10.2: Step 1 Input of airtightness

Consideration of airtightness in SAP 10.2

With a measurement

Air permeability value at 50 Pa by a fan pressurisation test	Air permeability value at 4 Pa By a low-pressure pulse test



UK adaptation

UK context @50 Pa

Divide-by-20 rule

Original Divide-by-20 rule	Adapted version in the UK
$N_{50}/20$	$Q_{50}/20$

Where, N_{50} is the building air change rate measured at 50 Pa, h^{-1}
Q_{50} is the building air permeability at 50 Pa, $m^3/h/m^2$;

UK adaptation-SAP 10.2

Step 1: Input of airtightness measurement

Air permeability value, AP_{50}, ($m^3/h/m^2$)	☐	(17)
Air permeability value, AP_4, ($m^3/h/m^2$)	☐	(17a)
If based on air permeability value at 50 Pa, then (18) = [(17) ÷ 20] + (8)		
If based on air permeability value at 4 Pa, then (18) = [0.263 x $(17a)^{0.924}$] + (8)	☐	(18)
If no air permeability test data, then (18) = (16)		
Air permeability value applies if a pressurisation test has been done, or a design or specified air permeability is being used		
Number of sides on which dwelling is sheltered	☐	(19)
Shelter factor (20) = 1 - [0.075 × (19)] =	☐	(20)
Infiltration rate incorporating shelter factor (21) = (18) × (20) =	☐	(21)

Source: The Government's Standard Assessment Procedure for Energy Rating of Dwellings. Version 10.2

UK adaptation-SAP 10.2

Step 1: Input of airtightness (Pulse: $0.263\times(AP4)^{0.924}$)

AP50 Bin	Count	Average n	Average AP4 multiplier	AP4 Predicted Average
0-1	625	0.72	6.36	0.12
1-2	2943	0.68	5.65	0.30
2-3	18620	0.67	5.50	0.50
3-4	72584	0.66	5.46	0.69
4-5	134585	0.66	5.46	0.88
5-6	40330	0.64	5.18	1.10
6-7	14171	0.63	5.02	1.33
7-8	5286	0.63	4.94	1.55
8-9	2073	0.62	4.89	1.78
9-10	1146	0.62	4.92	2.00
10-11	248	0.61	4.79	2.24
11-12	111	0.62	4.82	2.44
12-13	69	0.62	4.95	2.65
13-14	38	0.62	4.89	2.83
14-15	24	0.62	4.89	3.04
15-16	18	0.63	4.99	3.21
16-17	13	0.62	4.97	3.55
Total	**292,884**	**0.64**	**5.16**	**1.78**

- Based on a sample of 100 UK homes
- Validation against the n exponent profile of 293k blower door tests

UK adaptation-SAP 10.2

Step 2: Shelter factor

A side of a building is sheltered if there are adjacent buildings or tree-height hedges which effectively obstruct the wind on that side of the building.

Air permeability value, AP_{50}, ($m^3/h/m^2$)	☐	(17)
Air permeability value, AP_4, ($m^3/h/m^2$)	☐	(17a)
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Source: The Government's Standard Assessment Procedure for Energy Rating of Dwellings. Version 10.2

UK adaptation-SAP 10.2

Step 3: Wind factor

Infiltration rate modified for monthly wind speed:

Monthly average wind speed from Table U2

	Jan	Feb	Mar	Apr	May
$(22)_m$ =	$(22)_1$	$(22)_2$	$(22)_3$	$(22)_4$	$(22)_5$

Wind Factor $(22a)_m = (22)_m \div 4$

$(22a)_m$ =	$(22a)_1$	$(22a)_2$	$(22a)_3$	$(22a)_4$	$(22a)_5$

Adjusted infiltration rate (allowing for shelter and wind sp

$(22b)_m$ =	$(22b)_1$	$(22b)_2$	$(22b)_3$	$(22b)_4$	$(22b)_5$

Table U2: Wind speed (m/s) for calculation of infiltration rate

Region	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 **UK average**	**5.1**	**5.0**	**4.9**	**4.4**	**4.3**	**3.8**	**3.8**	**3.7**	**4.0**	**4.3**	**4.5**	**4.7**
1 Thames	4.2	4.0	4.0	3.7	3.7	3.3	3.4	3.2	3.3	3.5	3.5	3.8
2 South East England	4.8	4.5	4.4	3.9	3.9	3.6	3.7	3.5	3.7	4.0	4.1	4.4
3 Southern England	5.1	4.7	4.6	4.3	4.3	4.0	4.0	3.9	4.0	4.5	4.4	4.7
4 South West England	6.0	5.6	5.6	5.0	5.0	4.4	4.4	4.3	4.7	5.4	5.5	5.9
5 Severn Wales / Severn England	4.9	4.6	4.7	4.3	4.3	3.8	3.8	3.7	3.8	4.3	4.3	4.6
6 Midlands	4.5	4.5	4.4	3.9	3.8	3.4	3.3	3.3	3.5	3.8	3.9	4.1
7 West Pennines Wales / West Pennines England	4.8	4.7	4.6	4.2	4.1	3.7	3.7	3.7	3.7	4.2	4.3	4.5
8 North West England / South West Scotland	5.2	5.2	5.0	4.4	4.3	3.9	3.7	3.7	4.1	4.6	4.8	4.7
9 Borders Scotland / Borders England	5.2	5.2	5.0	4.4	4.1	3.8	3.5	3.5	3.9	4.2	4.6	4.7
10 North East England	5.3	5.2	5.0	4.3	4.2	3.9	3.6	3.6	4.1	4.3	4.6	4.8
11 East Pennines	5.1	5.0	4.9	4.4	4.3	3.8	3.8	3.7	4.0	4.3	4.5	4.7
12 East Anglia	4.9	4.8	4.7	4.2	4.2	3.7	3.8	3.8	4.0	4.2	4.3	4.5
13 Wales	6.5	6.2	5.9	5.2	5.1	4.7	4.5	4.5	5.0	5.7	6.0	6.0
14 West Scotland	6.2	6.2	5.9	5.2	4.9	4.7	4.3	4.3	4.9	5.4	5.7	5.4
15 East Scotland	5.7	5.8	5.7	5.0	4.8	4.6	4.1	4.1	4.7	5.0	5.2	5.0
16 North East Scotland	5.7	5.8	5.7	5.0	4.6	4.4	4.0	4.1	4.6	5.2	5.3	5.1
17 Highland	6.5	6.8	6.4	5.7	5.1	5.1	4.6	4.5	5.3	5.8	6.1	5.7
18 Western Isles	8.3	8.4	7.9	6.6	6.1	6.1	5.6	5.6	6.3	7.3	7.7	7.5
19 Orkney	7.9	8.3	7.9	7.1	6.2	6.1	5.5	5.6	6.4	7.3	7.8	7.3
20 Shetland	9.5	9.4	8.7	7.5	6.6	6.4	5.7	6.0	7.2	8.5	8.9	8.5
21 Northern Ireland	5.4	5.3	5.0	4.7	4.5	4.1	3.9	3.7	4.2	4.6	5.0	5.0

Source: The Government's Standard Assessment Procedure for Energy Rat

UK adaptation-SAP 10.2

Step 4: Effective air change rate

Effective air change rate is then determined based on the ventilation type:

- Balanced mechanical ventilation with heat recovery
- Balanced mechanical ventilation without heat recovery
- Whole house extract ventilation or positive input ventilation from outside
- Natural ventilation or whole house positive input ventilation from loft

+Chimneys, flues, fans, PSVs,

Then the infiltration heat loss is calculated using

0.33NVDT

UK adaptation-SAP 10.2

Comparison with LBL

Factors	LBL	UK-SAP
Airtightness	Yes	Yes
Wind	Yes	Yes
Temperature difference	Yes	No
Shelter factor	No	Yes
Building height	Yes	Yes
Terrain class	Yes	No
Leakage distribution	Yes (Assumption)	No

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Home Energy Model Consultation

	Very sheltered [City]	Sheltered [Urban]	Normal [Country with scattered windbreaks]	Exposed [Open flat country]
House: 1-storey	41.2	30.7	20.6	13.7
House: 2-storey	34.0	25.4	17.0	11.3
Flat (Storeys 1-5)	34.6	25.8	17.3	11.5
Flat (Storeys 6-10)	30.2	22.5	15.1	10.1
Flat (Storeys 11+)	29.3	19.9	13.7	9.3

Table 1 – Divisors used to convert the N50 pressure test figure into an infiltration rate

Space for improvement

When the ratio is favoured

- Divide-by-rule should be based on UK data.
- Divide-by-rule for LPP, should have its own equivalent value, rather than taking up to 50 Pa.
- Enhanced understanding of the leakage distribution of UK homes.
- Perhaps the temperature difference should be considered too.

An academic perspective

- A better leakage-infiltration correlation should be considered.

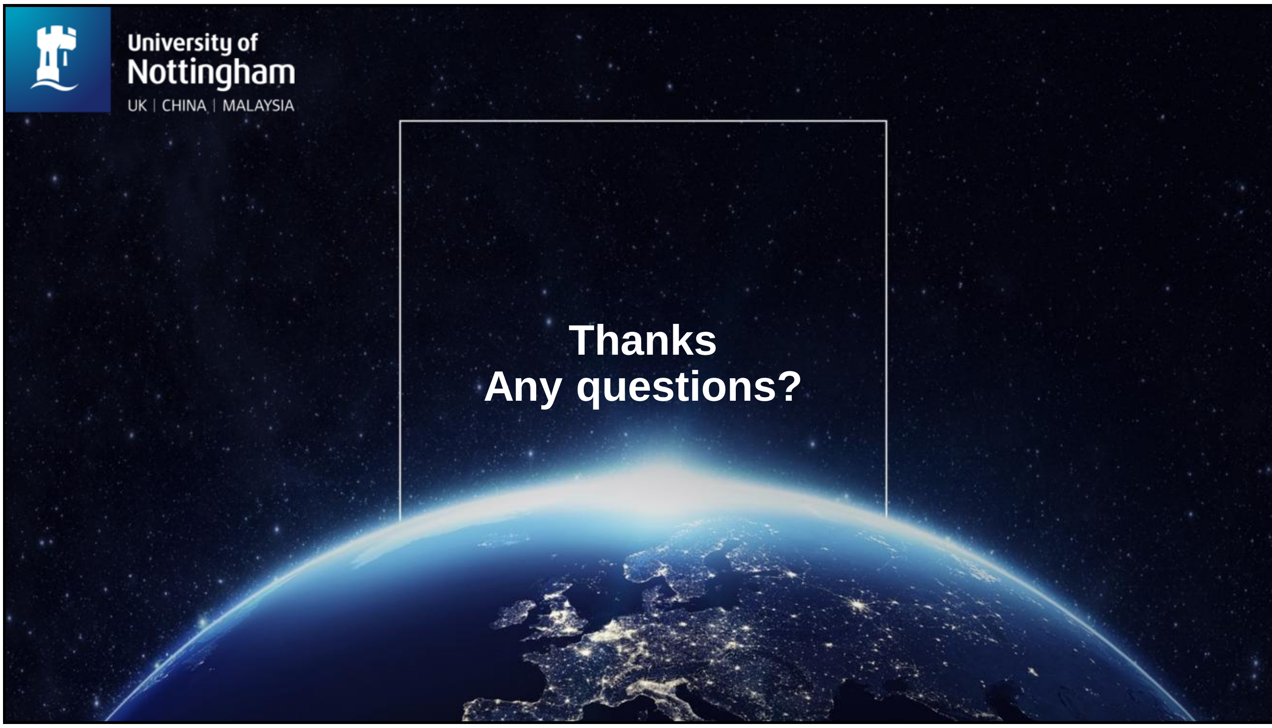
UK Field Study Results

UK field study- A PhD research

The sample of field trial test properties is representative of UK housing stock, in terms of dwelling size, form, construction, ventilation system type and air leakage levels.

The leakage-infiltration ratio has been assessed and the initial results showed that the ratios obtained in the field test should be double of what is used in the latest SAP (10.2). i.e. Divide-by-40 for the blower door, and divide-by-8.6 for the Pulse method.

In comparison with the simple leakage-infiltration ratio, LBL model improves the accuracy of predicting infiltration by at least a factor of two.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Thanks
Any questions?