Lifecycle costing for construction projects

RICS CPD Foundation

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Quick Overview of training

- Introduction
- Part 1 – Basic Awareness Training
  - What is WLC/LCC?
  - Why bother?
  - Definitions, process, scoping and Standards
  - Process
  - What does an LCC model involve?
  - Worked examples at different levels
- Part 2 – Practical Application
  - Recap of Part 1
  - Specific requirements – when, what scope, metrics etc
  - Sustainability and BREEAM
  - BIM, COBIE and LCC
  - Worked example using IES VE IMPACT software modelling tool
  - Look Forward for LCC

About Whole Life Ltd

- Specialist consultants in whole life issues
- Performance, cost and value, all aspects of the whole life
- Managing Director Kathryn Bourke is a Chartered Building Surveyor and convenes ISO working group on LCC, as well as representing UK on CEN working group.
- Kathryn was the lead author for the RICS Black Book on Life Cycle Costing 2016.

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WHOLE LIFE LTD

PART 1 –Lifecycle Costing Basic Awareness

- What is Whole Life Costing / Lifecycle Costing?
- Why Bother? Why it matters
- BS/ISO 15686-5 and UK Standardised Method – including definitions, distinction between LCC and WLC, process and scoping
- The Process – what information is required, the timescale etc.
- What does a model involve?

What is Lifecycle Costing (LCC)?

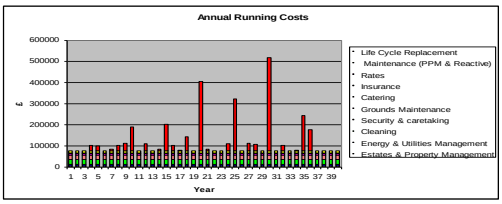
In summary….

- What work do I need to do to the building?
- When do I need to do it?
- How much will it cost?
- Generally expressed in today's values…

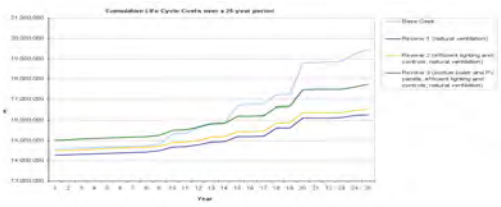
What is it for?

- To set budgets
- To compare options
- To judge whether an investment is affordable over the long term
- To identify high cost items to focus on
- To comply with client requirements…

What does LCC involve?



WLC Option Comparisons



Why Bother?

The Iceberg!

Why Bother? (2)

1:5:200

1 = Construction Cost
5 = Maintenance and Building Operating Costs
200 = Business Operating Costs (including staff costs)

**source: The Royal Academy of Engineering (based on office building – but BEWARE....)*

Why Bother (3) – the clients view

- Clients want:
  - To deliver energy cost reductions for customers
  - To assess and (im)prove durability/specification choices
  - To help customers to produce (and reduce) FM and operational budgets for their buildings
  - To measure whole life carbon and environmental cost impacts
  - To meet funding criteria and gain access to funding

Why Bother (4) - Cost v Environment?

- World Green Building Council Report 2013 says:
- Building green doesn't necessarily cost more.
- Green buildings are easier to let, purchasers will pay more (and expect a discount for non-sustainable buildings).
- Green buildings save money through reduced energy and water use, lower long term operations and maintenance costs.
- Energy savings normally exceed any premium on design and construction, with reasonably short payback periods.
- Good indoor environment can improve worker productivity and occupant health and well-being, giving bottom line business benefits.
- Sustainability risk factors can affect rental income, asset value and return on investment, increasing risk of obsolescence.
- Reduced maintenance requirements provide less disruption to normal operation.

Standards, Definitions, etc.

WLC Definition (BS/ ISO 15686-5)

- Whole Life Costing (WLC) is defined in BS/ ISO 15686 Part 5 as:
- *"economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value.*
- *The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability".*
- **WLC includes all costs and incomes (including land costs for example)**

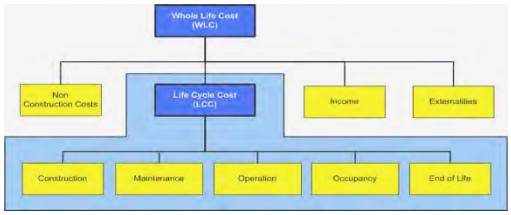
LCC Definition (BS/ ISO 15686-5)

- Life Cycle Costing is....*'Methodology for systematic economic evaluation of the life cycle costs over a period of analysis, as defined in the agreed scoping'.*
- Life Cycle Costs are..... *"cost of an asset or its parts throughout its life cycle, while fulfilling the performance requirements".*
- **LCC is about the costs (only) associated with the building.**

LCA Definition (ISO 14040)

- Life Cycle Assessment (LCA) is a systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life-cycle.
- **LCA is about environmental assessment, not about cost assessment – so not dealt with further today….**

What is the difference between WLC and LCC?



LCC – BS/ISO 15686-5 – 2008 and now 2017

Part 5 covers life cycle costing:

- Principles of life cycle costing
- Definitions, terminology and guidance on the use of information and data sources
- Forms of LCC calculations and the methods of economic evaluation (with informative examples)
- Setting the scope for LCC studies and how to deal with risks and uncertainty
- How LCC forms part of the whole life costing investment option appraisal process.

It links to other aspects of guidance in the rest of the ISO 15686 Series, such as data requirements (Pt 4) and reference service lives (Pts 1 and 8), - in order to help improve 'value for money through sustainable procurement'.

bsi.

UK Standardised Method for LCC 2008

1 Introduction
2 Guiding principles
3 Life cycle cost data structure
4 Applications
5 Metrics
6 Risks and uncertainty
7 Information and data assumptions
8 Terms, definitions and abbreviations

ANNEXES

A Menu of LCC and WLC (In/out of scope)
B BCIS SFCA elemental cost breakdown
C Cost mapping to BCIS and ITOC structures
D Informative worked examples
E Example LCC risk log
F Forms for LCC analysis and benchmarking
G Sources of information

BS 8544: 2013

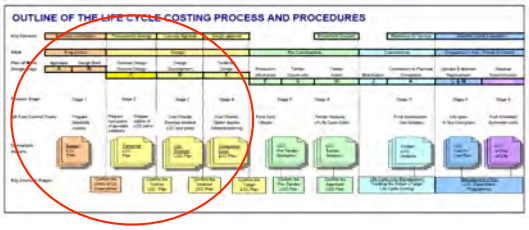
- It provides a consistent basis for maintenance cost planning and comparison.
- Allows clients to target precisely what is being spent and where and when
- Informs option appraisals (e.g. during budgeting and funding scenarios of projects and cost in use)
- Gives a basis for transparent / fair procurement and avoiding adversarial contracting
- Provides rules for interoperable data for effective CAFM solutions and the BIM data drops

Economic performance as part of sustainability – BS/ EN 15643-4 2012 and BS/EN 16627 2015

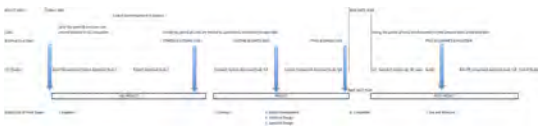
RICS Black Book on LCC 2016

THE PROCESS

When? The SMLCC says....

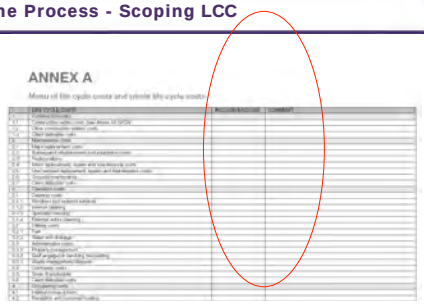


When – Different levels of LCC study at different project stages



The Process - Scoping LCC

ANNEX A



The Process - Scoping LCC (2)

0	Maintenance costs	
0.1		Major replacement costs
0.2		Subsequent refurbishment and adaptation costs
0.3		Redecorations
0.4		Minor replacement, repairs and maintenance costs
0.5		Unscheduled replacement, repairs and maintenance
0.6		Grounds maintenance
0.7		Client definable costs
1	Cleaning Costs	
1.1		Cleaning costs
1.1.1		Windows and external surfaces
1.1.2		Internal cleaning
1.1.3		Specialist cleaning
1.1.4		External works cleaning
1.2		Utilities costs
1.2.1		Fuel
1.2.2		Water and drainage
1.3		Administrative costs
1.3.1		Property management
1.3.2		Staff engaged in servicing the building
1.3.3		Waste management/disposal
1.4		Overheads costs
1.5		Taxes (if applicable)
1.6		Client definable costs

LCC Worked Examples

RICS

Whole building budget level LCC

RICS

Table D.1 Budget life cycle cost plan at stage 1

	GIFA	1065 m²	(a)		
	Period of analysis	30 yrs	(b)		
1.0	Construction costs	£/m²		£	
1.1	Building	1265	x (a)	2,081,250	(c)
	Fees 12.5%		x (c)	260,156	
	Total			2,341,406	(d)
2.0	Maintenance costs	£/m²/yr			
2.1 and 2.4	Maint and minor replacement, repairs and maintenance				
2.1a and 2.4a	Fabric maintenance	9.40	x (a) x (b)	369,630	
2.1b and 2.4b	Services maintenance	13.10	x (a) x (b)	664,945	
2.3	Redecorations	3.65	x (a) x (b)	182,318	
	Total	26.15		1,306,193	(e)
3.0	Operation costs				
3.1	Cleaning	15.40	x (a) x (b)	769,230	
3.2	Utilities	8.42	x (a) x (b)	420,579	
3.3	Admin	18.36	x (a) x (b)	917,082	
	Total	42.18		2,106,891	(f)
	Total Life Cycle Cost		(d) + (e) + (f)	**5,754,490**	(g)
	Total LCC £/m²/yr		(g) ÷ (a) ÷ (b)	**115.31**	

Component level LCC analysis

RICS

System Reference	Option 1							Option 2							
Period of Analysis	60 years							60 years							
Discount Rate	3.5%							3.5%							
Description	External Aluminium Door and Frame							External Hardwood Timber Door and Frame							
Investment Costs															
Capital Cost							41,618								51,510
Maintenance Costs	Quantity	Adjustment to Quantity (Cost Driver)	Quantity Replacement %	Adjusted Replacement Cost	Replacement Cycle (Years)	Present Value	Replacement Cost Present Value	Quantity	Adjustment to Quantity (Cost Driver)	Quantity Replacement %	Adjusted Replacement Cost	Replacement Cycle (Years)	Present Value	Replacement Cost Present Value
Option 1														
Replace Frame and Door	41.618	1.000	100%	41,618	40	0.250669	10,431							
Replace Ironmongery	1000	1000	100%	1000	20	0.502629	503							
					40	0.252372	127							
					60	0.126721	127							
Replace Seal	826	826	100%	826	20	0.502629	415							
					40	0.252372	208							
					60	0.126721	105							
Option 2														
Replace Frame and Door								51,510	1.237	100%	63,725	60	0.126721	8,076
Painting to Doors								826	1000	100%	826	5		0
Painting to Door Frame								826	1000	100%	826	5		0
Replace Ironmongery								1000	1000	100%	1000	20	0.502629	503
												40	0.252372	252
												60	0.126721	127
Replace Seal								826	1000	100%	826	20	0.502629	415
												40	0.252372	208
												60	0.126721	105
Total Maintenance Cost														1,779
Operation Costs														
Operation Cost (Initial & for Period of Analysis)							41,618							51,510
Total Life Cycle Cost NPV							43,397							53,289

WLC/LCC costs are future costs!

- The time value of money £1 now or next year?
- How do we represent this?
- The discount rate represents the "opportunity cost"
- For the public sector, there are rules about the discount rate to apply (HM Treasury Green Book) – currently 3.5% up to 30 years.
- For the private sector, the opportunity cost is the cost of borrowing the money, or internally funding the investment.
- The higher the discount rate, the lower future costs are in present day terms

LCC is typically measured in NPV (Net Present Value)

- The NPV is the sum of all the future cash flows, discounted to the present day OR
- The amount to be invested to pay for all future costs at a given interest rate and time horizon.
- It allows you to compare options with different cash flows over different time periods
- For education projects, it is a requirement to report the NPV of the life cycle replacement costs only (not the whole LCC or WLC).

How to calculate NPV

- Note that if inputs to the equation change, the answer may (hence sensitivity analysis)
- NPV is the sum of all the PV's

$$\frac{\text{PV = Future Cost in year N}}{(1+\text{discount \%})^{N}}$$

(where N is number of years between base date and year of occurrence)

How to calculate NPV

- Note that if inputs to the equation change, the answer may (hence sensitivity analysis)
- NPV is the sum of all the PV's

PV = Future Cost in year N

(1+ discount %)^{N}

(where N is number of years between base date and year of occurrence)

How to calculate NPV (2)

- Identify a future costs in today's money
- Identify when it will be spent
- Discount the future cost by the agreed discount rate

For example:

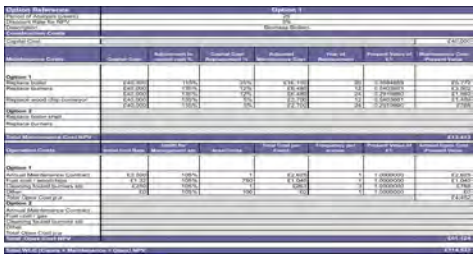
£100 in year 5 @ 3% = £86.26

OR

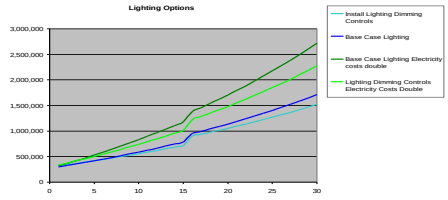
£100

(1+0.35$^{5)}$ = £100 x 0.862608784

Component level LCC analysis



Sensitivity Analysis – e.g electricity costs



PART 2

Recap of Part 1

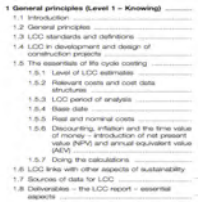
- WLC / LCC is not very complicated in terms of concept – what needs doing, when, how much will it cost?
- Its important because clients are committing to much more than the capital costs
- There are standards which lay out the rules in detail – including scoping
- There are two main types of costs – recurring (hard and soft FM) and occasional (major replacements)
- Allow time and provide the necessary information – LCC follows capital cost estimating in level of detail

Part 2 – Overview of Practical Application

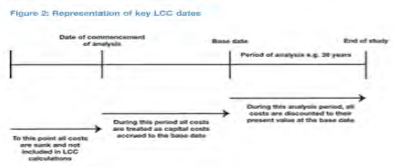
- RICS Black Book on LCC (Knowing / Doing / Advising levels)
- Practical application – briefing, analysis, calculations, models
- Practical application – reporting on energy, sustainability, risk
- Practical application – brief overview of BREEAM requirements for LCC
- LCC and BIM – different stages of DPOW and brief link to COBIE
- Case study on use of a proprietary LCC tool in association with BIM level 2

RICS Black Book on LCC

RICS LCC Black Book level 1



Base Date and other key dates



Real and Nominal Costs

Real Costs – at today's cost, excluding inflation OR
Nominal Costs – at future costs, including inflation

RECOMMENDATION IS….

- Use real costs
- Do not mix real and nominal
- Discount rate will depend on real or nominal
- Use sensitivity analysis to examine differential inflation
- See section 1.5.5. of Black Book

Annual Equivalent Value AEV

Metric 2 – annual equivalent value (AEV) – see also 1.5.6

To calculate the AEV:

$$AEV = \frac{Cr}{(1+d)^n - 1}$$

where

AEV annual equivalent value
C is the cost in year n
d is the expected **real discount rate** per annum
n is the number of years between the base date and the occurrence of the cost

For example:

$$AEV = \frac{100 \times 5.00}{(1+0.050)^{25} - 1} = 1.42$$

Therefore, a cost of 100 units in 25 years' time at an interest rate of 5% will be equivalent to an annual investment of 1.82 units.

Other Aspects – sustainability and data sources.

- Sustainability – will cover BREEAM assessment later. Also note the CEN TC350 series of standards on integrated sustainability assessment (BS/EN 15643-4 is the methodology and BS/EN 16627 is the calculation rules). They are based on the ISO rules but there are some specific pitfalls to be aware of if you are asked to report to these standards….
- Data sources –
  - In house data (essential but rarely in easily used forms)
  - Published historical data (e.g. RICS Running Costs Online, CIBSE Guide M)
  - Modelling data (normally for experts)
  - Manufacturers etc data (dose of salt, adjust for project conditions!)

RICS LCC Black Book Level 2

Defining the Brief

- What's the problem to be solved, what's it for?
  - To predict cash flows (e.g. for budget)
  - To appraise options (i.e. a comparison)
  - To review tenders (rules should be provided transparently)
- What information does the client need to make the decision?
  - For example, is sensitivity analysis necessary
  - How far has design developed (LCC follows level of capital cost availability)
  - For existing buildings is there enough data to assess the condition etc or are surveys required first?

Terminal and residual values

- Terminal or Scrap value – of something which fails within the period of analysis – this represents a minor (positive) cash flow and is included in the calculation of NPV
- Residual values – of something that has not yet failed at the end of the period of analysis – are only relevant to option appraisals (i.e. one option has a residual value, the other might not). If the value is the same for all options it can be ignored. Otherwise typically assume straight line depreciation.
- Note – if the building is at the end of its life no residual value (may be costs associated with end of life).
- Sale value (major revenue) falls outside LCC and in WLC or investment appraisal – outside today's topic…

RICS LCC Black Book Level 3

Level of analysis and project stage

Sustainability and LCC

BRE 2017 Briefing Paper on payback of offices

BREEAM UK New Construction 2011 to 2014 scheme
Covers costs associated with:

- 'Pass' to 'Excellent' ratings
- Energy and water capital and life cycle costs,payback and utility savings

Key contributors

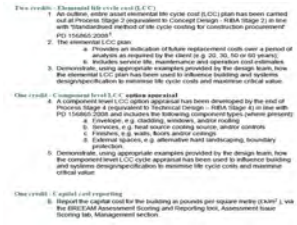
- BRE Global – project managers and authors
- BRE Trust and Cabinet Office – funding bodies
- Sweett Group – provided costing information, conducted cost studies and produced cost results

Other BREEAM publications see
https://www.breeam.com/discover/resources/value/

BRE Case study – example of energy savings

BREEAM Excellent (Energy)	Energy price scenario	Capital cost	Lifecycle savings over 25 years	Lifecycle savings over 25 years (discounted)	Payback Period	Payback Period (discounted)	Net Present Value (discounted)	Annual Gas Saving	Annual Electricity Saving	Annual CO_2 Saving
	£	£	£	£	Years	Years	£	kWh	kWh	kg CO_2
NOT London Plan	Reference scenario	59,610	429,906	280,710	3	5	221,100	-20,664	170,087	83,582
	High Prices scenario		612,531	401,491	2	4	341,881	-20,664	170,087	83,582
MEETING London Plan	Reference scenario	146,032	539,281	367,677	7	10	527,763	82,660	221,750	131,876
	High Prices scenario		806,202	543,439	5	7	580,384	82,660	221,750	131,876

BREEAM 2014 Reporting – MAN 02 LCC



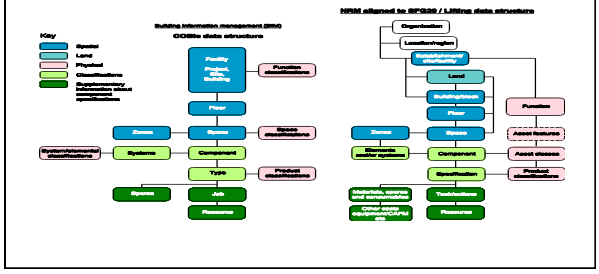
BREEAM Reporting for MAN 02 – LCC Analysis

- LCC model and reports can provide the elemental LCC plan at the level of detail required for first two credits. In order to illustrate the impact of changing design options GIFA level analysis and rates can be used for these credits.
- Calculation alone can't provide the text required for item 3 – needs collaboration.
- Case study will show how model can be used at elemental level of specification to illustrate the requirements for item 4. Again the text for 5 needs collaboration.
- Capital Costs – item 6 - are reported via the BREEAM assessor's portal.

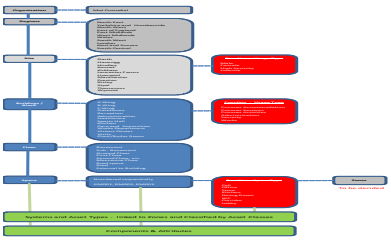
BIM, COBIE and LCC….

- BS 8544 (on LCC of maintenance) includes mapping of LCC guidance and cost data structure to COBIE requirements.
- Case studies are ongoing with MOJ, various universities and local government on how to undertake LCC on existing buildings and exchange data via COBIE.
- There are BIG gains to be made in application of BIM to existing buildings…..

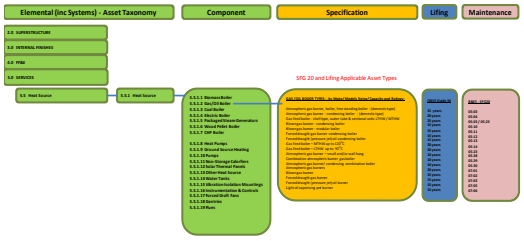
Section 8 aligns COBIE with NRM 3

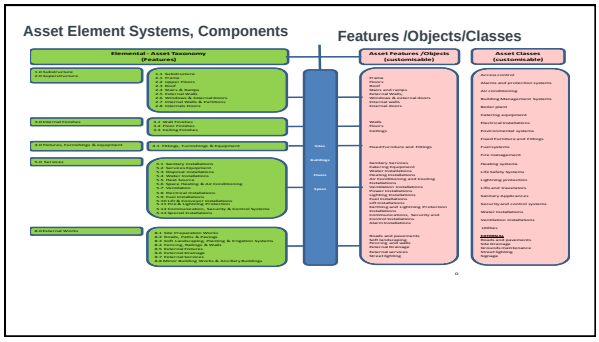


Annex A - Standard / integrated asset database



Asset Element Systems, Components - linked to SFG20 and CIBSE Guide M



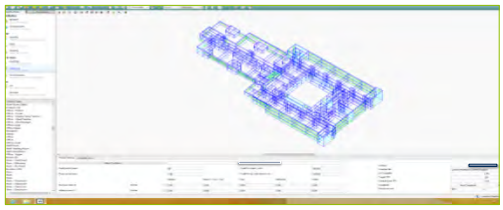


Worked Example – Using IES IMPACT modelling for LCC

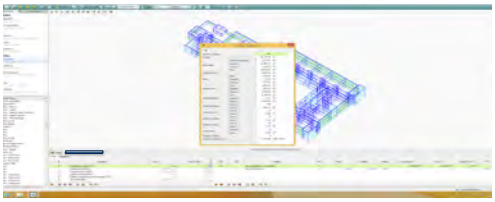
- The following slides show a school project and show how use of a proprietary tool (in this case IES IMPACT) can allow library data to be used and re-used.
- They also illustrate the use of the tool to meet level 2 BIM requirements.

Geometry imported from DWG or IFC

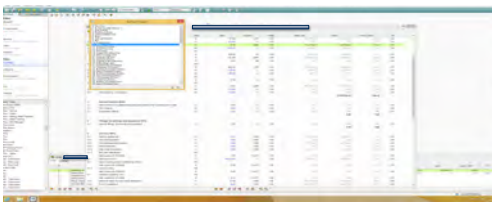
Project LCC settings – TPI, location, discount rate, period of analysis



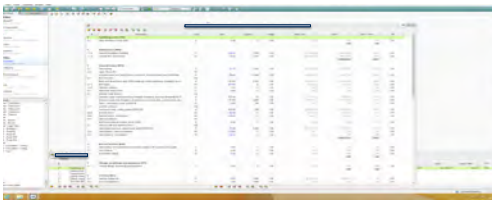
Model high level measures



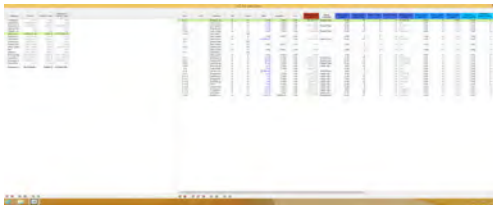
Use of element codes to get specific model measures



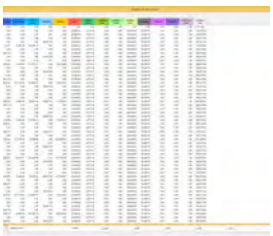
Capital cost plan



LCC cost plan



Example of LCC plan NPV p.a.



Example of LCC plan graphics

Summary of LCC/ WLC in practice

- Guidance has moved on fast over the last few years
- LCC is becoming mainstream, not so confined to very specific procurement routes
- LCC is already achievable in the context of BIM Level 2 and arguably also level 3 as it extends to handover and existing buildings – e.g. RICS Black Book and BS 8544.
- There is increasing interest in LCC as one indicator of sustainability e.g. BS/EN 15643-4 and BS/EN 16627.
- Practitioners will be expected to understand the basics, not just pass clients onto a specialist for all LCC /WLC analysis.