The Built Environment: Performance Management Now and Future

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Facilities Solutions
Building perspective.

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Waypoints in This Brief

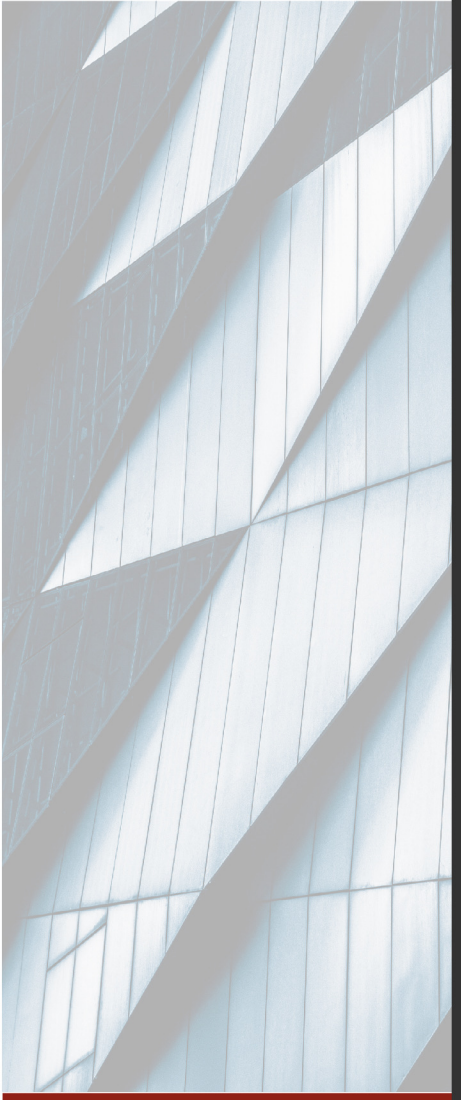
The Challenge

Research Findings

Potential Power of using Multiple KPIs

Applying the Research to BUILDER

Key Performance Indicators (KPIs) not in the Research Findings



The Challenge

The Challenge

How do you keep buildings in good condition and usable by the occupants

How do you meet all the environmental standards while minimizing the cost of ownership?

How do you prioritize when there isn't enough funding to fix everything immediately and upgrade equipment to meet all environmental standards?

Create a set of Key Performance Indicators (KPIs) and use them to trigger spending.

Research Findings

What Key Performance Indicators (KPIs)?

“There is a need to identify the core indicators of performance that cover not only financial aspects but also focus on aspects such as business organization goals, job satisfaction, work environment, environmental issues and other non-financial qualitative aspects in a detailed manner” (Lavey et al., 2014)

Joint Research to Identify Core Indicators of Performance

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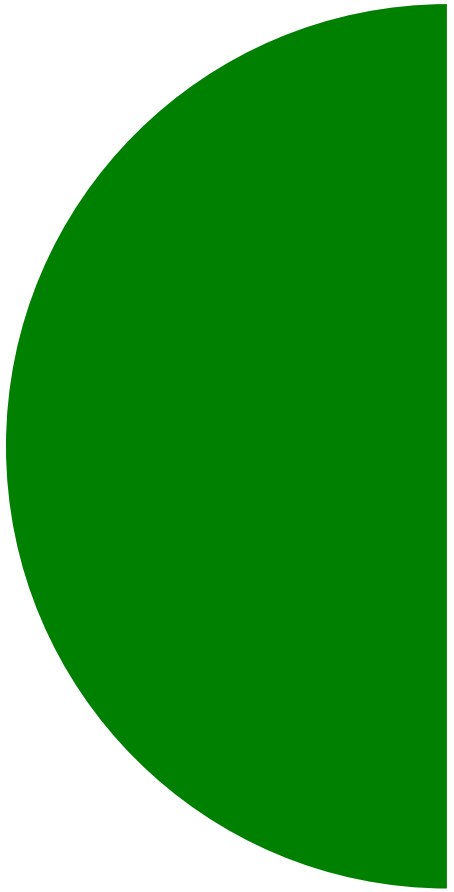
KPI Categories

Research Indicates:

1. User Perception Surveys
2. Indoor/Outdoor Environmental Quality
3. Functional Index
4. Facility Condition
5. Maintenance Efficiency
6. Replacement Efficiency

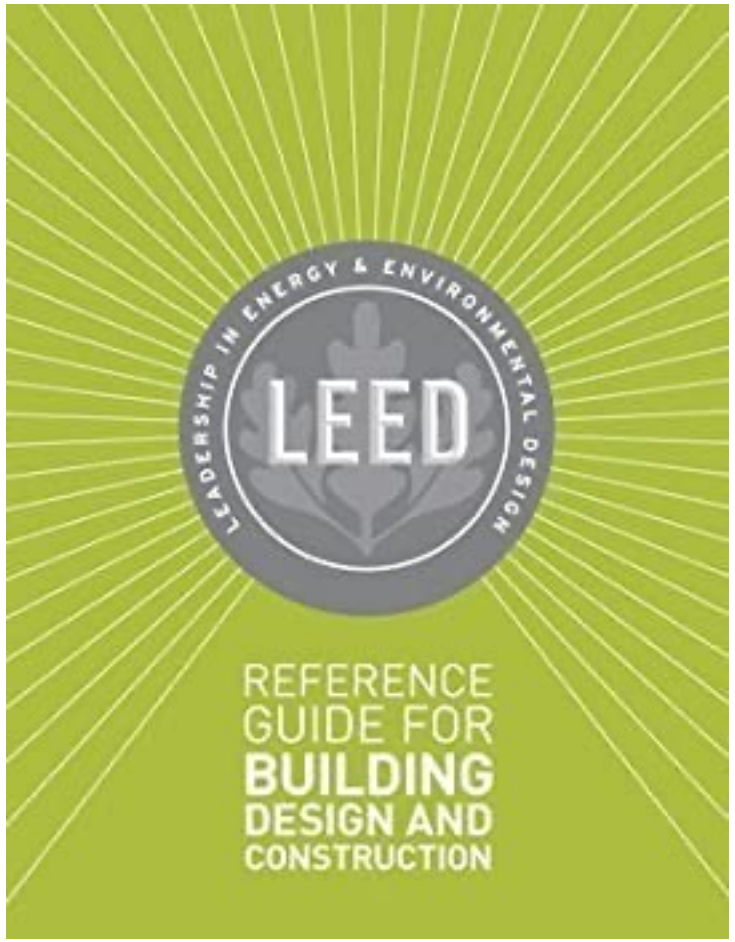
User Perception Surveys



Asking the user can give you another source of data for all the other KPI categories

- Indoor / Outdoor Environmental Quality
- Functional Index
- Facility Condition
- Maintenance Efficiency
- Replacement Efficiency

Indoor / Outdoor Environmental Quality (IOEQ)



Based on the LEED-EB® Green Building Operations and Maintenance Reference Guide (USGBC, 2009)

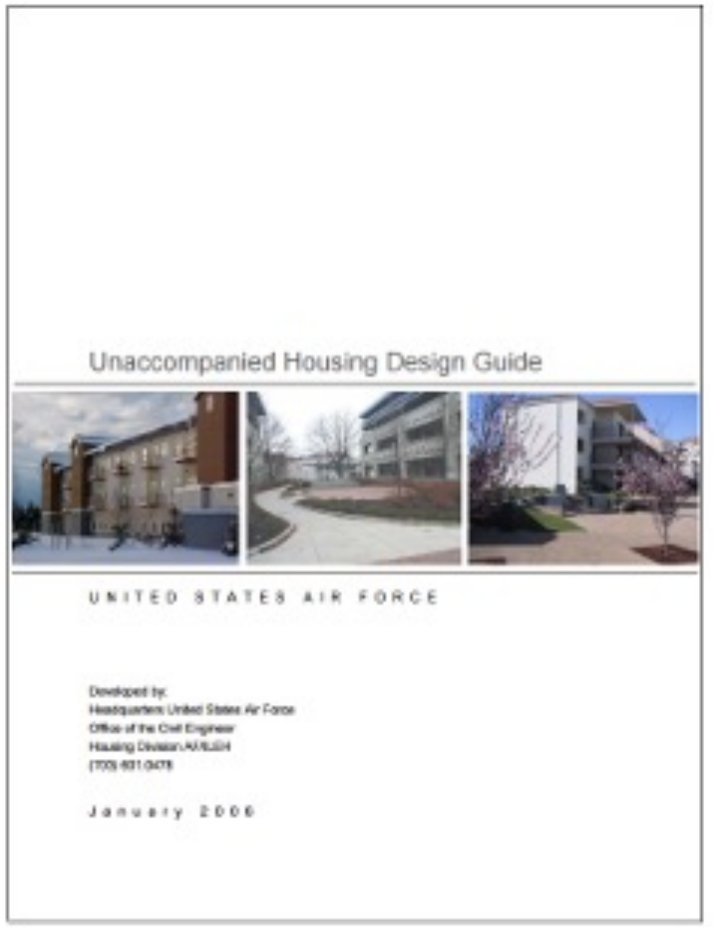
Covers

- Indoor air quality
- Site conditions
- Energy demand
- Water use
- Solid waste generation

Functional Index (FI)

Covers the functionality of a space, building or campus.

Easiest to implement when there is a design guide for a building type.



Facility Condition Index (FCI)

Measure of the deferred maintenance for the building

It is a financial metric and does not measure physical condition

Most organizations define FCI as:

FCI = Deferred Maintenance / PRV

Most used KPI in the industry

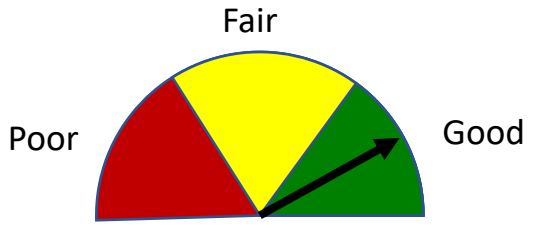
Maintenance Efficiency Indicator (MEI)

The following are used to assess the maintenance program

Total Expenditure = Preventative Maintenance Cost + Corrective Maintenance Cost

Spending percentage on Deferred Maintenance (SDM)

SDM = 100 x Actual spending on DM / Targeted spending on DM



Maintenance Efficiency Indicator (MEI)

MEI = 100 x SDM / FCI

Corrective to Preventive maintenance Ratio (CPR)

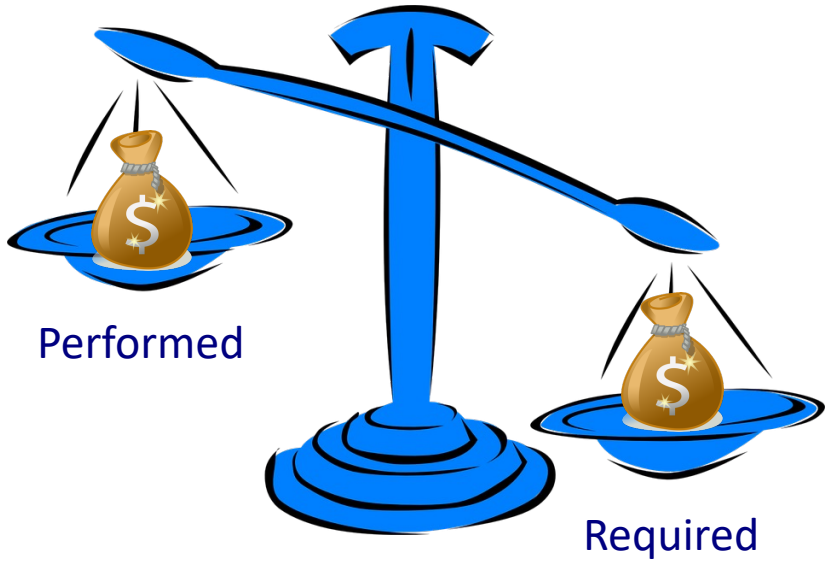
CPR = Corrective Maintenance Cost / Preventive Maintenance Cost

Replacement Efficiency Indicator (REI)

The following is used to assess the replacement program:

Replacement Efficiency Indicator (REI)

REI = Work Performed / Work Required



Potential Power of Using Multiple KPIs

Potential Power of Using Multiple KPIs

Enabling Simulations

"In this paper the authors demonstrate the power and potential of understanding and using KPIs through computer simulations."

Construction Management and Economics, 2014
Vol. 32, No. 12, 1183–1204, http://dx.doi.org/10.1080/01446193.2014.970208

Routledge
Taylor & Francis Group

Key performance indicators for facility performance assessment: simulation of core indicators

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Potential Power of Using Multiple KPIs

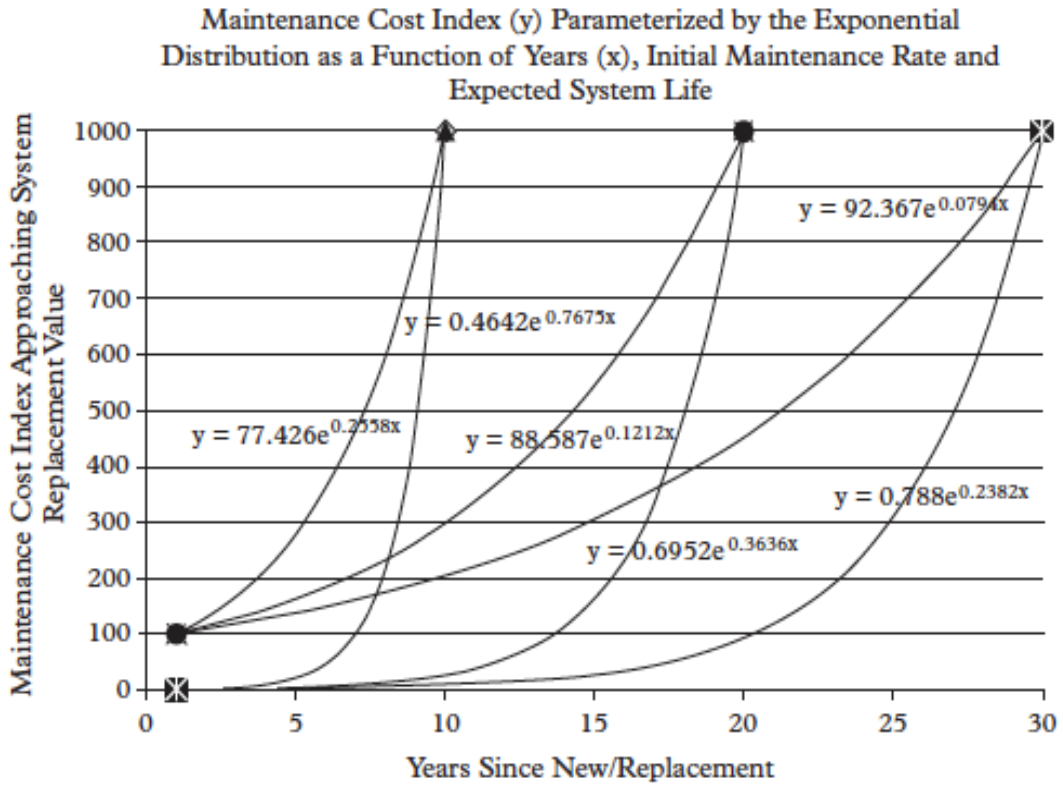
STUDY OBJECTIVES

1. Simulate the identified core KPI outputs for facility performance assessment.
2. Demonstrate how simulation allows for the study of correlations and relationships between and among KPIs.
3. Highlight the sensitivity of outputs and outcomes to input variable sensitivity.
4. Demonstrate that due to variability and future uncertainty, simulation is a valuable tool for generating future possible scenarios and making decisions based upon forecasts and logic.

Potential Power of Using Multiple KPIs

SIMULATIONS

1. Five Individual systems - 4 Scenarios
2. 1 building with 5 systems – 4 Scenarios
3. Variables – Maintenance Budget, Years Until Replacement
4. Core KPIs Evaluated – CI, DFM, PRV, MEI, REI
5. Key Assumption – Maintenance cost model based on exponential rate of deterioration.



Potential Power of Using Multiple KPIs

SIMULATIONS – INPUT DATA

Table 2 Input data for Part 2

Variables/Parameters	Value fields for each system				
	Roof	HVAC	Plumbing	Electrical	Other
Estimated Life Cycle (Years)	20	30	20	18	20
Initial Maintenance Rate (%)	2	1.5	0.25	0.65	2
Final Maintenance Rate (%)	100	100	100	100	100
PRV when New/Replaced	$110	$1400	$800	$1200	$2100
Current PRV (end of Year 1)	$113	$1442	$824	$1236	$2163
Years Until Planned Replacement	X	X	X	X	X
Renewal Rate Factor	1.2	1.1	1.17	0.84	0.77
*Budget for Maintenance	Y	Y	Y	Y	Y
*The Discount Rate (%)	2	2	2	2	2
*Rate of Inflation for DFM (%)	2	2	2	2	2
*Rate of Inflation for System (%)	2	2	2	2	2
*Environmental, etc. Rate (%)	1	1	1	1	1
Scenario					
Scenario 1:	X = (Estimated Life Cycle), Y = 70%				
Scenario 2:	X = (Estimated Life Cycle + 5), Y = 50%				
Scenario 3:	X = ((Estimated Life Cycle/2) + 1), Y = 50%				
Scenario 4:	X = (Estimated Life Cycle), Y = 99.9%				

Note: *These variables are subject to variability according to the beta distribution in the simulation.

Potential Power of Using Multiple KPIs

SIMULATIONS – A BUILDING SCENARIO (S3) RESULT

Objectives 1 and 2

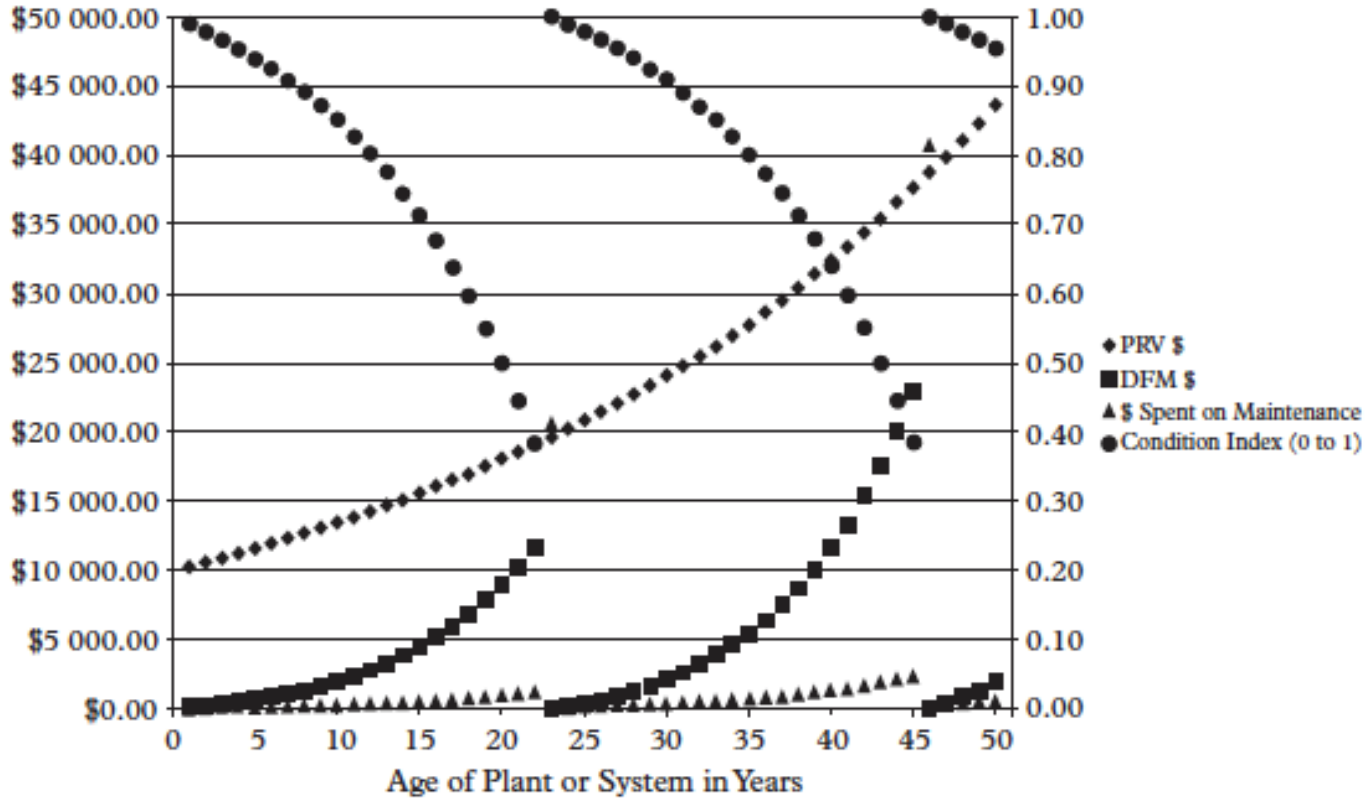


Figure 5 Scenario 3 showing KPI relationships over service life (NPV of $ spent = $47k)

Potential Power of Using Multiple KPIs

SIMULATIONS – A BUILDING SCENARIO (S3) RESULT

Objectives 1 and 2

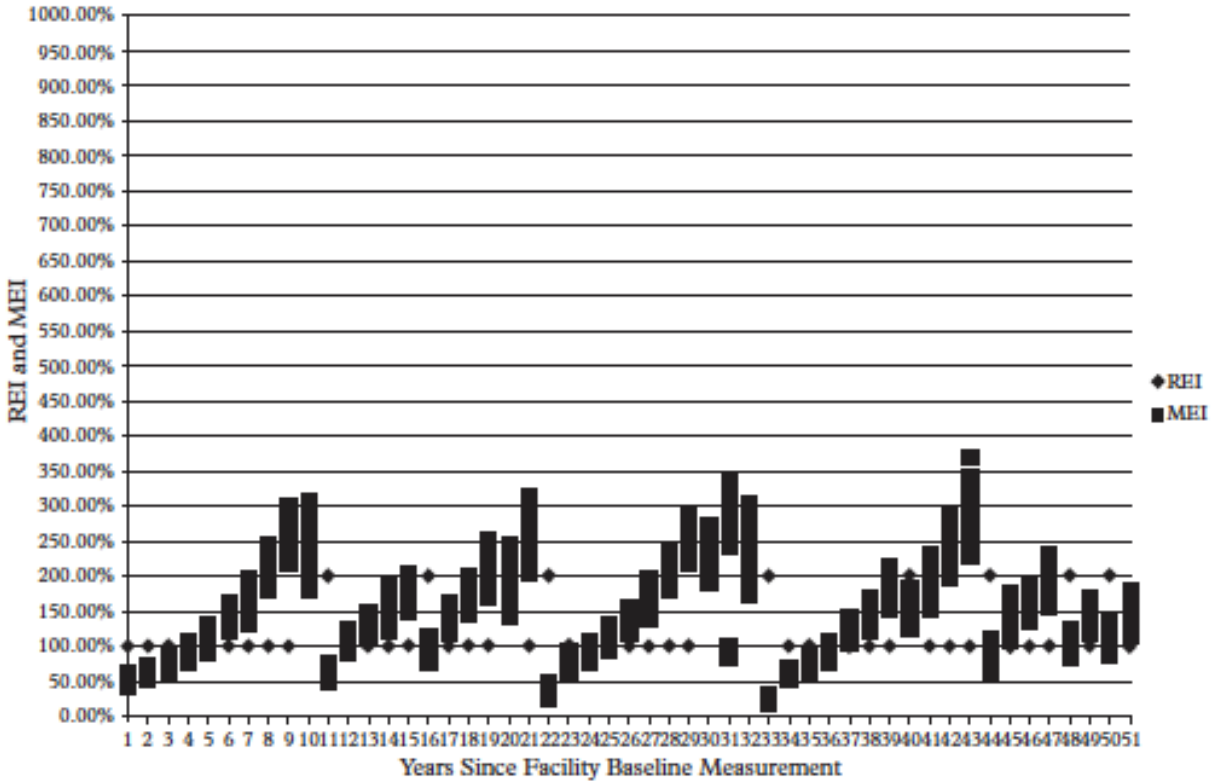


Figure 12 MEI and REI under scenario 3 based on user inputs and assumptions

Potential Power of Using Multiple KPIs

SIMULATIONS – Maintenance Rate Sensitivity Analysis

Objective 3

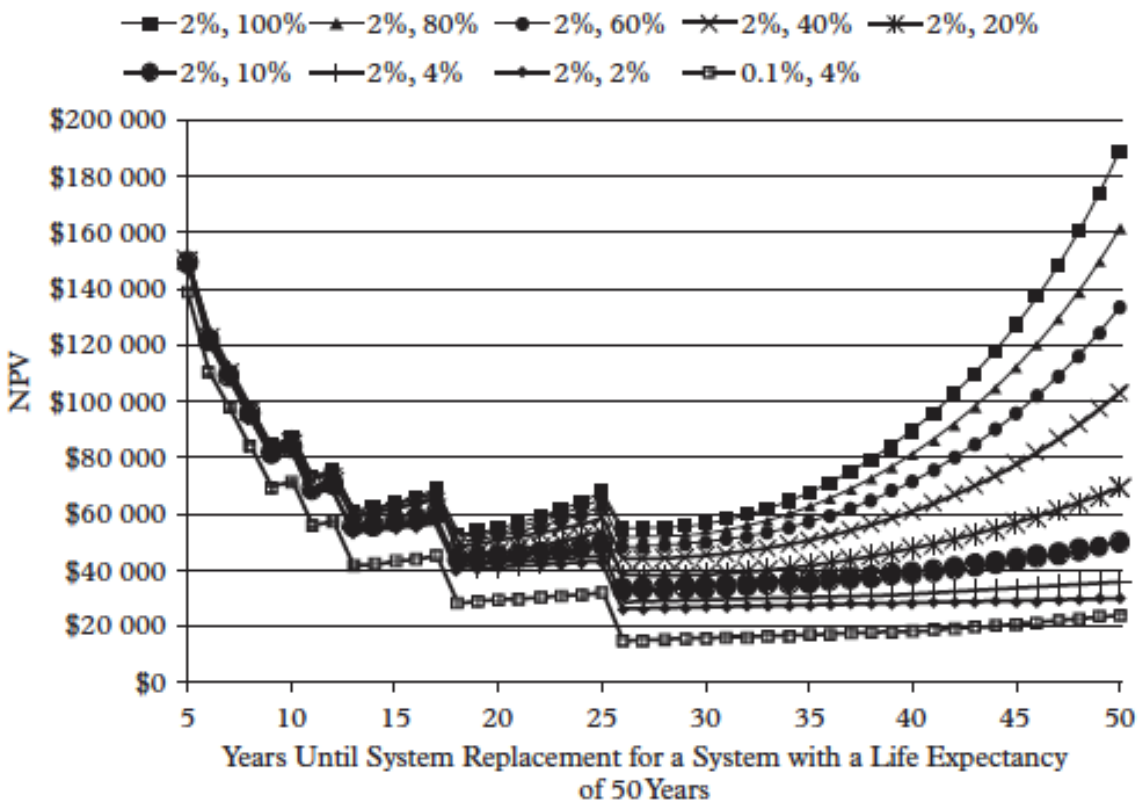


Figure 13 Net Present Value over a period of 50 years under various maintenance rate assumptions

Potential Power of Using Multiple KPIs

SIMULATIONS – A Few Examples of Key Observations

1. **Objectives 1 and 2** **Scenario 3 (early replacement) was the least expensive to implement while still maintaining a better overall CI than other Scenarios.**
2. **Objective 3** **For a service life of 50 years the optimum, or near optimum, NPV was achieved with a replacement at 26 years in all scenarios.**
3. **Objective 4** **The accomplishing of this objective is evident throughout the paper, as simulation is a powerful tool in understanding and projecting relationships among KPIs, their inputs, and their outputs.**

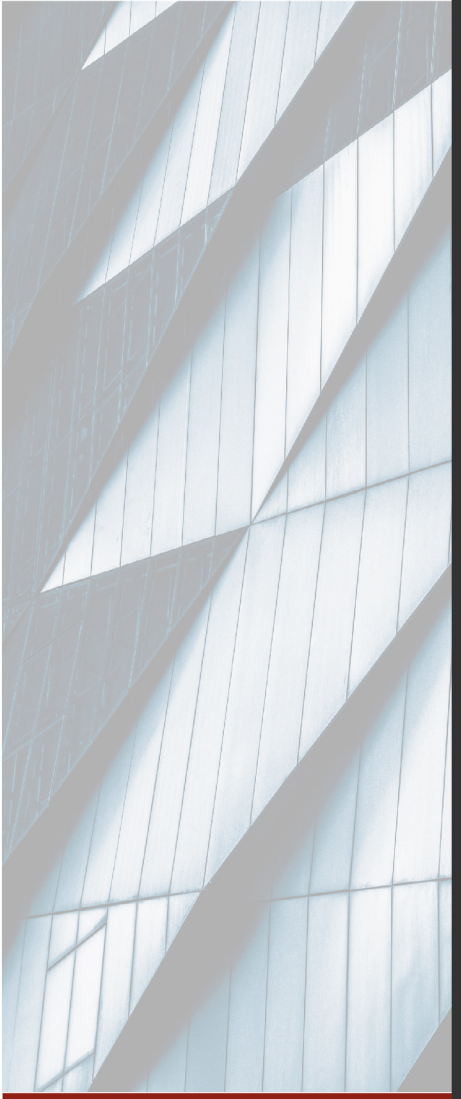
Potential Power of Using Multiple KPIs

ONGOING-FUTURE

1. Improving Database: Validating the identified core KPIs and the simulation results using broader aggregated industry data.

2. Improving Simulation Methods: Selecting actual facilities with available historical data supporting these and new KPIs and comparing assumptions yielding optimum simulated results.

3. Improving KPIs: Identifying composite KPIs to better link KPIs to organizational performance.



Applying the Research to BUILDER

Indoor / Outdoor Environmental Quality, User Perception Surveys and BUILDER

These two KPIs are independent of BUILDER

Both KPIs can suggest replacement activities.

Create a manual work item in BUILDER to reflect the need to replace the sections.

FI and BUILDER

BUILDER supports FI

Not used by the majority of BUILDER users

Challenge with FI is pricing the corrections to an FI issue

REI and BUILDER

Not calculated by BUILDER but can be calculated from BUILDER data.

REI = Work Performed / Work Required

REI = (Work Oct - Work Sept)/ Work Oct

Work Oct

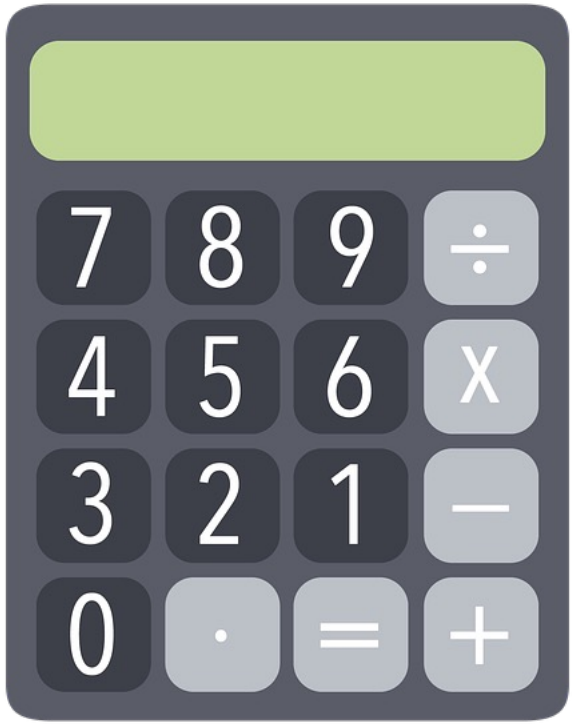
Run a Final 8 Custom Report in Oct

Add up all the costs for a building

Work Sept

Run a Final 8 Custom Report in Sept

Add up all the costs for a building



MEI and BUILDER

Independent of BUILDER

MEI and associated calculations are best calculated from a CMMS

BUILDER can be used as a warning that CPR could go higher

CPR = Corrective Maintenance Cost / Preventive Maintenance Cost

Corrective maintenance costs are unplanned costs, that happen when sections break down.

CSCI is a measure of the risk of break down for a section.

FCI and BUILDER

BUILDER defines FCI according to the DoD

FCI = 100 * (1 - Work / PRV)

FCI is a financial metric, not a physical condition metric (like BCI)

Pros:

- Easy to explain
- Easy to calculate the cost to meet a standard

Cons:

- PRV not related to the CRV
- PRV and CRV have different inflation rates
- Repairs impact FCI
- Point in Time

FCI and BUILDER Pros

Easy to Explain:

FCI is the % of the building that does not currently need replacing or repair.

Easy to calculate the cost to get to a standard:

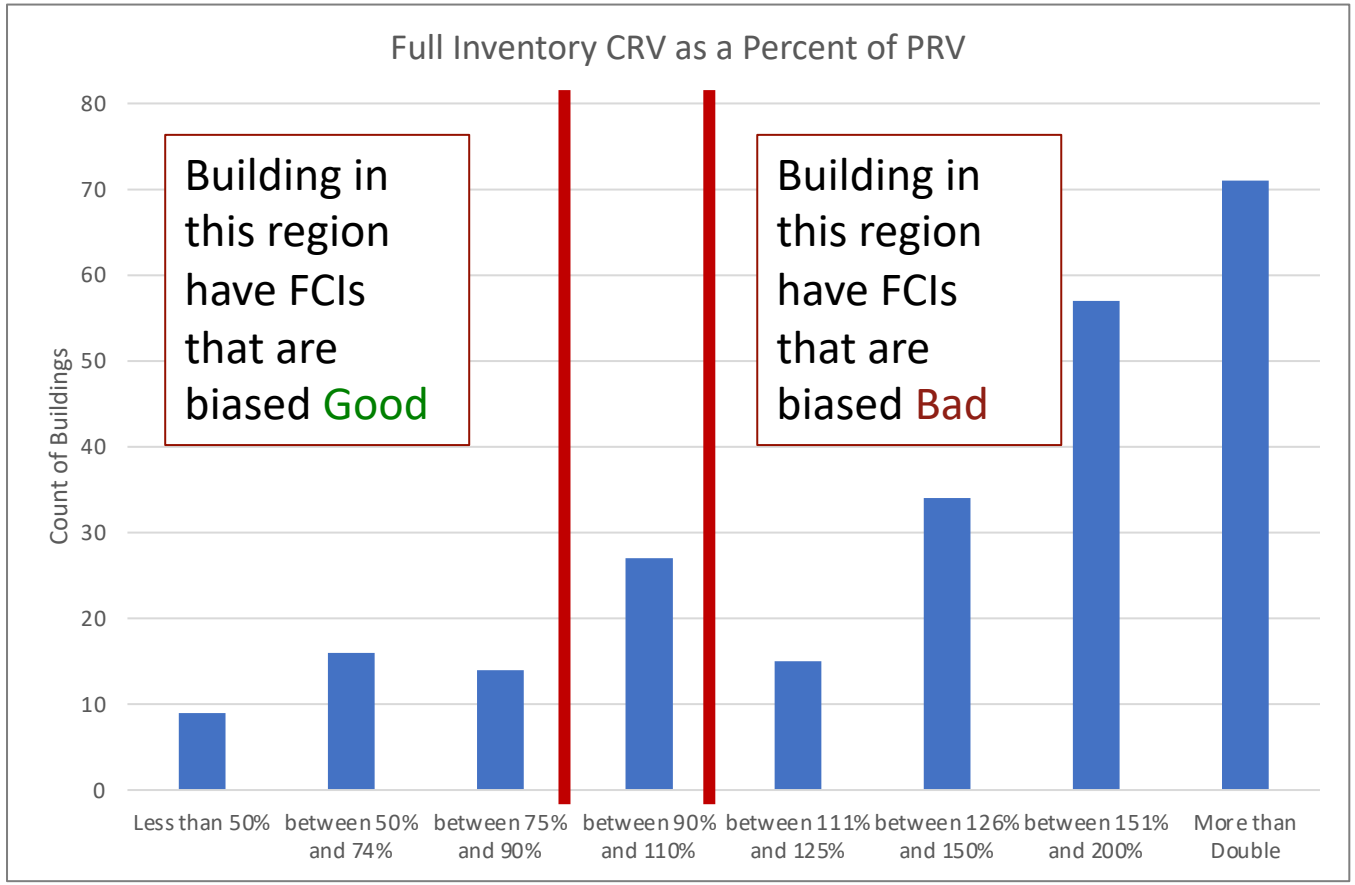
Cost = (Target FCI - FCI) * PRV

FCI and BUILDER Cons

PRV not related to CRV

CRV - Cost Book

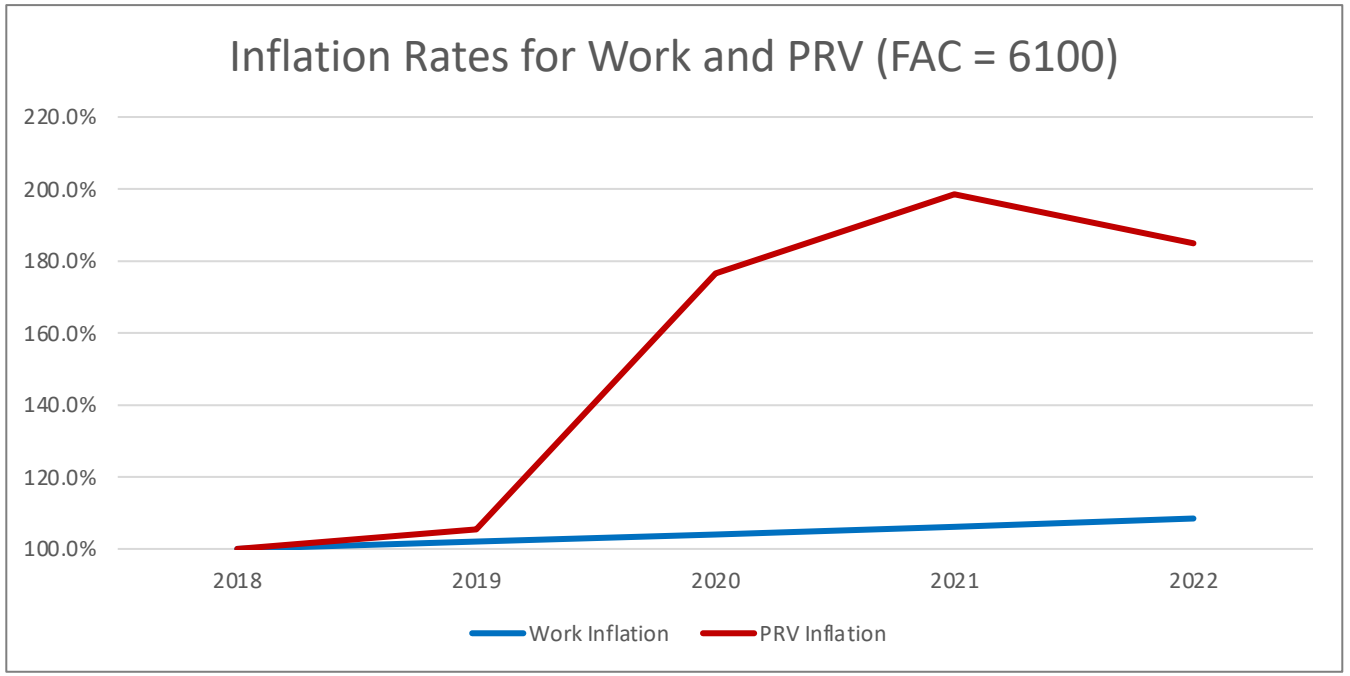
PRV - DoD Price Book



FCI and BUILDER Cons

PRV and CRV have different Inflation Rates

- Work inflated by the inflation table in the DoD Facility Pricing Guide
- PRV is parametric cost from the DoD Facility Pricing Guide

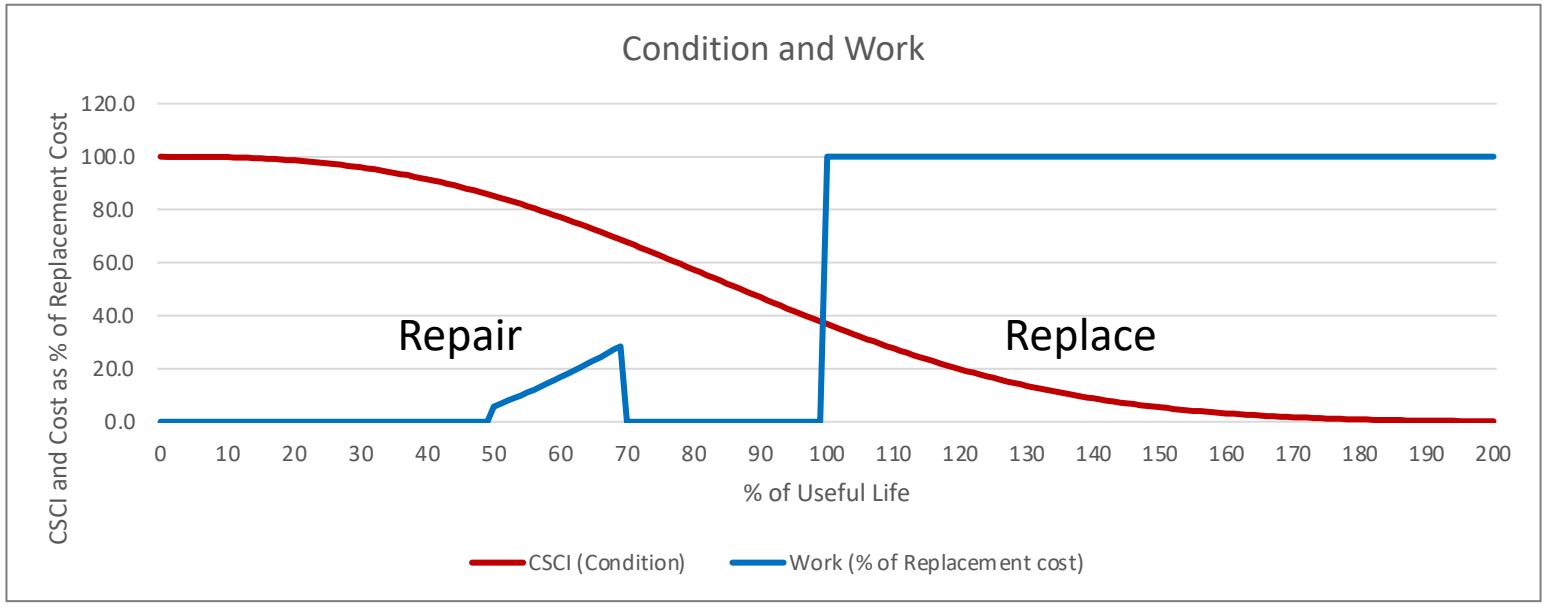


FCI and BUILDER Cons

Repairs

Impact the FCI and if not fixed in a couple of years, they go away

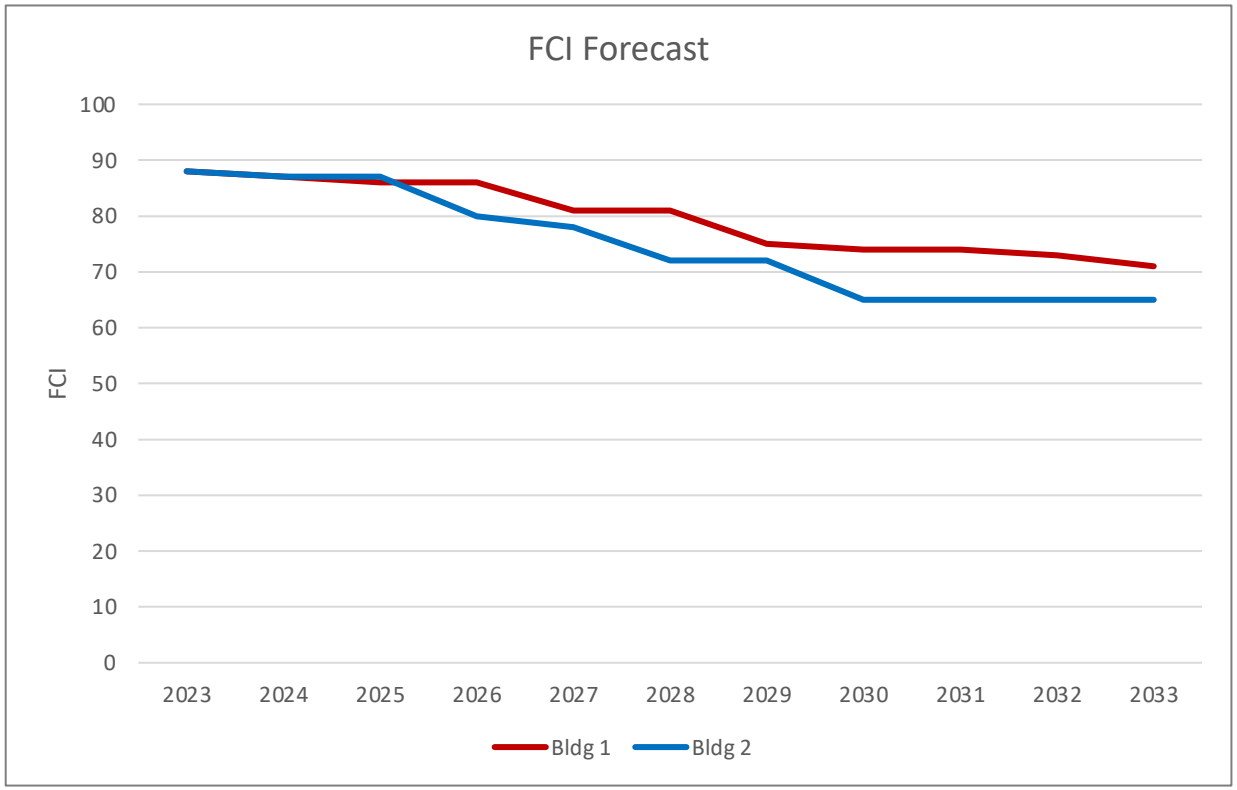
Leads to my building got better by doing nothing explanation.



FCI and BUILDER Cons

FCI is a Point in Time

Future can be different for 2 buildings with same FCI



FCI and BUILDER CONS - Minimization

For Non-DoD Users

Set PRV = CRV

Eliminates FCI bias and inflation issues

Point in Time

- Forecast your FCI

Set Maximum RSL For Replacement Threshold = 0

- Use RSL to trigger reminders that you will need work

FCI and BUILDER CONS - Minimization

Repairs

- BUILDER Strength
- No Action impacts the FCI
- To avoid negative impacts to the FCI
  - Eliminate repairs by setting the Minimum CI for Repair to 1
  - Use Final 3 reports to look for CSCI in the repair zone

KPIs not in the Research Findings

Building Condition Index (BCI) and BUILDER

It is the average section condition weighted by the replacement value

$$BCI = \frac{CSCI_1 * CRV_1 + CSCI_2 * CRV_2 + \ldots + CSCI_n * CRV_n}{CRV_1 * CRV_2 * \ldots * CRV_n}$$

BCI is a physical condition metric, not a financial metric (like FCI)

Pros:

- Easy to relate to
- Independent of the PRV

Cons:

- Hard to Explain
- Hard to calculate the cost to meet a standard
- Point in Time

BCI and BUILDER Pros

Easy to relate to:

BCI is close to what you see, feel and hear when you go into a building

Independent of the PRV:

PRV is not part of the equation, so you don’t have the same PRV challenges that you have with FCI

BCI and BUILDER Cons

Hard to explain: Starts with the question:

What is BCI and what does 60 mean?

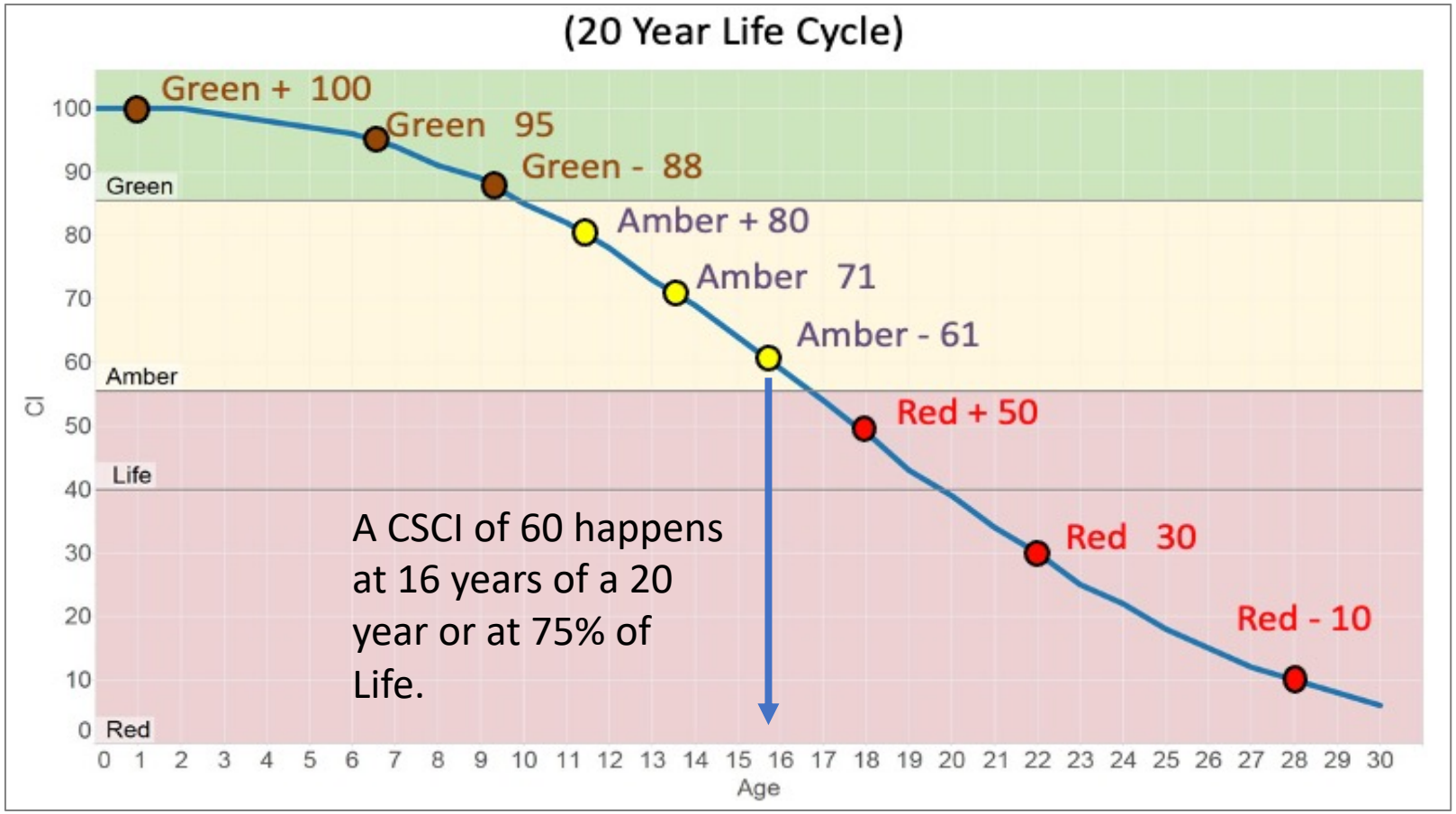
- Its the average condition of all the sections of a building weighted by their replacement cost.
- A 60 is in the Amber - range:

  Component-section or sample has significant serviceability or reliability loss. Most subcomponents may suffer from moderate degradation or a few major (critical) subcomponents may suffer from severe degradation.

RATING	SRM NEEDS	RATING DEFINITION
Green (+)	Sustainment consisting of possible preventive maintenance (where applicable)	Entire component-section or component-section sample is free of observable or known distress.
Green	Sustainment consisting of possible preventive maintenance (where applicable) and minor repairs (corrective maintenance) to possibly few or some subcomponents.	No component-section or sample serviceability* or reliability* reduction. Some, but not all minor (non-critical) subcomponents may suffer from slight degradation or few major (critical) subcomponents may suffer from slight degradation.
Green (-)		Slight or no serviceability or reliability or reliability reduction overall to the component-section or sample. Some, but not all minor (non-critical) subcomponents may suffer from slight degradation or more than one major (critical) subcomponents may suffer from slight degradation.
Amber (+)	Sustainment or restoration to any of the following: Minor repairs to several sub-components; or Significant repair, rehabilitation or replacement of one or more subcomponents, but not enough to encompass the component-section as a whole; or Combinations thereof.	Component-section or sample serviceability or reliability is degraded, but adequate. A very few major (critical) subcomponents may suffer from moderate deterioration with perhaps a few minor (non-critical) subcomponents suffering from severe deterioration.
Amber		Component-section or sample serviceability or reliability is definitely impaired. Some, but not a majority of major (critical) subcomponents may suffer from moderate deterioration with perhaps many minor (non-critical) subcomponents suffering from severe deterioration.
Amber (-)		Component-section or sample has significant serviceability or reliability loss. Most subcomponents may suffer from moderate degradation or a few major (critical) subcomponents may suffer from severe degradation.
Red (+)	Sustainment or restoration required consisting of major repair, rehabilitation or replacement to the component-section as a whole.	Significant serviceability or reliability reduction in component-section or sample. A majority of subcomponents are severely degraded, and others may have varying degrees of degradation.
Red		Severe serviceability or reliability reduction to the component-section or sample such that it is barely able to perform. Most subcomponents are severely degraded.
Red (-)		Overall component-section degradation is total. Few, if any subcomponents are salvageable. Complete loss of component-section or sample serviceability.

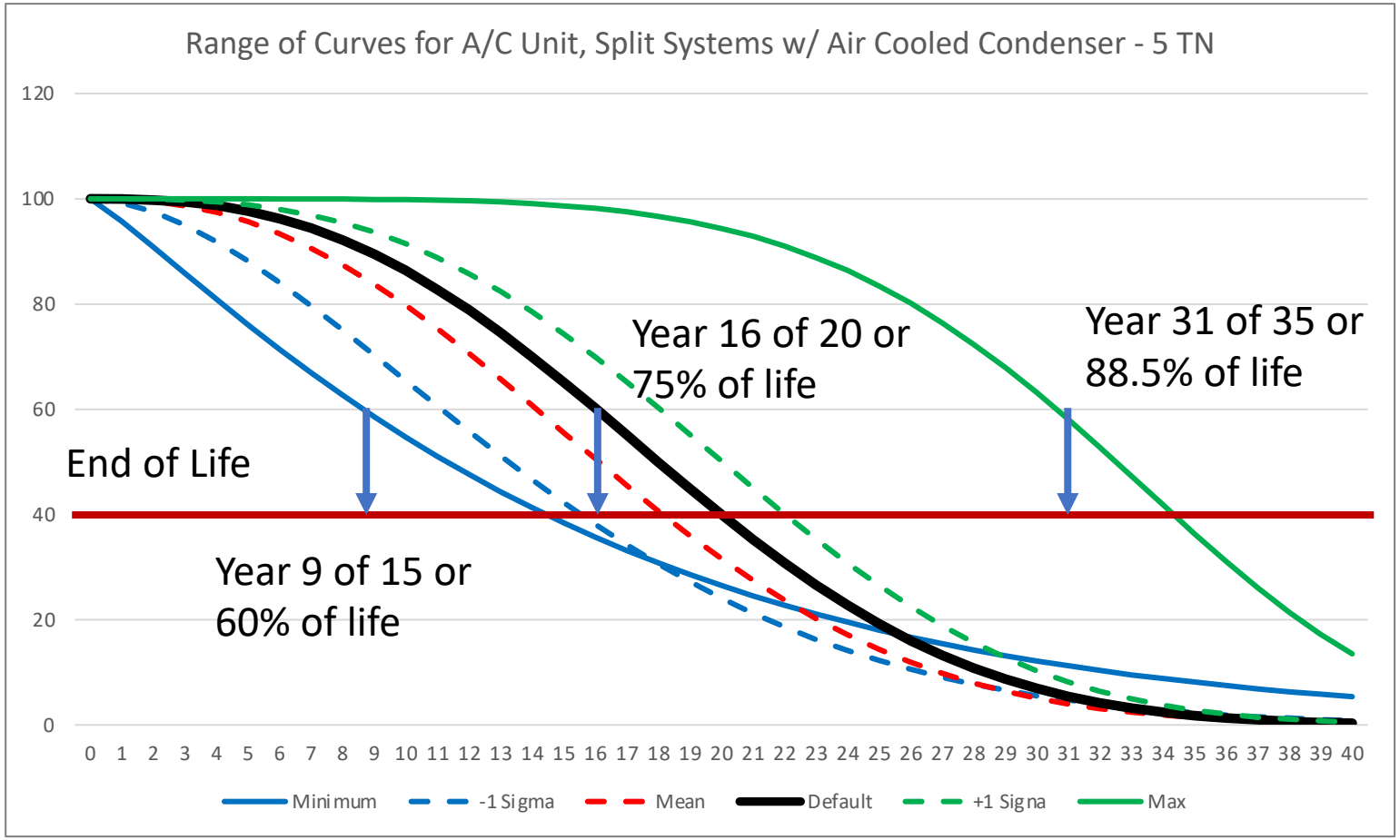
BCI and BUILDER Cons

Hard to explain: 60 seems high for that rating



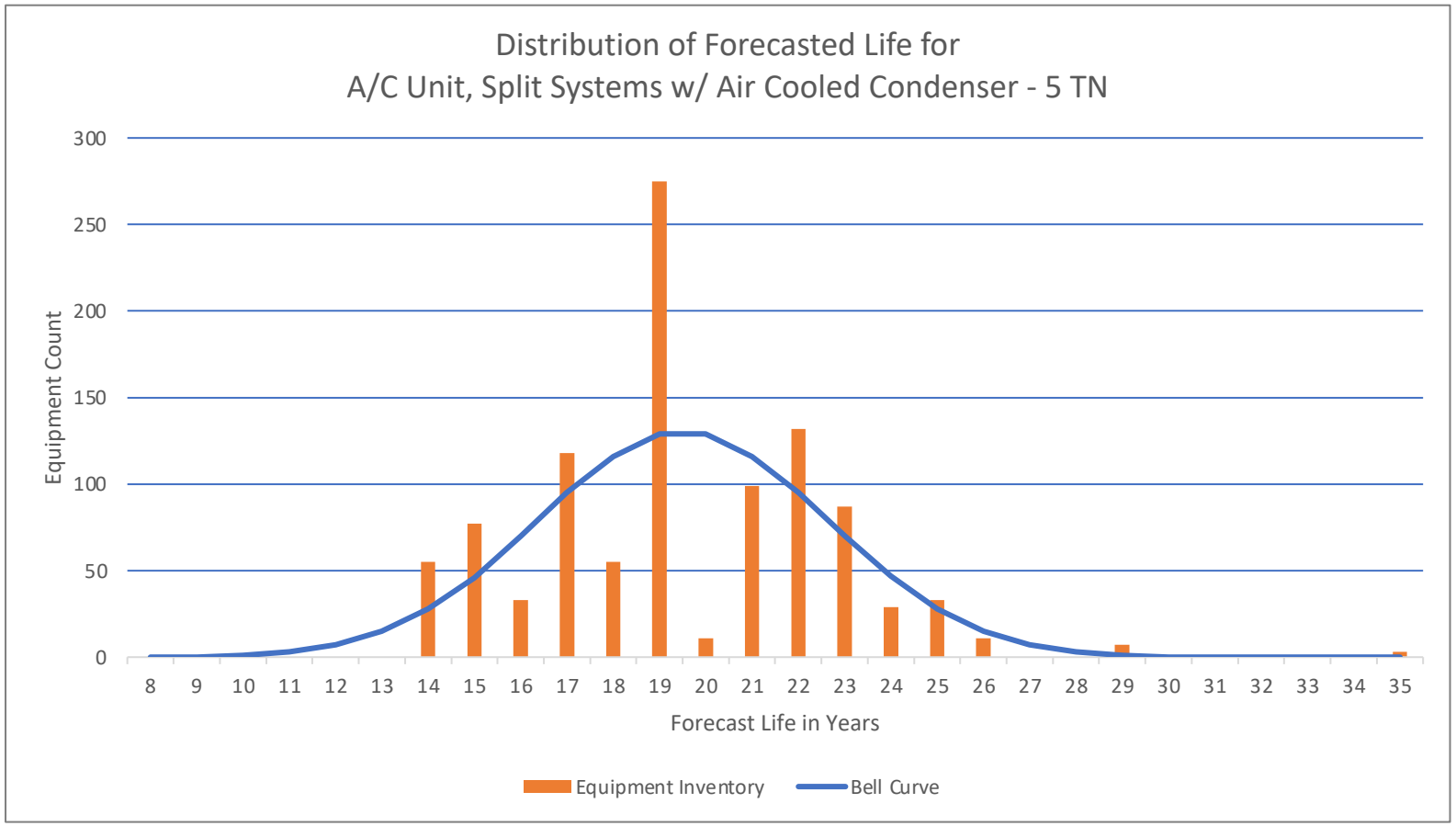
BCI and BUILDER Cons

Hard to explain: a BCI of 60 means approximately 75% of Life?



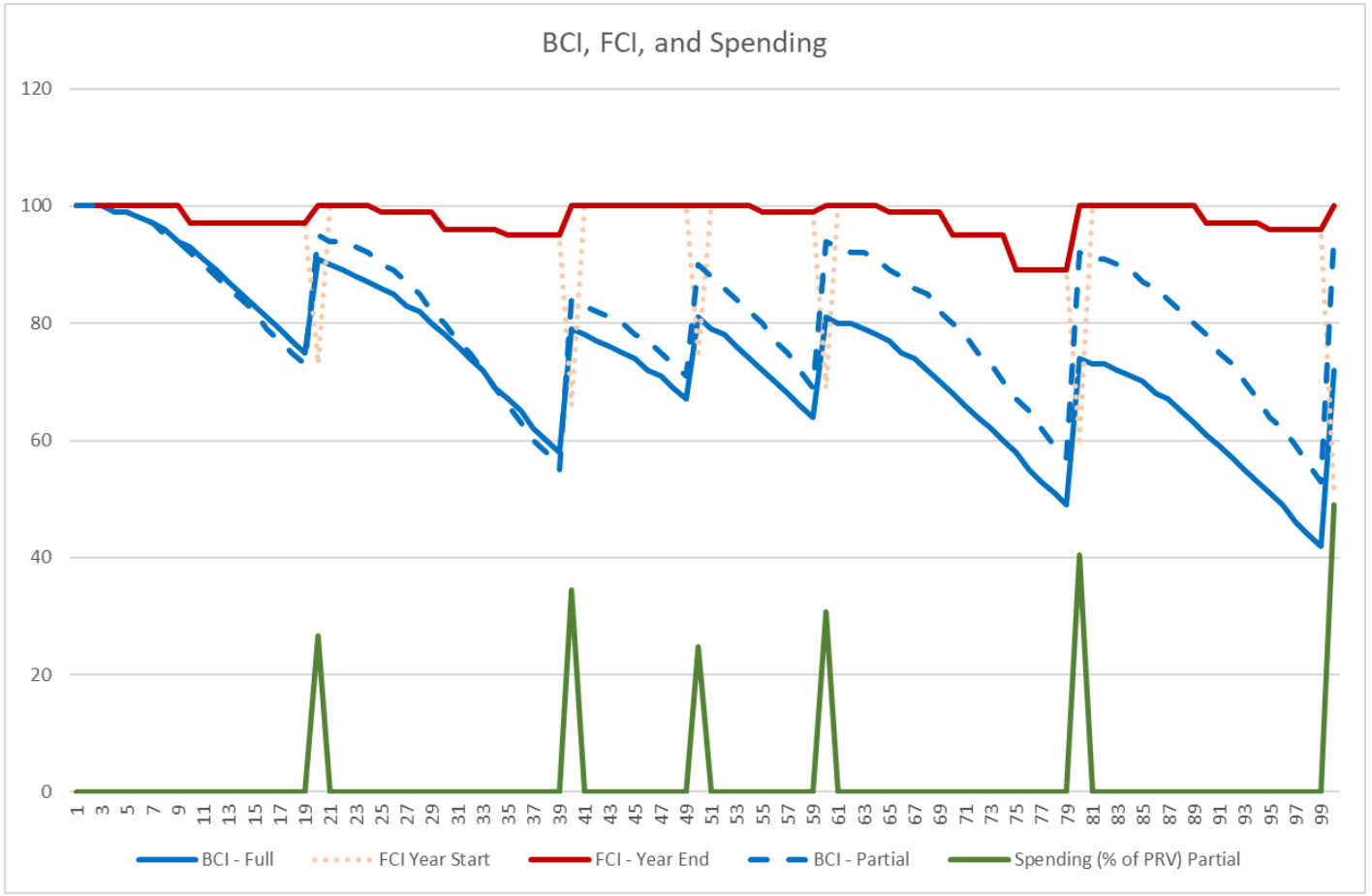
BCI and BUILDER Cons

But the variation allows BUILDER to predict this



BCI and BUILDER Cons

Hard to explain: How does this relate to the FCI



BCI and BUILDER Cons

Hard to calculate the cost to meet a standard

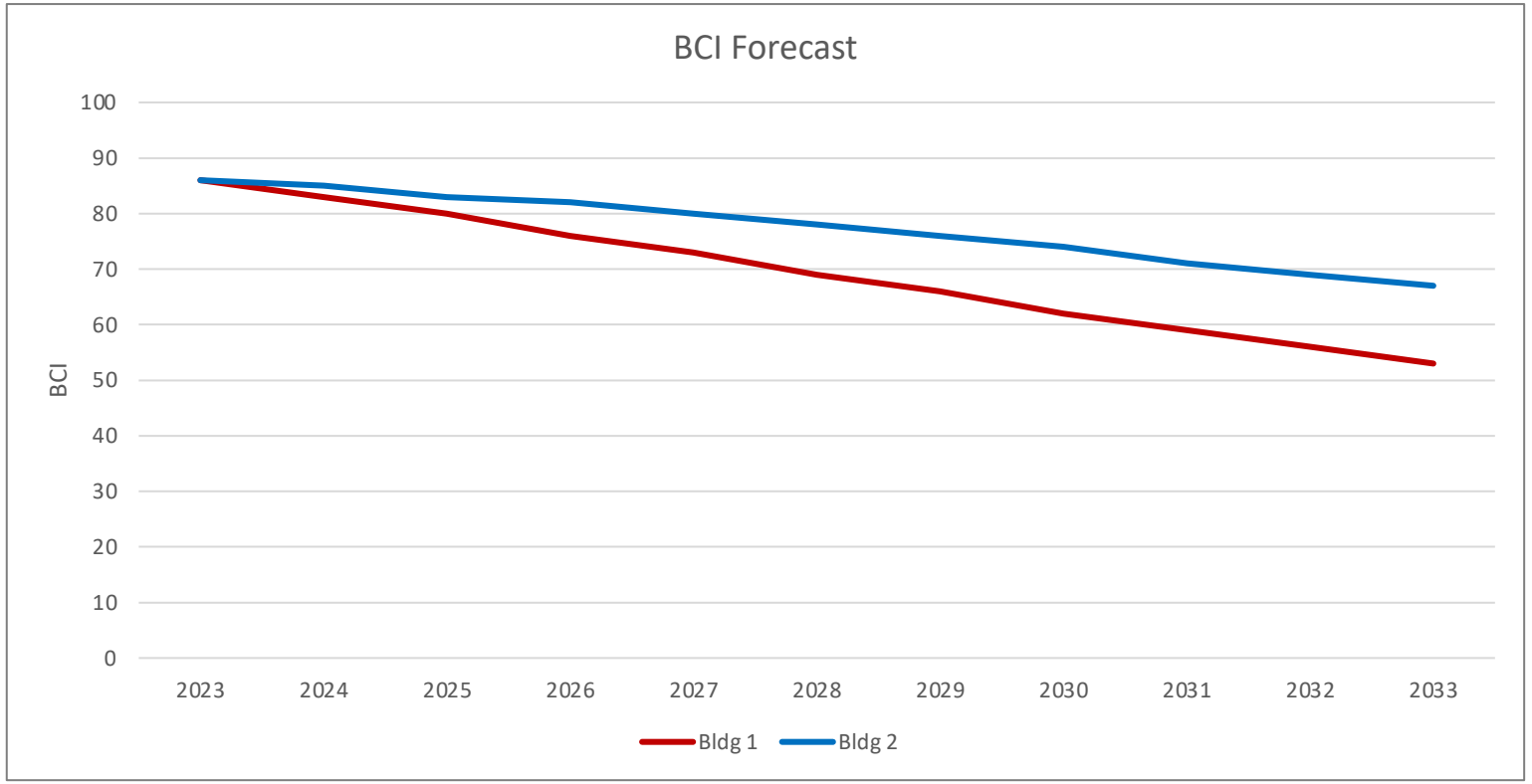
- The cost to replace a section is 100% of the cost
- The benefit is not static like FCI
  - CSCI gain = (100 - Current CSCI) * % of Total CRV

Scenario	% of the CRV that is being fixed	CSCI of the sections being fixed	BCI Increase
1	10%	40	6 points
2	10%	30	7 points

BCI and BUILDER Cons

BCI is a Point in Time

Future can be different for 2 buildings with same BCI



A New Metric

Is there another metric that:

- represents the physical condition
- Is easy to explain
- Takes advantage of the forecast capability?

Remaining Service Life Index (RSLI)

RSL is a function of condition and the forecast curve

RSLI is the average of the section RSLs weighted by their replacement values.

$$RSLI = \frac{RSL_1 \times CRV_1 \times RSL_1 \times CRV_2 \times \ldots \times RSL_1 \times CRV_n}{CRV_1 + CRV_2 + \ldots + CRV_n}$$

Alternative: Remaining Service Life Percent Index (RSLPI)

RSLPI = Replace RSL with RSL / Life in the above equation

RSLI and BUILDER

Pros:

- Easy to explain
- Has a forecast component
- Independent of PRV
- Measures condition

Cons:

- Hard to calculate the cost to meet a standard

RSLI and BUILDER

RSLI Pros

Easy to explain:

- An RSLI of 10 means that the average section weighted by replacement value of the building has 10 years remaining before it needs to be replaced.

Has a forecast component:

- Remaining Service Life is a forecast

Independent of PRV:

- RSL is based on the CSCI, Age and Expected Life

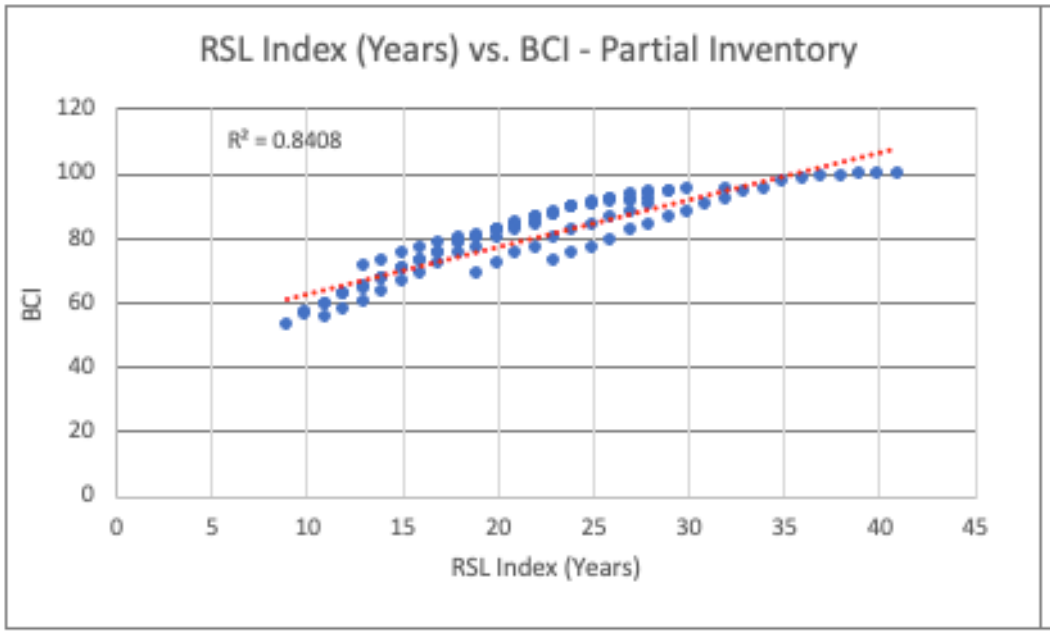
RSLI and BUILDER

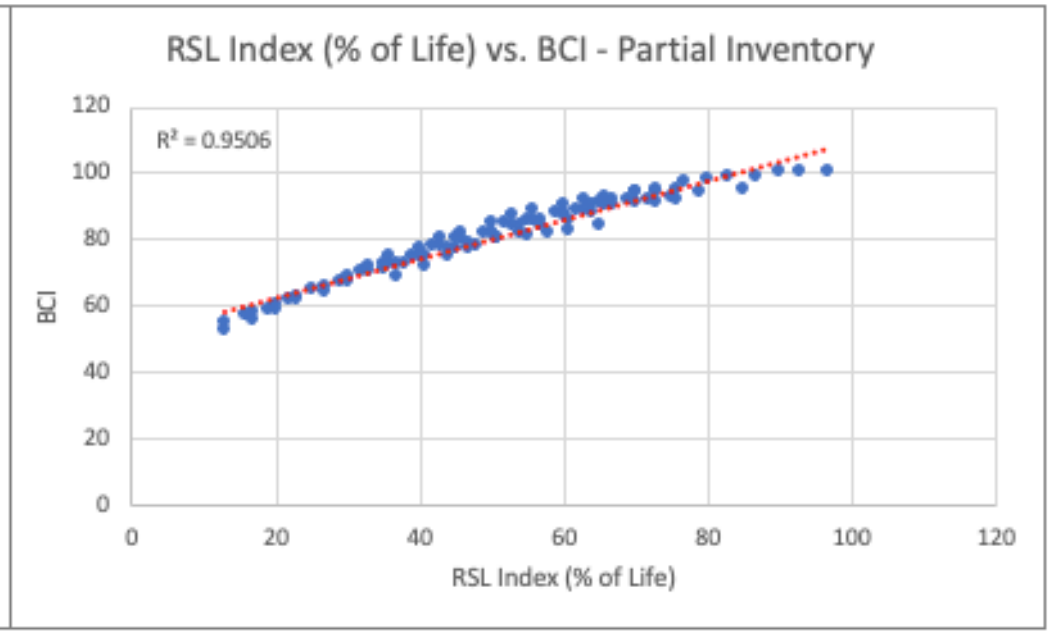
Does RSLI measure condition?

RSLI and BUILDER

Does RSLI measure condition?

- RSLI has an R^2 value of 0.84
- RSLPI has an R^2 value of 0.95





RSLI and BUILDER Cons

Hard to calculate the cost to meet a standard

- The cost to replace a section is 100% of the cost.
- The benefit is not static like FCI

  - RSLI gain = (Expected Life - RSL) * % of Total CRV

Scenario	% of the CRV that is being fixed	CSCI of the sections being fixed	BCI Increase
1	10%	40	6 points
2	10%	30	7 points

Risk Index and BUILDER (RI)

Risk Index is the % of the building's sections that has a CSCI that is close to failing.

$$RI = \frac{\text{Replacement Cost of Sections with a CSCI < Threshold}}{\text{Cost of all Sections in the building}}$$

Pros:

- Easy to explain
- Easy to calculate gain
- Independent of PRV

Cons:

- None

RI and BUILDER

RI Pros

Easy to explain:

- A RI of 10 means in 10 years, 50% of the sections need replacement

Has a forecast component:

- Remaining Service Life is a forecast

Independent of PRV:

- RSL is based on the CSCI, Age and Expected Life

Performance Management

KPIs are the trip wires to indicate that the asset is not performing to specifications.

When the wire is tripped, action (spend money) is required to bring the asset back into specifications.

How you spend it can involve other indicators besides the ones we talked about.

- Age and expected life of the building
- Mission Dependency Index
- Expected condition when building is removed from inventory
- Removal strategy (demo, sell)
- Asbestos present or not

Thank You!

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Building perspective.