LCA: a complementary tool for measuring sustainability

BuildingEnergy 14

March 6, 2014

Boston

Amanda Pike

amanda.pike@quantis-intl.com

NESEA is a registered provider with the American Institute of Architects Continuing Education Systems. Credit earned on completion of this program will be reported to CES Records for AIA members. Certificates of Completion for non-AIA members will be mailed at the completion of the conference.

This program is registered with the AIA/CES for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product. Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

CONTINUING EDUCATION AIA

Session Description

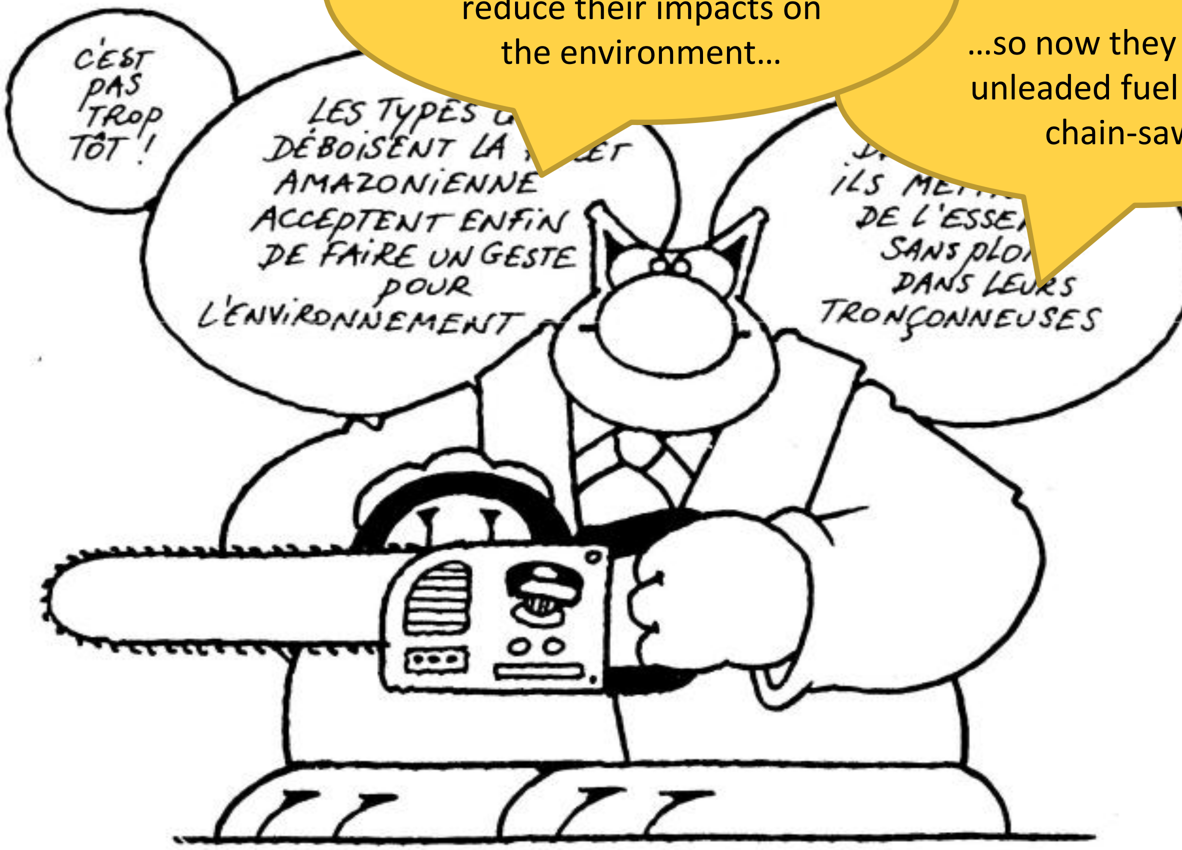
Life Cycle Assessment (LCA) is a robust and quantitative process that provides a comprehensive evaluation of environmental benefits and trade-offs. Speakers will describe LCA methodologies for whole building analysis and reference studies that sought answers to complex questions about building reuse and new construction. One case study demonstrates how environmental costs and benefits were incorporated into traditional life-cycle cost analyses (LCCAs) and total ownership cost (TOC) analyses for military construction projects.

Questions?

This concludes the American Institute of Architects Continuing Education Systems Program

Amanda Pike, Quantis amanda.pike@quantis-intl.com
Cherilynn Widell, Seraph LLC ciwidell809@yahoo.com

How do we make decisions that move us in the right direction?



The guys cutting the forest in the Amazon agreed to reduce their impacts on the environment…

…so now they will use unleaded fuel in their chain-saws.

What do these tell us about environmental impact?

Life cycle assessment: just another sustainability tool?

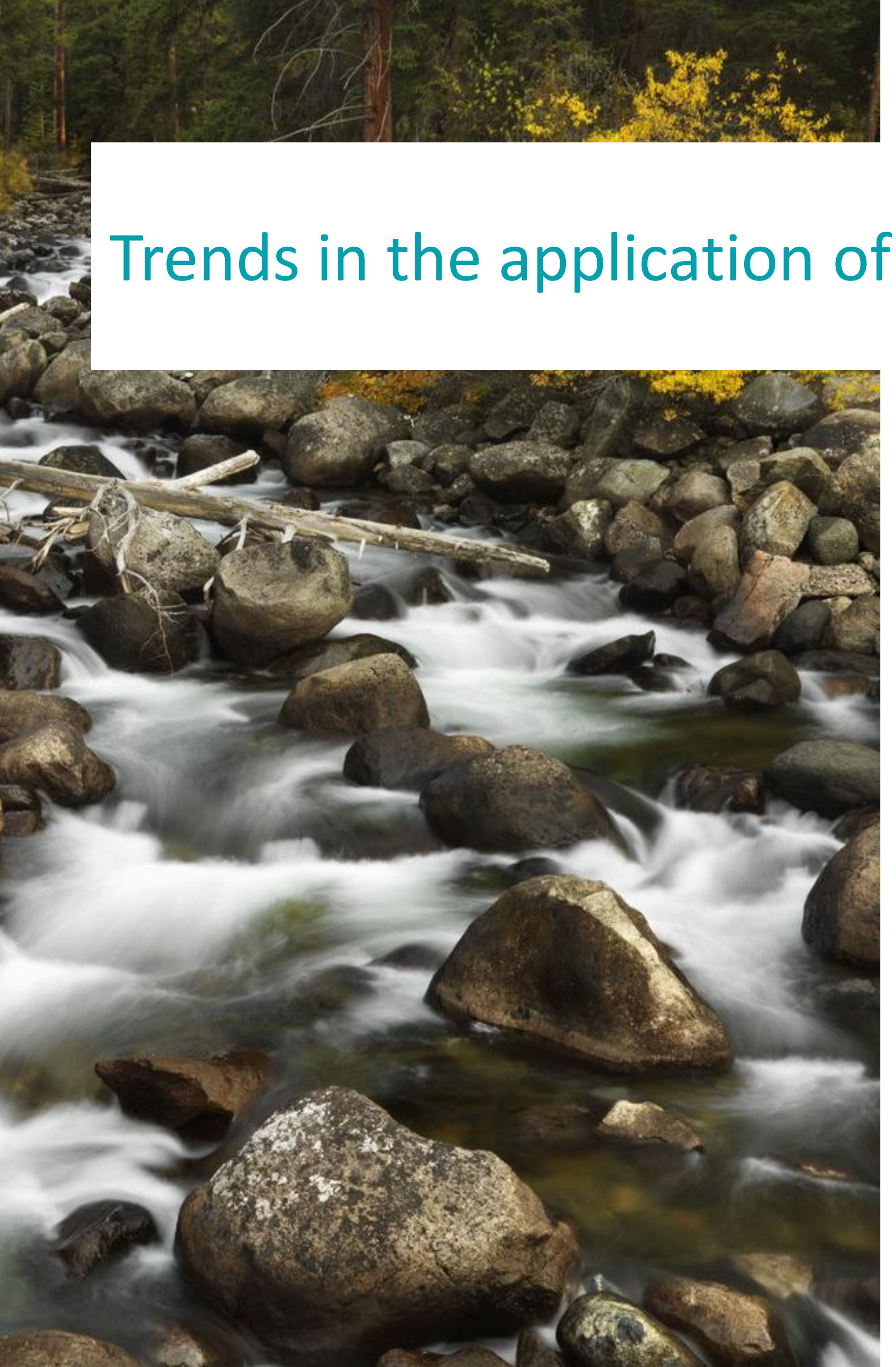
Life Cycle Assessment is a tool for assessing *systems*.

Measuring a multitude of environmental and social impacts…

…across the system, from raw material extraction through end-of-life.

LCA identifies burden-shifting and trade-offs when comparing alternative choices.

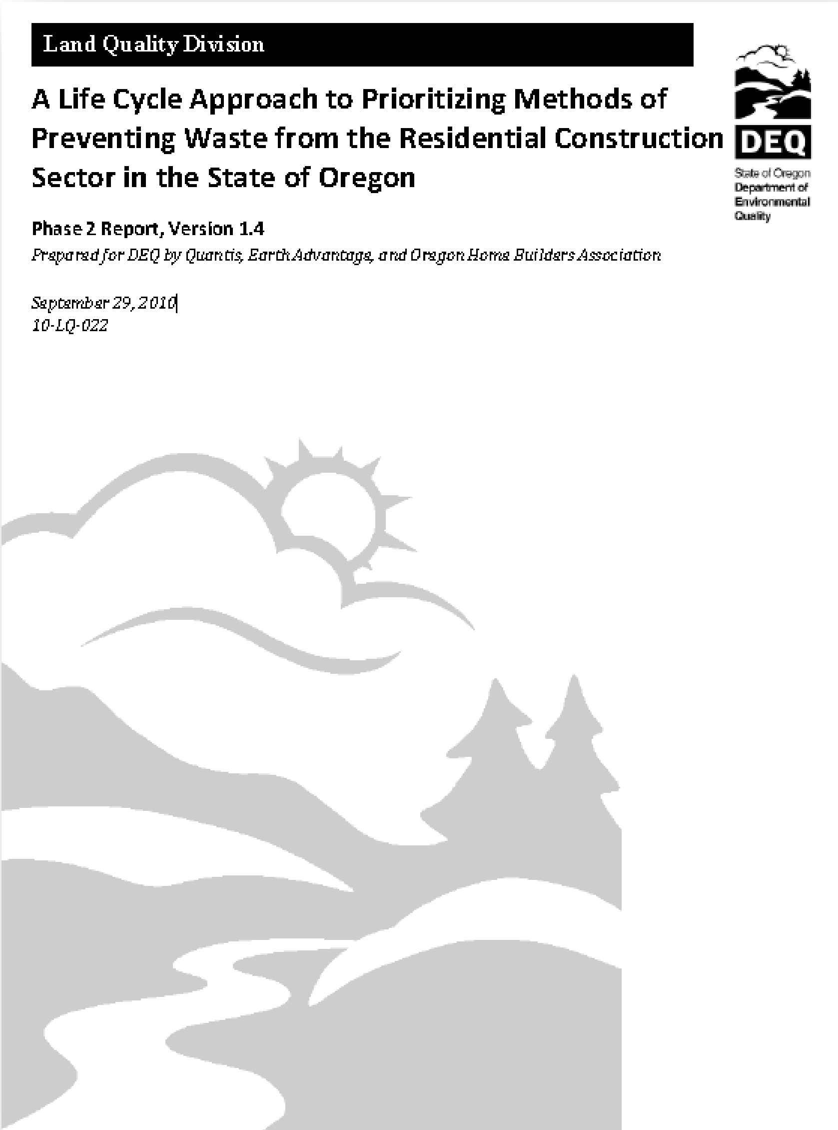
Trends in the application of LCA



Product LCA to support ***actions and claims***

Corporate footprints for ***strategy and reporting***

Life cycle guidance for ***product and process design***



Case study

- Published 2010 by Oregon Department of Environmental Quality.
- Identify residential construction practices that **reduce waste and avoid causing other impact**.

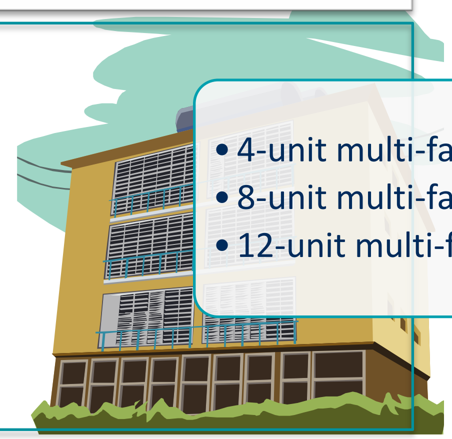
Available at: http://www.deq.state.or.us/lq/sw/wasteprevention/greenbuilding.htm

Numerous types of housing exist – where do we focus?

HOME SIZE

- Extra-small home (1,149 ft^2)
- Small home (1,633 ft^2)
- Medium home (2,262 ft^2)
- Large home (3,424 ft^2)

MULTI-FAMILY HOUSING



- 4-unit multi-family (2,262 ft^2)
- 8-unit multi-family (1,149 ft^2)
- 12-unit multi-family (1,149 ft^2)

An initial screening identified scenarios of interest to stakeholders and those with the potential to reduce waste.

- Medium home (2,262 ft^2)

WALL FRAMING	Intermediate framing
	Advanced floor framing
	Advanced framing (w/drywall clips)
	Double wall
	Insulating concrete forms (ICFs)
	Staggered stud
	Strawbale home
	Structural insulated panels (SIPs)

OTHER	Waste prevention home
	Durable roof, floor, & siding

MATERIAL RE-USE	Deconstruction
	Design for Disassembly
	Design Using Salvaged Materials
	Restoration
	Maximized Reuse

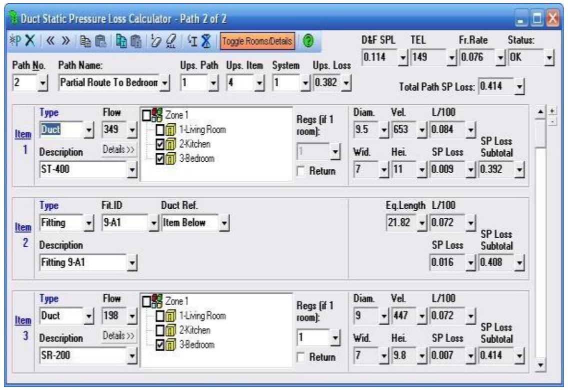
BENCHMARKS	Green Certified Home
	Green Certified Home w/ Passive Solar
	High Performance Shell Home
	Optimized End-of-Life, Reuse Excluded

Project partners provided data and expertise to develop the LCA model.

Materials

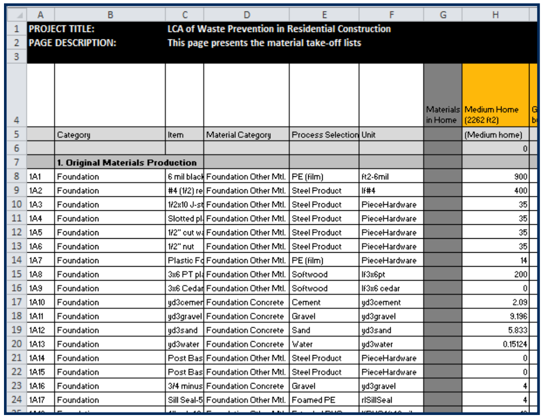
- Types
- Quantities
- Replacement
- End-of-life fate
- Transport distances

Operating energy

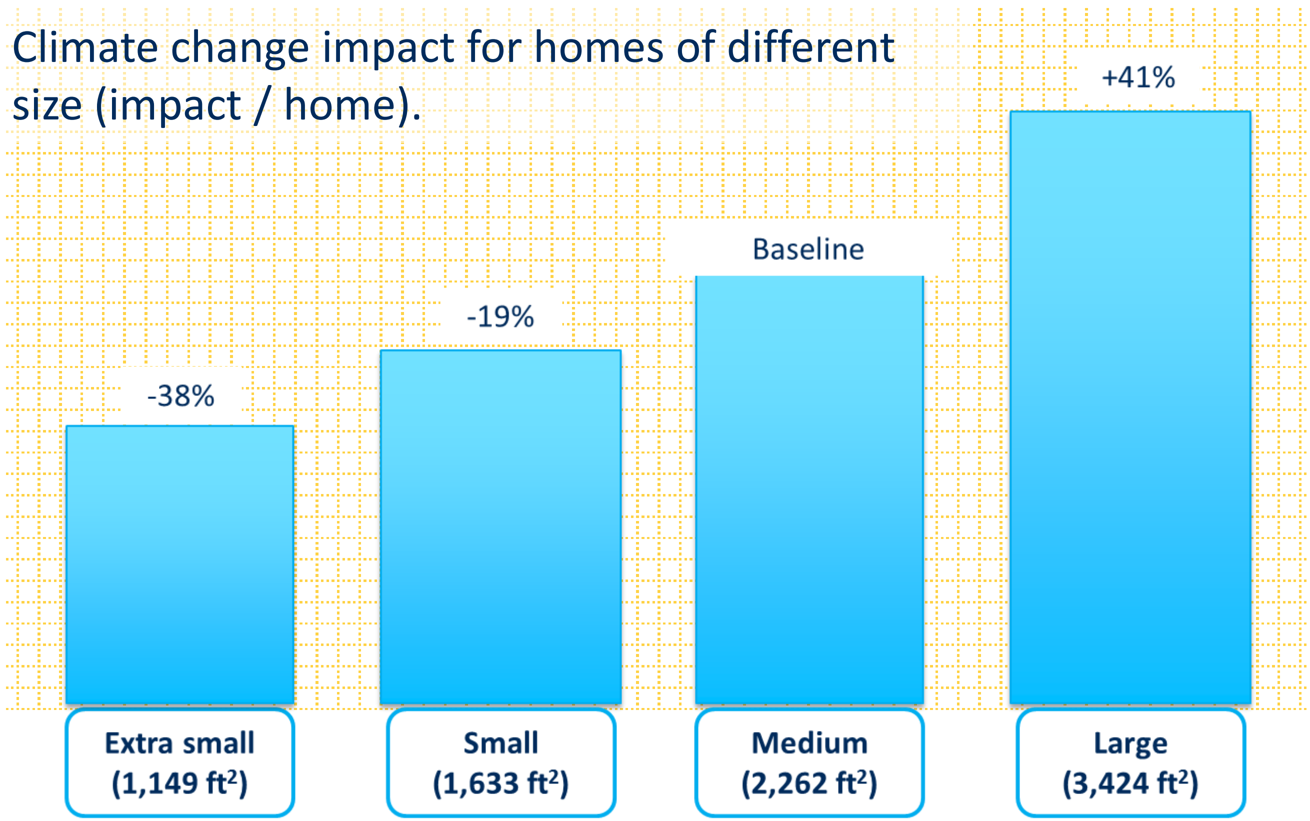


- Types (sources)
- Quantities
- Electricity grid mix

LCA modeling

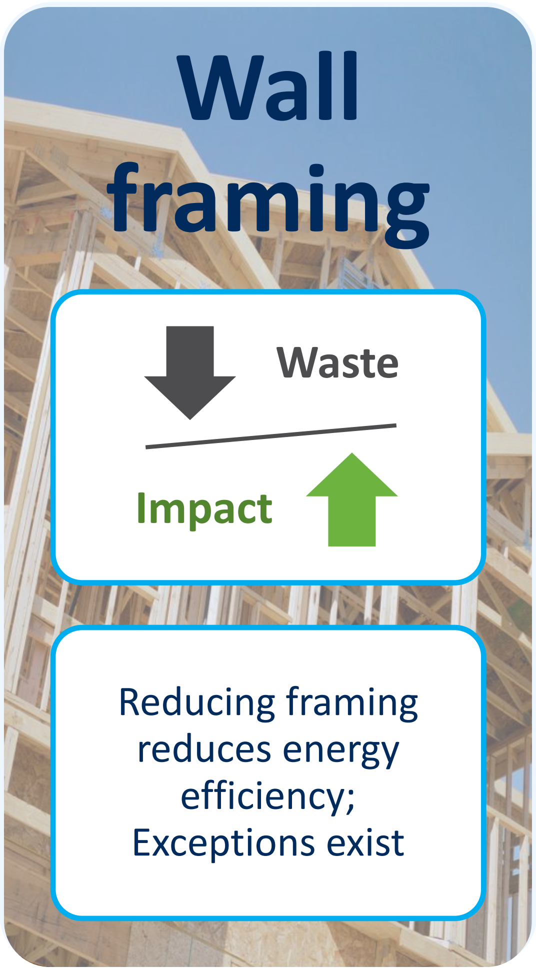


Conclusion: Smaller homes result in less impact on a per-home basis.



Conclusion: Waste generation is not a good indicator of environmental impact.

Conclusion: Waste generation is not a good indicator of environmental impact.



Conclusion: Waste generation is not a good indicator of environmental impact.

Wall framing

Waste

Impact

Reducing framing reduces energy efficiency; Exceptions exist

Salvage & Reuse

Waste

Impact

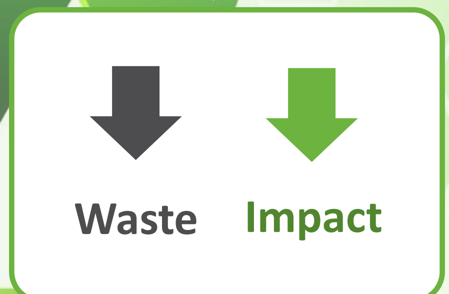
Large potential benefits: wood, metals, insulation, plastics

Conclusion: Waste generation is not a good indicator of environmental impact.

Wall framing

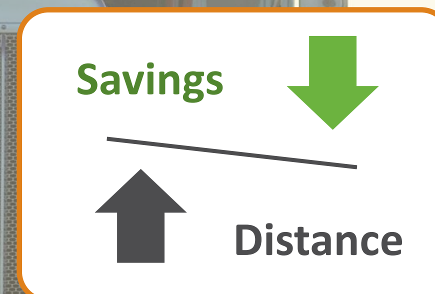
Reducing framing reduces energy efficiency; Exceptions exist

Salvage & Reuse



Large potential benefits: wood, metals, insulation, plastics

Reuse vs. Transport

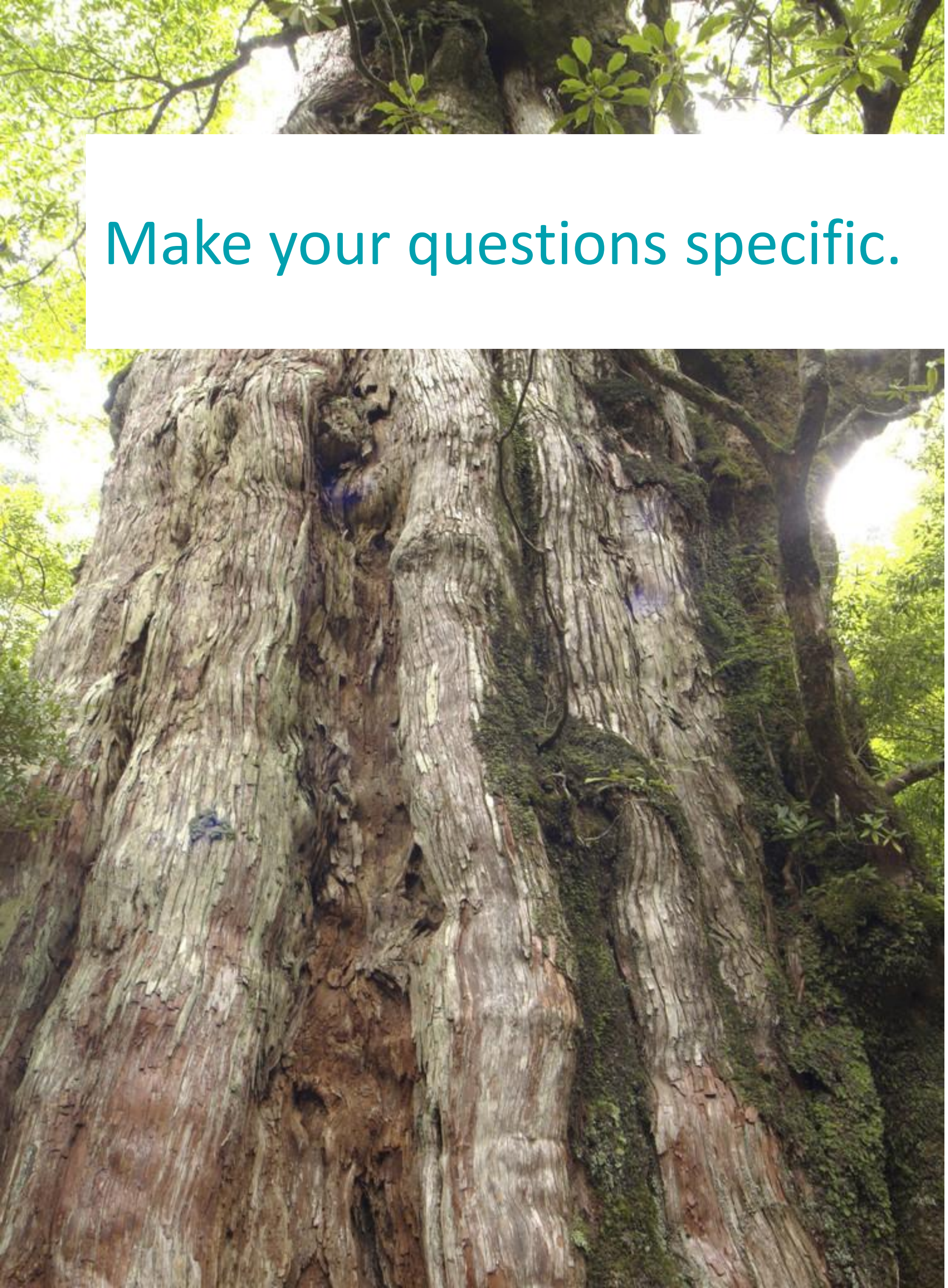


Local reuse maximizes benefits

Outcomes are being used to inform state code revisions, rating systems and other programs.

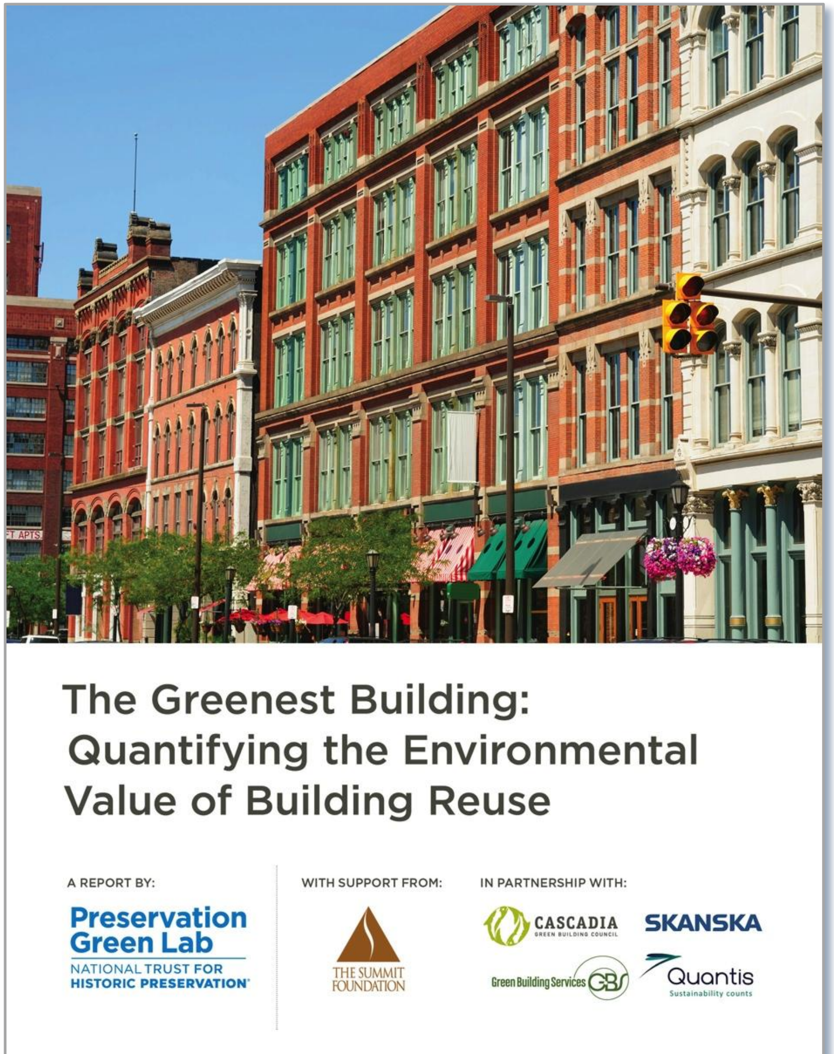
- Development of size-based tier system for residential code (REACH code)
- Permit regulations to promote material recovery during remodel and demolition
- Prospective alignment of tax credit with LCA results; Incentives to be based on size
- Potential exclusion of large homes from incentives provided by Energy Trust of OR
- Recalibration of rating system to emphasize house size

Make your questions specific.



"The most serious mistakes are not being made as a result of wrong answers. The truly dangerous thing is asking the wrong question."

-Peter Drucker



Available at: www.preservationnation.org

Case study

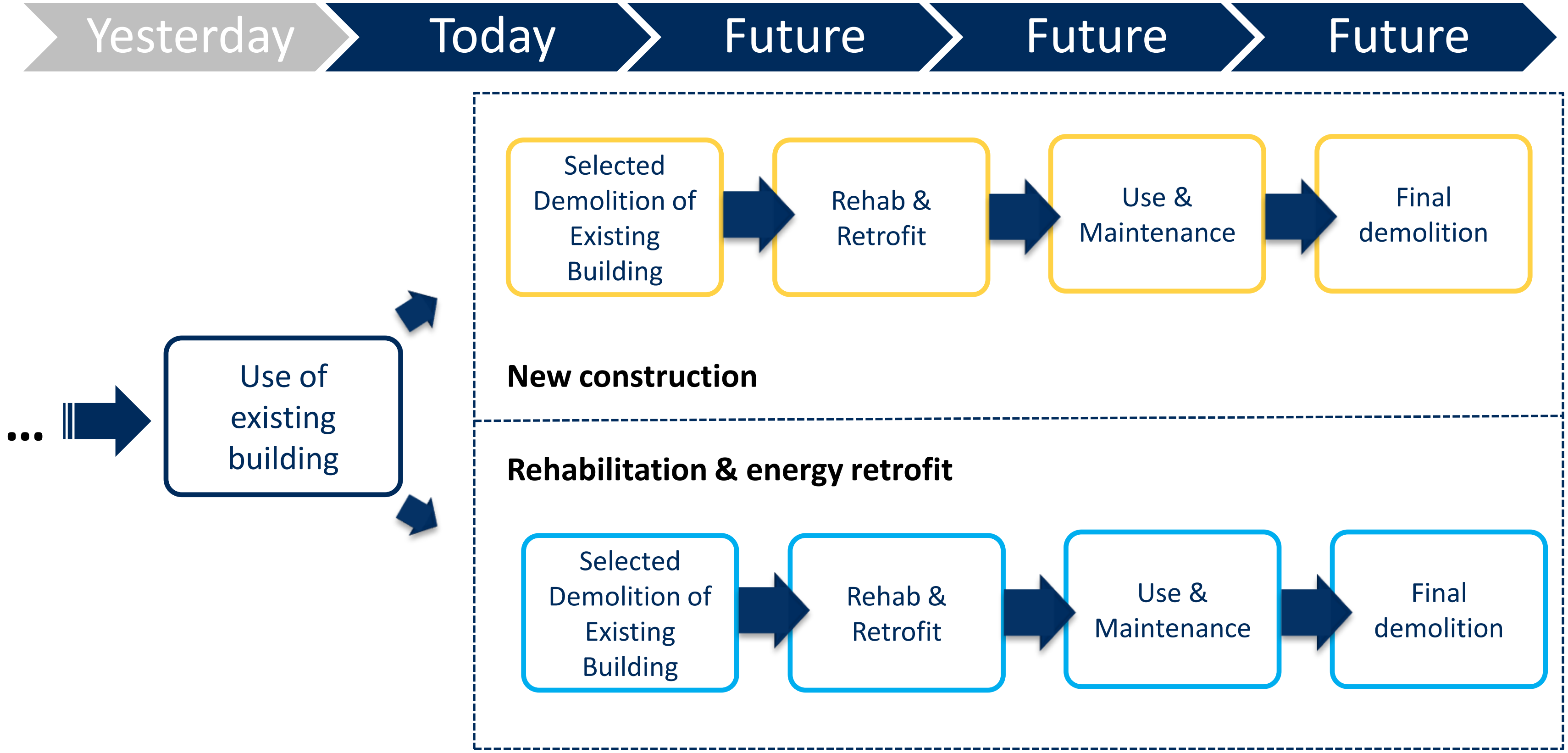
- Published January 2012 by National Trust for Historic Preservation.
- Characterize the relative environmental performance of **new construction compared to rehabilitation with energy retrofits.**

Identifying guiding questions focused the study.

Under what conditions is rehabilitation (with energy retrofits) environmentally advantageous to new construction?

- What role do building…
  - Type
  - Location
  - Energy performance
  - Lifetime …play?

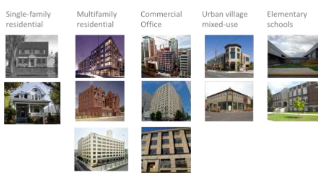
Impact incurred in the past are not considered because we cannot change those decisions.



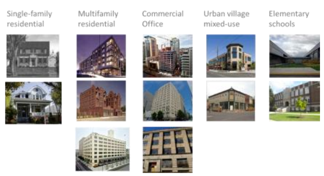
Study snapshot

Functional unit	1 ft^2 of usable interior space 75-year lifespan

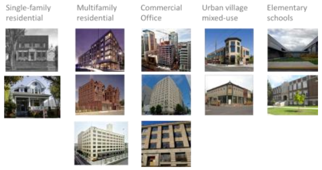
Study snapshot

Functional unit	1 ft^2 of usable interior space 75-year lifespan
	5 types of buildings (+2 warehouse repurposing projects)

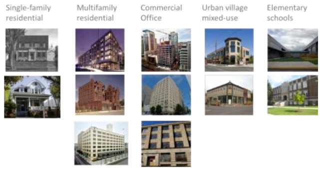
Study snapshot

Functional unit	1 ft^2 of usable interior space 75-year lifespan
	5 types of buildings (+2 warehouse repurposing projects)
	4 climate zones in the US

Study snapshot

Functional unit	1 ft^2 of usable interior space 75-year lifespan
	5 types of buildings (+2 warehouse repurposing projects)
	4 climate zones in the US
	2 energy performance scenarios

Study snapshot

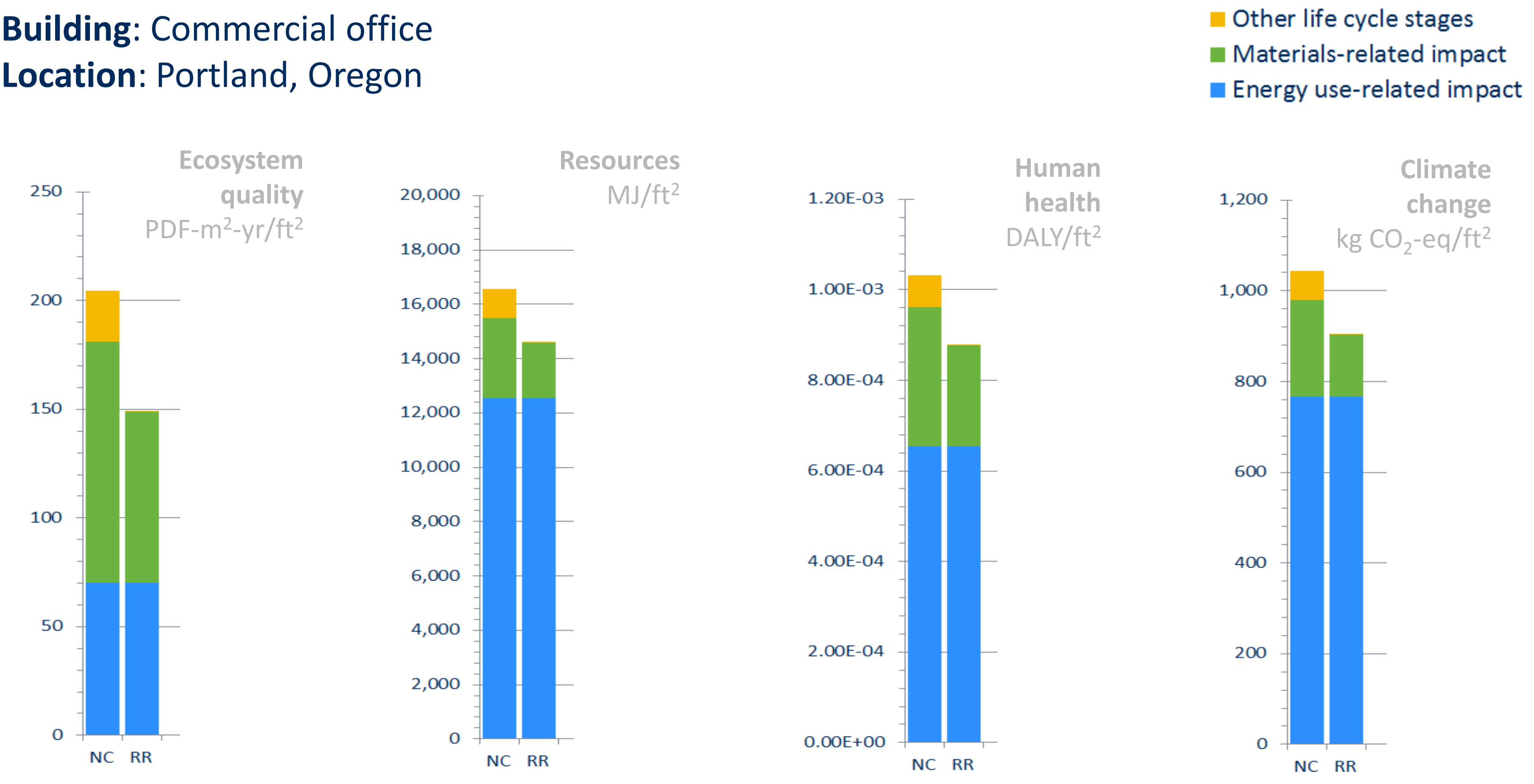
Functional unit	1 ft^2 of usable interior space 75-year lifespan
	5 types of buildings (+2 warehouse repurposing projects)
	4 climate zones in the US
	2 energy performance scenarios
	19 environmental indicators

Study exclusions

- Land occupation of buildings
- Building furnishings
- Maintenance
- Water use during building operation
- Indoor air emissions
- Impacts of building occupants (transport)
- Final demolition

Building reuse almost always yields lower environmental impacts than new construction when comparing buildings of similar size, functionality and energy use.

Building: Commercial office
Location: Portland, Oregon

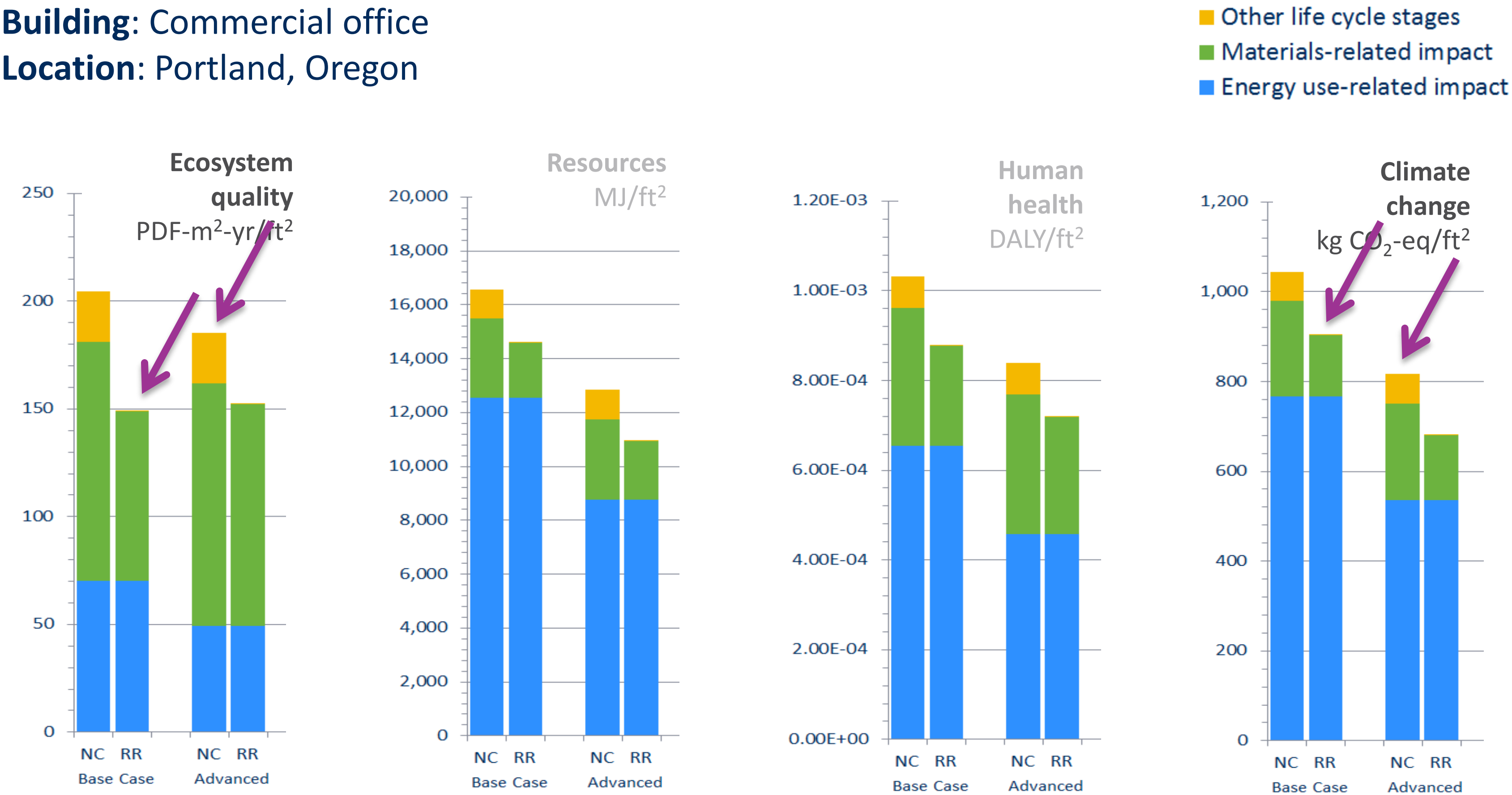


…Except for repurposing projects.

- Changing building function (commercial to residential)
- Quantity of materials similar to New Construction
- Further research needed

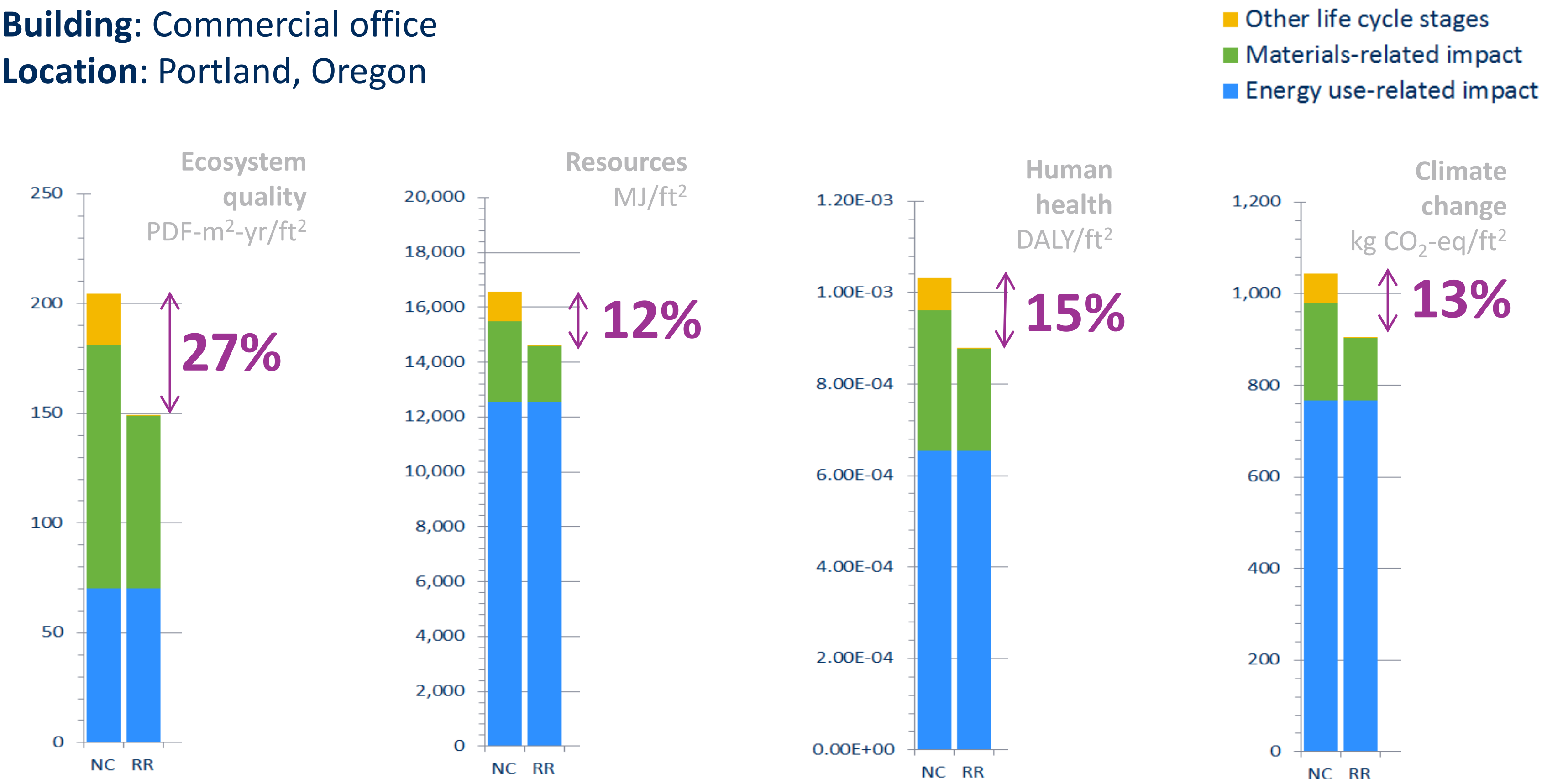
Energy performance affects relative results only of indicators that are dominated by energy-related impacts…

Building: Commercial office
Location: Portland, Oregon

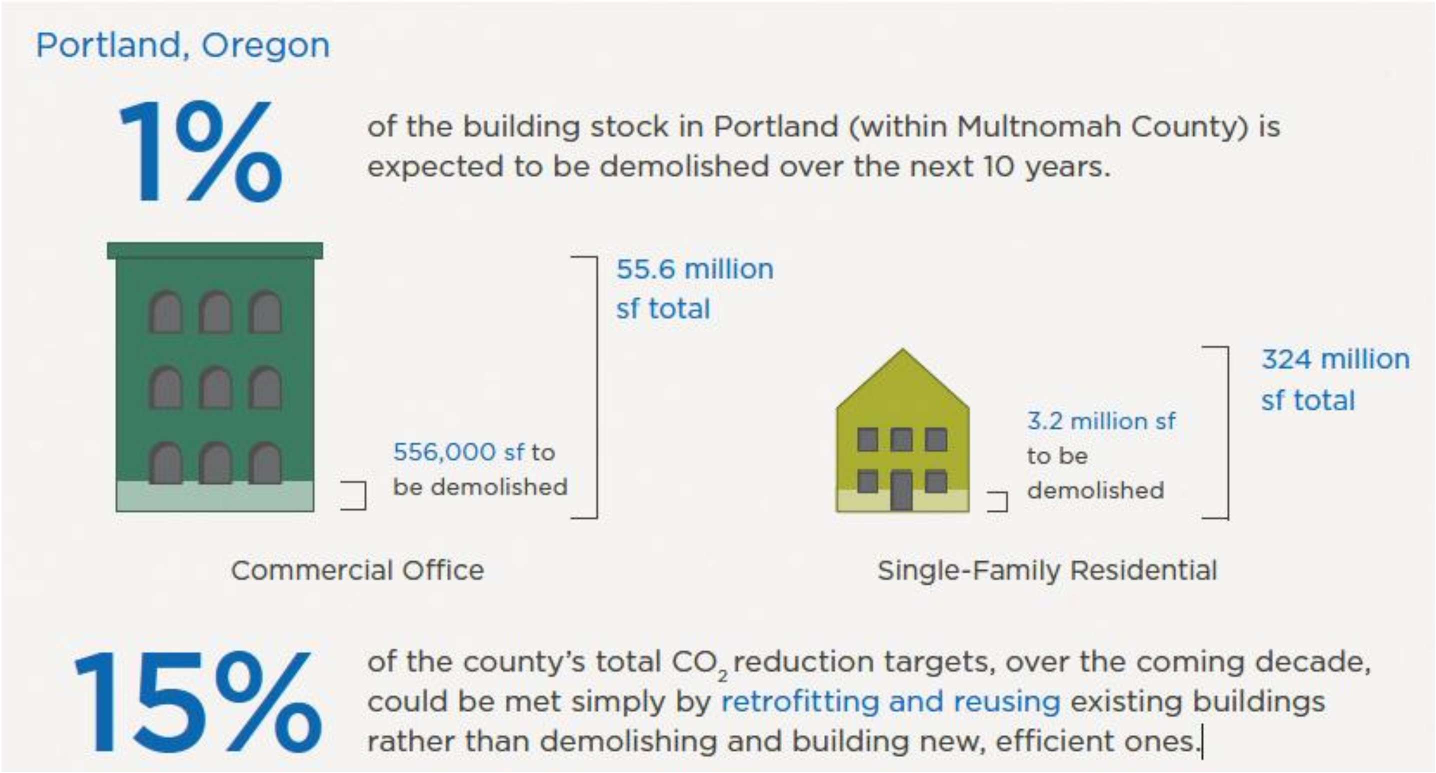


Impact savings can be substantial when scaled across the building stock of a city.

Building: Commercial office
Location: Portland, Oregon



Rehabilitating 1% of offices and homes in Portland would meet 15% of the county's CO_2 reduction targets.



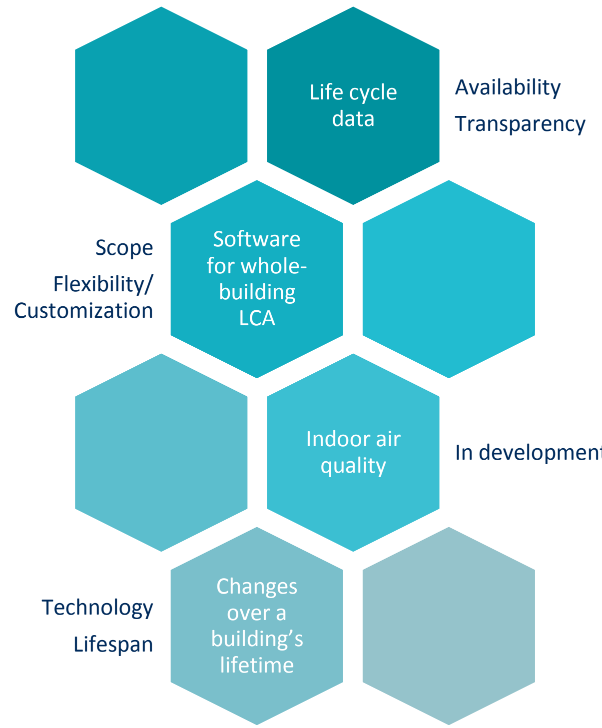
Study outcomes helped the National Trust develop science-based messages to promote building preservation and reuse.

Retrofitting can provide environmental advantages as compared to demolishing and new construction

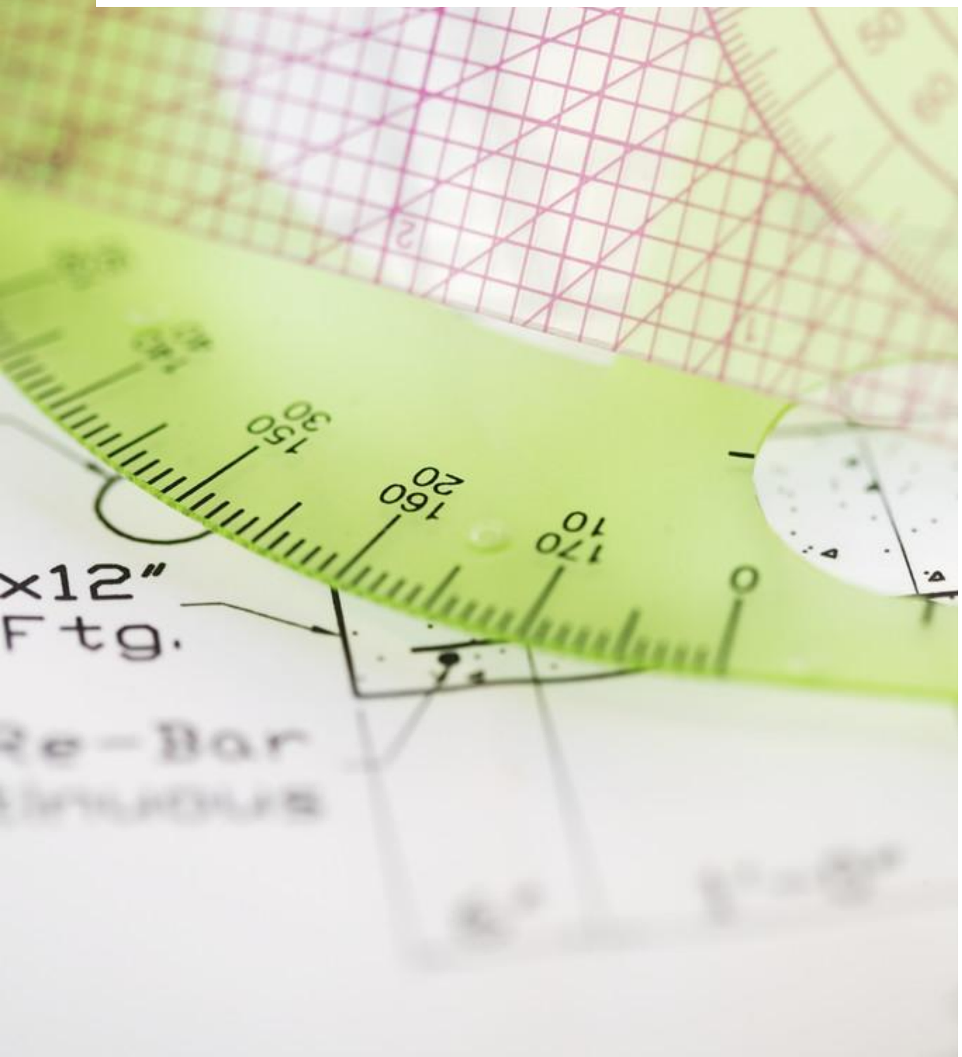
Building retrofit and reuse can help communities achieve their near-term carbon reduction goals.

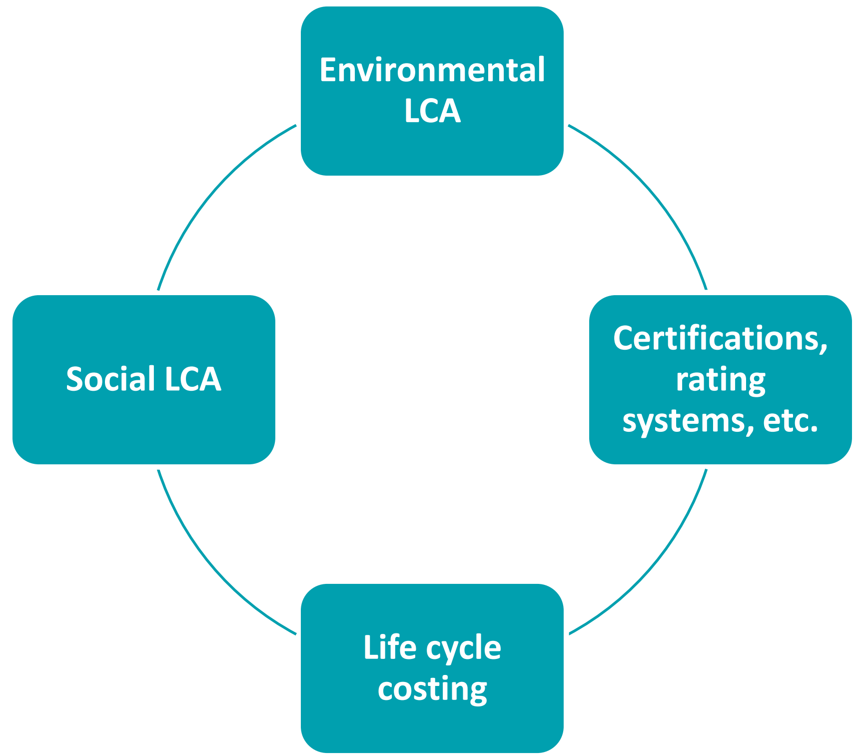
Building lifespan is an important consideration when considering energy efficiency improvements.

Some limitations are common to whole-building analyses but can be addressed with additional effort.



LCA is a complementary tool for decision-making.





Questions about LCA?

Carbon footprint

Water footprint

Ecosystem quality

Natural resources

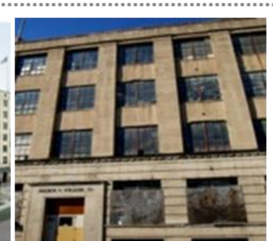
Human health

Medium standard home (2,262 ft^2)

Characteristic	Description
Interior Size	2,262 square feet
Exterior Dimensions	33 ft x 35 ft
Stories	2
Garage	Yes, attached
Foundation	Vented crawl space
Conditioned Building Volume:	20358 ft^3
Bedrooms/Bathrooms	3/2
Framed Floor Insulation	R30 fiberglass
Walls Insulation	R21 fiberglass, framing factor 26%
Ceiling Insulation	R38 fiberglass
Windows	Double-glazed, low-e, vinyl frame, U-0.35; 374 ft^2 of windows, minimal solar gain orientation
Doors	2¼-in solid wood, R2.8
Heating	90% efficient gas furnace
Water Heating	58% efficient gas storage tank
Building Standards	Oregon building code minimum
Air Conditioning	None
Flooring	2,000 ft^2 carpet, 200 ft^2linoleum
Roofing	Asphalt shingles
Roof Truss	Standard truss
Duct Leakage	RESNET/HERS default, all leakage outside of thermal envelope
Building Air Leakage	6.5 ACH@50 Pascals
Siding	2124 $ft^2$of wood siding
Walls	92-5/8-in studs; 8'1" height; single sole/double top plates, headers on all
Floor Framing Style	Post and beam
Floors	4" x 8" beams,, 32" on-center, plywood subfloors
Wall Interiors	Drywall
Plumbing	PEX

Medium standard home (2,262 ft^2)

Real buildings provided real materials quantification

	Single-family residential	Multifamily residential	Commercial Office	Urban village mixed-use	Elementary schools
New Construction					
Rehabilitation and Retrofit					
Warehouse Conversion					

<table>
<tr><th rowspan="2">Activity</th><th colspan="4">LIFE CYCLE STAGE</th></tr>
<tr><th colspan="2">Pre-occupancy</th><th>Occupancy</th><th>Post-occupancy</th></tr>
<tr><td>Extraction of raw materials</td><td colspan="2" rowspan="4">Production of original materials</td><td rowspan="4">Production of replacement materials</td><td rowspan="4"></td></tr>
<tr><td>Refinement of raw materials</td></tr>
<tr><td>Manufacture of products</td></tr>
<tr><td>Transportation occurring upstream of the product supplier</td></tr>
<tr><td>Transportation of products from supplier to building site</td><td colspan="3">Transportation of materials</td><td></td></tr>
<tr><td>Operation of heavy machinery</td><td rowspan="3">Demolition/ Selected demolition</td><td rowspan="3">New construction/ Rehabilitation & retrofit</td><td rowspan="3">Maintenance</td><td rowspan="3"></td></tr>
<tr><td>Use of electricity by construction-related activities</td></tr>
<tr><td>Transportation of construction workers to and from building site</td></tr>
<tr><td>Space and water heating</td><td colspan="2" rowspan="2"></td><td rowspan="2">Heating, cooling & plug loads</td><td rowspan="2"></td></tr>
<tr><td>Electricity use</td></tr>
<tr><td>Water use</td><td colspan="2"></td><td>Water use</td><td></td></tr>
<tr><td>Operation of heavy machinery</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3">Final demolition</td></tr>
<tr><td>Use of electricity by demolition-related activities</td></tr>
<tr><td>Transportation of construction workers to and from building site</td></tr>
<tr><td>Transportation of materials from the building site to end-of-life</td><td colspan="4" rowspan="2">Materials end-of-life management</td></tr>
<tr><td>Landfill, recycling, and incineration/waste-to-energy processes</td></tr>
</table>

Impact assessment: IMPACT 2002+ (Joliet et al. 2003)

Resources

- Non-renewable energy use
- Mineral extraction

Ecosystem quality

- Aquatic acidification
- Aquatic ecotoxicity
- Aquatic eutrophication
- Land occupation
- Terrestrial acidification/ nutrification
- Terrestrial ecotoxicity
- Ozone depletion
- Photochemical oxidation

Human health

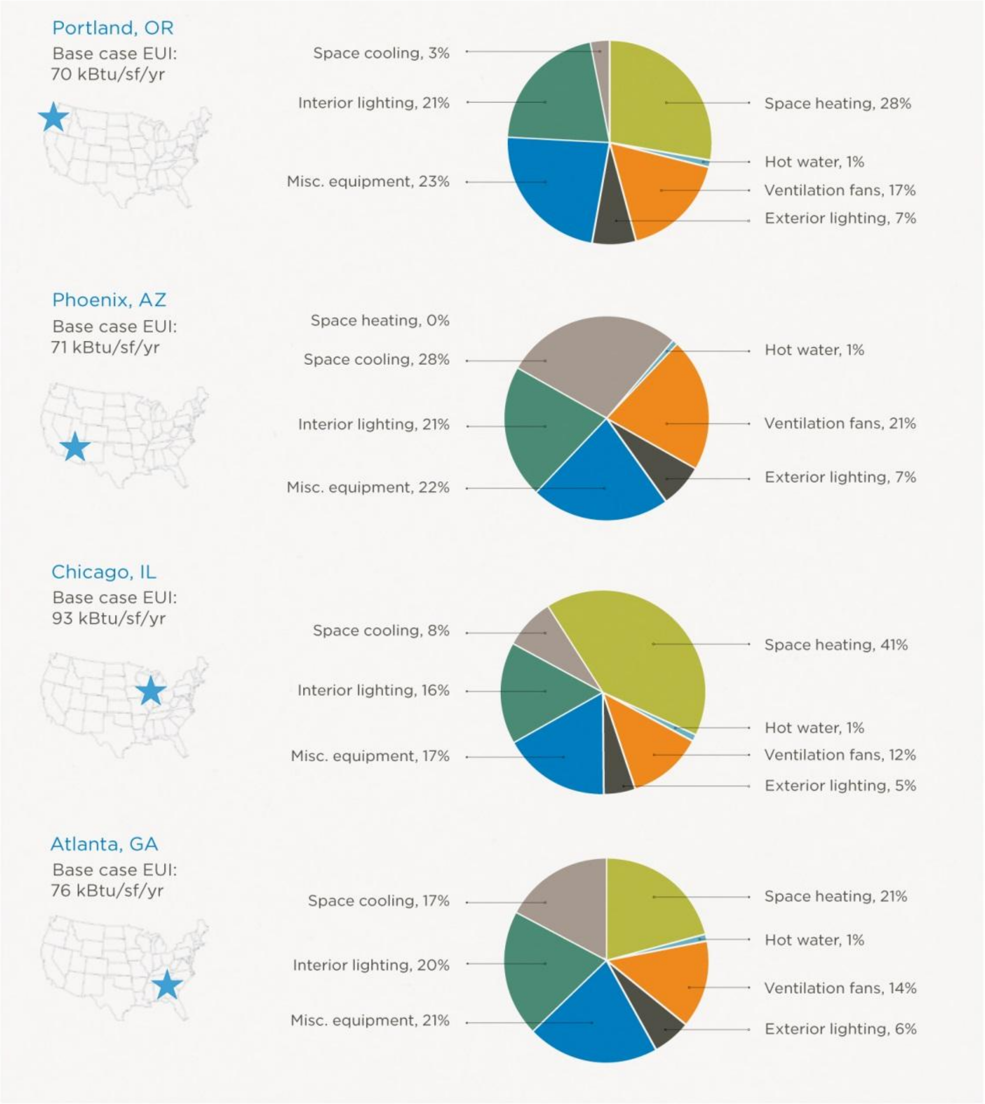
- Human toxicity
- Ionizing radiation
- Respiratory effects
- Ozone depletion
- Photochemical oxidation

Climate change

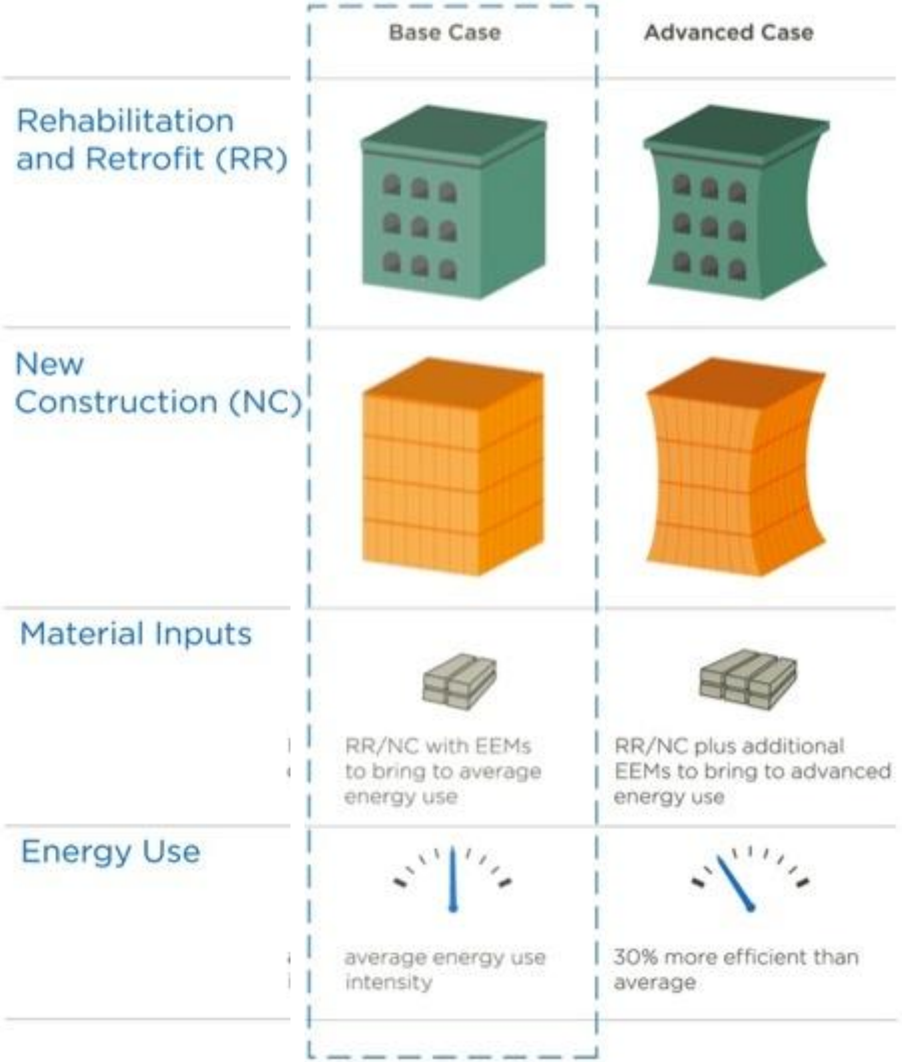
IMPACT2002+ (Joliet et al. 2003)

Energy profile determined by building location

Quantity
Type
Grid mix



Energy performance scenario testing



Energy performance scenario testing

Example:

Commercial office in Portland




	Base Case	Advanced Case
Energy kBTU/ft²/y	70	49
Materials	RR/NC With additional energy efficiency measures	RR/NC With additional energy efficiency measures

Energy efficiency measures

EEM	BASE CASE	ADVANCED CASE
LIGHTING/DAYLIGHTING		
Lighting Power Density 0.8 watt/sf	X	
Occupancy Sensors	X	
Daylight Dimming Controls	X	
HVAC		
Demand Control Ventilation (DCV)		X
Variable Frequency Drive (VFD)	X	X
Chilled Beams		X
Boiler 90%+ Efficiency	X	
Economizer Control	X	X
Heat Recovery		X
ENVELOPE		
R-20 Roof Insulation	X	
R-13 Wall Insulation	X	
R-19 Wall Insulation		X
Infiltration Reduction-Caulking	X	
Infiltration 0.20 air change/hour	X	X
GLAZING		
U-0.32 or Better	X	
Low-e Coated	X	