
Constructing a Retrofit Plan
Sarah Gray, M.Sc, P.Eng.
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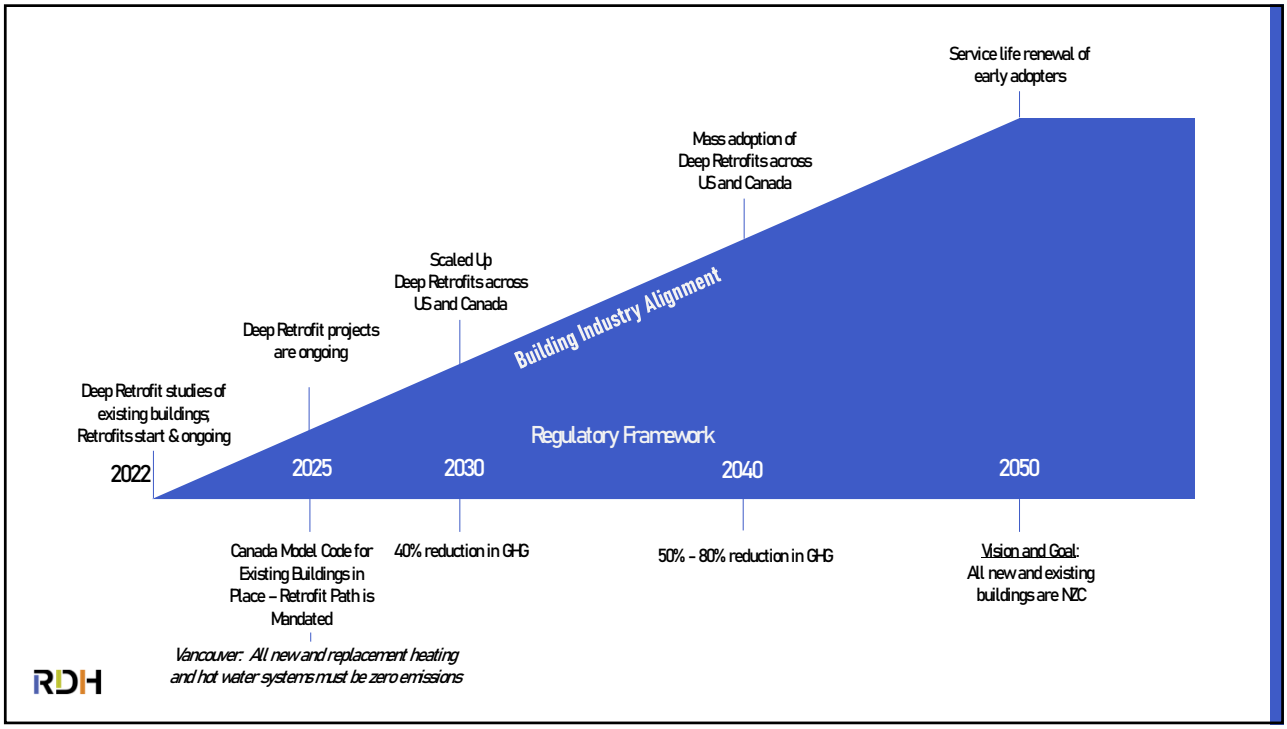
Service life renewal of early adopters
Mass adoption of Deep Retrofits across US and Canada
Scaled Up Deep Retrofits across US and Canada
Deep Retrofit projects are ongoing
Deep Retrofit studies of existing buildings; Retrofits start & ongoing
Building Industry Alignment
Regulatory Framework
2022
2025
2030
2040
2050
Canada Model Code for Existing Buildings in Place – Retrofit Path is Mandated
40% reduction in GHG
50% - 80% reduction in GHG
Vision and Goal: All new and existing buildings are NZC
Vancouver: All new and replacement heating and hot water systems must be zero emissions
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Every building needs a plan.

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From RMI's *Best Practices for Achieving Zero Over Time*

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Identify Potential Retrofit Goals

Internal and/or External Goals

Greenhouse gas/carbon reduction

Thermal comfort improvement

Energy efficiency improvements

Indoor air quality improvement

Operations cost reduction

Improve curb appeal / resale value

Fire/smoke mitigation

Seismic retrofit

Flood mitigation

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Document Your Retrofit Goals

Current & Future Cost

- Increase leasing revenue
- Improve resale value
- Reduced operational cost (current/future, inc. carbon pricing)
- Reduced maintenance costs and requirements (capital plan)

Code Requirements

- Anticipate more stringent energy codes and retrofit requirement

Comfort and IAQ

- Occupant health and Indoor Air Quality improvement
- Thermal comfort improvement
- Acoustic comfort improvement

Future Proofing

- Resiliency against future climate
- Passive survivability (response to extreme weather events)

Energy & Carbon

- Energy efficiency improvements
- GHG/carbon emission reduction
- Easier electrification
- Embodied carbon savings

Building Performance

- Actual performance vs predicted performance

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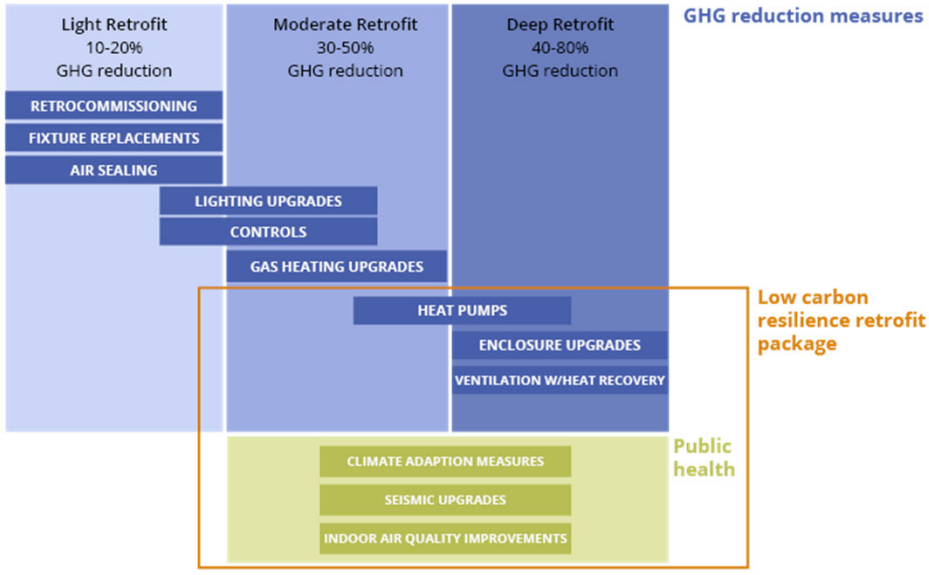

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Original Concept for Graphic: Pembina Reframed Initiative

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Write a Strong Retrofit Goal Statement

- Net Zero Carbon by 2040
- Net Zero Carbon by 2050
- 50% Greenhouse Gas Emissions reduction by 2030, then Net Zero Carbon by 2050
- Achieve Net Zero Carbon with our planned major retrofit starting soon

Show me the potentials for reduced energy consumption, reduced GHGs, and costs for light, medium or deep retrofit… then I'll decide my goal.

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RDH Retrofit Roadmap

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Project Scoping and Goal Setting

- Help owners determine objectives
- Discuss and capture goals
- Determine the next steps for the planning and assessment phase

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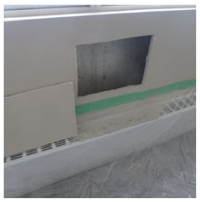
Conduct Building Assessment

- Review building documentation, previous reports, previous repairs
- Visual examination including exploratory work – primarily building enclosure and mechanical, but also electrical and structural/seismic
- Possibly conduct air tightness testing

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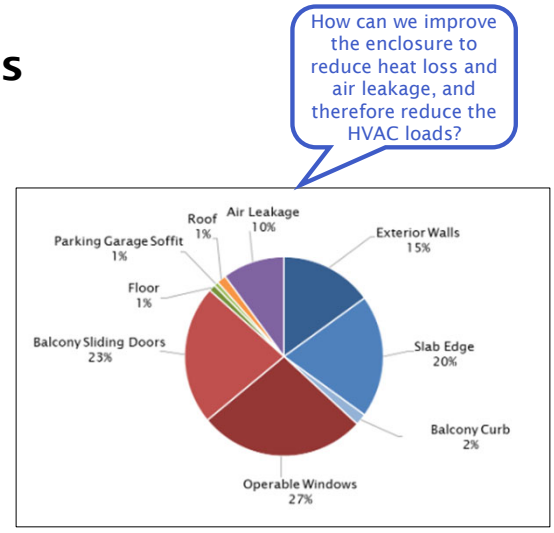
Establish Current Heat Loss

WHOLE BUILDING R-VALUE		Existing building effective R-value	R-1.4 (1)
PRIMARY ROOFS		Conventional roof assembly (exposed membrane) with 2" rigid polyisocyanurate insulation	R-11.4
MECHANICAL PENTHOUSE WALLS		Corrugated metal cladding with 1" thick exterior rigid EPS insulation	R-5.0
PRIMARY ABOVE-GRADE WALLS	PRECAST	Pre-cast panels with 2" thick exterior rigid EPS insulation and uninsulated steel stud wall	R-10.7
	STUCCO	Non-drained stucco over uninsulated steel stud wall	R-2.9
SLAB EDGE		Uninsulated pre-cast panels outboard of concrete slab edge	R-0.5
BALCONY SLAB EDGE		Uninsulated concrete balcony slab	R-1.2
PRIMARY EXTERIOR GLAZING SYSTEMS	FIXED WINDOW	Aluminum framed windows with clear double glazed IGUs, no low-e coating, and no argon gas fill	R-1.0
	OPERABLE WINDOW	Aluminum framed single pane windows with horizontal sliders	R-0.5
	BALCONY SLIDERS	Aluminum framed single pane balcony sliding glass doors	R-0.5
PARKING GARAGE SOFFIT		Uninsulated concrete deck	R-0.5



STEADY STATE HEAT LOSS THROUGH THE EXISTING BUILDING ENCLOSURE (ASHRAE DESIGN DAY CONDITIONS)

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Baseline Benchmarking

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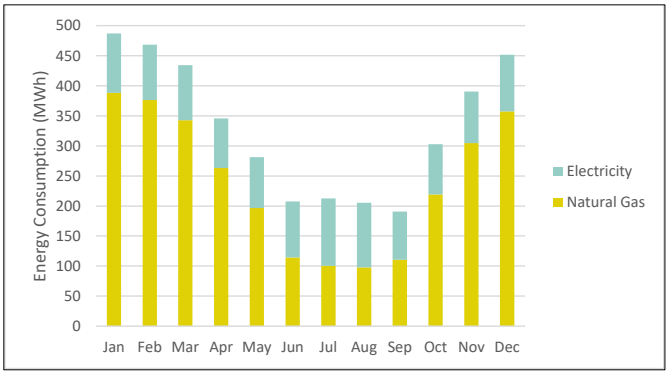
Existing Utility Bill Review and Analysis



	EXISTING
GHGI (KGCO$_2$e/M^2/YR)	14
TEUI (KWH/M^2/YR)	200
TEDI (KWH/M^2/YR)	77
ANNUAL CO$_2$e (TONNES)	230
ANNUAL NATURAL GAS (MBTU)	3,500
ANNUAL ELECTRICITY (kWh)	2,300,000

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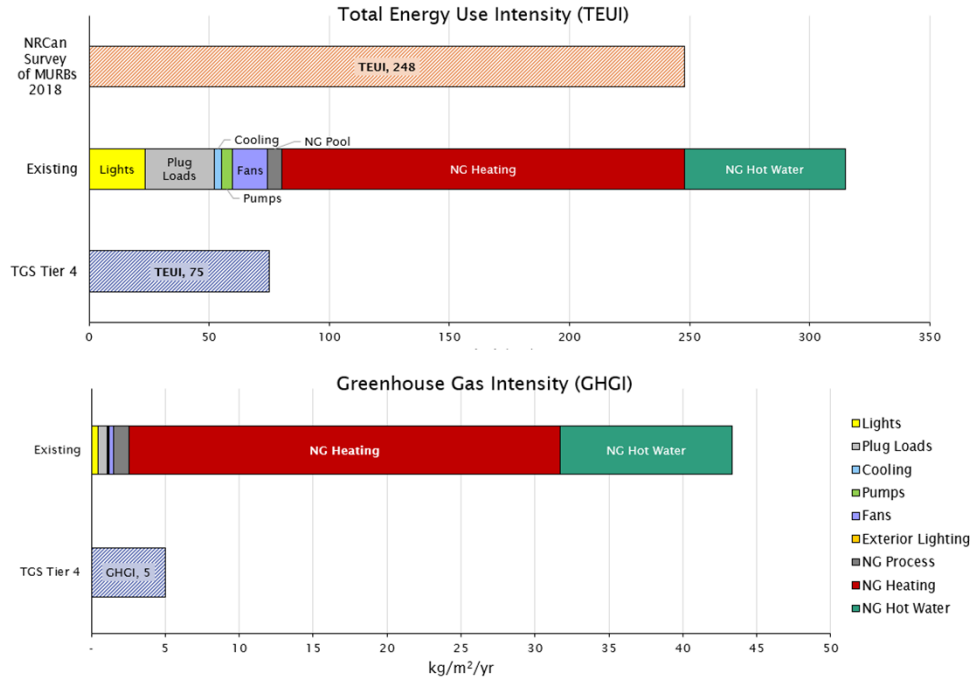

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Identify Potential Retrofits

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Retrofit Language

- Energy Conservation Measures (ECMs)
- Carbon Reduction Measures (CRMs)
- Low Carbon Resilience Measures (LRCMs) - combines climate adaptation and mitigation

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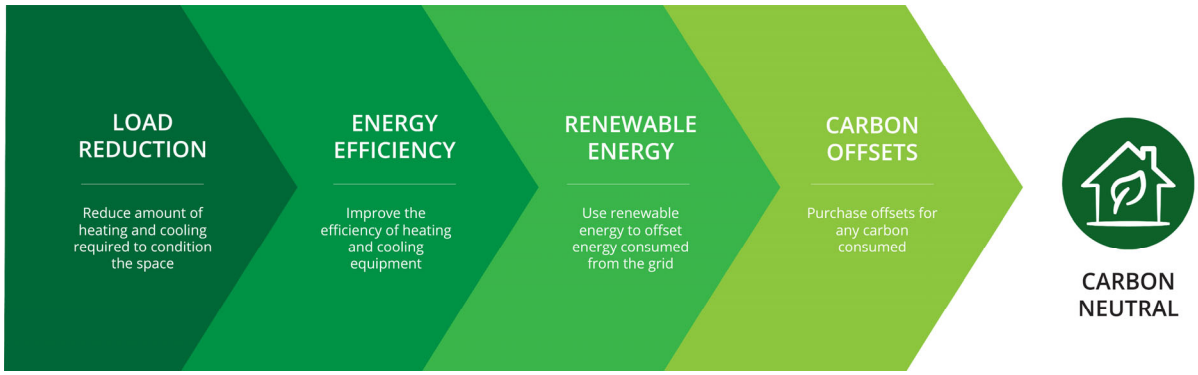

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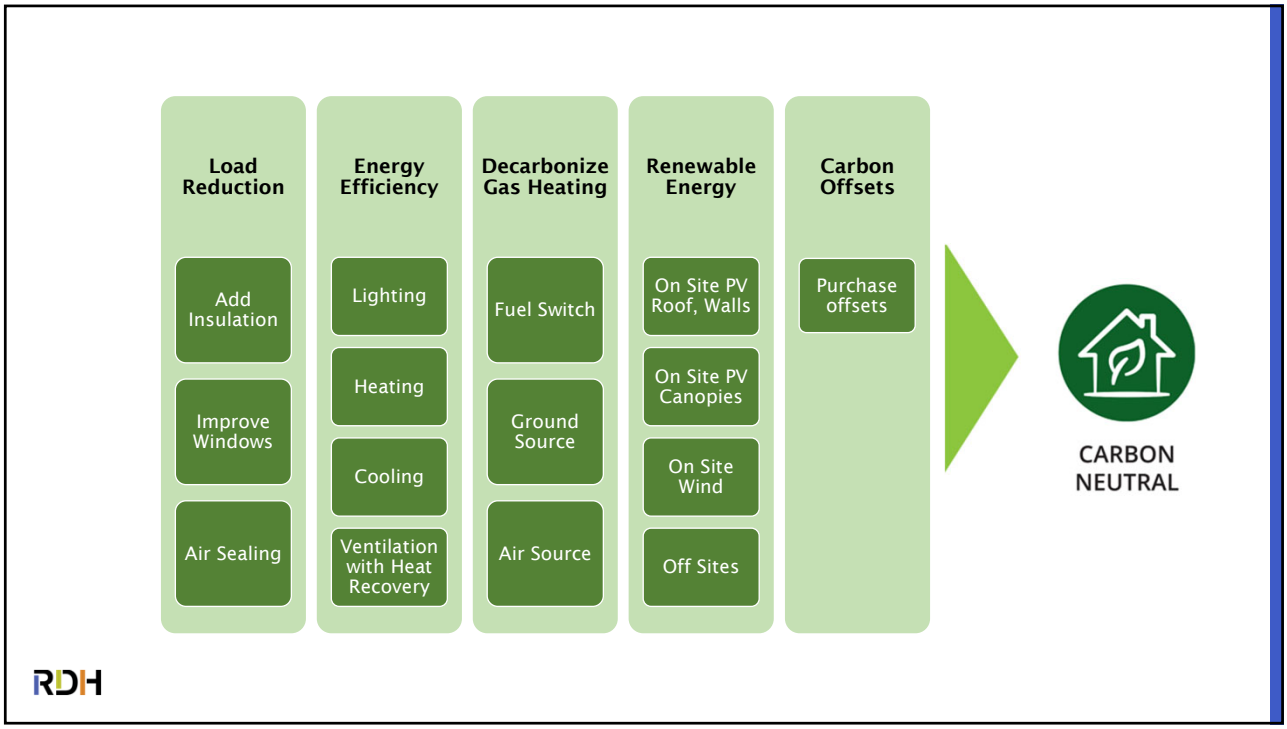

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Enclosure System Retrofit Options

System	Retrofit / Replacement Options	Considerations
Cladding	• Over-clad with EIFS, clip-and-rail, or panelized system • Full cladding replacement • Balcony slab and/or curb insulation	• Back-up wall condition and structural capacity • Flashing and AVB integration • Sequencing with windows
Windows	• Weatherstripping and sealing • Double or triple pane IGUs • Thermally broken frames • Fibreglass frames (?) • Passive House window system	• Anchorage at sill and jambs • Sequencing with overclad
Roofing	• Add insulation to field of roof • Wrap parapet with insulation • Accommodate PV	• Increase height of parapet, curbs, and door sills • Replace roof anchors with longer stem
Underground Parking Garage	• Insulate the soffit under occupied ground floor space	• Ceiling clearance • Fire protection of insulation

Assess ventilation (fresh air supply) needs and condensation risks for all retrofit options!

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Enclosure System Retrofit Options

		EXISTING BUILDING		LIGHT RETROFIT		MEDIUM RETROFIT						DEEP RETROFIT	
WHOLE BUILDING R-VALUE		Existing building effective R-value	R-1.4 [1]	No change from existing	R-1.4	Using **Option 1** Windows	R-3.5	Using **Option 2** Windows	R-3.7	Using **Option 3** Windows	R-4.0	Existing building effective R-value	R-11.5
PRIMARY ROOFS		Conventional roof assembly (exposed membrane) with 2" rigid polyisocyanurate insulation	R-11.4	Roof replacement to match existing	R-11.4	Roof replacement to match existing					R-11.4	Roof replacement to match existing	R-11.4
MECHANICAL PENTHOUSE WALLS		Corrugated metal cladding with 1" thick exterior rigid EPS insulation	R-5.0	No change from existing	R-5.0	No change from existing					R-5.0	Replace metal cladding with 4" thick exterior insulation and rainscreen cladding	R-15
PRIMARY ABOVE-GRADE WALLS	PRECAST	Pre-cast panels with 2" thick exterior rigid EPS insulation and uninsulated steel stud wall	R-10.7	Targeted repairs to precast and exposed concrete & exterior sealant replacement to match existing	R-10.7	Targeted repairs to precast and exposed concrete & exterior sealant replacement to match existing					R-10.7	Overclad pre-cast with 4" thick exterior insulation and rainscreen cladding (i.e., metal cladding or EIFS)	R-25
	STUCCO	Non-drained stucco over uninsulated steel stud wall	R-2.9	No change from existing	R-2.9	No change from existing					R-2.9	Replace non-drained stucco with 4" thick exterior insulation EIFS system	R-18
SLAB EDGE		Uninsulated pre-cast panels outboard of concrete slab edge	R-0.5	No change from existing	R-0.5	No change from existing					R-0.5	Overclad pre-cast with 4" thick exterior insulation and rainscreen cladding	R-15
BALCONY SLAB EDGE		Uninsulated concrete balcony slab	R-1.2	No change from existing	R-1.2	No change from existing					R-1.2	Exterior insulated concrete curb under balcony door	R-1.8
PRIMARY EXTERIOR GLAZING SYSTEMS	FIXED WINDOW	Aluminum framed windows with clear double glazed IGUs, no low-e coating, and no argon gas fill	R-1.0	Targeted IGU replacement to match existing	R-1.0	**ENCL Option 1** New aluminum framed, thermally broken windows and balcony sliders with clear **double glazed** IGUs [2]	R-2.5	**ENCL Option 2** New aluminum framed, thermally broken windows and balcony sliders with clear **double glazed View Glass** IGUs [2]	R-3.0	**ENCL Option 3** New aluminum framed, thermally broken windows and balcony sliders with clear **triple glazed** IGUs [2]	R-4.0	New **fiberglass** framed punched windows with clear **triple glazed** IGUs [2]	R-7.2
	OPERABLE WINDOW	Aluminum framed single pane window with horizontal sliders	R-0.5	Localized gasket and weatherstripping replacement	R-0.5								
	BALCONY SLIDERS	Aluminum framed single pane balcony sliding glass doors	R-0.5	Localized gasket and weatherstripping replacement	R-0.5								
PARKING GARAGE SOFFIT		Uninsulated concrete deck	R-0.5	No change from existing	R-0.5	2" semi-rigid mineral wool insulation installed to underside of concrete deck					R-8	2" closed-cell spray foam insulation installed to underside of concrete deck	R-12

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Mechanical System Retrofit Options

System	Retrofit / Replacement Options	Considerations
Heating and Cooling	Electric heat pumps: • Air-to-water (hydronic) heat pumps • Air-source heat pumps • Ground source (pending further study)	• Space on roof, at-grade, or on balconies to place the outside units • Noise of outdoor fans, line sets • New terminal units
Fresh Air Supply and Exhaust Air	• Central dedicated outdoor air supply (DOAS) • Energy/heat recovery ventilators (ERVs/HRVs) – in-suite or central	• Noise of outdoor fans • Installation challenges with central or in-suite ducts
Domestic Hot Water	• Low-flow water fixtures • Waste water and drain water heat recovery	• Space to install waste/drain heat recovery units

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Mechanical System Retrofit Options

		EXISTING BUILDING		DEEP RETROFIT #1		DEEP RETROFIT #2	
MECHANICAL							
VENTILATION	PLANT	Rooftop make-up air unit serving corridors	100 cfm/suite	Heat pump rooftop make-up air unit serving corridors	COP=2.5 20 cfm/suite	Heat pump rooftop make-up air unit serving corridors	COP=2.5 20 cfm/suite
	IN-SUITE	Direct exhaust from kitchen and bathroom	N/A	Addition of in-suite energy recovery ventilators (ERVs)	Sensible Eff=70% Latent Eff=50% 65 cfm/suite	Addition of in-suite energy recovery ventilators (ERVs)	Sensible Eff=70% Latent Eff=50% 65 cfm/suite
HEATING COOLING	PLANT	Two natural gas-fired boilers No cooling	85% Efficient	Central air-to-water heat pumps (AWHPs) to provide heating and cooling, with back-up natural gas-fired boiler.	Heating COP ~2.6 Cooling COP ~4	Central air-to-water heat pumps (AWHPs) to provide heating and cooling with back-up natural gas-fired boiler.	Heating COP ~2.6 Cooling COP ~4
	IN-SUITE	Hydronic perimeter baseboards	N/A	Hydronic perimeter fan-coil units to provide heating and cooling	0.09 W/cfm	Hydronic perimeter fan-coil units to provide heating and cooling	0.09 W/cfm
DOMESTIC HOT WATER	PLANT	Indirectly served by heating boilers	See heating boilers	Drain water heat pump heat recovery system	COP=5	Drain water heat pump heat recovery system	COP=5
	IN-SUITE	Regular water fixtures	Various flow rates	Low flow water fixtures	30% reduction in DHW load	Low flow water fixtures	30% reduction in DHW load
ELECTRICAL							
LIGHTING		LED in all common spaces	Various lighting power densities	Retrofit all lighting to LED	No savings modelled	Retrofit all lighting to LED	No savings modelled

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Typical Energy "Model" Options for Retrofits

Type of Energy Model	Description	Works best for…	Benefits	Challenges
Spreadsheet	Rough estimate of energy performance, typically based on previous similar result or simplified inputs; simplified geometry	→ Early-stage analysis → Understanding the biggest levers impacting performance → Rough comparisons to aid decision making	Quick and cheap	High level of uncertainty (~Class D level results) and variability of between energy consultants
Simplified Block Model	Typically an hourly energy model based on block-like massing; lacks design details	→ Early-stage analysis → Target setting → Preliminary decision making	More reliable than a spreadsheet model, but still fairly affordable	Based on a lot of assumptions, rules of thumb, and previous experience
Detailed Hourly Model	Hourly energy model based on drawings, calibrated against utility bills	→ Target setting + updating to ensure achievement of targets → Can be used to inform mech. design/sizing → Multiple retrofits w/ interdependence	Reliable results that are calibrated against real world data	Expensive and time-consuming

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Analysis Outcomes

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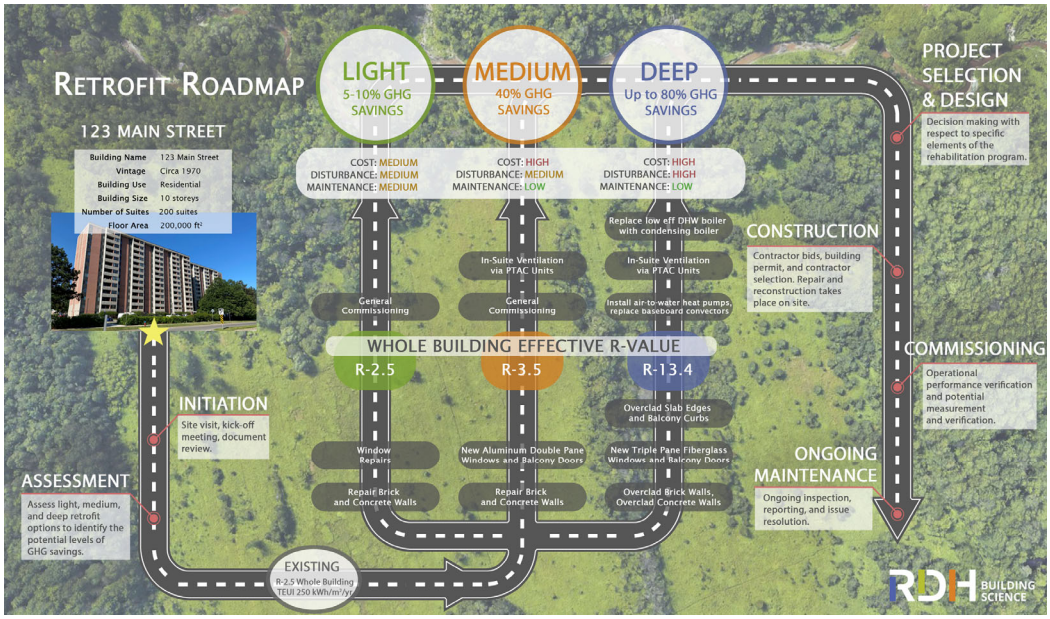

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Deep is likely the only option in regions with NZC mandates

SAMPLE MURB OPTIONS

	EXISTING	MEDIUM RETROFIT	DEEP RETROFIT
% ENERGY SAVINGS	0%	25%	35%
% GHG EMISSION SAVINGS	0%	7%	50%
WHOLE BUILDING THERMAL PERFORMANCE	R-6.7	R-9.2	R-11.3
RELATIVE CAPITAL COST	Low	High	High
RELATIVE CONSTRUTION IMPACT	Low	High	High
RELATIVE MAINTENANCE FREQUENCY	High	Low	Low
AESTHETIC	1970's vintage building	Flexibility with new façade design	Flexibility with new façade design

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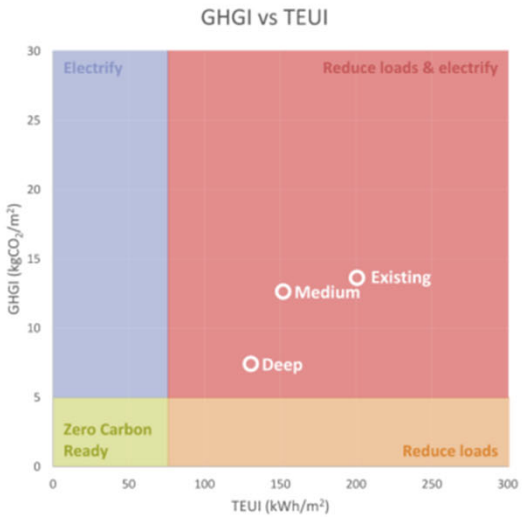
SAMPLE MURB OPTIONS

	EXISTING	MEDIUM RETROFIT	DEEP RETROFIT
GHGI ($KGCO_2/M^2/YR$)	14	13	8
TEUI ($KWH/M^2/YR$)	200	150	130
TEDI ($KWH/M^2/YR$)	77	49	47
ANNUAL CO2E (TONNES)	230	210	120
ANNUAL NATURAL GAS (MBTU)	3,500	3,500	1,800
ANNUAL ELECTRICITY (kWh)	2,300,000	1,490,000	1,650,000
ANNUAL NATURAL GAS COST	$30,000	$30,000	$15,000
ANNUAL ELECTRICITY COST	$298,000	$193,000	$214,000
TOTAL OPERATING COST	$328,000	$223,000	$229,000
SAVINGS COMPARED TO EXISTING	$0	$105,000	$99,000



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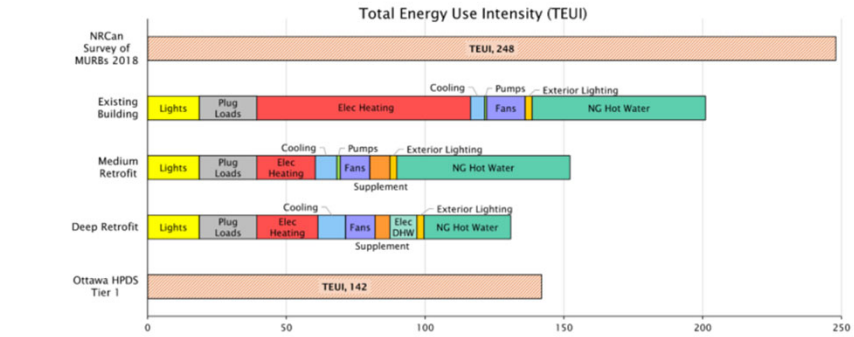

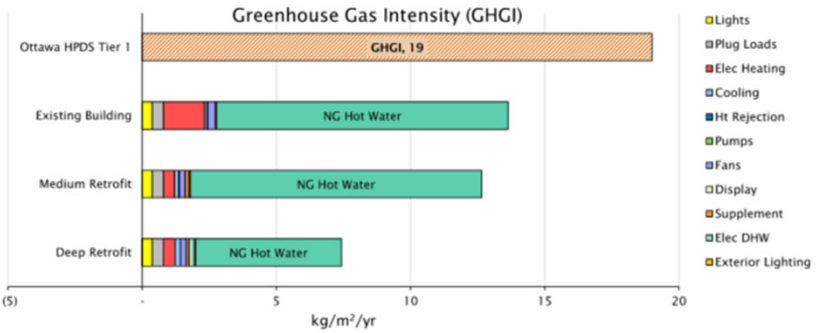

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Timing the Retrofits

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- Is there a "**Trigger Event**" coming soon that will start the process: *Window replacement? Roof replacement? Boiler replacement?*
- What is the local government's mandate for deep retrofit or for "getting to zero"?
- What is your goal for "getting to zero"?

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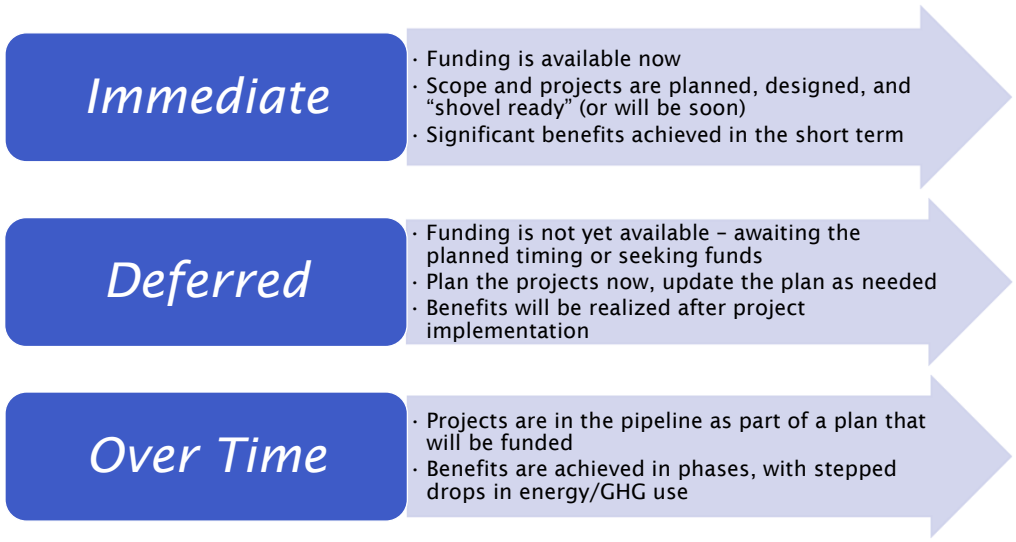

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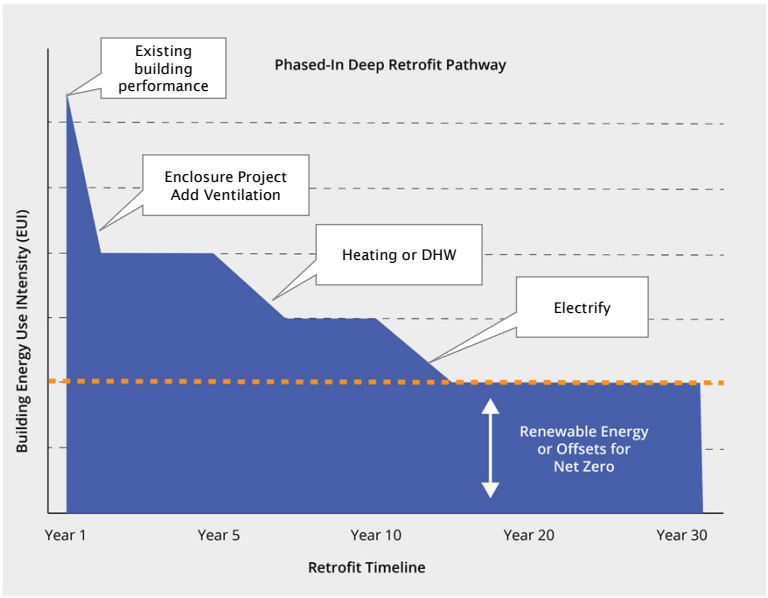

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Based on RMI's *Best Practices for Achieving Zero Over Time*

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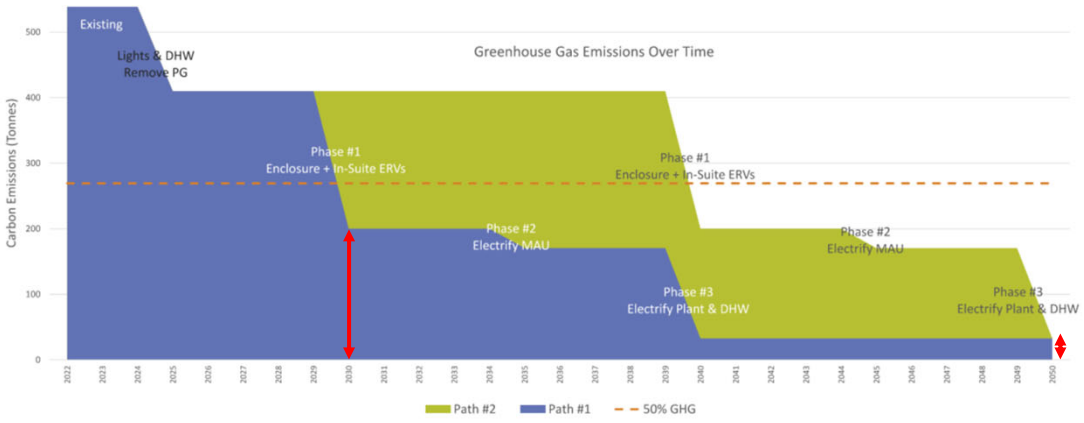

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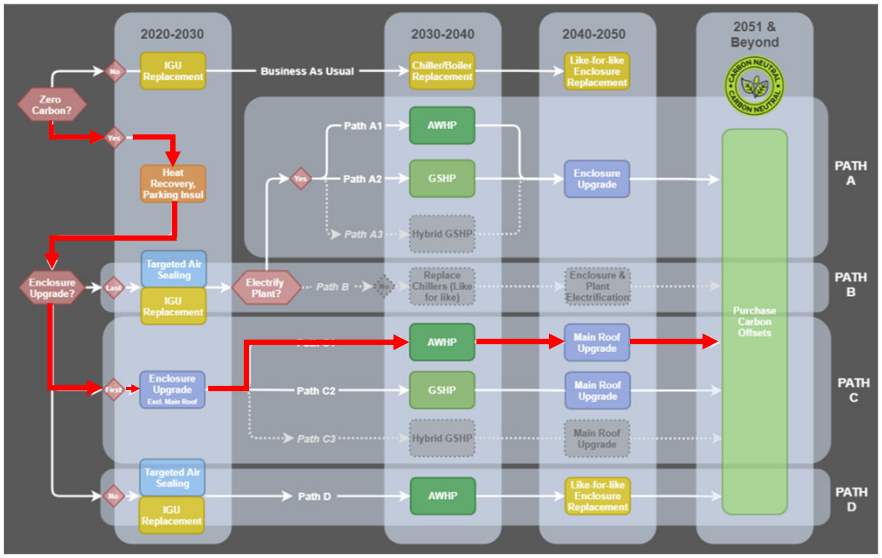

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RETROFIT PATH #1
50% GHG REDUCTION BY 2030
NET ZERO CARBON BY 2050

RETROFIT PHASE:	1	2	3	2022 Current Year Dollars*	CRM
Replace Lighitng with LED Fixtures and Lamps	X			$ 60,000	Load Reduction
Upgrade Suites with Low Flow Fixtures	X				
Overclad Exterior Walls and Soffits	X			$ 10,750,000	Enclosure Overclad & In-Suite Ventilation
Replace Windows & Doors	X				
Add In-Suite ERVs	X			$ 1,960,000	
Replace & Resize Corridor Make-Up Air Unit		X		$ 460,000	Central Ventilation
Replace Roof Exhaust Fans & Add Glycol Run Around for Heat Recovery		X			
Replace Central Heating Boilers with Air-Source Heat Pumps			X	$ 3,310,000	Electrify Plant & Add cooling
Replace Radiators with Fan Coil Units with Cooling			X		
Replace DHW Boilers with Drain Water Heat Pump Heat Recovery System			X	$ 910,000	Electrify DHW
Replace Roof			X	$ 1,570,000	Re-Roof

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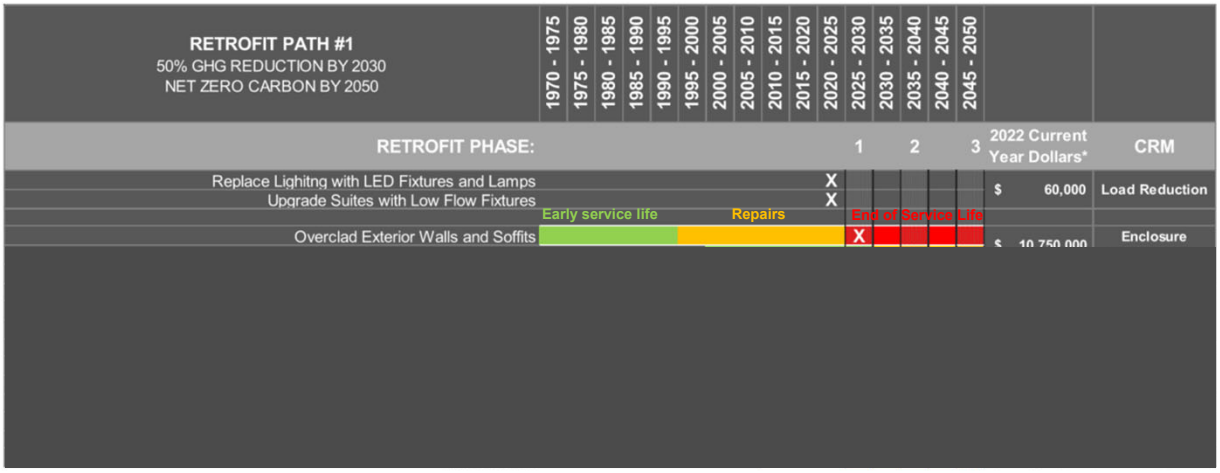
RETROFIT PATH #1
50% GHG REDUCTION BY 2030
NET ZERO CARBON BY 2050
1970 - 1975
1975 - 1980
1980 - 1985
1985 - 1990
1990 - 1995
1995 - 2000
2000 - 2005
2005 - 2010
2010 - 2015
2015 - 2020
2020 - 2025
2025 - 2030
2030 - 2035
2035 - 2040
2040 - 2045
2045 - 2050
RETROFIT PHASE:
1
2
3
2022 Current Year Dollars*
CRM
Replace Lighitng with LED Fixtures and Lamps
Upgrade Suites with Low Flow Fixtures
$ 60,000
Load Reduction
Early service life
Repairs
End of Service Life
Overclad Exterior Walls and Soffits
Enclosure

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RETROFIT PATH #1
50% GHG REDUCTION BY 2030
NET ZERO CARBON BY 2050
1970 - 1975
1975 - 1980
1980 - 1985
1985 - 1990
1990 - 1995
1995 - 2000
2000 - 2005
2005 - 2010
2010 - 2015
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RETROFIT PHASE:
1
2
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2022 Current Year Dollars*
CRM
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Upgrade Suites with Low Flow Fixtures
$ 60,000
Load Reduction
Overclad Exterior Walls and Soffits
Replace Windows & Doors
$ 10,750,000
Enclosure
Overclad & In-

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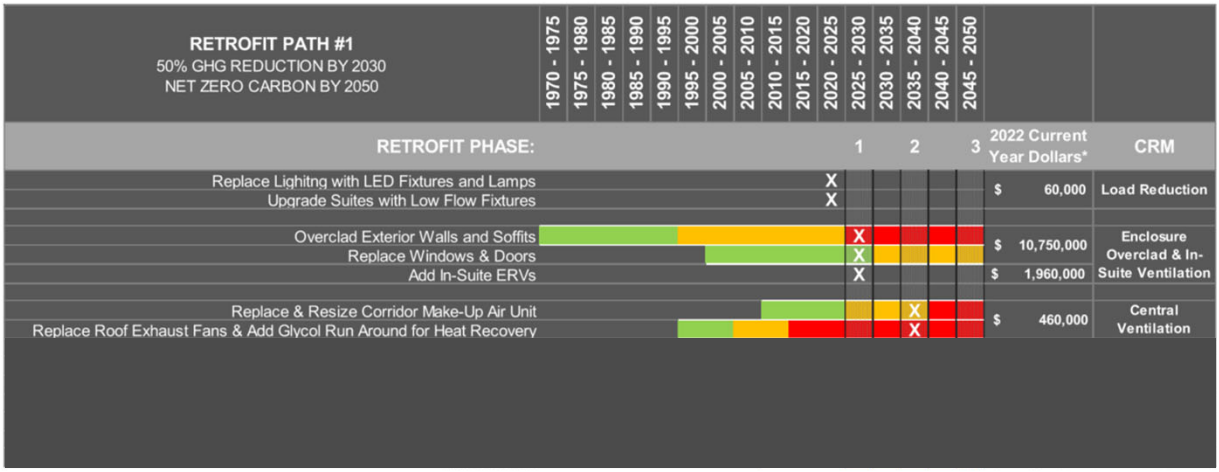
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Central Ventilation

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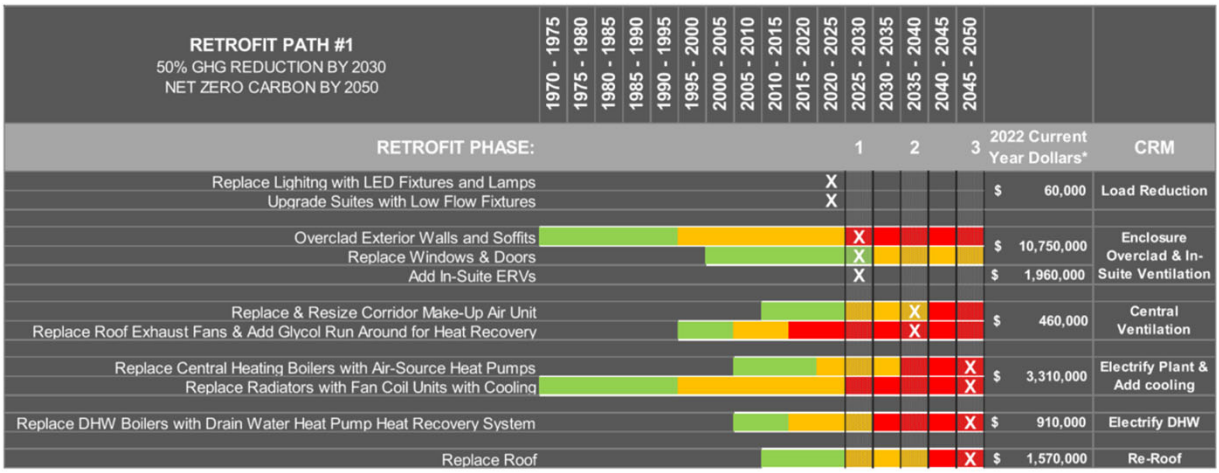
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2022 Current Year Dollars*
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Electrify DHW
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$ 1,570,000
Re-Roof

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Other Retrofit Considerations
include in your plan!

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Sequencing: "No un-do / re-do"

- What retrofit projects should be implemented first?
- Share your draft plan with internal stakeholders, maintenance contractors, consultants, and/or external peer reviewer – collaborate and don't work in isolation
- Consider operations continuity, build-in contingency time and money

Electrical System Capacity

- If fuel-switching the heating system to electric heat pumps or fan coils, does the building have enough juice?
- Capacity for adding ERVs, DOAS, etc?
- Need to upgrade hydro vault/electrical transformer? Main incoming feed? Main switch gear? New suite panels?

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Code and Accessibility

- Potential triggers that would require upgrades to fire suppression, fire separations
- Impacts to existing exiting paths and distances

Hazardous Materials

- Abatement requirements for old duct/pipe insulation, plaster/drywall compound, sealants
- Lead in older paints on walls and windows

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CL0

Impacts to Residents/Tenants

- Communicate, communicate, communicate
- Host Town Halls and/or send emails/newsletters
- Assign a point-person on the building side, consultant side, and contractor side
- Plan out access and optimize the number of suite "touches"

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Retrofit Planning for Portfolios

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From RMI's *Best Practices for Achieving Zero Over Time*

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1. Open your portfolio list or tool (spreadsheet, CapEx program, etc)
2. Identify which buildings have a long-term hold strategy vs. short-term hold
3. Identify age, energy system (gas/electric), or other opportunity 'tag'
4. Group by geographic location
5. Group by trigger point timing
6. Develop individual plans or make high-level archetype plans

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Carbon Risk Real Estate Monitor (CRREM)

https://www.crrem.eu/tool/

Asset Info *Energy Types* *Renewables* *Retrofits*

	General information							Total energy procurement						Renewable energy					Retrofit actions				
								Whole building total energy procurement						On-site renewable electricity (PV, wind)		Off-site renewable electricity			Retrofit action				
								Combined energy procurement of Common Areas + Tenant Space						Generated and consumed on-site	Generated on-site and exported	Generated off-site and consumed on-site							
								Energy procured by tenants and base building services to lettable/leasable and common spaces. This should include all								Generally, off-site renewables do not constitute a quality characteristic reducing carbon risk of individual buildings. Only renewable electricity purchased directly from							
								Grid Electricity			Natural gas												
Asset ID	Inclusion	Asset Name	Reporting year	Gross Asset Value (GAV)	Reporting period		Entity	Usage	Data Coverage	Maximum Coverage	Usage	Data Coverage	Maximum Coverage	Amount	Amount	Amount	Reporting method	Emission factor if market-based	Year	Investment	Achieved reduction of energy consumption [%] Leave blank to apply default values	Embodied carbon related to retrofit action	
Pre-filled	Dropdown	Text	Mandatory	Optional (required for calculating certain risk indicators)	Starting month Mandatory	Months of data Mandatory	Optional (for further possibilities of aggregation)																
ID	INC	NAME	AS.YR	[i] GAV	Drop-down AS.MON	Number of Months AS.LEMG	Text ENT	[kWh] EL.GRID	Mandatory if usage > 0 [m²] EL.DC	Mandatory if usage > 0 [m²] EL.HC	[kWh] NG.CON	Mandatory if usage > 0 [m²] NG.DC	Mandatory if usage > 0 [m²] NG.HC	[kWh]	[kWh]	[kWh]	Drop-down	[kgCO2e/kWh]	[yyyy] RF1.YR	[i] RF1.EUR	[%] RF1.PC	[kg] RF1.EC	DatCent
1	Include	Steinbach Tower	2019	2,000,000	January	12		300,000	10,000	10,000							Location-based approach		2040	300,000			
2	Include	Steinbach Tower	2019	2,000,000	January	12		300,000	10,000	10,000							Location-based approach		2040	300,000			
3	Include	Steinbach Tower B	2021	4,750,000	January	12	Fund 2	120,000	1,000	1,000	-	700	900	100	-	-	Location-based approach		2040	15,000			
4	Include	Maison Eiffel	2021	4,750,000	January	12	Fund 2	10,000	1,000	1,000	80,000	700	900	100	-		Location-based approach						

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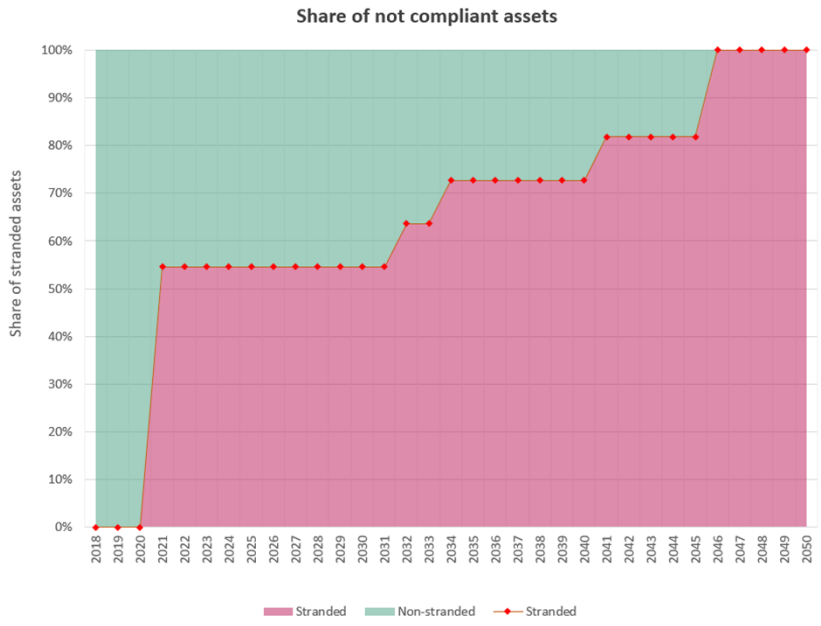
EVOLUTION OF NON-COMPLIANCE WITHIN PORTFOLIO

Diagrams on the right display the evolution of not compliant assets within your portfolio. Upper graph: Relative share of non-compliant assets. Lower graph: Absolute figures. Choose whether to display data based on the number of buildings, gross floor area (GFA) or gross asset value (GAV). Choose whether to exclude individual assets or exclude them from a certain year on.



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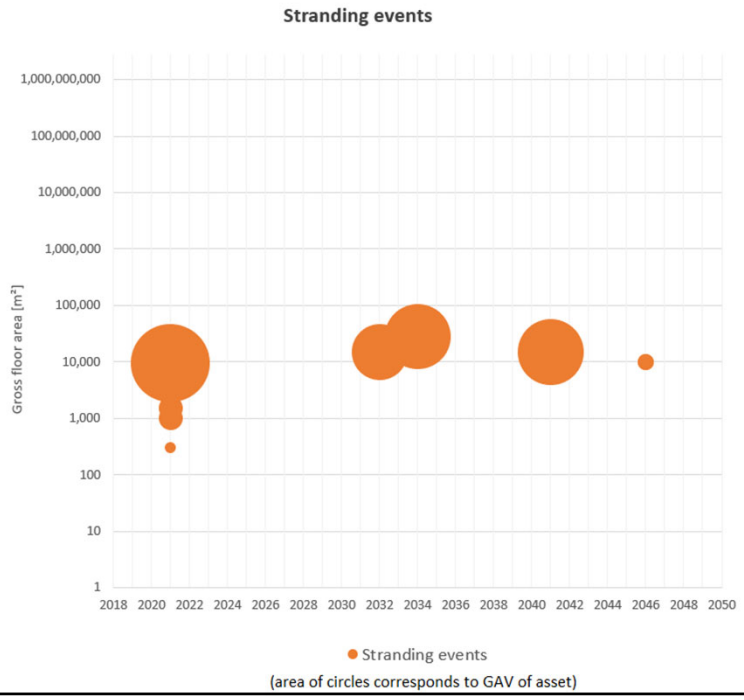
STRANDING EVENTS: NEED FOR ACTION?

The graph on the right provides a summary of stranding events in the course of time. Each circle corresponds to one asset not complying with its decarbonisation pathways for the first time. Circle size (GAV) and y-axis (Floor area) indicate the importance of an asset within the portfolio.

The area of the circles corresponds to the GAV of the stranded asset.
Choose below which global warming target to apply. The numbers next to the circles depict the asset ID.

Climate target: 1.5°C



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PORTFOLIO SUMMARY

Cost Risks *Emissions Risks*

Asset ID (click on an Asset ID to change input data)	Year of Stranding		Discounted costs of excess emissions (to 2021) (incl. value of emissions below pathway, red: costs > value - green: value ≥ costs)				Cumulated excess emissions until 2050				GHG-Intensity 2021 [$kgCO_2e/m^2/yr$]	Cumulative emissions to 2050 [tCO_2e]	Emission budget 2018-2050 [tCO_2e] (red: budget < cum. emissions - green: budget ≥ cum. Emissions)	
			Carbon value at Risk (costs per GAV)		Absolute [€]		Absolute [$kgCO_2e$]		Per GFA [$kgCO_2e/m^2$]					
			Set discount rate: 3%											
	1.5°C-target	2°C-target	1.5°C-target	2°C-target	1.5°C-target	2°C-target	1.5°C-target	2°C-target	1.5°C-target	2°C-target			1.5°C-target	2°C-target
1	2046	2°C-ready	-12.1%	-20.3%	- 242,891	- 406,317	82,701	-	8	-	9	2,495	8,228	11,020
2	2046	2°C-ready	-12.1%	-20.3%	- 242,891	- 406,317	82,701	-	8	-	9	2,495	8,228	11,020
3	2021	2021	3.9%	3.2%	186,330	152,959	3,105,138	2,539,589	2,070	1,693	119	5,022	2,420	2,998
4	2021	2021	0.4%	0.1%	17,597	5,818	292,821	96,277	293	96	21	601	370	568
5	2021	2021	2.8%	2.2%	27,773	22,497	466,561	377,847	1,555	1,259	80	684	269	359
6	2034	2040	0.5%	-1.1%	173,449	- 384,926	6,836,892	2,651,130	244	95	49	28,288	33,351	42,968
7	2032	2047	0.2%	-0.5%	59,377	- 129,447	1,797,992	40,012	120	3	21	7,768	8,526	11,741
8	2041	2049	-1.1%	-2.3%	- 386,093	- 799,310	1,267,918	17,653	85	1	50	12,453	25,050	32,171
9	2021	2021	11.6%	11.1%	5,805,533	5,566,403	99,934,053	95,873,429	10,519	10,092	609	115,515	19,410	23,565
10	2021	2021	2.3%	1.6%	678,536	481,608	11,454,468	8,111,814	1,636	1,159	174	24,090	15,736	19,156
11	2021	2021	10.5%	9.8%	4,183,539	3,931,822	70,864,836	66,590,494	7,086	6,659	316	87,266	20,432	24,806
Σ			4.5%	3.5%	10,260,259	8,034,790	196,186,080	176,298,244	1,828	1,643		286,678	142,021	180,374

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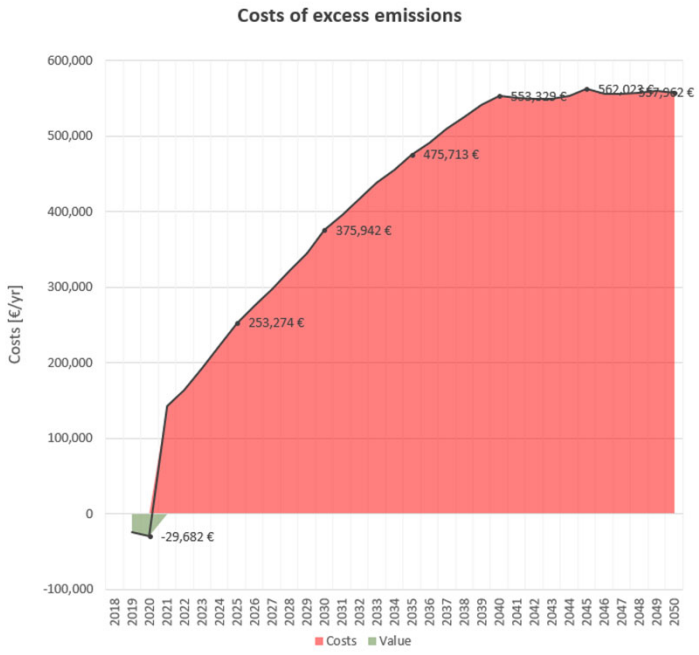
COSTS OF EXCESS EMISSIONS OF PORTFOLIO

Aggregated costs of excess emissions for all assets within selected portfolio.

Climate target: 2°C

Carbon Value at Risk: 3.50%



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Every building needs a plan.

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FROM RISK TO READINESS:
PRACTICAL SOLUTIONS FOR MEETING THE
EXISTING BUILDING RETROFIT CHALLENGE

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