ASSESSING THE ECONOMIC AND ENVIRONMENTAL CASE FOR WINDOW RETROFITS IN SINGLE FAMILY HOMES

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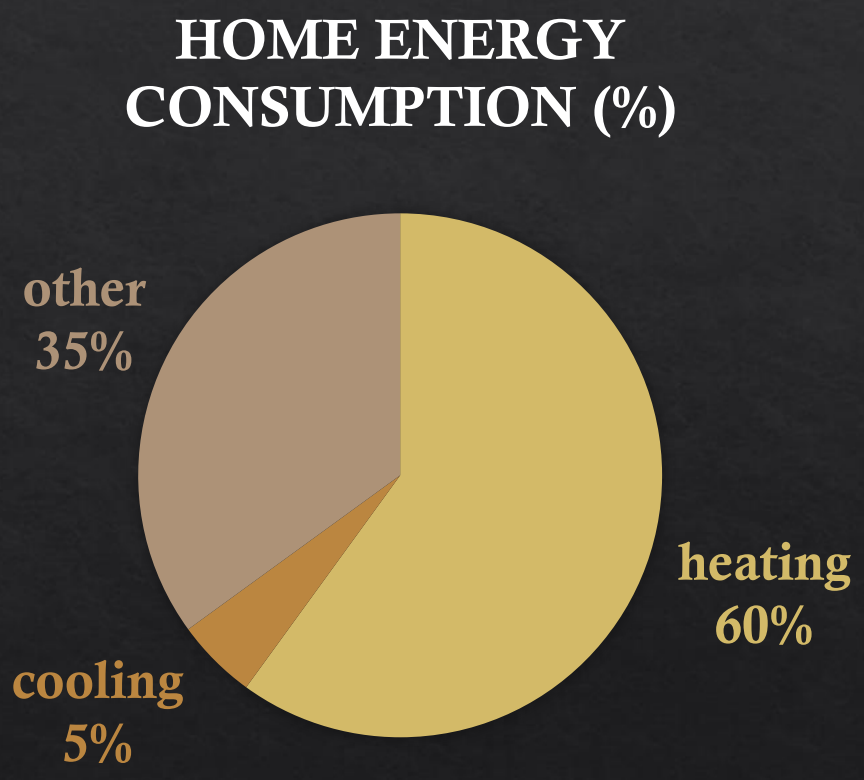
Energy costs are on the rise

- 59% of Canadians live in single-family homes
- More concern in cooling
  - Natural Gas vs. Electricity
  - 3¢/ekWh vs. 18¢/kWh
- Carbon Cap-and-Trade
  - Higher natural gas cost



Retrofit: Why Windows?

Improvements	Air Tightness
	Solar Control
	Aesthetics
	Home Value
	Comfort
Considerations	High Capital Investment
	Long Term
	Less Energy Savings than other BE Components

All homes will eventually require new windows

- Ideal Candidates
  - 1879 vs 1992 homes
- The norm: Consider the supply & installation of new windows
- Our method: Consider only incremental costs of upgrading to higher performance windows

Let the numbers speak for themselves…

- Like-for-like comparison
  - Model homes have identical layouts
- Energy Modelling
  - HOT2000
- Various retrofits
  - Double glazed, air-filled
  - Double glazed, Low-e, Argon filled
  - Triple glazed, Low-e, Argon filled
  - Vinyl vs. wood framing

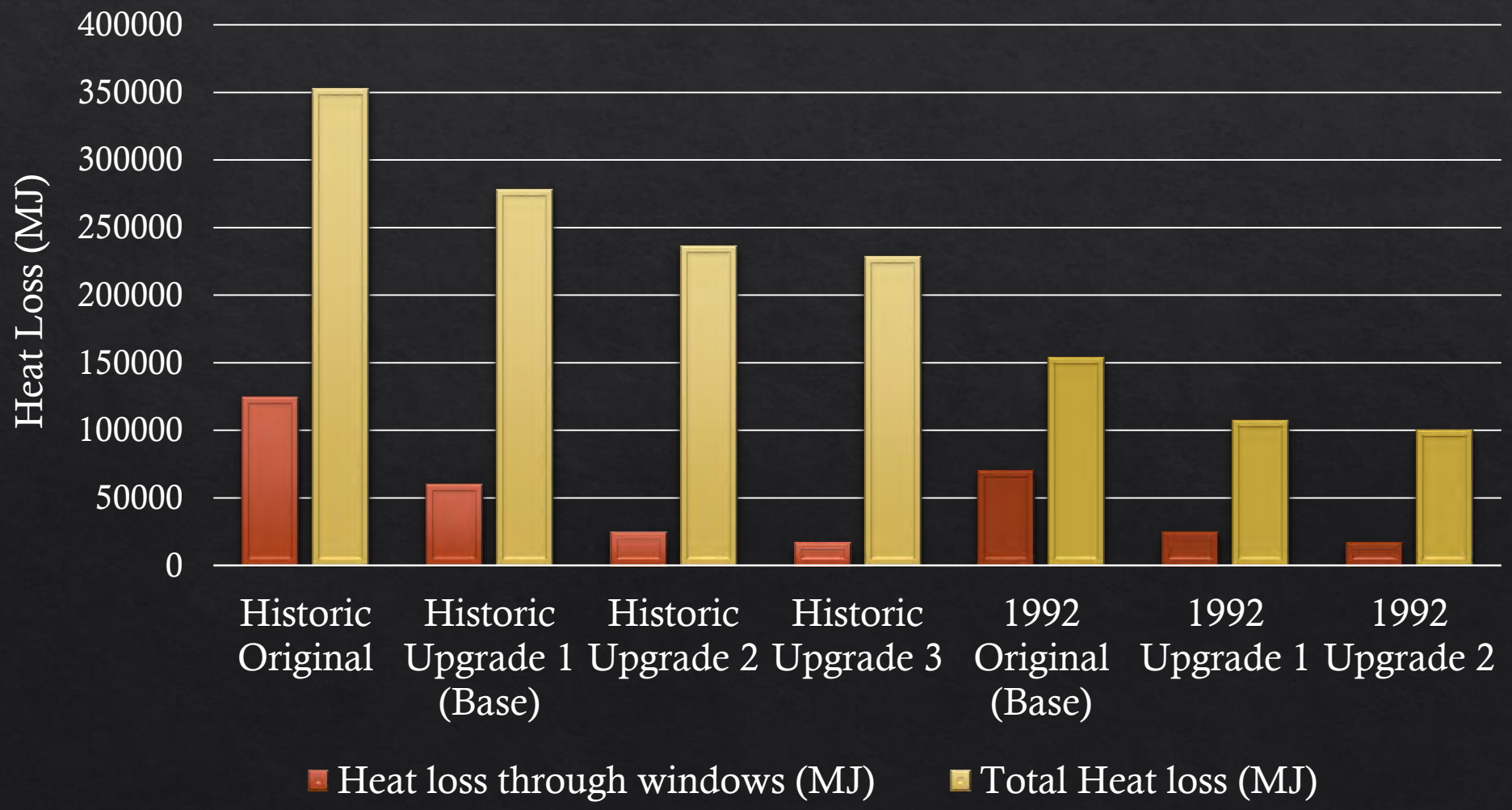
Model Parameters & Inputs

Parameter	1992 Home	Historic Home
Airtightness	4.55 ACH @ 50 Pa	16.41 ACH @ 50 Pa
Roof RSI (nominal)	5.4	2.6
Wall RSI (nominal)	3.25	0.57
Slab on ground RSI	0.75	1.76
Window Tightness (L/sm^2)	3.72	1.86 (A1)
Volume of Home	451 m3	451 m3
Building Envelope Surface Area	444 m2	444 m2
Window to Wall Ratio	0.194	0.194

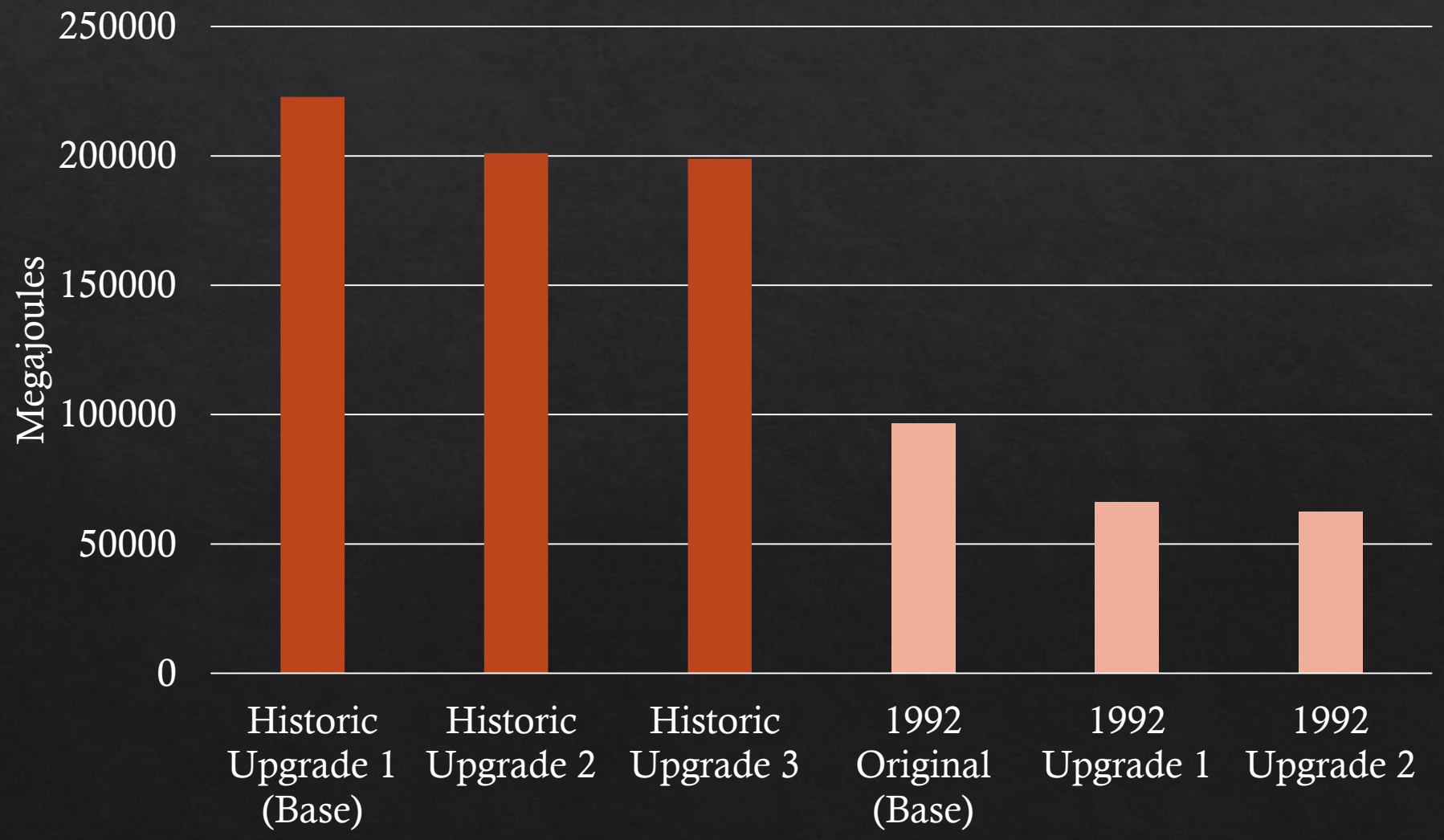
Upgrade Scenarios

Scenario	Description	RSI value	U value	SHGC	Air Tightness
Historic Original	Single-glazed, clear, wood frame	0.17	5.88	0.8	16.41 ACH_{50}
Historic Upgrade 1 (Base Case)	Double-glazed, 13 mm air filled, wood frame	0.34	2.94	0.6	14.0 ACH_{50}
Historic Upgrade 2	Double-glazed, low-e 0.35, 13 mm argon filled, wood frame	0.77	1.3	0.28	12.3 ACH_{50}
Historic Upgrade 3	Triple glazed, low-e 0.35, argon filled, wood frame	1.41	0.71	0.24	12.3 ACH_{50}
1992 Original (Base Case)	Double-glazed, 13 mm air filled, vinyl frame	0.28	3.57	0.6	4.55 ACH_{50} with A1 windows
1992 Upgrade 1	Double-glazed, low-e 0.35, 13 mm argon filled, vinyl frame	0.77	1.3	0.28	4.55 ACH_{50} with A2 windows
1992 Upgrade 2	Triple glazed, low-e 0.35, argon filled, vinyl frame	1.41	0.71	0.24	4.55 ACH_{50} with A3 windows

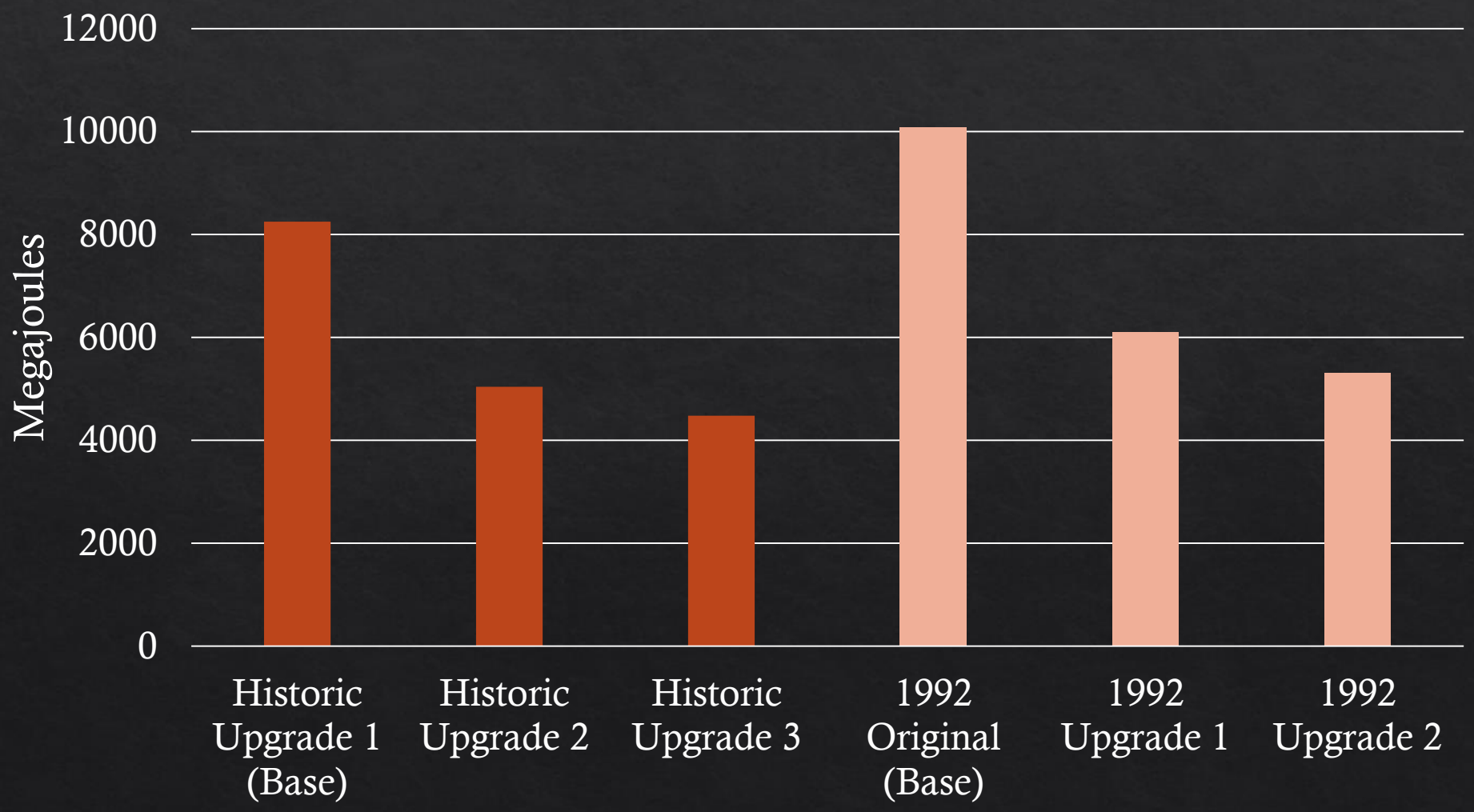
Window Heat Loss vs. Total Home Heat Loss



Total Annual Space Heating



Total Annual Space Cooling



Overall Savings

For the triple-glazed low-e argon filled windows

	1879 Home	1992 Home
Window Heat Loss	71%	75%
Total Heat Loss	18%	35%
Space Heating	11%	35%
Space Cooling	46%	47%

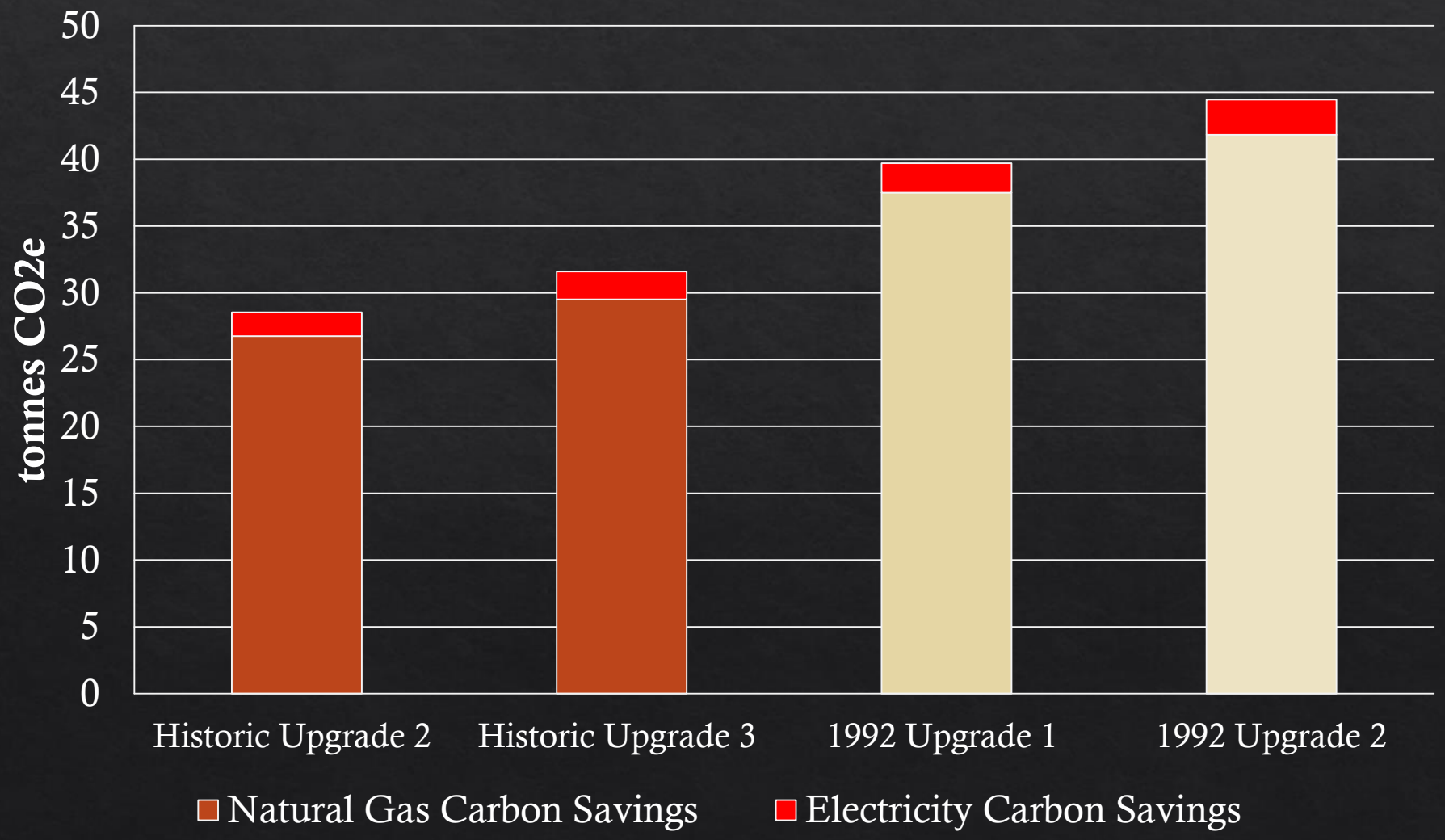
Overall

- Positive results: space heating and cooling reduced significantly
- Results vary due to:
  - Initial envelope conditions
  - Air tightness
  - Ventilation requirements
- Lower SHGC
  - Less wanted heat in winter
  - Less unwanted heat in summer

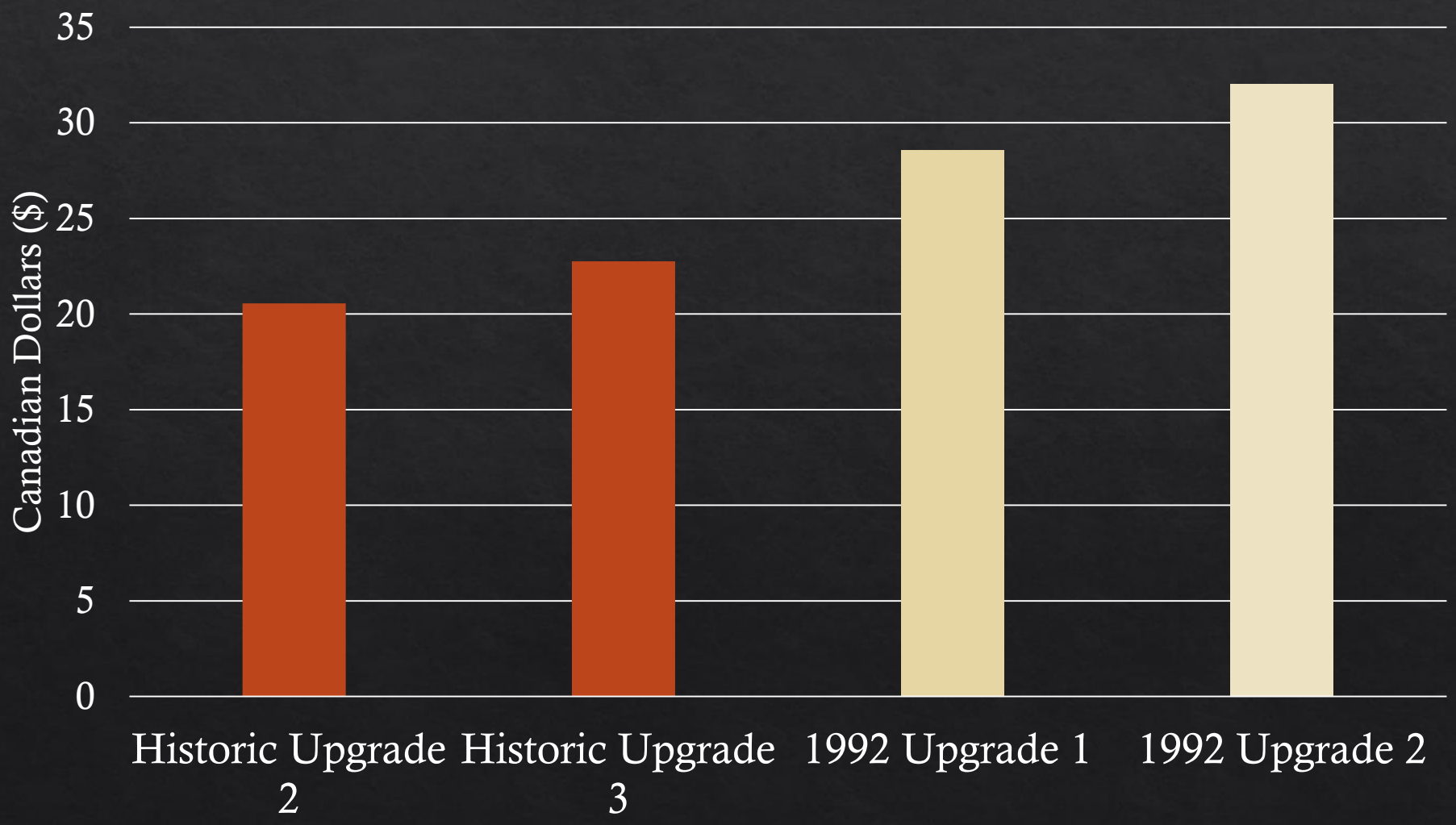
Environmental Analysis

- Carbon Cap and Trade Policy
  - Currently trading at $18/tonne (Federal Government)
  - Federal cost is set to rise by ~$5/year
  - Higher in some places (B.C. $30)
  - Green Bank – reinvest in green technology
- No more coal power plants = less CO_2e from electricity
  - 9% electricity sourced from natural gas

Total Service Life Carbon Savings from Base for Natural Gas and Electricity



Carbon Cap & Trade Savings (2017 $)



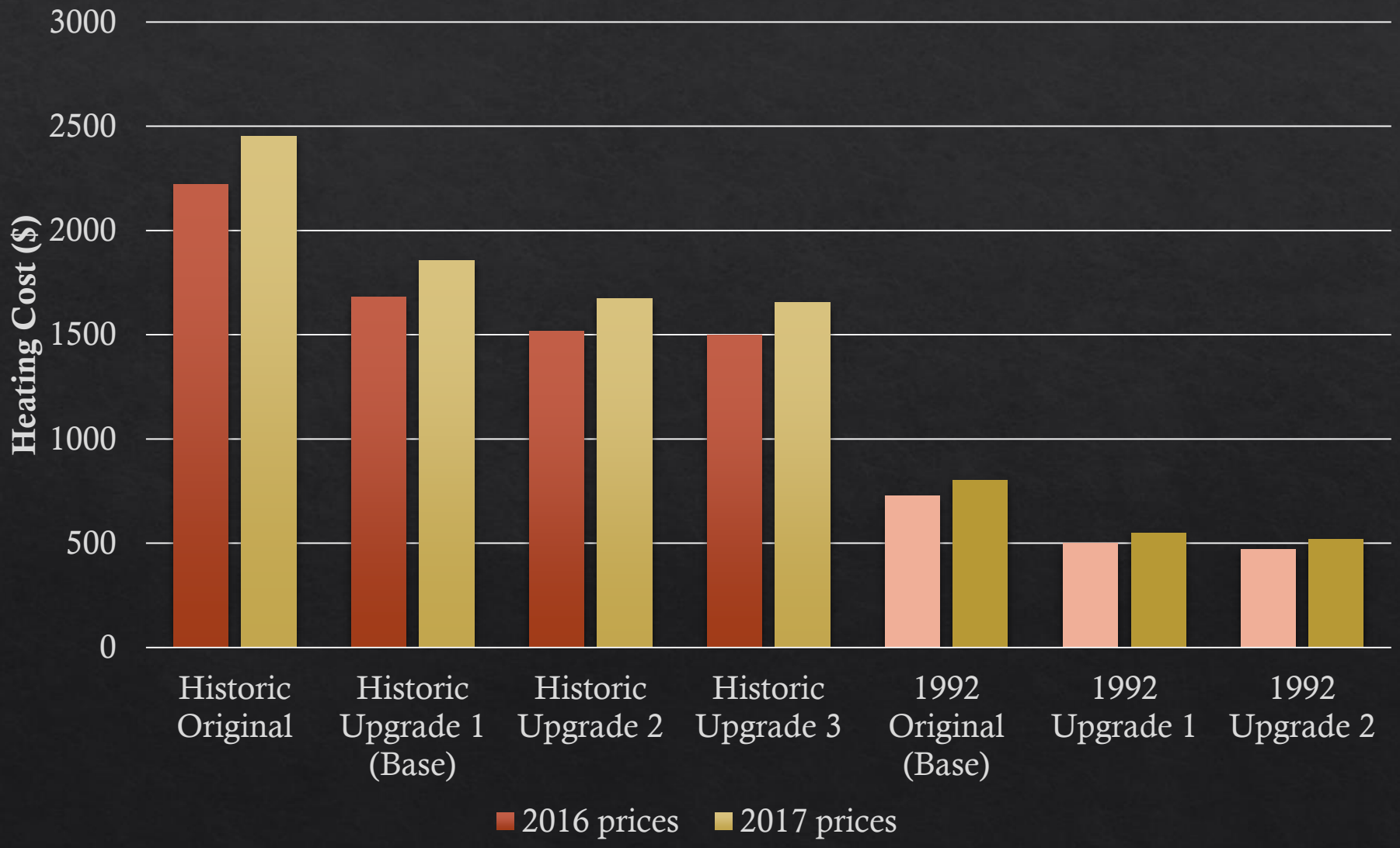
Overall

- Cap and Trade Savings will increase over time
- Carbon emissions expected to have increase of $150 per household in energy bills
- Electricity will move towards ZERO tonnes CO_2e
- Subsidize proactive techologies rather than retroactive programs that mitigate existing pollution
- Over a 25-year life cycle period:
  - Historic home: 32 tonnes CO_2e saved
  - 1992 home: 45 tonnes CO_2e saved

Energy Costing

- Natural gas increases 3.35 ¢/m3 (Ontario)
  - 2016 – 29 ¢/m3 (approx.)
  - 2017 – 32 ¢/m3 (approx.)
- Electricity (Ontario)
  - 18¢/kWh peak
  - Reduced by 25% in 2017
- Forecasts are volatile
  - Particularly Electricity

Heating costs 2016 vs. 2017



Economic Analysis: Window Material Costs

Building and Option	Description	Average Total Material Cost
Base Historic Home Upgrade 1	Insulated Dual Air Filled, Wood Frame	$12,310
Historic Home Upgrade 2	Insulated Dual Low-e Argon Filled, Wood Frame	$12,930
Historic Home Upgrade 3	Insulated Triple Low-e Advanced Glass, Argon Filled, Wood Frame	$14,920
Base 1992 Home	Insulated Dual Air Filled, Vinyl Frame	$9,970
1992 Home Upgrade 1	Insulated Dual Low-e Argon Filled, Vinyl Frame	$10,470
1992 Home Upgrade 2	Insulated Triple Low-e Advanced Glass, Argon Filled, Vinyl Frame	$12,080

Economic Analysis

- Incremental cost per upgrade
- Annual savings from base
  - Heating
  - Cooling
- Return on Investment (Year 1)
- Window cost/tonne of carbon saved
  - Compare with carbon floor price

Economic Analysis

Model	Incremental Cost Above Base	Incremental Annual Savings Above Base	Return on Investment	Window Cost per Tonne of Carbon Saved ($/tonne)
Historic Upgrade 2	$620	$300	48%	$22
Historic Upgrade 3	$2,610	$340	13%	$82
1992 Upgrade 1	$500	$400	80%	$13
1992 Upgrade 2	$2,110	$460	22%	$47

Conclusion

- As energy prices rise, savings will follow
  - ROI will increase
- As carbon floor price rises, as will carbon savings ($)
  - Retrofits will be environmentally justified
  - More attractive to provide incentives (Government)
- 1992 home – windows cost less and had a bigger impact on envelope
- Can recover up to 85% of investment due to increased value of home
- Cost of high performance windows will decline
- Should also consider other envelope retrofits for historic home

Thank You

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