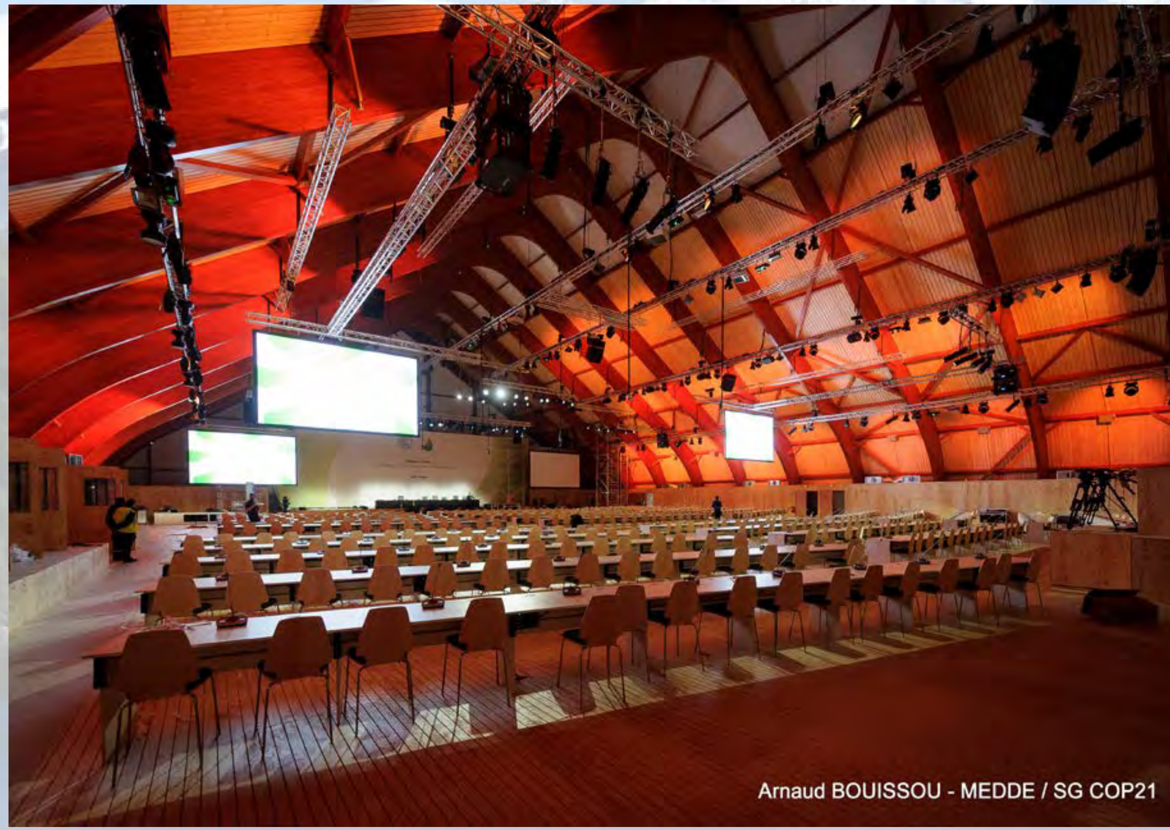
# Carbon, Construction And COP 21
## Trends and Opportunities for Wood Use




COP 21 Plenary meeting building

Wood Solutions Fair
Halifax, October 5, 2017

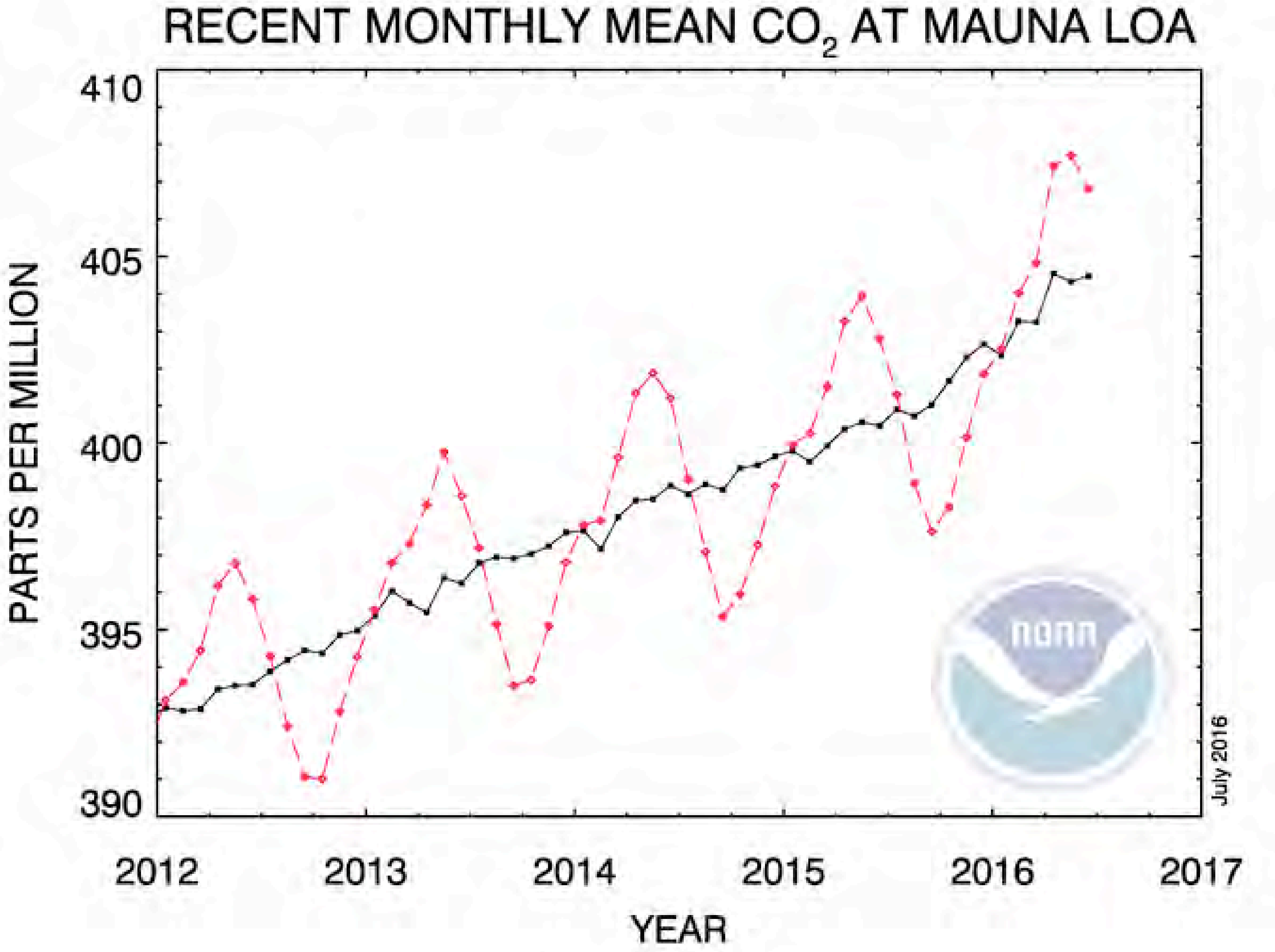
# What A Marine Biologist Thinks Designers Should Know About Carbon and Wood – Whether They Like it or Not

# Learning Objectives

1. Gain an understanding of the IPCC's recommendation about the role wood and forests can play in assisting in mitigating climate change.
2. Learn about the changing regulations about carbon that influence both operational and embodied carbon impacts;
3. Understand the temporal impacts of avoided emissions and the benefits of incorporating effective design, off-site construction practices and material strategies to reduce embodied impact of designs and enhance performance;
4. Understand how new LCA tools can easily and effectively provide pre-design information about materials and embodied impacts.

# Presentation Overview

- **International Focus On Carbon**
- **How Nations Are Addressing Global Carbon Aspirations**
- **The Role Of Forests And Wood**
  - **3-S Concept →→ Sink, Sequester, Substitute**
- **Carbon In Construction**
- **Life Cycle Analysis (LCA)**
- **Embodied Impact – Trends, Tools**
- **Thoughts / Recommendations For Designers**


RECENT MONTHLY MEAN $CO_2$ AT MAUNA LOA
410
405
400
395
390
PARTS PER MILLION
2012
2013
2014
2015
2016
2017
YEAR
July 2016
NOAA

# Global Climate Dashboard

▶ Climate Change ▶ Climate Variability ▼ Climate Projections

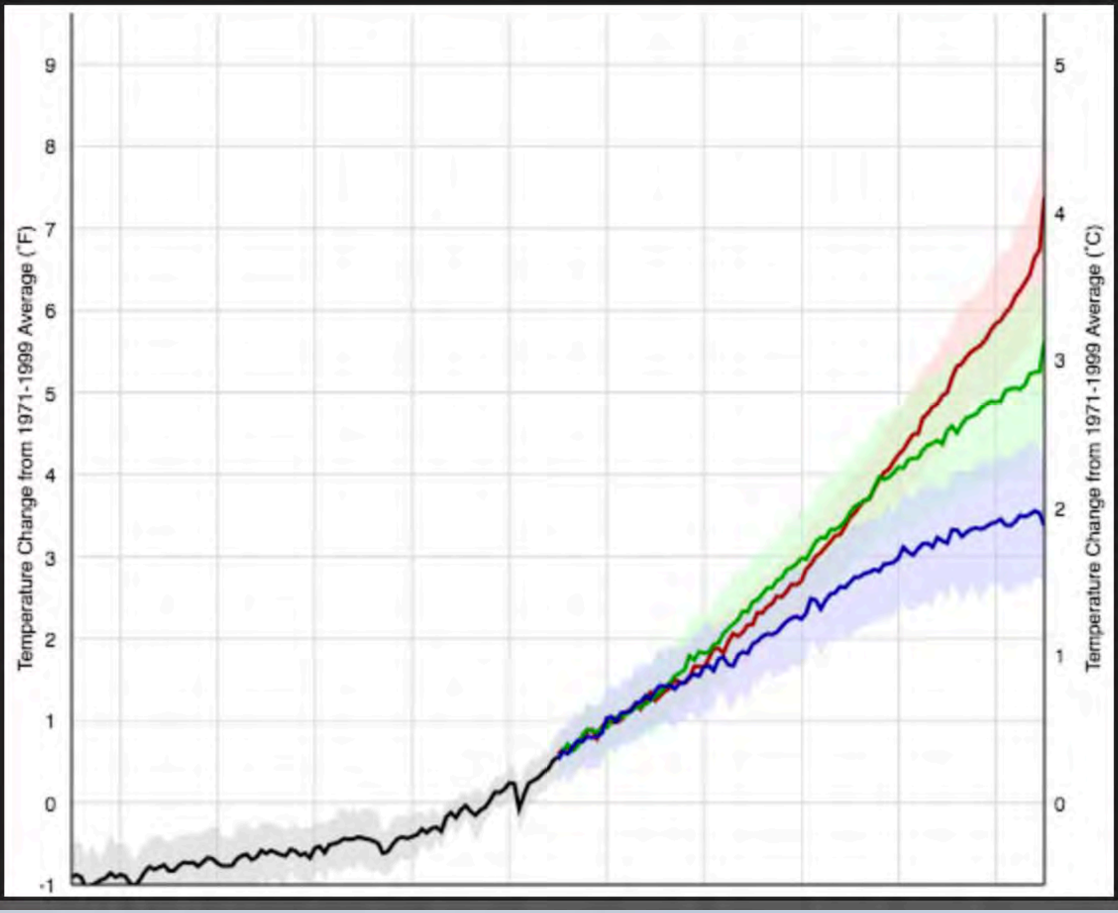
## Simulation of Global Temperature

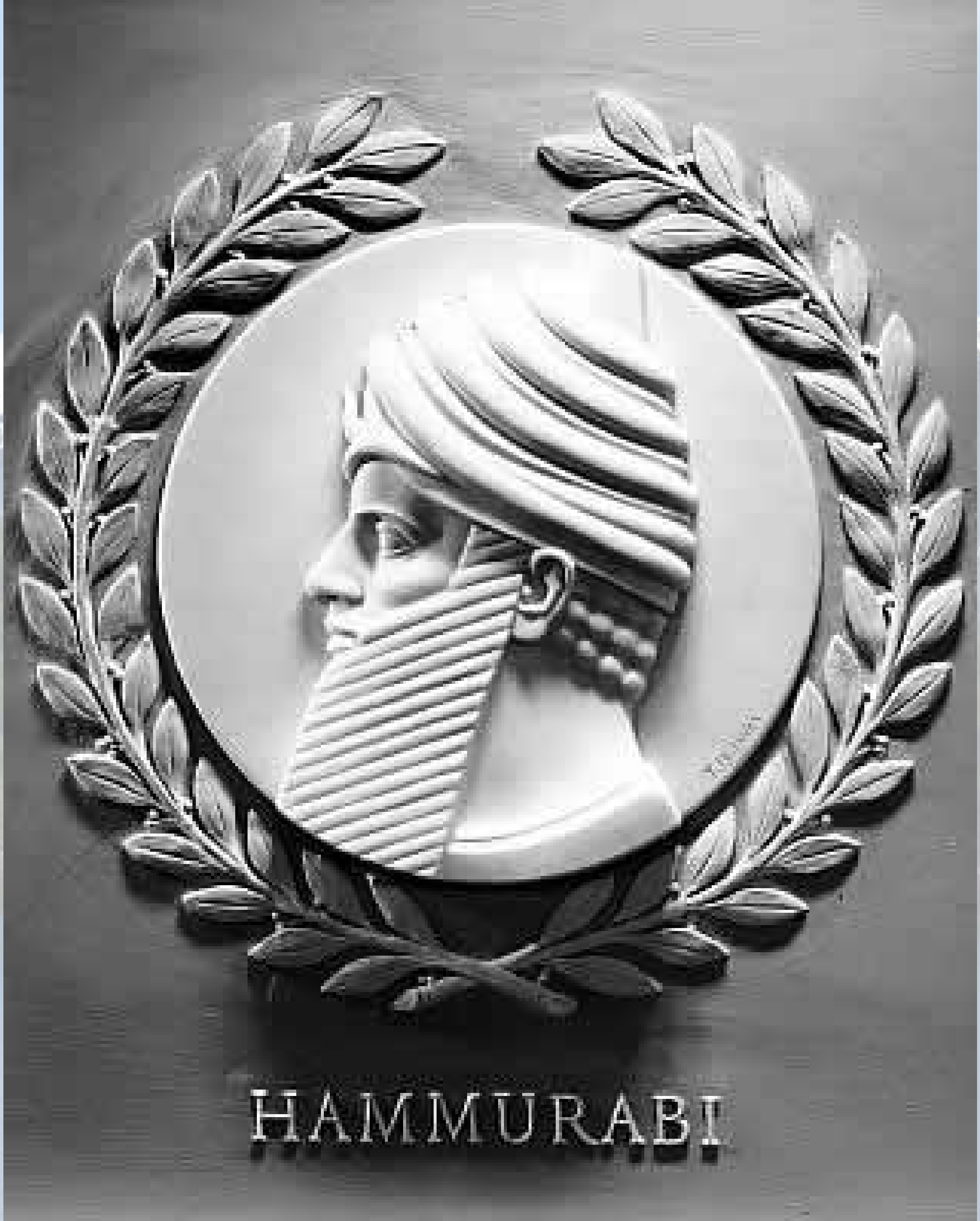
**Climate Model Data (CMIP3, 2007)**

- High Growth (A2)
- Moderate Growth (A1B)
- Low Growth (B1)
- 20th Century Climate

The black line shows the average of many different simulations of global temperature in the 20th century compared to average from 1971-1999, and the colored lines show projected temperature changes in the 21st century for three possible emissions scenarios. The shaded areas around each line indicate the statistical spread (one standard deviation) provided by individual model runs.

*learn more ››*

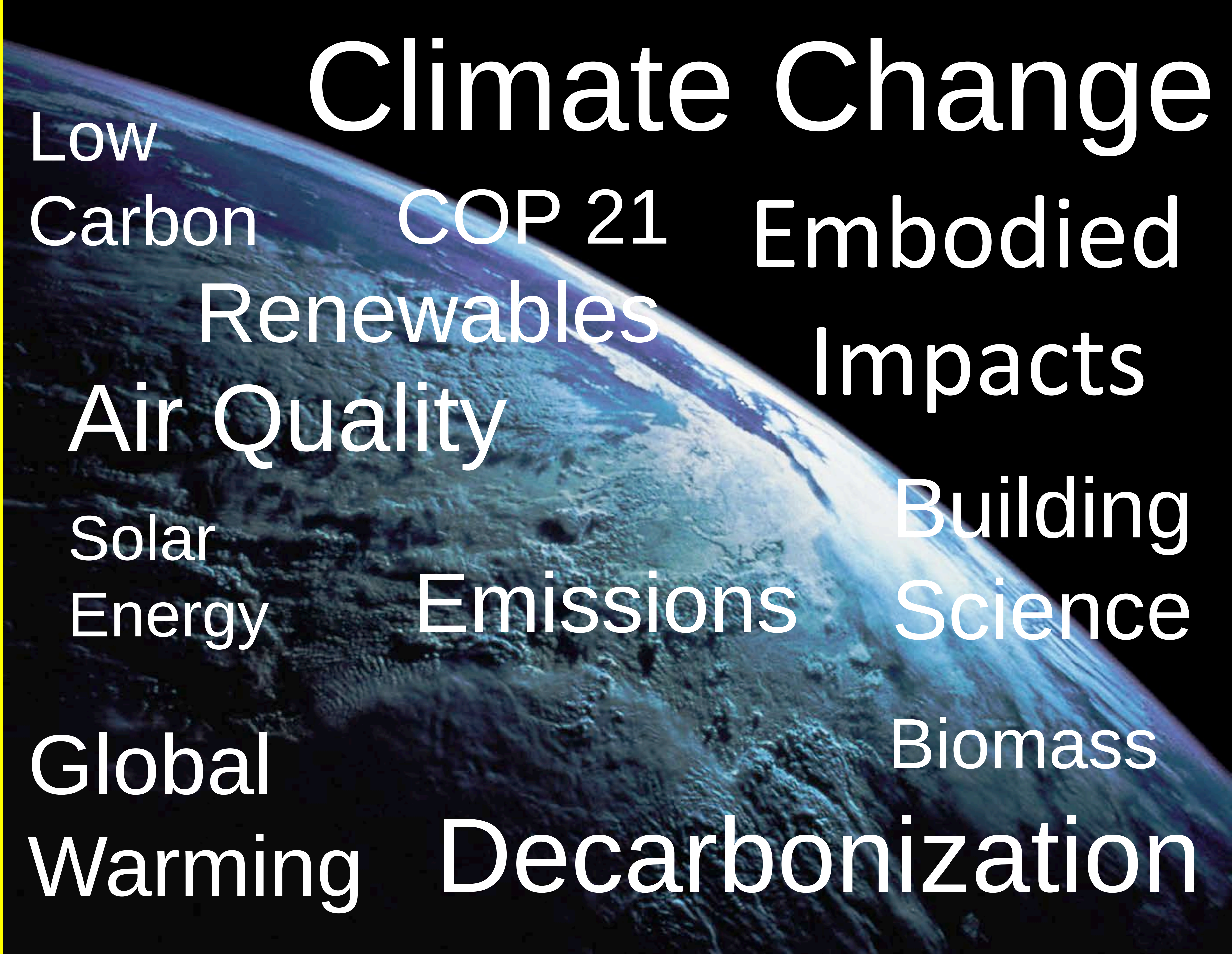



HAMMURABI

# First Building Code

If a builder build a house for some one, and does not construct it properly, and the house which he built fall in and kill its owner, then that builder shall be put to death.

If it kill the son of the owner, the son of that builder shall be put to death.


Climate Change
Low Carbon
COP 21
Embodied Impacts
Renewables
Air Quality
Building Science
Solar Energy
Emissions
Biomass
Global Warming
Decarbonization

**Netherlands Whole Building LCA**

**Germany BNB Whole Building LCA**

**U. K. BREAMM LCA**

**Belgium Embodied Impacts**

**France EPD**

**Zurich 2000-watt Society and Minergie (Eco Version)**


**Decarbonization** – increasing polices affecting both performance and embodied impacts.

# Provincial Initiatives

Carbon Taxes – BC & AB
Cap and Trade– ON and QC
Energy Step Code -- BC



City of Vancouver
July 5, 2016
Policy Report
Development And
Building


Passed July 12, 2016

THAT COUNCIL:

- Direct staff to build all new City-owned and Vancouver Affordable Housing Agency (VAHA) projects to be Certified to the Passive House standard or alternate zero emission building standard. (Applicable for all City-owned and VAHA building projects by 2018.)
- Incorporate requirements for calculating and reporting embodied emissions in the restructured Rezoning Policy for Green Buildings

EFFECTIVE MAY 1, 2017

# Forests And Wood

## 3-S Concept

- Sink
- Sequester
- Substitute

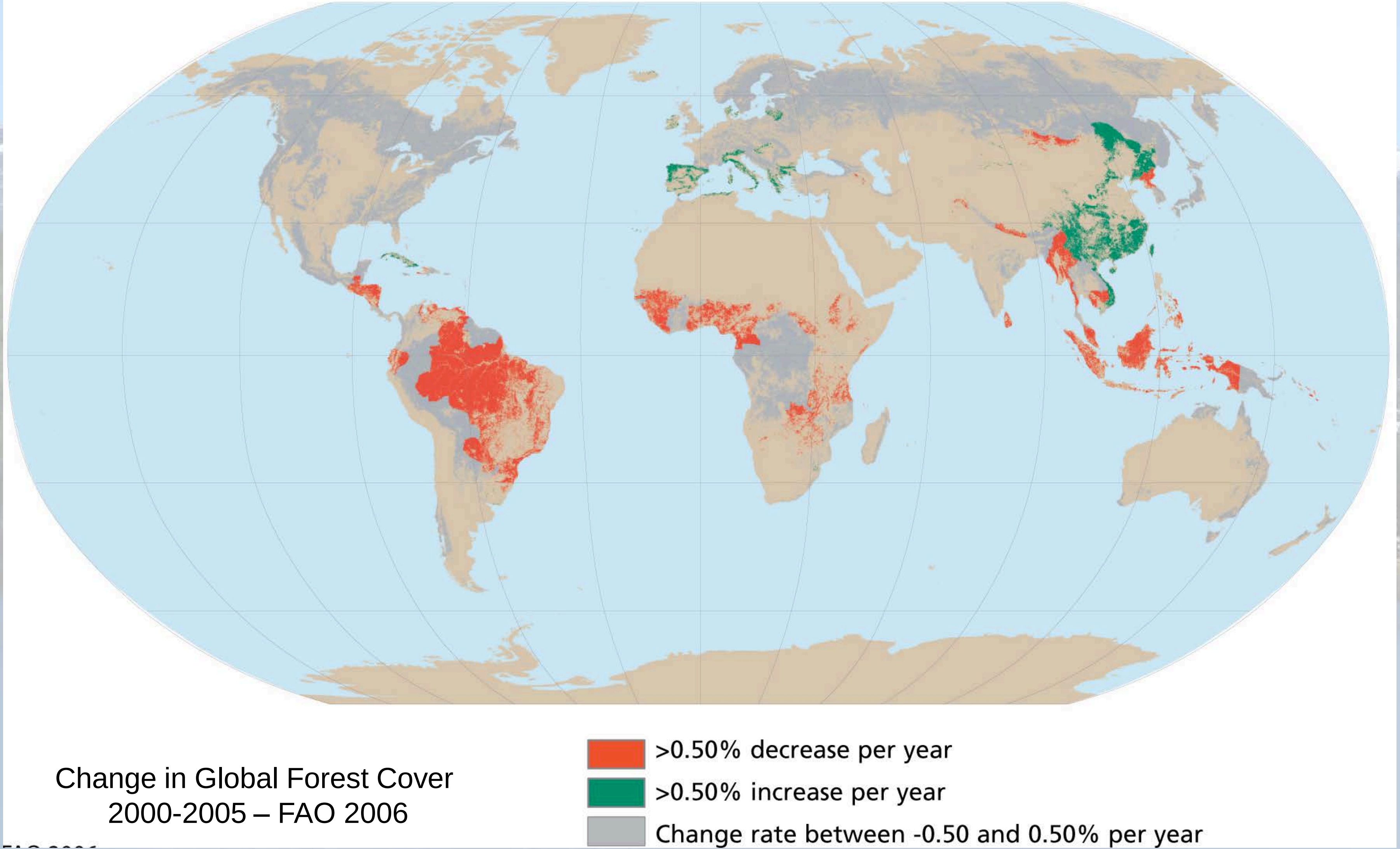
# Forests And Wood

## 4 ~~3~~-S Concept

- **<u>S</u>ustainable**
  - **Forestry**
- **<u>S</u>ink**
- **<u>S</u>equester**
- **<u>S</u>ubstitute**

# Importance of Forests as Carbon Sinks

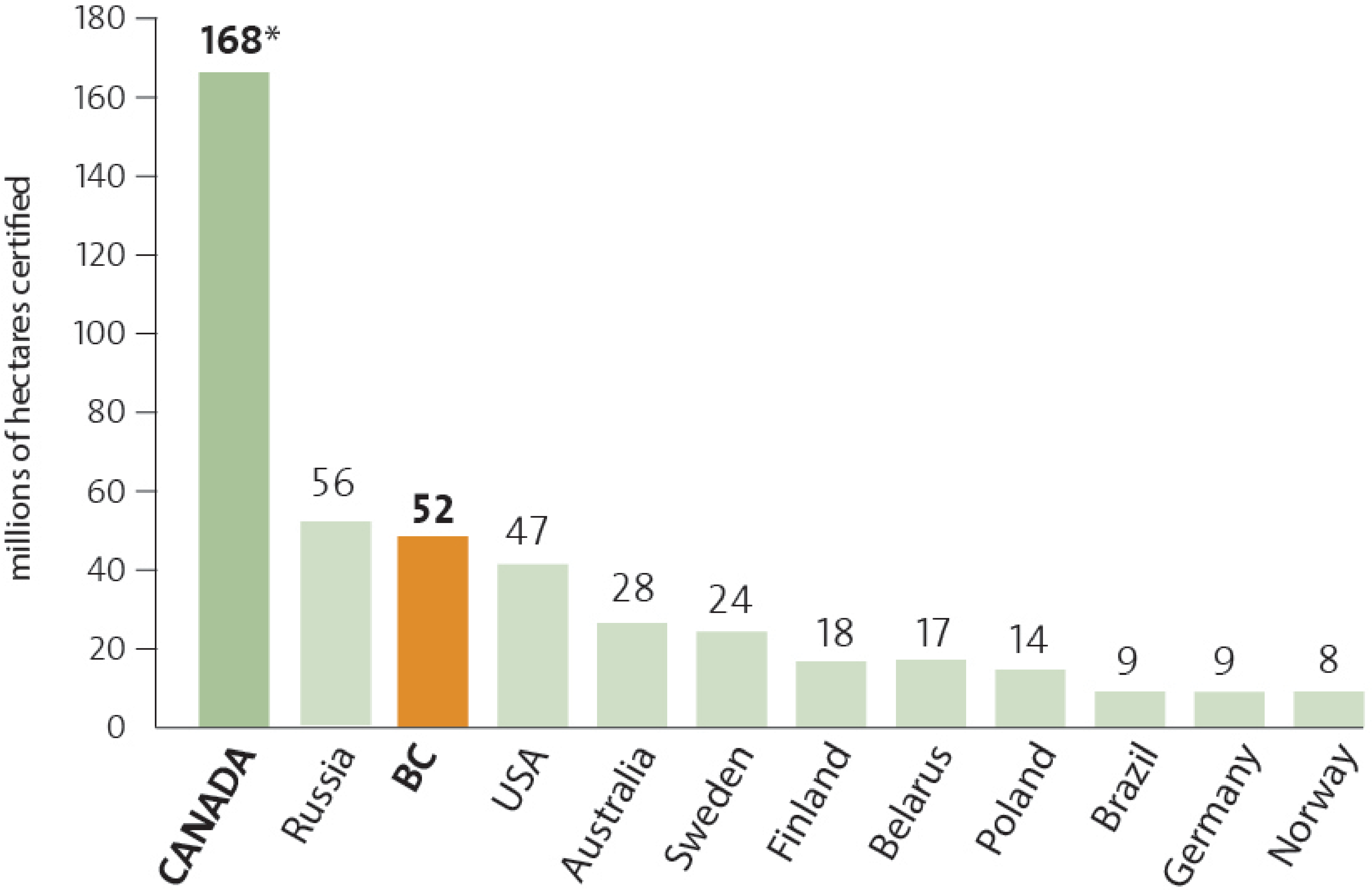
Deforestation account for 20% of GHGs (IPCC 2007)




Change in Global Forest Cover
2000-2005 – FAO 2006

# Canadian Certification in the Global Context

Dec 31, 2016

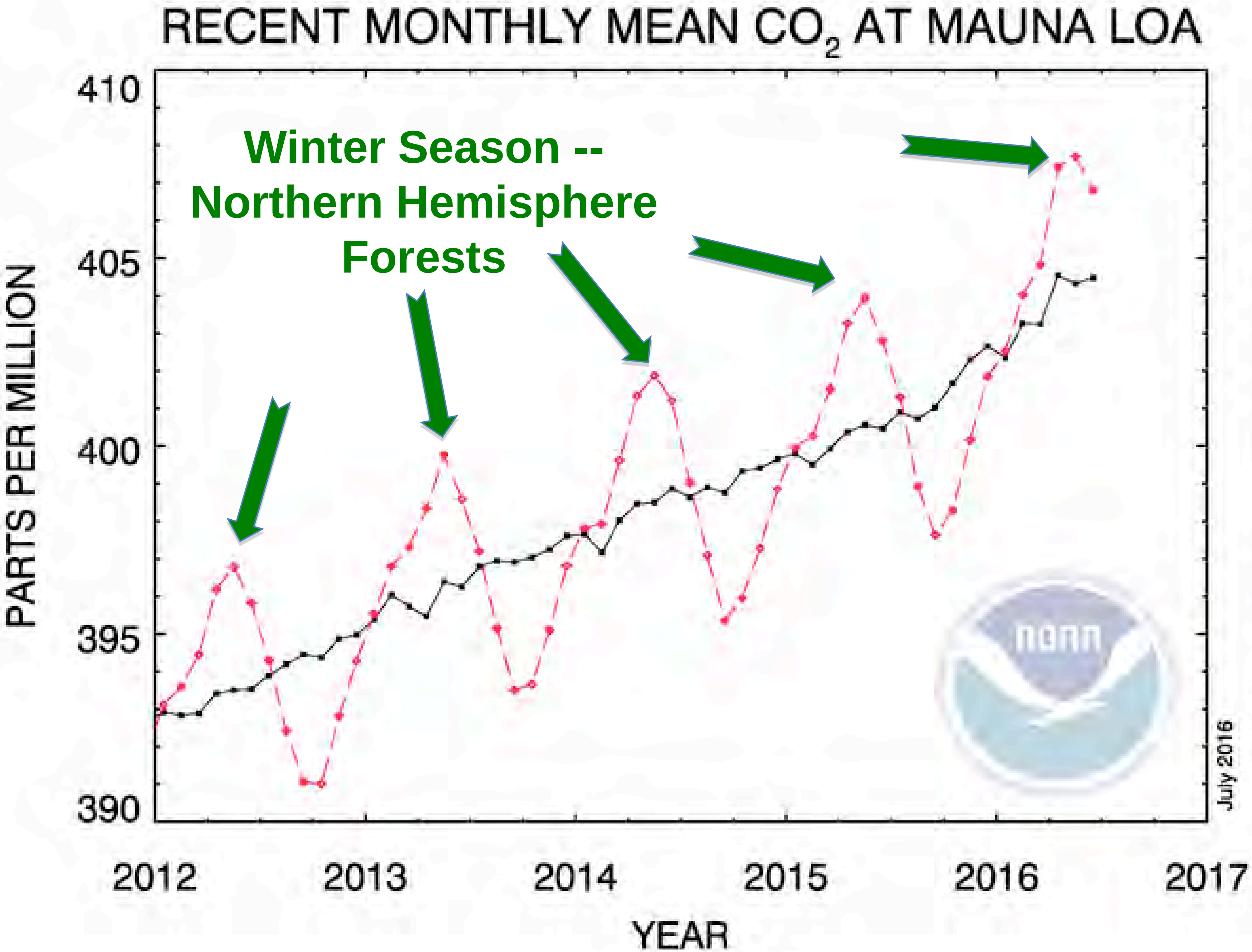



*Double counting of areas certified to more than one standard has been removed from this figure.

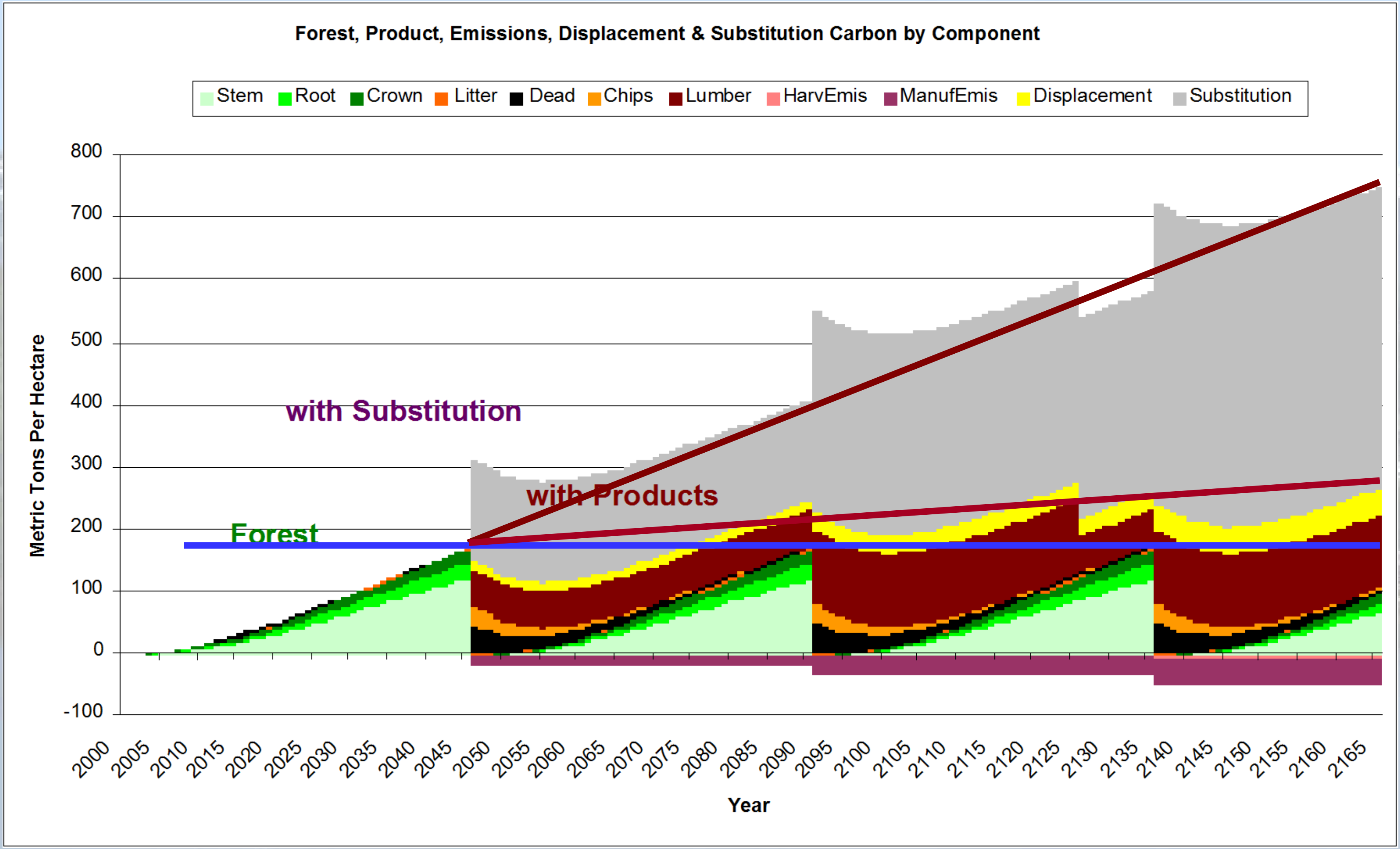
Natural Resources Canada Ressources naturelles Canada

# DEFORESTATION IN CANADA

## Canada's deforestation rate is among the lowest in the world


RECENT MONTHLY MEAN CO2 AT MAUNA LOA
Winter Season -- Northern Hemisphere Forests
410
405
400
395
390
PARTS PER MILLION
2012
2013
2014
2015
2016
2017
YEAR
July 2016
noaa

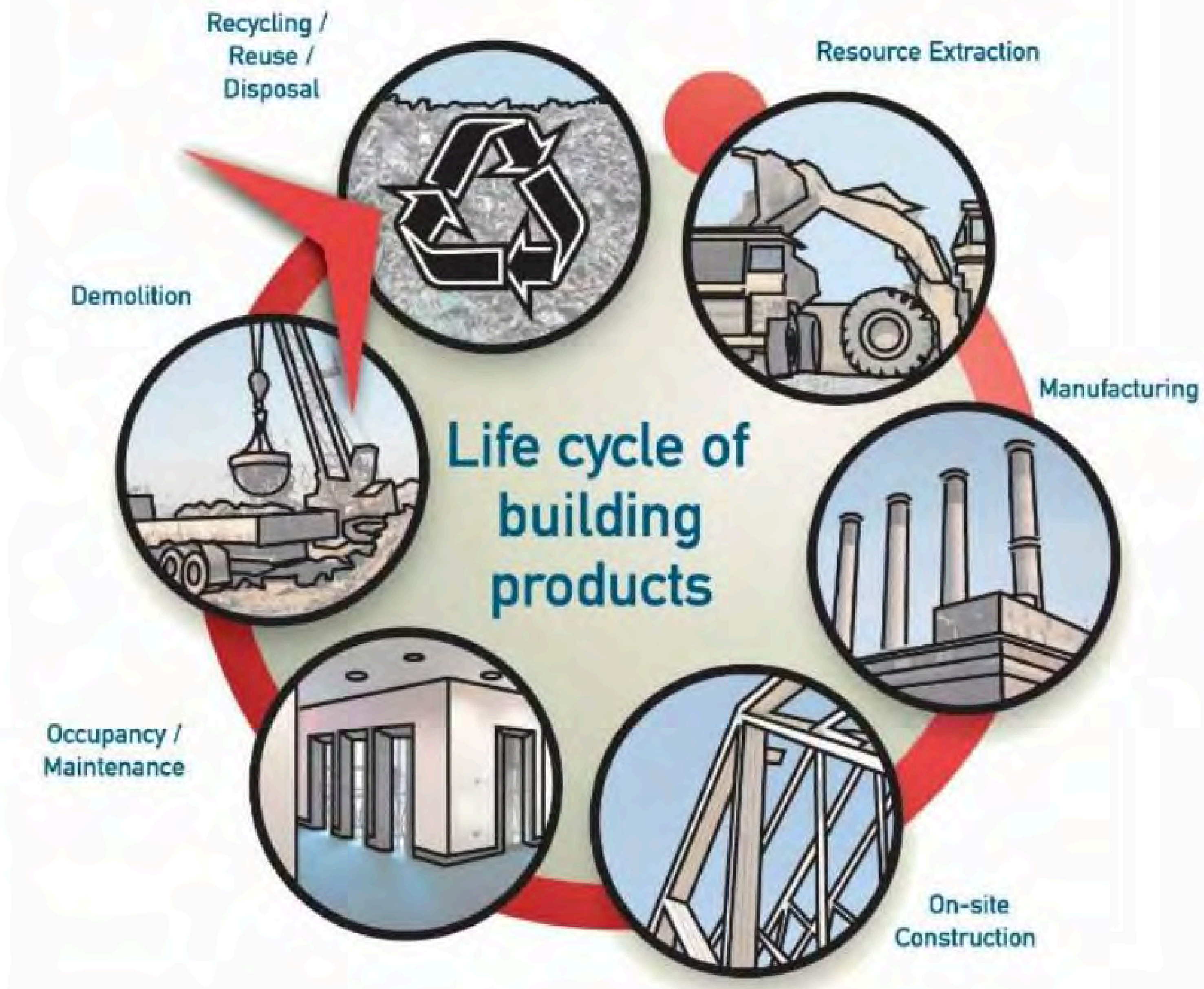
# Forest, Product and Substitution Pools
## (concrete frame vs wood)



# From the Co-Recipients of the 2007 Nobel Peace Prize…

***"In the long-term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, will generate the largest sustained mitigation benefit".***

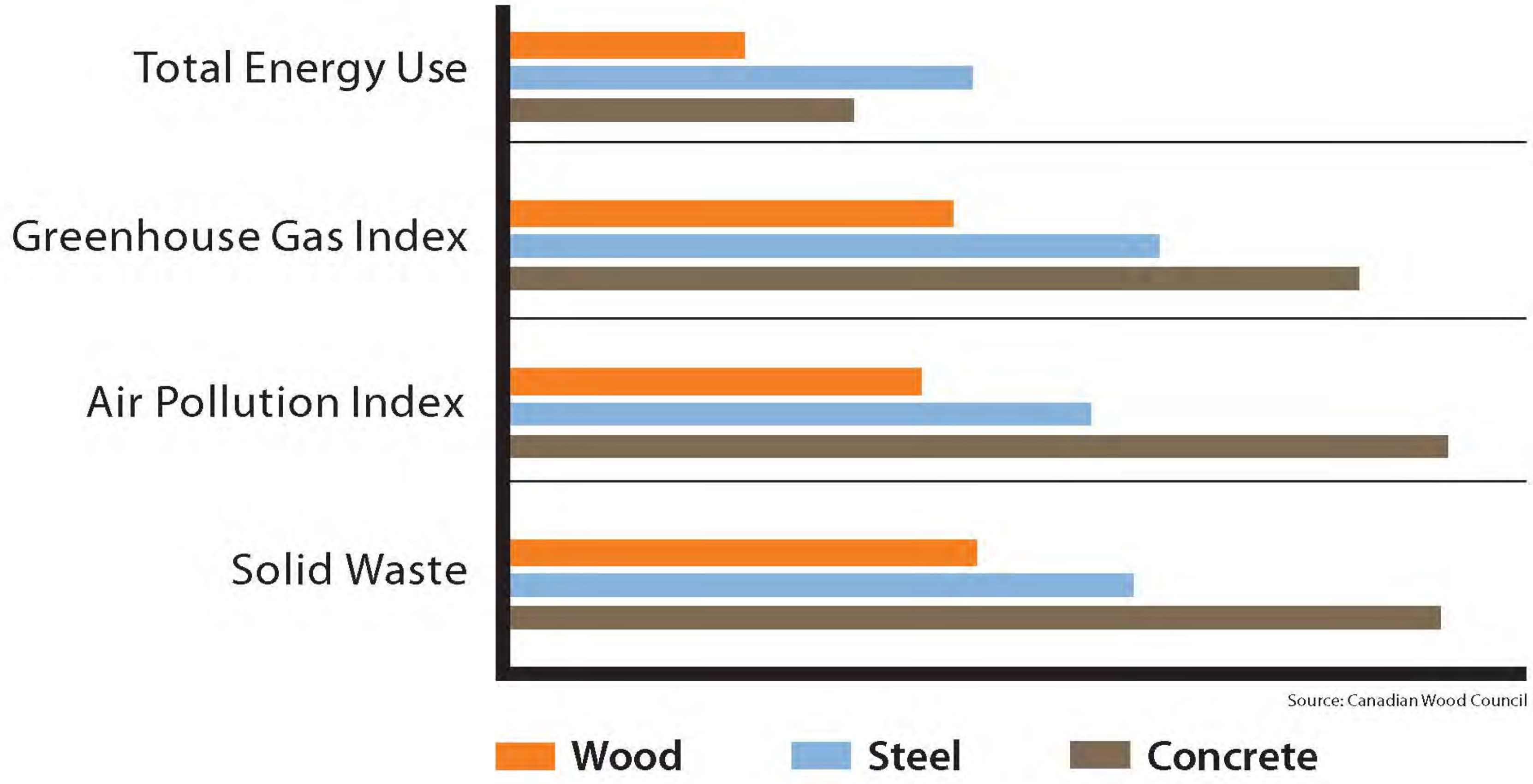
***IPCC 4th Assessment Report, November, 2007, (***Nabuurs et al.)

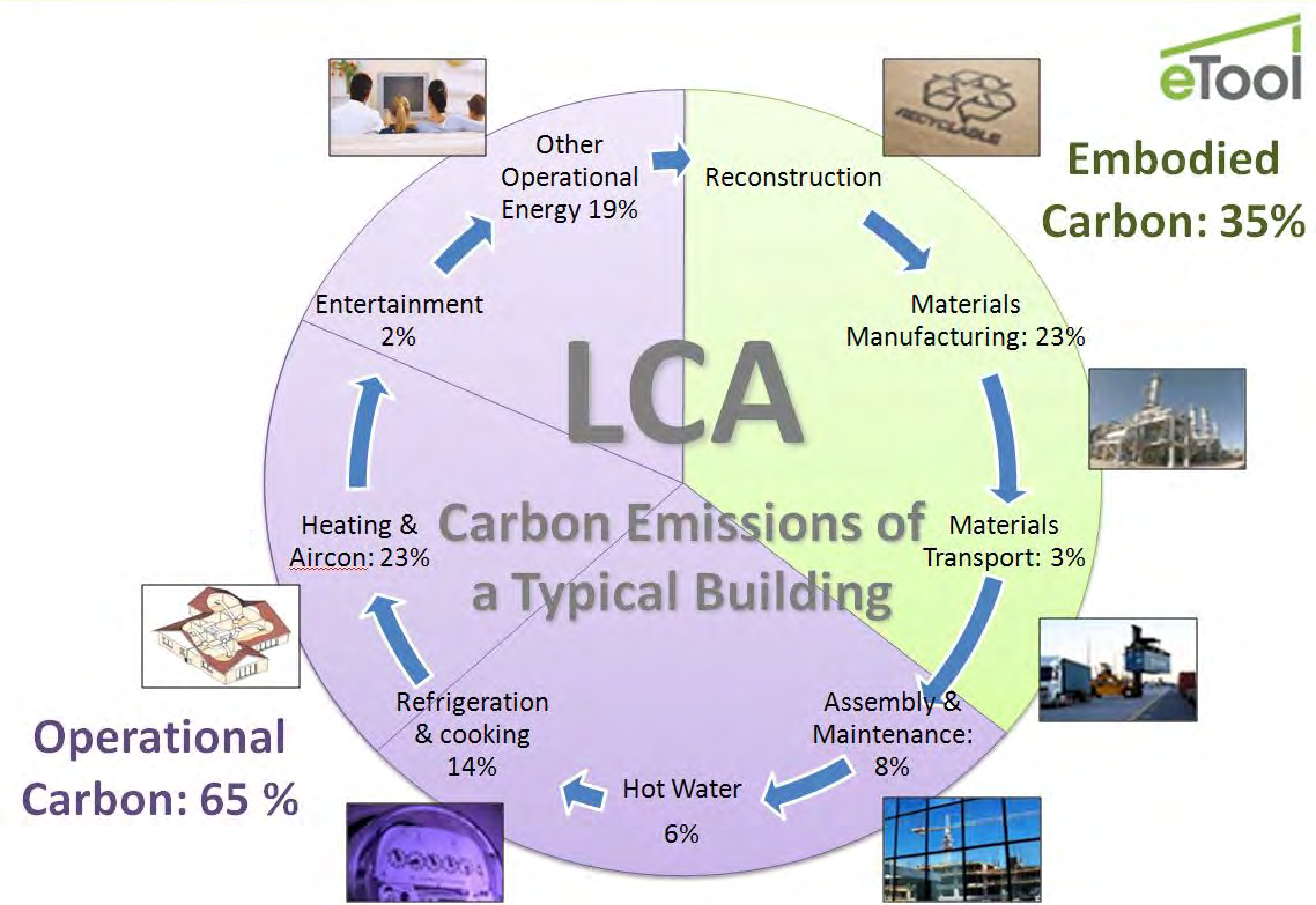


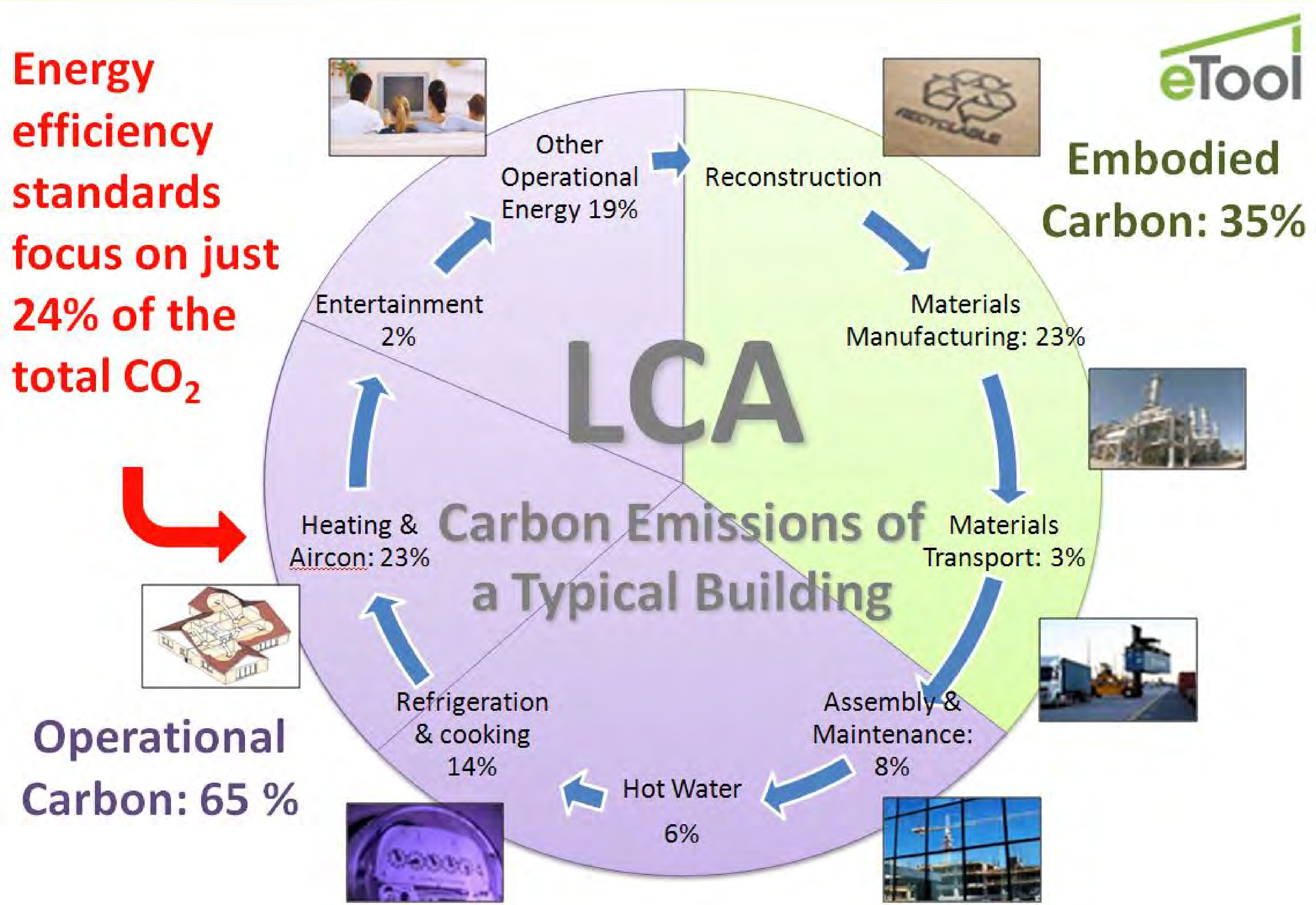

**Life cycle phases of buildings and building products Athena Sustainable Materials Institute**

# Life Cycle Assessment
## A Comparison of Wood, Steel and Concrete

In this graph, life cycle assessment results are given for three versions of the same typical office building, each designed with a different structural system.




eTool
Embodied Carbon: 35%
Operational Carbon: 65 %
LCA
Carbon Emissions of a Typical Building
Other Operational Energy 19%
Reconstruction
Materials Manufacturing: 23%
Materials Transport: 3%
Assembly & Maintenance: 8%
Hot Water 6%
Refrigeration & cooking 14%
Heating & Aircon: 23%
Entertainment 2%


Energy efficiency standards focus on just 24% of the total $CO_2$
eTool
Embodied Carbon: 35%
Operational Carbon: 65 %
LCA
Carbon Emissions of a Typical Building
Other Operational Energy 19%
Reconstruction
Materials Manufacturing: 23%
Materials Transport: 3%
Assembly & Maintenance: 8%
Hot Water 6%
Refrigeration & cooking 14%
Heating & Aircon: 23%
Entertainment 2%

# Example

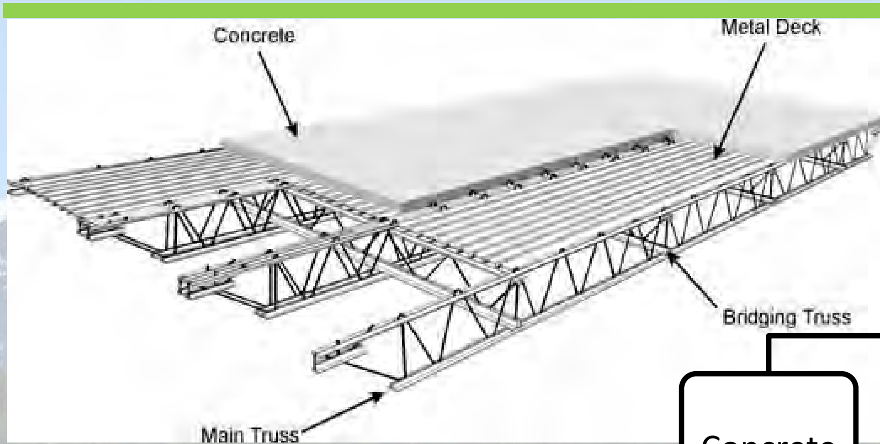
Study of GHG emissions of a floor structure *6m x 6m in an office building.*

Steel deck and Concrete Solution

?

Wood Solution

# Steel-Concrete Solution




**Steel girders and steel deck with concrete slab**

| | Concrete | Steel deck | Steel girders | Steel reinfor-cement |
|---|---|---|---|---|
| **Quantity of materials** | 3 m$^3$ | 0.4 tonnes | 0.2 tonnes | 0.03 tonnes |
| **Potential GHG emissions** | 540 kg $CO_2$ | 868 kg $CO_2$ | 198 kg $CO_2$ | 27 kg $CO_2$ |

**CIRAIG Data**

**Results**: 1633 kg $CO_2$ éq.

# Wood Solution

**Wood floor trusses with OSB**

| | Truss plates | Nails | OSB | Softwood lumber |
|---|---|---|---|---|
| **Quantity of materials** | 0.05 tonnes | 0.04 tonnes | 75 $m^2$ | 0.9 $m^3$ |
| **Potential GHG emissions** | 63 kg $CO_2$ | 37 kg $CO_2$ | 75 kg $CO_2$ | 32 kg $CO_2$ |

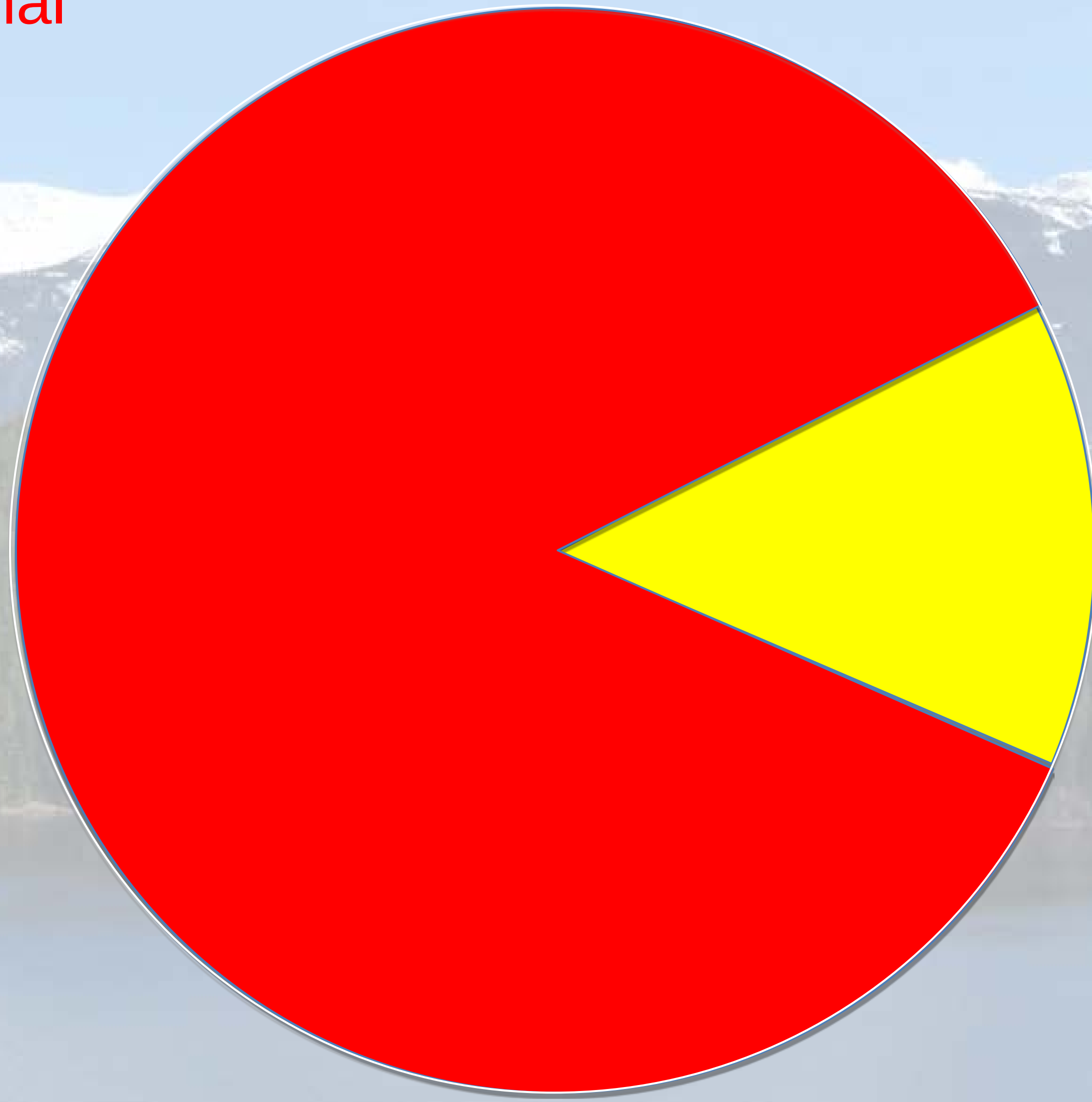
**CIRAIG Data**

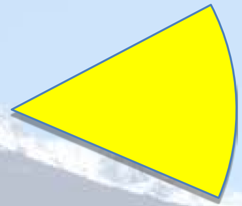
**Results**: 276 kg $CO_2$ éq.

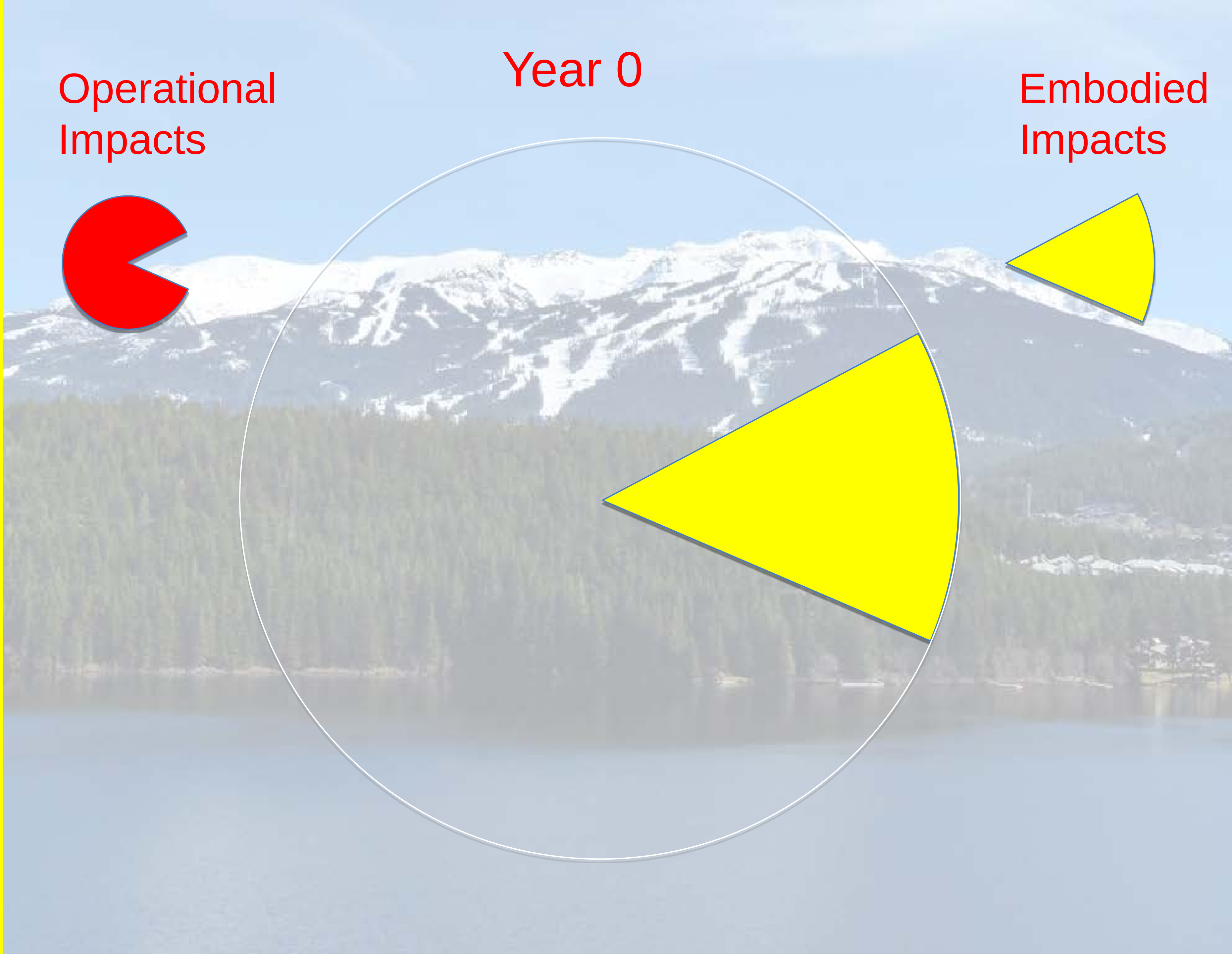
# Whole Life Impacts – 80 Years
## Variablility -- 12 – 20% (15%)

Operational

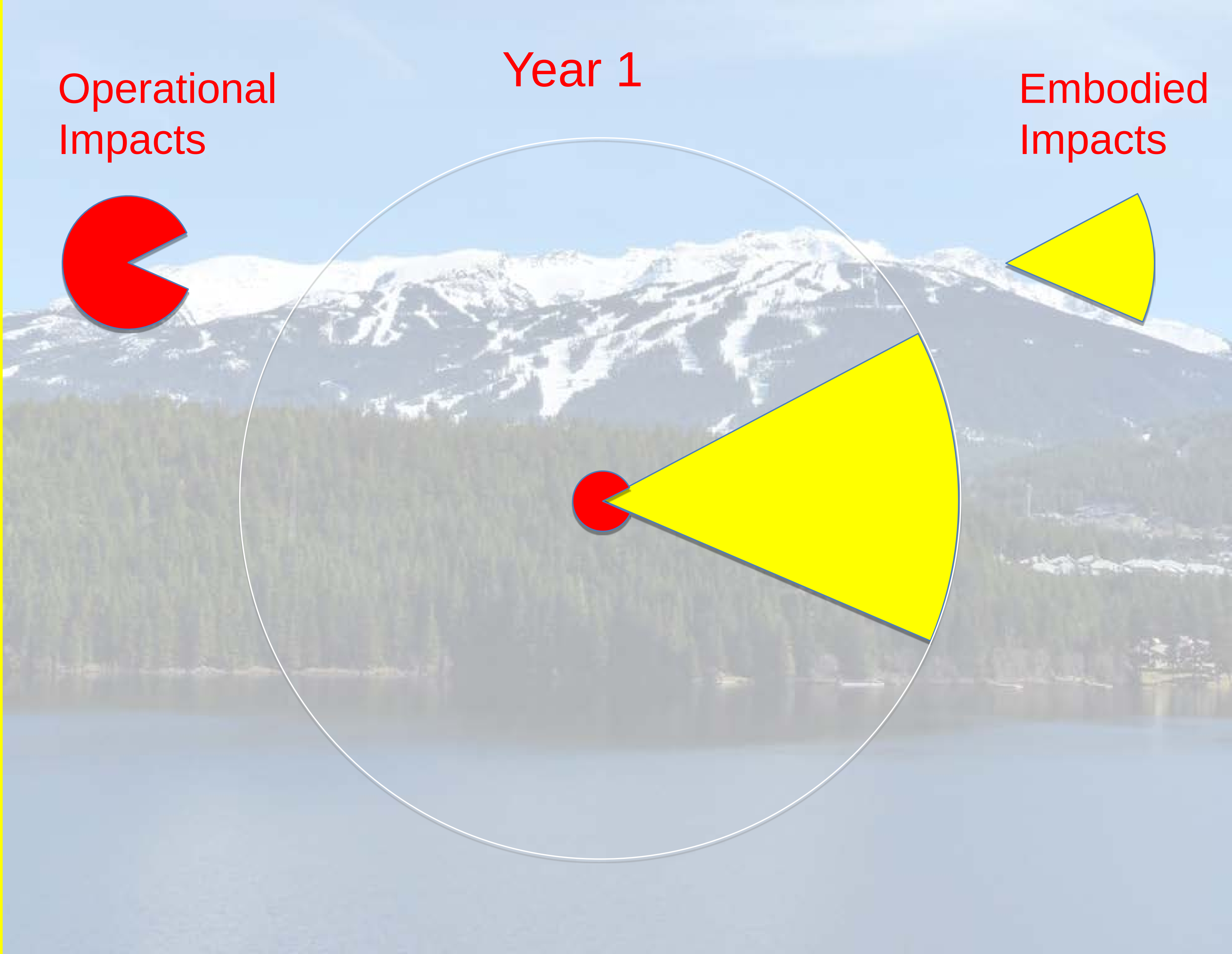
Embodied

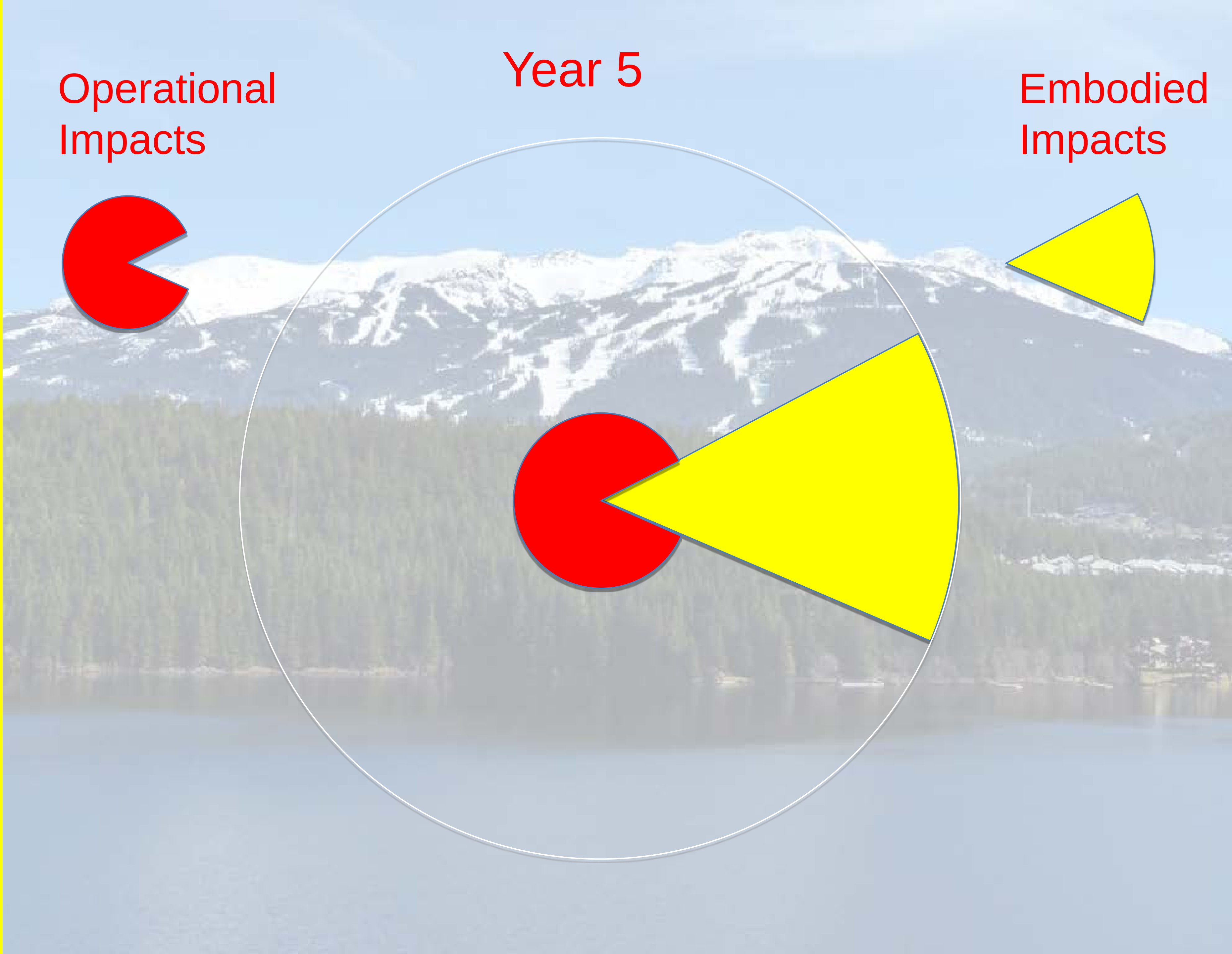


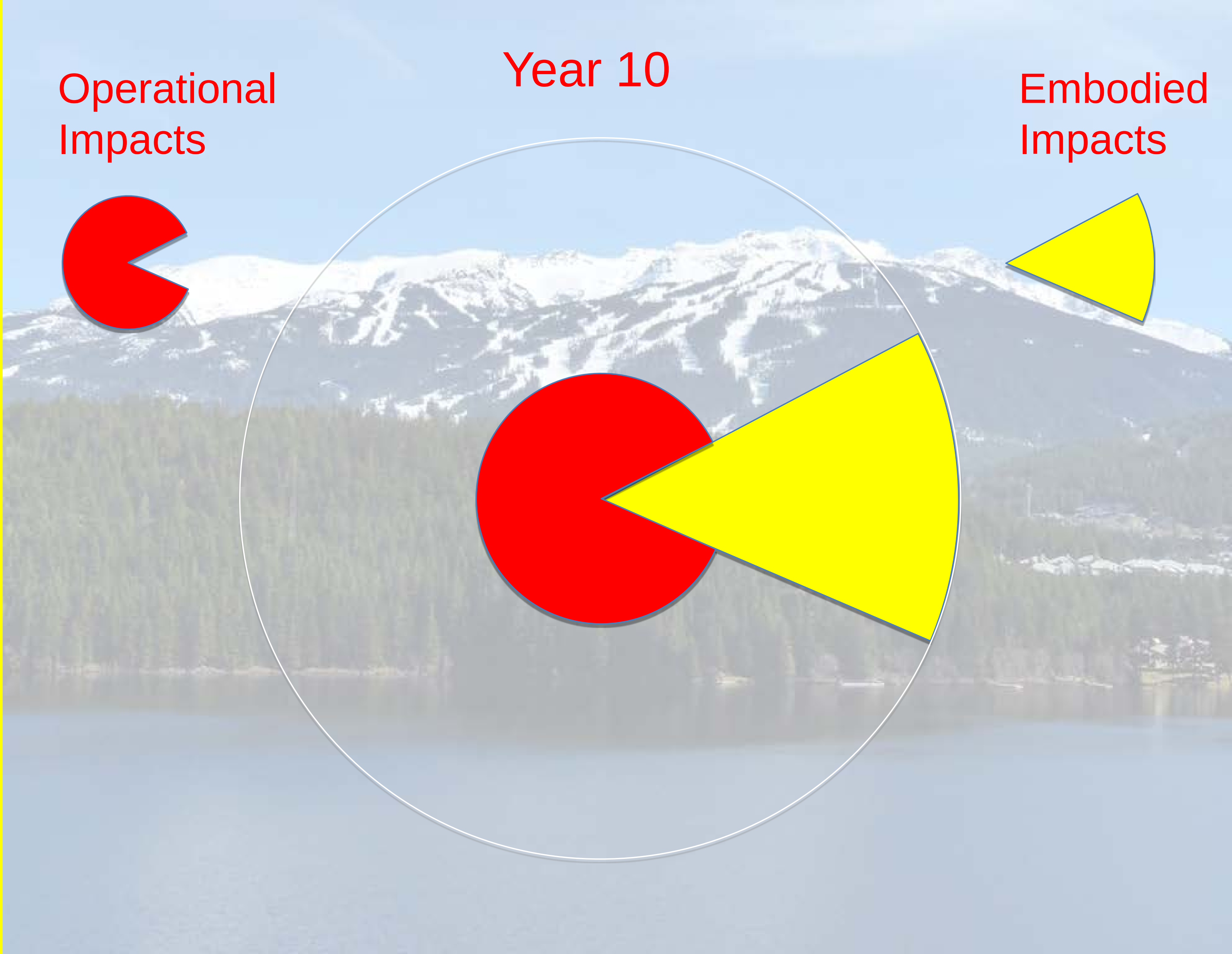



Year 0
Operational
Impacts
Embodied
Impacts

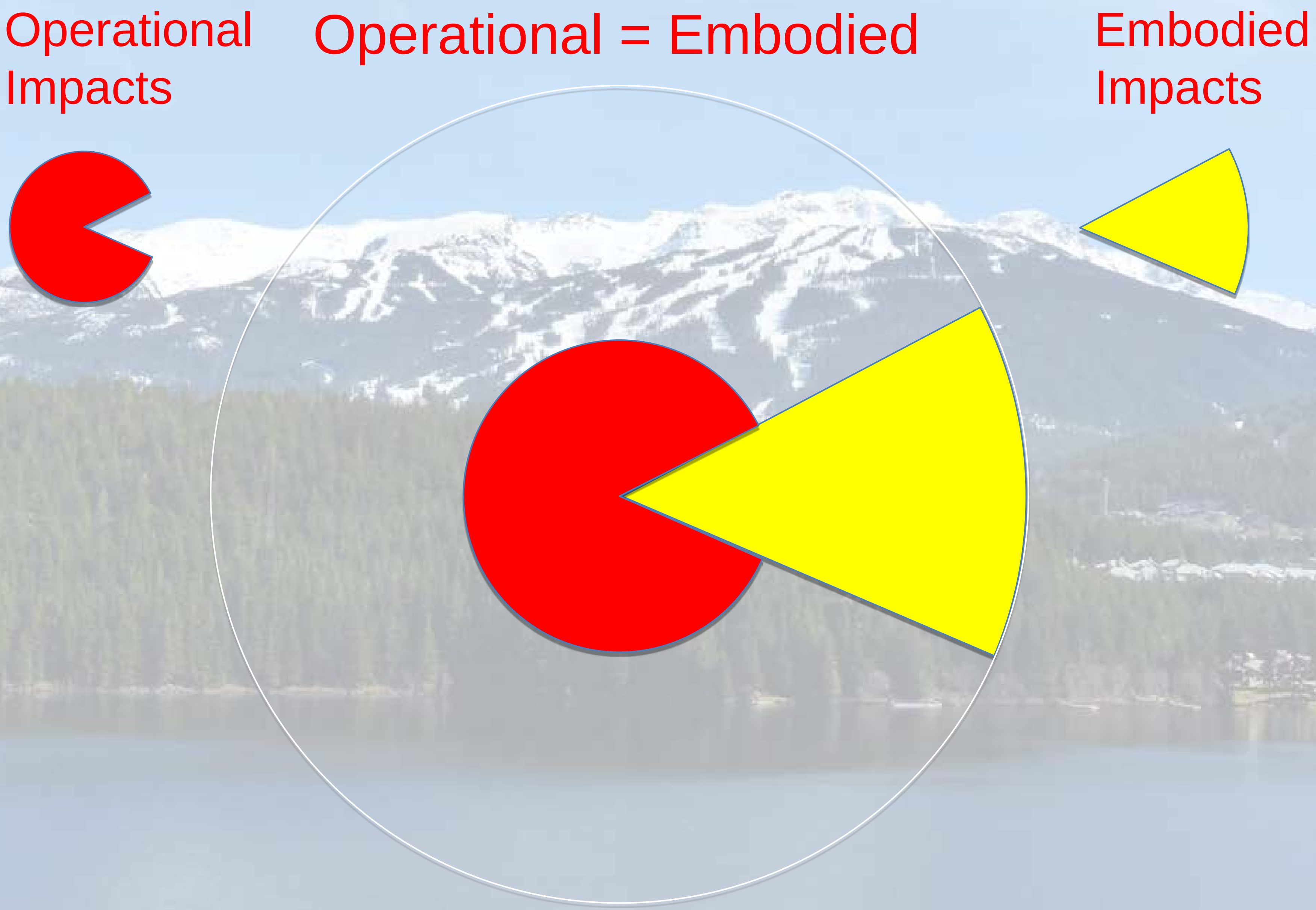
# Year 1




Year 5
Operational Impacts
Embodied Impacts


Year 10
Operational
Impacts
Embodied
Impacts

# Year 12
# Operational = Embodied

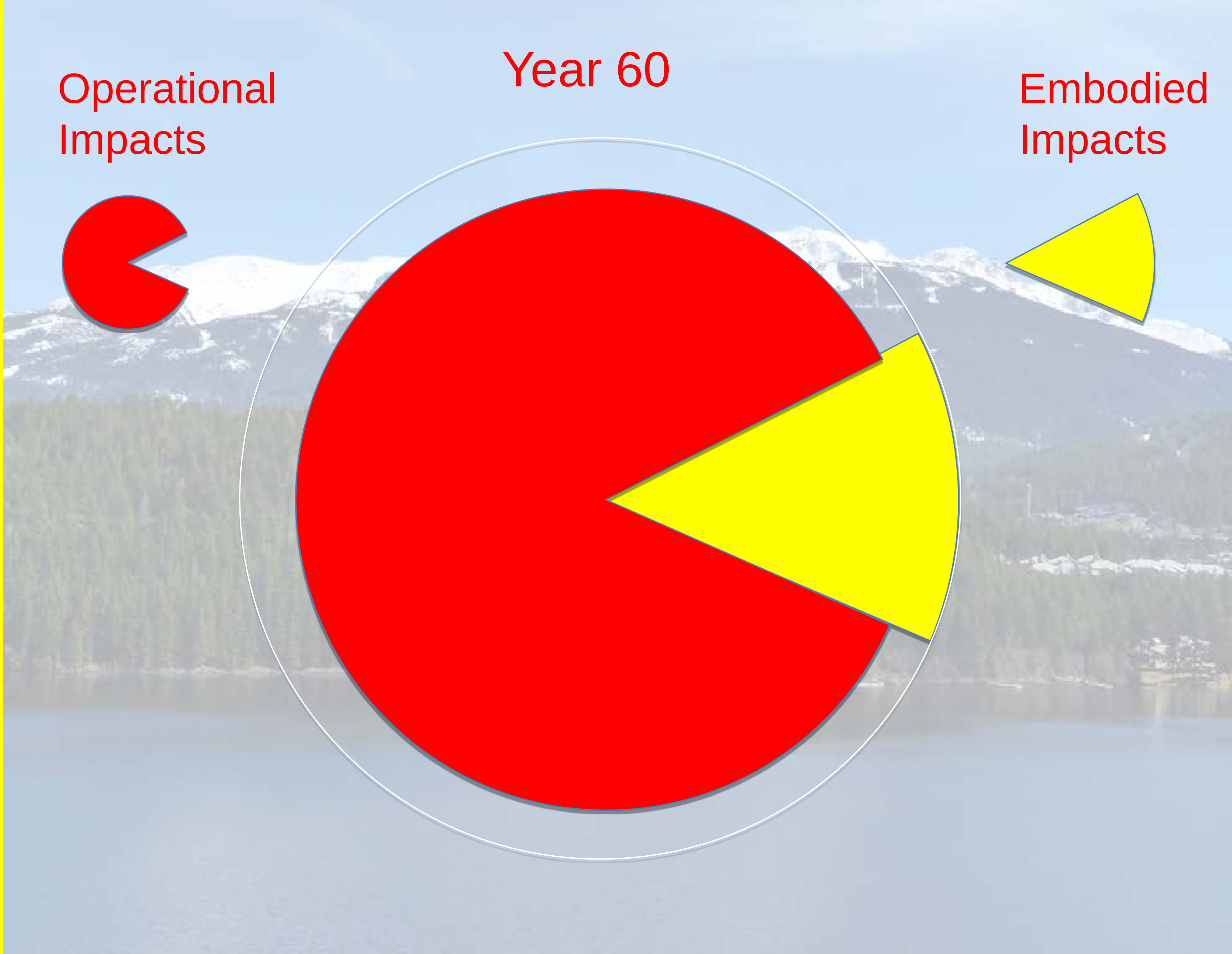


# Year 25

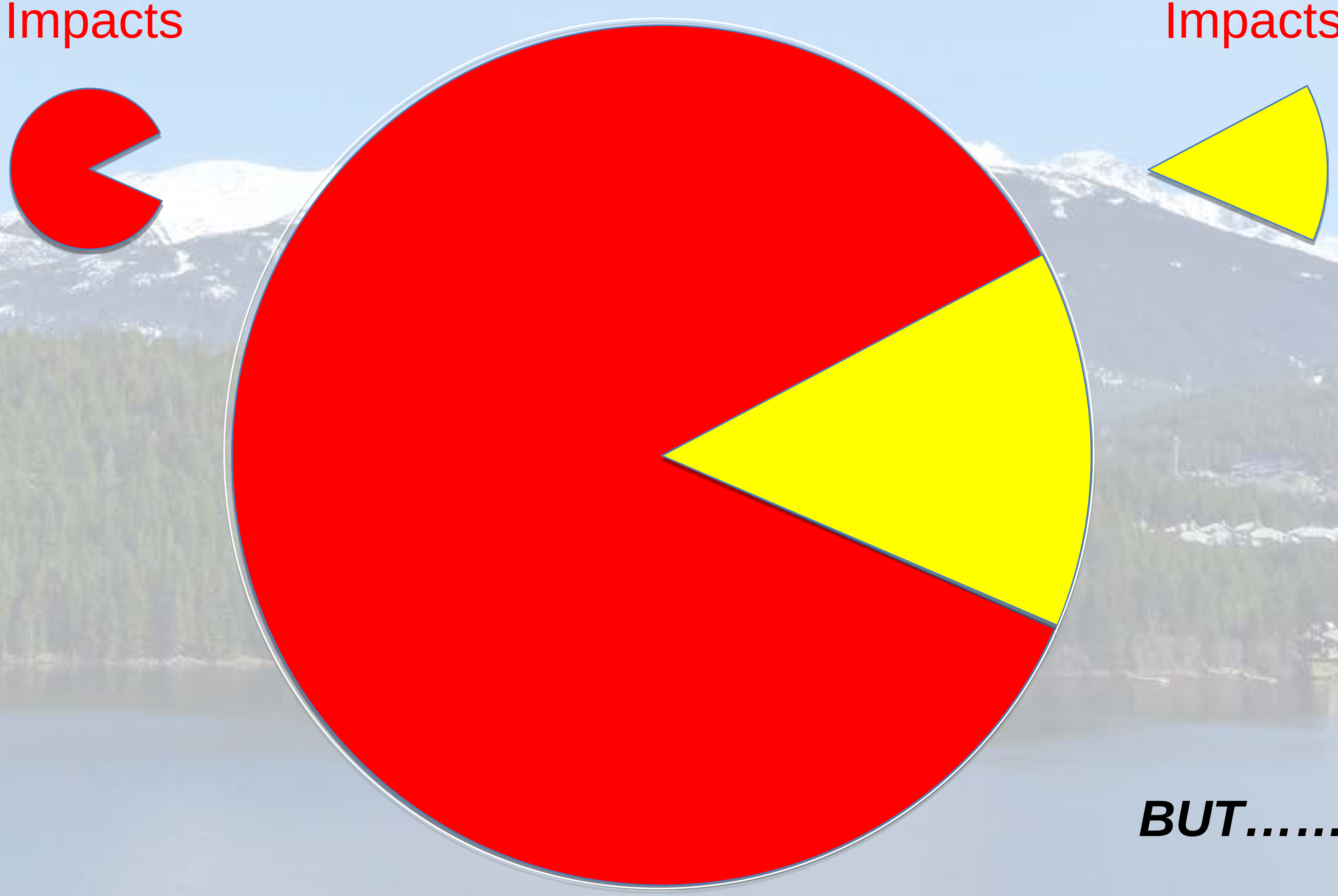
# Year 40

Operational Impacts

Embodied Impacts


Year 60
Operational
Impacts
Embodied
Impacts

# Year 80



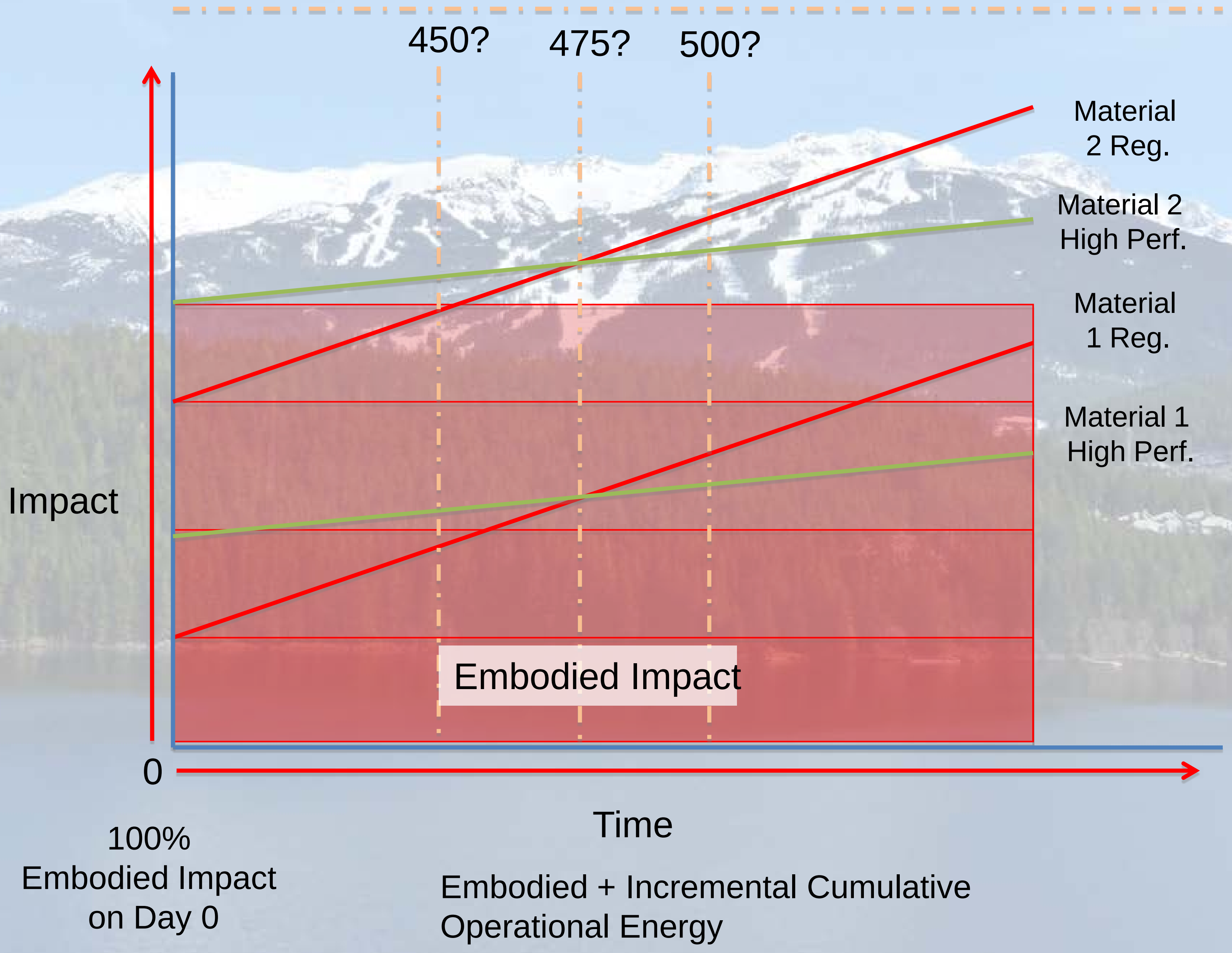

***BUT……***

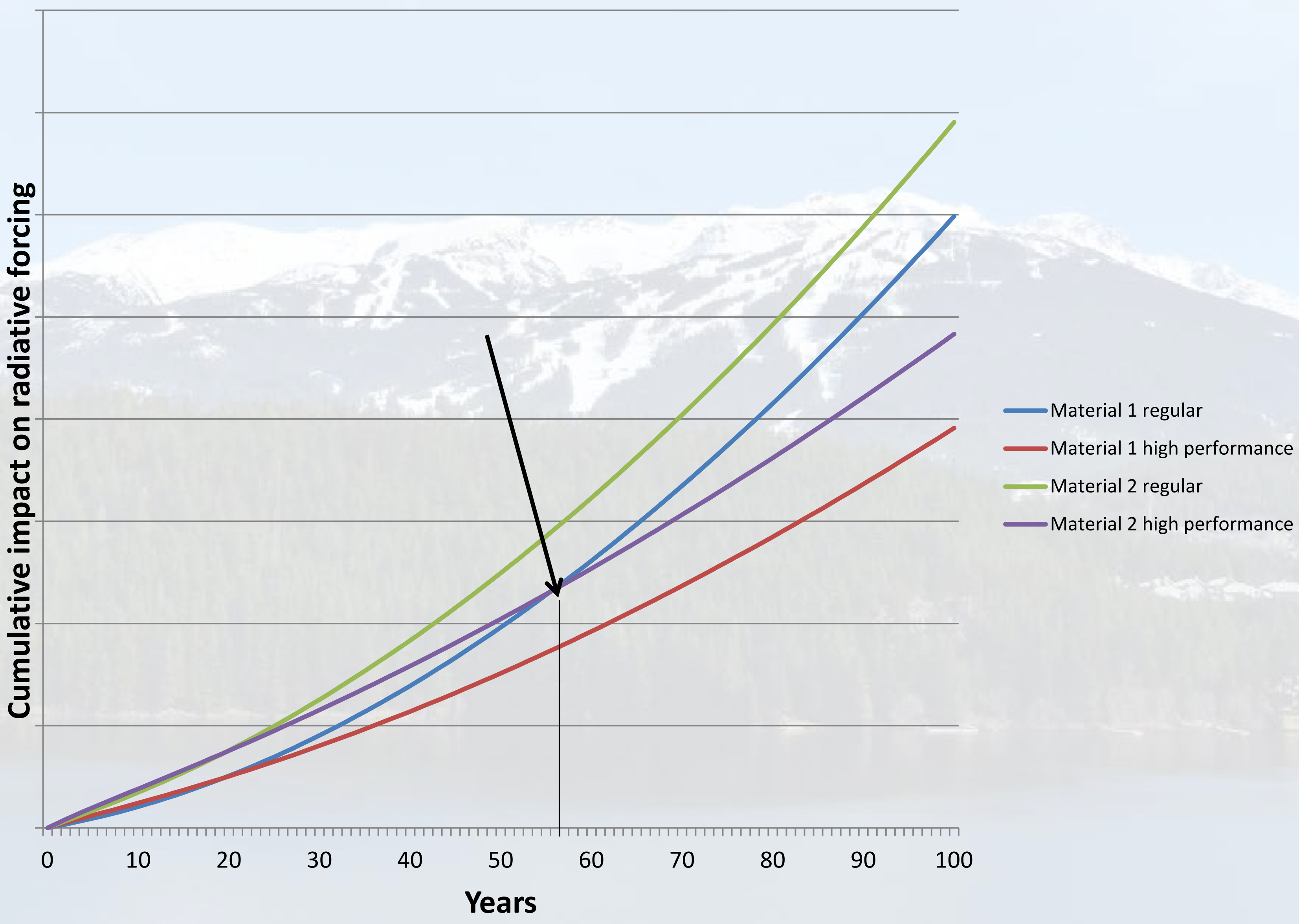
# *What if….*

- The building is poorly maintained and becomes decrepit before 80 years?
- The building is operated more efficiently?
- The land becomes more valuable for another use and the building is removed?
- The building uses using non-depleting, low-impacting energy, rendering operational impacts moot?
- The building is rendered unusable (fire, storm, flood…)
- A carbon tipping point is reached before the modeled savings are reached?
- Or….???

# Embodied and Operational Impact Variability

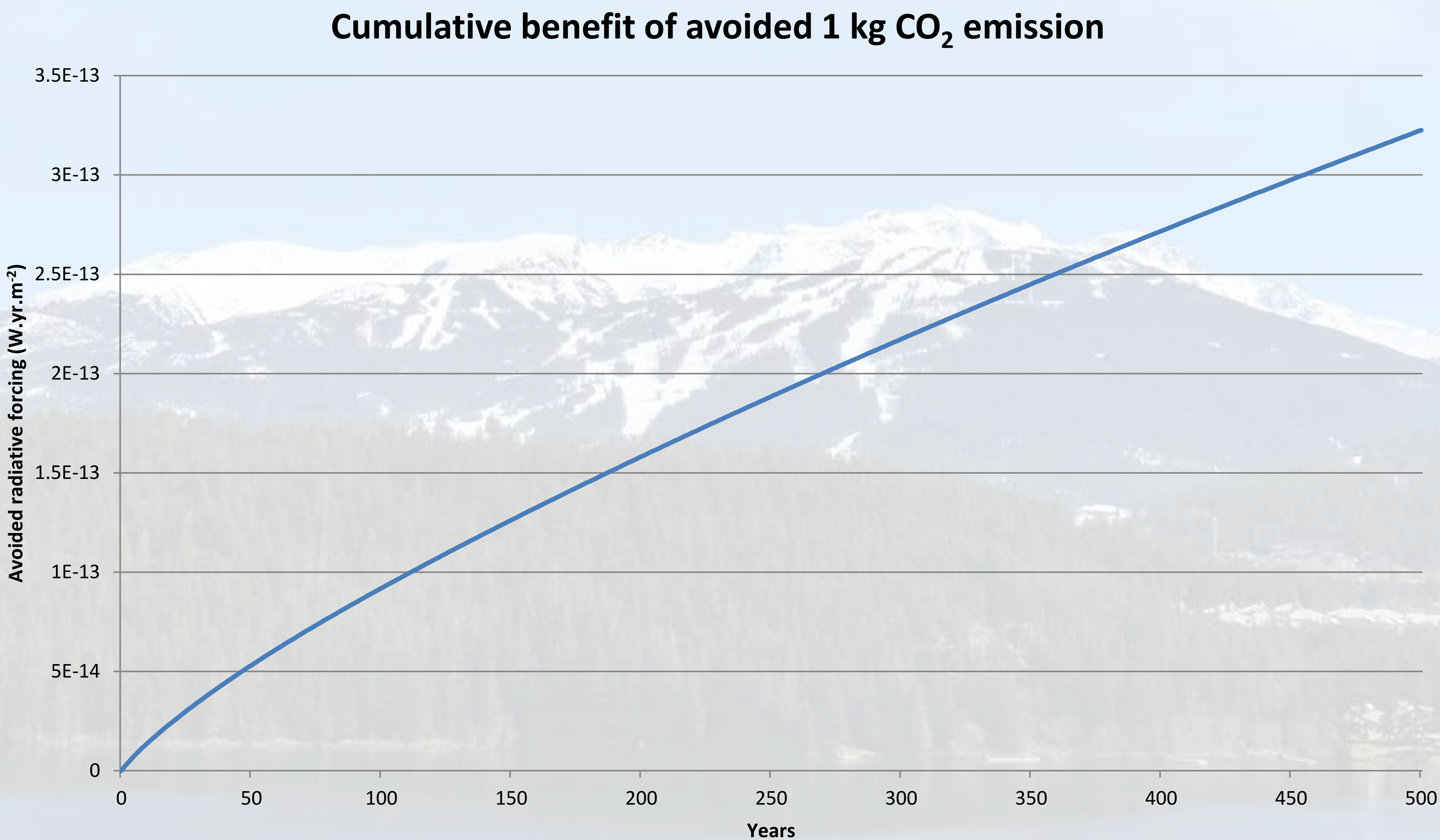
Atmospheric $CO_2$ (ppm)







**Annie Levasseur, ing. Ph.D.**
Chercheuse, Coordonnatrice scientifique



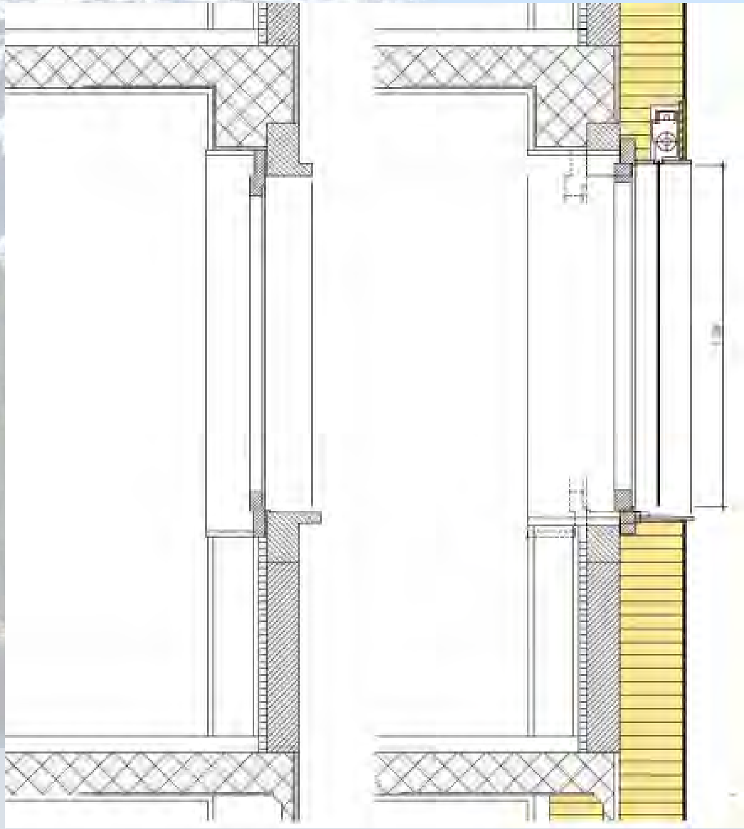

Net present value
1 tonne $CO_2$ in 80 years → .24 tonne.

**Annie Levasseur, ing. Ph.D.**
Chercheuse, Coordonnatrice scientifique

# Performance Opportunities

# Retrofitting / Renovation of Existing Buildings

- Biggest impact for environmental benefit
- Densification – opportunity to green existing buildings
- Envelope improvement using wood products
- Windows and doors



Exterior performance modification using wood products

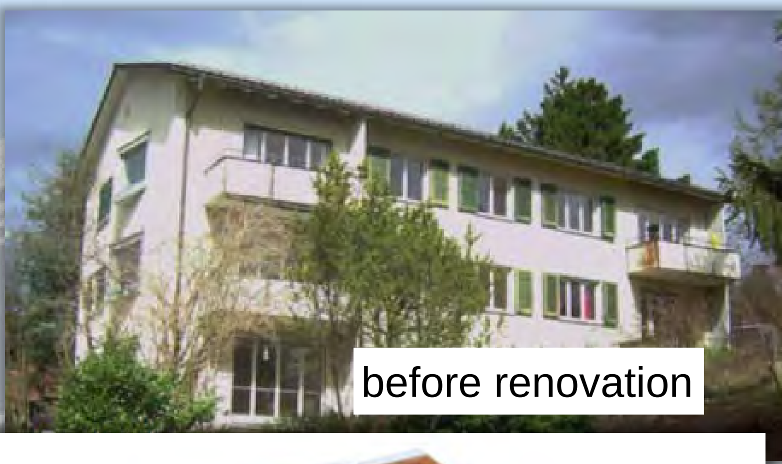
Courtesy Heiko Thomen / Ronald Giroux

*(Image: www.kaempfen.com)*

# Apartment Building

Renovation and addition of another storey

- Motivation and concept:
  - Limited space in Switzerland
  - Wood as lightweight material
  - Financed renovation by additional storey -- (cover 2/3 of building costs)







Courtesy Heiko Thomen / Ronald Giroux *(Images: www.kaempfen.com)*

# Building Physics / Passive Design

Energy Efficient
Cost Efficient
Fire Safe
Healthy
Adaptable
Sustainable
Structurally Safe
Durable
Acoustics Controlled
Aesthetically Pleasing
Resiliant: Seismic and wind
Deconstructable

**Multi-Disciplinary Approach**

# Why Passive

*“The best way for the planet to reduce it’s energy use is to build and retrofit every building to a passive design. Compared to all other options, doing so is the fastest, most effective and least expensive way to reduce energy.“*

Diana Ürge-Vorsatz, Director of the Center for Climate Change and Sustainable Energy Policy (3CSEP) at the Central European University

Speaking at the North American Passive House Network, Vancouver, B.C. Octopber 1, 2015

# Passive House Multi-Family


388 Skeena – Vancouver BC

Courtesy Scott Kennedy
Cornerstone Architecture

# Passive House Multi-Family

7350 Fraser Street – Vancouver BC – Archstone Projects

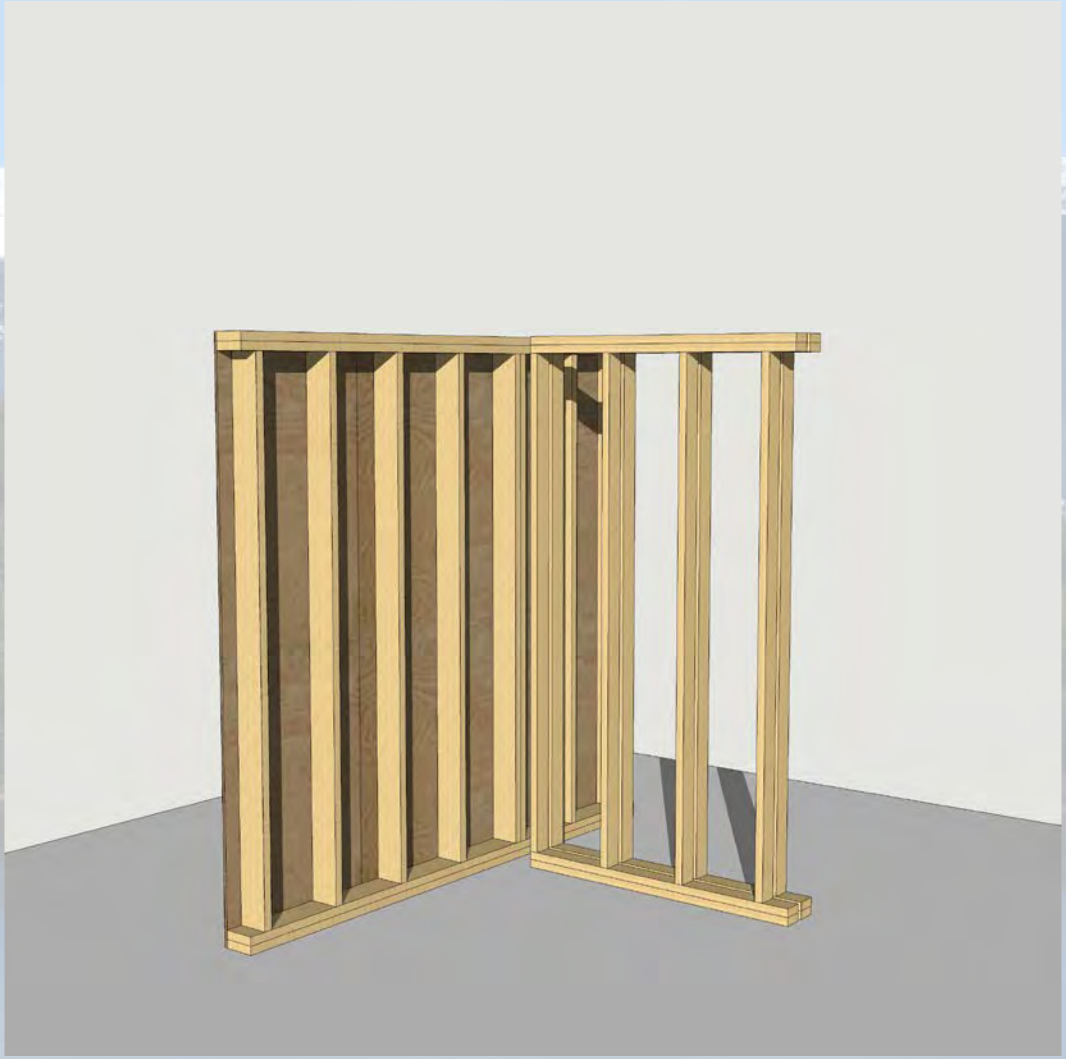
Courtesy Scott Kennedy
Cornerstone Architecture

# Economics of Passive House

- Cost Savings
  - Eliminate installing a hydronic heating system
    - Capital Saving
    - Maintenance Reduction
    - Electric Energy costs passed on to tenants
- Additional Costs
  - Additional insulation
  - Air sealing
  - Windows
  - High Efficiency HRV’s
  - Details to eliminate thermal bridges

Courtesy Scott Kennedy
Cornerstone Architecture

# Framing - stage 1



Courtesy Scott Kennedy
Cornerstone Architecture

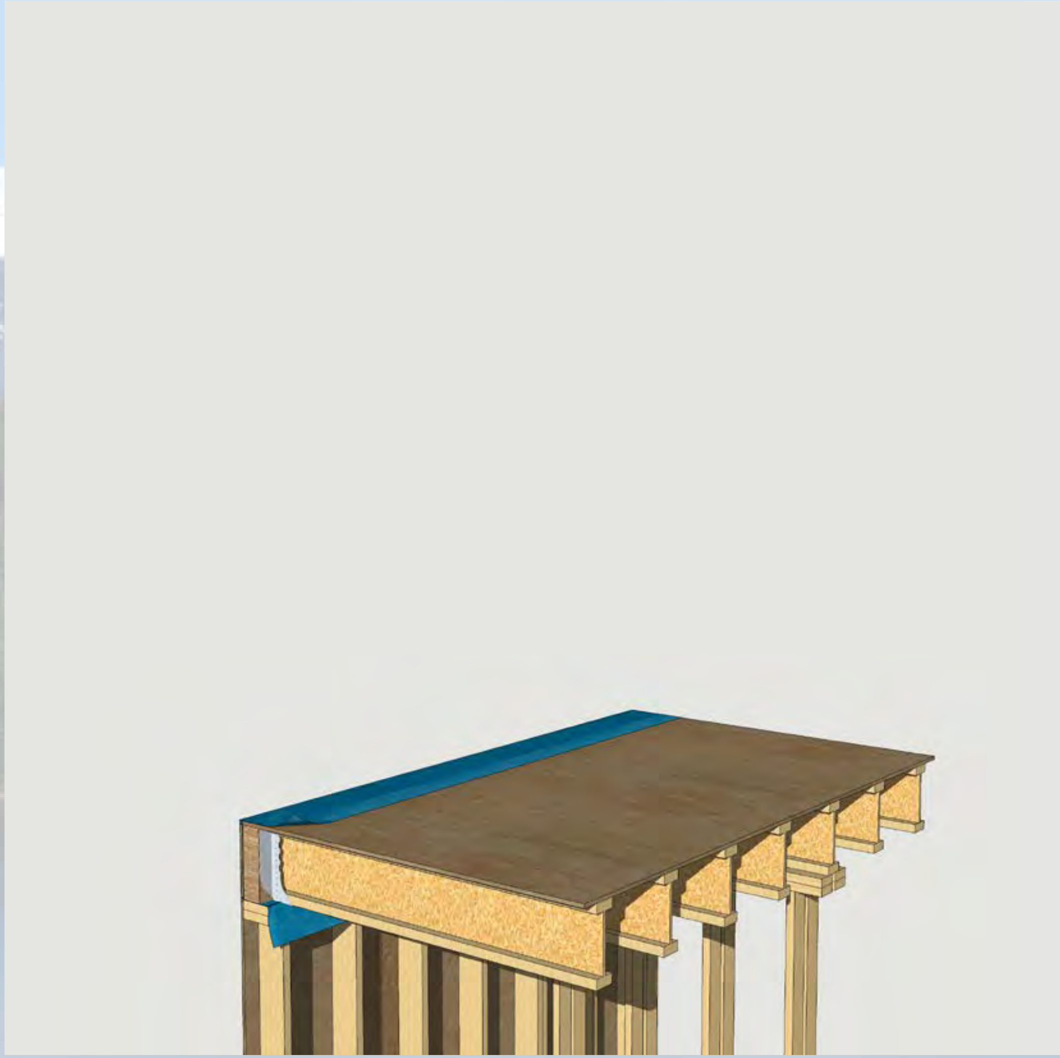
# Air Barrier - stage 1

Courtesy Scott Kennedy
Cornerstone Architecture

# Framing - stage 2

Courtesy Scott Kennedy
Cornerstone Architecture

# Air Barrier – stage 2



Courtesy Scott Kennedy
Cornerstone Architecture

# Framing – stage 3

Courtesy Scott Kennedy
Cornerstone Architecture

# Framing – stage 4

Courtesy Scott Kennedy
Cornerstone Architecture

# Window Installation

Courtesy Scott Kennedy
Cornerstone Architecture

# Insulation - stage 1

Courtesy Scott Kennedy
Cornerstone Architecture

# Air Barrier



Courtesy Scott Kennedy
Cornerstone Architecture

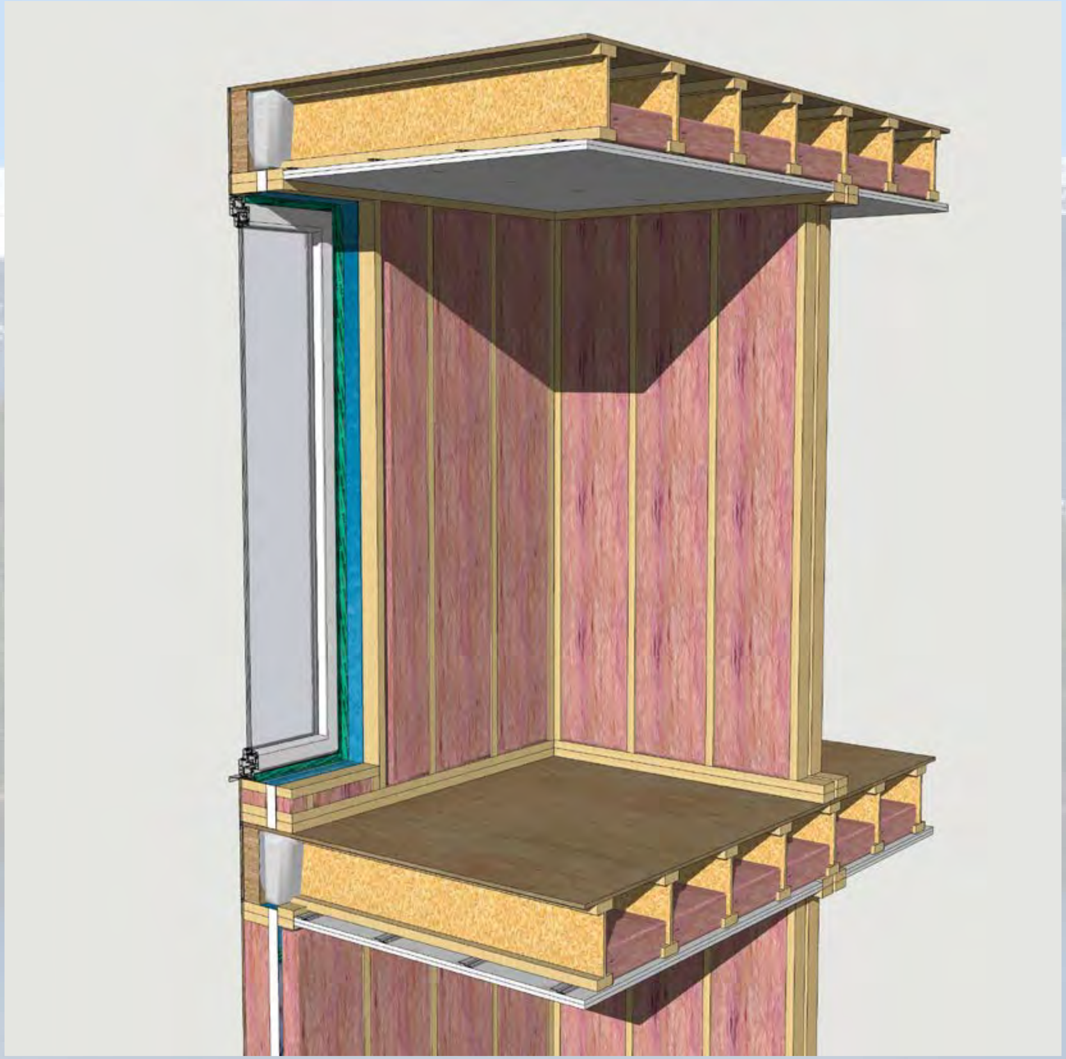
# Floor and Intersection Insulation


Courtesy Scott Kennedy
Cornerstone Architecture

# Framing – stage 4

Courtesy Scott Kennedy
Cornerstone Architecture

# Insulation final



Courtesy Scott Kennedy
Cornerstone Architecture

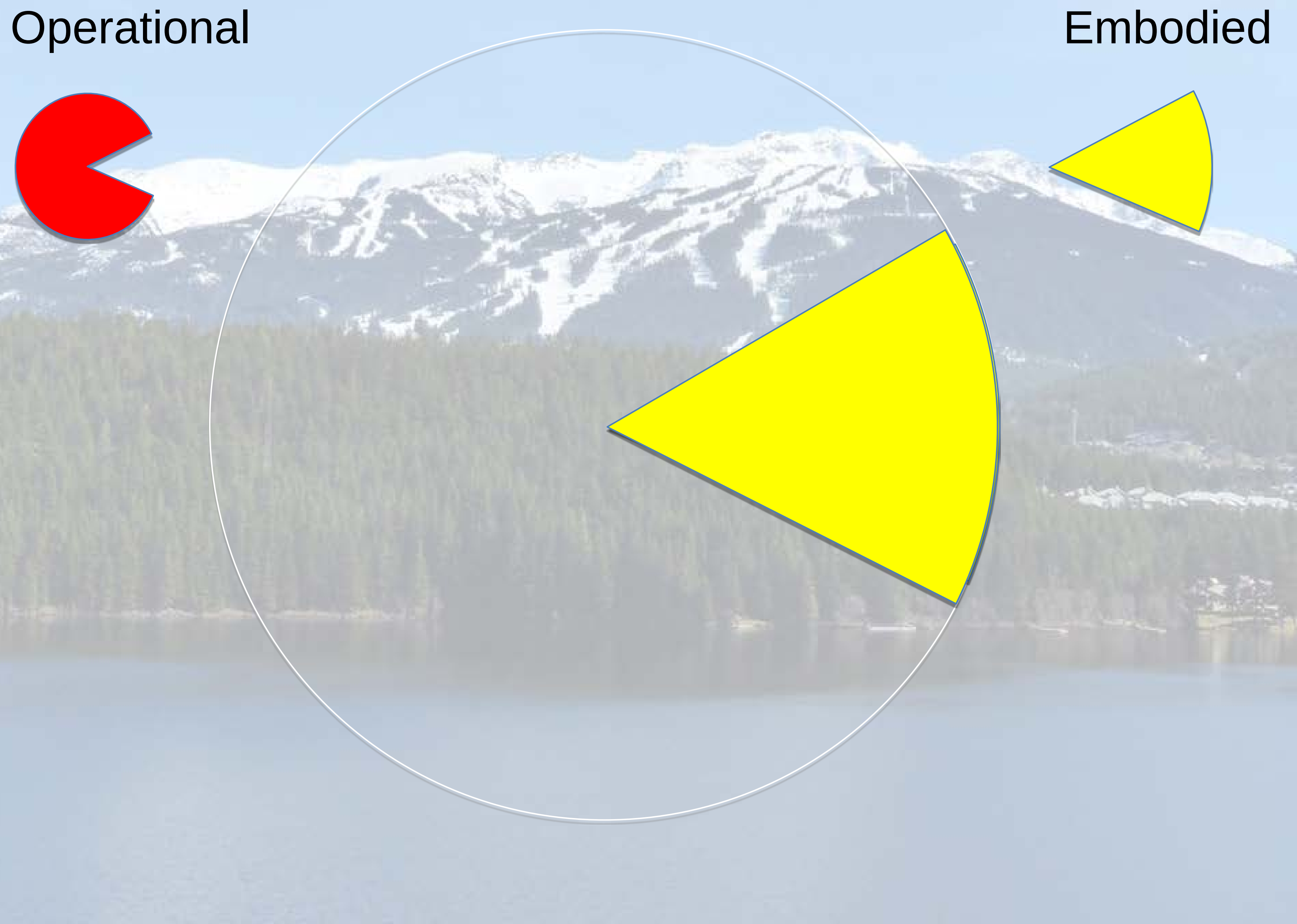
# Heating Energy

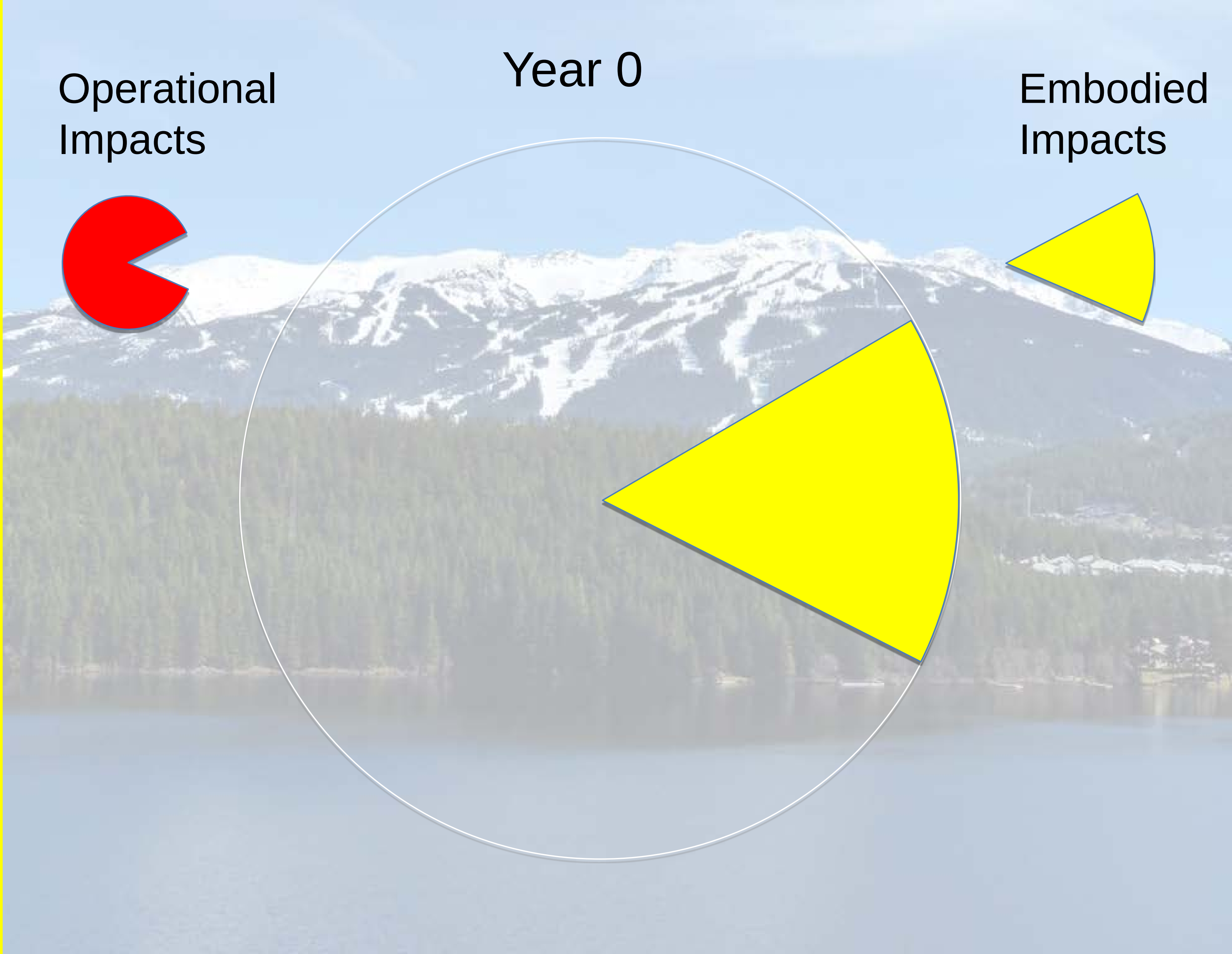
- Statistics Canada indicates the following average heating energy use in Canada:
  - Existing Buildings: 150 $kWh/m^2$
  - New Buildings: 100 $kWh/m^2$
- Passive House:
  - Target Energy 15 $kWh/m^2$
  - 388 Skeena PHPP Model 11 $kWh/m^2$

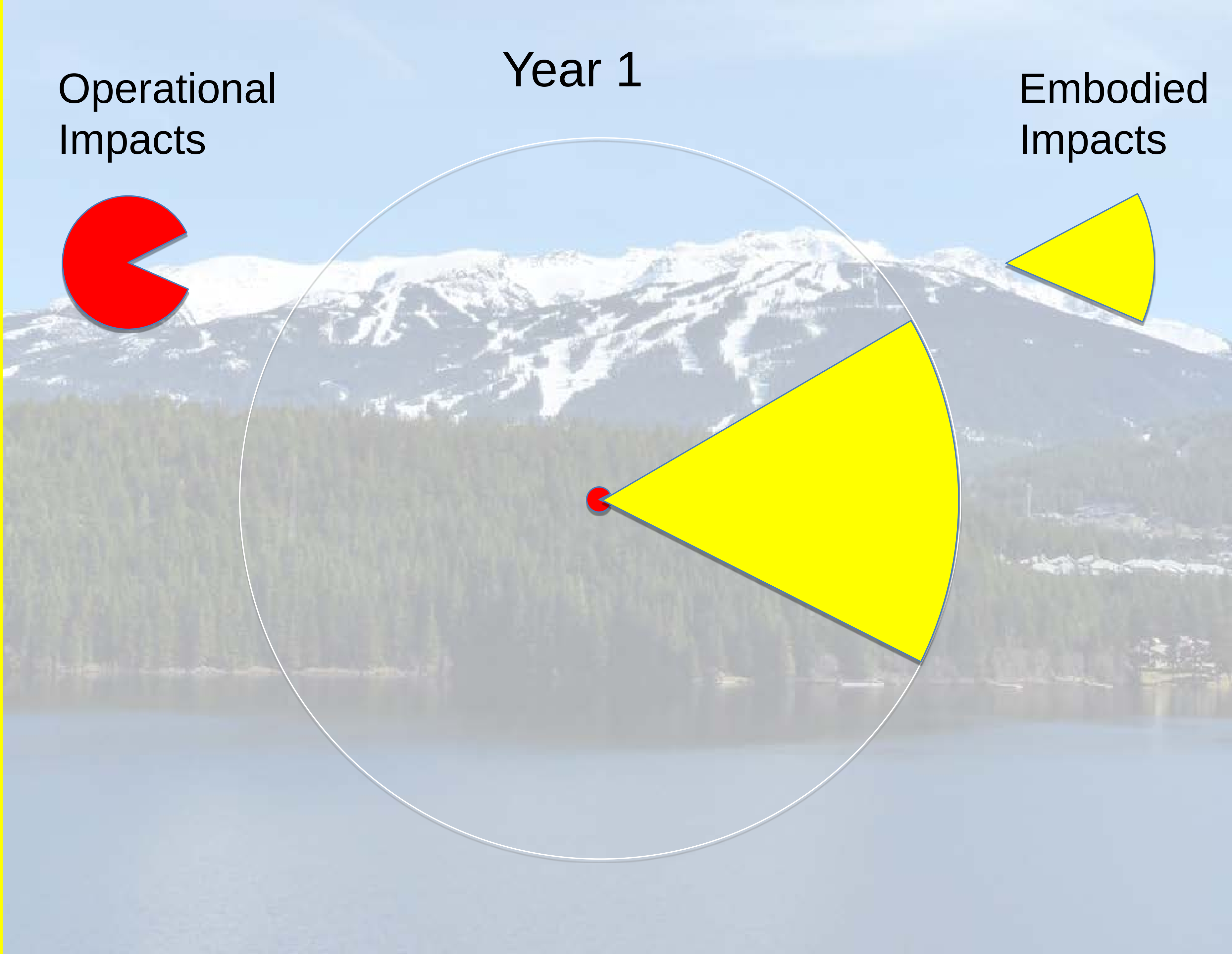
Courtesy Scott Kennedy
Cornerstone Architecture

# Whole Life Impacts Passive Design– 80 Years

## 12% increase in Embodied Impact, 85% Energy Reduction



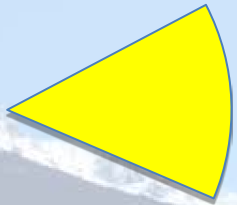

Year 0
Operational Impacts
Embodied Impacts

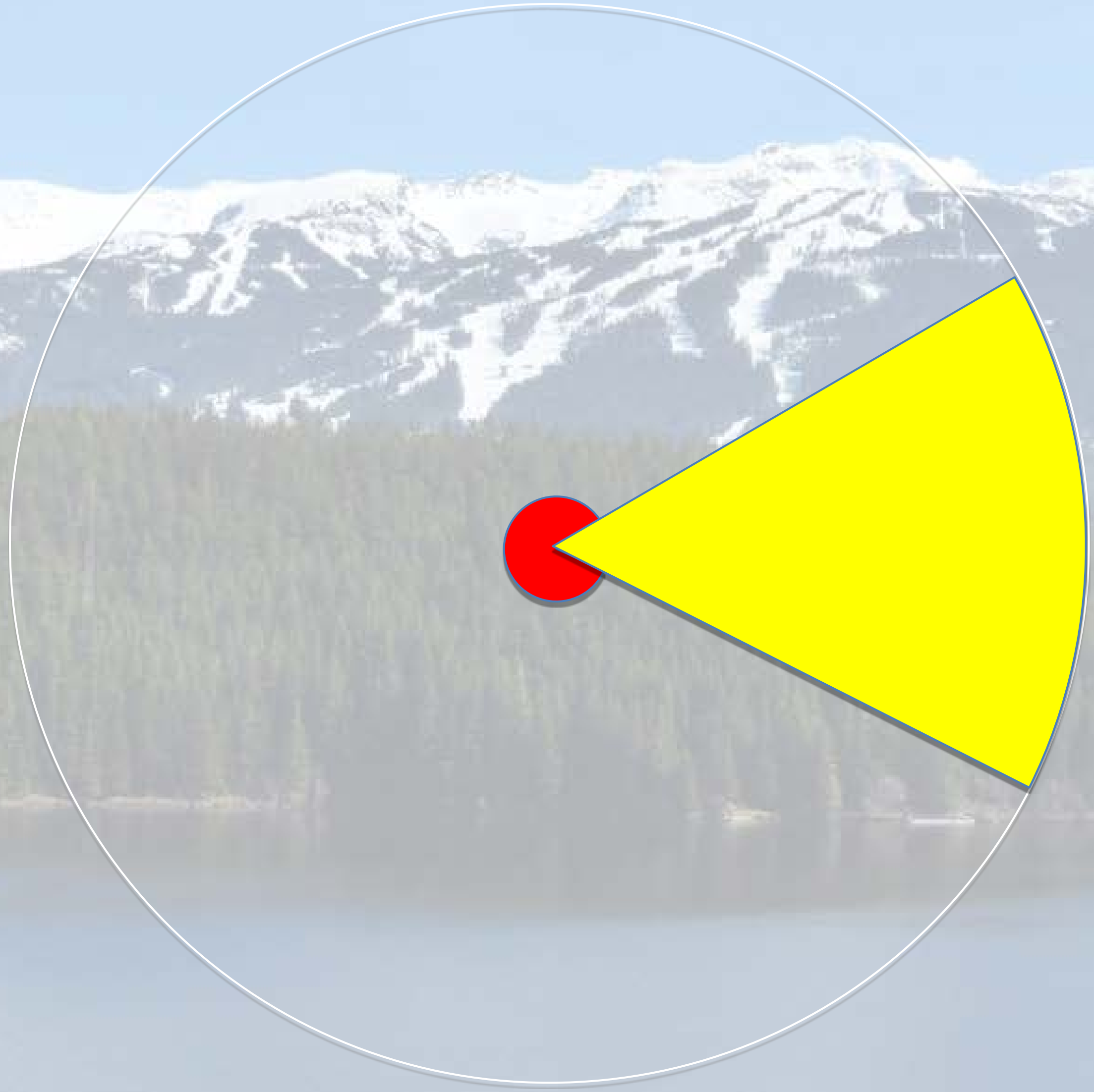

Year 1
Operational
Impacts
Embodied
Impacts

# Year 5

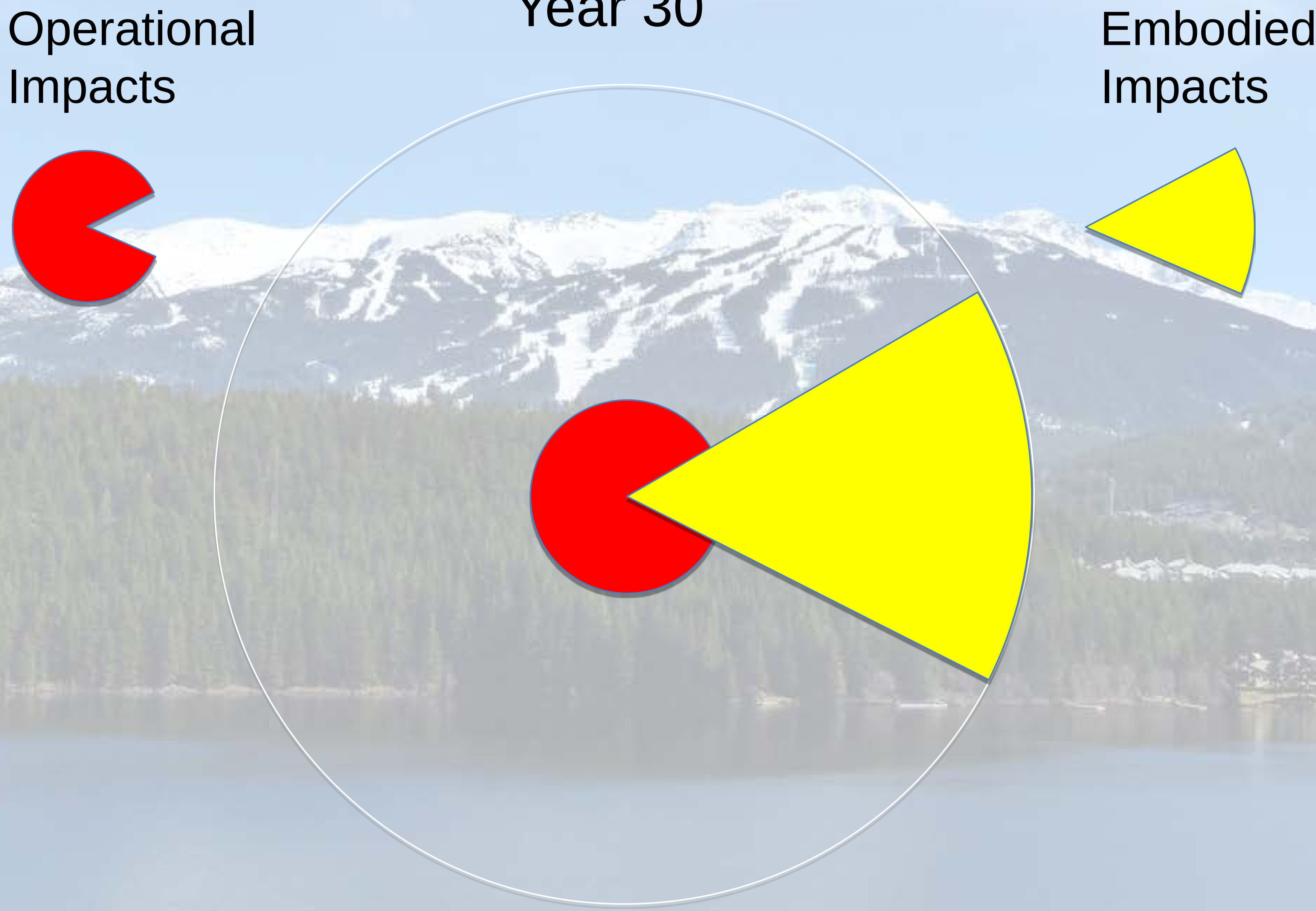
Operational Impacts

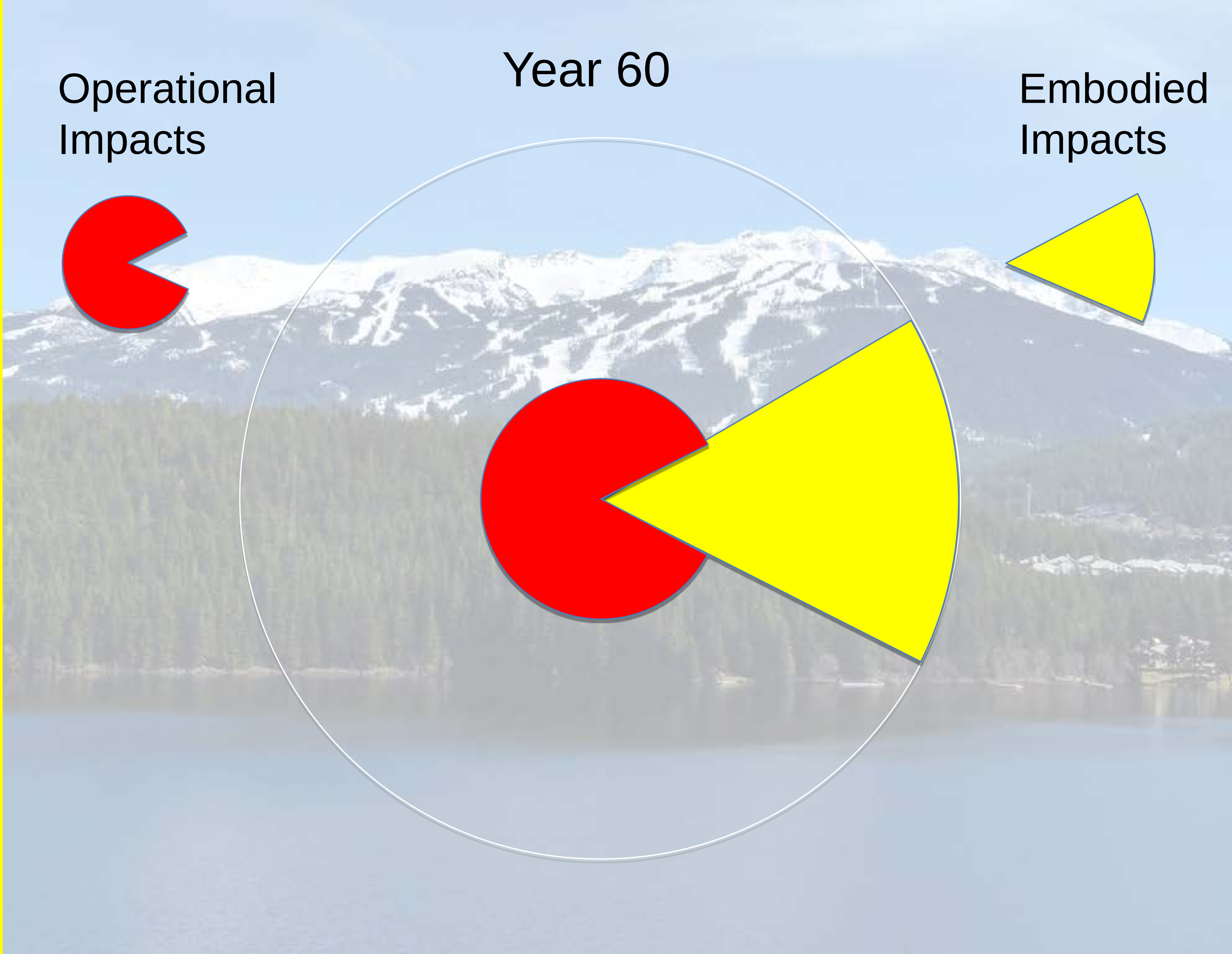
Embodied Impacts



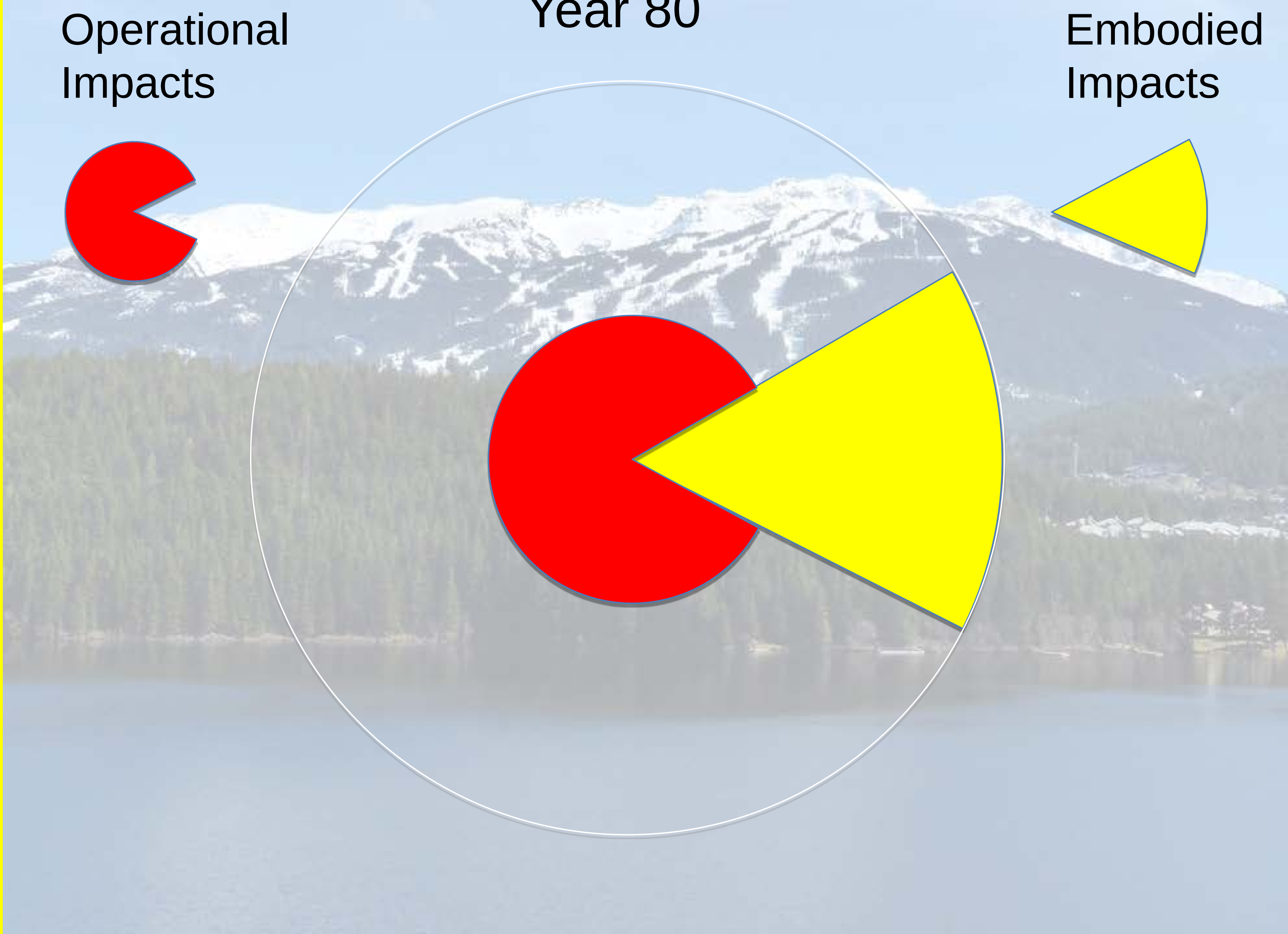


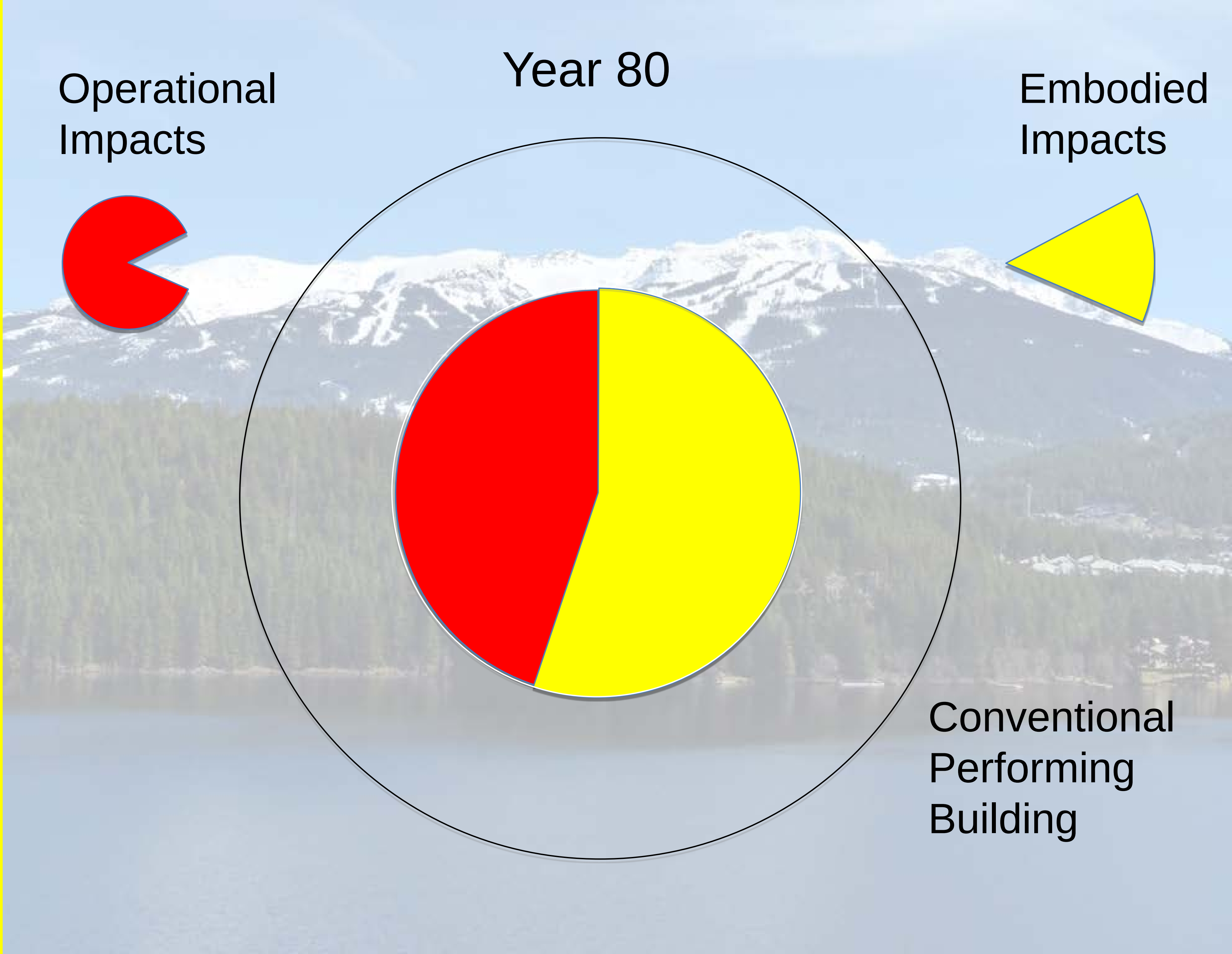
# Year 30




Year 60
Operational
Impacts
Embodied
Impacts

# Year 80




Year 80
Operational Impacts
Embodied Impacts
Conventional Performing Building

# Modern Tall Wood Buildings in Canada

# Origine: Quebec City

- **13-storey mass timber (12 + 1 concrete podium)**
- **Incorporates a CLT core as the LLRS + CLT shearwalls**
- **800 m² floor area @ 40m**

Fire, structural & acoustics testing performed
support design/approval

Construction is underway

A mixed of commercial and residential


**When complete, it will sequester more than 2000 tonnes of $CO_{2e}$**

# UBC Brock Commons: Vancouver

18 Storeys: 1 concrete + 2 concrete cores supporting 17 storeys of mass timber (a students residence)

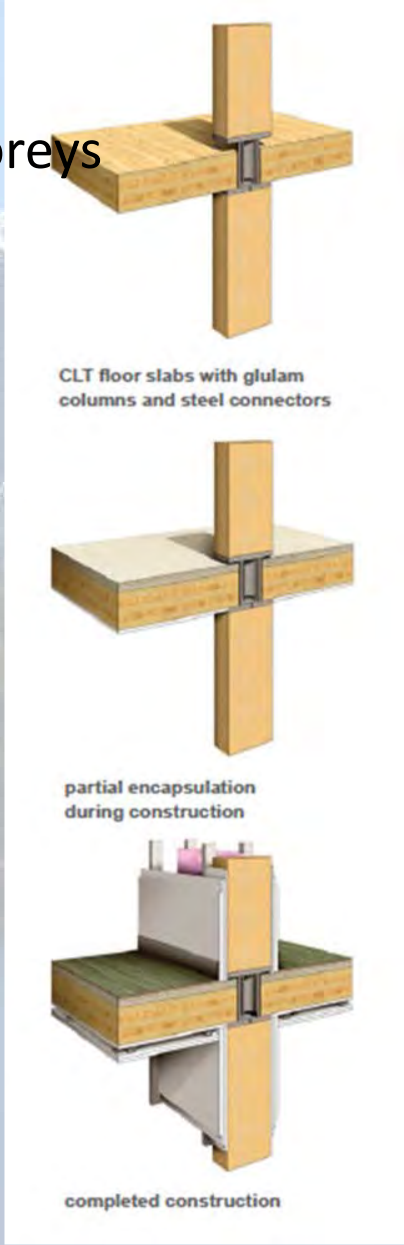
Encapsulated CLT and glulam columns

Two-way CLT floor system: NO BEAMS!

Innovative post-post connection system

Mock-up built to verify constructability

In-situ testing and monitoring




*UBC TWB Mock-up*

Source: Naturallywood.com

# Brock Commons

Exposed wood before Drywall

Connection at junction of 4 CLT panels

# Brock Commons

Concrete Core elevator shaft

Concrete topping before drywall

# Brock Commons

No Exposed wood, 3 layers of drywall


Aug 12
Week 10: 17
Storeys
Courtesy of SEAGATE Structures LTD

Credit: Structurlam Products, Penticton BC and naturallywood.com https://www.youtube.com/watch?v=GHtdnY_gnmE

# Brock Commons Carbon Impact

**Volume of wood:**
2,233 cubic meters of CLT and Glulam

**U.S. and Canadian forests grow this much wood in:**
6 minutes

**Carbon stored in the wood:**
1,753 metric tons of $CO_2$

**Avoided greenhouse gas emissions:**
679 metric tons of $CO_2$

**TOTAL POTENTIAL CARBON BENEFIT:**
2,432 metric tons of $CO_2$

**EQUIVALENT TO:**

511 cars off the road for a year

Energy to operate a home for 222 years

*Source: US EPA*

# CARBON CONSIDERATIONS

SINK

SEQUESTER

SUBSTITUTE

TIME

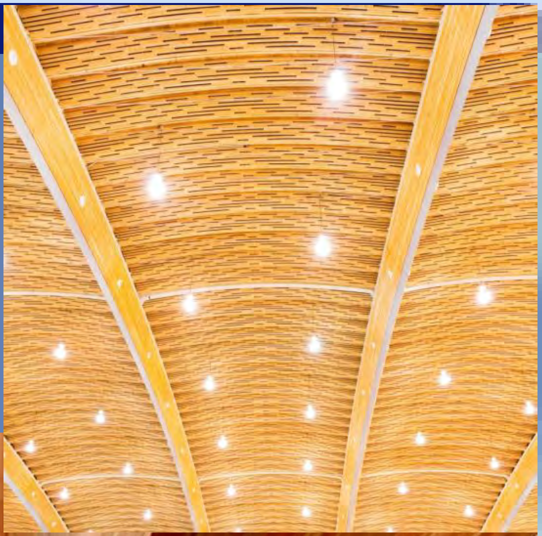
OPERATIONS

# What A Marine Biologist Thinks Designers Should Know About Carbon and Wood

- Regulations about Carbon impacts will only increase in the future
- Know the direction of local regulations and aspirations regarding carbon
- Understand the rationale, methodology and temporal aspects about embodied and avoided carbon impacts
- There is no perfect building material
- Learn about the appropriate, credible LCA tools for your region.
- Be an advocate for knowledge about wood at your alma mater.
- Build the best performing building you can.

# Why Wood? If Not Wood, *what*?

- Carbon Sink
- Renewable
- Recyclable
- Reusable
- Organic
- Cleans Air
- Cleans Water
- Provides $O_2$
- Biodegradable
- Habitat Source



- Avoids $CO_2$
- Strong
- Lightweight
- Flexible
- Diverse
- Attractive
- Easy to Use
- Available
- Inexpensive
- Versatile