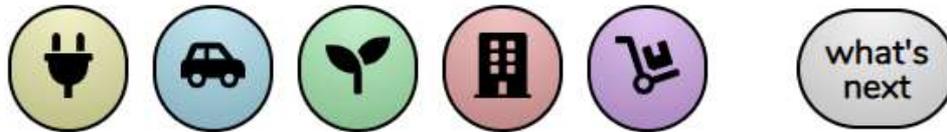
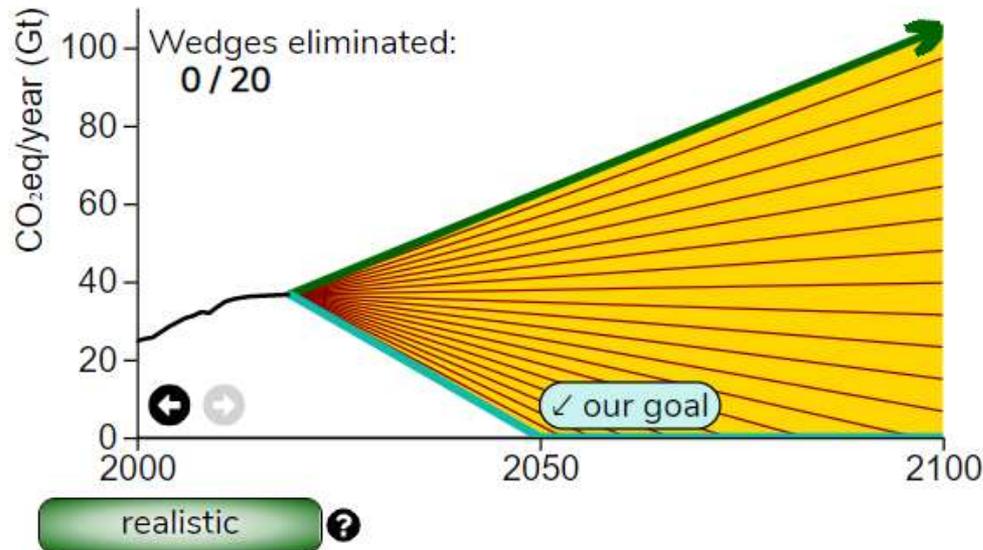


# Design Our Climate Interactive Simulation (DOCs) latest in the suite of *kcv.s.ca* climate education resources

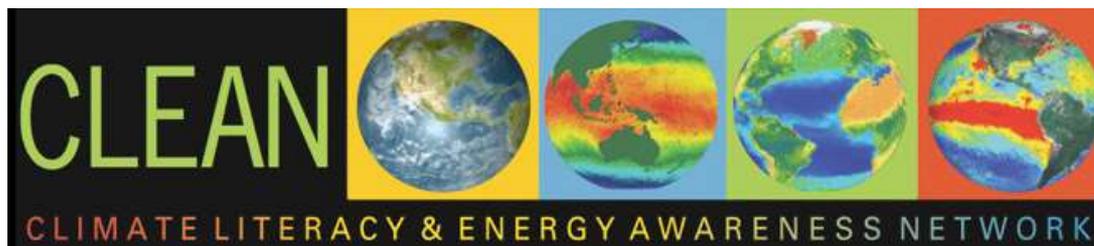


Where our GHG emissions are going: ?

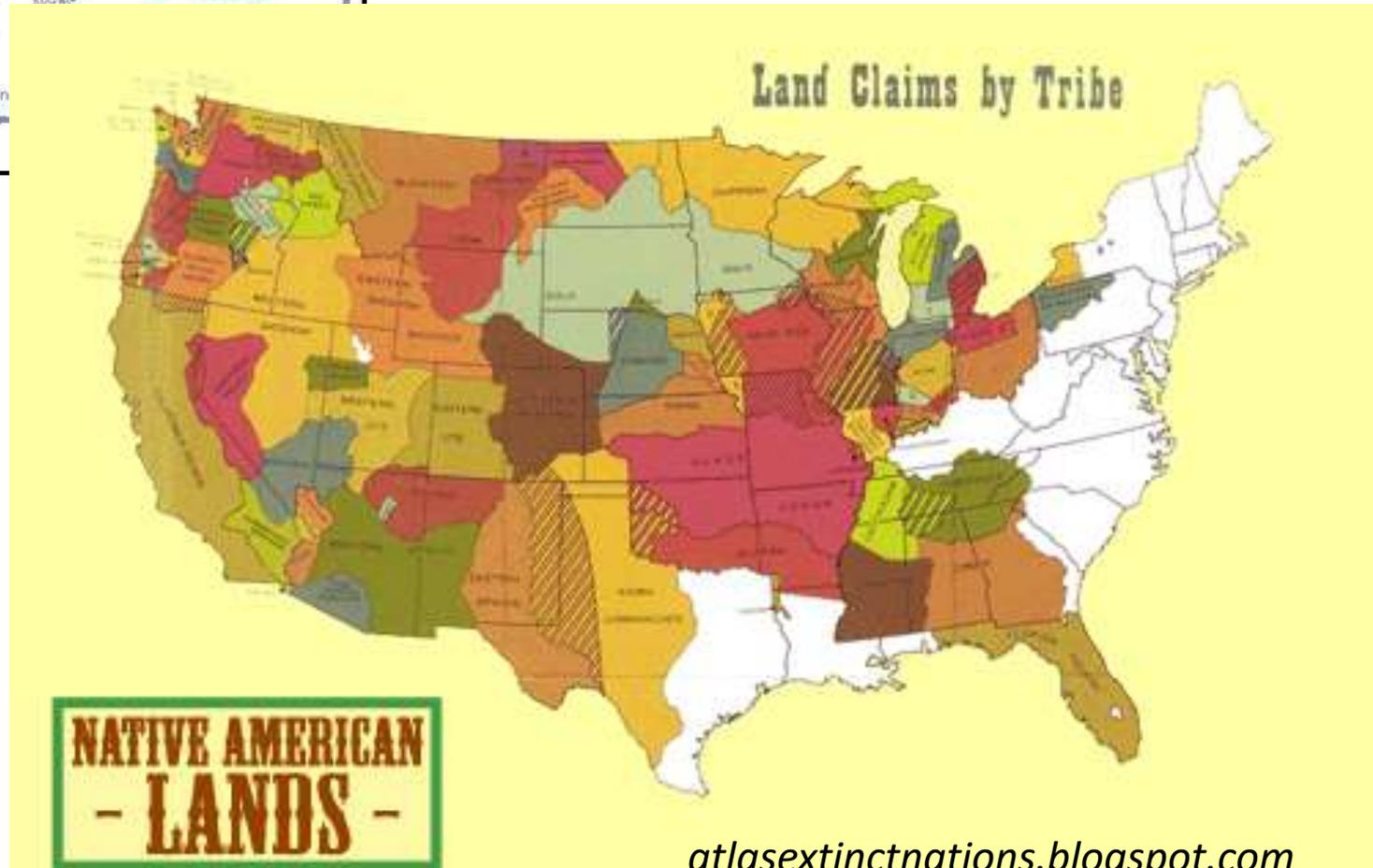


Peter Mahaffy  
Melanie Hoffman  
April 14, 2020  
CLEAN Network call

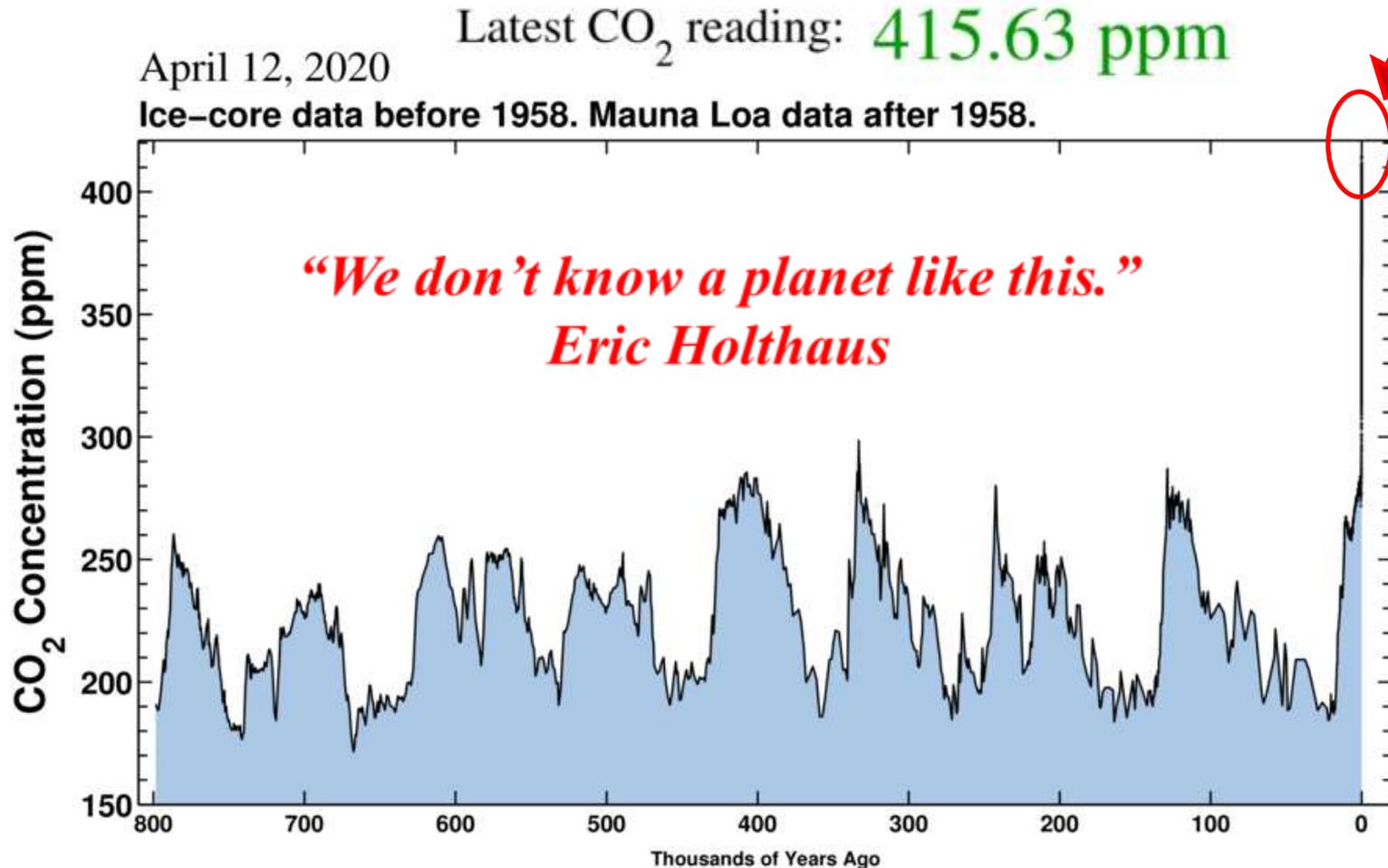
@petermahaffy  
kcv.s@kingsu.ca



# Acknowledgment of need for reconciliation



# Acknowledgment of need for reconciliation



There is more CO<sub>2</sub> in the atmosphere today than any point since the evolution of humans





- Interdisciplinary team of undergraduate students and faculty create interactive electronic learning tools accessed by ~ 500,000 users from >100 countries pa
- Helping the world see & understand science.
- Resources focused on chemistry, physics, elementary science, climate change
- Many reasons why science is hard to see & understand

American Chemical Society



**ACS**  
Chemistry for Life®

[Details](#) [Launch](#)

Center for Imagination in Research Culture and Education



**CIRCE**

[Details](#) [Launch](#)

Climate Literacy & Energy Awareness Network



**CLEAN**

[Details](#) [Launch](#)

Crystal Alberta



**CRYSTAL - ALBERTA**  
CRSNG CREA NSERC CRYSTAL

[Details](#) [Launch](#)

European Union



[Details](#) [Launch](#)

International Union of Pure and Applied Chemistry



**IUPAC**  
INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

[Details](#) [Launch](#)

The King's University



**KING'S UNIVERSITY**

[Details](#) [Launch](#)

Natural Sciences and Engineering Research Council of Canada



**NSERC CRSNG**

[Details](#) [Launch](#)

NSF International



**NSF**

[Details](#) [Launch](#)

Organisation for the Prohibition of Chemical Weapons



**ORGANISATION FOR THE PROHIBITION OF CHEMICAL WEAPONS**

[Details](#) [Launch](#)

Royal Society of Chemistry



**Royal Society of Chemistry**

[Details](#) [Launch](#)

Social Sciences and Humanities Research Council



**Social Sciences and Humanities Research Council of Canada**

[Details](#) [Launch](#)

United Nations Educational, Scientific and Cultural Organization



**UNESCO**  
United Nations Educational, Scientific and Cultural Organization

[Details](#) [Launch](#)

# Our Partners

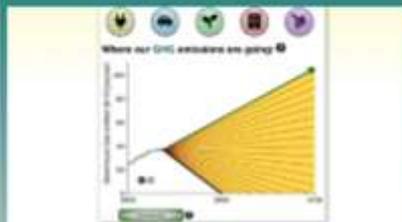
## Air Quality Matters



Details

Launch

## Climate Solutions



Explore strategies to reduce greenhouse gas emissions by making informed choices about electricity, transportation, food, and buildings.

Details

Launch

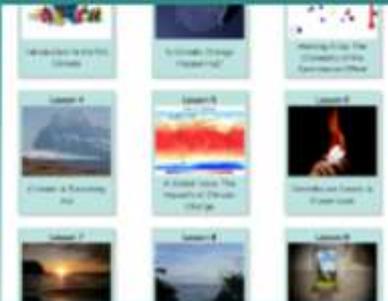
## Elementary Science Suite



Details

Launch

## Explaining Climate Change



Details

Launch

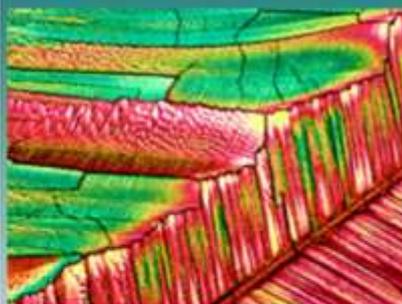
## Isotopes Matter



Details

Launch

## Multiple Uses of Chemicals



Details

Launch

## Visualizing the Chemistry of Climate Change (VC3)



Details

Launch

## West Nile Virus



Details

Launch

9 Sites and > 100 interactive visualizations

## Explaining Climate Change

The grid contains the following lesson cards:

- Introduction to Earth's Climate
- Is Climate Change Happening?
- Heating it Up: The Chemistry of the Greenhouse Effect
- Lesson 4: Climate is Changing - Act
- Lesson 5: A Global Warming: The Impacts of Climate Change
- Lesson 6: Greenhouse Gases: A Closer Look
- Lesson 7
- Lesson 8
- Lesson 9

**Details** **Launch**

## Visualizing the Chemistry of Climate Change (VC3)

**Details** **Launch**

[VC3Chem.com](http://VC3Chem.com)

## Climate Solutions

Where our GHG emissions are going

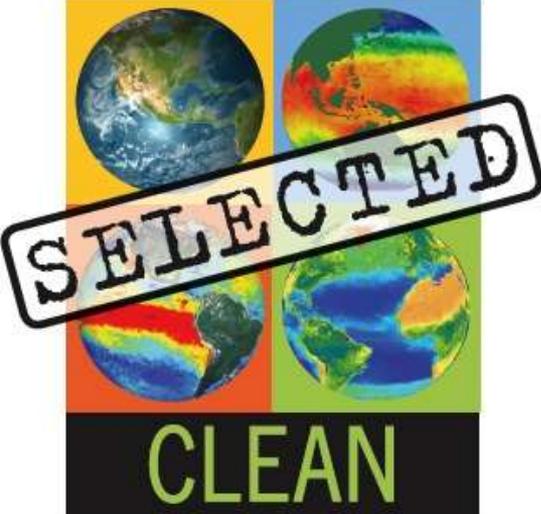
Explore strategies to reduce greenhouse gas emissions by making informed choices about electricity, transportation, land use, buildings...

**Details** **Launch**

[climatesolutions.kcvs.ca](http://climatesolutions.kcvs.ca)

# Climate change education

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- Many of the interactive learning materials are in the CLEAN collection



g  
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;

Lesson 1

Introduction to Earth's Climate

Lesson 2

Is Climate Change Happening?

Lesson 3

Heating It Up: The Chemistry of the Greenhouse Effect

Lesson 4

Climate: A Balancing Act

Lesson 5

Surface Air Temperature

A Global Issue: The Impact's of Climate Change

Lesson 6

Greenhouse Gases: A Closer Look

Lesson 7

Climate Feedback Loops

Lesson 8

Climate Change and the Oceans

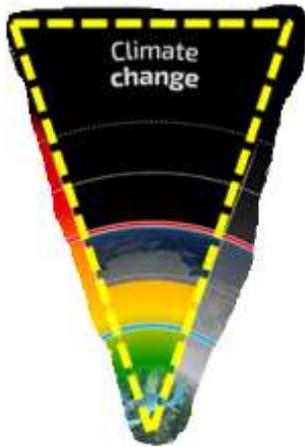
Lesson 9

What Now? Responding to Climate Change

# Lesson 4



Climate: A Balancing Act



## Planetary Climates: A Delicate Balance

PLANETARY DATA RESOURCES... RESET ABOUT KCVS.ca

### Build A Planet

Distance (AU)

Energy Balance

Energy In = 239.0W/m<sup>2</sup>

Energy Out = 246.2W/m<sup>2</sup>

Albedo (Reflectivity)  0.01 1

Distance from Sun (AU)  0.01 10

Greenhouse Factor  0 1

Surface Temperature (°C)  -200 750

**Control variable(s)**

**Planetary boundary  
(zone of uncertainty)**

**Current value of  
control variable**

Energy imbalance at top-of-atmosphere, W m<sup>-2</sup>

Energy imbalance: +1.0 W m<sup>-2</sup> (+1.0-1.5 W m<sup>-2</sup>)

2.3 W m<sup>-2</sup> (1.1-3.3 W m<sup>-2</sup>)

# VC3 Visualizing the Chemistry of Climate Change

[www.VC3chem.com](http://www.VC3chem.com)

NSF DUE CCLI 1022992



- Marcy Towns and Ashley Versprille (Purdue)
- Peter Mahaffy, Brian Martin and the KCVS team of undergraduate researchers (King's)
- Mary Kirchhoff (ACS)
- Lallie McKenzie (Oregon)
- Cathy Middlecamp (Wisconsin)
- Tom Holme, Evaluator (Iowa State)



# Examples of Rich Context Concept Questions

- **Isotopes:** How is 800,000 years of temperature data determined from ice core samples?
- **Gases:** Which atmospheric gases support life directly? Which gases support life by regulating the energy balance of our planet?
- **Acids/Bases:** How does atmospheric carbon dioxide influence the pH of the ocean? What are the implications for marine ecosystems?
- **Thermochemistry:** How is the way we power our planet altering Earth's energy balance?

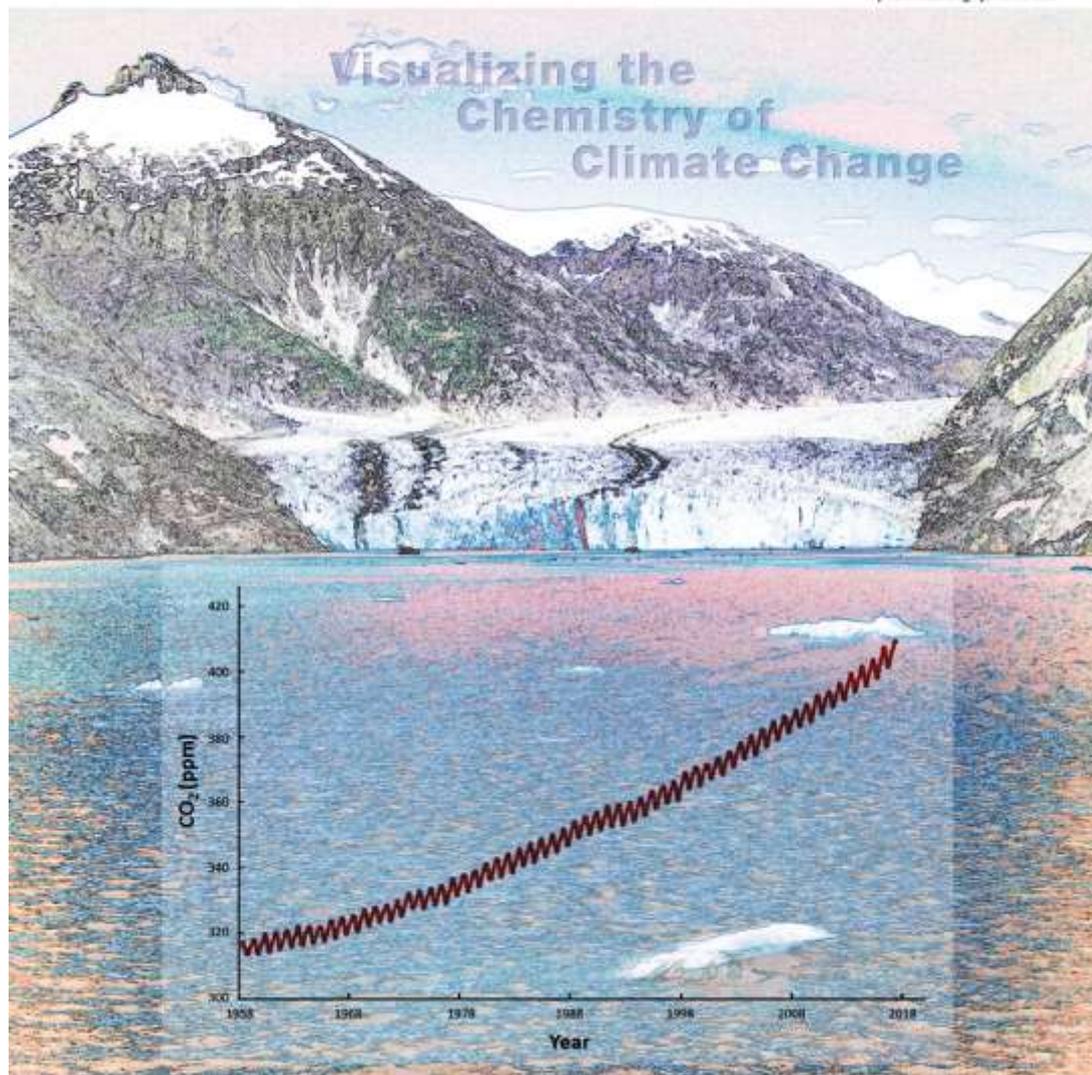


Visualizing the Chemistry of Climate Change

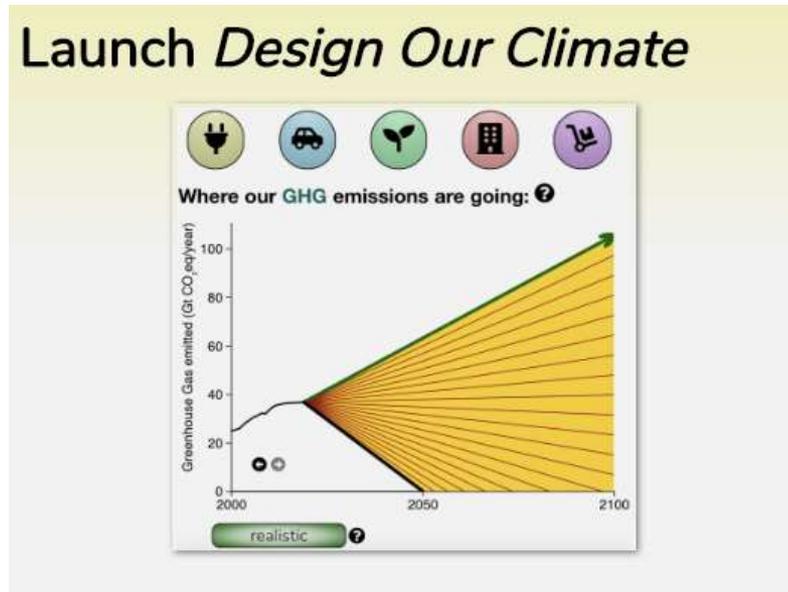
JOURNAL OF  
**CHEMICAL EDUCATION**

VOLUME 94, NUMBER 8 • AUGUST 2017

[pubs.acs.org/jchemeduc](http://pubs.acs.org/jchemeduc)



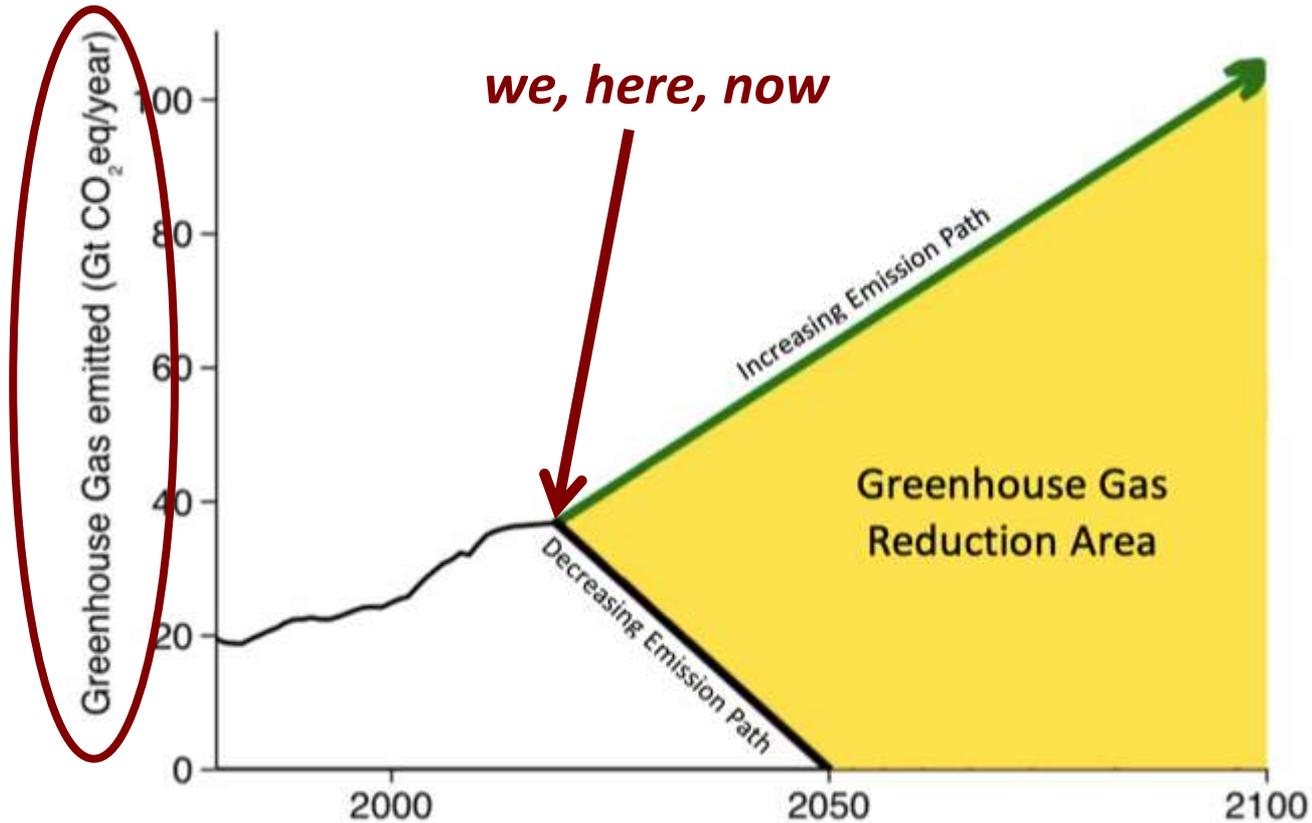
# Accessible solutions: visualizing energy choices and climate implications embedded in Alberta narratives.



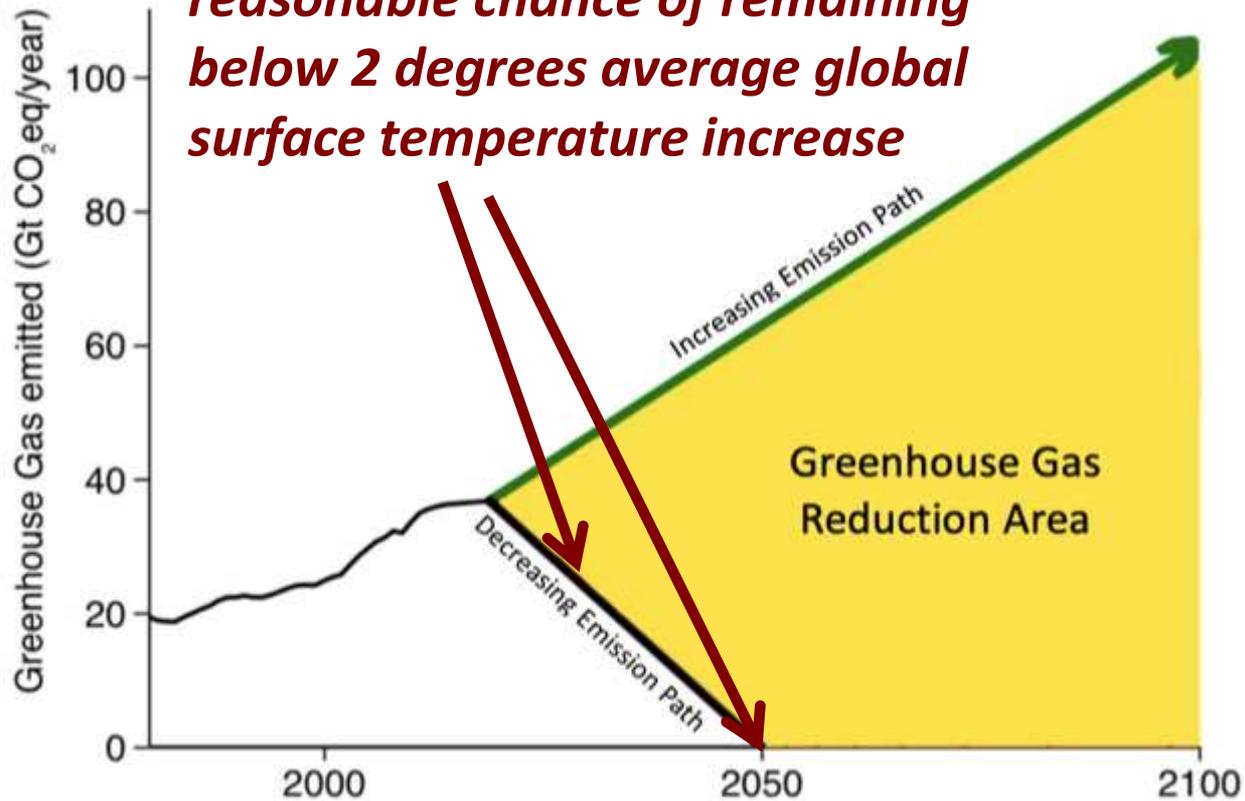
[climatesolutions.kcvs.ca](http://climatesolutions.kcvs.ca)

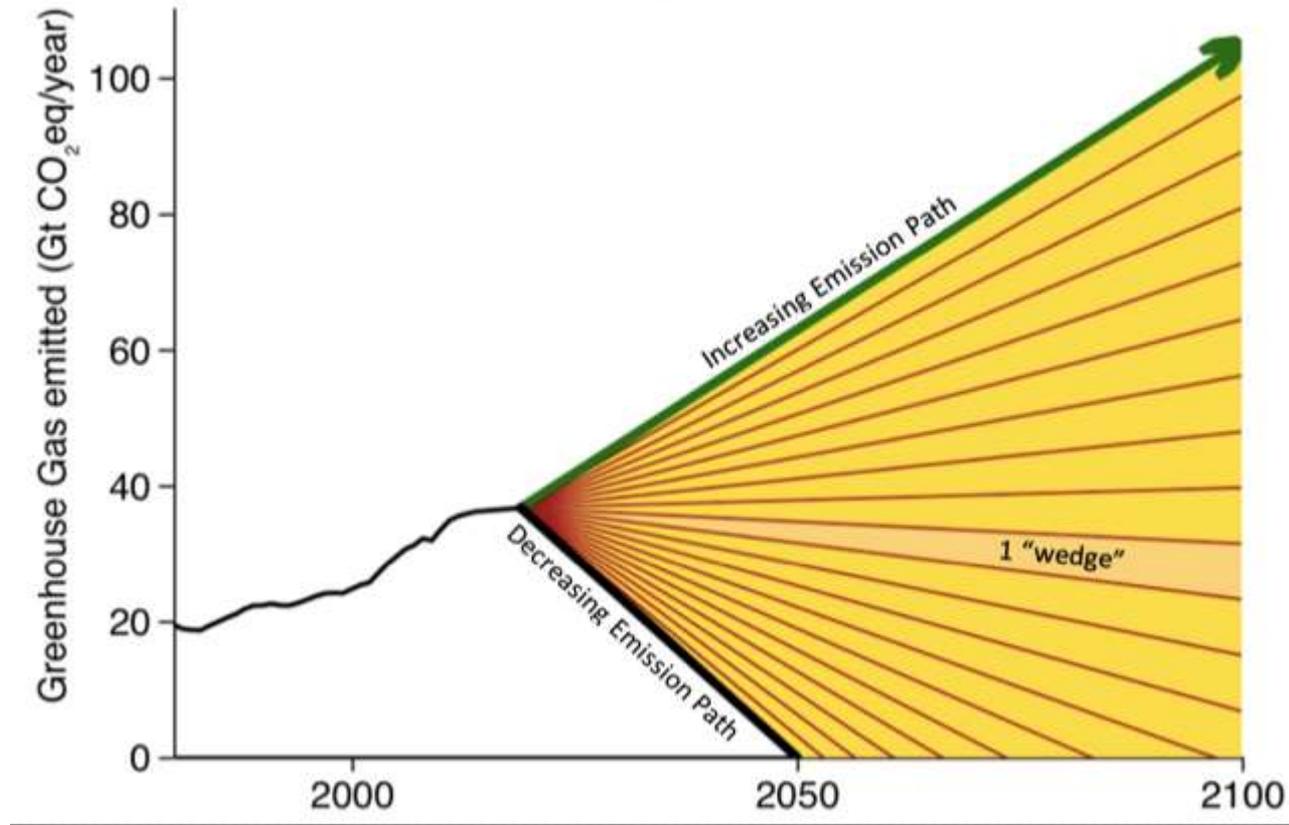
- Design the climate future for our planet
- Use what you learn in this process to engage in conversations about how these changes can be achieved in short order
- Create your own action plan to help tackle this complex and difficult challenge.

## *Amount of Greenhouse Gases (CO<sub>2</sub> equivalents) released every year*



**Paris Agreement targets:  
reasonable chance of remaining  
below 2 degrees average global  
surface temperature increase**





Inspired by the Princeton Carbon Mitigation Initiative's work in S. Pacala, R. Socolow "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies" Science 2004, 305, 968-972.

# Learning Goals

- Contrast the Paris Agreement targets for greenhouse gas emissions with our current trajectory.
- Compare the climate impacts of our current trajectory with achieving the Paris agreement target.
- Describe what is meant by carbon intensity of a fuel source, and rank sources for producing electricity in order of decreasing carbon intensity.
- From the five sectors for mitigation, identify the sector that you found has the greatest potential to reduce the amount of greenhouse gases by 2050.
- Defend using data from the simulation your “top 5” list of actions to reduce greenhouse gas emissions by 2050.

# Learning Goals

- Explain to a neighbour what is meant by a “mosaic of solutions” to reduce greenhouse gas emissions.
- Contrast the challenges of achieving mitigation strategies in your country with achieving them in a country with a lower standard of living.
- Identify the next steps you could take to use the DOC simulation as a tool within your circle of influence to create non-polarizing conversations about climate change and accessible solutions.

# Features to watch for

HOME...

RESET

SUMMARY

REFERENCES

ABOUT

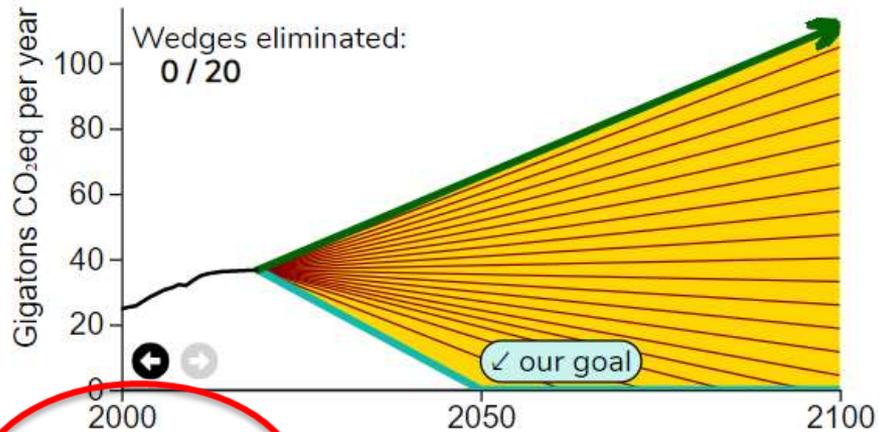
HELP...



KCVS.ca



Where our GHG emissions are going: ?



## Design Our Climate

This global simulation invites you to use currently available technology to

- design our climate future,
- use what you learn in this process to engage in conversations about how these greenhouse gas (GHG) reductions can be achieved in time, and
- create your own action plan to help tackle this complex and difficult challenge.

Billions of humans living on our planet require energy for all aspects of life, and contribute to changes in global biogeochemical

Show General Assumptions

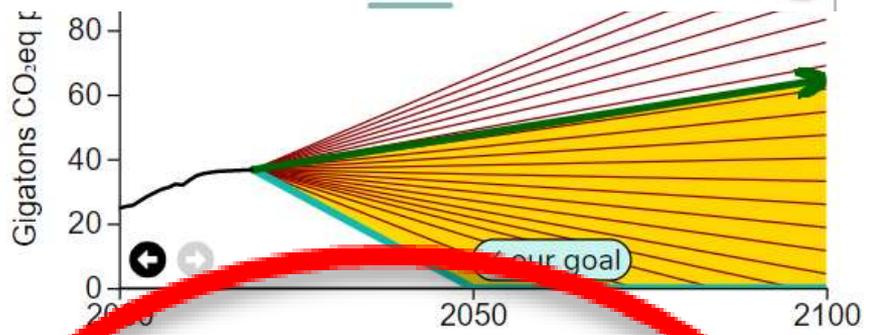
First time? Start here!

Terms of Use

First time? Start here!



This amount of wind energy corresponds to an area about the size of India.



# Electricity in 2100

Amount of electricity produced annually (relative to today)

2 0 2

Show controls

Sources of Electricity:

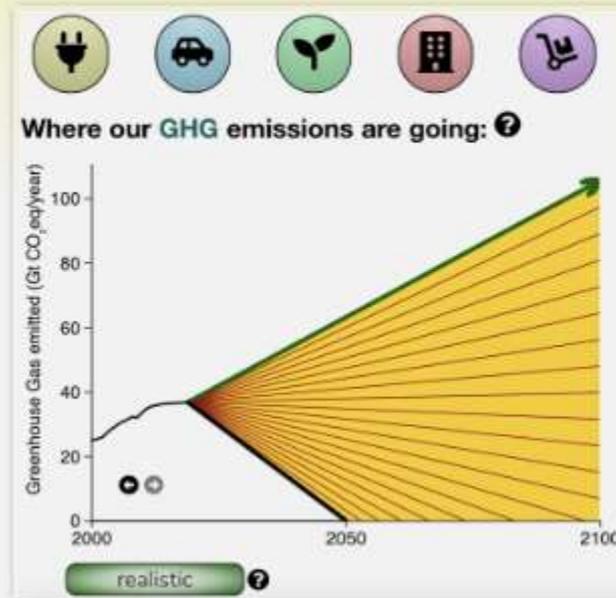
- Solar (%) 35
- Wind (%) 38 **not realistic**
- Nuclear (%) 9
- Geothermal (%) 1
- Hydroelectric (%) 14
- Natural gas (%) 0
- Biomass (%) 3
- Coal power (%) 0

What our GHG emissions will likely cause by 2100: ?

click sectors to show assumptions



# Launch *Design Our Climate*



[climatesolutions.kcvs.ca](http://climatesolutions.kcvs.ca)

# Work in progress

- Collaborating with [National Center for Science Education](#) on integrating the tool into climate change lessons
- Developing and disseminating lessons and activities for Grade 9 and 10 science and social studies students – expedited roll out for on-line learning.
- Supporting the linkage of climate change and general chemistry content (1<sup>st</sup> year university)
- Integrate with Drawdown outcomes at global/provincial/municipal levels



Launch *Design Our Climate*



Where our CO<sub>2</sub> emissions are going

Explore strategies to reduce greenhouse gas emissions by making informed choices about electricity, transportation, land use, buildings, and materials.

Teaching Resources

# Complementary Triad



EN-ROADS

— *Climate Change Solutions Simulator* —

### Explaining Climate Change

Introduction to Earth's Climate	Is Climate Change Happening?	Heating it Up: The Chemistry of the Greenhouse Effect
Lesson 4: Climate & Ecosystems	Lesson 5: A Global Warming: The Impacts of Climate Change	Lesson 6: Greenhouse Gases & Ocean Levels
Lesson 7	Lesson 8	Lesson 9

[Details](#) [Launch](#)

### Climate Solutions

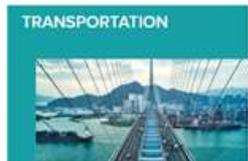
Where our GHG emissions are going

Explore strategies to reduce greenhouse gas emissions by making informed choices about electricity, transportation, land use, buildings...

[Details](#) [Launch](#)

# CLIMATE SOLUTIONS BY SECTOR

Within each of these sectors are solutions to climate change with actions that can be taken today.



- Global solutions to reach drawdown, quantified and ranked
- Avoid GHG emissions or sequester CO<sub>2</sub>

\* Gigatons CO2 Equivalent Reduced / Sequestered (2020–2050)

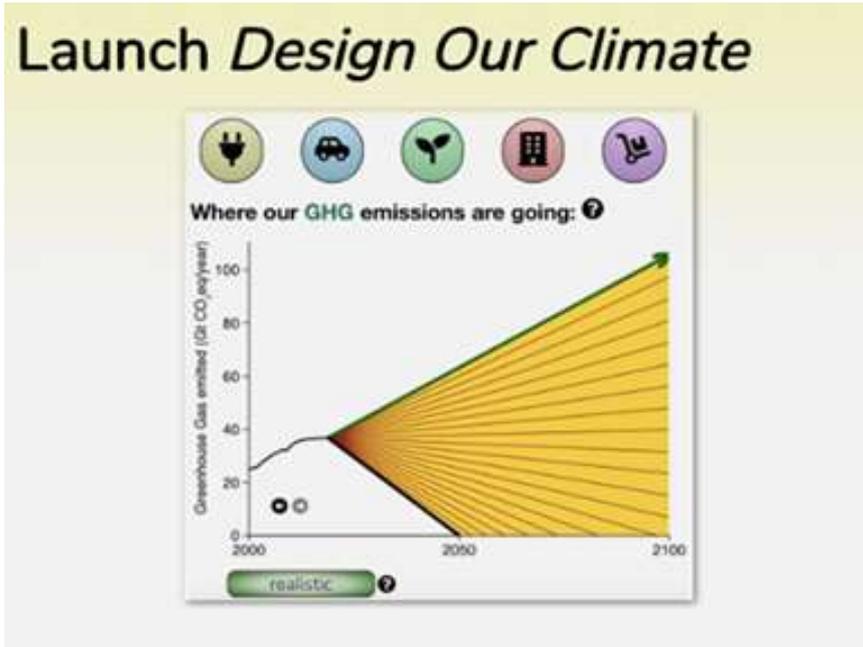
◆ SOLUTION	◆ SECTOR(S)	◆ SCENARIO 1*	▼ SCENARIO 2*
Onshore Wind Turbines	Electricity	47.21	147.72
Utility-Scale Solar Photovoltaics	Electricity	42.32	119.13
Reduced Food Waste	Food, Agriculture, and Land Use / Land Sinks	87.45	94.56
Plant-Rich Diets	Food, Agriculture, and Land Use / Land Sinks	65.01	91.72
Health and Education	Health and Education	85.42	85.42
Tropical Forest Restoration	Land Sinks	54.45	85.14
Improved Clean Cookstoves	Buildings	31.34	72.65
Distributed Solar Photovoltaics	Electricity	27.98	68.64
Refrigerant Management	Industry / Buildings	57.75	57.75
Alternative Refrigerants	Industry / Buildings	43.53	50.53



- Comprehensive systems dynamics model
- How do changes in energy, economic and policy systems affect GHG emissions and climate outcomes

# Design Our Climate

ClimateSolutions.kcvs.ca



- Educational tool, scaffolded with lessons and activities
- Interactive exploration of how to break a grand challenge of achieving net zero by 2050 into 20 incremental pieces
- Guide informed choices about electricity, transportation, land use, buildings, and materials.
- Semiquantitative, global model, based on currently available technology



# Thank YOU!



STUDENTENERGY



Connect with us!  
*Melanie Hoffman*  
*Peter Mahaffy*

