BUILDINGENERGY BOSTON

Reducing Embodied Carbon:
How Local Governments Can Help

August 13, 2020 · 01:00 pm

Presenters:

Alice Zanmiller (Marin County), Ani Krishnan (City of Seattle), & Stacy Smedley (SKANSKA)

Agenda

Embodied Carbon: The Basics

What is it? Why does it matter? How do we measure it?

Local Governments & Embodied Carbon

How are governments well-placed to tackle this issue? Case studies from Marin County and Seattle.

Opportunities for Collaboration & Resources


Reducing the Carbon Footprint of Every Building.

Building Transparency

Understanding Our Impact

Building Transparency

Understanding Our Impact

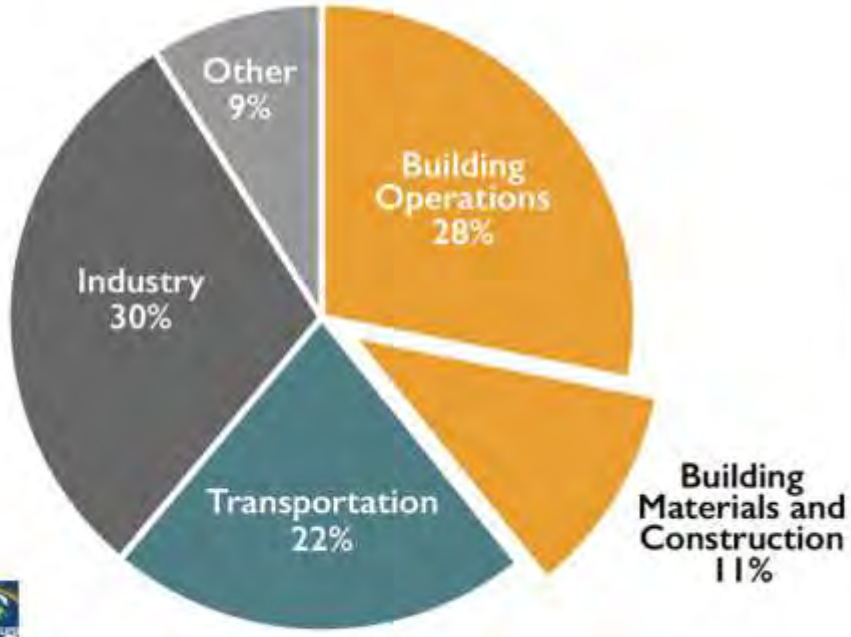
An entire New York City

every 35 days

for 35 years!

Understanding Carbon

Global CO_2 Emission by Sector



Total Building Material Impacts??

Building Transparency

Understanding Carbon

Embodied Carbon

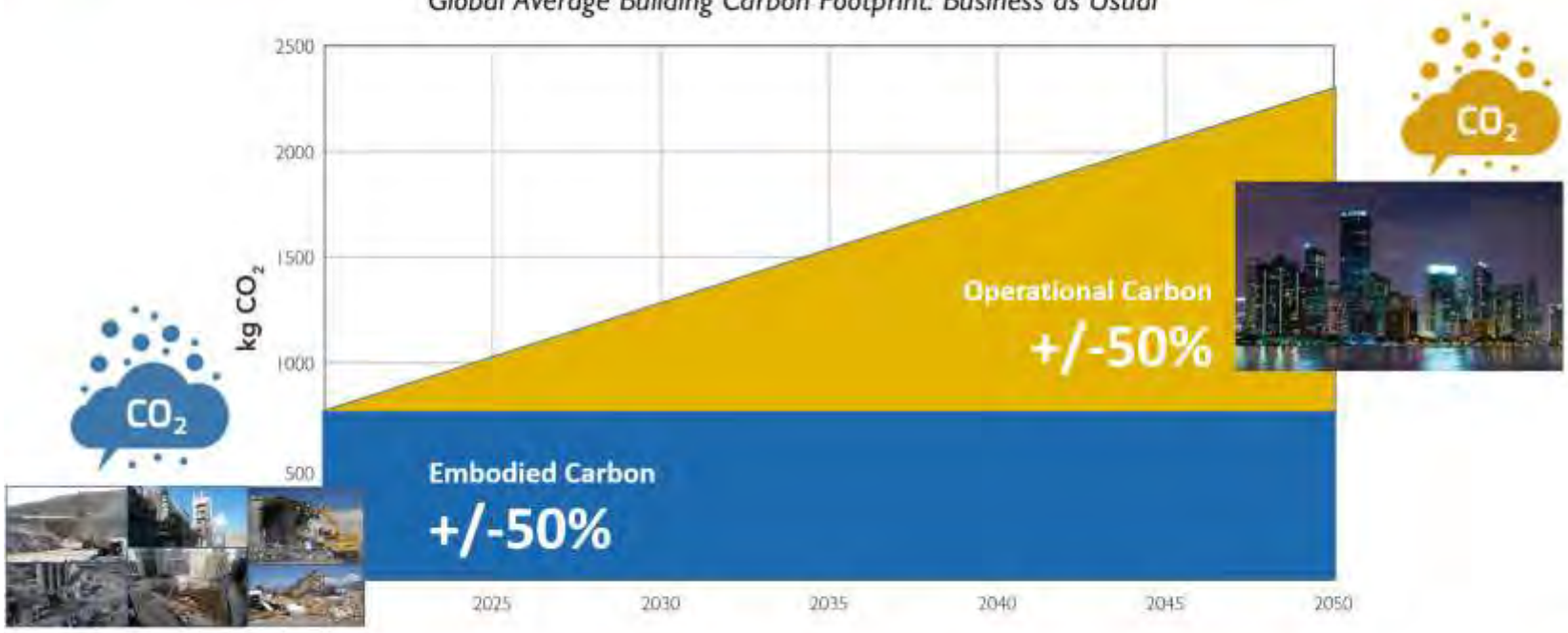
Operational Carbon

Building Transparency

Understanding Carbon

Total Carbon Emissions of **Single Building**

Global Average Building Carbon Footprint: Business as Usual



 Data Sources: UN Environment Global Status Report 2017; EIA International Energy Outlook 2017

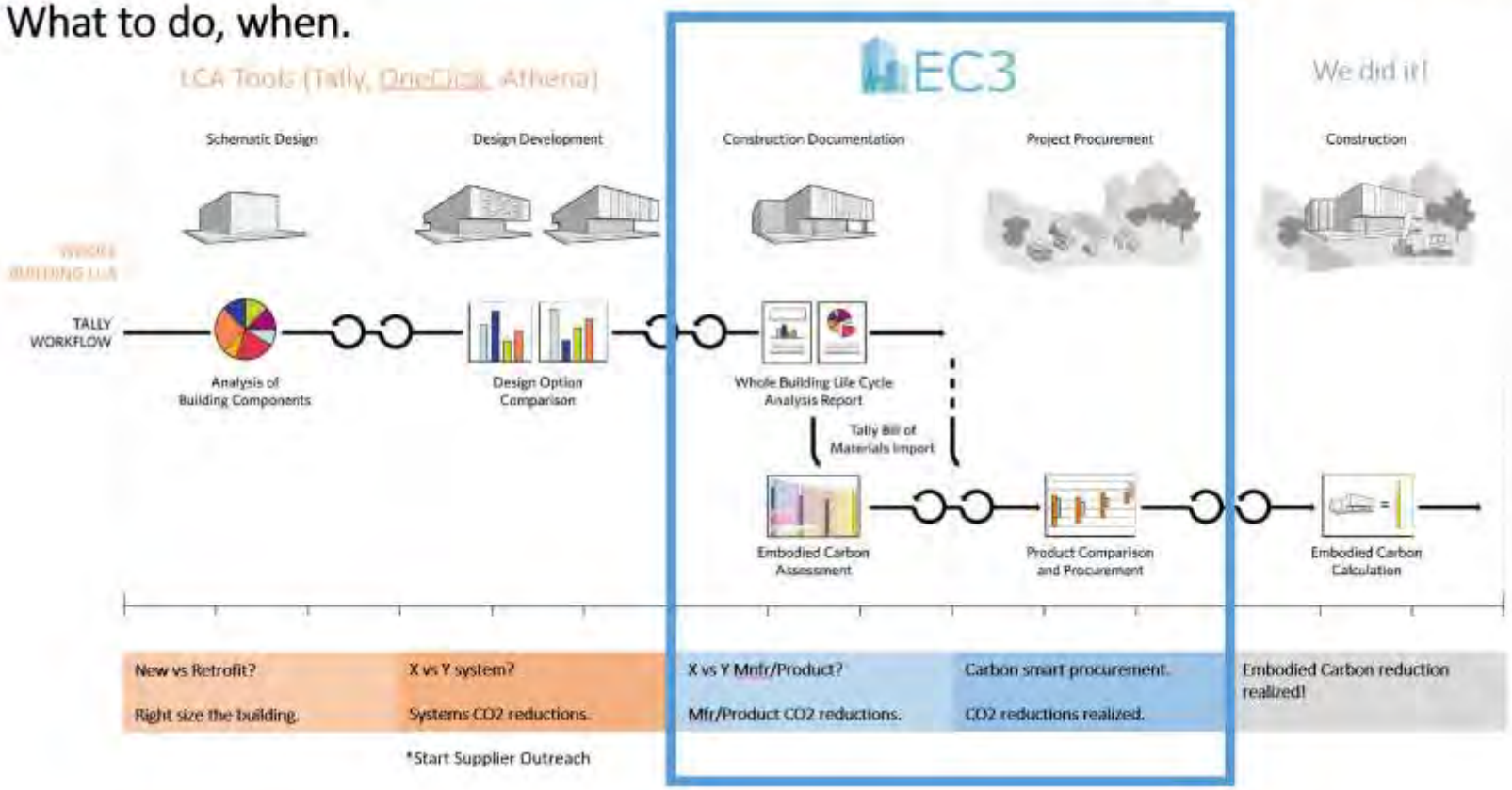
Building Transparency

Understanding Carbon

Building Transparency

Reducing Embodied Carbon

What to do, when.



Building Transparency The Embodied Carbon in Construction Calculator (EC3) tool

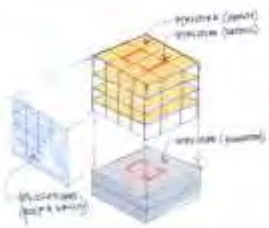
EC3

- First **free, open-access tool** for upfront embodied carbon
- First **free, open-access database** of EPDs
- Over **50 industry partners** supporting its development
- Over **7,500 registered users** since its launch in Nov 2019
- New **non-profit established** to continue its development

Register for tool at:
www.buildingtransparency.org

Building Transparency

Reducing Embodied Carbon



Material Quantities (from Construction Estimates/BIM 360/Tally

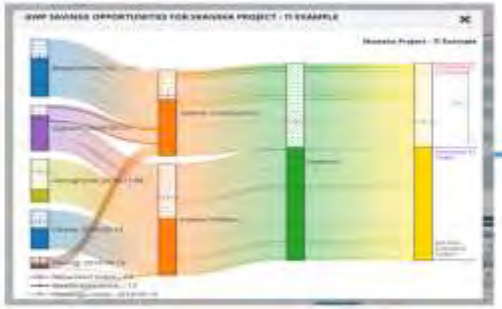
×

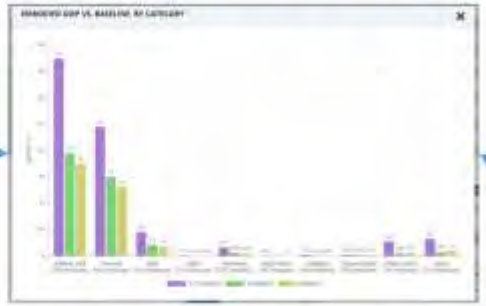
Stages A1-A3 Embodied Carbon Emissions data

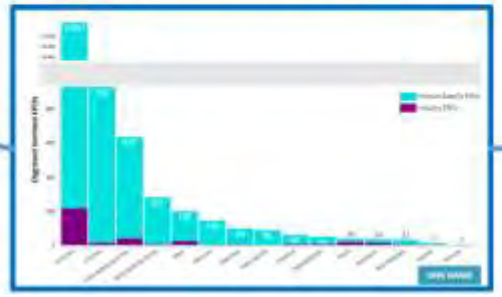
=

Building Upfront Estimate and Realized Embodied Carbon

Digital EPD Database for Comparing Product Embodied Carbon







EC3

Environmental Product Declarations

Kg CO2e from Environmental Product Declarations

Nutrition Facts

Serving Size 2/3 cup (55g)
Servings Per Container About 8

Amount Per Serving	
Calories 230	Calories from Fat 40
	% Daily Value*
Total Fat 8g	**12%**
Saturated Fat 1g	**5%**
Trans Fat 0g	
Cholesterol 0mg	**0%**
Sodium 160mg	**7%**
Total Carbohydrate 37g	**12%**
Dietary Fiber 4g	**16%**
Sugars 1g	
Protein 3g	

Life Cycle Impact Results (per m³)
Declared Unit: 1 m³ of 10,000 psi concrete at 28 days

OPERATIONAL IMPACTS	*PerformX™ PECC10K*
Plant Operating Energy (MJ)	38.6
On-Site Plant Fuel Consumption (MJ)	11.1
Concrete Batch Water (m³)	1.68E-01
Concrete Wash Water (m³)	1.91E-02
On-Site Waste Disposal (kg)	0.0
ENVIRONMENTAL IMPACTS	
Total Primary Energy (MJ)	3,017
Climate Change (kg CO_2 eq)	445
Ozone Depletion (kg CFC 11 eq)	1.31E-08
Acidification Air (kg SO_2 eq)	2.96
Eutrophication (kg N eq)	0.09
Photochemical Ozone Creation (kg O_3 eq)	0.61

*current database holds over 27,000 epds

Local Governments & Embodied Carbon

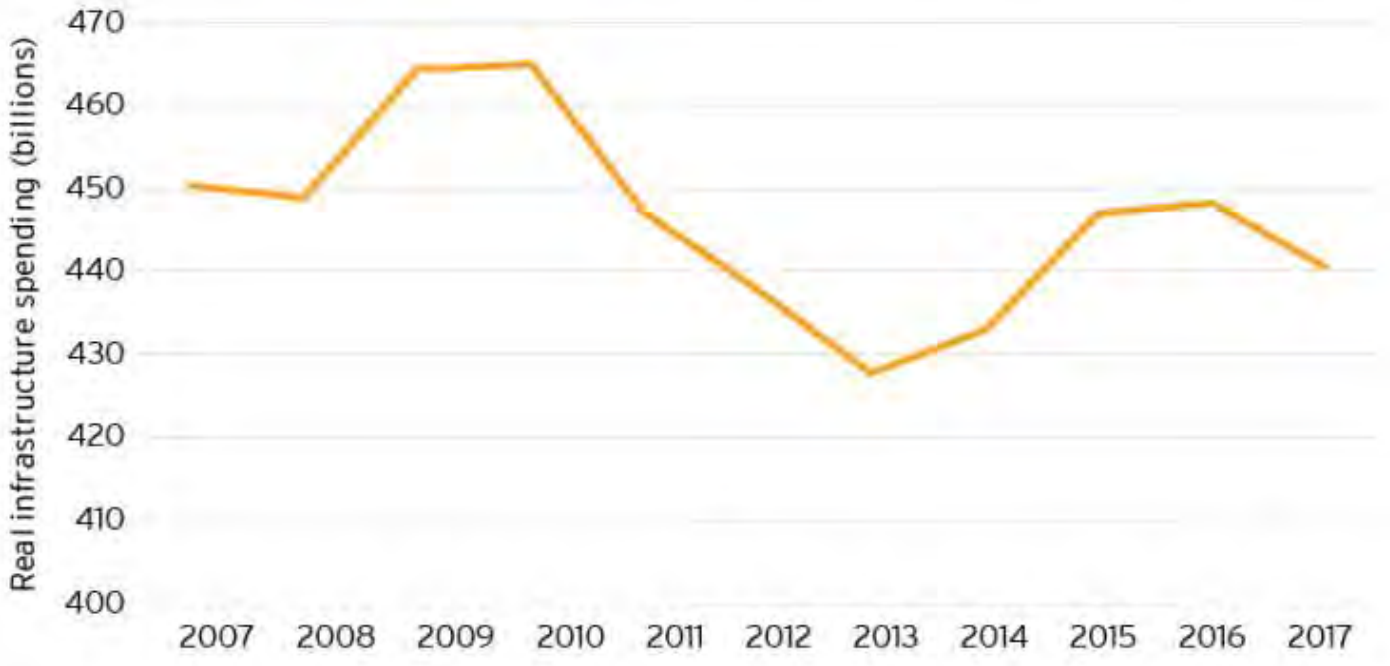
Local governments are:

- Consumers
- Regulators
- Climate leaders

Local Governments as Consumers

FIGURE 1

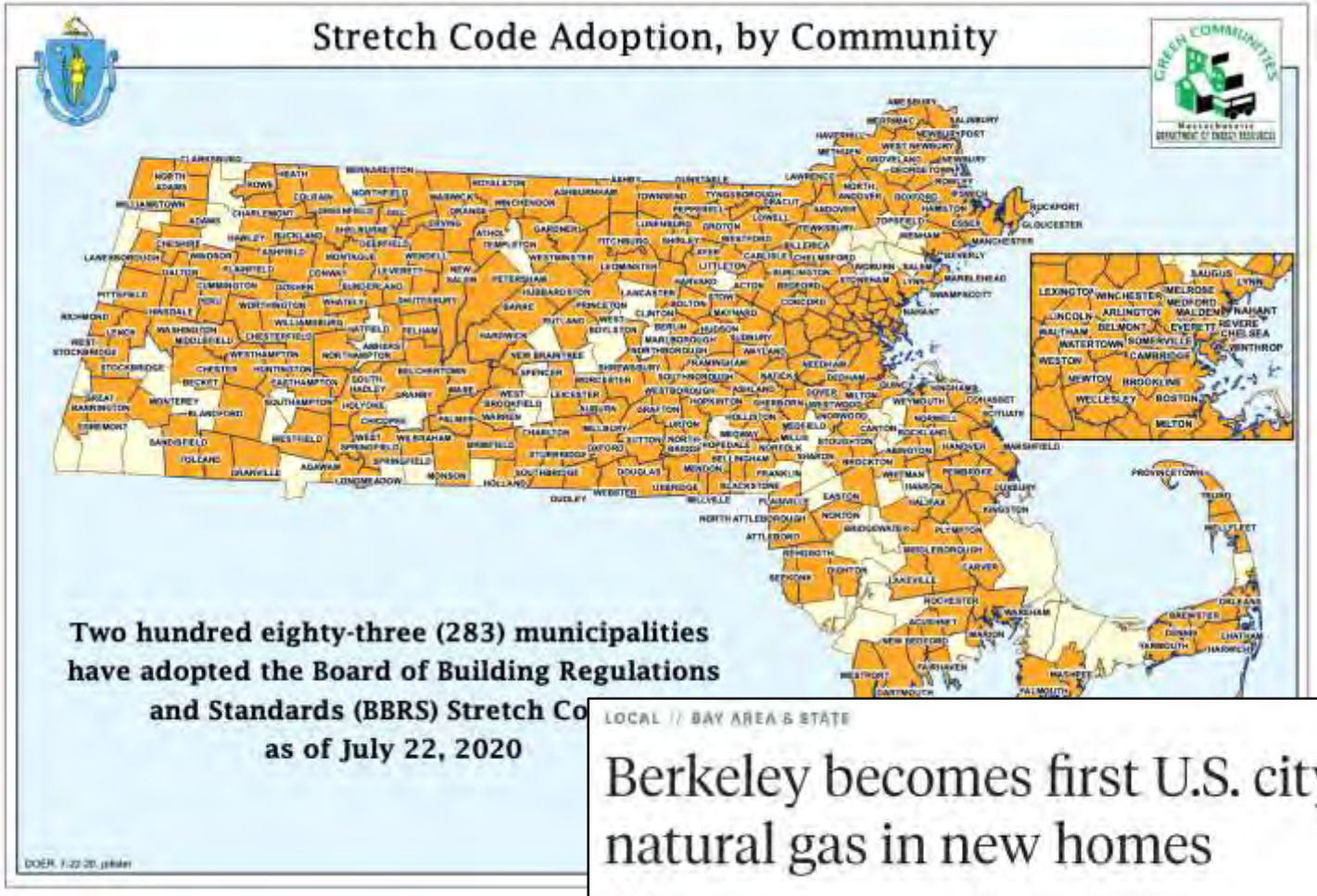
United States public infrastructure spending (in billions of 2017 dollars)
2007 to 2017



Source: Brookings analysis of CBO data.

B | Metropolitan Policy Program at BROOKINGS

Local Governments as Regulators



LOCAL // BAY AREA & STATE

Berkeley becomes first U.S. city to ban natural gas in new homes

Sarah Ravani | July 21, 2019 | Updated: July 9, 2020 7:48 p.m.

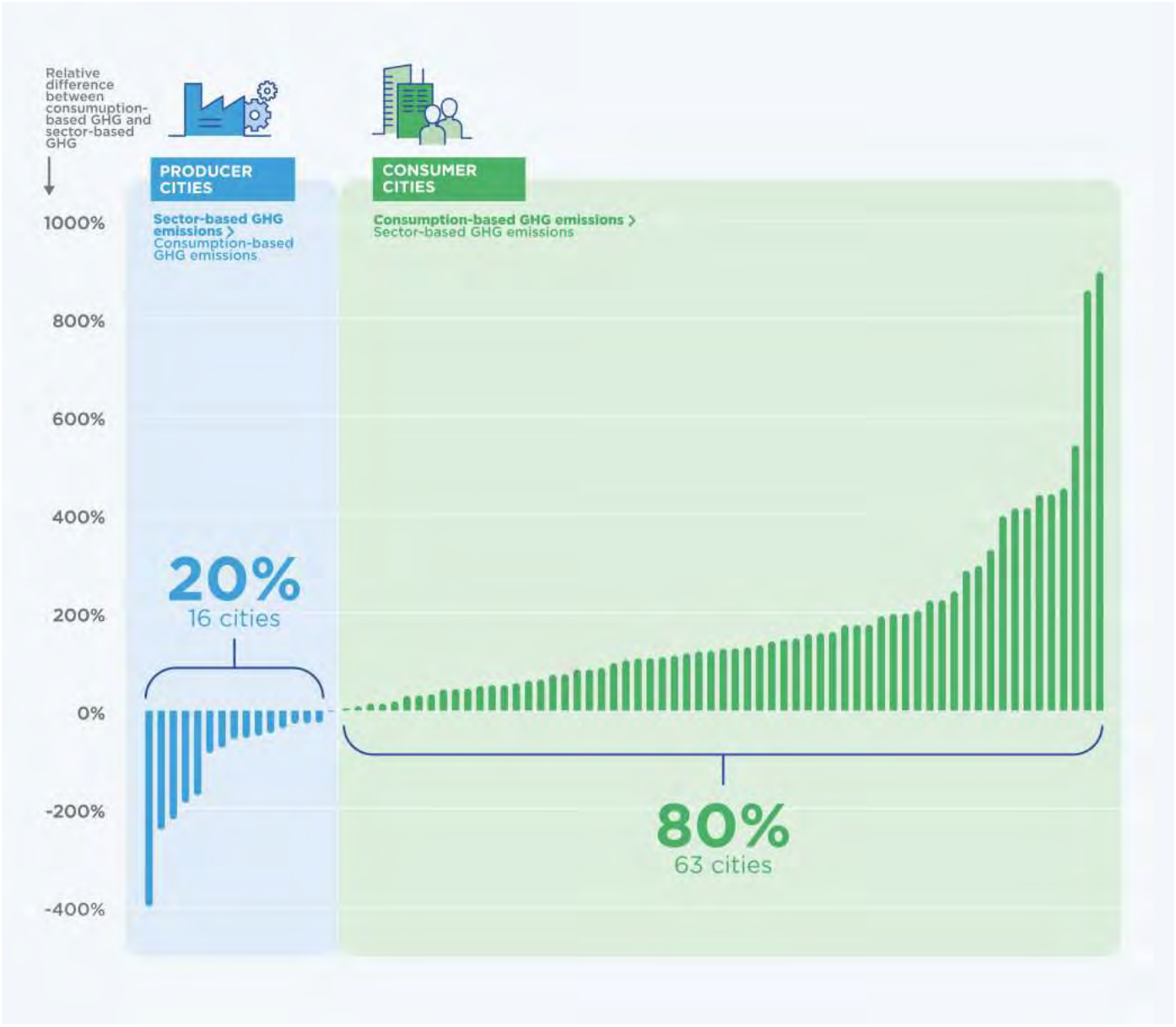
Local Governments as Climate Leaders

SUSTAINABILITY

Local Governments Lead Efforts to Combat Climate Change

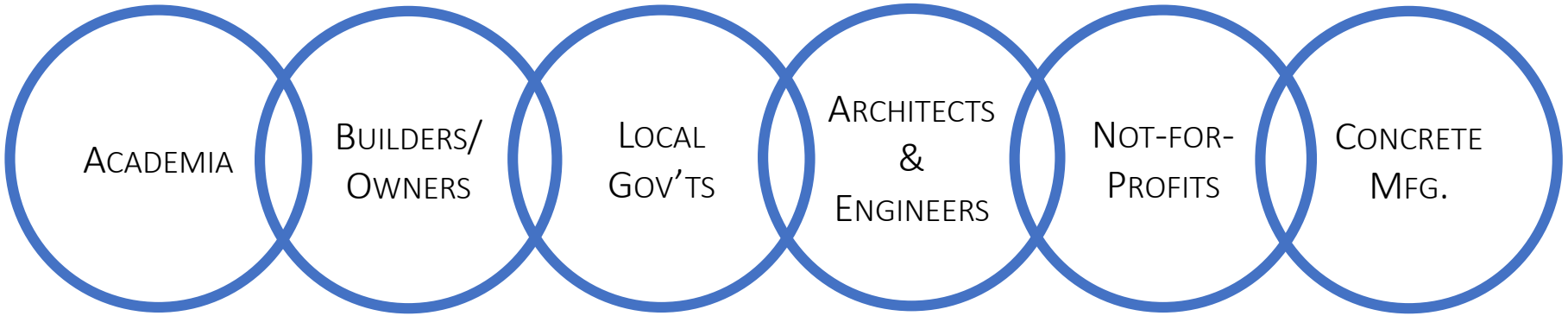
Local governments serve as idea labs for federal lawmakers as they consider changes to national climate and energy reform

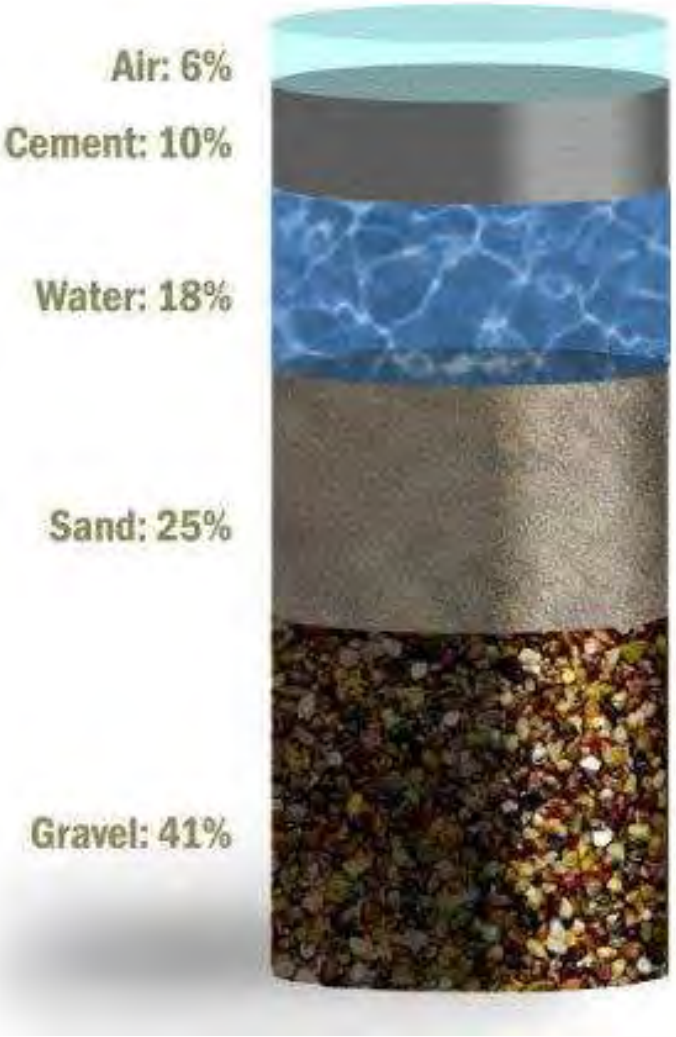
By Douglas Fischer, The Daily Climate on May 21, 2010

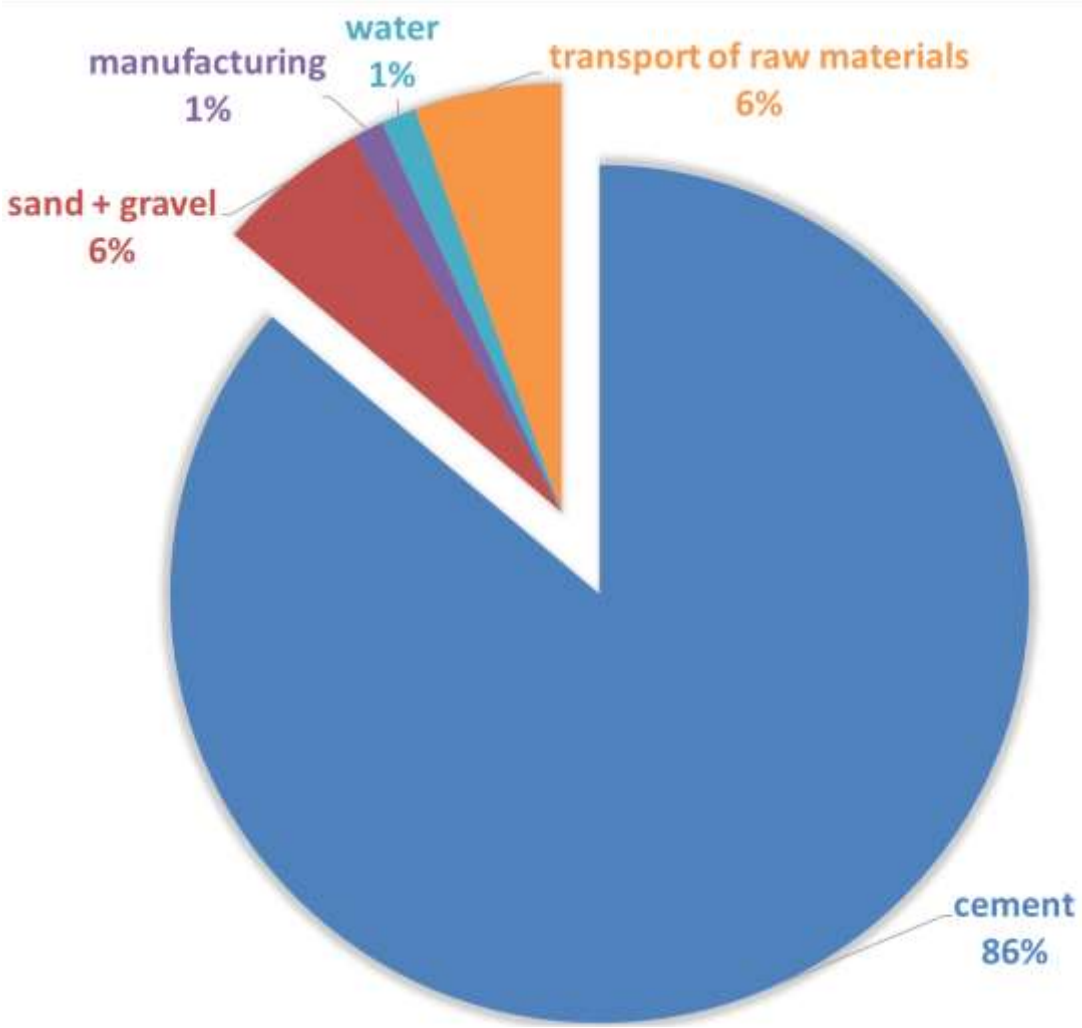

Relative difference between consumption-based GHG and sector-based GHG
PRODUCER CITIES
Sector-based GHG emissions > Consumption-based GHG emissions
CONSUMER CITIES
Consumption-based GHG emissions > Sector-based GHG emissions
1000%
800%
600%
400%
200%
0%
-200%
-400%
20%
16 cities
80%
63 cities

Government Efforts & Case Studies: Bay Area Low Carbon Concrete Code

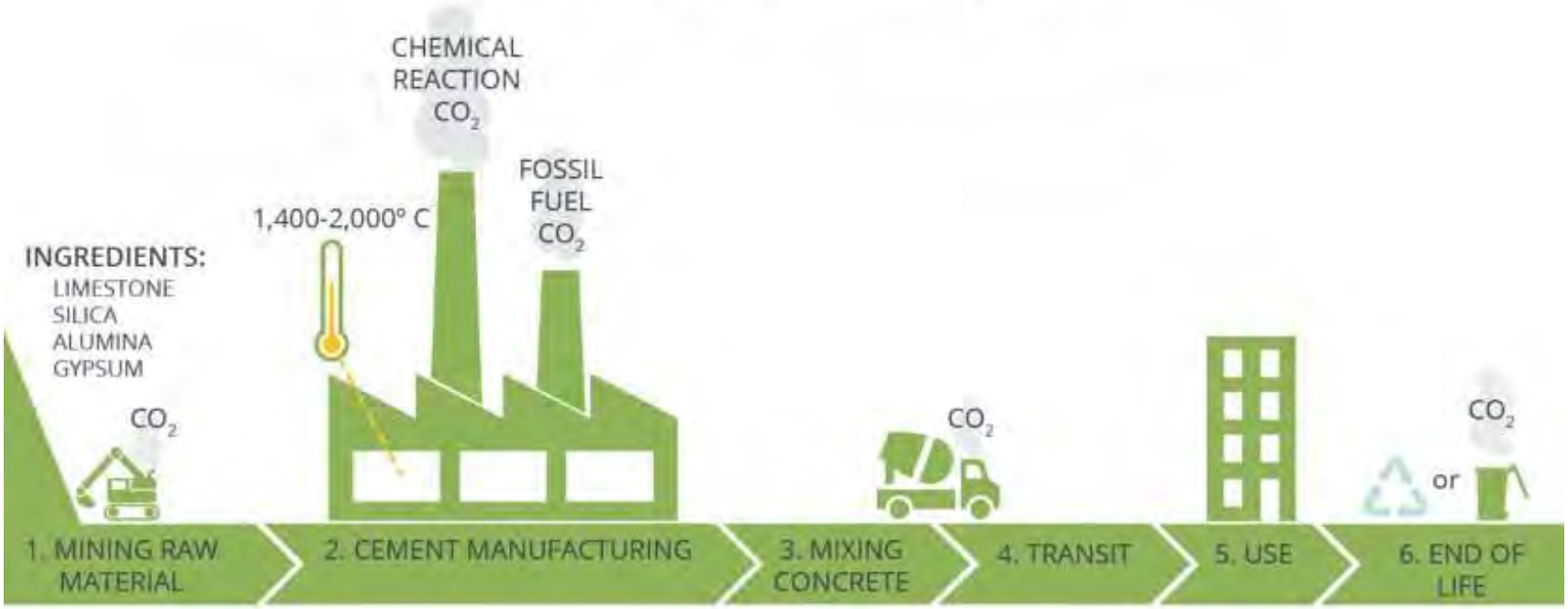
- Funded by BAAQMD's 2018 Climate Protection Grant Program under "Fostering Innovative Strategies with long-term impacts in reducing GHG emissions."
- A first-of-its-kind effort to address embodied emissions in an area of local government control.
- Partnership with local government, engineers, and academia, as well as a robust stakeholder group.



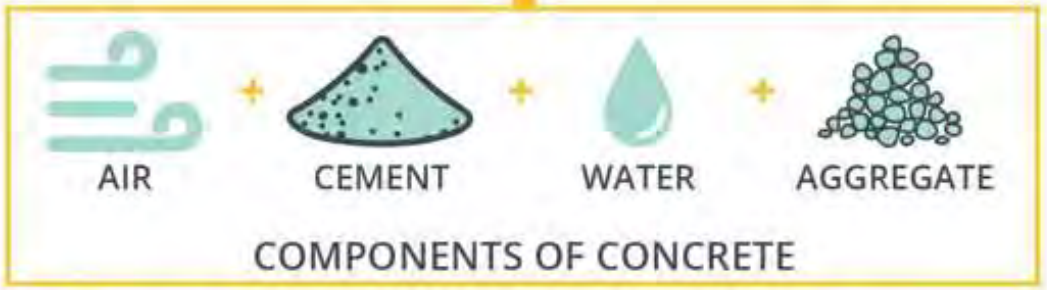

Air: 6%
Cement: 10%
Water: 18%
Sand: 25%
Gravel: 41%


water
1%
manufacturing
1%
transport of raw materials
6%
sand + gravel
6%
cement
86%

CARBON IMPACTS OF CONCRETE



END OF LIFE:
If not disposed of, concrete can be ground up at the end of its useful life to make aggregate for new concrete.



Government Efforts & Case Studies: Bay Area Low Carbon Concrete Code

- Model code language for adoption by local governments
  - Low embodied-carbon concrete specifications for residential and non-residential applications
  - Adopted unanimously by County of Marin on November 19, 2019
- Opportunity for these standards to be adopted across Bay Area jurisdictions; and for the framework to be replicated beyond our region.

Figure 2: Green building market transformation pathway

* Bay Area Regional Collaborative Bay Area Green Building Policy Assessment Aug. 20, 2010

Government Efforts & Case Studies: Bay Area Low Carbon Concrete Code

	Cement limits	Embodied Carbon limits
Minimum specified compressive strength f'_c, psi	Maximum ordinary Portland cement content, lbs/yd^3 (2)	Maximum embodied carbon kg CO_2e/m^3, per EPD
up to 2500	362	260
3000	410	289
4000	456	313
5000	503	338
6000	531	356
7000	594	394
7001 and higher	657	433
up to 3000 light weight	512	578
4000 light weight	571	626
5000 light weight	629	675

Government Efforts & Case Studies: Bay Area Low Carbon Concrete Code

- Four pilot projects receiving technical assistance to apply the specifications.

Source: LMS Architecture

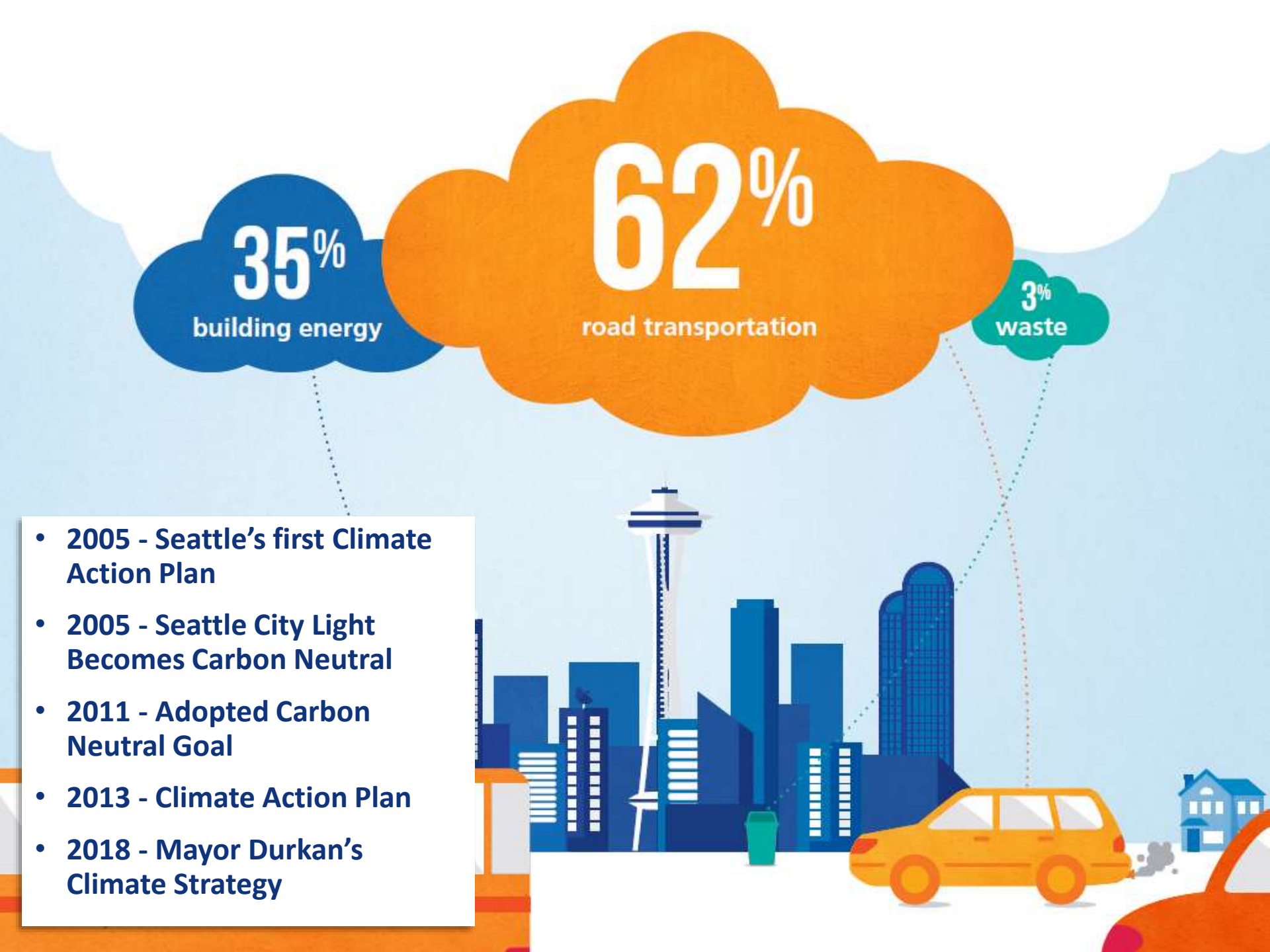
Barriers, Opportunities, & Questions

- How can this process expand to other building materials?
- How can we support innovative building materials without burdening applicants (both cost & process)?
- What is the right role for local government to play in materials regulations?
- How do we address consumption emissions in an economy rooted in consumption and growth?

Government Efforts & Case Studies: City of Seattle

Seattle
Office of Sustainability
& Environment

- Established in 2000 to develop and coordinate environmental policies.
- Staff of ~30 bring innovation, passion, and creativity to respond to and lead on Seattle's biggest environmental challenges.
- Advances racial, social, and environmental justice throughout Seattle's environmental work



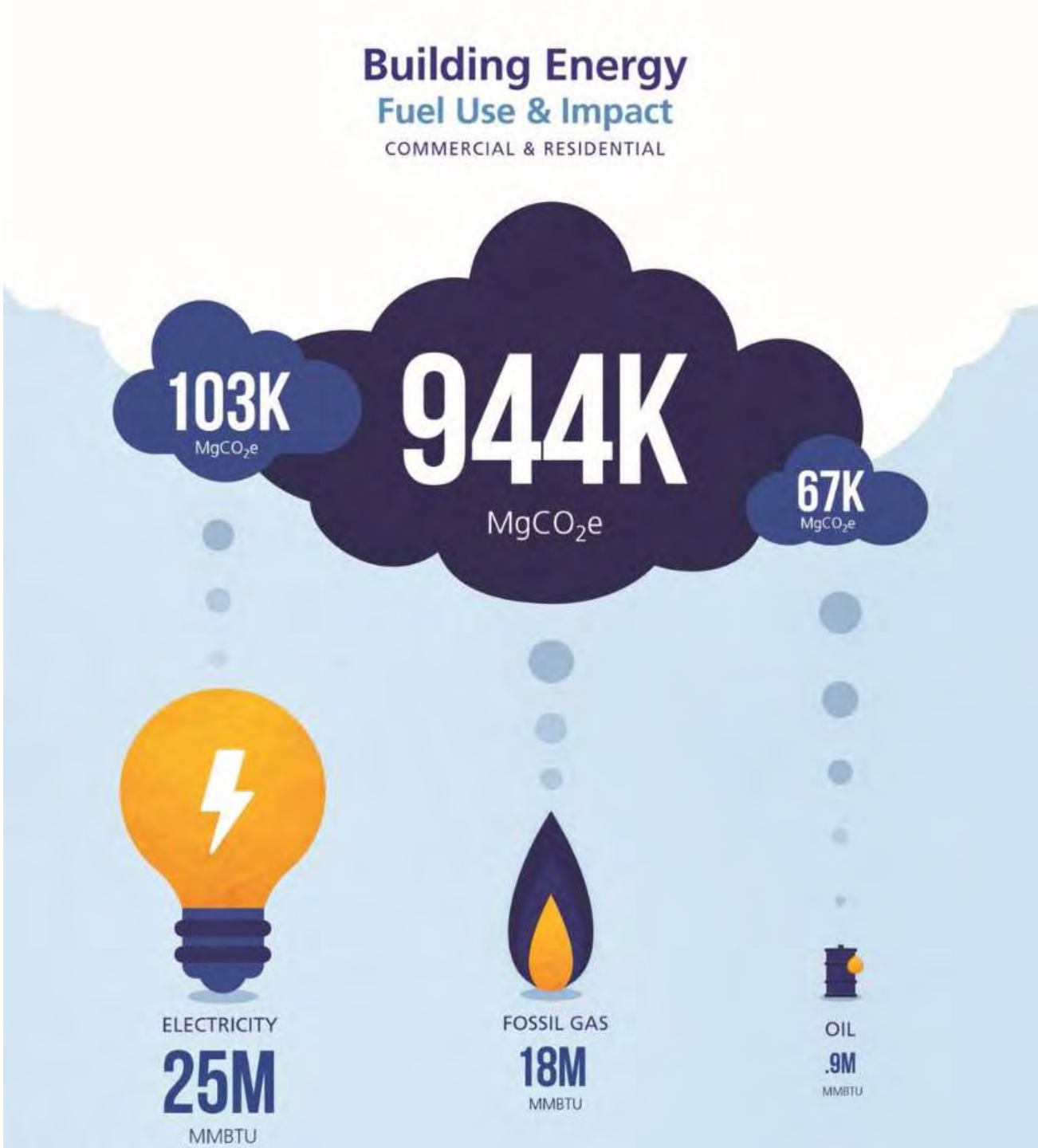
- 2005 - Seattle's first Climate Action Plan
- 2005 - Seattle City Light Becomes Carbon Neutral
- 2011 - Adopted Carbon Neutral Goal
- 2013 - Climate Action Plan
- 2018 - Mayor Durkan's Climate Strategy

BUILDING ENERGY EMISSIONS

2008
Baseline

39%
Reduction by
2030

Net Zero-Carbon by
2050



What about embodied carbon?

Mayor Durkan Issues Executive Orders Underscoring Seattle's Climate Commitment

by Kamaria Hightower on April 13, 2018

Seattle (April 13, 2018) – Seattle Mayor Jenny A. Durkan signed two Executive Orders that embed climate considerations more fully into City operations. The orders follow the release of new bold actions in Seattle to reduce carbon pollution from our transportation and building sectors and make Seattle a national leader in fighting climate change. The first executive order calls for accelerating the electrification of the City's municipal fleet and phasing out fossil fuel use in City vehicles by 2030. The second executive order directs the Office of Sustainability & Environment to develop a process for assessing the greenhouse gas emissions and climate resilience of major city policies, capital projects, and purchasing decisions.

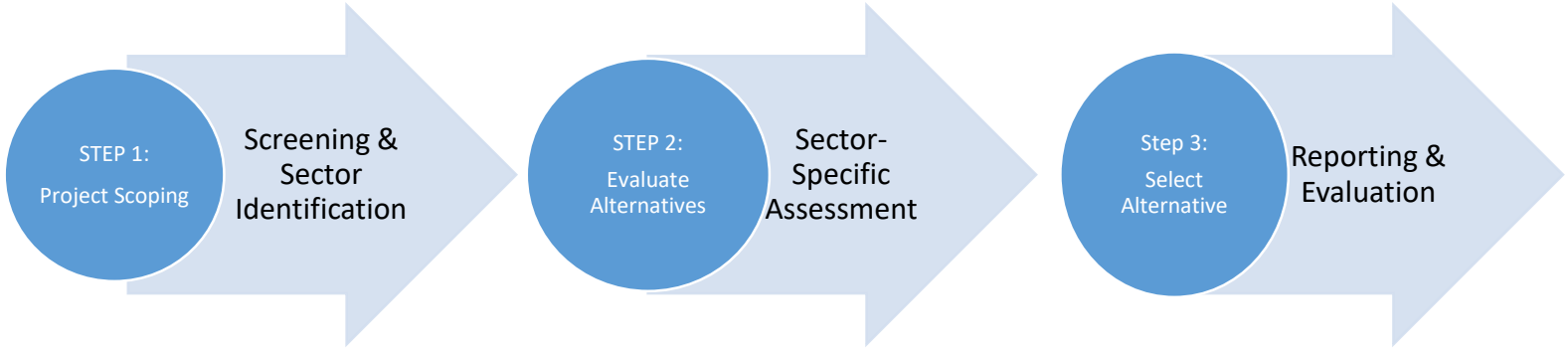
Climate Impact Toolkit: Scope

Seven “impact” areas:

- Transportation
- Land Use / Zoning
- Fossil Fuel Use in Buildings
- Fossil Fuels in Equipment
- Refrigerants
- Embodied Carbon
- SF6

Climate Impact Toolkit: Goals

- **Capacity building.** Building awareness and providing tools for city staff to ID low-carbon solutions in their work
- **Transparency and Accountability.** Filling out the reporting form creates documentation that influences behavior, even if not every single report leads to significant project level GHG reductions.
- **Explicitly identifying and championing low carbon solutions,** so that we can track what these are, how much they may cost, and decide how to address them.



Step 2. Climate Impact Screening

Please answer the following questions about your project (i.e., capital project, program, policy, plan, or procurement) to the best of your ability. When you select "Yes," you will be directed to the relevant Sector Guidance in Step 3. Below each question are examples of projects that involve decisions regarding the respective sector. If you are unsure whether your project does or does not involve decisions about the given sector, select "Yes" to explore the Sector Guidance to learn more; you can then return to this step and change your answer if needed. Be sure to only select one answer per question. If you select both answers, the cells will highlight in orange to indicate that you need to unselect an option.

Sector-Specific Information

1. Does your project involve decisions that could modify the use of FOSSIL FUELS WITHIN THE TRANSPORTATION SYSTEM?

Examples of City Decisions:

- Road restriping or repaving
- Capital projects
- Transportation programs
- Parking rules or investments
- EV infrastructure
- Technologies or policies to reduce trips
- Other infrastructure

☑ Yes
☐ No

2. Does your project involve decisions that could modify the LAND USE OR ZONING CODE?

Examples of City Decisions:

- Zoning or land use amendments
- Neighborhood planning
- Building code amendments
- Design guidelines
- Historic preservation
- Major institutions master planning

☑ Yes
☐ No

3. Does your project involve decisions that include the use of FOSSIL FUELS IN BUILDINGS?

Examples of City Decisions:

- New building construction
- Building retrofit or renovation
- Funding agreements/grants
- Building code changes
- Building incentives
- Occupancy, hours, or programming changes
- Putting unused/underutilized buildings into service
- Policies/codes that impact energy use

☐ Yes
☐ No

4. Does your project involve decisions that could modify the use of FOSSIL FUELS IN EQUIPMENT?

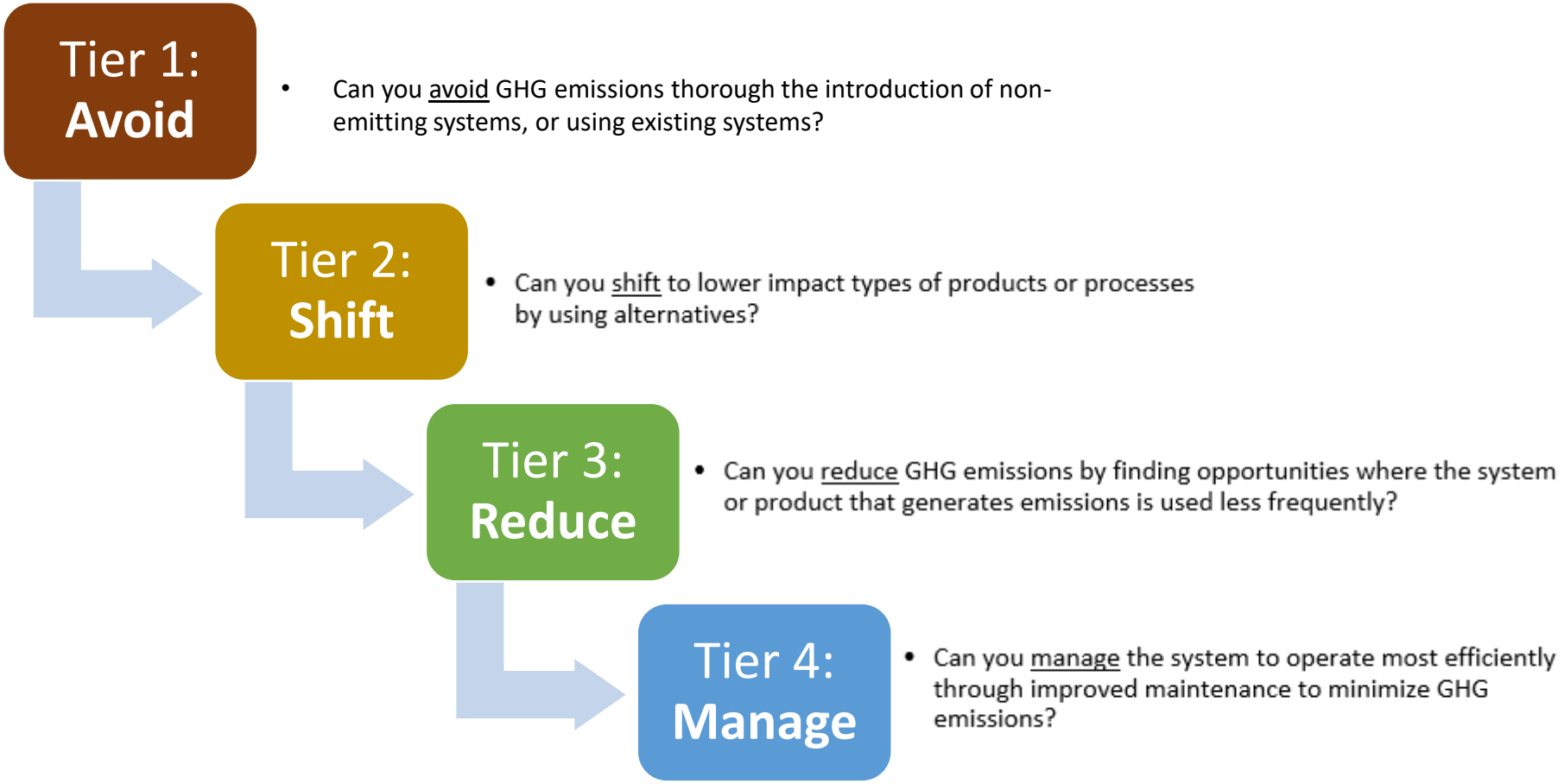
Examples of City Decisions:

- Heavy machinery purchases or contracting
- New/retrofit equipment
- Motorized landscaping equipment
- Construction equipment
- Pumps
- Dredging equipment
- Generators

☐ Yes
☐ No

5. Does your project involve decisions that could modify the use, maintenance, or purchase of products that contain REFRIGERANTS?

Climate Impact Toolkit: Framework



Please click on the following links to explore lower-carbon alternatives for your project. Guidance is provided for each sector that is relevant to your project (based on your responses in *Step 2. Impact Screening*). The information in these sections will help you complete the Reporting Form in Step 4. In addition, you may choose to review guidance for other sectors that are not directly relevant to your project, provided in the links in grey.

This white paper outlines options to aid in the decision-making process when choosing alternative refrigerants in commercial refrigeration equipment.

Embodied Carbon

Potential Impacts

The term "embodied carbon" refers to the collective impact of all the greenhouse gas emissions emitted during the manufacture, transport, and construction of buildings and infrastructure, as well as the end-of-life emissions. Embodied emissions are separate from operational emissions, which result from the energy used to run a building (heating, cooling, lighting, etc.).

As operational emissions are reduced through mitigation strategies, the impact of embodied emissions becomes increasingly significant. This is especially true in Seattle, where operational emissions are already lower due to our carbon-neutral electricity grid. For a typical office building in Seattle, 84% of its emissions are in embodied carbon over a fifty-year lifecycle. Once a building or piece of infrastructure is constructed, the embodied emissions of that structure are locked in and cannot be taken back or reduced. Therefore, it is crucial to address embodied emissions now to change the current upward trend in overall emissions.

The materials with the highest embodied carbon are those used in structures, such as concrete, steel, and timber, followed by building envelope materials, such as glazing, aluminum insulation, and metal framing. Asphalt, a material used in infrastructure, also contains significant embodied carbon. Infrastructure and ground-up construction projects tend to contain the highest emissions associated with embodied carbon due to their reliance on large amounts of concrete.

Relevant Projects

- Building construction
- Road paving
- Bridge and tunnel construction, rehabilitation, and replacement
- Reservoir construction
- Retaining/seawall construction

Best Practices

Avoid

The most impactful strategy is to avoid using materials with embodied carbon by eliminating the need for the project itself. Can the construction of a new building be avoided by purchasing and retrofitting an existing one? Can the provision of alternate modes of transit offset the need to build new road infrastructure? Will the lifespan of the project be negatively affected due to any future improvements or changes?

Shift

Explore project designs that promote the replacement of high-carbon materials with lower-carbon alternatives. For example, swapping out structural steel or concrete for cross-laminated timber can drastically reduce the embodied carbon of the project. Similarly, using high-recycled content materials in lieu of their virgin counterpart – particularly for metals like steel – can reduce embodied carbon by over 80%.

Step 4. Reporting Form

Change to PRINT view

Embodied Carbon

IDEATE

Use the space below to brainstorm ideas for reducing the climate impact of your project.

CALCULATE *(optional)*

If you have quantitative data about your project and you would like to calculate estimated emissions for your project, click the calculator icon below to explore how emissions may vary under various project options/scenarios.

Please write any considerations or notes about the emissions calculation, if desired.

SELECT SOLUTIONS

Please describe the ideas you selected to move forward in your project for reducing climate impacts.

General Feedback

Collaboration & Resources

CNCA
CARBON NEUTRAL CITIES ALLIANCE

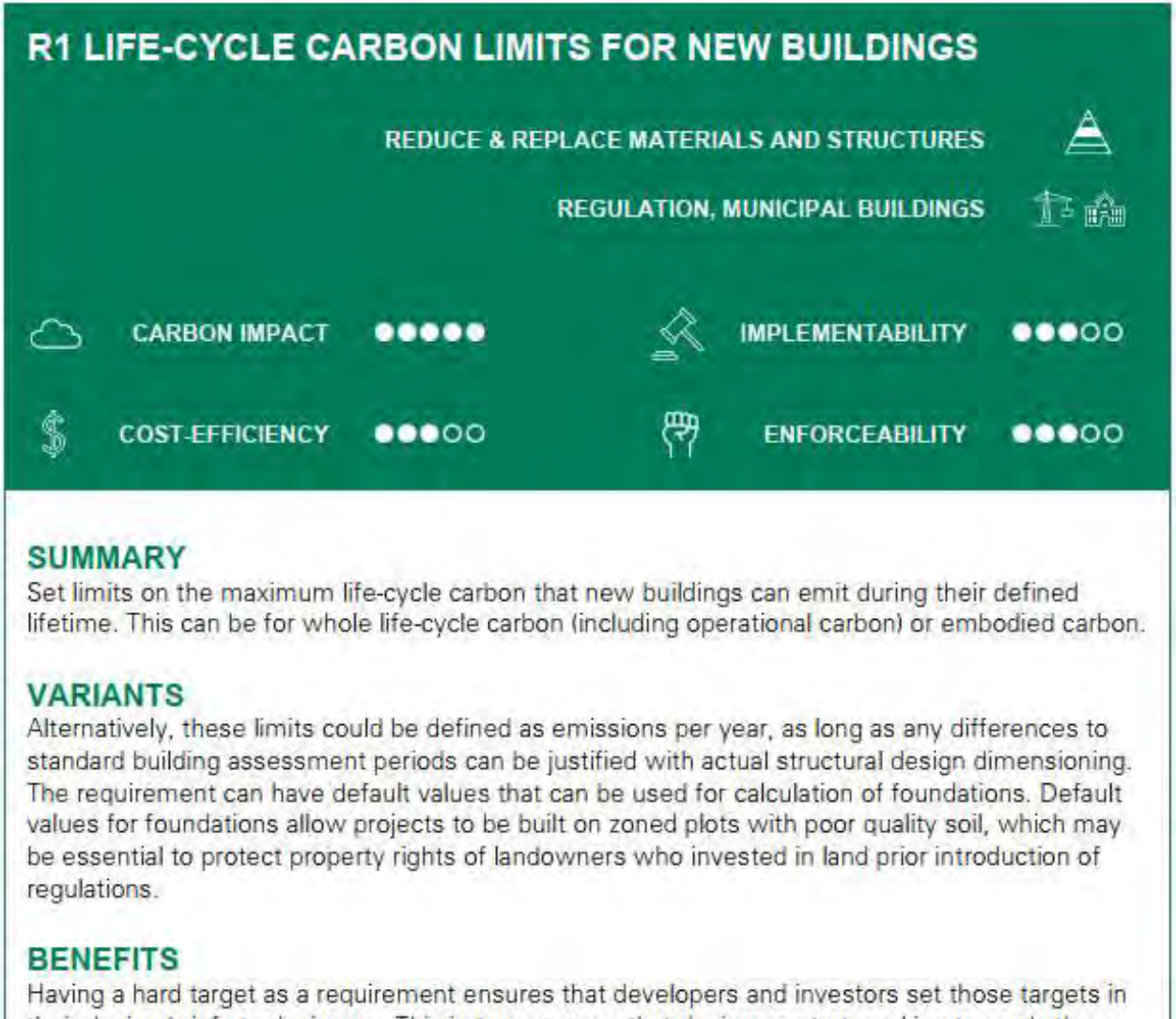
CLF Carbon Leadership Forum

Peer Cities & Jurisdictions

Collaboration & Resources

CNCA + OneClickLCA Policy Framework

(52 detailed policies to reduce embodied carbon)



R1 LIFE-CYCLE CARBON LIMITS FOR NEW BUILDINGS

REDUCE & REPLACE MATERIALS AND STRUCTURES

REGULATION, MUNICIPAL BUILDINGS

CARBON IMPACT ●●●●●

IMPLEMENTABILITY ●●●○○

COST-EFFICIENCY ●●●○○

ENFORCEABILITY ●●●○○

SUMMARY

Set limits on the maximum life-cycle carbon that new buildings can emit during their defined lifetime. This can be for whole life-cycle carbon (including operational carbon) or embodied carbon.

VARIANTS

Alternatively, these limits could be defined as emissions per year, as long as any differences to standard building assessment periods can be justified with actual structural design dimensioning. The requirement can have default values that can be used for calculation of foundations. Default values for foundations allow projects to be built on zoned plots with poor quality soil, which may be essential to protect property rights of landowners who invested in land prior introduction of regulations.

BENEFITS

Having a hard target as a requirement ensures that developers and investors set those targets in

Building Transparency

Operational

Resources

Embodied

architecture 2030

2030 CHALLENGE FOR EMBODIED CARBON

CARBON SMART MATERIALS PALETTE™

CLF Carbon Leadership Forum

Embodied Carbon Network

materialsCAN Carbon Action Network

....and more!

Embodied

Operational

architecture 2030

2030 PALETTE

2030 CHALLENGE

ASHRAE

BPD BUILDING PERFORMANCE DATABASE

WBDG WHOLE BUILDING DESIGN GUIDE
a program of the National Institute of Building Sciences

....and more!

Building Transparency

The Embodied Carbon Network

CLF Carbon Leadership Forum

Embodied Carbon Network

- First **free, industry network** focused on embodied carbon
- Over **15 local network chapters** and growing
- Over **2,000 network participants** currently egnaging

Chapters active/forming in:

ECN Austin
ECN Australia
ECN Atlanta
ECN Bay Area
ECN Boston
ECN Calgary
ECN Chicago
ECN Hong Kong
ECN NYC
ECN Pittsburgh
ECN Portland
ECN Rocky Mountain (Denver/Boulder)
ECN Seattle
ECN Toronto
ECN UK
ECN Vancouver
ECN Yellowstone

Join the ECN at: https://carbonleadershipforum.org

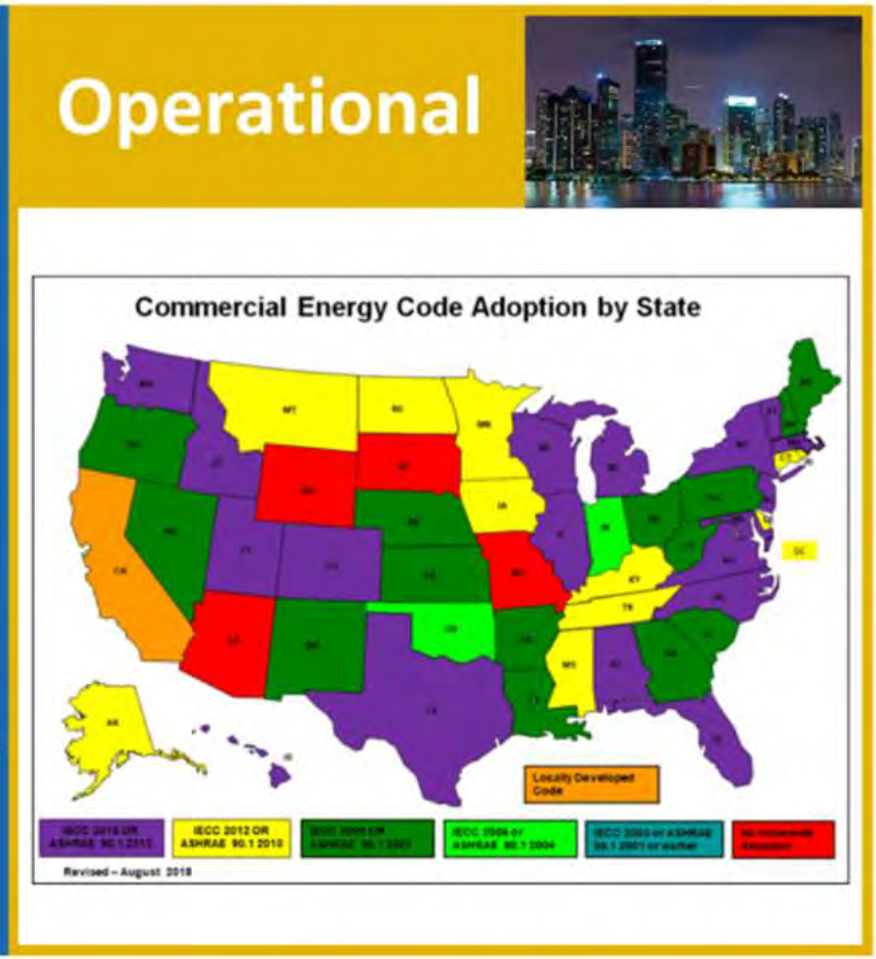
Building Transparency

Operational

Policy

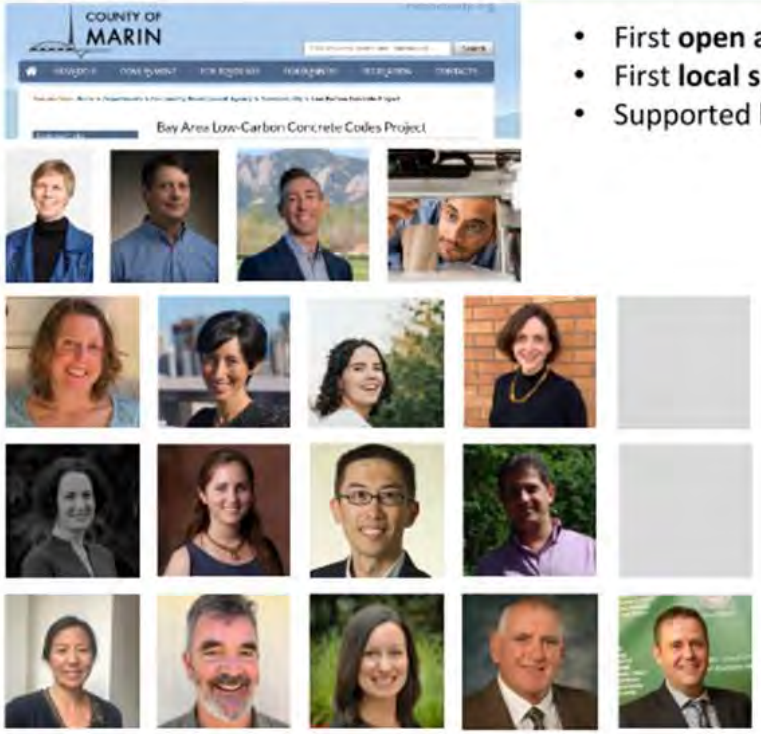
Embodied


COUNTY OF MARIN
Bay Area Low-Carbon Concrete Codes Project
CITY OF PORTLAND
OFFICE OF MANAGEMENT AND FINANCE
Buy Clean California Act
State agencies, University of California and California State University System, construction materials industries, other interested parties can learn more about the embedded carbon emissions of construction materials used in public works projects.
Marin County Low Carbon Concrete Code
EPD reporting and CO2e limits
Buy Clean California Act
EPDs and CO2e limits for certain building materials
Policy Implemented
Policy Under Consideration
Embodied


Operational
Commercial Energy Code Adoption by State
Locality Developed Code
IECC 2012 OR ASHRAE 90.1 2010
Revised – August 2018

Building Transparency

Bay Area Low-Carbon Concrete Code



- First **open access model policy language** for low embodied-carbon concrete
- First **local specifications** for low embodied-carbon concrete
- Supported by **4 jurisdictions** and over **30 industry partners**

Figure 12: Bay Area Low Carbon Concrete Limit vs. NRMCA US Avg., Cement vs. f'c

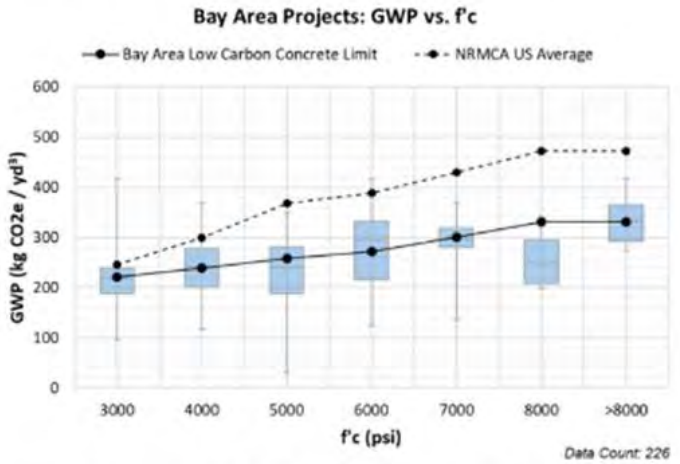


Figure 13: Bay Area Low Carbon Concrete Limit vs. NRMCA US Avg., GWP vs. f'c

Access the code at:

https://www.marincounty.org/depts/cd/divisions/sustainability/low-carbon-concrete-project

Building Transparency

Operational

Tools & Certifications

Embodied

Athena Impact Estimator for Buildings

EC3

One Click LCA

OPENLCA

tally

BREEAM

U.S. GREEN BUILDING COUNCIL LEED USGBC

LIVING BUILDING CHALLENGE

ZERO CARBON CERTIFICATION

....and more!

Embodied

Operational

BREEAM

U.S. GREEN BUILDING COUNCIL LEED USGBC

Radiance

LEED Zero

cove.tool

LIVING BUILDING CHALLENGE

Edge

ENERGY STAR® PortfolioManager®

SF TOOL

ZERO ENERGY CERTIFICATION

....and more!

Thank you!