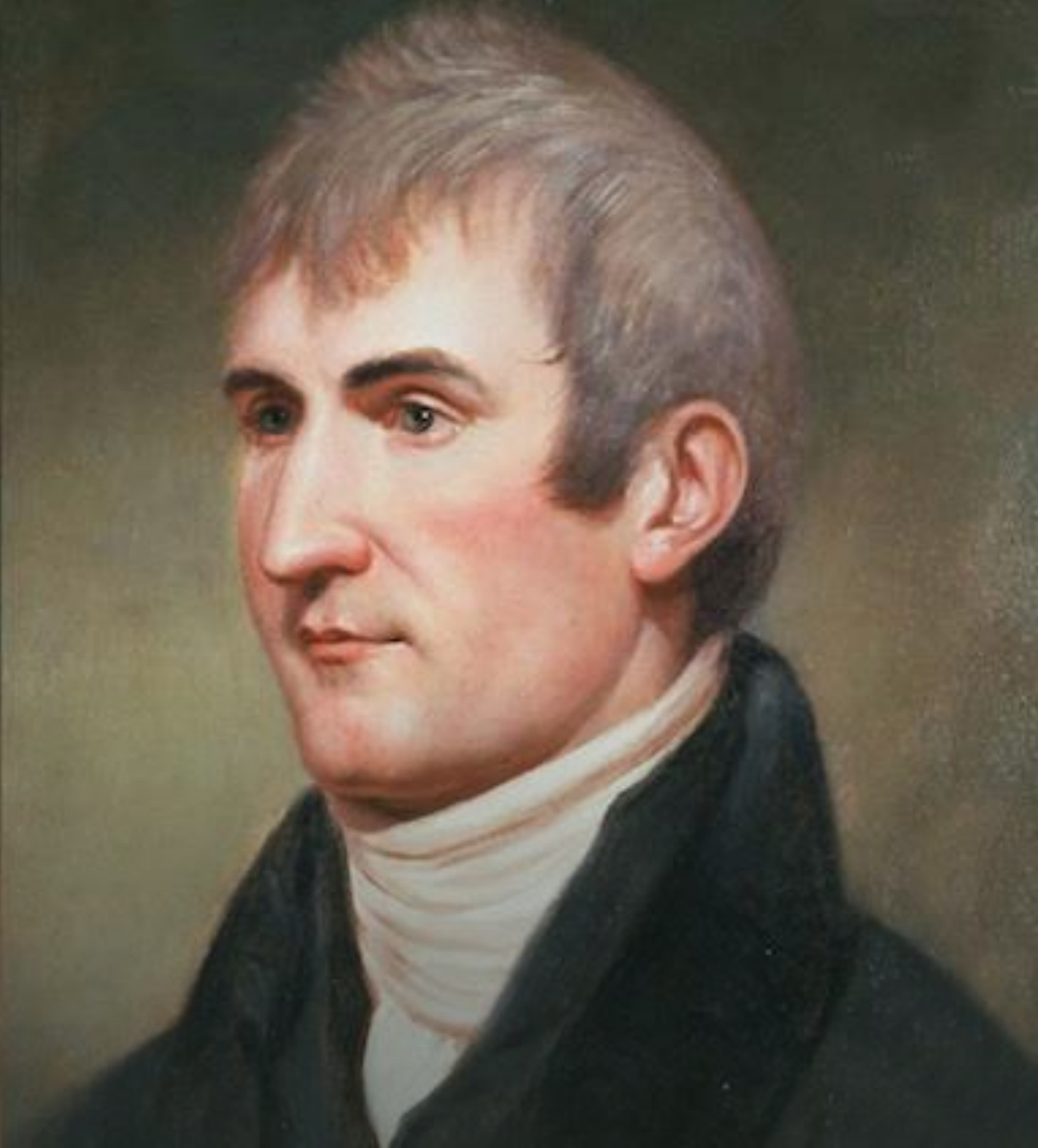
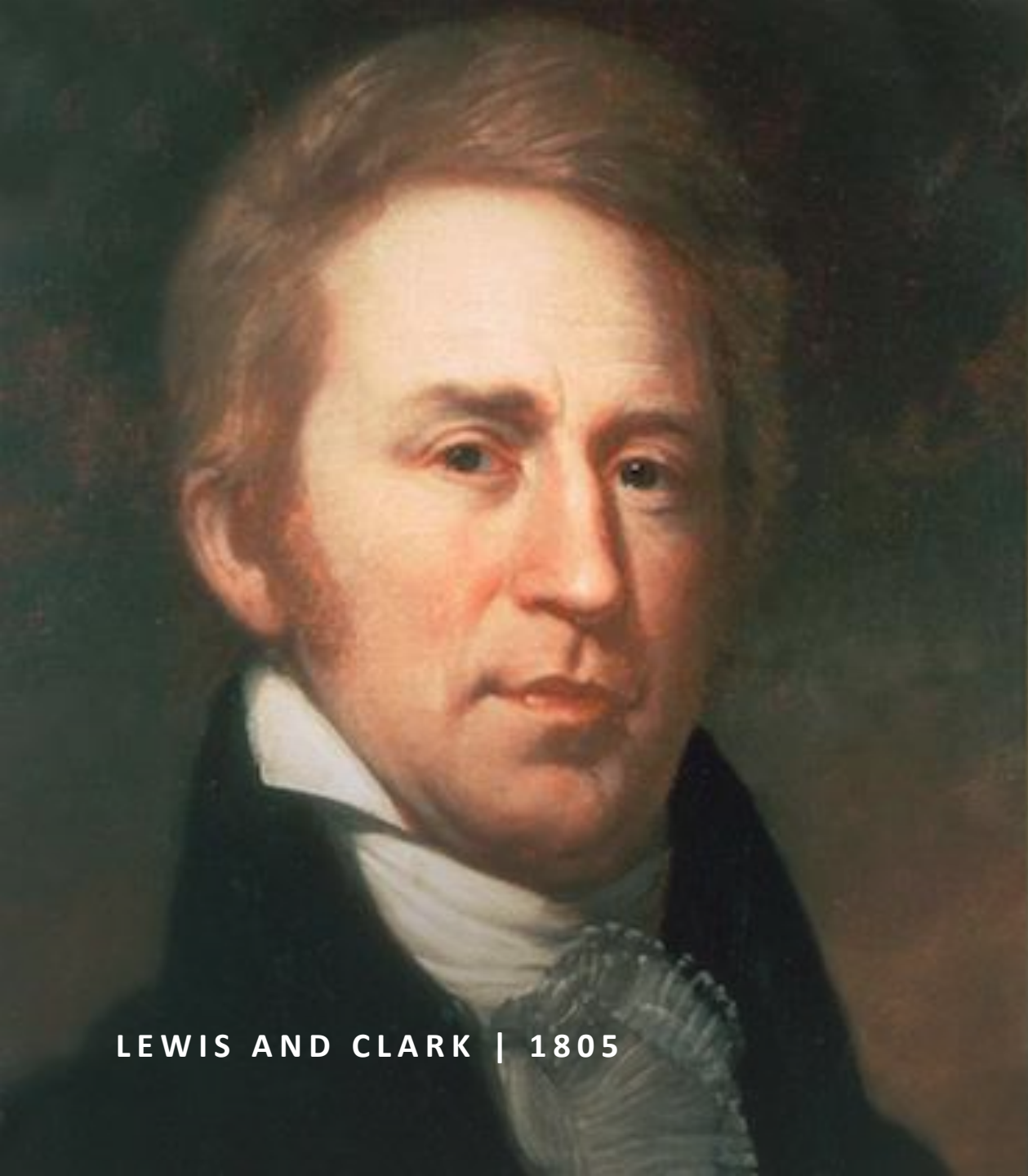




Greening Buildings for Carbon Neutrality

April 27, 2022 | Presented by Marc P Brune, PE





LEWIS AND CLARK | 1805



NG OFFICE.

D. COLEMAN

Flour

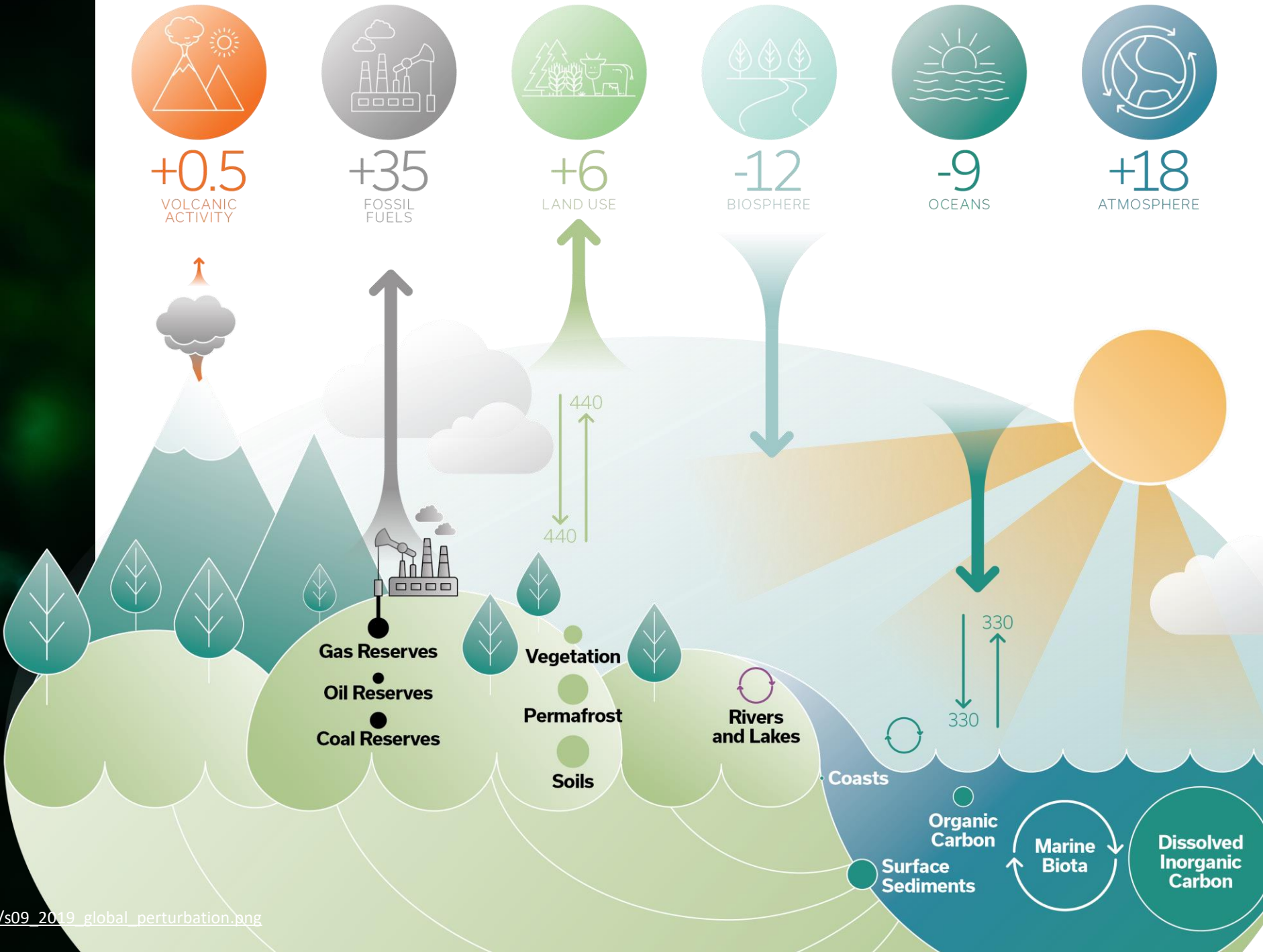
BAKERY

FIRST AND STARK STREET | 1852
PORTLAND, OR



CELILO FALLS | OREGON

Global Carbon Cycle



SOURCE: http://folk.uio.no/roberan/img/GCB2019/PNG/s09_2019_global_perturbation.png



INDUSTRY
32%

The image shows an industrial facility at night, with several tall smokestacks and buildings illuminated by green and white lights. The sky is dark, and the overall scene is lit up by the facility's own lighting.



TRANSPORTATION
29%

The image shows a multi-lane highway with several cars driving on it. In the background, there are several tall skyscrapers and other city buildings under a clear sky. The highway is elevated on a concrete structure.



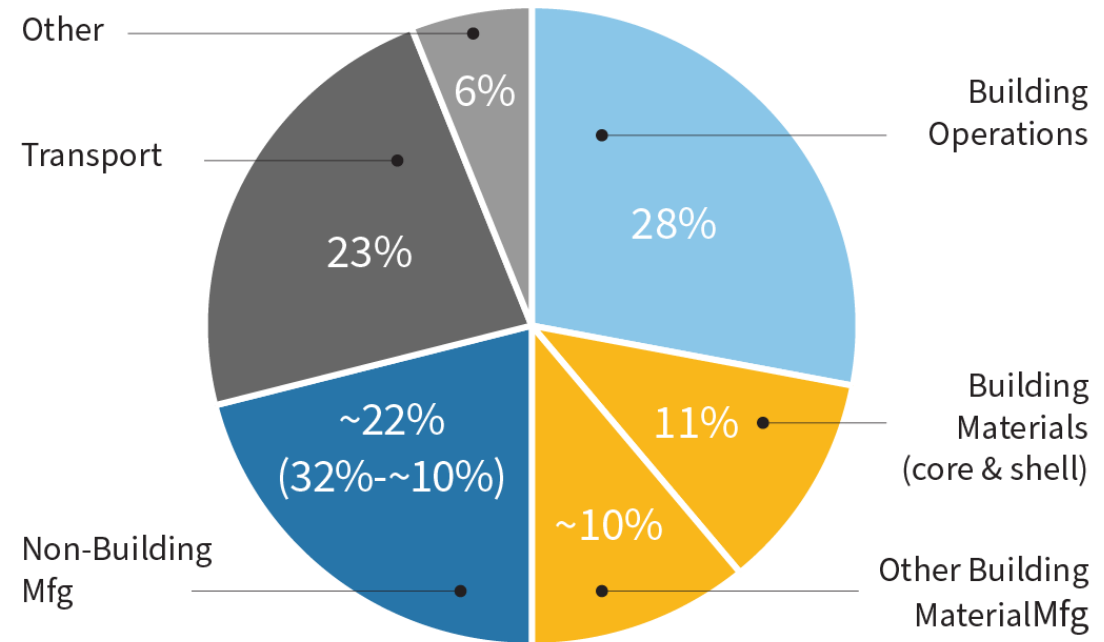
BUILDING
39%
(Residential 21%)
(Commercial 18%)

The image is an aerial view of a city, showing a dense collection of buildings, streets, and green spaces. A large body of water is visible in the lower right quadrant. The buildings are mostly multi-story structures, and the overall scene is a mix of urban development and natural elements.

UNITED STATES ENERGY USE BY SECTOR

Emissions by Sector

Global CO₂ Emissions by Sector

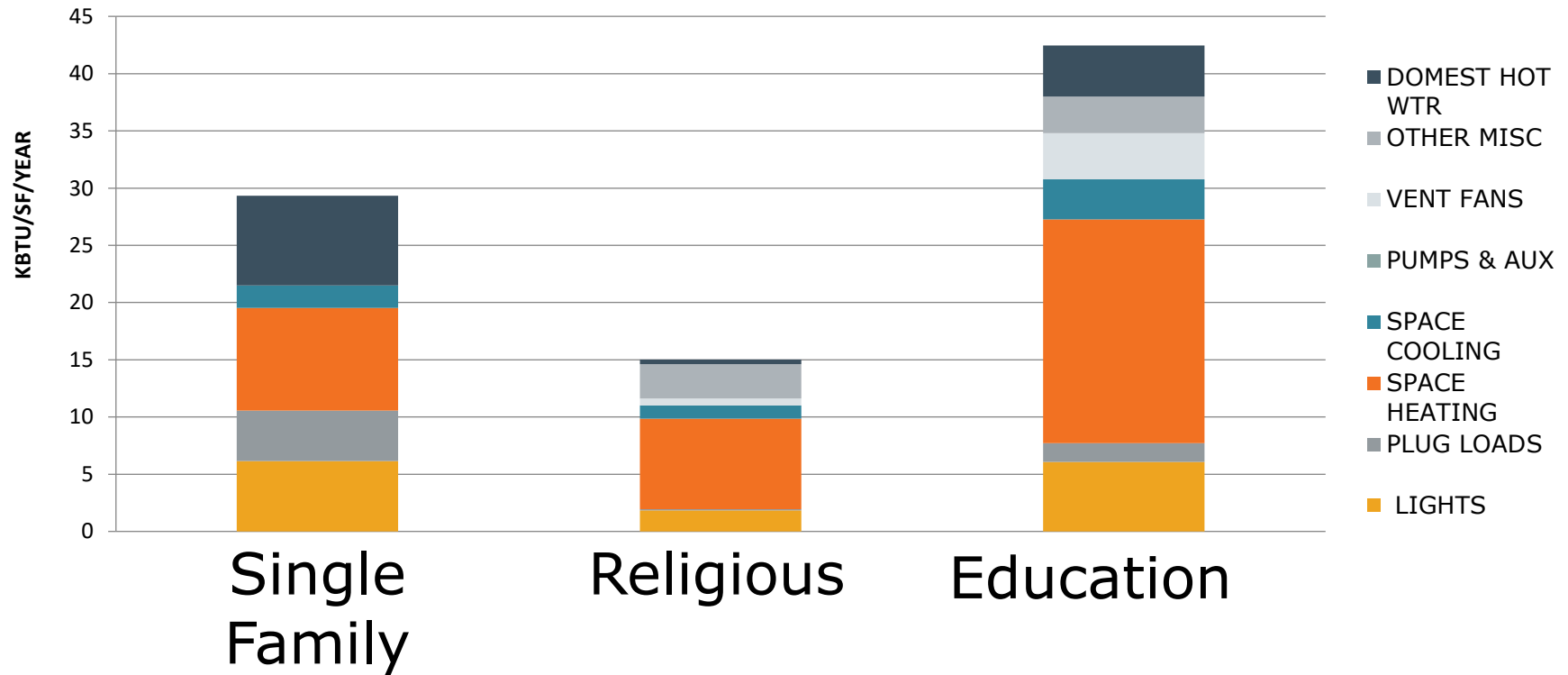


Adapted from 2019 Global Status Report, Global Alliance for Building and Construction (GABC) and Architecture 2030.

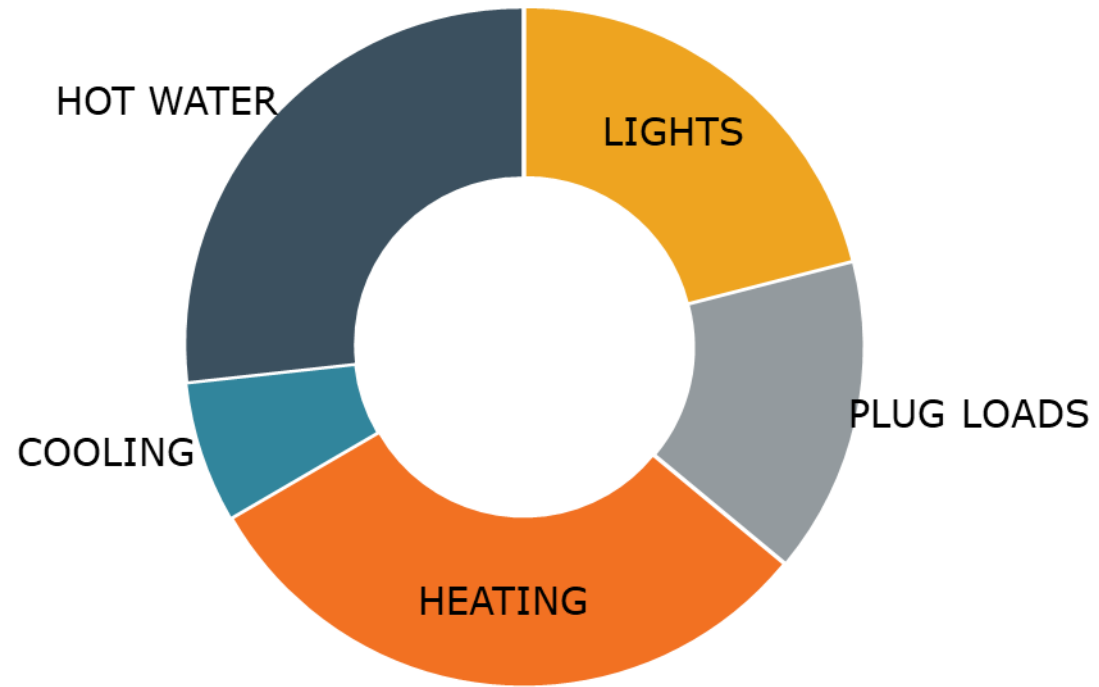
- The building and construction sector has a vital role to play in eliminating carbon, as it is responsible for approximately 40% of global carbon emissions.



Typical Energy Use



Typical Home Energy Use – Pacific Northwest



Lights



Incandescent



Compact
Fluorescent



LED



Domestic Hot Water


SMART

*Built-in Leak Detection
with Auto Shut Off*



Insulation



 dreamstime.com

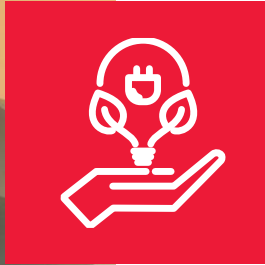
ID 209115974 © Ivansmuk





Electrification

Heating, Cooling, Kitchens

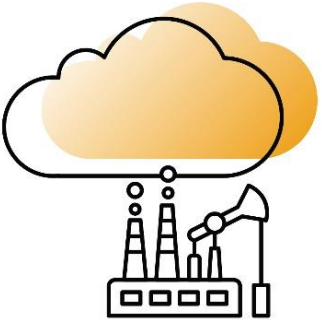


Why?

Why should we electrify buildings?

GREENING OF THE GRID

2019

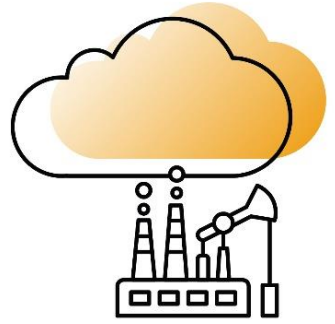


NATURAL GAS



ALL ELECTRIC

2030

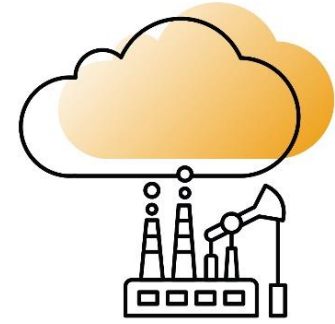


NATURAL GAS



ALL ELECTRIC

2045



NATURAL GAS

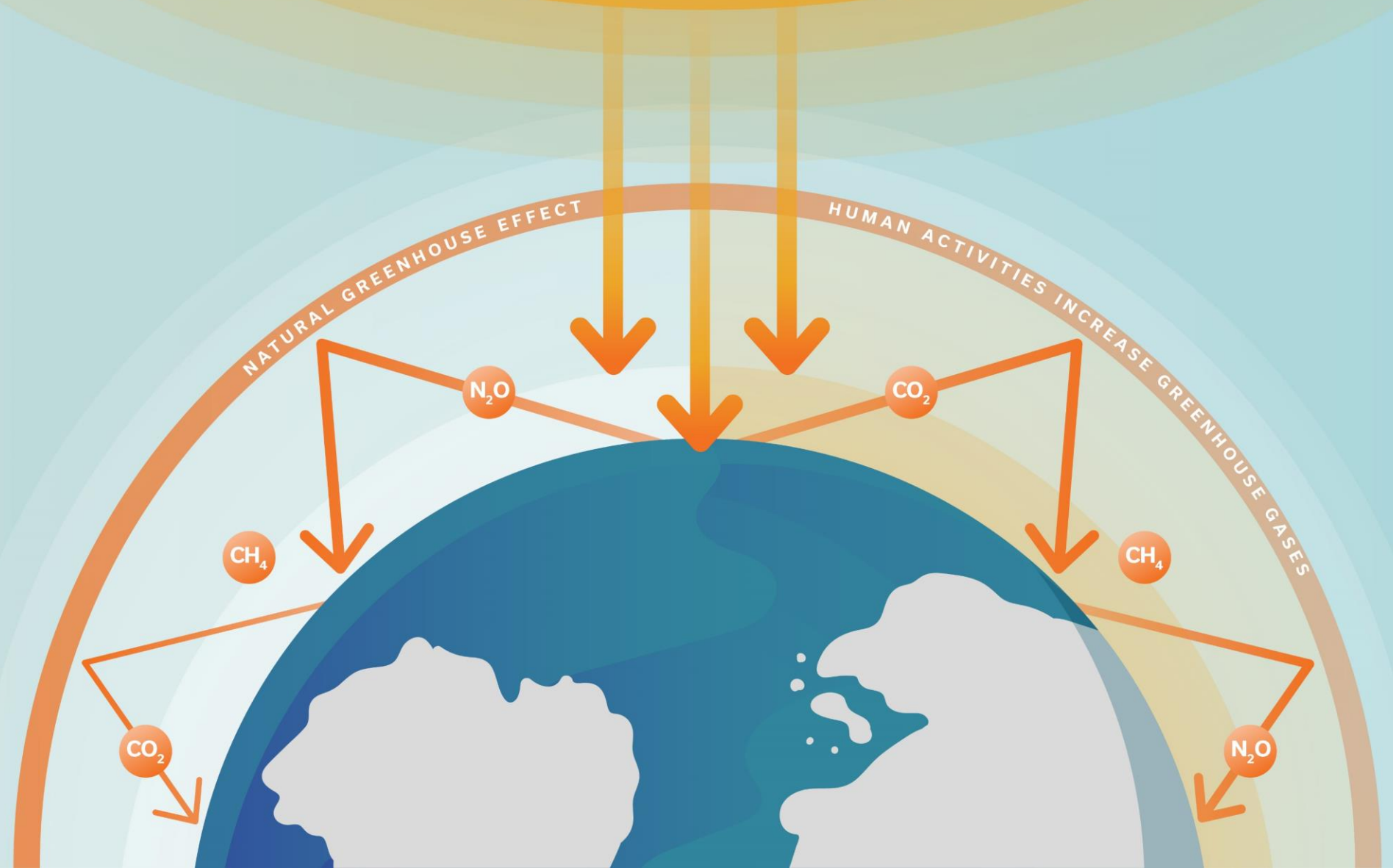


ALL ELECTRIC

Natural Gas



Greenhouse Gases



Global Warming Potential

Carbon Dioxide

1
UNIT OF CO₂



Methane – 100 Yr GWP

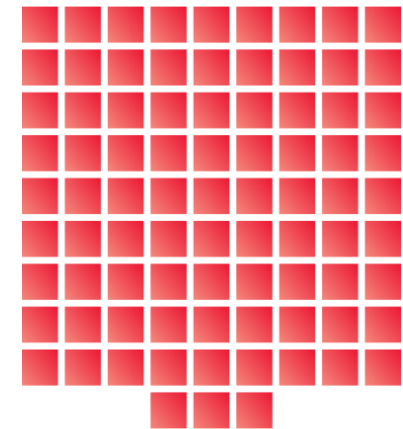
1
UNIT OF CH₄



28
UNITS OF CO₂

Methane – 20 Yr GWP

1
UNIT OF CH₄



84
UNITS OF CO₂


“ It's a better fuel all around as long as you don't spill it. But it doesn't take much methane leakage to ruin your whole day if you care about climate change.

The breaking point for natural gas leakage is about 3 percent. If more than that leaks, the fuel has a bigger climate effect than burning coal. ”

- **PAUL SHEPSON**

PURDUE'S JONATHAN AMY DISTINGUISHED PROFESSOR OF ANALYTICAL AND ATMOSPHERIC CHEMISTRY

<https://www.purdue.edu/newsroom/releases/2017/Q1/estimates-of-emissions-from-natural-gas-fueled-plants-much-too-low,-study-finds.htm>

A large, grey, cylindrical industrial storage tank is the central focus of the image. It is surrounded by a complex network of pipes, valves, and a metal staircase that spirals around its side. The sky is a uniform, overcast grey. A white text overlay is positioned on the tank's surface. In the foreground, a chain-link fence runs across the frame. To the right, a sign with various logos and text is partially visible. The overall scene is an industrial facility.

Do you see the methane leak
billowing from this tank?

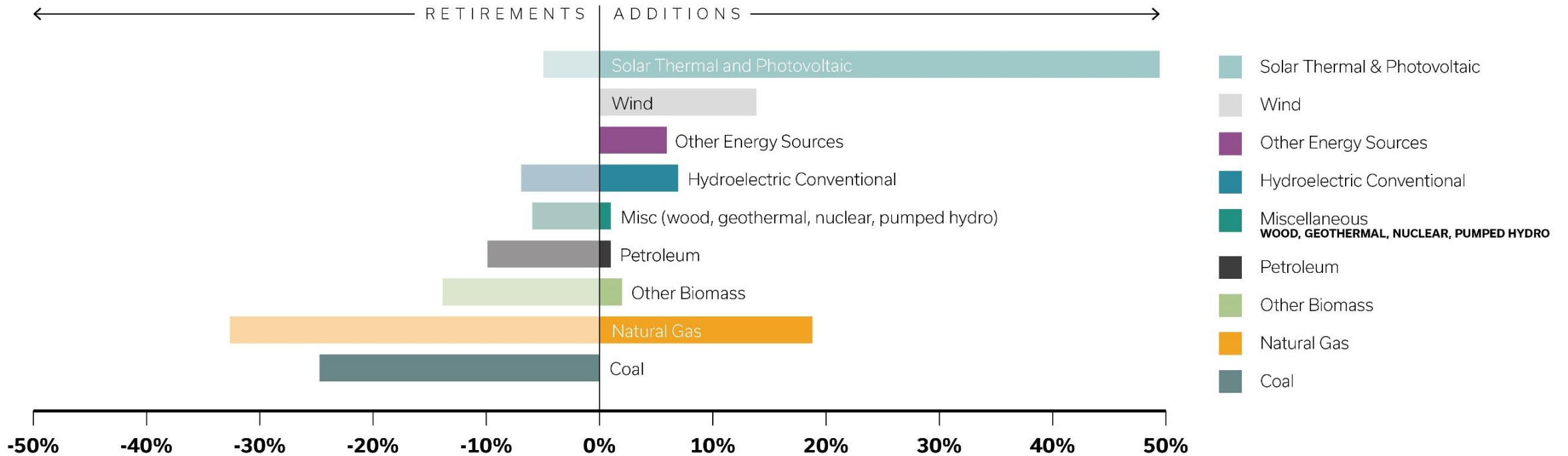
Electricity



NEW ELECTRICITY | NATIONALLY

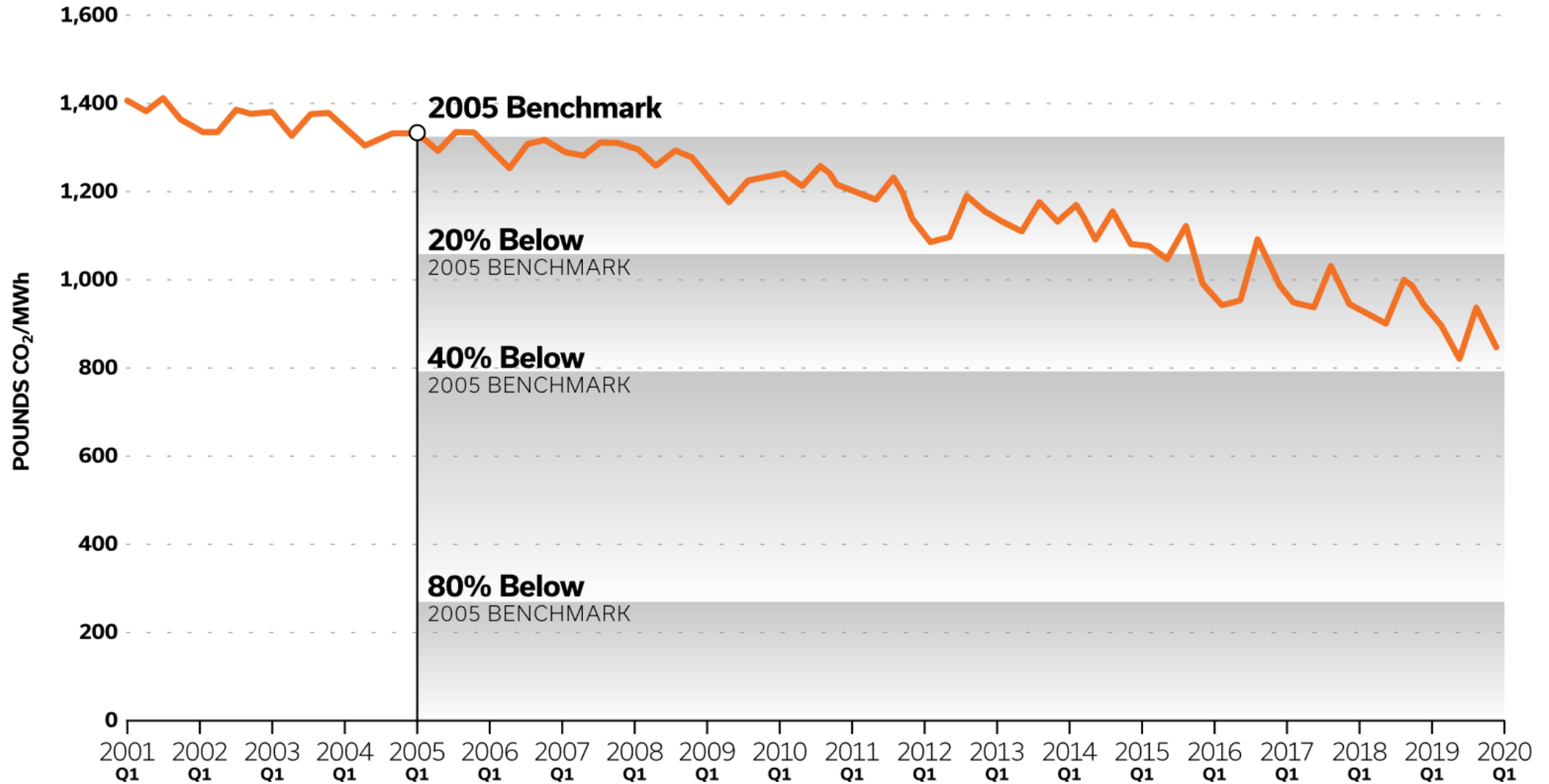
Anticipated Generation

2019-2023



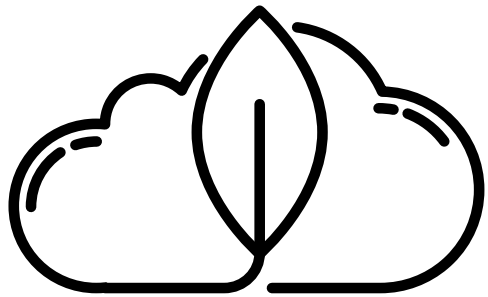
Source: U.S. Energy Information Administration, Form EIA-860, 'Annual Electric Generator Report.' | These data reflect plans as of December 31, 2018
Other Energy Sources include batteries, hydrogen, purchased steam, sulfur, tire-derived fuels and other miscellaneous energy sources. | https://www.eia.gov/electricity/annual/html/epa_04_05.html

US POWER SECTOR CO₂ EMISSIONS INTENSITY



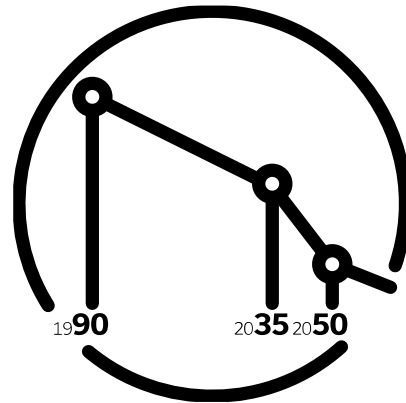
Decarbonization Plans

California



100%
Carbon-Free
ELECTRICITY BY 2045

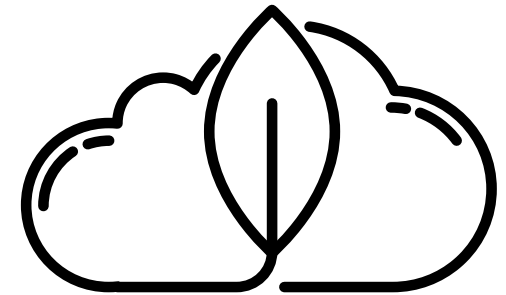
Oregon



BELOW 1990 EMISSIONS LEVELS

45% → **80%**
Carbon Reduction Carbon Reduction

Washington



100%
Carbon-Free
ELECTRICITY BY 2045
80% Carbon-Free
ELECTRICITY BY 2030

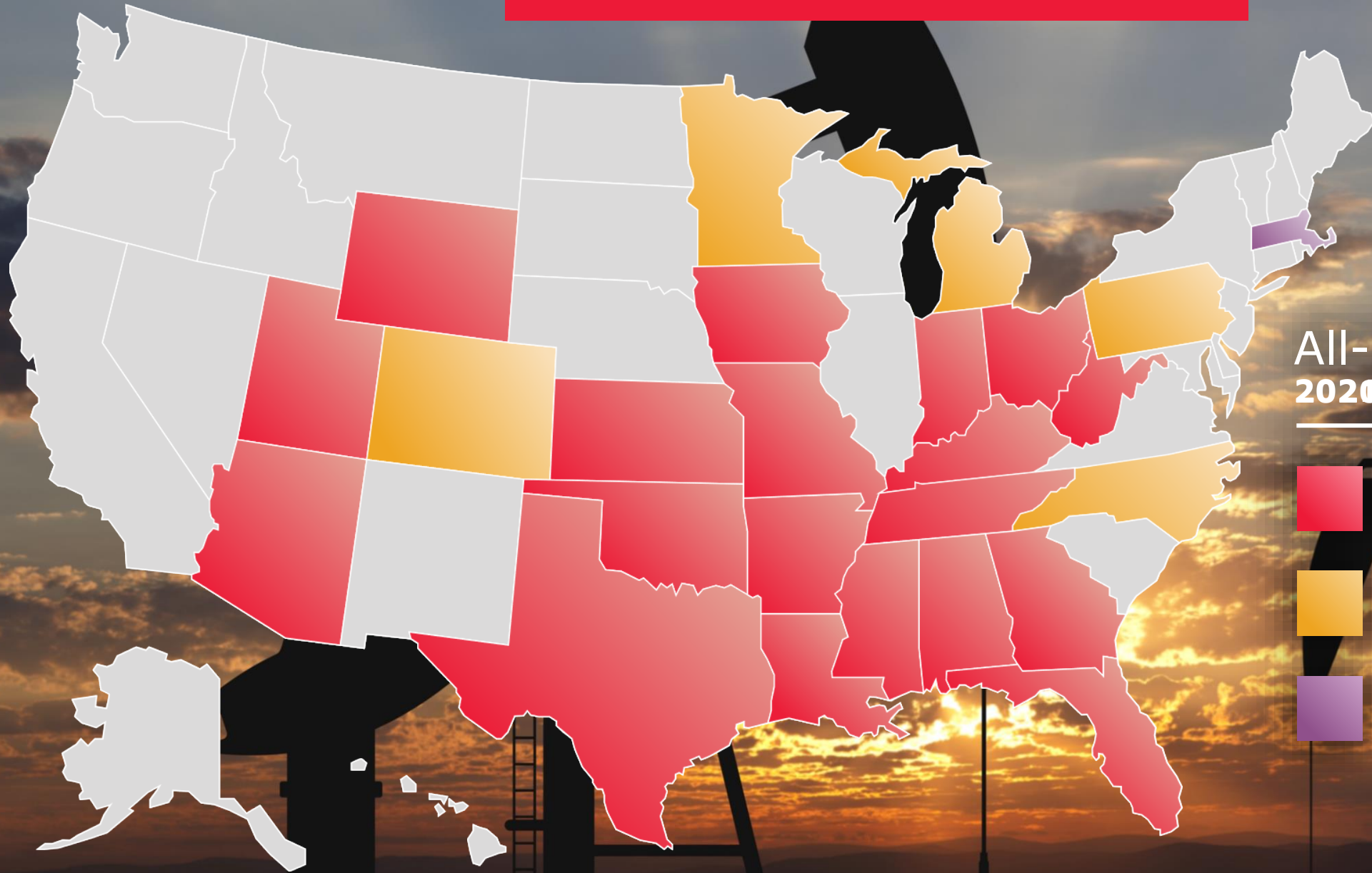
Oregon Passed House Bill 2021:

- **Commits to 100% Clean & Renewable Electricity by 2040**
- **Bans the construction or expansion of new natural gas plants in Oregon.**

Additionally:

- Provides \$50 million for community-based clean energy projects.
- Invests in the creation of good, family-wage jobs that benefit frontline communities.
- Requires good wages and benefits for workers employed on larger renewable energy projects.
- Requires tribal consultation on clean energy projects that could impact sites of archeological, traditional, cultural, and religious importance.
- Allows cities in Oregon to create so-called “green tariffs,” where they agree to pay utilities more money for power from a cleaner mix of sources in order to meet their own climate goals

REGULATION ROLLBACKS



All-Electric Bans 2020





All
Electric
at
Home

Cooking

Impact on Air Quality

Efficiency comparison

Speed, Precision and Ease of Use

Michelin Star Chefs switching to all electric kitchens



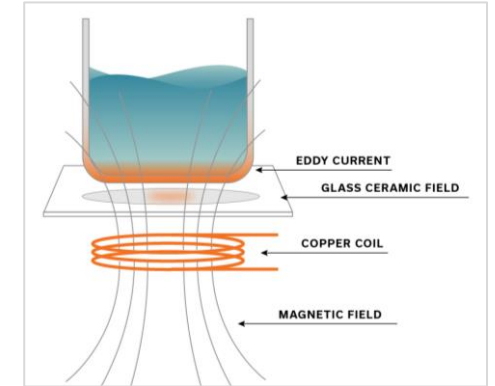
Gas Cooktop



Electric Conduction Cooktop



Electric Induction Cooktop



Gas emissions from combustion

No gas emissions from combustion

No gas emissions from combustion

~40% Efficiency

~75% Efficiency

~85% Efficiency

8 minutes to boil 0.75L water

7 minutes to boil 0.75L

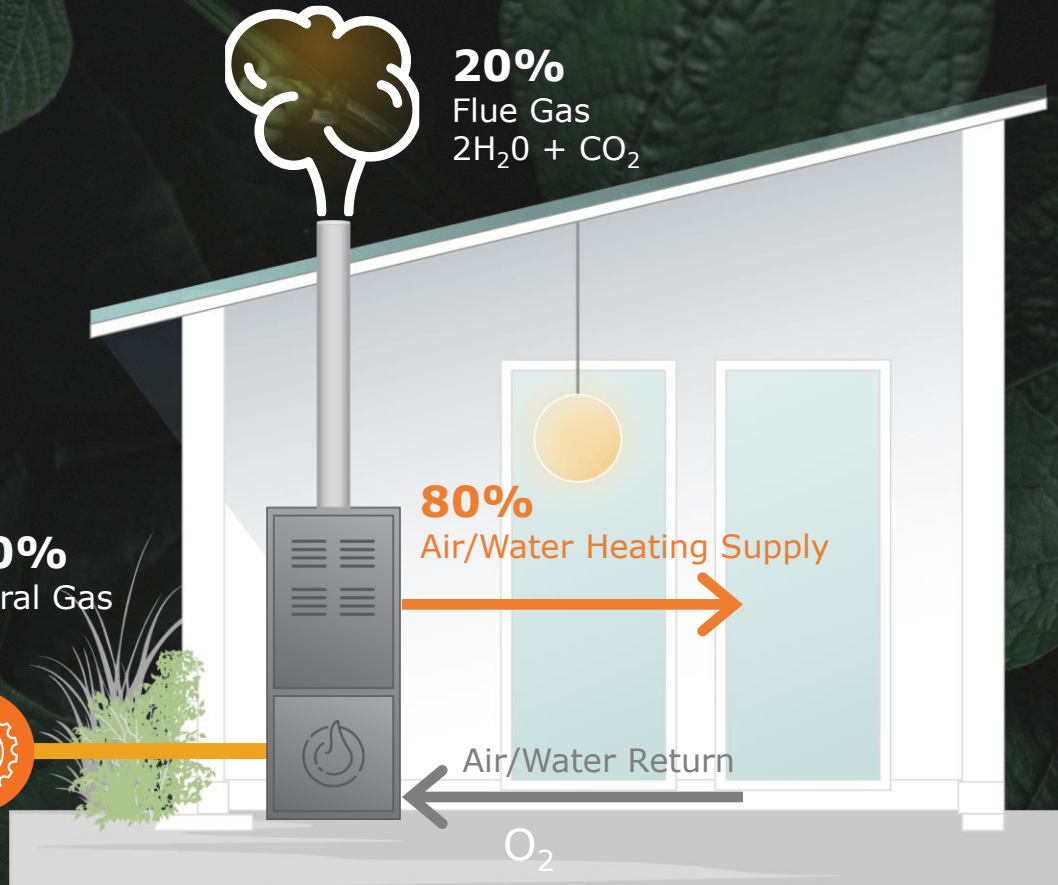
4 minutes to boil 0.75L water

HEATING FUNDAMENTALS



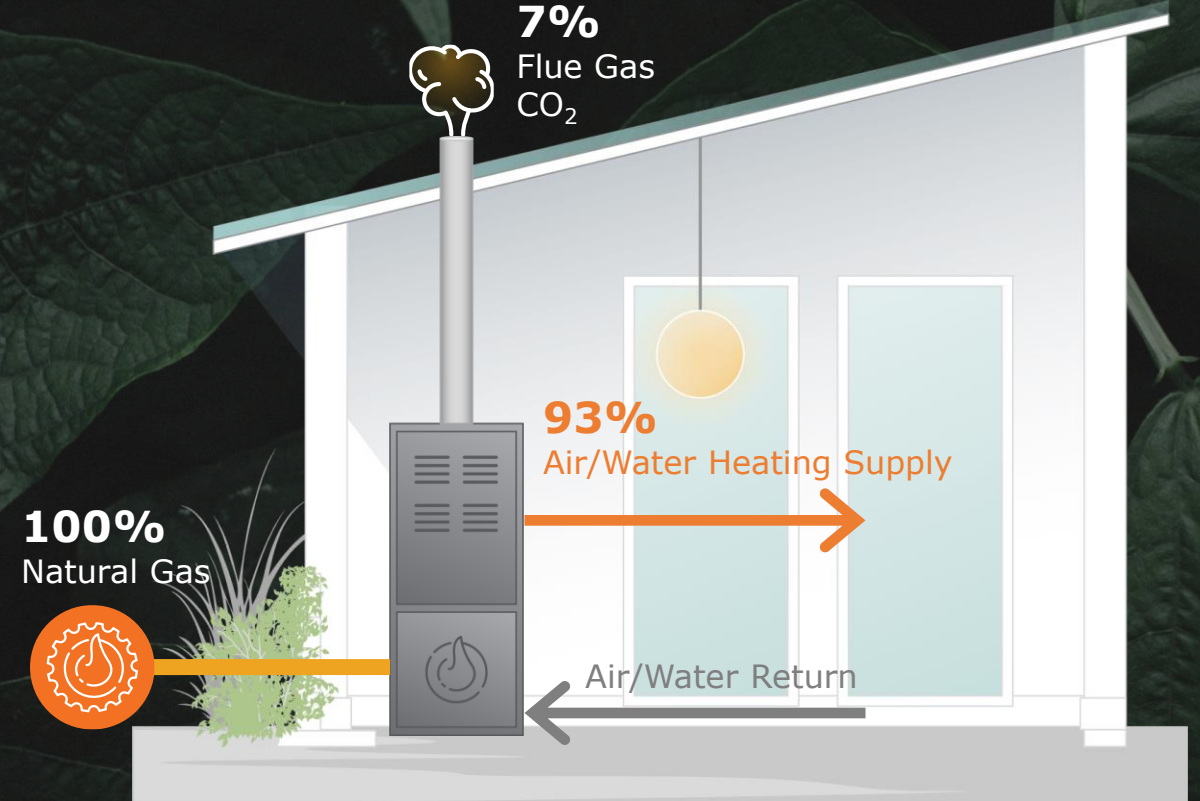
Conventional Gas Heating

BOILER | FURNACE | WATER HEATER



Condensing Gas Heating

BOILER | FURNACE | WATER HEATER

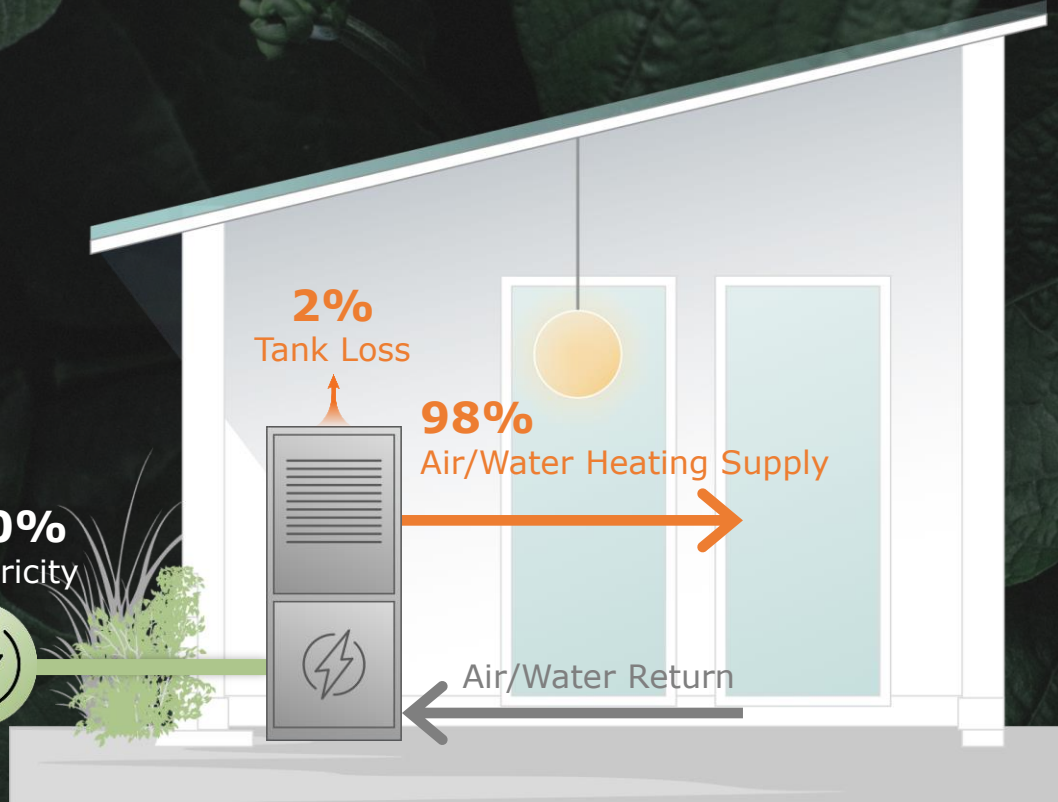


HEATING FUNDAMENTALS

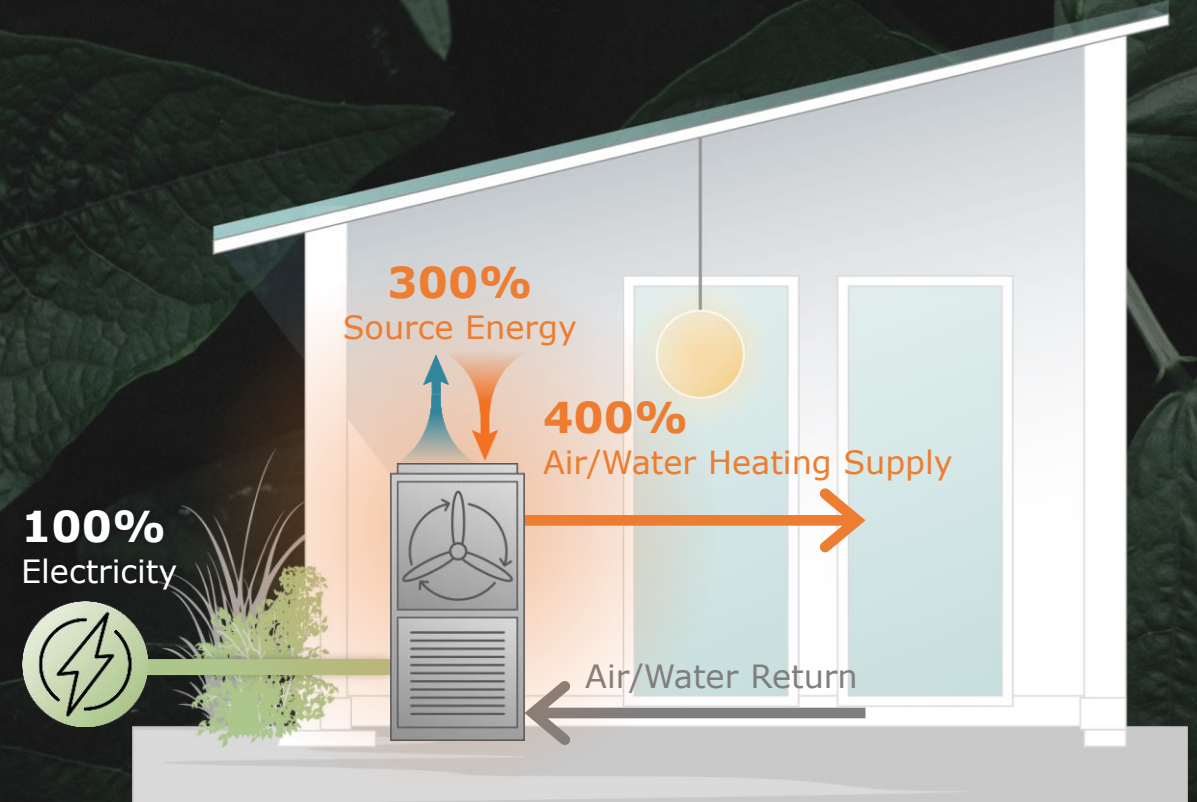


Electric Resistance

BOILER | FURNACE | WATER HEATER

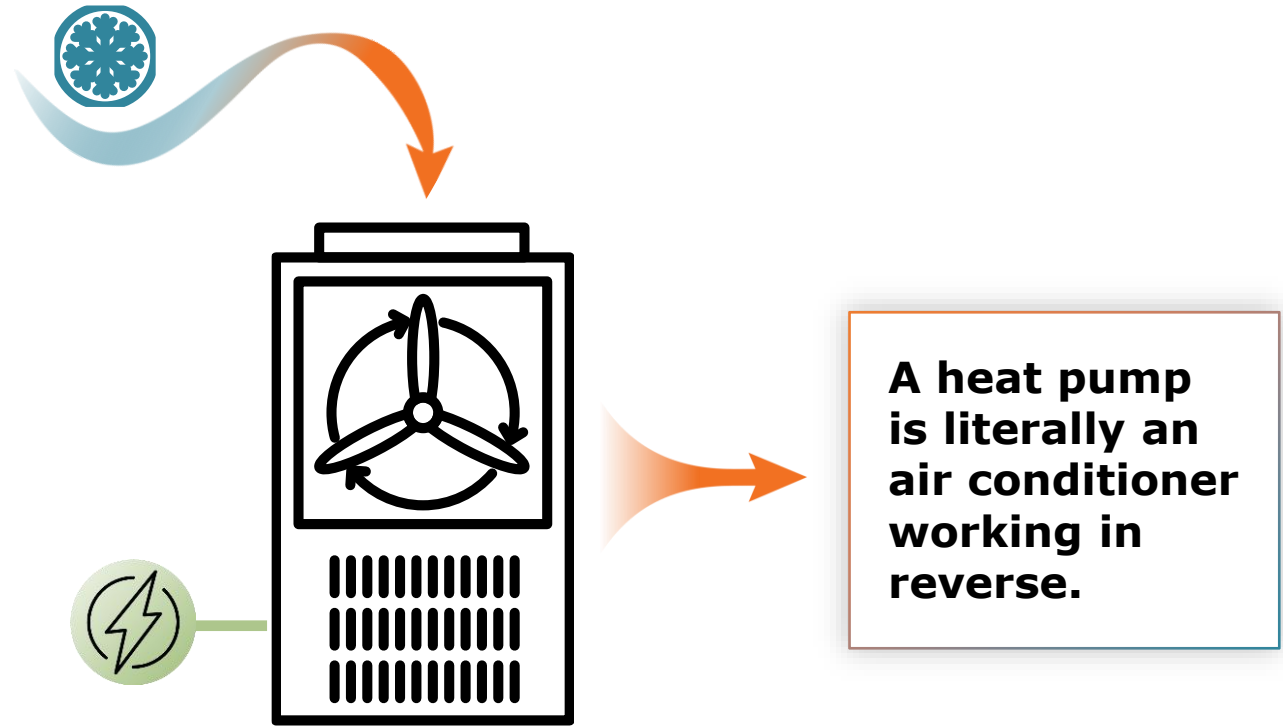


Electric Heat Pump



Heat Pump Fundamentals

Heat pumps transfer heat from a low temperature source to a higher temperature destination



Air Conditioning and Refrigeration

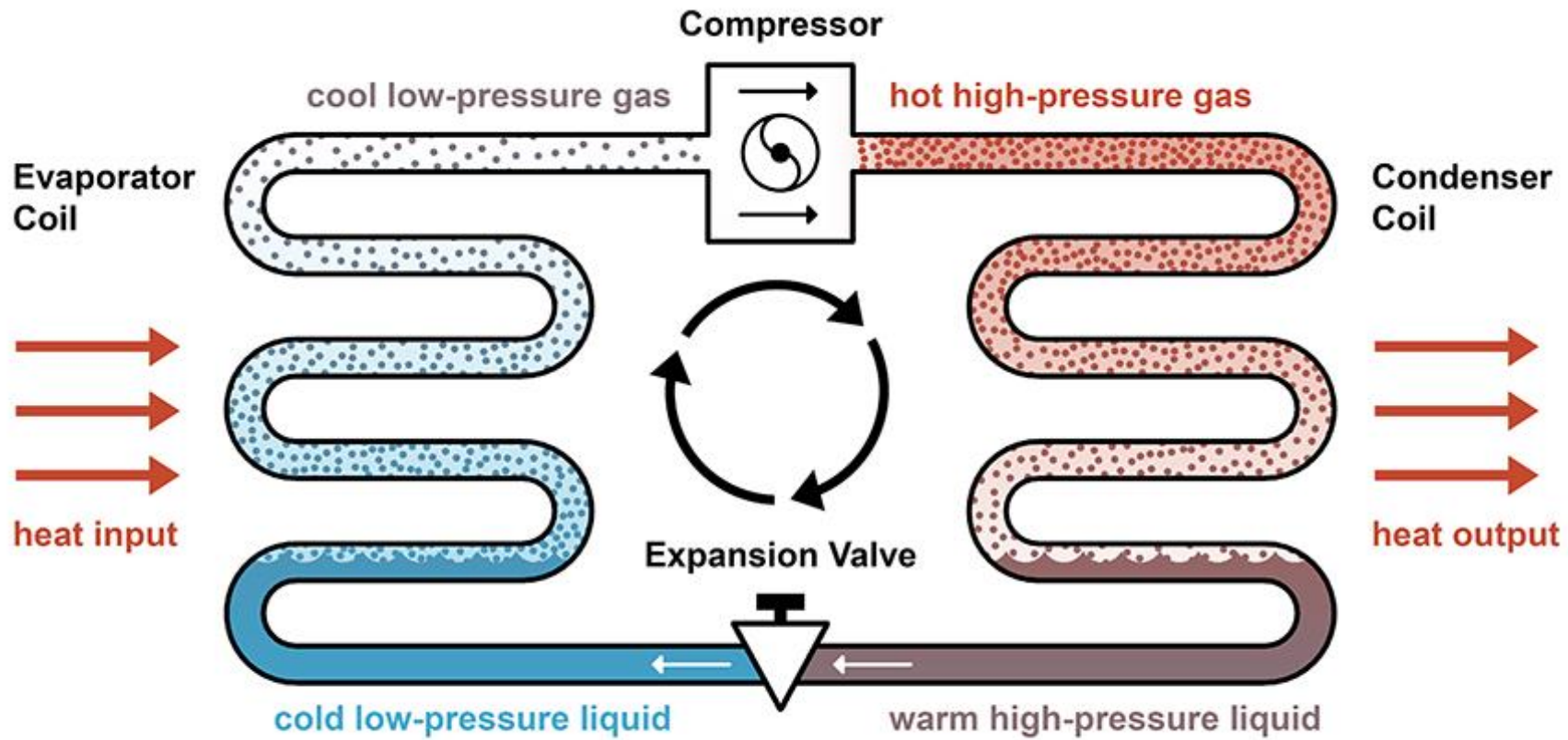
When you are trying to move heat **out of a cooler environment** to a warmer environment, we call it a refrigerator or air conditioner.



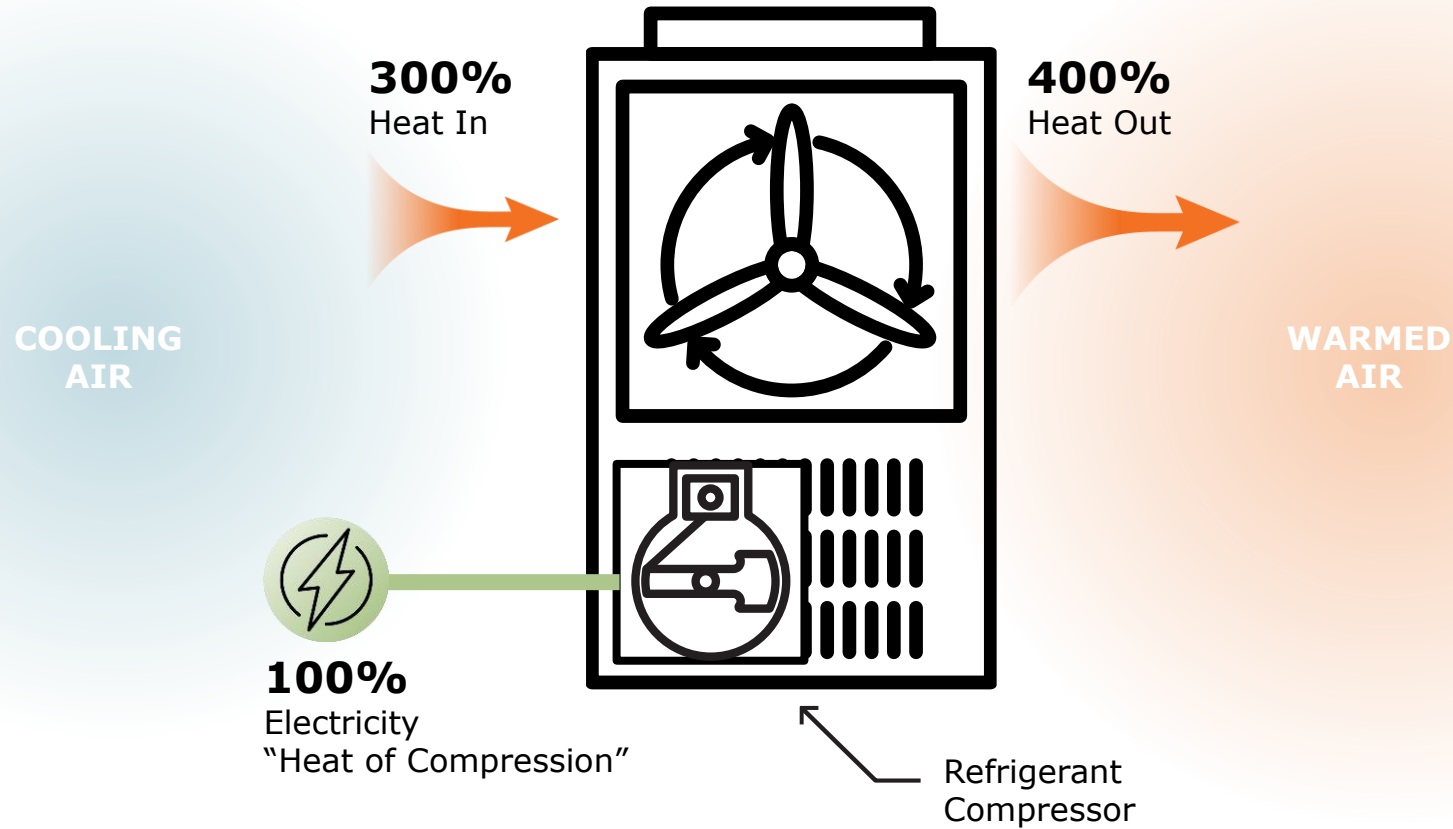
Heat Pump Heating

When you are trying to move heat **into a warmer environment** from a colder environment, we call it a heat pump.

REFRIGERATION CYCLE



HEAT PUMP EFFICIENCY



Coefficient of Performance (CoP)



HEATING EFFICIENCY
 $= 400\% / 100\% = 4$



COOLING EFFICIENCY
 $= 300\% / 100\% = 3$

Making it Pay

A photograph of a blue house with solar panels installed on its roof. The house has dark blue vertical siding and white trim around the windows and roofline. The solar panels are dark blue and rectangular, arranged in rows on the roof. A brick chimney is visible in the center of the roof. The sky is a clear, bright blue. The overall scene is bright and sunny.

- Incentives: Energy Trust of Oregon
 - Heat Pumps
 - Heat Pump Water Heaters
 - Solar
- Solar:
 - Oregon Department of Energy
 - Energy Trust
 - Federal Tax Credit

Solar Example

A photograph of a house with dark blue vertical siding and a brown shingled roof. A large array of solar panels is installed on the roof, with a brick chimney visible in the center. The sky is clear blue, and there are green trees and bushes in the background.

- 9.6kW System
 - Cost before incentives: \$36,000
 - Incentives: -\$11,000
 - Cost after incentives: \$25,000
 - Generation: \$1,100/year (\$92/month)
 - Equivalent Mortgage Value: \$20,000



“There are opportunities even in the most difficult moments.”

— **WANGARI MAATHAI**
Green Belt Movement Founder | 2004 Noble Laureate



LIVING BUILDING CHALLENGE

**A Visionary Path to a
Regenerative Future**



INTERNATIONAL
LIVING FUTURE
INSTITUTESM

CODE

GREEN

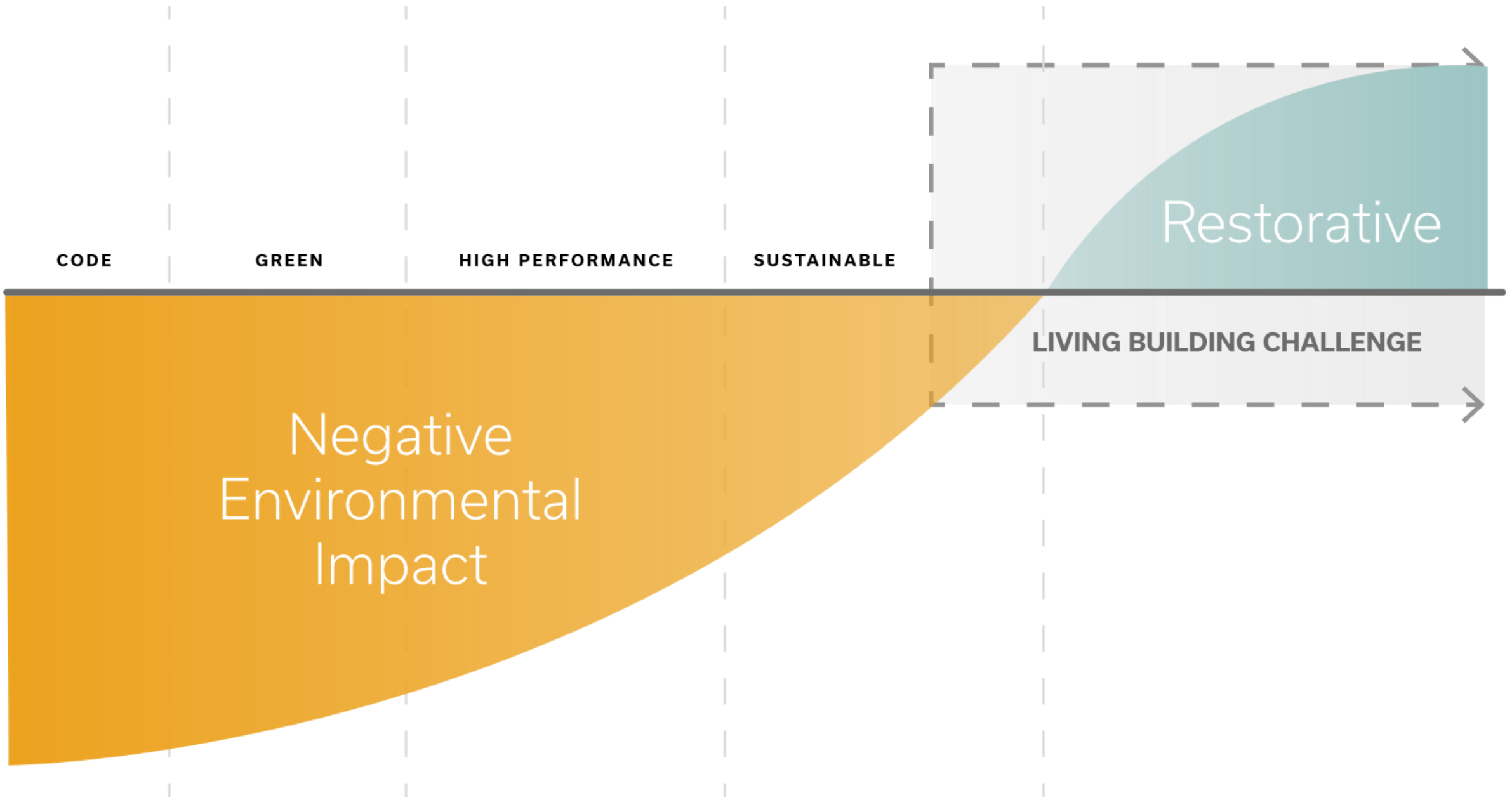
HIGH PERFORMANCE

SUSTAINABLE

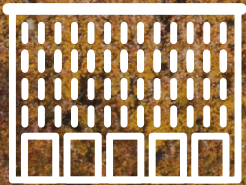
Negative
Environmental
Impact

LIVING BUILDING CHALLENGE

Restorative



PAE Living Building



STATISTICS

58,000 sf

Full ILFI 3.1 Certification

500 Year Life

Developer Driven



NET POSITIVE ENERGY

LIVING BUILDING PETAL

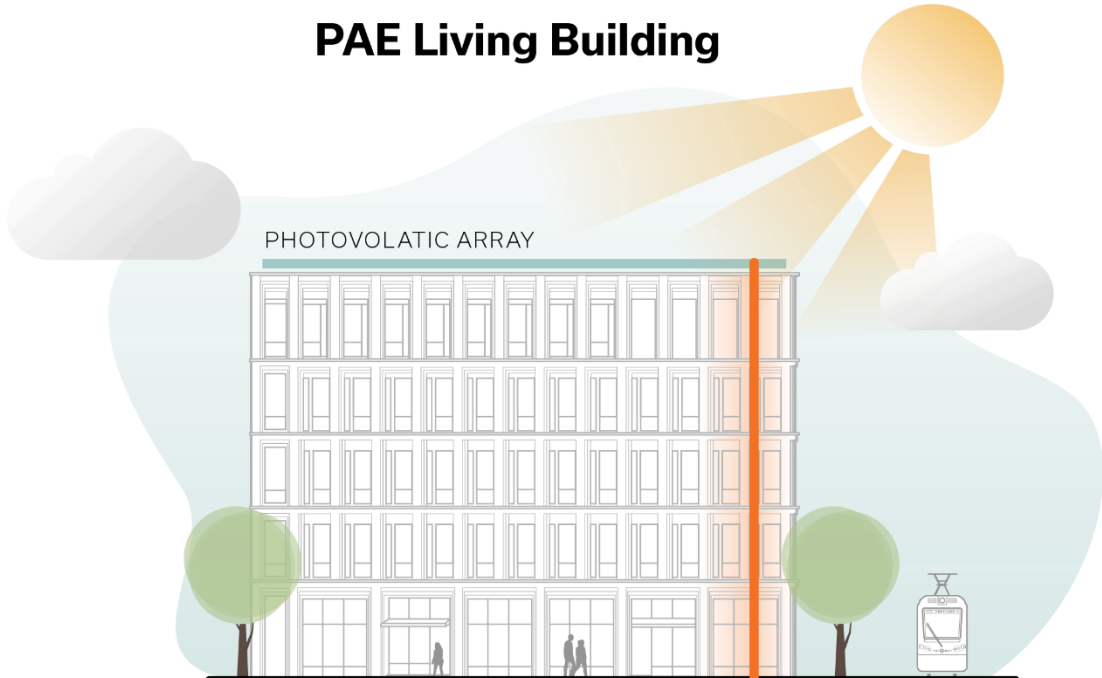
105% of building's energy use supplied by on-site renewable energy on a new annual basis.



Sustainable Communities

PAE LIVING BUILDING

PAE Living Building

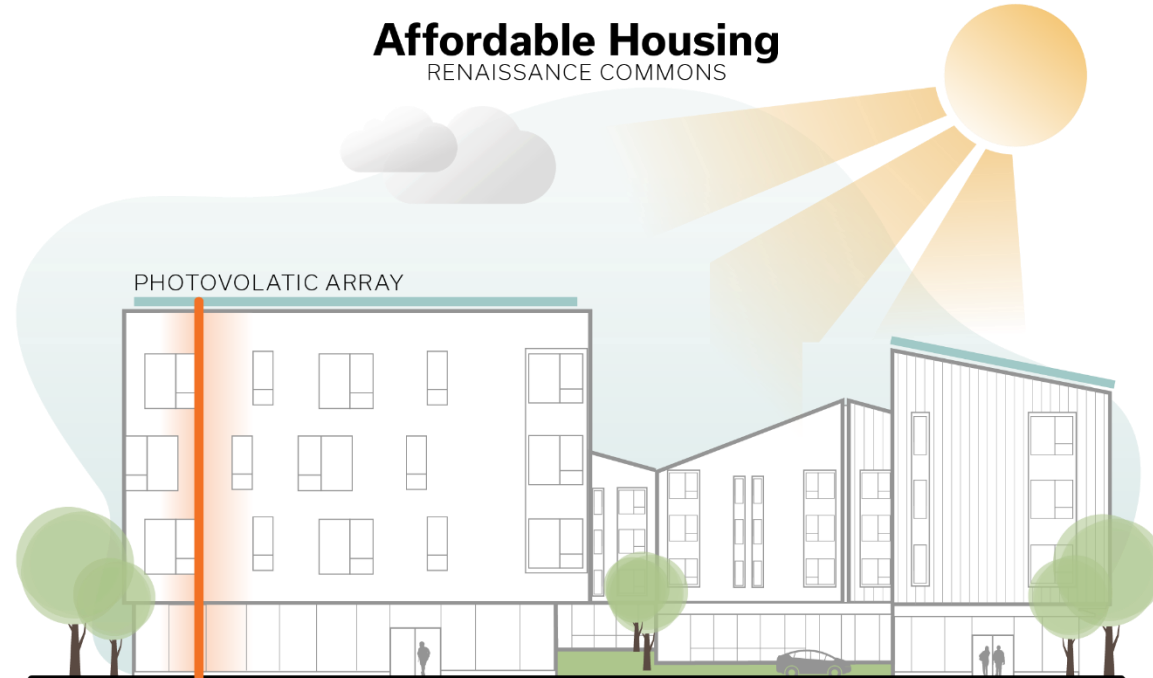


SUPPORTS



Affordable Housing

RENAISSANCE COMMONS



SUPPORTS



GRID

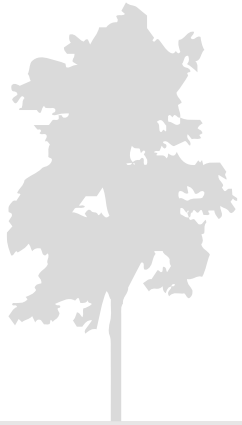


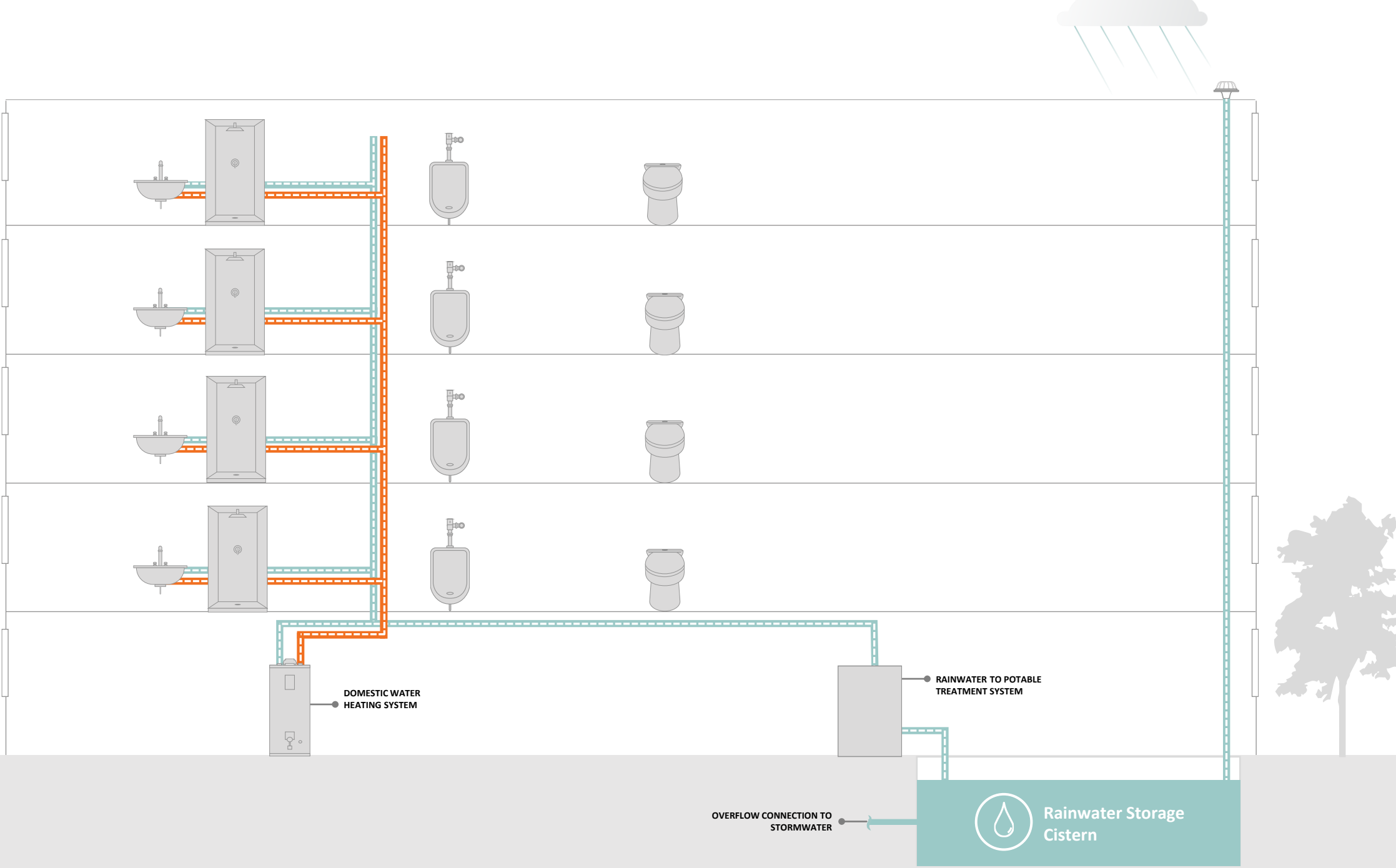
NET POSITIVE WATER
SUSTAINABLE WATER DISCHARGE
LIVING BUILDING PETAL

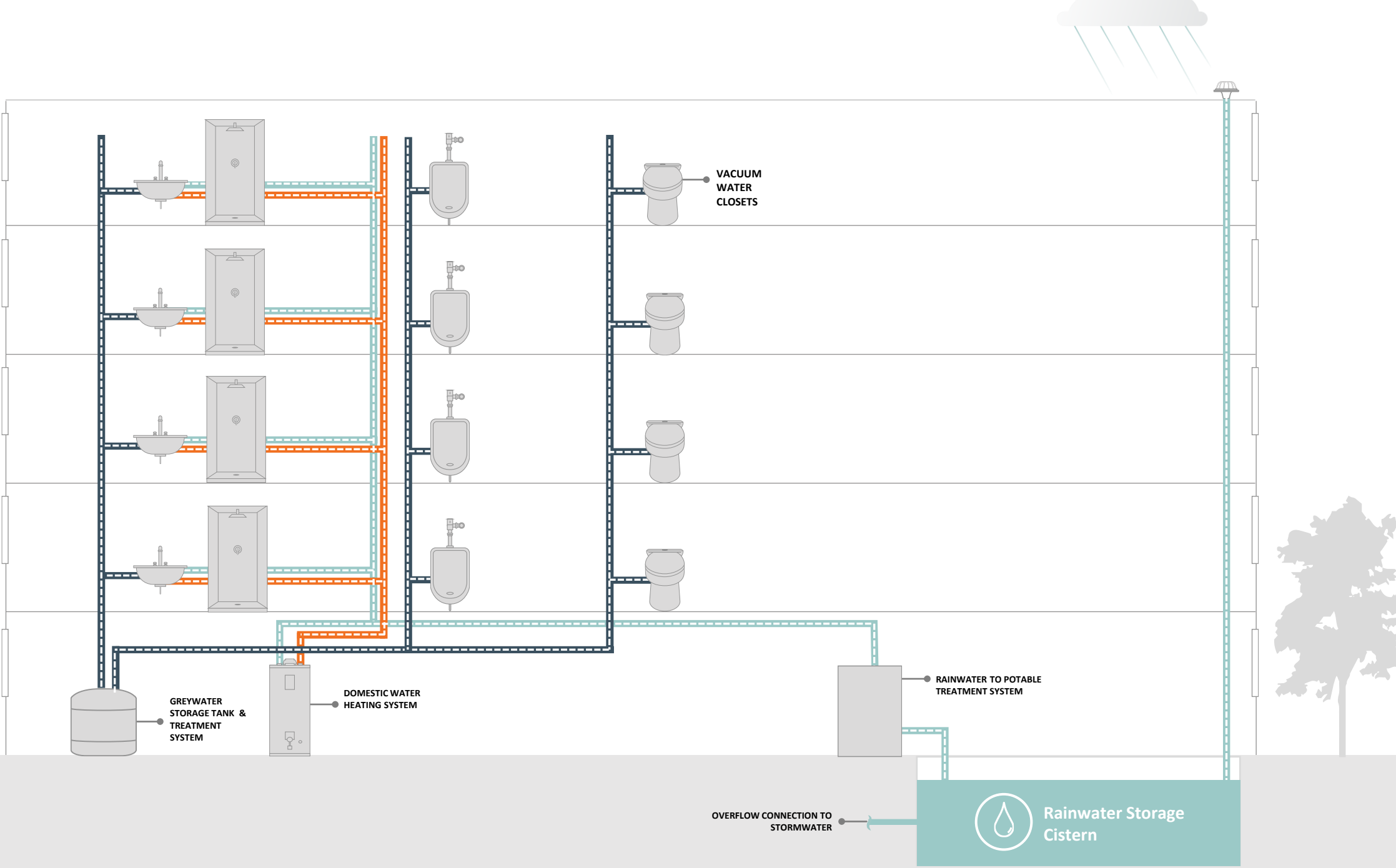
100% of water use from
captured precipitation or
closed loop water system.

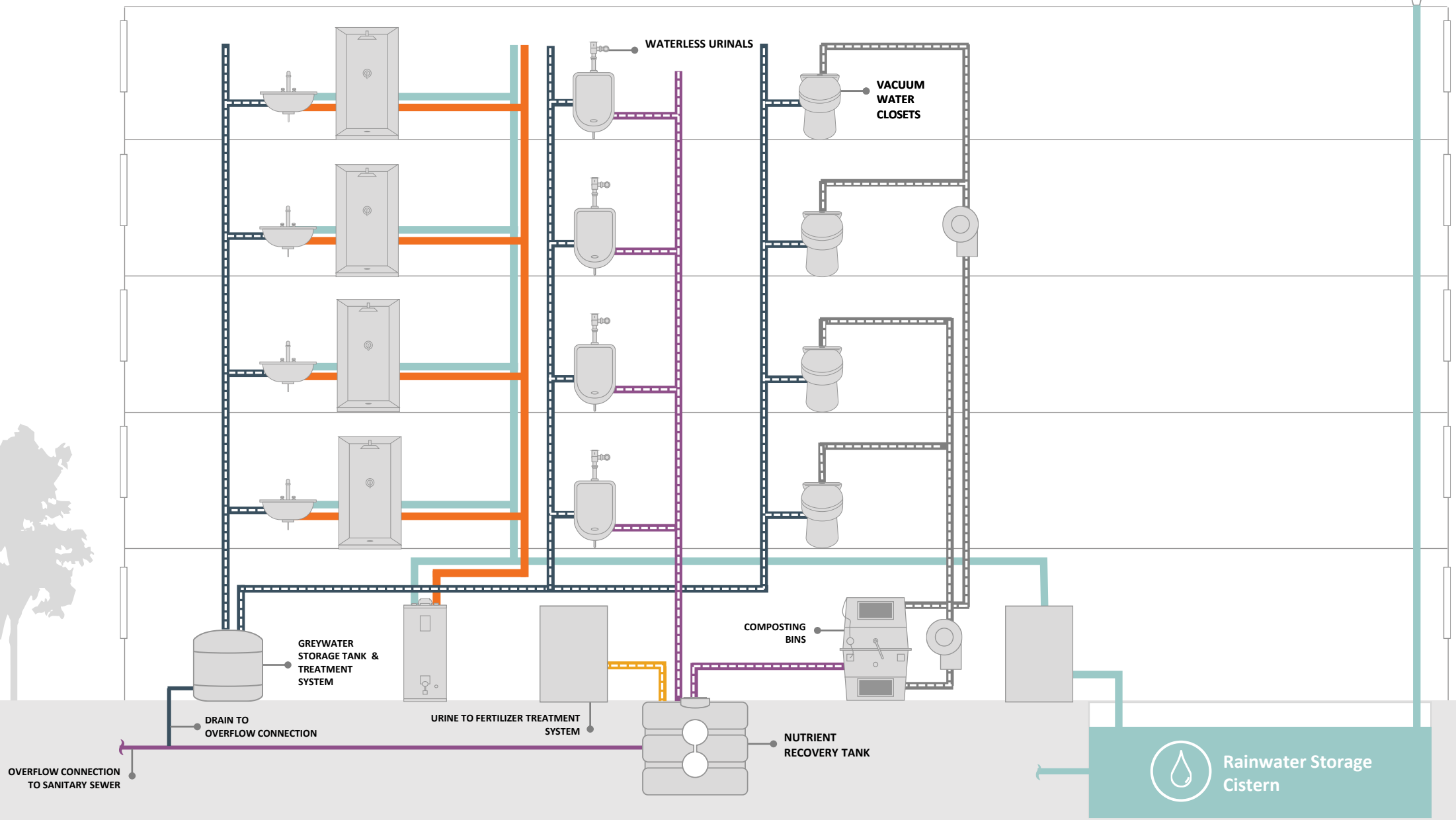


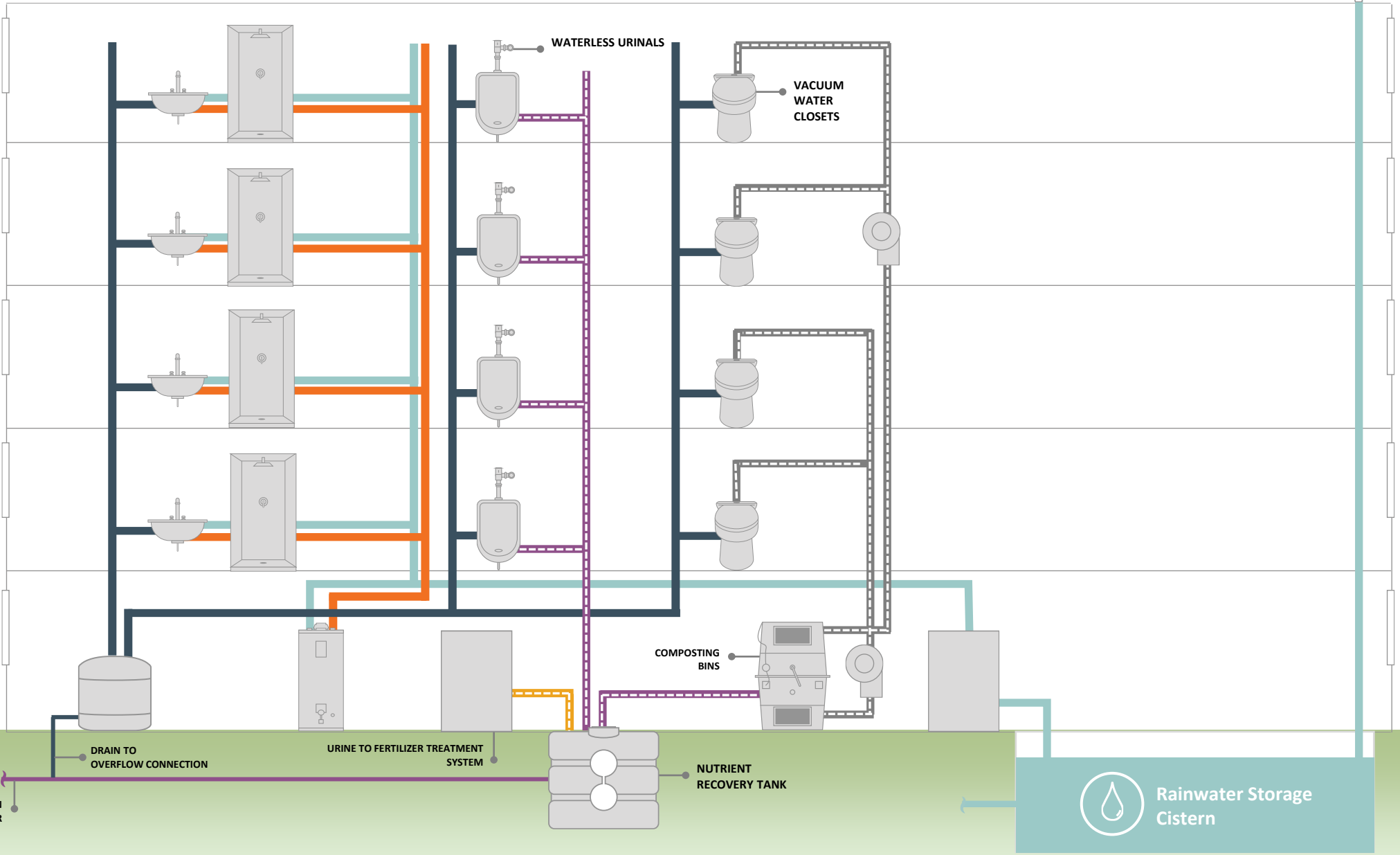
Net Positive Water











OVERFLOW CONNECTION TO SANITARY SEWER

DRAIN TO OVERFLOW CONNECTION

URINE TO FERTILIZER TREATMENT SYSTEM

NUTRIENT RECOVERY TANK

COMPOSTING BINS

VACUUM WATER CLOSETS

WATERLESS URINALS

 Rainwater Storage Cistern







LG
HYDRO KIT

LG
HYDRO KIT

LG
HYDRO KIT

CALL HEATING WATER SUPPLY









Creating a better environment

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PRINCIPAL, MECHANICAL ENGINEER
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Portland, OR 97204