CARBON DRAWDOWN

AN IMPERATIVE IN THE BUILT ENVIRONMENT

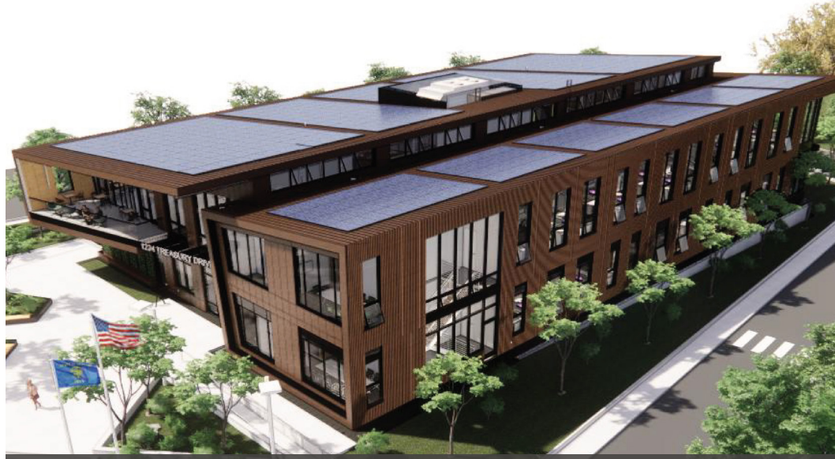
GLUMAC
A TETRA TECH COMPANY

BUILDINGS ACCOUNT FOR

58%

OF TOTAL CARBON EMISSIONS IN THE UNITED STATES

This, according to the World Resources Institute, which assesses the full carbon impact from buildings including emissions from operations, construction, material manufacturing, refrigerant leakage, and other fuel combustion. Buildings in the U.S. have a higher carbon impact than across the globe, where the average impact is around 40%.



The Oregon State Treasury Building in Salem, OR, features significant on-site solar energy generation and is designed to withstand a Cascadia 9.0 earthquake with battery storage and generator support sized for four days of independent microgrid operation. It is the first U.S. Resiliency Council Platinum certified building in Oregon and the first USRC-rated seismically isolated building in the U.S. With a design energy use 43% below Oregon Energy Code, the building will enter its International Living Future Institute Zero Energy certification performance period in 2022. | **Credit GBD**

A DRAMATIC UPSWING IN WARMING

Observed data from the last 20 years demonstrates a sustained increase in global surface temperatures, taking place at an unprecedented rate going back 2000 years. In its recent AR6 report, the IPCC demonstrates the planet has already warmed 1.09 degrees Celsius since 1900. Building designers have the power to mitigate this trend through dedication to high performance, low-carbon designs that generate or source clean, renewable power.

ipcc
INTERGOVERNMENTAL PANEL ON climate change

Human influence on warming the atmosphere, ocean, and land is an unequivocal fact. Each of the last four decades has been successively warmer than any decade that preceded it since 1850 as greenhouse gas (GHG) have continued to concentrate in the atmosphere. In 2019, atmospheric CO2 concentrations were higher than at any time in at least 2 million years.

The Intergovernmental Panel on Climate Change (IPCC) is the world's leading source assessing the science of climate change. Thousands of people from all over the world contribute to the work of the IPCC. 234 scientists from 66 countries volunteer their time to assess thousands of scientific papers published each year to provide a comprehensive summary of what is known about the drivers of climate change, its impacts and future risks, and how adaptation and mitigation can reduce those risks.

The latest Assessment Report (AR) 6 released in August, provides the most accurate modeling results ever to be produced in simulating warming trends and impacts due to human intervention. Unique to this report, is how models have demonstrated that the planet has already warmed 1.09 degree Celsius (1.9 degrees Fahrenheit) since pre-industrial times (1850-1900). Models can now differentiate between human-caused warming and natural climate cycles further validating the trends in greenhouse gas (GHG) emissions loading in the atmosphere from all industries across the globe like buildings, transportation, heavy industry, and agriculture. Because of the on-going warming, scientists are able to compare their simulations to real-time observations. Through sensitivity models, AR6 estimates a likely 3 degrees Celsius (5.4 degrees Fahrenheit) of warming with a high level of confidence range of 2.5 degrees Celsius to 4 degrees Celsius given the trends.

Changes in global surface temperature relative to 1850-1900

chart A Change in global surface temperature (decadal average) as reconstructed (1-2000) and **observed** (1850-2020)

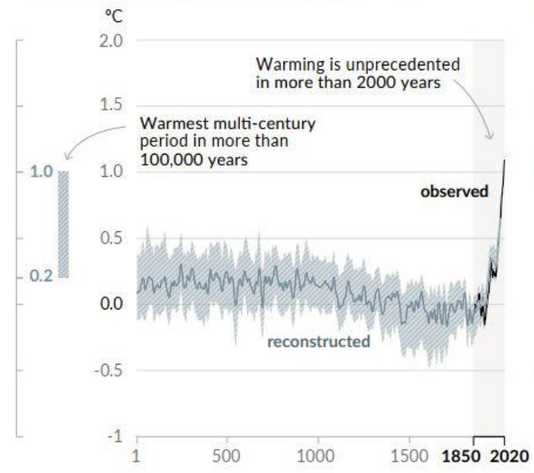
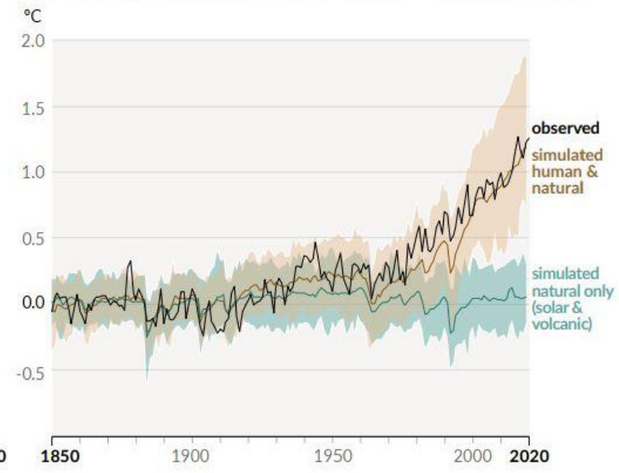


chart B Change in global surface temperature (annual average) as **observed** and simulated using human & natural and only natural factors (both 1850-2020)



As shown in IPCC AR6, Chart A demonstrates that the planet has already warmed 1.09 degree C (1.9 degrees F) since 1850 when temperature monitoring began, and Chart B gives a close-up view since that time, and demonstrates how the observed temperature rise trends with simulated climate models and the increase is mainly caused by humans and not a result of natural cycles, as once believed.

MEYER MEMORIAL TRUST

In Portland, Oregon, our MEP, energy, sustainability, and commissioning teams worked with LEVER Architecture, Project^, O'Neill/Walsh Community Builders on Meyer Memorial Trust's new headquarters - Oregon's first LEED NC v4 Platinum building. Designed to use 50% less energy than Oregon Energy Code, this all-electric building receives clean renewable energy from an on-site 53kW solar array. A digital dashboard shows building energy use and solar production in real time. The HQ is one of the first structures in the US to be constructed with mass plywood panels, beams, and columns which were produced locally by Freres Lumber in Lyons, Oregon. Designed with the occupants in mind, the building serves as a community meeting space. The project received $93,270 from the Energy Trust of Oregon Path to Net Zero program, and has received the 2021 USGBC Leadership Award and the 2020 Forest Stewardship Council Leadership Award and has been acclaimed widely by Fast Company, Architecture Record, and Metropolis Magazine.

PHOTO CREDIT: JOEL B. SANDERS

With the observed and modeled warming trends, AR6 lays out a suite of five future climate scenarios for policymakers to review. The scenarios show temperature and climate trends geographies can expect. Generally, with warming temperatures, drier climates will continue to get drier and wetter climates, wetter. Weather patterns will increasingly become more unpredictable and extreme in seasonal heat and rainfall, and in most locations, we can expect less snowpack storage to feed summer water supplies. The biggest risk to the economy is that industry was built on a climate of the past and not the changing climate of today and the trends of tomorrow. And this growing instability brings economic and human hardship that is happening in real time, and society struggles to adapt.

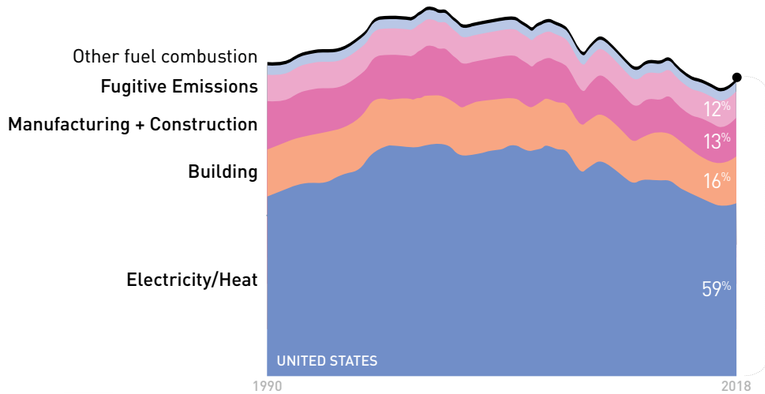
We have all felt the economic and social trickledown effects of extreme weather events that seem to be happening more frequently. Heatwaves, wildfire, drought, flooding, and winter storms have become a seasonal norm over the last 5 years. The disruption it causes to commerce, community, and families and the financial and human loss is felt locally and globally. Add a global pandemic, and it really feels like humanity is reaching a tipping point.

Although tipping points can create disruption and chaos, uncertainty and risk, the challenges offer renewed opportunity for swift and meaningful change. What AR6 presents in the climate science, is that we have an open opportunity to do more and be better. The question is how much better are we willing to become and how fast?

The IPCC AR6 shows that the planet can only absorb so much GHG loading; it has what is called a carrying capacity. And through continued development, we are eating up that GHG budget fast, and as we consume it, we tax the planet's ability to further absorb GHG's, so they end up lingering in the atmosphere trapping heat and causing the general warming trends the science has demonstrated. The extent of GHG build-up will ultimately determine how much the planet warms. The global scientific community has agreed that our cap is 1.5 degrees Celsius (2.7 degrees Fahrenheit), that's only a 0.4-degree Celsius more than the warming that's already occurred. 1.5 degrees Celsius is the cap that minimizes economic and social disruption, enabling communities, commerce and governments the time and ability to adequately adapt to changing climate conditions. And given the speed we are using up the GHG budget and the physics of climate change, the IPCC has set 2050 as the target date to transition markets to a low carbon economy.

A BREAKDOWN OF BUILDING-ASSOCIATED CARBON EMISSIONS

chart 2



3.51 Gt
-13%

The US building industry has reduced carbon output 13% since 1990, a far cry from what's needed to stop climate change.

World Resources Institute. Online at: wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters

> The incredible minds within the building industry know the design strategies that deliver cost-effective, high performance buildings operating on clean renewable power. Education and advocacy will get us there, improving each building, and establishing precedent for government, finance, and utilities to align their work in support of this market transformation.

CLIFFORD L. ALLENBY BUILDING | CONNIE ZHOU

NEW NATURAL RESOURCES AGENCY HEADQUARTERS | AC MARTIN

CALIFORNIA STATE CAPITOL | ADOBE STOCK

CLIMATE EXPERTS BELIEVE
1.5°c
REDUCTION IS NO LONGER REALISTIC

GHG'S WOULD NEED TO REDUCE
15%
PER YEAR, EVERY YEAR FOR US TO GET THERE BY 2050

CALIFORNIA STATE DEPARTMENT OF GENERAL SERVICES NET ZERO URBAN COMPLEX

In a large consolidation and expansion effort, the CA State DGS has added two large net zero energy and LEED Platinum assets to its portfolio - The Clifford L. Allenby building and the New Natural Resources HQ's. Both buildings beat the stringent Title 24 energy code by over 15% and to minimize gas use from central plant heating, heat recovery chillers were installed on the return hot water line from the Allenby building. In DGS's latest project with Glumac, The CA State Capitol will receive a new 500,000-sf all-electric annex. Off-site solar from the Sacramento Municipal Utility District will cover the annual energy use for all three buildings.

FIRST UNITED BANK OF FREDRICKSBURG

Mass timber design represents a significant opportunity to lower the carbon emissions of building construction and operation. **Properly sourced timber design elements can significantly reduce the embodied carbon** count of a building project and contribute to healthier spaces.

IMAGE CREDIT: CREDIT RYAN CONWAY

The misnomer is that we have 30 years to do something. More accurately, we have little time to act. Leading climate experts believe the 1.5 degree limit is no longer realistic. Greenhouse gases (GHG's) would need to reduce by 15% per year, every year, to get there by 2050. In almost all emissions scenarios in AR6, global warming is expected to hit 1.5 degrees Celsius in the early 2030s, without drastic changes, and limiting warming to at most 2 degrees Celsius now seems, at least, plausible.

Across all industries, buildings and automobiles have the biggest shot at minimizing climate change. We have the ability to make better decisions now, and change more quickly, because the technological solutions are readily available. By comparison, other industries, like aviation, will need more time to perfect low GHG fuels or electrify planes.

We are indeed being presented with the greatest business opportunity ever. According to the World Resources Institute, the building industry in the United States accounts for 58% of total GHG emissions. Our industry is half the problem!

And...half the solution!

Our charge, quite simply, is to drawdown carbon in a big way. Carbon is a proxy metric that represents a potpourri of greenhouse gases (GHG's). And, the most significant are Carbon Dioxide (CO2), Nitrous Oxide (NO2), Fluorenes (refrigerants), and Methane (CH4).

Here is where these gases exist in the construction and operation of buildings:

1. **Carbon Dioxide (CO_2):** Emits from burning fossil fuels (natural gas, propane, diesel) and certain chemical reaction (e.g., manufacture of cement). CO_2 is removed from the atmosphere (or sequestered) when it is absorbed by plants as part of the biological carbon cycle.
2. **Nitrous Oxide (N_20):** Emits from the combustion of fossil fuels.
3. **Flouridated Gases:** Are powerful gases used in refrigerants and have a high Global Warming Potential.
4. **Methane (CH_4):** Emits during the production and transport of fossil fuels, and decay of organic waste in landfills.

Carbon emissions from building operations is captured under what's called Scope 1 emissions. This mainly includes gas combustion emissions from heating and hot water systems as well as fugitive emissions from refrigerant leakage in cooling systems, kitchen, and specialty equipment. Emissions released from the generation and transmission of electricity and natural gas is captured under Scope 2 emissions. Scope 1 and 2 emissions are often mitigated first. Scope 3 emissions include everything else like building construction and the carbon released during the

manufacturing of construction materials (called embodied carbon). Drawing down emissions across these three scopes is what's captured in the work of building decarbonization.

Most of the decarbonization work is being done under Scope 1 and 2 emissions. According to the Rocky Mountain Institute and summaries from the IPCC 2018 Special Report, to be 1.5 degree Celsius aligned, new buildings and major renovations need to be constructed to zero or near-zero energy and carbon standards now while existing buildings undergo retrofits. New buildings need to surpass code and perform to zero standards to give time for the aged existing building stock to modernize. To put this in perspective, there are 110 million buildings in the U.S. and 70 million burn fossil fuels. Retrofitting 4 million buildings a year in the U.S. alone will enable us to cut operating emissions by 50% by 2030 and 100% by 2050. There is major work to be done, and this poses an incredible business opportunity.

Zero standards mean deep reductions in carbon emissions. The good news is that the solutions are market ready and deployable. Our sustainable design philosophy at Glumac has always been to guide our clients toward high performance building solutions and this philosophy has never been more important. For example, we promote tight envelope designs, efficient glazing, and natural ventilation and daylight. We actively partner with manufacturers and vendors that provide efficient MEP equipment, saving energy and water and offering long term financial savings to our clients. We promote smart water use and building recycled water systems, which also save pump energy at the municipal scale. And, we promote the use of renewable energy systems like solar, wind, and geothermal from on-site and off-site locations.

These practices represent the best in sustainable design as we progress toward zero net energy and water efficient buildings. Zero net energy buildings generate as much clean renewable power on-site as they use annually, and these building types are the model for modern design moving forward. To ramp up our efforts, we need to propose on-site renewable energy solutions for all feasible projects. This means coordinating with the architect to orient and slope the roof to maximize generation, clearing roof space to maximize energy generation area, and helping the contractor price options. Our goal is create buildings that move beyond zero, generating more clean renewable power than they consume and realize, what is often described, as net positive performance.

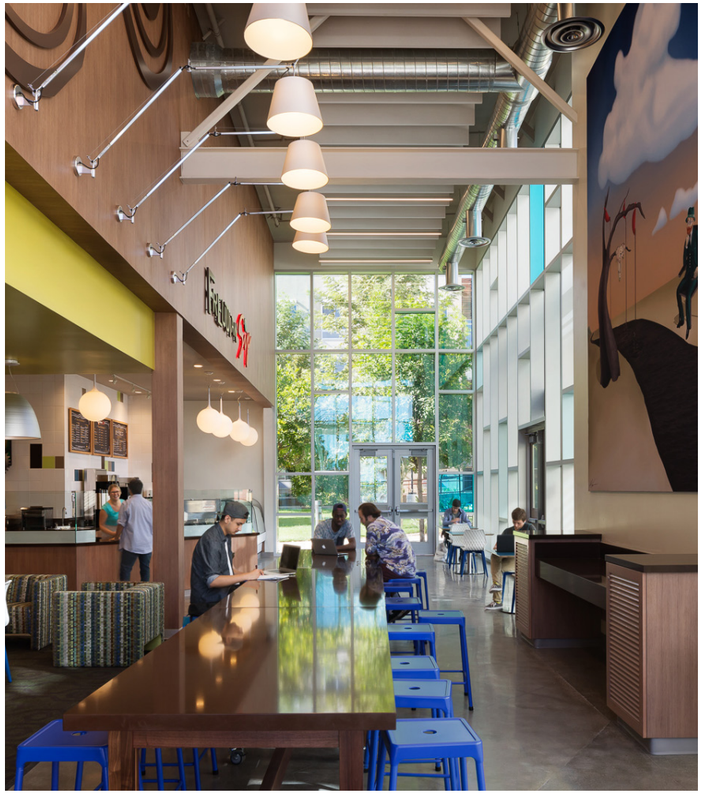
Zero net energy buildings are setting amazing precedent in the marketplace, but to align with the IPCC 1.5 degree Celsius charge, these and all buildings must also zero operational carbon emissions by avoiding natural gas to the greatest extant practical. As companies and owners investigate this option, carbon offsets can be purchased to offset on-going gas use and achieve what's coined "carbon neutrality," an interim solution in our industry's transition away from fossil fuels.

As the climate science strengthens, off-setting carbon emissions is losing credibility and is increasingly viewed as a band-aid solution. Business and government is feeling the pressure and avoiding gas use in many places is no longer a far-fetched idea. Many municipalities in California and other places have enacted gas moratoriums and electrification ordinances. Even gas-loving appliances are going electric. The electric range is making a comeback and induction cooking is growing in popularity because of healthier indoor air quality and advanced cooking precision. Fossil fuels are still important for back-up power needs, but for heating and hot water, we should be promoting radiant and heat pump technologies and heat recovery strategies wherever practical.

It is the building industry's promotion of electric systems and capital investment to modernize and clean the grid that will propel us forward at a pace necessary to align with the IPCC AR6 1.5 degree Celsius limit by 2050.

Switching to electric systems can have impacts on electrical service, but we can overcome these challenges through good utility partnerships and smart grid energy use. Grid interactive building technologies direct energy use (and on-site battery storage) based on utility signals such as peak use times and demand charges. We can even direct our buildings to use (and store) more energy when the grid is cleaner (meaning more power is sourced from renewables and hydro, for example).

Electrifying buildings will greatly accelerate the modernization of the electric grid. A more stable, reliable, and smart grid (meaning it can communicate between power sources and infrastructure to modulate supply and demand) is long overdue. And, this transformation brings the acceleration of clean, renewable power supplies and a departure from fossil fuels like oil, coal and natural gas. In fact, investments in renewable



CALIFORNIA STATE UNIVERSITY SYSTEM-WIDE DECARBONIZATION

Our decades-long partnership with the California State University system continues as we partner with them to chart their pathway toward an ambition Zero Carbon goal by 2030. Glumac Energy Analysis and Building Sciences groups are working hand in hand with CSU to provide systems recommendations and design approaches to reduce operational carbon and greenhouse gas emissions from their buildings - including a significant **electrification of facility systems**, energy production from **solar photovoltaics**, a reliance on LED lighting, and a transition to **zero emission vehicles**.

IMAGE CREDIT: RYAN GOBUTY, LAWRENCE ANDERSON, CSU LONG BEACH

ONE BEVERLY HILLS

One Beverly Hills will be one of the most climate forward, healthy, and sustainable luxury developments in the world. Working along with **Tetra Tech's High Performance Buildings Group**, our sustainability and energy team established energy, carbon, water, waste, and health benchmarks for the project. We are working with our engineers to implement all-electric, site-wide solutions to realize zero operational carbon emissions. Strategies include a central geothermal energy plant, solar PV, battery and thermal energy storage, induction cooking for all residential units, and we are going further by specifying low carbon refrigerants in cooling systems, proposing low carbon concrete structural solutions, and designing EV infrastructure throughout the underground parking garage. Our plumbing team designed a central rain and greywater recycling system that will supply 100% of the irrigation for the site's 8-acre botanical garden and building integrated landscaping. The project is targeting LEED Platinum and WELL certification and is scheduled to be complete in 2026.

RENDERING CREDIT: ONE BEVERLY HILLS

> Engineers are in the best position to create a clean, healthy future today through low carbon designs, building commissioning, and measuring the on-going performance of our buildings.

energy industries is now far outpacing that of fossil fuel. It is the building industry's promotion of electric systems and capital investment to modernize and clean the grid that will propel us forward at a pace necessary to align with the IPCC AR6 1.5 degree Celsius limit by 2050.

As we work to decarbonize buildings, there is new awareness of other lesser known, but equally important sources of carbon emissions. Heating and cooling accounts for 59% of carbon emissions in the U.S. building stock while the other 41% (shown in Chart 2) comes from building construction, material manufacturing, fugitive emissions such as refrigerant leakage, and other fuel combustion sources.

To this end, Glumac is actively working in two areas: low GHG building materials and alternative refrigerants. We currently have active contracts to model the embodied carbon in structural concrete, steel and mass timber designs and recommend lower GHG material, procurement, or construction practice alternatives. We are also investigating lower GHG refrigerants, particularly where refrigerant loads are high like in central plants and building VRF systems. For one of our central utility plant projects, we are investigating the use of R514 or R1233zd as the alternative to the more conventional R134a. Refrigerants are captured under a very potent GHG group called Fluorines, and even a small amount of refrigerant leakage can add to building emissions over time. The EPA has taken notice with the latest rule to phase down HFC refrigerants, like the commonly used R410A, over the next 15 years.

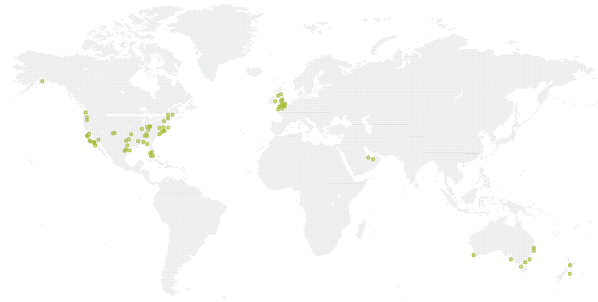
In summary, this is all to say, that the latest IPCC report has created quite a splash across the world. Avoiding climate change is now a very real risk to business, reputation and branding and many companies have publicly disclosed their commitment to take action. Tetra Tech, for example, has publicly committed to carbon reduction goals under the Science Based Targets platform, is tracking its progress in corporate annual reporting, and submitting carbon disclosures where required to conduct business, **like this one for the UK**. In 2021, the company announced its goal to become Carbon Negative and Climate Positive by 2030.

Hundreds of companies, many of which we do business with, have also committed to set targets based on science to limit global warming to 2 degrees Celsius or less.

As the building sector accounts for over half the GHG emissions in the U.S., engineers are in the best position to create a clean, healthy future today through low carbon designs, building commissioning, and measuring the on-going performance of our buildings. Our clients are reading the IPCC climate reports and summaries and are scared. They are struggling to develop a sound financial pathway to take action and we need to be there to help them. Let's actively listen, identify with their struggles, and present future-forward solutions today. G

NICOLE ISLE is Glumac's Chief Sustainability Strategist. Reach out to learn more at nisle@glumac.com.

BUILDING TOWARD A RESILIENT FUTURE THROUGH SUSTAINABLE DESIGN



Glumac is **a Tetra Tech Company, working within its High Performance Buildings Group**. Tetra Tech's High Performance Building group brings the expertise of 2,000 building designers and commissioners from across four continents, delivering cutting edge technical approaches to some of the most sustainable building projects across the globe.

TETRA TECH
High Performance Buildings Group

SOURCES

IPPC Sixth Assessment Report:
ipcc.ch/assessment-report/ar6/

Climate Brief
carbonbrief.org/in-depth-qa-the-ipccs-sixth-assessment-report-on-climate-science

Rocky Mountain Institute
rmi.org

IPPC 2018 Special Report
ipcc.ch/sr15/

Building Decarbonization Coalition
buildingdecarb.org/active-code-efforts.html

Bloomberg
bloomberg.com/news/articles/2021-07-06/private-equity-is-ditching-fossil-fuels-over-climate-change-concerns

Climate Analytics
climateanalytics.org/publications/2017/ten-key-short-term-sectoral-benchmarks-to-limit-warming-to-15c

EPA
epa.gov/climate-hfcs-reduction

Science Based Targets
sciencebasedtargets.org/companies-taking-action#table

World Resources Institute
wri.org/insights/interactive-chart-shows-changes-worlds-top-10-emitters

Tetra Tech UK Carbon Report
tetratecheurope.com/wp-content/uploads/2021/08/PPN_0621_Carbon_Reduction_Plans_Sept21-webFINAL.pdf

glumac.com