HUNTSMAN
BUILDING SOLUTIONS

Earth Warming & the Built Environment:

Pivotal Role of Energy Conservation and High-Performance Insulation in the Decarbonization of Buildings

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I. INTRODUCTION

With numerous sources of data indicating a continually warming planet, and key indicators and scientific conclusions from that data directly linking that warming to human-induced actions, technologies and destruction of eco-systems, there is no longer any doubt that climate change is real, it is occurring at an alarming rate and that many believe is being instigated through human actions.

Most climate scientists the world over agree that the main cause of the current global warming trend is human expansion of the greenhouse effect, or the warming that occurs when the atmosphere traps heat radiating from Earth toward space. In fact, anthropogenic greenhouse emissions, or emissions originating from human activity, have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.[i]

The warming of the planet has led to numerous effects, many of them catastrophic including hurricanes, prolonged droughts, tsunamis, ocean acidification, the decline of non-human species, and countless others, but all of which provide valid reasons to find ways to dramatically reduce emissions and the greenhouse effect.[ii]

The scientific community has identified the primary cause of human-induced greenhouse gas emissions as the burning of fossil fuels. According to the EPA, the core categories contributing to the burning of fossil fuels and the emissions resulting are: Transportation, Electricity Production, Industry, Commercial and Residential Properties, Agriculture, and Land Use and Forestry.[iii] This paper specifically addresses Commercial and Residential structures and, more specifically: 1) the reasons why the decarbonization of buildings is fundamental to the health of the planet and 2) readily available solutions and initiatives for reducing the carbon impacts of both commercial and residential structures, one of which is optimized insulation in building envelopes via high performance spray polyurethane foam solutions.

II. CURRENT STATISTICS ON CLIMATE CHANGE

The NOAA's Global Climate Report (2021), the latest annual NOAA report which studies the Earth's climate trends annually, notes that the combined land and ocean temperature has increased at an average rate of 0.13 degrees Fahrenheit (0.08 degrees Celsius) per decade since 1880; however, the average rate of increase since 1981 (0.18 degrees Celsius / 0.32 degrees Fahrenheit) has been more than twice that rate.[iv]

The same study found the average global land and ocean surface temperature for January-December 2020 was 0.98 degrees Celsius (1.76 degrees Fahrenheit) above the 20th Century average of 19.9 degrees Celsius (57.0 degrees Fahrenheit) – the second highest global land and ocean temperature for January-December in the 1880-2020 record, behind 2016 which was the warmest. The ten warmest years during the 1880-2020 period, in order starting with the warmest, are: 2016, 2020, 2019, 2015, 2017, 2018, 2014, 2013 and 2005.[v]

2020 was the second warmest year on record for the globe. The 2020 average global CO2 concentration, calculated from measurements collected at NOAA's remote sampling locations, was 412.5 parts per million. The global rate of increase was fifth highest in NOAA's 63-year record, following 1987, 1998, 2015 and 2016. The year's economic recession, instigated by the COVID-19 pandemic, was estimated to have reduced carbon emissions by about 7 percent during 2020. Without the economic slowdown, the 2020 increase would have been the highest on record, according to Pieter Tans, senior scientist at NOAA's Global Monitoring Laboratory.[vi]

The general population's understanding of the effects of climate change varies. For example, some effects are more commonly referenced in mainstream media sources and include the shrinking of glaciers, rising sea levels, and longer and more intense heat waves. Others perhaps referenced less include ice on rivers and lakes breaking up earlier, shifting plant and animal ranges and trees flowering sooner than usual.[vii] All of these effects, as well as many others, disrupt the ecological balance and grow in magnitude as the planet continues to warm.

According to the Intergovernmental Panel on Climate Change (IPCC) Working Group I report, Climate Change 2021: The Physical Science Basis, which is the first installment of IPCC's Sixth Assessment Report (AR6) expected to be fully completed by 2022, greenhouse gases from human activities are responsible for 1.1 degrees Celsius of warming since 1850-1900. The report asserts that, averaged over the next 20 years, the global temperature is expected to reach or exceed 1.5 degrees Celsius of warming.

IPCC's Working Group I report also projects the following effects of global climate change: an intensified water cycle bringing about more intense rainfall and associated flooding, as well as more intense drought in many regions; affected rainfall patterns including likely increased precipitation in high altitudes, projected decreased rainfall over large parts of the subtropics, and changes to monsoon precipitation varying by region; continued sea rise throughout the 21st century in coastal areas, contributing to more frequent and severe coastal flooding in low-lying areas, coastal erosion, and extreme sea level events (which previously occurred once in 100 years) happening every year by the end of this century; amplified permafrost thawing, loss of seasonal snow cover, melting of glaciers and ice sheets, and loss of summer Arctic sea ice; changes to the ocean including warming, more frequent marine heatwaves, ocean acidification, and reduced oxygen levels affecting ocean ecosystems and the people that rely on them; and, for cities some aspects of climate change may amplify, including heat (since urban areas are usually warmer than their surroundings), flooding from heavy precipitation events, and sea level rise in coastal cities.[viii]

Indications of these warming trends, and the extreme consequences of them, are already visible. The 2017 Atlantic Hurricane Season will long be remembered as one of the most prolific and disastrous on record, with Hurricane Maria's decimation of Puerto Rico; Maria and Irma's extensive damage incurred in the Virgin Islands; Hurricane Harvey's brute strength, rainfall and destruction as a cyclone over Texas, Louisiana and the Tennessee and Ohio Valleys; and others. In September 2018, the southeast was hit with Hurricane Florence, which caused catastrophic damage and deaths in the Florida panhandle and the Carolinas, primarily as a result of freshwater flooding. In 2019, Hurricane Dorian became the most intense tropical cyclone and worst natural disaster to strike the Bahamas, to date. In late August 2021, Hurricane Ida left over one million people in Louisiana without power[ix] before bringing catastrophic levels of rainfall and flood damage to the northeastern United States, creating many casualties across numerous states, and flooding New York City's subway system and halting air travel at airports.[x]

Examining 2021 further, scientists and researchers from Colorado State University (CSU), Tropical Storm Risk (TSR), North Carolina State University (NCSU), and AccuWeather expect above normal activity, projecting 12 to 15 tropical storm events, according to Allianz Global Corporate & Specialty's (AGCS) Atlantic Hurricane Season Outlook 2021. The report notes that an above average season is typically characterized by seven to nine storms reaching hurricane strength and two to four becoming major hurricanes. [xi]

Drought and wildfire activity mirrors the intensity of hurricanes over the same period. In the third quarter of 2018, California's Camp and Woolsey fires burned more than a quarter million acres combined, destroyed the town of Paradise, and claimed 89 lives.[xii] The state recorded its first ever gigafire in October 2020 when the August Complex fire, which burned across Glenn, Lake, Mendocino, Tehama, Trinity and Shasta counties, scorched over one million acres.[xiii] In August 2021, the Dixie fire, which razed the town of Greenville, became the largest single fire in the state's history.[xiv] Simultaneously, the Caldor Fire burned through thousands of acres of picturesque forest in California Sierra Nevada, forcing evacuations in South Lake Tahoe and Alpine County, as well as across state lines in Douglas County, Nevada.[xv]

This summary of storm, drought and wildfire events is not comprehensive and represents just a slice of inclement and concerning weather pattern activity. However, these severe weather events are a direct cause of the human expansion of the greenhouse effect. Understanding this, what efforts can be made by the human population to slow down, or reverse, the greenhouse effect?

III. CORE CATEGORICAL CAUSES OF GREENHOUSE GASES

Observed increases in well-mixed greenhouse gas concentrations since around 1750 are unequivocally caused by human activities,[xvi] and the largest source of that increase is the burning of fossil fuels, specifically for electricity, heat and transportation. The EPA tracks total U.S. emissions in the Inventory of U.S. Greenhouse Gas Emissions and Sinks,[xvii] an annual report that estimates the total national greenhouse gas emissions and removals associated with human activities across the United States. The EPA categorizes and explains the primary sources of greenhouse gas emissions in the United States, by economic sector, as:

TRANSPORTATION

Comprising 29 percent of 2019 greenhouse gas emissions, the transportation sector generates the largest share of greenhouse gas emissions. Within this sector, these emissions originate primarily from burning fossil fuel for cars trucks, ships, trains and planes. Petroleum-based products supplied over 95 percent of the energy used for transportation, with 60 percent from gasoline consumption in automobiles and highway vehicles.[xviii]

ELECTRIC POWER

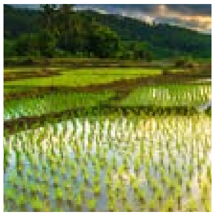
Accounting for 25 percent of 2019 emissions, electric power generates the second largest share of greenhouse gases. Approximately 62 percent of our electricity comes from burning fossil fuels, which are mostly coal and natural gas.[xix] Notably, the types of fuel consumed to produce electricity have changed in recent years. Total electric power generation decreased 1.3 percent from 2018 to 2019. However, carbon dioxide emissions decreased 8.4 percent from 2018 to 2019 due to increasing electric power generation from natural gas and renewables and decreasing generation from coal. Carbon dioxide emissions from coal consumption for electric power generation decreased by 52 percent since 2005. The decrease in coal powered energy generation and increase in natural gas and renewable electricity generation have contributed to a 33 percent decrease in overall carbon dioxide emissions from electric power generation from 2005 to 2019.[xx]

INDUSTRY

According to the EPA, 23 percent of greenhouse gas emissions originates from the industrial sector, primarily coming from burning fossil fuels for energy, as well as from certain chemical reactions necessary to produce goods from raw materials.

COMMERCIAL AND RESIDENTIAL

The EPA cites the commercial and residential sectors as accounting for 7 and 6 percent of greenhouse gas emissions respectively in 2019, for a total of 13 percent combined. Emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases and the handling of waste.



AGRICULTURE

Agriculture contributes to the greenhouse effect via the emissions from livestock such as cows, agricultural soils and rice production. This sector accounted for 10 percent of 2019's total greenhouse gas emissions.

LAND USE AND FORESTRY

Land areas can act as a sink, absorbing carbon dioxide from the atmosphere, or a source for greenhouse gas emissions. In the U.S., since 1990, managed forests and other lands are a net sink, having absorbed more carbon dioxide from the atmosphere than they emit, ultimately removing 12 percent of total greenhouse gas emissions.

IV. DRILLING DOWN INTO THE ROLE BUILDINGS PLAY IN EMISSIONS AND GLOBAL WARMING

The C2ES, or Climate Innovation 2050, brings together fortune 500 companies to examine pathways toward substantially decarbonizing the U.S. economy. Participants include Amazon, CBRE, Shell, JP Morgan Chase & Co., BP, Intel, Dow, GE, Microsoft and numerous other notables. In its recent 2018 Decarbonizing U.S. Buildings report,[xxi] the initiative, like the EPA, also points to the commercial and residential buildings sector as one of the biggest contributors to greenhouse gas emissions. C2ES finds that fossil fuel combustion attributed to residential and commercial buildings accounts for roughly 29 percent of total U.S. greenhouse gas emissions. Lee Paddock, associate dean for environmental law studies, and Caitlin McCoy, associate professor of law and environmental program fellow, at George Washington University Law School in their Deep Decarbonization of New Buildings (2018) [xxii] report found that buildings use approximately 40 percent of energy produced in the United States and are responsible for about 30 percent of the nation's carbon dioxide emissions, indicating that carbon emissions from buildings are a priority for reduction.

These two figures are notably higher than the EPA's 13 percent figure, likely reflecting that EPA separates electric power generation into its own category, even though a portion of that power generation undoubtedly attributed to powering structures. Regardless, all three findings demonstrate an alarming trend, indicating a substantial need for this sector to address and employ more environmentally responsible building and building use practices.

Buildings utilize large quantities of energy to heat and cool interior spaces, to light, and for other uses. Emissions from residential and commercial buildings are classified by the EPA as either direct or indirect in its recent report.[xxiii]

Direct emissions include fossil fuel combustion for heating and cooking needs, management of waste and wastewater, and leaks from refrigerants in homes and businesses. These occur in a variety of ways. Combustion of natural gas and petroleum products for heating and cooking emit carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Natural gas consumption emissions account for 80 percent of direct fossil fuel CO_2 emissions from the residential and commercial sectors in 2019. Coal consumption is a minor component of energy use in these sectors.

Organic waste sent to landfills emits CH_4 and wastewater treatment plants emit CH_4 and N_2O. Anaerobic digestion at biogas facilities emits CH_4. Fluorinated gases (mainly hydrofluorocarbons, or HFCs) used in air conditioning and refrigeration systems can be released during servicing or from leaking equipment.

Indirect emissions are produced by burning fossil fuel at a power plant to make electricity, which is then used in residential and commercial facilities for activities such as lighting and for appliances.

The EPA in its report also identifies the reduction of energy use through energy efficiency as a key means for reducing emissions from homes and business properties. The C2ES report[xxiv] indicates that improvements in energy efficiency have led to emissions reductions in the residential and commercial real estate sectors of 17.3 and 11.4 percent, respectively, since a 2005 peak. While the current emissions figures are still alarming, these reductions point to energy efficiency as a focal point in the ongoing effort toward the decarbonization of buildings.

V. DRIVING ENERGY EFFICIENCY IN BUILDINGS THROUGH HIGH PERFORMANCE INSULATION MATERIALS

When looking at meaningful ways to conserve energy in structures, whether residential or commercial, the building envelope takes center stage. High-performance building envelopes are designed and constructed to be particularly well adept at acting as an environmental separator, keeping outdoor elements from infiltrating and impacting the encapsulated indoor environment. Well designed and constructed envelopes provide exceptional resistance to air, water, heat, light and noise transfer. In addition to providing support, to resist and transfer structural and dynamic loads, and to provide indoor and exterior aesthetics, controlling the flow of matter and energy of all types is the core function of the envelope.

Optimal insulation of the building envelope is key for preventing energy transfer through it. Reducing energy transfer through the envelope ultimately reduces the energy consumption directly attributed to heating and cooling the structure. In turn, fossil fuel consumption, a cause of greenhouse gases, is reduced.

However, not all insulations are equal. R-value measures the ability to limit conductive heat flow (heat transferred through it). But conductive heat flow is only one heat transfer mechanism. Air leakage or heat transfer via convection is also an important mechanism to regulate. Controlling air leakage in a building can result in up to a 25% reduction in space conditioning energy usage[xxv] – an opportunity that is not possible with insulations that only deal with conduction heat flow reduction. R-value is important, but an airtight seal is equally important for achieving energy savings.

OPEN CELL SPRAY POLYURETHANE FOAM

Open cell, or low density, spray polyurethane foam is an ideal insulation material for both residential and commercial structures. Commonly offered at 0.5-pound density per cubic foot, the open cell class of spray polyurethane foam provides notable air sealing, soundproofing and thermal insulation capabilities, helping to adequately control ventilation rates, indoor temperatures and humidity. Professionally spray applied, it fully adheres to most substrates, is lightweight and durable. The material is ideally suited for filling interior walls and ceilings where there is no risk of water contact. Impermeable to air movement, it helps to reduce the escape of conditioned air which, in turn, dramatically reduces energy demands and operating costs. Furthermore, since it is not a vapor retarder, it allows for assemblies it is installed in to dry if they become wet.

CLOSED CELL SPRAY POLYURETHANE FOAM

One of the highest performing insulation options available today, medium-density closed cell spray foam insulation performs remarkably well as a single-source solution for thermal, air, vapor and water control. Closed cell spray foam is a higher density consistency than open cell, commonly used for insulation at 2.0-pounds per cubic foot with a closed cell structure. Roofing foam, also a closed cell variety and which doubles as insulation, is commonly sourced between 2.5 and 3.5 pounds per cubic foot. As a thermal insulator, closed cell SPF boasts one of the highest R-values per inch of all insulation options available. Like its open cell counterparts, the material forms in-place and fully adheres, virtually eliminating cracks and gaps that leak air or water, creating an airtight structure.

The capabilities of closed cell SPF insulation protect the structure against mold and water damage, maintain indoor temperatures and dramatically reduce energy costs. They also improve indoor air quality, minimizing the volume of allergens and pollutants able to enter the structure. Combined, these qualities result in a high-performance envelope, creating greater indoor comfort and significantly reducing long-term heating and cooling demands. The superior thermal performance and air-sealing from SPF lowers energy costs for the building over the lifespan of the product. Closed cell SPF also provides structural enhancement and qualifies as both a vapor retarder and secondary water barrier.

THE ARGUMENT FOR CLOSED CELL SPRAY FOAM IN CONTINUOUS INSULATION APPLICATIONS

Generally speaking, with no other variation in factors, a building will perform better in the area of energy efficiency with the application of continuous insulation on the exterior of side of the building envelope walls, when compared to an exact structure replica without continuous insulation. Closed cell SPF is ideally suited for continuous insulation applications and can be used in both interior and exterior applications where it can essentially replace commonly utilized rigid XPS and PIR foam boards. It is also ideally utilized in smaller spaces where a higher R-value is required or where severe moisture could be an issue.

Combining closed cell spray polyurethane foam as continuous insulation on the exterior of the walls, along with the application of spray foam insulation in the stud cavities, creates a building envelope which mirrors a coat (continuous insulation) and a sweater (cavity insulation) acting in concert, and further optimizes the energy efficiency of the total building envelope.

WITH PROVEN ENERGY EFFICIENCY PERFORMANCE, IS THE VALUE OF SPF RECOGNIZED?

The use of closed cell spray polyurethane foam as continuous insulation has become much more common in the design and construction of newer commercial properties. The current energy codes recognize the advantage of CI on wall exteriors, and this likely plays a factor (and is believed to be a driver) in the growing specification of closed cell spray foam insulation in CI applications in non-residential structures. However, the adoption of spray foam as continuous insulation in newly constructed residential properties remains much rarer. With many new communities and homes today being built by production homebuilders, an industry which has undergone widely publicized consolidation and is currently dominated by public companies,[xxvi] many of the new homes built today in the United States are value engineered, with cost reductions in design, materials and labor (i.e. construction timelines) a key focus. Builders are thus known for basing many decisions on initial upfront cost, rather than on the long-term value to the homebuyer or potential negative ramifications to the environment and climate.

The lack of adoption of closed cell spray polyurethane foam for continuous insulation on new homes is thus widely believed to be a result of two factors:

1) The product is considered a premier building material and is priced a bit higher than other insulations.
2) When applying spray foam, it adds another step in the construction process, potentially affecting the construction timeline. Thus, residential builders tend to avoid installing spray foam in this manner and instead usually install it solely in the wall cavity.

Finding cost solutions, and providing better education to homebuilders, could in fact help to increase their use of closed cell spray foam as continuous insulation on the nation's new housing stock, which in turn would make a huge impact in the decarbonization of buildings. Education for builders should include cost vs. value, as well as application best practices, information.

VI. THE ROLE AND IMPORTANCE OF ENVIRONMENTAL PRODUCT DECLARATIONS AND ENERGY MODELING ANALYSES

In order to reduce the construction & building operations sectors' contribution to global warming, it is imperative to do two things. The first is to use insulation products that demonstrate reduced embodied carbon. Environmental Product Declarations, or EPDs, are important tools for this as they tell the life cycle story of a product in a single, comprehensive report, providing information about a product's impact upon the environment, including global warming potential, smog creation, ozone depletion and water pollution. While EPDs do not rank products, and the existence of an EPD for a product does not indicate that environmental performance criteria have been met, they are an important disclosure tool that helps purchasers better understand a product's sustainable qualities and environmental repercussions, so they can make informed product selections.[xxvii]

Secondly, buildings must be constructed tighter, better sealed, and more energy efficient to reduce their operational carbon emissions. To assess performance in this area, Energy Modeling is useful. Energy Modeling is a pre-construction, whole-building assessment of energy efficiency that uses computer programs for calculation. A model of the entire building is created on a computer and that model is run through simulations to show energy performance, usually for an entire year and based on meteorological information. The modeling accounts for all systems within a building and examines how they impact each other.[xxviii]

Both types of carbon reduction, embodied carbon reduction and operational carbon reduction, work hand-in-hand and are necessary to reach climate goals. Both are also achievable by using spray foam over alternative insulation materials.

Addressing embodied carbon, Huntsman Building Solutions in August 2021 released an Environmental Product Declaration for the company's HEATLOK HFO and HEATLOK Soya HFO closed cell spray foam systems. Completed by Sphera and certified by UL, the EPD provides objective and comparable information about the lifecycle impacts and emissions of the two spray foam products. HEATLOK HFO and HEATLOK Soya HFO both leverage 4th generation blowing agents, with the former product branded and distributed within the U.S. market and the latter branded and distributed within Canada. With the release of the EPD, the HEATLOK HFO products notably became the first and only spray foam system with a product-specific, Type III EPD both independently completed and verified.

Completed in accordance with strict ISO standards, including ISO 14044, ISO 14040, ISO 14025, ISO 21930, and EN 15804, the Huntsman Building Solutions EPD is based on the spray foam system's Life Cycle Assessment (LCA), which evaluates the products' impacts in six key Environmental Impact Categories, one of which is Global Warming Potential, or GWP. As demonstrated by the EPD, HEATLOK HFO and HEATLOK Soya HFO GWP performance comparative to other insulation options is: 39% lower than the spray foam industry average; up to 96% lower than HFO extruded polystyrene; 77% lower than heavy density mineral wool; 52% lower than light density mineral wool; and 55% lower than unbonded loose fill and blown-in mineral wool. These comparisons account for embodied carbon before consideration of additional building energy savings and the resulting operation carbon emission saving made possible with spray foam.

HBS also developed a summary that evaluates different insulation products' EPDs to assess and compare GWP of a wall assembly insulated solely with HEATLOK HFO/HEATLOK Soya HFO to assemblies insulated with mineral wool, HFO extruded polystyrene board stock and fiberglass insulation. The EPD comparison results show that by simply replacing all insulation types and membranes in assemblies A and B with the single product HEATLOK HFO/HEATLOK Soya HFO at an equivalent R-value, the assembly's GWP is cut nearly in half (45% reduction in GWP).

Addressing operational carbon, the Spray Polyurethane Foam Alliance (SPFA) in February 2021 published a residential energy modeling case study comparing SPF and fiberglass insulations' embodied carbon and energy savings to assess their respective environmental impacts. Although foam plastic insulations' initial environmental impact is higher than fiberglass insulation, their inherently higher R-values and seamless air impermeability provide significant additional energy savings when installed at the same R-value as fiberglass insulation.[xxxii] Notably, HFO-based SPF insulation offers much lower embodied carbon than many types of insulation (mineral wool, board stock insulation, etc.).

The SPFA's case study evaluated cumulative energy demand and global warming potential of HFO-based spray foam insulation over a 75-year period. These impacts were estimated for a typical new 2,512-square-foot home insulated and air sealed to 2018 International Energy Conservation Code (IECC), constructed in three different US climate zones, and compared to three homes using the same parameters but insulated with fiberglass. The study found that a 2,512-square-foot home insulated with HFO-based spray foam can prevent the release of 67 years x 1,556 kg CO_2/year, representing 104 metric tons of CO_2. The HFO spray foam insulated home will also provide total energy savings of 5,638 Kw/h per year compared to the fiberglass insulated home with the same insulation value.

The study demonstrates that in just eight years, HFO-based closed-cell SPF offsets, or cancels, its higher initial embodied carbon compared to fiberglass due to the increased energy efficiency and operational carbon reductions it brings to buildings. After eight years and during the 67 remaining years of its 75-year service life, HFO-based closed-cell SPF will remove carbon that would otherwise be released in the atmosphere with the use of fiberglass insulation, thereby providing a net positive environmental impact.

The SPFA's energy modeling report uses the SPFA industry-wide EPD value for spray foam's global warming potential to calculate the carbon payback period of eight years in its energy modeling case study. However, Huntsman Building Solutions' HEATLOK HFO and HEATLOK Soya HFO spray foam systems have a lower GWP than the spray foam industry average, thus the products' payback period is four years instead of eight.

VII. NEW & EXISTING STRUCTURES MUST BOTH BE ADDRESSED TO FULLY DECARBONIZE THE NATION'S BUILDING STOCK

In 2012-2013, the median ages of a U.S. home and commercial building were 37 and 32 years old respectively.[xxx] This implies that much of the country's building stock is aging. One key consideration is that older buildings do not benefit from newer and more innovative materials, which are both increasingly earth-friendly and energy efficient. The exception is older structures which have undergone energy performance-focused retrofits.

On the other side of the spectrum is new construction, which increases alongside population and economic growth. Even though increasingly advanced materials are readily available for newer buildings, not all new properties are constructed responsibly, with decarbonization in mind. Thus, when looking for comprehensive solutions to reduce emissions across the full spectrum of the building sector, both existing and new buildings must be addressed.

VIII. INFLUENCING CHANGE: ADDITIONAL SOLUTIONS TO MOVE THE NEEDLE IN CURBING BUILT ENVIRONMENT'S GLOBAL WARMING IMPACTS

In addition to optimizing the energy efficiency of the building envelope through the application of open and/or closed cell spray polyurethane foam, there are additional efforts that, when combined with SPF solutions, will dramatically contribute to the decarbonization of buildings. These are:

CONTINUED MOVE TOWARD ELECTRIFICATION

There is undoubtedly a marked shift toward renewable energy sources to power both residential and commercial structures. With the wider adoption of one of the more obvious technologies – photovoltaic systems – there is real potential to reduce the burning of fossil fuels to generate electricity for heating and cooling properties. When combined with optimized energy efficiency in the same building(s), a more complete energy solution is achieved – one that both generates clean energy and conserves that energy. Electrification efforts are thus a key part of the overall decarbonization solution.

MORE STRINGENT BUILDING CODES

U.S. building codes are, and have been, one of the primary drivers of more environmentally responsible and higher performing homes and structures. In fact, the increasing stringency of building codes is often cited as hindrances to the business of building, insofar as many builders believe they limit profitability. Regardless, the mandating of higher performance structures undoubtedly plays a pivotal role in decarbonization. While the current codes have pushed the industry toward greater energy consumption reductions, they will need to progress to net zero energy or net positive energy standards to align with complete decarbonization.

SUPPORT FOR CLIMATE CHANGE POLICIES

Like enhanced building codes, support for climate change policies at both the state and federal levels will elevate climate change efforts to government participation. Policies that support efforts to reduce emissions will not only play a part in stopping climate change, but will also heighten awareness of the state of, and risks to, the environment across the general public. One example is the state of California's new codes which adopt electrification standards aimed at dramatically limiting the use of natural gas in buildings and homes.[xxxi]

OPTIMIZED DESIGN OF BUILDINGS & MORE EFFICIENT MECHANICAL EQUIPMENT

The design of buildings plays a large role in energy performance, as does the efficiency of the mechanical equipment in them. Optimizing both for energy performance will play a huge role in reducing emissions in both residential and commercial structures.

BETTER, AND MORE, FINANCIAL INCENTIVES

Financial incentives that reward the reduction of fossil fuel use and emissions are a key means for influencing stakeholders toward more responsible building and living practices. Incentives may come in the forms of rebates, favorable financing, tax credits, property assessed clean energy (PACE) programs, weatherizations assistance for low-income households, solar credits, and others. Better, and more, energy efficiency incentives must also be introduced in the fight against emissions. Energy-focused retrofits must be financially incentivized and prioritized as much as those for new construction projects.

WIDER ADOPTION OF INTELLIGENT EFFICIENCY TECHNOLOGIES

Many technologies exist that assist consumers and business owners in the monitoring of energy consumed within the home or property. These technologies help individuals monitor energy consumption, which likely creates greater awareness of the impacts of that energy usage, leading to energy consumption reductions.

SUCCESSFULLY CONFRONT THE BATTLE BETWEEN UPFRONT COST AND LONG-TERM VALUE & ENVIRONMENTAL PROTECTIONS

Possibly one of the greatest barriers to achieving decarbonization is the dilemma centered around who builds a structure or home, and who ends up using it in the long-term. Because so many structures are sold after completion, the properties built are a business endeavor driven by profit. Conversely, the user of the structure typically desires indoor comfort and long-term energy solutions and savings. These two interests essentially lie in conflict, with the former often much less concerned about the environmental impacts of the structures built than the latter. The building industry's ongoing challenge is to resolve this. In doing so, healthier, carbon neutral homes and commercial buildings will flourish.

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