WHITE PAPER

Artificial Intelligence (AI) in the building sector
as a change driver towards carbon neutrality

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Executive summary

The urgency of combatting climate change through concrete, practical measures has surely not escaped anyone. Looking across all sectors of life, only a very small minority would argue against the logic that decisive action must be taken to decelerate global warming and overcome the obstacles to a sustainable future.

But what exactly does 'decisive action' mean for private businesses? How can the existential threat of climate change be countered in a way that is simultaneously effective, financially sustainable, and not perceived as ineffectual greenwashing?

While this white paper cannot hold all the answers to the complex issues of global warming, it does aim to outline challenges and possible solutions in a sector that is easily overlooked when discussing decarbonization, energy efficiency, and return on investment (ROI): the building and real-estate sector.

According to the International Energy Agency's (IEA) 2020 Global status report[1] building construction and operations account for a resounding 38 percent of total energy related $C0_2$ emissions globally. Energy is responsible for producing 76 percent of greenhouse gases worldwide[2]. Furthermore, the figures for building operations in isolation have increased to a record high of 28 percent of global energy-related CO_2 emissions.

The "economic and social transformation" referred to in the Paris Agreement as necessary in implementing effective counter measures to global warming is no understatement. Just as vital as the economic and social considerations however is a third transformation: a technological one.

For ABB and BrainBox AI, smart technologies that streamline the energy efficiency of both new and older buildings and safeguard the wellbeing of their occupants is of central importance in reducing the sector's extensive carbon footprint. Perhaps the most important point of departure in the discussion of these technologies is the concept of the smart building.

Joining forces and technologies to drive change in the smart buildings sector

Smart buildings, also called 'intelligent' or 'automated', is a broad term encompassing many different processes and technologies. Smart buildings refers to any facility where internal systems are controlled by an automated, centralized system. Building systems that can be automated include heating, ventilation & air conditioning (HVAC), physical security, electrical, lighting, plumbing, fire alarms, water, elevators and more.

Automation is not, however, the end goal of building smartly. Since HVAC and lighting alone can account for about 50 percent of energy use in an average commercial building[3], implementing central and automated controls has a significant impact in terms of energy conservation and waste reduction. In fact, according to the American Council for an Energy-Efficient Economy, by investing in smart automation, building owners and operators frequently report decreased energy costs of 30 to 50 percent.

Next to smart technology systems, and of equal importance, is collaboration. The holistic nature of the climate change challenge can only be addressed effectively by the long-term, concerted efforts of those with the means to do something about it. In line with ABB's commitment to affecting positive change, the company recently invested in a new generation of artificial intelligence (AI) and a collaboration that will help make buildings even smarter, safer and more energy efficient.

In late 2021, ABB announced its investment and strategic engagement with Montreal-based scale-up BrainBox AI. A pioneer in the field of AI, the company develops solutions that help reduce energy costs and carbon emissions from HVAC (heating, ventilation, and air conditioning) systems in commercial buildings. Through the collaboration, the companies can combine their existing portfolios of digital solutions, specifically the ABB Ability™ solutions and BrainBox AI's predictive, self-adaptive, and scalable cloud-based artificial intelligence.

With HVAC systems accounting for most of the energy use and carbon footprint of a typical commercial building, the rationale for the joint endeavor is compelling to say the least. In fact, the solution ABB and BrainBox AI has brought to market has the potential to reduce carbon emissions by up to 40 percent[4] while enabling up to 25 percent[5] reductions in energy costs. From commercial office towers, retail shopping centers, hotels and other asset classes, the technology is delivering significant results right now.

Supporting sustainability goals

As we've seen, anyone with a stake in building operations needs to consider the intersecting, and seemingly contradictory, needs for effective HVAC and reduced energy consumption to achieve our sustainability goals. In this regard, and as brought into action in ABB's **Mission to Zero™** program, building owners, operators, and technology providers must work together to turn data and insights into concrete action.

At this point, the viability of a zero-emission transition should be beyond question. Drawing on the insights from ABB sites in Ede, the Netherlands, and Porvoo in Finland (carbon-neutral and energy self-sufficient production site) ABB has proven once and for all that industrial sustainability is possible for any organization with the vision and conviction to see it through.

In practical terms, the solution leverages a combination of solar power and smart energy management components that are digitally networked and controllable to create a decentralized system that can be replicated in other areas of life - from smart homes and smart buildings to smart transportation and smart factories.

Despite the availability of enabling technology, and despite ample climate-related incentives, many companies have yet to start on their own zero-carbon journey. Concerns regarding steep upfront technology investment costs, and prolonged implementation times, still prevent businesses' shift toward greener operations. Although these are certainly valid concerns, it is important to use digital solutions to minimize capital expenditure.

Speed and impact matter

There's a powerful return on investment for smart buildings that makes good sense. More effective and efficient use of power can save money, quickly repaying initial technology expenditure. HVAC and lighting alone can account for about 50 percent of energy use in an average commercial building.

By using software and control hardware that connects to the existing HVAC systems in commercial buildings they become self-adaptive and more intelligent. This process involves no upfront capital expenditure and delivers a return on investment of more than 150 percent via energy cost savings of up to 25 percent and up to 40 percent reduction in a building's carbon footprint[7].

Achieving carbon neutrality with new buildings is relatively easy. But in many regions of the world retrofitting the existing building stock with legacy technology will likely take so long, and cost so much, that climate targets will be missed. It is therefore critical to innovate, and to favor solutions that are not only cost effective and simple to install but are open source and interoperable with existing building systems.

AI as an enabler

AI is already embedded in our everyday life, whether we're aware of it or not. Day to day we experience AI serving up relevant content in our social media feeds or suggesting the next binge watch on our streaming services, yet in an industrial setting, if effects are far-reaching. In fact, AI can fast track our journey to carbon neutrality.

According to Capgemini Research Institute, by 2030, AI is likely to have reduced overall greenhouse-gas emissions by 16 percent and is estimated to have helped organizations fulfill up to 45 percent of the Paris Agreement targets. The big upside of AI-enhanced climate tech is that it can be rapidly and widely deployed, having an immense impact on decarbonizing several sectors - particularly when used to reduce energy consumption, which is responsible for producing 76 percent of greenhouse gases worldwide[3].

In the realm of commercial HVAC systems, AI-enhanced technologies are positively impacting the environment by making commercial buildings smarter and more efficient. Consider a basic, non-programmable thermostat without AI. With this device, the desired temperature is set and when it deviates from this setting the system triggers the heat or air conditioning through an electrical connection. Even HVAC systems in larger buildings may perform in this manner.

By adding AI to this equation, however, existing HVAC equipment can be transformed. Leveraging readily available AI technology, any building's heating and cooling system can be upgraded to learn, reason, and even solve problems, through:

- **Learning:** An office lobby, for example, has recently been redesigned and revolving doors installed, regularly letting outside air in. A standard HVAC system would have wasted a great deal of energy struggling to regulate the fluctuating temperatures. With AI installed, the upgraded system quickly and easily learns and adapts so that the HVAC system reacts predictably to its changing surroundings.
- **Reasoning:** Using machine learning, AI can deduce that an office's communal area will grow warmer at lunchtime because of a spike in congregating workers in that space.
- **Problem-solving:** Knowing, or predicting, that the room will be warmer at this time, AI can adapt and adjust the air conditioning proactively prior to lunchtime, keeping the area consistently comfortable for occupants.

This kind of speedy, accurate auto-adjustment not only conserves energy, but it also eases the burden on those tasked with managing office workers' comfort, enabling them to concentrate on other, more pressing tasks.

The Efficiency AI solution: A real-world example of how technology can support the green shift

As we've seen, AI stands out as a powerful enabling technology to achieve the trifecta of emissions reduction, cost savings, and improved occupant comfort. However, despite its seemingly boundless potential, AI alone is no panacea. Instead, it needs to be thought of as a key component in a larger system that, crucially, has been designed with ease and speed of implementation and operation as its guiding principles. This last consideration is vital to affect the kind of mass adoption that will be needed over the coming years as the sector works to deliver on its green commitments.

One example of how this infrastructure can be realized is with **Efficiency AI**. Built on the ABB Ability digital platform and powered by BrainBox AI, the solution has been engineered to provide smart building owners with a simple way of optimizing their energy consumption.

Simplicity in this context means an easy addition any existing HVAC system, predictive algorithms that eliminate the need for human intervention, and an array of monitors, analyses, and reports to help track energy efficiency. Existing HVAC equipment can be readily upgraded with Efficiency AI-companies that invest report up to 40 percent decreases in carbon footprint, up to 25 percent reductions in energy costs, and up to 60 percent improvements in occupant comfort. This adds up to 50 percent to the lifecycle of HVAC equipment. Intelligent, fit-for-purpose solutions like the one described here have a major role to play in ensuring the long-term viability of the world's building stock, which, as the 2021 Global Status Report for Buildings and Construction points out, needs to be at net zero emissions by 2050. One important aspect in this domain is compliance with the standards that regulate HVAC and indoor environments.

Any solution claiming to mitigate the effects of a building's heating and cooling must be built to conform to the standards and guidelines set out by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) and the EU6. Besides standards for decarbonization, smart-building ventilation also need to consider the demands on airborne virus mitigation, as stipulated by the Centers for Disease Control and Prevention (CDC). In a post-COVID-19 world, the latter point can have immense consequences for building owners, especially in the commercial and retail sectors.

Building owners and operators looking to start their Mission to Zero journey are faced with a wide and varied range of environmental and financial considerations which can possibly delay progress. One way of breaking the gridlock is to baseline and plot a course of action based on best practices, lessons learned, and implementing cost effective solutions to achieve the end goal.

Ways to proceed: best practice projects

To understand fully how AI-enabled building management technology can be deployed in real-world environments to address sustainability and cost-saving challenges, major industry players like ABB need to be willing to share the learnings they've amassed over the decades.

In other words, by sharing the experiences of staff, partners, and customers, the field can be opened to new entrants who may recognize themselves in the challenges of others and be inspired to address them. Therefore, the best-practice examples offered here should be considered based on their generalizability and practicability.

The solution brought to market by ABB and BrainBox AI is also currently used in approximately 100,000,000 square feet of commercial real estate. The accumulated effects on carbon footprint reduction when considering such vast spaces are nothing short of remarkable.

For example, at a 275,000 square foot shopping center in Australia, owners have realized a 36 percent annualized energy savings on HVAC equipment, saving 388 metric tons in annualized carbon emissions. At a 300,000 square foot office building in Ontario, Canada, owners have realized a 29 percent annualized energy savings on HVAC equipment, saving 218 metric tons in annualized carbon emissions.

Leveraging predictive and self-adaptive capabilities, the technology has also been installed in a 215,800 square foot shopping center in Casula, Australia.

This relatively simple update has allowed the system to seamlessly transform into an autonomous one using AI, cloud computing, and a set of custom-curated algorithms. The application resulted in electricity savings on HVAC equipment of 43,731 kWh or 16 percent after only five months, translating to drastically reduced utility costs.

This predictive and self-adaptive technology is installed in an 82,500 square foot medical center in Garden City, New York. It controls fresh air handling units (FAHU) and downstream variable air volume (VAV) connecting through a proprietary driver to the existing Niagara Framework®. Once the data mapping, building analysis and an AI learning period was completed, the technology delivered a significant reduction in asset and equipment run-times as well as energy consumption from HVAC operations. The center achieved 39 percent electricity savings on HVAC equipment (114,145 kWh) in just six months, with positive cash flow after three months.

The solution has also been installed at a 509,612 square foot shopping center in Granby, Quebec where approximately 60 percent of the building is being controlled. After a few weeks of data mapping, building analysis and an AI learning period, a significant reduction in asset and equipment runtimes as well as energy consumption were achieved. Electricity savings on HVAC equipment came in at 216,758 kWh (16 percent) after a year of operation, with significant reduction in shopping center operating expenses and improvements to its net operating income.

Results for Quebec multi-site retailer

Another multi-site retailer in Quebec, Canada piloted the concept with four buildings. The intention was to implement a solution that accomplished energy reduction and lowered the company's carbon footprint across its entire portfolio. With 20,000 square feet piloted, it realized electricity and gas savings of 15 percent and 19 percent respectively, as well as a reduction of 15 tonnes CO_2 equivalent. After recognizing the results, the retailer committed to rolling out the solution in 217 of its locations across Canada.

While the above real-world examples showcase the breadth, range, and flexibility of a truly intelligent, AI-powered solution, they also indicate the magnitude of the ecological and financial benefits such a system can bring about.

While there certainly are reasons to argue that the importance of profitability pales in comparison to the peril of climate change, it is one of the central claims of this white paper that such a binary conception of the issue – where companies choose between either environment or money – is hurting more than it is helping. The two are inextricably linked.

The balanced benefits of AI-powered smart building technology

In the not-too-distant past, the only way to ensure a building's HVAC system was operating at optimal levels was through frequent inspections or commissioning projects. In other words, not only was the equipment consuming energy during normal, but not necessarily optimal, operations, it was also reliant on service technicians traveling to and from the site to maintain that equilibrium.

The cumulative impact is worth considering:
From an environmental perspective, the energy needed to power the equipment is added to the constant traffic of maintenance technicians needed to keep it online to create two distinct carbon footprints per unit. From a financial point of view, this scenario requires building owners to pay a premium for human intervention while simultaneously risking unnecessary additional costs related to HVAC equipment running outside of optimal tolerances.

In contrast, by bringing a building's HVAC system onto an intelligent, autonomous, AI-enabled digital platform, the need for costly service visits is eliminated while equipment health and performance is monitored and managed around the clock. The benefits to the environment and the bottom line, in other words, are complementary and amplify each other.

A truly smart digital solution should not, however, be considered as a static piece of inventory once it has been deployed. For example, once installed, the **Efficiency AI** learns the patterns of the building's HVAC system by observing crucial data points.

Within four months, the system has established a workable map of the HVAC system's operational patterns and is gathering ideas for greater efficiencies. Following this period of initial analysis, the solution examines other external factors that affect a building's indoor environment, such as weather, occupancy trends, local electricity prices and even outdoor pollution.

With these extra factors in mind, it can reduce inefficiencies while providing building occupants with optimal comfort. The platform then continues to learn the particulars about the building's energy usage and makes ongoing micro-adjustments that prevent inconsistencies and energy waste, providing a new, refreshed update every five minutes.

Efficiency AI, in other words, is smart enough to leverage machine and deep learning to continue to deliver environmental and financial benefits 24 hours a day, 365 days of the year, until it is deliberately switched off.

Removing obstacles to mass adoption

Effectively combatting climate change will undoubtedly require the concerted efforts of everyone, everywhere and will involve economic, social, and technological transformation.

Central to the success of this work will be the intelligent management of our living and working spaces. Given the enormity of the building and construction sector's contribution to our collective carbon footprint, there is an urgent need for improvement in terms of emissions, energy consumption, and the necessity to keep people comfortably cool as the outside world heats up.

Parallel to these needs runs the necessity of safeguarding companies' profitability, investment budgets, and, ultimately, their ability to retain and attract talent. As we've discussed here, AI is not on its own a universal solution to all these problems. It is, however, a crucial component of a responsible approach to decarbonization that takes ease-of-use, rapid implementation, and interoperability as its central tenets.

In whatever ways the exact details of these approaches are realized by technology providers such as ABB and BrainBox AI, they should all be geared toward lowering the threshold for adoption on a wide scale. As organizations such as the IEA make abundantly clear, mass adoption of smart building technology is an absolute necessity if we're to hit emissions targets and ensure a cooler future.

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