# The Scale-up Challenge

## How Mission from MaRS is working to accelerate the adoption of climate tech solutions

# Table of contents



# Executive summary

When it comes to preventing widespread devastation due to climate change, action is urgently needed. The latest **International Panel on Climate Change report**, released in August 2021, described planetary warming as a "code red" crisis that is accelerating faster than previous forecasts indicated. The condensed timelines required to make significant gains in emission reduction efforts are intensifying policy-maker and investor focus on several key sectors: energy, transportation and buildings, which together account for more than half of all carbon released into the Earth's atmosphere. **Canada generates** about 725 megatonnes (Mt) of $CO_2e$ annually, accounting for more than 2 percent of the total emissions produced globally — which amounted to **31.5 gigatonnes (Gt) in 2020**. The federal government has pledged to reduce carbon by **40 to 45 percent** by 2030 relative to 2005 levels, and reach net zero by 2050, but Canada has a long track record of missing previous emission-reduction targets.

Due to the slow pace of climate policy-making and the world's continued reliance on fossil fuels, the window of opportunity for effective deployment of new and cleaner technologies in capital-intensive verticals (for example, building materials, the automotive sector, heavy manufacturing and electricity generation) has narrowed substantially. In fact, the normal-course replacement cycle of carbon-intensive capital equipment may actually exceed the remaining time available for the global community to make the necessary changes to ensure that temperature increases remain under 1.5 degrees Celsius by 2050, the Paris Accord target.

A positive development within this complex dynamic is a growing understanding of the carbon-reduction potential associated with the scaling of emerging cleantech solutions in high-emissions sectors. Some are based on engineered technologies that can, for example, remove and sequester carbon from the air. In other cases, these technologies draw on software tools such as artificial intelligence, big data and Internet of Things (IoT) sensors to optimize energy usage and integrate renewable electricity sources.

The Mission from MaRS (MfM) initiative has identified 10 ventures that have developed technologies capable of achieving significant carbon reduction in cost-effective ways, making these ventures attractive in high-emissions sectors, such as real estate, transit and grid management. For instance, Stash Energy has developed in-home smart air-source heat pumps that also store energy, Effenco electrifies heavy-duty vehicles and Opus One Solutions has built a smart-grid software platform. What's more, these ventures were selected for their scalability in recognition of the critical importance of making rapid gains in GHG reductions.

For investors and policy-makers considering the potential of such solutions, there are new methods for making focused predictions about the potential of such innovations if they gain traction and scale significantly. The Carbon Reduction Assessment of New Enterprises (CRANE) tool was the first such projection software available, and has been used in partnership with Mission from MaRS to estimate the emission-reduction potential of cleantech solutions developed by the 10 ventures. The modelling indicates that if these technologies achieved even a 0.1 percent global market share in their respective sectors, they'd collectively cut GHG emissions by 42 Mt of $CO_2e$, or about 6 percent of Canada's total carbon output. If these technologies reach a 1 percent share, the total reductions will exceed 400 Mts — roughly the annual amount of carbon used by 87 million cars or 8.3 million U.S. households. Canada — and the rest of the world — needs cleantech solutions that can achieve significant reductions quickly and sustainably to meet its emissions-reduction targets. In order to do that there needs to be clear methods of determining which solutions can have the greatest impact.

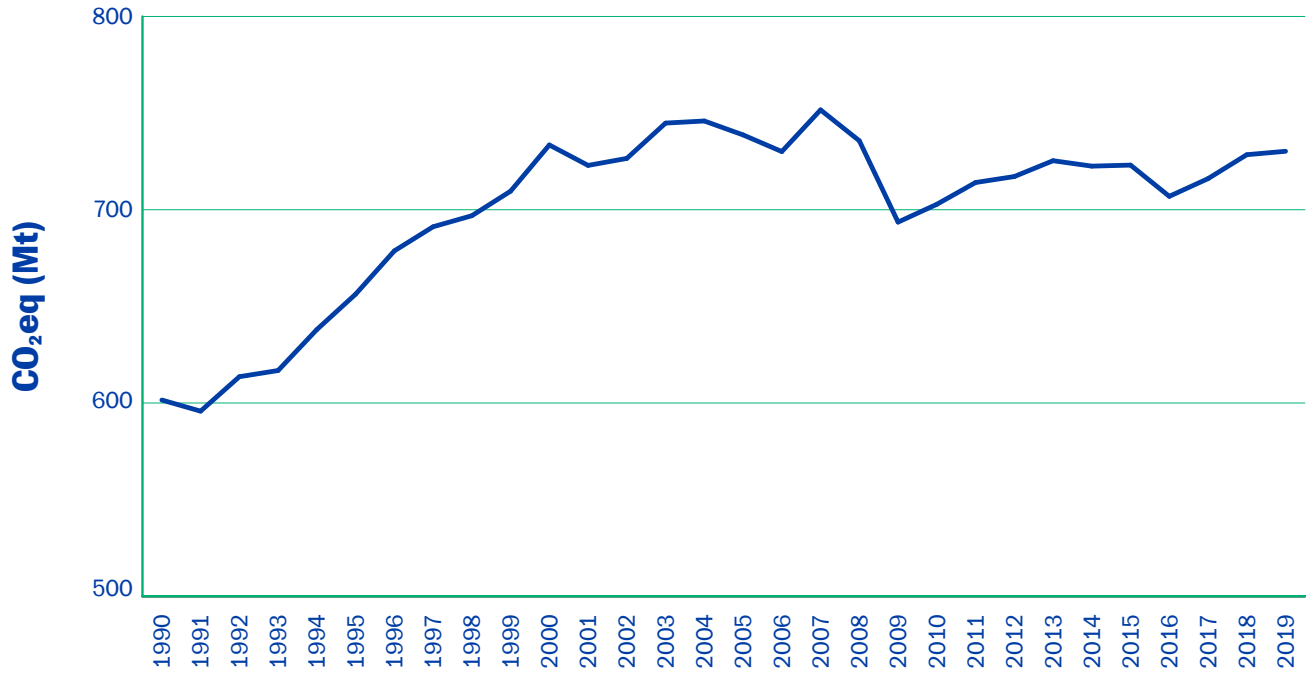
# Introduction

The extreme weather disasters that marked the summer of 2021 — heat waves and wildfires in Canada, excessive rainfall and flooding in other parts of the world — have offered a bracing reminder that warming trends continue to accelerate, even as governments convene this fall at the COP26 conference in Glasgow to negotiate new emission targets for 2030 and 2050. As the International Panel on Climate Change described the situation in its latest report, global warming is now a "code red" crisis.

## Canada's emissions over the past 30 years

*After a drop in emissions during the recession following the 2008 credit crisis, annual totals have been steadily rising, despite Canada's endorsement of the 2015 Paris Accord.*

**Source: Canada's Official Greenhouse Gas Inventory**

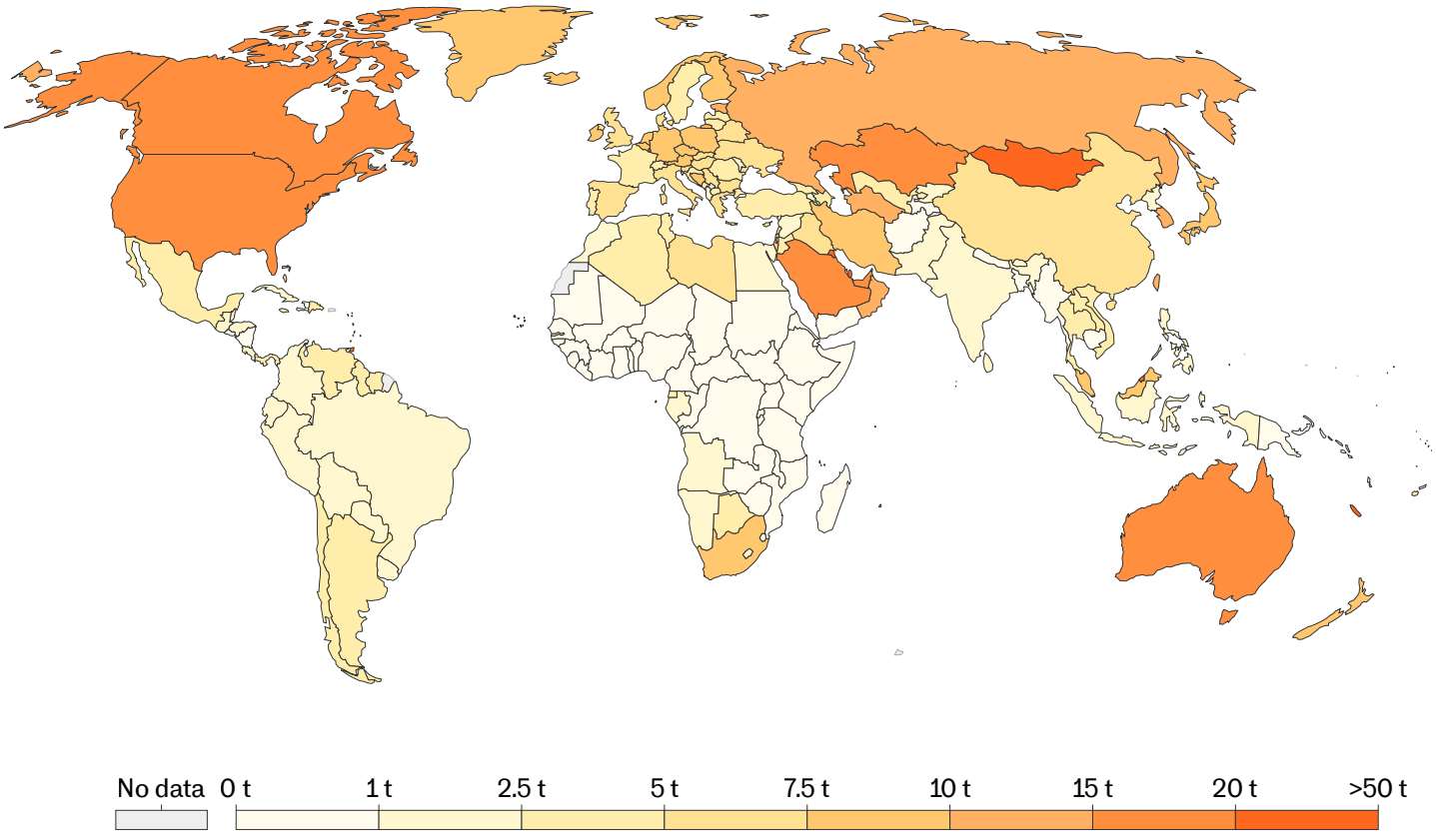



Canada has **committed** to reducing GHG emissions to 40 to 45 percent below 2005 levels by 2030, as well as pledging to move to net zero by 2050. Despite those targets, Canada still **lags behind most other G7 countries**. With per capita emissions of 15.5 tonnes of $CO_2e$ annually in 2018, Canada has one of the highest rates in the world, a figure well in excess of the OECD average of 8.8 tonnes, according to **World Bank data**. Three high-emissions sectors account for more than half of Canada's GHG emissions production: electricity, heat production and energy make up 36 percent; transportation represents 25 percent; and buildings 12 percent, based on 2019 data. **Globally**, the comparable data are electricity, heat production and other forms of energy (35 percent), transportation (14 percent) and buildings (6 percent).

# Per capita greenhouse gas emissions

*With per capita emissions of 15.5 tonnes of $CO_2e$ annually in 2018, Canada has one of the highest rates in the world and exceeds other countries with northern climates.*

**Source: Our World in Data**




With climate-related disruption accelerating, the time horizons for mitigation and reduction efforts have become more constrained, partly because they can now be measured against asset replacement and technology uptake cycles. In some high-emissions sectors — energy, utilities, transportation and heavy manufacturing — the pace of capital asset replacement is measured in decades, from 20 to 40 years for gas or nuclear power plants to more than a century for hydro-electric facilities. But for industries such as cement manufacturing, the phase-in of alternative materials or lower carbon variations is determined by the pace of change among end users, such as developers and municipal or regional governments.

Even in the automotive sector, the accelerating market acceptance of electric vehicles, while encouraging, won't produce a complete phase-out of internal combustion engines for at least 15 years — an adoption cycle that roughly mirrors global consumer acceptance of cellphones and then smartphones. Various U.S. states, such as California, have targeted 2035 as the end date for combustion engines, while **most EU nations** are aiming for 2030. And if electric vehicles are being charged from a grid that depends on fossil fuels, then they will still be contributing to emissions.

To achieve the necessary GHG reductions in only a few decades, the climate-tech innovations with the most potential need to be expanded massively and rapidly. Some focus on

new technology, like Carbon Engineering's pioneering system for filtering and then sequestering or recycling $CO_2$. Others draw on new applications for existing technologies. Flash Forest, for example, facilitates reforestation in remote logged areas and regions that have been damaged by forest fires through the use of digital mapping technology and unmanned aerial vehicles (UAV). Extract Energy, another company in the Mission from MaRS program, uses memory titanium alloys to capture and store ambient heat that can be subsequently recycled for residential applications. StormFisher builds and operates facilities that recycle food, water, energy and waste into renewable natural gases and organic-based fertilizers.

Scaling solutions like these requires significant capital investment but the need is urgent. ***The Economist*** recently added context to the scope of the challenge. "To stay on track for net zero by 2030, annual production of electric vehicles needs to be ten times higher than it was last year and the number of roadside charging stations 31 times bigger. The installed base of renewable-power generation needs to rise three-fold. Global mining firms may have to raise the annual production of critical minerals by 500%. Perhaps 2% of America's land will have to be blanketed in turbines and solar panels."

Because of Canada's very high per-capita emissions levels, it will be imperative that all orders of government, private sector emitters and investors move quickly to adopt and finance solutions with the greatest potential for scaling up. In the past, market forces and firm-level innovation drove capital allocations. Looking ahead, we need faster ways of predicting the viability of technologies that, when deployed at scale, will provide the most cost-effective emissions reductions in the most GHG-intensive sectors.

# Measuring potential

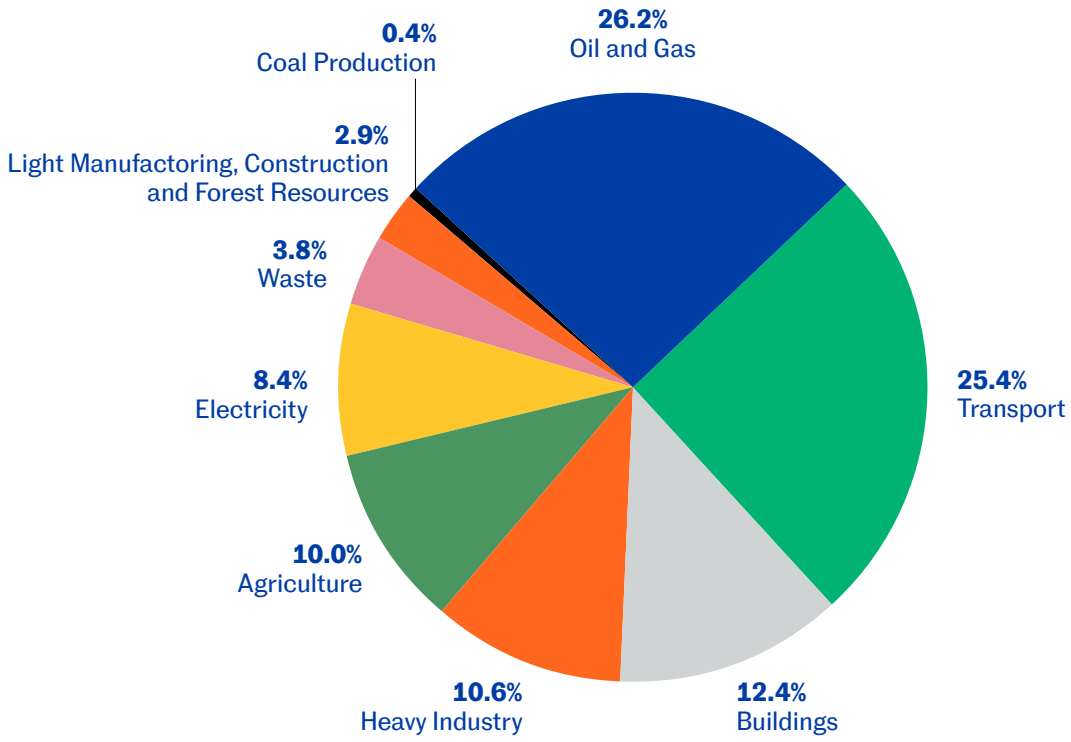
To make substantial inroads on carbon reduction, policy-makers and investors need to focus on commercially viable technologies that hold the greatest potential savings in sectors with the largest carbon footprints. The **Climate Impact Challenge** launched by Mission from MaRS earlier this year sought to identify, implement and scale Canadian climate-tech solutions with the highest potential to economically reduce GHG emissions. The goal is to eliminate barriers to adoption that prevent such solutions from scaling globally. After a national call for proposals, MaRS selected 36 ventures, then refined those entrants to 10 finalists last May (see list on next page). All focus on three carbon-intensive sectors — energy, real estate and transportation, which, combined, account for more than 70 percent of Canada's GHGs.

## Canada's greenhouse gas emissions

*More than 70 percent of Canada's emissions are attributable to activity in just three sectors: energy, transport and buildings.*

**Source: Canada's Official Greenhouse Gas Inventory**

### Source of GHG Emissions



# 10 Climate Champions

The finalists in the Mission from MaRS program.

## Energy sector:

**Carbon Engineering**: This B.C.-based "direct air capture" firm is building large-scale facilities for removing $CO_2$ from ambient air and trapping it below ground. It's also developing "ultra low-carbon" jet fuel, using water, air and renewable energy.

**Extract Energy**: The Cambridge, Ont.-based venture created a heat engine with memory titanium alloys that captures low-grade waste heat — affordable and emissions-free — for recycled power generation.

**Opus One Solutions**: An example of digital cleantech, Toronto-based Opus One has created a smart-grid software platform that integrates and optimizes renewable energy from wind and solar into the electrical system.

**StormFisher**: Based in London, Ont., the company recycles organics, water and waste energy to produce biogas for renewable natural gas distribution as well as organic fertilizer.

## Real estate sector:

**BrainBox AI**: Using cloud processing and machine learning tools, the Montreal firm's platform optimizes HVAC systems to minimize carbon emissions.

**Peak Power**: The Toronto company's AI-based software integrates in-building electricity sources, such as EV chargers and stationary batteries to reduce peak period demand.

**Stash Energy**: Headquartered in Fredericton N.B., Stash Energy has developed in-home, smart air-source heat pumps that store energy, reducing reliance on fossil fuel sources or electric baseboards.

## Transportation:

**Effenco**: The Montreal company's technology electrifies heavy-duty vehicles, like dump trucks, to support carbon reduction for fleets.

**Flash Forest**: Using drones and aerial-mapping technology, this Toronto company provides automated naturalized reforestation services to speed regeneration efforts.

**Pantonium**: An on-demand-based bus route optimization platform, Toronto-based Pantonium improves customer service, increases ridership, reduces operating costs and minimizes use of diesel fuel.

The 10 Mission from MaRS ventures all offer novel or innovative approaches with a strong emphasis on scalability. B.C.-based Carbon Engineering, for example, has developed a direct air capture (DAC) system that filters and then sequesters or recycles $CO_2$ from the air. A handful of small DAC plants in North America are currently demonstrating the viability of the technology. The International Energy Agency estimates that DAC, if scaled, could remove 10 million tonnes of $CO_2e$ from the atmosphere annually.

Founded by Harvard University physicist David Keith, Carbon Engineering is in the process of building two plants, in Texas and Scotland, with a potential savings of 1 million tonnes. Customers and investors include oil and gas companies that

can use the sequestered $CO_2$ to extract hard-to-recover energy from wells and reserves. “Even if all the other measures that we’re taking to avoid emissions, electric cars, renewable energy … succeed, you still need carbon removal,” Steve Oldham, CEO of Carbon Engineering, **told the BBC in June 2021**. “Direct air capture I think is going to be a significant part of the UK’s net zero plan.”

Other MfM firms draw on new applications for existing technologies. Flash Forest, for example, uses digital mapping technology and unmanned aerial vehicles (UAV) to develop and execute reforestation projects in remote regions. Traditionally, tree planting has been slow and labour intensive; the company says its approach, including the use of UAVs to plant up to 100,000 seed pods per day, can automate reforestation, providing new carbon sinks. Extract Energy has developed a heat pump using Shape Memory Alloys (SMA) to capture waste heat and convert it to clean electricity. Wasted energy is a sizable problem: currently, more than 60 percent of the energy produced worldwide is lost in the form of waste heat.

Still other MfM ventures use integrated software and hardware systems to optimize energy consumption and integrate new or untapped sources of clean power to the grid. Peak Power and Brainbox AI draw on technologies such as machine learning, IoT sensors, cloud analytics, energy storage, solar, and stationary batteries to create integrated platforms designed to find incremental energy savings or incorporate low-carbon power into grids. Because these technologies are digital and work using established business models (e.g. SaaS), they don’t require costly capital investments and may be scaled more quickly than other clean solutions. This is a critical feature, given the time constraints posed by global warming.

All 10 MfM ventures were selected on the basis of a modelling tool that projects the cumulative carbon reduction impact of their respective technologies when scaled to various market share levels. “What we were looking for was a tool that could accurately and reliably forecast or predict, to some degree, the potential for a company to reduce GHG emissions through their technology,” says **Jason Sukhram**, director of impact management and impact investing for MaRS. “What will happen if they scale their business over time, and what impact will that have on GHG emissions 10, 20, 30 years down the line. We needed a tool that is essentially going to help us forecast.”

The software MfM used for this evaluation process is known as **CRANE**, or Carbon Reduction Assessment for New Enterprises (see sidebar). Launched in 2019 by Prime Coalition, Rho AI, Greenometry, Clean Energy Trust and Project Drawdown, CRANE is an open-source modelling tool that aims to standardize data-driven climate impact assessments of early stage ventures. (The project is supported by The John D. and Catherine T. MacArthur Foundation, New York State Energy Research and Development Authority and Massachusetts Clean Energy Center, and draws on the expertise of an academic advisory board.)

## Climate impact assessment models

Climate modelling is a well-established feature of climate science, although there’s a wide variety of technical and econometric tools available. Those that pertain to individual firms tend to be retrospective, estimating the emissions generated by operations over time.

Prior to CRANE, however, there was no standardized method for estimating the potential climate impact of new ventures and the technologies, solutions, or business models they bring to market. While it is being continuously refined, the CRANE model doesn’t aspire to provide predictions about the market viability of individual ventures, but rather aims to characterize the potential trajectory of emerging technologies.

“In some cases, investors aspire to use the potential climate impact of a new venture as part of their decision-making process about whether or not to invest,” says Seth Sheldon, director of impact analytics at CRANE and co-founder of Rho AI. “For many, climate impact assessment is also important after making an investment for reporting purposes. And for some investors, they are merely seeking awareness.”

The use of impact modelling provides estimates of how a given technology, if scaled over time, will reduce carbon at various market share levels. “The key inputs in the CRANE tool are things like market penetration, target market, rate of growth,” says Sukhram. “We can actually plan for some scenarios and get a more accurate picture of what’s possible.”

The tool allows ventures to input a range of metrics and assumptions, such as anticipated market size, market penetration goals, geographic scale, time horizons, uncertainty levels, emissions generated by incumbent technologies and, in the case of novel or early stage ventures, proxy sectors whose performance and growth can be used to generate estimates. CRANE’s analytics also draws on a large data library that includes more granular information on sectoral GHGs, as well as the performance and market penetration of more established or older forms of clean technology. “We tried to keep it fairly simple,” Sukhram says, adding that companies were asked to validate their assumptions and provide supporting evidence for claims about market share and the effectiveness of their technology at reducing GHGs.

One of the market dynamics that CRANE aims to evaluate is the impact that newer cleantech solutions may have on more established ones, such as the potential of all-electric vehicles to eclipse gas-electric hybrids. “CRANE is based on the idea that you can compare two futures — one in which a technology has taken off and one in which it hasn’t,” says **Seth Sheldon**, director of impact analytics at CRANE and co-founder of Rho AI, an Ohio-based firm which began by generating strategic analytics for NASCAR teams. “The difference between those two futures is the ERP, or emissions reduction potential.”

Using the CRANE assessments of each of the selected technologies, MfM estimated that if these 10 ventures achieved 0.1 percent global market penetration, they could deliver a cumulative reduction of 42 Mts $CO_2e$, which is **approximately equivalent** to the yearly emissions produced by all residential space heating in Canadian homes. Canada’s annual emissions from all sources was 725 Mts, or about 2 percent of global totals, so the projected reductions delivered by the technologies developed by these 10 ventures represents a savings of almost 6 percent. The modelling further indicates that potential GHG reduction grows exponentially as market share increases, and the earlier these ventures can scale, the greater the reward.

## Finding a common measure

With more than $3 billion under management, BDC Capital serves as the leading strategic partner to Canada’s most innovative firms. BDC’s Cleantech Practice has invested more than $500 million in Canadian cleantech firms since 2018, making it one of the largest and most active Canadian investors of its kind. BDC has started to test the CRANE tool to forecast the impact the technologies developed by its portfolio companies will have on the climate. “The CRANE tool helps us measure the GHG emission reduction potential of an array of cross-sector technologies with a standard approach and rigour,” says Susan Rohac, vice president of the Cleantech Practice at BDC. “The adoption of a common tool across the industry would help by providing a common language and repeatable assessments of impact based on the same methodology.”

# Emissions Reduction Calculator

## Cumulative $CO_2e$ emissions reductions by year

| | 2030 | | | 2040 | | |
|---|---|---|---|---|---|---|
| | Market Penetration achieved in | | | Market Penetration achieved in | | |
| Market Penetration | 2028 | 2029 | 2030 | 2028 | 2029 | 2030 |
| **0.10%** | 232.57 Mt | 137.66 Mt | 190.80 Mt | 683.82 Mt | 662.48 Mt | 642.15 Mt |
| **0.25%** | 578.72 Mt | 527.24 Mt | 474.45 Mt | 1,709.52 Mt | 1,656.41 Mt | 1,603.39 Mt |
| **0.50%** | 1,159.80 Mt | 1,056.67 Mt | 949.54 Mt | 3,417.04 Mt | 3,309.92 Mt | 3,206.69 Mt |
| **0.75%** | 1,738.75 Mt | 1,582.51 Mt | 1,422.27 Mt | 5,125.60 Mt | 4,968.30 Mt | 4,810.10 Mt |
| **1.00%** | 2,319.70 Mt | 2,110.34 Mt | 1,898.99 Mt | 6,833.20 Mt | 6,624.80 Mt | 6,413.50 Mt |

**Source: Emissions Reduction Calculator**

At the individual firm level, reaching the 0.1 percent market share target used in the CRANE modelling is ambitious, but the reductions as a proportion of overall emissions remain modest. This interactive graphic, based on the CRANE data, demonstrates what the potential emissions reduction impacts could be cumulatively for some of the technologies within the MfM venture portfolio. The key variables for these technologies are how much of the global market share companies deploying them are able to reach, and how quickly they do so. If these technologies attained 1 percent global market share by 2040, it could reduce emissions by 420 Mts each year — about 60 percent of Canada's current annual GHG emissions. While this data does not necessarily represent the planned growth trajectories of the MfM companies, it nonetheless helps illustrate both the potential these technologies have in supporting the fight against climate change, and the urgent need for them to reach scale as quickly as possible.

## Getting to 1 percent

While a 1 percent global market share can seem like something requiring investments in numerous markets, in reality it depends on strategically investing in only a few key countries. The 19 countries and the EU that make up the G20 of advanced and developing economies collectively account for more than **80 percent of world GDP**. While market share varies greatly from sector to sector, roughly speaking, with the U.S. accounting for more than **15 percent of global GDP based on Purchasing Power Parity**, securing just a 6 percent market share there and in Canada could be enough to take a technology to more than 1 percent of the global market share, while investments in rapidly growing economies such as India could yield substantial market share in the long term.

# Challenges to scaling

The next step for the 10 ventures is scaling — a goal that requires a network of supporters. The MfM team is now in the process of assembling coalitions of investors, customers, partners, policy champions and other advisors around each of the finalists to help them grow quickly and sustainably.

All new technologies must defeat the inertia of incumbents in order to gain market, investor and policy acceptance, and this process is by no means linear. The example of the smartphone is instructive. The early 1980s breakup of telephone monopolies introduced competition, new entrants and an innovation dynamic that led to the introduction of cellular phone service. But the early evolution of the market required new regulatory systems, the deployment of network infrastructure, the presence of early adopters and disruptors, and massive product innovation as cellphones transformed into pocket-sized super-computers. But the market's maturation also turned on the resolution of impediments (creating interoperable international networks, for example), the emergence of attractive business and pricing models, and, ultimately, the displacement of predecessor telecommunications technologies that were clearly inferior, from the traditional landline phone to first-gen smartphones such as the BlackBerry. Cleantech solutions are still in the early stages of market adoption, but the potential for widespread uptake is clear given the smartphone's trajectory: Over the course of a few decades, this revolutionary device has become entrenched in our daily lives.

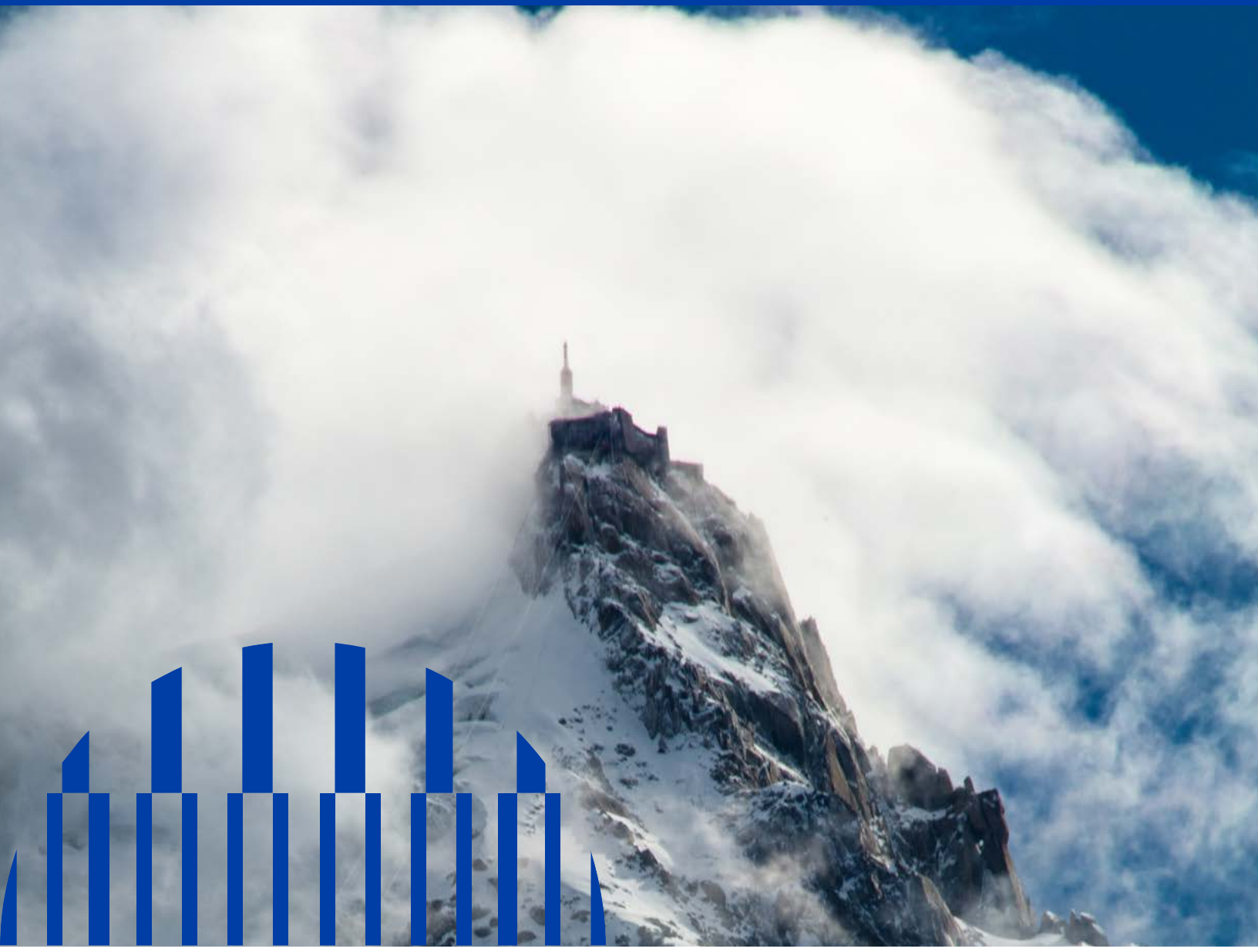
The CRANE evaluations of individual ventures offer a glimpse of a potential future for these technologies, but many other factors must fall into place in order for the 10 MfM firms to scale at the pace required to produce significant emissions savings. These include:

- the engagement of a range of investor classes, from early stage/patient to growth-oriented/strategic;
- the presence of flexible and ambitious regulatory regimes, from carbon pricing and carbon offset markets to the adoption of policy instruments that remove subsidies or market advantage for high-emission incumbents;
- the development of innovative business models that offer clear benefits to consumers or corporate/institutional customers, and which include the marketing of alternatives to business-as-usual approaches to functions like building energy management;
- the cultivation of forward-looking customers, both private and public sector, willing to take calculated risks on new/emerging technologies, such as electric heavy vehicles, drone-based reforestation programs, or the use of stationary batteries as a hedge against peak electricity prices;
- market development and promotional strategies that target regions with the optimal combination of investors, regulators and customers that enable ventures to transition from pilots or limited deployments to larger-scale commercial operations with mature business/pricing models that can be applied in other jurisdictions.

Ultimately, the scaling requirements will vary from firm to firm. For a cloud-based software venture like Pantonium, the primary driver of scale will come from the recruitment of transit agency customers and changing customer experiences about bus service. With others, like Carbon Engineering or BrainBox AI, scaling will be a function of substantial infusions of investor capital and external policy factors that impact the business model, like carbon pricing. By leveraging the collective expertise and resource networks of its MfM coalition, each venture will work to remove market barriers and develop plans for fast, sustainable growth.

# Case studies

Digital cleantech solutions, which use established business models (Software-as-a-Service, for instance), are often able to secure efficiencies within existing infrastructure. As they can also be deployed relatively quickly, these technologies can be a way to rapidly reduce emissions while longer-term capital investments are being made. These detailed profiles of three selected Mission from MaRS finalists feature insights about digital technology approaches, business models and commercialization successes to date.



CASE STUDY

# BrainBox AI

## Optimizing energy efficiency in buildings with data

**Focus:** building energy efficiency

**Solution:** AI-powered HVAC-control platform

**Customers:** BrainBox's clients include property managers and real estate companies. Because these technologies are digital and work using established business models (e.g. SaaS), they don't require costly capital investments and may be scaled more quickly than other clean solutions. This is a critical feature, given the time constraints posed by global warming.

**Potential impact:** A highly cost-effective AI-powered approach to improving major building mechanical systems offers property/asset managers significant opportunities to reduce carbon footprints without major capital outlays. Company estimates suggest it cuts a building's carbon emissions by up to 40 percent.

The typical approach to improving a building's energy efficiency is often capital intensive and time consuming: new cladding or windows, improved insulation, upgraded mechanical systems. Such retrofits are important, but there are also potential efficiencies to be had by optimizing existing infrastructure, and particularly HVAC systems, through better use of data.

Most HVAC controllers operate from an in-house server linked to sensors, such as thermostats, fan controls and occupancy monitors, installed throughout the building. Observes **BrainBox AI president Sam Ramadori**, "a 30-storey office tower could have as many as 15,000 devices continuously gathering data, but conventional HVAC control system computers overwrite all this critical information instead of analyzing and leveraging it."

Using a Software-as-a-Service (SaaS) business model, BrainBox collects and stores a building's HVAC data in the cloud, then uses AI and machine-learning algorithms to generate analytics to improve energy efficiency. Drawing on historical use patterns and outside data sources, such as exterior temperatures and building occupancy readings, the system can predict desired room temperatures up to six hours in advance with 99 percent accuracy, Ramadori says. In jurisdictions with time-of-use pricing, BrainBox's algorithm is designed to optimize for cost by constantly making micro-adjustments to heating or cooling levels.

Finally, when there's access to grid information about the operating status of low-carbon generating sources (wind, solar and other distributed energy resource or DER), BrainBox's platform is engineered to make adjustments to maximize their use. The company says its technology can improve workers' comfort levels by 60 percent while cutting a building's carbon emissions by 40 percent. BrainBox's software is used at more than 160 sites, including a Holiday Inn in Quebec **where it has slashed energy use in common areas by one-third**.

"When I saw the sheer impact of this technology, I just about fell off my chair," Ramadori told *The Globe and Mail* earlier this year. He joined the firm in 2019 after a career in the private equity sector, working with heavy industries such as manufacturing and pulp and paper. "In a pulp mill," he told ***The Globe and Mail***, "you're fighting to get efficiency improvements of like 2 percent, 3 percent. With this system, the technology achieves gains of 20, 30, 40 percent." Time Magazine included BrainBox's technology in its Best 100 inventions list for 2020.

Building-related emissions represent a formidable challenge in terms of carbon reduction efforts. When indirect emissions from upstream power generation are considered, buildings were responsible for 28 percent of global energy-related $CO_2$ emissions in 2019, according to the **International Energy Association**. In absolute terms, buildings-related $CO_2$ emissions reached an all-time high of 10 $GtCO_2$ in 2019.

Ramadori points out that a **2015 study by the U.S. government found** that HVAC systems in commercial or office complexes, malls and apartment blocks account for about half of all building-related carbon — a figure that equates to about 15 percent of all GHG emissions in the U.S. (Building emissions overall account for 40 percent of the U.S. total carbon output.)

The sheer scale of this problem demands rapidly scalable solutions, which explains why BrainBox's current clients can now be found in 18 countries worldwide. The company says its customers have reported 25 percent to 29 percent savings on energy bills by adopting BrainBox's algorithmic approach as opposed to more costly and time-consuming HVAC system retrofits. For example, GWL Realty Advisors installed the BrainBox system in a 300,000-square-foot office tower and a 500,000-square-foot residential building in Toronto. The technology yielded energy efficiency gains of 29 and 25 percent, respectively.

"We've seen great results in our pilot projects with BrainBox AI thus far, and are currently evaluating other assets where we can implement this technology," says Glenn Way, GWL's executive vice president and chief operating officer. The firm's largest client is Australian investment manager AMP Capital. BrainBox is fitting out AMP's entire real estate portfolio of about 40 office buildings, shopping centres and logistics facilities in Australia and New Zealand.

If the data-driven approach yields a 25 percent savings, he says, it translates into a reduction in GHGs globally of between 3 percent and 4 percent. (BrainBox's figures don't include small-scale residential properties.)

The efficiencies improve landlord margins, represent potential savings for their tenants and add capacity to local or regional electrical grids. "When you know the future, you can make better decisions," says Ramadori.

BrainBox works in **collaboration with research partners** including the U.S. **Department of Energy's National Renewable Energy Laboratory** (NREL), the **Institute for Data Valorization** (IVADO) as well as educational institutions including Montreal's **École de technologie supérieure** (ETS) and **McGill University**.

CASE STUDY

# Pantonium

## Using data to build a cleaner bus service

**Focus:** inefficient transit service

**Solution:** optimization software for flexible bus routing

**Customers:** transit agencies that operate buses

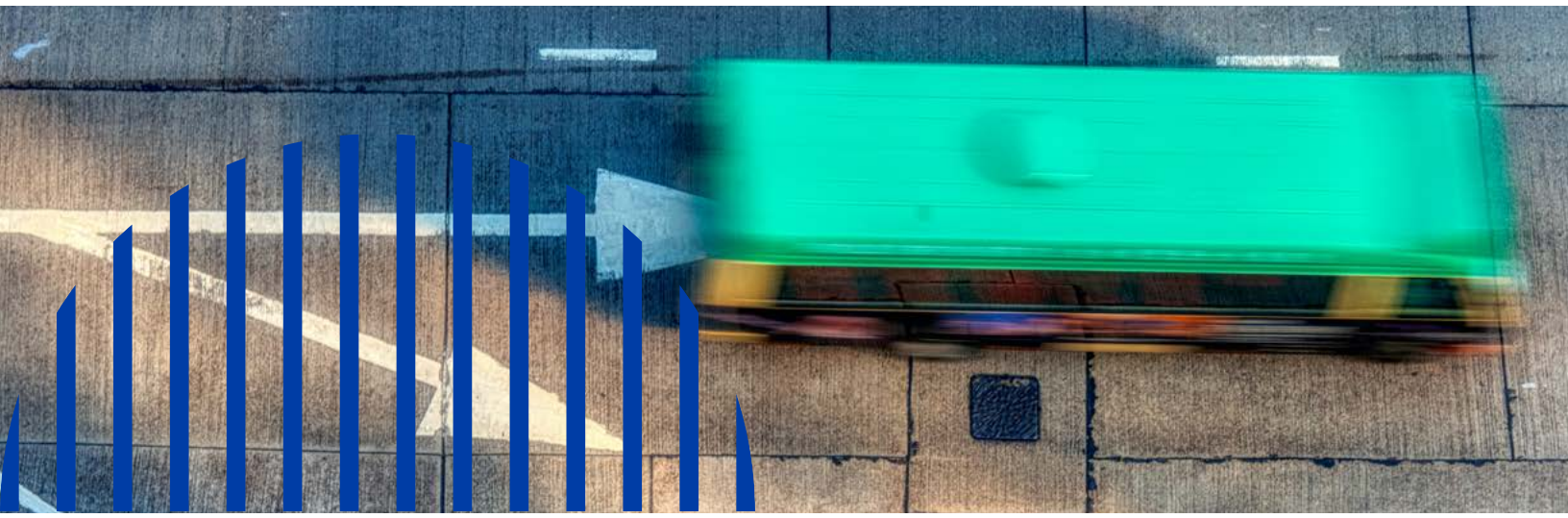
**Potential impact:** With technology that disrupts long-held approaches to municipal bus service in small to medium-sized cities, Pantonium's platform offers the potential to significantly improve transit usage in thousands of highly car-dependent, low-density communities. One bus service that adopted it reported a 300 percent increase in ridership, a need for fewer buses and reduced reliance on cars that likely avoided 650,000 kilo-tonnes of carbon dioxide emissions per year.

When transit agencies talk about greening their operations, most focus on the procurement of hybrid or fully electric buses, which are capital-intensive investments and can take many years to design, build and deliver. For instance, it will take **until 2027** for the City of Ottawa to take delivery of 450 electric buses, which is only half the overall fleet. But there are other ways to think about how transit agencies can further reduce emissions. One is to make use of real-time rider data and route optimization software to reduce travel times, increase convenience and as a result, provide more trips that might otherwise have taken place in a car.

Pantonium's founders have a background in logistics and decided to apply their operational insights from that sector to local bus service. "Transit intrigued us because the benefits — social, environmental and economic — are so significant," says **CEO Remi Desa**, who founded Pantonium in 2011 after spending four years as managing partner of a logistics firm.

In large urban centres with subway and LRT systems, transit ridership is typically high. But in more than 4,500 smaller cities in North America, transit ridership tends to be extremely low because the service is delivered entirely by buses running on fixed routes and fixed schedules.

Pantonium's platform, **developed with $2 million in seed funding from Sustainable Development Technology Canada (SDTC)**, introduces a completely different approach, with flexible routes that respond dynamically to customer demand. The app-based system allows riders to enter the beginning and end stops on their journey, along with a desired arrival time. (Pantonium's system is technology neutral and can be accessed via smartphone app, web portal or phone.) The back end, in turn, optimizes the routes, based on inputs such as vehicle location, capacity and the cost-effectiveness of the trip in terms of mileage. "Every time I go to a bus stop, it's a cost," says Desa. By eliminating unnecessary stops,



agencies can deliver service with fewer buses, typically one-third to half the number of vehicles in a conventional fleet. The reason? “The bus only stops where it needs to stop,” he says.

Early trials have shown highly positive results. In Belleville, Ont., an eight-bus service has seen a 300-percent increase in ridership, from between six and eight passengers per hour per bus to 20 to 30. The optimization software, moreover, has allowed the city to run only four buses, even as it provides improved service to passengers. Desa says that emissions modelling demonstrated that the increased ridership has translated into reduced car use in Belleville, avoiding 650,000 kilotonnes of carbon dioxide emissions per year.

In Stratford, Ont., the average Saturday driving distance for the city’s six-bus fleet dropped from 2,200 km to 720 km when it switched from fixed route to Patonium’s on-demand service, according to a report in the ***Stratford Beacon Herald***. “For the majority of people, this is a quicker way of getting where you need to go,” transit manager Mike Mousley said. “It puts customers in control of transit. You’re not waiting for a transit schedule — it’s your schedule.”

The company’s platform has also been adopted successfully in regions in the U.S., such as central and northwest Arkansas, and regional centres like Little Rock, Rogers and Bentonville, where Walmart’s head office is located. Joel Gardner, executive director of Ozark Regional Transit, **told the *Arkansas Democrat Gazette*** in July that the service in Rogers was meeting demand “very, very well.” The agency started using Pantonium in mid-2020.

The platform produces a virtuous circle familiar to transit planners, with increased convenience leading to more ridership, lower vehicle emissions and additional fare revenues that local transit agencies can use to help finance the greening of their bus fleets.

Pantonium was selected this year as one of 24 semi-finalists for the **GS Beyond Energy Innovation Challenge**, an annual competition hosted by San Francisco-based Cleantech.org.

CASE STUDY

# Peak Power Energy

## Reducing building emissions with distributed energy resources and AI

**Focus:** tapping electricity storage in buildings

**Solution:** AI-driven platform combined with EV chargers and stationary batteries

**Customers:** property managers and real estate companies

**Potential impact:** The company's business model offers property/asset managers an opportunity to both reduce building carbon and sell surplus clean power into the local grid, effectively transforming urban built form into a net provider of low-carbon electricity.

Peak Power Energy's software allows property managers to use their own buildings as backup batteries that they can harness to improve efficiency, cut cost and generate revenue. Imran Noorani, the company's chief strategy officer, points out that in the real estate sector, GHG reductions can be achieved through digital systems that enable property management companies to forgo coal- and gas-based energy and draw on electricity storage devices, such as stationary batteries, installed in their buildings.

Peak Power's platform, known as SynergyTM, knits together three types of batteries to achieve grid benefits that can be used to offset consumption. These include stationary batteries, EV batteries with bi-directional chargers, and "synthetic" batteries, which are controlled by algorithms that optimize the way buildings consume energy during peak periods. The technology provides cost savings for its customers and also reduces pressure on the wider grid, thus preventing utilities from drawing on sources such as coal or gas. Aggregated across a portfolio of assets, Noorani says, "there's a huge environmental benefit."

The firm describes its business model as "Energy Storage as a Service" (ESaaS), and characterizes its approach as a "virtual power plant" — an integrated combination of energy optimization and energy storage systems within a building or portfolio that can be activated during peak periods to reduce both costs and pressure on the broader electrical grid.

The company's software can also be connected to the Independent Ontario System Operator (IESO) so it responds to "grid events," like high load periods. In other words, beyond just shifting around internal energy systems, as happens with conventional time-of-use demand management software, Peak Power's platform is designed to sell electricity back into the wider grid if it can access surpluses within its customers' portfolios, thus providing a revenue stream for building owners. The system uses AI, but still allows the property managers of each building to make adjustments based on their tenants' needs.

The target market includes real estate investment trusts and asset managers with large property portfolios. One of Peak Power's strategic partners is Osmington Inc., the real estate arm of the Thomson empire. Its flagship energy system has been installed in the **Thomson head office** in downtown Toronto since 2017, and uses a combination of electric vehicle charging stations and on-site energy storage devices to reduce the building's peak-period demand charges. Data from the firm's client base suggests savings of 15 percent to 20 percent.

In 2017, the company also received a $1.9 million SDTC grant to scale up its technology on six sites in Ontario and New York state. The overall value of those projects was $5.4 million, with the balance of the investment provided by its consortium partners: BGIS, a Brookfield Company, **Black & McDonald**, Alectra and **National Research Council Canada**.

In January 2020, Peak Power installed its platform on eight office buildings in Toronto, all of which had all three types of batteries. The trial included 11 EVs, storage batteries in all the buildings and a network of IoT sensors deployed across the portfolio to detect and optimize ongoing electricity consumption. The project was supported with a $7.6-million federal economic development grant.

Company officials expect that market adoption of electric vehicles, whose batteries represent an important source of latent electricity supply, will provide further opportunities. Noorani points to IESO forecasts for EV growth to illustrate Peak Power's potential: By 2030, the grid will likely support 700,000 EVs, which collectively could provide 7 GW of flexible and on-demand capacity to the grid, offsetting the need for dirtier natural gas plant expansions.

He adds that the market potential for tapping latent capacity in the U.S. is even greater due to **FERC 2222**, which requires electrical utilities to allow EVs, building batteries and other DERs to be connected to the wider grid.

The regulation has opened markets in the U.S. "In the **Brooklyn-Queen's Demand Management** (BQDM) program," Noorani says, "Con Edison had initially projected an estimated cost of U.S.$1 billion to build new distribution substations and infrastructure to meet projected demand. ConEd sourced non-traditional technologies to unlock the needed capacity via the BQDM program, with a budgeted cost of $200 million to unlock 69MW of latent flexibility [at] 20 percent of the cost of traditional solutions." The company is also working on projects in Westchester County and San Diego.

There's no comparable regulation in Canada, although Noorani adds that in Ontario's York Region, **local utility Alectra, Natural Resources Canada and the IESO** are testing the "Non-Wires Alternative" to examine the potential of DERs. In his view, the latent economic potential in traditional electric grids could deliver gains in both carbon reduction efforts and opportunities for cleantech innovators. "We have one of the best innovation sectors in clean tech," he says. "Where Canada really falls short is in commercializing those companies."

# Conclusion

As climate change horizons grow ever tighter, climate advocates are focusing on rapidly scalable solutions, some of which involve the rollout of powerfully disruptive analytics platforms and others that rely on engineering innovations, such as DAC.

In the policy context, concepts like “momentum,” “exponential scaling” and “pace” have gained in importance. With little margin for error, investors, entrepreneurs and policy-makers need better tools in order to make bets that produce innovation and emissions reduction at scale. Massive change is clearly needed to mitigate the devastating effects of our changing climate. The sooner these cleantech solutions can scale, the faster they’ll produce the deep reductions we require.

# Report contributors

Mission from MaRS: Climate Impact Challenge has received generous donations from its founding funders: HSBC, RBC Foundation, Trottier Family Foundation and Thistledown Foundation. Program donors and partners also include Peter Gilgan Foundation, Business Development Bank of Canada (BDC), Export Development Canada (EDC) and Mitsubishi Corporation (Americas).

For more information on Mission from MaRS: Climate Impact Challenge, visit **www.missionfrommars.ca**.

**Writer**
John Lorinc

**Art Direction**
The Workhouse

**Policy Analyst**
Thomas Goldsmith

**Program Managers**
Andy Lam and Irene Lam

**Data Analyst**
Nigel Biggar

**Interactive Designer**
Andrea Teolis

**Editors**
Carol Toller and
Kathryn Hayward

**Program Lead**
Tyler Hamilton