VIA SEPARATIONS

Transforming Industrial Manufacturing: Via Separations Delivers Energy-Efficient Process Intensification

December 2024

Filtration for the Future of Industry

2,500+	Hours of commercial operation
76%	Reduction in energy
1 Ton	Carbon avoided every 80 mins
$10mm+	Value creation per facility annually *(cost savings and debottlenecking)*
8 Miles	Of GO membrane material
0%	Yield loss

30% of U.S. emissions come from industrial manufacturing: cement for buildings, steel for cars, paper for packaging, and a broad, multifaceted chemical sector[1].

But such commodity products are typically unwilling and/or unable to support green premiums[2]. There are few decarbonized solutions that are financially attractive to manufacturers, and even fewer that do not require policy levers to drive value.

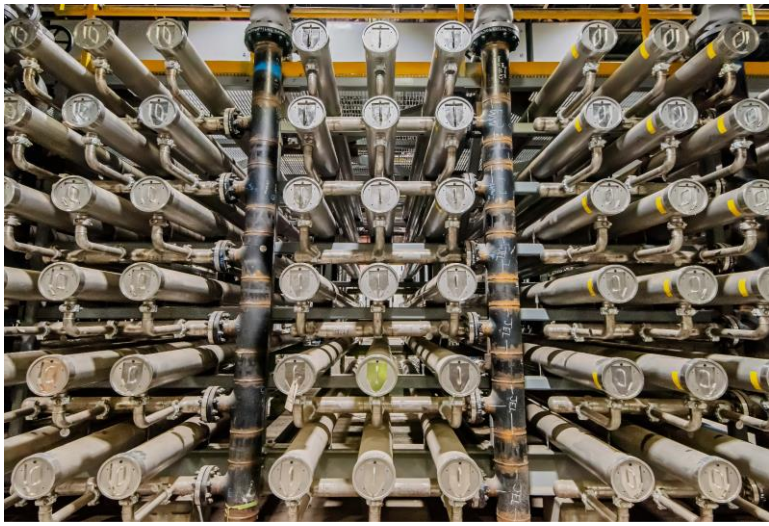
Via Separations has delivered a product that improves the financial performance of a manufacturing facility while simultaneously decarbonizing the operation, with no green premium decarbonizing operations.

Separation processes in the manufacturing of goods driven by industrial heat (evaporators and distillation columns) account for more U.S. emissions than cement, lime, iron, and steel combined[3]. Globally, **separations account for 10-15% of carbon emissions**[4] and up to **70% of the cost of producing a raw material or chemical**[5].

Via Separations was founded to create operational value for industrial customers while simultaneously decarbonizing their operations. Via augments and replaces existing evaporator or distillation column infrastructure and decarbonizes through both energy efficiency and electrification. **By offering chemical savings, equipment stability improvements, production increases, and up to 90% energy savings,** sites benefit from process intensification that aligns with financial objectives.

In 2024, Via **delivered its first-of-a-kind (FOAK) commercial project** to the pulp & paper industry, providing washing and production benefits to International Paper's Grande Prairie facility. Grande Prairie produces 380,000 air dry tons (ADT) of Northern Bleached Softwood Kraft (NBSK) pulp per year and directly employs 400 people. NBSK is primarily used in tissue and towel manufacturing. The FOAK Via system processes more than 20% of the mill's black liquor, a valuable byproduct of the manufacturing process that is leveraged for re-use in manufacturing.

Construction of **Via's first facility was completed in 10 months**. The system – consisting of over 600 membrane modules – was integrated into the customer's manufacturing plant with **no downtime, has now surpassed 2,500 hours of operation and encountered a 0% yield loss in the 100 million times scale up** of the novel membrane technology.

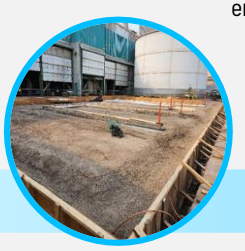


1. U.S. EPA
2. A "Green Premium" is the additional cost of choosing a clean technology over one that emits more greenhouse gases
3. U.S. EIA, LBNL, ORNL, EERE, EPA, USDA, & Royal Society
4. Sholl, D.S., Lively, R.P.; Seven Chemical Separations to Save the World. Nature 2016, 532, 435-437
5. Humphrey J. and Keller G., Separation Process Technology, New York: McGraw-Hill, 1997

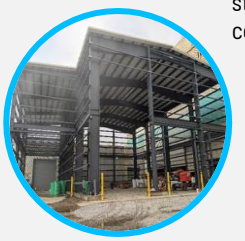
Proven Value, Delivered Today

The value drivers for mechanical separation enable up to a 5-10% increase in corporate EBIDTA when implemented across a pulp & paper manufacturer's portfolio. Here, we share these opportunities quantified from data from the first six months of operation at scale. The data included herein is real, observed performance from the Via system, but economic numbers have been generalized based on industry averages and do not communicate any statements or insights about International Paper's operations at Grande Prairie or generally.

June
Broke ground (project approved in March 2023)



July
Established initial foundation



August
Street support erected

September
Building structure complete

October
Initial tanks arrive on site

November
Construction of membrane housings

December
Arrival of major equipment on site

2023

January
Made final electrical connections

February
Commissioning subsystems

March
Mechanical completion

April
Commissioning and start of operations

2024

This FOAK plant represents the largest implementation of membrane technology in industrial environments outside of the food & beverage and water purification & treatment sectors. Combining lessons of project delivery, the benefits of mechanical separations, and the novel material platform first discovered at MIT, Via Separations has achieved meaningful commercial scale.

Figure 1: The implementation of membranes in IP-GP's facility represents a 100,000,000 scale up in the technology and fully retires technical risk.

Via Separations integrates into existing pulp manufacturing facilities between the washers and the evaporators, increasing the concentration solids of the black liquor and reducing the subsequent steam demand for evaporation, the chemical demand for the washers, and increasing the stability and production of the evaporators. In the case of Grande Prairie, Via processes a slip stream, but can also integrate into the full stream. Figure 2 illustrates the process flow integration.

Pulp Mill Flow Diagram

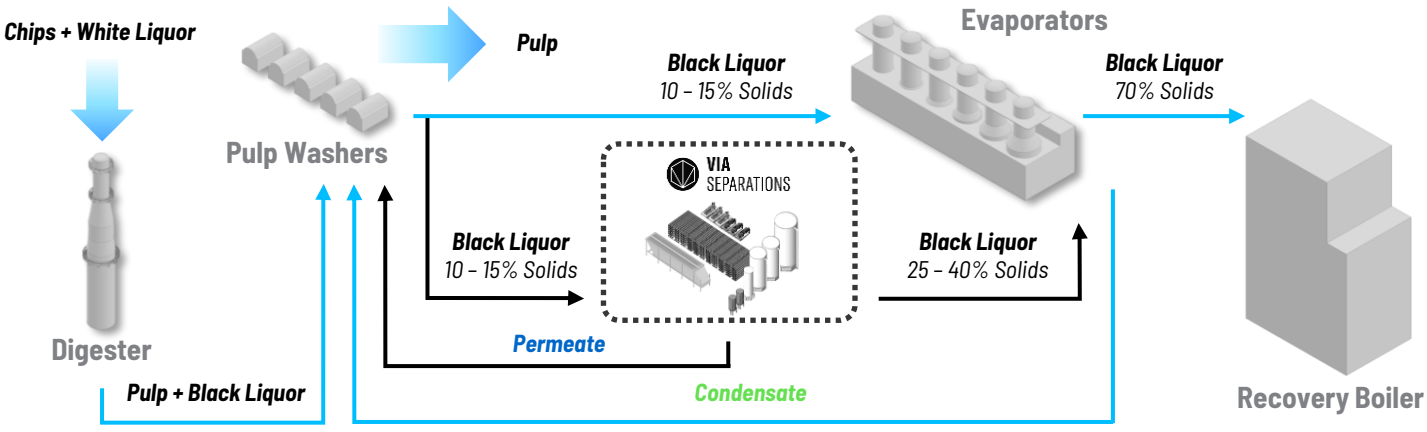


Figure 2: Via integrates into existing pulp mill operations, delivering value without any downtime for installation or major retrofits of existing equipment.

Separating Out Savings

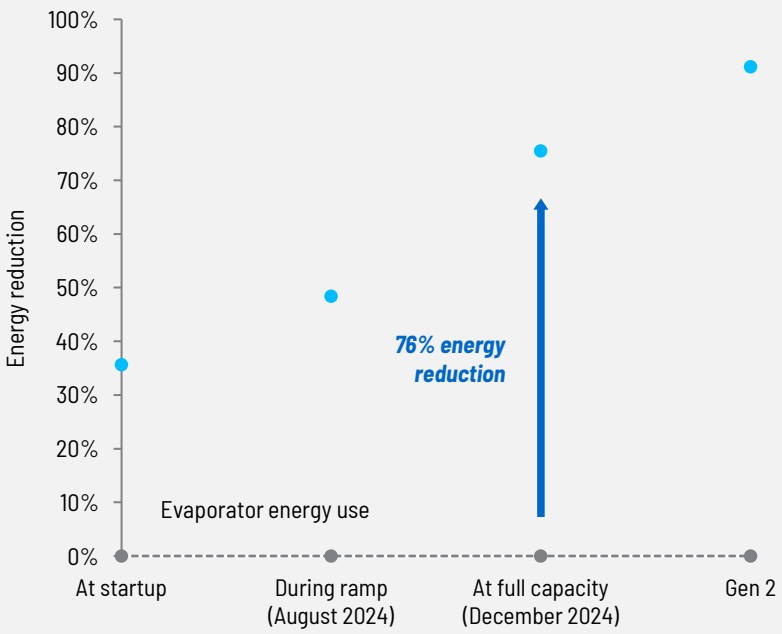


Figure 3: Via delivers a 76% energy reduction in commercial operation as compared to an average North American evaporator with a median lifetime of 44 years and a steam economy of 4.25 lbs of water evaporated per lb of steam supplied.

A ***Energy Savings***

Via delivers a 76% reduction in energy consumption compared to the incumbent evaporators. This figure already nets any reductions in power generation associated with reduced steam load. Energy consumption is measured as a specific energy per gallon of clean water removed (kWh/gal) including auxiliary systems and is compared to the thermal energy required to operate the evaporators. This dramatic energy reduction is possible because Via eliminates the need to drive a phase change in the fluid using heat. Via Separations' membrane system uses electricity as the driving force (pressure) at a significantly reduced load than the thermal alternative.

The North American evaporator fleet is primarily composed of evaporators nearing end of life (median age 44 years) with a typical steam economy of 4.25 pounds (lbs) of water evaporated per lb of steam supplied[5]. Grande Prairie installed a new set of evaporators in 2011[6], and as a result, they are more energy efficient than the average North American evaporator. Despite this, Via has demonstrated >70% energy savings per gallon of clean water produced.

The Gen 2 implementation of Via's membrane technology will further reduce system energy consumption by delivering throughput increases in the graphene oxide membranes. It will represent a 90% reduction in total energy consumption relative to evaporation.

5. Cantrell, J.G.; Black liquor evaporator upgrades— life cycle cost analysis. TAPPI Journal March 2021, Vol. 20 No. 3, 208-221
6. Pulp & Paper Canada, https://www.pulpandpapercanada.com/evaporator-for-grande-prairie-completes-mill-upgrades-1000725530/

B *Chemical Savings*

An alternative mechanism to leverage the operational benefits of membrane performance is to maintain the evaporator load, but increase the amount of water used in pulp washing to reduce chemical consumption. The additional water removal capacity from the membrane system is used to optimize the washing process; the energy per unit of water removed is reduced, but the amount of water is increased so that the total energy consumption remains relatively unchanged. **In effect, this implementation converts Scope 1 emissions savings to Scope 3 emissions savings, and, at 2024 natural gas prices, often has a more attractive cost benefit to mills in the U.S.**

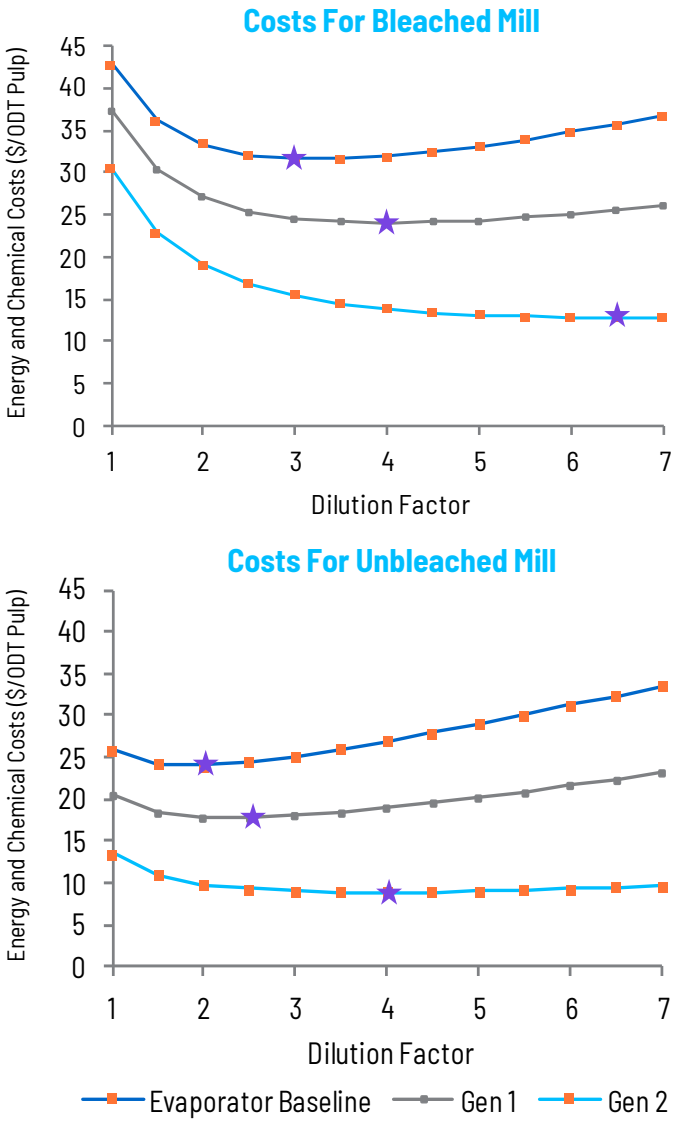


Figure 4: Total energy and chemical costs for washing of pulp and concentration of weak black liquor to 50% solids for a typical bleached (left) and unbleached (right) mill as defined in Rivera et al[7]. The minimum cost is marked with a star. Introduction of lower cost concentration increases the most economic dilution factor for both mill classes.

The impact of this effect can be quantified by analysis of the optimum amount of water the mill should use to clean the pulp. This is represented by the net amount of water per ton of pulp added during washing, defined as the dilution factor. Increasing the dilution factor increases the required amount of water removal by a Via system or an evaporator set, while reducing the dilution factor increases the chemical costs to the mill for bleaching and makeup. The minimum costs associated with these steps thus defines the optimum dilution factor for mill operation. Utilizing the methodology published by Rivera et al.[7] and updated to reflect typical energy prices for delivered gas and electricity to a U.S. pulp mill ($6.50/MMBTU and $45/MWh, respectively), the impact of the measured performance of the Via system on washing economics can be calculated.

The specific energy consumption for the FOAK at full capacity shifts the ideal dilution factor from 3 to 4 in a bleached mill (such as Grande Prairie) and 2 to 2.5 in an unbleached mill in this analysis. This generates savings of $7.60 and $6.30 per oven dry ton (ODT) of pulp, respectively. Implementation of Gen 2 systems pushes the anticipated savings for bleached and unbleached mills to $18.50 and $15.20 per ton, respectively, or $13.1 million and $10.7 million annually for a 2,000 ton/day mill at full scale. Gen 2 will offer further financial benefits, as illustrated in the figures. *All dollar values are expressed in USD.*

The basis for this analysis was first published by Via in TAPPI Journal in 2021. It has been updated here to reflect observed data.

7. Rivera et al.; Addressing production bottlenecks and brownstock washer optimization via a membrane concentration system. TAPPI Journal July 2021, Vol. 20 No. 7, 467-478

C *Evaporator Stability*

Facility upsets and associated downtime often result in low solids flow entering the evaporator, which translates into instabilities and lost production. Though these may occur only a couple of times per year, they can represent a substantial amount of lost revenue with negative implications for facility margins. Inherent in the membrane system design is increased output during low solids events; the permeate (clean water) output at low solids is demonstrably higher than at high solids, delivering water removal when the facility needs it the most. **With observed data summarized in Figure 3, the mill can translate the 93% boost in membrane production into accelerating the facility startup or recovery from an upset.**

For a typical 2,000 ADT/day mill, a slowdown of 20% costs the mill roughly $700,000 per week.

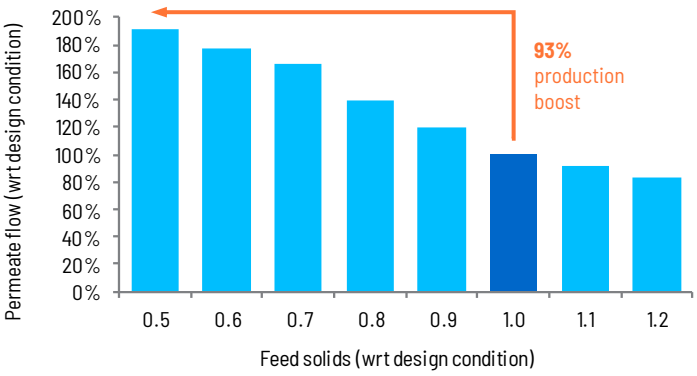


Figure 5: Via produces up to 93% more permeate flow during low solids events.

D *Production Debottlenecking*

When a facility is seeking to produce additional tons of product – whether below or above nameplate capacity – **water removal can be partially or fully leveraged for pulp production to drive revenue increases.** The table below illustrates the marginal net revenue uplift for allocating permeate production to debottlenecking. For this analysis, a marginal value of $250/ton was used to predict the approximate net revenue uplift.

When utilized in this manner, Via Separations enables a conversion of absolute Scope 1 emissions reduction (energy savings) to biogenic emissions (recovery boiler) and Scope 2 emissions reduction (chemical savings/washer optimization).

Permeate Production (gallons per minute)	**Pulp Production** (tons per day)	**Marginal Net Revenue Uplift** (dollars per year)
33	20	$1.8mm
80	50	$4.5mm
130	80	$7.2mm
250	150	$13.5mm

Table 1: System capacity (permeate production) allocated to debottlenecking and the associated marginal net revenue uplifts.

E *Decarbonization*

A system the size of Via's Grande Prairie installation avoids one ton of fossil fuel CO_2 every 80 minutes, or 6,500 metric tons per year. To date, assuming a biogenic or renewable source of electricity and full turndown of the evaporators, the project has displaced >600 tons of CO_2, equivalent to 1.6 billion 'miles driven by gas powered vehicles[8].

F *System Performance*

Via's black liquor concentration system is successfully meeting specific intermediate key performance indicators. Two of these – throughput and quality – are illustrated below.

Throughput

System performance is a culmination of over a dozen membrane parameters, but one of the most significant drivers of capital and operating cost is throughput. The graph below illustrates expected and actual performance of membrane throughput for the 540 graphene oxide membranes representing over 8 miles of material, normalized for confidentiality. The fluctuations in throughput through the first two months of operation represent system tuning and optimization, further variation is a result of fluctuations in feed solids. Across the entirety of the range average throughput was 37% higher than the initial design target.

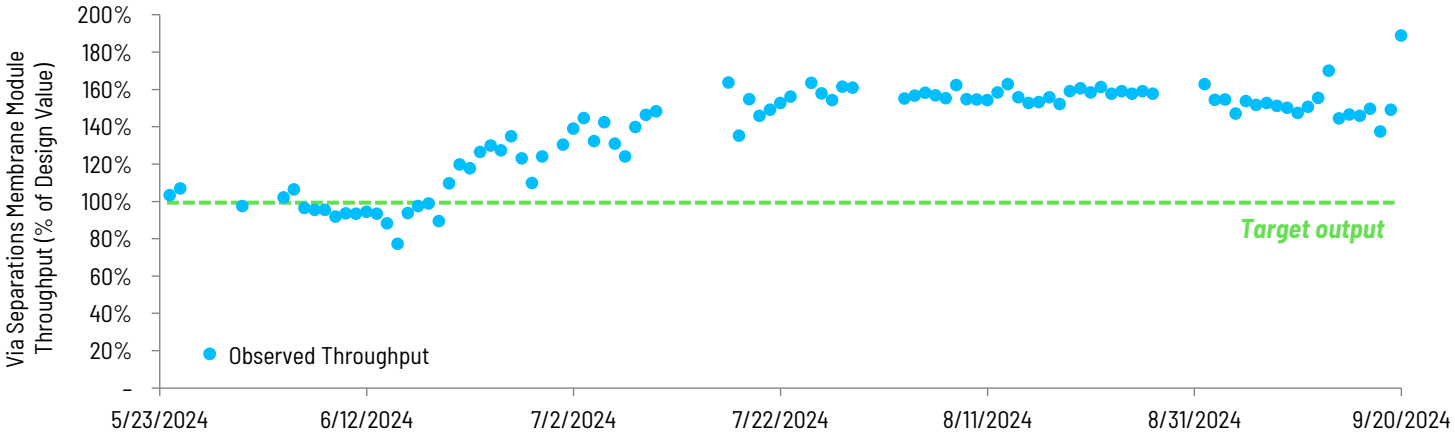


Figure 6: Observed throughput of graphene oxide membranes is exceeding the targeted output. Variability is due to variability in the feed solids.

Quality

The quality of the separated, clean water, or permeate, is critical for its reuse in the mill's process. Via has ensured the system can automatically respond (divert) should the quality of the permeate exceed design specification. The graph below shows the raw data for conductivity, which is used to measure the quality of the output. The shaded white regions are due to errors with the instrumentation. Minor excursions past the threshold can also be observed, quickly returning to within specification automatically without affecting mill operations.

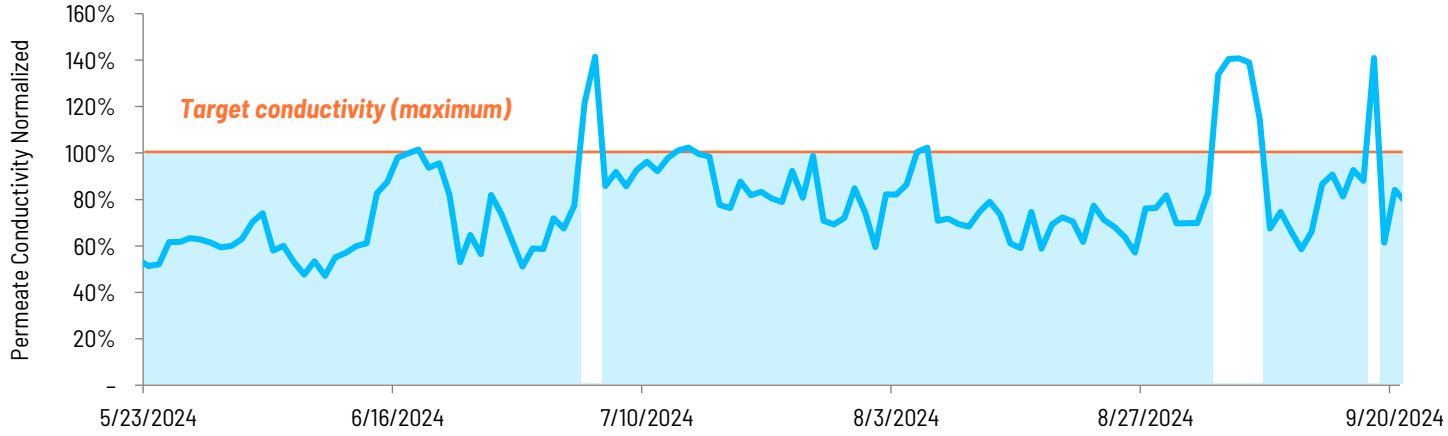


Figure 7: Observed conductivity consistently meets customer quality specs since day 1 of operations (normalized for confidentiality).

8. U.S. EPA GHG Equivalencies calculator

The First of Many of a Kind

In September 2024, joined by representatives from International Paper & Natural Resources Canada, Via hosted a ribbon cutting in Grande Prairie. Building on this success, Via has three new products under development in adjacent sectors, and an inbound pipeline in pulp & paper, chemicals, and fuels. The industrial sector's demand for process intensification will drive the company's climate impact.

Achieving scale is critical for the growth of all climate technology businesses, and the burden of proof for demonstration in the industrial sector is particularly high. Frequently referred to as the "Climate Valley of Death", the challenges scaling up include financing, transition of company focus, and customer offtakes. In delivering this project, Via has successfully productized a revolutionary technology developed in an academic lab in seven years with support from venture capital investors like Engine Ventures, NGP, Safar Partners and Prime Impact Fund, industry partners such as the Biorenewable Development Consortium (BDC), accelerators such as Greentown Labs, and government programs including the U.S. Department of Energy ARPA-E (DOE), MassCEC Catalyst, NSF Seed Fund and Natural Resources Canada IFIT (NRCan).

In closing, we are not stopping here. Via is tackling the 700+ million metric ton (MMT) annual emission reduction opportunity across industrial manufacturing because we believe that growth and sustainability are not in conflict. We dare to acknowledge that the things we need should not come at the expense of the climate and that decarbonizing the hardest to abate sectors is both our responsibility, and opportunity.

For more information about our products and services,
please visit www.viaseparations.com or reach out to info@viaseparations.com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