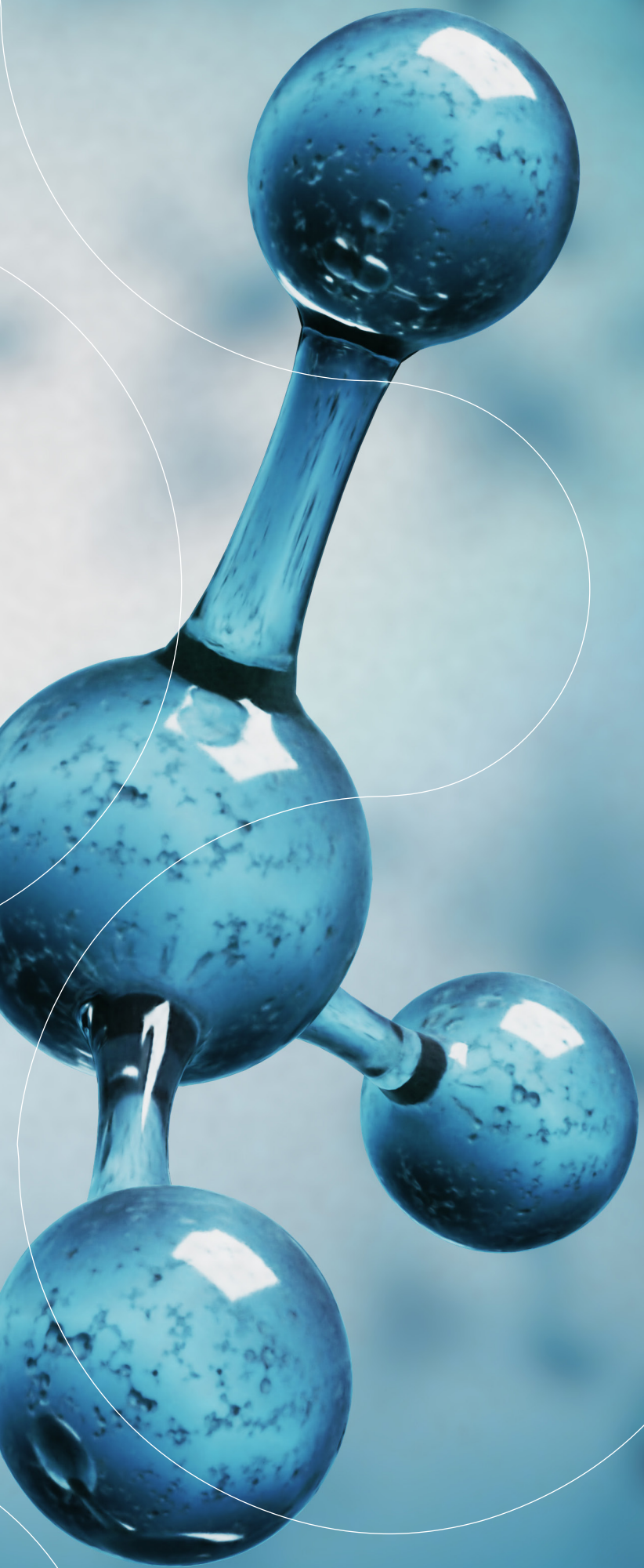


PRIMA

Advanced Materials Moving Forward

ADVANCED

Materials
Quebec Innovation in Action

May 2024

ADVANCED MATERIALS: A SOURCE OF INNOVATION FOR QUEBEC IN A CHANGING WORLD

While advanced materials remain little known to the general public, they represent an essential source of innovation in Quebec. The remarkable and often revolutionary properties associated with these alloys, polymers, nanomaterials and membranes are constantly pushing the boundaries of what is possible.

These materials are at the heart of several key sectors in Quebec. The province continues to stand out in renewable energy, the electrification of transportation and clean technologies, along with innovations in health and life sciences, all of which represent key sectors for the future. Advanced materials also play a pivotal role in niche markets that help Quebec position itself on the world stage, including artificial intelligence, aerospace and aluminum production.

PRIMA Québec is proud to bring together the forces that drive the advanced materials industry by providing an essential link to our evolving world.

2024 UPDATE

Since the publication of the last two editions of this study by E&B Data, PRIMA Québec has identified new companies that actively work in the advanced materials sector, including start-ups. To some degree, the 2018 and 2021 editions did not fully appreciate the number of companies involved. As a result, the aggregate estimates for employment and sales figures appeared lower than the actual figures.

This document uses the same conventions as those used in the previous studies, particularly in terms of company stratification by size. However, very large companies with more than 1,000 employees have been treated separately, since their contribution to employment and sales figures outweigh that of most companies (95%) working in this sector.

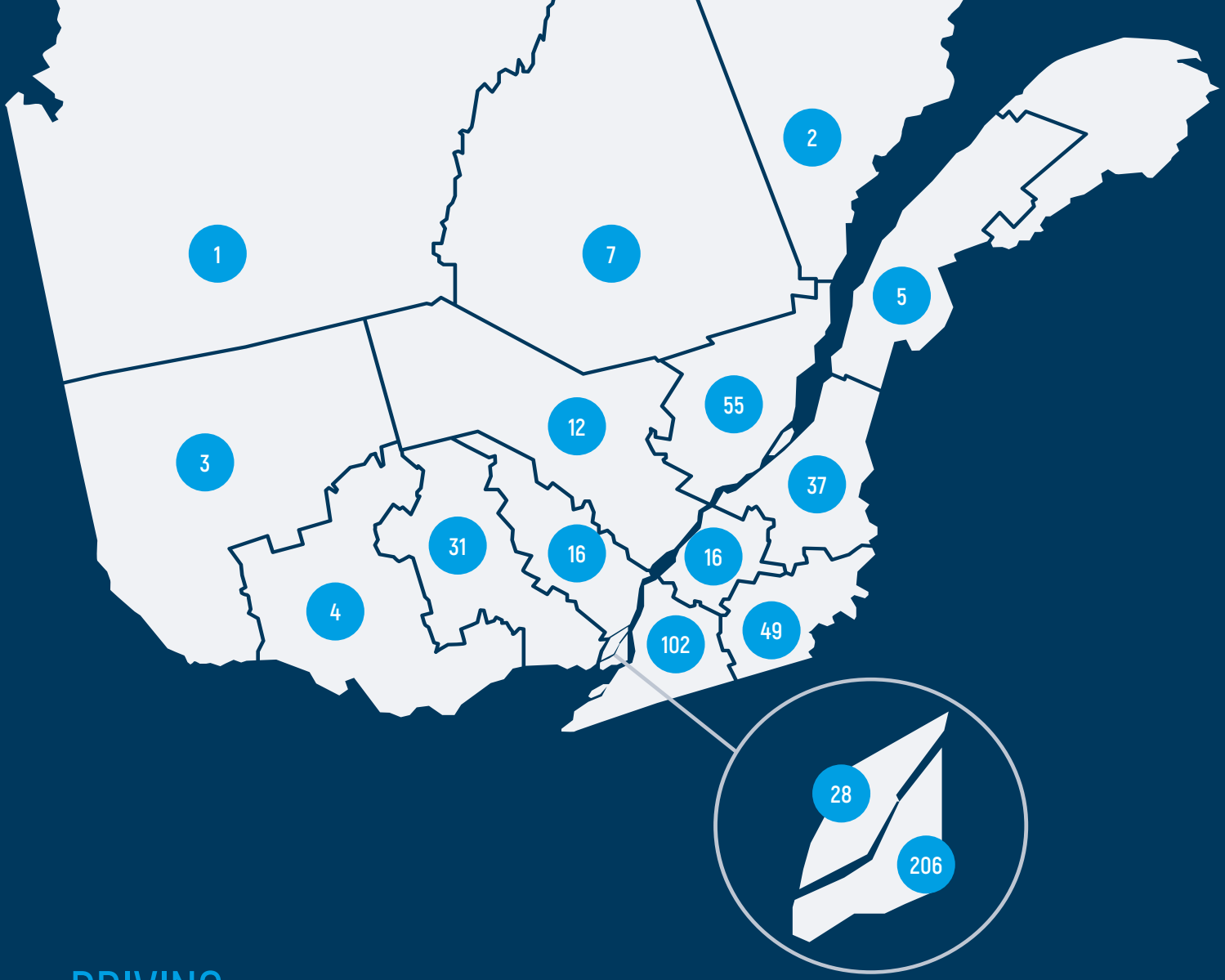
- Survey: 120 respondents from a pool of 574 identified companies – January and February 2024

TOMORROW'S MATERIALS, TODAY'S ENGINEERING

Advanced materials are new or improved materials that offer greater performance than previous materials. Advanced materials can, for example, withstand unprecedented temperature variations, recreate skin, and replace polluting materials. They can be superconductive, ultralight, invisible, etc.

EXAMPLES OF PROPERTIES SOUGHT IN ADVANCED MATERIALS

PHYSICAL PERFORMANCE	FUNCTIONAL PERFORMANCE
Electrical conductivity	Icephobic/hydrophobic coatings
Thermal conductivity	Self-repairing materials
Mechanical strength	Biodegradability
Hardness	Biocompatibility
Efficiency	Antimicrobial coatings
Optical properties	Super absorbent and waterproof materials
Magnetic properties	



DRIVING INNOVATION AND PROSPERITY

The advanced materials industry is a driving force in Quebec, with companies working in almost every region.

- **More than 570 companies** are actively developing, producing and integrating advanced materials, or developing and producing equipment associated with advanced materials.
- These companies have created **more than 49,000 jobs** linked to advanced materials in Quebec, with **combined sales of $15 billion.**
- **Polymers and membranes** (1) along with **metals, alloys and metal powders** (2) represent the two largest categories of advanced materials processed by Quebec companies.
- **Transportation, construction, housing, and energy are the main end markets** for the advanced materials produced by Quebec companies.
- **Seventy-four percent of companies in the industry export outside of Canada;** on average, **international sales account for 70% of revenues for these companies.**
- For companies with fewer than 1,000 employees, **less than half (44%) have invested more than $1 million over the past three years.** Projected investments will increase this number over the next three years; close to half of all respondent companies employing fewer than 1,000 workers plan to invest more than $1 million.
- Nearly 15% of the large and medium-sized companies surveyed made no investments between 2021 and 2023. However, **more than 70% of these have already made investments, or are planning to invest over $1 million in the near future.**

ENERGY

TRANSPORTATION

CONSTRUCTION/ HOUSING

DEFENCE/ SECURITY

TELECOMMUNICATION/ MICROELECTRONICS

MINING AND METALLURGY

UNLIMITED FIELDS OF APPLICATION

Advanced materials lead to a multitude of innovations. They are used in almost every sector of activity, and a dozen fields of application in particular.

MANUFACTURING

ENVIRONMENT

HEALTH AND BIOTECHNOLOGY

INSTRUMENTATION AND EQUIPMENT

AGRO-FOOD

TEXTILES/ CLOTHING

AN IMMENSE VARIETY OF PRODUCTS AND SOLUTIONS

The companies that make up the advanced materials industry can be divided into three sub-sectors: Production, finished or semi-finished product integration, and process/instrumentation development. The advanced materials industry offers a considerable range of products and services.[1]

ADVANCED MATERIALS

Category	% of Respondents
Metals, alloys and metal powders	40%
Polymers and membranes	37%
Nanomaterials (e.g., nanopowders, nanocarbons, nanofibres)	32%
Composites	31%
Coatings and thin films	25%
Biomaterials	21%
Chemical products	19%
Semiconductors	18%
Ceramics	14%
Biocompatible materials	12%
Glass	12%
Concrete	11%
Fibre and textiles	10%
Engineered wood	4%
Other	4%

FINISHED OR SEMI-FINISHED PRODUCTS

Category	% of Respondents
Components: Electronic, electrical and optical	30%
Components: Other	13%
Components: Transportation	13%
Systems: Other	13%
Components: Sensors	8%
Biocompatible components (including orthoses, prostheses and medicines)	8%
Packaging	8%
Systems: 3D printing software and components	5%
3D-printed parts	3%
Non-optical characterization systems	3%
Quantum technology	3%
Systems: Imaging, optics (laser) and optical characterization	2%
Technical and intelligent textiles	2%
Other finished and semi-finished products	7%

PROCESSES AND INSTRUMENTATION

Category	% of Respondents
Formulation, synthesis and electrochemistry	45%
Surface modification and treatment	38%
Shaping	32%
Additive manufacturing	30%
Recycling	27%
Modelling, simulation, quantum computing, AI applied to materials	26%
Micro/nanomanufacturing	26%
Machining	13%
Characterization instruments	13%
Other	8%

1 Most of the data contained in this document are drawn from surveys that were conducted in 2018 and 2021, then updated in 2024, using a sample of 120 companies considered representative of Quebec's advanced materials ecosystem.

PRIMA QUÉBEC: DEVELOPING THE ADVANCED MATERIALS ECOSYSTEM

PRIMA Québec was created by the Quebec government in 2014 to stimulate the advanced materials ecosystem and to promote collaborative research between public research centres and companies while offering various economic sectors a set of innovative, high-performance and environmentally friendly solutions that generate benefits for society as a whole.

PRIMA Québec manages funding programs for innovative projects that involve advanced materials.

PRIMA Québec supports companies and research centres to facilitate partnerships for innovation projects.

PRIMA Québec provides access to a variety of resources and skills at every project stage, from laboratory operations to marketing, in an effort to maximize the likelihood of success.

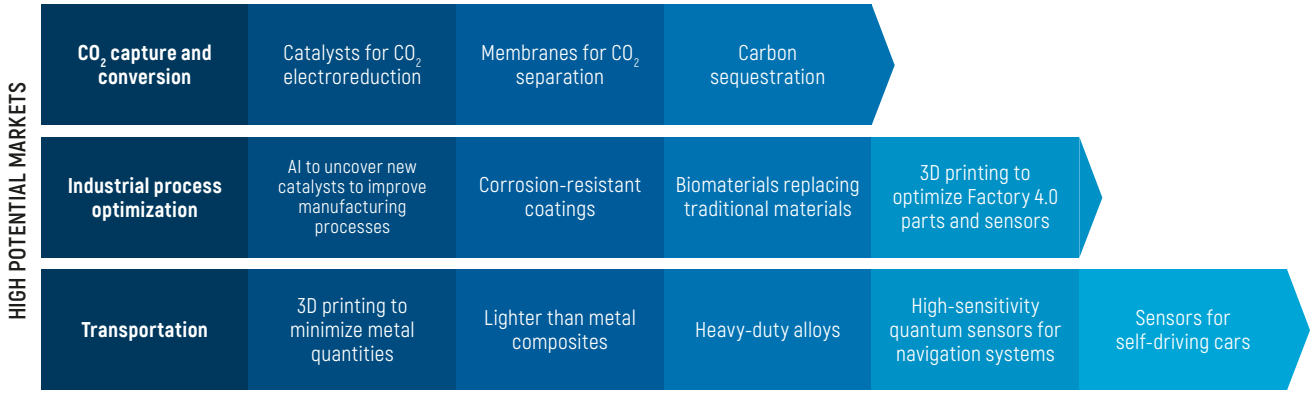
One hundred and eighty-one (181) innovative projects were made possible through PRIMA Québec's involvement over the 2015-2024 period, for a combined value of $157.9 million. Through its direct contribution of $47.5 million, along with $44.7 million from other public partners (NSERC, MITACS), PRIMA Québec has leveraged $65.7 million in private investments for innovation. These projects have brought together more than 270 industrial partners and 30 academic institutions with an approach based on collaborative research. These fertile collaborations have generated 402 scientific publications and 97 intellectual properties (patent applications, licencing, and invention declarations). They have also helped 789 master's, doctoral and postdoctoral students further their education and contributed to the advancement of knowledge. Several projects involving College Technology Transfer Centres (CTTCs) have also helped train dozens of highly qualified technicians.

ADVANCED MATERIALS ADDRESS SEVEN DEFINING ISSUES FOR OUR TIME

The demand for advanced materials is growing steadily, and for good reason. Advanced materials belong to the solutions and tools that will help solve the most significant challenges of our time.

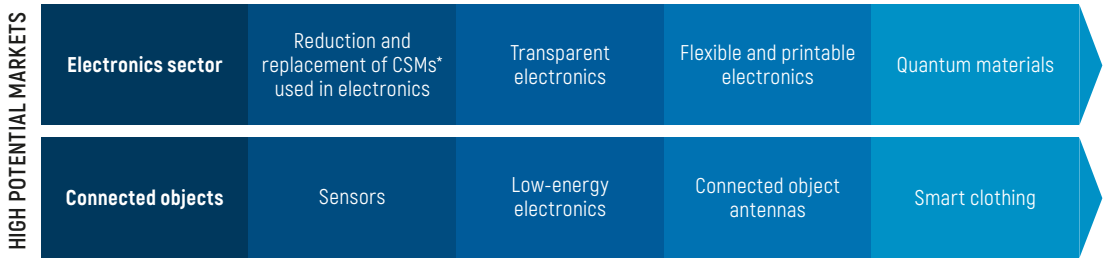
1 THE FIGHT AGAINST CLIMATE CHANGE AND DECARBONIZATION

Advanced materials offer technological solutions to reduce CO_2 emissions while adapting infrastructures to climate change. For example, the adoption of technologies powered by advanced materials can optimize energy performance and develop new and environmentally responsible manufacturing techniques for a variety of industries.



2 THE EXPANDING DIGITAL REVOLUTION

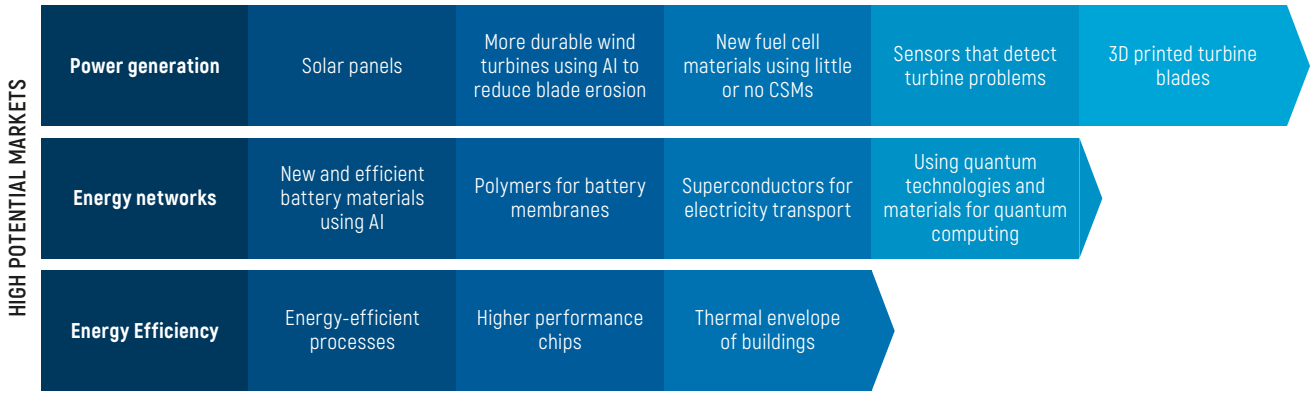
The digital revolution will continue to spread under an increasingly connected population, widespread use of the Internet of Things, new phenomena like telework and 5G connectivity, along with the upcoming emergence of selfdriving cars. Other significant developments are on the horizon and the revolution is showing no signs of slowing. The rise of artificial intelligence, virtual reality applications and quantum processors will usher in a new chapter for the digital age. Advanced materials are inextricably linked to all of these cutting-edge technologies, from the most significant breakthroughs to the solutions that reduce and replace toxic elements in semiconductors. Moreover, the tools used in quantum computers are typically built using quantum materials.



*Critical and Strategic Minerals (CSM)

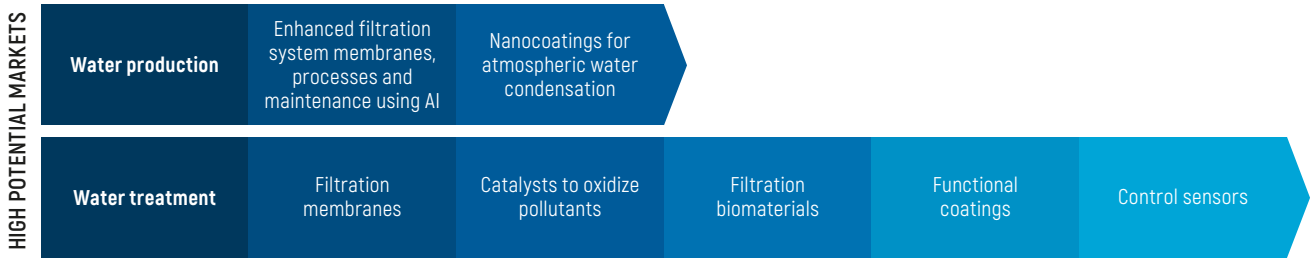
3 THE GROWING DEMAND FOR ENERGY

Growing energy demands and our need to fight climate change will lead to major innovations in energy production and network management. The challenges that surround renewable energy, energy efficiency and energy recovery call for the use of advanced materials; these challenges will be explored to meet industrial, housing and transportation demands without failing to protect the environment.



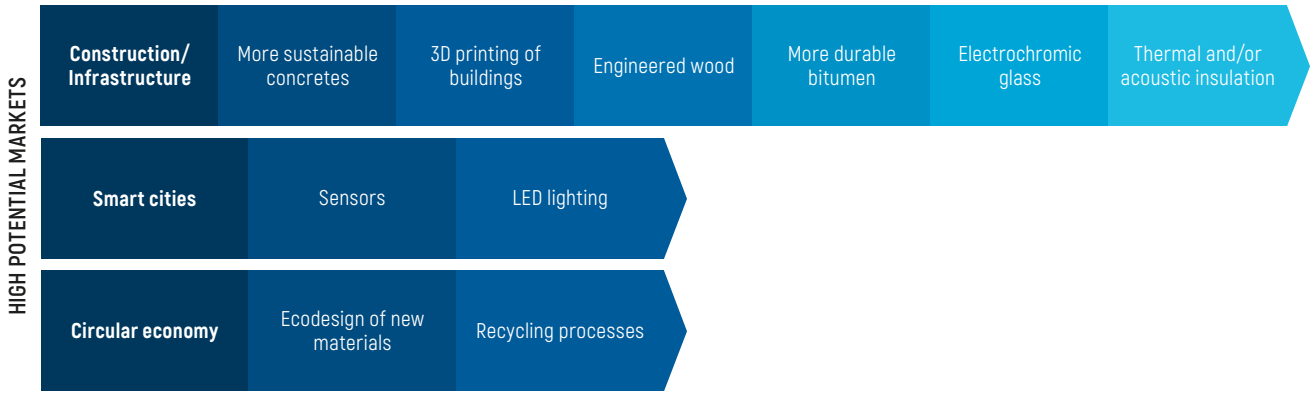
4 THE PRESSURE ON WATER RESOURCES

Water availability, drinking water quality, wastewater management and the protection of fisheries are of tremendous concern. Advanced materials offer new technological solutions that can improve the production and treatment of drinking water while optimizing consumption.



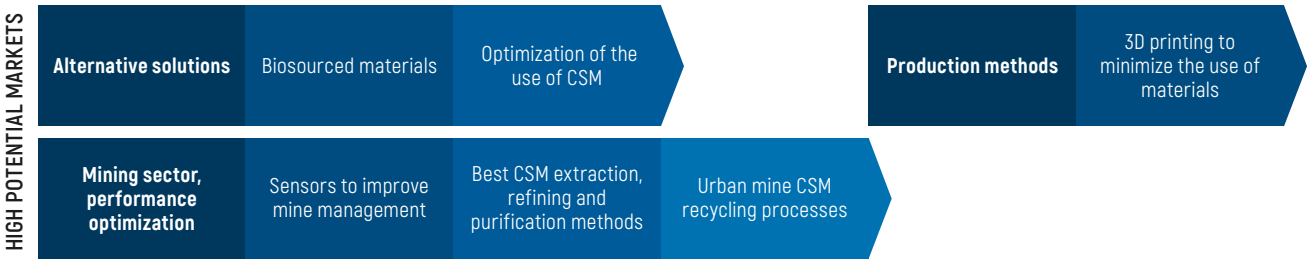
5 POPULATION GROWTH

The world's population is set to reach 9.5 billion by 2050. This population growth will lead to an increase in basic needs, including food and water, while increasing our demand for resources. Population growth will also lead to the acceleration of urbanization. Housing construction and public infrastructure, building heating and maintenance, and mobility management are already fermenting innovation. Advanced materials can help reduce the cost and the environmental footprint of buildings and cities while improving quality of life for their inhabitants.



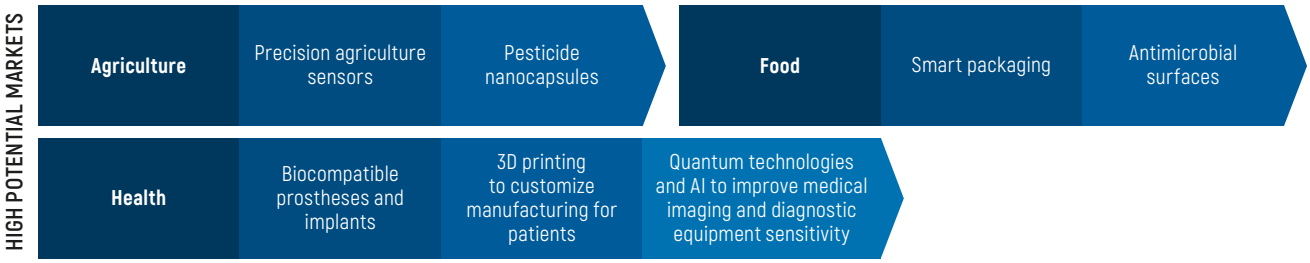
6 THE SUPPLY OF NATURAL RESOURCES

Increasing energy needs and population growth, along with economic and technological developments, continue to drive our demand for resources. In addition, new technologies often require critical and strategic minerals (CSMs). Occasionally, these minerals can be found upstream of certain advanced materials. In the coming years, major efforts will be made to curb the consumption of non-renewable resources. Reuse, substitution, recycling, recovery and remanufacturing will become an integral part of industrial practices thanks to new, more environmentally responsible methods. For CSMs in particular, the recycling of old electronic devices – veritable urban mines – will become essential to reduce virgin resource extraction. These methods will lead to greater responsibility when using natural resources thanks to solutions developed by the advanced materials industry.



7 FOOD AND HEALTH: TWO PRIORITIES FACING SIGNIFICANT CHALLENGES

Food and health represent societal priorities and these essential functions continue to face complex challenges. By 2050, our demand for food will increase by 60%, yet food and agri-food systems are already struggling to keep up. Meanwhile, the COVID-19 pandemic highlighted the many gaps that exist in our health systems while raising new concerns regarding public health, among other issues. Advanced materials are already being used to minimize the environmental impact of agriculture and reduce food waste. These materials are also being used in a growing number of health care services and research projects to develop new drugs, reduce side effects and improve therapeutic performance.



A DIVERSE AND ROBUST ECOSYSTEM

Quebec's advanced materials industry is home to over 570 companies that create 70,000 jobs. Companies with fewer than 1,000 employees provide 49,000 jobs, for an average of 90 jobs per company.

- A typical company includes 27 jobs (median).

The sales figures for all companies combined is estimated at $15 billion, based on the value of sales per worker (excluding very large companies). This estimate represents total sales, however, not those associated solely with the production of advanced materials.

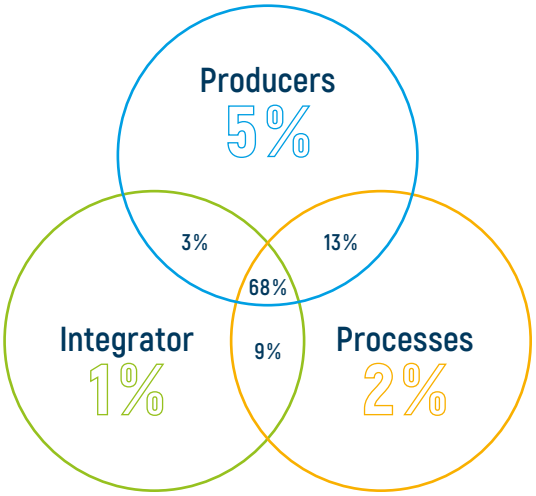
QUEBEC'S ADVANCED MATERIALS INDUSTRY COMPANY SIZE AND EMPLOYMENT INDICATORS

	Companies		Jobs	
Company Size	**Nb**	**%**	**Nb**	**%**
Very large companies (1,000+ employees)	26	5%	70,964	59%
Other (1-999 employees)	548	95%	49,055	41%
Large and medium-sized companies (100-999 employees)	137	24%	39,650	33%
Small companies (10-99 employees)	223	39%	8,547	7%
Very small companies (1-9 employees)	188	33%	858	1%
Total	**574**	**100%**	**120,018**	**100%**

HIGH LEVELS OF COMPETENCE

The vast majority of companies (92% of the sample) operate in more than one sphere of activity. Nearly 90% describe themselves as producers, 91% as process developers, and 81% as advanced materials integrators. A significant number of companies fall within two of these categories (25%), while others fall within all three categories (68%).

INDUSTRY COMPOSITION BY NUMBER OF *ESTABLISHMENTS*



A STRONG CULTURE OF RESEARCH AND INNOVATION

Almost ever company surveyed has been working actively in both internal and external research.

Jobs devoted to research and development are inversely proportionate to company size. These jobs represent over 60% for very small companies, and 7% for large and medium-sized companies.

RESEARCH INTENSITY INDICATORS FOR THE SURVEYED COMPANIES

	Intramural Research		*Extramural* Research	
Company Size	**Percentage of Companies Active in R&D**	**Percentage of Jobs**	**Percentage of Companies**	**Partnerships**
Very large companies (1,000+ employees)	100%	3%	100%	3
Other (1-999 employees)	97%	12%	98%	2
Large and medium-sized companies (100-999 employees)	100%	7%	100%	3
Small companies (10-99 employees)	100%	37%	98%	2
Very small companies (1-9 employees)	96%	59%	96%	2
Total	**99%**	**8%**	**98%**	**2**

THE PRIMA QUÉBEC METHOD: COLLABORATIVE RESEARCH

On average, respondents have collaborated with approximately two types of partners for their research and development projects since January 2020.

Ninety percent (90%) of respondents collaborated with universities, while just over half collaborated with CCTTs and research centres. The number of partnerships increased with the size of the company.

***EXTRAMURAL* R&D PARTNERSHIP DISTRIBUTION**

Partner	% of Total Respondents	% of Respondents by Company Size			
		%VLC	%LMC	%SC	%VSC
Universities	90%	100%	89%	87%	93%
College Technology Transfer Centres (CTTCs)	56%	67%	64%	57%	46%
Research centres (e.g., NRC, Corem, IQ-CRIQ)	56%	100%	71%	46%	54%
Testing laboratories	30%	33%	46%	24%	25%
Other (vocational training centre, etc.)	11%	33%	11%	13%	7%
Average number of partner types	**2**	**3**	**3**	**2**	**2**

A DYNAMIC AND GROWING INDUSTRY

Excluding very large companies, the annual growth rate has been 5.3% since 2021, an estimate based on the level of employment in the companies surveyed. This growth is marked by an increase in small companies (10-99 employees), showing an annual growth rate of 6.6% since 2021.

EMPLOYMENT PROFILES AND TRENDS BY COMPANY SIZE

Company Size	2021-2023 Annual Growth Rate	2021-2023 Employment Trends		
		Reduction	Stable	Increase
Very large companies (1,000+ employees)	0%	0%	100%	0%
Other (1-999 employees)	5.3%	12%	20%	68%
Large and medium-sized companies (100-999 employees)	4.9%	12%	28%	60%
Small companies (10-99 employees)	6.6%	9%	12%	79%
Very small companies (1-9 employees)	14%	17%	26%	57%
Total	**2.3%**	**12%**	**23%**	**65%**

FOREIGN MARKET PRESENCE

Overall, exports account for roughly 70% of revenues for exporting companies; this figure applies to almost every company category. More than 85% of companies with 10 or more employees are active on foreign markets. However, only a minority of very small companies export. The tendency to export increases with company size, and increases significantly when very small companies move up to the next category.

EXPORT INTENSITY BY COMPANY SIZE

Company Size	Percentage of Exporters	Weighted Average Export Rate
Very large companies (1,000+ employees)	100%	80%
Other (1-999 employees)	74%	70%
Large and medium-sized companies (100-999 employees)	93%	71%
Small companies (10-99 employees)	85%	65%
Very small companies (1-9 employees)	36%	63%
Total	**74%**	**74%**

ENVIRONMENT AND SUSTAINABLE TRANSITION

For the first time, the study surveyed companies on matters of environmental management. Just over 20% of those surveyed stated having undertaken no environmental management activities, a number that rises to almost 35% for very small companies. On average, companies tend to be active in two environmental management activities, while companies with more than 100 employees are active in three categories.

- The most common activities include energy efficiency improvements regarding processes (47%), and the assessment of environmental footprints and GHG emissions associated with materials and processes (36%).

Overall, more than half of respondents plan to undertake environmental management activities by the end of 2026. Moreover, the number of companies that plan to undertake such activities by the end of 2026 increases with the size of the company.

Overall, more than 80% of those surveyed are active in sustainable transition. There is, however, greater inaction among small and very small companies.

INTELLECTUAL PROPERTY STRATEGY

The 2024 edition of this study includes a new component involving intellectual property strategies. Overall, more than 95% of respondents are equipped with at least one tool for their intellectual property strategy.

- By far, the most popular strategies involve trade secrets and patent registration (used by more than 75% of respondents).
- Patent acquisition is favoured by very large companies, but ignored by others.

Overall, nearly 15% of companies with fewer than 1,000 employees use trade secrets as their sole intellectual property strategy tool. This percentage drops to 11% for very small companies, and 13% for small companies, but rises slightly to 16% for large and medium-sized companies.

INTELLECTUAL PROPERTY STRATEGY TOOLS

Intellectual Property Strategy Tools	% of Total Respondents	% of Respondents by Company Size			
		%VLC	%LMC	%SC	%VSC
Trade secrets	83%	100%	92%	82%	75%
Patent registration	79%	100%	68%	78%	89%
Trademark	51%	50%	44%	53%	54%
Licence acquisition	26%	0%	24%	27%	29%
Licencing	24%	50%	24%	27%	18%
Industrial design	19%	0%	28%	16%	18%
Patent acquisition	11%	50%	16%	9%	7%
Printed circuit topography	3%	0%	8%	2%	0%
Other	2%	0%	0%	2%	4%
No IP strategy	4%	0%	8%	4%	0%

KEY GROWTH-RELATED CHALLENGES

The advanced materials industry has the wind at its back. It cultivates knowledge that leads to significant economic, environmental and social progress. It is a community that envisions the future.

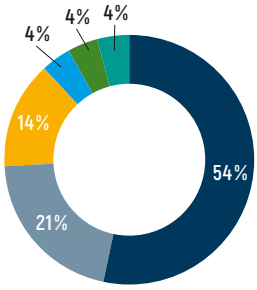
Nevertheless, challenges emerge when developing this strategic industry. Asked to comment on their development prospects, some entrepreneurs expressed concerns.

As the graphs above illustrate, the challenges vary according to the size of the company. Access to financing and capital represents an issue for companies with fewer than 100 employees. This hurdle remains high for large and medium-sized companies. Obtaining capital in the early stages of a business project presents many challenges, which can often be significant in a field like advanced materials, which involves high levels of innovation.

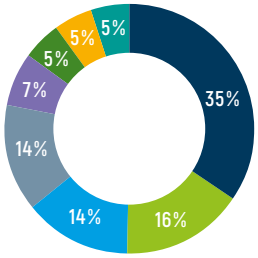
Human resources represent the main obstacle to growth, but only for companies with more than 100 employees; it ranks third among small companies (ex æquo with marketing), and fourth among very small companies.

Problems related to foreign competition are most prevalent among companies with more than 10 employees, but do not appear to be an obstacle for very small companies. Marketing-related challenges rank among the top three for all company sizes. Regulation and certification also represent obstacles, especially for very small companies, which rank these third on their list of growth-related challenges.

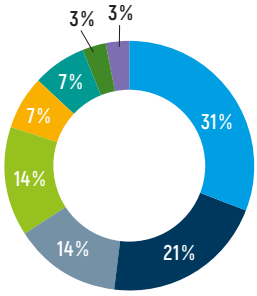
MAIN GROWTH-RELATED OBSTACLE FOR VERY SMALL COMPANIES



MAIN GROWTH-RELATED OBSTACLE FOR SMALL COMPANIES



MAIN GROWTH-RELATED OBSTACLE FOR LARGE AND MEDIUM-SIZED COMPANIES



- Access to capital/Financing
- Foreign competition
- Human resources
- Marketing
- Export/Internationalization
- Supply
- Regulations and certification
- Other

COURSES OF ACTION

Among the possible solutions to counter these obstacles to growth, all respondents favoured internal research and development projects, as well as partnerships with research clusters, centres and institutes. By a wide margin, the least considered solutions among the companies surveyed include recruiting abroad and securing supply chains, with the exception of very large companies.

Most seek to meet their funding challenges through external partnerships (64%), along with internal research and development projects (54%). On the other hand, government support appears to be widely preferred to private sector support (74% and 56%, respectively).

Most respondents favoured collaboration and partnerships, along with internal research and development projects. More than half seek to resolve their marketing challenges through government assistance, since it would grant them access to additional levers like public markets and support for certification.

OVERCOMING THE OBSTACLES

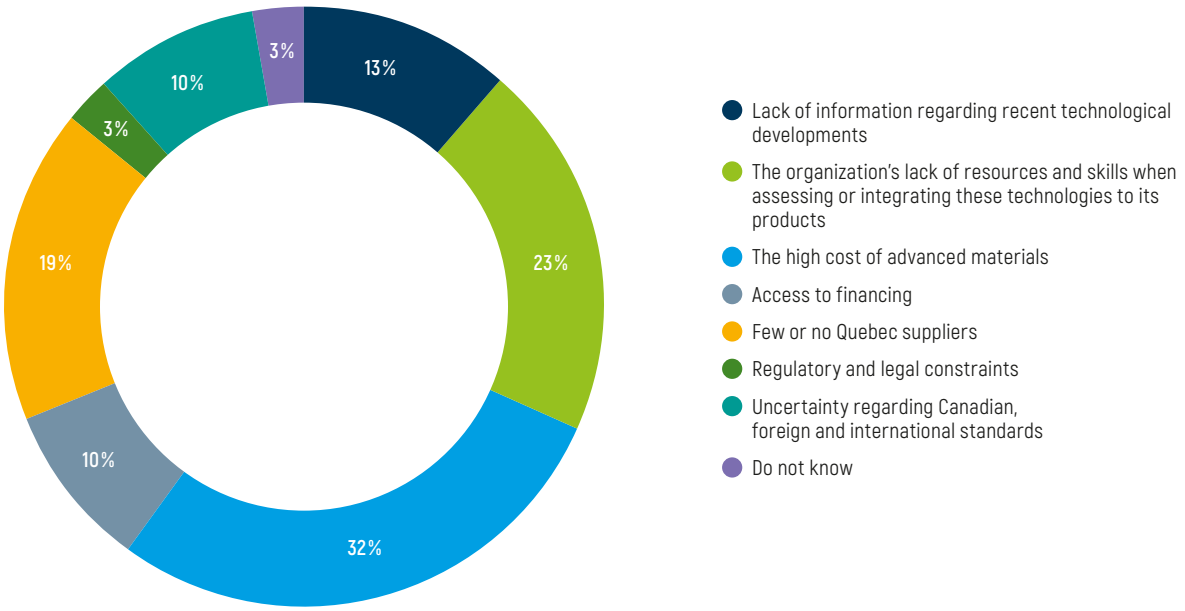
Several factors were identified as hindering the demand in advanced materials. To obtain information regarding demand, E&B Data surveyed industry associations and consortia like PRIMA Québec, which represents companies that work in sectors involving advanced materials.

First, financial issues were cited by 42% of respondents, including the high cost of advanced materials and difficulty accessing financing.

Next, an organization's lack of resources and skills were cited by over 35% of those surveyed, along with a lack of information on recent technological developments.

Finally, a scarcity of suppliers in Quebec, along with uncertainty about Canadian, foreign and international standards, were also frequently identified (19% and 10%, respectively).

TO YOUR KNOWLEDGE, WHAT ARE THE PRIMARY CONSTRAINTS THAT HINDER THE ACQUISITION OF ADVANCED MATERIALS IN THE QUEBEC COMPANIES THAT YOU REPRESENT?



PROSPECTS AND CHALLENGES

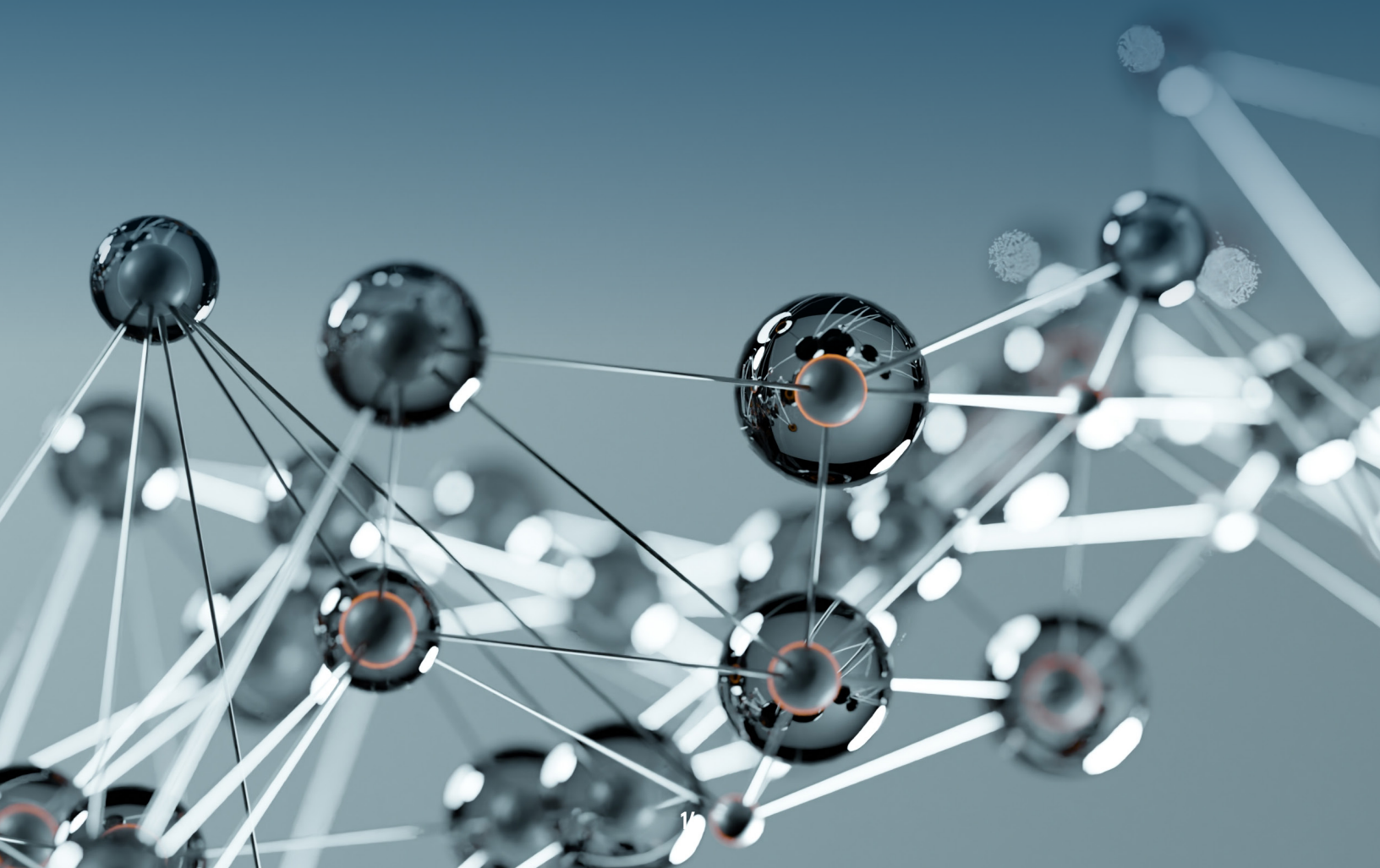
In conclusion, an analysis of the overall data highlights a sustained growth within companies, despite some notable challenges. With the exception of very large companies, the annual growth rate has reached 5.3%, and even 7% for small companies. Thus, Quebec's advanced materials landscape appears remarkably vibrant.

Growth is underpinned by high levels of investment, with almost 45% of companies having invested, and over 55% planning major investments between now and 2026. However, the trend toward local ownership appears to diminish as companies grow in size, raising questions regarding long-term economic self-sufficiency.

Companies are facing significant obstacles, primarily in areas that involve funding for research and development, marketing, regulation and human resources. These challenges have persisted since the 2018 and 2021 studies, highlighting the need to pursue, and even strengthen, strategic efforts that can sustain growth.

The tendency to export remains high, despite a significant drop since 2018, highlighting the importance of foreign trade in the Quebec economy. However, a marked decline in exports among very small companies calls for greater support due to their significant role in maintaining a vigorous market.

Finally, the commitment toward improved environmental management over the next few years, along with an equal commitment to a sustainable transition, reflects the industry's growing awareness and accountability toward environmental issues. We will be able to monitor the resulting measures in the coming years. Nevertheless, the challenges associated with certification represent a clear hindrance to the implementation of sustainable practices.



PRIMA

info@prima.ca | 514 284-0211

PRIMA Québec is an advanced materials research and innovation hub that supports and promotes the advanced materials ecosystem and acts as an engine of innovation and growth in Quebec. Through support and funding, it stimulates the competitiveness of Quebec companies by facilitating access to research expertise. Acting as a Sectoral Industrial Research Group (SIRG), PRIMA Québec relies on financial support from the Quebec government as well as the private sector when promoting research-industry relations.

A list of industrial and academic members and partners can be found on the PRIMA Québec website.

www.prima.ca

PRIMA Québec, a proud partner of the Quebec government.

Québec