Future Ready

Technological Innovation & Workforce Diversity in the Advanced Manufacturing Sector

NOVEMBER 2023

About Future Ready

The Future Ready program is a $19 million program funded in part by Employment and Social Development Canada's Sectoral Workforce Solutions Program to support companies in onboarding new and diverse workers to Canadian manufacturing. The initiative will also aid Canadian manufacturers in identifying their critical skills gaps to support the future profitability and growth of their organization through NGen's highly regarded Transformation Leadership Program. Through these approaches, the program aims to provide demand-driven solutions for the manufacturing sector, one of the sectors hardest hit by the pandemic, and a key to the recovery of the Canadian economy.

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Executive Overview

- Technological innovation is influencing manufacturing, not just on the shop floor, but in all aspects of the organisation – R & D, human resources, marketing, sales, logistics, inventory management, etc. There is opportunity for the sector, as it adapts to new technologies, to re-brand and attract people from various equity-deserving groups (EDGs) such as youth, women, and persons with disabilities.
- Labour force data suggest that there are not dramatic changes in the proportion of women in the manufacturing labour force with a steady rate of 27%-29% participation over the last 20 years, with no sustained variance of that range since the 1970s.
- Light manufacturing has a higher percentage of women in the workforce than heavy manufacturing, highlighting the opportunity for expanded participation, and the need for new approaches.
- For occupations requiring traditional STEM education, more women should be encouraged to enter fields of study related to advanced manufacturing. While women are studying more in these fields, they are clustering in fields related to the bioeconomy.
- Labour force data also suggest that more youth with a background in traditional and emerging fields of study in STEM need to be attracted to manufacturing in an era of rapid technology adoption within the sector.
- Co-bots and robots provide opportunities for those with physical disabilities to work in manufacturing as they are getting so sophisticated that they have much promise for making a variety of occupations accessible to those with physical limitations. They also allow workers who develop physical limitations, such as older workers, to continue to work.
- Promotion of STEM fields of education need to continue with collaboration among employers, government, relevant not-for-profits serving various equity-deserving groups, higher education institutions, and targeted communities.
- A company that is innovative can use technological innovation in its production process and products, especially related to greening, to attract talent, especially young people who have the most stake in the future.
- Employee expectations, especially young people, include an *inclusive workplace* where people of all backgrounds, abilities and genders feel comfortable. Technology can also be used to organise work in such a way to integrate, support, and retain high skilled talent from these diverse labour market segments.

Introduction

Manufacturing is the fourth largest industry in Canada and according to the Labour Force Survey, in 2022, it employed approximately 1.8 million people.. The skills required by manufacturing workers are changing rapidly as companies introduce technologies that change the way goods are produced, marketed, and sold, as well as the nature of jobs and the way that work is organised. These technology changes are being accelerated and complicated by evolving international and national policies on climate change and greening of production, as well as consumer tastes and expectations. Compounding the challenge being faced by Canadian manufacturers is the fact that the manufacturing workforce is ageing and young people are not choosing careers in manufacturing at a sufficient rate to replace retiring workers or support growth.

Manufacturing needs to explore opportunities to attract and retain workers from diverse, nontraditional labour market segments. The paper examines the role technology and innovation could have on labour market participation of equity-deserving groups (EDGs), specifically youth, women, and persons with disabilities. The focus was to understand how technological innovation could be used to attract more people from these equity-deserving groups from the perspective of both changes in manufacturing technologies, as well as emerging technologies that allow for greater inclusion and participation of different groups.

The paper focuses on the following questions:

1. What are the opportunities, given technological innovation, for companies in manufacturing *to attract and hire* from specific EDGs?
2. What are the opportunities for greater participation of EDGs in manufacturing, given technological innovation that allow for *productivity and inclusiveness* in workplaces?
3. What is the representation of specific EDGs in manufacturing companies?
4. To what extent are certain EDGs studying in the fields that allow them to work in advanced manufacturing?

The paper provides some recommendations based on the findings.

Methodology

LITERATURE REVIEW

The research involved a review of academic and grey literature related to equity-deserving groups in working in manufacturing and technological innovation. Technological changes in manufacturing have led to a need for new skills and re-organisation of work with new technologies. The review looked for academic articles and industry reports and case studies on advances in technology in manufacturing, with consideration of how they will allow for accommodation and inclusion of people from underrepresented or EDGs.

GOVERNMENT DATA

The paper also utilised secondary data from government sources. We reviewed 2021 census data and the Labour Force Survey (LFS) data to understand workforce representation in manufacturing for women, youth, persons with permanent disabilities (PPDs) in manufacturing subsectors; and selected occupations related to advanced manufacturing, along with related educational background. We also reviewed the literature on technology adoption, impact on occupational changes and links to recruitment efforts among diverse groups.

Technological Innovation and Opportunities for Recruiting From Equity-Deserving Groups

Advanced Manufacturing and Technology Changes

Advanced manufacturing refers to the increased use of automation and digital technologies in the workplace. These technologies (at least most of them), combined, are what we refer to as Industry 4.0. The increasing use of technology to change manufacturing processes in turn impacts occupations – the skills required, and the way work is structured and organised. The technologies commonly associated with Industry 4.0 are: Artificial intelligence (AI) which includes Machine learning/Deep Learning; smart sensors; Internet of Things (IoT), big data and analytics; robotics; cloud computing; digital twinning and simulation; augmented reality and additive manufacturing, 3D printing, and Cybersecurity (FOCAL 2020).[1]

A company can utilise technology to improve different functional aspects of its operations. This is not limited to the production line. In production, a company can introduce technology in selected or specific aspects of the workflow or across the entire production process. The emergence of new manufacturing technologies and materials offers opportunities for manufacturing industries to rethink their operations to improve production processes, re-organise work and productivity, address labour shortage challenges, and reduce their carbon footprint.

Companies are also shifting to sustainable materials and green energy sources to reduce the carbon footprint of manufacturing facilities and the impact of final products (consumer and product). For instance, the shift to electric vehicles has led to investment in new technologies – batteries, production processes, and software related to smart mobility and smart cars. These technologies allow companies to create life cycle solutions and innovations (from research, production, marketing, sales, customer service, logistics, inventory management and warehousing, and workforce training) that improves productivity and product quality. Productivity improvement occurs when new tools and technologies help manufacturers increase production at a lower cost with the existing labour force or produce the same amount of goods with fewer workers which is important in a context of high retirements and labour shortages. These efficiencies then provide the opportunity for growth and increased exports, resulting in stable or increasing levels of employment.

[1] See 2020 Focal Report, *Impact of Industry 4.0 Technologies on Key Occupations in Automotive Manufacturing* for mor details on technologies used in Industry 4.0.'

Opportunities for Technological Advances in Human Resources

RECRUITMENT

Advances in AI allow more efficient recruitment by creating focused searches of the large volume of resumes online. AI searches could target various groups for recruitment based on country, region, or rural versus urban preference. Companies can also conduct outreach through social media using AI to target talent from equity-deserving groups, recruit based on age, gender, Indigenous identity, and black and other racialized communities who may be facing disadvantage in the labour market. Thus, AI allows for efficiency and equity in recruitment from various labour market segments. However, there is a risk with AI that biases in the algorithms can be propagated inadvertently. Companies need to be aware of this issue and carefully design programming and test cases to avoid bias.

Workforce Development

OCCUPATIONAL CHANGE AND SKILLS DEVELOPMENT

Manufacturing occupations can change because of *product* changes and *process* changes with new technologies. Manufacturing occupations could change because of industry 4.0 technologies that change *processes* in three ways: altering a task; partially eliminating a task (difficult or repetitive); fully eliminating a task.[3] New technologies may also introduce a new task. These process alterations provide opportunities for new skills to be deployed in the manufacturing facility. Product changes have implications for skills and occupations in the supply chain, as well.

The shift to decarbonization also has implications for the labour force. Since the Earth Summit in Rio in 1992[2], and the various climate change commitments made by countries, companies have been slowly shifting towards greening. This has accelerated under governments' commitments to the United Nations' Sustainable Development Goals. Occupations such as health and safety have expanded to include environmental impact activities. This has led to a need for knowledge on biodiversity and environmental impacts of operations on communities. Policy levers by governments and other supporting sectors (e.g., insurance) will accelerate this impact in greening manufacturing.

Technological changes mean workers must adjust to manage, operate, or maintain new machinery, equipment, systems, or processes. Upskilling and re-skilling workers are needed depending on the type of worker (managerial and supervisory; professional and technical; skilled trades; production) and the nature and magnitude of the changes in tasks within and across occupations. AI can be used to assess the skills of a workforce to assess the transferability of skills of existing workers to occupations within the same industry, or within other industries or sectors. Using AI to assess competencies and make recommendations for workforce development within a context of changing technologies, allows for more opportunities

[2] See https://www.un.org/en/conferences/environment/rio1992

and job security for workers and supports Canadian manufacturing and our economy.

INFORMATION, AND COMMUNICATION TECHNOLOGIES (ICTS) AND LEARNING

Workforce development and learning is also being impacted by technological changes and evolution of ICTs, which provide opportunities for different types of learners to access learning in the mode that is most suitable and effective for them. For example, a digital twin in manufacturing is a virtual copy of part of a process, an entire process, or an entire plant, and can simulate real-life behaviour. Digital twinning (DT) allows workers to train and understand processes before applying them to the real world. DT can be used in planning, R & D, to assess risk as well as collect information from processes and equipment/plant. For high-risk tasks in plants, DT allows virtual testing and technical simulations in 3D that allows learning while eliminating safety hazards, reducing upfront expenditures, and making the critical functions of process planning and monitoring accessible to a larger potential workforce. This technology may make it possible for people to work as process engineers without the need to work directly on the shop floor or with heavy equipment.

- Immersive learning through custom, real-time 3D immersive experiences through augmented reality (AR) and virtual reality (VAR), and simulations through digital twinning (DT) provide opportunities for workers to learn in a safe environment and with learning programs tailored to individual learning styles, or native languages, critical for the full engagement of newcomers to Canada within our manufacturing workforce. The evolution of software technologies come with the benefits of also allowing workers to *learn in engaging and more inclusive ways*, which improves speed of learning and retention of information.
- Virtual learning and mobility in learning and instructions, that is, the availability of training modules and instructions on the internet and on *mobile phones* allows for real time, digital on-the-job training. This is beneficial for people with learning disabilities and retention issues to have information readily available to do their jobs, while also providing flexibility of learning times and locations. These tools are so readily accessible as to enable even small manufacturers to develop bespoke applications.

Work Organization, Robotics, and Accessibility

The advances in robotics and use of sophisticated machinery provides equity opportunities for specific demographics who may traditionally have been locked out of roles, for example people with disabilities or people with less upper body strength. Collaborative robots (Cobots) or assistive robots are designed to assist workers. Cobots do heavy lifting, take equipment off shelves, fetch items, makes some line jobs more accessible to people of smaller build who would not have been physically able to work in some occupations. In addition, they assist workers on modified duties, for example with repetitive stress injuries, to work safely. Technology and the use of robotics throughout various functional areas of a manufacturing company can also help promote participation of persons with disabilities.

In a 2022 healthcare sector study, Biton et al found that 'although cobots can perform the entire process autonomously, better performance is achieved by cooperation with a human caregiver/nurse'. They further note that the integration of cobots into industrial environments may bring better results when robots are considered as additions to humans, rather than replacements. A real-world example is the use of a *Robbie the Cobot* deployed in a Ford factory in Germany 'to work with people with reduced mobility to undertake tasks that would otherwise be considered difficult or impossible by such workers due to their ailment.' (Industry Insider, 2022) The experiment was a success and Robbie has 'permanent employment' with the factory. Ford also has cobots programmed to assist production workers with complex procedures. Cobots and robots are getting so sophisticated that they have much promise for providing opportunities and making various types of occupations accessible to those with physical limitations.

The wider implementation of "Robbies" could allow people with physical limitations to work in shop floor roles across the manufacturing sector.

Integration of Accessibility Into Software

The evolution of accessibility and universal design embedded in routine software, allows greater opportunities for people with visual, hearing, and manual dexterity challenges (temporary or permanent) to be productive workers. While specialised accessibility software is expensive for persons with disabilities, the integration of accessibility features such as voice recognition, closed captioning, screen reading and other accessibility features into general use software such as MS-Office, as well as the evolution of generative AI in search engines and other software, provides an opportunity to employ more people with disabilities, while also increasing productivity of the general workforce.

Workforce Representation in Manufacturing for Selected Equity-Deserving Groups

This section looks at subsectors in manufacturing in Canada and *technology-related occupations* using Census and labour force survey data to examine workforce representation focusing on gaps for women, youth, and persons with disabilities (PWDs). We need to understand where women, PWDs, and youth work in terms of occupations and sectors, to understand what opportunities and challenges exist for attracting them to advanced manufacturing and to subsectors within manufacturing. The current employment profiles for these groups need to be understood before making recommendations for change at an organisational or policy level

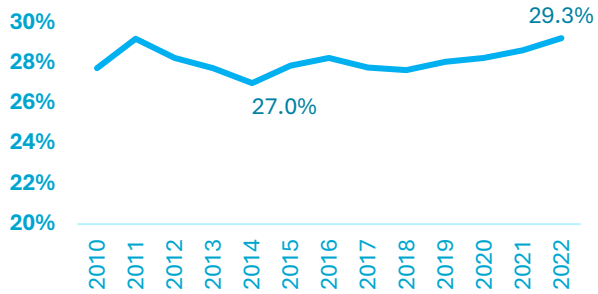
Women in the Canadian Labour Force

- In Canada, 48% of people in the labour force are women. Of these, 25% of employed women are immigrants.
- Historically, women were predominately employed in specific sectors of the economy; for example, Health care and social assistance (81%), Educational services (69%), Finance and insurance (56%), and Accommodation and food services (55%), and retail trade (51%).

Women in Manufacturing

Women have accounted for about 27%-29% of the labour force in manufacturing since the 1970s. See Figure 1.

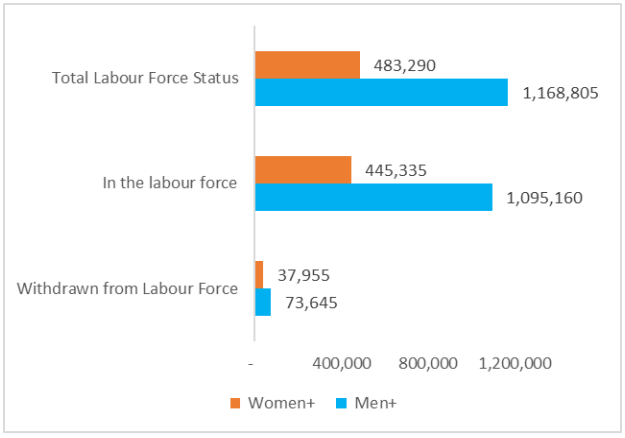
Figure 1: Women in the Manufacturing Labour Force in Canada



Source: Labour Force Survey, Custom Request, 2023

In 2021, manufacturing was still feeling the impact of COVID-19. While women are underrepresented in manufacturing, a larger percentage of women withdrew from the manufacturing labour force at 8% (or 37, 955) than men at 6%. See Figure 2.

Figure 2: Total Labour Force Status by Gender in Manufacturing, 2021



Source: Census 2021

WOMEN EMPLOYED IN MANUFACTURING SUBSECTORS

- According to the Census in 2021, *35%* of the women in manufacturing were immigrants which is higher than their share of 25% of the Canadian labour market.
- Women are overrepresented in light manufacturing of consumer goods such as clothing and accessories manufacturing, and food manufacturing. For example, seventy-three (73%) of the work in *cut and sew clothing manufacturing* is done by women. See Table 1.
- Women are underrepresented in heavy manufacturing sectors such as metal, steel, heavy machinery, and wood product manufacturing. See Table 2.

Table 1: Top 5 Manufacturing Sub-Sectors Employing Women

Industry	Women as a share of Employed
3152 Cut and sew clothing manufacturing	73.4%
3151 Clothing knitting mills	69.7%
3159 Clothing accessories and other clothing manufacturing	61.4%
3131 Fibre, yarn and thread mills	57.8%
3118 Bakeries and tortilla manufacturing	54.5%

Source: Census 2021

Table 2: Manufacturing sub-sectors with low participation rates of women

Industry	Women as a share of Employed
3365 Railroad rolling stock manufacturing	13.4%
3273 Cement and concrete product manufacturing	13.1%
3335 Metalworking machinery manufacturing	13.0%
3312 Steel product manufacturing from purchased steel	11.4%
3311 Iron and steel mills and ferro-alloy manufacturing	11.0%

Source: Census 2021

TOP 3 OCCUPATIONS EMPLOYING WOMEN IN MANUFACTURING

In absolute terms, the top three occupations where women were employed in the manufacturing sector were motor vehicle assemblers, inspectors, and testers (34%); manufacturing managers (21%) and Process control and machine operators, food, and beverage processing (29%). See Figure 3.

Figure 3: Top 3 Jobs in Manufacturing employing women

Source: Census 2021

SHARE OF WOMEN IN MANUFACTURING OCCUPATIONS

The 2021 Census shows that the occupations where women predominate in manufacturing are in semi-skilled occupations on the factory floor, but there are also some high-skilled occupations that have a high share of women. See table 4 below.

- The highest percentage of women in manufacturing jobs occur in the clothing manufacturing industry - 88% of Industrial sewing machine operators and 78% of Inspectors and graders, textile, fabric, fur, and leather products manufacturing identify as women.
- Biomanufacturing stands out for employing highly-skilled women with a significant percentage (59%) of

Table 3: Top 10 Occupations employing Women based on share in Manufacturing

Occupation	Share of Women
Industrial sewing machine operators	88%
Inspectors and graders, textile, fabric, fur and leather products manufacturing	78%
Geoscientists and oceanographers	62%
Weavers, knitters and other fabric making occupations	61%
Testers and graders, food and beverage processing	60%
Biologists and related scientists	59%
Bakers	59%
Biological technologists and technicians	57%
Supervisors, textile, fabric, fur and leather products processing and manufacturing	53%
Electronics assemblers, fabricators, inspectors and testers	52%
Public and environmental health and safety professionals	51%
Fish and seafood plant workers	50%
Food counter attendants, kitchen helpers and related support occupations	50%
Database analysts and data administrators	49%

Source: Census 2021

biological technologists and technicians identifying as women.

- Gender parity in lower-skilled jobs appears in the food manufacturing sector, such as *Fish and seafood plant workers* (50%).

Automation of processes for greater efficiency and productivity in lower-skilled occupations could free up labour for re-training to do other tasks in the same sector or transition to other sectors. It could also address labour challenges in filling these positions.

The Census data shows that women continue to have low participation in manufacturing in key occupations related to advanced manufacturing such as industrial designers (33%); chemical engineers (30%); computer and information systems managers (19%); engineering managers (15%); aerospace engineers (14%); and mechanical engineers (9%). Women's participation in diverse skilled trades across various subsectors continue to be low, ranging from 1% to 8%, despite several years of efforts to promote the skilled trades to women.

WHAT ARE WOMEN STUDYING?

Women's educational achievements in Canada have increased significantly in the past decades. According to statistics Canada, in 2016 40.7% of women ages 25 to 34 reported having a bachelors' degree or higher, whereby comparison only 29.1% of young men reported the same. Looking at all fields of STEM studies, women represent 43.6% of the population.

Although women are still vastly under-represented in the more traditional fields of study such as engineering and computer science (at 19% and 27% respectively), the bioeconomy seems to be attracting women given the share of employed women who studied in related fields at 59%. See table 4 below. Regardless, women attrit from STEM programs at a rate almost double that of men (23% vs 12%). This is indicative that improvements still need to be made to support women through the education life cycle and beyond.

Table 4: Share of Women Employed with a STEM- related education

Field of Study	Women employed (%)
Biological and biomedical sciences	59.1%
Physical sciences	34.1%
Computer and information sciences and support services	25.8%
Engineering	19.2%
Engineering/engineering-related technologies/technicians	12.1%

Source: Census 2021

Implications for Human Resource Policies and Practices to Recruit Women

The data suggests different areas of focus for employers. Specific sectors with low representation of women in high-skilled professional occupations may want to explore opportunities to recruit from this labour pool.

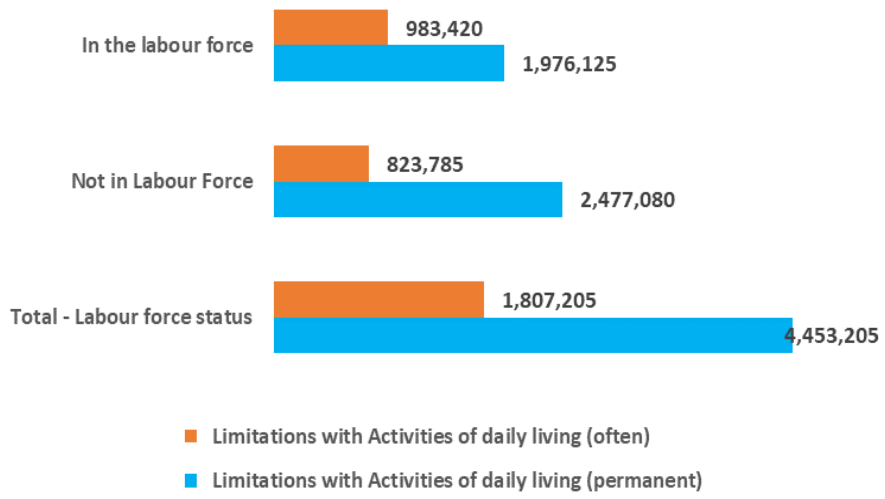
- Given its success in attracting women, biomanufacturing may offer insight to other manufacturing sectors.
- Newcomer women are also a very promising pool of potential manufacturing workers. It is important to consider the opportunity to upskill or re-skill from this labour pool into high skilled jobs, as many of these women are over-educated and under-employed.
- Employers need to assess how well they are doing in terms of creating an inclusive work environment that is attractive for women that includes: gender pay equity, health and benefits plans, remote and hybrid work opportunities where technology shifts allow, flex hours, and a gender-inclusive culture. The physical plant must also be modified as necessary to fully accommodate women in an equitable way.

Employment of Persons with Disabilities (PWDs) in Manufacturing

An underutilised segment of the Canadian labour force is people with disabilities. The majority of the labour force has a temporary disability at some point in their life. However, those with permanent disability (including invisible disability) are now recognised to be a much larger share of the population. Disability is measured in the Census as '*difficulties a person may have doing certain activities of daily living as a result of physical, cognitive, mental, or other health-related conditions or problems*' (Statistics Canada). Disability can therefore be visible and invisible, permanent, or temporary including mental health disability. The Accessible Canada Act (ACA) which came into force in 2019 includes "any physical, mental, intellectual, cognitive, learning, communication or sensory impairment" which can be "permanent, temporary, or episodic in nature.'

Almost 4.5 million persons declared a permanent disability in the Census and of those 56% (approx. 2.5 million) were *not in the labour force*. See Figure 4 below. While some of these people may be unable to work, there are also those who are willing to work but unable to find employment, which represents a loss of human capital for the economy and contribution to society.

Figure 4: Disability Status Declared by Persons in Canada by Labour Force Status, 2021



Source: Census 2021

- According to the 2021 census, 13% (over 262 000) of those in the *in the labour force* with 'permanent difficulties in activities of daily living' or persons with permanent disability (PPDs), were unemployed, and 14% (over 135 000) who often faced difficulties were unemployed. These are much higher unemployment rates than the general population. The 2022 Labour Force Survey also shows that the unemployment rate for persons with disabilities (aged 16-64) was higher (6.9%) than that of persons without disabilities (3.8%). The Labour Survey also showed that PWDs tend to *work in the public sector or be self-employed* (Statistics Canada, 2023). Discrimination in hiring, a lack of workplace accommodation, and workplace discrimination are all potential contributors to this high unemployment rate.
- Manufacturing (along with Construction) has the lowest proportion of employees who have permanent limitations in activity at 8%. This may be related to the physical requirements and manual nature of many occupations. Other sectors typically fall in the range of 9-11%, while *Public Administration* has the highest share of employees with permanent disability at 12%.
- However, in terms of actual numbers employed, manufacturing is the 6th largest employer among industrial sectors of persons with a permanent disability (PPD) – 121,815 persons, as well as persons who often have difficulties (temporary disability).

OCCUPATIONS IN MANUFACTURING EMPLOYING PPDS

The 2021 Census data show that PPDs in manufacturing tend to work in low-skilled or semi-skilled occupations. See Table 5 below. However, the occupation with the highest number of PPDs in manufacturing was *Manufacturing managers* – 5,525 (or 8%) of the managers.

Table 5: Occupations Employing Persons with permanent disabilities in Manufacturing

Occupation	Number Employed	%
Manufacturing managers	5525	8%
Labourers in food and beverage processing	4405	8%
Material handlers	4370	9%
Motor vehicle assemblers, inspectors and testers	4250	9%
Other labourers in processing, manufacturing and utilities	3855	9%

Source: Census 2021

PPDS EMPLOYED WITH EDUCATION RELATED TO ADVANCED MANUFACTURING

The education profiles of the labour force and employees demonstrate that PPDs are studying in diverse fields related to advanced manufacturing. A more granular look at fields where PPDs study demonstrates that even when persons study in areas in high demand in the advanced manufacturing sector, the sector is not necessarily the employer of choice for these highly skilled individuals.

Exemplifying the high demand for these individuals, in the Canadian labour force, PPDs in Genetics, Microbiology and immu*nology*, *Nuclear medical technology/technologist, Electrical and computer engineering, Health/medical physics* were 100% employed. PPDs in *AI* were 94% employed, and those studying in the field of *robotics technician* had an employment rate of 88%.

- Table 6 below shows the very high employment rates of PPDs in the labour force who studied in STEM-related fields and indicates the percentage of that employed population that works in manufacturing. This population therefore represents a potential source of additional workers for the sector.

Table 6: Employment Share of PPDs in the labour force by selected fields of study – All sectors and Manufacturing

Field of Study	Share of PPDs *in the labour Force* that are employed - Canada	Share of PPDs *in the labour force* that are employed - Manufacturing
Chemical engineering	100%	45%
Mechanical engineering	90%	36%
Biomedical/medical engineering	92%	64%
Industrial engineering	91%	59%
Manufacturing engineering	94%	25%
Mining and mineral engineering	94%	0%
computer science	93%	34%
Mechatronics, robotics, and automation engineering	91%	25%
computer engineering	92%	42%
Environmental/environmental health engineering	96%	100%
Aerospace, aeronautical and astronautical/space engineering	90%	41%
Mechanic and repair technologies/technicians	100%	46%

Source: Census 2021

Implications for Human Resource Policies and Practices to Recruit Persons With Disabilities.

Persons with *permanent* disabilities may face problems finding work and *persons with invisible disabilities* (such as autism and other neurodiversity, mental health disability) may have problems retaining employment if accommodations are not in place. This is a labour pool that needs more attention for several reasons. As workers get older, they may develop mental, cognitive, and physical limitations that employers could address through accommodations to retain talent, especially hard to replace talent – skilled trades and highly educated professionals.

Appropriate accommodations for individuals with invisible disabilities may make successful integration and long-term retention of these employees much more likely, increasing the potential worker pool.

- The federal government aims to create accessibility standards around employment, the built environment, information and communications technologies, communication, procurement of goods, services, and facilities, design and delivery of programmes and services, and transportation. The provinces of Ontario, Manitoba, Nova Scotia, British Columbia and Newfoundland and Labrador are also in various stages of developing and /or implementing accessibility legislation which impact employers and the recruitment, retention, and treatment of employees with disabilities, especially with regards

to employment and design of facilities to be inclusive of persons of all abilities.

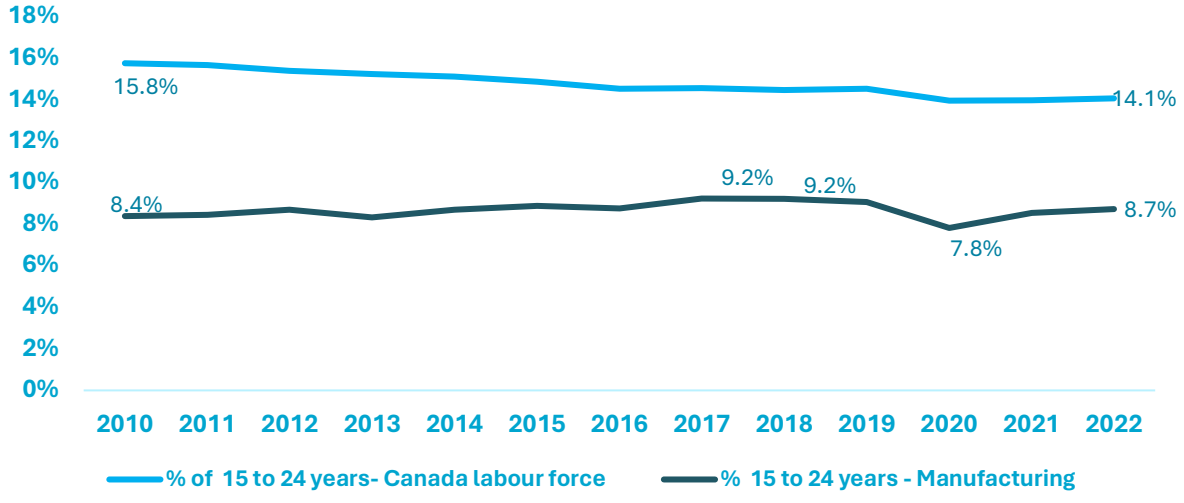
- Manufacturing companies now have more opportunities to employ persons with *temporary and permanent physical disabilities and mobility limitations*. There are also lots of opportunities to employ PPDs in diverse functional areas of the organisation in occupations in management, R & D, marketing, logistics, the professions (law, health, policy), etc. Evolution in adaptive technologies for PPDs and advances in computer technologies, especially with integration of AI (traditional and generative), allow for usage for people of all abilities, whether onsite or remote. Hiring *PPDs with invisible disabilities* also (such as mental health, neurodiversity) provides another labour pool for employers.
- As discussed previously, companies have ready access to accessibility features integrated into common tools such as MS Office, and search engines to support visually impaired, hearing impaired, and persons with manual dexterity challenges. They can also offer ergonomic supports and specialised accessibility software to attract and retain high skilled workers. Hybrid and remote work also allow for ways to employ workers with physical or mental health challenges in working on site.

Youth Participation in the Manufacturing Labour Force

TRENDS IN YOUTH PARTICIPATION

According to LFS data, the share of youth aged 15-24 years *in the labour force* in Canada continues to be much higher than the share in manufacturing. The total share of this group in the workforce is approximately 14-16%, versus 8.3%-9.2% for manufacturing, a nearly forty percent difference. The share of youth in manufacturing peaked at 9.2% in 2017 and 2018 and was at a low during COVID at 7.8%. As of 2019, it had not recovered to pre-covid levels of 9.1%. See Figure 5.

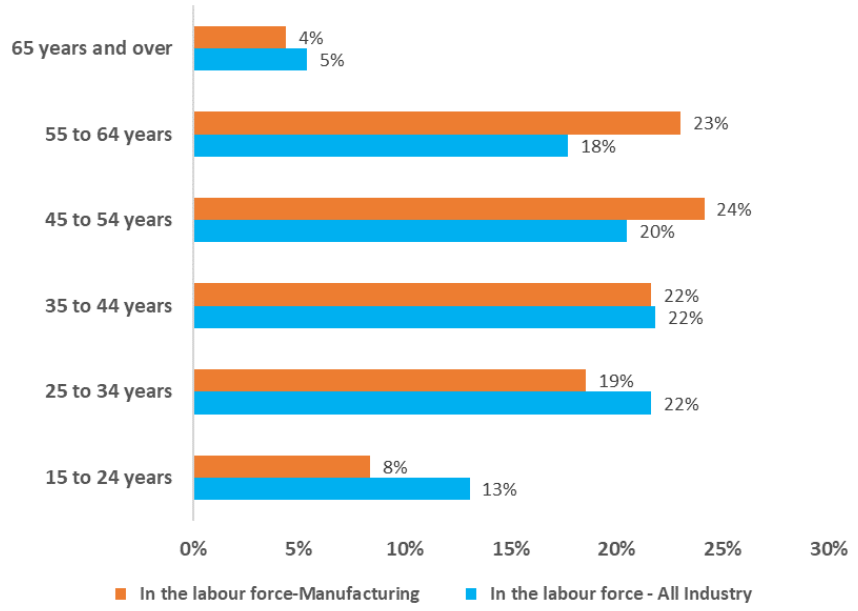
Figure 5: Trends in Youth Participation in Manufacturing, 15-24 years



Source: Labour Force Survey, Custom request 2023

According to the Census 2021, the share of youth aged *15-24* years in the manufacturing labour force was 8% which was lower than the labour force of the overall economy at 13%. The group aged *25-34* years is also lower at 19% compared to 22% in the overall labour force. For the broader definition of youth as *15-34* years age group, those in the labour force for the overall economy was 35% and 27% in manufacturing. See Figure 6.

Figure 6: Age Break-down of people in the Labour Force in Manufacturing and overall economy



Source: Census 2021

YOUTH LABOUR FORCE IN MANUFACTURING VERSUS OTHER INDUSTRIAL SECTORS

Compared to some sectors that have more than 30-60% of the labour force in the 15-34 age group, manufacturing is one of the oldest sectors with 27% aged 15-34 yrs. Manufacturing ranks15th among the 19 sectors with *Accommodation and Food Services* being the youngest sector with 57% of its labour force 15-34 years, followed by *Retail trade* at 48%, and *Arts, entertainment, and recreation* (44%).

YOUTH LABOUR FORCE IN MANUFACTURING SUBSECTORS

The 15–24-year group

The majority of subsectors in manufacturing had a low share of 15–24-year-old in the labour force, ranging from 4%-8%. This is to be expected as many individuals in this age group are still full time college or university students, or opt to work in other sectors part-time. However, there were a few sectors with higher shares of these workers than the overall manufacturing sector (8%) and the overall Canadian labour force (13%). These sectors were *Manufacturing and reproducing magnetic and optical media* (21%); *Bakeries*

and tortilla manufacturing (19%); and *Cannabis product manufacturing* (15%).

The 15-34 age group

In a broader grouping of the youth labour force of *15–34-year-old* workers, the same three subsectors were among the six highest sectors. Three of these top six sectors involved in light manufacturing of consumer goods. See Table 7.

Table 7: Top 5 Manufacturing Subsectors with highest Share of 15-34 yr. old

Manufacturing subsectors	Share of 15–34-year-old workers in the Labour Force
Cannabis product manufacturing	49%
Manufacturing and reproducing magnetic and optical media	44%
Beverage manufacturing	40%
Bakeries and tortilla manufacturing	38%
Pesticide, fertilizer and other agricultural chemical manufacturing	33%
Ship and boat building	33%

Source: Census 2021

WHAT ARE YOUTH STUDYING?

In terms of total numbers, the top three *broad fields of study* for youth (aged 15-34 yrs.) in the *Canadian labour force* provides labour pools from which advanced manufacturing sector could hire – *business, healt*h, and *engineering*. *Health professions and related programmes* could provide workers for the Bio-manufacturing economy. However, workers with an educational background in these three fields of study are also in high demand by other sectors of the economy. Other fields of study such as social sciences, construction, arts, and education steer youth to other sectors and occupations, and may not be in high demand in technology and innovation manufacturing jobs, since most of these occupations require a STEM education. See Table 8.

Table 8: Top 10 fields of study for youth in the labour force, aged 15-34 years in Canada

Field of study of Persons in the Labour Force	People in Labour Force aged 15-34 yrs.	% aged 15-34 yrs.
Business, management, marketing and related support services	760,425	29%
Health professions and related programs	505,195	33%
Engineering	243,615	34%
Social sciences	184,125	34%
Construction trades	171,560	34%
Computer and information sciences and support services	169,450	32%
Visual and performing arts	162,860	38%
Education	158,075	23%
Engineering/engineering-related technologies/technicians	141,720	27%
Mechanic and repair technologies/technicians	124,360	26%

Source: Census 2021

- At a more specialised study level, table 9 below shows the number of youth (aged 15-34 years) in new and established fields of study related to certain occupations that may be linked to innovation and technological change in advanced manufacturing. The table also shows the share of youth in the fields of study in manufacturing in relation to the numbers in the Canadian Labour force. These youth shares range between 15% to 29% for most fields of study. However, there are some fields where the youth shares are low, ranging from 3% to 6%, such as in environmental studies, which is important to greening the sector. The manufacturing sector needs to consider shifting policies related to technological innovation, cleaner production, and climate change policies nationally and internationally, which will require hiring workers in some of these specialised fields of study. Demand for these workers may require more youth enrolling in these programmes.

Table 9: Share of Youth (15-34 yrs.) in the Canadian and Manufacturing Labour Force by Selected Fields of Study

Specialised Fields of Study of people in the labour force	No. of youth in the labour Force - Canada	No. of youth in labour force - Manufacturing	Youth in Manufacturing as a % of the Canadian Youth Labour Force
Computer science	74950	2620	3%
Mechanical engineering	41495	11700	28%
Computer engineering	28560	1265	4%
Chemical engineering	12165	2770	23%
Biotechnology	6705	1010	15%
Industrial engineering	6210	1465	24%
Environmental control technologies/technicians	5430	340	6%
Aerospace, aeronautical and astronautical/space engineering	4110	1080	26%
Environmental/environmental health engineering	2835	155	5%
Mining and mineral engineering	1770	80	5%
Genetics	1490	50	3%
Manufacturing engineering	1140	330	29%
Mechatronics, robotics, and automation engineering	3120	720	23%
Nanotechnology	680	145	21%

Source: Census 2021

Implications for Human Resource Policies and Practices to Recruit Youth

Improving participation of youth in manufacturing continues to be a challenge which requires employers, policymakers, and educational institutions to collaborate to promote opportunities in manufacturing to youth. As discussed in a FOCAL paper[3], 'manufacturers have worked with local workforce institutions, municipal and regional governments, and community colleges to promote annual *Manufacturing Days* every October.' Youth learn about careers in manufacturing and the education and skills required.

- Recent research completed by CSTEC (Interviews, 2023) suggest manufacturers do engage directly with local post-secondary education

[3] See FOCAL (2019 October). 'Automotive Industry Labour Market Analysis: Women, Youth, and Indigenous Persons in Canada's Automotive Industry'

institutions to recruit and train employees and have had some success. Outreach and engagement by local companies and manufacturing industry associations to schools, colleges and universities career departments need to continue. However, targeted outreach for specific STEM -related and skilled trades programmes of study with faculty and students at higher education institutions and training centres, may be more effective for companies who have specific skills needs. ISWI America (2021) suggests that structured apprenticeships that allows young people to obtain work experience may be particularly suited to *young people with disabilities*.

Establishment of *formal co-op. or work-integrated learning (WIL) or apprenticeship placement* programmes on an industry, trade, or company level, provides an opportunity for employers to engage youth early to get ahead of the competition. It allows companies to contribute to their training which provides an advantage in subsequent recruitment. Companies can take advantage of wage subsidy programmes available for such initiatives from provincial governments and the federal government, but information on these opportunities need to be communicated to employers by government and intermediaries involved.

A marketing strategy at a company or industry level has to increase awareness of shifts in the industry in terms of technology and innovation, inclusivity, and the contributions to greening, which could be draws for youth. International Federation of Robotics (2023) suggests that futuristic technology may attract young people to the shop floor, 'If there is a robot operating on the shopfloor, the employer can advertise a job to prospective employees as work that involves controlling a robot. ... Since the robot takes on the 4 "Ds" of dull, dirty, dangerous and difficult work, their use is even more attractive' (Para. 4). But the shift to robotics first has to take place to create this draw.

Conclusion

There are opportunities to recruit from the three labour pools of women, youth, and persons with disabilities - temporary and permanent (and people with intersecting identities) to expand labour force participation in manufacturing and resolve some labour shortage challenges. There is evidence that women, youth and persons with disabilities have uneven participation in occupations and subsectors in advanced manufacturing. While innovation and technological changes, which are impacting occupations, provide an opportunity to enhance the image of the sector and market to various demographic groups, other sectors are also innovating and using new technologies that change the way people work. There are different factors to consider depending on the demographic group from which companies are trying to recruit. New technologies, in and of themselves, will not attract more women, persons with disabilities or youth to manufacturing. The manufacturing sector as a whole and on a company basis have to continue to take action in the following areas:

- **Outreach and perceptions**: Change perceptions of *nature* and *conditions of work* in manufacturing which may be off-putting based on traditional views of old factories and technologies that were polluting and unsafe. Increase *awareness of technological changes* in various sectors and opportunities for various types of jobs that may interest women, youth and PWDs. Utilise various media and engage people directly in their schools, colleges, universities, and *local communities*. Explore opportunities to sell specific occupations based on skills that youth develop early in life. For instance, many young people develop skills in gaming activities, which are very transferrable to manufacturing roles such as hand-eye coordination, learning and replicating a structured sequence of activities (a work instruction versus an interactively developed solution path within a game). Companies or third-party providers to manufacturing also require computer skills to digitise, create animations, AR/VR development, simulation, modelling, and digital twining which could be a selling point to bring young people into manufacturing careers.
- **Outreach and education**: Promote *fields of study* essential to manufacturing (skilled trades and degree level studies) through collaboration among employers, unions, government, higher education institutions (HEIs), and *local communities*. Higher education investments need to support recruitment for the innovation and greening of manufacturing, through funding of specific programmes and courses at HEIs. This outreach and promotion should start with secondary school and outreach to NGOs serving various groups, and communities where people live. Trying to increase interest after people have already selected fields

of study and potential occupations will result in the status quo.

- **Remuneration:** Offer competitive wages and *inclusive benefits packages* to attract people, especially to high skill occupations. Consider generational shifts in values, attitudes and expectations around employee benefits packages needed versus offered, and options for flex benefits.
- **Diversity, equity, and inclusion**: The legislative and policy environment require employers to meet certain human rights and safety obligations, (e.g., federal *Employment Equity Act* for federally regulated employers, provincial and federal Human Rights Codes, accessibility legislation, violence in the workplace, etc). Regardless of these laws and policies, employee expectations have changed in terms of workplace culture towards a more inclusive and equitable environment that goes beyond legislative requirements. Employers should consider specific *barriers and challenges* and take advantage of the diverse ways that *technologies can assist with* reasonable *workplace accommodation* for people with invisible and visible disabilities. Employers also must address visible and invisible *gender-based barriers* and implement measures to create more inclusive environments in plants and facilities, through integrated policies and practices. Having a *reputation as an inclusive employer* is a key competitive factor in attracting talent in the 21st century.
- **Policy support**: There is a role for Government to support manufacturers to procure new technologies such as the co-bots/robots with an eye to increasing productivity and quality, but also to better integrate Canadians with a physical disability into the manufacturing workforce (an underutilised talent pool) and also allow older workers with physical limitations to stay in the labour force, if they have that need or desire.

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