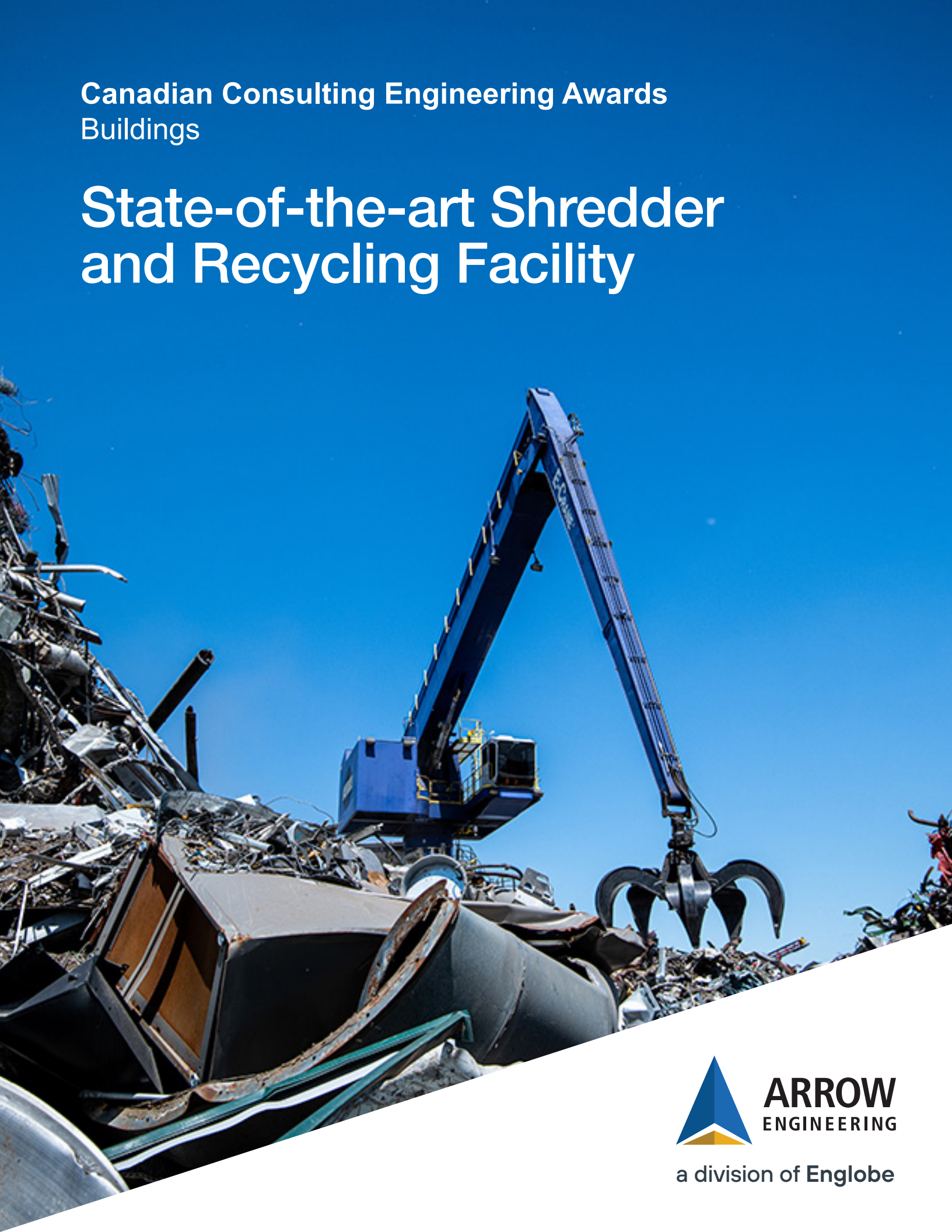
Canadian Consulting Engineering Awards
Buildings

State-of-the-art Shredder and Recycling Facility



ARROW ENGINEERING

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EXECUTIVE SUMMARY

In February 2022 the General Recycling Industries, Ltd. (General Recycling) team gathered at their newly redeveloped recycling facility in the Morris Industrial Park in Edmonton, Alberta to witness an exciting spectacle. After two years of consultation, design work, coordinating, planning and construction, the team was finally ready to turn on their new cutting-edge, multi-staged scrap metal processing facility. With the 'flip of a switch', to boil a very intricate process down to a simple concept, the brilliantly engineered recycling facility worked flawlessly. The team relaxed and could breathe again, their advanced shredding metal technology was ready.

One of the most technologically advanced systems of its kind in Canada, with the impressive capacity to process 80 cars per hour, the facility is comprised of 2 unique buildings that function together as a formidable recycling operation: the automobile shredder building, affectionately dubbed 'the Shredder', and the Auto-Scrap Residue (ASR) building known as the ASR plant. As a united system the operation's sophisticated equipment fragmentizes, sorts, and reclaims recyclable materials from scrap cars, appliances, and other metallic waste. Capable of processing 120 tons per hour of mixed scrap, the facility is nothing short of incredible; a true engineering marvel.

The overall environmental impacts for the project are just as impressive as the operations itself. The upgraded processing plant diverts waste from landfill, resulting in a greenhouse gas (GHG) reduction of more than 700,000 tons annually, all while supporting manufacturing demands for steel, aluminum, and copper. Further, anticipating an influx of materials volume correlating with population growth, designs for the integrated shredder and reclamation system account for increased processing capacity, ensuring the plant will preserve natural resources, save energy, and reduce GHG emissions for years to come. As a bonus, General Recycling purchased a decommissioned shredding plant on the west coast to serve as the heart of its new recycling operation, upgrading and repurposing the dormant plant to suit their needs.

The phrase is used often but this was truly a once-in-a-lifetime project. Some parts of the new facility were purchased whole, dismantled, and reassembled, while others were prefabricated with all the equipment in it or built entirely from scratch. The integrated operation is one of a handful in Canada, 1 of only 2 in Alberta, and is the largest scrap metal processing plant in Western Canada. Each building was technically complex and no one firm in Canada had existing in-house expertise to manage. General Recycling, the owner of the integrated shredder and reclamation system, trusted Arrow Engineering (Arrow) to engineer the complex mechanical, electrical, and structural designs needed to bring their vision of 'shredding for a better tomorrow' to life.

Arrow's specialized mechanical, electrical, and structural engineering team was responsible for designing the plans for the multi-stage facility and the scope involved dismantling, reconstructing, and upgrading the massive automobile shredding machine, along with designs for 2 buildings

housing specialized recycling equipment. There were no guidelines to provide a ‘how to’ approach for a project of this magnitude, no published technical papers, articles, or books. Everything was custom, everything was unprecedented, everything needed to be carefully and expertly engineered and then executed exactly.

To implement the project successfully, Arrow’s team developed an innovative approach including advanced structural engineering to support the Shredder equipment’s enormous weight, intricate electrical to accommodate the immense load needed to operate the facility, especially the Shredder, mechanical upgrades to improve the Shredder and ASR operations, specialized safety considerations, creative insight to reassemble the Shredder on the Edmonton site, and proactive consultation with all project partners and stakeholders.

The project was successfully completed making it one of the most remarkable projects Arrow has ever managed, and an impressive example of world-class engineering achieved by a proudly Albertan team.

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PROJECT OBJECTIVES, SOLUTIONS AND ACHIEVEMENTS

OBJECTIVES

The Client's objective was to redevelop their recycling facility to include cutting-edge shredding technology that would scale up their metal processing in a way that was more efficient and more sustainable. The upgraded facility would increase their scrap metal processing to 120 tons per hour, significantly strengthening their business and improving the environmental footprint of their operations. Wherever possible, they wanted a better system and upgrades that would improve their long-term processing capacity.

Arrow was retained for the project and had a clear mandate: design the mechanical, structural, and electrical systems needed for a multi-stage, integrated metal shredding and reclamation system. All stages in the system had to be robust, work seamlessly with all recycling machinery able to weather Edmonton's harshest weather. With no playbook to guide the project, the engineered solutions came from Arrow's advanced expertise.

SOLUTIONS

Arrow applied sophisticated, innovative engineering to achieve all project objectives:

- Worked with contractors that dismantled the state-of-the-art Scrap Metal Shredder machinery on the west coast, reassemble the machinery in Edmonton, Alberta with upgrades improving efficiency.
  - Upgrades included: modern, high-efficiency motors to run the massive Shredder equipment.
  - Custom structural solutions to support the Shredder's drive system. Located on the second floor, the motors needed the help of gravity to drive the shredding operations and required a custom engineered structural solution. The team designed a 2-storey above ground floating concrete block (425 square feet) to encase and stabilize the motors.
- Customized mechanical design for the Shredder facility to handle extra heating, ventilation, and code requirements.
- Specialized electrical design to accommodate the massive power needed to operate the recycling process. Incoming voltage was utility size and required a utility substation on site.
  - Proactive consultation with local utilities to manage electrical needs of the facility.
  - Systems in place allow the facility to draw enough power to shred up to 80 cars in an hour, safely and without impacting power for other businesses.
  - Advise on acceptable hours of the day to operate, to ensure local brownouts do not occur.
- Comprehensive project management plan covering quality control, risk management, changes to scope etc.

The cutting-edge sorting technology used by General Recycling for their Edmonton operation is unlike any other built in Canada, and the mechanical, electrical, and structural engineering that allow this plant to operate required advanced technical knowledge and skillful planning. Under Arrow's technical direction, the electrical systems are safe, the mechanical systems are robust, and the structural integrity of the building housing massive recycling equipment is sound. A combined engineering feat that ensures the facility functions at peak performance every day.

The team achieved their mandate in a way that perfectly captured the sustainable, and safe vision General Recycling had for their premier project.

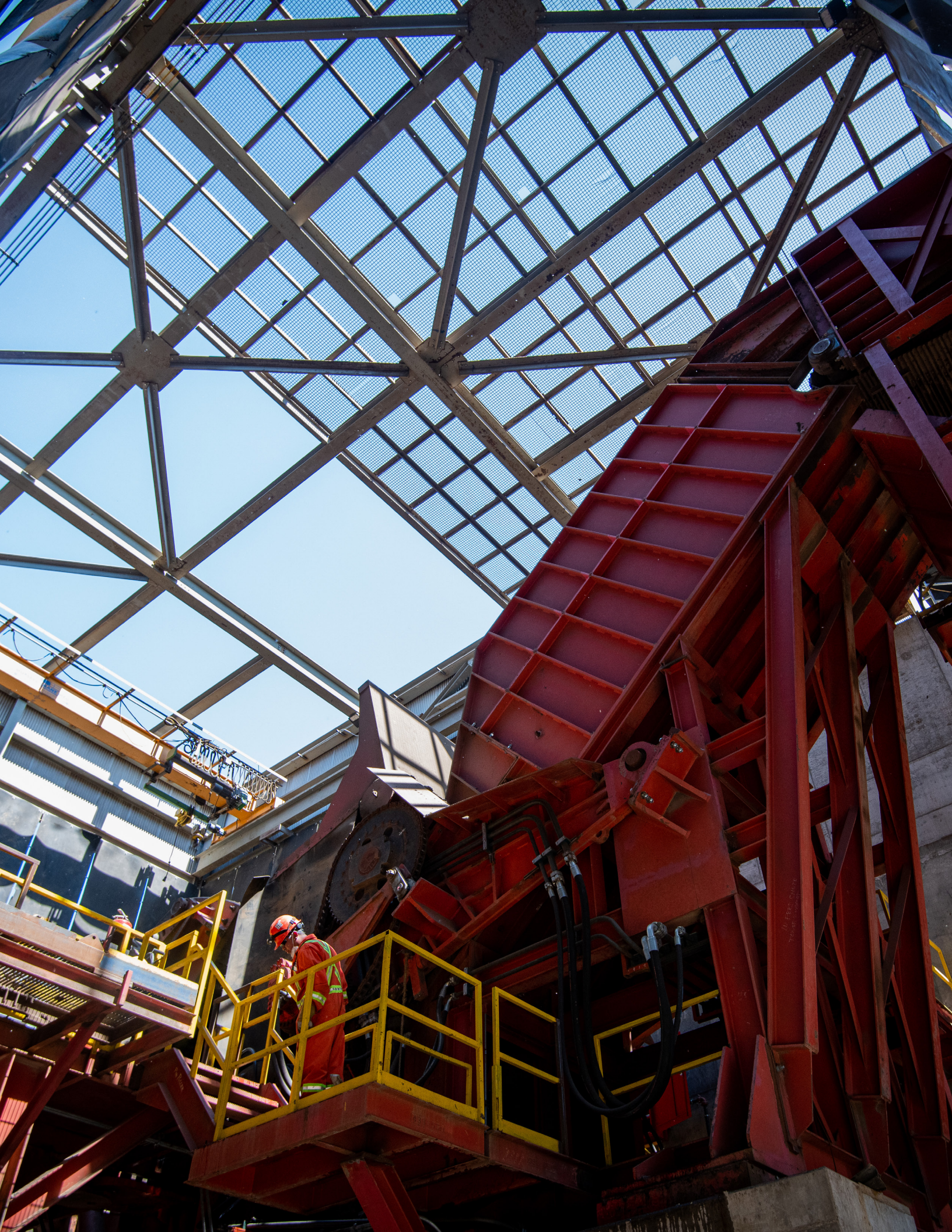
ENVIRONMENTAL IMPACT

If reducing GHG emissions is considered the highest ideals of the sustainability mandate, then a recycling facility that contributes to a significant cut in GHG could be considered the ultimate pursuit. A facility like General Recycling's reclamation system is crucial for the sustainability and health of the planet. At project completion, the upgraded facility is capable of processing over 120 tons per hour and reducing greenhouse gas emissions by over 700,000 tons on an annual basis. Environmentally, this means energy savings, significant landfill space reduction, debris diversion from incinerators, and a reduction in pollution and Edmonton's carbon footprint. Economically and socially, it means recyclables are redirected back into the manufacturing process and reusable materials to appropriate sites, helping to drive better pricing for steel, aluminum, and copper.

Recycling of material that has reached the end of its useful life is one of the most direct methods of reducing GHG emissions. Recovering recyclable components from the waste stream and returning them to the manufacturing process to produce new materials is essential in reducing the environmental impact of the manufacturing and industrial sectors. With the aims of metal reclamation and waste diversion at its core, this plant enhances existing efforts to reduce GHG emissions resulting from foundry and manufacturing activity by creating in the Province of Alberta a larger and purer feedstock to produce new metals. The products generated by this plant will ultimately be used in the manufacturing of new steel, aluminum, and copper, thereby decreasing the environmental impact of new metal production that results from mining for ore and extraction of other raw materials.

TABLE: CARBON FOOTPRINT AND SAVINGS EXPRESSED IN KILOTONNES OF CO2 (KTCO2)/100,000 TONNES

			Saving/100,000 Tonnes	
Material	**Primary**	**Secondary**	(% savings CO2 in parentheses)	
Aluminum	383	29	**354**	(92%)
Copper	125	44	**81**	(66%)
Steel	167	70	**97**	(58%)



Once fully operational and running on a single shift, the plant is projected to produce significant quantities of reusable product on an ongoing basis. Accordingly, the use of the plants products in the manufacturing of new metals will result in a total annual GHG reduction of 722,386 equivalent tons CO2. Greater GHG reduction can be achieved with the addition of a second operating shift, effectively doubling the emissions reduction.

Another way the facility reduces GHG emissions is by retaining the recyclable feedstock for processing within the Province of Alberta and preventing its export over long distances to markets beyond provincial borders. Data suggests that significant quantities of unprocessed but reclaimable material is leaving Alberta each month due to a shortage of local processing capacity. As a result, the material is typically shipped by truck in large, unwieldy, and loosely compacted bails. The low density of the bails and the heightened safety concerns resulting from the bailed packaging format restrict the total weight contained in a single load to 45 tons per truckload. The finished shredded product, by comparison, is a highly densified material with minimal handling safety concerns. This is typically shipped by rail with a weight of 100 tons per railcar. The environmental impact of this export activity cannot be overstated. Rail shipment is four times more fuel efficient than trucking, with trucking averaging an efficiency of 120 ton-miles per gallon (ie., one gallon of diesel fuel can move one ton of freight 120 miles) versus 480 ton-miles per gallon for rail transportation (The Environmental Benefits of Moving Freight by Rail, Association of American Railroads, 2018). Being able to capture and process the excess material locally would result in immediate and significant GHG reductions. We estimate that this export activity produces 2.57M lbs of GHG emissions monthly. This amounts to 15,429 tons of GHG emissions annually that could be avoided by keeping the material in Province, processing it locally at facilities like the upgraded General Recycling plant, and only shipping the highly densified finished product by rail – an important and effective means of strengthening Alberta's competitive advantage in an increasingly low-GHG global economy.

As one of the most advanced integrated waste management centers in North America, the City of Edmonton has made landfill diversion a key municipal priority. The new advanced recycling facility will play a key role in helping the City of Edmonton work towards its goal of 90% landfill diversion. Thanks to the new state-of-the-art technology that can recover the maximum amount of metallic content from the plant's waste stream, the operation will help recover and recycle 82% of the material processed by the plant. This will result in only 18% of the plant feedstock being sent to the landfill where it will serve as landfill cover. Additionally, by removing virtually all the metallic content from the waste stream, the plant will produce a waste product that can be incorporated into downstream reclamation processes and ideally be consumed completely, achieving a near 100% landfill diversion. Similarly, proper drainage and disposal of fluids from the recyclable material, as well as the removal of hardware components containing chemicals that are harmful to the environment, is an essential component of the preparation for processing materials – another important step in protecting local land and water sources.

ENGINEERING ACHIEVEMENTS

This project was extremely challenging from an engineering perspective. The reclamation system consists of 3 major phases: (1) Shredding, (2) ferrous downstream separation, and (3) non-ferrous downstream separation. Each phase takes place in separate but interconnected buildings with phase 1 of the process feeding processed materials to phase 2 and phase 3. Although the scope of the project included 3 integrated buildings, the Shredder building alone inspired many innovations.

The equipment was purchased used from a facility on the west coast, so the team had drawings from the previous site they could reference. However, there are vast differences between the west coast and Edmonton, AB which meant that many design aspects of the machine needed to be changed to account for the climate differentials. This included mechanical and electrical upgrades for extra heating, different code requirements, different ventilation needs, etc.

It is in the Shredder where scrap material is fragmentized into smaller chunks, approximately 2-5' in diameter, broken down to be more easily sorted and separated. Huge cranes deliver the material to a double-feed roll system where it is transported to the hammermill. Utilizing two 2500 horsepower motors and twelve 500 lb hammers swinging around at 600RPM, the Shredder pulverizes the feedstock and generates material for the sorting phase of the system.

The structural, mechanical, and electrical engineering achievements to safely accommodate such massive equipment was incredible.

Structural engineering: Foundation and building design for the Shredder building, along with foundation design of the ASR pre-engineered building. The shredder building included many engineering challenges including supporting the two 2500 horsepower motors and isolating the forces generated from swinging the shredder's 12 500lb steel hammers around at 600RPM and was located on the second floor of the building. To accommodate this massive weight the structural engineering team recommended a floating concrete block extending from the ground all the way up to the second level. The rest of the Shredder building was constructed around the concrete block, ensuring that all parts of the shredder were supported by a separate solid foundation, unaffected by shock and vibratory forces generated by the shredder motors.

Mechanical engineering: the Client wanted a better system than the one they originally purchased. Instead of one 5000 horsepower motor, the team recommended two 2500 horsepower motors, as well as integrated facilities for operations and maintenance to support the daily activities onsite. To account for the local climate and yard conditions, the mechanical team-built upgrades for localized heating, largescale cooling, air filtration, and ventilation into the design.

Electrical engineering: a facility of this magnitude has an enormous electrical load requirement needing a utility substation on-site, among many other obstacles having to provide a new electrical infrastructure for existing equipment of this load.

Stakeholder consultation: When operational, the Shredder system alone pulled power for the entire area and the team needed to coordinate with utility providers to find a workable solution.

The operation will help recover and **recycle 82% of the material processed** by the plant.

LEVEL OF COMPLEXITY AND PROJECT CHALLENGES

ELEMENTS TO OVERCOME

The biggest challenge faced by the team for this project was related to structural engineering: designing a structure that could safely house and stabilize the equipment over the long life of the facility. This structural design for the Shredder building was most complex. To propel the shredder equipment, the team needed the help of gravity meaning the motors for the machinery had to be housed on the second level. To support the motors the team designed a mega floating concrete block that extended all the way from the ground up to the second level completely encasing the system. The building was then built around the concrete block, taking the unique aspects of the shredder system like the 12 500lb hammers into consideration.

Another element that the team had to overcome was the reality that this was a complex project with no Canadian engineering precedent. Other than the architectural design firm and Arrow's team of engineers, the entire list of project partners were international spanning the globe from the United States to Europe. For this one-of-a-kind recycling facility, there was no standard engineering design template that Arrow could follow. One of the greatest challenges faced by the team was that engineering for this type of project had never been completed by their team. Even internationally, there are limited examples of a project of similar scope and complexity. With no pre-existing guidelines, the team was developing its own design from scratch for the most complex group of specialized equipment they had ever managed. To predict and engineer a positive outcome, the team had to rely on experience, structural data, and information specific to the equipment. The designs that were engineered for this project were just as unique as the new facility.

ENGINEERING SUSTAINABLE COMMUNITIES

When Arrow successfully completed work for General Recycling's integrated multi-stage reclamation system, something a bit out of the ordinary for the industry happened. The General Recycling team invited Arrow's engineering team to come for a tour. Seeing firsthand the entire system in action was an amazing experience that reinforced that this project was special. Their work has enabled the Client to make a significant environmental impact. From an extreme scale-up in the volume of materials that will be diverted from landfill to the quantity of usable metals that will be returned to the market, to the enormous amount of GHG reduction annually, this project makes a big difference.

Arrow's engineers helped create a modern, sustainable facility poised to set new standards for recycling. With no other design like it in Canada and the continued move towards engineered systems that are in balance with the environment, this project demonstrates to the consulting engineering community the significant impact engineers have on society.

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