EGA Story from Humble Beginnings to a Mega Smelter

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Abstract

Emirates Global Aluminium (EGA) started the first Kaiser P69 technology cells in Jebel Ali smelter in 1979 with annual production of 149 kt of metal in 1982 when the first three potlines were in operation. Since then, many smelter expansions, modernizations and innovations brought the total production of its two smelters in Jebel Ali and Al Taweelah to 2.501 Mt aluminium in 2021. The potline modernizations and expansions have used EGA's own cell technologies, developed inhouse since 1990: D18, CD20, D20, DX, DX+, DX+ Ultra, D18+ and D20+. Excellent CAPEX and OPEX performance led to the licensing of DX+ Ultra technology to ALBA for its Potline 6 expansion. This technology development was based on continuous innovation, supported by EGA's mathematical modelling and design engineering. Cell control systems are also the result of EGA's own development which culminated in the latest advanced Pot Control System (PCS), using standard programmable logic controllers (PLC) for easy maintenance and future development with increased HMI capabilities. The PLC based PCS is implemented in EGA's Al Taweelah Potline 3 using DX+ technology and in DX+ Ultra technology in ALBA's Potline 6. During all these years, EGA has been continuously reducing the impact of its aluminium production on the environment and made the production more sustainable with improvements in capture, cleaning and recycling. In 2018, EGA achieved world-benchmark low PFC emissions of 0.020 t CO_2 eq/t Al and fluoride emissions of 0.3 kg/t Al. Upstream, EGA established Guinea Alumina Corporation (GAC) in 2013, which makes EGA one of the biggest merchant suppliers of bauxite in the world, and also supplies bauxite to Al Taweelah alumina refinery, commissioned in 2019 and which produced 2.326 Mt of alumina in 2021. EGA also relies on its many Industry 4.0 initiatives in all of its activities to improve the sustainability, the efficiency and the profitability of the smelter of the future. The development of EGA from the modest beginnings in 1979 to an integrated global aluminum giant today will be described in the paper.

Keywords: Emirates Global Aluminium (EGA), Technology development and innovations, Potline expansions, Potline emissions control, Reduction of carbon footprint.

1. Introduction

Emirates Global Aluminium (EGA) started its operations in Jebel Ali smelter in 1979 as Dubai Aluminium Company Limited (DUBAL) with Kaiser P69 technology cells with annual production of 149 kt of metal in 360 cells in 1982 when the first three potlines were in operation. Since then, many smelter expansions, modernizations and innovations brought the total production of its two smelters in Jebel Ali and Al Taweelah to 2.501 Mt aluminium in 2021. The potline modernizations and expansions have used EGA's own cell technologies, developed inhouse since 1990: D18 replaced by D18+, CD20, D20, D20+, DX, and DX+ Ultra operating in Jebel Ali, and DX, DX+ and DX+ Ultra operating in Al Taweelah. Figures 1 and 2 show Jebel Ali smelter in 1990 and today. Figure 3 shows Al Taweelah potlines.

Figure 1. EGA's Jebel Ali smelter in 1990 with 4 potlines and 504 D18 cells.

Figure 2. EGA's Jebel Ali smelter in 2022 with 7 potlines, 6 cell technologies, 1577 cells.

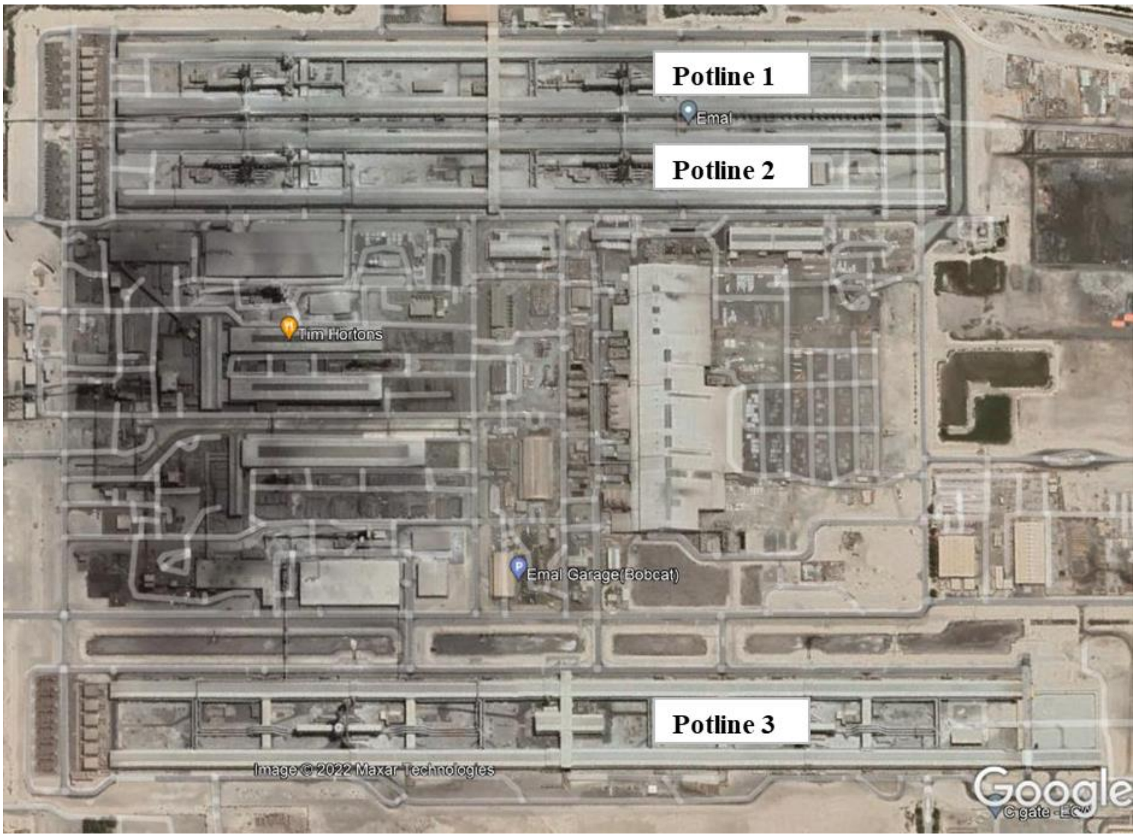

Figure 3. EGA's Al Taweelah smelter in 2022 with 3 potlines, 3 cell technologies and 1266 high amperage cells (picture from Google Earth).

2. EGA Production Increase

EGA increased the production of aluminium with smelter expansions and amperage increase.

2.1 Smelter Expansions

In 1990, EGA started its first expansion project by adding a fourth potline having EGA's improved version of a Kaiser P69 cell called D18 technology. These 144 pots allowed for further amperage increase to 200 kA. The improvement was attractive enough to subsequently convert all previous three potlines from P69 pots to D18. More cells were added in 2008 and 2009, bringing the total number of D18 cells to 520 [1]. Then, Potline 4 was merged with Potline 3 in 2008 and Potline 2 was merged with Potline 1 in 2010. In 2015-2018, all D18 cells were replaced by D18+ technology developed by EGA and designed for higher amperage and lower energy consumption [2, 3]. The modernization of the two potlines increased the production by approximately 32 kt (2021 compared to 2014). Figure 4 shows a D18 and a D18+ potroom.

Figure 4. D18 cells (left) [3] were replaced by D18+ cells, shown in test section of Potline 1 (right) [3] in Jebel Ali, now installed in full Potlines 1 and 3.

In 1996 and 1999, through joint development with Comalco of Australia, EGA added two more potlines using CD20 technology, developed at EGA Jebel Ali site. Potlines 5 and 6 had 240 cells each, operating at 230 kA. In 1998, five CD26 demonstration cells were added at the end of Potline 5, in so called Eagle section. In 2003 and 2005-2007, EGA further expanded its production by adding 496 cells in lines 7 and 9. These were modified CD20 cells, named D20 cells [4]. In 2007-2008, Line 5 was extended to 5B which has 32 D20 cells, connected to a booster to operate at 270-275 kA. Seven of these cells were converted to D20+ technology in 2016 [5, 6].

In 2005 EGA made a decision to independently develop its own high amperage reduction cell technologies. EGA built 5 DX cells in Eagle demonstration section in Jebel Ali Potline 5 to develop its first high amperage technology, which started up at 325 kA and ended at 350 kA in 2010. As part of demonstrating large-scale capabilities of DX technology, EGA built Potline 8 in 2008, with 40 DX cells in Jebel Ali site, which was expanded by 4 additional cells in 2015 to a total of 44 cells now. Figure 5 shows a D20 potroom and a DX Potline 8 potroom in Jebel Ali.

Figure 5. D20 potroom (left) [Alfarsi, TMS 2008 presentation] and DX (right) Potline 8 potroom in Jebel Ali.

The next significant step in in EGA expansion was construction of Potlines 1 and 2 in EGA Al Taweelah smelter in Abu Dhabi (Emirates Aluminium (EMAL) at the time) with 378 DX cells each, commissioned from December 2009 to January 2011 at 350 kA with a nominal production capacity of 740 000 tonnes per year [7].

Once the DX technology start-up commenced at Al Taweelah, Jebel Ali started a new technology development: DX+ in 5 Eagle demonstration cells. By 2011 the successful demonstration of the DX+ technology led to EGA Al Taweelah’s first expansion; Potline 3 was built with 444 DX+ cells, started-up from September 2013 to June 2014 at 440-444 kA [8]. Potline 3 operates at 465 kA now and the plan is to increase amperage to 480 kA [9]. The design capacity of the potline was 520 000 t/year, but now it produces 578 000 t/year.

In 2021, Al Taweelah smelter was extended by 52 DX cells in Potlines 1 and 2, 26 in each potline, and 14 DX+ Ultra cells in Potline 3, increasing the production by approximately 80 kt [10].

Figure 6. DX (left) [6] and DX+ (right) [7] potroom in Al Taweelah.

2.2 Amperage Increase

EGA's strategy for amperage increases is to use mathematical models for key cell parameter calculations. EGA has full mathematical modelling capability for cell design and amperage increase studies [11-12]. With these models, the planned amperage increase is evaluated beforehand so that there is greater certainty when actual cells are tested. Cell parameter adjustments for increased amperage were linked to three strategies: constant anode-cathode distance (ACD), constant voltage and constant net internal heat [11]. Often a combination of these three strategies is required. The objective is to keep favourable conditions for cell performance with bath temperature in the range of 955-965 °C and avoid squeezing ACD beyond a certain limit in order to avoid instabilities and current efficiency loss. Each potline adjusts the strategy as required for stepwise amperage increase. Decreasing anode cover height and increasing metal height to lose more heat and avoid squeezing ACD were often the first parameter adjustments for heat balance during amperage increase.

Each new technology was designed for higher amperage. Moreover, the strategy within a technology includes using amperage boosters on a smaller number of cells, for testing increased amperage before implementation in a full potline. For DX technology, Jebel Ali Potline 8 with 44 cells is used for this purpose, for DX+ Ultra five Eagle demonstration cells and for D20, Potline 5B with 32 cells. All these are equipped with boosters. Figure 7 shows average amperage increase for Jebel Ali and Al Taweelah. Tables 1 and 2 give details by potlines.

Table 1. EGA Jebel Ali pot technologies and amperages.

			Amperage (kA)		
Potline	**Start-up**	**Technology**	**Original**	**June 2022**	**Future plan**
1	1979	P69, D18	150, 205 max	No more	No more
3	1981	P69, D18	150, 205 max	No more	No more
1	2016	D18+	205	238	245
3	2017	D18+	205	240	245
5	1996	CD20	200	244	269
Eagle, 5 cells	1998-2005	CD26	250, 280 max	No more	No more
Eagle, 5 cells	2005-2010	DX	320, 350 max	No more	No more
Eagle, 5 cells	2010-2014	DX+	420, 460 max	No more	No more
Eagle, 5 cells	2014-2021	DX+ Ultra, G1	440, 480 max	No more	No more
Eagle	2022-now	DX+ Ultra, G2	500	500	500
5B, 32 cells	2007, 2008	D20, D20+	225	267	275

6	1999	CD20	200	243	269
7	2005 (7A) - 2006 (7B)	D20	225	270	275
8, 44 cells	2008	DX	340	429	437
9	2003 (9A) - 2006 (9B)	D20	225	264	275

Table 2. EGA Al Taweelah pot technologies and amperages.

			Amperage (kA)		
Potline	**Start-up**	**Technology**	**Original**	**June 2022**	**Future plan**
1 and 2	2009-2011	DX	350	436	437
3	2013-2014	DX+	440-444	465	480
3, extension, 14 cells	2021	DX+ Ultra	465	465	480

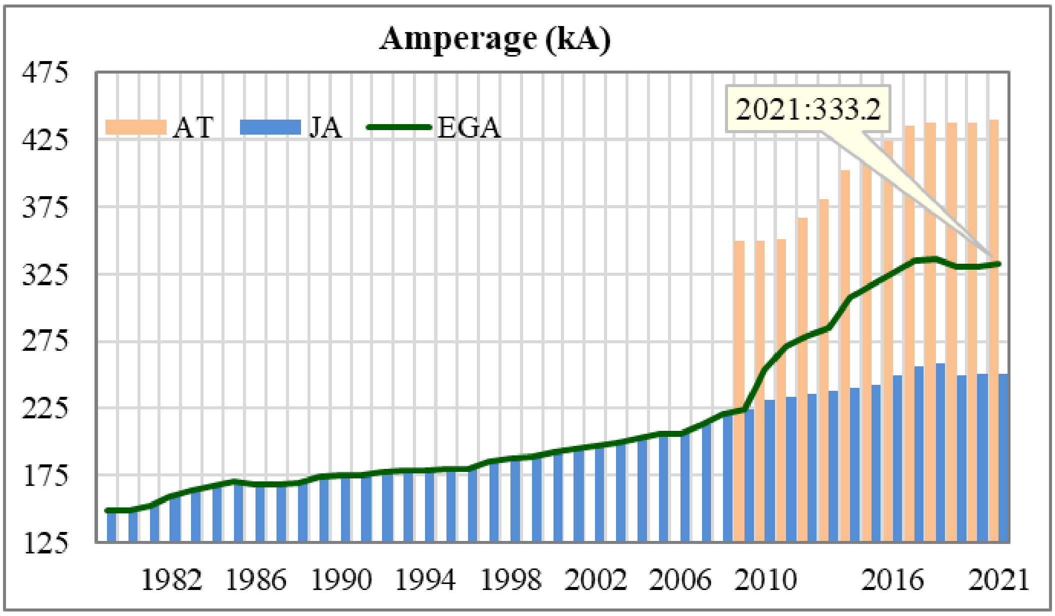

Figure 7. Average amperage increase in EGA potlines.
AT = Al Taweelah, JA = Jebel Ali.

2.3 Increase in Metal Production

Metal production increased with smelter expansions, new ever higher amperage technology designs, and with amperage increase. Figure 8 shows metal productions for Jebel Ali and Al Taweelah. From 149 kt of metal in 1982, the production increased to 2.501 Mt in 2021.

2.4 Decrease in Specific Energy Consumption

Specific energy consumption decreased by approximately 18 % from its peak in 1984 to 2021. Figure 9 shows this graphically.

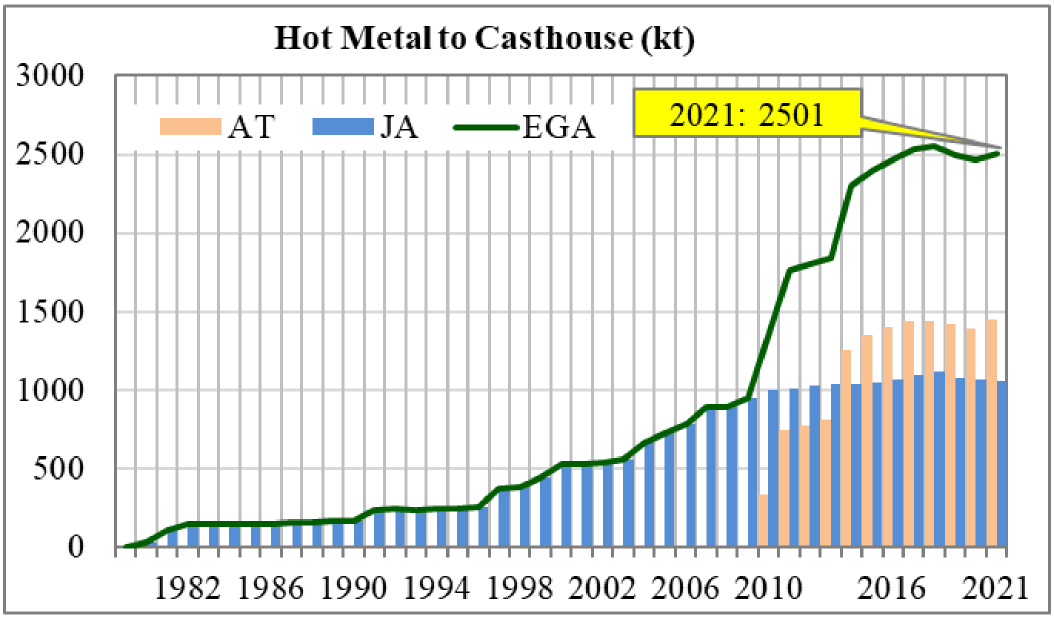

Figure 8. Increase of annual production of aluminium is the result of smelter expansions and amperage increase.

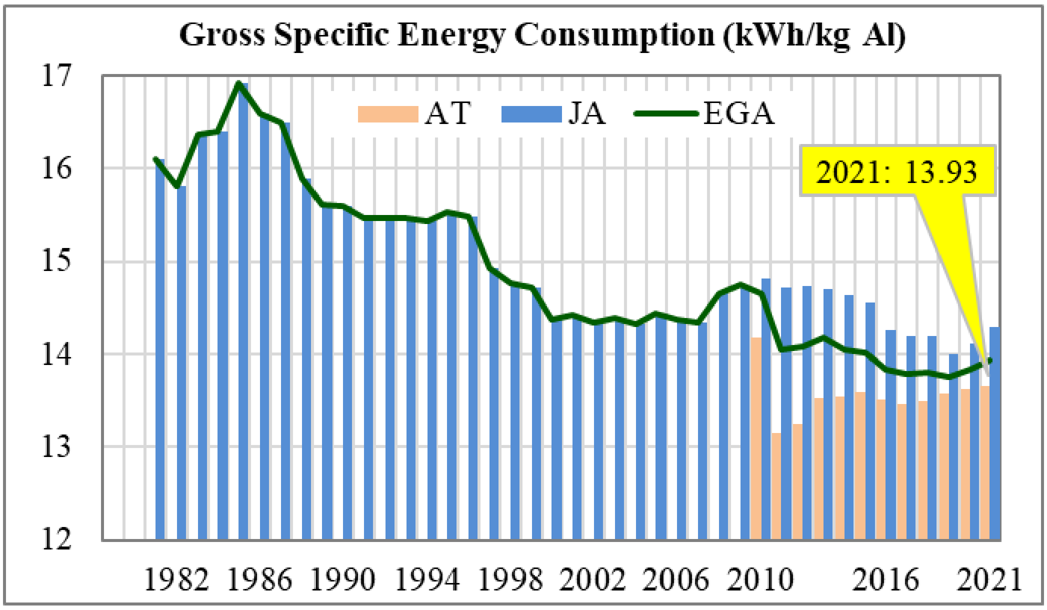

Figure 9. Decrease of specific energy consumption over time.

3. Technology Development and Transfer, and Technology Excellence

EGA's Technology Development and Transfer Department develops new technologies that further improve the aluminium smelting process; designs, builds and operates pilot reduction cells to test and validates new ideas; and supports the industrialisation of new technologies either at EGA or in customers' smelters. Technology Development is responsible for cell design and optimization using its expertise in modelling, process and engineering. Technology Transfer is responsible for managing the transfer of the technology to the Licensees with the best available resources of EGA [13].

Technology Excellence is based on innovations, inventions and continuous improvement with EGA's Employee Suggestion Scheme. Figure 10 shows the structure of EGA's Technology Development, Technology Transfer and Technology Excellence.

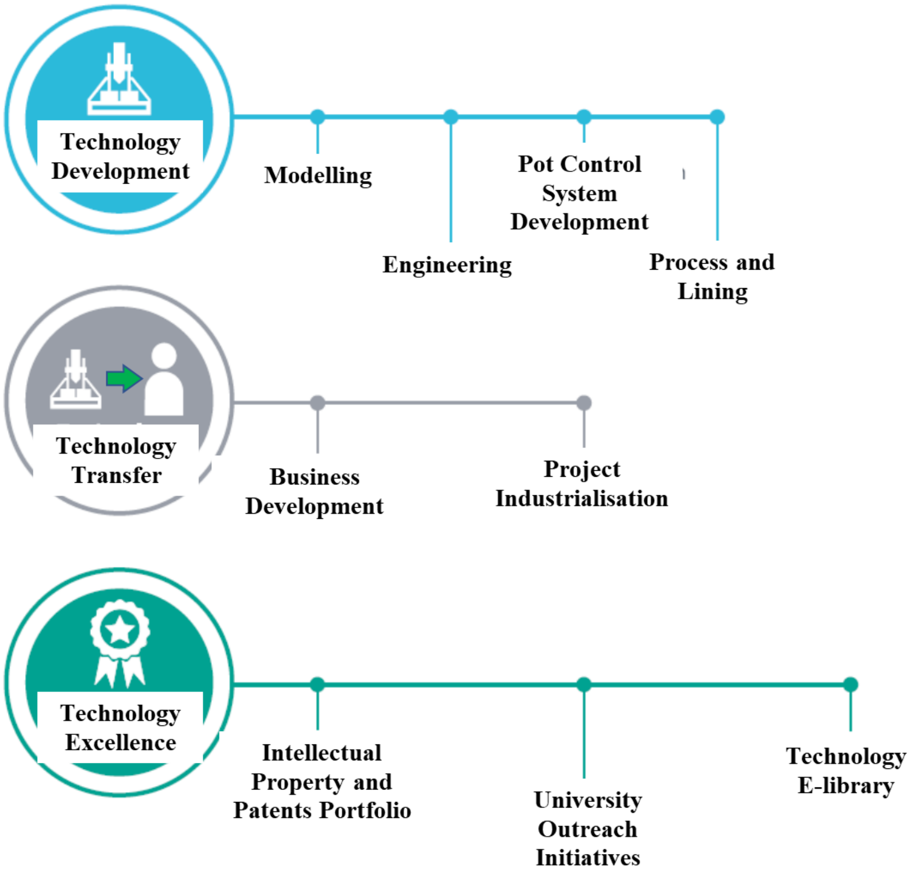

Figure 10. Structure of EGA's technology development and excellence.

3.1 Cell Technology Development

EGA has developed and industrialised eight reduction technologies in greenfield projects and brownfield retrofits. EGA has used its own technology for every smelter expansion since 1990, and has retrofitted all older production lines. All 2843 reduction cells at EGA use EGA cell technology.

EGA is licensing its technology to other aluminium companies. In addition to delivering revenue, technology licensing creates further opportunities to industrialise EGA's innovations, which strengthens continuous technology development processes for the interest of the company and technology customers.

In 2016, EGA licenced its flagship DX+ Ultra technology, entirely developed inhouse, to Aluminium Bahrain for Potline 6, commissioned in 2019. In addition, EGA provides technologies and services to support upgrades to existing smelters.

3.1.1 D18 and D18+ Cell Technology

The original 360 P69 cells were modified in-house to D18 with a new cathode design, longer anodes and improved alumina feeding system (Pseudo Point Feed) [1]. This allowed increased production through higher amperage >200 kA from original 150 kA and better current efficiency.

During 2013, the in-house development team conceived and designed an improved D18 cell (called D18+) that could replace the existing 520 D18 cells with more energy efficient cells. D18+ cells have the same cell-to-cell distance with new magnetically compensated aluminium bus bars and four side anode risers. The pots are lengthened to accommodate two additional anodes and two cathode blocks. All this is achieved by modifying the existing potshell and install a modern alumina point feeding system [2]. In 2015-2018, the two D18 potlines (consisting of four original D18 potlines) were modernized to D18+ cells.

3.1.2 D20 and D20+ Cell Technology

In 2013 a development program was initiated to upgrade existing CD20 and D20 technologies, which have operated at EGA Jebel Ali since 1996, to improve their cell energy efficiency. The new cells were named D20+ [4, 5] (Figure 11). The D20+ changes include the use of graphitized cathode block with copper insert collector bar, revision of external busbar design, retrofit anode superstructure and potshell to accommodate the increased number of anodes from 20 to 24 and cathode blocks from 19 to 22. The cell control logic was also improved. The D20 cells underwent only partial busbar re-engineering to accommodate higher current and to enhance magnetohydrodynamic stability [4]. D20+ cells have the same width as D20 but they are 1.7 m longer.

Figure 11. D20 and D20+ Cell Technologies [5].

In 2016 seven D20+ trial cells were started in Potline 5B at Jebel Ali in order to validate the cell design and performance. To minimize metal production losses while converting, one pot retrofit was carried out one at a time with the total conversion process lasting 128 days.

The D20 technology originally started operation at 220 kA. Through in-house development and upgrading of the process capability the D20 technology operates at 270 kA now.

3.1.3 DX Cell Technology

In 2004, DUBAL independently designed and engineered entirely in-house the DX reduction cell (Figure 12). From 2005 to 2010, DX technology progressed successfully from initial prototyping through to large scale industrialization. Five DX demonstration cells were installed in Eagle section of Potline 5 at Jebel Ali and started up at 325 kA between September and December 2005.

In 2010, before they were stopped to give place to DX+ cells, the amperage was 350 kA. In 2008 DX technology was implemented in jebel Ali Potline 8 (40 cells) and in 2009-2011 in Potlines 1 and 2 in Al Taweelah (808 cells now).

Figure 12. DX cell in Al Taweelah Potline 1 [14].

3.1.4 DX+ Cell Technology

After successfully implementing DX technology in EMAL Potline 1 and 2. the technology development at DUBAL continued. In July to August 2010, DUBAL started up five DX+ demonstration cells. As the name indicates, DX+ technology is an extension of the DX design to higher amperage, higher metal production per pot-day at lower capital cost per installed tonne of capacity.

DX+ cells were designed to operate at 420 kA initially and were anticipated to operate at up to 460 kA. Accordingly, DX+ cells are larger than DX cells: the potshell is 0.3 m wider and 0.6 m longer. However, the pot-to-pot distance is 6.3 m, the same as for DX cells. The busbar configuration has also been maintained, but the busbar cross-sectional area in DX+ industrial cells is larger to accommodate the higher amperage without increase of external voltage drop. While both cells have 36 anodes, the size of the DX+ anode is greater than DX anode to match greater potshell dimensions and to limit the anode current density at higher amperage. Neither DX nor DX+ technology requires forced potshell cooling or external magnetic compensation.

DX+ demonstration cells were started up at 420 kA and cell amperage was increased in stages with long time operation at 440 kA and 450 kA before cells were shut-down in January 2014 to allow installation of the new DX+ Ultra cells [7].

An industrial scale full Potline 3 at EMAL comprising 444 DX+ cells was started up between September 2013 and June 2014 at 440 – 444 kA, with design capacity of 520 000 tonnes [8]. The potline is currently operating at 465 kA and the plan is to increase amperage to 480 kA [9]. The DX+ cell in EMAL Potline 3 is shown in Figure 13.

Figure 13. DX+ cell in Al Taweelah Potline 3 [14].

3.1.5 DX+ Ultra Cell Technology

Further efforts to develop lower CAPEX and even lower energy, high amperage reduction cells have led to the design of DX+ Ultra technology. By introducing various voltage drop reduction initiatives that address the key energy consumers in a reduction cell, DX+ Ultra technology has achieved substantially lower energy consumption than DX+ technology.

DX+ Ultra cells have the same dimensions as DX+ but incorporate a new cathode design with copper collector bar inserts to reduce cathode voltage drop and specific energy consumption. It also incorporates modified cell-to-cell busbar to accommodate decreased cell-to-cell centreline distance from 6.3 m to 6.0 m, thus saving in Capex. The end-result is the best-in-class production per building surface area.

In 2014, five DX+ Ultra demonstration cells were built and commissioned in Jebel Ali Eagle section of Potline 5 (Figure 14), replacing the five DX+ technology cells [15]. In 2017, two of these cells were upgraded to the industrial design to demonstrate operation at 460-480 kA for ALBA Potline 6. These Two cells were designed with asymmetric busbars and some modifications to the cathode lining [16]. ALBA Potline 6 was started up in 2019 at 460 kA and operates at 478 kA now, on the way to 480 kA [17]. DX+ Ultra Eagle cells were operating at 480 kA in March 2021 when they were stopped. The new generation of DX+ Ultra Eagle cells was started up in March 2022 at 500 kA.

Figure 14. DX+ Ultra cell in Jebel Ali Eagle Section [14].

3.2 Evolution of Cathode Designs

Along with smelter expansions, amperage increase and new cell technologies, cathode designs have equally gone through the whole spectrum of cathode blocks from anthracitic to graphitic and finally graphitized as well as several collector bar design changes, including full transition to copper inserts, with the aim to increase production through amperage increase and reduce specific energy consumption [18]. This evolution went through systematic testing of each cathode block type and grade, and collector bar design. The latest tests are with a proprietary and patented cathode design with full copper collector bars, which reduces the cathode voltage drop and specific energy consumption further [19]. The challenge has been that EGA operates seven different technologies at different amperages, which require not only good cathode designs but also good cell control and operation. Table 2 gives the evolution of cathode block designs by cell technology at EGA.

Table 2. Cathode designs by cell technology.

<table>
<tr><th>Start Year</th><th>Technology</th><th>Cathode Block Material</th><th>Collector Bar Details</th></tr>
<tr><td>1979</td><td>P69</td><td rowspan="2">Electrically Calcined Anthracite (ECA)</td><td rowspan="2">Single steel bar with square cross-section</td></tr>
<tr><td>1991</td><td>D18</td></tr>
<tr><td>1996</td><td>CD20</td><td>30 % graphitic</td><td rowspan="3">Single steel bar with round cross-section</td></tr>
<tr><td>2005</td><td>All</td><td>-</td></tr>
<tr><td>2007</td><td>D20</td><td>Graphitized & impregnated</td></tr>
<tr><td>2011</td><td>All</td><td>-</td><td rowspan="2">Single steel bar with rectangular cross-section</td></tr>
<tr><td>2013</td><td>D18</td><td>100 % graphitic</td></tr>
<tr><td>2013</td><td>All</td><td>-</td><td>Split steel bars with rectangular cross-section</td></tr>
<tr><td>2018</td><td>All</td><td>-</td><td rowspan="2">Split copper inserted steel bars with rectangular cross-section</td></tr>
<tr><td>2019</td><td>All</td><td>Graphitized & impregnated</td></tr>
<tr><td>2019</td><td>D20</td><td>Graphitized & impregnated</td><td>Full copper collector bar</td></tr>
<tr><td>2020</td><td>CD20, DX</td><td>Graphitized & impregnated</td><td>Full copper collector bar</td></tr>
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3.3 Cell Modelling and Engineering

During the last 15 years, EGA Technology Development department has developed in-depth mathematical modelling capability for aluminium electrolysis cells, based on commercial software packages, comprising thermo-electric, magnetohydrodynamic (MHD) and mechanical models of the cells as well as CFD models of gas extraction from cells and potroom ventilation (Figure 15) [11, 12].

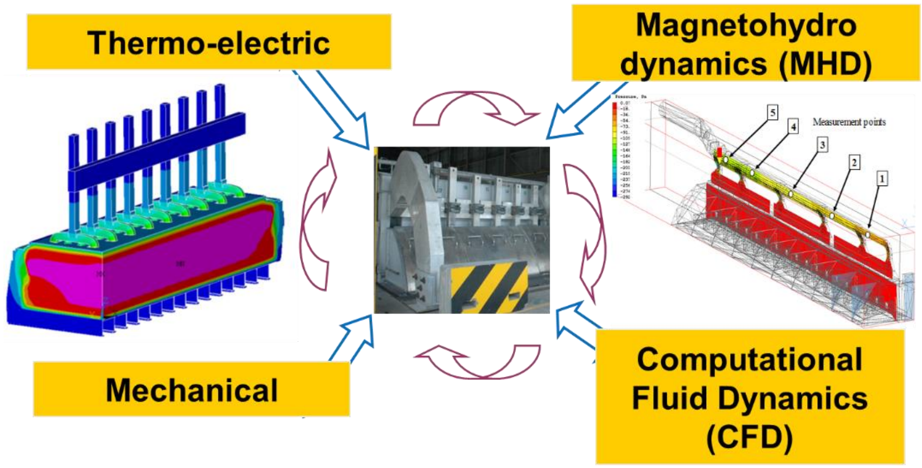

Figure 15. Mathematical models of aluminium electrolysis cells at EGA [14].

These models are used to design and develop the thermo-electrical design of the cells, electrical and MHD balance of busbars, mechanical structure of potshells and superstructure, potroom design for optimised cooling of pots and air circulation for better working environment.

The modelling team is supported by EGA engineering and by external engineering resources as required, for developing new pot designs, prototyping and installation and commissioning of the prototype cells. During the last 15 years, all new EGA cell technologies and retrofits were designed with mathematical models as well as cathode and anode modifications for amperage increase.

3.4 Control System Development

Over the last several years, Emirates Global Aluminium (EGA) has developed a new, advanced Pot Control System (PCS) based on standard programmable logic controller (PLC) hardware architecture which gives increased human machine interface (HMI) capabilities and assure easy maintenance and future development [20].

EGA PLC based Pot Control System optimizes performance of new potlines as well as potline retrofits. It has been in operation since 2013 on DX+ cells of EGA Al Taweelah Potline 3. EGA's PLC based PCS was also installed on 520 retrofitted/upgraded pots at EGA Jebel Ali in Potlines 1 and 3, using D18+ technology, and on 424 DX+ Ultra pots of ALBA Potline 6.

Figure 16 shows an Integrated Pot Control Panel with HMI in EGA Al Taweelah Potline 3. Figures 17 and 18 show just a few capabilities of the HMI: The main entrance panel (Figure 17) for data input and monitoring, and alumina feeding system parameter management (Figure 18).

Figure 16 Integrated pot control panel (IPCP) for two pots in EGA Al Taweelah Potline 3 with HMI screen (top right) [20].

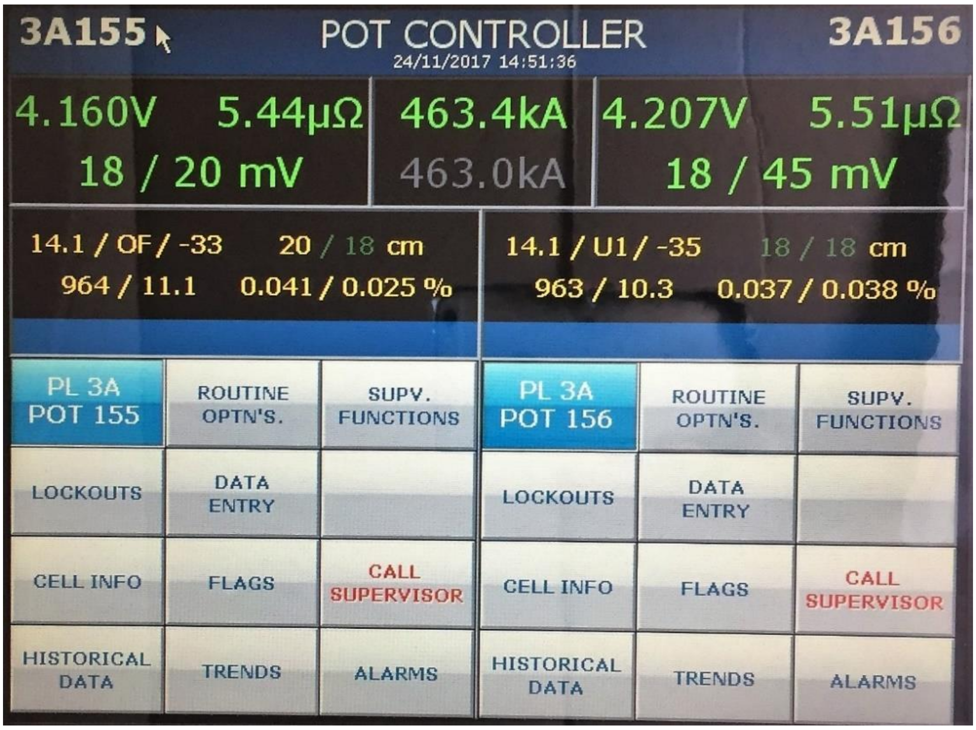

Figure 17. Picture of the main HMI touch screen for two pots in EGA Al Taweelah Potline 3. Primary (green) and secondary (grey) amperages are displayed [20].

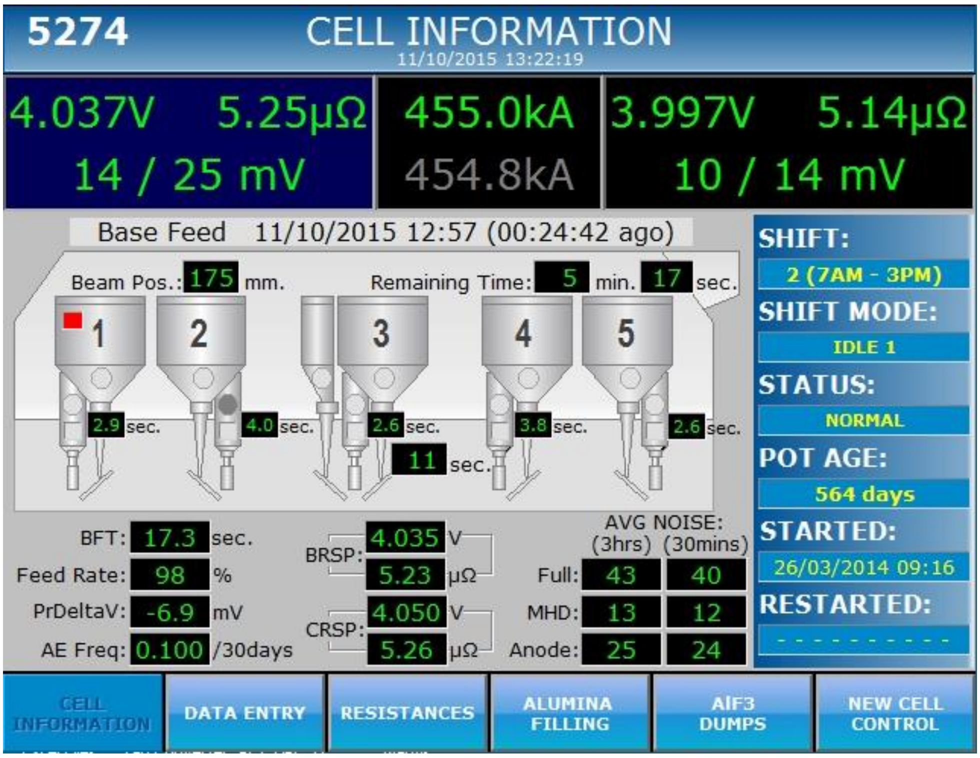

Figure 18. HMI for management of pot point feeder and breaker parameters DX+ Ultra demonstration Pot 5274 [20].

3.5 Continuous Improvement

The heart of continuous improvement is EGA Employee Suggestion Scheme, which was launched in 1981. Over the past few decades, nearly 500 000 suggestions for operational and technical improvements have been made by EGA employees, out of which 270,000 have been implemented to generate savings of 100 million dollars. Savings from these suggestions are shared with the employees who make them.

Under the ‘Tamayaz’ programme, launched in 2016, mid-level managers at EGA bring together their teams to understand problems, conduct detailed analyses to find potential improvements, and implement them. EGA has Lean and Quality improvement experts who coach these ‘Tamayaz’ teams in their work. The suggestion scheme and Tamayaz are part of EGA’s application of the lean manufacturing methodology.

The best suggestions are recognized each month and at an annual company-wide event. The program has received more than one hundred national and international awards since the year 2000. The Employee Suggestion Scheme and Tamayaz are part of EGA’s application of the lean manufacturing methodology.

3.6 IP and Patent Portfolio

EGA gives high priority to Intellectual Property (IP) protection and rights. The IP and Patent portfolio ensures that EGA’s know-how and technologies are protected and that IP rights of other companies are respected. This is particularly important for technology licencing where clients must be assured that another party will not patent in the future any part of the technology or claim infringement to their patents. The IP property protection can be through:

- Keeping ideas as trade secrets. This is a common strategy to retain know-how.
- Make it public. EGA publicly shares some ideas through publications, forums and events to be referenced widely as EGA publications. This is a very active field in EGA, which accelerated over the years. Up to the year 2000, EGA published 9 papers, from 2000-2009 – 23 papers, and from 2010-2022 over 150 papers. Some of these papers describe patentable technology which had been protected by patent filing prior to the publication. These papers also represent generous sharing of EGA knowledge, ideas, operation of EGA technologies, and environment protection with world aluminium community. The most well-known publishers are ICSOBA (Travaux), TMS (Light Metals), Australasian Aluminium Smelting Technology Conference, and Aluminium International Journal,
- Copyright. EGA obtains legal rights to protect its proprietary software and IT logics associated with its smelting technologies. EGA detains several copyrights.
- Filing a patent. Ideas are very carefully verified in EGA patent database, and if they do not infringe any prior patent, and need to be protected for EGA technology sales, a patent application will be filed. In July 2022, EGA had 39 filed patents, of which 35 are in smelting. Before 2014, EGA had 2 patents, from 2014 to 2018, 28 filings were made, and 9 from 2019- July 2022. The rush in 2014-2018 is associated with DX+ Ultra technology licence to ALBA, which had to be protected. At the same time, EGA built a Patent Database, which is updated every 3 months, and carefully monitored to make sure that EGA technology does not infringe any other patent.
- Trademark. This is for commercial protection of brands, products and services.

3.7 Certifications

International standards certification reflects the best and safest way to maintain consistency and quality of products, while also working toward a sustainable future. The customers and partners are assured that the business processes and management are reliable, safe and consistent in making good-quality products. Table 3 gives the list of certifications that EGA has obtained.

Table 3. EGA Certifications.

No.	Standard*	Standard Description	Initial Year
1	ISO 9001	Quality Management Systems	1996
2	ISO 14001	Environment Management Systems	1999
3	ISO 45001	Occupational Health and Safety Management Systems	2003
4	IATF16949	Quality Management System - for automotive production and relevant service part organizations	2003
5	ISO/IEC 27001	Information Technology - Information Security Management Systems	2006
6	ISO/IEC 17020	Lifting Equipment & Accessories Inspection	2012
7	ISO/IEC 17025	General Requirements for the Competence of Testing and Calibration Laboratories	2016
8	ASI	Sustainability Practices in the Aluminium Value Chain (Environmental, Social and Governance (ESG) & Responsible Sourcing)	2019

*ISO = International Organisation for Standardisation, IATF = International Automotive Task Force, IEC = International Electrotechnical Commission, ASI = Aluminium Stewardship Initiative.

4. Environment

Emirates Global Aluminium (EGA) is continuously striving to reduce the impact of its aluminium production processes on the environment and make the production more sustainable [21]. EGA increased the production from 149 kt of metal in 1982 to 2.501 Mt in 2021. At the same time the harmful emissions to the environment per tonne of aluminium have decreased due to improvements in capture, cleaning and recycling. In 2020, the greenhouse gas (GHG) emissions intensity from smelting and casting operations were 39.4 % lower than the global industry average [21]. A summary of most important environmental achievements in EGA is given below.

4.1 CO_2 Equivalent of Emissions

CO_2 equivalent of emissions (Figure 19) is the sum of direct CO_2 emissions and of CO_2 equivalent of perfluorocarbon (PFC) emissions. The main part of these emission come from electricity generation which uses natural gas. In 2021 in EGA, in total CO_2 equivalent emission of 8.0 t/t Al, which is 37.5 % lower than the global industry average for electrolysis [21, latest 2018 data]. The electrolysis process itself contributed only 1.5 t CO_2/t Al and the PFCs 0.12 t $CO_{2\ eq.}$/t Al. The improvement comes from replacing some generators with more efficient ones and from lower specific energy consumption (SEC) in the electrolysis as shown in Figure 19.

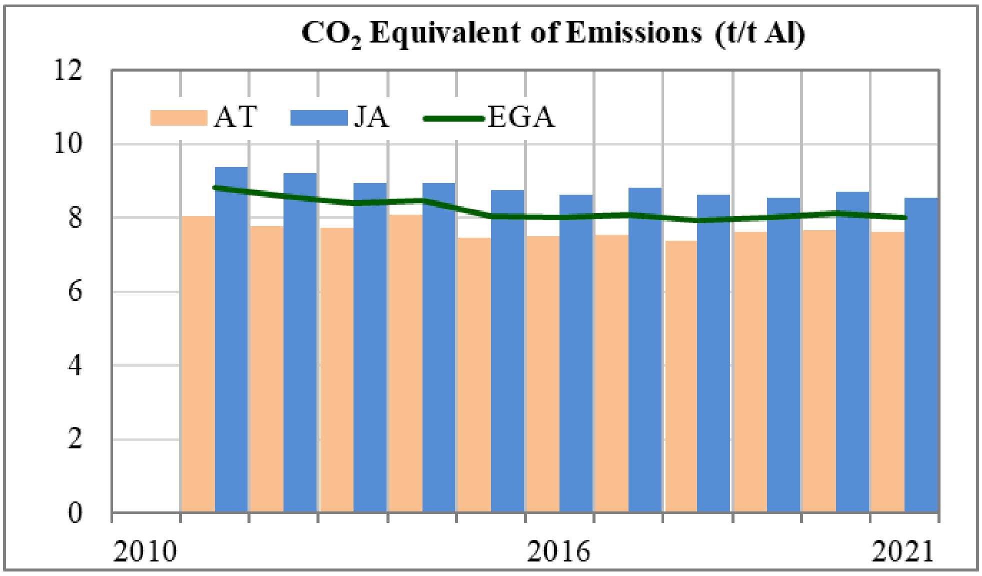

Figure 19. CO_2 equivalent of emissions. The data are available since 2011 only.

In order to reduce CO_2 emissions from electricity generation by natural gas, EGA has started to use solar power, supplied by the Dubai Electricity and Water Authority (DEWA), which operates the Mohammed bin Rashid Al Maktoum Solar Park (Figure 20) in the desert outside Dubai. The solar park has a current installed capacity of 1 013 MW using photovoltaic solar panels. Solar power is transmitted to EGA via Dubai's electricity grid and is tracked and traced through the use of the International Renewable Energy Certification system. This ensures that the energy used to produce EGA's CelestiAL solar aluminium has been sourced from the sun.

Figure 20. Mohammed bin Rashid Al Maktoum Solar Park, the source of solar electricity for EGA's CelestiAL solar aluminium [22].

4.2 PFC Emissions

Primary PFC emissions are the result of cell anode effects. PFCs are very potent greenhouse gases (GHGs) and their global warming potential (GWP) is calculated in terms of equivalent CO_2 emissions whose amount is proportional to anode effect frequency and duration. Figure 21 shows the PFC emissions.

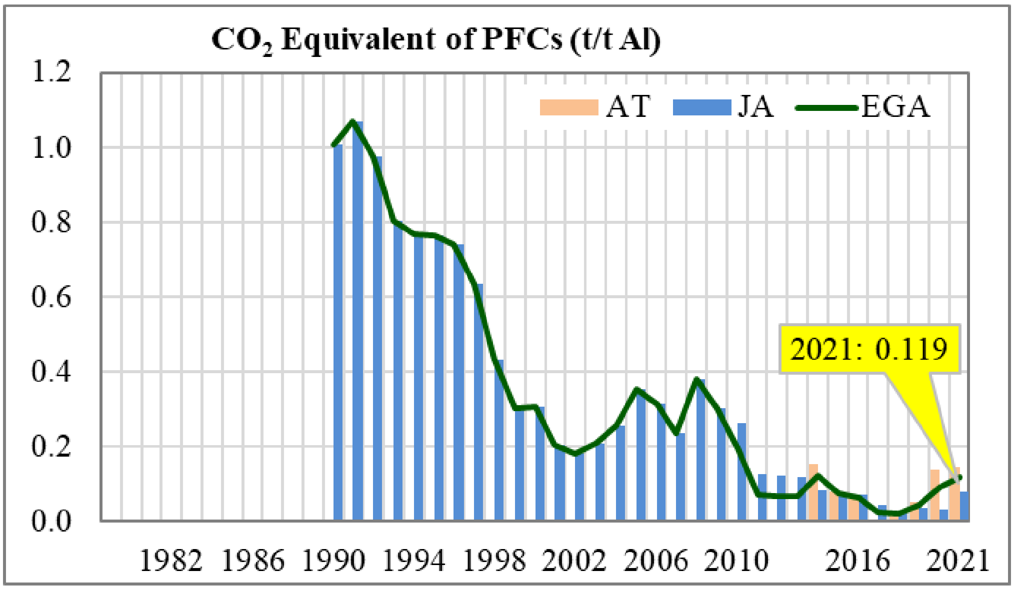

Figure 21. CO_2 equivalent of PFCs in EGA.

The PFC emissions have been reduced by 50 times since 1990 because of very low anode effect frequency and duration provided by advanced cell control systems, used in all EGA potlines now. At 0.12 t/t Al in 2021, the CO_2 equivalent of PFCs at EGA is world benchmark, being 6 times lower than the world mean PFC emissions intensity of 0.75 t/t Al in 2021 [23].

Background PFC emissions are not included in Figure 21, since there is yet no universally accepted formula to include them.

4.3 Fluoride Emissions

EGA's fluoride emissions have always been carefully controlled and are in full accordance with international and UAE requirements thanks to the application of modern, EGA's home-grown smelting technology. Figure 22 shows total fluoride emissions from EGA Smelters. EGA's fluoride emissions are approximately 35 % below the global average: EGA emissions of 0.34 kg/t Al compared to 0.52 kg/t Al global average for prebake technology in 2021 [23].

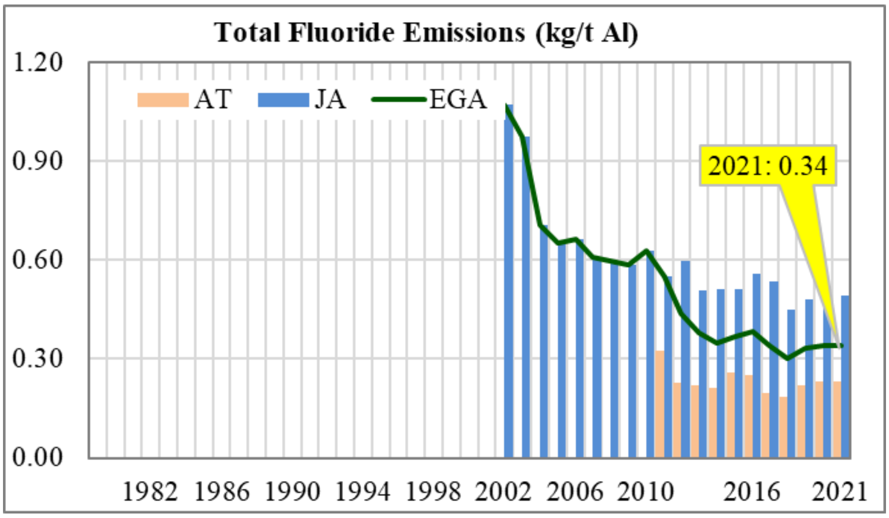

Figure 22. Total fluoride emissions in EGA.

4.4 Spent Potlining (SPL) Recycling to Cement Industry

EGA started to recycle SPL to cement industry in 2010 and sustained 100 % recycling since 2016. SPL landfilling was stopped in 2012. In 2020 EGA recycled 26 067 tonnes of SPL to UAE cement industry for use as a feedstock and alternative fuel [22].

5. Bauxite and Alumina Production

5.1 GAC Bauxite Export Mine

EGA's Guinea Alumina Corporation (GAC) bauxite mine in the Republic of Guinea is a global supplier of bauxite. The bauxite is comparatively high in Gibbsite and low in Bohemite, reactive silica and organic impurities. Exports of bauxite ore began in 2019. Both low temperature and high temperature bauxites are mined, meaning that the bauxite is able to be processed by a wide variety of alumina refineries. GAC operates a 690-square kilometre mining concession, located in the northwest of Guinea. Mined bauxite is transported to GAC's port at Kamsar by rail using shared rail infrastructure. Bauxite from GAC is predominantly supplied by EGA to third-party customers, with some shipped to EGA Al Taweelah alumina refinery in Abu Dhabi.

A second phase of the GAC project envisages construction of an alumina refinery in Guinea, delivering further value for the nation.

5.2 Al Taweelah Alumina Refinery

Al Taweelah alumina refinery (Figure 23) was the first in the United Arab Emirates and the second in the Middle East. Construction began in 2015 and commissioning started in early 2019. Nameplate capacity was achieved after the first full year of operation, a world-class start-up performance, and the plant is currently operating just above 2.3 Mt per year.

The plant converts bauxite into alumina, the feedstock for aluminium smelters. Al Taweelah alumina refinery meets more than 40 per cent of EGA alumina requirements, securing EGA's competitive supply of this important raw material.

Cape-sized bauxite ships arrive offshore from Guinea and other sources to the Al Taweelah Jetty and are lightered before unloading via a ship unloader and via overland conveyors to the bauxite storage facility (shed covered 600 kt bauxite storage capacity) before reclaim to the milling area and refinery proper.

Al Taweelah alumina refinery is located next to Al Taweelah smelter. Alumina is transferred to the smelter by a system of conveyor belts. The refinery is fully integrated energy-wise with the smelter and is thus an exceptionally low energy consumer.

A production increase program is in place to progressively increase refinery capacity through minor project implementation and procedural improvements.

Figure 23. Al Taweelah Alumina refinery.

6. Conclusions

Emirates Global Aluminium (EGA) started the first potline in Jebel Ali smelter in 1979 with annual production of 149 kt of metal in 1982 when the first three potlines were in operation. Since then, many smelter expansions, modernizations, innovations, and amperage increase brought the total production of its two smelters in Jebel Ali and Al Taweelah to 2.501 Mt aluminium in 2021.

EGA has developed and industrialised eight reduction technologies in greenfield projects and brownfield retrofits. EGA has used its own technology for every smelter expansion since 1990, and has retrofitted all older production lines. All 2843 reduction cells at EGA in operation now use EGA technology.

The basic building block of continuous improvement is EGA Employee Suggestion Scheme, which was launched in 1981. Over the past few decades, nearly 500 000 suggestions for operational and technical improvements have been made by EGA employees, out of which 270 000 have been implemented to generate savings of 100 million US dollars. Savings from these suggestions are shared with the employees who make them.

Emirates Global Aluminium (EGA) is continuously striving to reduce the impact of its aluminium production processes on environment and make the production more sustainable. While increasing the production, the harmful emissions to the environment per tonne of aluminium have decreased due to improvements in capture, cleaning and recycling. In 2020, the greenhouse gas (GHG) emissions intensity from smelting and casting operations were 39.4 % lower than the global industry average. The future is in using renewable energy for production of aluminium. EGA has already started this journey by using solar power to produce CelestiAl solar aluminium.

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