

GE  
Grid Solutions

# DC Substation Solutions For Metal Processing Applications



imagination at work



## Today's Environment

The metal processing industry has faced a number of years where global supply has outpaced global demand, resulting in depressed commodity prices. At these market prices, the aluminum smelting process requires highly efficient and reliable Direct Current (DC) power to ensure the profitability of the operation.

Electricity cost is the second most expensive part of the production operation for aluminum smelting, contributing approximately 30% of the entire cost structure. The efficiency of the DC power supply is therefore critical to the viability of the plant to produce aluminum at competitive rates.

The reliability is equally important as any outage in the supply of power has catastrophic effects for the continuous process of aluminum smelting.

As the aircraft, automobile and other industries continue to transition their reliance on lighter weight aluminum, the global demand is anticipated to rise. The competition for this incremental demand will be even more competitive as aluminum producers look to increase production at existing plants and also to bring idle plants back on-line. State-of-the-art DC supply equipment will be critical to ensure competitiveness in this industrial space.

**\$800M** Annually unplanned outages cost the mining industry an estimated \$800 million

**600kA** Did you know GE had provided the highest amperage DC substation at 600kA

**50%** Did you know that GE has supplied nearly 50% of the DC substations globally since 2007 for the Aluminium smelting market

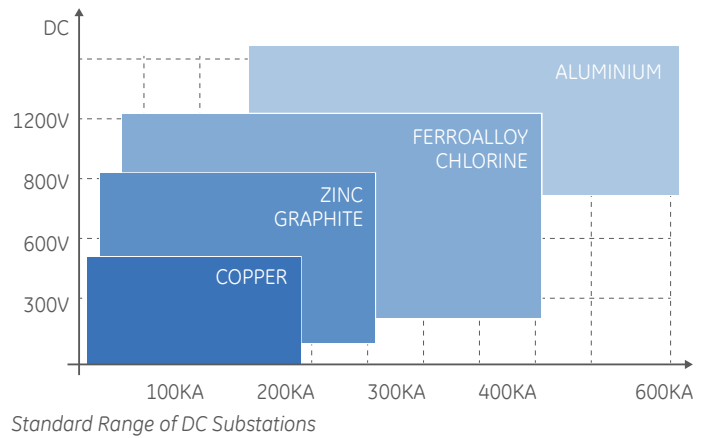
## GE Solution

GE's Direct Current (DC) substation solutions are custom designed systems that provide highly reliable and efficient DC voltage and current for specific metals processing operations.

GE has provided approximately half of all aluminium smelting DC plants globally since 2007. A significant reason for this is the technology advantages that GE provides over other competitive offerings. GE's solution in the aluminium smelting application currently provides the highest DC amperage of any offering in the industry, providing 600kA's to the potline process.

GE has over 60 years' experience in delivering over 600 DC substation projects for industrial applications in diverse and extreme environmental conditions in over 70 countries.

GE provides a comprehensive range of medium voltage and high voltage products and services for DC substations in various metal processing applications. These solutions can be delivered as Engineered Equipment Packages (EEP), Engineer, Procure and Construct (EPC) and support services.



# The GE Advantage

GE provides industrials with the following competitive advantages



## Deep domain technical expertise providing full system lifecycle support resulting in simplified and streamlined commercial offerings

- Only global supplier that can provide full scope from HV to MV integrated electrical distribution systems, including power plant DC substation, AC substation and ECS package.
- Eliminating project and logistical complexities by providing a single point of interface to the customer through the project lifecycle.
- Over 60 years' experience with more than 600 DC substation projects for industrial applications delivered in diverse and extreme environmental conditions in over 70 countries
- Vertically integrated advanced manufacturing facilities, certified to ISO 9001, ISO 14001 and OHSAS 18001 produce all major DC Substation components



## Industry leading technology maximizing plant efficiency and delivering reliable plant operations

- Superimposed compact rectifier design that is inherently more reliable, providing easy access to key components for maintenance, fitted with safer pressure relief devices and less subject to internal arcing.
- Industry leading transformer technology with one of the lowest loss designs available
- Specially featured Gas Insulated Switchgear (GIS) enabling ease of maintenance without disrupting 24/7 smelting operations
- Control system components/technologies are state-of-the art as used in many other industrial applications with wider knowledge community, support and documentation.



## Proven experience with track record of successful project execution to minimize the customers risk

- Supplied nearly 50% of the DC substations globally since 2007 for the Aluminium smelting market demonstrating that our customers recognize GE technology leadership and execution capability.
- Proven DC substation amperage at 600kA, the highest amperage of any project in the world.
- Recognized as the industry leader in compensation loop technology, providing higher efficiencies through magnetic field effect mitigation
- On-time project delivery on large revamping projects without production interruption
- Proven ability and flexibility to address customers' technical needs and to propose innovative, customized solutions

Typical DC System - Aluminium Smelter Conversion Substation





# Key Components and Offering

## Regulating and Rectifier Transformers

GE has optimized the design of power transformers and the interfaces with the rectifiers for reliable and economical DC supply operations by combining the most innovative designs, broad technical expertise and the reliability of field-proven technology.

With over 35 years of experience supplying rectifier power transformers, GE has refined the design and manufacturing processes required for the demands of the electrolysis processes.

GE rectifier transformer combinations can be made in one single tank or two separate tanks. In the single tank solution, all active parts are grouped in one tank. This is an economical solution, offering a reduced footprint and reduced installation works. In the two tank solution, the regulating (auto) transformer with its on load tap changer (OLTC) and/or de-energized tap-changer (DETC) is in one tank and the rectifier transformer assembly in the other.

## Regulating Transformers



The role of the regulating transformer within the DC substation is to:

- step down the AC voltage from High Voltage (HV) to (MV) Medium Voltage
- adjust the AC voltage using on-load tap-changer
- potentially connect the associated harmonic and power factor compensation filter on a tertiary winding

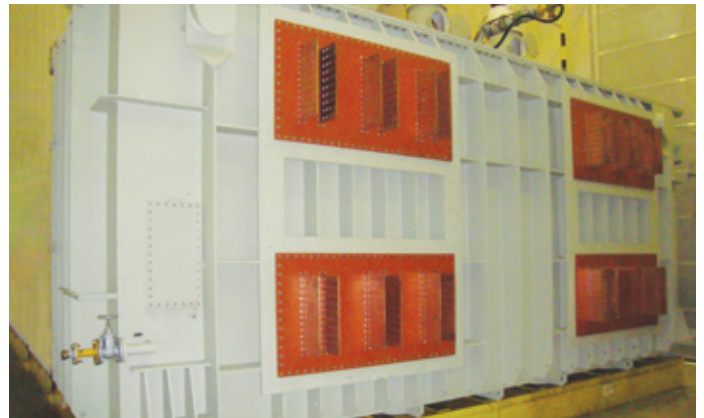
## Rectifier Unit



The role of the rectifier unit within the DC substation is:

- to rectify the incoming AC voltage, using either diode or thyristor based technology
- to supply a regulated, high DC current output

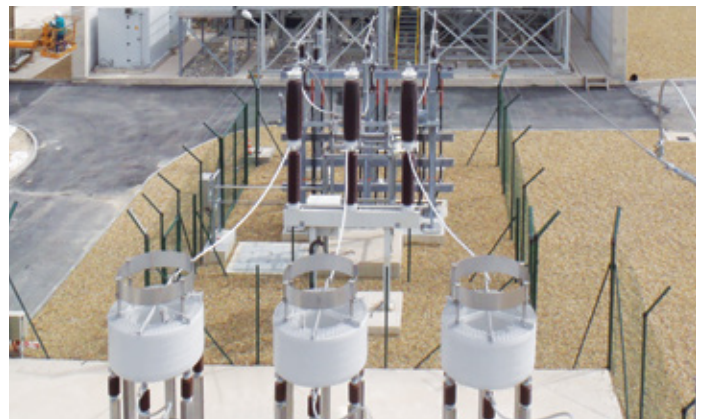
## Rectifier Transformers



The role of the rectifier transformer within the DC substation is to:

- allow phase shifting in case of several secondary windings (typical one or two secondary windings)
- allow multiple rectifier configurations: single or double Graëtz, double-star with interface transformer
- regulate the AC voltage using self-saturable reactors (transductors)

## Harmonic Filter and Power Factor Compensation



The role of the filters within the DC substation is:

- to limit the harmonic current injected into the network
- to supply reactive power to the transformer-rectifier group in order to improve the power factor seen from the AC network.

# Key Components and Offering

## Air Insulated Switchgear (AIS) or Gas Insulated Switchgear (GIS)

The role of the AIS/GIS switchgear within the DC substation is:

- to interconnect the DC substation's transformer-rectifier groups to the incoming High Voltage (HV) AC network



Typical GIS installation



Typical AIS installation

## GE offerings

Each DC substation is designed and customized based on customers requirements, GE provides a range of offerings



### Base Solution

- Reduction groups DC Substation
- Magnetic Compensation Loop DC Substation\*



### Variants

- Any customized grouping of the offering within the extended solution scope
- Brownfield and upgrades including control system retrofits



### Extended Solution

- AC substation (AIS or GIS)
- HV/MV Step-down Transformers, Auxiliary Power
- Harmonic Filters and Power Factor Compensation
- MV Power Loop
- Efficiency (load shedding) Programs



### Services

- Consulting scope for insulation, protection, etc.
- Capacity increase, life extension assessment
- Long Term Service Agreements

\* extended scope in some cases





# Case Studies

## Jonquiere Pilot Plant

**Client:** Rio Tinto Aluminium  
**Location of installation:** Canada  
**Site temperature conditions:** min -40 °C; max +40°C  
**Number of potlines:** 1  
**Potline rating:** > 600 kA / 1200 Vdc  
**Power system voltage:** 161 kV  
**Transformers:** 7 x (rectifier + regulating)  
130 MVA each  
**Rectifier groups:** 7 x 95 kA / 1200 Vdc

### Turnkey project without civil works

**In operation since:** 2013  
**EPCM:** SNC & HATCH



## Aditya Aluminum / Mahan Aluminum

**Client:** Hindalco  
**Location of installation:** Aditya (Odisha India)  
Mahan (Uttar Pradesh India)  
**Site temperature conditions:** min +10° C; max +50° C  
**Number of potlines:** 2  
**Potline rating:** 370 kA / 1650 Vdc  
**Power system voltage:** 220 kV (AIS)  
**Transformers: (each site)** 5 x (rectifier + regulating)  
188 MVA each  
**Rectifier groups: (each site)** 5 x 100 kA / 1650 Vdc

### Turnkey project without civil works

**In operation since:** 2013 / 2014  
**EPCM:** EIL



# Project References

GE has designed, delivered and supports over 600 DC substation projects for industrial applications in diverse and extreme environmental conditions in over 70 countries. The below details are a selected representation of recent projects, a complete reference list is available upon request.



- |  |   |  |   |
|--|---|--|---|
| <p><b>1. Bahrain</b><br/>Application: Aluminium<br/>Rating: 4x40kA / 40V<br/>Total DC Output: 6,4 MW<br/>Year: 2016</p> <p><b>2. Greece</b><br/>Application: Aluminium<br/>Rating: 1x32kA / 1160V<br/>Total DC Output: 37,1 MW<br/>Year: 2016</p> <p><b>3. Egypt</b><br/>Application: Aluminium<br/>Rating: 5x25kA / 850V 1x25kA / 450V<br/>Total DC Output: 139,1 MW<br/>Year: 2015</p> <p><b>4. Vietnam</b><br/>Application: Aluminium<br/>Rating: 6x105kA / 1450V 5x18kA / 210V<br/>Total DC Output: 934,6 MW<br/>Year: 2014</p> <p><b>5. Germany</b><br/>Application: Chlorine<br/>Rating: 5x13,75kA / 270V<br/>Total DC Output: 18,6 MW<br/>Year: 2012</p> <p><b>6. Germany</b><br/>Application: Zinc<br/>Rating: 1x45kA / 600V<br/>Total DC Output: 27 MW<br/>Year: 2012</p> <p><b>7. USA</b><br/>Application: Chlorine<br/>Rating: 2x21kA / 685V<br/>Total DC Output: 28,8 MW<br/>Year: 2012</p> <p><b>8. Germany</b><br/>Application: Chlorine<br/>Rating: 1x27,5kA / 480V<br/>Total DC Output: 13 MW<br/>Year: 2011</p> | <p><b>9. France</b><br/>Application: Aluminium<br/>Rating: 1x100kA / 1200V<br/>Total DC Output: 120 MW<br/>Year: 2011</p> <p><b>10. Iceland</b><br/>Application: Aluminium<br/>Rating: 1x92kA / 1650V<br/>Total DC Output: 152 MW<br/>Year: 2011</p> <p><b>11. France</b><br/>Application: Graphitization<br/>Rating: 2x70kA / 220V<br/>Total DC Output: 19,9 MW<br/>Year: 2011</p> <p><b>12. Finland</b><br/>Application: Chlorine<br/>Rating: 1x60kA / 315V<br/>Total DC Output: 18,9 MW<br/>Year: 2011</p> <p><b>13. Cameroon</b><br/>Application: Aluminium<br/>Rating: 1x54kA / 1300V<br/>Total DC Output: 70 MW<br/>Year: 2010</p> <p><b>14. Egypt</b><br/>Application: Aluminium<br/>Rating: 1x77kA / 450V<br/>Total DC Output: 35 MW<br/>Year: 2010</p> <p><b>15. India</b><br/>Application: Aluminium<br/>Rating: 5x100kA / 1650V<br/>Total DC Output: 825 MW<br/>Year: 2009</p> <p><b>16. India</b><br/>Application: Aluminium<br/>Rating: 5x100kA / 1650V<br/>Total DC Output: 825 MW<br/>Year: 2009</p> | <p><b>17. Turkey</b><br/>Application: Copper<br/>Ratings: 2x20kA / 170V 1x10kA / 30V<br/>Total DC Output: 7,1 MW<br/>Year: 2009</p> <p><b>18. Bahrain</b><br/>Application: Aluminium<br/>Ratings: 2x5x37kA / 1200V<br/>Total DC Output: 444 MW<br/>Year: 2008</p> <p><b>19. Germany</b><br/>Application: Chlorine<br/>Rating: 10x16,25kA / 540V<br/>Total DC Output: 88 MW<br/>Year: 2008</p> <p><b>20. Norway</b><br/>Application: Aluminium<br/>Rating: 36,2kA / 1360V<br/>Total DC Output: 49 MW<br/>Year: 2008</p> <p><b>21. Australia</b><br/>Application: Aluminium<br/>Rating: 3x60kA / 625V<br/>Total DC Output: 113 MW<br/>Year: 2008</p> <p><b>22. Russia</b><br/>Application: Aluminium<br/>Rating: 2x5x85kA / 1570V<br/>Total DC Output: 1335 MW<br/>Year: 2007</p> <p><b>23. Russia</b><br/>Application: Aluminium<br/>Rating: 2x6x85kA / 1570V<br/>Total DC Output: 1601 MW<br/>Year: 2007</p> <p><b>24. Germany</b><br/>Application: Chlorine<br/>Rating: 3 x 17,7kA / 610V<br/>Total DC Output: 32 MW<br/>Year: 2007</p> | <p><b>25. Germany</b><br/>Application: Chlorine<br/>Rating: 4 x 17,7kA / 610V<br/>Total DC Output: 43,188 MW<br/>Year: 2007</p> <p><b>26. Poland</b><br/>Application: Chlorine<br/>Rating: 2x16,9kA / 600V<br/>Total DC Output: 20 MW<br/>Year: 2007</p> <p><b>27. Portugal</b><br/>Application: Hydrochloric acid<br/>Rating: 2x12,5kA / 530V<br/>Total DC Output: 13 MW<br/>Year: 2007</p> <p><b>28. Canada</b><br/>Application: Aluminium<br/>Rating: 7x95kA / 1200V 6x102kA / 42V<br/>Total DC Output: 786 MW<br/>Year: 2007</p> <p><b>29. Sweden</b><br/>Application: Aluminium<br/>Rating: 2x40kA / 750V 1x40kA / 640V<br/>Total DC Output: 85,6 MW<br/>Year: 2007</p> <p><b>30. Norway</b><br/>Application: Aluminium<br/>Rating: 40kA / 1000V<br/>Total DC Output: 40 MW<br/>Year: 2007</p> |
|--|---|--|---|

For more information about  
GE's DC Substation Solutions visit  
[GEGridSolutions.com/DCSubstations](http://GEGridSolutions.com/DCSubstations)



GE

2018 Powers Ferry Road  
Atlanta, GA 30339 USA

1-877-605-6777 (toll free in North America)  
1-678-844-6777 (direct number)

[GEGridSolutions.com](http://GEGridSolutions.com)

GE and the GE monogram are trademarks of General Electric Company.

GE reserves the right to make changes to specifications of products described at any time without notice and without obligation to notify any person of such changes.

Copyright 2017, General Electric Company. All Rights Reserved.



imagination at work

GEA-32019(E)  
English  
170306