

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

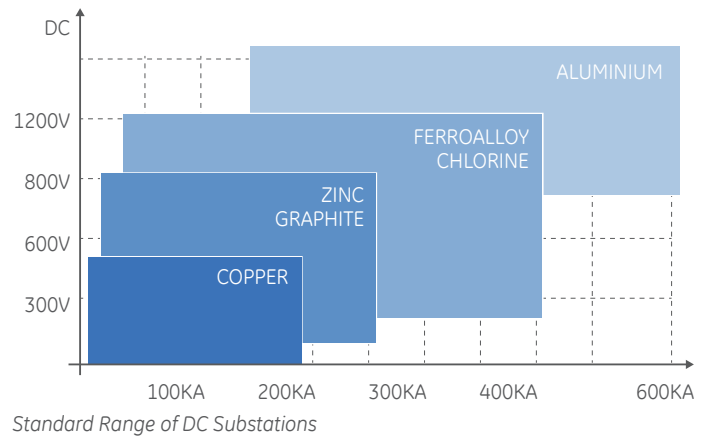
GE Solution

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

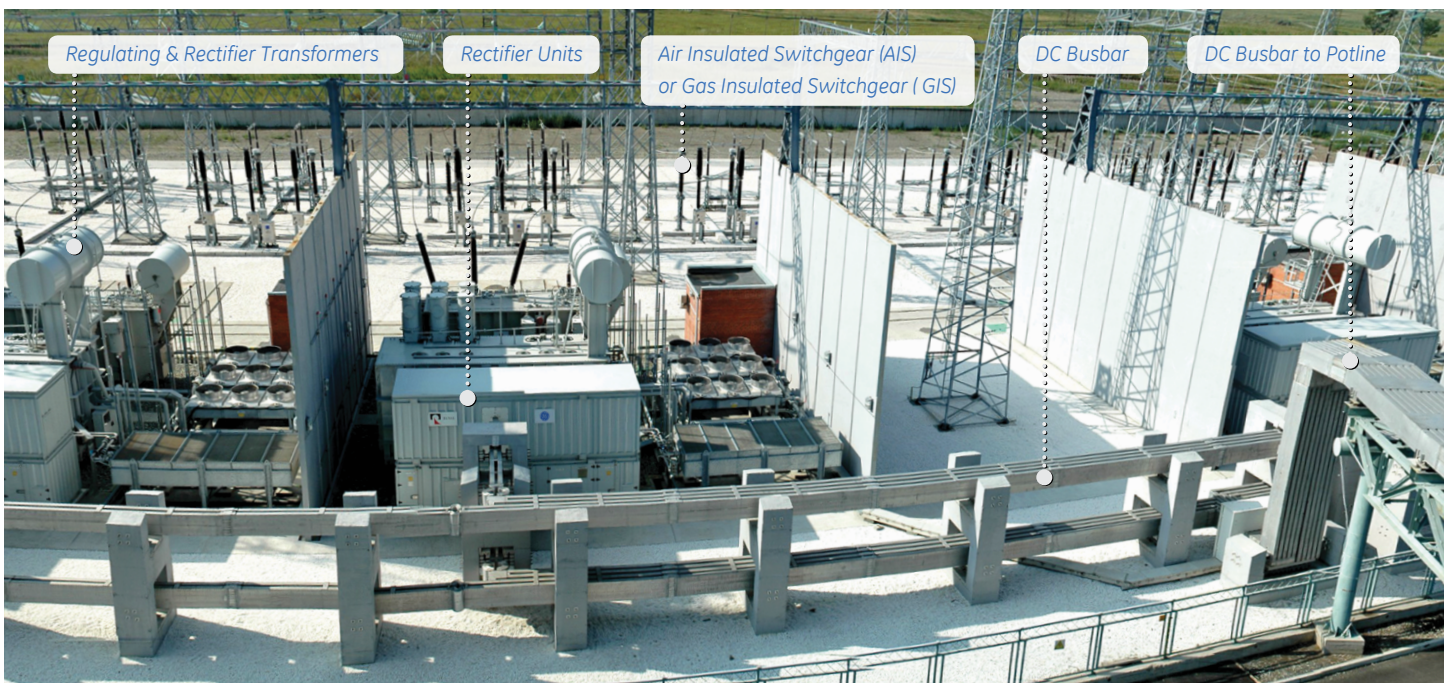
- Superimposed compact rectifier design that is inherently more reliable, providing easy access to key components for maintenance, fitted with safer pressure relief devices and less subject to internal arcing.
- Industry leading transformer technology with one of the lowest loss designs available
- Specially 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

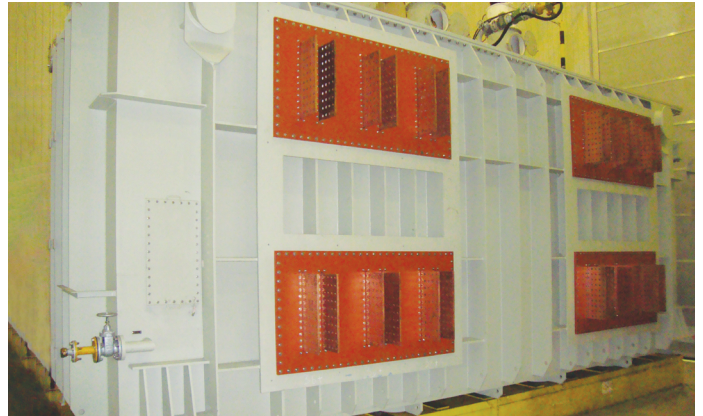
Rectifier Unit



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

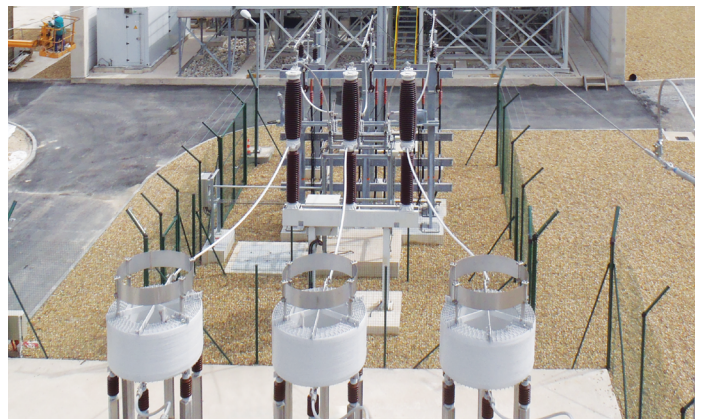
Rectifier Transformers



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



GE

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