

2014 Solution Catalog

Power System Stability Expert



Solution Provider

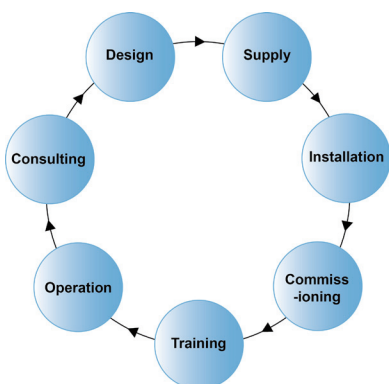
NR Electric is a leading solution provider specializing in electric power generation, transmission, and distribution for customers worldwide. The company is one of the largest protection and control manufacturers in the world. NR Electric occupies an important position in FACTS & HVDC and renewable energy generation fields.

NR Electric focuses on the research and development of innovative products and solutions with unique patents and know-how. We combine products, systems and services, to provide comprehensive solutions in the following fields:

- **Integrated Secondary System:** Integrated Secondary System consists of a full spectrum of hardware and software solutions for power system protection, automation and management.
- **FACTS & HVDC:** NR Electric's power electronics-based equipment provides proven and cost-effective solutions to achieve a Flexible AC Transmission System (FACTS) and HVDC transmission system to improve the safety, reliability and efficiency of any power system.
- **Renewable Energy Generation:** NR Electric's renewable energy generation solutions covers major solar/wind farm primary equipment, protection & control system, reactive power compensation, etc., to make your renewable energy system as effective as possible.

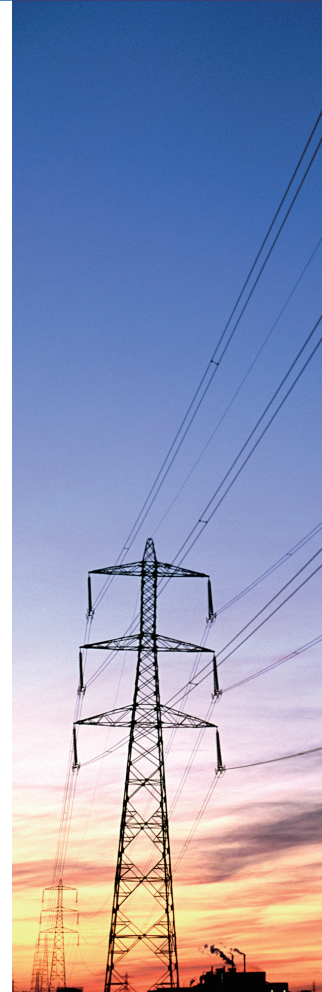
Built on cutting-edge technology, NR Electric serves power utilities and industrial enterprises with world-class products, all-around solutions and superior services. Our innovative and proven solutions improve the safety, reliability, efficiency and environmental friendliness of any power system.

"ALL-IN-ONE" Package Service



NR Electric commitment is to continuously provide excellence to our global customers. Our core mission is to solve practical problems, and to enhance the security and reliability of power systems with our down-to-earth attitude, innovative solutions, products and services.

In recent years, NR Electric has been continuously improving its localization level to realize fast and professional pre-sale and after-sale services. So far, NR Electric has founded subsidiaries and established technical service centers in different regions all over the world.



References

The following tables summarize the implementation of NR Electric's solutions:

Table 1: Number of Substations Which Have Used NR Electric IED Products in Field

Implementation	Category			Remarks
HVAC Transmission	Voltage Level			Highest AC voltage: 1,000kV
	750kV ~ 1,000kV	345kV ~ 500kV	110kV ~ 230kV	
	30+	1,000+	9,000+	
HVDC Transmission	HVDC Type			Highest DC voltage: ±800kV
	UHVDC	HVDC (including BTB)	VSC-HVDC	
	3	12	3	
Generation	Unit Size			Largest thermal and nuclear generator: 1,000MW Largest hydro generators: 800MW
	1,000MW	600MW ~ 1,000MW	300MW ~ 600 MW	
	35	300+	600+	
Industrial	Industry Enterprises			300km/hour high-speed railways
	Oil, Gas & Petrochemical Enterprises	Mining Enterprises	Metal Enterprises	
	100+	200+	400+	

Table 2: Number of NR Electric Products Which Have Been Used in Service

Solution	Product Line	Application	Installation	Remarks
Integrated Secondary System	IED protective Relays	Transmission	150,000+	
		Distribution	500,000+	
	Substation Automation System	Substation	6,000+	
	Smart Substation Solution	Total Solution	300+	
		Electric/Optical Measurement Transformer	1,500+	
		Merging Unit	4,000+	
		Intelligent Controller	3,000+	
	Power Stability Control System (PSCS)	Regional Network	20+	Largest PSCS with over 400 substations.
		Substation	1,000+	
	EMS/DMS	Regional Network	30+	
FACTS & HVDC	Reactive Power Solution	SVC/STATCOM/FSC	100+	Dual-SVC cross control HVDC-SVC cross control 500kV Series Compensators
	DC De-Icer		20+	
	HVDC Interconnection	LCC-HVDC	15	
VSC-HVDC		3	5-terminal, 3-terminal and 2-terminal	
Renewable Energy	Products for Renewable Energy	Solar & Wind Power Generation	6GW+	
	PV Inverter	Solar Power Generation	600MW+	
	SCADA System	Solar & wind Power Generation	500+	
	Energy Forecast System	Solar & wind Power Generation	80+	



Solutions for Integrated Secondary System



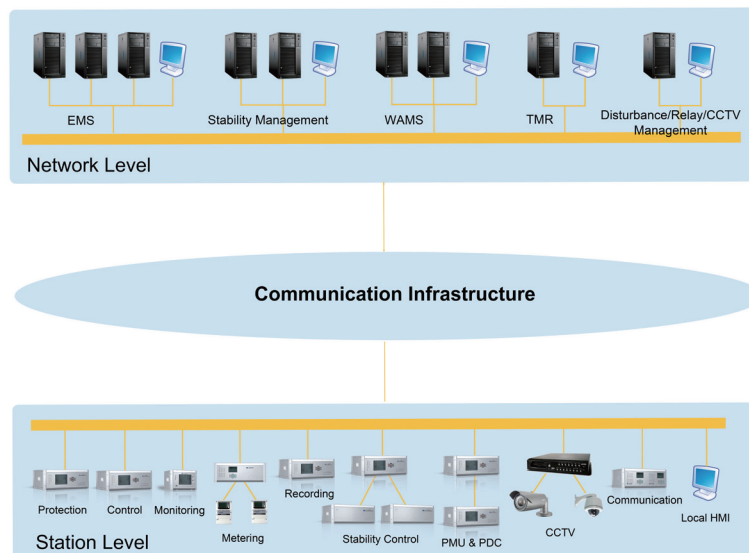
Built upon decades of research, development, and leveraging numerous operational experiences in secondary power systems, NR Electric has developed a unified and integrative solution for the secondary system; from the station level to the grid level, including communication infrastructure.

At a station level, the ISS solution integrates protection, control, monitoring, metering, recording, video surveillance (CCTV) and communication in each substation. At a network level, it provides the following:

- Energy Management System (EMS)
- Distributed Management System (DMS)
- Tele-Meter Reading System (TMR)
- Power Stability Control System (PSCS)
- Wide Area Measurement System (WAMS)
- Disturbance & Fault Management System (DFMS)
- Relay Management System
- CCTV Management System.

Furthermore, the communication infrastructure between substations and dispatching centers are compatible with our system. The Local Area Network (LAN) is used for the internal communication between substations and dispatching centers. The Wide Area Network (WAN) and/or Synchronous Optical Networking (SONET)/ Synchronous Digital Hierarchy (SDH) networks can be adopted for the inter-station communications according to the specific application requirements.

With the ISS solution, the utilities operators can unify the management system of dispatching centers and substations. Based on the IEC 61850 and the IEC 61970 standards, and other communication protocols, data is classified and can be shared by several applications within the ISS system. The unified data format allows for easy extension of new applications. The cyber security is acquired via the authorization and hardware security devices.



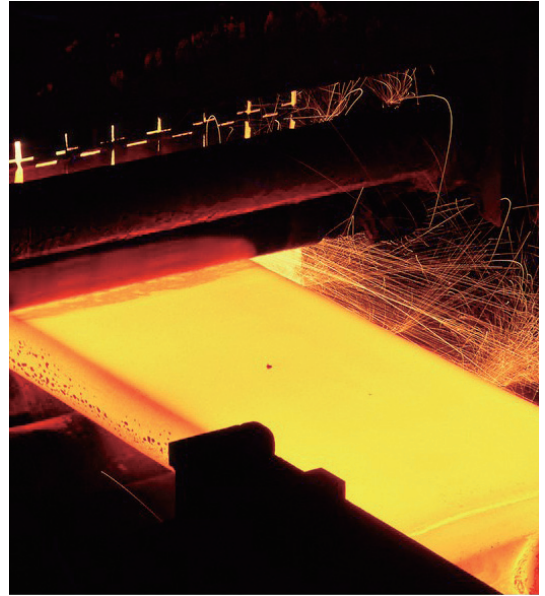
Protection & Control

NR Electric is dedicated to providing diverse protection and control products with well-proven technologies that have been widely implemented in thousands of projects worldwide. The protection and control solution plans cover all primary assets including: generator, transformer, transmission line, busbar, circuit breaker, reactor, capacitor, motor and beyond.

As for hardware architecture, NR Electric's innovative two-out-of-two logic is implemented to eliminate mal-operations due to the component failure. The combination of the two-out-of-two logic and the implementation of a redundant scheme ensure the dependability and security of our protection and control solution systems. NR Electric invented the Deviation of Power Frequency Component (DPFC), a protection principle, which can help identify and confirm the fault in milliseconds and aid in the issuing of control commands accordingly. NR Electric's continuous focus on research and development has led to the creation of many innovative technologies and patents that have greatly improved the performance of NR Electric's protection products.

Protection and Control for Substations

NR Electric's protection and control devices are fully compatible with the IEC 61850 standard protocol, and can be implemented in completely autonomous buildings, in an extension or in renovated conventional substations, and digital substations.



Power Generation Protection and Control

For power generation plants, NR Electric offers the generator protection, the transformer protection and the comprehensive generator-transformer unit protection. The comprehensive generator-transformer protection features the "all-in-one" solution for the protection and control of the generator-transformer unit.

Protection and Control for Industrial Enterprises

Uninterrupted power supply is always critical to industrial enterprises and thus highly reliable protection and control is necessary. NR Electric's innovative protection and control solutions are also suitable for applications in a variety of industrial fields such as petrochemical, coal, iron, steel, metallurgy and electric railway industries.

NR Electric can provide automation systems for asset management, power system status monitoring, remote/local control, fault analysis and evaluation, operators' authorization, history data statistical analysis and communication for dispatching centers.

Automation

NR Electric can provide automation systems for asset management, power system status monitoring, remote/local control, fault analysis and evaluation, operators' authorization, history data statistic analysis and communication for dispatching centers. It manages utility assets, monitors operation states and measures load profiles. All the information is collected and visually displayed in the control room. Operators can execute remote control via the workstation.

Substation Automation

NR Electric provides the integrated automation solution for new substations and/or retrofit substations. The solution complies with IEC 61850 standards over double-star LAN or ring LAN. It includes Bay Control Unit, Protective Relay, Fault Recorder, PMU, Protocol Converter, Gateway, GPS Receiver, Gigabit Switch and HMI Software. NR Electric can also integrate metering and CCTV devices into the automation system.



Power Plant Automation

- Electrical Control System (ECS) for Auxiliary Power System
The Electrical Control System is a cost-effective automation system for applications in auxiliary power system with a capacity of up to 1000MW in a power plant. It provides high performance control and monitoring for feeders, startup/standby transformers, auxiliary transformers and other intelligent devices.



- Network Control System (NCS) for Power Plant Station
A Network Control System is intended for the control of transmission lines, substations and generators with the capacity of up to 1000MW in a power plant. It provides advanced automatic functionality including safety monitoring of primary devices and real-time monitoring of electric parameters.
- Distributed Control System (DCS) for Thermal Control
A Distributed Control System provides a control process for all types of power plants. It adopts distributed architecture and provides diagnosis in each branch circuit. So far, NR Electric's DCS has been put into service in many power plants with an installed capacity of up to 600MW.

Industrial Automation

NR Electric's innovative automation solutions for industrial needs consist of a system automation that is applicable to industrial power systems, and the industrial-class devices. Automation provides fast and real-time control and monitoring of electrical power systems in different industrial fields.

Digital Substation

Through the development of protection, control, automation and communication technology, NR Electric's digital substation technologies offer a fully digitalized solution that fully connects the control room to the switchyard with optic fiber links. This proven solution reduces your capital investment, operational and maintenance costs. It also offers unmatched information integration, and provides better reliability and security for substations.

Our digital substation includes:

- Electronic/Optical measurement transformer (ECVT/OCT)
- Merging Unit (MU)
- Intelligent Circuit Breaker Controller (ICBC)
- Network enabled Intelligent Electronic Devices (IED)

The baseline communication topology of NR Electric's Digital substation Solution consists of a process bus and a station bus. Other communication topologies, such as optical Point-to-Point network, are also supported. The process bus employs IEC 61850-9-2 Sampling Value, IEC 61850-8-1 GOOSE for time-critical message and IEEE 1588 protocols. The station bus employs IEC 61850-8-1 MMS, GOOSE message and SNTP protocols.

Communications between equipment can be realized by fiber links in the entire substation. This unique and smart solution is suitable for newly constructed and

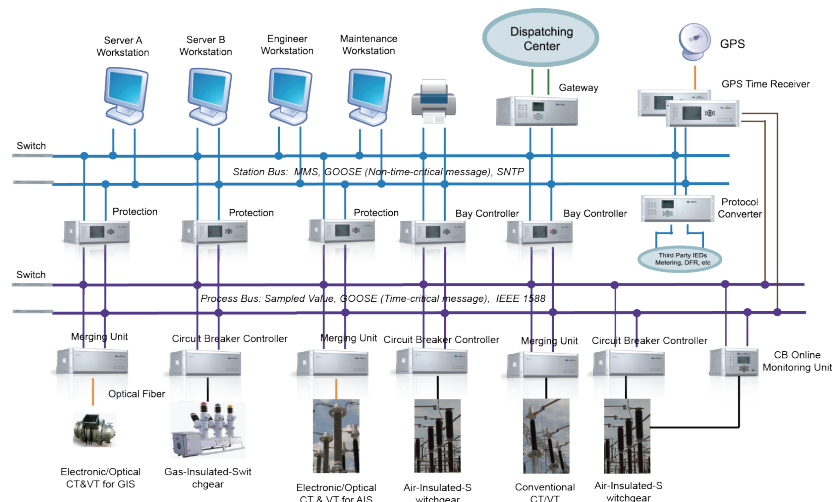
refurbishment substations. The merging units not only support connections to electronic CT/VT and optical CT, but also conventional CT/VT.

NR Electric offers full product series to support the implementation of digital substation solutions, including:

- 10kV-800kV Electronic CT/VT and Optical CT for GIS and AIS
- Merging Unit supporting conventional and Non-conventional CT/VT
- Circuit Breaker Controller executing binary inputs/outputs for Breaker/Isolator/Earth Switch via GOOSE message
- Protection and Control complying with IEC 61850-9-2 and GOOSE message
- Gigabit Ethernet Switch for process bus and station bus
- IEC 61850 Protocol Converter for third-party IED
- Clock Receiver providing IRIG-B/SNTP and IEEE 1588 clock signal
- Gateway supporting IEC 61850
- HMI Software for IEC 61850 substation

Electronic CT/VT

NR Electric has pursued advanced research on electronic CTs and VTs to ensure maximum reliability and availability in the applications of metering and protection relays. ECTs/EVTs have the advantages of no magnetic saturation, none ferromagnetic resonance, large dynamic measuring scope, wide frequency band and compact structure.



Energy Management

The Energy Management System (EMS) and Distribution Management System (DMS) monitor, manage and optimize energy generation, transmission, distribution and consumption in order to help utility or industrial customers to maximize efficiency and minimize cost. It supervises the whole power network and produces the accurate control strategies to accomplish energy optimization.

Energy Management System

The PCS-9000 Energy Management System (EMS) is a highly specialized, real-time, computer based supervisory control system designed to assist electric power system operators in monitoring, controlling, managing and optimizing the transmission grid and/or the performance of power generation reliably and efficiently. With hundreds of licenses deployed in China and all over the world, the PCS-9000 EMS is the state-of-the-art solution for optimal grid analysis and operation in regards to security, quality and economy.

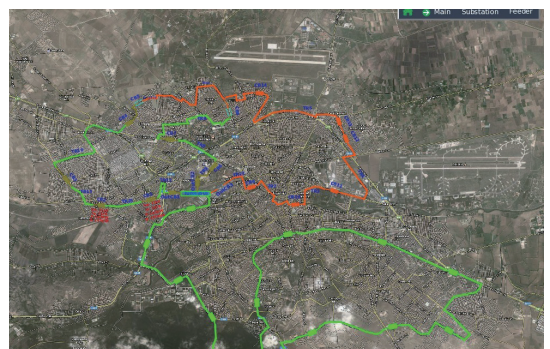
NR Electric's Energy Management System provides versatile interfaces and protocols for RTU or Gateway in substations, such as IEC 61870-5-101, IEC 61870-5-104 and DNP 3.0. Redundant scheme is adopted for server, database and communication systems to improve reliability. It fully complies with the IEC 61970 standard, providing a unified data platform based on Common Information Model (CIM).

NR Electric's EMS solution provides diverse functions that are tailored to specific project requirements. These include but are not limited to Supervisory Control and Data Acquisition (SCADA), Automatic Generation Control (AGC), versatile Power Application Software (PAS), Dispatcher Training Simulator (DTS), Wide Area Measurement System (WAMS) and Tele-Meter Reading (TMR).



Distribution Management System

Keeping the path of Smart Grid moving forward, NR Electric has developed innovative solutions for electric distribution networks based on state-of-the-art software and hardware technologies. The PCS-9000 Distribution Management System, designed to serve for distribution control centers around the world, provides integrated functions and advanced applications for the control, management, analysis and optimization of day-to-day operations.



NR Electric's Distribution Management System (DMS) features complete automation of dispatching, distribution, operation and service. Therefore, ensuring the reliable and economical operation of the distribution system. The system complies with IEC61970 and IEC61968 standards.

Power Stability Control

Blackouts can severely impact the flow to modern society in many ways, from economic repercussions to life setbacks. Blackouts can be particularly damaging to enterprises such as hospitals, underground mining operations, gas stations, sewage treatment plants, etc.

NR Electric provides the innovative Power Stability Control System (PSCS) to improve power system stability and significantly reduce possible blackouts. This technology differs from other System Protection Schemes (SPS) because the PSCS relies on instability prediction instead of instability measurement. Before installation, the tactic table is pre-determined and simulated according to the previous stability studies and strategy analysis. After installation, PSCS acquires all the necessary real-time data from substations or power plants and seeks appropriate remedy actions in the tactic table to pull the power system back to a stable state before it goes into a state of instability.

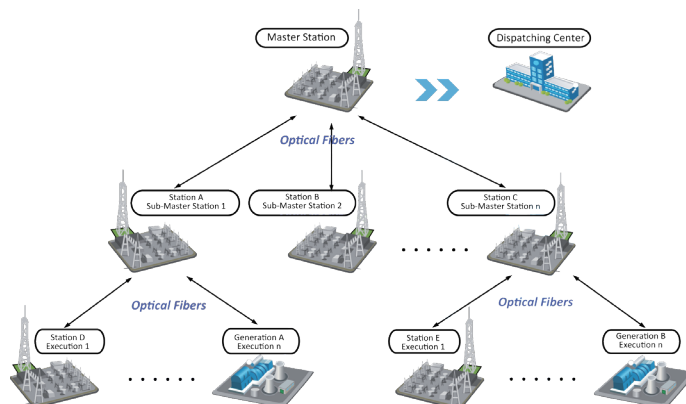
Out-of-step controllers and frequency/voltage controllers detect the system's parameters and take actions to prevent the expansion of instability. Generally a basic requirement for these controllers is that they should not operate during short-circuit fault, which would be cleared by protective relays. Vice versa, the relay should not operate during system instability; allowing the controllers to take measurements. The after-disturbance analysis is important for discovering potential problems in a power system and help customers enhance the system's reliability.



Power Stability Control System

NR Electric's Power Stability Control System (PSCS) is used to prevent and reduce the possibility of system oscillations. Imbalance between loads and power generations can result in system frequency and voltage changes that could ultimately lead to system collapse. Power stability control can quickly restore a system's balance by load shedding or generator shut down based on the preset control tactic. Ultimately, bringing voltage and frequency back to an acceptable value, so as to minimize the affected area and avoid cascading instability.

A Power Stability Control System is composed of one master station, several sub-master stations and execution stations. Communications between master station and sub-master stations are implemented by optical fibers.



Recording & Measurement

Disturbance and Fault Recorder (DFR)

The Disturbance and Fault Recorder (DFR) is a multifunctional data acquisition system designed to address the data recording requirements of transmission or distribution power substations. It captures the curves of monitored quantities and aligns the values of different supervised objects to build disturbance records. DFR helps users to simplify disturbance analysis by combining the discrete records in different protective relays.

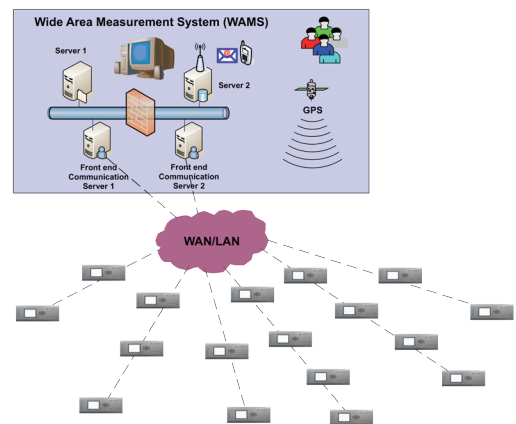
Disturbance, Fault Management and Recording System (DFMR)

To enhance the analysis capabilities, NR Electric provides the DFMR system to manage DFRs in the regional network. It collects the disturbance data of a whole power network and provides real-time monitoring and waveform analysis based on the information collected. Operators in local substations are capable of modifying settings, viewing alarm information and analyzing waveforms. Brief information is available for retrieving upon request. The DFMR system adopts SDH/SONET or WAN in order to comply with IEC61850, FTP and IEC60870-5-103 standards.



Wide Area Measurement (WAMS)

NR Electric provides Wide Area Measurement System (WAMS), Phasor Measurement Unit (PMU) and Phasor Data Concentrator (PDC) for the real-time monitoring and visualization to keep track of the state of a power system. Stability estimation and remedial control functions can be integrated into this system.



NR Electric's The Phasor Measurement Unit (PMU) relies on a GPS time signaling to provide extremely accurate time-stamping signals of the power system information. The measured vector quantities are sent to the control center to provide a basis for monitoring, protecting and controlling power networks. PMUs are installed in substations and power plants as part of the Wide Area Measurement System (WAMS) and the Power Stability Control System (PSCS). It can improve the system's economical operation and enhance power stability against any severe disturbances. PMUs installed in different locations are synchronized by a GPS clock. If the GPS source is lost, an internal high-precise clock source is used instead.

The Phasor Data Concentrators (PDC) receive and store synchronized phasor data from PMUs through optical fibers, and send the collected information to WAMS in real-time. NR Electric's phasor data concentrator allows for the communication with more than eight WAMS stations.

Solutions for FACTS & HVDC



Flexible AC Transmission System (FACTS)

Flexible AC Transmission System (FACTS) is a power electronics-based system that can enhance controllability, capacity and flexibility of the AC power network. NR Electric's FACTS solutions are built upon in-depth knowledge of existing transmission systems, providing power companies with fast voltage regulation, effective active power control and load flow control to improve the reliability and quality of power supply. The cost-effective solutions include Static Var Compensator (SVC), Static Synchronous Compensator (STATCOM), Series Compensation (SC), DC De-Icer, Controllable Shunt Reactor (CSR), Unified Power Flow Controller (UPFC), Dynamic Voltage Recovery (DVR), and Fault Current Limiter (FCL).

NR Electric has already completed hundreds of FACTS projects worldwide, including one of the world largest SVC projects, 500kV series compensation, CSR in 750kV substation and so on. Based on the abundant experiences, NR Electric offers a turnkey solution for FACTS projects. The working scope covers system analysis, design, supply, installation, commissioning and maintenance.

HVDC Transmission

A high-voltage, direct current (HVDC) electric power transmission system may be less expensive and suffer lower electrical losses for long-distance transmission. In addition, HVDC avoids the heavy currents required by the cable capacitance for submarine power cables. HVDC also enables power transmission between asynchronous AC power grids, and can supply power to urban heavy load center.

NR Electric's HVDC transmission solutions include VSC-HVDC converter valve, DC instrument transformers, VSC-HVDC and LCC-HVDC control and protection system. NR Electric provides turnkey VSC-HVDC services include system study, schematic design, product delivery, site commissioning and operation support.

So far, NR Electric 's leading-edge multi-terminal VSC-HVDC power transmission technology has been applied to Zhou Shan, Nan Ao and Nanhui VSC-HVDC transmission projects. Zhou shan project is the the first five-terminal VSC-HVDC transmission project in the world. The power is transmitted from mainland to five isolated islands via submarine cables. Nan Ao project uses the VSC-HVDC transmission technology to realize the grid interconnection for wind farms on isolated islands. Nan Hui two-terminal VSC-HVDC transmission project was put into service in the year 2011, it interconnects the offshore wind farm to Shanghai city power network.

Static VAR Compensator (SVC)

The Static Var compensator (SVC) system is an effective way to achieve rapid adjustments in grid reactive power and improve power quality. It is widely used in power transmission, HVDC converter station, industrial field and wind farm, supporting reactive power control and realizing transient compensation, dynamic damping and other functions.



NR Electric provides the 'all-in-one' solution for SVC systems including study, design, supply, installation, training, commissioning and operation. The solution adopts innovative valve technologies, a reliable thyristor triggering method, an efficient cooling system and advanced protection and control system. It has gained extensive market value by supplying dynamic reactive power with fast response time and low-cost maintenance schemes. NR Electric's SVC system features:

- Vertical and free-floating pressstack structure for the valve. A valve block features: small size, convenient layout, low costs of infrastructure, simple valve block structure, high reliability and simple installation and maintenance.
- Advanced electro-optical trigger mode employs a high-voltage fiber-optic one-to-one trigger. This technology provides strong anti-interference performance; reliable operation and fast trigger speed.
- Patented water-cooling technology with high reliability and high thermal efficiency. This cooling method has been widely used for the locomotive and aerospace industries. It has also been used in one million kilowatts generating units, and high-pressure and UHVDC transmission.
- High-performance control and protection system. NR Electric SVC system adopts a high-performance decentralized and distributed structure to facilitate functional expansion and remote maintenance.
- Short response time and improved voltage flicker.

Static Synchronous Compensator (STATCOM)

High-power rapid impact loads and rapid growth of asymmetrical impact loads can lead to considerable reactive disturbances in power systems. Ultimately, affecting power stability, power quality and the economic operation of power grids. Additionally, the overcurrent and overvoltage caused by these disturbances may damage the associated electrical apparatuses.

Maintaining voltage stability and reactive power compensation is crucial. The most advanced solution is using high performance Insulated Gate Bipolar Transistor (IGBT) to provide fast and variable reactive power to the grid. The Static Synchronous Compensator (STATCOM) can be considered as an advanced static Var compensator.



NR Electric provides a Voltage-Sourced Converter (VSC) based STATCOM for reactive power regulation in applications such as flexible AC transmission, renewable energy generation, and industrial field load consumption. It helps both utility and industrial customers gain economical benefits through solving voltage unbalance and distortion problems, restraining system overvoltage, supplying damped oscillations and improving power factor.

NR Electric's STATCOM system is composed of control panel, power panels, start panel and series-connected reactors. The control panel contains the PCS-9583 master unit and PCS-9589 trigger control unit. The PCS-9583 adopts innovative UAPC platform with embedded CPU, DSP and high-capacity FPGA design. It uses industry standard high-speed Ethernet and IEC standard data collection as the data transmission link. The power panel uses advanced IGBT for power conversion. The circuit adopts a chain structure and redundant design to meet requirements for continuous and optimal operation.

DC De-Icer

Severe weather, such as frozen rain, can create ice coating on transmission lines and steel towers. Leading to damage of the power grid and threatening the safe operation of power systems. Possibly even resulting in blackouts and heavy economic losses. Ice coating on transmission lines, steel towers, and fittings can lead to mechanical damage.

NR Electric provides the innovative and versatile De-Icer system to help customers solve some of the dangerous problems caused by serious climate. In severe climate situations, the De-Icer serves to melt the ice cover and reduce the risk of tower collapse. In other situations, the De-Icer could be used as SVC to compensate the reactive power in the power grid.

De-Icer adopts thyristor rectifier to convert AC current into DC current. The DC current flows through the line resistance producing heat for de-icing. When de-icing a transmission line, the line should be out of service and the 3-phase conductor should be connected to the De-Icer. At the opposite substation, the 3-phase transmission line terminals should be short-circuited. The DC current is injected into the conductor via Phase Selecting Switches (PSS) in the De-Icer.



Series Compensation

The series compensation (SC) can improve the transmission capacity of the network and achieve optimal power flow. Ultimately, reducing losses and making full use of power supply at minimum energy cost.

Series compensation uses a series of connected capacitive reactors to change line impedance. It can increase the power transfer capability by raising the transient stability limit, improve the voltage profile, and reduce transmission losses. Furthermore, it reduces power transmission costs by using fewer parallel lines and less required shunt compensation.

NR Electric series compensation solutions are composed of Series Compensation (SC) and Thyristor Controlled Series Compensation. The solutions consist of a control and protection system, capacitor bank, MOV, spark gap, damping reactor, Thyristor Controlled Series Compensation (TCSC), bypass breaker and insulation platform. NR Electric provides the 'all-in-one' solution for series compensation covering design, supply, installation, training and commissioning.

Unified Power Flow Controller (UPFC)

Unified Power Flow Controller (UPFC) can control power system parameters such as terminal voltage, line impedance and phase angle. NR Electric UPFC can be used not only for power flow control, but also for power system stabilizing control. UPFC are capable of directing real and reactive power flows through a designated route and regulating the system voltage through reactive power compensation. Thus, UPFC provides several features for power flow control namely: voltage control through shunt compensation, real power flow control through quadrature voltage injection and reactive power flow control through in-phase voltage injection. Hence, the capability of transmission facilities can be better utilized. The mechanism of these three control methods of UPFC in improving the transient stability of the power system will be examined.



Controllable Shunt Reactor (CSR)

A Controllable Shunt Reactor(CSR) system can be used to absorb step-changing inductive reactive power in a very fast response time. NR Electric's PCS-9578 CSR can adjust the reactive power to stabilize the line voltage and achieve a reasonable power flow distribution. Furthermore, when applied in transmission line, CSR can also restrain the secondary arc current to improve reclosing success rate.PCS-9578 consists of a controllable shunt reactor and a control and protection system, which is used to control and protect transformer and reactors in the valves. So far, the CSR system has been used successfully in electric power system.

VSC-Based HVDC

NR Electric SuperCon™ for the VSC-HVDC transmission provides flexible transmission solution with small footprint, low losses and high reliability. It is suitable for many applications such as:

- Renewable energy grid-connection
- Island and offshore platform power supply
- City DC transmission and distribution grid
- Asynchronous power grid interconnection
- Multi-terminal DC power transmission grid

NR Electric company undertakes turnkey projects for VSC-HVDC transmission utilizing our own innovative products and third party qualified products. The equipment supplied includes:

- VSC Valve
- Electronic CT/VT
- Control & Protection
- Power Transformer
- DC Yard Equipment
- AC Yard Equipment

The turnkey services consist of consulting, system analysis, designing, supplying, procuring, testing, installing, commissioning, maintaining and training for consumer.



VSC-HVDC Valve

The Valve is the core equipment of VSC-HVDC solution. NR Electric's SuperCon™ converter employs multi-level technology, the cutting-edge technology features lower switching frequency, lower harmonics, lower power loss and higher overload margin.

With modular drawer type design, the vertical valve tower has a compact hierarchical and sectional structure, it requires smaller footprint and provides large flexibility for the system extension and maintenance.



Control & Protection System

The control and protection system is the “brain” of the VSC-HVDC solution. The SuperCon™ control and protection system adopts the high performance hardware platform; it fully complies with the IEC61850 standard. With optimized control strategy and accurate protection schemes, it achieves diversified applications including multi-terminal VSC-HVDC transmission.

LCC-HVDC Transmission

Conventional HVDC transmission technology is used in long distance bulk power transmission through overhead lines or submarine cables. It is also used in asynchronous interconnection to AC networks. NR Electric's solution to conventional HVDC transmission focuses on the control and protection system.

The control and protection system is the key to the overall performance of the HVDC transmission system. It guarantees a safe and steady system operation, provides flexible operating modes and accurate control effects. Furthermore, it helps to clear faults and assist in system recovery during system disturbances.



Control and Protection System

A complete PCS-9550 HVDC control and protection system can be divided into the following sub-systems:

- Interface with remote control center
- Operator control system
- AC/DC station control system
- DC control system
- DC protection system



DC Yard Electronic Transformer

NR Electric provides DC electronic CT, electronic VT and DC filter electronic CT for both line commutation converter (LCC) and voltage source converter (VSC-based) HVDC transmission projects. The DC electronic transformers have the advantages of small size, light weight, and no ferromagnetic resonance problems.

DC Electronic CT/VT is used in HVDC converter stations to measure the DC current/voltage and send the signals to the control and protection devices. Filter electronic CT uses the low power CTs (LPCT) to convert primary current to digital signals. It can be used for current measurement in the high voltage side, low voltage side and imbalance branch for DC filter.



DC Yard Electronic CT/VT

Solutions for Renewable Energy Generation



NR Electric values environmentally friendly and renewable energy projects. NR Electric is committed to the protection of the environment. Our integrated renewable energy offerings include major solar/wind farm equipment and systems such as photovoltaic inverters, wind energy converters, SVC/STATCOM, protection, automation, SCADA, and renewable generation management systems.

The strength of NR Electric's renewable energy generation solutions is based on our deep knowledge of electrical grids and over twenty years of experience as a key power system solutions provider. Our technologies, unique patents and know-how are at the heart of our solutions.

NR Electric is an independent innovator in renewable energy technology and a leader in power system protection & control. NR Electric offers integrated solutions for PV inverters, wind power converter, substation monitoring and power prediction, renewable power stations, centralized monitoring and control. With the rich experience gained from years in grid safety and stability control, NR Electric's products and services feature superb performance, low cost, safety and reliability. NR Electric will fully protect your renewable energy station and make your renewable energy system as effective as possible.

Solutions for Solar Power Generation

- PV Inverter
- SCADA
- Reactive Power Compensation
- Power Forecast

Solutions for Wind Power Generation

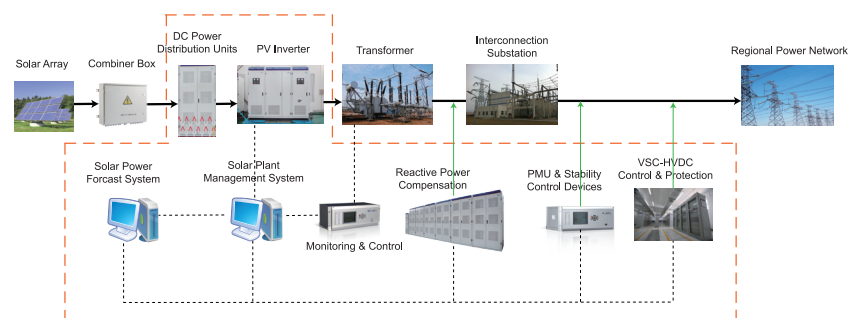
- Wind Converter
- SCADA
- Reactive Power Compensation
- Power Forecast

Solutions for Energy Storage & EV Charger

- PCS for BESS
- Large Capacity EV Charger

Solutions for Generation & Industry

- Static Frequency Converter
- Generator Excitation System



Overview of NR Electric PV Power Solution

Renewable Energy SCADA

Integrated Automation System

Taking into account the characteristics of PV power stations, the Centralized Supervision and Control System (CSCS) for the control and management of PV power stations is necessary. NR Electric's PCS-9700 CSCS can perform real-time monitoring and control on the PV solar array, DC current convergent cubicle, DC distribution cabinet, grid-connected inverter, step-up substation, and environmental monitoring system. It is equipped with rich user interfaces, strong analysis and processing functions as well as complete monitoring alarm mechanisms.

Centralized Control Center

More and more distributed solar power plants have been built and put into service. Hence, the owner tends to centralize monitoring, control and operation of solar power sub-plants. NR Electric provides centralized control center solution to centralize the monitoring and control of equipment in solar power plant and process the data for operators and maintenance personnel.



Reactive Power Compensation

The output of solar/wind power generation varies rapidly and the large fluctuations can threaten the stability of electrical power grid. To solve this problem, reactive power compensation is necessary.

NR Electric provides the 'all-in-one' solution for SVC/STATCOM system covering study, design, supply, installation, training, commissioning & operation. The solution adopts innovative valve technologies, reliable thyristor triggering method, efficient cooling system and advanced protection & control system.

PV Inverter

The PV grid-connection system consists of advanced IGBT controlled inverter and protection & control equipment. NR Electric's PV grid-interconnection system consists of an advanced IGBT controlled inverter, protection & control equipment, I/O switchgear, etc.

The PV inverter is a critical component in a PV system that it converts solar power to electric power which can be fed into the grid. During grid-connection operation, the inverter detects the self-operation conditions and the status of PV array and AC grid in real-time. The control system provides SCADA, soft grid-connection control, Maximum Peak Power Tracking (MPPT) control, dynamic Var control, islanding detection, Low Voltage Ride Through (LVRT) operation and Power Quality (PQ) control functions. The protection system can protect IGBT modules by detecting abnormal dv/dt and di/dt across IGBT and blocking the triggering pulse instantly. As a result, it can ensure a safe and reliable operation or rapid and safe shutdown in severe environments.



Power Conversion System for Energy Storage

The energy storage technology allows stored energy to be accessed exactly when it is required. NR Electric provides bi-directional power conversion system for energy storage in renewable energy generation application. The PCS-9562 power conversion system is equipped with low voltage ride through function and smart battery energy management with AGC/AVC function. The conversion system has outstanding output power quality ($I_{thd} < 1.2\%$).

Wind Converter

Due to the rapid development of computer science and control technologies, wind power technologies have also advanced at an equivalent rate. Wind power generation control methods have evolved from simplex constant pitch stall control to full blade variable pitch and variable speed control. At present, the doubly fed converter system with variable speed and constant frequency control is widely used in the wind power generation market.

Power Forecast

NR Electric's PCS-9700F power forecast system forecasts the output power of PV power station based on highly accurate Numerical Weather Prediction (NWP). It consists of two power forecast servers (main/standby), one weather data processor server, one WEB-based engineer workstation, one reverse isolation equipment, and one fire wall.

Static Frequency Converter

Static Frequency Converter (SFC) is used for the starting and speed control of large capacity synchronous machine (generator/motor) to improve efficiency and reduce cost. It supplies current with varying frequency to the stator of motor to control the motor speed. SFC is suitable for pumped storage power plant, gas turbine power plant and some industrial enterprises.

NR provides the advanced SFC products for the power plant and industrial customers. The SFC injects the variable-frequency current into the stator winding of synchronous machine to produce a varying magnetic flux. The SFC is composed of rectifier, inverter and controller. It could detect the initial position of rotor without any external sensor.

- Pumped Storage Power Station
SFC is used control the motor startup from 0Hz to 50Hz (or 60Hz) before it operates in pump mode. SFC makes the motor switch smoothly without impact on grid operation.

- Gas Turbine Power Plant
In gas turbine power plant, SFC system is used to drive the generator unit through purging, warming, firing and accelerating.
- Other Industrial Enterprises
SFC system can be used for initial start and speed control in other industrial enterprises where synchronous motors with large capacity are widely used.



Generator Excitation System

Excitation system is an important part of generator that is used to inject the exciting current into rotor to establish the magnetic field. The excitation system need to maintain the generator voltage level and is required to act on power system static and transient conditions.

NR provides microprocessor-based excitation system to improve generator performance and reduce maintenance costs. It offers the comprehensive control strategies for different applications, such as power system stabilizer, optimum control or adaptive control,

etc. It also can be customized to meet the various specifications of specific project. The current rating is available from 100A up to 7000A and the voltage rating is available from 100V up to 700V.

NR's excitation system consists of numerical excitation regulation system, thyristor rectifier, diode valve rectifier, de-excitation equipment and auxiliary cabinets. According to the different requirements of each excitation mode, the above equipments can be flexibly tailored to combine the compatible solution.

Comprehensive Service, Design & Training



Engineering Service

NR Electric's full portfolio of products enables us to provide "All-In-One" turnkey services that cover the entire lifecycle of the solution. We value comprehensive services, long-term warranty and long-lasting spare part supply for our customers. Experienced engineers and experts from NR Electric deliver services such as consulting, system analysis, installation, configuration, integration, verification, commissioning, operation, troubleshooting, and maintenance services for our global customers. Our oversea subsidiaries and Technical Service Centers (TSC) enable NR Electric to provide effective and efficient services for local customers.

Consulting

NR Electric's experienced engineering service teams provide a wealth of telecom consulting and on-site commissioning for customers all over the world. Their abundant on-site experience and expert skills help users solve any emergencies and potential problems. The dedicated service group offers a wide range of professional consulting services, including:

- Power stability study
- Data migration from legacy systems
- On-site commissioning
- Solution and product customization to meet the needs of customer-specific requirements
- Software maintenance

System Analysis

NR Electric owns a strong system analysis team, who can provide system analysis and technical consultation for both planned and operating power grids, helping to realize the economic and reliable operation of grids. System analysis and technical consultation cover the comprehensive design of power, selection of power transmission modes (DC, AC), power supply access and other primary systems and protection and control systems.

Setting Calculation

Reasonable settings are essential for the operation of protection devices. It can improve the system protection scheme of the whole project. NR Electric has a group of professional engineers to fulfill the setting calculation services. Those engineers have years' of site service experience and are familiar with operation requirements of power generation and transmission systems.

NR Electric can offer setting calculation services for the following parts:

- Generation units, power plant auxiliary electrical system
- Substation transmission lines, busbars, transformers and low-voltage protection devices
- Regional power grid
- Industrial enterprises, such as mines and petrochemical industries

Testing

NR has groups of qualified testing engineers to accomplish different kinds of factory tests. To ensure the performance and quality, NR has built up complete test laboratories to perform factory acceptance tests. Based on specific requirement for difference projects, our testing engineers can also complete site acceptance tests with external testers.

- **Closed-loop Digital System Testing**
NR Electric utilizes real time simulators (RTDs) lab to simulate the real power grid according to each project. The protection coordination and the relay settings are validated by the closed-loop test between RTDs and the protection equipment.
- **Dynamic Physical Model Testing**
To guarantee and enhance the safe operation of our products, NR Electric has built a world-class precise analogue lab with small-size electric power apparatus, including generators, transformers, motors and distributed transmission lines. These physical models have the same dynamic characteristics as the on-site equipment, such as the transformer, can be used to simulate the inrush current and saturation case.
- **Field Testing and Commissioning**
NR Electric's regional engineering teams are always working in close cooperation with users to reduce commissioning time and cost. These services enable customers to work with our factory-trained technician



staff on-site to support testing and commissioning efforts and provide hands-on training for your personnel.

- **Fault Tracing and Analysis**
NR Electric assigns experienced engineers to assist customers to trace and analyze fault data. The fault causes can be determined in short period and analyzed in detail. The analysis results can help to improve the protection performance.

Commissioning and Maintenance

NR Electric's regional engineering teams are always working in close cooperation with end users to reduce commissioning time and cost. This service enables customers to work with our factory trained technical staffs to support commissioning and maintenance efforts and provide hands-on trouble shooting for your personnel.

Furthermore, NR Electric continues the offering of long term warranty and spare parts supply. NR Electric provides 15 years' spare parts supply and long-term product warranty from date of shipment as per customer's requirement. The product warranty coverage includes relays, control devices, channel devices and accessories, automation systems, fiber optic communication systems and special protection systems for power stability control.

Engineering Design

In the past tens of years' of serving power utility and industry clients, NR Electric always insists that a detailed and precise engineering design work is the foundation for the well construction and safe operation of a power grid. For this reason, we keep striving to improve our engineering design capabilities to maximize clients' benefits from the beginning of a project. Based upon experiences gained from thousands of projects of different voltage levels, NR Electric offers complete engineering design works for substations, step-up power stations of thermal power plants and renewable energy generation farms. NR Electric's design scope covers from electrical designs, civil construction designs, communication designs, fire protection designs, to heating ventilation air conditioning designs.

Electrical Designs for Primary System

- **Scheme Design**

Relying on the in-depth studies of project background and clients' demands, NR Electric's professional engineering design team will propose a complete scheme design including the following design works:

- Main electrical wiring of the primary system
- Overall electrical layout of the primary system
- Physical layout of systems with difference voltage levels
- Wiring of auxiliary power network
- Primary equipment lectotype for power utilities and power plants
- Instructions to the above scheme designs

For the primary system of power utilities, NR Electric also provides the lectotype design for reactive power compensation, including the compensation capacity, SVC/STATCOM valve, series compensation platforms and spark gaps, electrical parameters for capacitors, reactors and cooling system.

- **Construction Design**

Once the scheme designs are approved by clients, our engineering design team will conduct the construction designs of the primary system. The construction design work covers the designs of primary equipment installation, lightning protection, earthing and illumination system.

- **As-Built Design**

After the construction is completed, NR Electric engineering design team collects site feedbacks and wiring and equipment changes to update the construction designs. The finalized as-built design is important for the operation and maintenance of the primary system in the future.

Electrical Design for Secondary System

- **Scheme Design**

With the aid of years' leading-edge researches on integrated secondary system solutions, NR Electric provides solid and field-proven scheme designs for the secondary system of a power grid. The complete scheme design including the following design works:

- System integration
- Configurations of protection, control and automation systems
- Device layouts inside the panel
- Instructions to the above scheme designs



- **Construction Design**

During construction design stage, our engineering design team will conduct the construction designs of the secondary system, including,

- Panel installation
- Panel Design
- Cable wiring from panel to panel and from panels to primary equipment
- DC power supply
- Cable lectotype and layout
- Fireproof cable layout

- **As-Built Design**

After the installation is completed, NR Electric engineering design team collects site feedbacks and wiring and devices changes to update the construction designs. The finalized as-built design is important for the safe operation and maintenance of the secondary system in the future.

Engineering Training

To keep pace with the rapid developed technology and product innovation, NR Electric is committed to providing customers with numerous and comprehensive training courses throughout the year as well as on-demand training at your facility. The training is a combination of tutoring, factory training and "on-the-job" training, including fundamental knowledge of power system, and introductions to Integrated Secondary System (ISS), Power Electronics Applications (PEA) and HVDC power transmission.

Training Center

NR Electric has founded a training center with samples of all products to provide professional training for domestic and oversea customers. At NR Electric's advanced training center, we offer regularly scheduled courses containing theoretical courses and hands-on interactions using relays & meters, relay test tools, automation software, communication equipment and personal computers.

The key to the successful training program is qualified and expert instructors. At NR Electric's training center, a group of well-trained instructors with years of practical experience in the protection industry is dedicated to bringing high quality technical topics in different languages, including English, Russian, French and Spanish.

NR Electric insists to keep the class sizes small so instructors can interact with each trainee. Trainees receive theoretical course manuals and detailed lab

exercises guidelines to ensure they can apply this knowledge in their workplace. Debugging tools such as Omicron and HMI software are provided to perform the static electrical test for further understanding. Trainees can manipulate and test the protection and automation devices in laboratories to gain operating experiences.



On-site Training

To maximize customers' benefits from our training, NR Electric offers the option of conducting training courses at users' facility. These on-site courses can be tailored based on the specific engineering project and requirements. All the necessary testers and literature will be provided on-site for operation practice.

Every year, NR Electric Training Center offers more than 120 on-site training sessions to customers all over the world. The training covers the application, maintenance and fault diagnosis of NR Electric's products such as protection and control devices, automation system, digital substation technology and electronic products.

Training Courses

- Fundamentals of Protective Relay
- Substation Automation System
- Digital Substation Technology
- Line Distance Relay
- Line Differential Relay
- Transmission Line Protection
- Transformer Protection
- Busbar Protection
- Generator Protection
- IED Test





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