HOTEAM

Ultimate answer for greener power

Hoteam HTSVG STATCOM (Static Synchronous Compensator)

HOTEAM ELECTRIC CO., LTD

ABOUT US

Hoteam Electric is the leading company specializing in providing power quality solutions for utility and industry customers to ensure efficient and reliable operation of electrical systems. The company's broad range of products includes active power filters (APFs), STATCOMs (also known as SVG), capacitor banks, MCRs and many other customized power quality solutions.

In order to solve the power quality problems related to fast growing new energy installations such as rooftop solar farms as well as traditional industrial applications, Hoteam Electric offers a wide range of STATCOMs available in different voltage levels, kvar ratings and dimensions. The whole Hoteam STATCOM family includes floor standing HTQF STATCOMs with voltage level ranging from 400V to 35kV, and rack-mount/wall-mount STATCOMs for flexible installation.

LEADING PROVIDER OF POWER QUALITY TECHNOLOGY

Our company will always adhere to the "Technology leads the future" business philosophy and currently owns over dozens of patents and software copyrights

STANDARDIZED MANUFACTURING PROCESS & COMPLETE QUALITY ASSURANCE SYSTEM

As a high-tech company aiming at global power qulality market, Hoteam Electric are acquired ISO9001 certification, ISO14001certification and our products has passed CE certifications and SGS inspections successfully, in order to regulate our manufacturing. All our products are fully tested before delivery to minimize the time needed for assembly and commissioning.

OPERATION PRINCIPLE

STATCOM (Static Synchronous Compensator, also known as SVG) represents the most advanced technology in the reactive power compensation field. As an indispensable part of Flexible AC Transmission Systems (FACTS), STATCOM is a shunt device in the power grid and acts as a controllable reactive current source to provide variable reactive power in response to load reactive current instantly and continuously. In the meantime, the function of harmonic filtration can be performed by STATCOM to meet the grid code requirements further. As a result, a STATCOM system, which is capable of providing dynamic reactive power to stabilize the system voltage, PF correction and harmonic mitigation, serves as the ultimate power quality solution in the power grid.

Specifically, Hoteam LV HTSVG uses IGBTs to form a self-commutated converter, which is connected to the power grid via coupling reactors. By adjusting the amplitude and phase angle of output voltage on the AC side of the converter, or just controlling the current on the AC side directly, the circuit can absorb or generate required reactive current to fulfil the purpose of dynamic reactive power compensation.

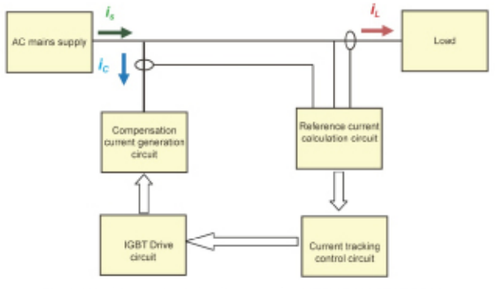


Fig.1: Working principle diagram for HTSVG LV STATCOM

As shown in Fig.1, HTSVG LV STATCOM is mainly comprised of the reference current calculation circuit and the compensation current generation circuit. The reference current calculation circuit monitors the load current in real time, and converts analog current signal into digital current signal, which is fed into DSP controller to be processed. The DSP controller generates reference current by extracting the reactive current component and harmonic current component from the digital current signal. Based on the value of reference current, the current tracking circuit and IGBT drive circuit will send PWM signals as IGBT driving pulse, to drive the IGBTs or IPM power modules in the compensation current generation circuit. As a result, the compensation current, which is of the same value but the reversed phase of the load reactive or harmonic current, is generated and injected into grid to achieve dynamic and precise reactive power as well as harmonic compensation.

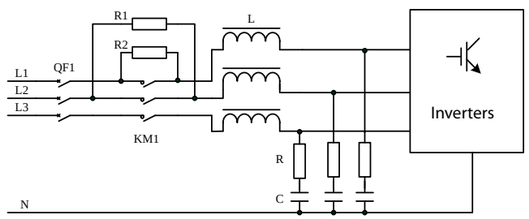


Fig.2: HTSVG LV STATCOM primary circuit diagram

As shown in Fig.2, QF1 is the incoming circuit breaker, KM1 being the precharge contactor and R1, R2 being the precharge resistors. The purpose of the precharge circuit is to avoid high inrush currents that could damage DC capacitors when HTSVG powered on. Output filter resistor R, output filter capacitor C and output reactor L make up output filter to reduce ripple current. For 3 phase, 3 wire STATCOM, there is no neutral connection in Fig.2.

MAIN FUNCTIONS

1. Maintaining load side voltage and improving reliability of electrical distribution system

For load center, heavy load burden without the proper support of large capacity reactive power supply can easily lead to low grid voltage or stability accident like voltage collapse. With the STATCOM's dynamic reactive power compensation ability, the voltage at the load side and grid stability can be raised effectively.

2.Compensating reactive power, improving power factor, lowering line loss and enhancing energy efficiency

From the point of view of electrical distribution system, large loads like induction motors, arc furnaces, rolling mills and large capacity rectification equipment, require large amount of reactive power during operation. In the meantime, the transformers and line impendence cab also generate reactive power demand. All these factors combined lower the power factor of the system.

Hoteam STATCOM improve the power factor of the load by injecting suitable reactive power in the power distribution line.

3.Mitigation of voltage fluctuation and flicker

Voltage fluctuation and flicker are mainly caused by load fluctuation. This is because load fluctuation will result in current fluctuation, which in return causes voltage flicker at the load side. Typical loads causing voltage flicker are arc furnaces, rolling mills and electric locomotives.

Hoteam STATCOM can provide dynamic reactive current super fast to mitigate voltage fluctuation and flicker caused by load fluctuation. To date, the most effective solution to voltage fluctuation and flicker is STATCOM.

4.Harmonic compensation

The non-linear loads prevailing in electrical distribution system, such as VFDs, rubber mixers, hoists and arc furnaces, generate large amounts of harmonics. Those harmonics distort voltage and current waveform, increase failure rate of loads and power loss throughout the distribution system, or cause system resonance and related tripping accidents.

To solve the harmonic issues, H type HTSVG LV STATCOM can cancel harmonics by injecting reversed-phase harmonic current into grid. The maximum harmonic compensation capacity of H type HTSVG STATCOM is 30% of rated power.

5.Load unbalance compensation

Unbalanced loads, such as electric locomotive traction systems and AC arc furnaces, are quite common in electrical distribution system. In addition, the three-phase impendence unbalance of transmission and distribution equipment, like power lines and transformers, can also result in voltage unbalance.

HTSVG LV STATCOM is capable of compensating the negative sequence current generated by unbalanced loads rapidly, to ensure the balance currents between three phases.

TYPICAL APPLICATIONS

- **Smart grid installations such as rooftop solar farms**
- **Sugar mills and wood mills**
- **Fans and pumps**
- **Utilities and wind farms**
- **Mining hoists**
- **Machinery & equipment industry**
- **Food industry**
- **Chemical industry**
- **Harbor cranes and welding machiness**

KEY PRODUCT FEATURES

Based on the proven technologies of active harmonic filters and decades of experience in the power quality field, Hoteam HTSVG STATCOM is a cutting-edge dynamic var compensation solution presented by Shandong Hoteam Electric.

Network stabilization

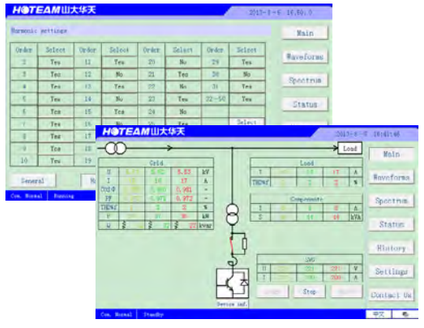
- High dynamic performance: very fast response time less than 10ms for flicker mitigation
- Excellent undervoltage performance: highly efficient voltage support for weak grid
- Patented control algorithm and hardware design to eliminate resonance

Versatility: Far beyond dynamic reactive compensation

- Harmonic mitigation: the H model of HTSVG STATCOM is capable of assigning its 30% current capacity to compensate harmonics up to 50th order.
- The load balancing function making Hoteam HTSVG LV STATCOM highly desirable for industrial grids dominated by single phase loads such as spot welding machines.

User-friendly LCD control

- 7-inch English language menu-based touch screen featuring harmonic order selection, waveform display for easy commissioning and opeation

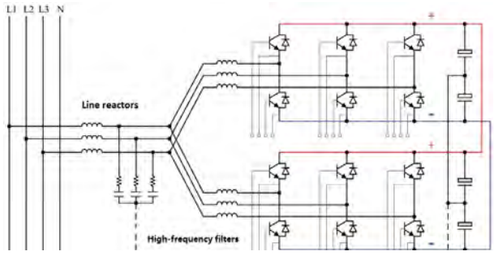


User-friendly interface featuring harmonic order selection and grid parameters

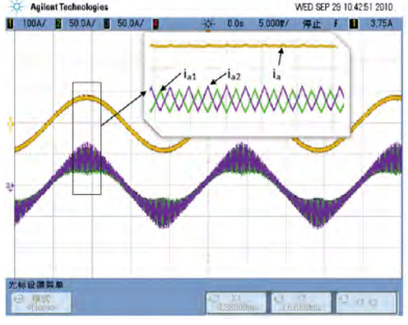
Super low harmonic generation

- Hoteam HTSVG LV STATCOMs utilize double interleaved inverter topology to ensure dynamic response time, reduced ripple current and lower heat loss.

  In detail, the high-frequency components of the two inverters' output currrents are staggered by 180 degrees in order to cancel each other. As a result, the overall ripple current is reduced by 80% and the power loss decreases by 30% without compromising the response time and the need to rising the switching frequency.



Electrical diagram of the Hoteam HTSVG LV STATCOM



Waveforms of individual inverter ripple current as well as the overall ripple current

Individual inverter ripple current i_{a1}

Individual inverter ripple current i_{a2}

Overall ripple current i_a

Easy dispatchability and scalability to fit all installations

- Up to ten units can operate in parallel for capacity expansion
- Modular construction allowing for easy transportation, quick deployment and future capacity upgradation. The HTSVG LV STATCOM can be used for MV reactive power compensation with a step-up transformer.
- Low space requirements due to the reduced size and fewer passive components.
- The controller of the HTSVG STATCOM can output control signal to switch on and off the existing capacitor banks, which means the kvar size of the STATCOM system can be reduced accordlingly.

3-units parallel configuration with a step-up transformer for MV PFC application

Ubiquitous protection

- Well-thought-of protections ensuring the maximum safety of the STATCOM system in case of abnormal working conditions, which includes:
  - AC overvoltage & undervoltage on the mains
  - DC overvoltage on the DC bus
  - Inverter overcurrent & overtemperature
  - IGBT, reactor, capacitor overtemperature
- Optical fiber link between the main control board and individual power modules to provide complete galvanic isolation and EMI immunity.
- Automatic current limitation without risk of overload

Model description system

HTSVG — 0.69 / 200 — H

- H: the H model with harmonic mitigation function
  N/A: the general models without harmonic mitigation function
- Compensation capacity (kvar)
- Nominal voltage (kV)
- Hoteam STATCOM (also known as SVG)

Product Selection Tables

Hoteam HTSVG -0.4 400V module type SVG					
Model	Capacity (kvar)	Reference dimensions			Installation Methods
		Width (mm)	Depth (mm)	Height (mm)	
HTSVG - 0.4 / 30	30	440	445	150	Rack-mount
HTSVG - 0.4 / 50	50	440	575	177	Rack-mount
HTSVG - 0.4 / 100	100	500	580	270	Rack-mount

Hoteam HTSVG -0.4 400V module type SVG					
Model	Capacity (kvar)	Reference dimensions			Installation Methods
		Width (mm)	Depth (mm)	Height (mm)	
HTSVG - 0.4 / 30	30	440	195	445	Wall-mount
HTSVG - 0.4 / 50	50	440	177	575	Wall-mount
HTSVG - 0.4 / 100	100	500	270	580	Wall-mount

Hoteam HTSVG -0.4 400V cabinet type SVG					
Model	Capacity (kvar)	Reference dimensions			Installation Methods
		Width (mm)	Depth (mm)	Height (mm)	
HTSVG - 0.4 / 100	100	800	800	2200	Floor-standing
HTSVG - 0.4 / 150	150	800	800	2200	Floor-standing
HTSVG - 0.4 / 200	200	800	800	2200	Floor-standing
HTSVG - 0.4 / 250	250	800	800	2200	Floor-standing
HTSVG - 0.4 / 300	300	800	1000	2200	Floor-standing
HTSVG - 0.4 / 350	350	1000	1000	2200	Floor-standing
HTSVG - 0.4 / 400	400	1000	1000	2200	Floor-standing

Specifications

Model name	HTSVG STATCOM (SVG)
General electrical parameters	
Nominal voltage	0.4 kV -20%/+15%(1)
Nominal frequency	50/60 Hz ±5%
Performance specifications	
Rated capacity	30kvar~100kvar per module, 100kvar ~ 400kvar per cabinet
Var compensation range	100% of rated capacity, from capacitive to inductive continuously adjustable
Functionality	Power factor correction, flicker mitigation, harmonic mitigation(2), load balancing
Response time	Instantaneous response time < 0.1ms Full response time < 10ms
Inverter topology	Patented interleaved inverter topology for ripple current cancellation
Protection	Over-voltage, Under-voltage, Over-current, Over-temperature, etc.
Power loss	3% when at the full load
Harmonic mitigation performance for the H model of HTSVG STATCOM	
Harmonic spectrum	2^{nd} to 50^{th} harmonics
Harmonic selective compensation	2^{nd} to 31^{st} harmonics all can be selected individually, 32^{nd} to 50^{th} harmonics can be selected simultaneously
Compensation capacity	30% of rated current capacity (3)
HMI & communication	
Display	2.2inch,4.3inch or 7-inch English language menu-based touch screen
Communication interface	RS-232, RS-485, TCP/IP
Communication protocol	MODBUS-RTU
Digital I/O	4 digital inputs, 2 digital outputs
Operation configuration	
Parallel operation	Up to 12 units (different rated kvar capable)
CT requirement	3 CTs required (class 0.2 or better) Secondary rating: 5A
CT location	Supply side or load side, please specify when placing order
Color	RAL9004 Black for module type, RAL 7035 for cabinet, other color on request
Environmental conditions	
Operation environment	Indoor
Protection class	IP20 (higher protection classes available on request)
Operation temperature	-10 ~ 40°C (higher operation temperature allowed with derating)
Storage temperature	-25 ~ 70°C
Cooling type	Forced air cooling
Humidity	Maximum 95% non-condensation
Altitude	1000m (higher operation altitude allowed with derating)

(1) Other nominal voltages available on request. For medium voltage applications a step-up transformer is required.
(2) Harmonic mitigation function only applies to H model.
(3) And the rated current capacity of the HTSVG STATCOM equals to 1.5 times of the rated capacity based on kvar.

CASE STUDY

HTSVG : dynamic PFC solution in facility with grid-tie roof-top solar farm

Suth Africa project background

Voestalpine VAE SA (Pty) Ltd is a leading partner for complete turnout systems in Republic of South Africa (RSA), including drive and safety technology, as well as for diagnostic and hazard notification systems for all railway applications – ranging from high speed to heavy haul, urban traffic and mining.

The manufacturing processes at the heavy-engineering VAE Plant in Isando, Gauteng, creates an electrical demand from the local supply authority that is very dynamic in nature, with processes switching on and off throughout the day. VAE is purchasing the electricity from the supplier against a two-part electricity tariff, which is basically a kWh real energy consumption part and a kVA Maximum Demand part.

In a drive to reduce the annual electrical energy purchases from the local supply authority, the VAE plant in Isando, Gauteng, has installed a 314kW Rooftop Solar PV Plant in 2014. This plant was commissioned in August 2014, and since then there was a reduction in kWh real energy purchases from the supply authority.

To reduce the monthly kVA Maximum Demand cost on the electricity bill, Power Factor Correction (PFC) is the most general solution to realise this. However, the low voltage (LV) PFC system of the switched-capacitor type was not functional at this plant due to failed components. These failed components could be attributed to higher than normal switching frequency of the capacitor steps as a result of the high dynamic nature of the plant's electrical load, and due to resonant over-voltages in the capacitors caused by harmonic currents and voltages present on the LV network.

On the other hand, the connection of the Solar PV Grid-tie Inverters on the plant's LV electrical network in August 2014 introduced another dynamic to the electrical load of the plant as seen from the supply utility's side. The Grid-tie inverters were configured to generate power directly into the AC grid at unity Power Factor (PF), meaning that only real power (kW) is injected into the grid from the Solar Plant. The result of this is that during daytime when the sun shines, the Solar PV Plant will reduce the instantaneous kW real power demand from the supply utility, while the instantaneous kVAr reactive power demand will remain unchanged at that instant, and will only be determined by the electrical load of the manufacturing plant itself. While the kW demand from the supply utility drops when the sun shines, the kVAr demand stays the same – the result is that the PF of the plant as a whole as seen by the supply utility decreases

How grid-tied roof-top solar farms can cause low power factor problems

National regulations requires inverters to operate at a high power factor. Further, most modern inverters operate at unity power factor. As such, the inverter itself does not constitute a problematic load with regard to power factor. However, one side effect of inverters operating at unity power factor is that solar PV systems may reduce power factor at distribution transformers. This is due to the fact that active load current is generated locally by the inverters while the upstream grid must supply all reactive load current. This results in a higher proportion of reactive to active load currents passing through distribution transformer resulting in reduction of the power factor at the transformer. However, this in itself does not present any operational problems for the network. In fact, local generation of active current reduces network losses as power does not need to be transported as far. Figure 3 illustrates graphically the mechanism by which power factor may be reduced at distribution transformers due to the interaction of PV systems.

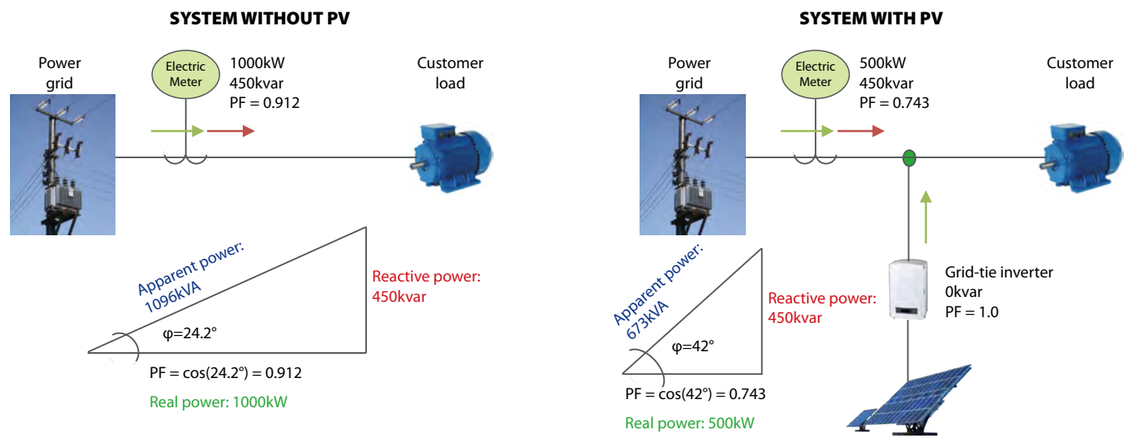


Fig.3: How PV Systems can Impact on Distribution Substation Power Factor

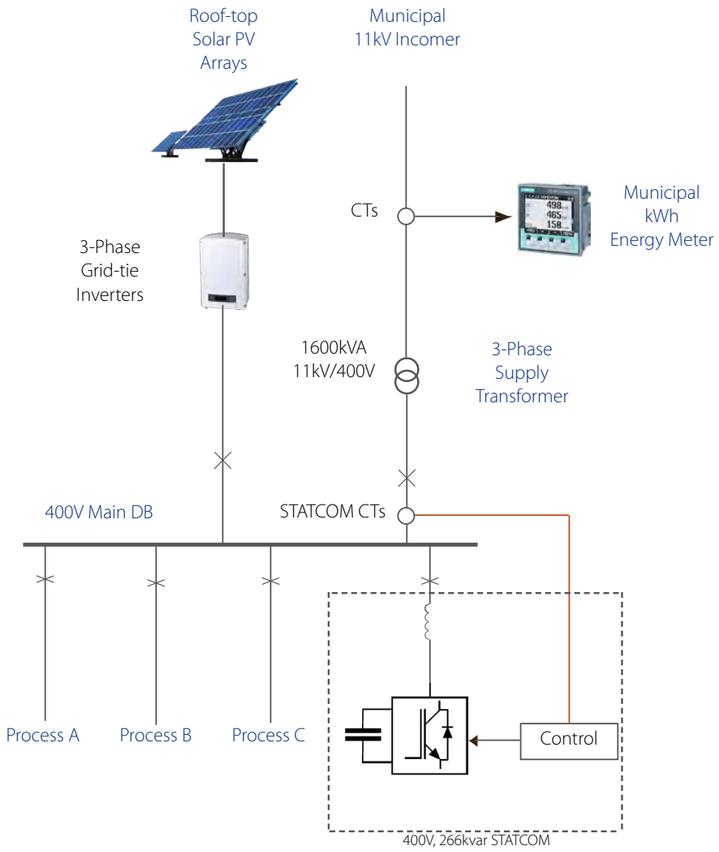
Solution

So VAE SA required a new PFC solution to control the PF of the plant continuously at a target level better than 0.96 (lagging) under dynamic load conditions and dynamic power generation conditions from the Solar PV plant.

A LV STATCOM solution was designed and implemented at the VAE SA plant in Isando in April 2015. The rating of this STATCOM is 266kVAr @ 400V.The single line below shows the Solar PV Plant feeding into the LV (400V) plant network, while the STATCOM is also connected on the same 400V Bus. The STATCOM uses measured current of the Main LV Incomer to calculate the correct amount of instantaneous reactive power to be injected into the network. This amount of reactive power required is determined by the plant's instantaneous electrical load and by the instantaneous real power generated by the Solar PV Plant.

The single line below shows the Solar PV Plant feeding into the LV (400V) plant network, while the STATCOM is also connected on the same 400V Bus. The STATCOM uses measured current of the Main LV Incomer to calculate the correct amount of instantaneous reactive power to be injected into the network. This amount of reactive power required is determined by the plant's instantaneous electrical load and by the instantaneous real power generated by the Solar PV Plant.

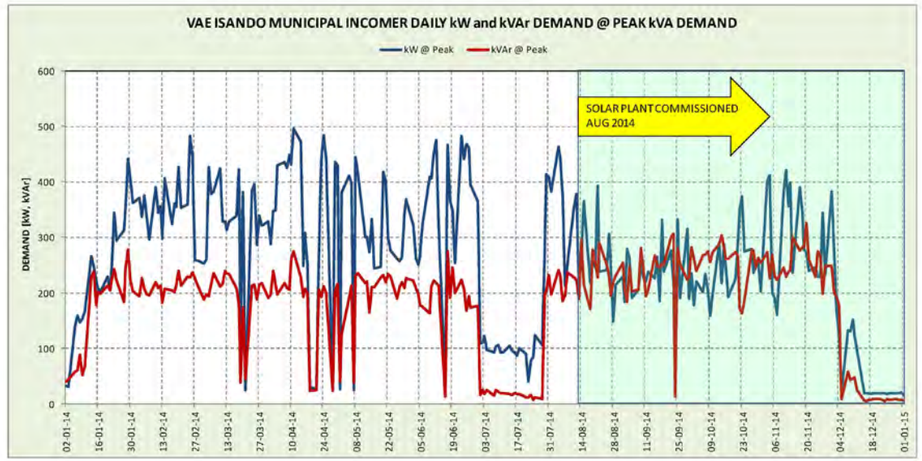
The STATCOM dynamically varies the amount of reactive power that it injects into the 400V Bus in order to keep the instantaneous PF on the Main LV Incomer better than 0.96. The transient response time of the STATCOM is 0.1ms, meaning that it will follow very fast step changes in the electrical load of the plant. In this application the PF on the LV Incomer is controlled on 0.98 (lagging), while the PF on the 11kV Input of the Transformer follows that on a constant 0.97 (lagging).



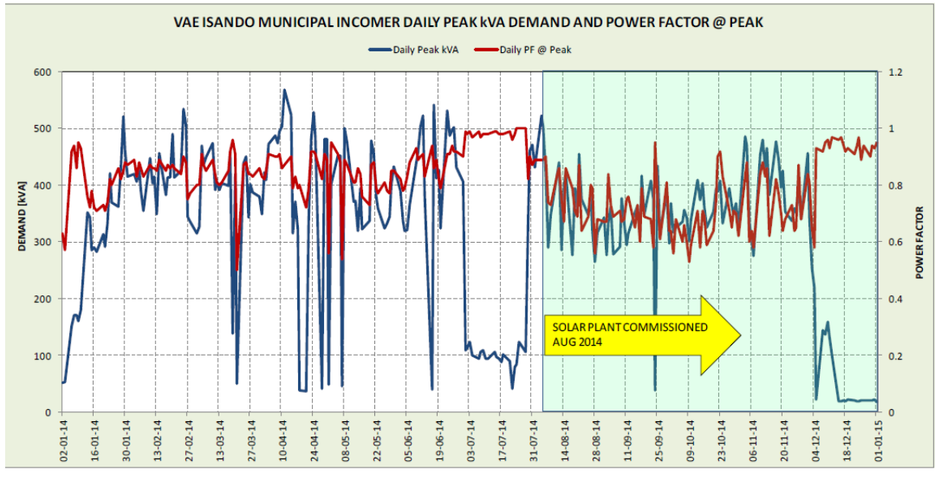
The picture below show the 266kVAr LV STATCOM installed at the VAE SA plant in Isando, Gauteng.

Results

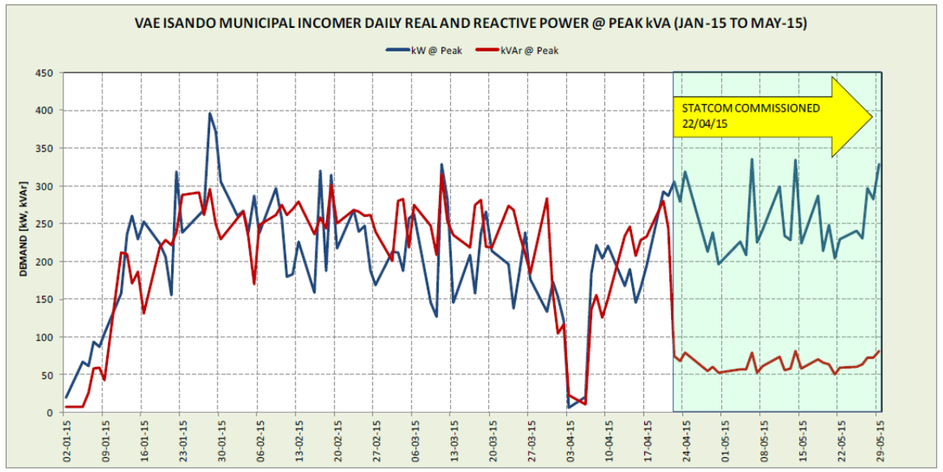
Just to give some background, the effect of the Solar PV Plant at VAE SA in Isando that was commissioned in August 2014 is shown below. The first graph below shows the weekday daily kW real power and kVAr reactive power profiles taken at daily kVA peak demand, as measured on the 11kV Municipal Incomer, for 2014. The reduction in kW real power demand (blue line) is evident since the commissioning of the Solar PV Plant. The peak kW values dropped from about 500kW to about 400kW.



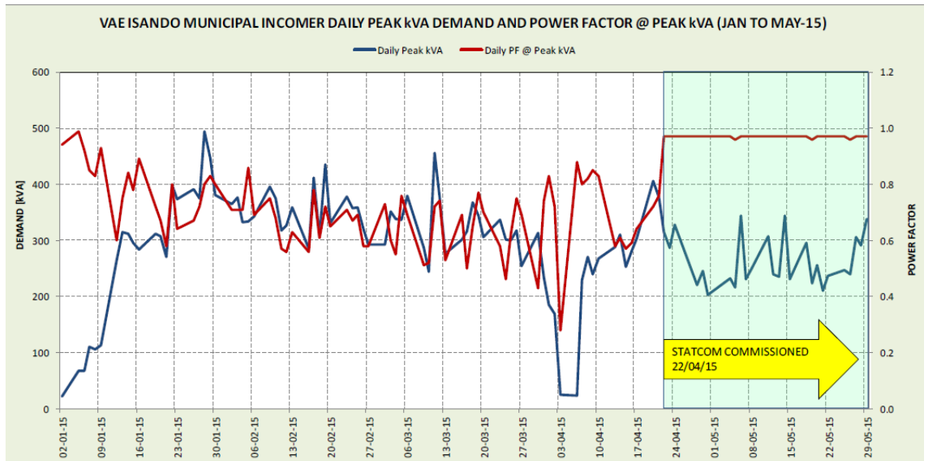
The graph below shows the weekday daily Peak kVA demand and the Power Factor @Peak. The reduction in daily kVA Peak demand as well as the reduction in Power Factor @ Peak is evident since the commissioning of the Solar PV Plant.



The effect of the STATCOM is shown in the graphs below. The first graph shows the weekday daily kW real power and kVAr reactive power profiles taken at daily kVA peak demand, as measured on the 11kV Municipal Incomer, for 2015 until the end of May 2015. The reduction in the kVAr reactive power demand (red line) is evident since the commissioning of the STATCOM in April 2015.



The graph below shows the weekday daily Peak kVA demand and the Power Factor @ Peak for 2015 until the end of May 2015. The reduction in daily kVA Peak demand as well as the increase in Power Factor @ Peak is evident since the commissioning of the STATCOM in April 2015. The Power Factor @ Peak as measured on the Municipal Incomer is constant on 0.97 since commissioning of the STATCOM. The kVA Peak demand dropped from about 500kVA in earlier months to 350kVA in May 2015.



Conclusion

The LV STATCOM that was implemented at the VAE SA manufacturing plant in Isando proves to be a very efficient and successful solution to control the Power Factor of the plant, as measured on the Municipal Incomer, on an excellent 0.97 (lagging) under dynamic plant and solar conditions.

Since commissioning of the STATCOM, the monthly kVA Maximum Demand is reduced by about 50 - 150kVA, which will result in monthly cost savings on VAE SA's electricity bill.

OUR CLIENTS

6kV-35kV HTSVG D-STATCOM

HTVQ mediu-voltage automatic capacitor bank

HTSVG rack-mount low-voltage STATCOM

HTSPO pole-mount power network equipemnt

HTSVG floor-standing low-voltage STATCOM

HTEQ thyristor-switching capacitor bank

HTTSVG hybrid var compensator

Meet the whole HOTEAM power factor correction product family

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