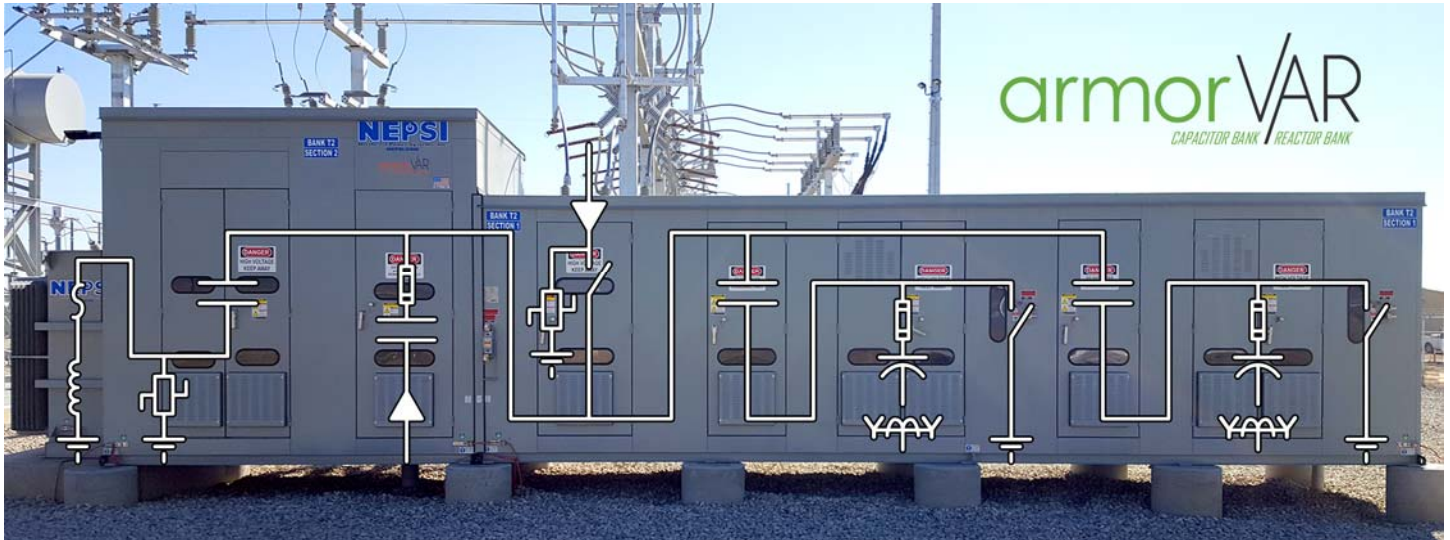




Hybrid Shunt Reactor & Shunt Capacitor Compensation Systems



General

Northeast Power System, Inc. (NEPSI) armorVAR™ medium-voltage hybrid shunt power capacitor and shunt reactor compensation systems are a fully integrated solution designed specifically for renewable power collector systems that require both inductive and capacitive compensation.

NEPSI's armorVAR™ is a compact, fully integrated economical alternative to the traditional approach of using open air components. The hybrid armorVAR uses space saving oil-insulated shunt iron-core reactors for inductive compensation and NEPSI's proven single stage and multi-stage metal-enclosed capacitor banks for capacitive compensation.

The hybrid armorVAR™ comes with all switching, all protection, and all controls integrated. When compared to open air systems, the armorVAR™ is easier to purchase, engineer, install, commission, and maintain as it is built, designed, and tested at NEPSI's factory. The hybrid armorVAR™ offers lower risks and lower costs to **wind farm** and **solar plant** developers and contractors.

Product Benefits

- **Single point of supply;** one purchase order, one set of drawings to approve, one vendor
- **Lead time;** ~ 1/2 the lead time of open air system, 1/3 lead time for project completion
- **Smaller foot print;** less site work, less risk (~1/3 the area requirement of an open air system)
- **All inclusive design;** Systems includes all disconnecting, switching, protection, and control
- **Reliable;** Enclosed and protected from the environment, designed and manufactured by a ISO 9001:2008 company
- **Flexibility;** Equipment designed to match your needs
- **Filter Ready;** Provisions for harmonic filtering
- **Safety;** Complete protection for inadvertent contact, key interlocked.



Available Ratings, Features, and Configuration Options

The **armorVAR™** - Hybrid Shunt Reactor and Shunt Capacitor Compensation System is custom rated and configured to meet customer requirements for voltage, basic insulation level (BIL), reactive power rating, frequency, and the environment.

The table below list our most standard features, ratings, and configuration options.

Feature/Rating	Description & Range
Bank Configuration:	Shunt Reactor Bank: Single Step/Multiple Step/Fixed Step, ungrounded/grounded wye Shunt Capacitor Bank: Single Step/Multiple Step/Fixed Step, ungrounded split-wye, ungrounded single-wye, grounded
Nominal Operating Voltage: Max Operating Voltage:	2.4kV – 34.5kV 2.64kV – 38kV
Operating Frequency:	50 Hertz 60 Hertz
Reactive power output:	Inductive: 0.1MVAR – 50 MVAR, (largest stage size: 15 MVAR at 34.5kV) Capacitive: 1 MVAR – 60 MVAR
Impulse withstand voltage (Basic Insulation Level):	60kV – 200 KV (third party tested)
Power Connection	Live-Front, Dead-Front, Roof-Bushing, Side-Wall Bushing With/Without Terminal Housing, Cable entry through bottom, top, or sides
Standard Operating temperature range (Shunt Reactor Bank):	-20°C to +40°C (-4°F to 104°F) (30°C average max temp of cooling air over 24 Hour cooling period 30°) (Contact NEPSI for unusual service conditions)
Shunt Reactor Temperature Rise	Average Winding Temperature Rise: 65°C (hottest-spot winding temperature: 80°C)
Standard Operating temperature range (Shunt Power Capacitor Bank):	-50°C to +55°C (-58°F to 131°F)
Maximum altitude without de-rating:	1,000 Meters (3,300 Feet)
Enclosure Rating	(NEMA): 1, 3R, 4X, 12 (IEC): IP10, IP14, IP56, IP52 Arc Resistant Enclosure Designs: Type 1, Type 1D-SR-SL, Type 2 Hazardous Location: NEC Class 1 & 2 Div. II
Enclosure Materials:	Reactor Enclosure: Carbon Steel Plate, Paint: Baked on Powder Coat Capacitor Bank: 11 gauge Galvaneel, optional 12 gauge 409 or 316 steel. Paint: Salt Spray Rating: 5,500 Hr.
Dielectric Fluid	Shunt Reactor Bank: Mineral Oil (high fire point fluids (RTemp, FR3) available on request Shunt Capacitor Bank: Mineral Oil
Reactor Winding Material	Copper
Cooling	ONAN OFAN
Fusing:	Shunt Reactor: Internally fused—Bay-O-Net Fuse Shunt Capacitor: Internally fused, or externally fuses with current limiting fuses
Seismic:	As specified—Zone 4
Control Voltage:	AC Volts: 110, 115, 120, 220, 50/60 Hz DC Volts: 24, 48, 110, 125, 220
Short Circuit (asymmetrical momentary):	16kA—61kA



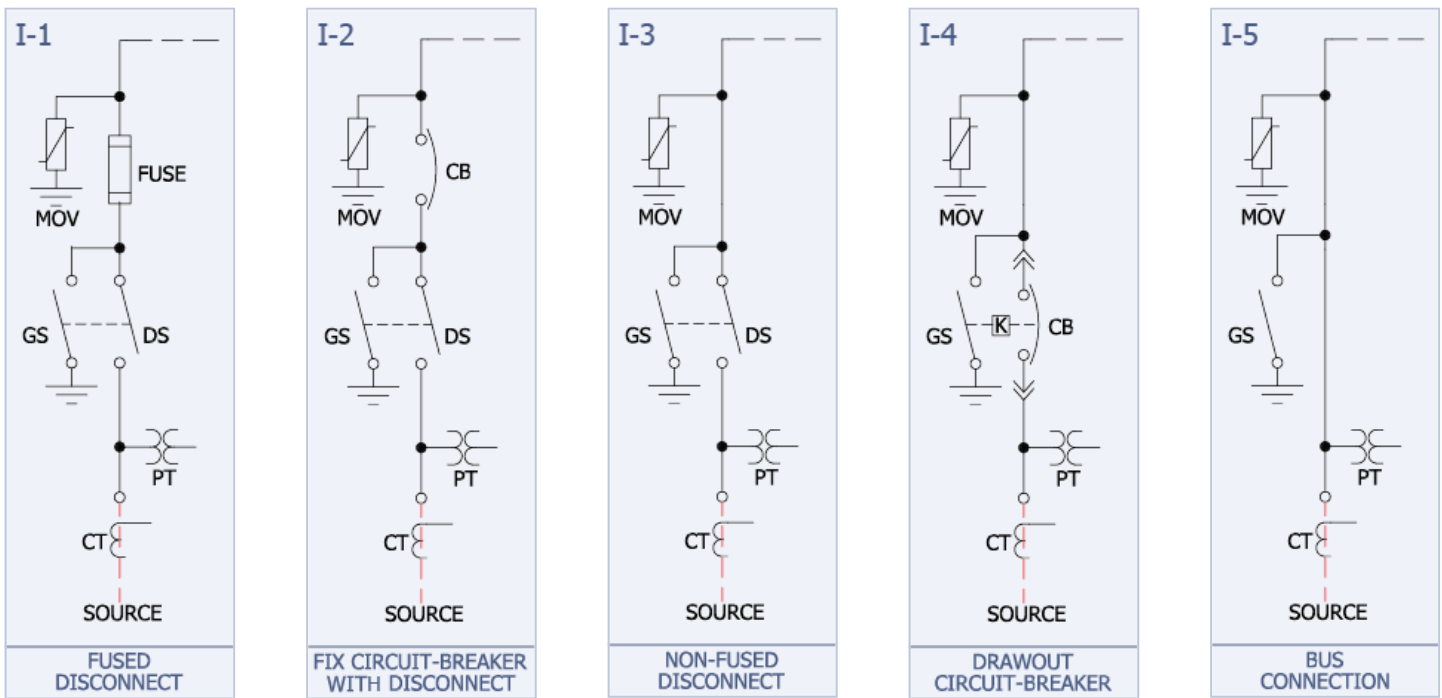
Equipment Configuration

The armorVAR™ - Hybrid Shunt Reactor and Shunt Capacitor Compensation System is custom designed to meet your requirements for disconnecting, switching, protection, and control. Sections 1, and 2 that follow provide details on some of the more common options. Contact NEPSI for required options that are not shown.

1 Incoming Compartment Configuration Options

The incoming compartment of the armorVAR™ is available with a range of options based on system ratings and customer preference. Generally, all armorVAR's should be equipped with a "visible break" and a grounding switch to allow for safe maintenance of the equipment. The "visible break" may be accomplished using a disconnect switch or a draw-out circuit breaker. Short circuit protection should also be provided and can be accomplished with main incoming fuses or a main incoming breaker. Only consider a bus connection when a visible break and short circuit protection are available on the feeder cables.

Incoming compartment configurations include the following:



Accessories For Incoming Compartment

The following items are available for placement in the incoming compartment. On simpler systems, CPT's or PT's can serve double duty as both protection/control signals and control power for the armorVAR™. Roof bushings provide a simple means to connect to overhead bus in a substation yard. Key interlocks help ensure proper sequence of operation and safe entry into the enclosure. Lightning arresters provide transient voltage surge protection for the equipment in case of lightning strikes or breaker/switch restrike/prestrike.

PT	POTENTIAL TRANSFORMER	MOV	SURGE ARRESTER		ROOF BUSHING OVERHEAD BUS
CT	CURRENT TRANSFORMER	CPT	CONTROL POWER TRANSFORMER		KEY INTERLOCK

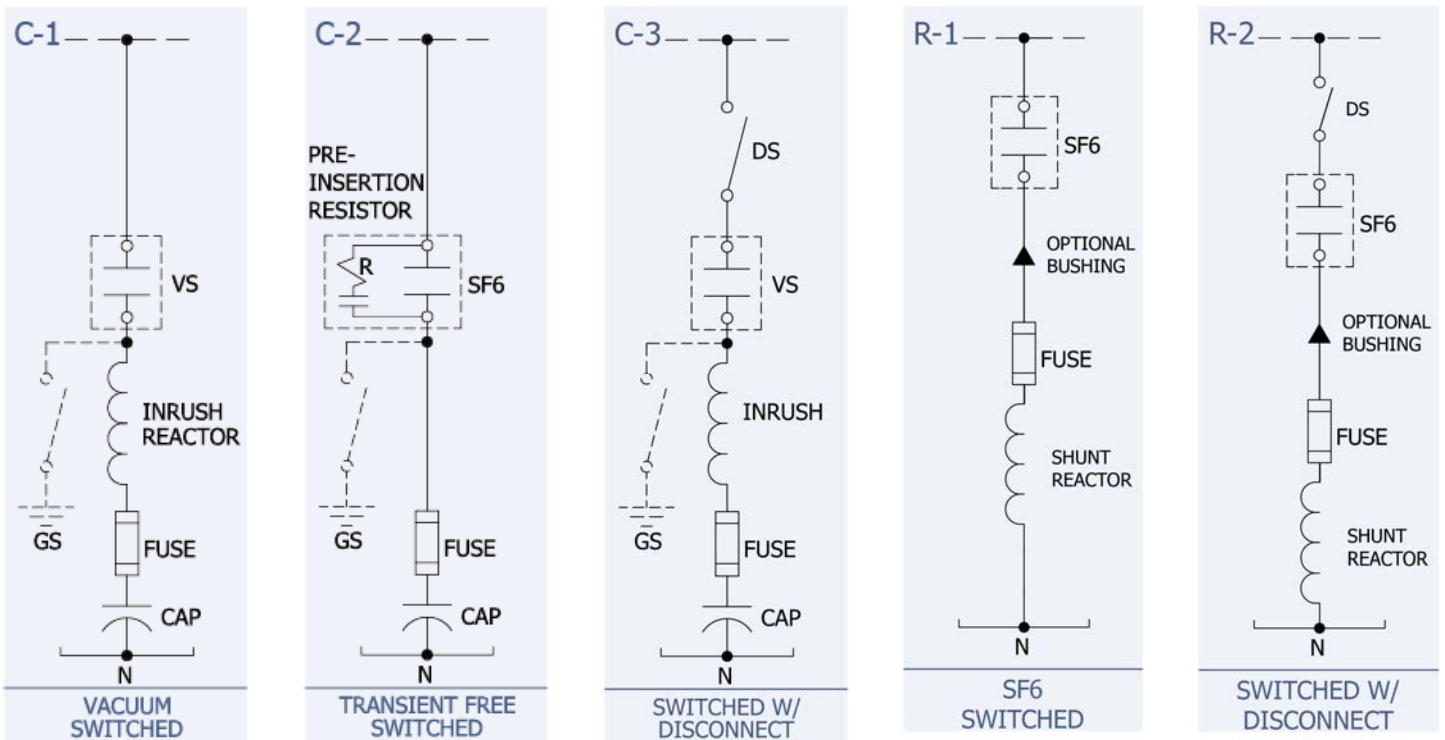


2 Shunt Reactor and Capacitor Compartment Configuration Options

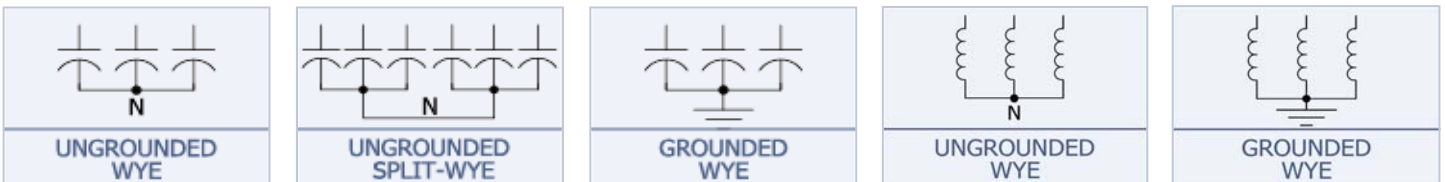
The hybrid armorVAR's capacitor and reactor stage compartments are compartmentalized and consists of one or more stages to meet your reactive compensation requirements. The capacitor stage(s) normally consists of capacitors, capacitor fuses, switching device, and transient inrush reactors. Typical shunt capacitor stage configuration options, C-1 through C-3, and shunt reactor stages options R-1 and R-2 are shown below (contact NEPSI for other options).

Reactor stages at the 38kV level are typically switched with Southern States RLSwitcher. Lower voltage levels may employ a vacuum or SF6 circuit breaker.

For system voltages at or above 24.9kV, NEPSI recommends option (C-2), a Southern States CapSwitcher® or option (C-3) a vacuum or SF6 circuit breaker. Optional ground switches provide a secondary means of capacitor discharge and ensure capacitors are discharged should a capacitor discharge resistor fail. The optional disconnect switch, "DS" allows for maintenance while leaving other stages of the armorVAR™ in operation.



The capacitor bank stages can be connected in a number of different ways depending upon bank rating and protection requirements. Typically, capacitor banks on renewable power systems are connected in an ungrounded wye or ungrounded split-wye connection, but a grounded wye connection is also available. The reactor stages can be connected in either a ground or ungrounded configuration as shown.





Control Options

NEPSI's **armorVAR™** can be furnished with a fully integrated control and protection system that can form an integral part of the equipment or be remotely mounted in the E-house. In either case, your control system will be fully assembled, tested, and calibrated at the factory, relieving your contractors of costly onsite setup and commissioning cost.

Capacitor Bank Control Options

- 4-Quadrant Control for inductive and capacitive PF control in power plant applications
- Voltage Control
- Harmonic Voltage / Current Distortion Control
- Remote / SCADA Control
- Remote control by plant DCS / EMS system

Typical Control Features

- On | OFF | Auto & Local | Remote Controls
- Stage status indication
- Circuit Breaker Control Switches
- Power quality meters on all main or on all filter branches/stages
- Control power circuit breakers for all branch circuits, lights, strip heaters, thermostatically controlled fans
- 5-Minute Discharge | re-energization timers
- Key interlocks to dictate sequence of operation and safe entry into enclosure
- PT/CT test and short switches

Protection Options

The **armorVAR™** can be furnished with host of protection options to keep your system up and running with minimum downtime. Standard and advanced protection options are available including arc flash mitigation, blown fuse detection, overload protection, short circuit, over-voltage, and overvoltage/overcurrent distortion (high THD). Protection relays are chosen based on customer preference, including Schweitzer, GE Multilin, Basler, and ABB.

The Table on the following page summarizes the protection device numbers that are typically provided with NEPSI's **armorVAR™**.



FULLY INTEGRATED SYSTEMS

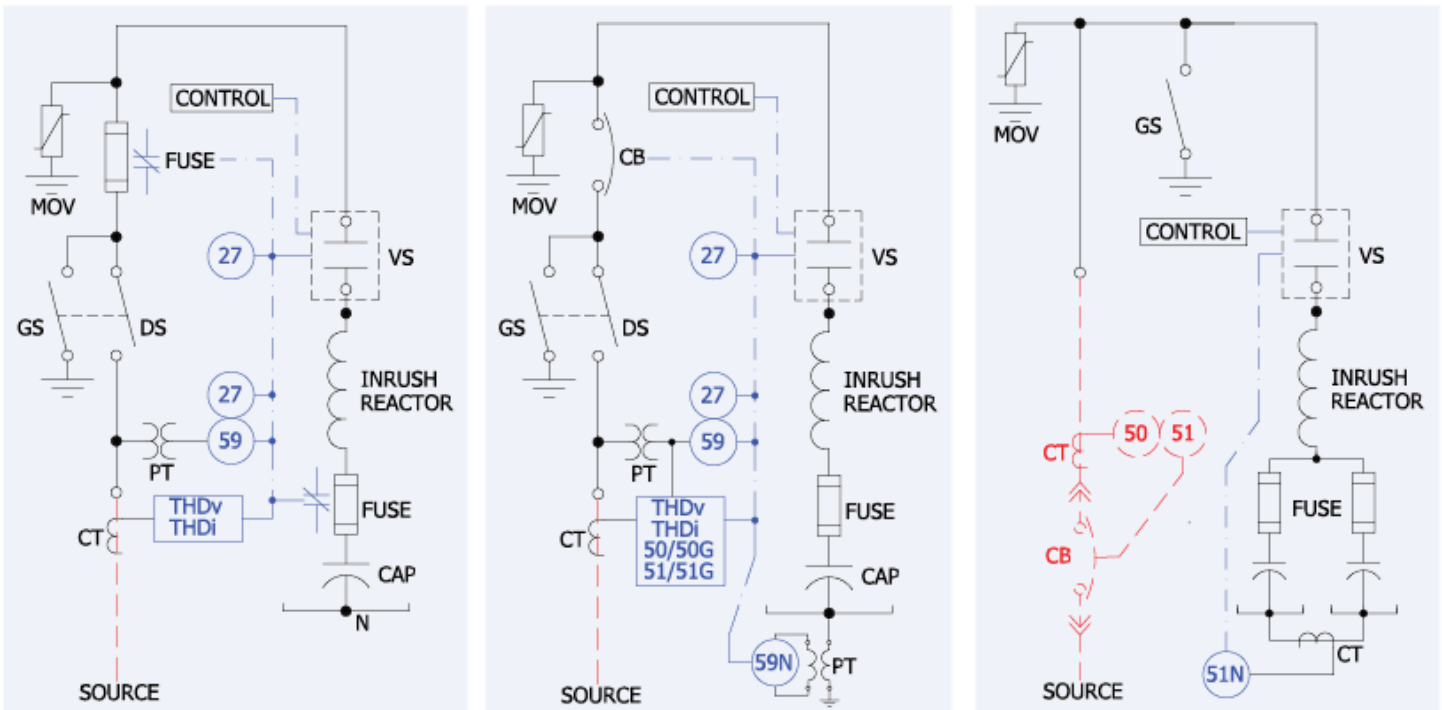
Available with all protection, control, disconnecting, and switching functions



Protection Type	Designation	Description
Short Circuit and Overcurrent Protection	50/51 50/51G	Phase and Ground Short Circuit Protection
Over-Voltage/ Under Voltage	59/27	Over-voltage and Under Voltage Protection
Neutral Unbalance (Blown Fuse Detection)	59N or 51N or 51G or Direct	Relay or direct fuse sensing to detect a capacitor fuse operation. This is critical since a blown fuse condition will change filter de-tuning, lower var output, lower performance, and possibly create system resonance.
Over-Load	49	Over-load protection of the high-pass resistors (if provided), iron-core reactors, and thyristor valves. Relay is sensitive to RMS current associated with the filter's fundamental current and harmonic current.
Harmonic Voltage & Current Distortion	I_{THD} , V_{THD}	Protection against harmonic resonance, high voltage & current distortion, and harmonic overload
Over-Temperature	26	Protection for the thyristor valves, capacitors, and iron-core reactors. Also protects against fan failure.
Arc Flash Detection & Mitigation	Arc Flash	Arc flash detection relays as well as the ABB UFES system for fast detection and clearing of arcing faults.

Typical Protection System

Typical relay protection diagram for the **amorVAR™**. Protection systems are custom designed based on customer preference, customer relay platform, budget, and cost of equipment.





armoVAR® Ordering Guide

The **armorVAR®** is custom built to meet your requirements. Feel free to contact NEPSI for a quote or to discuss your specific application.

Additionally, visit our webpage at www.nepsi.com and follow the product page link to metal-enclosed harmonic filter banks or power capacitor banks. There you will find additional information, including:

- Guide form specifications
- Component Cut Sheets and Instruction Manuals
- Pictures of Equipment and Components
- Technical Resources, including spread sheet design tools, relay settings tools, and design calculators

Power System Studies

NEPSI performs power system studies to evaluate the expected performance of our metal-enclosed products. Studies offered by NEPSI include:

- Stability
- Motor Starting
- Load flow
- Reactive Power / Var Flow Studies
- Coordination
- Voltage Drop | Voltage Rise Analysis
- Harmonic Analysis
- Short Circuit
- Protective Coordination

Our Power System Studies are tailored to your needs and project requirements.



Hybrid armorVAR™ - Project Showcase

Below is a three-line diagram of a Hybrid armorVAR system designed for a solar plant application. It is rated 24 MVAR capacitive, and 0.4 MVAR inductive at 34.5kV. It consists of an incoming roof bushings with a chain drive operated disconnect switch, two 12 MVAR switched stages, with integral ground switches, and Southern States CapSwitchers, with provisions for easy conversion to a HP, C-HP, or notch filters. The 0.4 MVAR iron-core shunt reactor is equipped with an RLSwitcher, lightning arresters, and current transformers for protection. Additionally the equipment contained an additional disconnect switch and SF6 switch for connection to a 500 kVA stowing transformer and an integral protection and control system.

When compared to an open air system, this system was more economical, had 1/3 the foot print, 1/2 the lead time for delivery, and 1/3 the lead time for installation and commissioning.

