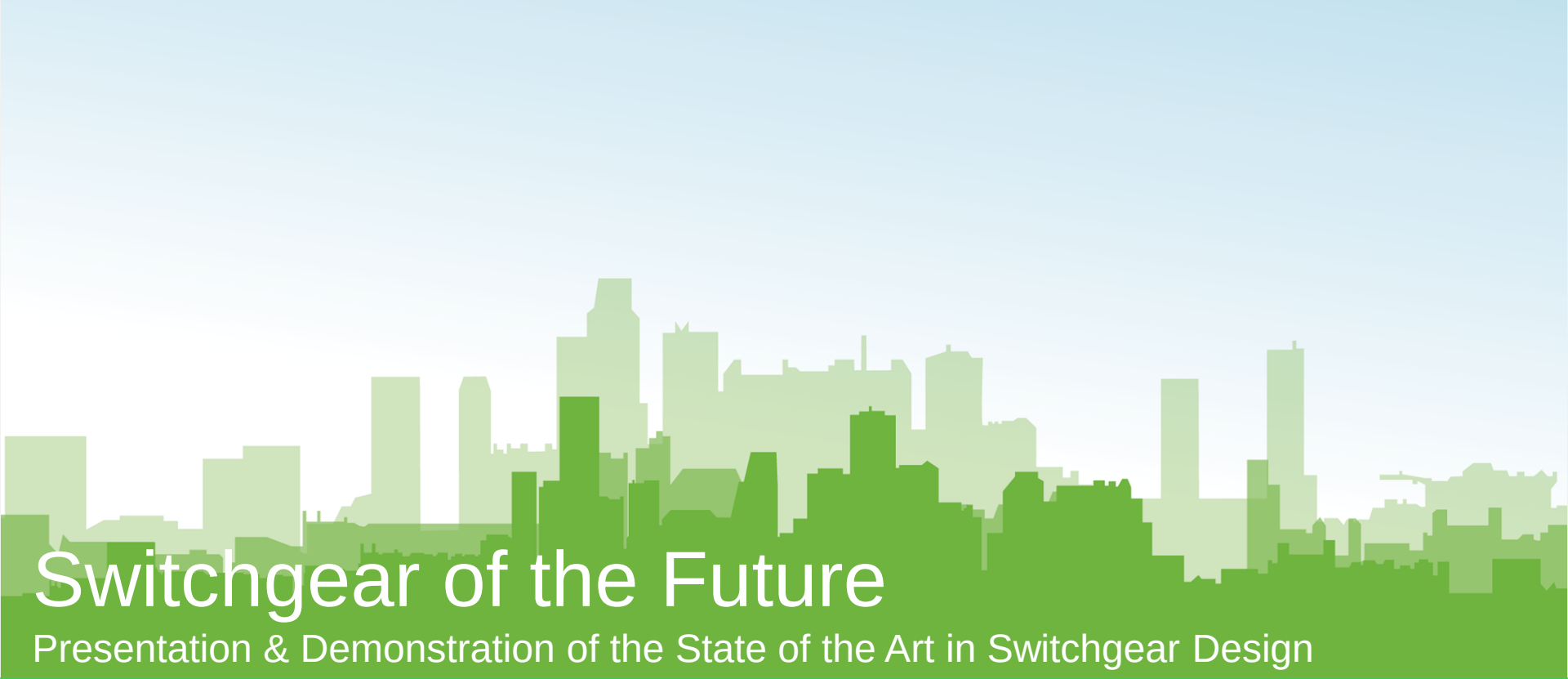

Switchgear of the Future

Presentation & Demonstration of the State of the Art in Switchgear Design

Presented by: James K. Stacy

For: IEEE

Life Is On Schneider Electric

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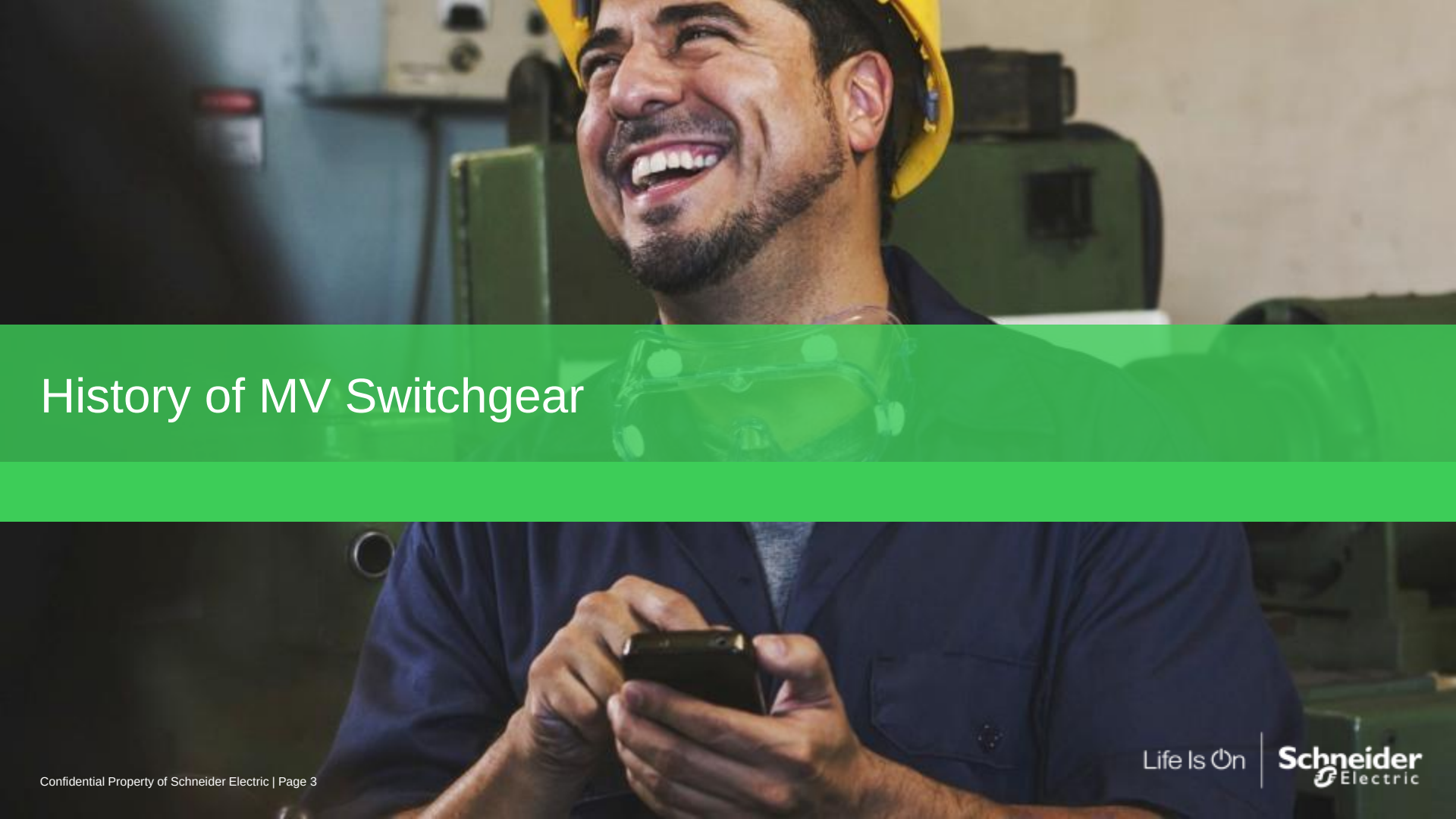
This presentation focuses on medium voltage AC electrical distribution systems with voltages above 1 kV, up to and including 52 kV.



History of MV Switchgear

Medium Voltage Switchgear Evolution

Fixed oil filled circuit breakers were difficult & dangerous to use & maintain

Oil filled circuit breakers were put into withdrawable switchgear in order facilitate maintenance but reliability was still an issue.

SF6 & Vacuum circuit breakers increased the reliability of MV circuit breaker switchgear in the 1970's. Metal clad today has very little differences compared to metal clad from the 70s. It is large and expensive.

30's – 40's
Air-insulated
Open switchgear
Air CBs

50's – 80's
Air-insulated
Metal-enclosed
Air & Oil CBs

70's - 90's
Air-insulated
Metal Clad
Vacuum &
SF6 CBs

80's - today
Gas-insulated
Hybrid
Vacuum &
SF6 CBs

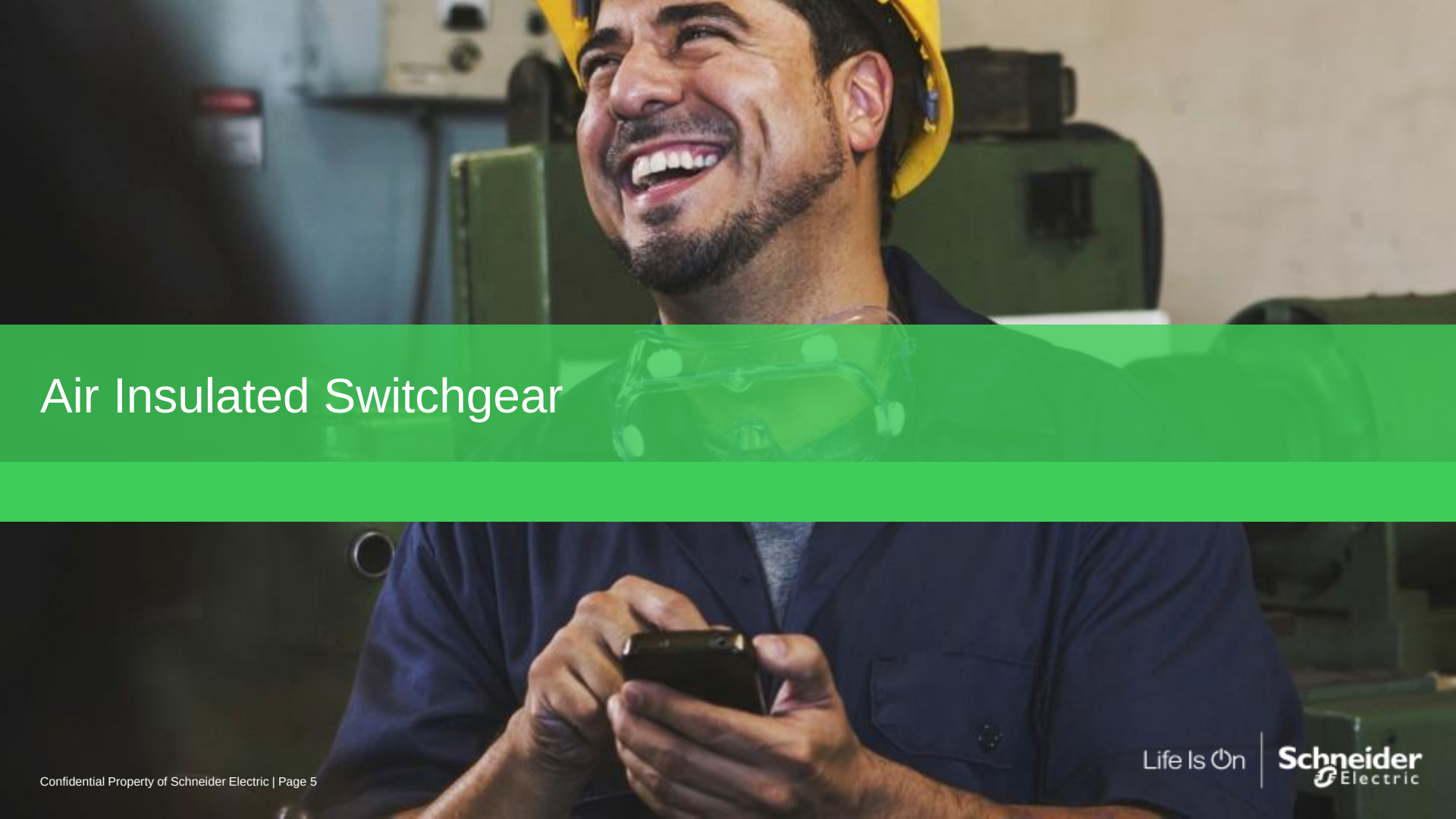
2010 - Today
Solid-
insulated
Vacuum CBs

Main drivers of innovation:

- Service continuity
- Safety
- Compactness
- Cost reduction

Optimization of trouble shooting

Fault prevention

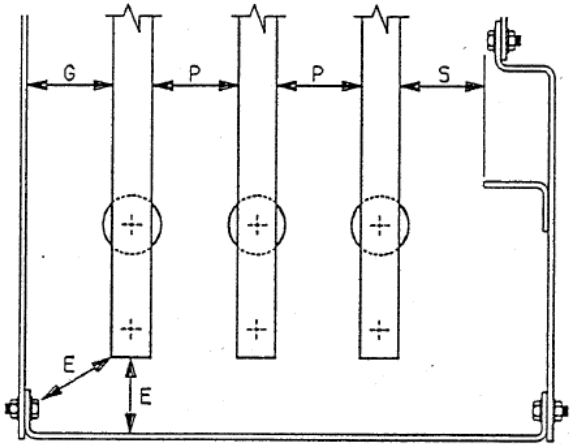


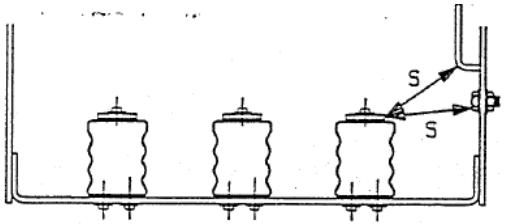
Air Insulated Switchgear

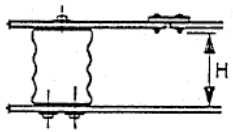
Existing MV Switchgear Technology - AIS

Air Insulated Switchgear

- Very mature technology…so mature, can we do better?
- Uses air as the dielectric…very sensitive to the environment
- Largest of the switchgear types
- Requires most maintenance of the switchgear types







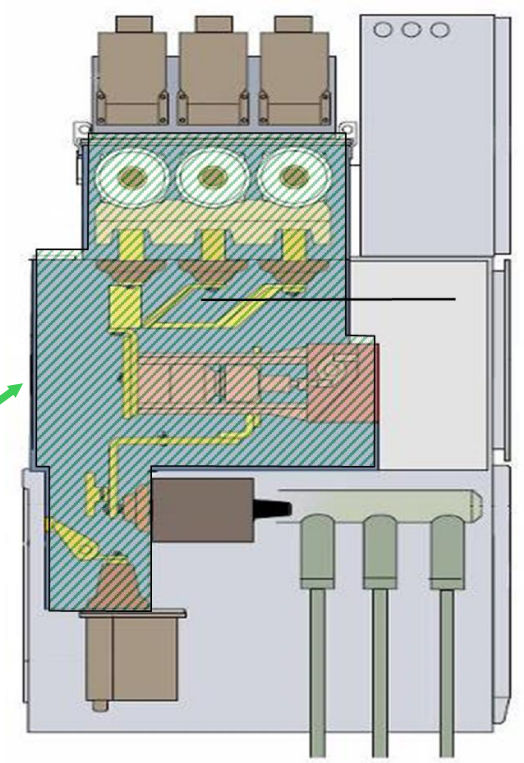
Gas Insulated Switchgear

Existing MV Switchgear Technology - GIS

Gas Insulated Switchgear

- No maintenance in the MV circuit by having a clean electrical atmosphere (Isolation)
  - Particles
  - Small animals
  - Salt
  - Dusty environment
  - Humidity
- Accidental- touch safe
- Reduced risk of internal arc

Sealed Pressure System



Existing MV Switchgear Technology - GIS

Table 1: Overview of failure causes

Causes of failures in air-insulated switchgear	Share of air-insulated switchgear failures	Failure causes not relevant to gas-insulated switchgear
Thermocycling	7%	
Mechanical structure failure	3%	
Mechanical damage from foreign source	7%	☑
Shorting by snakes, birds, rodents, etc.	3%	☑
Malfunction of protective device	10%	
Above normal ambient	3%	
Exposure to chemicals or solvents	3%	☑
Exposure to moisture	30%	☑
Exposure to dust or other contaminants	10%	☑
Exposure to non-electrical fire	7%	
Normal deterioration from age	10%	
Severe weather condition	3%	
Others	4%	

Source: IEEE 493 Gold Book, Annex E, table XVIII, page 479.

>50% of the failures are not relevant

High percentage of the remainder reduced:

- Less mechanical efforts
- It is an indoor equipment
- Fixed components reduce the possibilities of “hot points”
- Maintenance is not needed in MV parts

Existing MV Switchgear Technology - GIS

	Common causes of arc flash in AIS	GIS
Human error	Careless cover or device removal	Fully insulated / only the cable compartment is accessible
	Dropped tool	Fully insulated / only the cable compartment is accessible
	Installing cabling or components live	Switch disconnector to ground the section prior maintenance
	Test instrument misapplied	Integrated test instruments for voltage test / Switch disconnector to ground the section prior maintenance
	Other human intervention	User-friendly & intuitive operation together with fully integrated mechanical interlocking system. Limit human intervention to the minimum due to HV part maintenance free
Equipment failure	Misalignment of moving contacts	Fixed breaker / No moving contact and shield
	Breakdown of insulating	Insulating (SF6) system monitored
	Conductive linkage contacting live parts	Compartment sealed for life

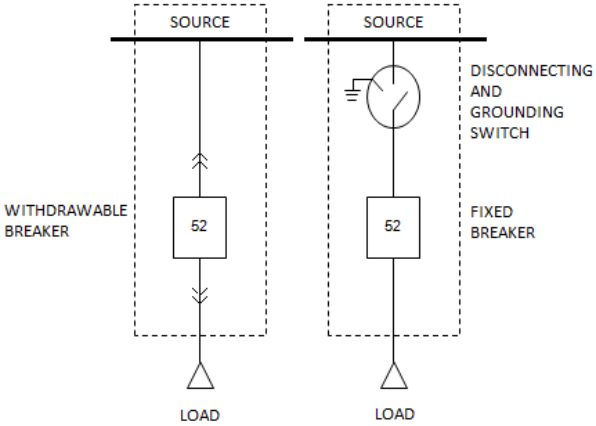
Moving from Withdrawable to Fixed Mounted Medium Voltage Circuit Breaker Switchgear

Moving to Fixed Mounted Switchgear - Drivers

- Racking circuit breakers is a known cause of electrical arc flash events and is cited multiple times in IEEE 1584 Annex C.
- NFPA 70E PPE tables require higher levels of PPE for racking operations.
- Fixed circuit breaker switchgear eliminates racking and therefore eliminates one potential risk.
- Generally, racking problems are uncommon. When they do occur, they are often due to improper breaker reinstallation. They can increase in frequency with lack of maintenance and age of the equipment.

Withdrawable Circuit Breaker Switchgear w/ breaker racked out

Fixed Mounted Circuit Breaker Switchgear



One-Line Example

Moving to Fixed Mounted Switchgear - Drivers

Attribute	Fixed Circuit Breaker Switchgear	Withdrawable Circuit Breaker Switchgear
Design & Operability	• Isolation via disconnect • Compact design w/ front access	• Isolation via breaker withdrawal from cubicle • Larger design requiring rear access
Safety	• Has grounding switch • Interlocked to prevent entry until system is grounded • Has some level of arc resistance • Removes risks associated w/ removing withdrawable components	• Requires manual grounding via hot stick & cable assemblies • Allows access while switchgear is energized • Arc resistance construction is a unique design • Retains the risk assoicated w/ racking operations
Reliability	• Intuiative interlocked operation • Has no complex racking mechansim or shutter assemblies	• User dependent manual steps to withdraw the breaker to isolate circuit • Requires use of racking mechanisms and shutter assemblies
Cost	• Lower in both capital & operational expenses	• Higher in both capital & operational expenses

Shielded Solid Insulated Switchgear (aka SSIS or 2SIS)

The Newest Category of Medium Voltage Switchgear

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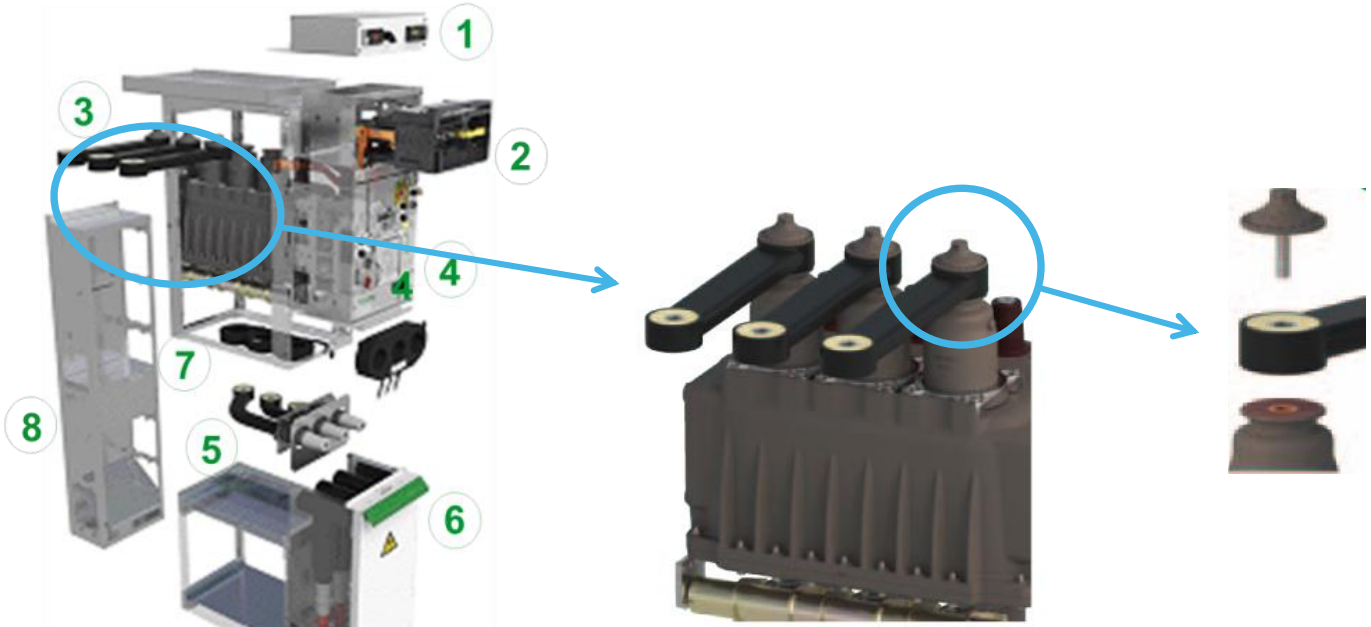
Shielded Solid Insulated Switchgear (aka SSIS or 2SIS)

What is 2SIS (shielded solid insulation system)

- A new class of MV switchgear
- Entire MV live circuit path is grounded
  - “accidentally touchable” per IEC…user safety
  - No more exposed conductors
    - Likelihood of internal arc is extremely limited
- Protected against the environment
  - Dust, pollution, condensation, humidity, aggressive atmosphere, etc.
  - Removes risk of ineffective or no maintenance…no need for cleaning
  - No electric fields = no tracking, no partial discharge

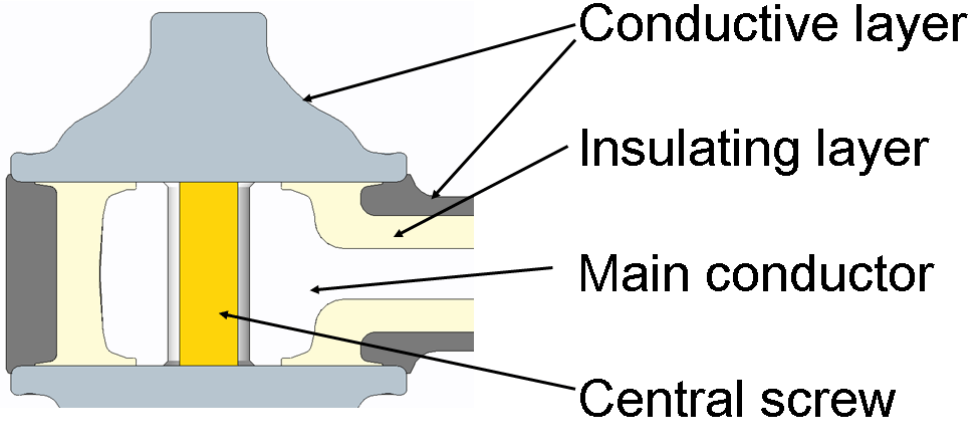
Shielded Solid Insulated Switchgear (aka SSIS or 2SIS)

1. Low Voltage cabinet
2. Cable test
3. Top connections
4. Core unit
5. Bottom connections
6. Bottom compartment
7. Sensors (CTs and VTs)
8. Gas exhaust duct



Shielded Solid Insulated Switchgear (aka SSIS or 2SIS)

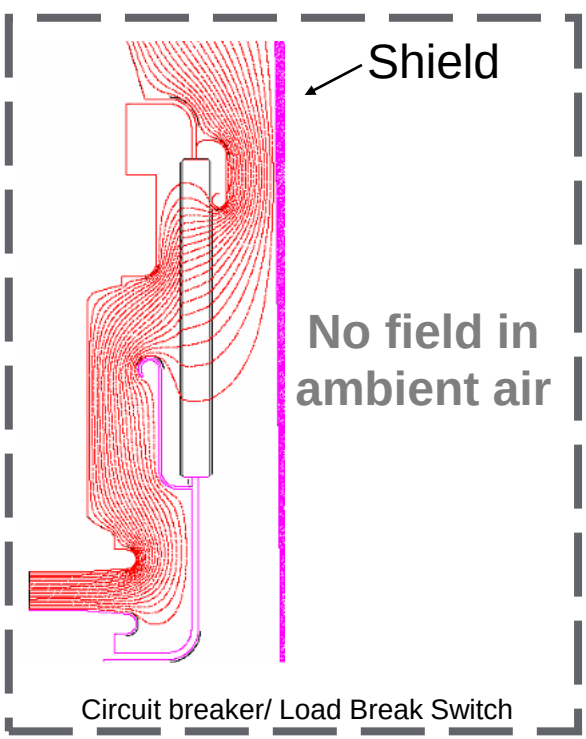
Solid insulation covered by a conductive layer

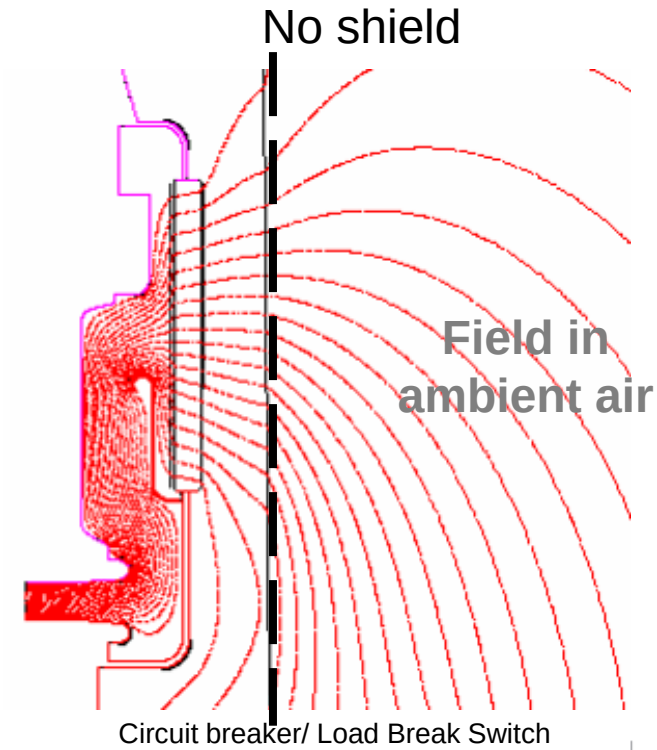


Flat interface cross-section

Shielded Solid Insulated Switchgear (aka SSIS or 2SIS)

2SIS vs SIS





Shielded Solid Insulated Switchgear (aka SSIS or 2SIS)

Busbar Connections

Busbars with Solid Insulation

Busbar Connection to Circuit Breaker

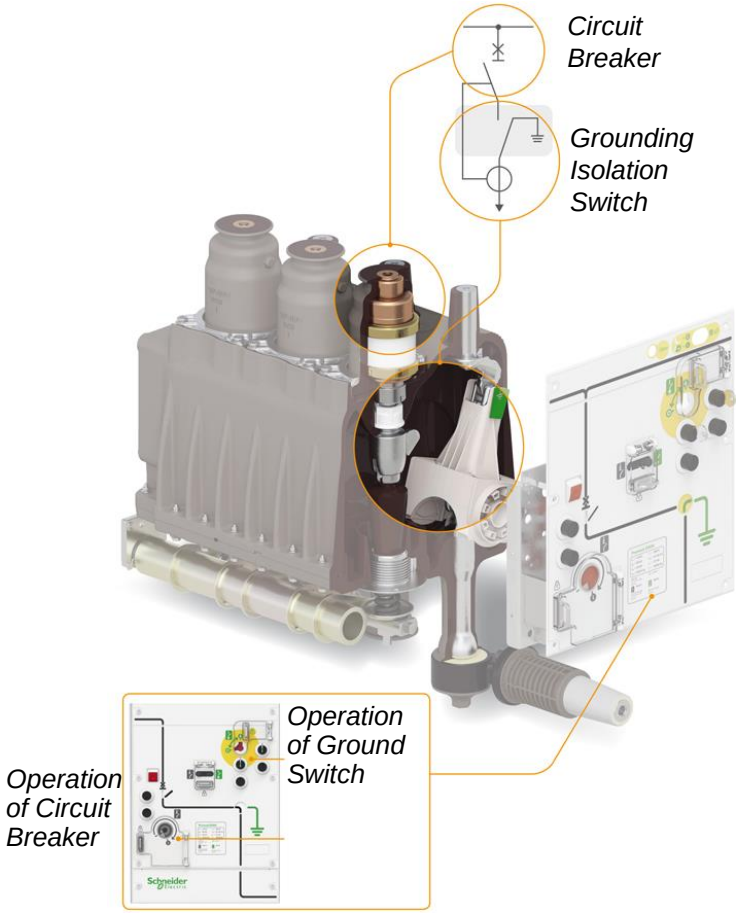
Elbow Cable Connections

Core Unit

Vacuum Circuit Breaker

Grounding Isolation Switch

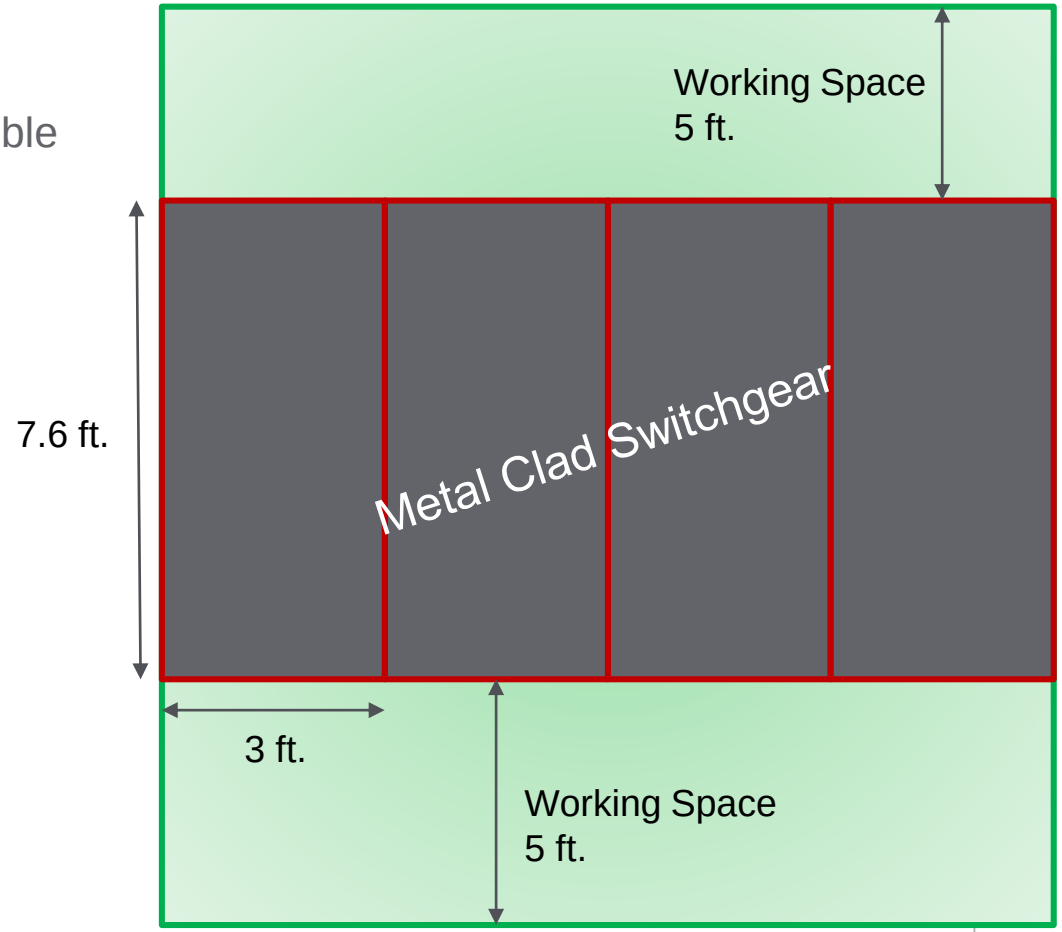
Completely Epoxy Insulated & Shielded



SSIS Space Savings

Small Footprint and Front Accessible

Total Footprint:
211 sq. ft.

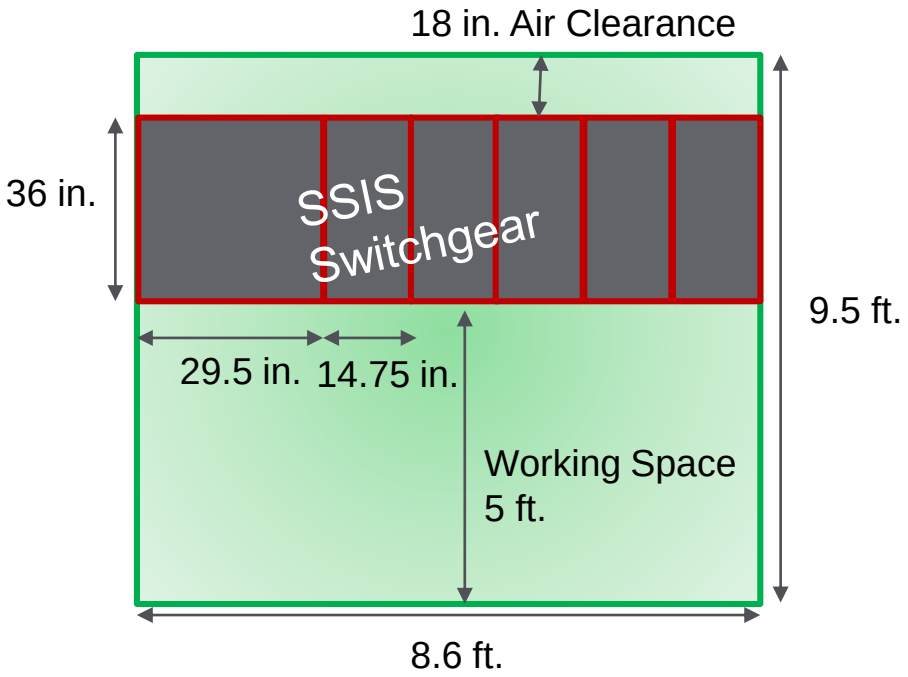


SSIS Space Savings

Small Footprint and Front Accessible

Total Footprint:
82 sq. ft.

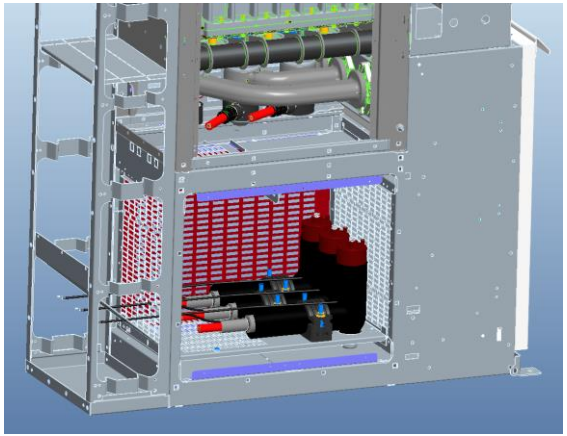
60% Footprint Savings!



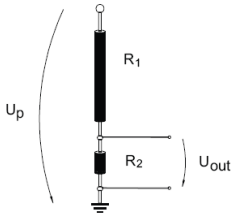
Sensor Technology

LPVT

MV Connection up to 15kV

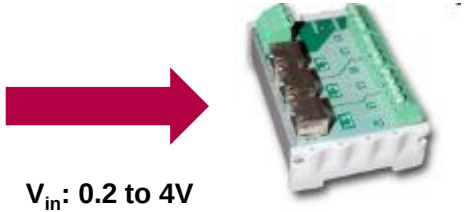


Resistive divider



LPVT

Converts Voltage up to 120V Signal



V_{in}: 0.2 to 4V

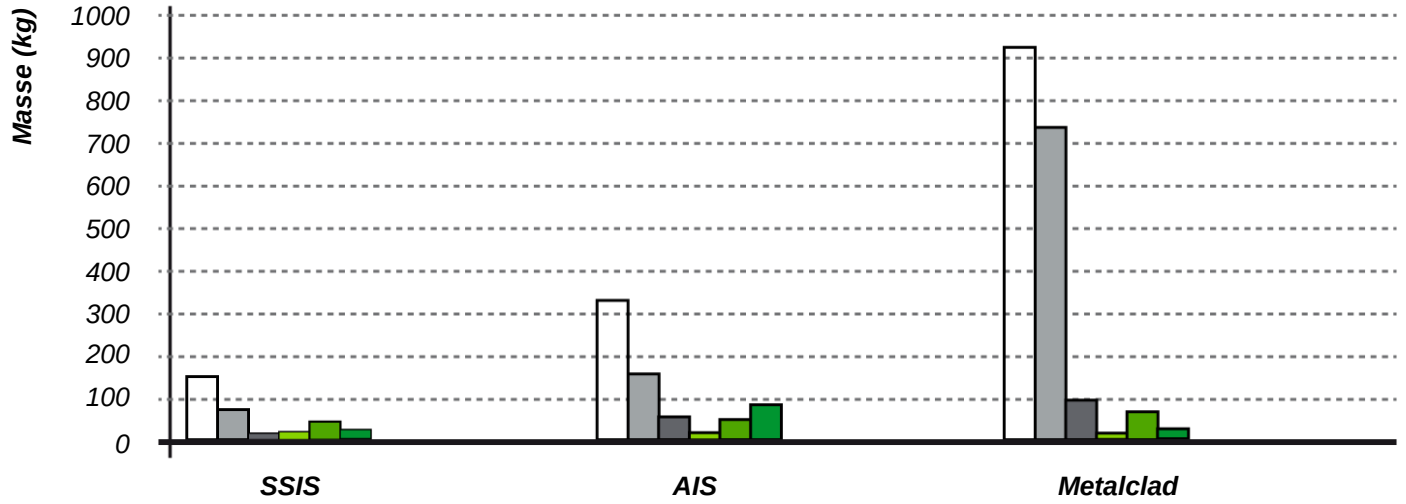
Converter

V_{out}: 100/ sqrt 3 = 120V

Voltage Protection Scheme

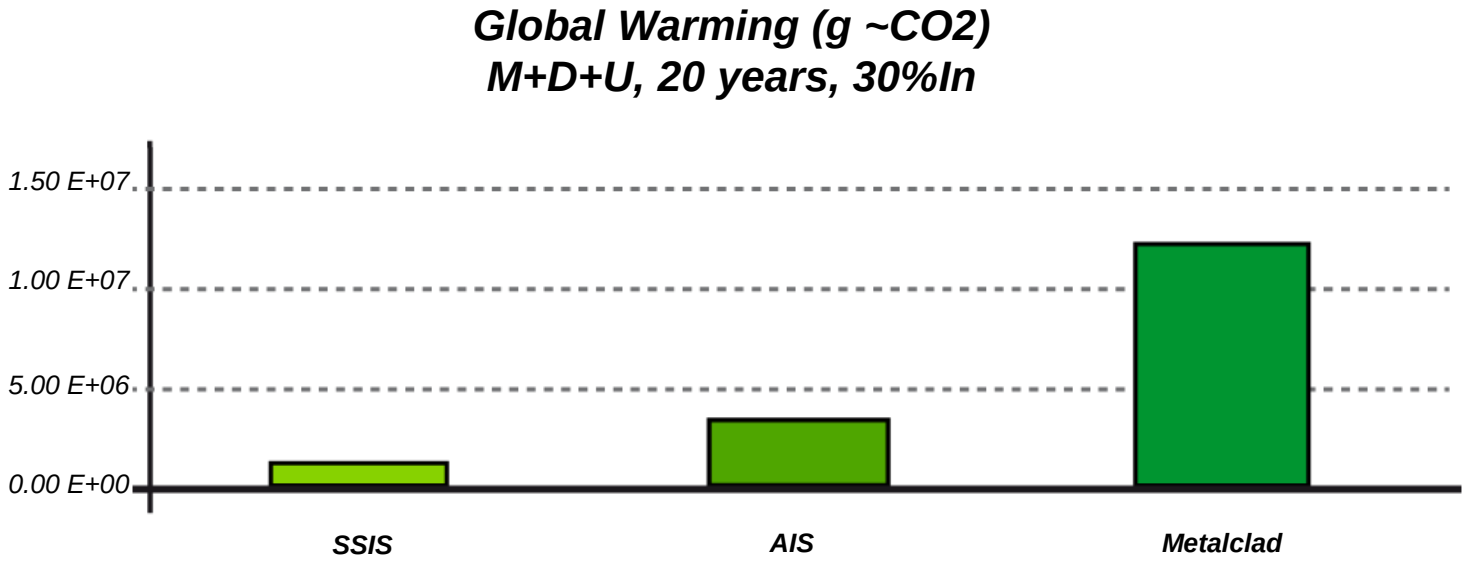
Protective Relay

SSIS Environmental Impact – Core Materials



Product weight	***148.3***	***326.0***	***923.0***
Steel	***73.0***	***154.0***	***732.4***
Copper	***9.0***	***45.0***	***95.2***
Aluminium	***10.0***	***10.0***	***10.6***
Epoxy Resin	***34.0***	***52.0***	***60.1***
Other	***22.3***	***65.0***	***24.7***

SSIS Environmental Impact – CO2 Contribution

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Questions?

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