

The Evolving Grid: IBR & The Advanced Inverter Systems

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The Evolving Grid: IBR & The Advanced Inverter Systems

AGENDA:

- ❑ **The Evolving Grid**
-The Nature & Driver

- ❑ **Technical Insights & Challenges:**
 - Inverter Control
 - Advanced Grid Support
 - Higher DC/AC Ratio
 - Multiple MPPTs
 - Reliability & Standards

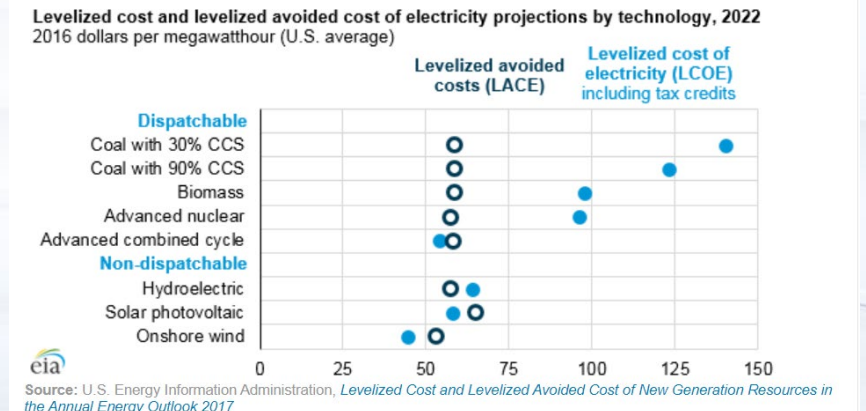
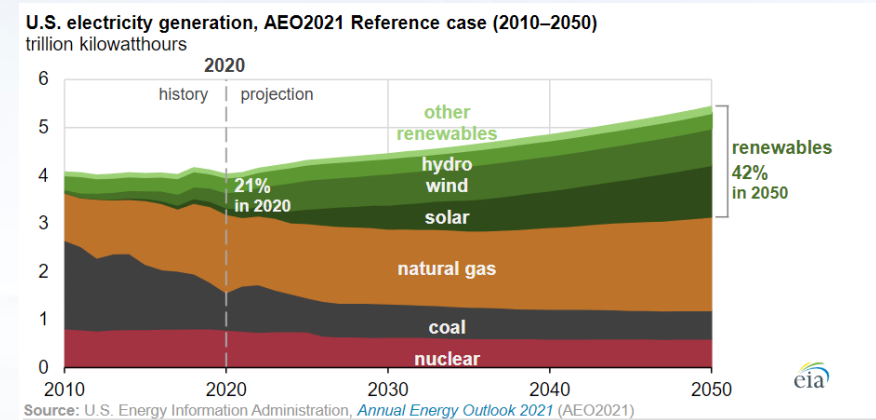
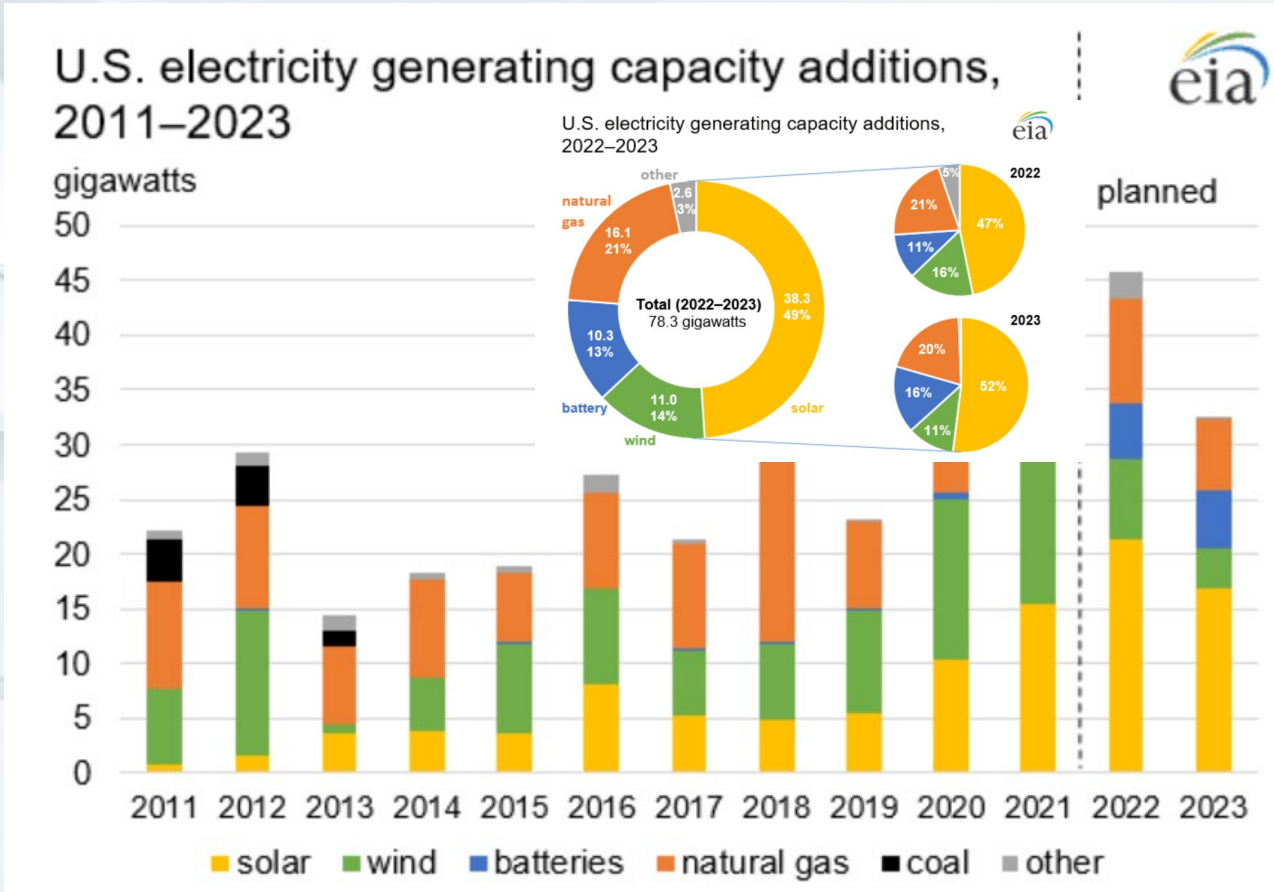
- ❑ **IBR & The Advanced Inverter Systems:**
 - IBR: Grid Challenges
 - IBR: Wind, Solar, BESS etc.
 - Advanced Inverter Systems

- ❑ **Conclusion & Q&A**



The Evolving Grid

The Nature: Increasing IBR/ Generators, Variable, Less Inertia/ Synchronous Gens

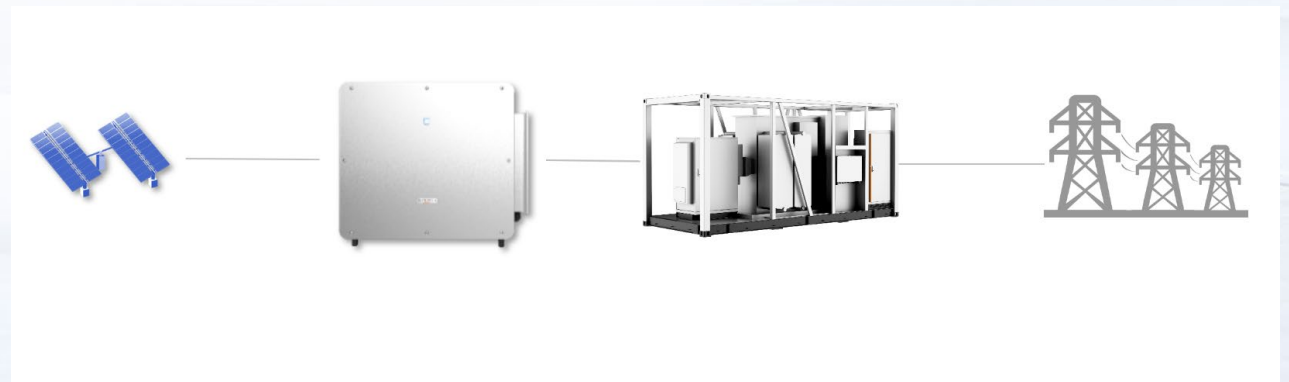


The Evolving Grid

IBR & The Grid Challenges

Grid Challenges :

- More Variable Resources /Generations added
- Less Synchronous Generators- Retirements/ages
- More Distributed Generation
- Reduced Inertia: Transient & Dynamic Stability issues
- Advanced Control System
- Demanding Ride-through (voltage and Frequency) Regulations
- Reactive Power capabilities
- More & more challenges



The Evolving Grid

The Inverter System: Must be more Advanced

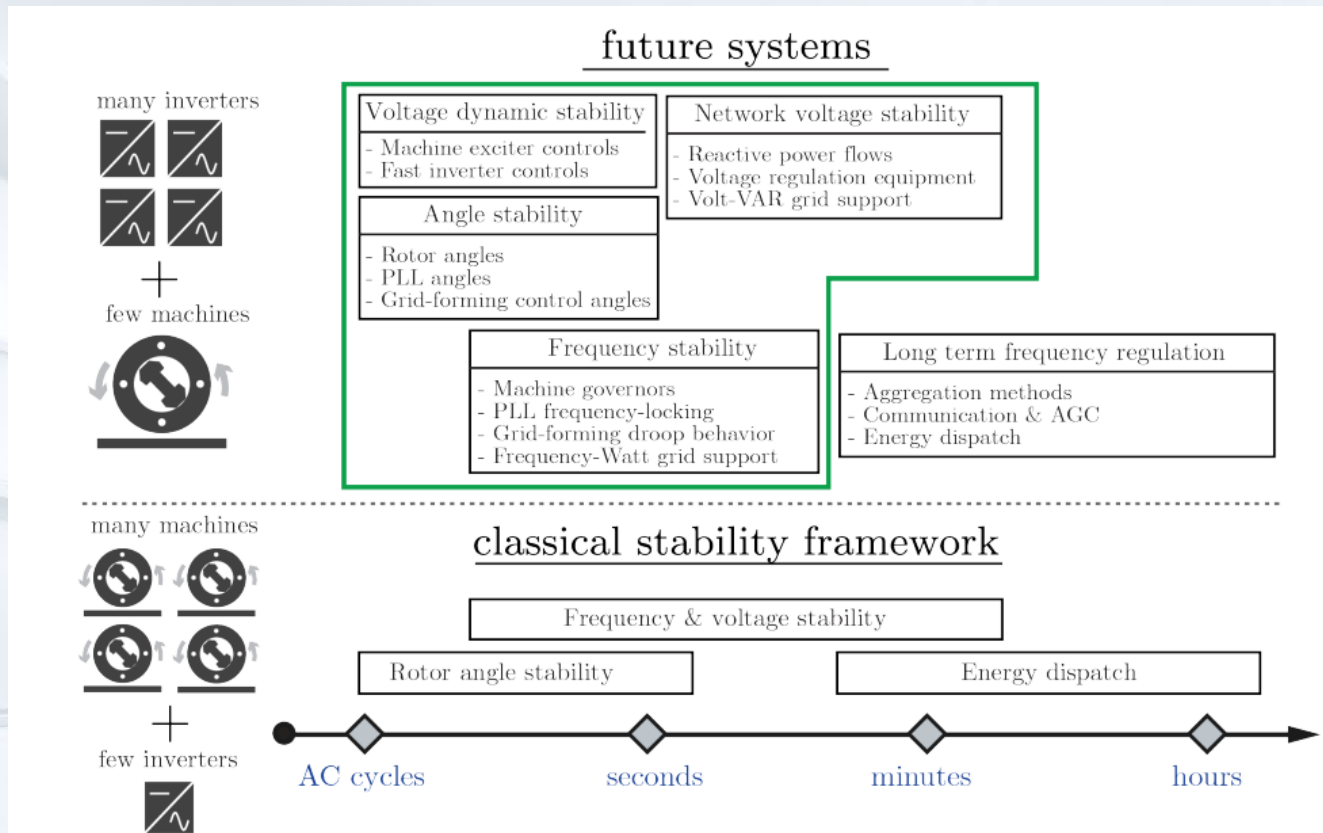


Fig 1[1]

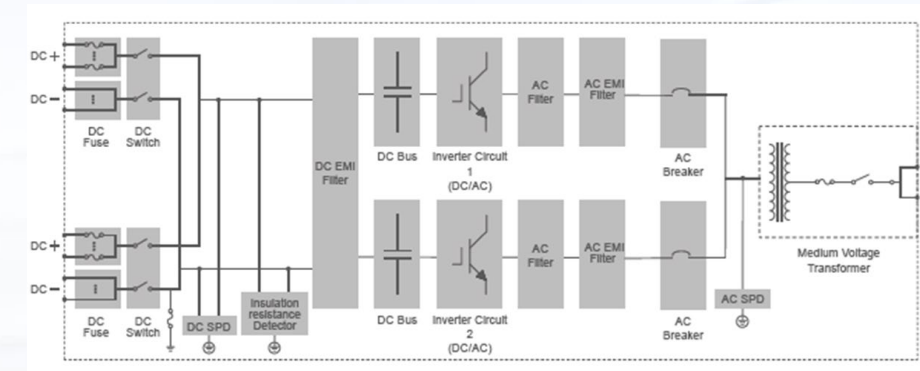


Fig 2

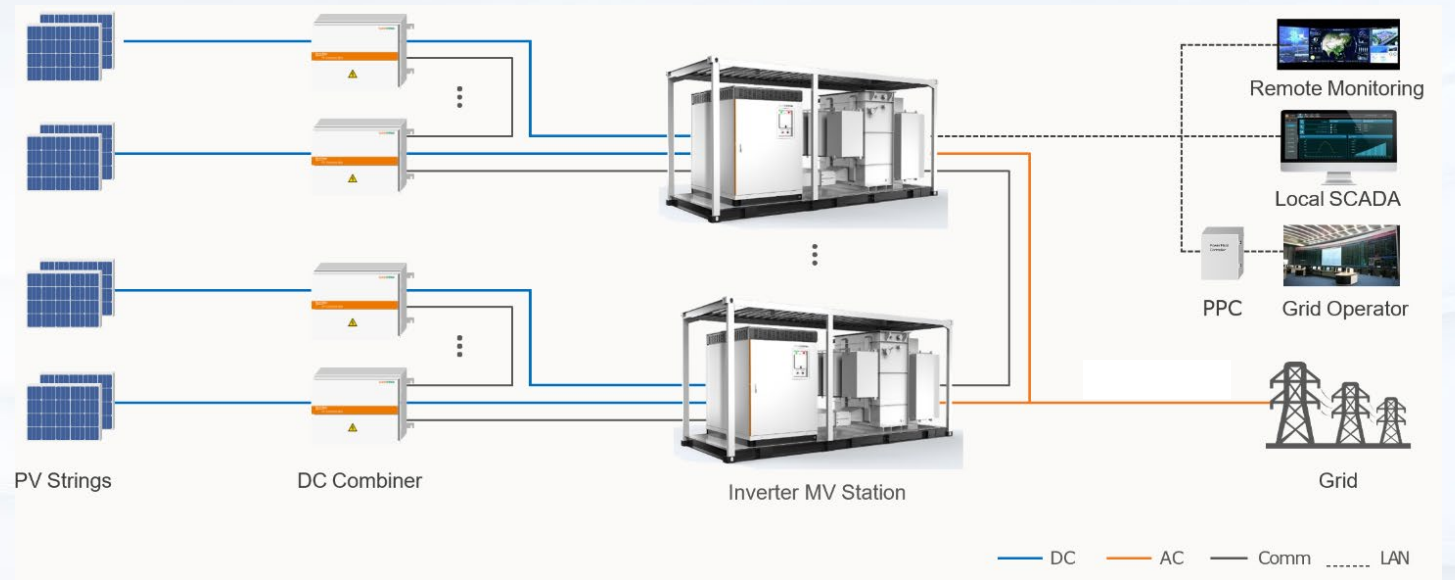
Ref [1] Fig 1- NREL <https://www.nrel.gov/docs/fy21osti/73476.pdf>

The Evolving Grid

The Advanced Inverter Systems:

The Advanced Inverter System:

- Advanced Control system
- Grid forming control*
- FFR (Fast frequency response)
- ROCOF & Anti-Islanding Protection
- Volt-VAr (voltage regulation)
- Power Factor Control
- Frequency-watt (frequency regulation)
- System protection
- Low/High Voltage Ride-Through
- Low/High Frequency Ride-Through
- AI/ML Integration – production forecast - ancillary services
- Black-start capability
- Q @ night
- Advanced data acquisition
- Grid codes – IEEE1547, UL1741, IEEE 2800, NOGRR245 etc.



The Evolving Grid

The Advanced Inverter Systems:

Technical Insights & Challenges:

- More Integration
- Capability for Grid Forming
- Advanced Grid Support
- Advanced modeling req
- Reliability & Standards

More Integrated

Re-combiner box

Communication Devices

Step-up transformer

Auxiliary Transformer

Supply for Tracker and monitoring

Trunkbus compatible

UL 1741

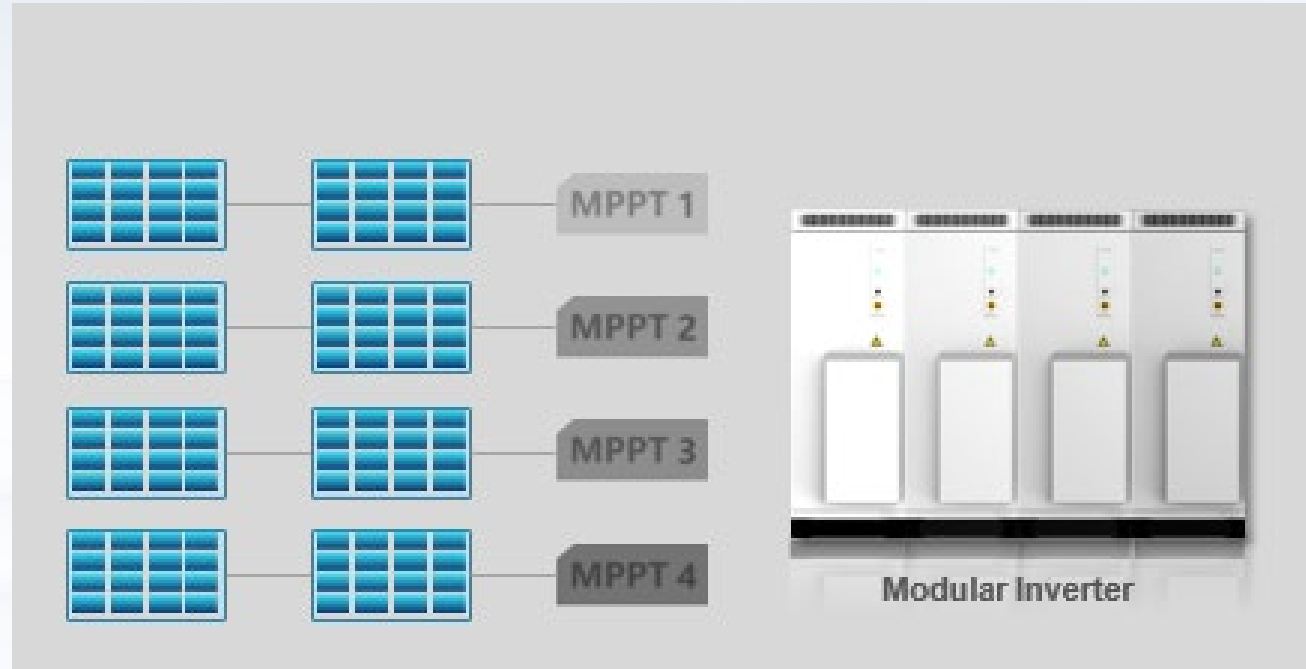
NEC 2017/UL1741

The Evolving Grid

The Advanced Inverter Systems:

Additional Technical Insights

- Higher DC/AC Ratio
- Multiple MPPTs
 - Independent optimization
 - Flexible layout/terrain
 - Multi-Dimensional Integration
- Reliability & Standards
- Lower LCOE
- Advanced Safety Design
 - Active breaking fault
 - Redundant protection

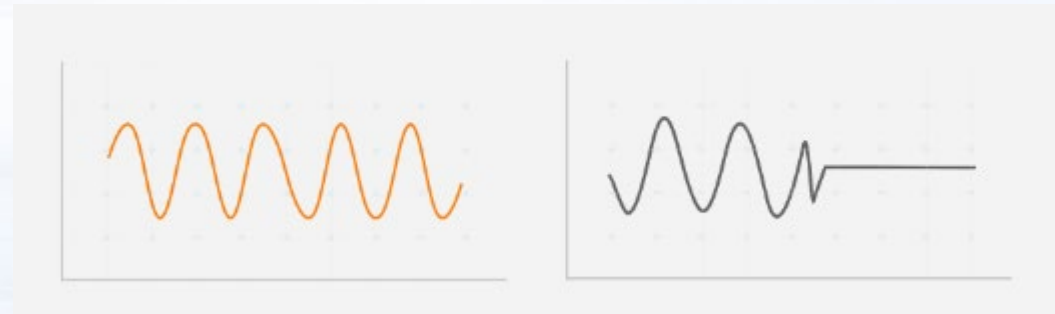
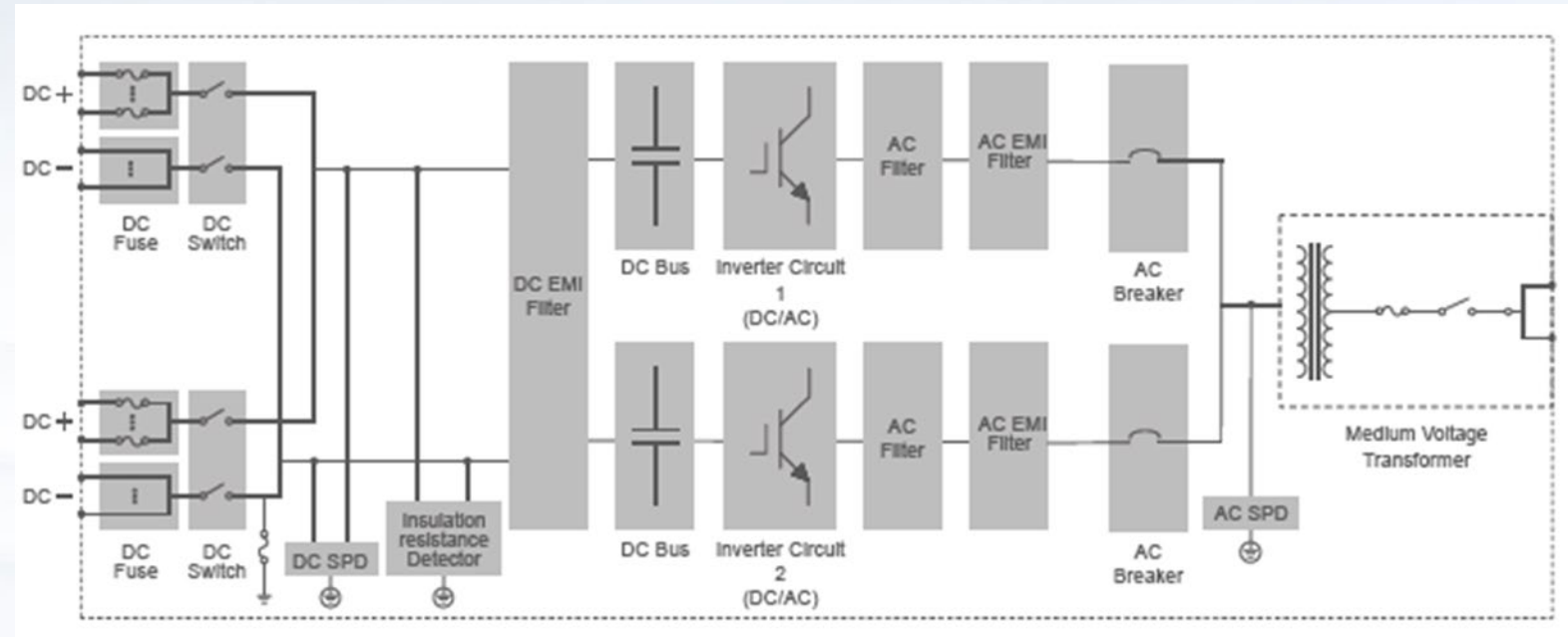


The Evolving Grid

The Advanced Inverter Systems:

Grid Support

- Ride-Through- Continuous operation during HVRT and LVRT
- Active/Reactive Power/Power Factor Control
- Quick Active/Reactive Response to Grid command Within - ms
- Grid Adaptability & Support
 - Stable Operation Under very weak grid system as low as SCR = 1.15
 - Dynamic Impedance Shaping
 - Transient Overvoltage Suppression

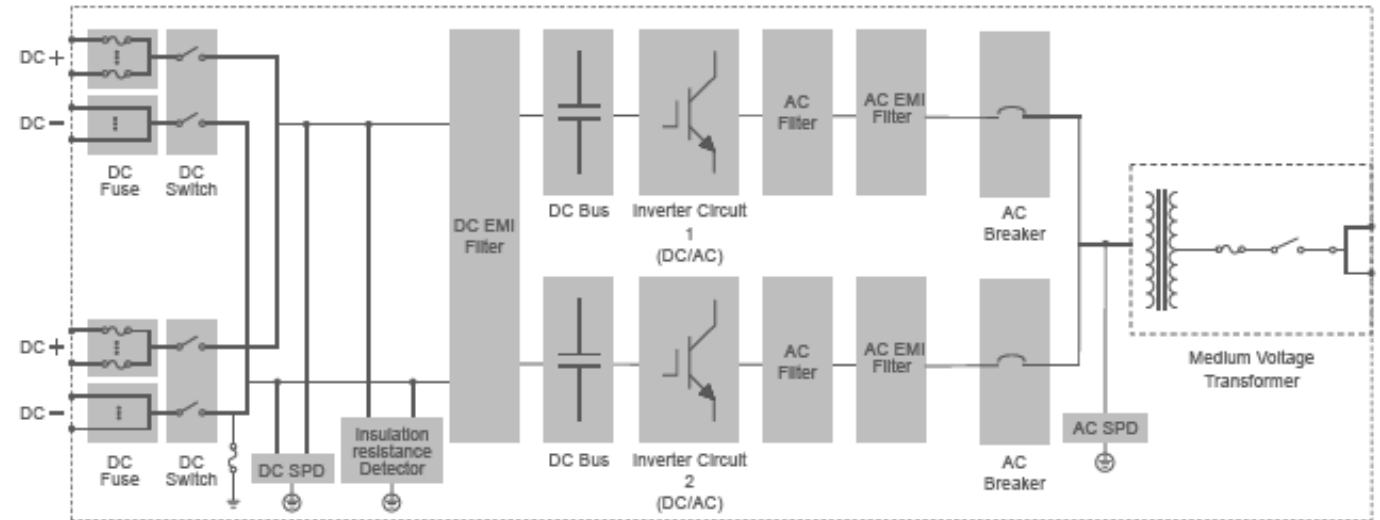


The Evolving Grid

Safety & Reliability :

- Advanced Safety Design
 - Advanced Software algorithm
 - Redundant protection
 - DC Protection
 - AC –short-circuit protection
 - Surge Protection
 - Harmonics & Power Quality
- Real Time Fault monitoring
 - AC/DC Insulation Monitoring
 - O&M Predictive warning
- Harsh Climate /Environmental Protection
 - NEMA 4X protection, C5 Anti-Corrosion
 - Advanced Therma Design
- **Standards** – UL1741, IEEE1547, IEEE2800* , NOGRR245, NERC/FERC requirements etc.

The Advanced Inverter Systems:



Thank You & ???