# Superconducting Fault Current Limiters

*Strategic Intelligence Update*

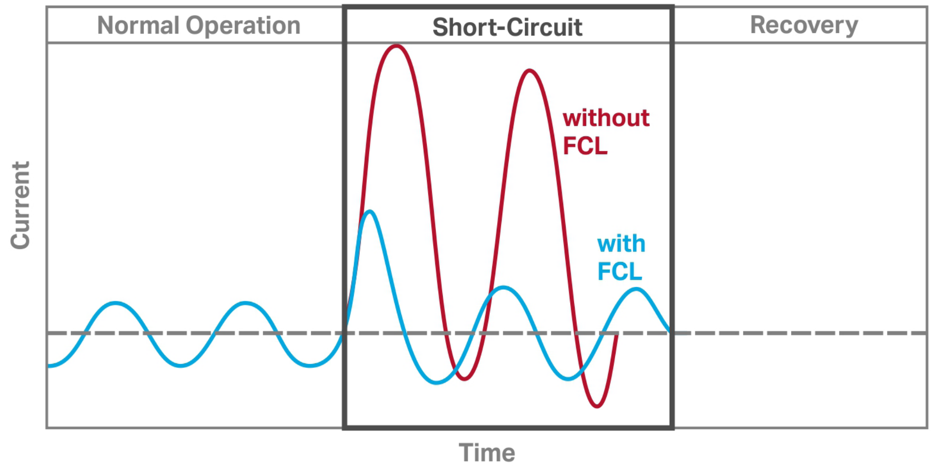
Superconductivity
INTERNATIONAL ENERGY AGENCY

## What are the benefits of FCLs to utilities?

- Enhanced system safety, stability, and efficiency of the power delivery systems
- Reduced or eliminated wide-area blackouts, reduced localized disruptions, and reduced recovery time when disruptions do occur
- Reduced maintenance costs by protecting expensive downstream T&D system equipment from constant electrical surges that degrade equipment and require costly replacement
- Improved system reliability when renewables and DG are added to the electric grid
- Elimination of split buses and opening bus-tie breakers
- Reduced voltage dips caused by high resistive system components
- Increased short circuit handling capacity of existing grids without having the need to upgrade existing equipment

## What are Fault Current Limiters?

A fault is an unintentional short circuit, or partial short-circuit, in an electric system. A variety of factors such as lightning, downed power lines, or crossed power lines cause faults. During a fault, excessive current—called fault current—flows through the electrical system. Circuit breakers or fuses protect the system from damage but in doing so often isolate one or more sections of the system resulting in temporary loss of service to some customers or loss of capacity to serve load. A fault current limiter (FCL) limits the amount of current flowing through the system and allows for the continual, uninterrupted operation of the electrical system. Currently, two broad categories of FCL technologies exist: high-temperature superconducting (SFCL) and solid-state (SSFCL).




This graphic shows when a short circuit (or fault) occurs, a transmission or distribution line's current can spike and cause damage to downstream equipment. An FCL would limit the current to normal levels in less than one cycle.

## Why do we need Fault Current Limiters?

The need for FCLs is driven by rising system fault current levels as energy demand increases and more distributed generation and clean energy sources, such as wind and solar, are added to non-optimal locations on the distribution network.

| Technology | Features |
|---|---|
| Explosive fault-limiting fuses | • Available today for voltages under 35 kV<br>• Service call required to replace blown fuse |
| Series reactors | • Used routinely in the electric grid<br>• Consume reactive power and may impact grid dynamics |
| Solid state fault current limiters | • Electronic controls provide flexible integration with downstream protection |
| Superconducting FCLs | • No impedance on the T&D grid. Passive operation |

## About the IEA HTS TCP

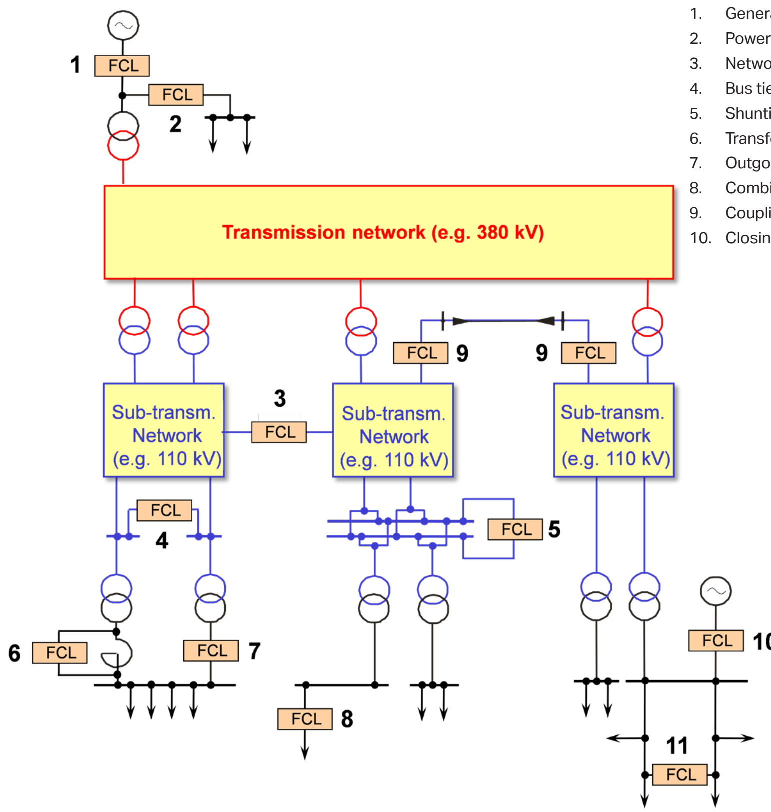
The International Energy Agency's High Temperature Superconductivity Technology Collaborative Program (IEA HTS TCP) aims to analyze superconductivity technology, monitor developments in industry standards, and assess the benefits and existing barriers to deployment. It brings together manufacturers, cryogenics research, laboratories and trade organizations to enable significant improvements in the generation, transmission, distribution and use of electric power.

*www.ieahts.org*

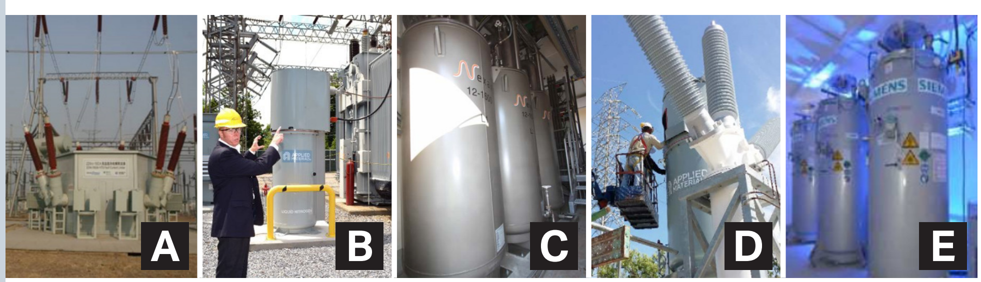
## Examples of Fault Current Limiter Projects.

| Lead Company | Country / Year | Operating Characteristics |
| --- | --- | --- |
| A. Innopower | China/2011 | 220 kV / 300 MVA |
| B. Applied Materials | United States/2013 | 15 kV / 1 kA |
| C. Nexans | United Kingdom/2015 | 12 kV / 1.6 kA |
| D. Applied Materials | United States/2016 | 115 kV / 550 A |
| E. Siemens | Germany/2016 | 10 kV / 817 A |

The image below shows the various locations on the electric grid where FCLs can be integrated. Letters on the image below correspond to projects listed in the above table, which are also shown in images below.




1. Generator feeder
2. Power station auxiliaries
3. Network coupling
4. Bus tie
5. Shunting current limiting reactor
6. Transformer feeder
7. Outgoing feeder
8. Combination with SC cables
9. Coupling local generating units
10. Closing ring circuits




(From left to right) A. Innopower 220 kV FCL courtesy of (Hong et al., 2013 DOI: 10.1109/ASEMD.2013.6780832). B) Applied Materials 15 kV FCL (L. Martini, 2016). C) Nexans 12 kV FCL (M. Noe, 2016). D) Applied Materials 115 kV FCL (M. Noe, 2016). E) Siemens 10 kV FCL (M. Noe, 2016).