



Reliability Assessment of Grid Connected Photovoltaic Generation Systems

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Reliability

- Reliability is a measure of how well a system performs its expected function.
- The two components of reliability are adequacy and security.
- A system is adequate if it has sufficient resources to perform its function. A system can be adequate but unreliable.
- Reliability studies shall be performed after design and before implementation.



Reliability Assessment

- **Reliability evaluation**
 - Reliability may be measured by the frequency, duration and magnitude of adverse effects on the electric supply.

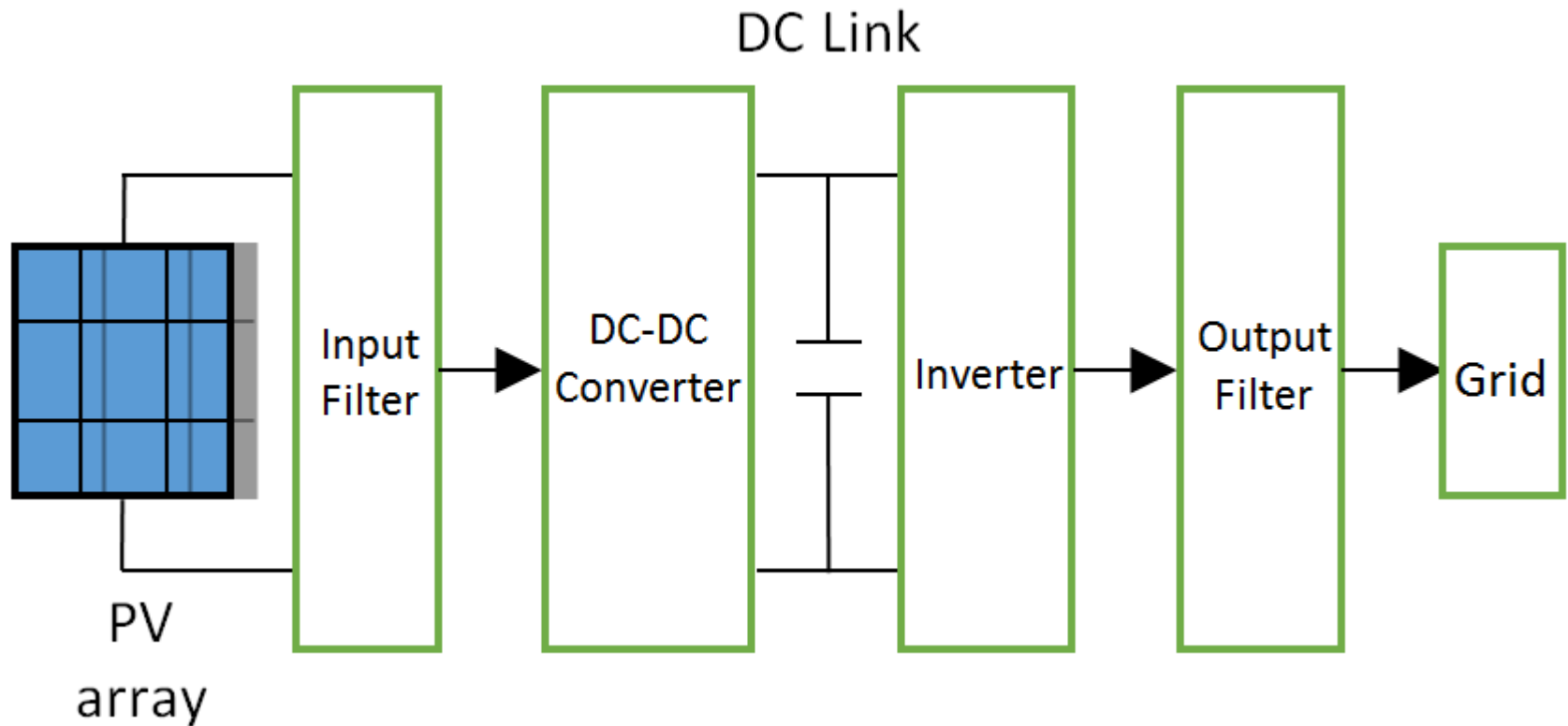
- **Reliability indices**
 - Component indices
 - System indices
 - Customer indices



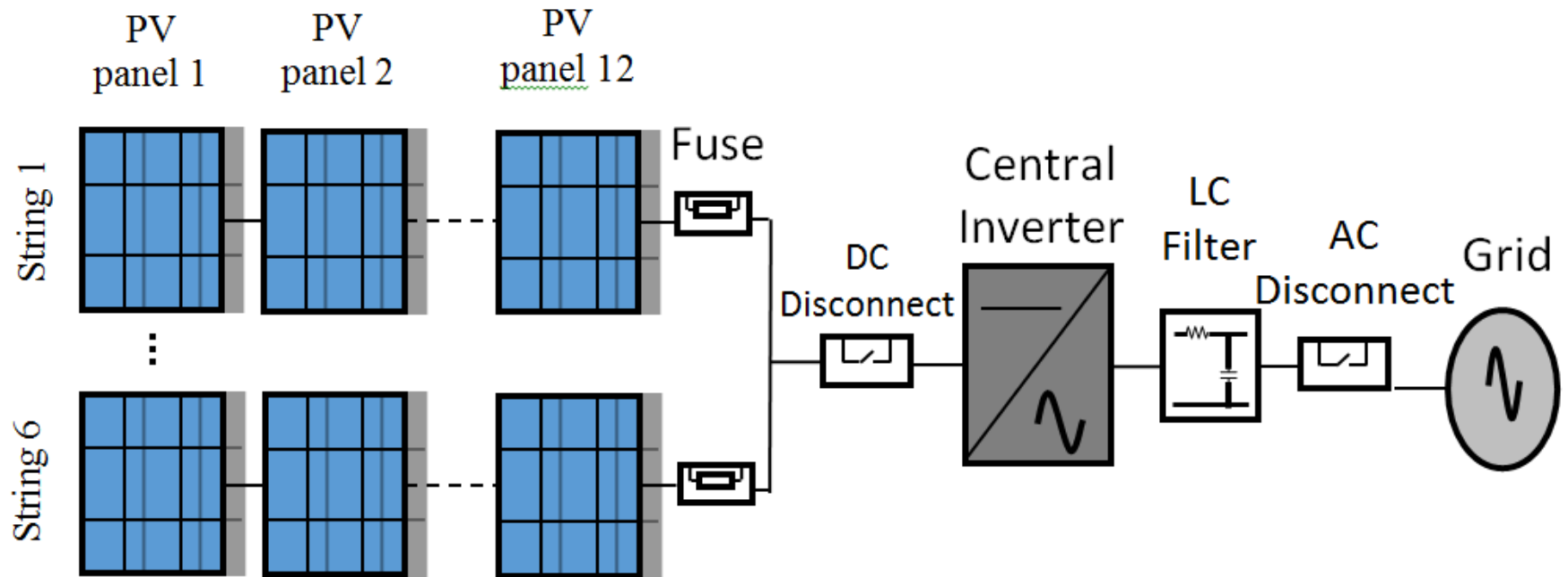
Reliability indices

- ***Ideal Supplied Energy (ISE)***. It is the energy that can be delivered to the grid by a 100% reliable PV system,
- ***Expected Supplied Energy (ESE)***. system availability considering failure rates of different components.
- ***Energy Availability (A_e)***. It is the ratio of ESE to ISE.
- ***Time Availability (A_t)***. It indicates the time which the PV system is expected to operate in non-failure mode every year.
- ***Available Hours (T_{av})***. It is the time duration (in hours) per operating period for the PV system when operating with no component failure.

A Grid Connected Photovoltaic system

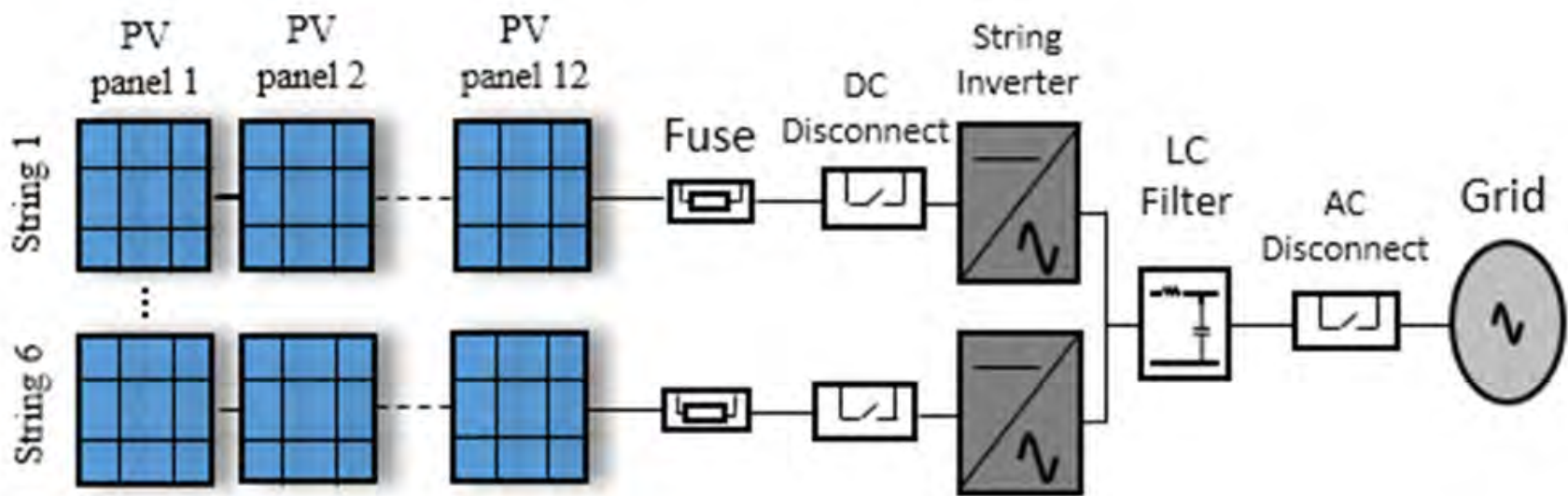


PV System Topologies



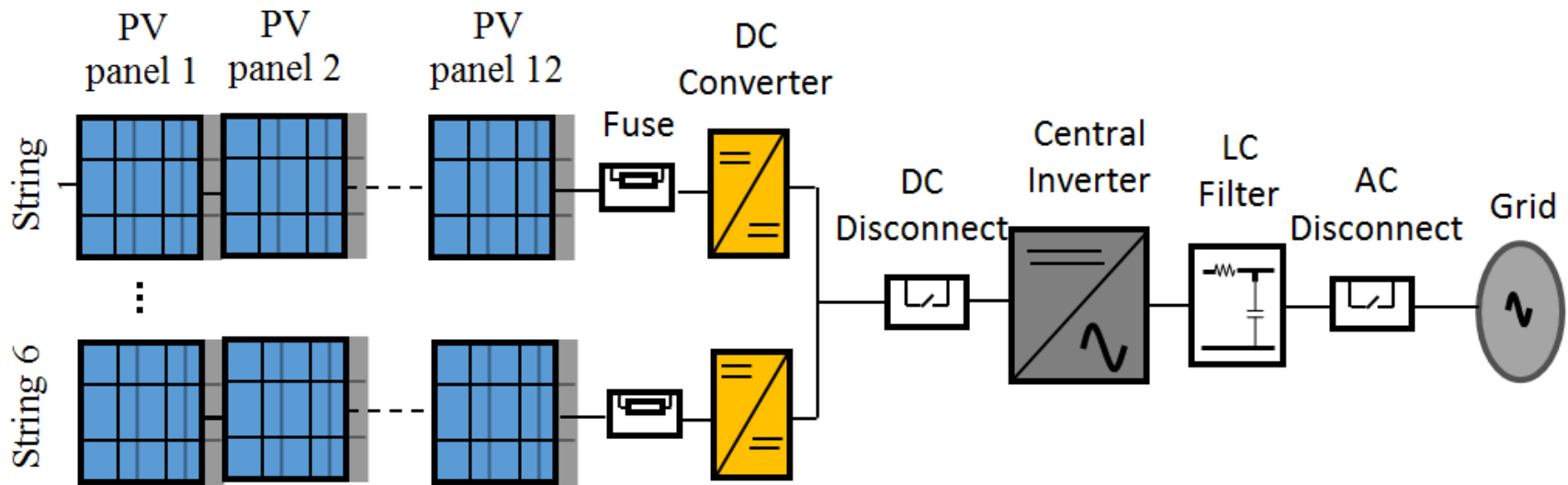
(a) *Centralized topology.*

PV System Topologies



(b) *String topology.*

PV System Topologies



(c) *Multi-string topology.*



Reliability Parameters

- **Technical**
 - Failure rate of each component
 - Repair time
 - Topology
- **Weather related**
 - Pollution
 - Time of the day



Performance Remarks

- For the central inverter topology, the outage of the inverter reduces the output of the PV system to zero. Thus, this topology has a low reliability from the energy point of view with low ESE and energy availability.
- For the string inverter topology, the failure of one inverter affects its own PV string only without reducing the output of the whole PV system to zero.
- The multi-string topology has lower ISE due to the additional losses inside the DC-DC converter.
- The string inverter topology has the highest output energy



Conclusions

- Reliability is a general engineering concept and has to be considered in the design and implementation of renewable energy systems.
- Reliability indices are affected by the adopted topology.
- Cost/Worth analysis should be performed to select the most appropriate topology for a specific location.