Renewable Energy
Fire protection
Developments
Solar

Shane Erasmus

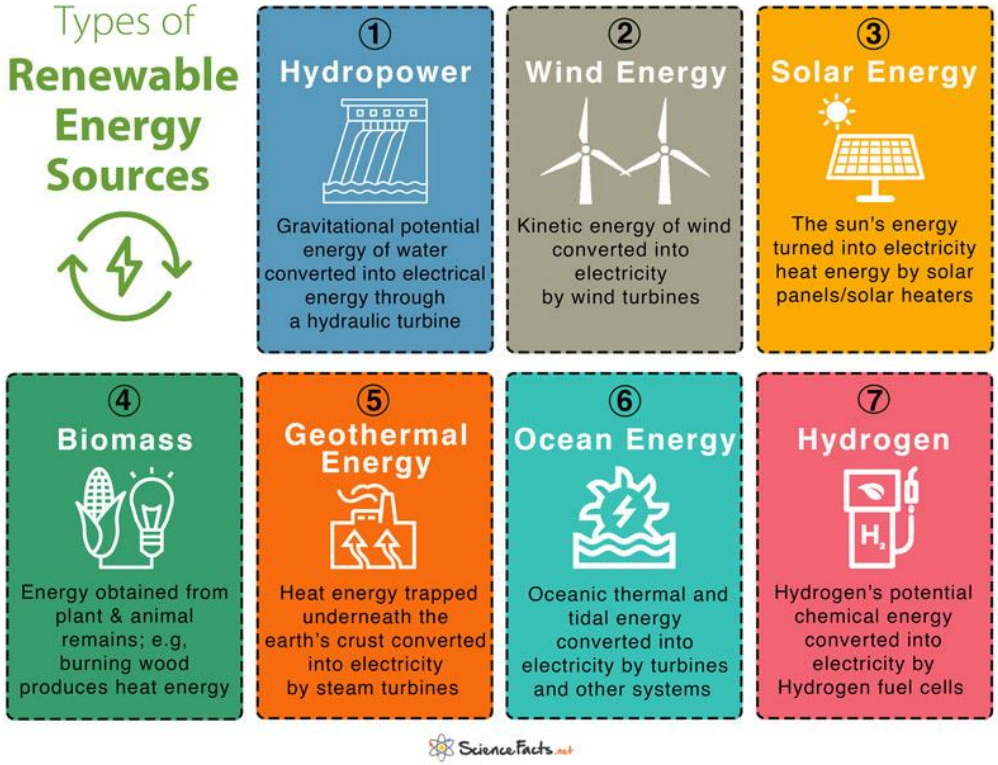
20 February 2024

sapia | South African Petroleum Industry Association

Fire Fighting Developments

+ **There are 7 Types of Renewable Energy**

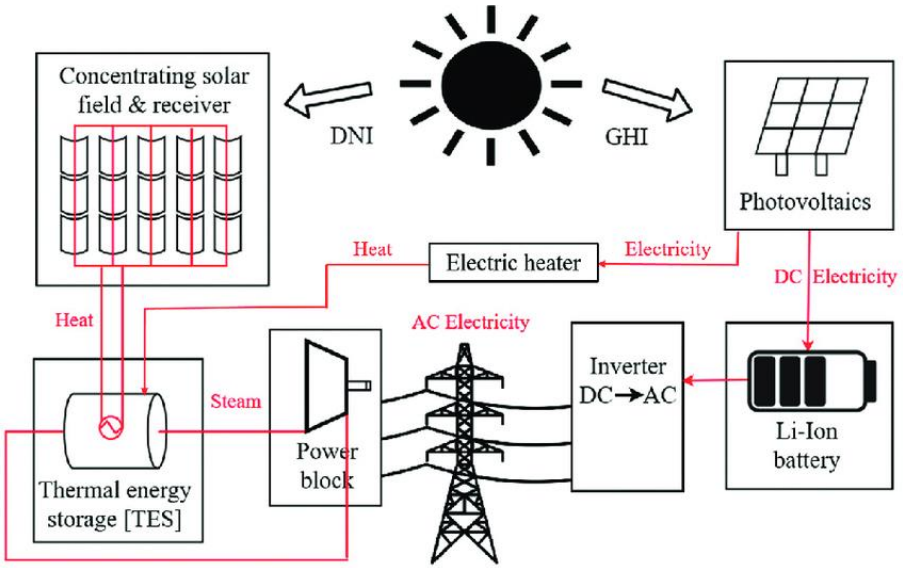
- Solar
- Wind Energy
- Hydroelectric
- Ocean Energy
- Geothermal Energy
- Biomass
- Hydrogen

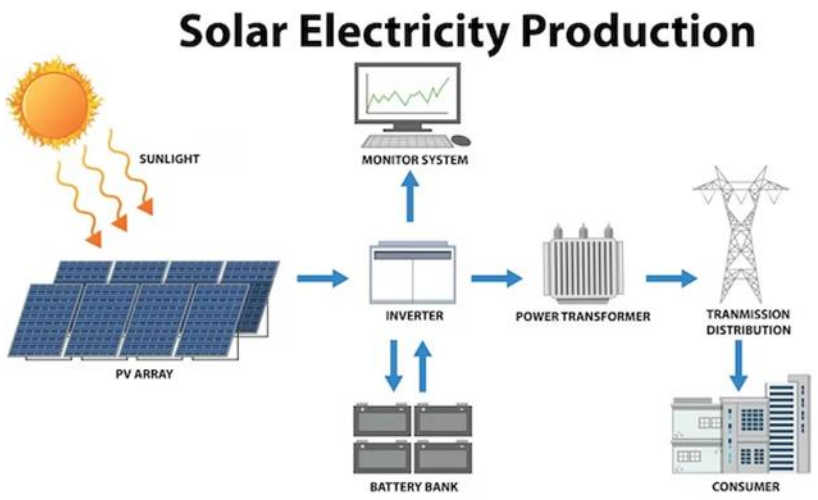


sapia | South African Petroleum Industry Association

Solar Energy

CSP (Concentrating solar-thermal power systems) convert the sun's energy using various mirror configurations that drive a heat engine (power a turbine) and produce electrical power. Photovoltaic solar panels, on the other hand, use the sun's light, rather than its energy. Unlike CSP, PV converts light into electricity directly.





sapia | South African Petroleum Industry Association

Solar Farms

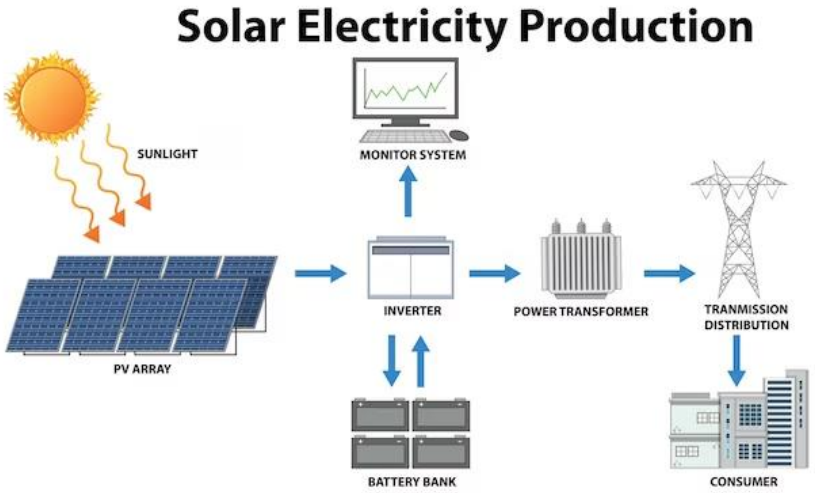
- The Bhadla Solar Park is a solar power plant located in the Thar Desert of Rajasthan, India. It covers an area of 56 square kilometers and has a total installed capacity of 2,245 megawatts (MW), making it the largest solar park in the world as of 2023.
- 1MW = 800 houses = 1.8 million homes

SAFER JOURNEYS
4me, 4you, 4all.

sapia South African Petroleum Industry Association

Solar Farms

- **What causes fire in solar panels?**
- PV solar panel fires are typically caused by poor installations, ground faults, DC arcing, maintenance operations, roof debris, water ingress, animal nests, physical damage, error in the design system, faulty product design or quality issue or panel overheating.
- A number of fires start in inverters, which form the most complex part of a PV system and manage the power that flows through them.
- A solar inverter is one of the most crucial parts of a solar power system. Solar inverters are devices that convert the direct current (DC) output of a photovoltaic (PV) system into an alternating current (AC) that can be fed into the electrical grid. Solar panels produce DC electricity, but most appliances in our homes run on AC. So, the inverter is essential for making use of the power generated by our solar panels.



Solar Farms

SAFER JOURNEYS
4me, 4you, 4all.

sapia | South African Petroleum Industry Association

Solar Farm

Solar Farms

SAFER JOURNEYS
4me, 4you, 4all.

sapia | South African Petroleum Industry Association

Concerns for First Responders

- The primary concern for first responders is exposure to electrical components that present a hazard to electric shock.
- All solar equipment on site contains lethal AC and DC voltages.
- All inverters contain energy storage devices that require **15+ minutes** to safely discharge lethal voltages.
- Electricity is supplied from multiple sources.
- The site should only be accessed by personnel or emergency responders under the direction of the Operator.
- **The following are the most hazardous locations**
- Inverters and disconnects; Vicinity of the solar electric photovoltaic panels; Field wiring, collection lines, all electrical boxes associated with the system; and Substations.
- Photovoltaic panels are made of glass and may break. If any cracks occur in the modules, touching a crack may expose a person to the full voltage and current of the array. Do not touch the modules without wearing electrical insulating gloves.

Emergency Response

Response

- Let the facility burn.
- Burning electrical equipment is already damaged and must be replaced.
- Protect adjacent exposures, such as homes and forested areas, as needed, to limit the potential of the fire spreading.
- Solar and substation components are always hot and should always be considered electrically energized. DC voltage is always present, even at night.
- Electrical components produce gas during combustion. All responders should use a self-contained breathing apparatus (SCBA).
- Before committing apparatus to the access roads within any of the fenced panel array enclosures, understand that turn arounds will often be well over 300m away.
- Under the direction of the Operator, isolate or shutdown the electrical power at the site of the fire, if possible.
- Do not assume the system is de-energized and do not attempt to de-energize any equipment.
- Additionally, fencing around the Substation includes an to determine the appropriate response procedures and methods for shutting down the nearest components to ensure safe access
- Toxic gases including sulfur dioxide, hydrogen fluoride, hydrogen cyanide and a small amount of volatile organic compounds are released when such a PV system burns.

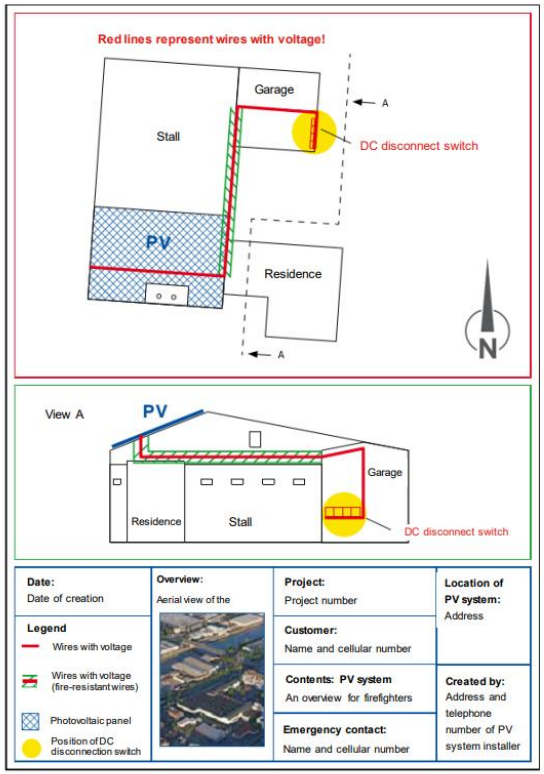
Protection Measures

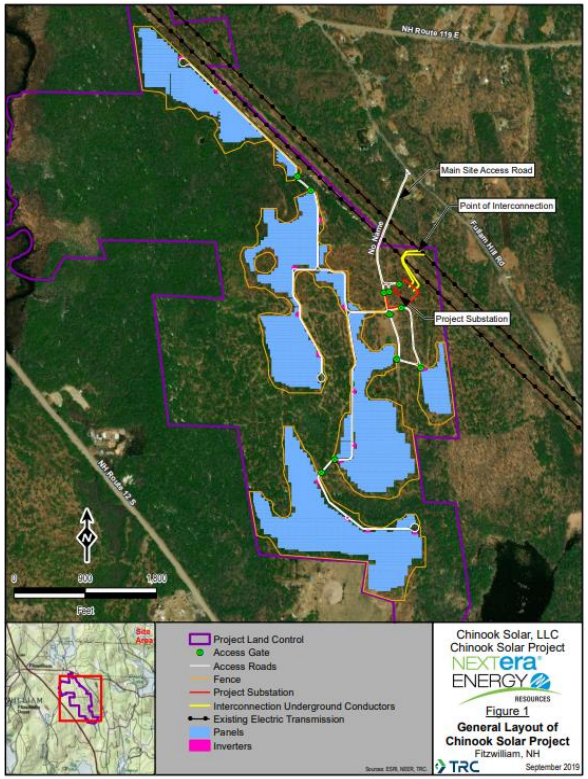
- **Protection Measures**
- Each container is to be provided with an automatic gas suppression system
- The right fire suppression technology has the ability to eliminate the risk of high voltage DC electrocution by shutting down the solar PV system inverter entirely.
- Water supply or storage tank 20 000l.
- Fire detection and suppression systems in Substations and inverters (Critical equipment)
- Provide a minimum 6.1 m wide access road (or as required by local code requirements) to the site and around the perimeter to ensure accessibility for firefighting apparatus to approach a fire inside the solar farm.
- Install panels having a Class A or B rating in the Spread of Flame test.
- The flame spread should not exceed: Class A – 1.82 m, Class B – 2.40 m, & Class C – 3.90 m
- Consider medical emergency access.

- **Electrical Protection**
- Provide DC ground fault protection for grounded array systems.
- Provide overcurrent protection on the AC and DC sides of the inverter against short-circuit faults and overload.
- Provide overvoltage and undervoltage protection on the AC and DC sides of the inverter.
- Provide a disconnect at the output of each combiner box.
- Provide electrical protection for the substation transformers.

Emergency Response Plan

Response Plan





- Emergency response plan indicating emergency response numbers high risk critical equipment and save making. equipment
- Indicating fire protection measures provided and means of activation.
- Include potential fire scenarios in the emergency response plan.

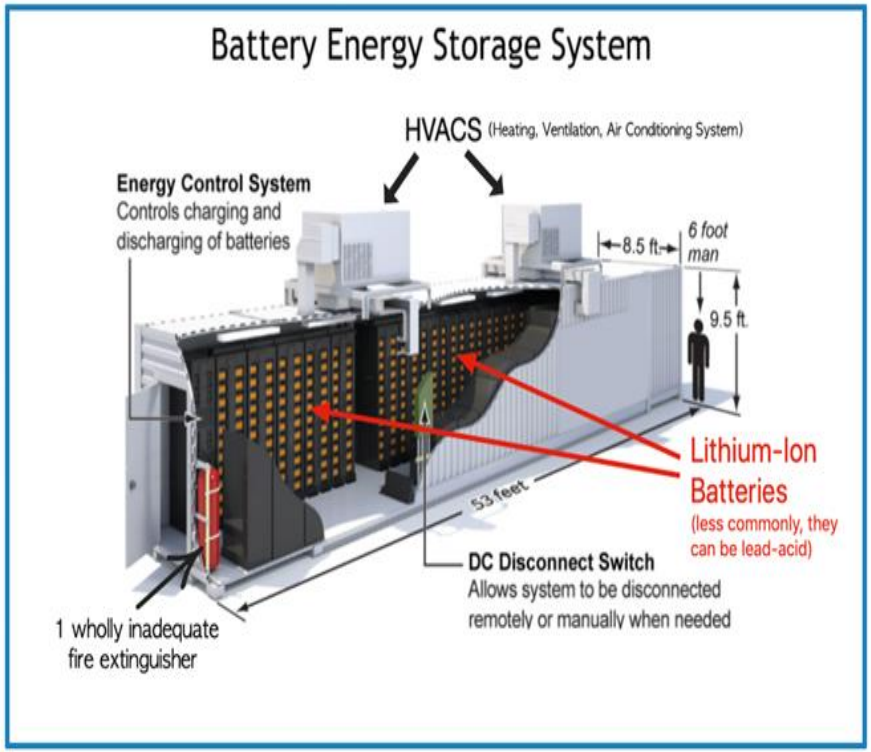
sapia | South African Petroleum Industry Association

Inverter Fire Protection

- **Inter gases** include nitrogen, argon, and CO2, or a combination of two or more, and reduce oxygen levels to a point where combustion cannot be sustained. These gaseous agents are safe for both people and the environment.
- **CO2 sprinkler system** provides a heavy blanket of gas that reduces the oxygen level to a point where combustion cannot occur. Because it's unsafe for people, CO2 is only recommended for localized applications or areas generally inaccessible by employees or customers.
- **Water mist systems** water mist systems remain highly recommended as it is one of the most effective methods of suppressing fires from thermal runaway.
- **Traditional smoke detectors**, heat detectors, thermal imaging flame detectors, and gas detectors each play an important part in any early-warning detection system; they can activate power shutoffs, trigger alarms, vent gas-filled.

Battery Emery Storage System

- Malfunctioning cells can easily trigger a thermal runaway, where damage spreads catastrophically throughout neighboring battery racks. High heat causes flammable outgassing and explosive ruptures in the surrounding batteries, which can in turn propagate the damage outward
- The BMS protects batteries from damage and ensures battery cells aren't being overcharged, or operating outside of their recommended operating conditions.
- The BMS is your first line of defense, helping you avoid damaging your ESS and alerting you to unsafe conditions.
- Beyond this line, there are explosion vent panels, which offer passive protection that prevents an uncontrolled rupture in portable ESS units. These work by directing explosive pressure, gasses, and flames upward, away from people and other units.



ENERGY STORAGE SYSTEMS

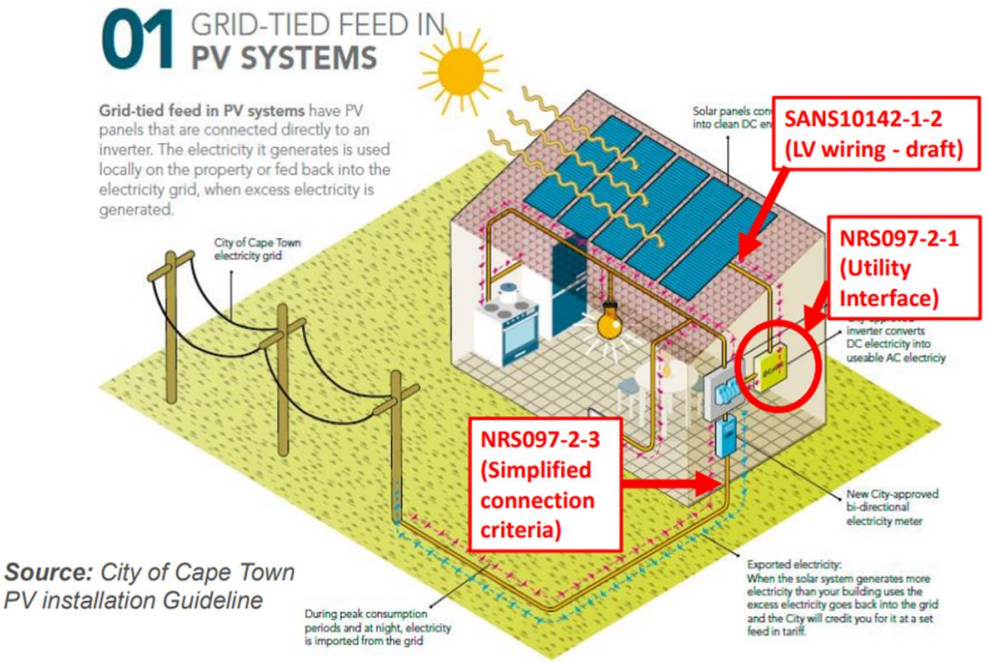
- If the enclosure has been vented by automatic door or panel opening and there is no indication of high temperatures, the enclosure may be approached by responders using continuous gas monitoring to warn of any residual atmospheric risk.
- Even when disconnected from external circuits, batteries retain their stored energy and should be considered to be energized. A battery may be partially destroyed by fire yet retain stranded energy at hazardous levels. All batteries, whatever their visual condition, should be treated as fully charged with respect to arc flash and electric shock hazards.
- Toxic chemicals, including hydrogen fluoride, hydrogen chloride, hydrogen cyanide, and carbon monoxide, may be released during an incident. Spraying water on smoke or vapor released from the battery, whether burning or not, may cause skin or lung irritation and contaminated run-off similar to plastic fires .
- If a thermal runaway occurs, the most important factor in preventing a cascading effect of burning racks is the ability to rapidly cool the overheated module and its surroundings. This is because fire involving Li-Ion batteries are known to reignite any time from minutes to days after the initial event.

ENERGY STORAGE SYSTEMS

- A lithium-ion fire can be caused by damage, manufacturing defects, improper use, and excessively hot storage temperatures. The damaged battery then begins to emit gas, typically hydrogen, as well as heat. Eventually, the heat creates smoke which means that the next likely event to occur is "Thermal Runaway", where the heat inside of the battery is created faster than it can disperse, leading to fire.
- The fire caused by the single battery then affects the adjacent batteries, causing them to fail, creating a chain reaction of battery failure which can lead to an explosion if enough batteries fail and produce heat and gas.
- Once the fire has self-extinguished, there may be ongoing releases of flammable or toxic gases. Full protective gear and SCBA should continue to be used until releases (such as carbon monoxide) are measured to be at a safe level.
- If system sensors (temperature, smoke, heat, and/or flammable gas) indicate that a thermal runaway event occurred, but there is no sign of fire, it should be assumed that an explosion risk is present. Personnel should be stationed outside the potential blast radius, at an angle to the doors, and upwind of the enclosure.

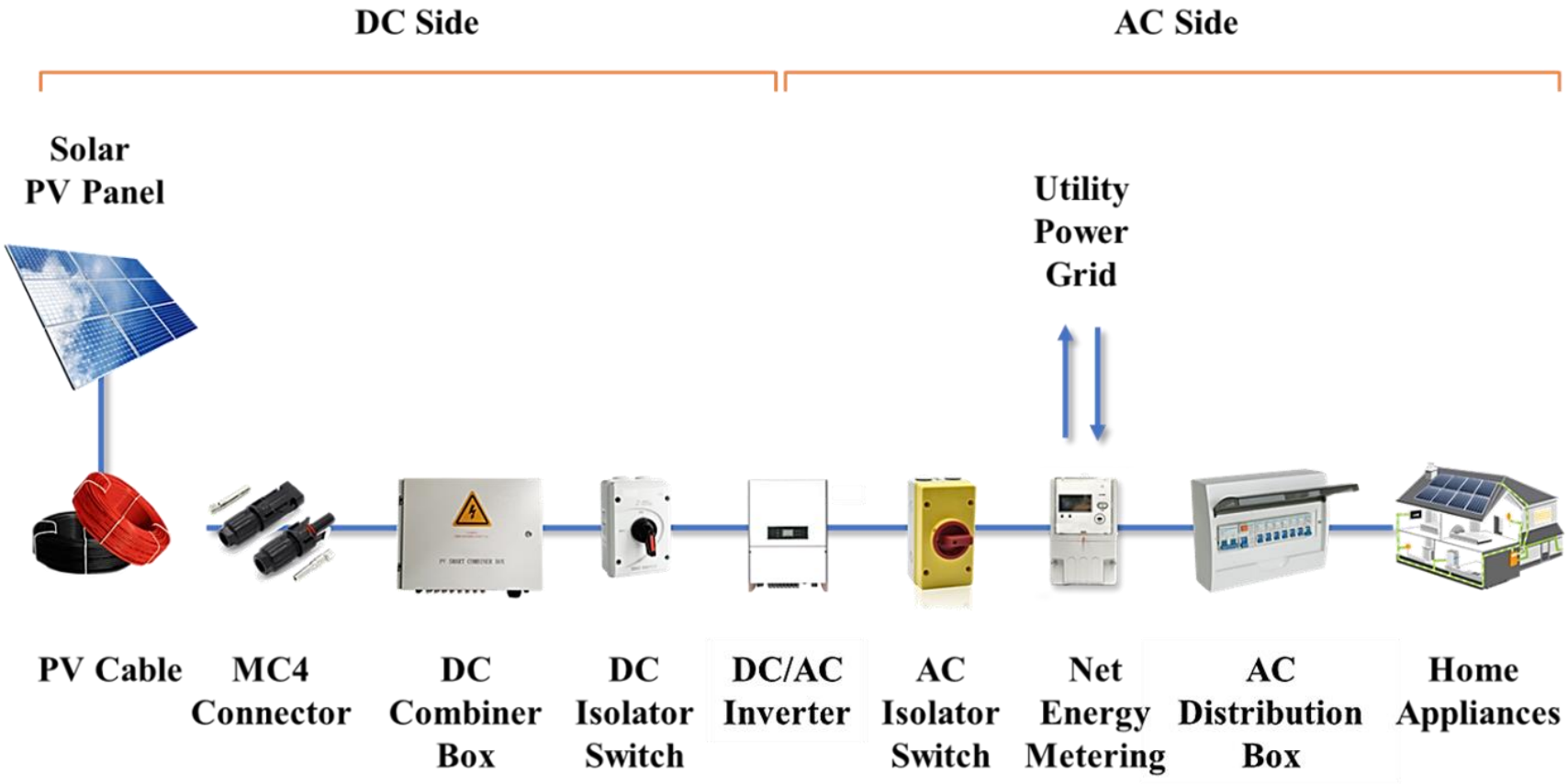
Lithium-Ion Energy Storage Systems

- A primary cause of solar PV fires is electrical arcing, which occurs over high-voltage direct current (DC) lines.
- This occurs anytime there is a compromise of the electrical system's wiring or connections. There is an increased risk over time for arcs to occur.
- This can be attributed to the normal “wear and tear” that a solar PV system is subjected to which makes system maintenance a priority



Source: *City of Cape Town PV installation Guideline*

Solar Panel System



sapia | South African Petroleum Industry Association

Fire Risk Solar Panels on Buildings

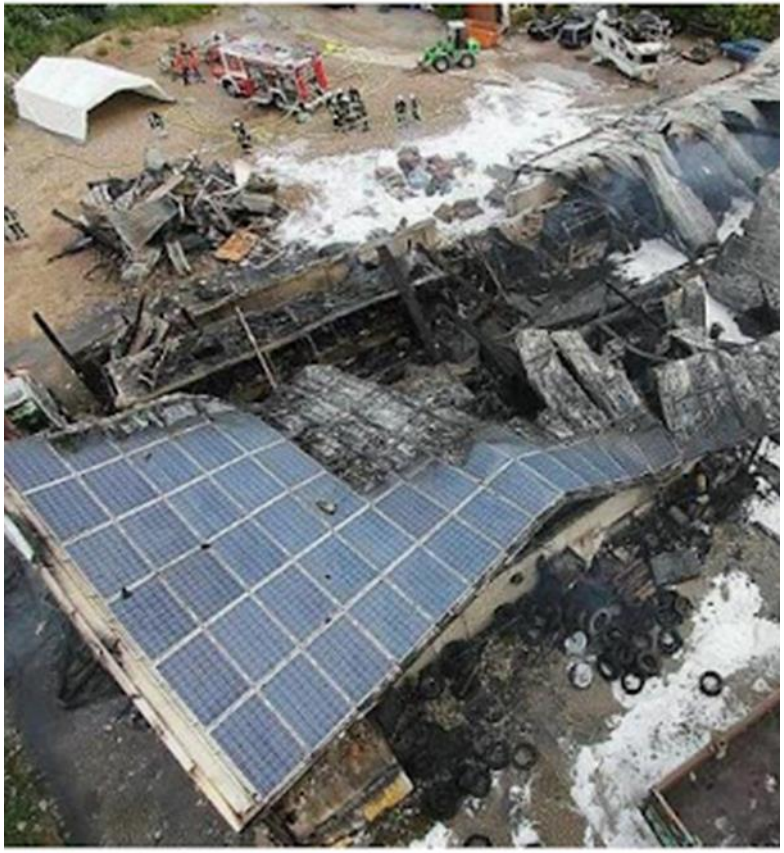
- **There are many factors that contribute to this condition:**
- Corroded cables and connections.
- Loose wiring between junction/splice boxes.
- Improper cable support.
- Animals chewing on wires.
- Improper grounding (leading to a ground fault, phase to ground).
- Ground fault “blind spot” that manifests itself at too low of a level for the ground fault device to operate
- ARC fault (phase to phase).

- When a solar panel catches fire, it does not just result in the reduction of power generation but also emissions of toxic gas), property damage, injuries and even death.

SAFER JOURNEYS
4me, 4you, 4all.

sapia | South African Petroleum Industry Association

Fire Risk Solar Panels on Buildings



- Another potential source of a fire could be the solar module itself. It could have manufacturing defects that, over time, cause internal “hot spots.” The plastic backsheet of the module could be compromised, which can expose conductors.
- There have been cases where once a fire has started on a roof, it will reach into the roof assembly and travel. The fire spread is greater in a roof array than a standalone roof assembly. The potential exists for the PV wiring to cause ignition of the roof assembly. Once started, the flame propagation, which is determined by the type of roofing material and insulation, can be redirected by the configuration of the solar racking system.
- These common primary ignition scenarios show that the causes of fire in PV systems can be classified into DC arc fault and localised overheating of PV components. In comparison to AC arcing, DC arc faults are more hazardous as the voltage continues to remain once the arcing is established.

SAFER JOURNEYS
4me, 4you, 4all.

sapia South African Petroleum Industry Association

Solar Panels on Roofs

Source: Birdblocker.eu

Solar Panels on Roofs

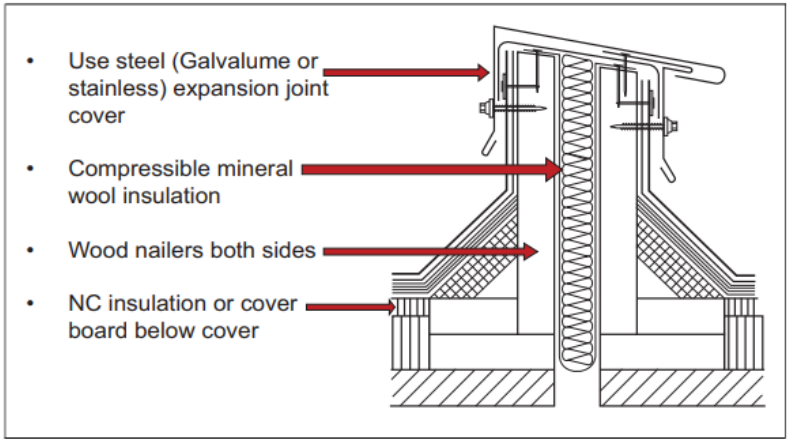


Fig. 2.1.2.1. Recommended roof expansion joint detail

Fig. 2.1.1.11a. Slotted pedestal

- Fire rated solar panels.
- Fire rated material underneath solar panel or coating.
- Regular maintenance.
- Fire risk design evaluation
- Choose roof assemblies that limit potential fuel contribution in the event of an exterior fire.
- Construction materials that melt at low softening temperatures and can flow when burning (such as expanded or extruded polystyrene insulation or multi-ply roof covers) may require protection such as a gypsum cover board installed over the insulation or a coating over the roof cover.
- Most importantly, it is best to use a PV panel that has passed a fire test with the proposed roof assembly.
- FM Global Property Loss Prevention 1-15 Installation guidance

Firefighting Activities

- Find the ESS and shut off al systems
- Ventilation strategies, solar panels generate electricity any time day or night, Staying away from the roof is the easiest and safest technique for firefighters.
- Firefighters can safely put off the fire by using a straight spurt of water from a distance of at least 6m or a fog pattern from 2m. A solar panel or battery fire does not require foam to put off. In addition to that, tests have revealed that the most helpful tool is plain water to stop solar fire. Same tactics for battery fire.
- Fire fighting foam is not effective.
- Cover panels with sheet (opacity blanket)
- CO2 and DCP fire extinguishers can be used.