

BUILDING SUSTAINABLE GROWTH

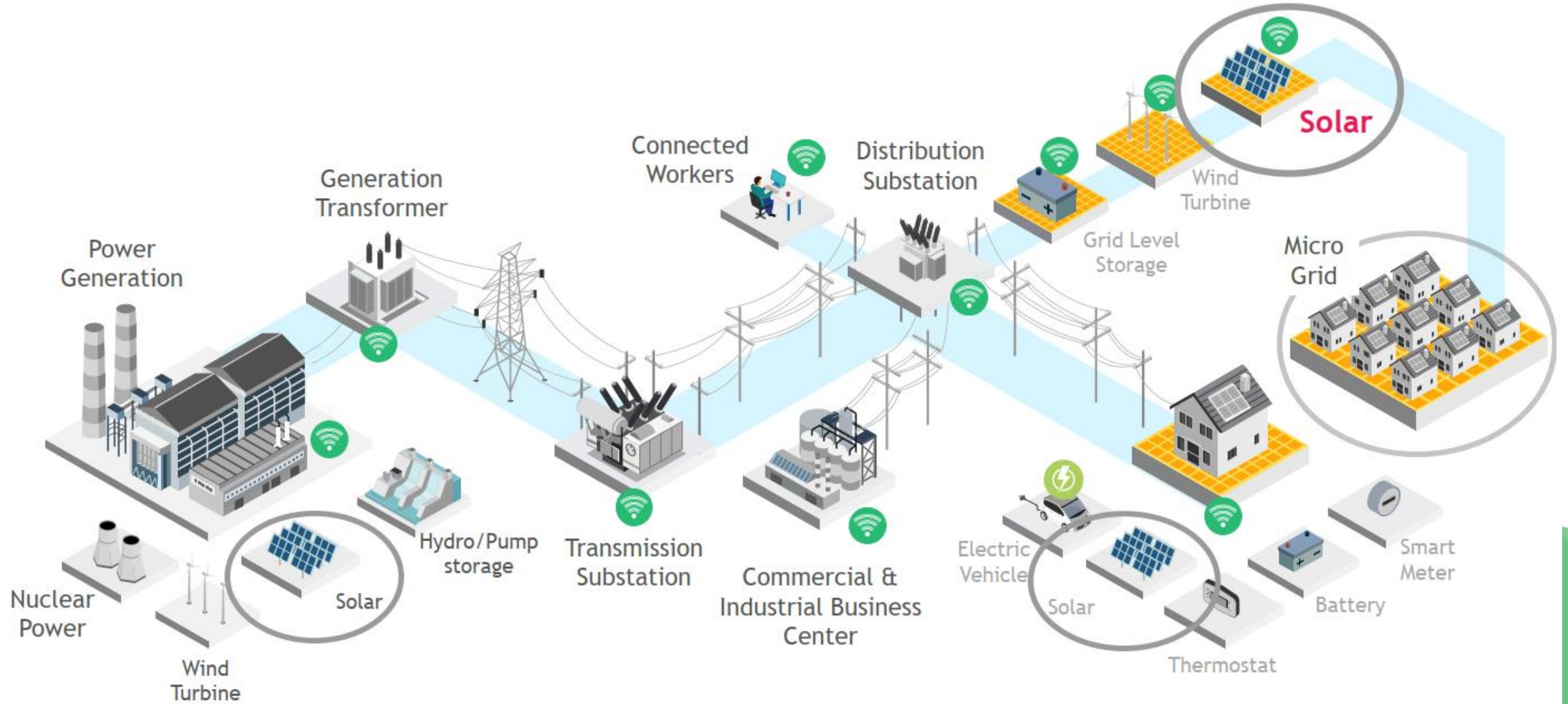
NEXT-GENERATION SOLAR CABLES FOR ADVANCED RENEWABLE ENERGY NEEDS

Vitthal Sawant

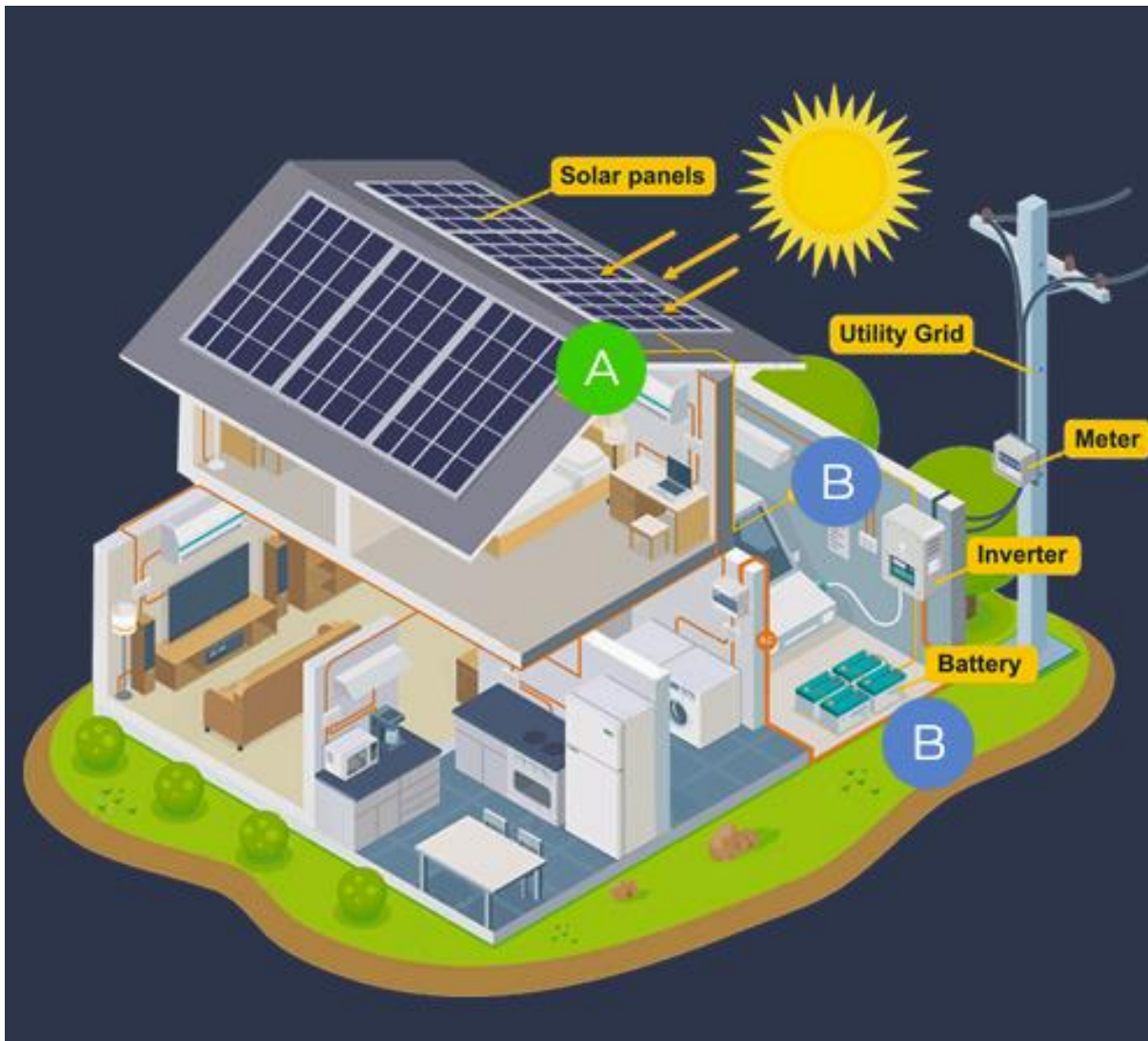
R&D and Innovation Director

Oman Cables

MEART Region, Prysmian Group

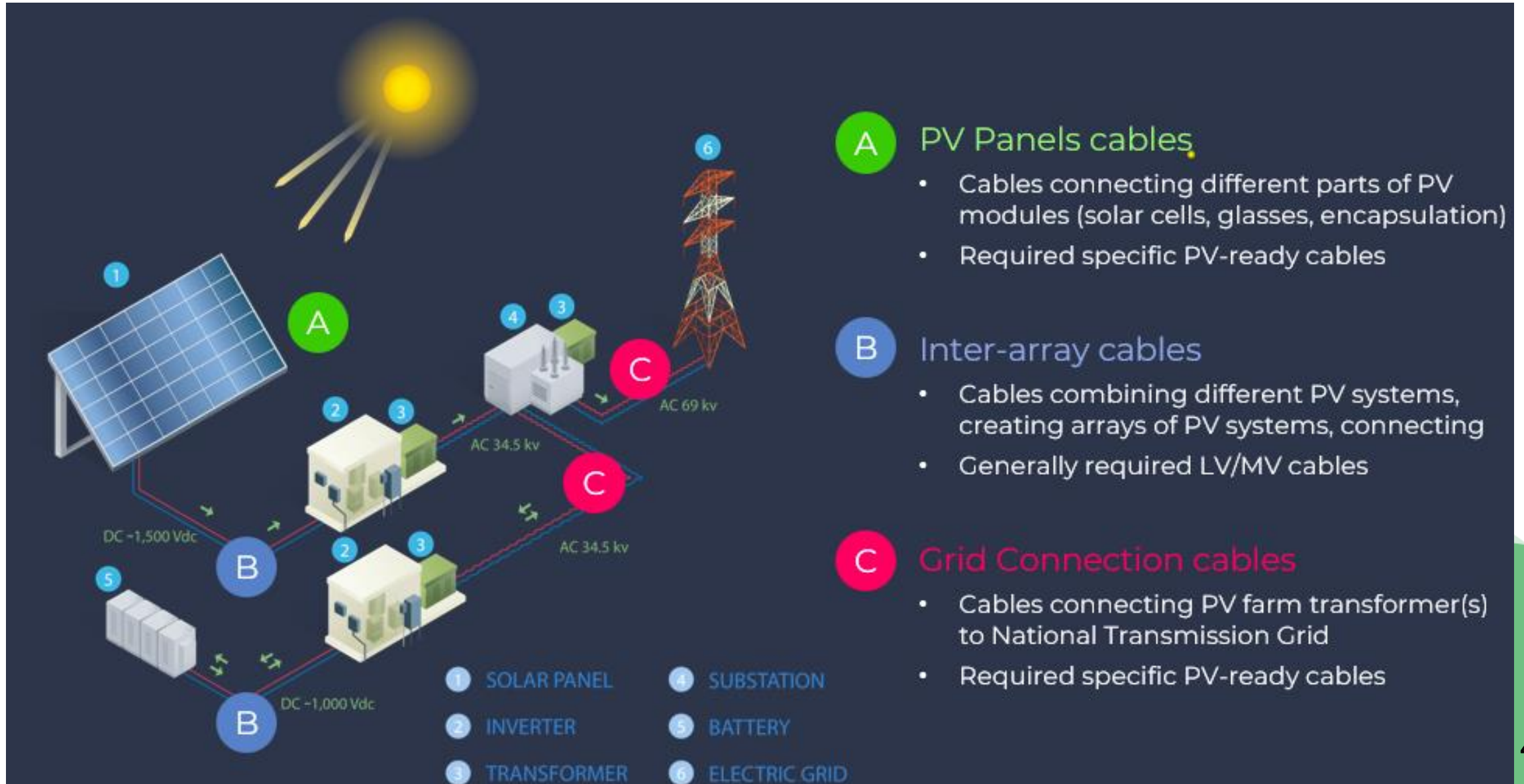


SCHEMATIC OF SOLAR PV COMPONENTS



- A** PV Panels cables
 - Cables connecting different parts of PV modules (solar cells, glasses, encapsulation)
 - Required specific PV-ready cables
- B** Panel-to-inverter cables
 - Cables connecting the PV panels together and to the inverter/batteries
 - Direct current connection to inverter

SCHEMATIC OF SOLAR PV COMPONENTS



- A PV Panels cables**
 - Cables connecting different parts of PV modules (solar cells, glasses, encapsulation)
 - Required specific PV-ready cables
- B Inter-array cables**
 - Cables combining different PV systems, creating arrays of PV systems, connecting
 - Generally required LV/MV cables
- C Grid Connection cables**
 - Cables connecting PV farm transformer(s) to National Transmission Grid
 - Required specific PV-ready cables

CABLE TYPE AND APPLICATIONS

1. **Application;** Between Panels and Panel to Junction Box
2. **Typical Size;** 1x4, 1x6 and rarely 1x10

1. **Application;** Inverter to Grid
2. **Typical Size;** 1x300,1x400,1x500 &1x630
3. **Conductor;** Aluminium
4. **Voltage Grade;** 33KV



1. **Application;** Utility Buildings
2. **Typical Size;** 1.5 to 400
3. **Cores;** 1C and Multi core
4. **Conductor;** Copper and Aluminium (bigger c/s)
5. **Voltage Grade;** 1KV

1. **Application;** Junction Box to Inverter
2. **Typical Size;** 1x185,1x240,1x300 &1x430
3. **Conductor;** Aluminium
4. **Voltage Grade;** 3KV & rarely 1KV



PHOTOVOLTAIC UTILITY SCALE PLANTS – MAIN CAUSES OF FAILURE BY COMPONENT

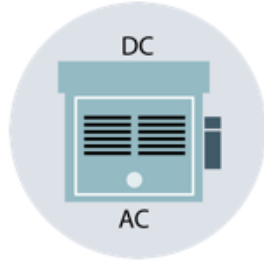


TRACKERS

- Trackers used to **increase efficiency of a module by orienting payload** toward the sun
- Being the **only movable part** of a PV plant, has the highest failure likelihood



Failure / attrition likelihood



INVERTERS

- Inverters represent another **sensitive component** of PV farm
- String generally having higher failure rate than central, with causes related to **heat, faulty installation, humidity, poor maintenance**



PANEL SOLAR

- Poor module conditions may have an impact on overall efficiency
- Main causes related to **discoloration, delamination and hotspots**
- Usually related to **poor component quality**



CABLING SYSTEM

- Cable considered **overall very reliable** over PV farm life span
- Potential failures / attrition causes coming from **soil corrosion, excessive heat, water and physical break**

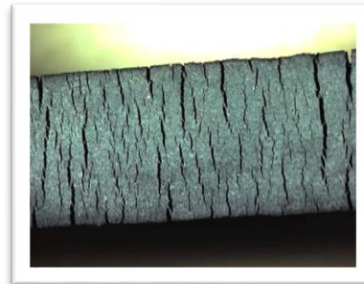


FAILURE CAUSES ON PV PLANTS

Typical Failures / Frictions of PV Farms

Main Root Causes

Component	Failure	Description	Component Quality	Assembly, Installation, Design	Weather & Climatic Events	Other External Factors
Balance of System	Damage due to water effect	<ul style="list-style-type: none"> Humidity / water, corrosion, oxidation may cause interference with electricity production, reducing overall productivity and efficiency 	✓	✓	✓	
	Other failures in conductor and sheath	<ul style="list-style-type: none"> Poor installation procedures during the laying, assembly and harnessing UV / Ozone exposure Rodents or machines damage 	✓	✓		✓
	Rated voltage increase at 1500 V	<ul style="list-style-type: none"> Higher electrical stress reduces the insulation resistance allowing leakage 	✓			



- *Original:* TÜV 2 PfG 1169/08.2007 was the reference PV cable standard until the European standard replaced it.
- *Current:* The European standard EN 50618 has been followed not only in Europe, but in most of the world for the last years in the lack of regional or international standards
- *NEW:* The international standard IEC 62930 was published at the end of 2017
- North America: UL 4703 standard is mainly required

DESIGN & CONSTRUCTION

1 CONDUCTOR

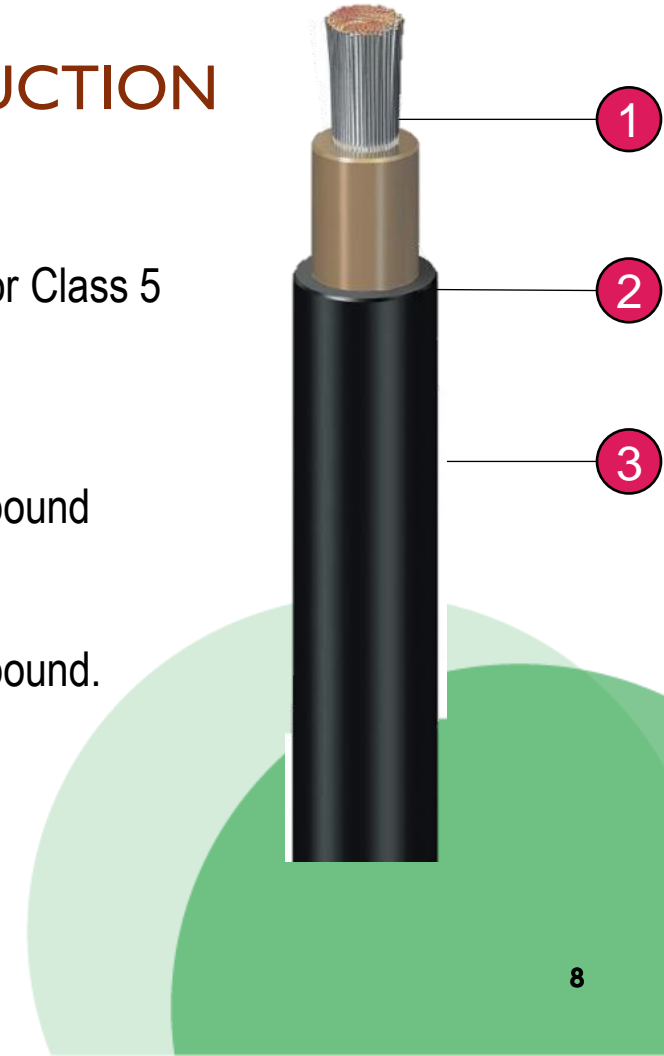
Flexible tinned copper conductor Class 5 according to IEC 60228

2 INSULATION

Halogen free cross-linked compound

3 OUTER SHEATH

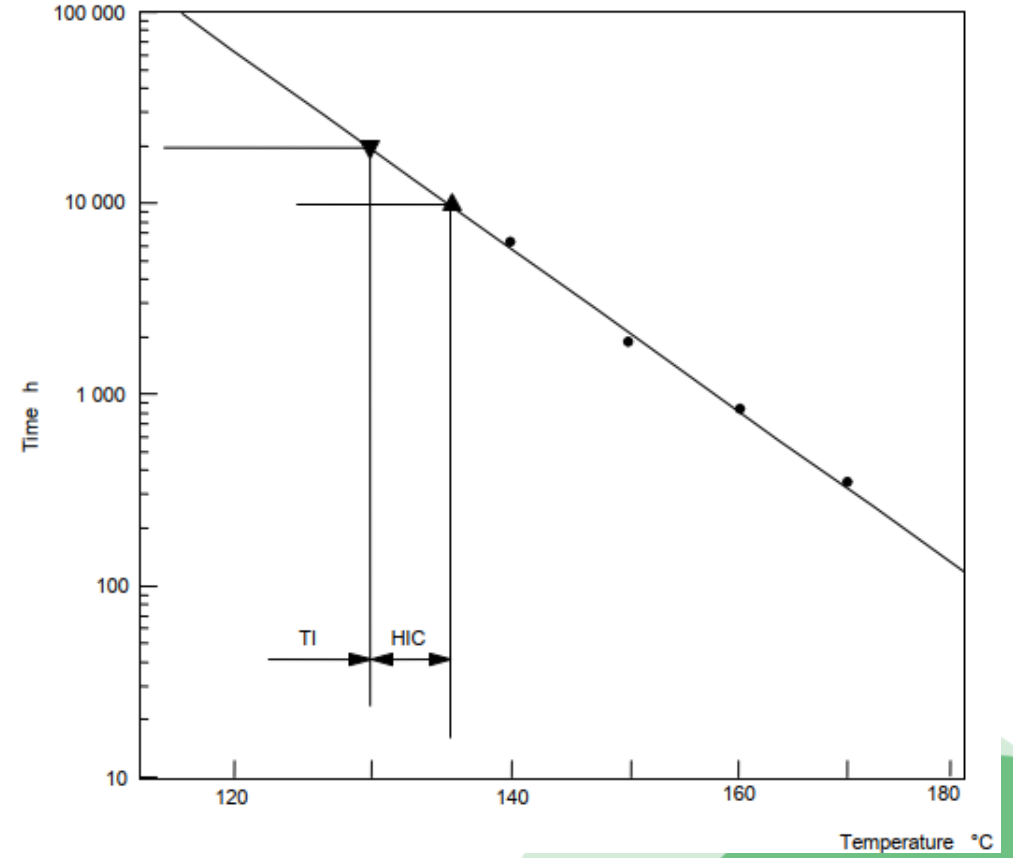
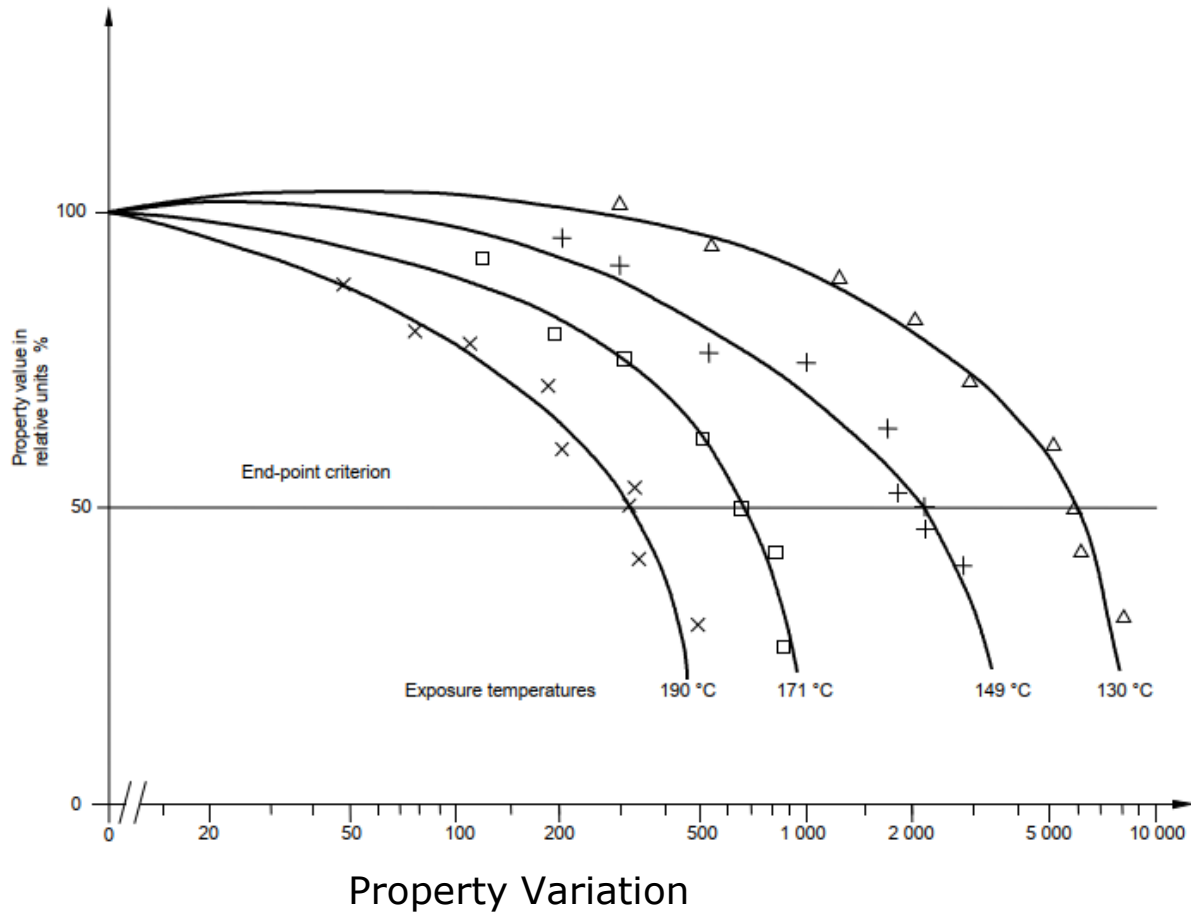
Halogen free cross-linked compound.





- Dimensional tests.
- Conductor resistance test.
- Voltage test.
- Long term resistance of insulation to DC.
- Ovality of complete cable.
- Sheath marking.
- Hot set test.
- Mechanical properties of insulation and sheath after ageing.
- Compatibility test.
- Cold Bend/Elongation
- Cold impact test.
- Sheath resistance against acid and alkaline solution.

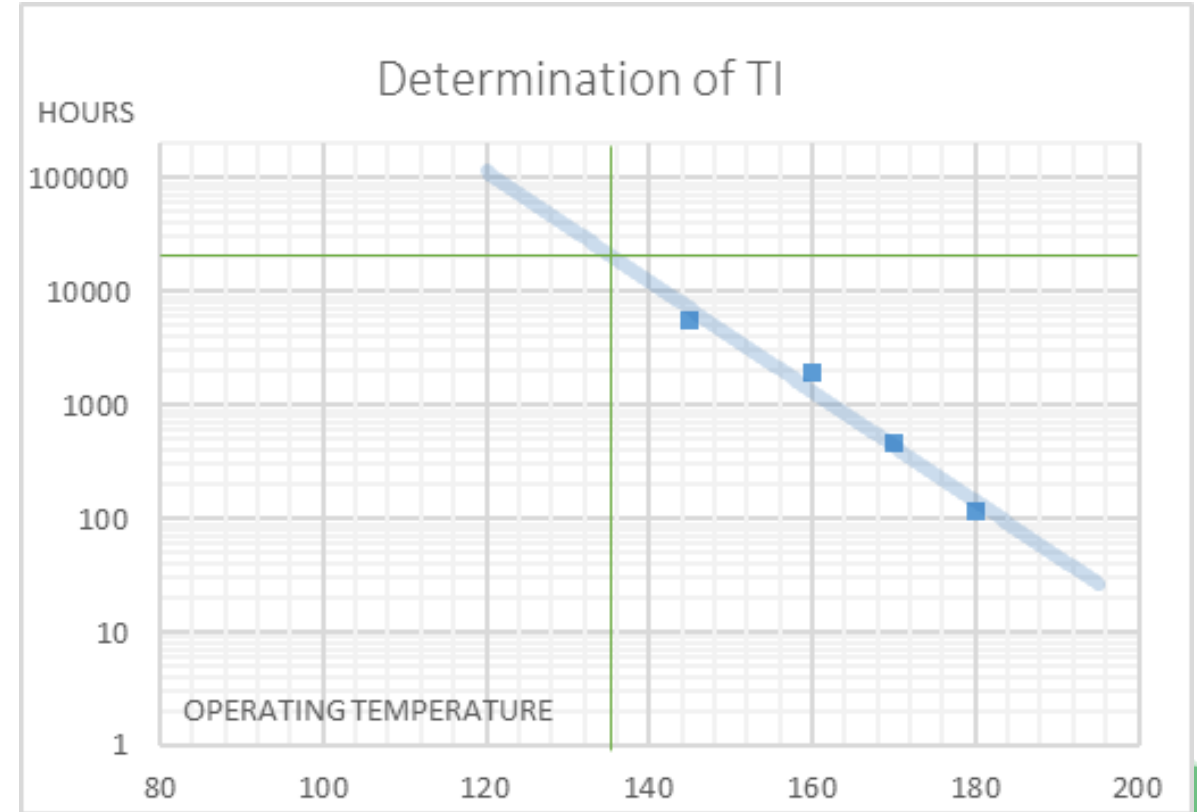
- Arrhenius or Thermal Endurance is a type test for PV cables defined in IEC 62930 and EN 50618.
- Arrhenius equation (named after its inventor Svante Arrhenius) that describes the temperature dependence of chemical reactions.
- Tests the thermal capabilities of electrical insulating materials, based on service experience.
- Plots the temperature index (TI) as a single-point characteristic based upon accelerated ageing data.
- This is the numerical value of the temperature in ° C at which the time taken for deterioration of a selected property to reach an accepted end-point is that specified (usually 20 000 h).



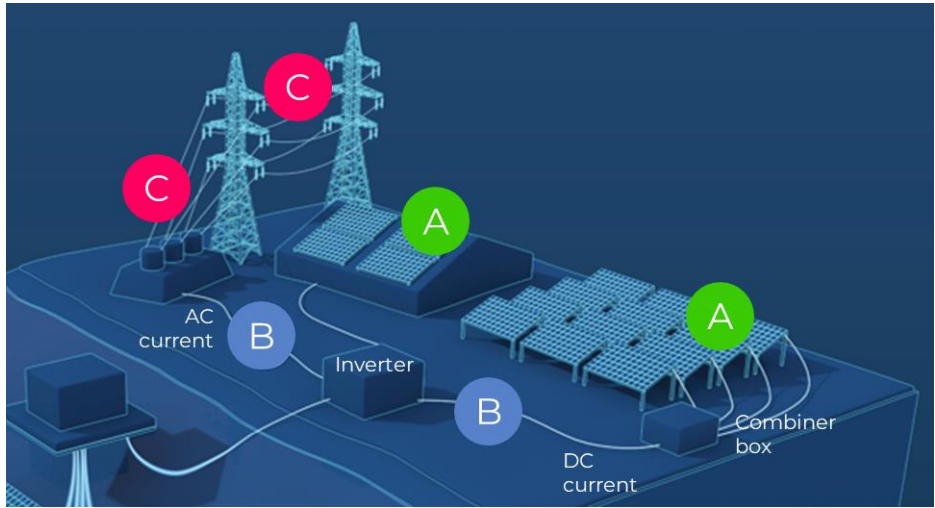
Thermal Endurance Graph

THERMAL ENDURANCE- EXTRAPLOTATION

Temperature (°C)	Temperature (K)	Time to end-point (h)
180	453.15	116
170	443.15	470
160	433.15	1885
145	418.15	5616



NEW



The Prysmian Group WET-I 1500 testing protocol is the **first in the industry to certify long term resistance in water for DC cables.**

WET-I 1500

- / Prysmian Group proprietary test for long term resistance in water up to 1500 V DC
- / Simulation of similar conditions that a cable installed in a PV plant can withstand
- / **Test parameters:**
1,800 V DC
Water @ 70 °C
1,500 cycles

AD8



- / Manufacturer self-declaration

- / No reference standards
- / Ensures that the cable can operate permanently when immersed in water
- / Designed for AC up to 450/750 V



IEC 62930 / EN 50618

- / Long term insulation resistance DC
- / AD7 (partial or total intermittent immersion)

Prysmian PRYSOLAR®

Photovoltaic PV wire H1Z2Z2-K DC solution





EXTREME CLIMATE STRENGTH

Long term immersion in water is a major cause of cable failures.

This is why we have designed a first-in-the-industry test protocol that certifies long term resistance in water for DC cables.



INCREASED OPERATION EFFICIENCY OF ASSETS

The better a cable withstands operation-critical conditions, the least likely it is to fail.

Prysmian PRYSOLAR reliability translates into **higher asset efficiency, reduced OPEX and lower Levelized Cost of Energy.**



RELIABLE RETURN ON INVESTMENT AND +30 YEARS LIFETIME

A cable with long term water resistance guarantees **reliability even in the most unpredictable events.**

Prysmian PRYSOLAR ensures +30 years lifetime.



SUSTAINABLE SUPPLY CHAIN

Prysmian PRYSOLAR production footprint with **one production hub per region ensures lead-time-efficient and sustainable product sourcing.**





OmanCables
الكابلات العمانية

THANK YOU

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