This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 792059

goPV

Oct. 28th

Corrosion resistant of tracker operating in aggressive environment

(10:00-12:00)

GLOBAL OPTIMIZATION OF INTEGRATED PHOTOVOLTAIC SYSTEM FOR LOW ELECTRICITY COST

PV TRACKER – DESIGN & CONTROL - *Convert Italia -*

General Topics	*Speaker*	*Time*
Introduction to Tracker Device for PV plant. Mono axial tracker Concept Design: performances vs reliability	*G. Demofonti*	*10 min*
Structural Design of mono axial tracker	*A. Ricci*	*20 min*
Structural Design of mono axial tracker: Wind Loads and Aerodynamic design	*A. Ricci*	*20 min*
Questions & Answers	**All**	***10 min***
Criteria for the evaluation of corrosion resistant of tracker operating in aggressive environment	***G. Demofonti***	***20 min***
Electronic control board and powering system of mono axial tracker	*A. Timidei*	*15 min*
Failure modes, Qualification of tracker and Maintenance actions	*G. Demofonti*	*15 min*
Questions & Answers	**All**	*10 min*

Evaluation of corrosion resistant of tracker operating in aggressive environment

Specific Topics:

1. Criteria for the choice of materials and coatings to be used in the manufacture of trackers in relation to the aggressiveness of the environment: ***atmosphere and soil.***

2. Available codes and guidelines.

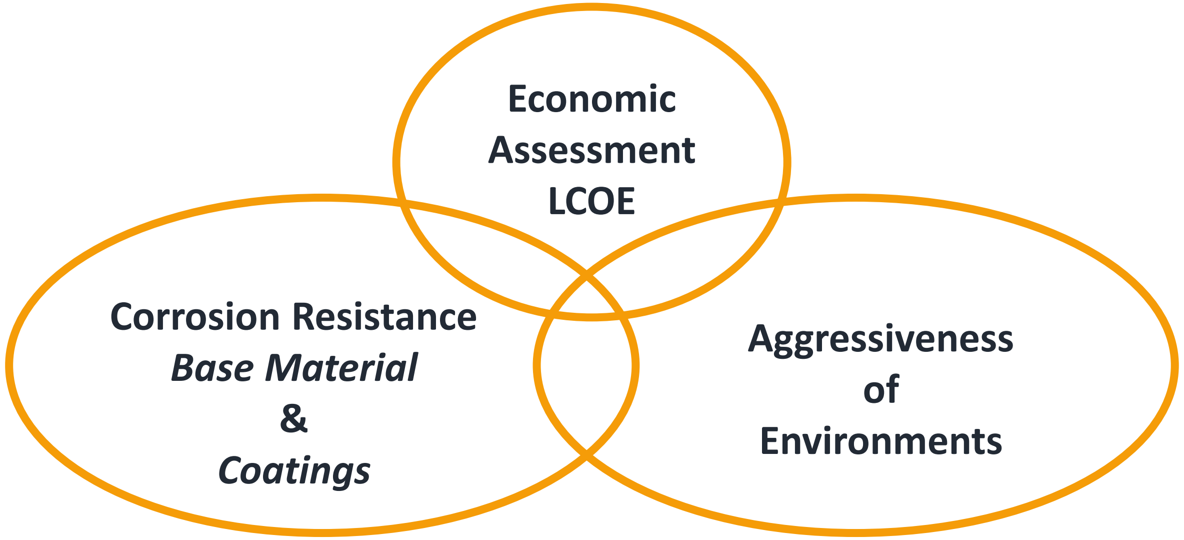
3. Presentation of solutions developed in GOPV project

Speaker:

Giuseppe Demofonti, Convert

Time: 20 minutes

Evaluation of corrosion resistant of tracker operating in aggressive environment



The input data:

- The “corrosivity class” of the atmosphere and soil: *chemical and physical investigation/study of PV plant area*
- Selection of steel and coating to use: *chemical analysis, performances, availability on the market and cost*;
- The useful life of the tracker.

Factors influencing corrosion atmosphere aggressiveness

- **Relative Humidity**: it has a negative effect when it leads to the formation of dew and condensation, as it produces the formation of the liquid film that gives rise to corrosion.
- **Precipitation:** exposure to rainwater has a generally beneficial effect, as the surface is washed from pollutants and salts.
- **Temperature:** generally an increase in temperature produces an increase in the rate of corrosion.
- **Pollutants:** the presence of pollutants (eg SO2, NOx, ...) and hygroscopic salts promote the formation of condensation on surfaces, even above the dew point. Furthermore, pollutants can acidify the water layer.
- **Aerosol particles:** composition, concentration and particle size are dependent on location, time, weather conditions, local sources, ... strongly aggressive is marine aerosols
- **Wind:** has a direct influence on corrosion as they affect the transport of particles (in particular, sand and dust, has an erosive action on the material, which produces an increase in the exposed surface, which leads to an increase in corrosion).

Atmospheric corrosivity categories: class C1, C2, C3, C4, C5, Cx

Corrosively category of the atmosphere: *ISO 9223*

CORROSIVITY CATEGORY			CORROSION RATES OF METALS for the first year of exposure – r_{corr}				
Class	Corrosivity	Outdoor – Typical examples	Unit	Carbon steel	Zinc	Copper	Alluminium
C1	Very low	Dry or cold zone, atmospheric environment with very low pollution and time of wetness, e.g. **certain deserts, Central Arctic/Antarctica**	$g/(m^2 y)$ µm/y	$r_{corr} \leq 10$ $r_{corr} \leq 1.3$	$r_{corr} \leq 0.7$ $r_{corr} \leq 0.1$	$r_{corr} \leq 0.9$ $r_{corr} \leq 0.1$	--- ---
C2	Low	Temperate zone, atmospheric environment with low pollution (SO_2 < 5 µg/m³), e.g. **rural areas, small towns dry or cold zone, atmospheric environment with short time of wetness**, e.g. deserts, subarctic area	$g/(m^2 y)$ µm/y	$10 < r_{corr} \leq 200$ $1.3 < r_{corr} \leq 25$	$0.7 < r_{corr} \leq 5$ $0.1 < r_{corr} \leq 0.7$	$0.9 < r_{corr} \leq 5$ $0.1 < r_{corr} \leq 0.6$	$r_{corr} \leq 0.6$ ---
C3	Medium	Temperate zone, atmospheric environment with medium pollution (SO_2: 5 µg/m³ to 30 µg/m³) or some effect of chlorides, e.g. **urban areas**, coastal areas with low deposition of chlorides, Subtropical and tropical zone, **atmosphere with low pollution**	$g/(m^2 y)$ µm/y	$200 < r_{corr} \leq 400$ $25 < r_{corr} \leq 50$	$5 < r_{corr} \leq 15$ $0.7 < r_{corr} \leq 2.1$	$5 < r_{corr} \leq 12$ $0.6 < r_{corr} \leq 1.3$	$0.6 < r_{corr} \leq 2$ ---
C4	High	Temperate zone, atmospheric environment with high pollution (SO_2: 30 µg/m³ to 90 µg/m³) or substantial effect of chlorides, e.g. **polluted urban areas, industrial areas, coastal areas without spray of salt water** or, exposure to strong effect of de-icing salts. Subtropical and tropical zone, atmosphere with medium pollution.	$g/(m^2 y)$ µm/y	$400 < r_{corr} \leq 650$ $50 < r_{corr} \leq 80$	$15 < r_{corr} \leq 30$ $2.1 < r_{corr} \leq 4.2$	$12 < r_{corr} \leq 25$ $1.3 < r_{corr} \leq 2.8$	$2 < r_{corr} \leq 5$ ---
C5	Very high	Temperate and subtropical zone, atmospheric environment with very high pollution (SO_2: 90 µg/m³ to 250 µg/m³) and/or significant effect of chlorides, e.g. **industrial areas, coastal areas, sheltered positions on coastline**	$g/(m^2 y)$ µm/y	$650 < r_{corr} \leq 1500$ $80 < r_{corr} \leq 200$	$30 < r_{corr} \leq 60$ $4.2 < r_{corr} \leq 8.4$	$25 < r_{corr} \leq 50$ $2.8 < r_{corr} \leq 5.6$	$5 < r_{corr} \leq 10$ ---
CX	Extreme	Subtropical and tropical zone (very high time of wetness), atmospheric environment with very high SO_2 pollution (higher than 250 µg/m³) including accompanying and production factors and/or strong effect of chlorides, e. g. **extreme industrial areas, coastal and offshore areas, occasional contact with salt spray**	$g/(m^2 y)$ µm/y	$1500 < r_{corr} \leq 5500$ $200 < r_{corr} \leq 700$	$60 < r_{corr} \leq 180$ $8.4 < r_{corr} \leq 25$	$50 < r_{corr} \leq 90$ $5.6 < r_{corr} \leq 10$	$r_{corr} > 100$ ---

Factors influencing corrosion soil aggressiveness

- **Condition of soils**: *undisturbed soils* (little oxygen, not very corrosive), *disturbed* (rich in oxygen, more corrosive), *recomposed* (similar to those undisturbed).
- **Grain size:** determines the ability to drain water, which decreases with decreasing particle size.
- **Electrical resistance**: gives indications on the soil's ability to make current flow and is a joint measure of water content and salinity. The soil resistivity is inversely proportional to the corrosion rate.
- **Redox Potential**: allows the identification of anaerobic soils, in which sulphate-reducing bacteria could be present
- **Presence or absence of corrosive substances**: ***chlorides*** are particularly dangerous, and ***sulphates***, which, although potentially harmless, can become highly corrosive in the presence of sulphate-reducing bacteria.
- **Soil pH**: acid soils are corrosive.

Soil corrosivity categories *:* class I, II, III, IV,…V

Methodologies for classifying soil aggression:

- *DIN 50929 – PART 3 Approach*
- *Eurocode 3, EN 1993-5 Approach*

Eurocode 3, EN 1993-5 Approach

Proposes a qualitative classification of the soil, focusing on corrosion loss, once the type of soil is known. Soils are classified into 5 categories, for which the amount of thickness loss with time is given.

Required design working life	5 years	25 years	50 years	75 years	100 years
Undisturbed natural soils (sand, slit, clay, schist, …)	0,00	0,30	0,60	0,90	1,20
Polluted natural soils and industrial sites	0,15	0,75	1,50	2,25	3,00
Aggressive natural soils (swamp, marsh, peat, …)	0,20	1,00	1,75	2,50	3,25
Non-compacted and non-aggressive fills (clay, schist, sand, slit..	0,18	0,70	1,20	1,70	2,20
Non-compacted and aggressive fills (ashes, slag, …)	0,50	2,00	3,25	4,50	5,75

Notes:

1) Corrosion rates in compacted fills are lower than those in non-compacted ones. In compacted fills the figures in the table should be divided into two.
2) The values given for 5 and 25 years are based on measurements, whereas the other values are extrapolated.

Methodologies for classifying soil aggression:

- *DIN 50929 – PART 3 Approach*
- *Eurocode 3, EN 1993-5 Approach*

DIN 50929 – PART 3 Approach

- DIN standard provides a methodology for classifying soil aggression: soils are classified descriptively into 4 categories.
- The method is based on a quantitative analysis of the parameters that determine soil corrosion, to which a weight Zi is associated.

	EVALUATION OF SOIL SAMPLES	weight
1	TYPE OF SOIL	Z1
2	SOIL SPECIFIC RESISTANCE	Z2
3	WATER CONTENT	Z3
4	PH VALUE	Z4
5	BUFFER CAPACITY	Z5
6	SULFIDES (S^{2-})	Z6
7	NEUTRAL SALT $c(Cl^{-})+2\,c(SO_4^{2-})$	Z7
8	SULFATES (SO_4^{2-})	Z6

	ON-SITE EVALUATION	weight
9	LOCATION OF GROUNDWATER	Z9
10	SOIL HOMOGENEITY, HORIZONTAL	Z10
11	SOIL HOMOGENEITY, VERTICAL	Z11
12	Potential between object and soil	Z12

VALUE OF RANGE B_0 E B_1	CLASS OF SOIL	SOIL AGGRESSIVENESS	UNIFORM CORROSION RATE 100 years mm/a		UNIFORM CORROSION RATE (30 years mm/a	
			Average	Range	Average	Range
≥ 0	Ia	No aggressive	0.005	0.0025–0.01	0.03	0.015 – 0.06
-1 a -4	Ib	weakly aggressive	0.01	0.005 – 0.02	0.05	0.03 – 0.12
-5 a -10	II	aggressive	0.02	0.01 – 0.04	0.2	0.1 – 0.4
< -10	III	Very aggressive	0.06	0.03 – 0.12	0.4	0.2 – 0.8

Index for homogeneous soils: $B_0 = Z_1 + Z_2 + Z_3 + Z_4 + Z_5 + Z_6 + Z_7 + Z_8 +$

Index for non-homogeneous soils: $B_1 = B_0 + Z_{10} + Z_{11}$

Corrosion Resistance:
Base Material / Coatings

Base Material of tracker : Low-alloy carbon steels, grade S235 ÷ S355, *EN 10025*

External Coating to improve the corrosion resistance:

External Coating made using zinc or zinc alloys:

- Each components of tracker are **Hot Dip Galvanized** .
- Use of pre-hot galvanized strips (**SENDZIMIR**)

Use of patinable low carbon structural steels, weathering steel: External coating generated by a compact/non-porous oxide layer due to the corrosion process of steel

Protection Mechanism

Protection by barrier effect. The coating insulates the steel from the external corrosive environment.

Cathodic or sacrifice protection. Zinc forms the anodic part in the corrosion stack and corrodes slowly, thus protecting the steel.

Protection by barrier effect. The coating insulates the steel from the external corrosive environment.

Corrosion Resistance
Base Material / Coatings for Tracker

STATE OF ART

Trackers are mainly fabricated from **Hot Dip Galvanized (HDG) steel** that has proven to present an excellent protection against corrosion and a service lifetime of 25 years.

HDG STEEL

- HDG process represents about **20% of the cost of the tracker.**
- The Hot Dip Galvanization method does **not allow to chose the specific quantity of zinc** required to protect the structure during its lifetime: the quantity of zinc cannot be less than a minimum.
- Frequently the **zinc amount is over-dimensioned** respect to the corrosion resistance required by the environment classification and the planned service-life.

NEW PROPOSAL

Alternative materials should be explored to **reduce costs**, maintaining similar or higher performance levels, and **increase lifetime up to 35 years**.

The Weathering Steel an be a technically and economical possible and promising solution

Weatering Steel: History and fields of application

- **First** weathering steel patented in 1933 by United States Steel Corporation, as Cor-Ten **-Ten**
- **Distribution:** first applications in the USA in '30, but in '60 they start to be used all over the world.
- **Main uses:** civil structures such as bridges, guard rails, architectural scopes.
- **Availability on the market:** nowadays provided by all the main steel suppliers.

Only recently W.S. is used for fabrication of PV trackers

An "Old" steel for a "New" application

Corrosion Resistance: Weatering Steel

DEFINITION

- Low-alloy carbon steels with improved resistance to atmospheric corrosion on the time
- Typical alloy elements: Cu, Cr, Ni, P, Si < 3-5% wt

PROPERTIES

- Self protection from corrosion through the formation, on exposed surfaces, of a compacted layer of oxides (patina), obstructing oxygen diffusion.
- Corrosion rate 4-5 times lower than traditional carbon steel.
- Color of the patina changes with exposure time.
- Corrosion rate dependent on the aggressiveness of environment and on the chemical composition of the steel.
- Particularly indicated for atmospheres in categories C1, C2, C3 (ISO 9223).

Corrosion in atmosphere:

- Thickness of hot galvanizing coating
- Sacrificial thickness of W.S.

ISO 9224

First 20 years of exposure a trend

$$D = r_{corr} \cdot t^{b}$$ [ISO 9224 – (2)]

After the 20 years of exposure linear trend

$$D(t>20) = r_{corr} [20^{b} + b (20^{b-1}) (t-20)]$$ [ISO 9224 – (3)]

t	*[y]*	exposure time (years)
D	*[µm or mg / m2]*	mass lost due to corrosion at time t
r_{corr}	***[µm/y or mg/(m2 y)]***	**corrosion rate of the first year function of corrosivity class of the atmosphere, *ISO 9223***
b		is the metal-environment-specific time exponent, usually less than 1.

***b* metal-environment-specific time exponent**

Steel

$$b = 0.569 + \Sigma b_i w_i$$ *ISO 9224 – (C.1)]*

b_i multiplicative coefficient for the alloy element *i*

w_i [%] fraction of the alloy element *i*

Zinc

b = 0,813 ÷0,873

Corrosion in Soil: Sacrificial thickness of W.S.

valmont Convert

Prediction of the corrosion rate of WS in soil:

- Evaluation of class of soil corrosion under examination by DIN 50929,
- Evaluation of average corrosion rate of W.S. It can be evaluated by DIN 50929 (integrated by EN 1993-5 for a life of structure < 30 years), using the specifications given for low carbon structural steels (*conservative approach*) .

INDEX OF SOIL B_0 , B_1	CLASS OF SOIL	SOIL AGGRESSIVENESS	UNIFORM CORROSION RATE 100 years mm/y		UNIFORM CORROSION RATE 30 years mm/y	
			Average	Range	Average	Range
≥ 0	Ia	No aggressive	0.005	0.0025– 0.01	0.03	0.015 – 0.06
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< -10	III	Very aggressive	0.06	0.03 – 0.12	0.4	0.2 – 0.8

Index of soil

Corrosion in Soil: Thickness of hot galvanizing coating

Prediction of the corrosion rate of hot galvanizing coatings in soil:

- Evaluation of class of soil corrosion under examination by DIN 50929,
- Evaluation of average corrosion rate of Zinc in soil can be evaluated on the base of **existing available technical know**. .

INDEX OF SOIL B_0 , B_1	CLASS OF SOIL	SOIL AGGRESSIVENESS	UNIFORM CORROSION RATE µm/year
			Average
≥ 0	Ia	No aggressive	0,6
-1 a -4	Ib	Weakly aggressive	1,25
-5 a -10	II	Medium aggressive aggressive	2,4 ÷ 3,2
< -10	III	Very aggressive	5,0

Aim and Activity in GOPV Project

Aim:
Improving existing know how for predict the corrosion behavior of Weathering Steel in specific environment, in order to reduction of the LCOE of the PV plant by decreasing tracker cost and extending its service lifetime up to 35 years.

On the basis of both the knowledge available in the literature and the international standards , **analytical procedures for W.S. application** have been developed , in order to achieve:

- an **easy classification of the environment aggressiveness** (atmosphere and soil),
- a reliable **evaluation of sacrificial extra-thickness** for tracker cross sections when weathering steel is used

A **long-term corrosion test program** is in progress to improve the corrosion assessment procedures on weathering steel structures:

- Mechanical connections and bolts and possible use of hot galvanized bolts,
- Prediction of the corrosion rate of Weathering Steel in soil,
- Connection between Weathering Steel and Hot galvanized steel
- Synergy between zinc-coating and WS

Testing in progress in "Tuscania Lab"

PV TRACKER – DESIGN & CONTROL - *Convert Italia -*

General Topics	*Speaker*	*Time*
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PV Tracker – Design and Control

CONTROL and POWERING SYSTEM

(10:00-12:00)

GLOBAL OPTIMIZATION OF INTEGRATED PHOTOVOLTAIC SYSTEM FOR LOW ELECTRICITY COST

Control & Powering Systems of mono axial tracker

Specific Topics:

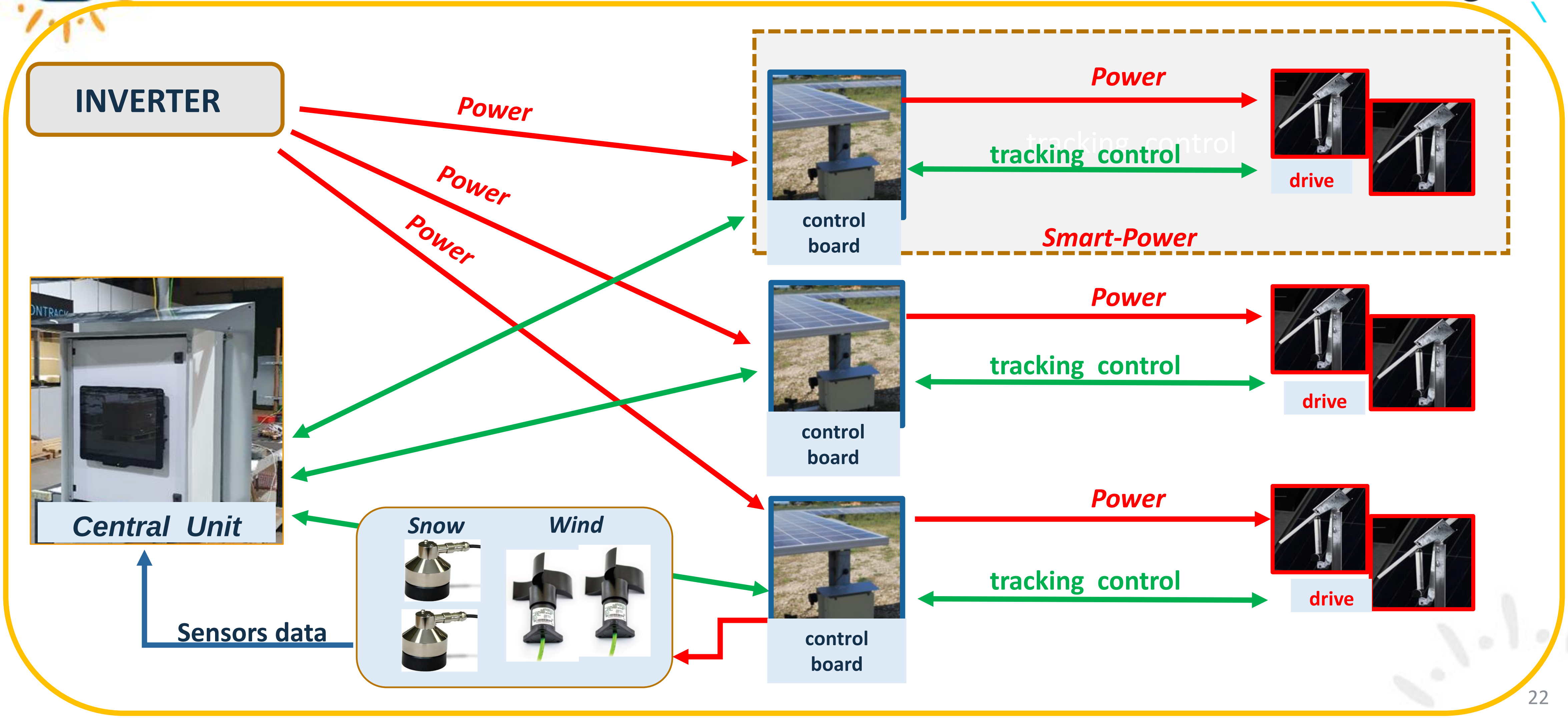
1. *Powering System*
2. *Tracking Control*
3. *Supervisory control and data acquisition (SCADA)*

Speaker:

Antonio Timidei and G.Demofonti, Convert

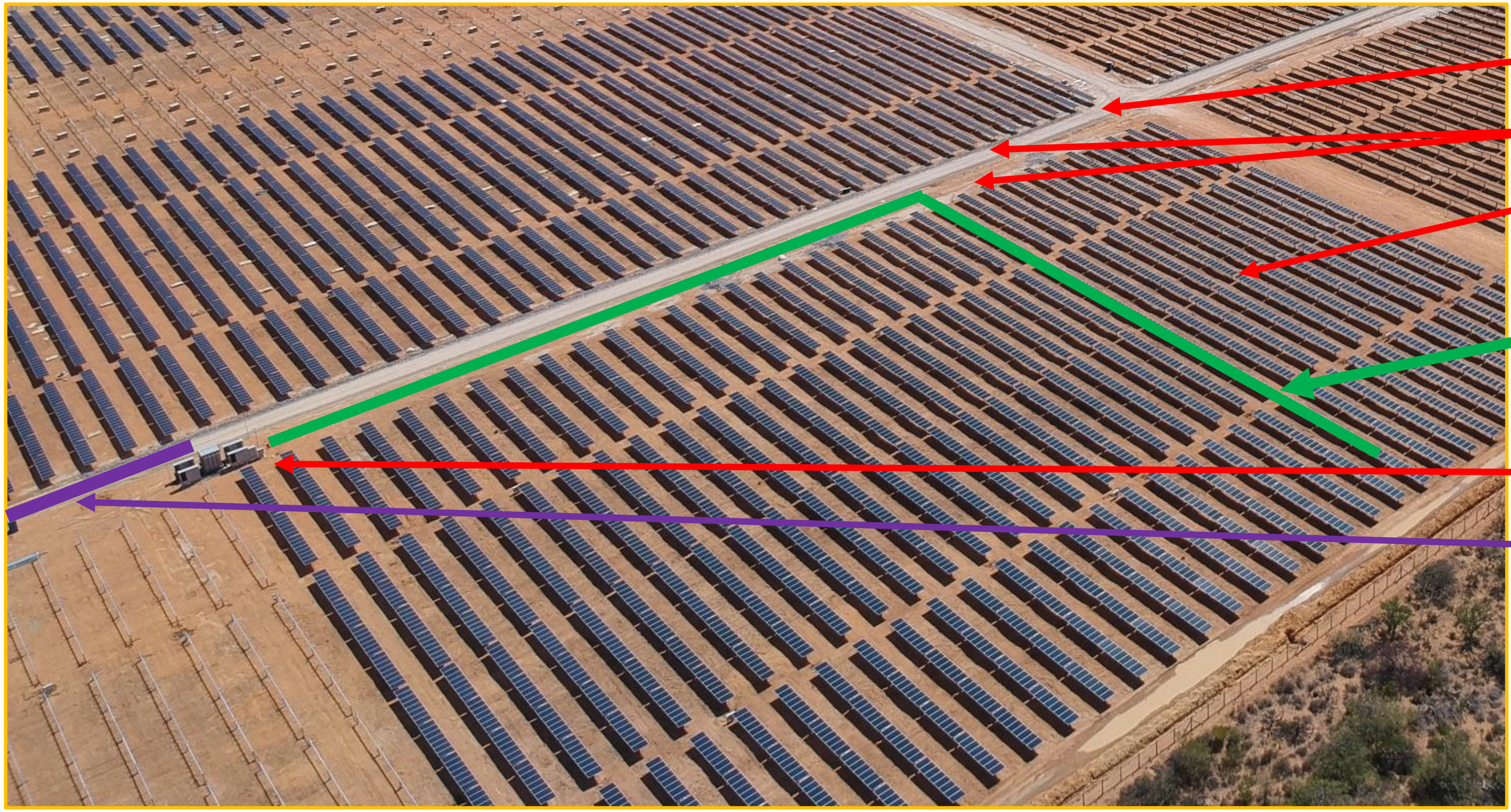
***Time*: 15** minutes

Control & Powering Systems of mono axial tracker: *Base lay-out*



Control & Powering Systems of mono axial tracker: *Base lay-out*

PV Utility Scale Plant layout



Control & Powering Systems of mono axial tracker: *Base lay-out*

PV Utility Scale Plant

The trenches are very expensive

PV cables

Service road cable path

Control & Powering Systems of mono axial tracker

Base Knowledge

Depending on plant configuration and dimension mainly exists different solutions:

- Wired *vs* Wireless configuration for the communication system,
- Distributed or centralized inverter for the energy production/supply,
- Centralized and/or distributed control system

Depending on PV-plant dimensions and specifications, *in order to reduce LCOE*,
there is an optimal solution for each of possible configurations.

Control & Powering Systems of mono axial tracker: *GOPV Project*

In today's presentation some possible solutions are shown, but they are not all those possible: the presentation makes reference to solutions studied and developed **within the GOPV project**.

GOPV Specific Issues:

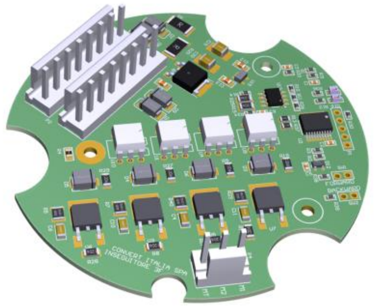
- Improve *Wired Communication Control Board and Drive* to reduce the length of cables
- Develop a "new" *Tracker Wireless Control System*: SCADA 2° level
- Improve a *Self-Power System* to supply locally and independently groups of trackers

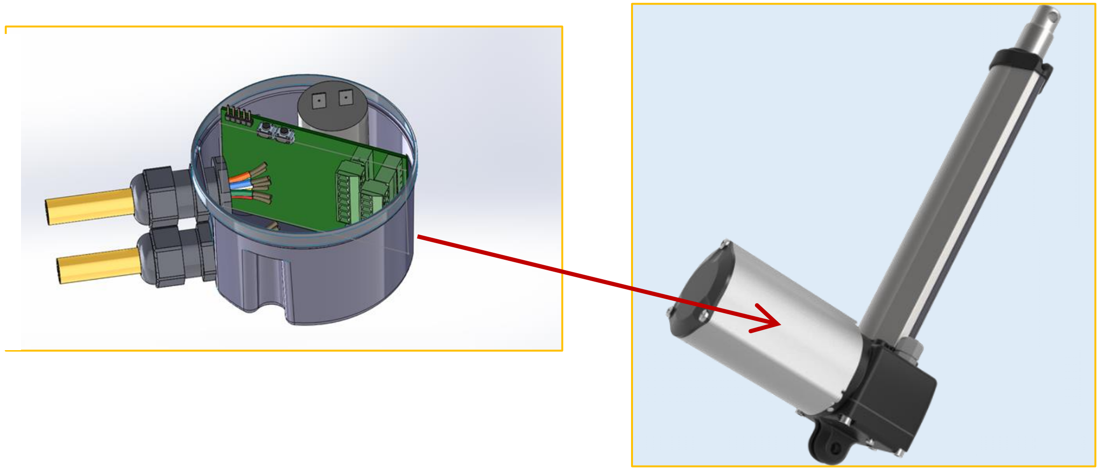
Control & Powering Systems of mono axial tracker: *GOPV Project*

Wired Communication Control Board and Drive:

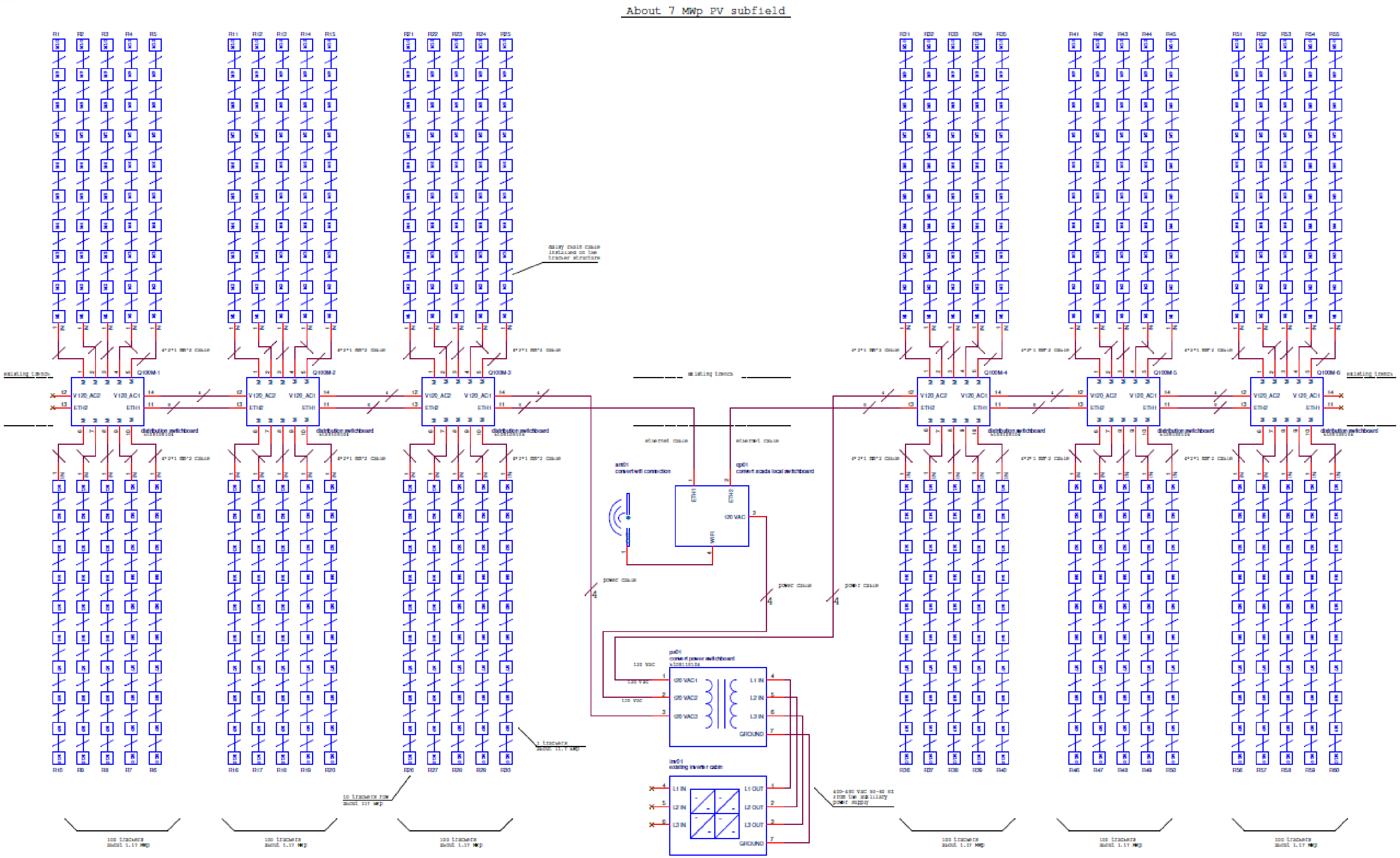
GOPV Project solution cost-reduction proposal consist in:

- ➢ Move the control system directly inside the actuator → reducing dimension of control boards (backside shadows redaction)
- ➢ Set cabling in a Daisy Chain configuration → to reduce cabling length





100M System



Control & Powering Systems of mono axial tracker: *GOPV Project*

A new Tracker Wireless Control System: SCADA 2° level

In-put for the design:

- A modular device able to manage PV field units up 5 MW.
- Possibility of being applied in a modular way to PV fields of greater dimensions by local switchboards.
- Low impact device on the LCOE.

Control/Management Parameters

Wind: *by wind sensor*	→	Safety Position for wind
Snow: by snow sensor	→	Safety Position for snow
Drive monitoring: *by check on encoder*	→	Warning
Clock monitoring /tracking control	→	Warning

Control & Powering Systems of mono axial tracker: *GOPV Project*

Wind strategy

- Wind speed and direction are measured sensors placed at strategic positions of PV plant
- If safety thresholds are exceeded, trackers are put in planned *Safety Position for Wind*

Snow strategy

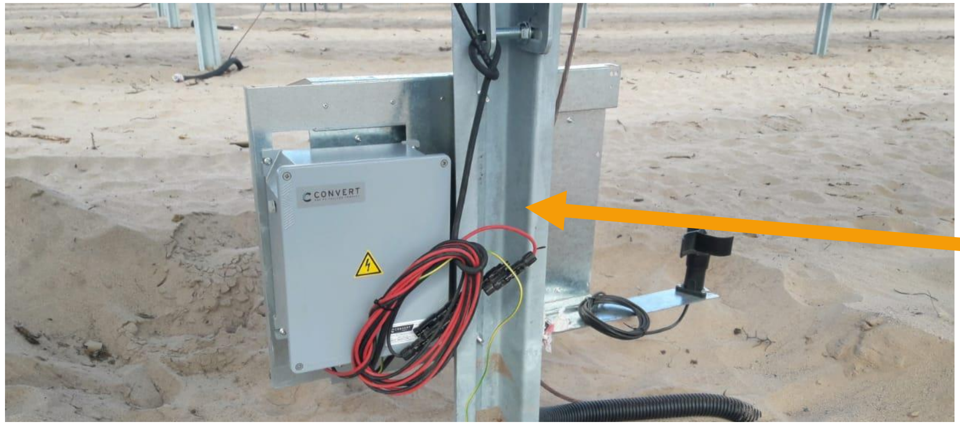
- Snow accumulation is measured using sensor placed at strategic positions of PV plant,
- If safety thresholds are exceeded, trackers are put in planned *Safety Position for Snow*

Plant design

- Each PV-plant can be subdivided into several zones,
- Each zone can have different parametric values for triggering the wind and snow mode,
- Each single Control Board can be represent a different zone

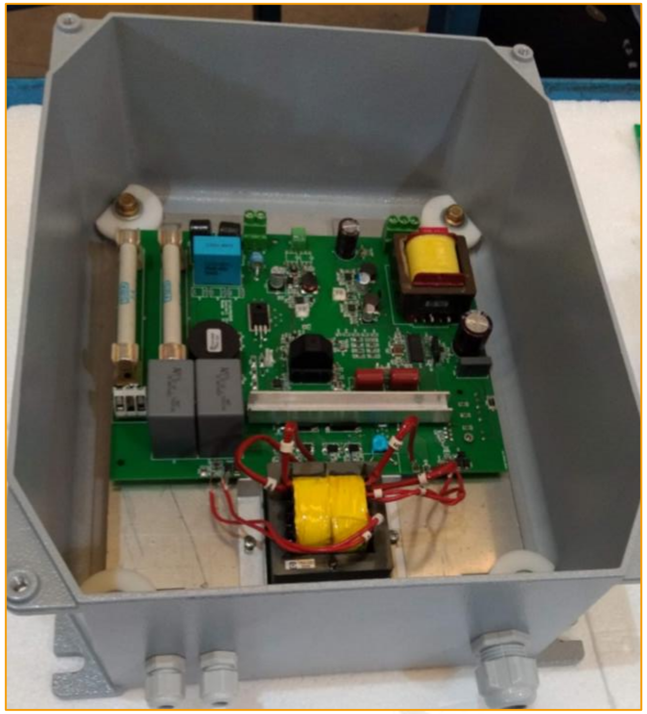
Control & Powering Systems of mono axial tracker: *GOPV Project*

Improve a ***Self power solution* to supply** locally and independently groups of trackers



Tracker controller to be powered

Self power box that provide power from the local string



The Self Power

- It is a power convert that transforms the DC voltage input from the PV plant (500V ÷ 1500V) in an AC voltage (220V - 50Hz) to supply the tracker system
- The self power system allows to power supply the solar tracker without additional power cables inside PV plants.
- This system helps to reduce the PV plants costs.

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Failure Modes, Tracker Qualification, Maintenance

(10:00-12:00)

GLOBAL OPTIMIZATION OF INTEGRATED PHOTOVOLTAIC SYSTEM FOR LOW ELECTRICITY COST

Failure Modes, Tracker Qualification and Maintenance

Specific Topics:

1. Main tracker Failures
2. Qualification procedures to evaluate the tracker performances.
3. Maintenance actions

Speaker:

Giuseppe Demofonti, Convert

***Time*: 15** minutes

Main tracker Failures

Failure mode	Potential causes	Effect	Duration	detection	Repair time	Probability	Severity
Failure of structural components of tracker	Most frequent cause Wind speed higher of design limit. Catastrophic events related to climate change	PV string can be not aligned with the optimized orientation of tracker. In catastrophic case full structural resistance of tracker may be damaged	Temporary, during extreme wind conditions persistence	Immediate	From few hour to days. Depending on the severity of the failure and how many trackers are involved.	Low probability if the wind hazard assessment has been correctly carried out.	For not catastrophic event there is a lower current/power generation than expected, minor for bifacial PV modules.
Failure of driving devices: electric motor, mechanical components, bearings.	Incorrect electric or mechanical assembly of actuator. Incorrect service conditions: accidental stress. Early “infant mortality” failure	Single tracker is failure. Reduction of production is associated to nominal peak power of a tracker.	Maintenance procedure: components failure replacement	Immediate by SCADA	One hour, starting from availability of new actuator and maintenance structure.	1% for year. GOPV project:1 failure /Mw/year . Maximum average value for first five years of work.	There is a lower current/power generation than expected, minor for bifacial PV modules.
Failure of electronic control boards and connection cables.	Non correct electric or mechanical assembly of electronic box Incorrect service conditions electronic box. Early “infant mortality” failure	Max ten trackers could be involved in the failure. Maxima reduction of production is associated to the peak power of ten trackers,	Maintenance procedure: electronic control board replacement	Immediate by SCADA	One hour, starting from availability of new components and maintenance structure.	0,4% for year: 0,4 failure for Mw/year. Maximum average value for first five years of work.	There is a lower current/power generation than expected, minor for bifacial PV modules
Corrosion of steel structural components	Change over time of the corrosive aggressiveness of environment. External accidental damage	Not immediate effect in the short to medium period. Possible effect on the total lifetime of the tracker	Persistent until the repair of the coating	During periodic inspection	From few hour to days. Depending on the severity of the failure and how many trackers are involved.	Low probability if corrosive aggressiveness of environment has been correctly carried out.	Not redaction of current/power generation than expected, in the short to medium period

***Table makes reference to solutions studied and developed within the GOPV project*.**

Qualification procedures to evaluate the tracker performances

Main Code: **ISO EN 62817, Photovoltaic systems - Design qualification of solar trackers**

Scope and object

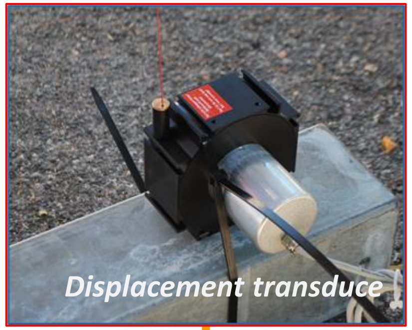
1. *"This international Standard is a design qualification standard applicable to solar trackers for photovoltaic systems, but may be used for trackers in other solar applications."*
2. *"The standard defines test procedures for both key components (as electronic and powering devices) and for the complete tracker system."*
3. *"In some cases, test procedures describe methods to measure and/or calculate the parameters to be reported in the defined tracker specification sheet".*
4. *"In other cases, the test procedure results in a pass/fail criterion".*

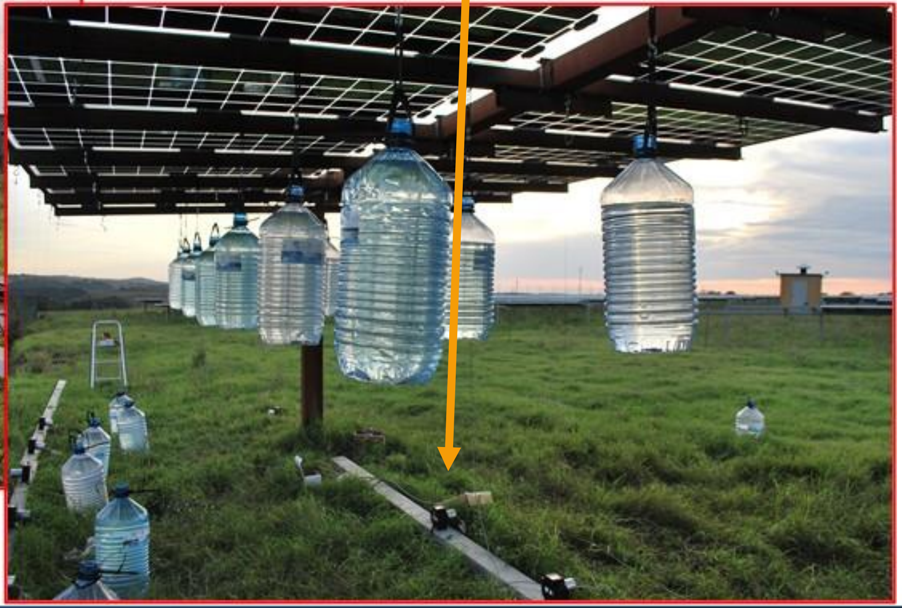
Outdoor testing

ISO EN 62817, Photovoltaic systems - Design qualification of solar trackers

- **Structural tests and analysis of deformation** of the structure during the load application.
- **Accelerated mechanical cycling**: to induce failures or infant mortality associated with design that may occur as a result of accelerated cycling on the drive system, control board and wiring
- **Accuracy of the tracker pointing**
- **Functional of tracker validation tests** to assure the functionality of tracker in the range of service loads fixed in the design of tracker: *Tracking limits verification; Automatic sun tracking after power outage; Emergency stop; Wind Stow*

Evaluate the tracker performances : *Out Door Tests in Tuscania*





Measuring sensors:

- ***Displacement transduce***
- ***Inclinometer***

Evaluate the tracker performances : *Out Door Tests in Tuscania*

Torsional stiffness

Indoor testing

ISO EN 62817: ***Environmental testing of fully functional drive train.***

Scope: to induce failures associated with design that may occur as a result of an accelerated environmental cycling of the **drive system**, **control system**, and **associated wiring** in a wide range of environmental conditions.

Procedure:

- fully functional drive train shall be mounted for operation in an **environmental chamber**.
- a **typical duty cycle shall be repeatedly applied to the drive train** while under environmental cycling and with in the manufacturer-specified operational temperature range.

Indoor testing

ISO EN 62817: ***Test on tracker electronic and powering equipment*.**

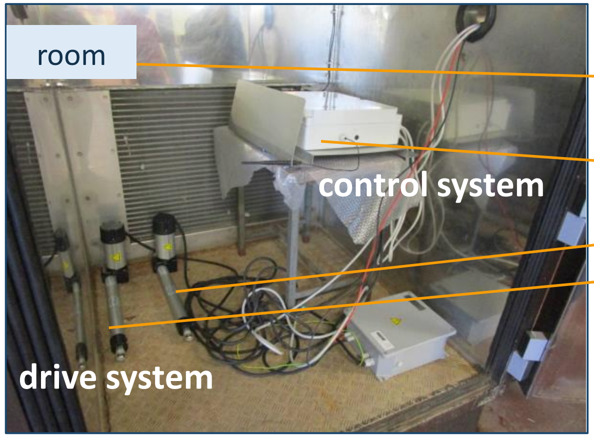
Scope: *“The following tests are specifically designed to uncover early failures associated with the tracker's electronic components system (ECS). The ECS consists of control electronics , power supplies, sensors, encoders, and enclosures, but does not include drive components such as motors, […] or equipment that is generally under a mechanical classification”*

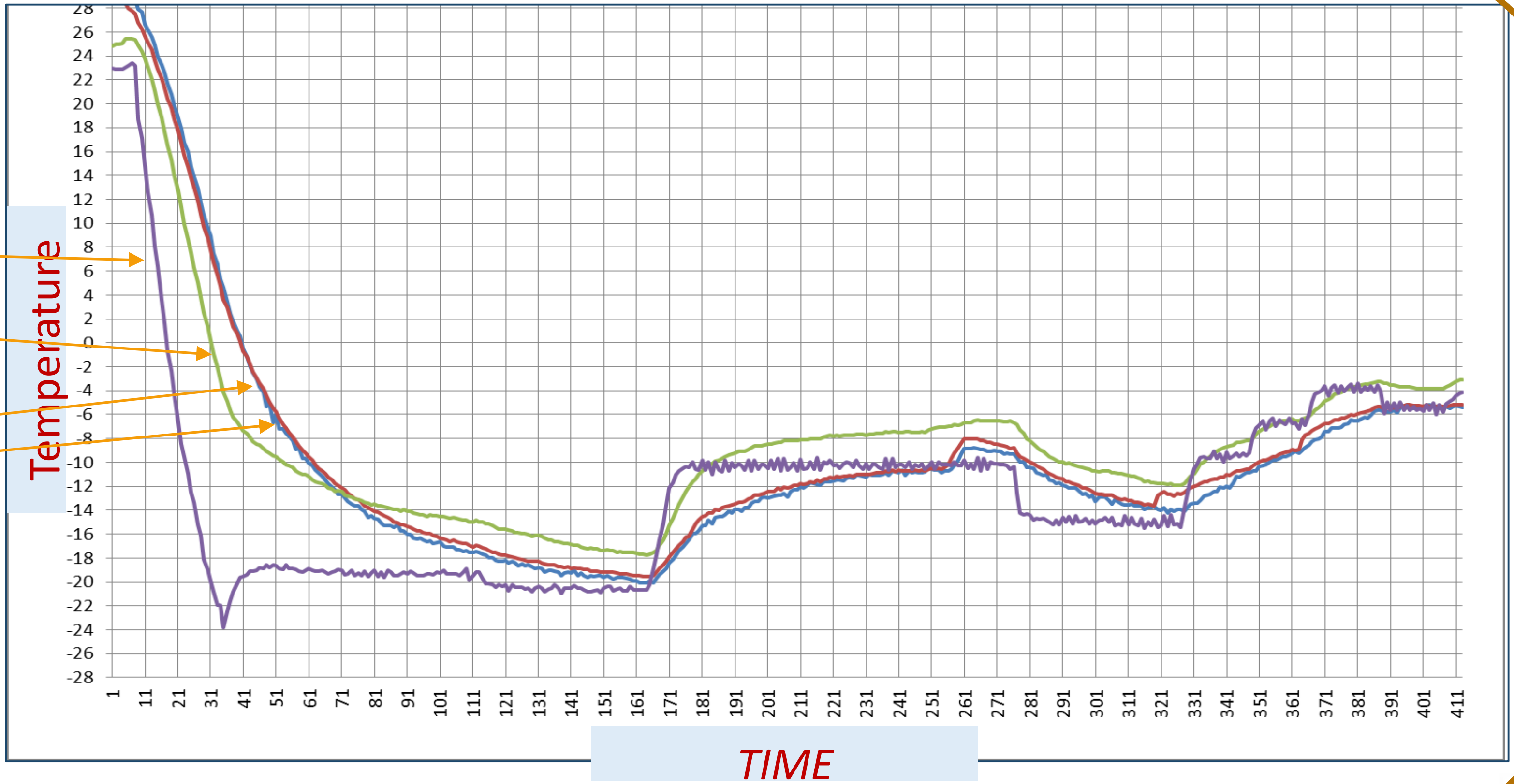
Procedure:

- fully functional ECS shall be mounted for operation in an **environmental chamber**.
- a **typical duty cycles shall be repeatedly applied to the ECS, as:** Thermal cycles, Humidity cycles, UV test,….

Qualification procedures to evaluate the tracker performances

Indoor testing





- Correct behaviour of *Control System and Driving Device* up to – 20 °C.
- Need a correct grease selection for driving device when temperatures is below -20°C

Maintenance Actions

Main Maintenance activities (*)

- Tracker ordinary maintenance activities have the purpose of keeping the PV-plant functioning correctly, preventing possible failures and / or issues.

- Maintenance activates are described into the "*O&M Plan*" which is one of the tracker documents.

- Maintenance activates to be performed during plant lifetime:
  - ✓ **Mechanical structures/component inspections,**
  - ✓ Maintenance of **electrical** connections

(*) referring to solutions studied and developed within the GOPV project.

Maintenance Actions

Mechanical structures/components, Main inspections topics:

- **Corrosion issues**: Inspection of all steel parts to identify any possible signs of corrosion, due to impacts, metal slags or other pollutants *(depending on site aggressiveness scheduled at different times);*
- **Bolts tightening:** Control that at least the main bolts connections are all well tighten *(scheduled every 1-2 years),*
- **Tracker alignment:** through a visual inspection, verify the tracker correct alignment. The non-aligned point could be in correspondence of each pile due to bolt loosing tight and/or posts/foundation "failure" *(scheduled every year)*

Maintenance Actions

Maintenance of Electrical Connections, Main inspections topics

To perform **every year**:

- ✓ **Checking the electrical boxes:** covers closure, structural integrity of box and cable glands
- ✓ **Checking the grounding system** of the tracker structure (central foundation pile)

To perform every **2 years**:

- ✓ Checking the **tightening of the connector** screws of the control board,
- ✓ Checking the correct **position of the connectors** (*the weight of the cables must not load connectors*).

GLOBAL OPTIMIZATION OF INTEGRATED PHOTOVOLTAIC SYSTEM FOR LOW ELECTRICITY COST

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Thank you for your attention.

Please Questions !

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