GEOTECHNICAL SURVEYING AND SOIL TESTING FOR SOLAR PROJECTS (PV)

Geology and Energy Transition
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TECSOL geo

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TECSOLGEO LTD

CONTENTS:

1. ***TECSOLGEO, COMPANY, HISTORY***
2. ***SOLAR PV INSTALLED EVOLUTION***
3. ***SCOPE OF WORKS GEOTECHNICAL AND ELECTRICAL/THERMAL - RESISTIVITY SURVEY. WHEN? WHY? ADVANTAGES***
4. ***GEOTECHNICAL SURVEY – GEOTECHNICAL SURVEY FOR SOLAR FARMS***
5. ***EQUIPMENTS AND SOIL TESTING DEVICES:***

   Dynamic Penetration Super Heavy (DPSH)

   Boreholes (Drilled or Driven)

   Dynamic Penetrometer Test – Panda Equipment (penetration and compactation)

   Soil sampling and Lab testing

   DCP – CBR In situ Testing

   Electrical Tomography – Landfill Investigation / Resistivity Testing – Wener Array

   RHO Thermal Resistivity

   Others: Trial Pits, Corrosivity Tests, Plate Bearing Tests, GPR, …

TECSOLGEO LTD - HISTORY

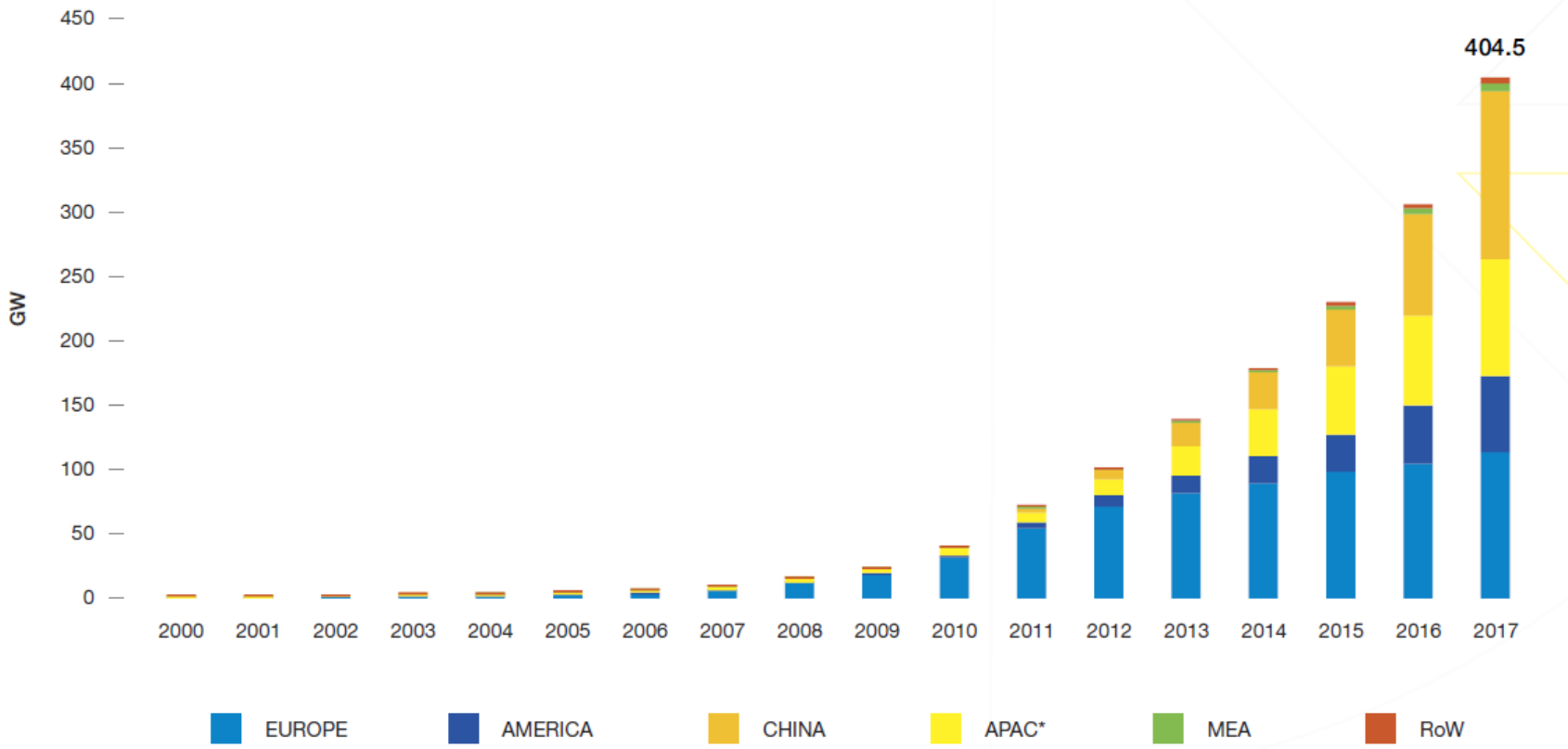
- *TECSOLGEO LTD, FOUNDED IN BARCELONA IN 1999*
- *TECSOLGEO IS OPERATING IN EU and WORLWIDE FROM 2008*
- *WORLDWIDE EXPERIENCE (Spain, Portugal, Panam, Netherland, Uk, Ireland, Perú, Argentina, Xile, Mexico, Panamà, Caribean, …)*
- *OWN EQUIPMENTS , FACILITIES AND TEAM.*
- *MULTIDISCIPLINARY TEAM (GEOLOGISTS, GEOTECHNICS, SURVEYORS, ENGINEERS,..)*
- *WIDE EXPERIENCE IN SOIL INVESTIGATION (Geotechnical, soil/water contamination)*
- *MORE THAN 350 GEOTECHNICAL SURVEYS IN PV SOLAR FROM 2012 - BIG SITES*

Intipampa, Perú – 40 MW

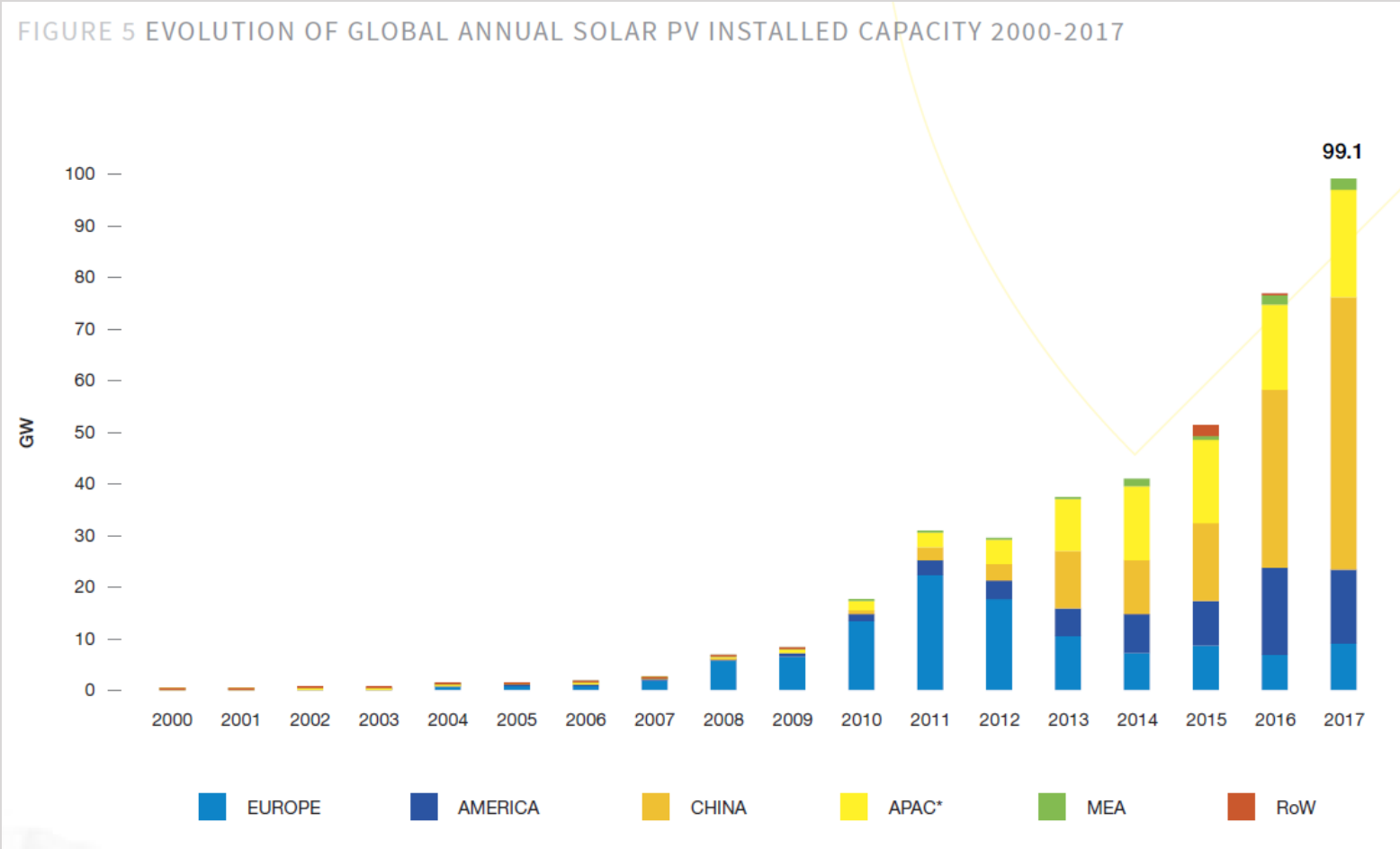
Our biggest Project is located in Argentina – 250 Mw (aprox. 450 Ha)

SOLAR PV INSTALLED EVOLUTION

FIGURE 6 EVOLUTION OF GLOBAL TOTAL SOLAR PV INSTALLED CAPACITY 2000-2017

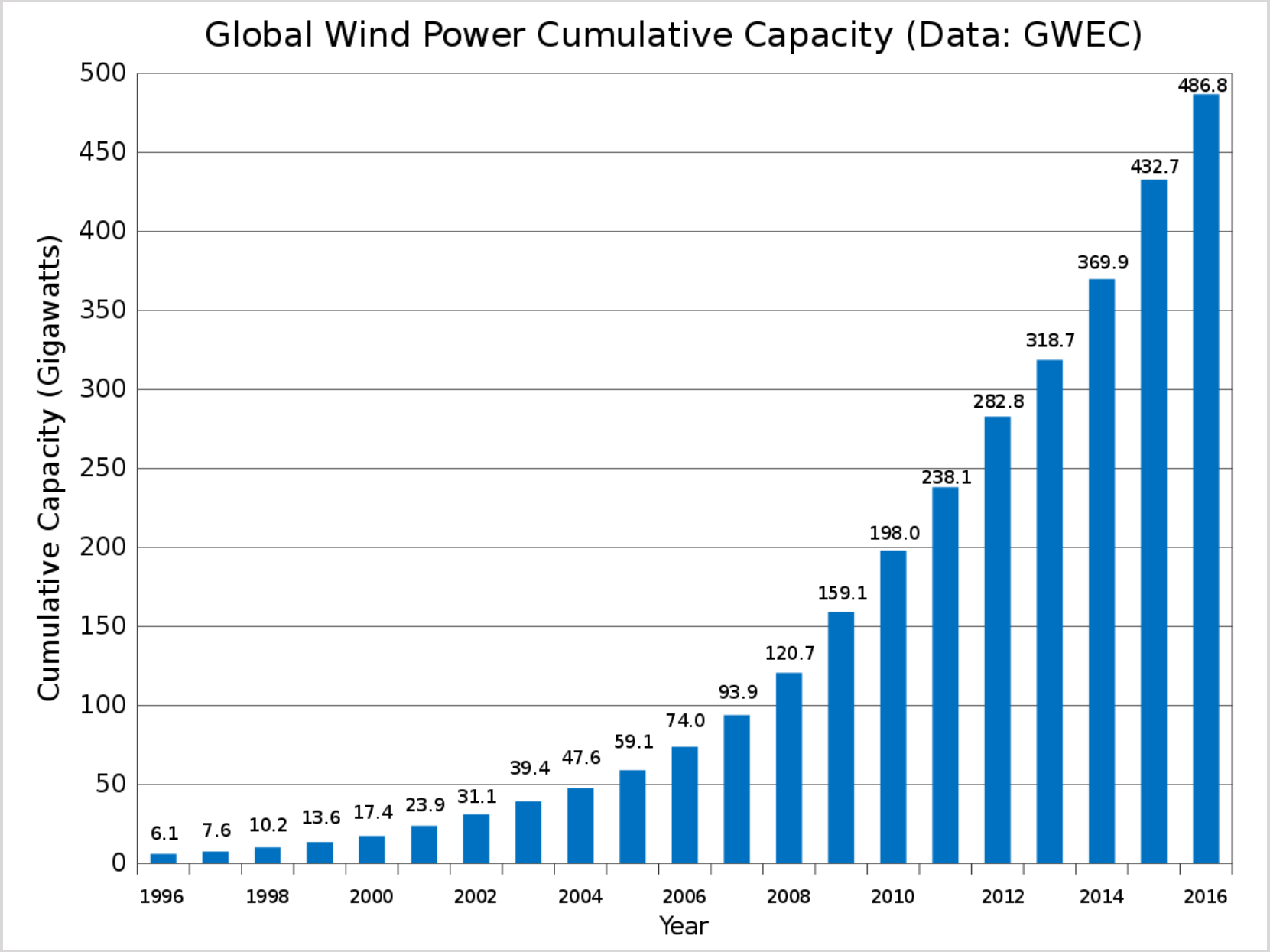


SOLAR PV INSTALLED EVOLUTION



Big and growing market

WIND INSTALLED EVOLUTION

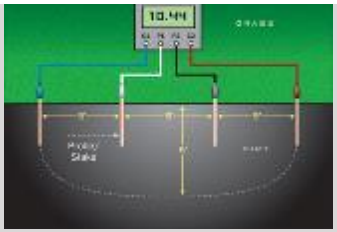
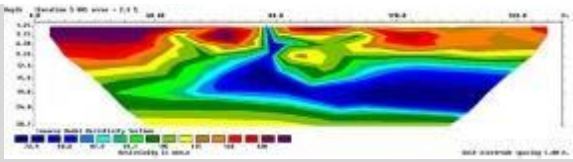


SOLAR PV – SCOPE OF WORKS




S=Surface 1 Ha = 2,47 ac	Penetration test	Trial Pit	Soil Sample	CBR	SEV
0-14 Ha	1,3 Test/Ha (min. 10	0,50 Test/Ha (min. 5)	0,35 Test/Ha (min. 3)	0,50 Test/Ha (min. 6)	0,30 Test/Ha (min. 3)
15-30 Ha	1,1 Test/Ha	0,40 Test/Ha	0,30 Test/Ha	0,40 Test/Ha	0,20 Test/Ha
31-50 ac	0,9 Test/Ha	0,30 Test/Ha	0,25 Test/Ha	0,35 Test/Ha	0,15 Test/Ha
50-100	0,7 Test/Ha	0,25 Test/Ha	0,30 Test/Ha	0,30 Test/Ha	0,15 Test/Ha
>100	0,45 Test/Ha	0,15 Test/Ha	0,18 Test/Ha	0,30 Test/Ha	0,12 Test/Ha
>250	0,35 Test/Ha	0,13 Test/Ha	0,15 Test/Ha	0,25 Test/Ha	0,10 Test/Ha
>400	0,28 Test/Ha	0,12 Test/Ha	0,12 Test/Ha	0,20 Test/Ha	0,08 Test/Ha
>600	0,25 Test/Ha	0,11 Test/Ha	0,10 Test/Ha	0,18 Test/Ha	0,07 Test/Ha



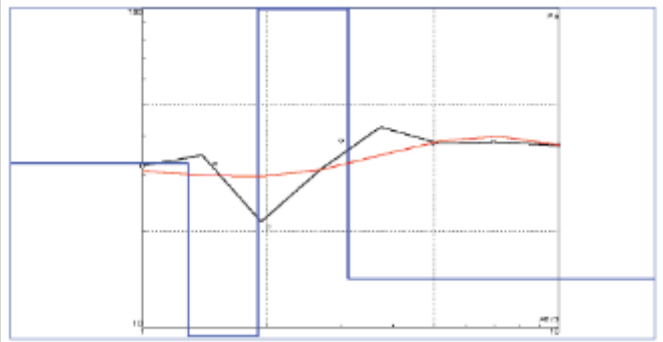



GEOTECHNICAL SURVEY.. WHEN?.. WHY??

CARRIED OUT IN THE RIGHT MOMENT WILL LET SAVE MONEY
BAD GEOTECHNICAL CONTEXT MAY KILL THE PROJECT: ROCK, SOFT SOIL, LANDFILL..
BAD GEOLECTRICAL CONTEXT MAY KILL THE PROJECT: COLD/HOT SITE

GEOTECHNICAL SURVEY INVEST: TIME-AND-MONEY SAVING MATTER

GEOTECHNICAL + ELECTRICAL/THERMAL RESISTIVITY SURVEY → MEAN LESS THAN 0.08 % TOTAL PROJECT



GEOTECHNICAL SURVEY

GEOTECHNICAL SURVEY INVEST: TIME-AND-MONEY SAVING MATTER

ROCK PRESENCE → PREDRILL : POOR PERFORMANCE → LOSS MONEY → MORE TIME

CAN BE EXPECTED WITH THE GEOTECHNICAL SURVEY

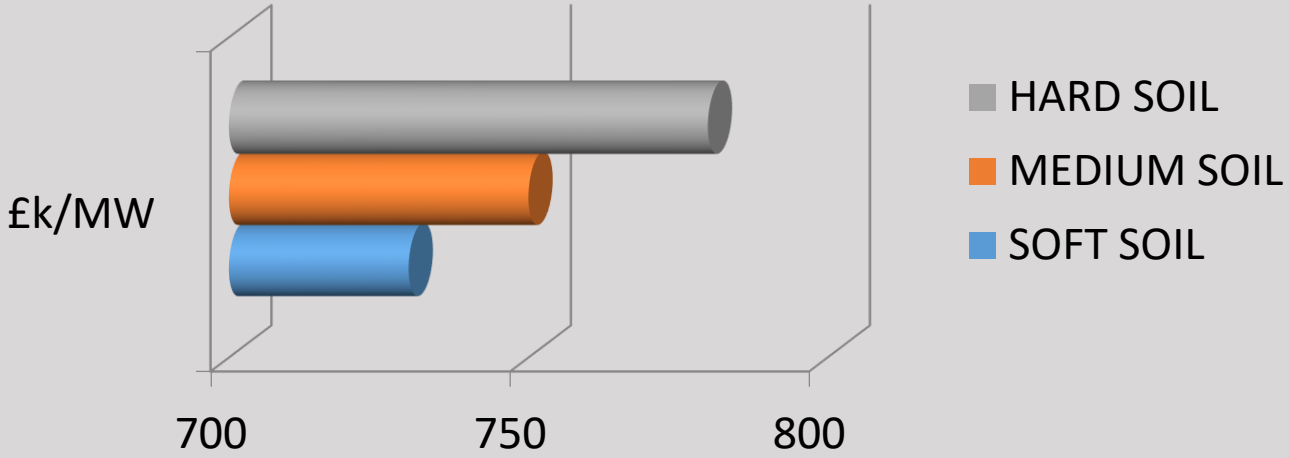
Geotechnical conditions prior knowledge will avoid surprises

MW price increase depending in hardness soil conditions:

SOFT SOIL: Easy for the EPC to drive piles at the stimated depth

MEDIUM SOIL: It is feasible to drive piles into the soil, but there are some hard intermediate levels which piles needs to overtake and it supposes drecease piling rendiment

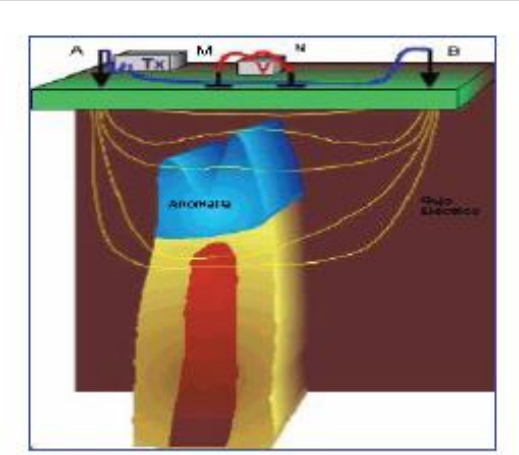
HARD SOIL: No feasible to drive piles into the soil due to the shallow hard rock depth, and it is necessary to carry out surface laid concrete founding blocs, predrilling ...



5 MW solar site development : Hard soil → Increases the project up to 250.000 €

ELECTRICAL RESISTIVITY SURVEY

(earthing design)



Design is correct. COLD:

Touch Voltage E_m	6.53%	of allowable Touch Voltage E_{touch}
Step Voltage E_s	1.41%	of allowable Step Voltage E_{step}

HOT SITE → EPR > 430 (650) V → ADDITIONAL REQUIREMENT → MORE EXPENSIVE

Epr = earth potencial rise

CAN BE EXPECTED WITH THE RESISTIVITY SURVEY

Rho Thermal resistivity survey

Calculation of ampacities and maximum accepted cable temperatures have been done using a value of RHO =xx k·m·w^{-1}

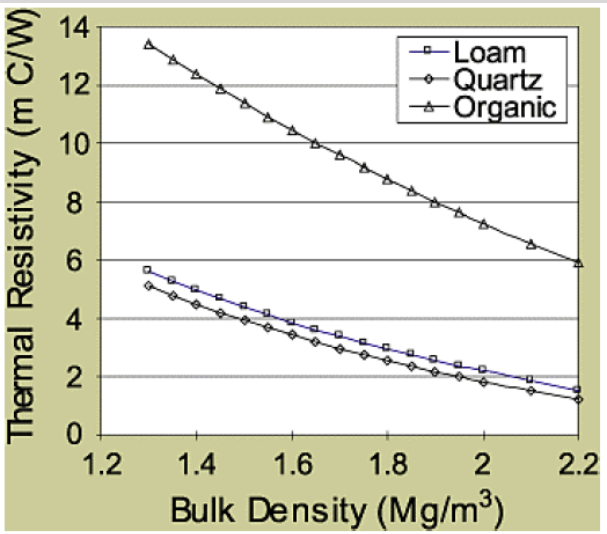
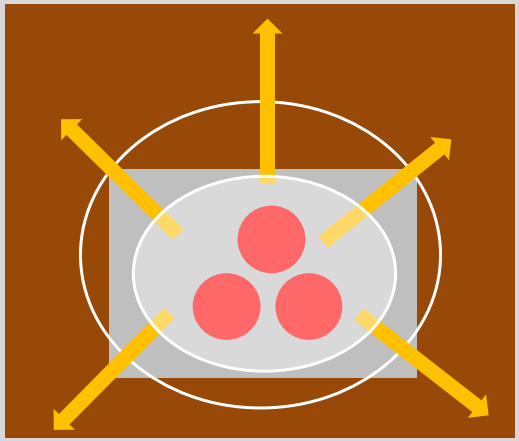


Fig. 1- The thermal resistivity of a dry, porous material is strongly dependent on its density.



$$Rho = \frac{1}{\lambda}$$

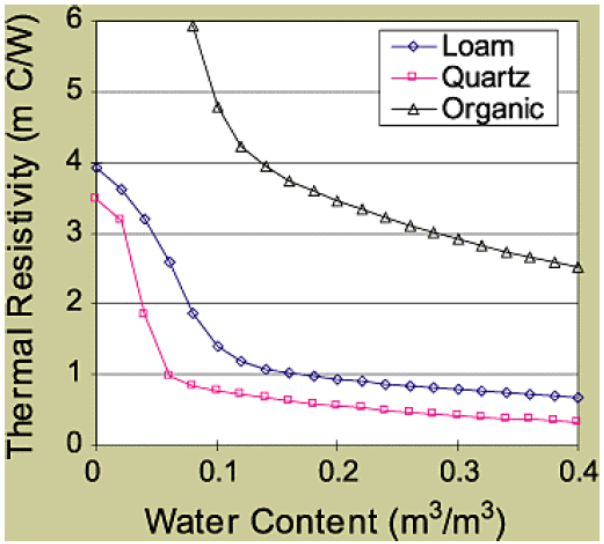
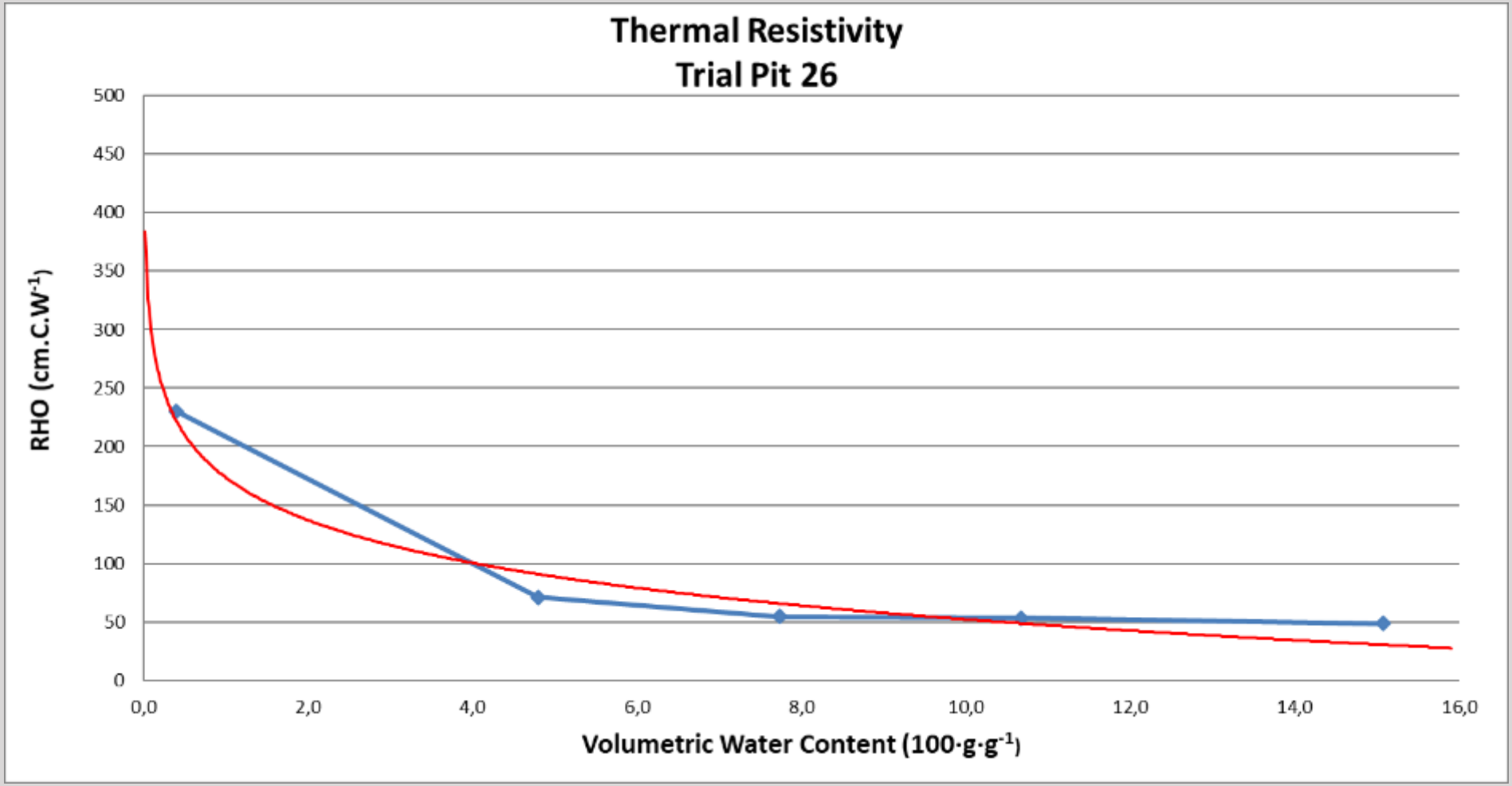


Fig. 2- Adding water to a porous material drastically decreases its thermal resistance.

The water content depends on the season of the year ….. So …

Rho Thermal resistivity survey

Field test and lab test



< cable section → save money

GEOTECHNICAL & RESISTIVITY SURVEY.. WHEN?.. WHY??

NEW PROJECT / INCOMING PROJECT

PRELIMINARY EVALUATION

FINANCIAL MODEL / PRELIMINARY RED FLAG REPORTS / TECHNICAL&LEGAL

EVALUATION AND NEGOTIATION

PROJECT ADQUIRED

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GEOTECHNICAL&RESISTIVITY SURVEY

EPC AGREEMENT → CONSTRUCTION WORKS

PROJECT ENERGISED

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5. EQUIPMENTS AND SOIL TESTING DEVICES:

Dynamic Penetration Super Heavy (DPSH)

Boreholes (Drilled or Driven)

Dynamic Penetrometer Test – Panda Equipment (penetration and compactation)

Soil sampling and Lab testing

DCP – CBR In situ Testing

Electrical Tomography – Landfill Investigation

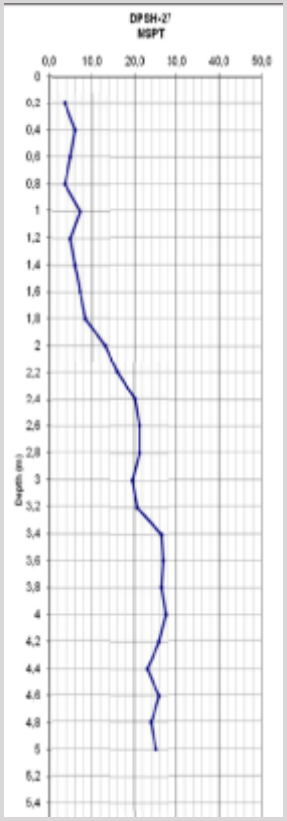
Resistivity Testing – Wener Array

Thermal test – RHO

Others: Trial Pits, Corrosivity Tests, Plate Bearing Tests, GPR, …

Dynamic Penetration Superheavy - DPSH

- *Small Equipment*
- *Rubber tracks – Suitable in moddy /flooded fields*
- *Non invasive (suitable in cultivated fields)*
- *Fast execution*
- *Up to 20 m (most common for PV 5 m)*
- *Self-propelled*
- *Carried in a Van*
- *DPSH test – BS-EN ISO 22476:2005*
- *Resistance /Depth continuos Result*
- *Piling ramming correlaction*
- *Continuous Tests*

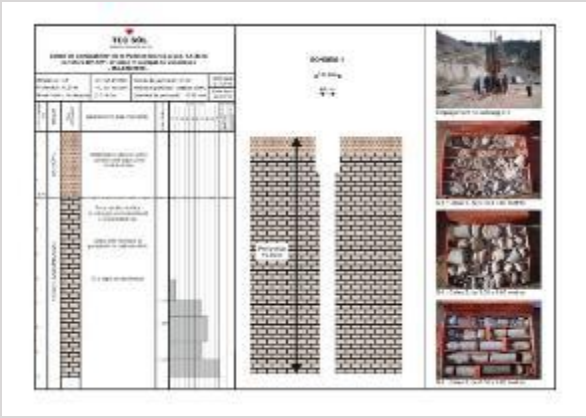


GEOTECHNICAL SURVEY – GEOTECHNICAL SURVEY FOR SOLAR FARMS

-SIZE EQUIPMENT USED

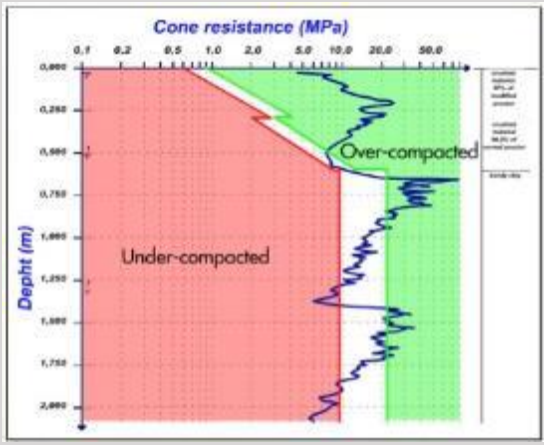
Boreholes – Drilled or Driven

- *Diferent equipment sizes*
- *Rubber tracks – Suitable in moddy /flooded fields*
- *Non/few invasive*
- *Any depth required*
- *Self-propelled*
- *Continuous core –define layer boundaries*
- *Obtain undisturbed samples.*
- *Drilled/Driven depending soil composition/hardness*
- *Slower rate than penetration tests*
- *Core box stored*



Panda: Penetration and compactation

- *Very Small Equipment*
- *All in a suitcase – Portable in a plane*
- *Non invasive (suitable in cultivated fields)*
- *To be used in confined spaces*
- *Up to 5 m (most common for PV)*
- *Provides Results on site*
- *Resistance (Mpa)/Depth Results*
- *Direct correlation with SPT value*
- *Piling ramming correlaction*
- *Continuous Tests*
- *Also provide CBR % values*
- *Compactation Control NF XP P 94-105*



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Laboratory tests quoted	YES	NO
Geomechanical		
Particle size distribution	✓	
Atterberg Limits	✓	
Density (dry/wet)	✓	
Moisture content	✓	
Expansivity (Lambe)		✓
UU Direct shear strength		✓
Oedometric tests		✓
Chemical		
Sulphate content	✓	
Sulphide content	✓	
Organic matter	✓	
Chloride content	✓	
Electrical Conductivity	✓	
Carbonates	✓	
Potential Redox	✓	
pH	✓	
Double alcalinity (total and up to ph 8,3)		✓
Water agressiveness		✓
Baumann Gully		✓
Others:		

DCP – CBR In situ Testing

- *DCP test devoted to in situ CBR measurement*
- *Very Small Equipment*
- *All in a suitcase – Portable in a plane*
- *Non invasive (suitable in cultivated fields)*
- *To be used in confined spaces*
- *Cone driven untill desired depth (800 mm)*
- *CBR% value for every present layer*
- *New embankments /strengthening existing pavements*
- *Procedure according ASTM-D6951-3 (2003).*
- *Also concucted with Panda equipment described*

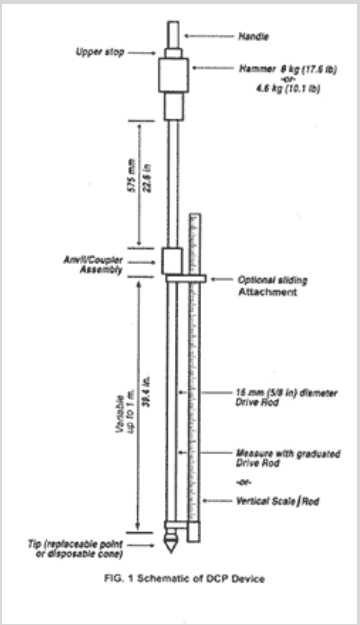
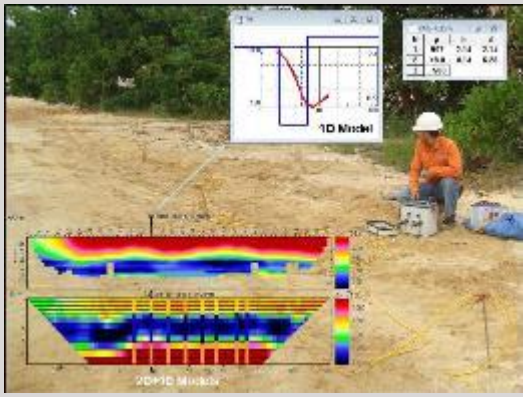
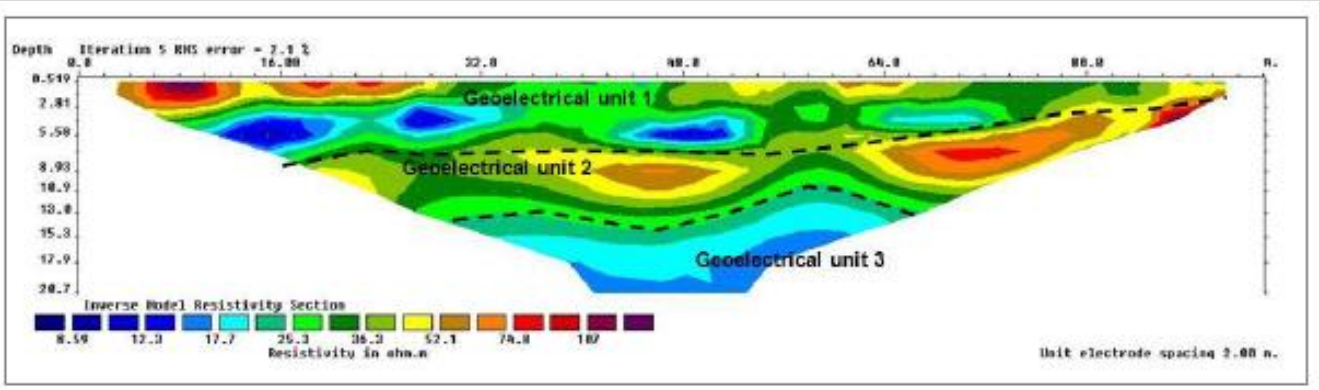


FIG. 1 Schematic of DCP Device

Electrical Tomography (ERT) – Landfill Investigation

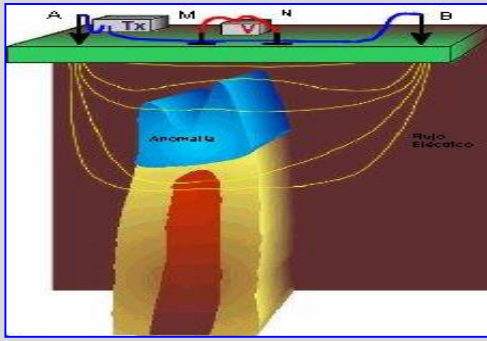
- *Geophysical Method– Non destructive*
- *2D high resolution soil underground representation*
- *Fully automated - ⬆ Measurements in ⬇ time*
- *Combined with boreholes tunes interpretation*
- *Good Landfill detection untill 80-100 m depth*
- *Useful in old graveries, opencast mines, ..*
- *All suits in a suitcase – Portable in a plane*

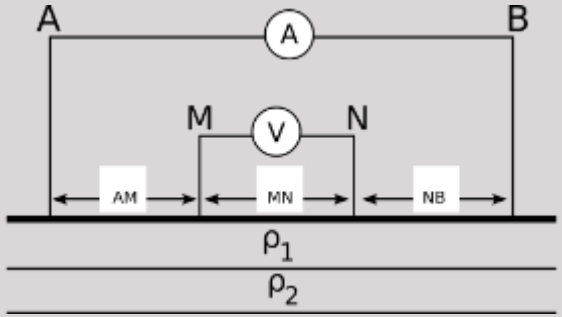




Resistivity Testing – Wenner Array

- *Geophysical Method– Non destructive*
- *Fully automated*
- *Suits in a suitcase – Portable in a plane*
- *Measures the soil resistance (ohm.m)*
- *Establish Geoelectric soil layers model*
- *Critical factor in electrical ground design*
- *Soil measurement with Megger DET 2/2 device*
- *Accepted by Power distribution companies*
- *Wenner Array*
- *Data used for the earthing design*





Some other tests and methods used

Trial pits

Soil Investigation and soil sampling
Allow to Establish Geotechnical and litological layers
Ground water level presence
3 meters depth investigation
Easy to find a contractor all over the world

Some other tests and methods used

Dynamic Plate Test

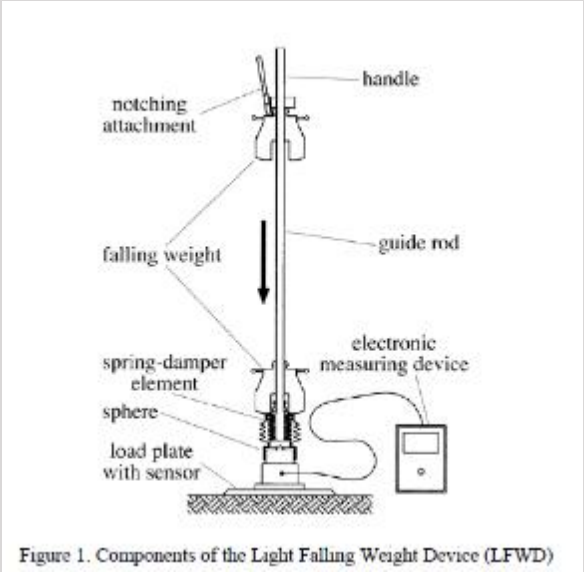
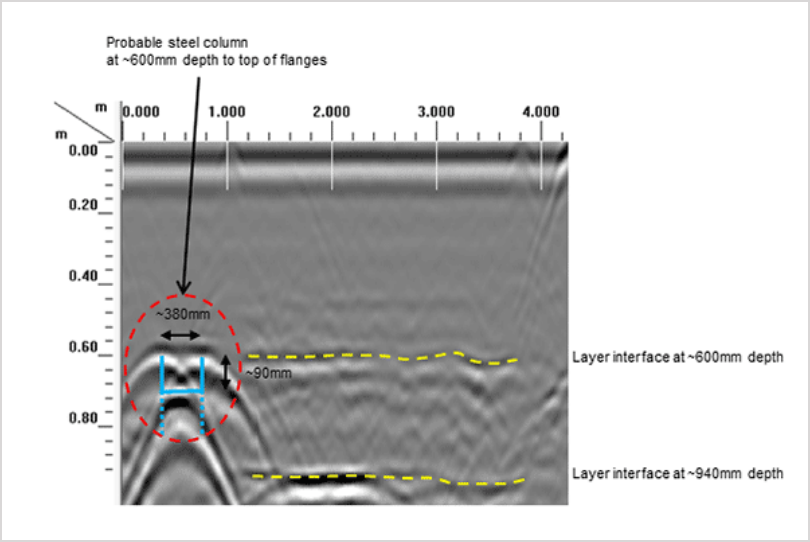


Figure 1. Components of the Light Falling Weight Device (LFWD)

method to determine dynamic modulus of subsoil and fills
Compaction control
Load-bearing subsoil capacity assessment
Comparison with the static one doesn't need and external reaction (loaded truck)
Provides Results on site directly on a screen
To be used in confined spaces

Some other tests and methods used

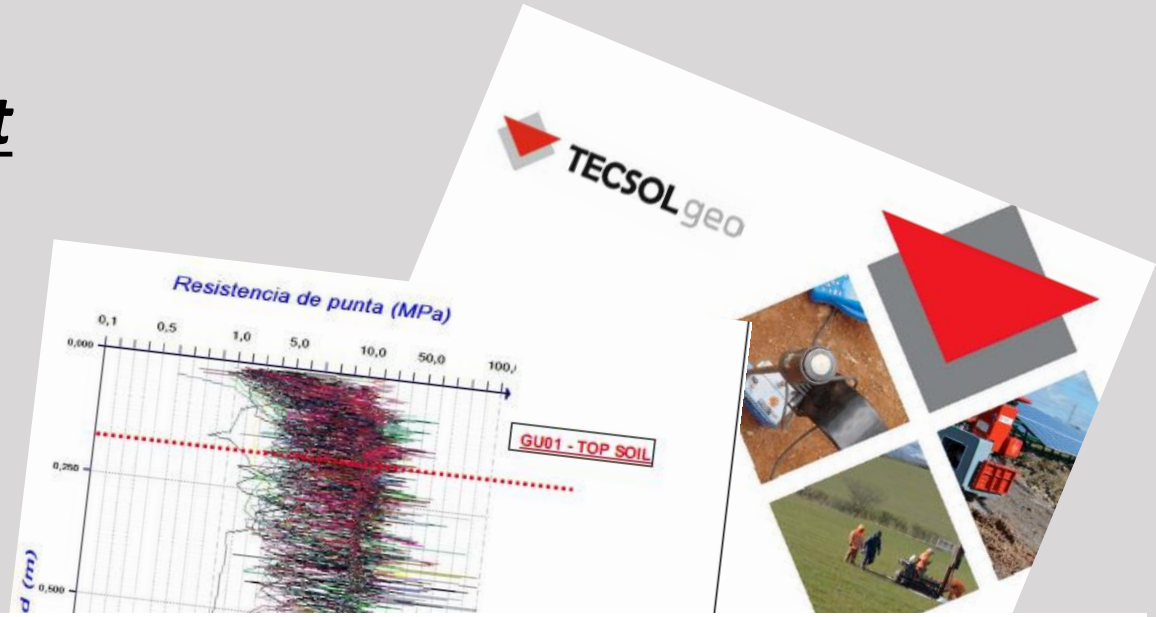
Ground Penetration Radar (GPR)



Geophysical Method – Non destructive
Uses radar pulses to image the subsurface
Uses electromagnetic radiation in the microwave band
Useful tool to identify buried pipes and structures alike or <u>bombs</u>.
Brings excellent results when good pipe-soil permitivity ratio are found

Finally, …. The report

- *Geologycal report*
- *Geotechnical report*
- *Resistivity – Thermal survey*
- *Hidrological*
- *Topo survey*
-



Sorry, is not correct. The final step is not "the report", the final step is ….

make the invoice and collect it

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THANK YOU VERY MUCH!!!