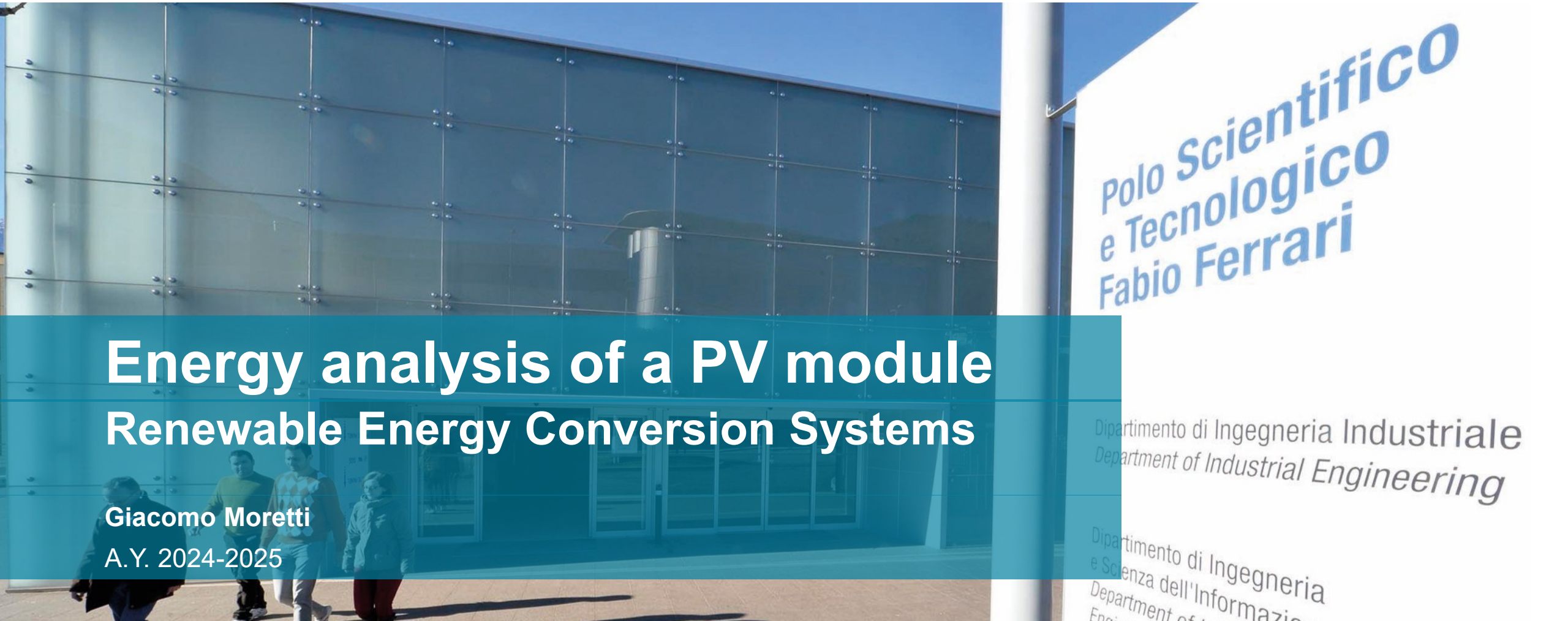
UNIVERSITÀ DI TRENTO

DIPARTIMENTO DI

INGEGNERIA INDUSTRIALE



Energy analysis of a PV module

Renewable Energy Conversion Systems

Giacomo Moretti

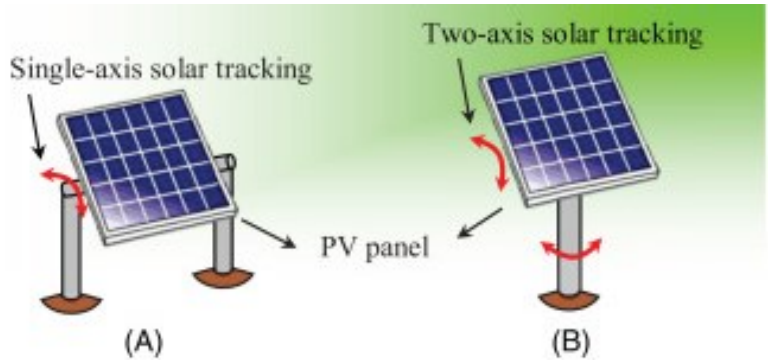
A.Y. 2024-2025

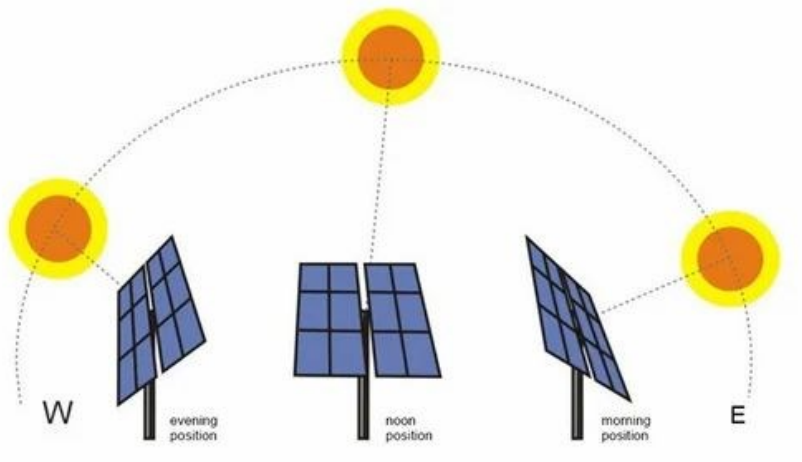
Objective

Calculate the *annual energy production* and *capacity factor* of a commercial PV module, assuming different mounting configurations:

- Fixed (either horizontal, or tilted facing South)
- Equipped with a tracking system

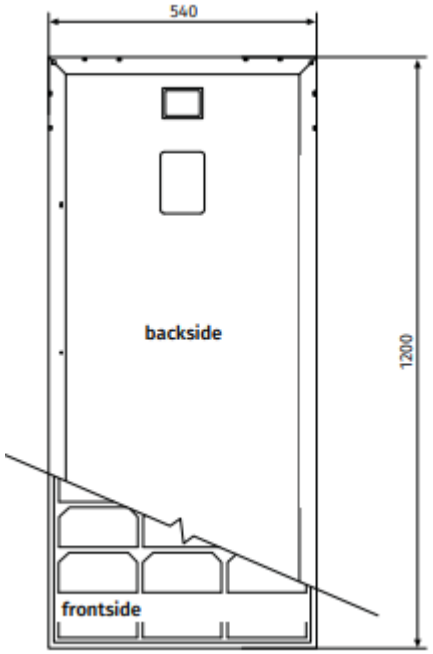
PV tracking systems





Reference PV module

Source :Offgridsun.com



Solar Module 100 W

Monocrystalline 36 cells

ELECTRICAL DATA		
MODULE		FU 100 M next
Standard Test Conditions STC 1000 W/sqm - AM 1.5 - 25 °C - measuring tolerance <3%		
Module power (Pmax)	W	100
Module efficiency	%	15.29
Maximum power voltage (Vmpp) V_{mpp0}	V	18.40
Maximum power current (Impp) I_{mpp0}	A	5.43
Open circuit voltage (Voc) V_{oc0}	V	22.95
Short circuit current (Isc) I_{sc0}	A	5.85
Maximum system voltage	V	1000

TEMPERATURE RATINGS		
Temperature coefficient (Isc) χ	%/°C	0.02
Temperature coefficient (Voc) ξ	%/°C	-0.33
Temperature coefficient (Pmax)	%/°C	-0.48
NOCT *	°C	47
Operating temprature	°C	from -40 to +85

** Nominal Operating Cell Temperature*

MECHANICAL SPECIFICATIONS	
Dimensions	1200 x 540 x 30 mm
Weight	6.7 kg
Glass	Tempered, transparent, 3.2 mm
Cell encapsulation	EVA (Ethylene Vinyl Acetate)
Cells	36 five bus-bar monocrystalline cutted-cells
Backsheet	Composite multilayer film
Frame	Anodized aluminium frame with mounting and drainage holes
Junction box	Junction box with or without cables

PV module simplified model

- Thermal model

Module temperature: $T_m = T_a + (NOCT - 20[°C])\frac{I}{800\left[\frac{W}{m^2}\right]}$, T_a: ambient temperature, $I\left[\frac{W}{m^2}\right]$ instantaneous incident radiation

- OC voltage and SC current (functions of temperature and radiation):

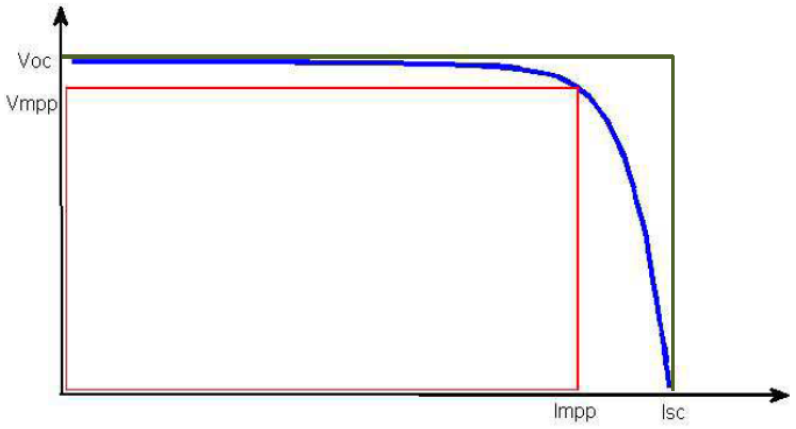
$$I_{sc} = I_{sc0}(1 + \frac{\chi}{100}(T_m - 25[°C]))\frac{I}{1000\left[\frac{W}{m^2}\right]}, \quad V_{oc} = V_{oc0}\,(1 + \frac{\xi}{100}(T_m - 25[°C]))$$

- MPP current/voltage

We assume that the fill factor stays constant

$$FF = \frac{I_{mpp}V_{mpp}}{I_{sc}V_{oc}} = \frac{I_{mpp0}V_{mpp0}}{I_{sc0}V_{oc0}}$$

Power output: $P = FF \cdot I_{sc}V_{oc}$



Reference location

Trento, latitude $\phi = 46.07°$

Given meteorological data (see Data.m):

- Global, beam and diffuse daily irradiation (monthly avg)
- Max./min. temperatures (monthly avg) → assume sinusoidal distribution, with peak at 2pm (solar time)

Estimation of radiation profiles ($I - t$) from daily data → see attached reference