Simulation of tracking PV installations with PVsyst

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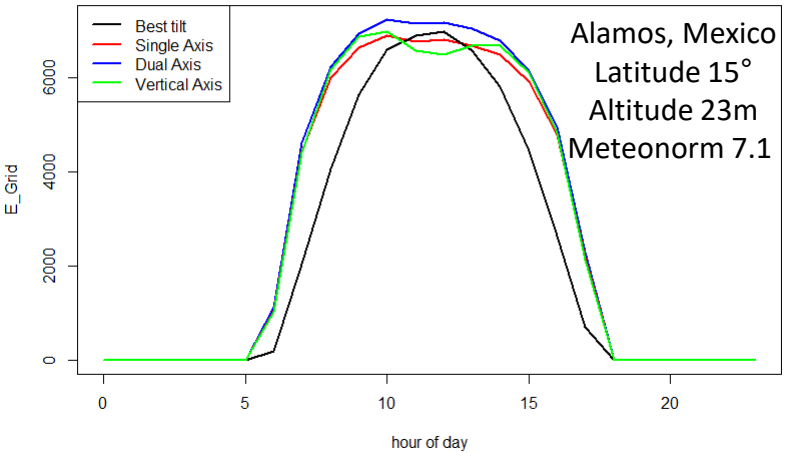
Overview

- **Introduction**
  - Benefits of tracking
  - Modeling Trackers in PVsyst
- **Simulation results**
  - Optimizing Tracking Parameters
  - Single and Dual Axis Tracking
  - Impact of Latitude
  - Impact of Climate
  - Shadings (Row Spacing)
  - Backtracking
  - Stroke Limits
- **Outlook**
  - Bifacial Tracking

Benefits of Trackers

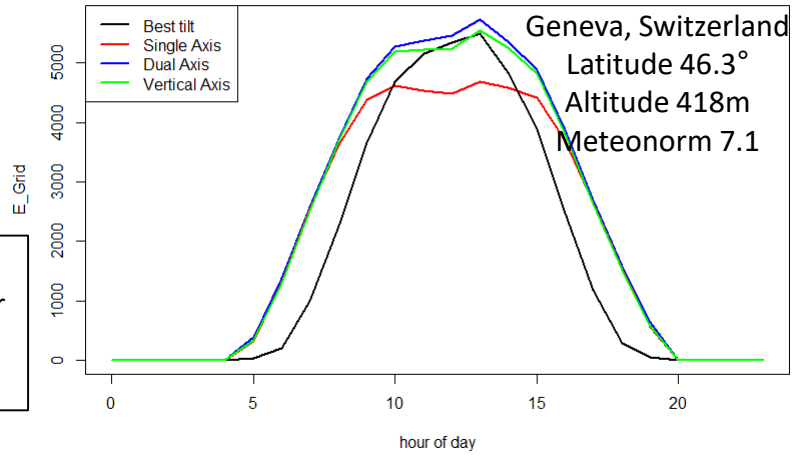
Examples of tracking simulations

Average daily production for an entire year

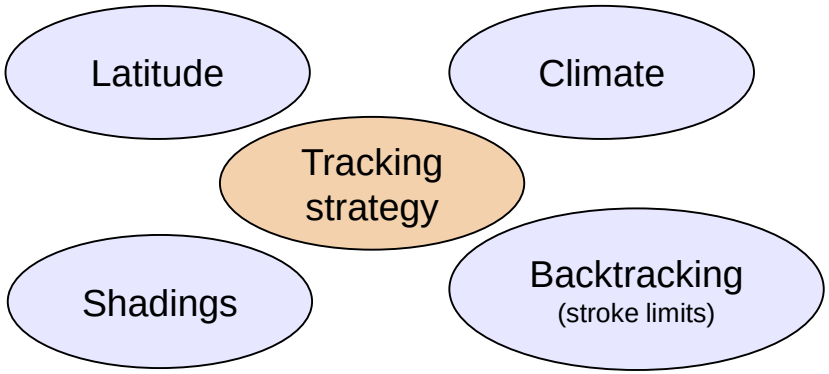


The absolute production is higher **The production peak is flatter!**

Average daily production for an entire year



Tracking Gain depends on many parameters

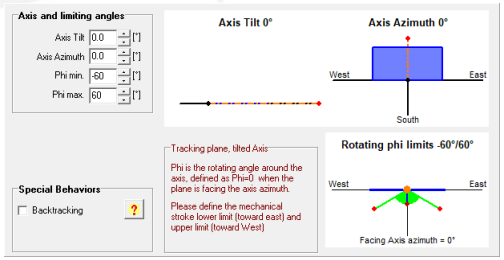


Tracking gains from 10% - 50%,
depending on tracking strategy, location,
climate and shadings (Ground Covering Ratio)

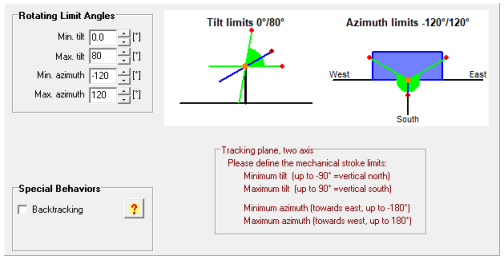
Tracking Strategies in PVsyst

Most common Tracker Types

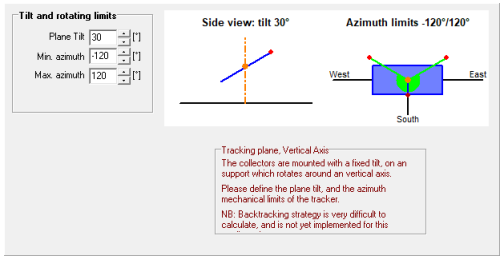
Horizontal axis

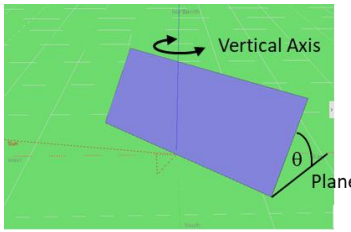


Dual Axis



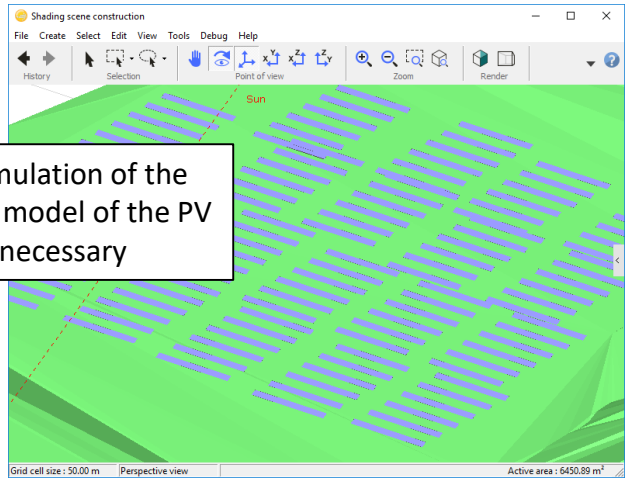
Vertical Axis





3D drawings for shadings

To get a correct simulation of the shading losses, a 3D model of the PV installation is necessary



Other tracking strategies in PVsyst:

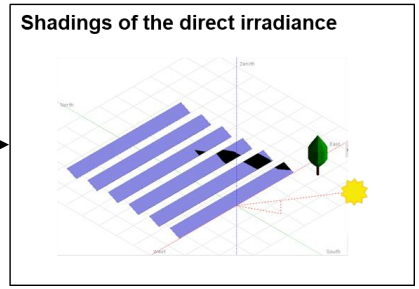
- Tilted Axis
- Frames
- Sun shields
- Horizontal EW-axis
- Unlimited trackers

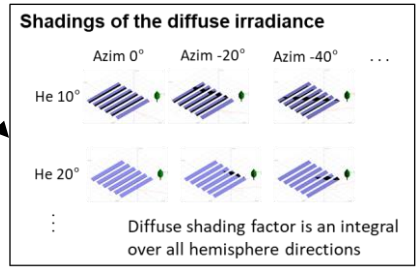
Tracking algorithms in PVsyst minimize the Incidence Angle

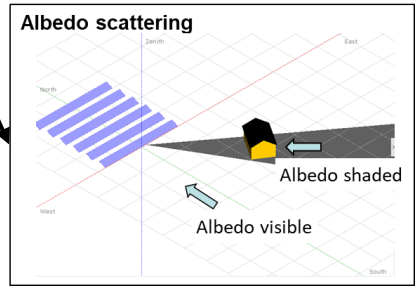
Tracker modeling in PVsyst

Shadings

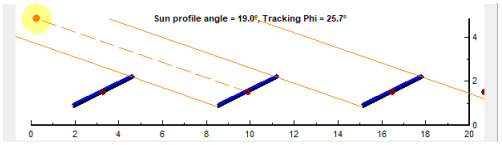
- **Direct**
  Subject to near shadings depending on sun position
- **Diffuse**
  Subject to shading factor that is constant for a given plane orientation
  For trackers it changes with the plane orientation
- **Albedo**
  Subject to shading factor that is constant for a given plane orientation
  For trackers it changes with the plane orientation







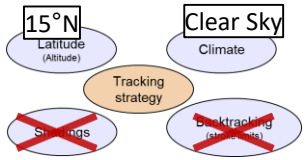
Backtracking



Backtracking algorithm avoids beam shadings
Diffuse and albedo shadings are still present!
Large installations => Albedo almost invisible

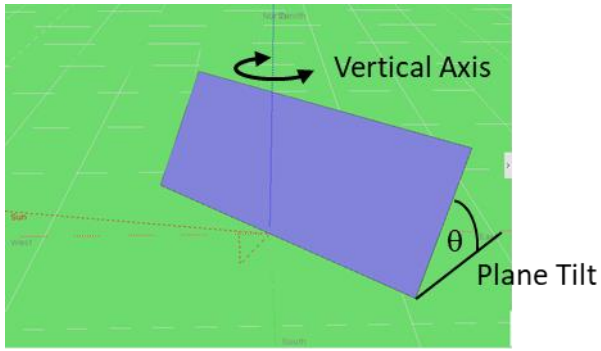
Backtracking in PVsyst is available for all tracker types except vertical axis.
Two-axis algorithms apply backtracking only in one of the two directions.

Vertical axis tracking

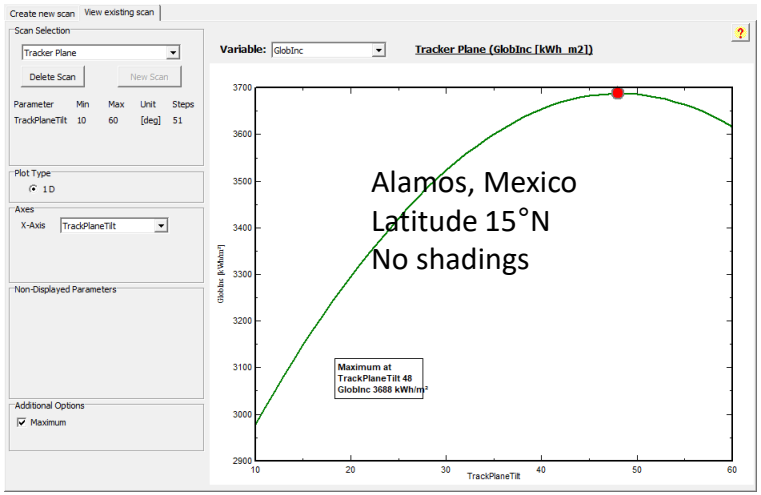


Optimization of Plane Tilt

Definition of Plane Tilt



Global PoA Irradiance as function of plane tilt

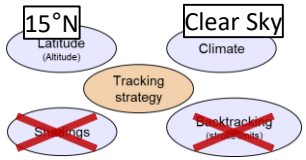


Best Plane Tilt depends on latitude, climate and shadings

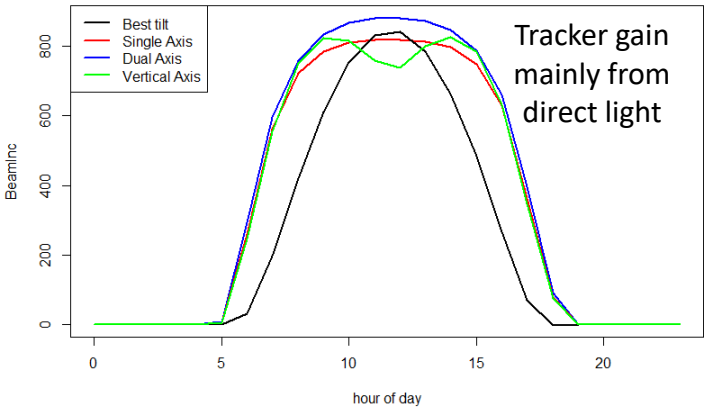
Site	Sevilla			Alamos	Kunming	Xiamen	Hotan	Quingdao	Linfen
Latitude	37.4°N			15°N	24°N	24°N	36.5°N	36.5°N	36.4°N
Climate data	Clear Sky	MN 7.1		MN 7.1	MN 7.1	MN 7.1	MN 7.1	MN 7.1	MN 7.1
Ground Coverage	10%		30%	10%	10%	10%	10%	10%	10%
Best plane tilt	**55°**	**52°**	**45°**	**42°**	**42°**	**39°**	**49°**	**45°**	**47°**

MN 7.1 :
Meteonorm 7.1
synthetic hourly values
based on average monthly data

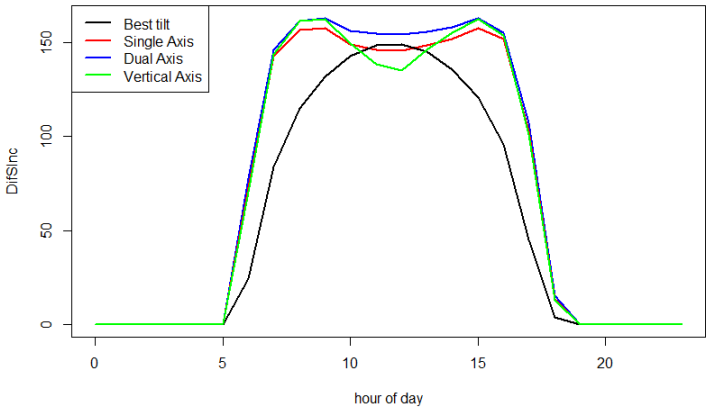
Single and Dual Axis Tracking



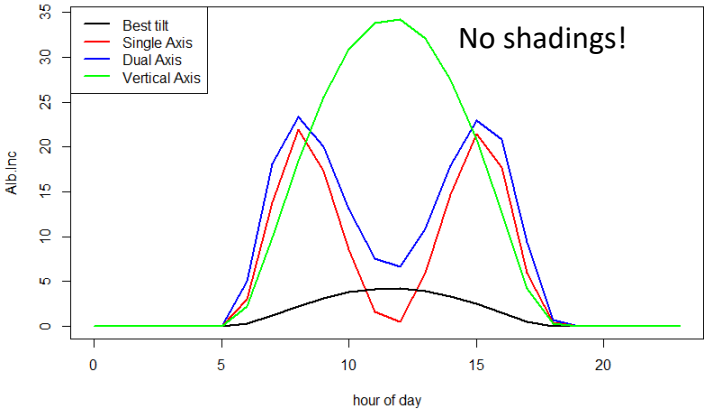
Beam Irradiance



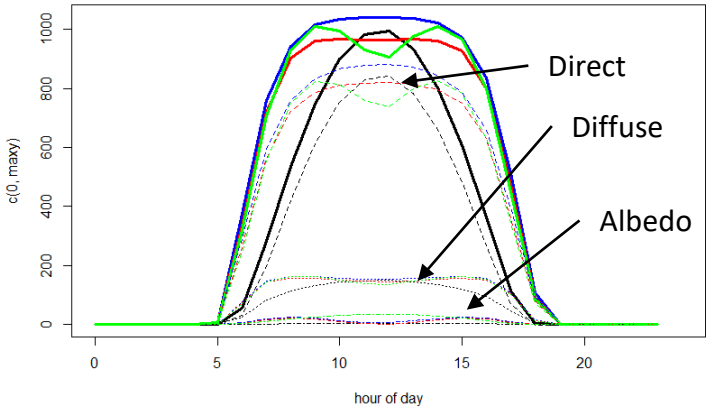
Diffuse Sky Irradiance



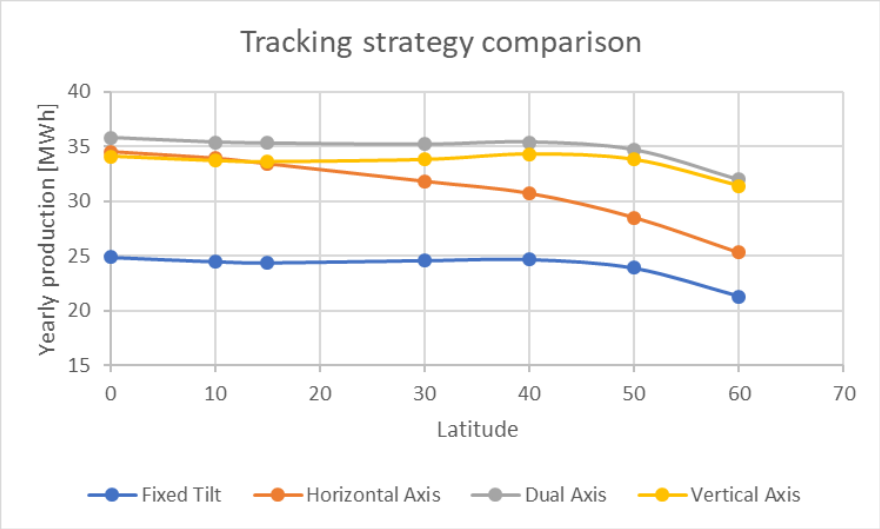
Albedo Irradiance



All three components together

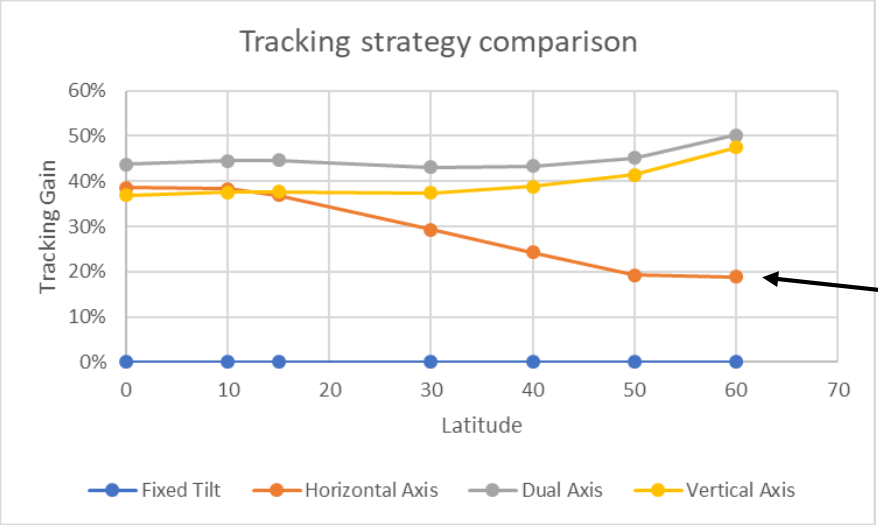


Impact of latitude



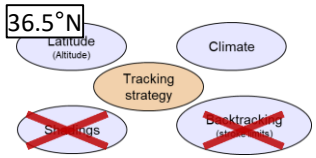
No mutual shadings considered in these plots!

Plane tilt optimized for fixed tilt and vertical axis

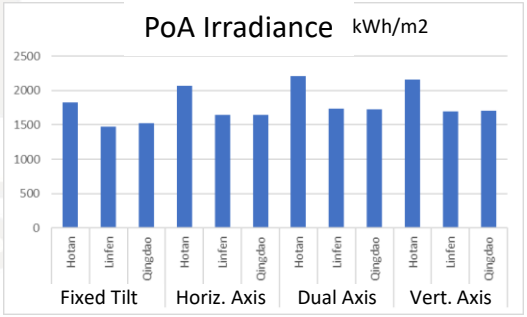


Horizontal axis performs better close to equator

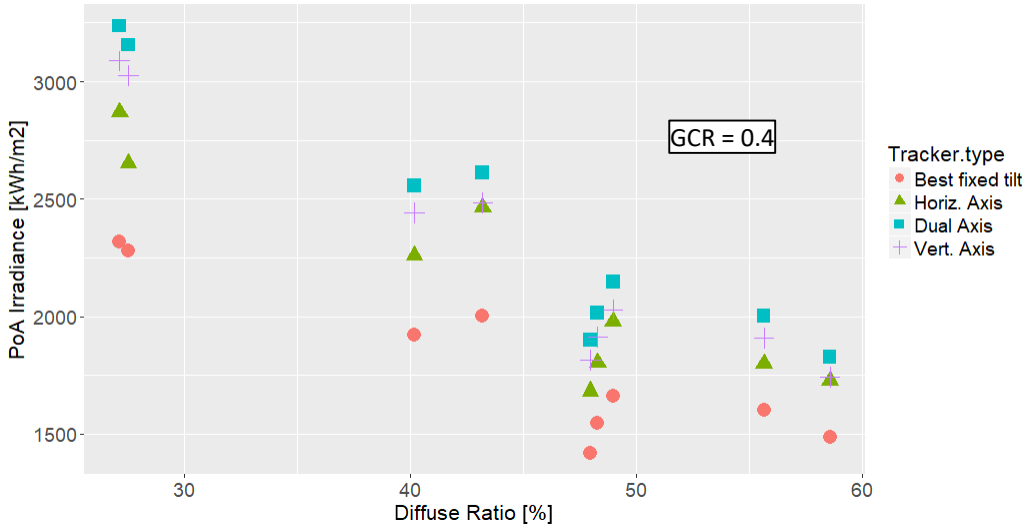
Impact of climate



Same latitude (36.5°N)



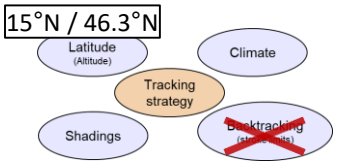
Dependence on diffuse ratio



Diffuse/Global ratio

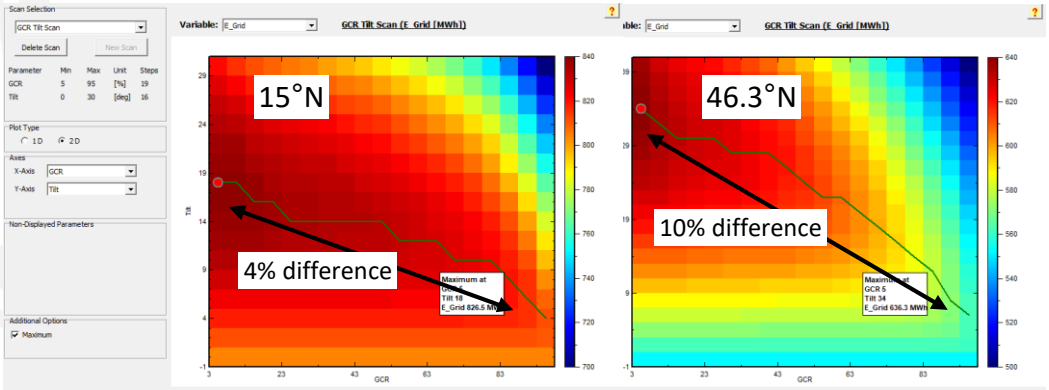
Site	Alamos	Albuquerque	Weihai	Geneva	Kunming	Xiamen	Hotan	Quingdao	Linfen	Ejin Qi
Latitude	15°N	35°N	37.5°N	46°N	24°N	24°N	36.5°N	36.5°N	36.4°N	42°N
Diffuse/Global	43%	27%	53%	48%	49%	59%	40%	56%	48%	28%

Pitch and shading



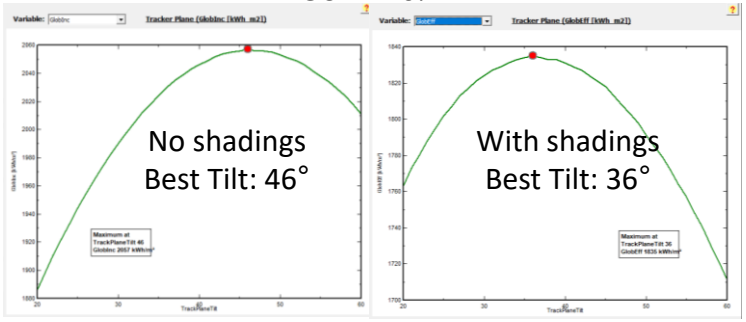
Ground Covering Ratio (**GCR**) = PV Module surface / PV installation surface

Optimize best **fixed tilt** as function of GCR

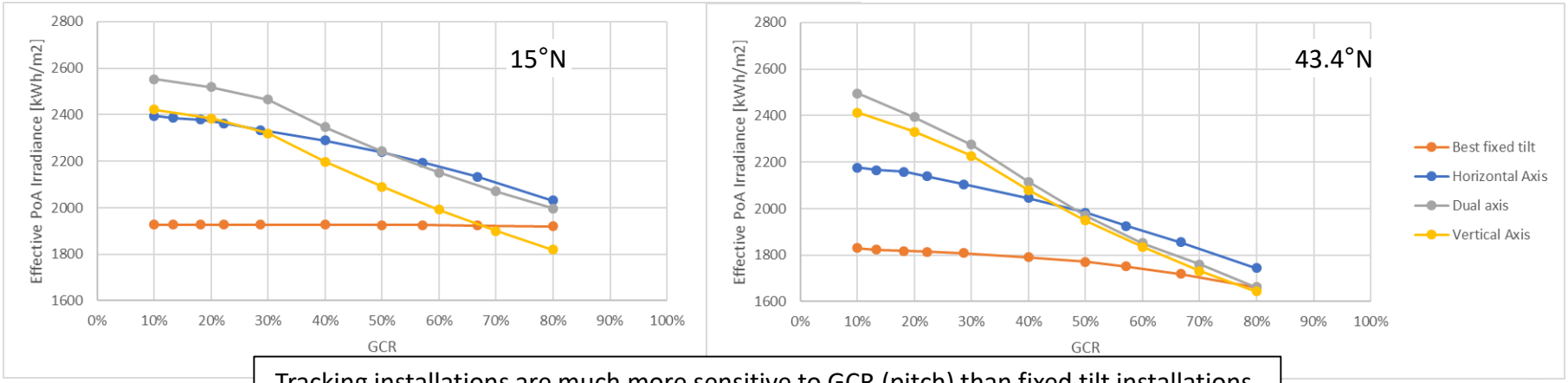


Impact of shadings on best tilt for **vertical axis** trackers

GCR = 40%

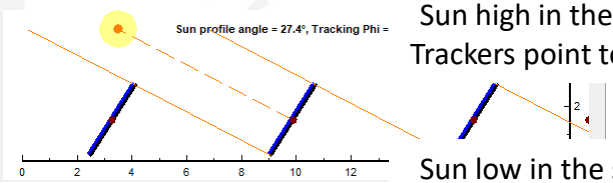


Tracker effective PoA as function of GCR



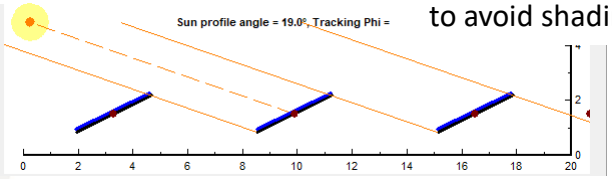
Tracking installations are much more sensitive to GCR (pitch) than fixed tilt installations.
Horizontal axis is less sensitive to dense packing.

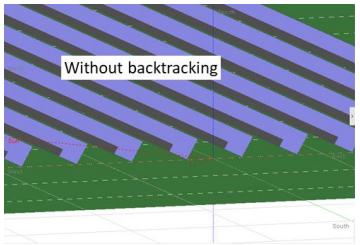
Backtracking

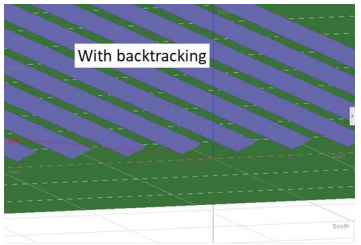


Sun high in the sky:
Trackers point to sun

Sun low in the sky:
Trackers move back,
to avoid shadings







Backtracking does not increase the Irradiance reaching the PV modules
It reduces electrical shading losses

Example: Horizontal Axis

Backtracking	PoA Irradiance [W/m2]	Effective Irradiance [W/m2]	Electrical Shading loss [kWh]	Injected Energy [kWh]	Performance Ratio
No	3665.7	3374.2	60.7	1304.2	0.684
Yes	3430.6	3327.5	0	1339.2	0.751
Difference	-6.4%	-1.4%	-100%	+2.7%	+6.7%

Orientation

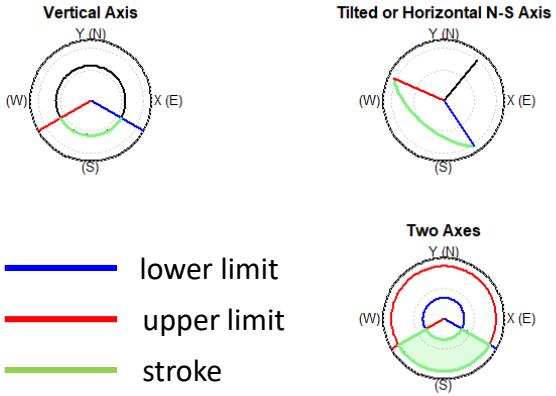
Shadings and
Reflection (IAM)

No direct
shadings!

Performance Ratio
is not a suitable
metric

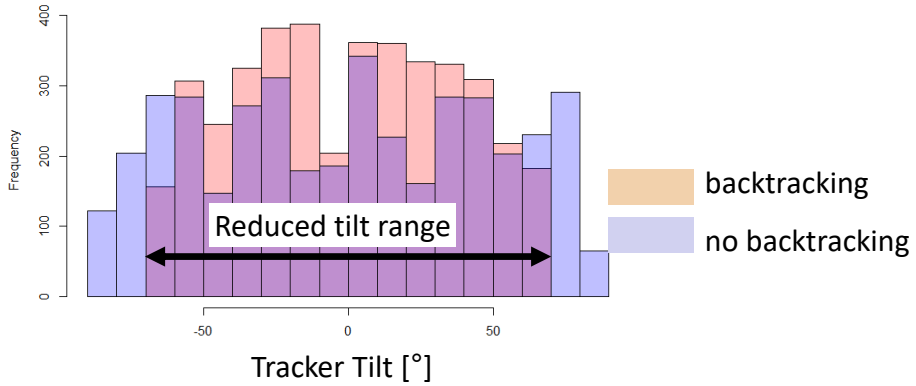
Stroke limits

Stroke limit for different tracker types



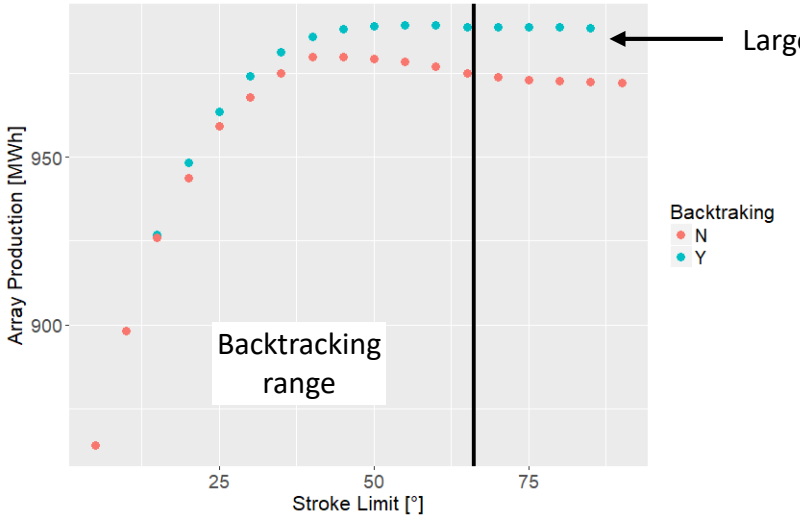
Distribution of tracker tilt without/with backtracking

Horizontal axis Tracker



Impact of stroke limits on yield

Alamos, Mexico
Latitude 15°
Meteonorm 7.1
GCR=40%
Horizontal axis



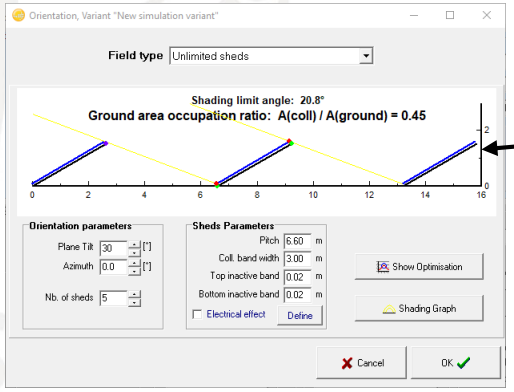
Large plateau

Increasing tracker stroke limits does not always increase yield!

Bifacial tracking

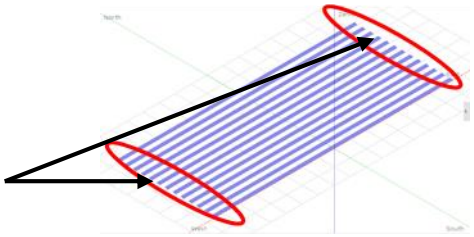
2-dimensional approach for long rows

PVsyst 'Unlimited Sheds' model
for long rows with fixed tilt

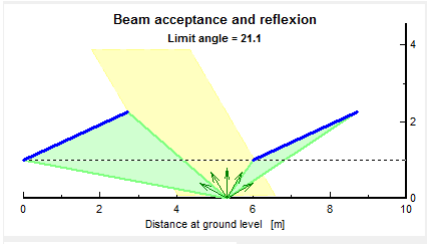


2-dimensional model

neglects border effects of the rows



Bifacial model
for fixed tilt sheds
available (since V6.6.0)



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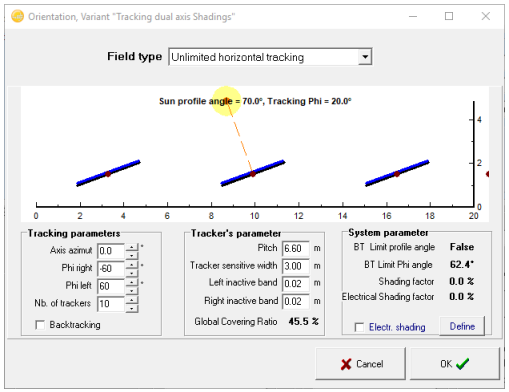
Unlimited trackers:
first step towards
horizontal bifacial tracking model
(since V6.6.7)



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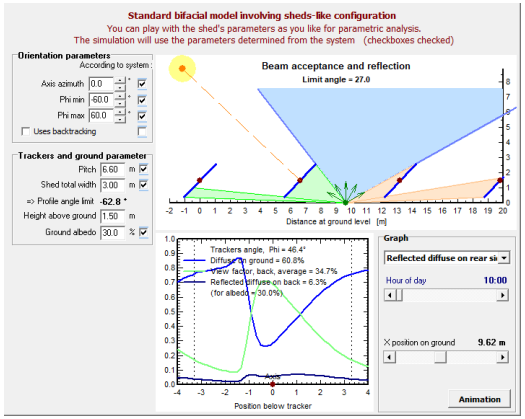
Bifacial tracking
for horizontal axis
close to publishing



Summary and Outlook

- **The benefits coming from tracking depend on many factors**
  - Tracking strategy (horizontal axis, vertical axis, dual axis)
  - Latitude and climate
  - Tracker layout (tracker distance, axis tilt, stroke limits)
  - Backtracking strategy
- **PVsyst allows a detailed simulation and analysis**
  - Simulation of different tracking strategies with detailed loss diagram
  - Output of hourly intermediate results in CSV files for custom analysis
  - Multiple simulations and parametric scans for parameter optimization
- **Some general behaviors were presented**
- **Modelling of trackers in PVsyst continues to evolve**
  - Tracking with bifacial PV modules
  - Two-axis backtracking in all directions