STRATEGIES FOR ELECTRICAL SHADING MODELING WITH PLANTPREDICT

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PVPMC

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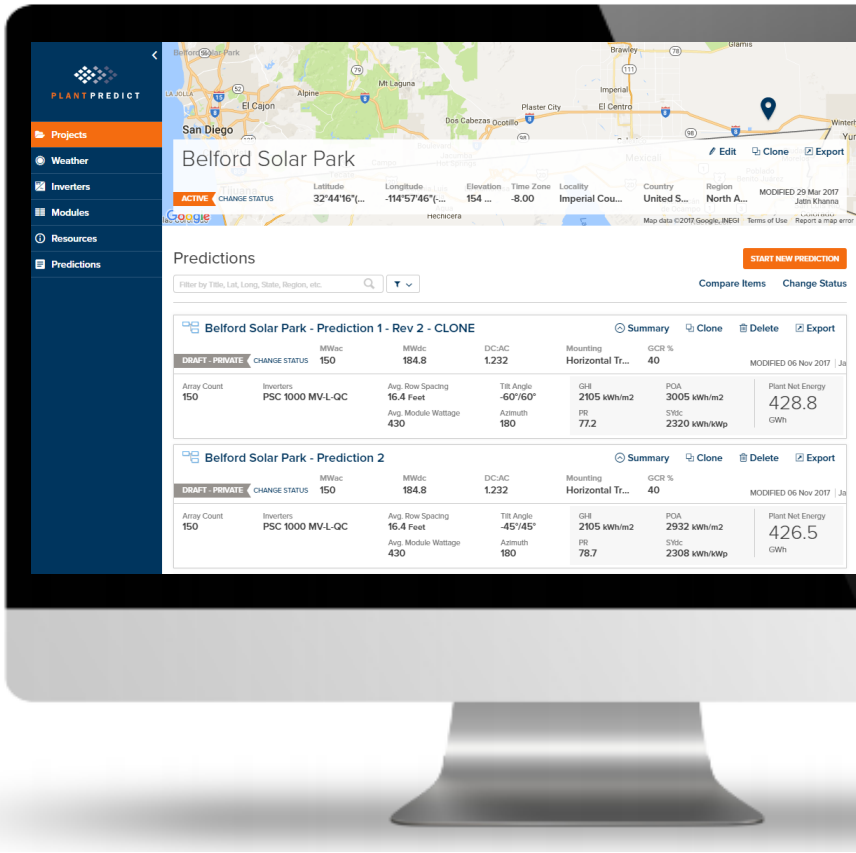
LEADING THE WORLD'S
SUSTAINABLE ENERGY FUTURE

AGENDA

1. PlantPredict Overview

2. Electrical Shading in PlantPredict

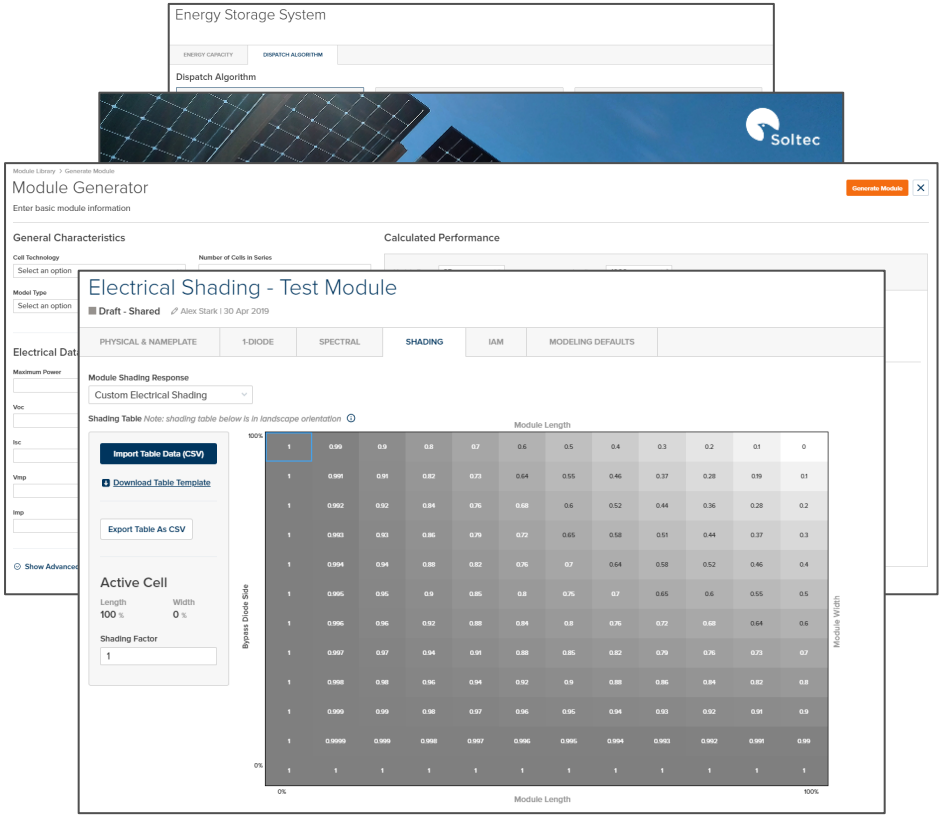
3. Analysis of Unique Electrical Shading Reponses



INTRODUCTION

PLANTPREDICT OVERVIEW

- Generate quick, contract-grade predictions via a streamlined user interface
- Over 600 companies globally with accounts
- Used in over 500 MWAC of contracted utility-scale PV projects
- Independently reviewed and benchmarked against more than 1 GW of operating facilities
- Recently Added Features
  - PV + Storage Modeling
  - Bifacial Modules
  - Module File Generator
  - Electrical Shading



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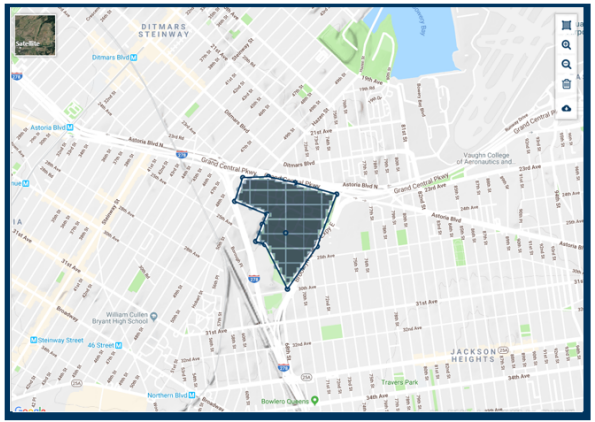
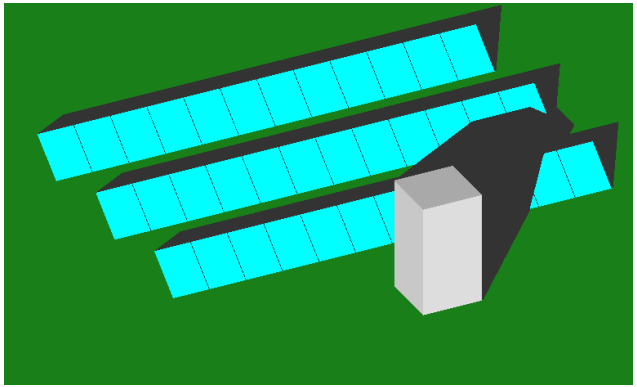
UPCOMING FEATURES

- *Time Series Parameter Import*
  - *Inverter Set-point, Tracker Angle, MST, LGIA Limit*
- *Advanced Layout Design*
- *Object Shading*

Row-to-row shading during BackTracking due to tracker error.



Map Builder example



Object Shading example

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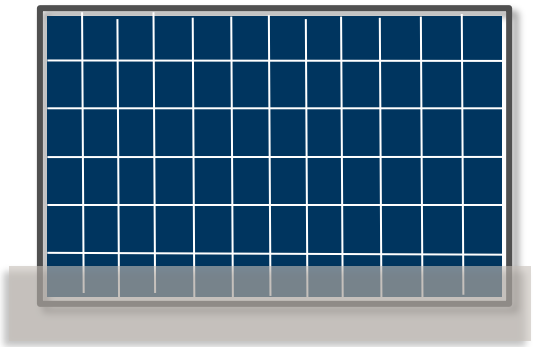
ELECTRICAL SHADING IN PLANTPREDICT

NEAR SHADING VS. ELECTRICAL SHADING

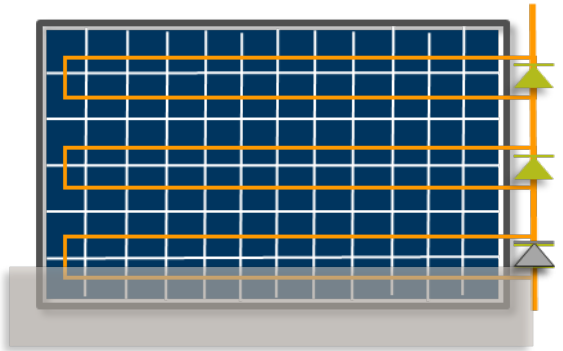
- **Near Shading:** caused by row-to-row and near object shading
- **Electrical Shading:** occurs when the bypass diodes are partially shaded

Near Shading Loss (Linear):



10% Shading = 10% Power Loss

Electrical Shading Loss (Non-Linear):



10% Shading = 33% Power Loss

For this hour:

Near Shading Loss = 10%

+

Electrical Shading Loss = 23%

Total Power Loss due to Shading = 33%

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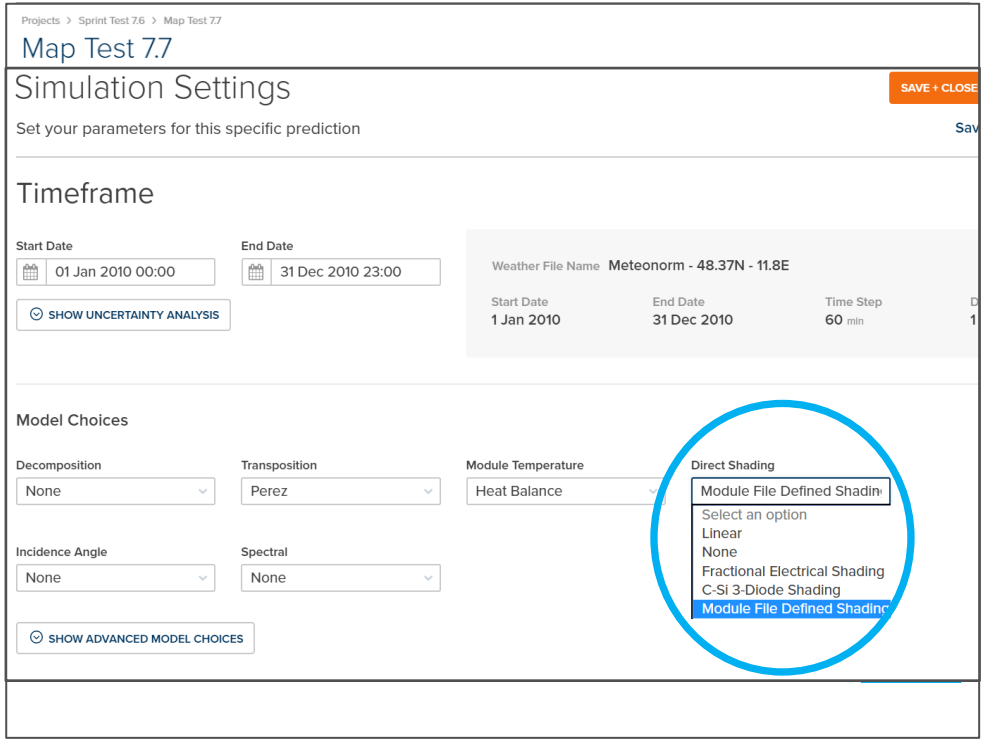
ELECTRICAL SHADING IN PLANTPREDICT

Navigating to the new Electrical Shading models:

Three new Direct Shading options:

1. Fractional Effect
2. 3-Diode
3. Custom Shading Response



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FRACTIONAL EFFECT SHADING MODEL

If fractional effect is enabled, module shading reduces the power output depending on the fractional value.

Example Case:

100% FRACTIONAL EFFECT

10% Shading =
- 10% Near Shading Loss
- 90% Elec. Shading Loss
- 100% Power Loss

50% FRACTIONAL EFFECT

10% Shading =
- 10% Near Shading Loss
- 45% Elec. Shading Loss
- 55% Power Loss

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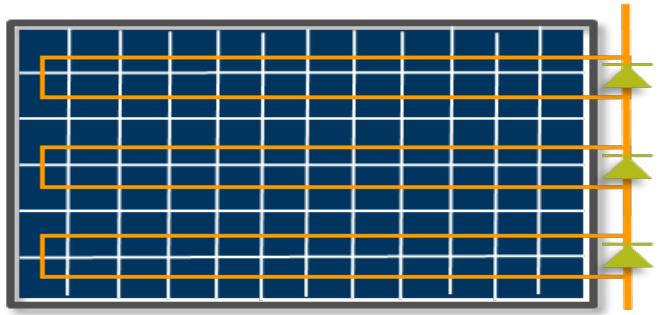
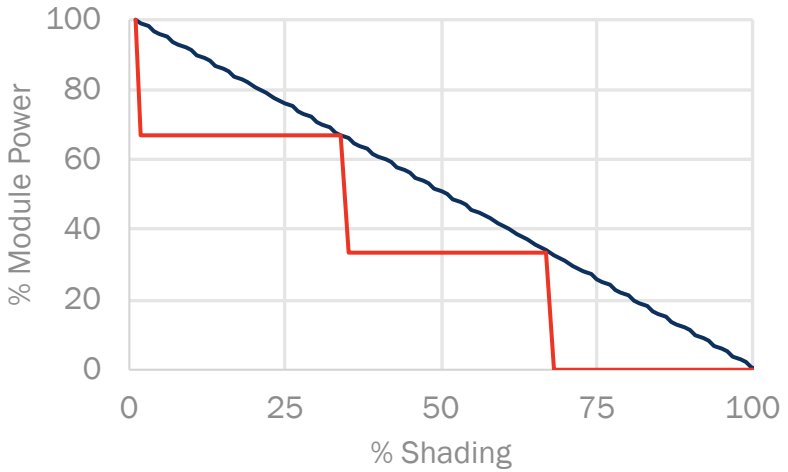
THREE DIODE SHADING MODEL

- Most common structure in 72 cell c-Si modules is the 3 bypass diode configuration
- Bypass diodes connect 2 rows of cells in the landscape direction
- Any shading of the series string activates the corresponding bypass diode



10% Shading = Up to 33% Power Loss



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MODULE FILE SHADING MODEL LAYOUT

Module Library > Test - Electrical Shading

Test - Electrical Shading

Draft - Private Alex Stark | 17 Dec 2018

PHYSICAL & NAMEPLATE | 1-DIODE | SPECTRAL | **SHADING** | IAM | MODELING DEFAULTS

Module Shading Response

C-Si 3-Diode Shading

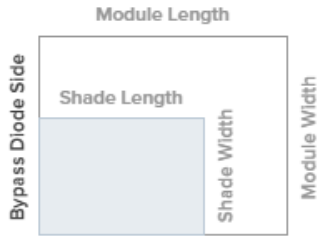
Shading Table *Note: shading table below is in landscape orientation*

100%	1	0	0	0	0
67%	1	0	0	0	0
34%	1	.33	.33	.33	.33
01%	1	0.66	0.66	0.66	0.66
00%	1	1	1	1	1
% Shaded	00%	01%	34%	67%	100%

% Shaded X and Y Axes:
The % of the module along either the length or the width that is shaded.

Fractional Production Values:
Fraction of power produced depending on % of module shaded.

Example for C-Si 3-Diode Case:
When the module is shaded at 15% length and 15% width, the module will produce at a factor 0.66 of expected power.



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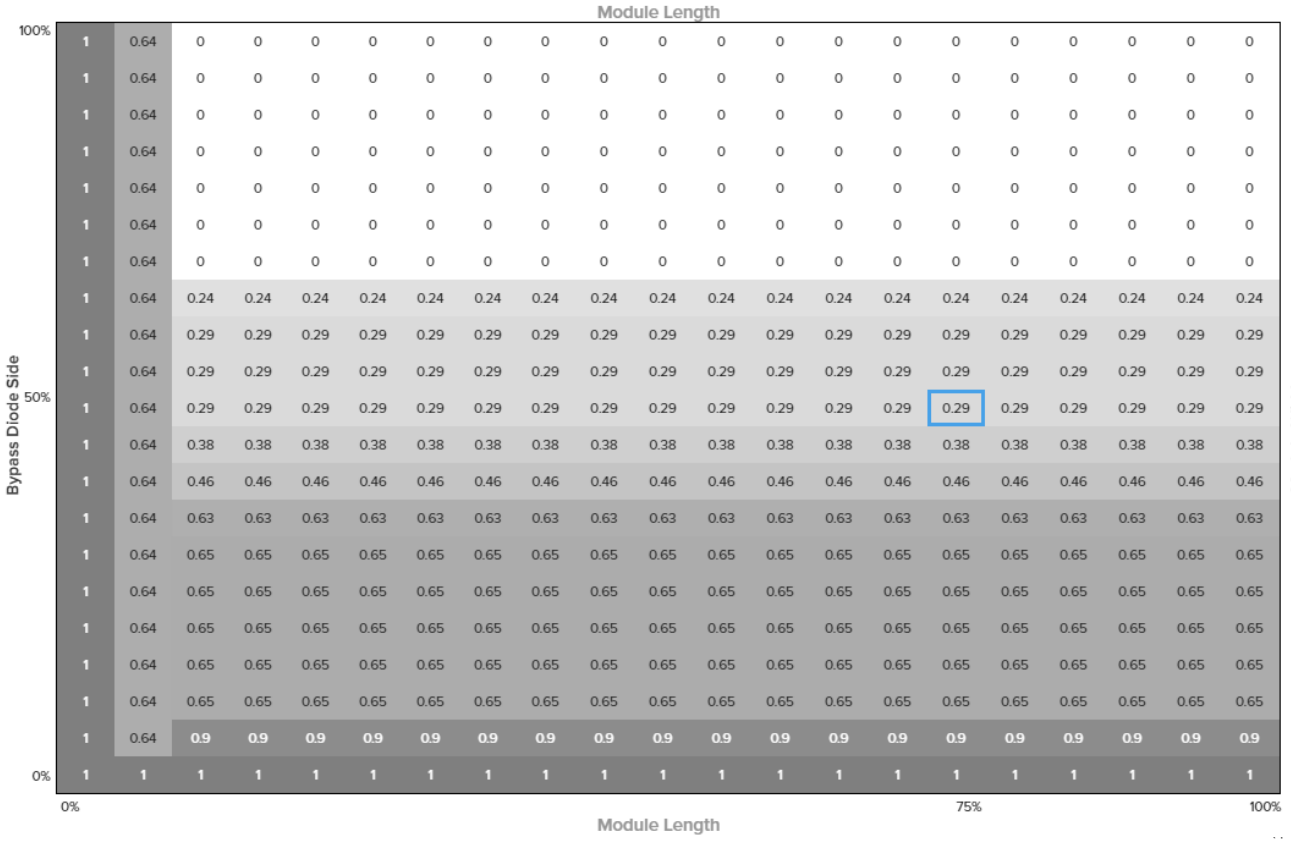
CUSTOM SHADING TABLE INPUT

- For defined module length/width shaded user can define power loss
- Able to upload up to a 100x100 table
- Could represent:
  - Shingled modules
  - Half-Cut Cell modules
  - Multiple Bypass Diodes



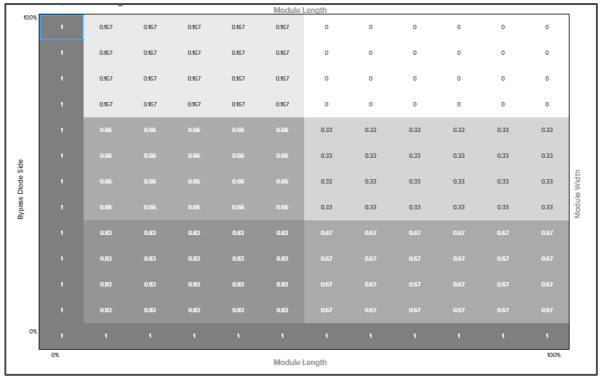
COMPLEX SHADING RESPONSES

SIMULATION SETUP

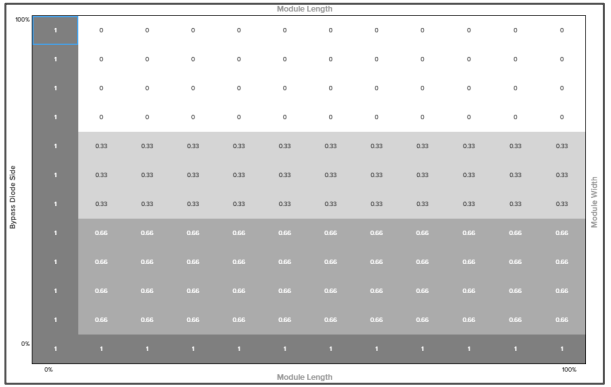
Parameters	Values
GCR	30%-80%
Tracking	Fixed Tilt True-Tracking Backtracking
Shading Responses	8 unique responses
Sites	AZ OH

*NOTE: All simulations done for non-sloped arrays

Half-Cut Cell Module Shading Response



3 Bypass Diode Module



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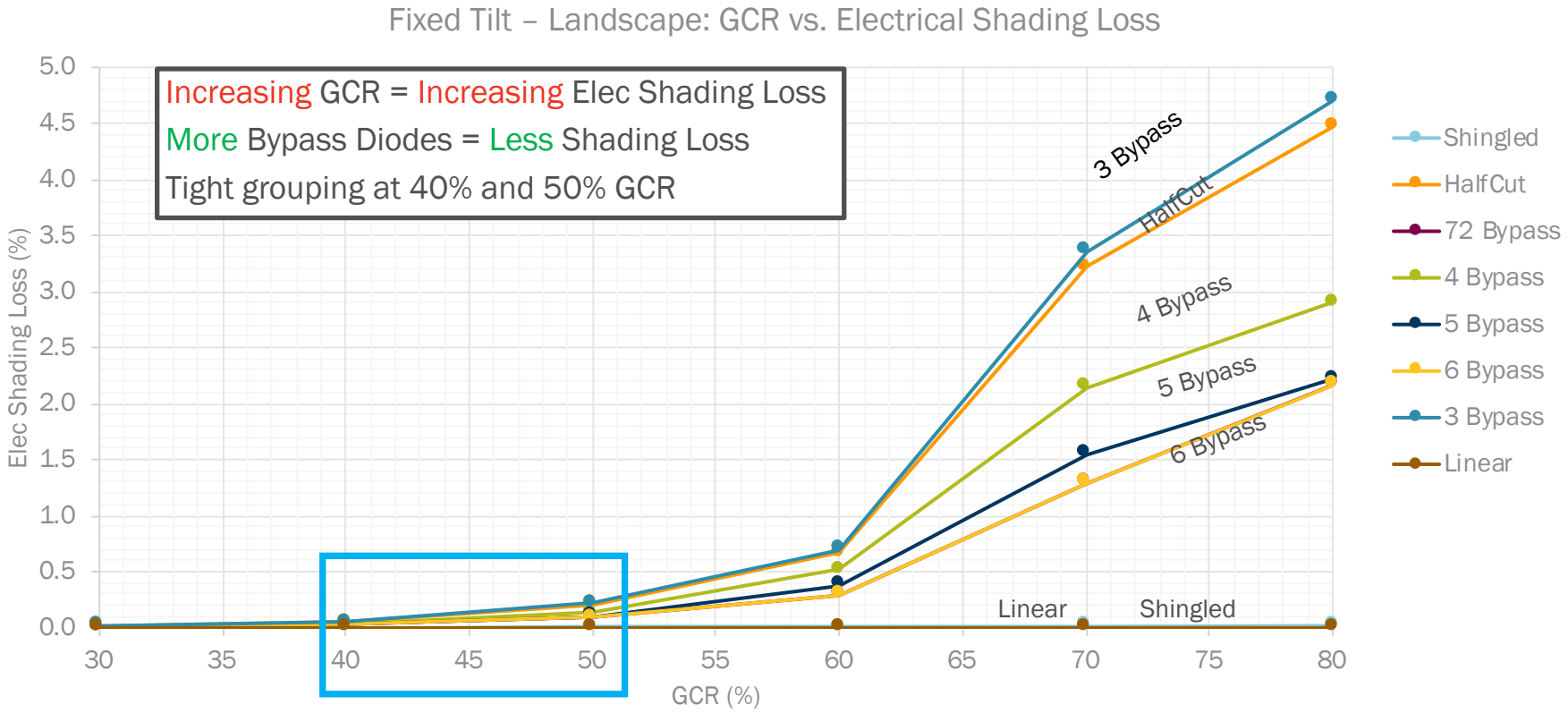
ARIZONA – HIGH DIRECT, LOW DIFFUSE IRRADIANCE



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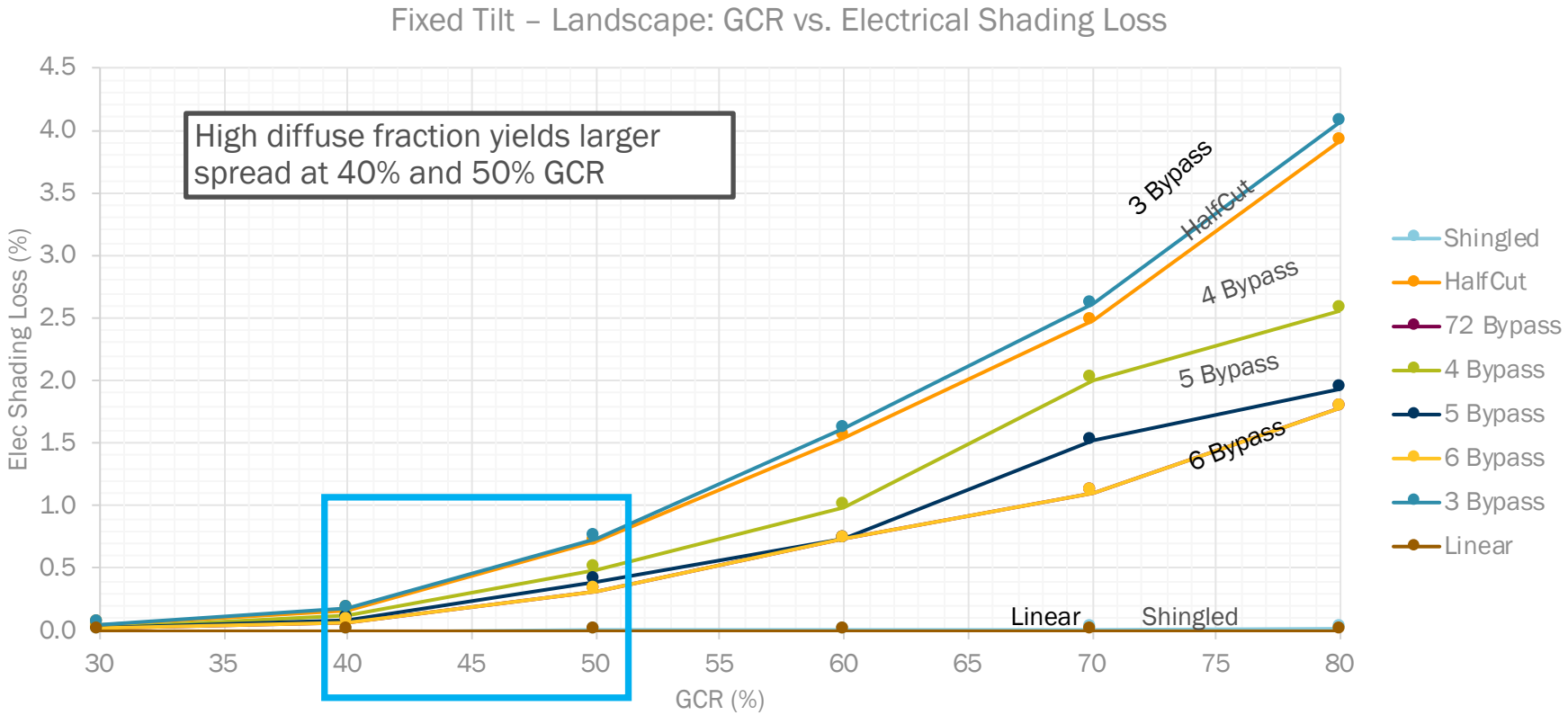
OHIO – LOW DIRECT, HIGH DIFFUSE IRRADIANCE



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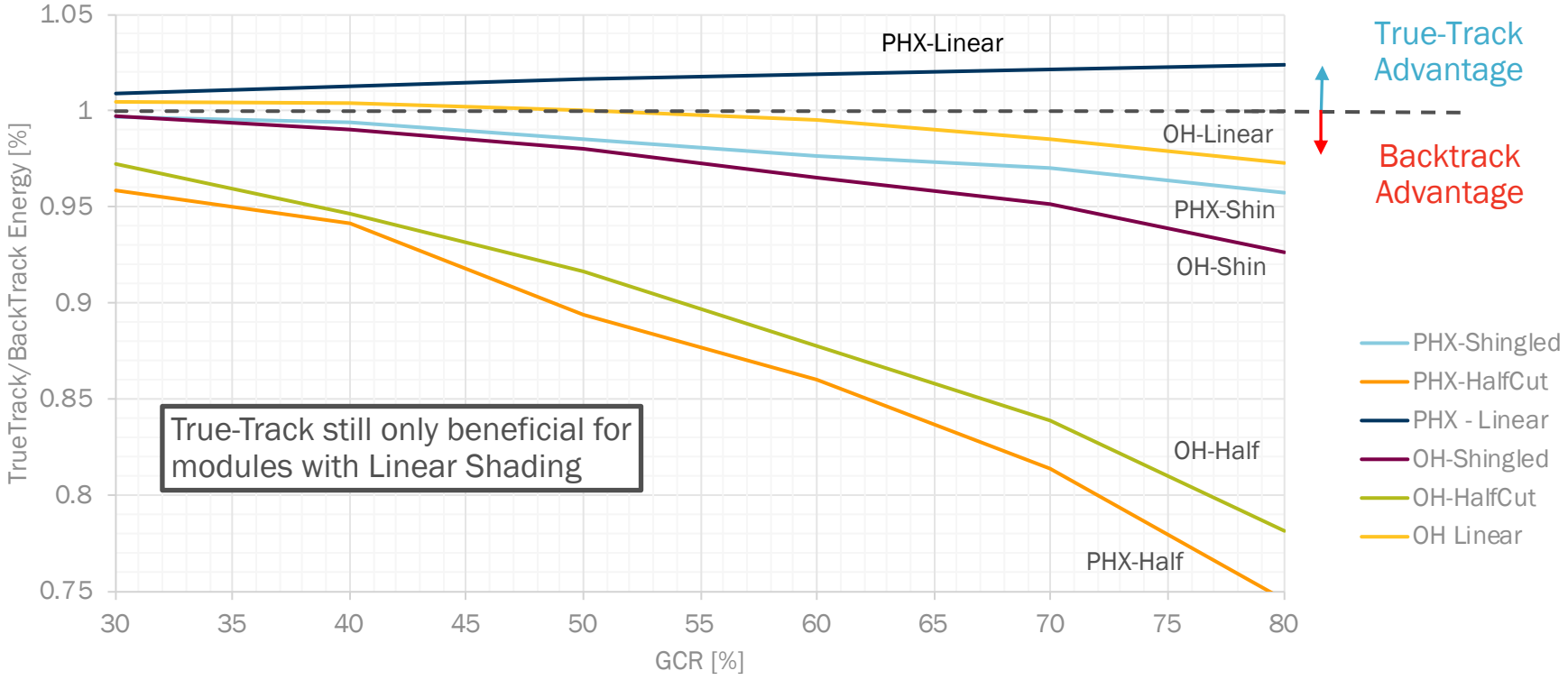
ARIZONA VS. OHIO – TRUETRACK VS. BACKTRACK ENERGY



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RESULTS: KEY TAKEAWAYS

- Fixed Tilt – Landscape
  - — The more bypass diodes, the lower the electrical shading loss
  - — The benefit of adding bypass diodes increases at high GCRs

- Backtracking vs. True-Tracking
  - — Backtracking logical choice for all c-Si modules EXCEPT Shingled at low GCRs
  - — True-Tracking logical choice for thin film CdTe modules

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