System Losses and Derates
Mismatch Losses

- **Draft Definitions of System Loss Factors** — **Geoff Klise**, Sandia
- **Quantifying Mismatch Losses in Small Arrays** — **Sara MacAlpine**, University of Colorado, Boulder
- **Calculation of Mismatch Losses due to Shading in PVsyst, v6** — **André Mermoud**, PVsyst
- **Modeling Mismatch Losses in HelioScope** — **Paul Gibbs**, Folsom Labs
- **Calculating Model Shading Inputs from Design Data** — **Tarn Yates**, Borrego Solar
- **Discussion – Standardizing Definitions of Mismatch Losses**

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Derates / Loss Factors

- Is it a derate? Is it a loss factor? Is it both, or neither?
- Sandia has been tasked by DOE to convene an **“Industry working group to define PV performance modeling standards (loss definitions, reporting standards and templates, etc.)”**
- What do we intend to accomplish with your participation?

Draft Definitions

- We developed a **sample matrix** of the photon to “AC” electron conversion process with our knowledge of PV performance models and with “loss factors” provided by First Solar
- The goal was to show how different models map into each step, *and*
- Compile responses regarding steps/calculations/definitions that were valid, or should be changed

Overview of Working Matrix

- **What you'll see in the next few slides refers to the modeling steps and loss factor definitions on the left side of the matrix**

1 Unshaded Irradiance Incident on POA

	Modeling Steps (Calculations)
Unshaded Irradiance Incident on Plane-of-Array (POA)	Albedo (Snow, no snow)
	POA Orientation Normal Operation
	Suboptimal POA Orientation
	Calculate Spectral Content or Air Mass

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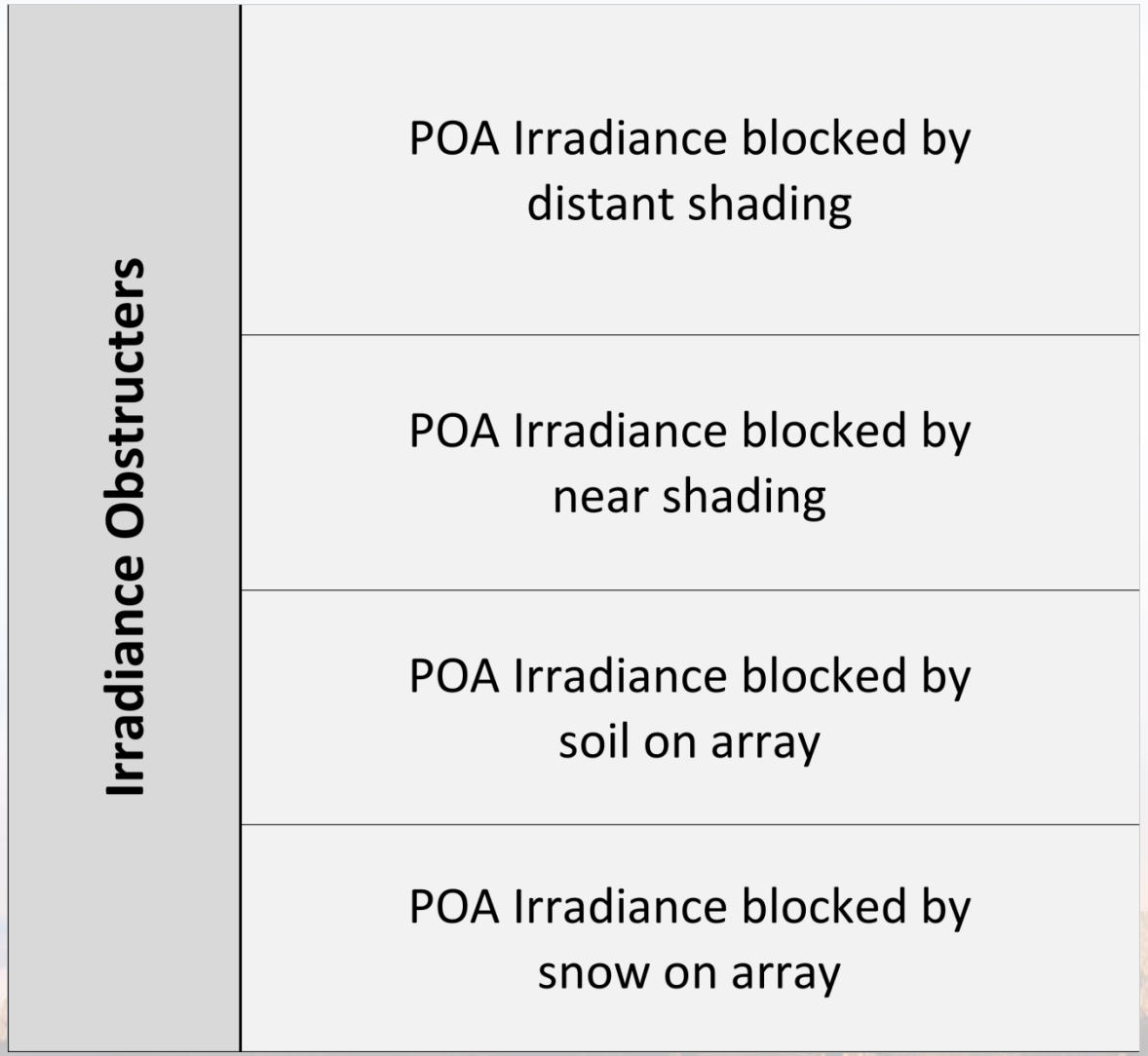
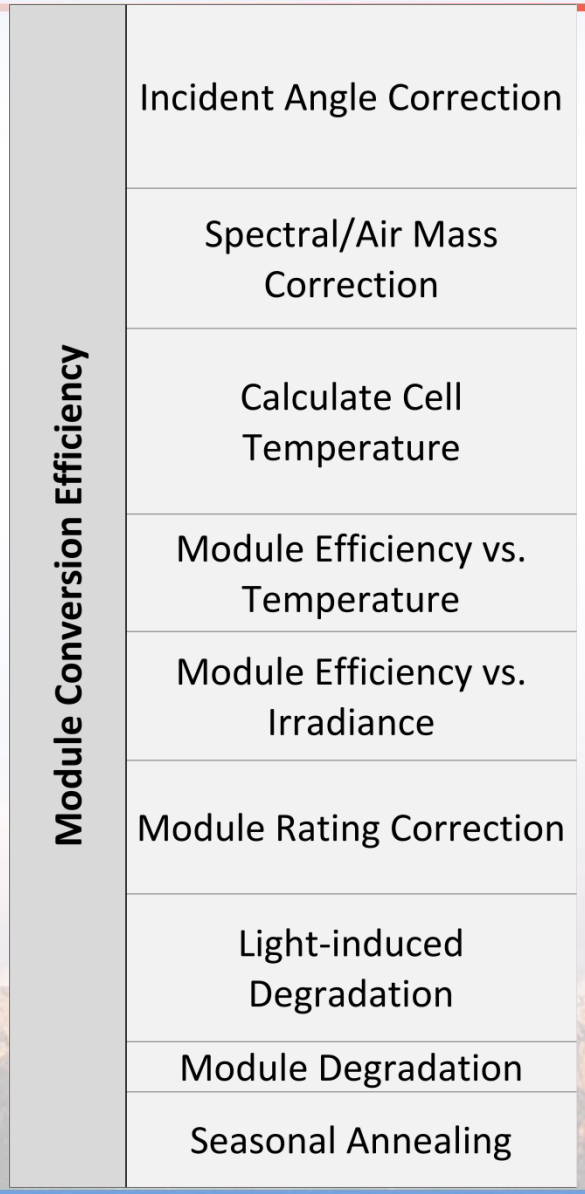
2 Irradiance Obstructers



3 Module Conversion Efficiency



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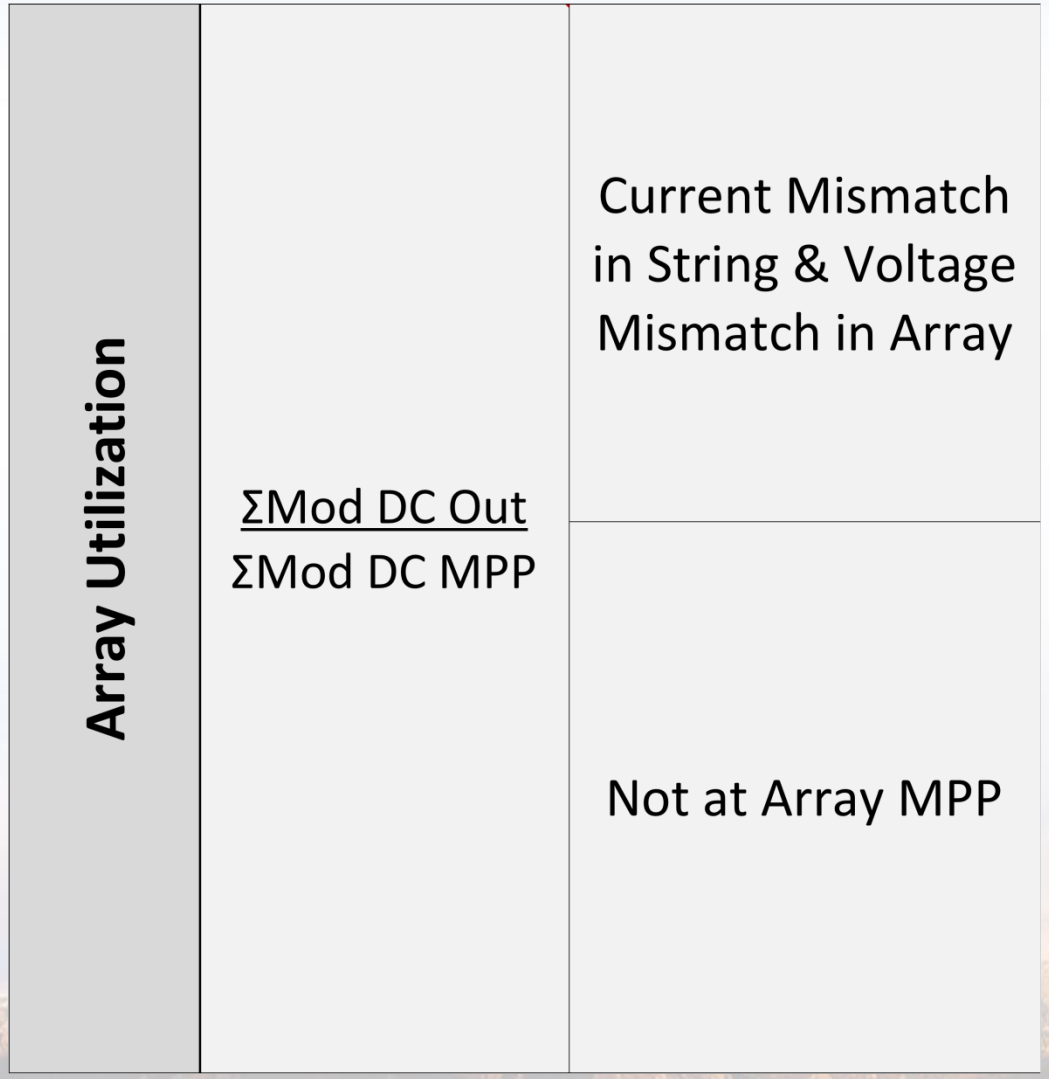
4 Losses in DC System

Losses in DC System	Losses in Diodes, Connectors, Fuses…
	Losses in DC Wiring

5 Array Utilization



Next 4 Speakers

- Mismatch

Results in energy loss due to:

  - Module manufacturing variability
  - Temperature gradient
  - Partial shading

System Losses and Derates

Panel Discussion: System Losses and Derates

- **Jeff Roche,** SunPower
  Rob Andrews, Queens U
  Paul Gibbs, Folsom Labs
  Alex Panchula, First Solar
- **Discussion – Standardizing System Loss Factor Definitions**

Performance Degradation

- **Modeling Module Power Degradation** — **Thomas Roessler**, Yingli Green Energy Europe
- **Fleet-Wide Study of System Degradation** — **Mike Anderson**, SunPower
- **Standardizing Definitions: Survey Results and Inputs to the Working Group** — **Geoff Klise**, Sandia

Overview of Working Matrix

- **What you'll see in the next few slides refers to the modeling steps and loss factor definitions on the left side of the matrix**

6 DC to DC & 7 DC to AC

	Modeling Steps (Calculations)
DC to DC	DC to DC Efficiency
DC to AC	DC to AC Efficiency
	Inverter Efficiency Adjustment
	Inverter Loads, Fans, Controls…

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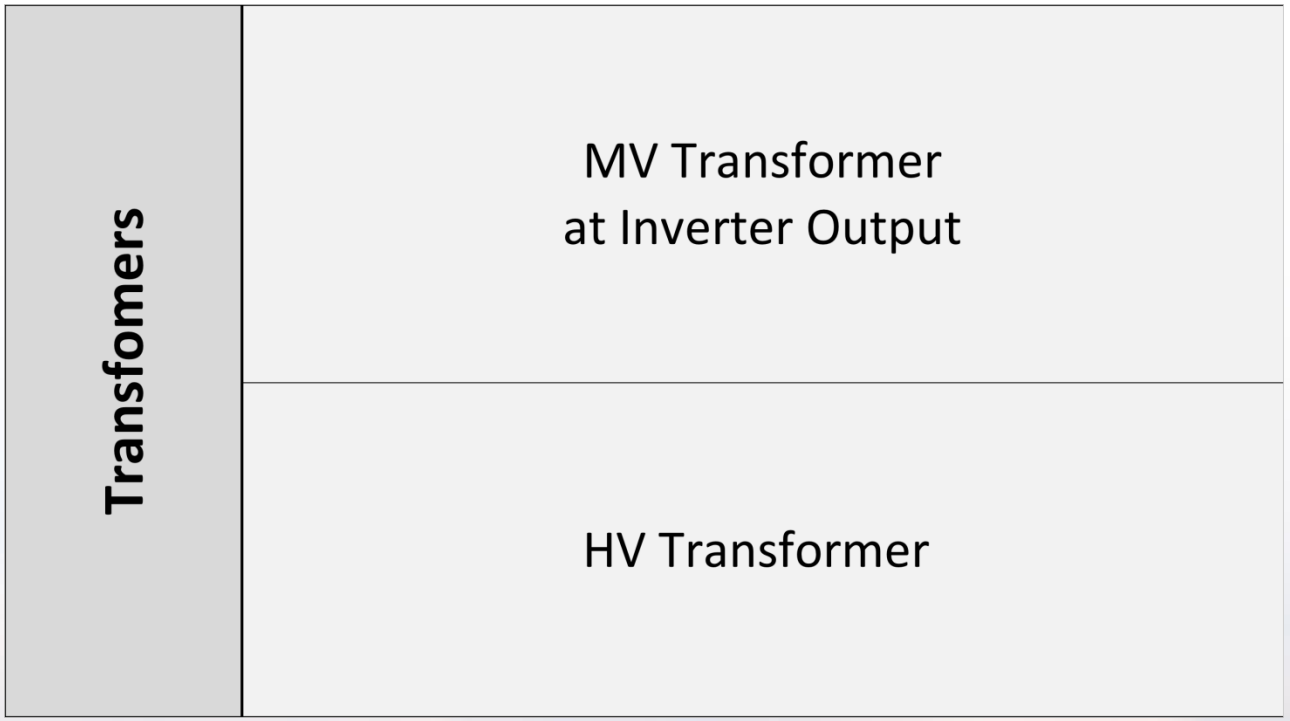
8 Transformers



9 Other AC Loads

Other AC Loads	
	Tracker Motors
	Data Acquisition & Aux

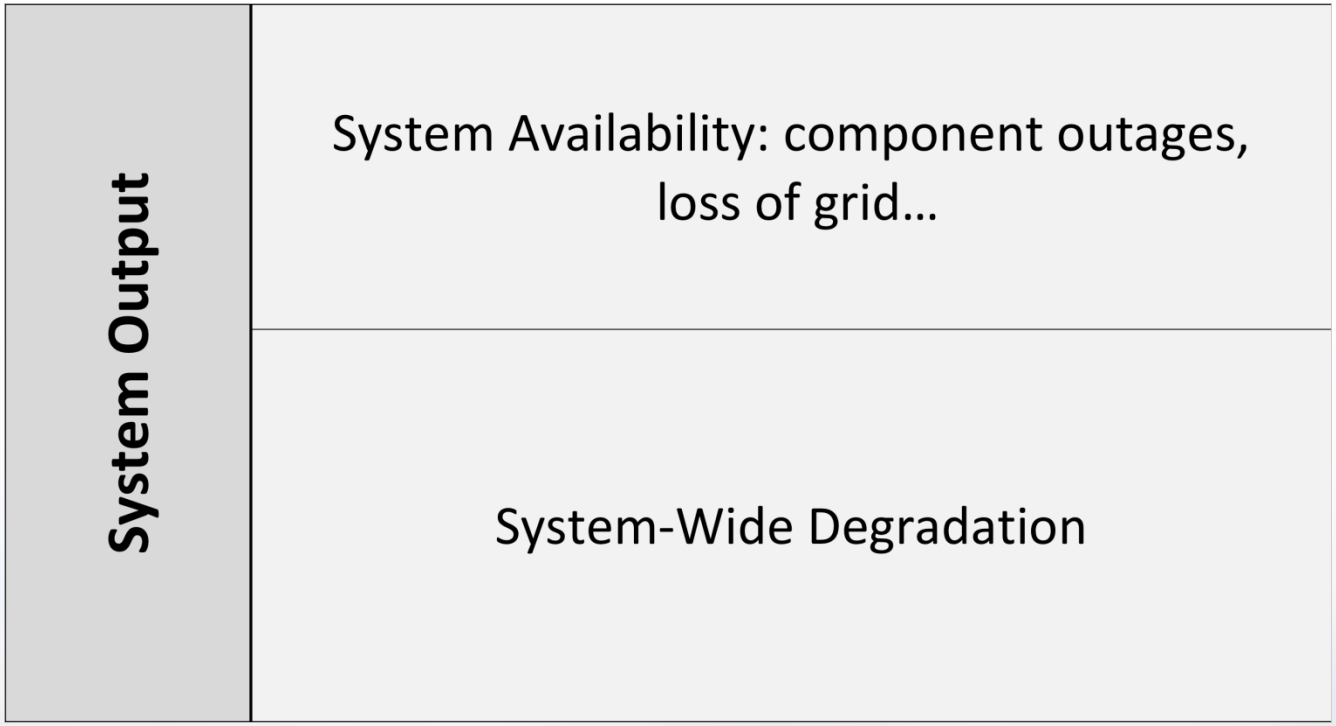
10 Losses in AC System

Losses in AC System
Plant AC Wiring Losses
AC Wiring Losses to Interconnection (Meter)

11 Utility Interactions

Utility Interactions	AC Interconnection Capacity Limitation
	Utility Line Loss

12 System Output



Standardizing Definitions:

Survey Results & Inputs to the Working Group

Model Matrix

- **Survey Response:**
  - **16** respondents
  - Ranged between ‘big-picture’ comments, changing modeling steps, definition changes, and the use of specific values for specific models
  - Models added to matrix include:
    - PV*Sol Expert,
    - PVSim v2.4 (SunPower),
    - PR-FACT, and
    - SRCL ‘Tester’ model

General Comments

- Consensus on **definitions of the terms** would be helpful
- Are **derate** and **loss factors** the same? Are they used to **describe an input** to the model, or are they a **modeling result**?
- Re-defining conventional language? Some nominal "**losses**" are actually **efficiency gains** (albedo, positive quality loss factor due to plus tolerance, etc.)
- …using these current naming conventions, "**loss**" and "**derate**" factors, in a standard may lead to some confusion. I don't have any ideas to get around this besides re-defining the conventional language as something like "**loss/gain**" or "**scale**" factors…

General Comments

- Should **losses be grouped** according to how they are **measured in the field**?
- Performance models should be **validated** through **measurement of derate factors**
- Certain **derate factors** should be **modeled stochastically** given their intrinsic variability and uncertainty
- Should there be ways to translate derate/loss factors to compare one model to another?

Specific ‘Step’ Comments

- **Regarding initial steps with POA irradiance**
  - Provide more clarity on what *blocks* irradiance and factors that *reduce* irradiance
  - Move the **spectral content or air mass** calculation below where sunlight is converted to DC energy
  - More granularity on what constitutes **sub-optimal POA orientation**

Specific ‘Step’ Comments

- **Regarding conversion of light to DC energy**
  - Change definition to reflect conversion step
  - More granularity in the **module efficiency vs. irradiance and temperature step**
  - The **module rating correction** step was discussed with regards to PVSyst
  - Addition of a **seasonal annealing** factor

Specific ‘Step’ Comments

- **Regarding Array Utilization**
  - Change definition
  - On module mismatch, requests for better defined and consistent modeling approach
  - In **not at array MPP**, more granularity for separating **MPPT error** and **clipping losses**
  - Should some of these descriptions be moved in inverter conversion steps (DC to DC, or DC to AC)

Specific ‘Step’ Comments

- **Regarding DC to DC / DC to AC / Transformers**
  - **DC to DC efficiency is** not a relevant loss/metric
  - Role of DC Optimizers and proper modeling techniques
  - What is **inverter efficiency adjustment**?
  - Should transformer losses be post-processed?

Specific ‘Step’ Comments

- **Regarding Other AC / Losses in AC / Utility Interactions / System Output**
  - Should the **AC Interconnection Capacity Limitation** take place at the inverter instead?
  - There should be more granularity to include factors such as **ramp rate control**, **operating at non-ideal power factors**, **curtailment issues**, etc.
  - Is a single **degradation factor** appropriate to model out to however many year, or should this change due to higher array to inverter ratios?

Working Group

- These definitions and matrix are not ‘set in stone’
- Friday working group will be ‘industry-driven’ to help us better understand what is important and necessary if standardized definitions are eventually agreed upon
- This work will be summarized in a report along with definitions published on the PVPMC website
- We will rely on the working group to recommend next steps for continuing work in this area