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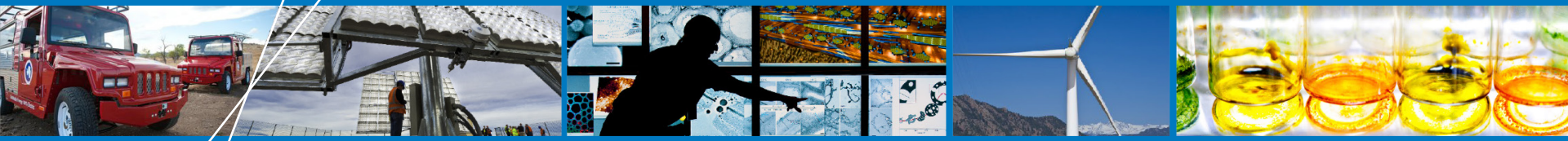
NATIONAL RENEWABLE ENERGY LABORATORY

PV Module Database Comparison



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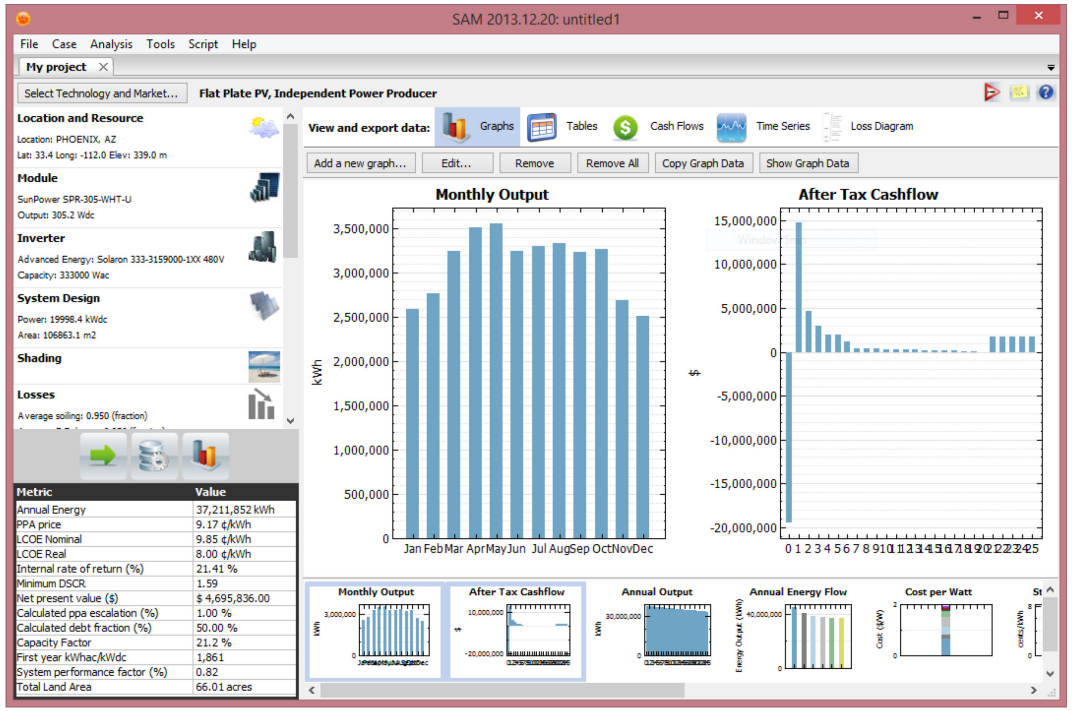
System Advisor Model

The System Advisor Model (SAM) is a free user-friendly computer program that **calculates a renewable energy system's hourly energy output** over a single year, and **calculates the cost of energy** for a renewable energy project over the life of the project.

These calculations are done using detailed performance models, a detailed cash flow finance model, and a library of reasonable default values for each technology and target market.

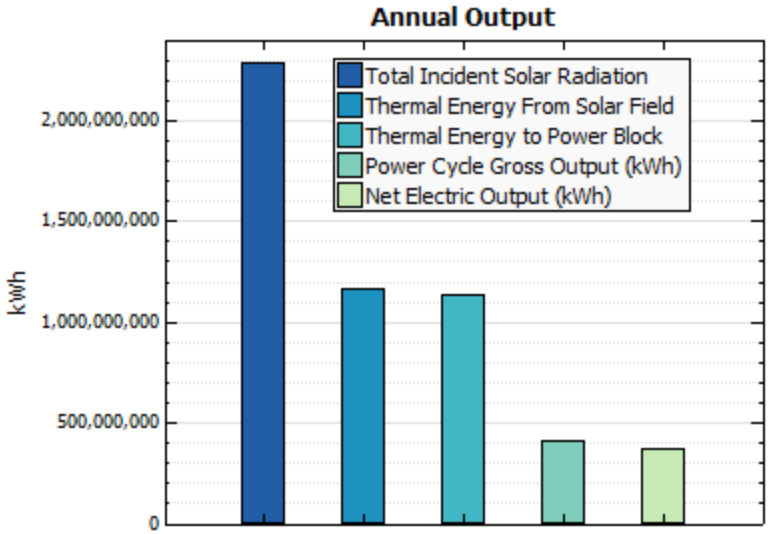


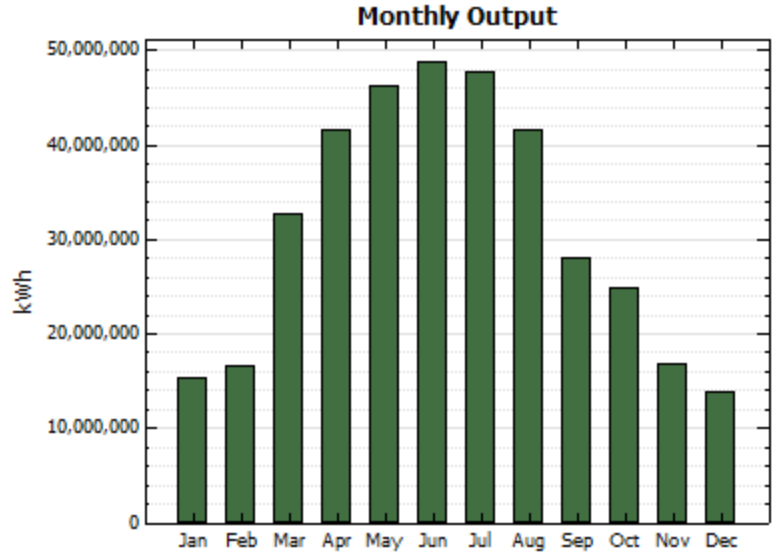
Technologies SAM can model:

- Photovoltaics (Flat plate, CPV)
- Solar Water Heating
- Concentrating Solar Power (Trough, Tower, Linear Fresnel, Dish Stirling)
- Geothermal
- Wind (Small + Utility scale)
- Biomass Power

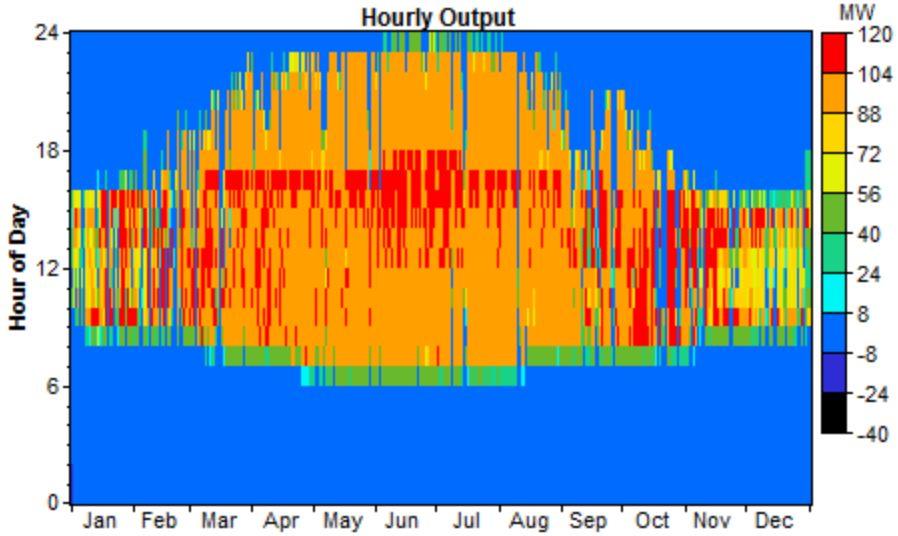
Weather Data + System Specs » Energy Production + Cost Data + Utility Rates & Incentives + Financing Options » Annual, Monthly, and Hourly Output, LCOE, NPV, Payback, Revenue, Capacity Factor

Generate electric output predictions





Example: 100 MW Parabolic trough system with 6 hours of storage



Goals for this Analysis

- **NREL is performing various other validation studies of SAM and other models**
  - Compare SAM to nine real-world datasets
  - Compare SAM, PVSyst, PVSol and RETScreen against all nine datasets as well
- **Are the variations seen between these models due to the algorithms themselves or the data inputs? It is believed that a large portion of the variations in results between models could be due to differences in definition of parameters for certain modules common to multiple databases.**
- **Note that many data inputs can be easily reviewed but not always the inputs about the module characteristics which are hidden in a database/table/library somewhere.**
- **Through this effort we hope to also characterize which modules are common between the databases in an effort to standardize defaults across all the models.**

Which databases did we compare?

- **Four different databases that we have access to and that use similar one-diode models were compared.**
  - System Advisor Model
    - Sandia Module Database
    - CEC Module Database
  - PVSyst Module Database
  - PV*SOL Module Database

What are the common Modules?

- **61 "groups" of modules are present in all four databases**
  - "Groups" mean that the physical characteristics of the modules are identical but the several model numbers represent differences such as colors, etc.
  - This is primarily due to the age and smaller size of the Sandia Module database.
- **However, this should be a statistical significant number to look for any systemic changes between databases.**

List of Module model groups common to all four databases

Module Families		
Aleo S16 165	Mitsubishi PV-MF180	SunPower SPR-205
Aleo S16 170	Mitsubishi PV-UD185MF	SunPower SPR-210
Aleo S16 175	Mitsubishi PV-UD190	SunPower SPR-215
Aleo S16 180	Moser Baer MBPV 220	SunPower SPR-220
Aleo S16 185	Sanyo HIP-186	SunPower SPR-225
BP Solar BP3220	Sanyo HIP-190	SunPower SPR-230
BP Solar SX3190	Sanyo HIP-195B	SunPower SPR-300
BP Solar SX3195	Sanyo HIP-200	SunPower SPR-305
BP Solar SX3200	Sanyo HIP-215	SunPower SPR-315
Canadian Solar CS5P/CS6P-220M	Sanyo HIP-225	Suntech STP170S
First Solar FS-267	Sharp ND-123	Suntech STP175S
First Solar FS-270	Sharp ND-160	Suntech STP180S
First Solar FS-272	Sharp ND-167	Suntech STP200S
First Solar FS-275	Sharp ND-187	Suntech STP260S
Kyocera Solar KC130	Sharp ND-208	Suntech STP270S
Kyocera Solar KD135GX	Sharp ND-216	Suntech STP280S
Kyocera Solar KD180GX	Sharp NE-165	Yingli YL210
Kyocera Solar KD205GX	Sharp NE-170	Yingli Solar YL220
Mitsubishi PV-MF165	Solar Semiconductor Inc. SSI-M6-220	Yingli Solar YL230
Mitsubishi PV-MF170	Solar World SW175	
Mitsubishi PV-UD175MF	SunPower SPR-200	

What variables were compared?

While some models (like Sandia) have over 30 characteristics that represent the module and some have only 5, none of the models (SAM, PVSyst, PVSOL) use exactly the same algorithm and so only high-level characteristics of each module could be compared.

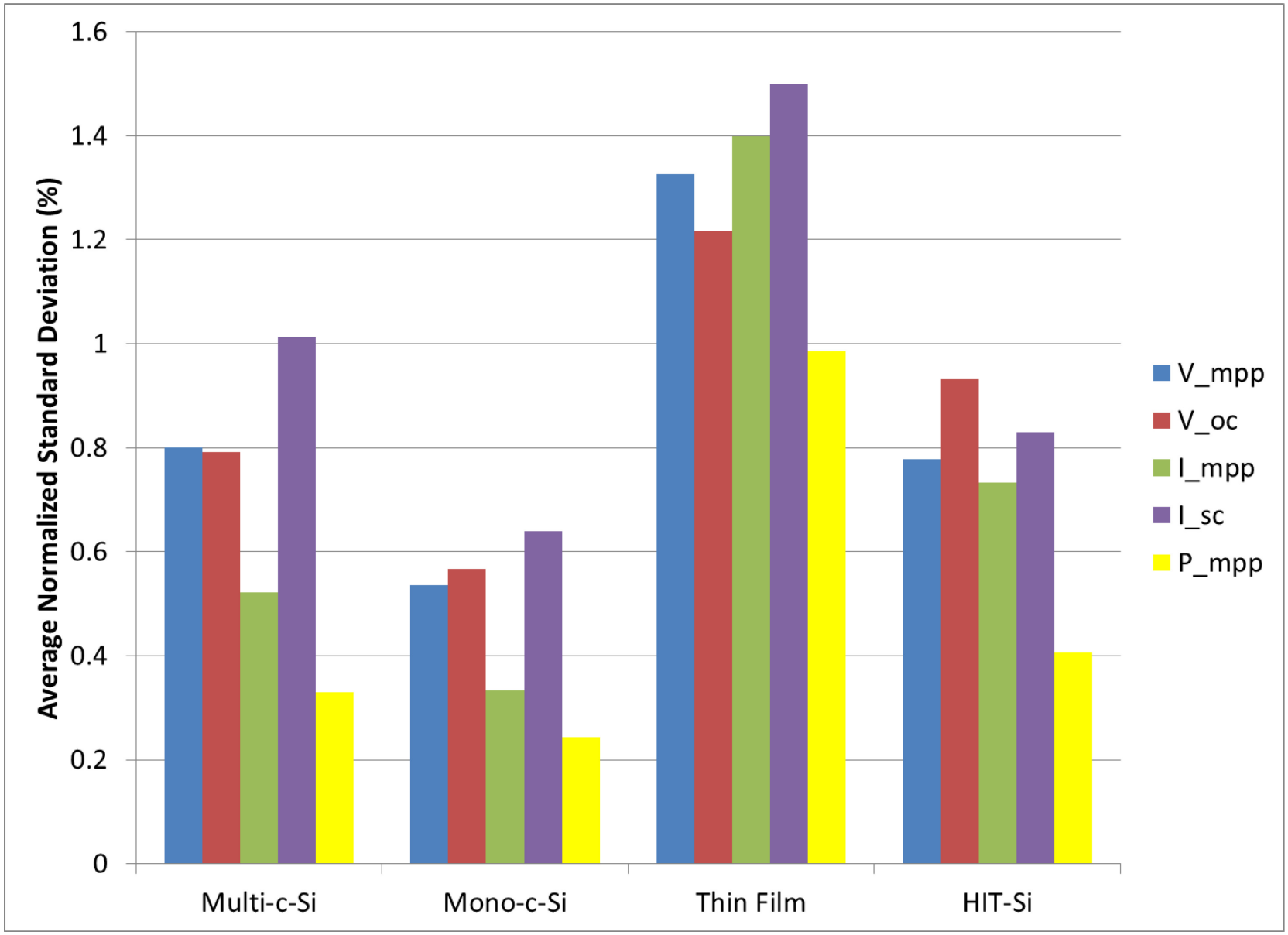
- Vmpp – voltage at the maximum power point
- Impp – current at the maximum power point
- Voc – open circuit voltage
- Isc – short circuit current
- P_mpp – maximum power point (Vmpp * Impp)

Variables in common between databases

CEC	Sandia	PVSyst	PV*SOL
Efficiency	Efficiency		Efficiency
Maximum Power (Pmp)	Maximum Power (Pmp)		
Max Power Voltage (Vmpp)	Max Power Voltage (Vmpp)	Max Power Voltage (Vmpp)	Max Power Voltage (Vmpp)
Max Power Current (Impp)	Max Power Current (Impp)	Max Power Current (Impp)	Max Power Current (Impp)
Open Circuit Voltage (Voc)	Open Circuit Voltage (Voc)	Open Circuit Voltage (Voc)	Open Circuit Voltage (Voc)
Short Circuit Current (Isc)	Short Circuit Current (Isc)	Short Circuit Current (Isc)	Short Circuit Current (Isc)
Material	Material		
Module Area	Module Area		Module Area
Number of Cells	Number of Cells in Series		Number of Cells

Red= Common to all databases BLUE = Common to several databases

Average Normalized Standard Deviation for Various Module Types



Conclusions

- A minimal number of modules are common between these four key databases. (61 out of potentially thousands)
- The individual module variance (shown in appendix slides) shows certain variables for a few panels have more than 3% but less than 3.5% standard deviation.
- Other system errors and variations within modules can be significantly more than 2% and would be larger sources of error between the various tools.
- When the errors are averaged within technology types, the standard deviation of the nominal power between these modules is less than 1% typically.
- There is some increase in variance of some variables with thin-film technologies but still less than 1.5%.
- Future work: Compare the IV curves for each module produced by the various models.

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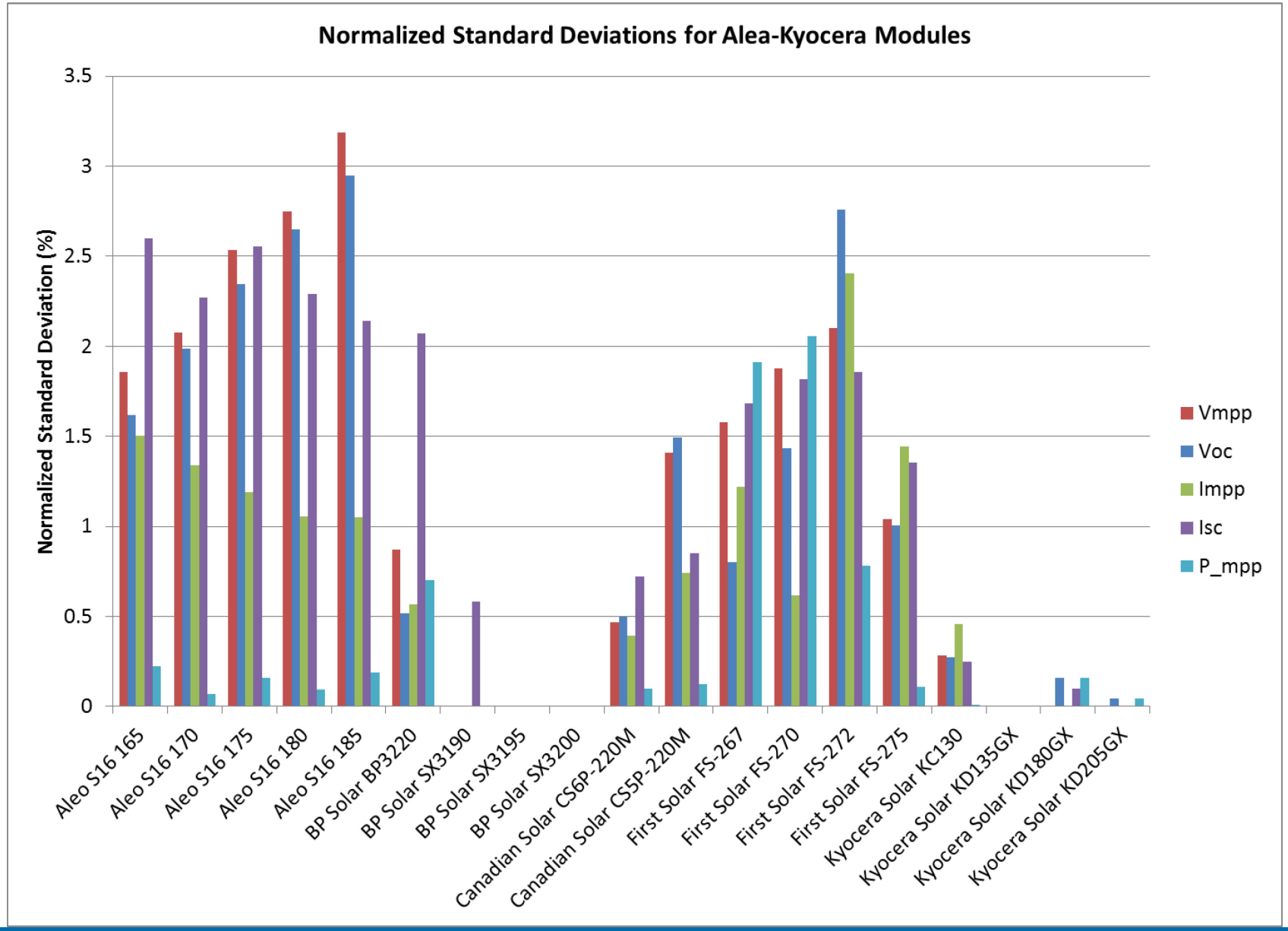
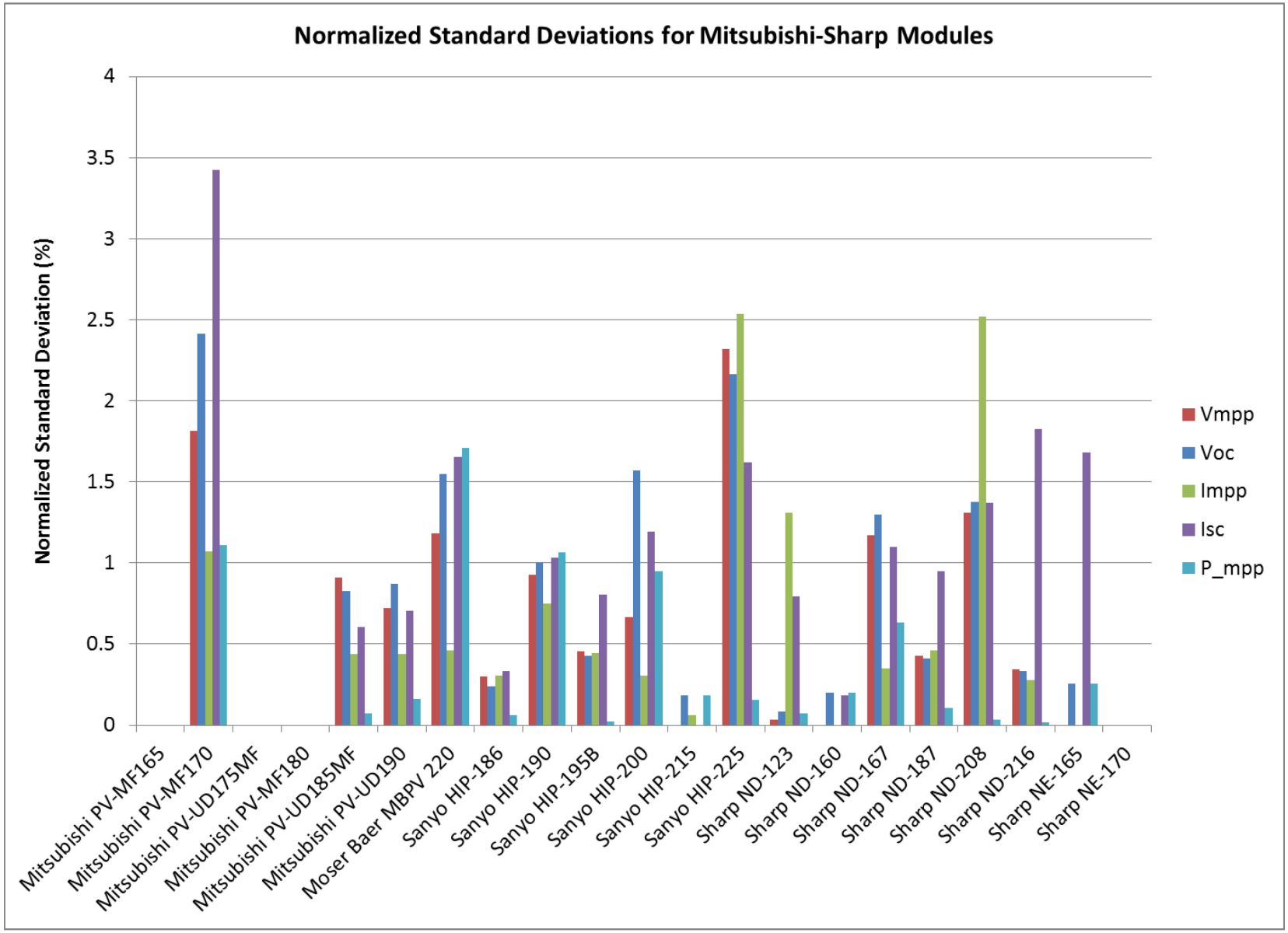
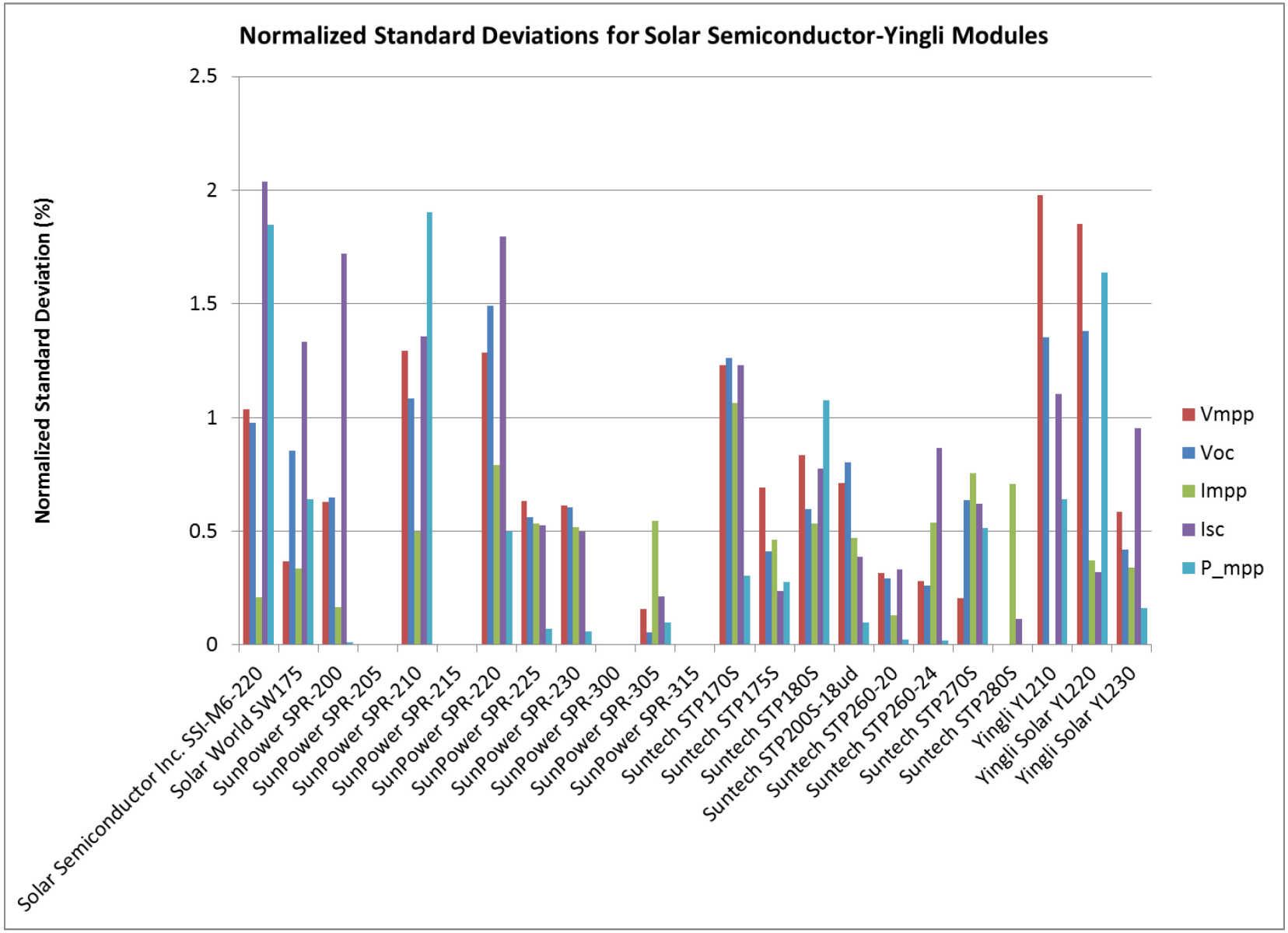
Appendix: Variations 1



Appendix: Variation 2



Appendix: Variation 3