pv magazine Webinar

1,500V Modules: Benefits and Challenges

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Background

➢ Upgrade of module system voltage from 1,000V to 1,500V

Advantages

- ✓ String length can be increased by 50%
- ✓ Reduces the number of parallel circuits
- ✓ Reduces the number of cables
- ✓ Reduces wire losses (DC)
- ✓ Reduces the PV system cost

To be noted

- ✓ Higher module material requirements
- ✓ Increases module cost (back sheet and junction box)
- ✓ The inconsistency of the module is higher
- ✓ System safety requirements are higher (inverter/ combiner box/ circuit breaker/ isolating switch and so on)

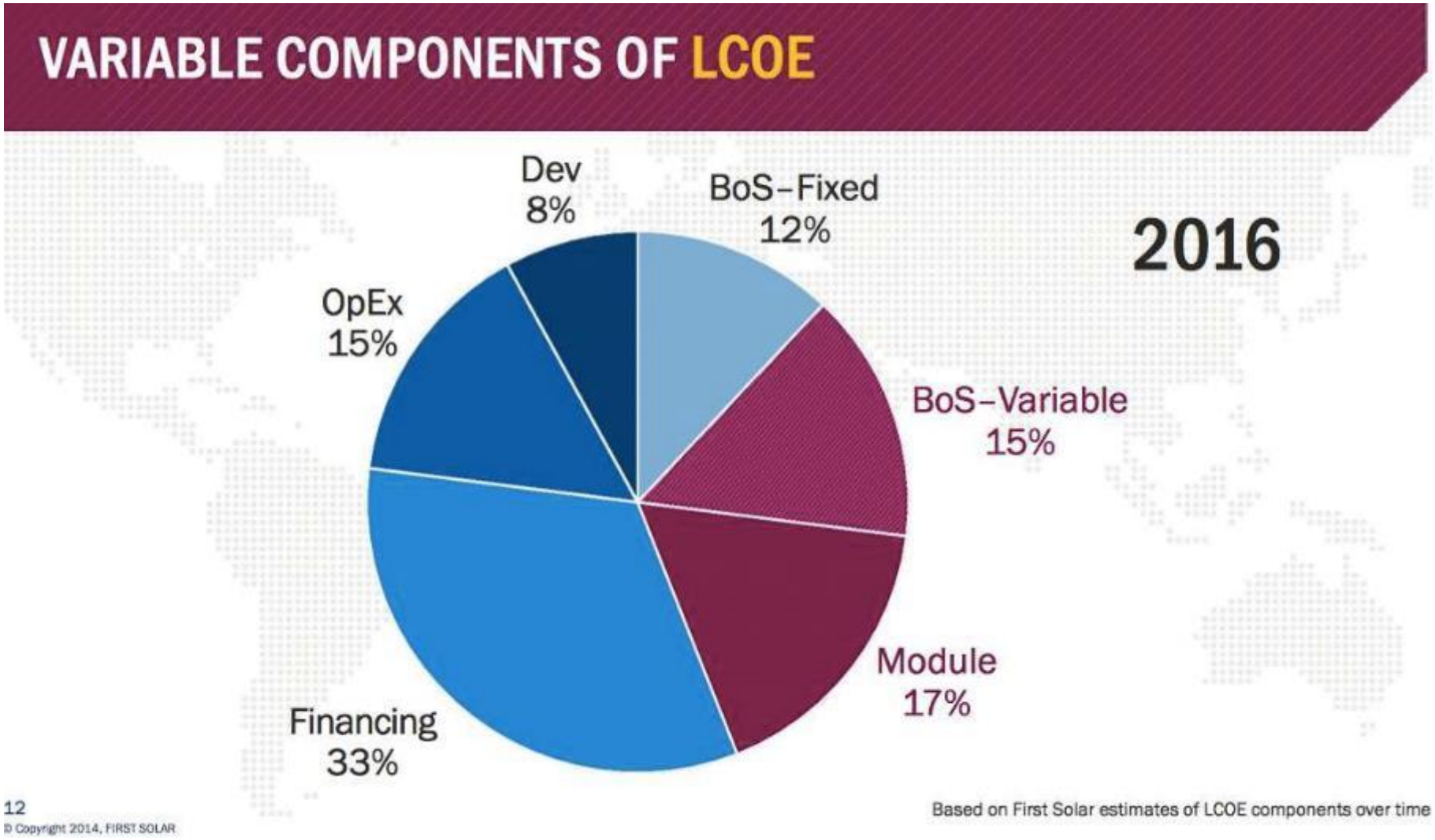
Reduces home-run wires

Reduces the number of combiner boxes, improves inverter power density.

Reduces the points of grid connected, reduces the amount of high voltage cable, reduces the transformer cost.

Reduces installation and maintenance workload, reduces construction and operation cost.

Levelized Cost of Energy



Source: http://www.greentechmedia.com/content/images/articles/first-solar-lcoe-2016.jpg

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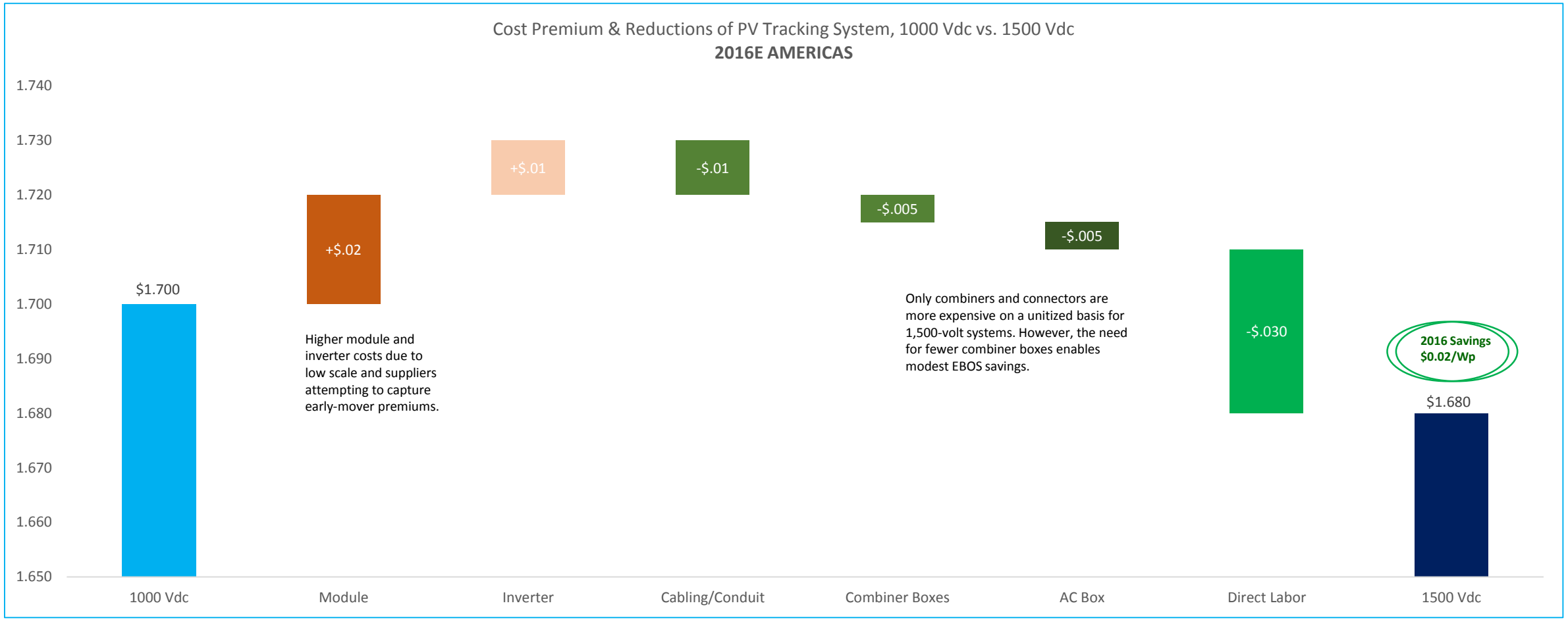
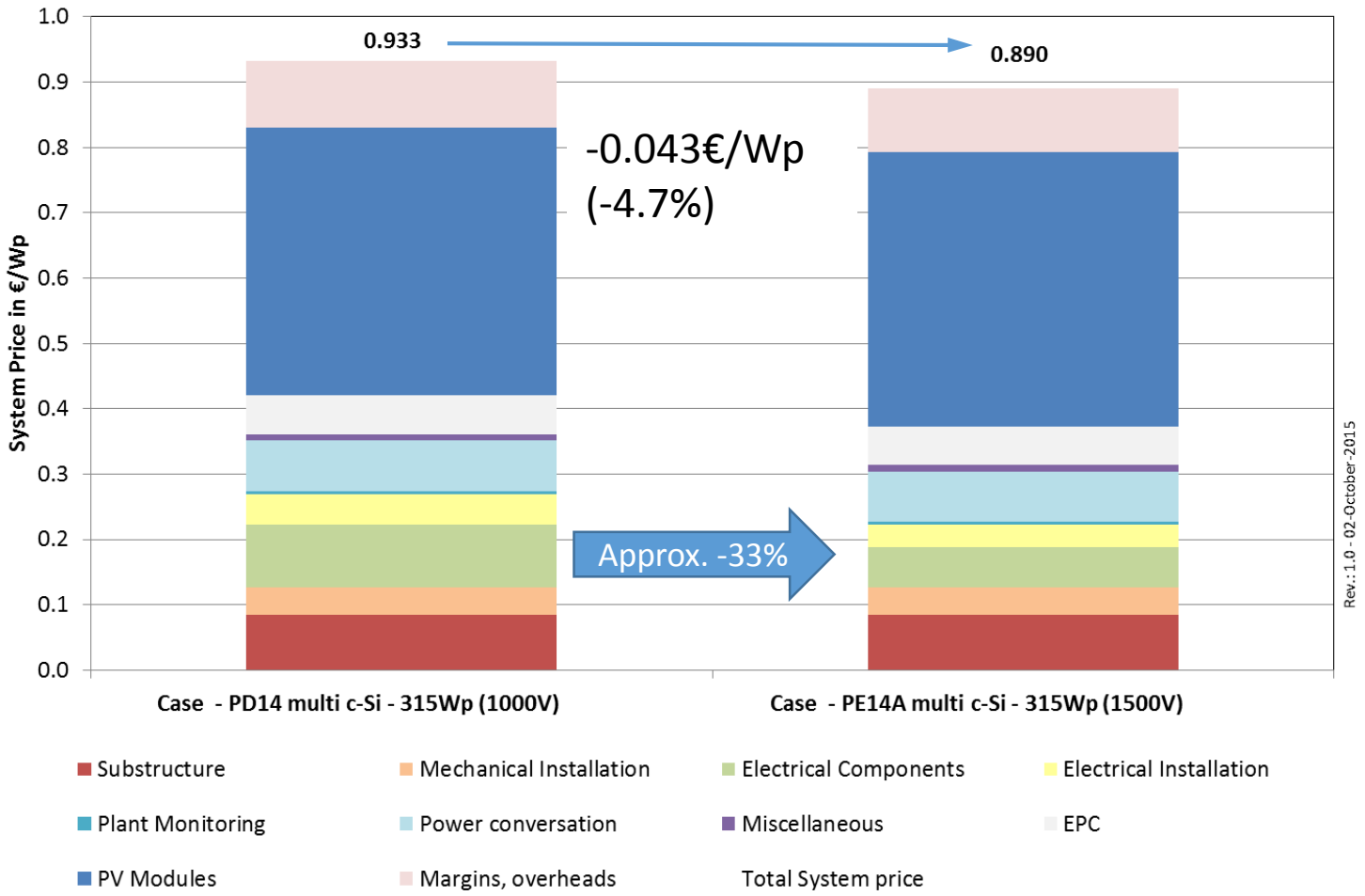
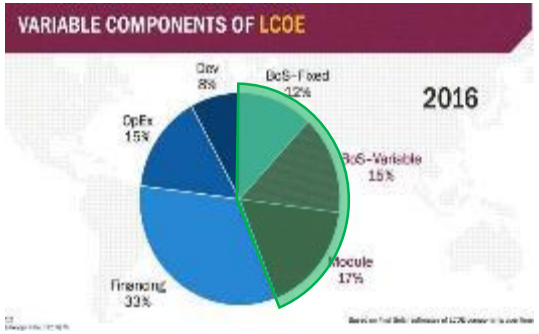
Balance of System Savings – Example USA



Source: GTM: 1500v pv systems & components_2016-2020: Jan2016

Balance of System Savings – Framed PV Modules





Assumptions

- Inverter costs are 0.08€/VA (1000V version and 1500V Version)
- Same block size of 1MW
- Module price difference 0.02€/Wp
- Framed 1000V PV module
- Framed 1500V PV module

System price can be reduced by 4.7% if using 1500V system
LCoE 1000V: 0.100
LCoE 1500V: 0.0954
LCoE reduction: -4.9%

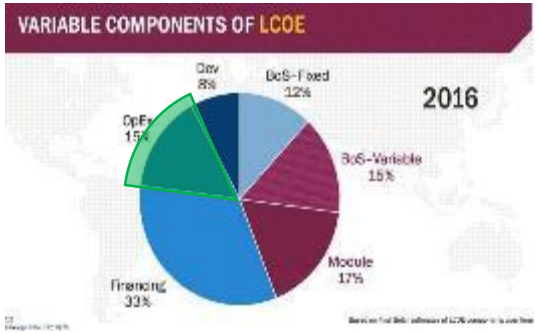
Performance Improvement

Inverter (Example)		Sungrow	
Type	[-]	SG3000HV-MV	SG2500MV
Max. AC output	[kVA]	3000	2772
Max. system efficiency	[%]	98.0	98.0
Max. Euro system efficiency	[%]	97.5	97.5
Source:	[-]	http://en.sungrowpower.com/	

Cable losses in % - Example based on 24 channel combiner box			
		1000V	1500V
String length	[-]	19	29
String cable	[6mm2]	0.12%	0.10%
Home run cable (combiner box to inverter)	[300mm2]	0.77%	0.63%
Note: This is only an example to show the impact, the detailed cable losses are depending system design and location			

Higher system voltage slightly reduces the losses of some system components.

Operation and Maintenance

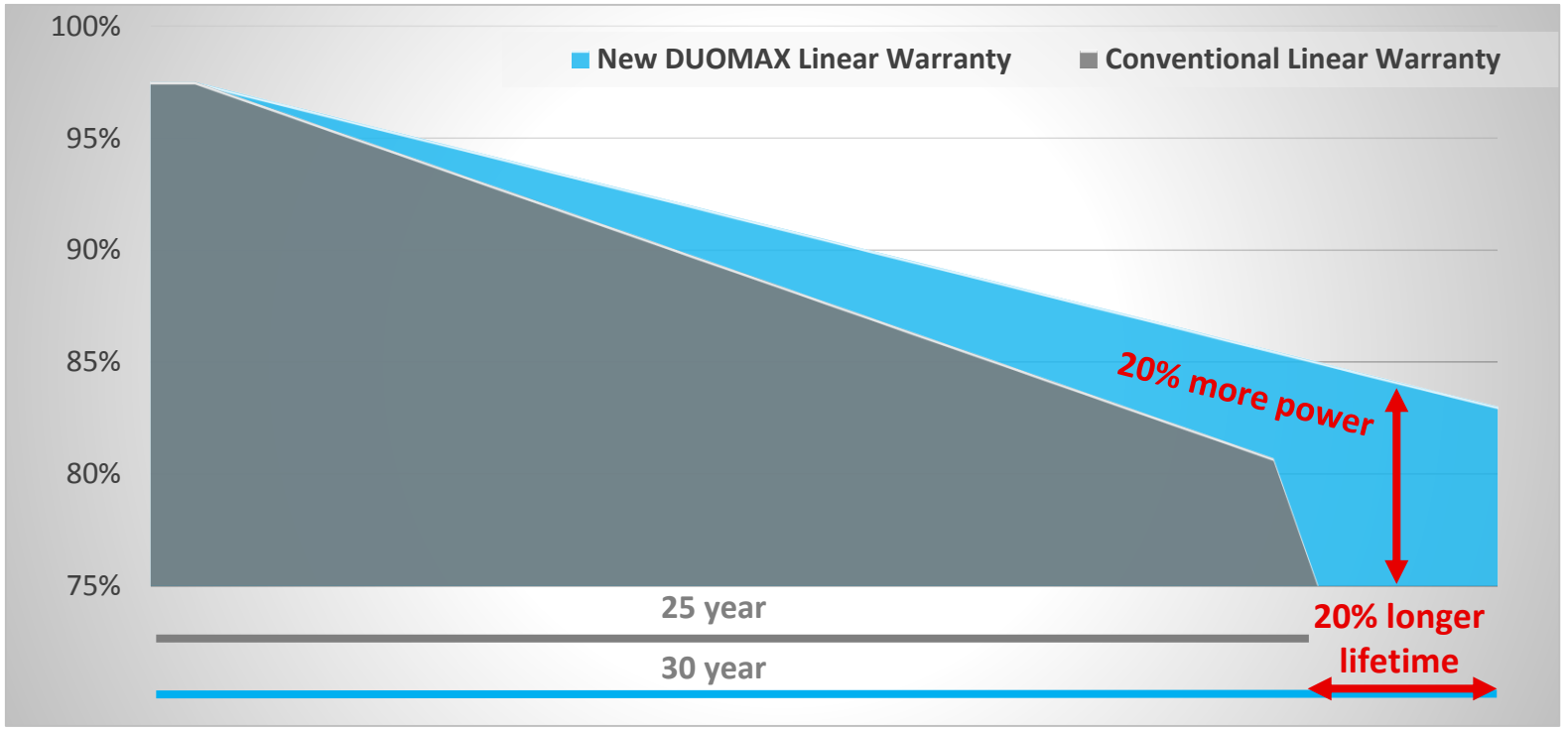


Maintenance for 10MW project with SMA inverter

- 1,000V System
  - 5pcs 2MW inverter station
  - 76 monitored combiner boxes
  - 31,250 PV Modules
- 1,500V System
  - 4pcs 2.5MW inverter station
  - 50 monitored combiner boxes
  - 31,250 PV Modules
- Remaining O&M costs are unaffected: cleaning, module inspection, component failure rates

→ **The reduced maintenance effort for electrical components leads to savings of approx. 4%**

Duomax 30 Years Linear Warranty



A reduced degradation of 0.5% instead of 0.7% leads to an LCoE reduction of 5.1%
(assuming system price of approx. 0.93€/Wp (utility scale))

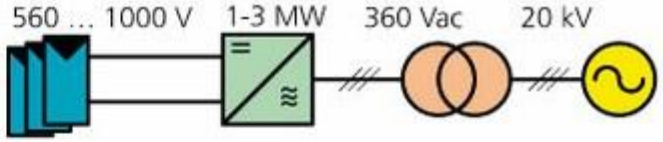
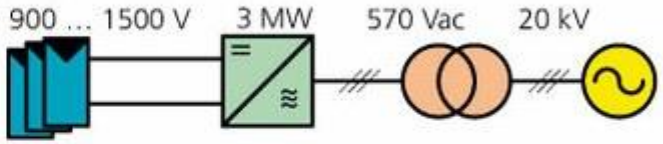
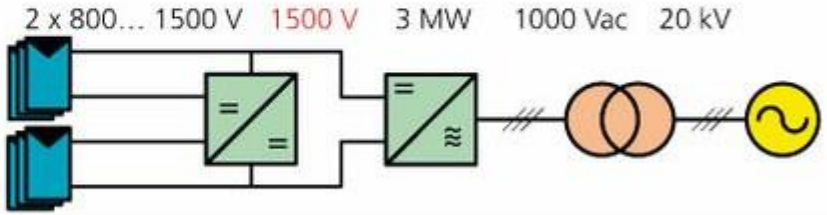
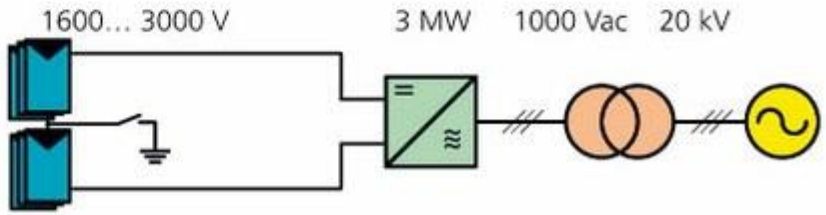
→ 5.1% increased profit due to lower degradation

DUOMAX: 0.5% Annual Degradation, 30 year Warranty

Conventional module: 0.7 % % Annual Degradation, 25 year Warranty

Note: LCoE = Levelized cost of Energy, EY based on irradiation London, estimation only

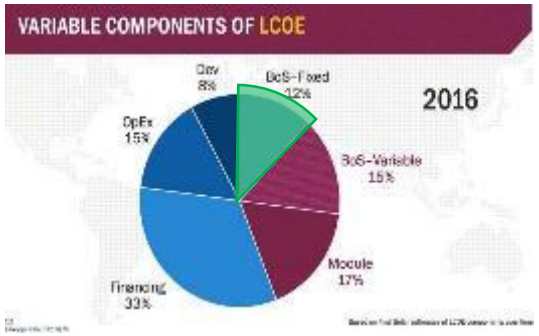
Power Plant Concepts discussed in the Industry

A	State of the Art (Referenz): 1.000 V_{DC} / 360 V_{AC} / 1-3 MVA	
B	State ot the Art with Higher Voltage: 1.500 V_{DC} / 570 V_{AC} / 3 MVA	
C	2-Stage Concept with Fixed Voltage DC -Link: 2x1.500 V_{DC} / 1.000 V_{AC} / 3 MVA	
D	Bipolar PV-Generator: 3.000 V_{DC} / 1.000 V_{AC} / 3 MVA	

Current decrease after inverter

Fig. 3: Overview of the investigated power station concepts with a DC voltage level of 1000 V to +/- 1500 V. With the new concepts, the potential for a maximum AC voltage of 1000 V allowed by the Low Voltage Directive can be fully exploited. © Fraunhofer ISE

Source: https://www.ise.fraunhofer.de/en/research-projects/hidc-pv-power-stations



Maximum transformer size based on current limitation of approx. 6,500A

Transformer size per Case

- A: 2.3 MVA
- B: 3.7 MVA
- C & D: 6.5MVA

Comparing cases A and B, the number of transformers for a 50MW project can be reduced from 22 (Case A) to 14 (Case B)
→ **Installation effort reduction of approx. 36%**

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Potential Induced Degradation (PID)

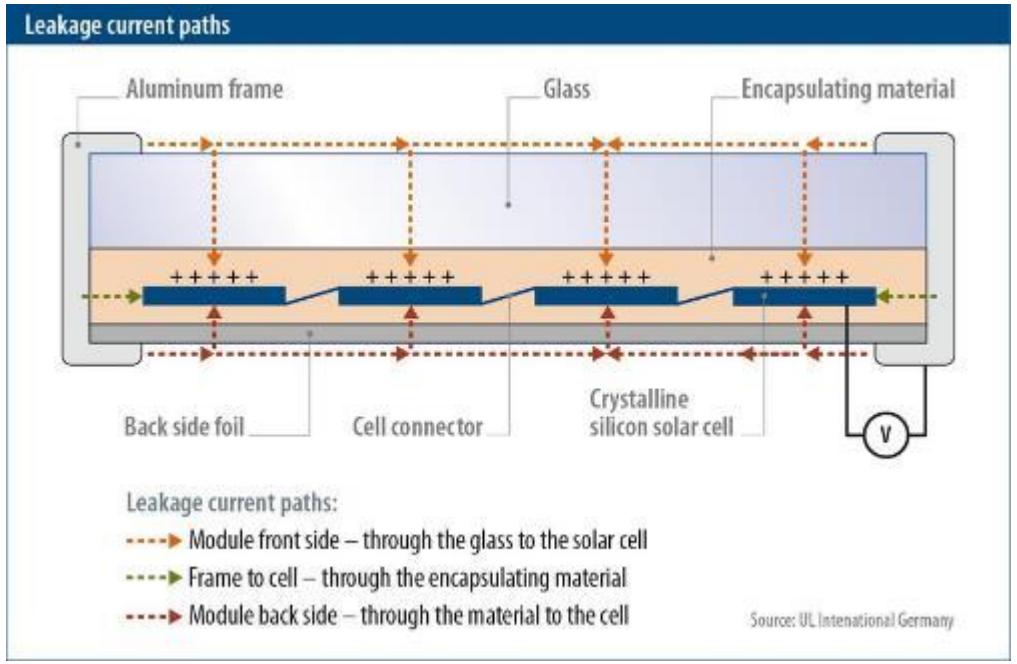
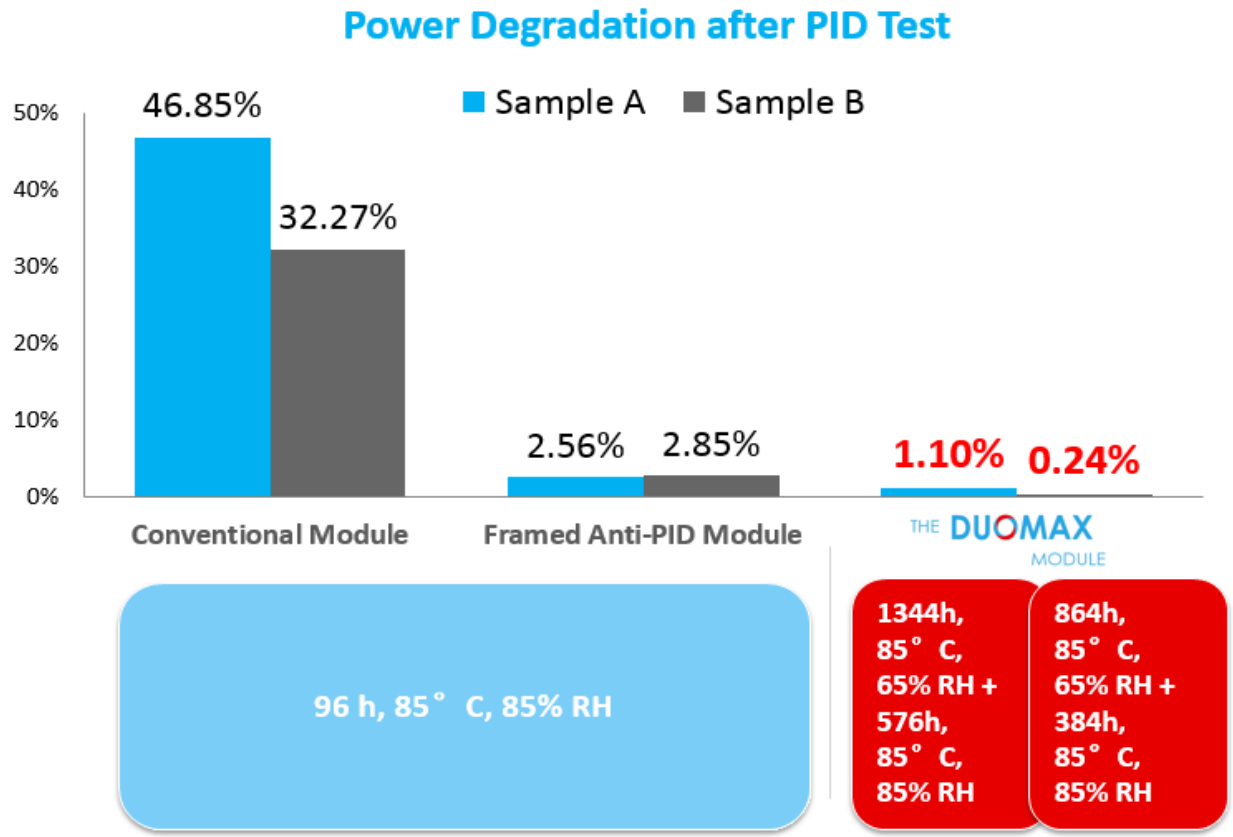


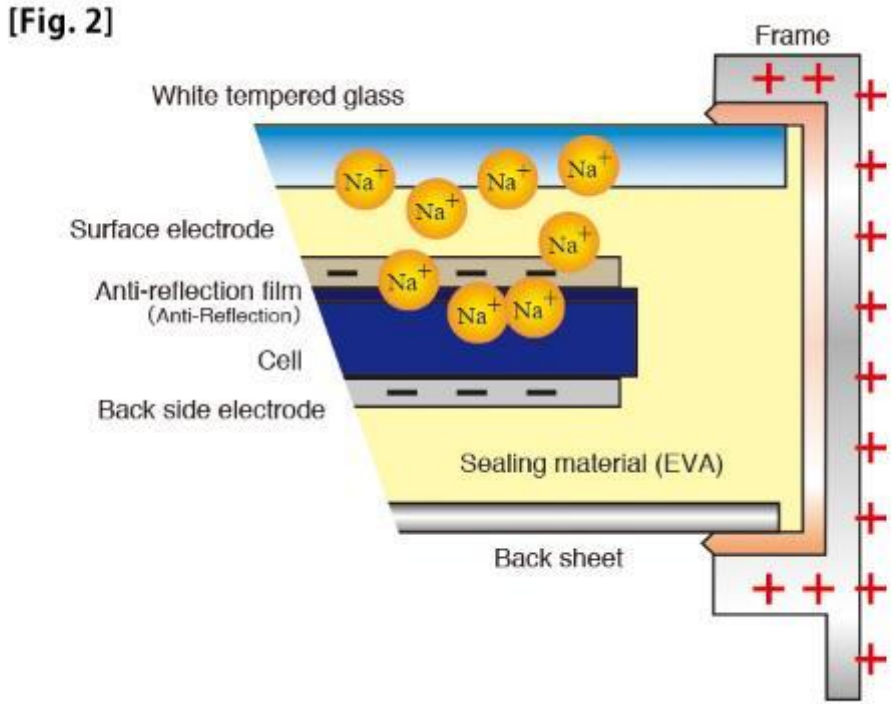
Figure 1: Cross section of a crystalline photovoltaic module with possible leakage current paths. In typical p-type cells, the damaging leakage currents flow from the frame to the negative pole on the top side of the cells. For the PID effect, the orange path is the critical one.Graphics: Solarpraxis AG/Harald Schütt

Source: http://www.pv-magazine.com/archive/articles/beitrag/no-confidence-in-manufacturer-tests-_100012909/572/#axzz4MDuJ2dmc



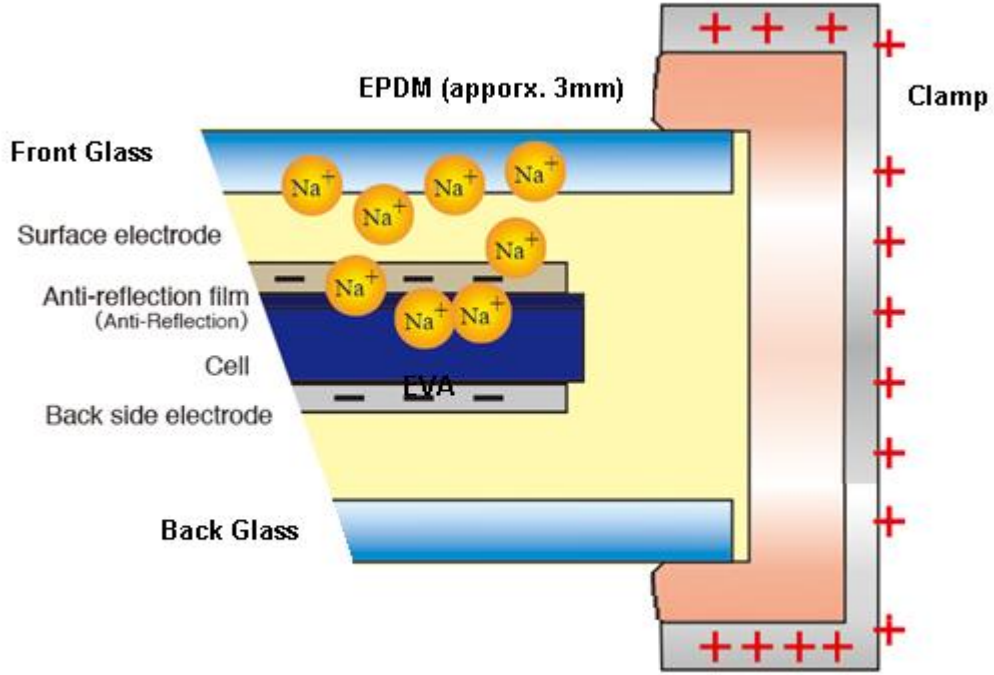
Potential Induced Degradation

Framed Module



Source: http://www.kikusui.co.jp/common/product/image/full/tos7210s_fig2_e.jpg

Frameless Module



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Overview: Benefits and Challenges

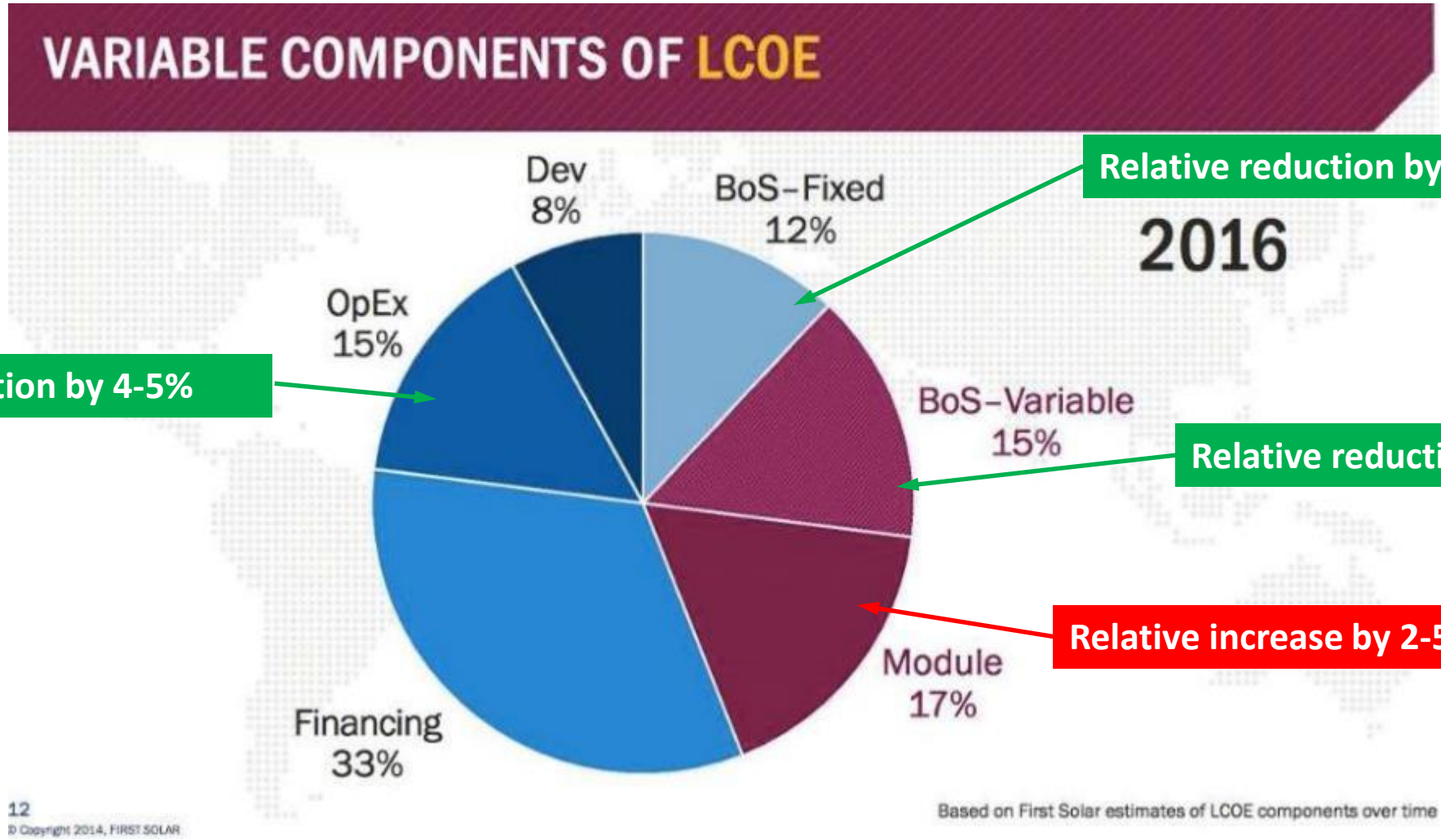
Benefits

- Reduced electrical components (33% less)
- Higher system voltage enables inverters with higher output voltage → larger transformers, less transformers
- Advanced power plant concepts
- Reduced O&M costs due to less components

Challenges

- Reduced range of 1,500V inverters (central and string)
- PID risk can be increased due to higher system voltage
- Limited experience with installing 1,500V systems
- Accuracy for monitoring system to identify malfunctions
- Module mismatch

Impact on LCoE with a 1,500V system



Relative reduction by 5%

Relative reduction by 4-5%

Relative reduction by 9-10.5%

Relative increase by 2-5%

Source: http://www.greentechmedia.com/content/images/articles/first-solar-lcoe-2016.jpg

Shown reductions are depending on the module and system design.

Thank you!

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