

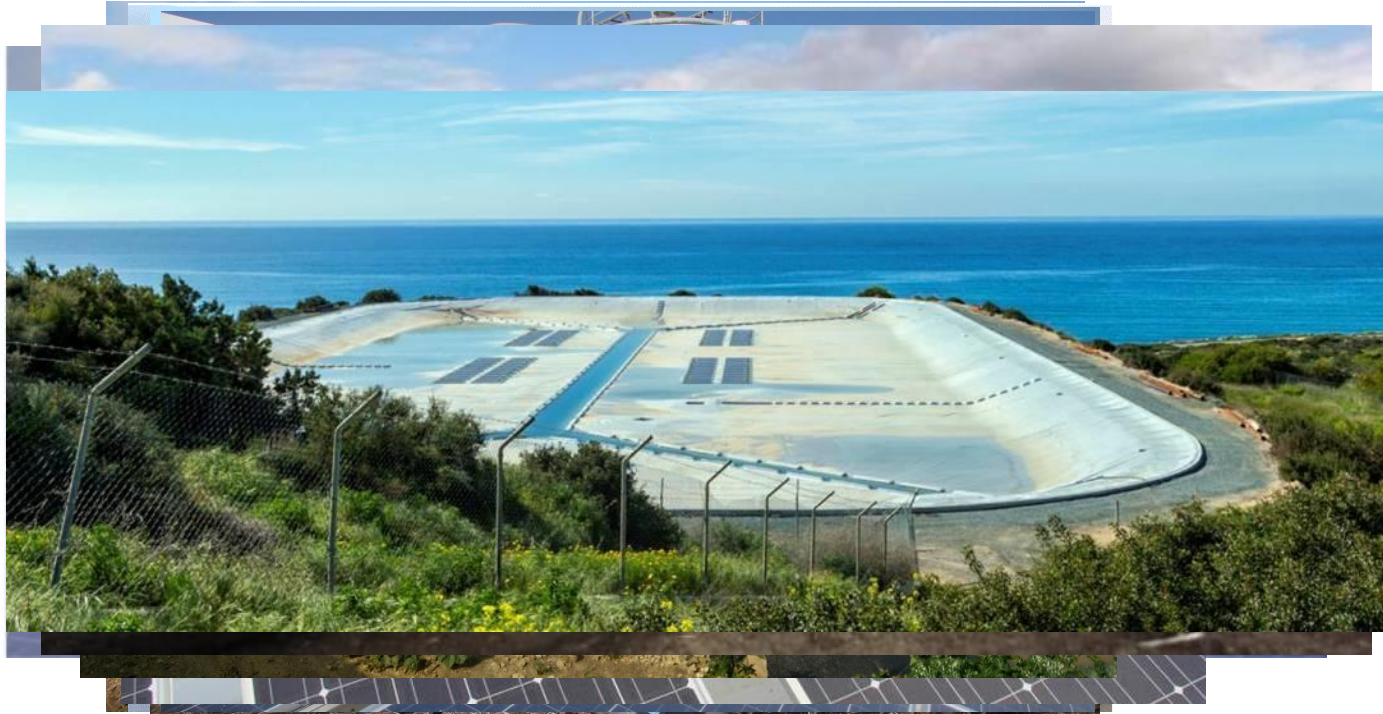
# ברוכים הבאים!

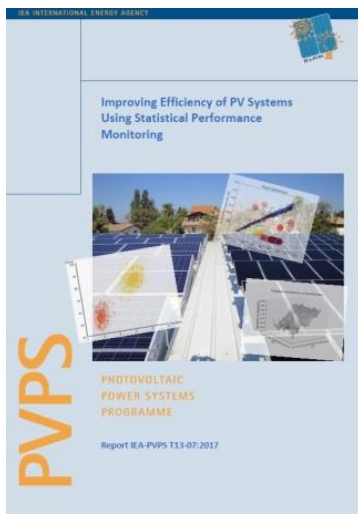
*Welcome!*

**Mike Green - M.G. Lightning Ltd.**

**Dr. George Makrides – University of Cyprus**

**Geffen BenYosef - Technion**



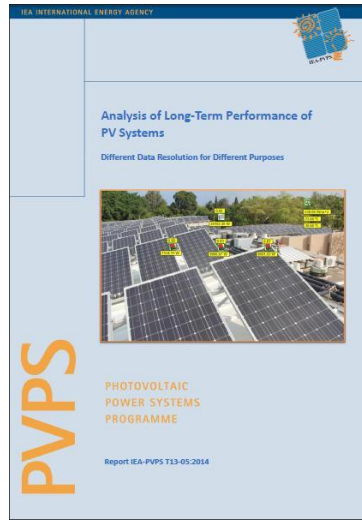


PHOTOVOLTAIC  
POWER SYSTEMS  
PROGRAMME

Report IEA-PVPS T13-07:2017



<http://www.iea-pvps.org/index.php?id=427>

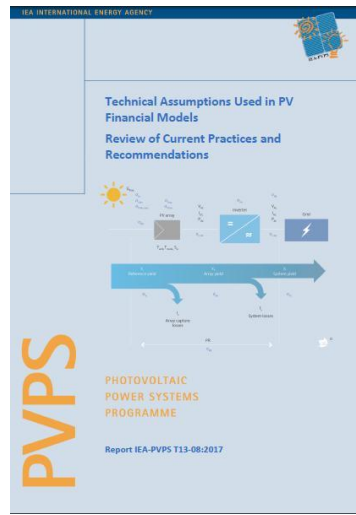


PHOTOVOLTAIC  
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PROGRAMME

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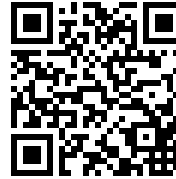


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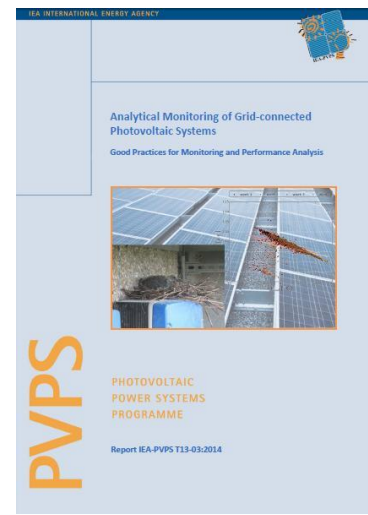


PHOTOVOLTAIC  
POWER SYSTEMS  
PROGRAMME

Report IEA-PVPS T13-08:2017



<http://www.iea-pvps.org/index.php?id=426>



PHOTOVOLTAIC  
POWER SYSTEMS  
PROGRAMME

Report IEA-PVPS T13-03:2014



<http://www.iea-pvps.org/index.php?id=276>

[www.iea-pvps.org](http://www.iea-pvps.org)

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mike@lightning.co.il

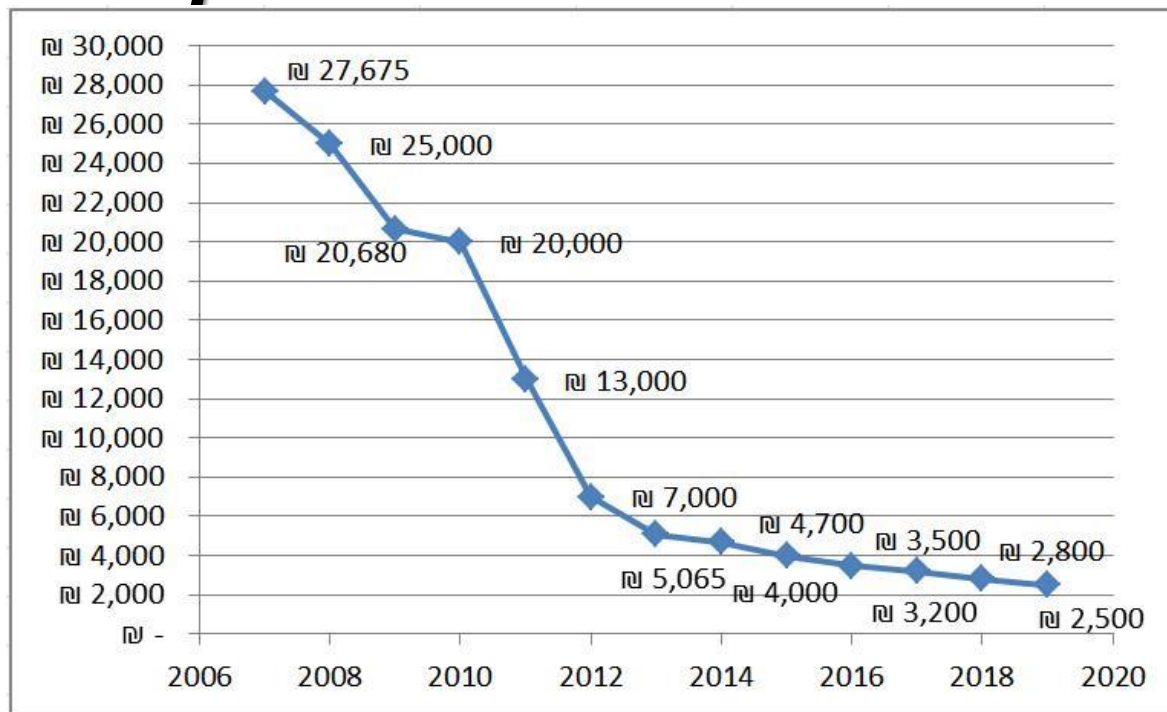
www.lightning.co.il





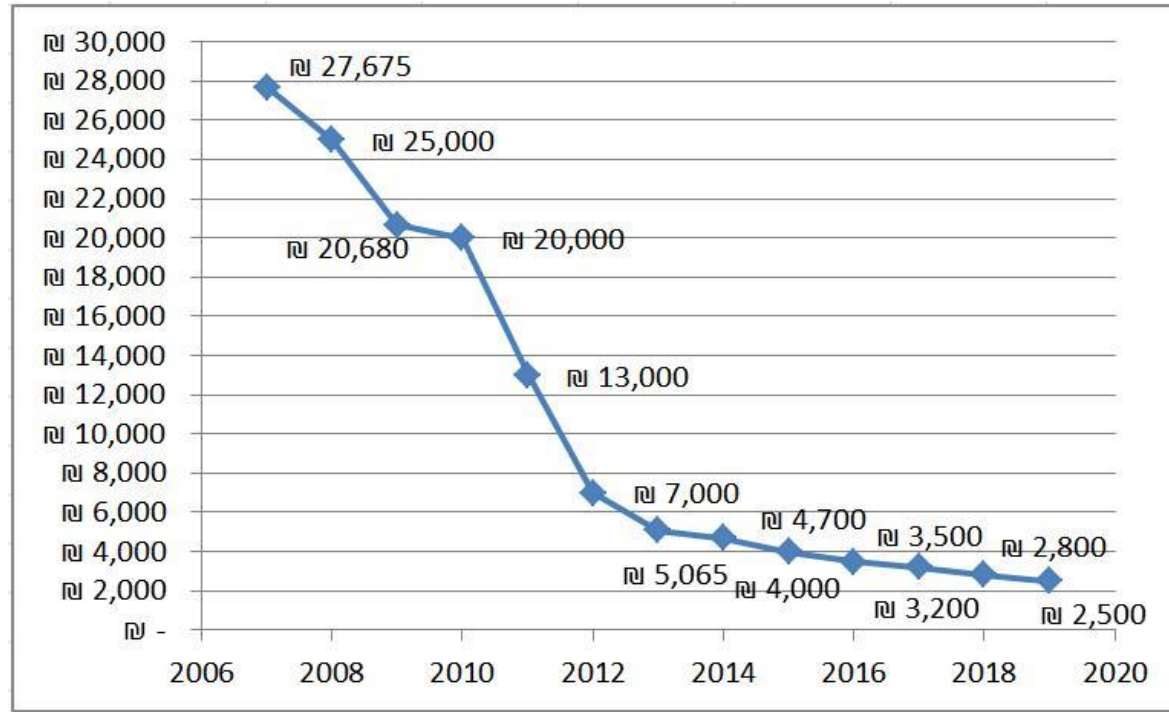
# הורדת עלויות התקנה בתחנות סולאריות קרקעיות ואתגר התחזוקה

EPC cost  
for PV  
systems



# Challenges Maintaining the New Generation of Low Cost PV Plants

**EPC cost for  
PV system  
installation**



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mike@lightning.co.il    www.lightning.co.il

# Defining the Trend

Feed in Tarrif → Tender pricing

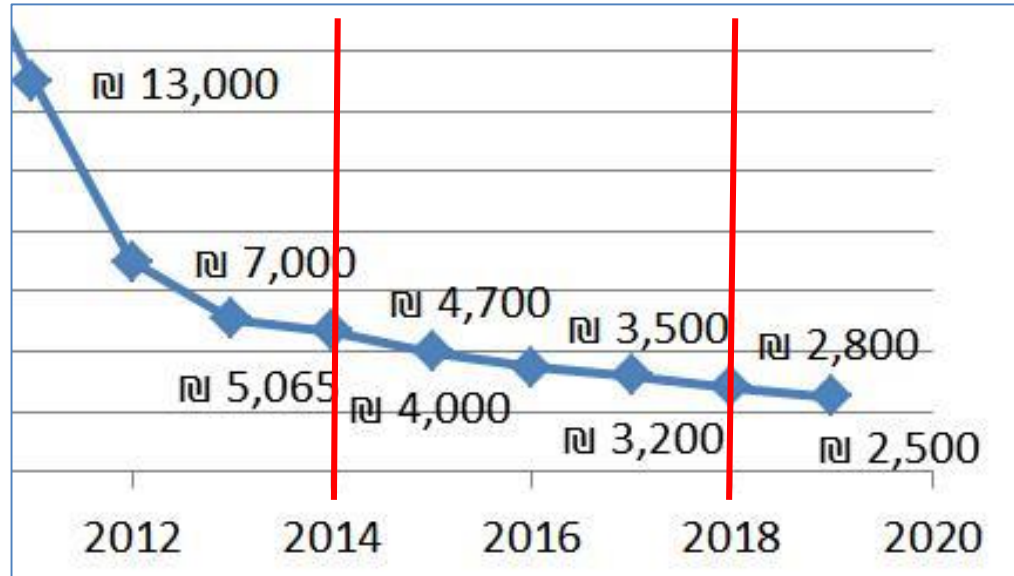
0.54₪ → 0.19₪ (→ 0.17₪)

4 k₪ → 2.5 k₪

CAPEX/Tariff

7kWh → 13kWh

1₪ ~ \$0.28 ~ €0.26



# Defining the Trend

Israel 0.19

Denmark/Germany 0.22

105 : 64



~2000 kWh/m<sup>2</sup>/year



~1400 kWh/m<sup>2</sup>/year

# Cost Cutting

1. Reduced angle  $26^\circ \rightarrow 12^\circ$
2. Reduced pitch – module packing
3. Minimal earth works
4. Circuit breaker  $\rightarrow$  Fuse switch
5. ~3 phase cabling  $\rightarrow$  3 single cables
6. No service ways
7. Cheaper roads
8. Quarry sand instead of quartz sand
9. String inverters instead of central inverters
10. Cheaper security (analytical camera vs electronic fence)
11. No string monitoring



# Cost Cutting

- ✓ String inverters instead of central inverters
- ✓ Quarry sand instead of quartz sand
- ✓ Cheaper security (analytical camera vs electronic fence – Go digital!)
- No control room – O&M is mobile based

# Reduced Angle $26^\circ \rightarrow 12^\circ$



# Reduced Pitch



# ***Reduced Pitch and Angle***

## **Cost Effectiveness Parameters:**

- Installation size
- Installation cost
- Energy produced
  - Shading
  - Tilt
  - azimuth

➔ **IRR/ROI**

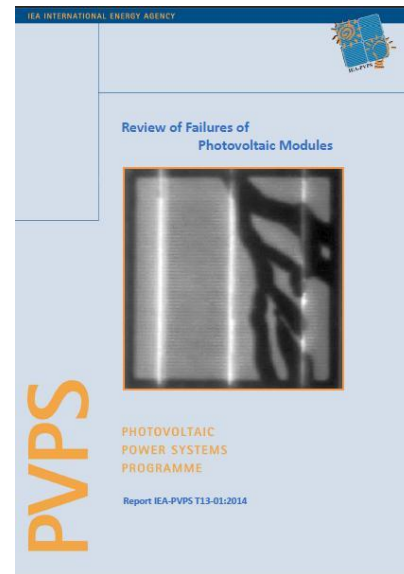
**Economy of Scale!**



# *Minimal Earth Works*



# Minimal Earth Works



## Increased installation challenges

Ch. 7.1:  
IEA-PVPS T13-Review  
of Failures of  
Photovoltaic Modules

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mike@lightning.co.il    www.lightning.co.il

# Minimal Earth Works



**Challenge:**  
**Balancing between the**  
**“shaded” and the “shading”**





# Minimal Earth Works



## Inadvertent Northern Slope



# Minimal Earth Works

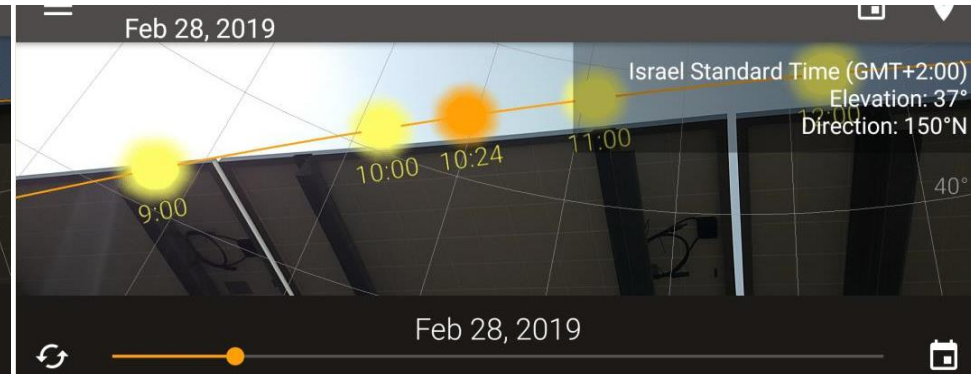
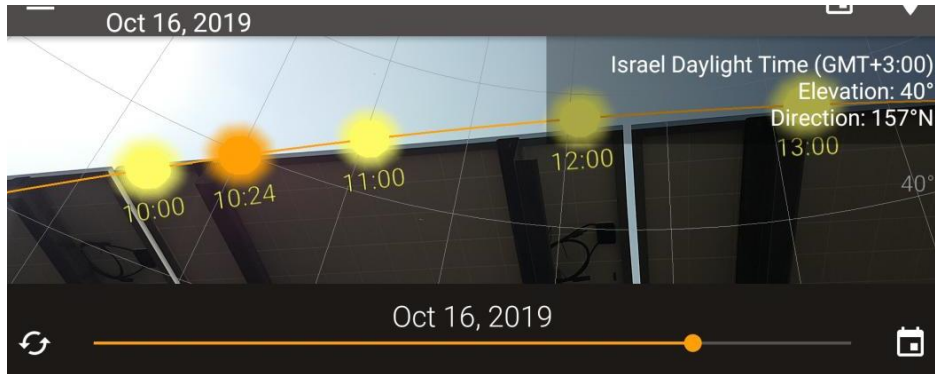
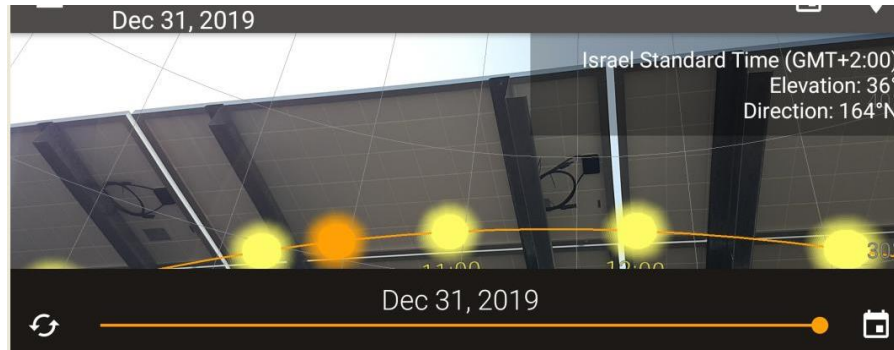


## Inadvertent Northern Slope





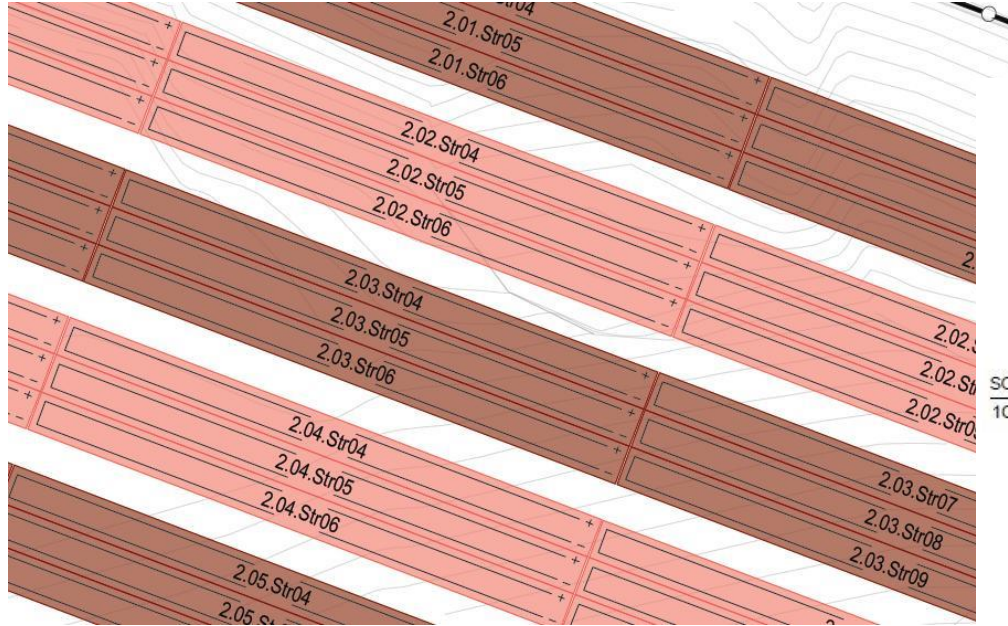
# Inadvertent Northern Slope



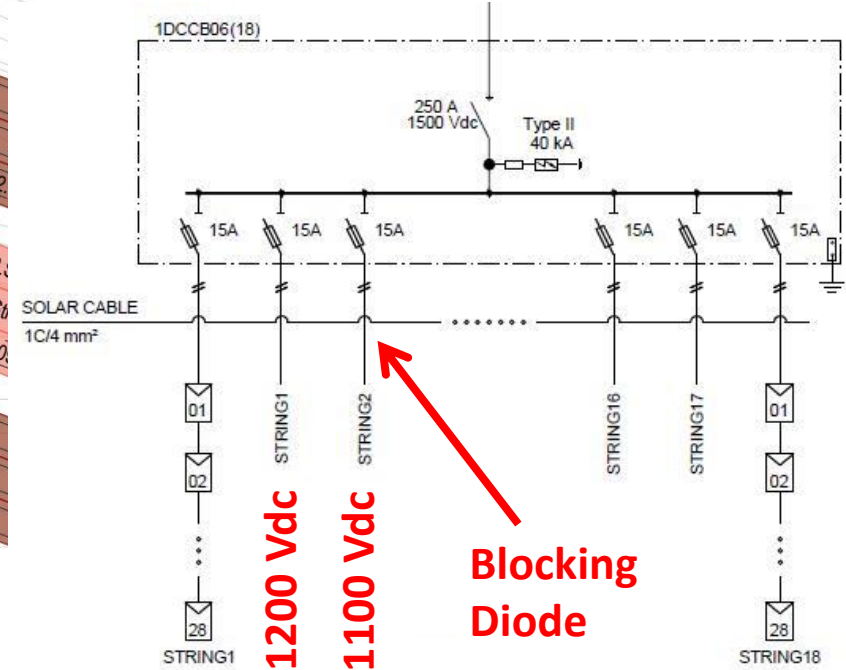
# Inadvertent Northern Slope



# Inadvertent Northern Slope



**String single rows in place of doubling back**



# Cost Cutting

**Circuit breaker → Fuse switch**

- ✓ **Smaller footprint**
- ✓ **Short circuit capacity**
- **Non symmetric tripping**
- **Reset = Replacement**
- **No monitoring on the inverter line**



# Cost Cutting

~3 cable → 3 single conductors

- More likely to be damaged
- Possibility for confusing phases between inverters



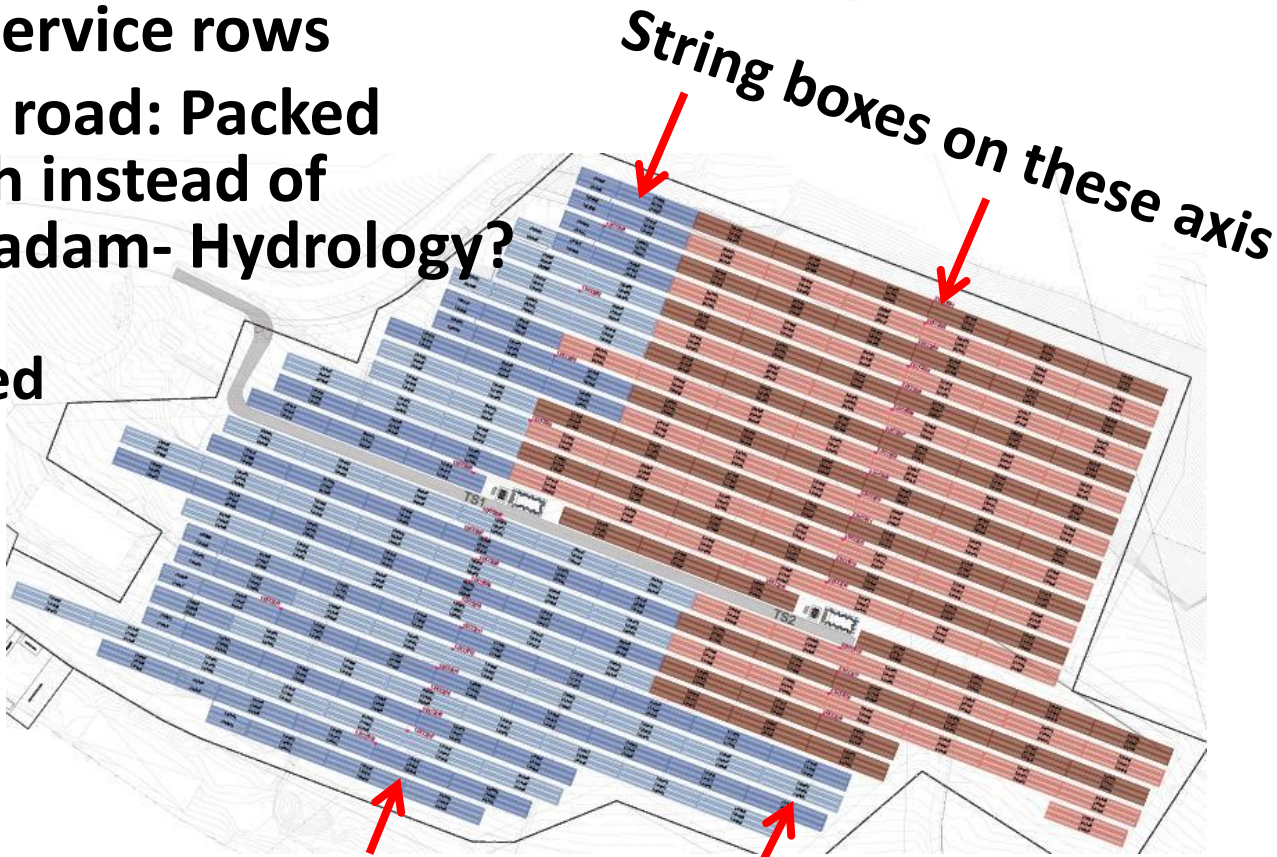
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# Cost Cutting

- No Service rows
- Ring road: Packed earth instead of macadam- Hydrology?

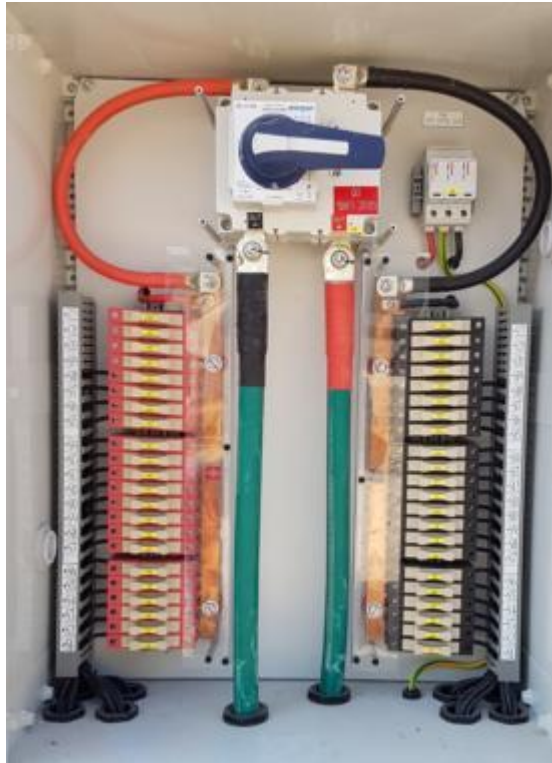
➔ Increased  
O&M costs



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# String Monitoring



**20 strings x 8A = 144A~4%**



**8 strings x 8A = 64A~12.5%**



# *Fluctuating shading patterns*





# Statistical Performance Monitoring

**No string monitoring :**

☐ Compare instead inverter DC current  
- ~20 strings

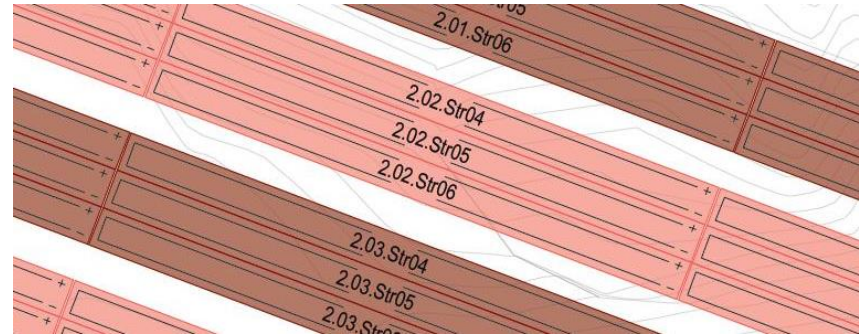
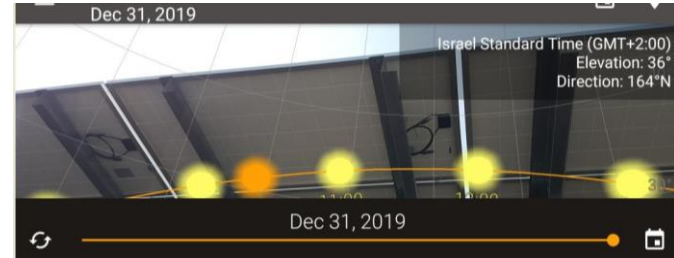
☐ Minimal earth works

➔ Fluctuating shading patterns

☐ 1 string = 4% of total SB

☐ Natural distribution of 2% between strings

➔ Uncertainty close to 10% when comparing Inverter DC current

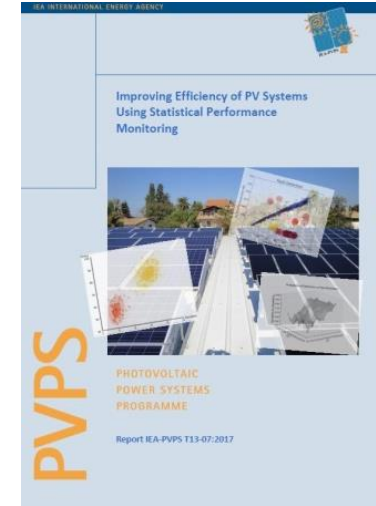


# Statistical Performance Monitoring

Input comparison? Not relevant

Statistical manipulation of existing data:

- ✓ Clustered regression tree
- ✓ Artificial neural networks
- ✓ Support Vector Regression
- ✓ Self-Organizing Map (SOM)
- ✓ Probabilistic Neural Network (PNN)



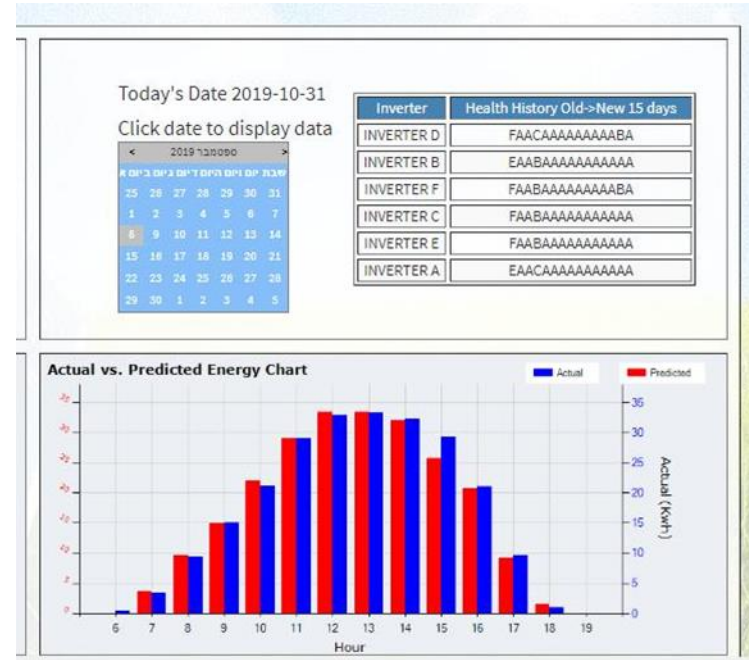
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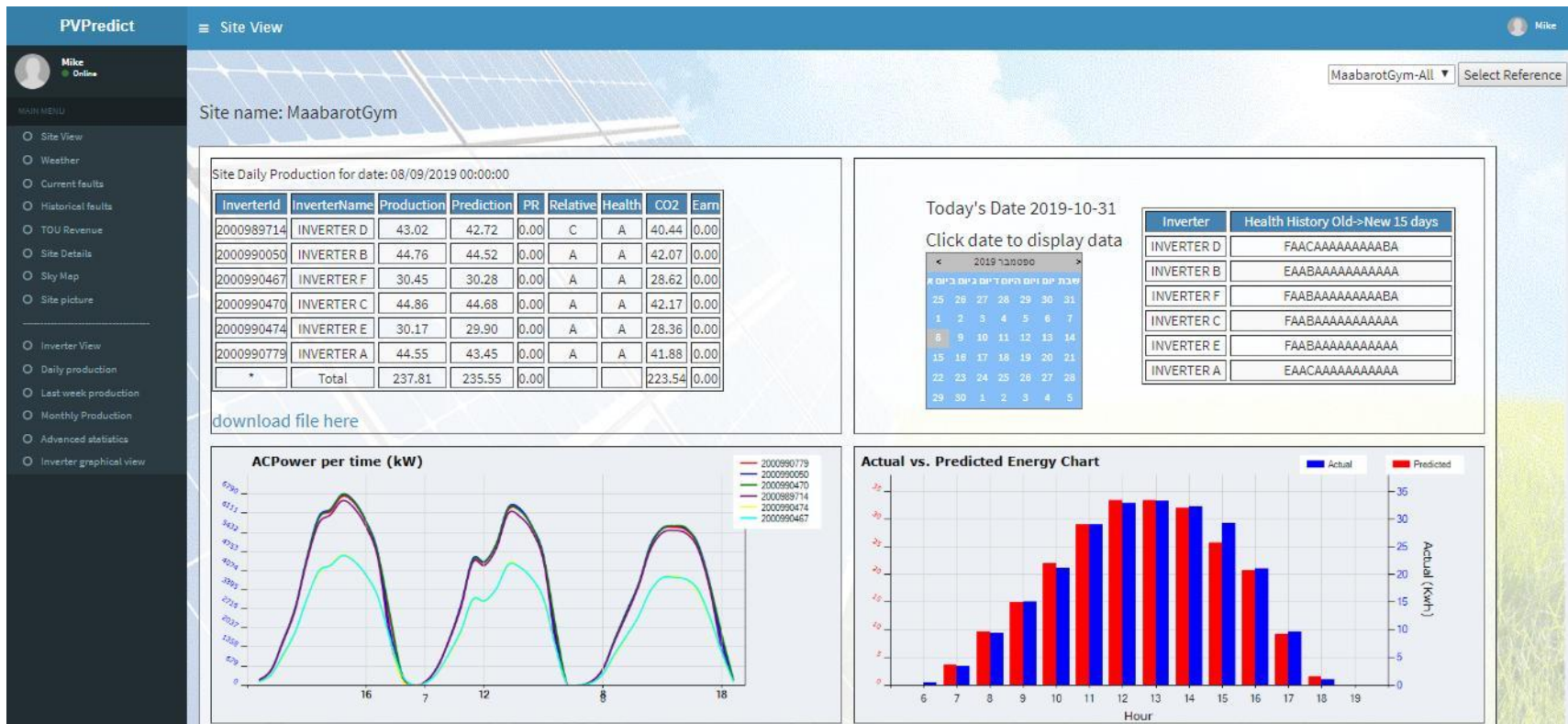
# Statistical Performance Monitoring

[www.PVpredict.com](http://www.PVpredict.com):

- ✓ Machine Learning  
(clustered regression tree)
- ✓ Input inverter parameters
- ✓ Input weather parameters
- ✓ Output energy forecast
- ✓ 3-5% accuracy on historical values



# Statistical Performance Monitoring





# Statistical O&M Optimization



➤ O&M optimization through AI

<https://www.raycatch.com/>

# Summary

- Many cost cutting ideas are improvements
- Saving on ground works can have unexpected implications on plant efficiency
- Inexpensive roads require careful hydrological examination
- Packing kWp can be at the expense of efficient O&M
- Saving on BOS should be undergo careful risk assessment
- Cutting back on quality monitoring ensures poor O&M
- Effective cost cutting is enabled by high tech solutions

# Conclusions

- Initial design must be carefully vetted
  - Access to String box
  - Shading issues
  - Insurance requirements
- QC is of supreme importance – no room for errors
- SOP for all workers – supervision
- Serious risk assessment
- Signage is critical ↔ Labelling is critical
- Balance CAPEX vs OPEX in business plan
- Go Digital!

*Thank You  
Questions?*

