# GSMA South Africa

# Cape Town November 2011

Lars Olav Elstrøm,

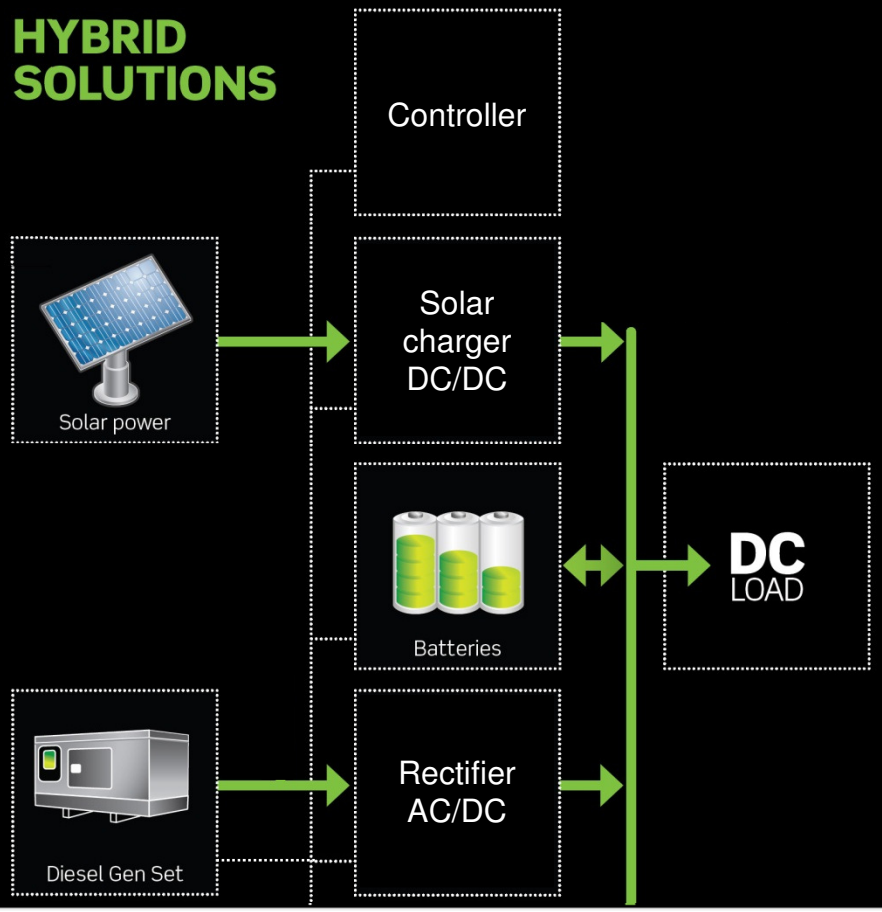
# MAXIMIZE THE POWER OF RENEWABLES

## HYBRID SYSTEM BUILDING BLOCKS



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# HYBRID SYSTEM BUILDING BLOCKS

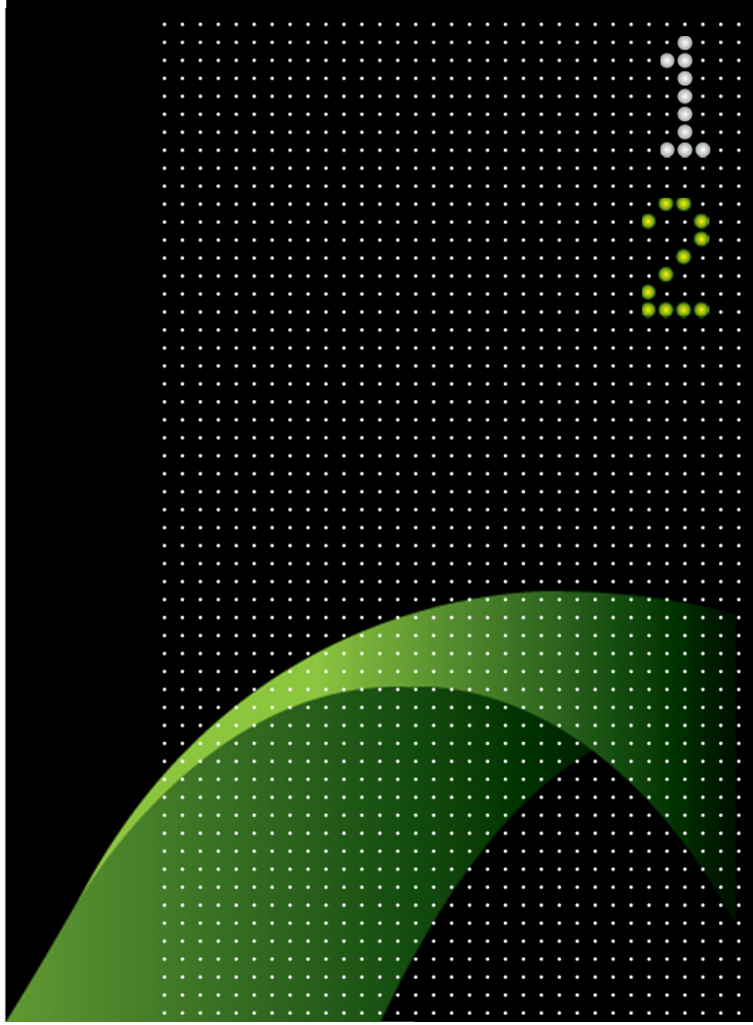



The challenge is to optimize and integrate, not just to put the system together



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# MAXIMIZE THE POWER OF RENEWABLES



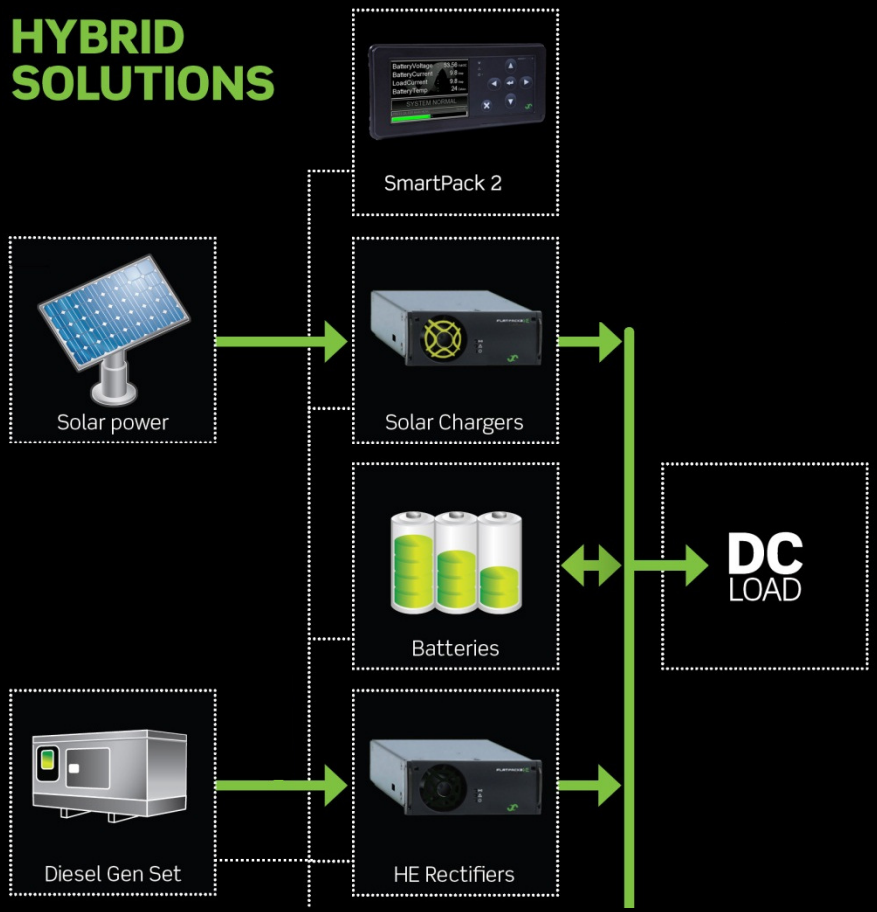
HYBRID SYSTEM BUILDING BLOCKS

SOLAR HYBRID FUNDAMENTALS



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# SOLAR HYBRID FUNDAMENTALS

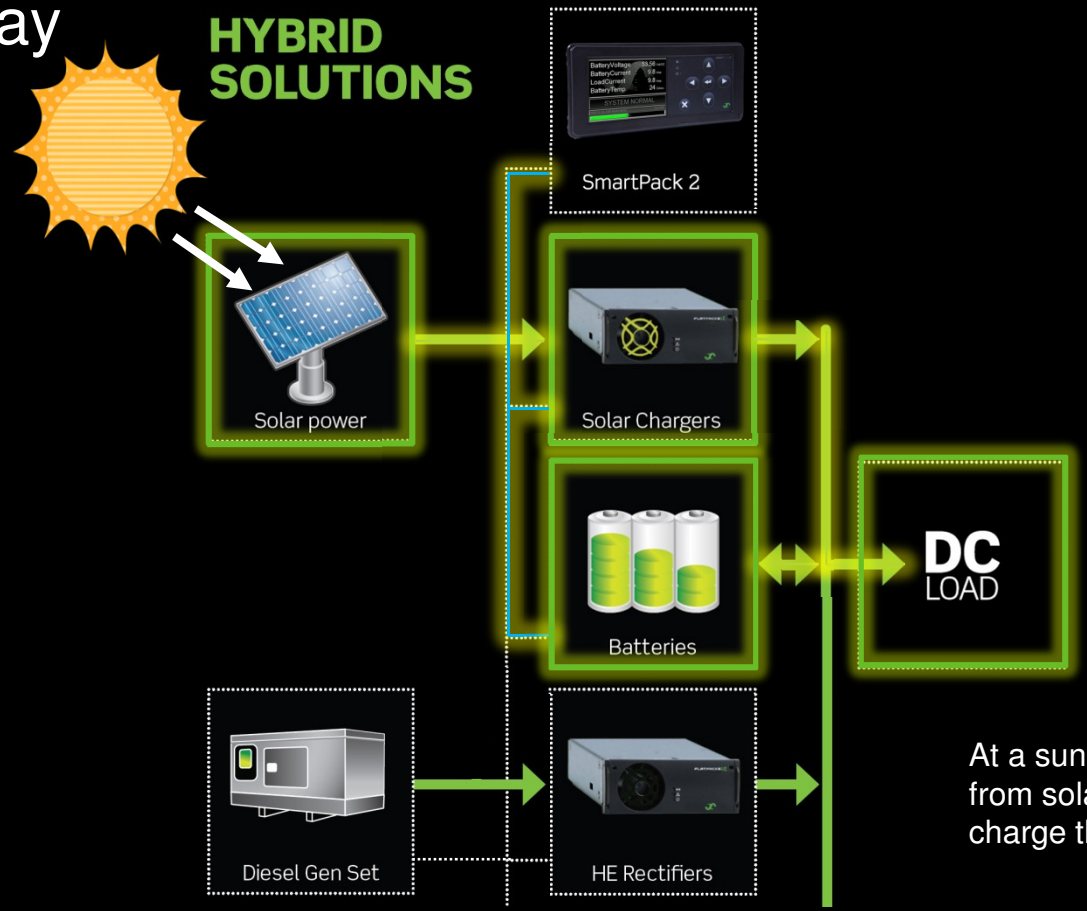





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# SOLAR HYBRID FUNDAMENTALS

Sunny day



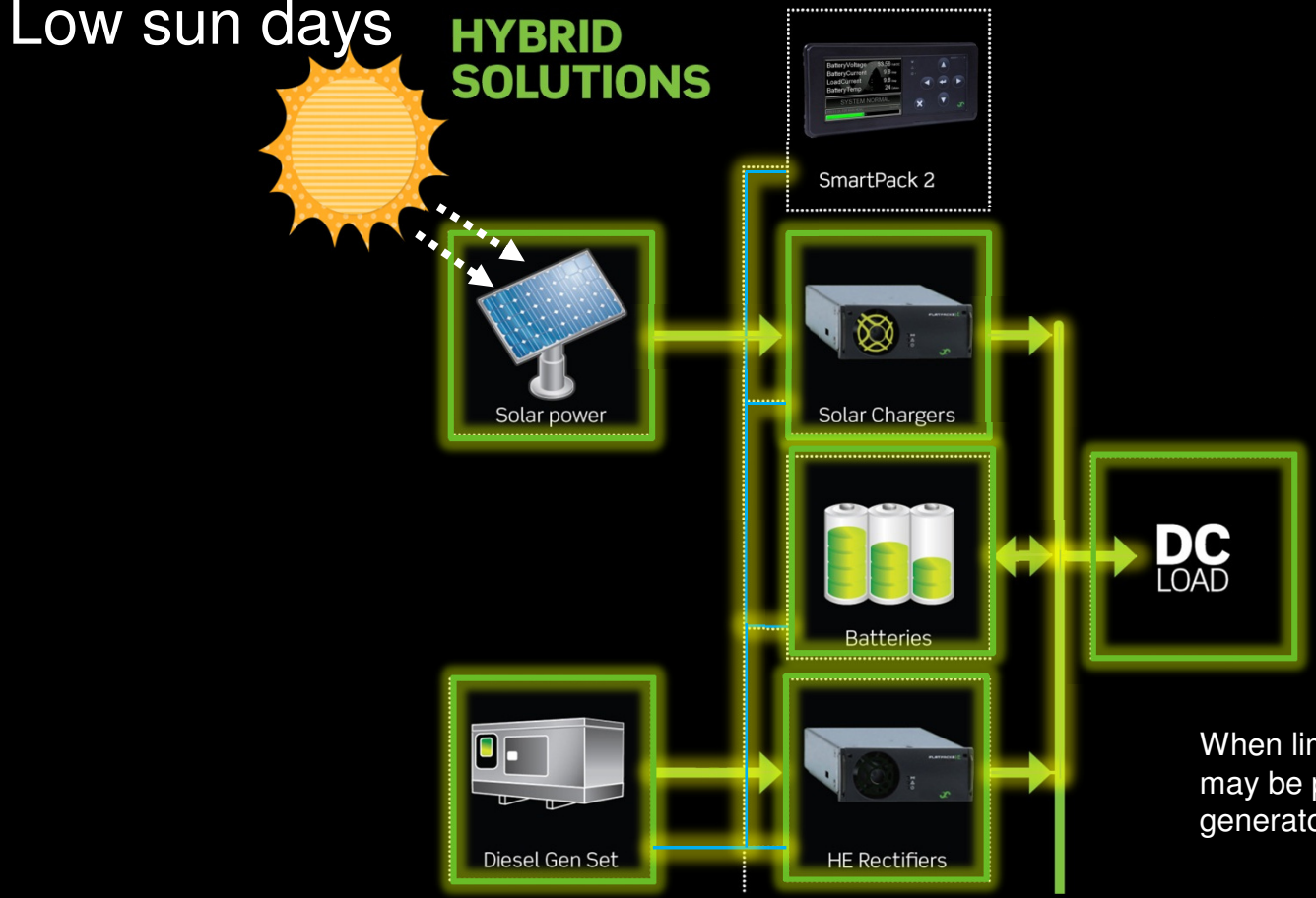

At a sunny day the load is powered from solar. Any excess energy will charge the batteries



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# SOLAR HYBRID FUNDAMENTALS

Low sun days



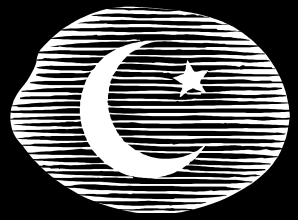

When limited sun (cloudy days) the load may be powered from both solar and generator

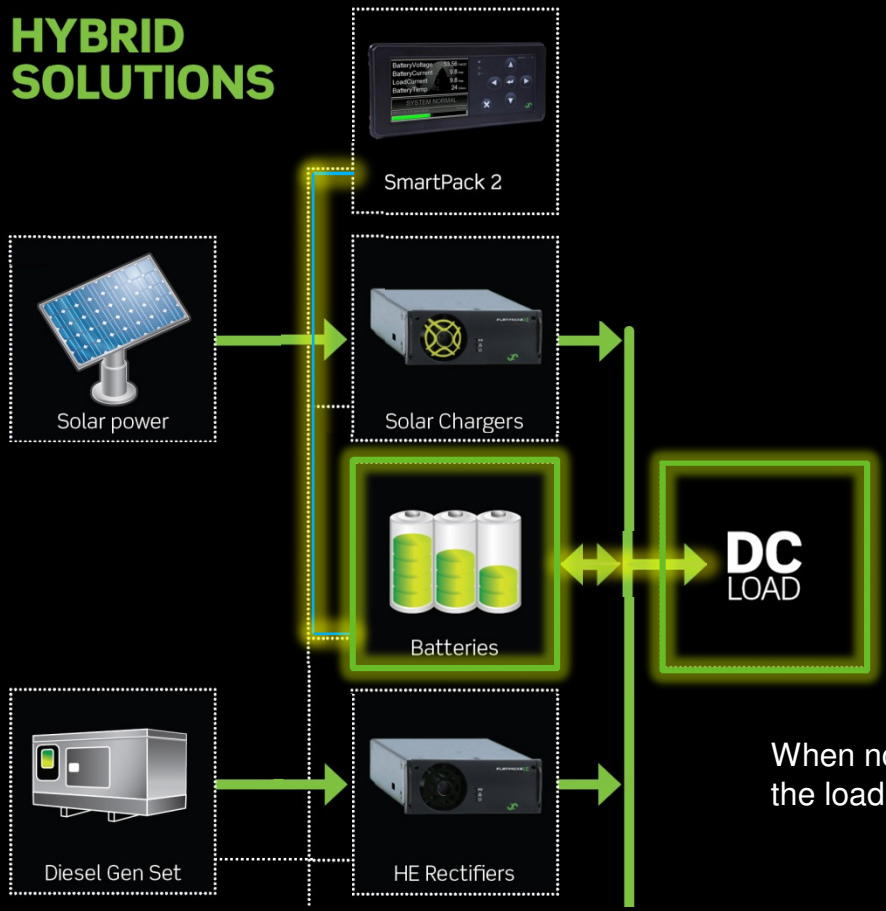


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# SOLAR HYBRID FUNDAMENTALS

During night





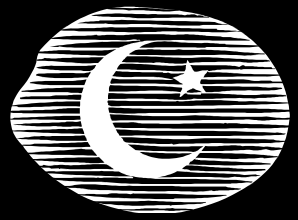

When no sun (rainy days or night time) the load is powered from the batteries.

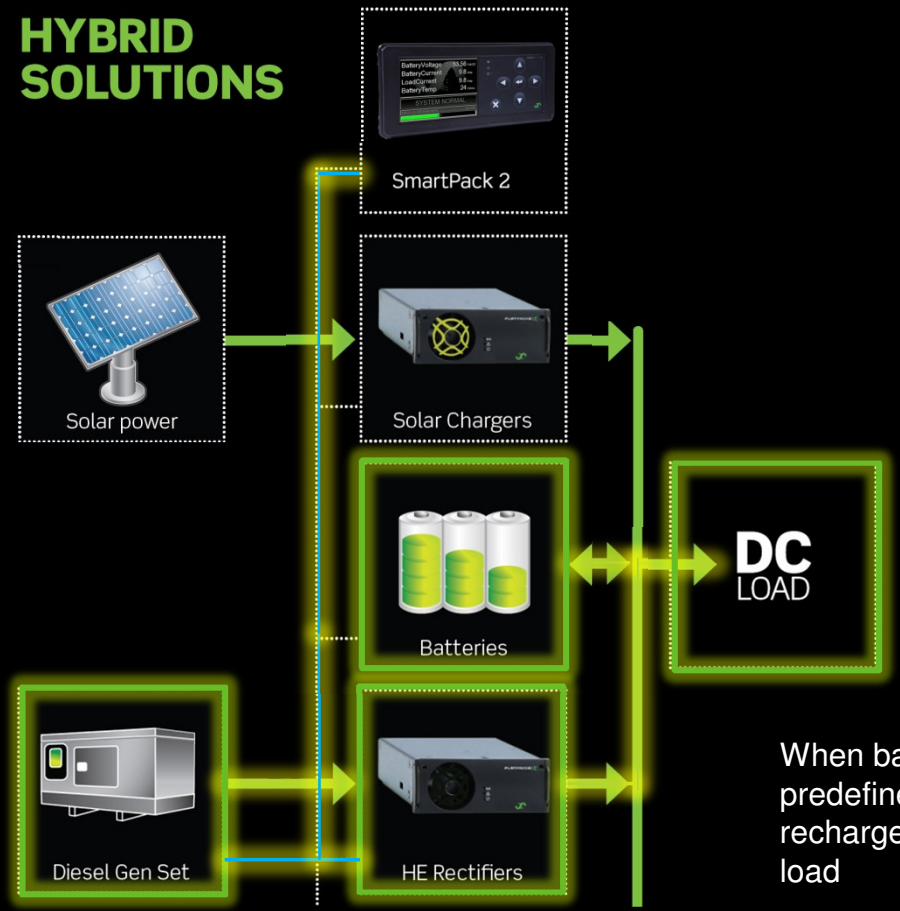


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# SOLAR HYBRID FUNDAMENTALS

During night



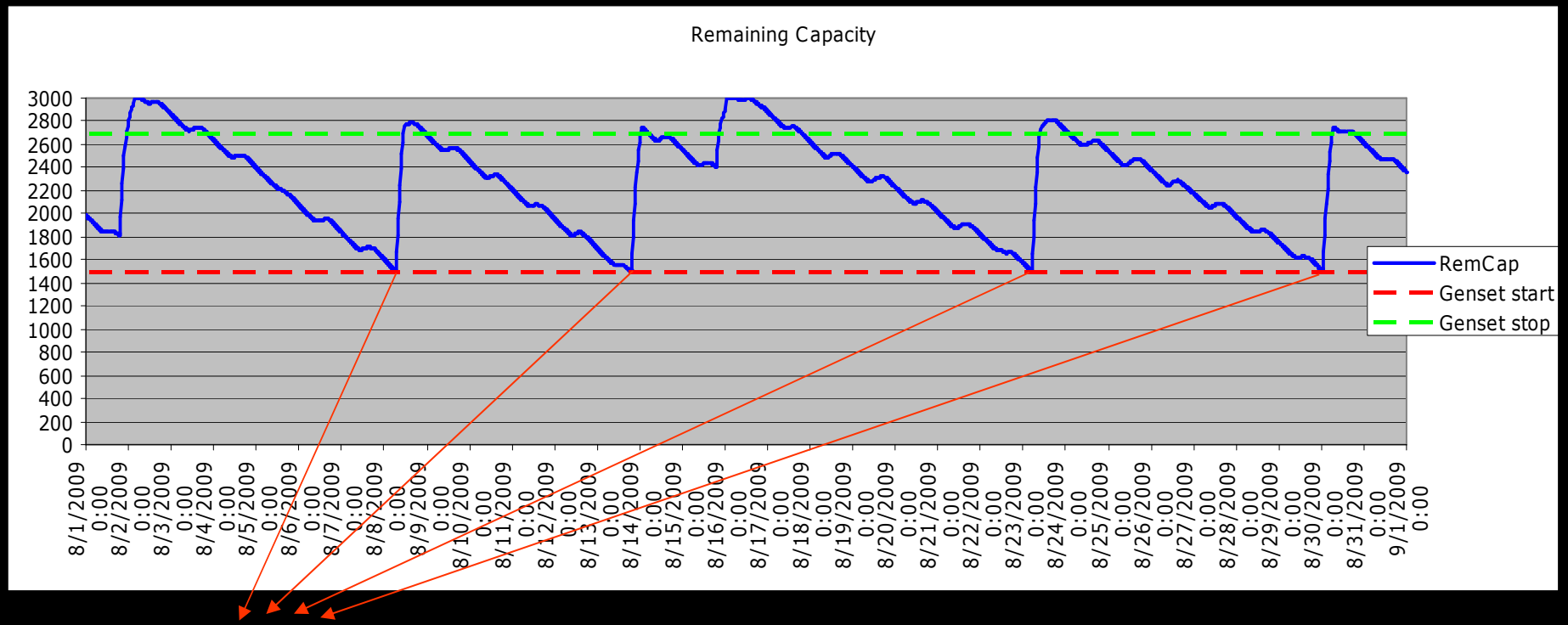



When batteries are discharged to a predefined level, generator will start to recharge the batteries and power the load



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# SOLAR HYBRID FUNDAMENTALS

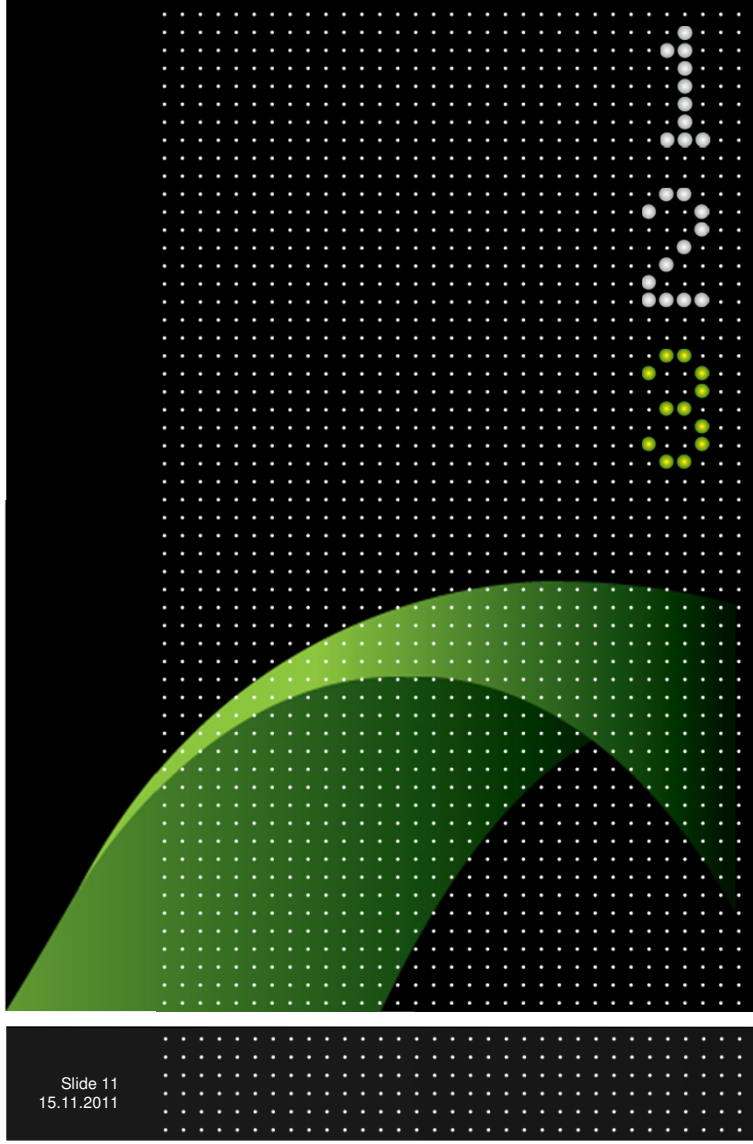



- It takes >5 days before Generator starts after discharge from 90% to 50% capacity



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# MAXIMIZE THE POWER OF RENEWABLES



HYBRID SYSTEM BUILDING BLOCKS

SOLAR HYBRID FUNDAMENTALS

TECHNOLOGY COMPARISON



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# TECHNOLOGY COMPARISON

Three major ‘solar charge control’ technologies

| | Type 1 | Type 2 | Type 3 |
|---|---|---|---|
| Technology | Contactor/Relay | Switch mode | Switch mode |
| Control | ON/OFF | PWM | PWM |
| Galvanic isolation | No | No | Yes |
| Regulated output | No | Yes | Yes |
| MPPT | No | Yes | Yes |
| Converter efficiency | ~100% (no conversion) | 90-98% | 85-90% **96,5% with Eltek** |



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# TECHNOLOGY COMPARISON

PV panel characteristics:

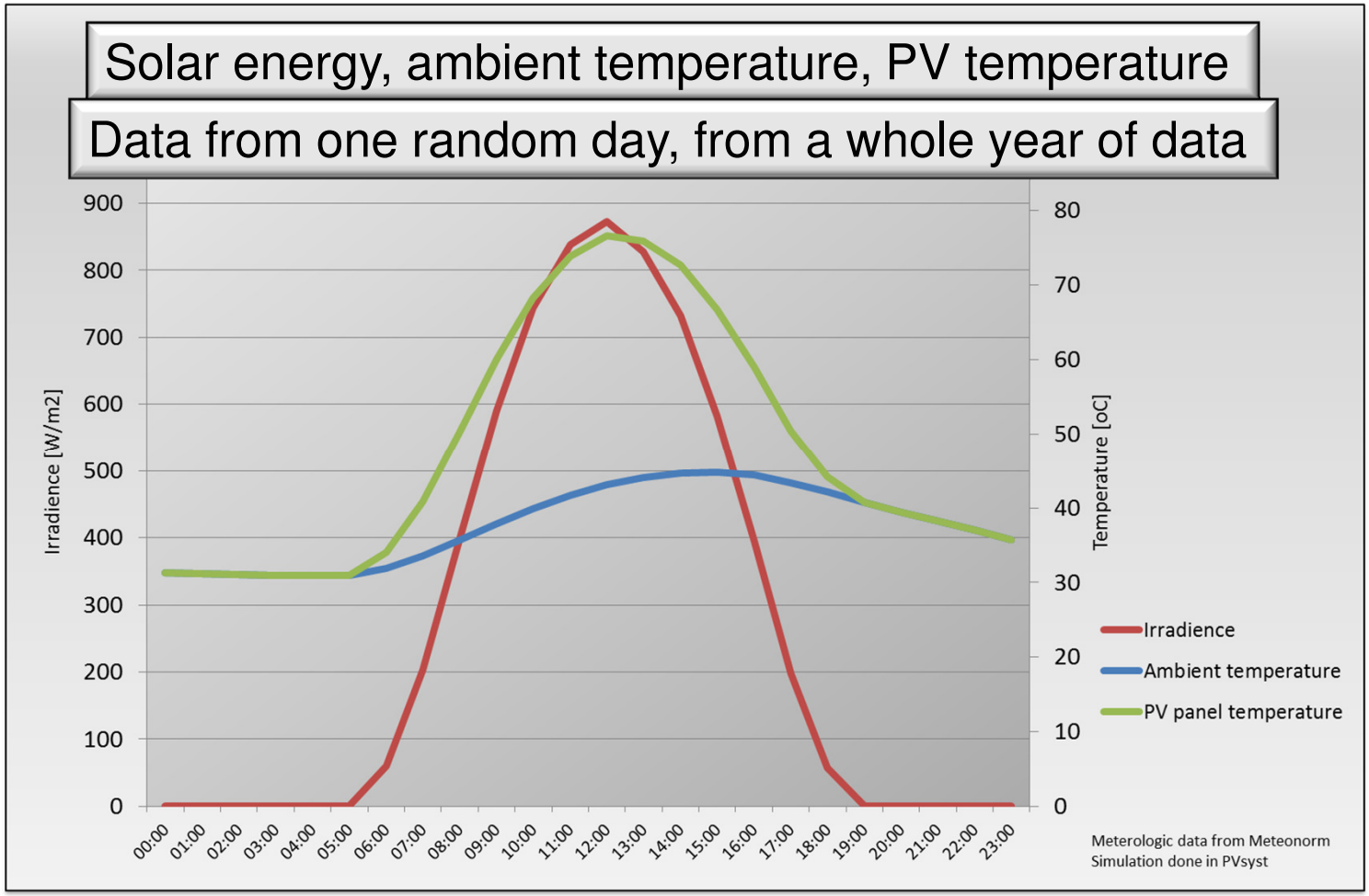
- The output of a PV panel depends on
  - Available solar energy
  - PV panel temperature
  - PV panel terminal voltage
  - +++

# TECHNOLOGY COMPARISON

- Solar energy (Irradiation) varies during a day.
- PV panel temperature varies by ambient temperature and irradiation
- PV terminal voltage is given either by
  - Battery voltage with a Type 1 technology chargecontroller
  - MPPT algorithm for Type 2 and Type 3
- Study some details from a **hot area** and how it will **affect the harvested PV energy**.

(Constraints at the end of presentation)

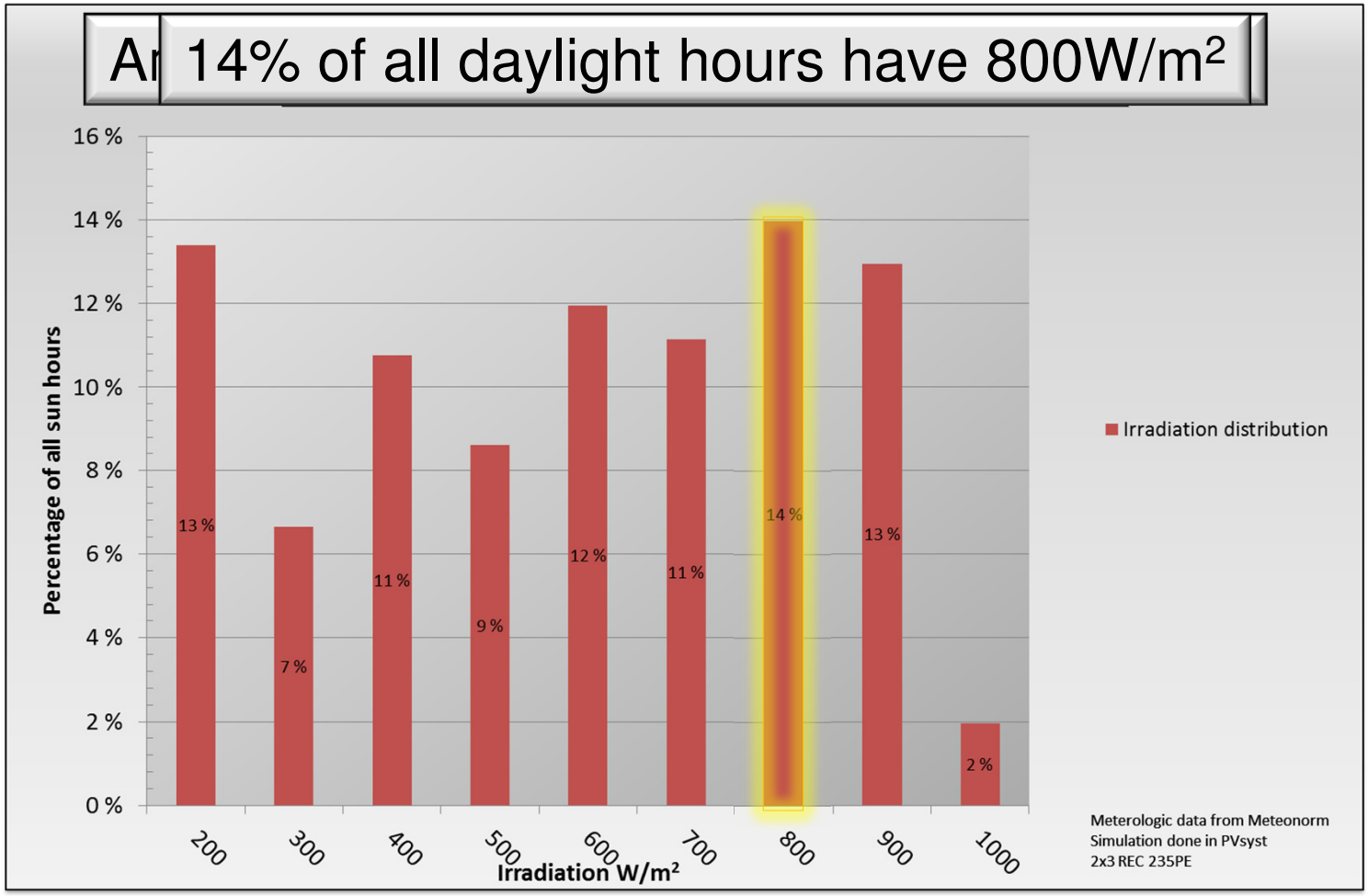
# TECHNOLOGY COMPARISON






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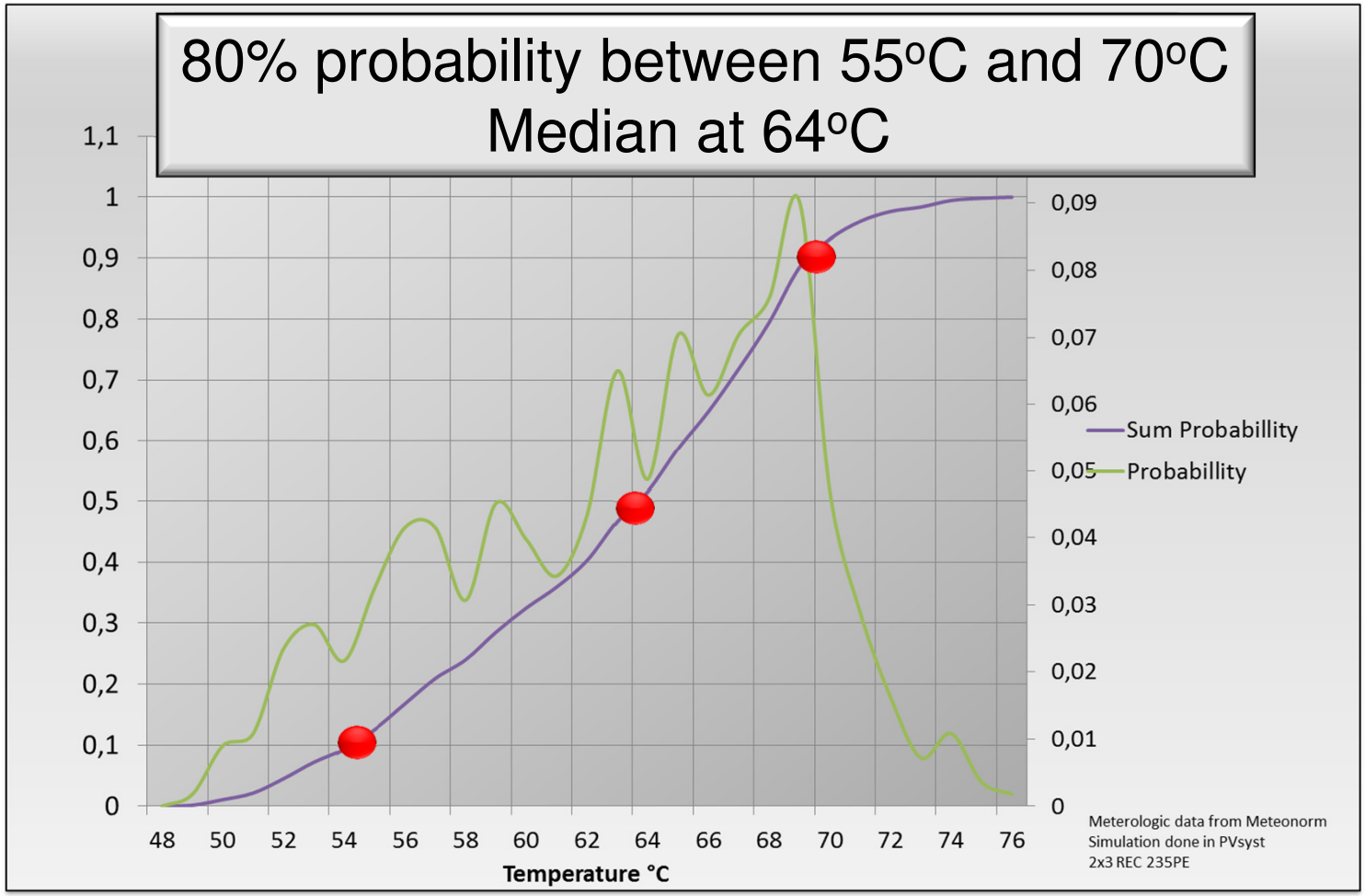
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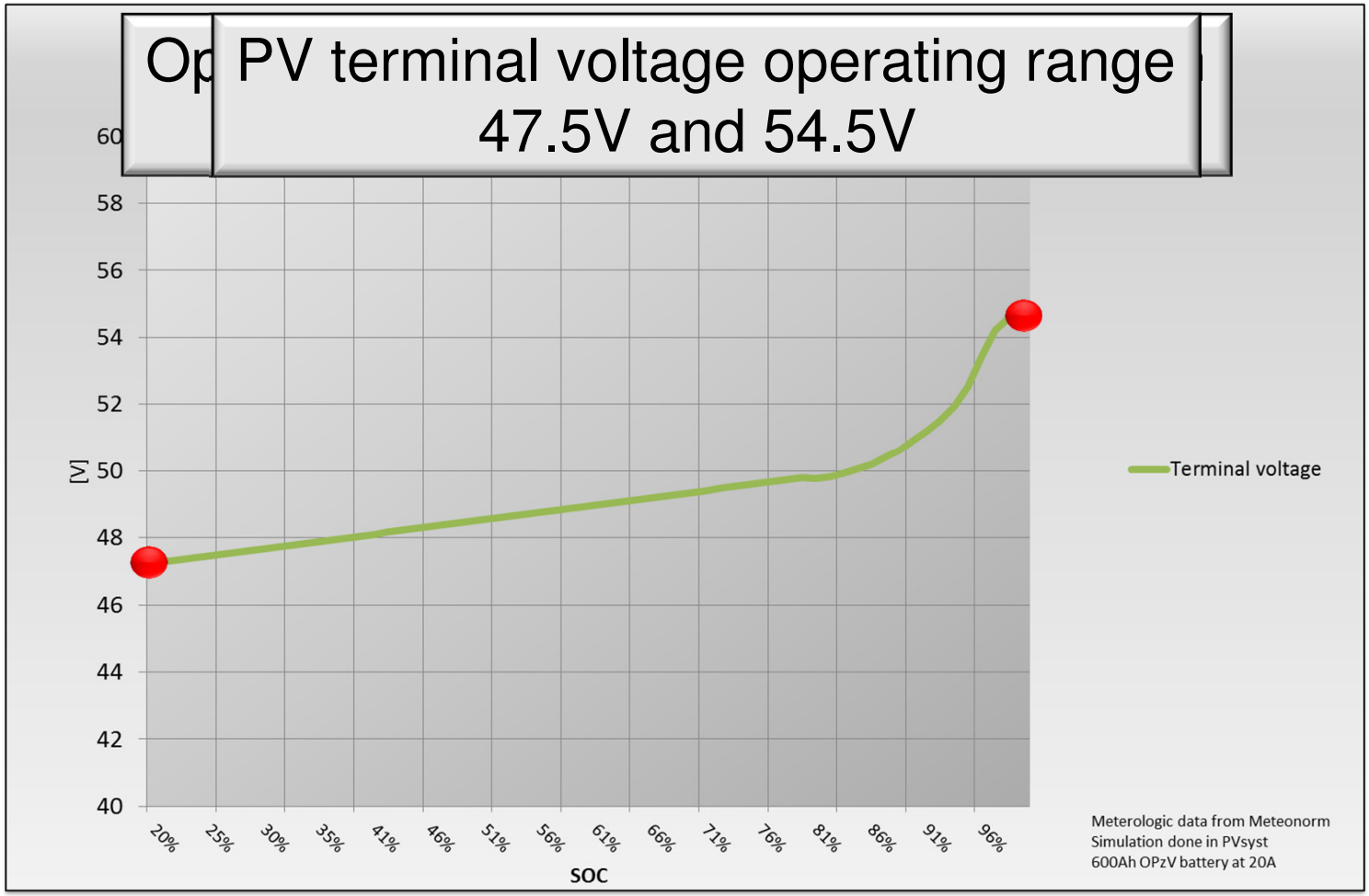
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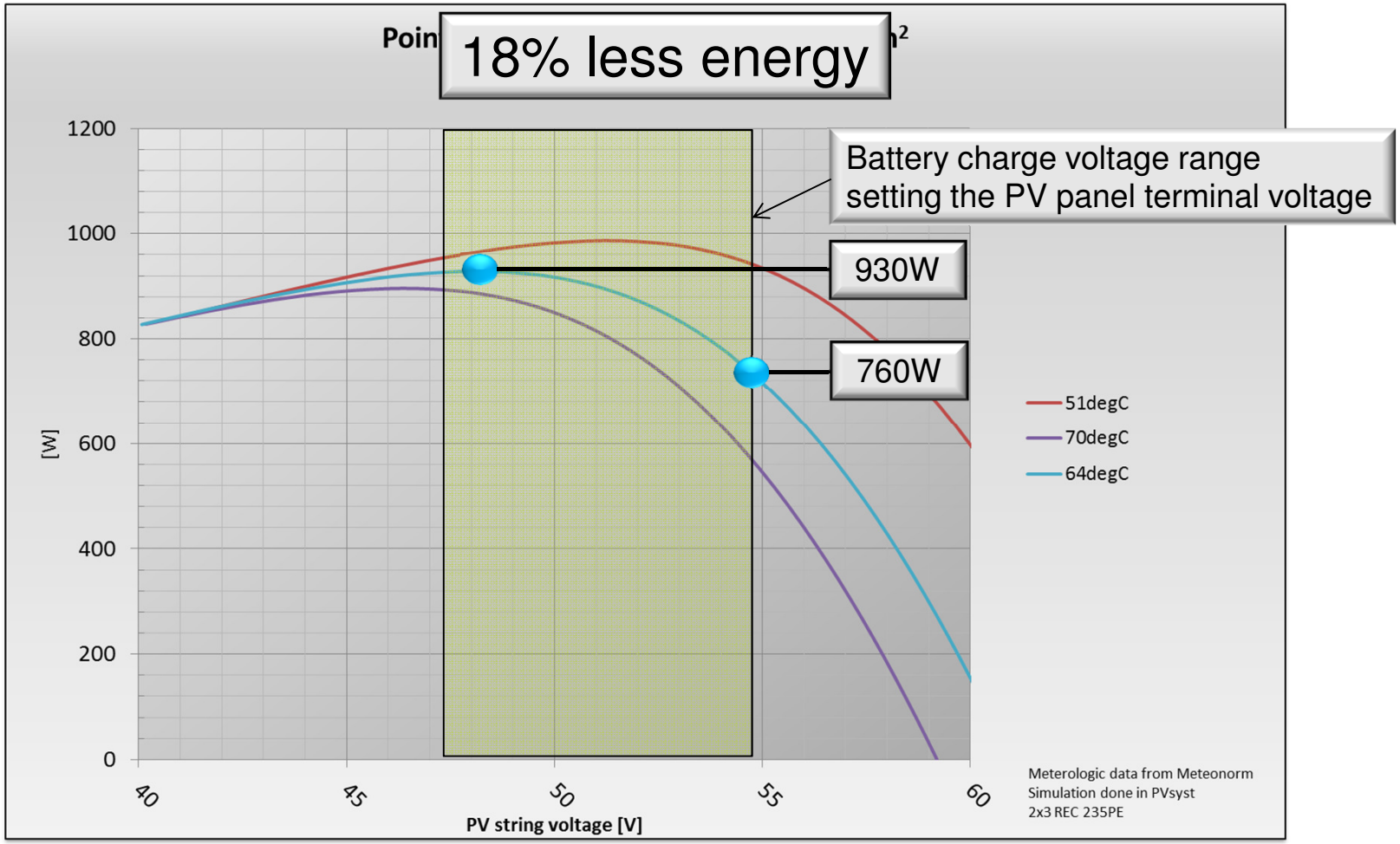
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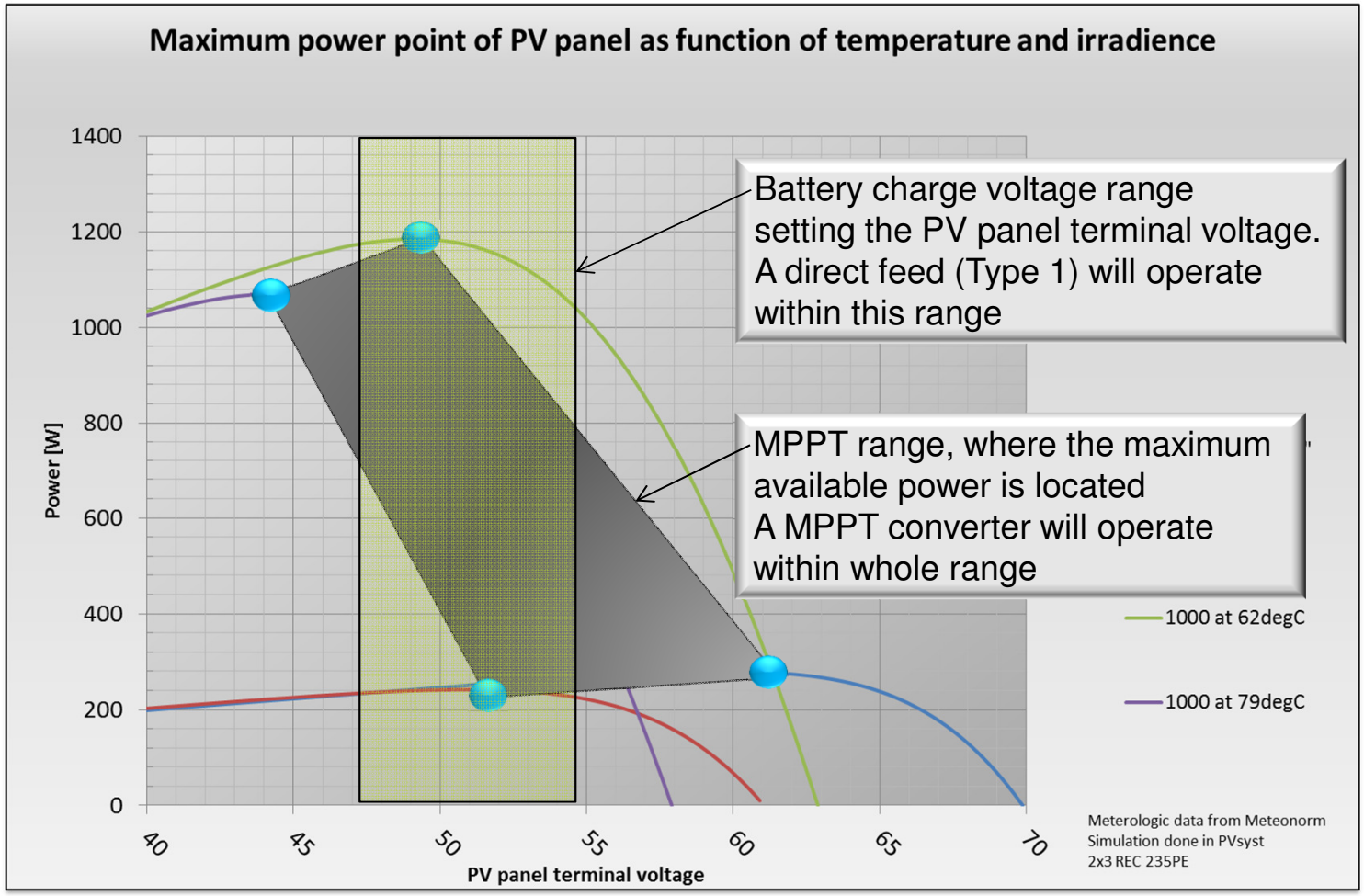
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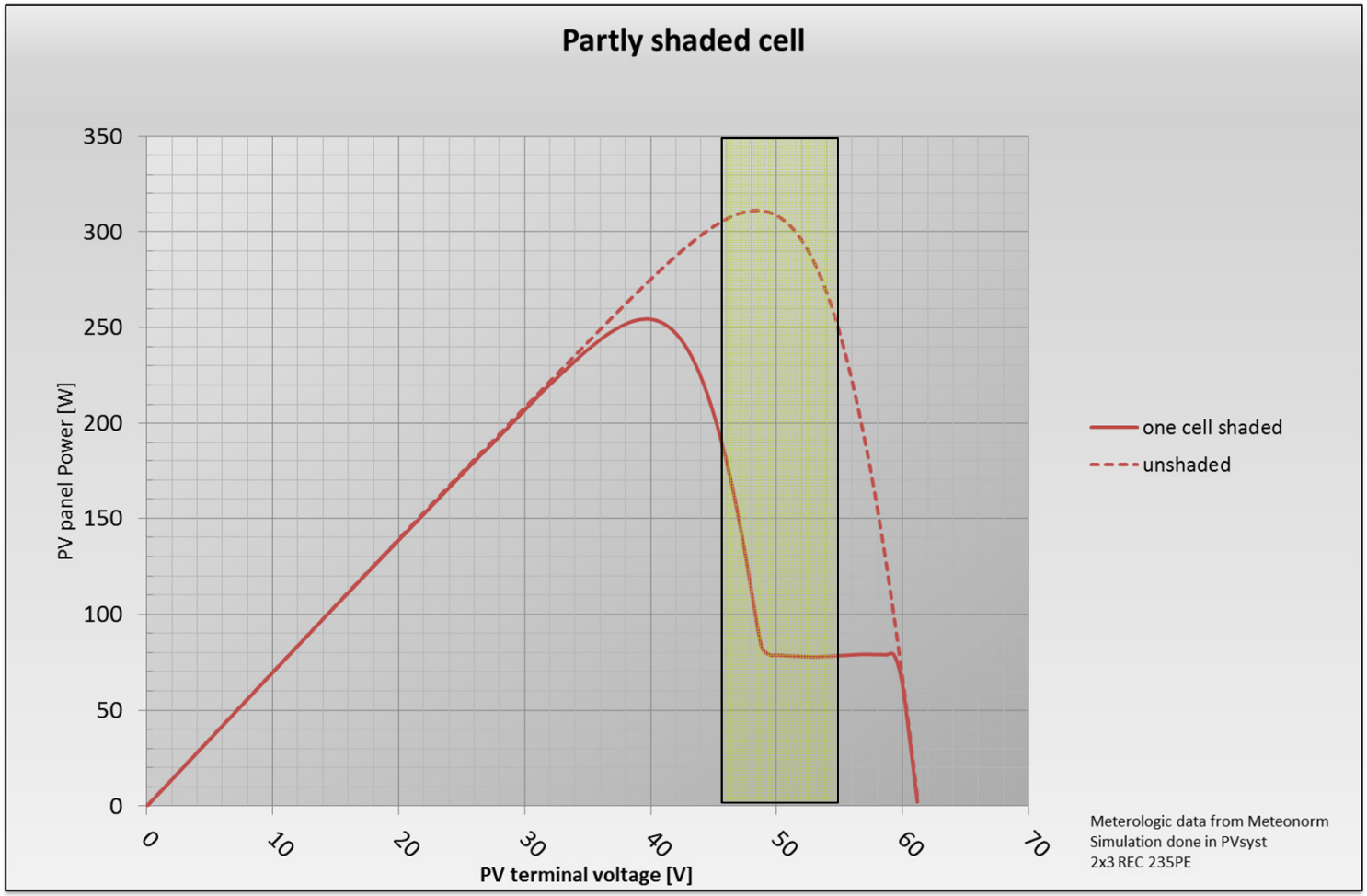
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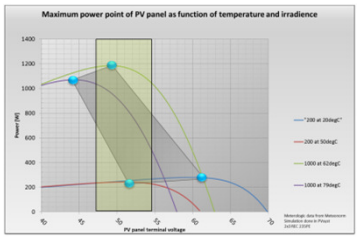


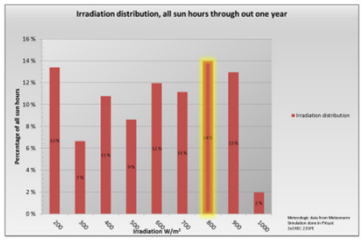


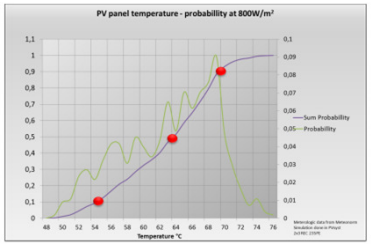

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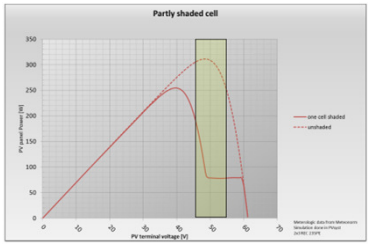
# TECHNOLOGY COMPARISON

- The constraints of the Type 1 system has been identified
- Every irradiation level and panel temperature there will be:
  - A maximum available energy
  - A maximum energy that the Type 1 can give
  - A minimum energy that the Typ1 can give.
- For a whole year the contribution from each irradiation level will be according to their hourly distribution.
- Effect of partly shading not considered



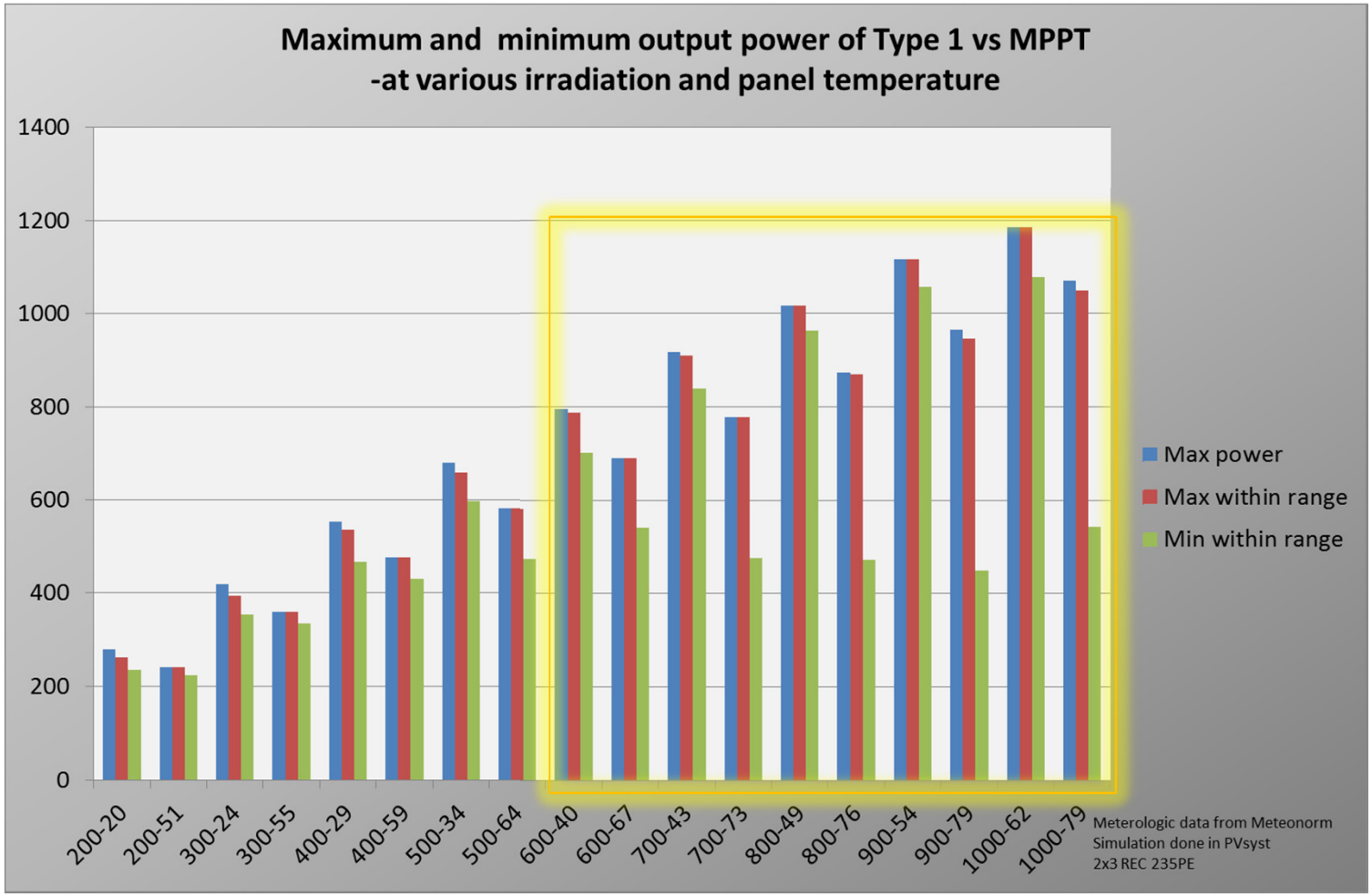






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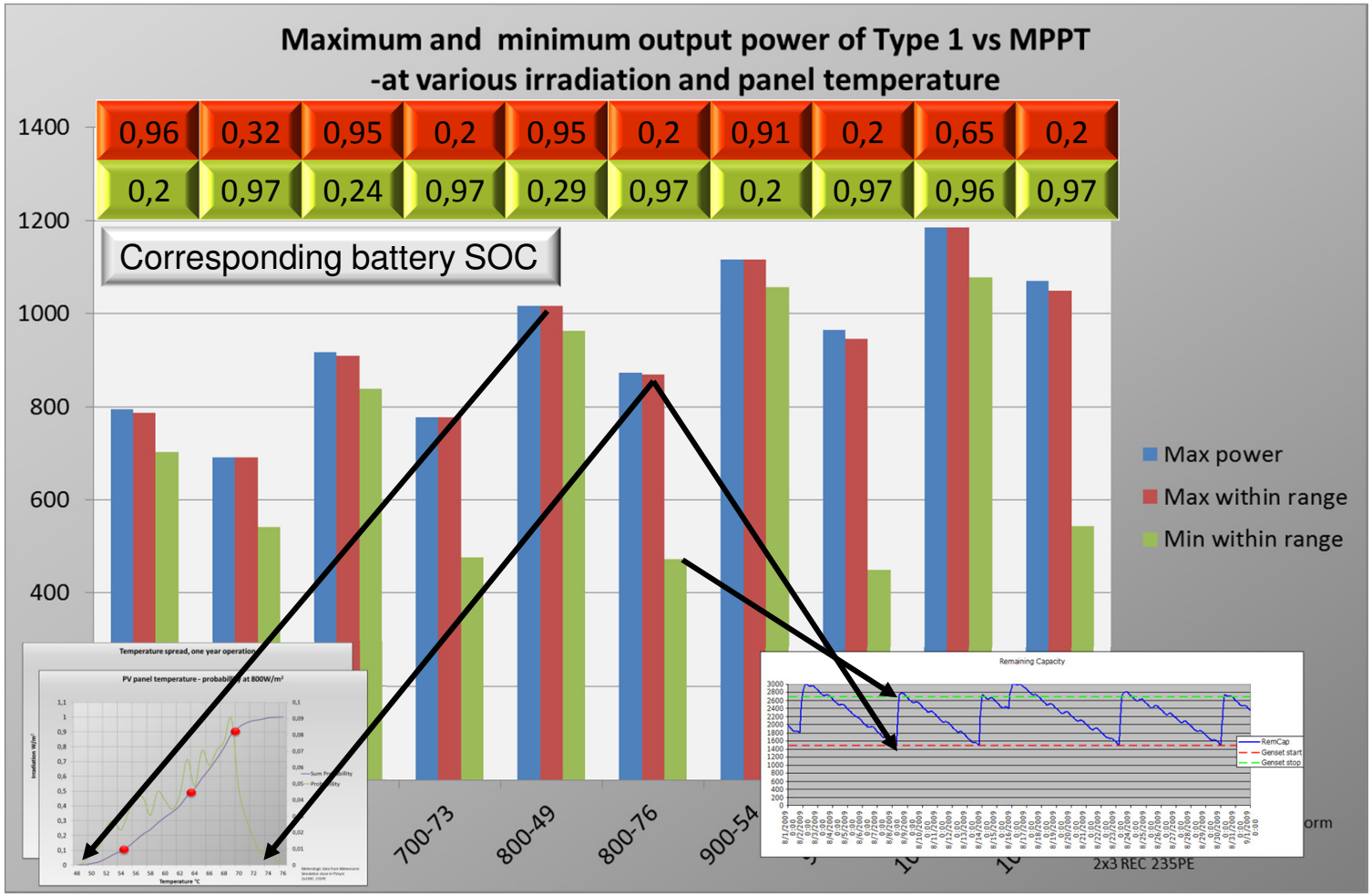
# TECHNOLOGY COMPARISON






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# TECHNOLOGY COMPARISON






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# TECHNOLOGY COMPARISON

- From here it is all about probability and statistics…
  - Best case and worst case conditions are not likely to dominate.
  - Higher PV temperature will dominate
- Assume 20% less PV contribution from Type 1 (Including conversion losses in the MPPT) on yearly basis.
- Type 1
  - Needs 20% more PV panels to achieve same solar fraction
  - Increased CAPEX

***OR***

  - 20% more energy from the generator.
  - Increased OPEX

# TECHNOLOGY COMPARISON

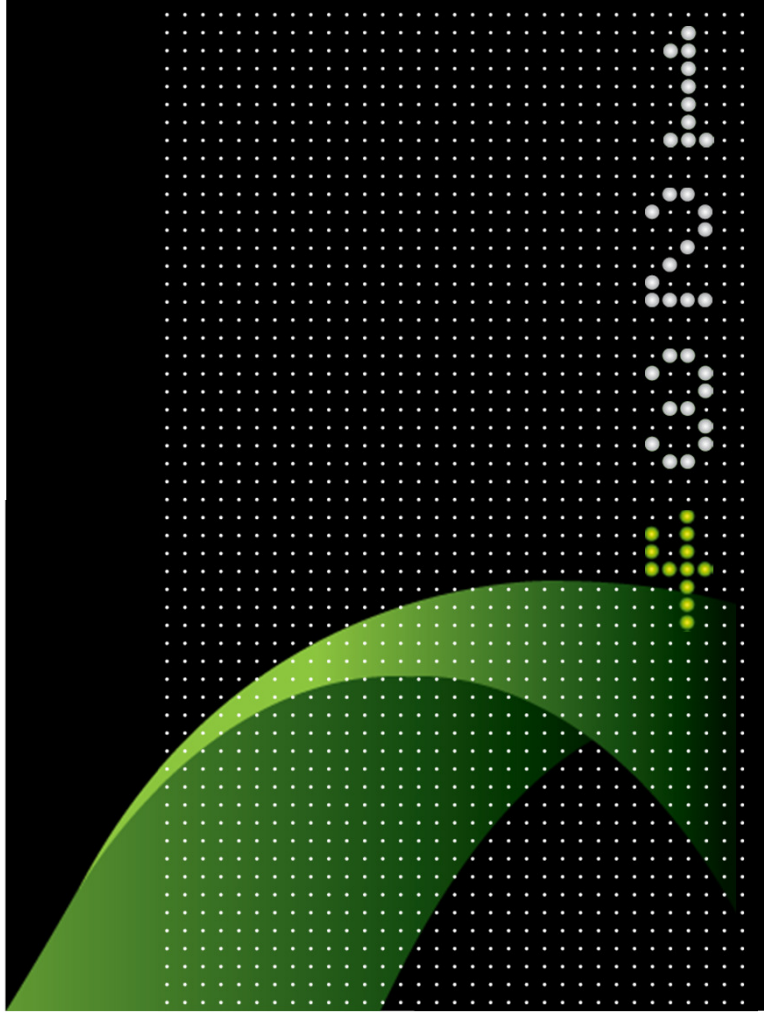
## Technology difference summary

| | Type 1 | Eltek | Impact |
|---|---|---|---|
| Technology | Contactor/Relay | Switch mode | |
| Control | ON/OFF | PWM | |
| Galvanic isolation | No | Yes | Surge immunity<br>Safety |
| Regulated output | No | Yes | Energy priority<br>Charge control |
| MPPT | No | Yes | Energy yield |
| Converter efficiency | ~100%<br>(no conversion) | 96,5% | System losses |



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# MAXIMIZE THE POWER OF RENEWABLES



HYBRID SYSTEM BUILDING BLOCKS

SOLAR HYBRID FUNDAMENTALS

TECHNOLOGY COMPARISON

FINANCING SOLUTIONS

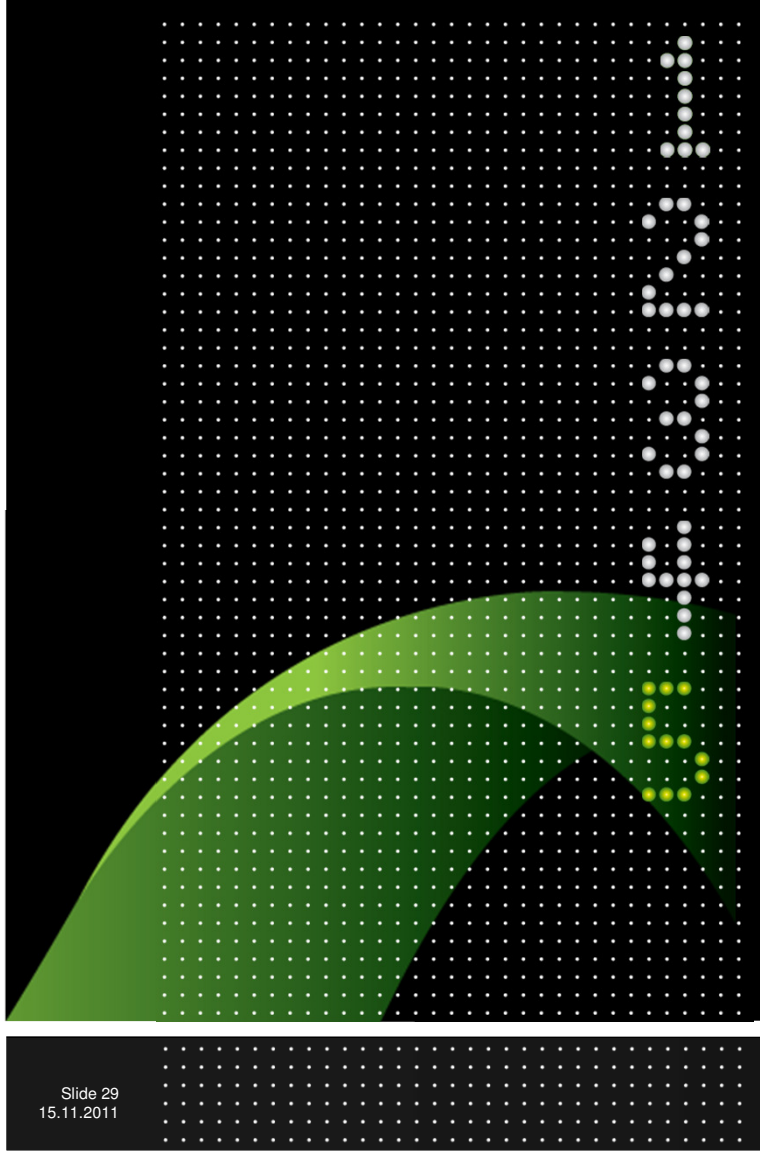


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# ELTEK VALERE FINANCIAL SOLUTIONS

- Does it make sense to pay upfront for equipment that delivers you monthly income?
- Would an OPEX solution help your budgets?
- Would you buy more technology if you could buy now and pay later?
- Would you invest more quickly if the monthly saving was greater than your monthly cost?
- Our models typically require no CAPEX investment, where monthly savings are greater than the monthly payments you make – would that help with your business case to choose Eltek Valere?

# MAXIMIZE THE POWER OF RENEWABLES



HYBRID SYSTEM BUILDING BLOCKS

SOLAR HYBRID FUNDAMENTALS

TECHNOLOGY COMPARISON

FINANCING

PROJECTS IN AFRICA



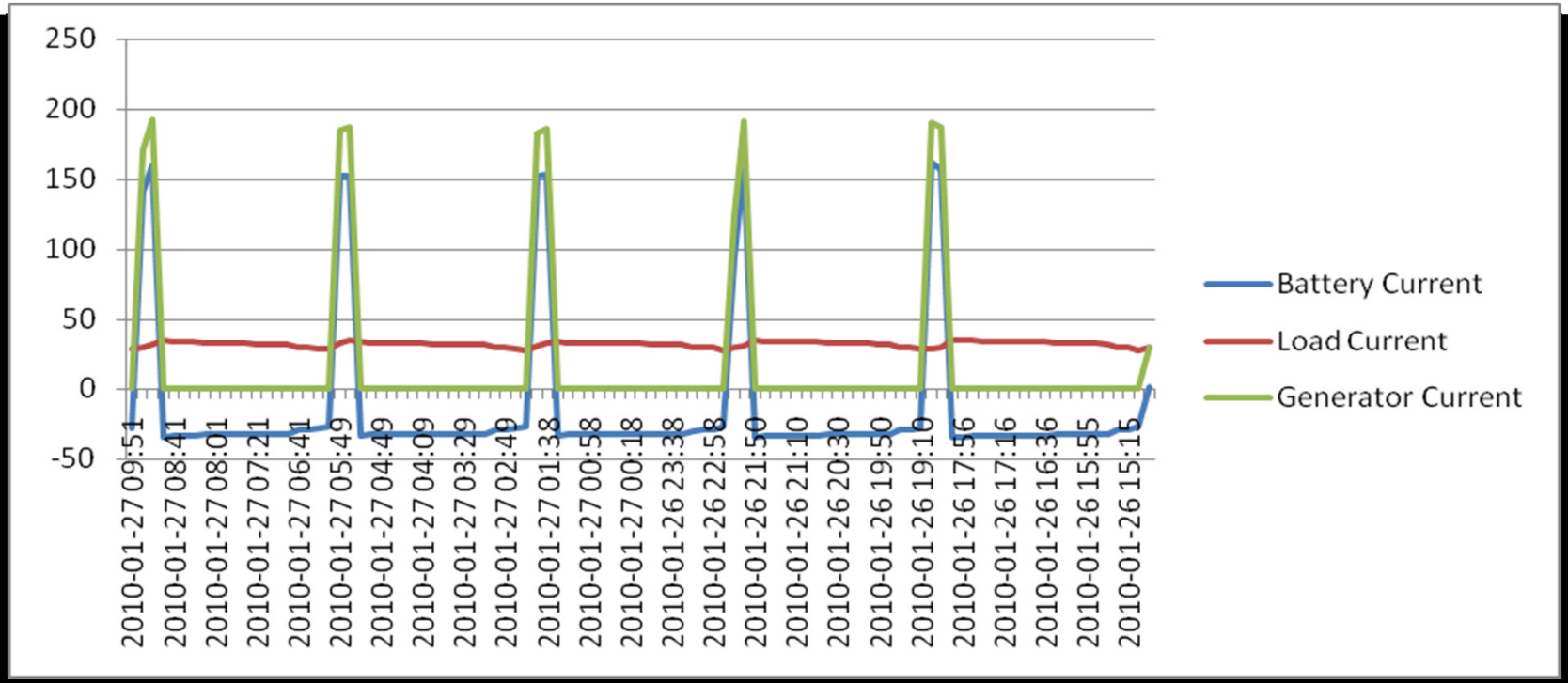
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# HYBRID SITE ANALYSIS



- Site: Lagos, Nigeria
  - 27KvA Generator
  - 22% DOD
  - 150A Recharge current available
  - Peak Load 3Kw
  - Average Load  2.5Kw (50A)
  - FCU  1800M3/hr
- Breakdown of Analysis
  - Generator run time – 06Hrs
  - Battery run time – 18Hrs (Nicad Batteries)
  - Load – 50A Average
  - 6 Cycles per day

# INSTALLED HYBRID SITE ANALYSIS - GRAPHS




- Diesel Savings: 2160 liters per month = approx $3024 per month ($1.4 per liter delivered to site)

- OPEX Savings : 75%



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# HYBRID SITE ANALYSIS

- Rural electrification



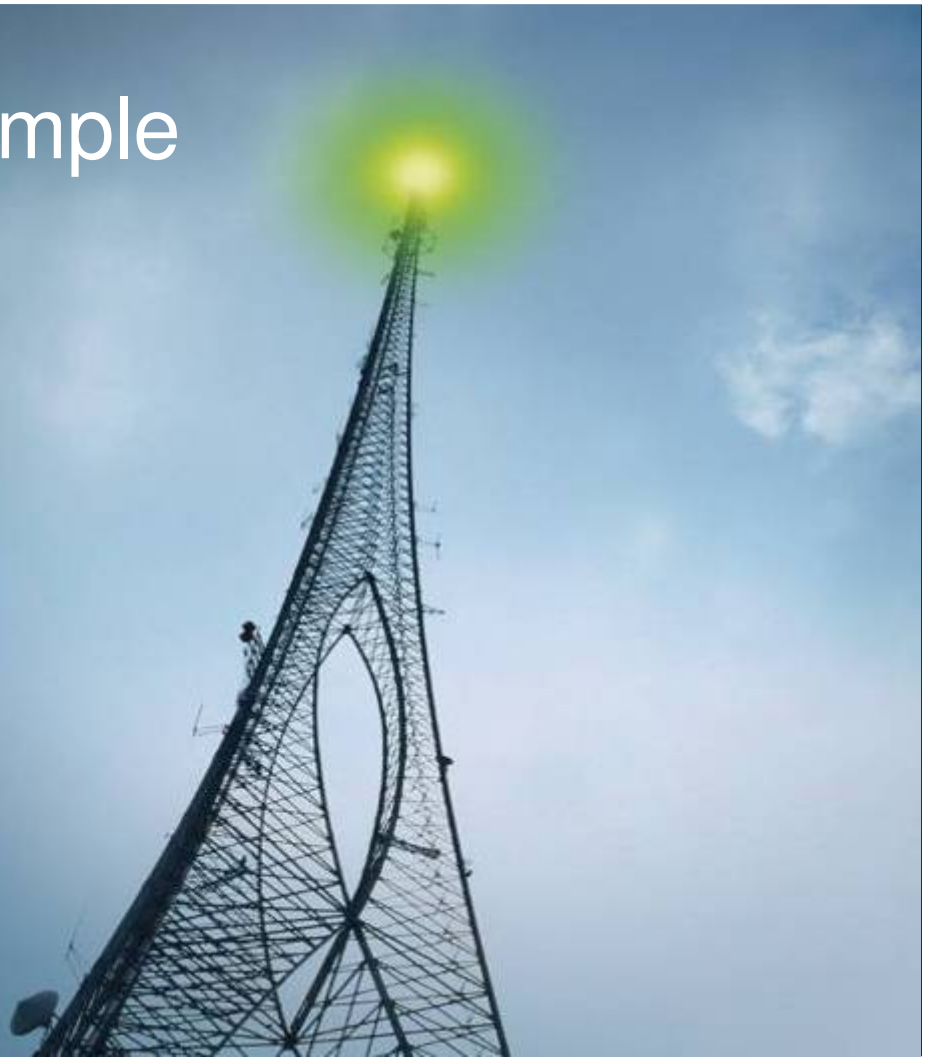


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# Eltek Valere – The Greenest Power in the Industry

## Leading Through Example

**Thank you for your time**





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# Study constrains

- The output of a PV panel is limited by three major parameters.
  - Level of energy coming from the sun (Irradiation [W/m$^2$]
  - Temperature [$^o$C]
  - Air mass (AM ,Height above sea level)
  - Operation point
- The rating of a PV panel is given under Standard Test Conditions (STC):
  - Irradiation 1000 W/m$^2$
  - PV panel temperature 25$^o$C
  - air mass AM 1.5,
- PV panel rating cont.
  - A PV cell is a diode.
  - A PV panel consists of multiple cells connected in series
  - The nominal voltage of a panel in given by the number of cells, ie 60 cells gives a open circuit voltage of ~36V
  - To improve the performance incase of shading, the cells are organized into strings protected by bypass diodes.



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