SOLAR POWER

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ECE 421 Group Project

Overview

- History
- Advantages and Disadvantages
- Photovoltaic Panels
- Power Quality Issues Associated with PV
- Solar Tower
- Solar Trough
- World's Largest Concentrated Solar Farm

History

- William Adams and Richard Day – 1876
- Silicon Cell discovered in 1953
- USA and Soviet Space Programs – 1960s
- Exxon 1970s

Advantages and Disadvantages

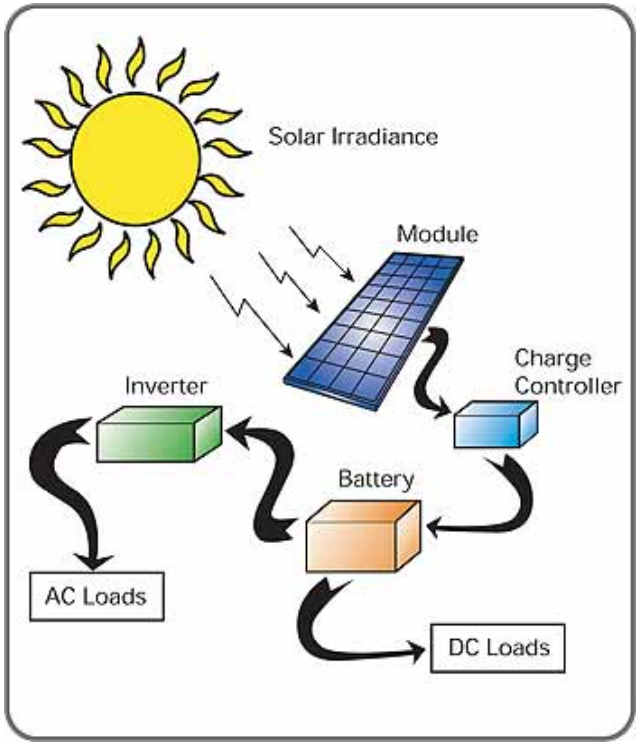
- Advantages
  - Carbon-Free Admissions
  - Renewable Energy
  - Monetary Saving over time
- Disadvantages
  - Lower Efficiency
  - Peak Hours
  - Multiple Areas are less likely to be able to harness enough energy to see some of the advantages associated with Solar Power

Photovoltaic Panels

Photovoltaics (PV)

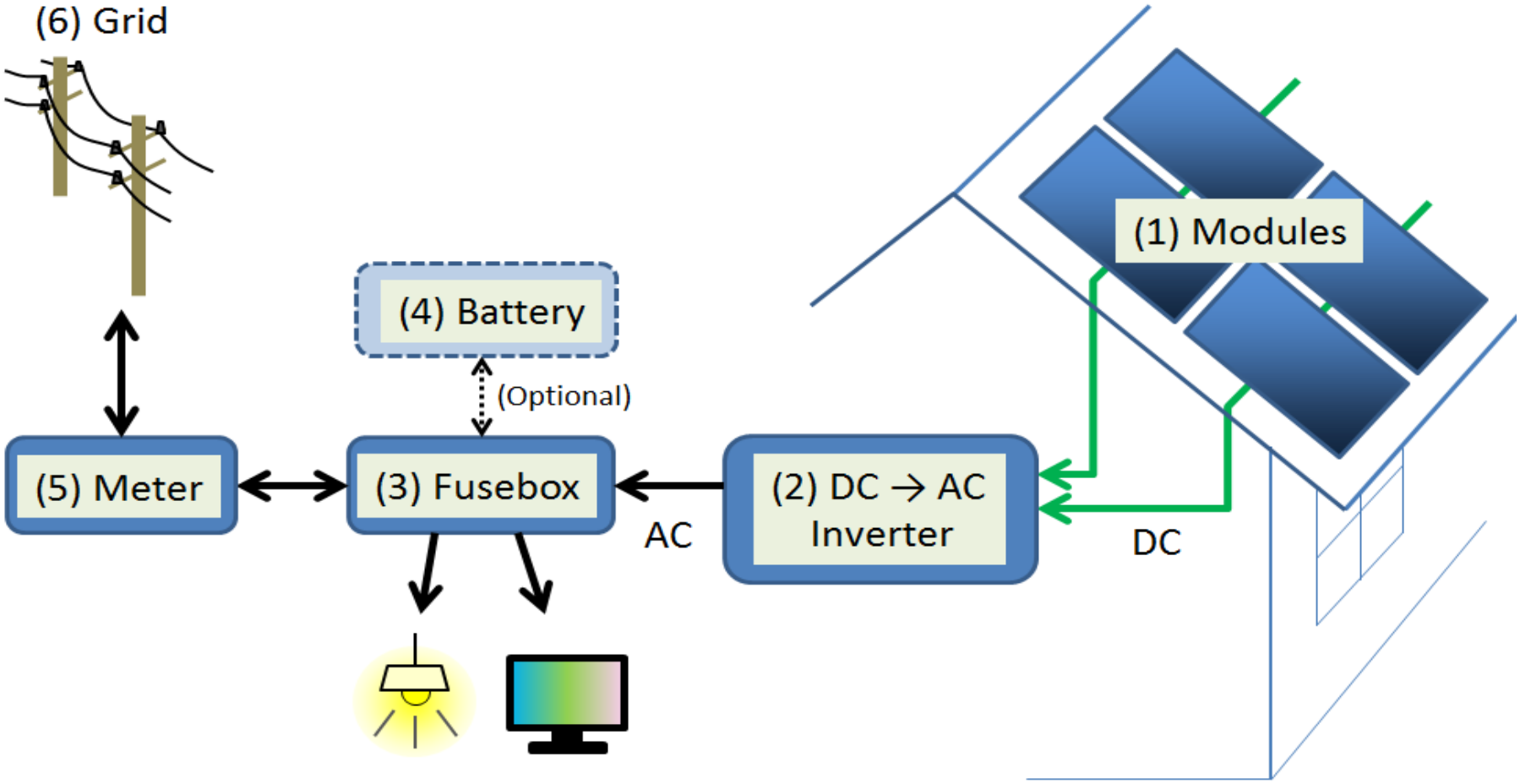
Sunlight → DC

- Charging batteries
- Running loads
- Generating AC power



Solar Cells and their Applications Second Edition, Lewis Fraas, Larry Partain, Wiley, 2010, ISBN 978-0-470-44633-1 , Section10.2.

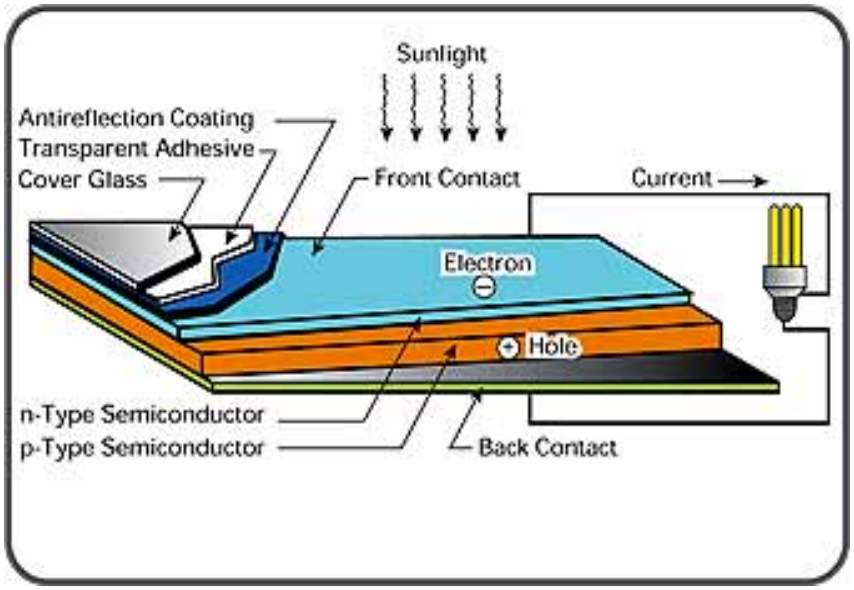
Photovoltaic Panels cont.

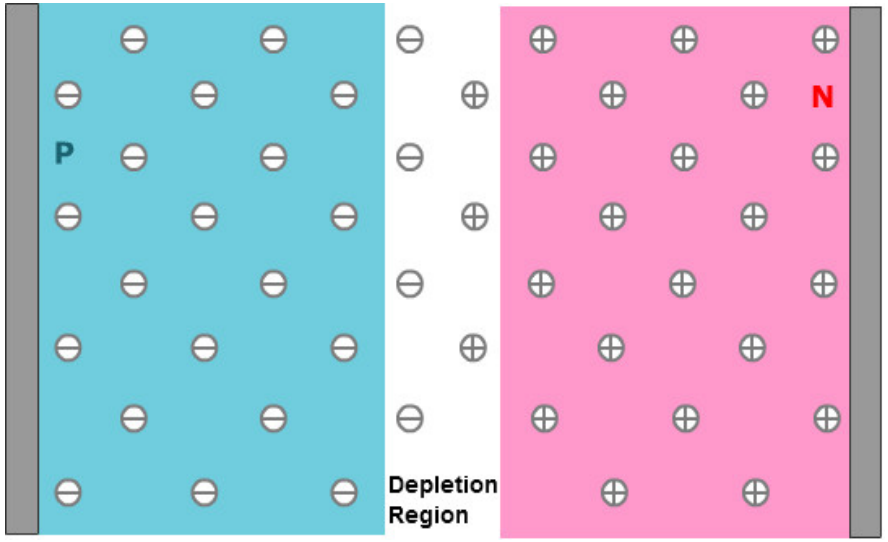


Solar Cells and their Applications Second Edition, Lewis Fraas, Larry Partain, Wiley, 2010, ISBN 978-0-470-44633-1 , Section10.2.

Photovoltaic Panels cont.

Structure

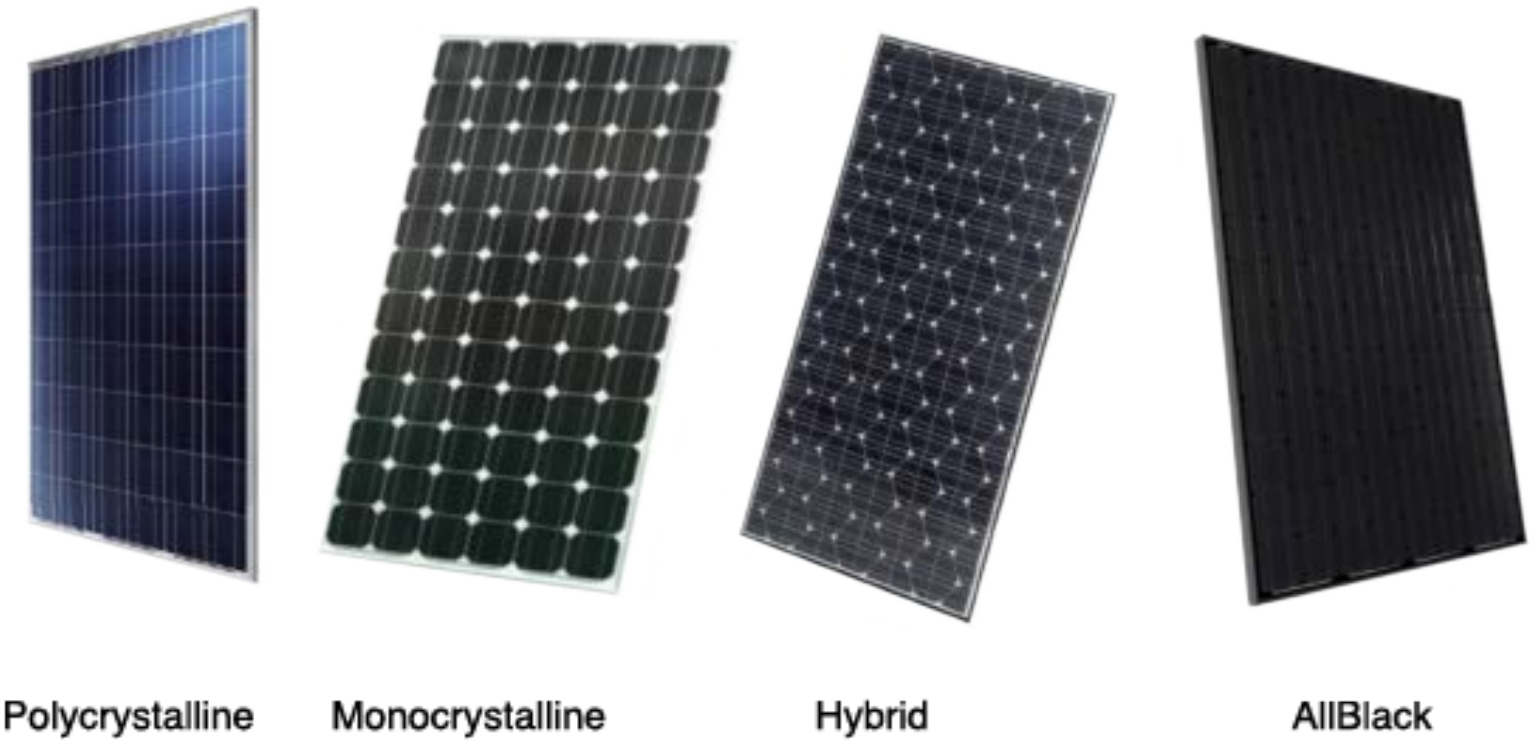




http://www.smartwaterandenergy.com.au/SolarElectricitySystems/tabid/68/Default.aspx
http://pveducation.org/pvcdrom/solar-cell-operation/photovoltaic-effect

Photovoltaic Panels cont.

Categories



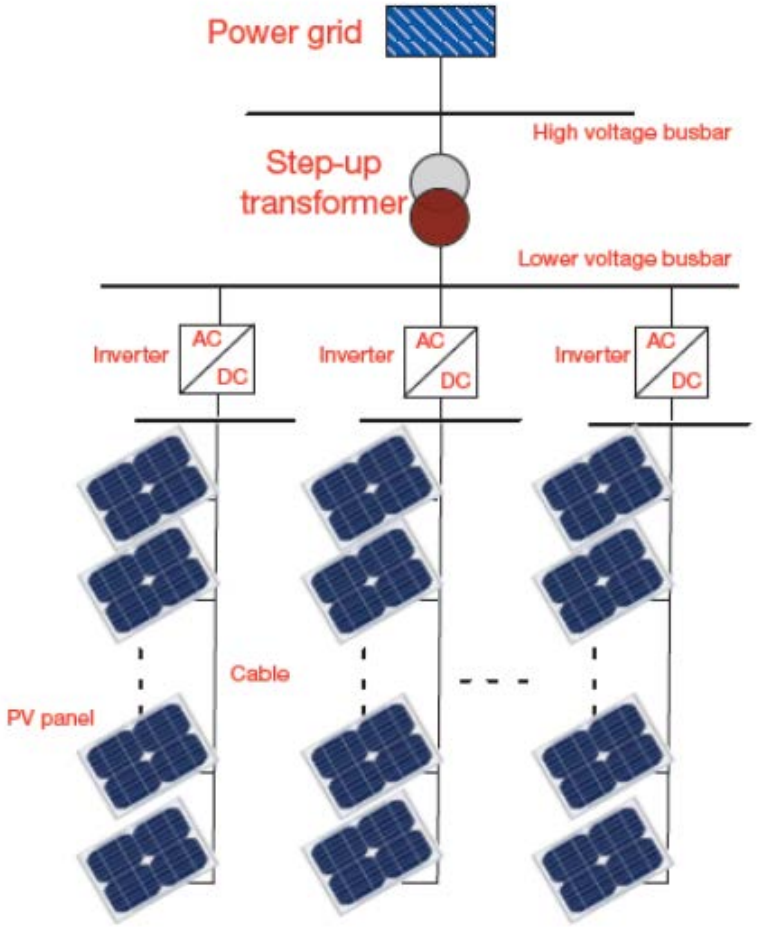
http://www.c-changes.com/types-of-solar-panel

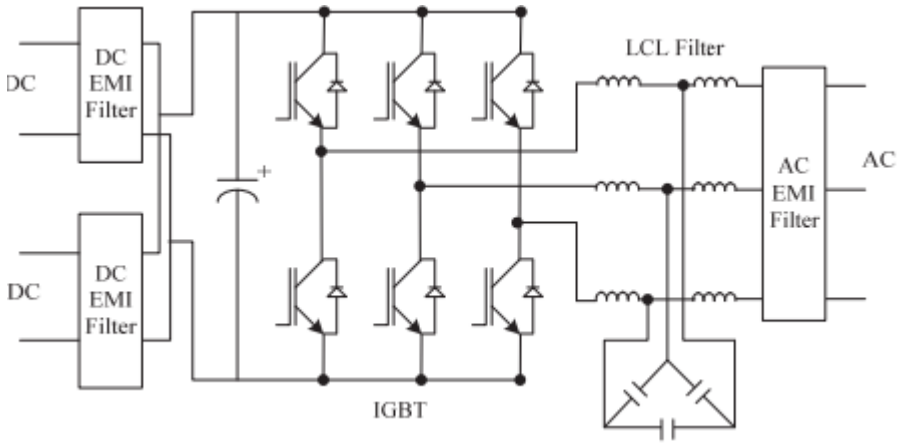
Power Quality Issues with PV

- Challenges of PV System
  1. Non-controllable Variability
  2. Partial unpredictability
  3. Location Dependence
- Research Papers

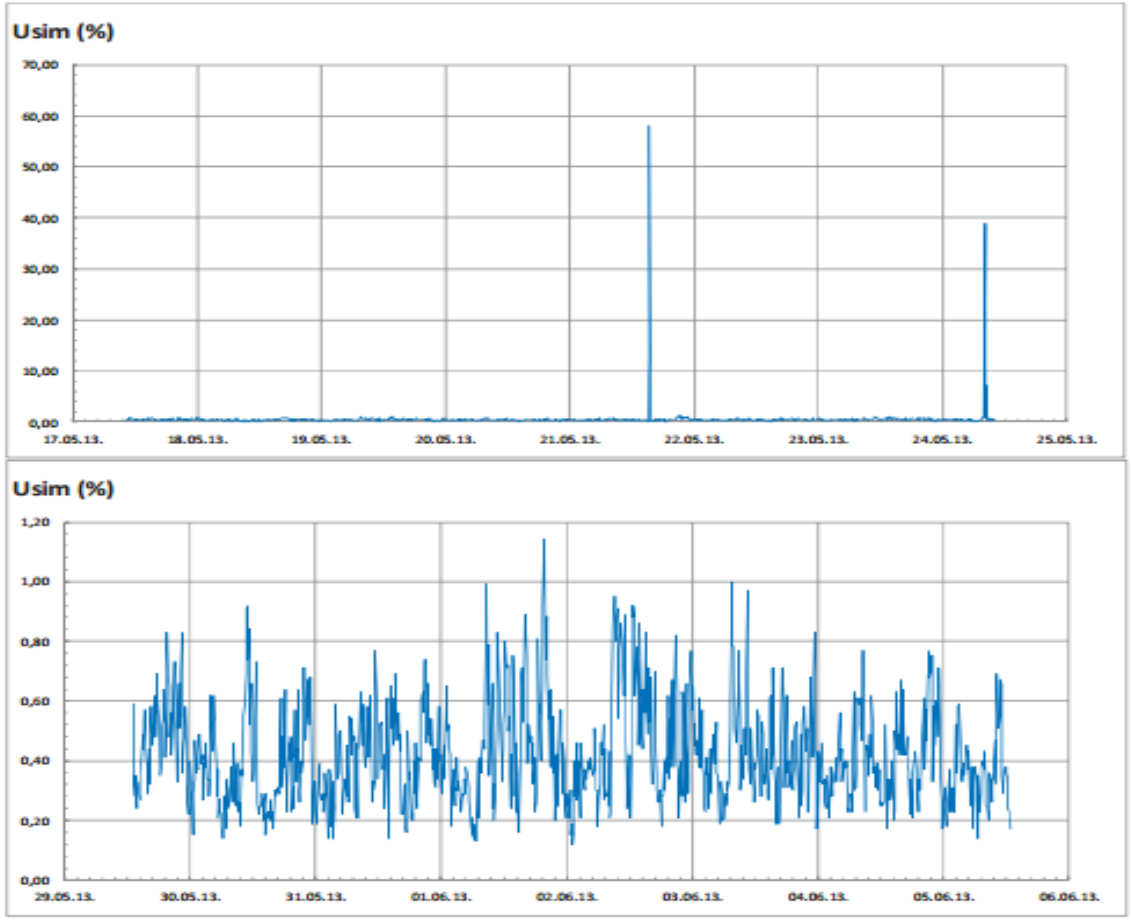
1. Galzina, D., "Grid integration of distributed energy sources regarding power quality," *Energy Conference (ENERGYCON), 2014 IEEE International* , vol., no., pp.1320,1324, 13-16 May 2014
2. Rodway, J.; Musilek, P.; Misak, S.; Prokop, L., "Prediction of PV power quality: Total harmonic distortion of current," *Electrical Power & Energy Conference (EPEC), 2013 IEEE* , vol., no., pp.1,4, 21-23 Aug. 2013
3. Gorecki, K.; Szmajda, M., "The power quality in low-power solar off-grid system," *Harmonics and Quality of Power (ICHQP), 2014 IEEE 16th International Conference on* , vol., no., pp.244,248, 25-28 May 2014
4. Aiqiang Pan; Yingjie Tian; Haisheng Zhao; Xingang Yang; Jiapei Jin, "Power quality analysis of PV system of summer and winter," *Integration of Renewables into the Distribution Grid, CIRED 2012 Workshop* , vol., no., pp.1,4, 29-30 May 2012

Structure of PV System and Inverter





Voltage unbalance before and after connection of PV system



Galzina, D., "Grid integration of distributed energy sources regarding power quality," *2014 IEEE Energy Conference (ENERGYCON),*

Harmonics Differences Between Seasons

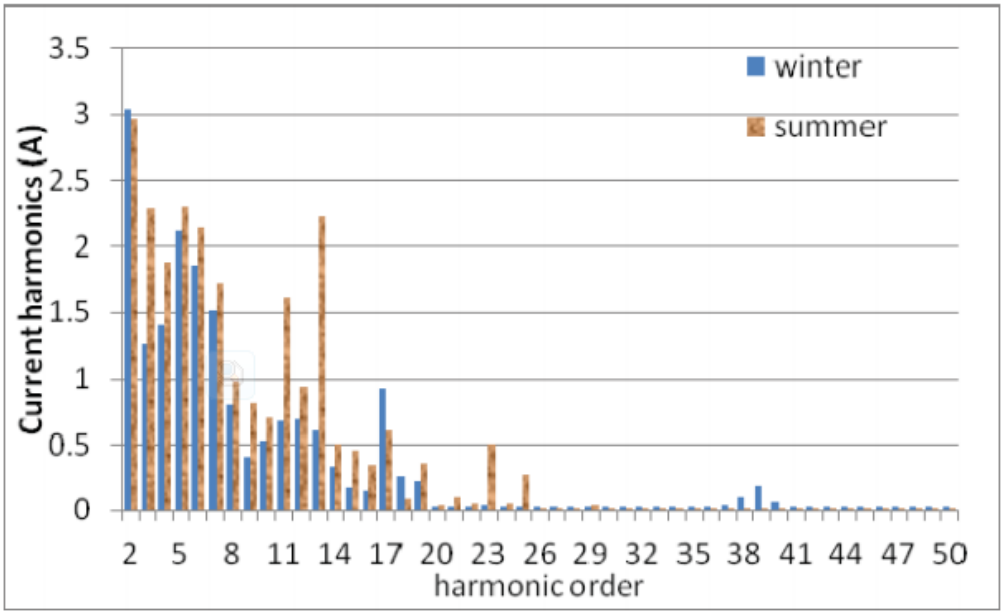


Fig.6 the current harmonics spectrum

Table.1 Characteristic harmonics of voltage (%)

order	**THD**	**5**	**7**	**11**	**13**
winter	1.91	1.7	1.06	0.16	0.07
summer	1.23	0.89	0.41	0.63	0.58
limit	4	3.2	3.2	3.2	3.2
order	**17**	**19**	**23**	**25**	
winter	0.06	0.04	0.02	0.02	
summer	0.15	0.14	0.32	0.14	
limit	3.2	3.2	3.2	3.2	

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Power Quality Prediction Method

- Data:

  voltage, current , power

  frequency

  total harmonic distortion

  voltage unbalance

  short and long term flicker

……

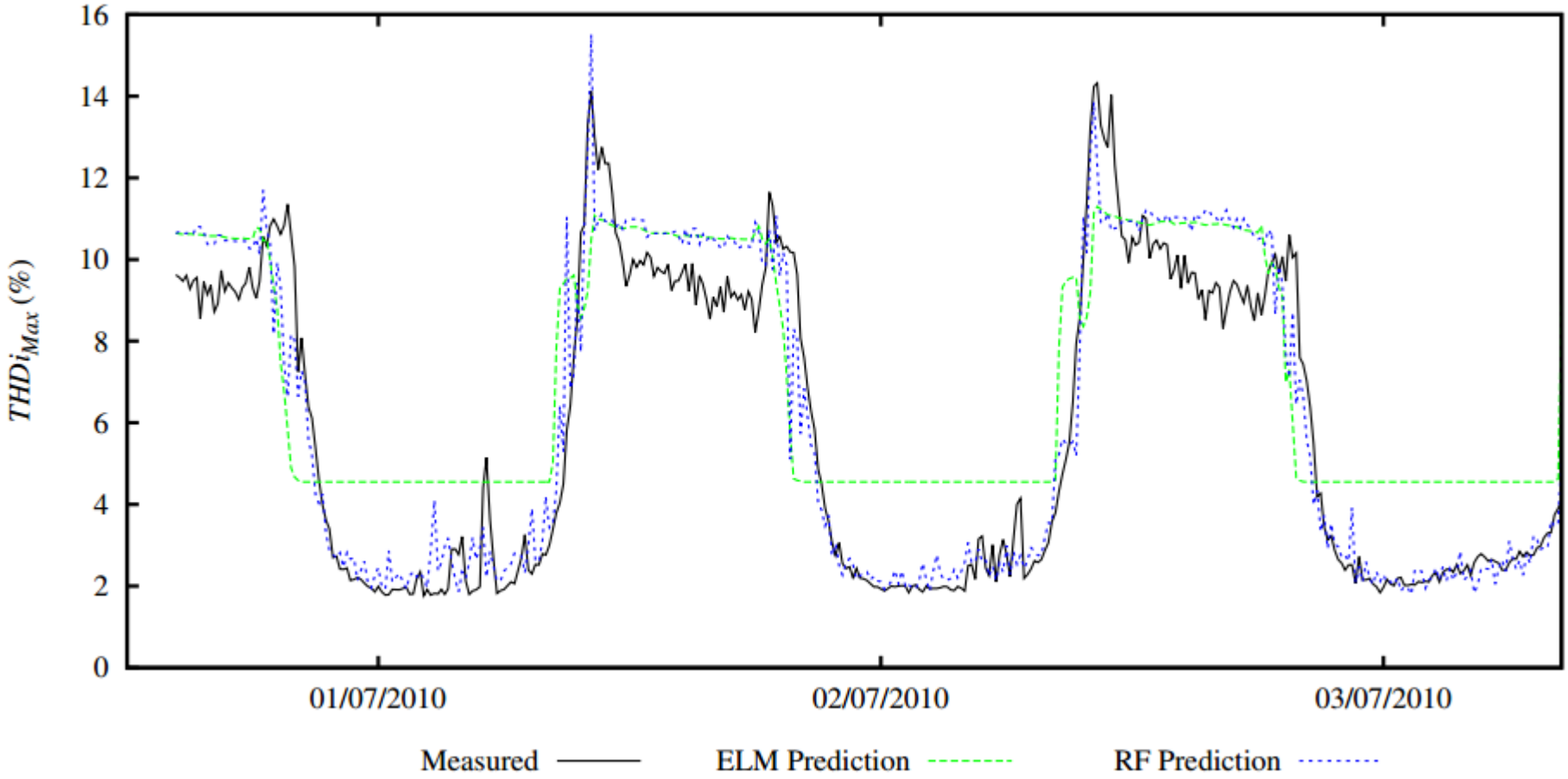
Prediction method:

  ELM:

    (extreme learning machine)

Rodway, J.; Musilek, P.; Misak, S.; Prokop, L., "Prediction of PV power quality: Total harmonic distortion of current," *Electrical Power & Energy Conference (EPEC), 2013 IEEE* , vol., no., pp.1,4, 21-23 Aug. 2013

Prediction Result



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Solar Power Tower

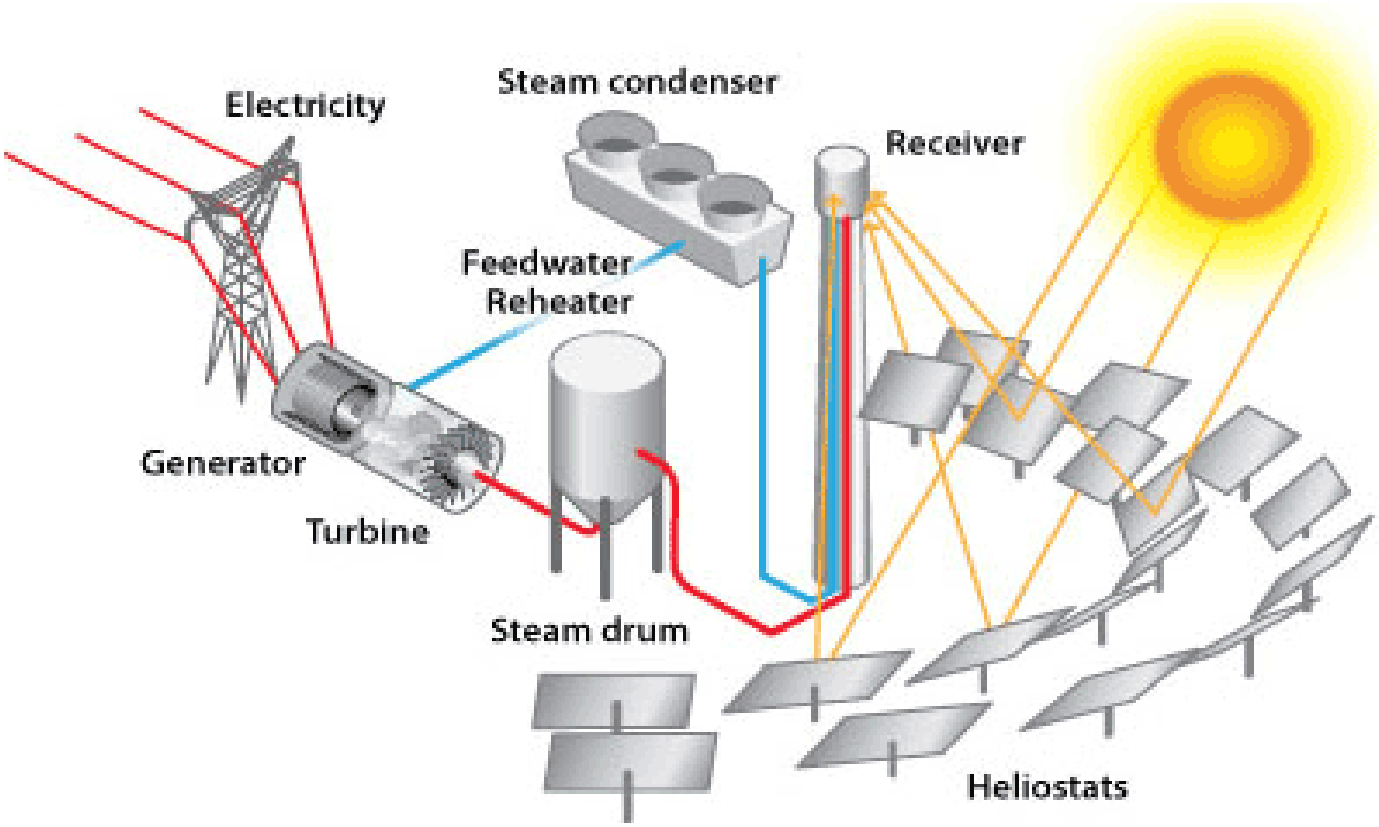
http://en.wikipedia.org/wiki/Solar_power_tower

Solar Tower – Basic Principle

- Field of flat moveable mirrors (heliostats)
  - Track sun & reflect sunlight onto receiver
- Heat Working fluid which circulates in receiver
  - synthetic oil or molten salt
- Heat exchanger to generate steam
  - Drive steam turbine generator

Solar Energy -> Thermal Energy -> Electric Energy

Solar Tower cont.



http://climatekids.nasa.gov/review/concentrating-solar/power-tower.gif

Solar Energy -> Thermal Energy -> Electric Energy

Solar Tower cont.

- Advantages
  - No pollution
  - No noise
  - Low maintanance costs
  - Thermal storage
- Disadvantages
  - Sole dependance on sun
  - Panels are expensive
  - A lot of water & land required

Solar Tower cont.

http://upload.wikimedia.org/wikipedia/commons/2/22/PS20andPS10.jpg

Solar Tower Conclusion

- **Solar Energy -> Thermal Energy -> Electric Energy**
- A lot of space needed
- Very economical excluding initial cost
- Heat capacity -> Molten salt
- Non pollutant power technology

Sources: http://en.wikipedia.org/wiki/Solar_power_tower
http://www.authorstream.com/Presentation/aSGuest124661-1310916-orini-sptt-ppt-2003/
Book: Power System Analysis – Hadi Saadat

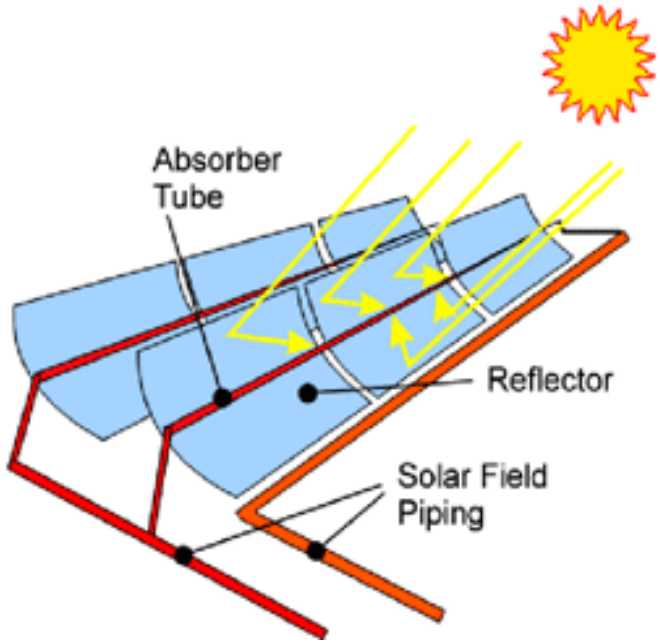
Solar Troughs

Solar Troughs - History

- In the late 1800's and early 1900's concentrated solar energy was first being explored.
- Solar Energy Generating Systems (SEGS) was built in 1984 and is the second largest solar farm in operation, using solar trough technology.

Solar Troughs - Function

- A row of reflective mirrors are placed with an absorbing tube placed at the focal point along the mirrors.
- An oil is circulated through the tube and is heated to about 400°C
- The oil is then used to heat steam for a standard turbine generator to harness the heat energy collected by the troughs.



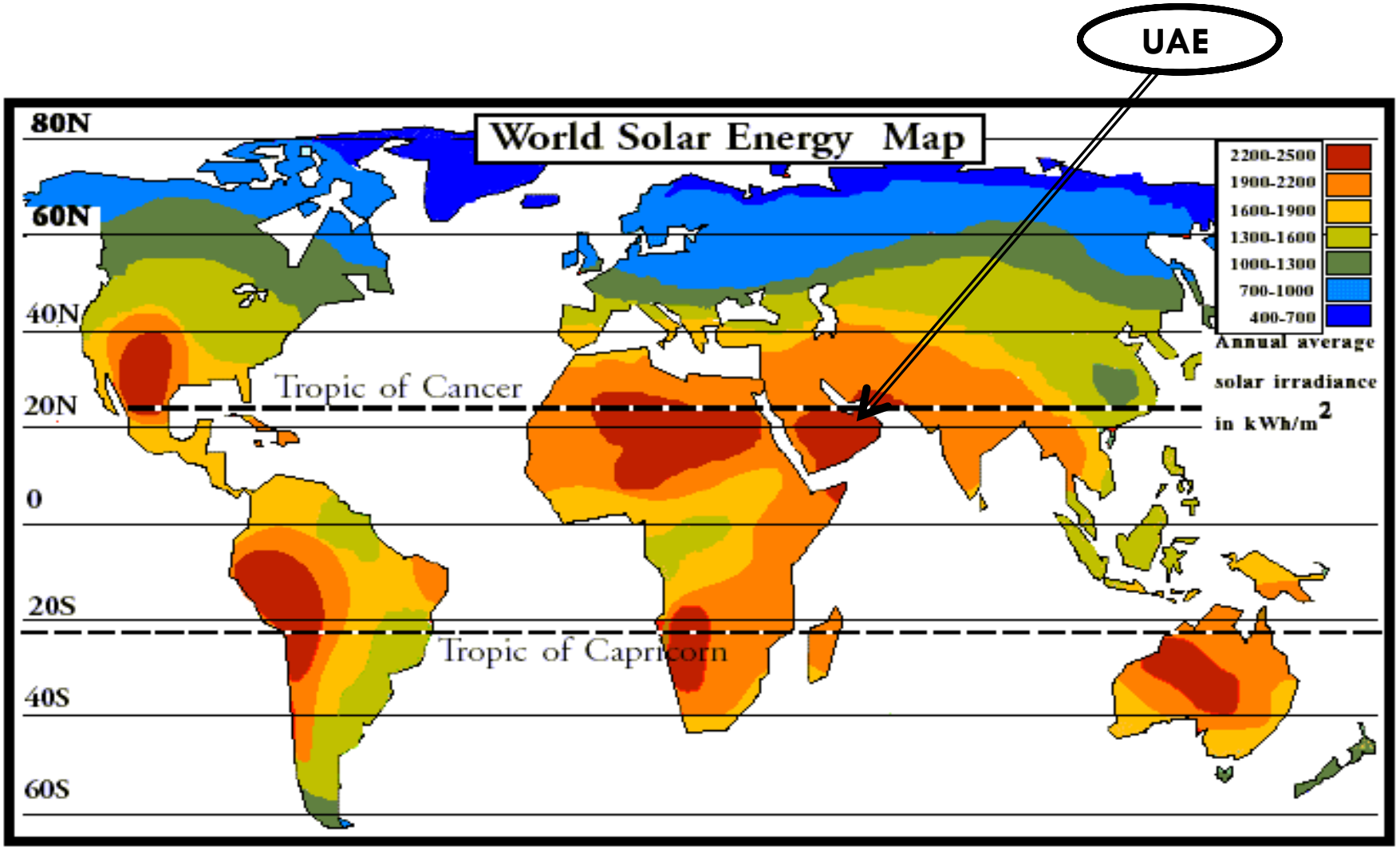
Solar Troughs - Downfalls

- Only work optimal in direct sunlight
- Reverts to using natural gas and fossil fuels at night and without sunlight (about 25% of the time)
- Can only be utilized in areas that receive great amounts of sunlight
- Only operate at about 15% overall efficiency after heat transfer

Solar Troughs – In Use

- Solar Energy Generating System (SEGS)
- Largest solar trough plant in the United States
- 229 miles of mirrors over 1600 acres
- 75 MW average gross output
- Is reported to power 232,500 homes during peak hour each day
- Reduces carbon emissions by using solar

World's Largest Concentrated Solar Plant



World's Largest Concentrated Solar Plant cont.

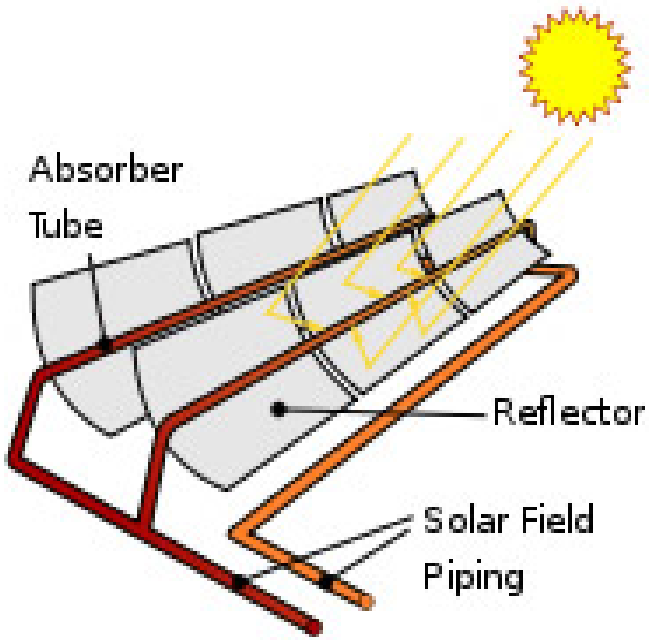
- Growing in power demand.
- Utilizing sustainable energy sources.

World's Largest Concentrated Solar Plant cont.

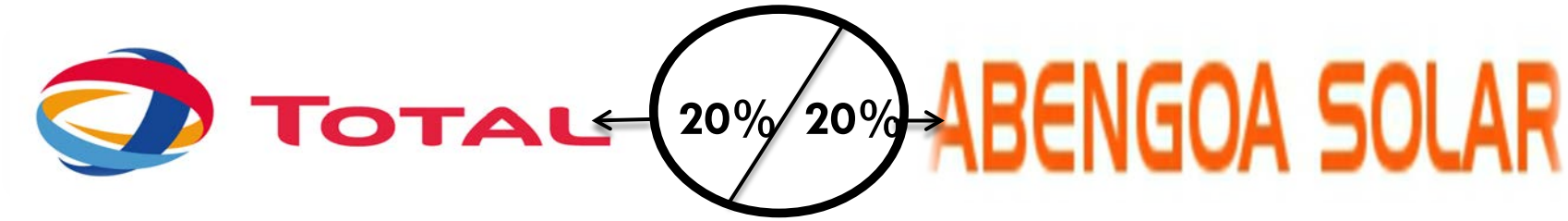
- Technical Information
  - Area of 2.5 km2.
  - Capacity 100MW.
  - Power around 20,000 homes.
  - Project started on 2010 and completed on 2013.
  - Total cost $600 millions.

World's Largest Concentrated Solar Plant cont.

- How it works
  - It utilizes parabolic trough collectors.
  - It consists of 258,000 mirrors mounted on 768 parabolic trough collectors.
  - It has a dry-cooling system.



World's Largest Concentrated Solar Plant cont.



World's Largest Concentrated Solar Plant cont.

- Environmental Benefits
  - It reduce the carbon footprint by roughly 175,000 tons.

1.5 Millions tree

1500 Cars

Summary

QUESTIONS?