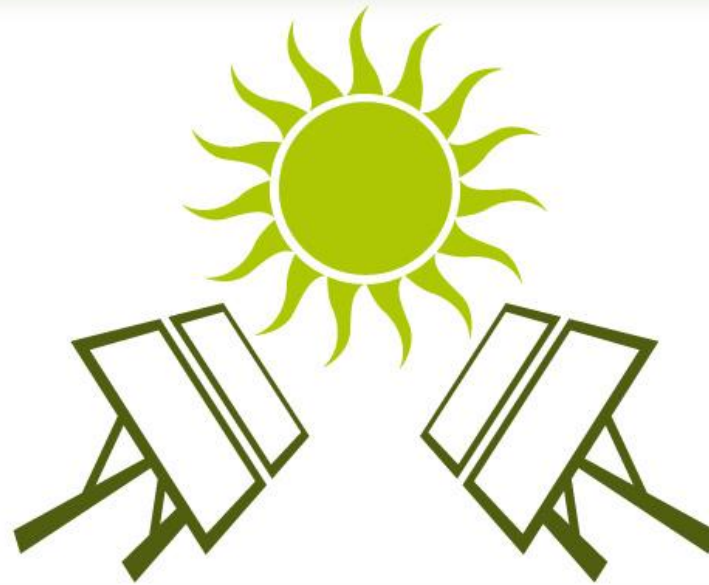


# Solar Energy Grid Integration

## *Present status and future challenges*



**SP7 Project 20 March 2017**  
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**RE&EE Expert and**  
**CEO of GREENSol Company**

# Speaker Introduction and holistic overview

- Some info about the speaker
- Energy as a prime mover for development
- Integrated vision on renewable energy offering value chain in the developing countries
- Importance of RE integration to power systems and grids for future energy demand scenarios
- Constraints of RE particularly wind
- Need for considering intentionally the integration of distributed generation at the extreme parts of grids to improve supply quality.

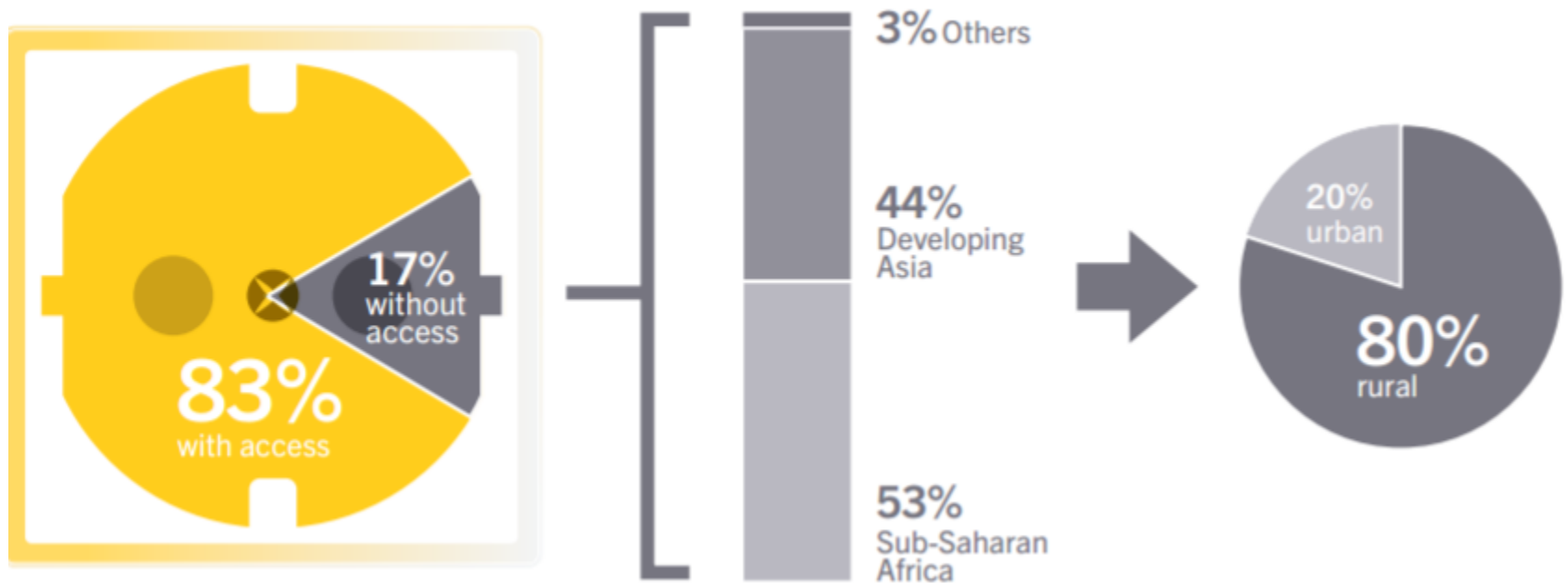


# Introduction

- This presentation explores what is needed to integrate power generating facilities from solar energy (either large scale or distributed) into existing electricity grids.
- It also explores the given various characteristics and difficulties which necessarily accompany such a process.
- These difficulties impose consequent challenges for the existing grid owners regarding its upgrading and also for its operators as well as for producers of electricity themselves, both renewable and conventional.
- The higher the proportion of solar (or generally renewables), the higher the challenges increases.



# Introduction (Contd.): size of electricity access problem



Source:  
REN 21: RENEWABLES 2016 GLOBAL STATUS REPORT



# Introduction (contd.): examples of off-grid distributed solar generation

Mexico

Peru

Kenya

Tanzania

Bangladesh Nepal



Solar Lighting Systems



**15-20%**  
of households  
use off-grid  
solar lighting  
systems

About  
**530,000**  
pico-solar  
products were  
sold during  
2014-2015  
under Lighting  
Global



Solar Home Systems (SHS)

Residential and commercial small-scale SHS markets represent  
**80%**  
of total solar PV installed

In 2015, a government contract was awarded for the installation of  
**500,000**  
SHS

More than  
300,000 SHS installed and  
**30,000**  
SHS sold annually



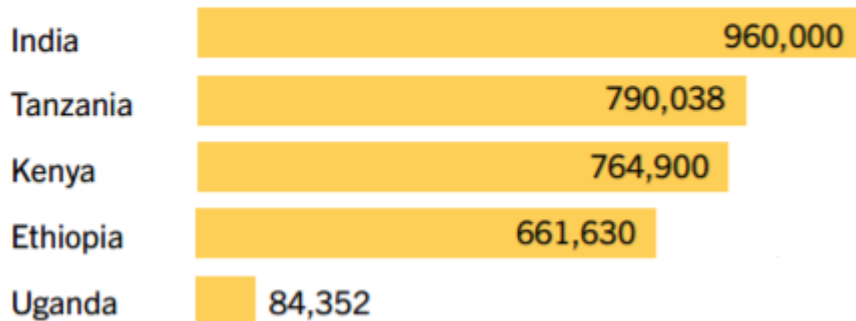
**10%**  
of population  
is served  
by SHS



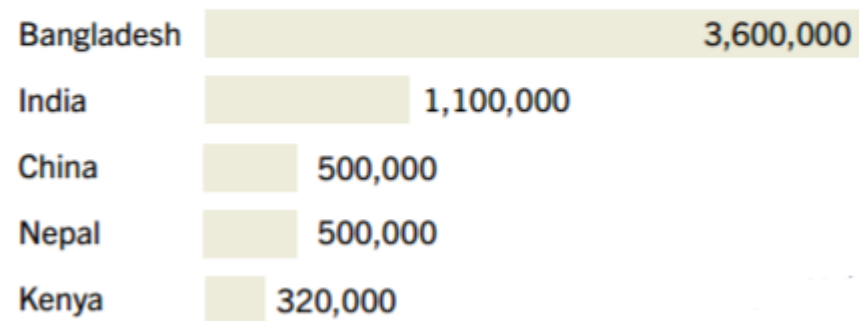
# Introduction (contd.): examples of Off-grid distributed solar generation in addition to distributed grid connected



## Solar Lighting Systems



## Solar Home Systems



Source:

REN 21: RENEWABLES 2016 GLOBAL STATUS REPORT

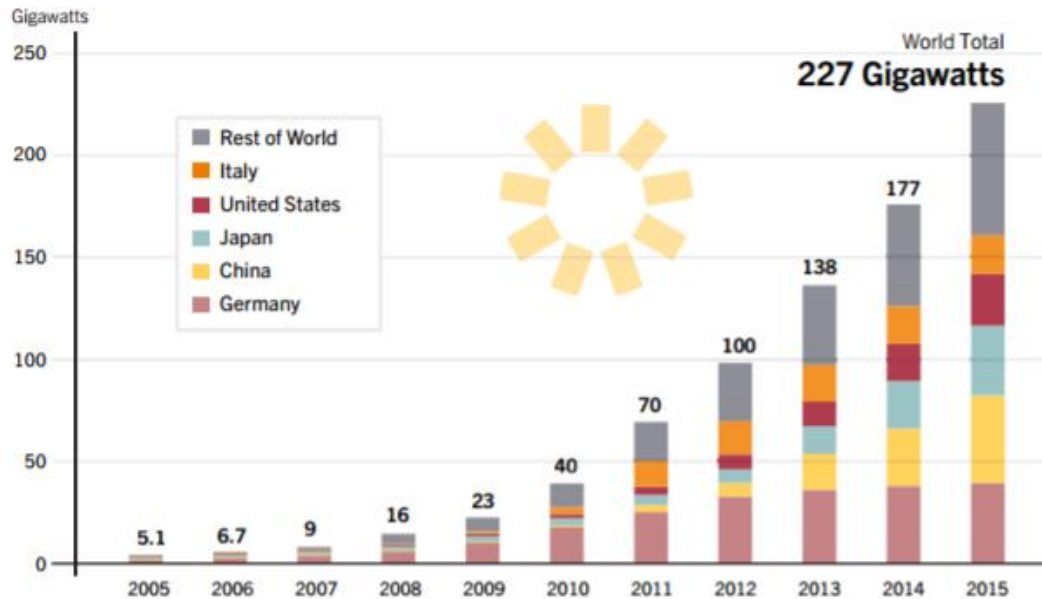


# Introduction (contd.): large scale PV

# 50 GW added in 2015

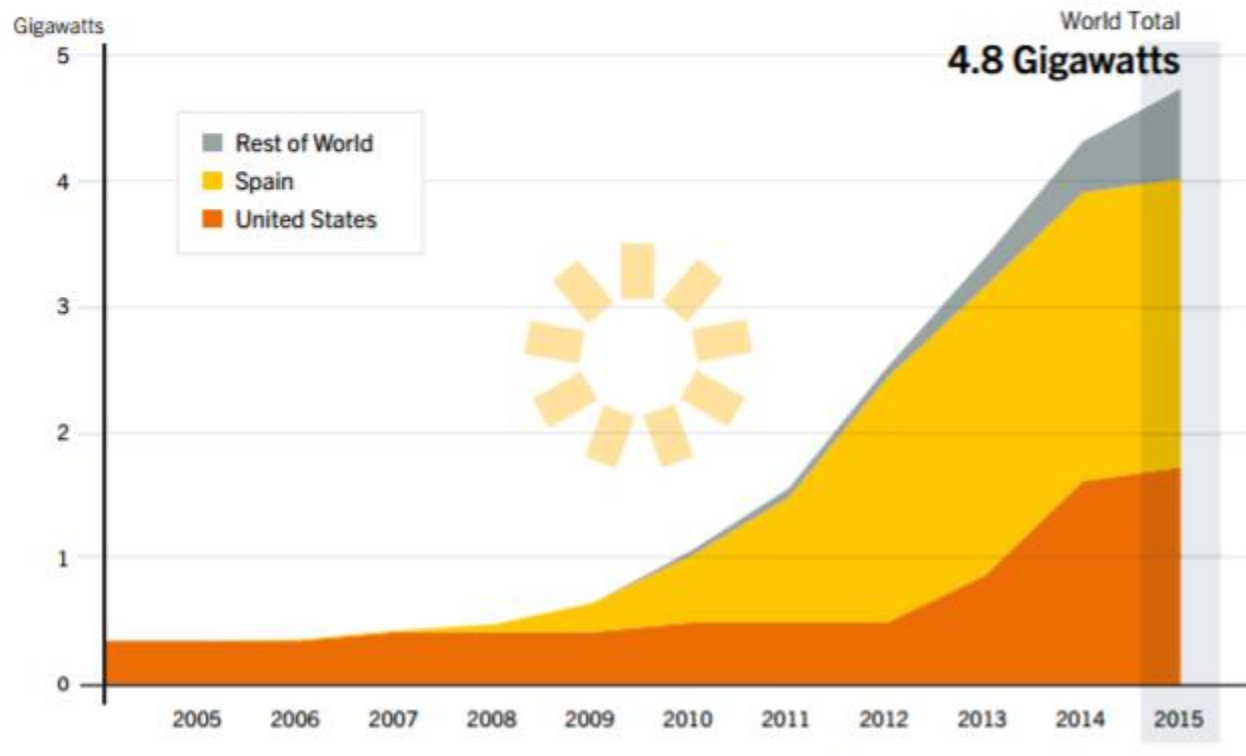


Figure 15. Solar PV Global Capacity, by Country/Region, 2005–2015



# Introduction (contd.): large scale CSP power generation

Concentrating Solar Thermal Power Global Capacity, by Country/Region, 2005–2015





# Present: state of the art in integrating solar power generating facilities

- **Present status:**
  - ❖ Transmission technology
    - AC transmission
    - VSC-HVDC transmission
  - ❖ Operational technologies and practices
    - Power forecasting
    - Operational practices



# Present: challenges for integrating larger solar capacities

- Grid integration challenges
  - ❖ Non-controllable variability
  - ❖ Partial unpredictability
  - ❖ Locational dependency



# Future: technical solutions for integrating more capacity from solar power (SP)

## 1. Grid-friendly SP generation

- ❖ Need for grid-friendly SP generation
- ❖ Advanced characteristics of SP generating plants
- ❖ Centralized control and clustering of SP plants
- ❖ Improvements in modeling SP generation

## 2. Improved flexibility in conventional generation

- ❖ Need for more flexibility in conventional generation
- ❖ Assessment of generation flexibility
- ❖ Generation planning for both adequate capacity and adequate flexibility



# Future: technical solutions (Contd.)

## 3. Transmission expansion

- ❖ Needs for transmission expansion
- ❖ Application of new transmission technologies
- ❖ Developments in transmission planning

## 4. Operational enhancement

- ❖ Need for operational enhancement
- ❖ More accurate SP power forecasts
- ❖ Enhancement of operational tools and practices

## 5. Demand response

- ❖ Demand response applications for SP integration
- ❖ Demand response practices and trends
- ❖ Technologies supporting more demand response



# Future: electrical energy storage as an additional technical solution

1. Promising large-capacity EES technologies
2. Roles of EES in RE integration
  - ❖ Grid-side roles of EES
  - ❖ Generation-side roles of EES
  - ❖ Demand-side roles of EES
3. Technology needs of large-capacity EES applications



# Conclusions and recommendations

## 1. To policy-makers and regulators

- ❖ Coordinating all actors
- ❖ Single framework for connecting and controlling SP
- ❖ Regulations to enable integration

## 2. To utilities, industry and research

- ❖ Enhanced transmission as a precondition for SP
- ❖ Stochastic forecasting and foresighting
- ❖ Research for forecasting and complex modeling
- ❖ Research for cluster connection and control
- ❖ Research into EES
- ❖ Forecasting the demand side



# Main references

1. **Grid integration of large-capacity Renewable Energy sources and use of large-capacity Electrical Energy Storage, IEC, white paper.**
1. **REN 21: RENEWABLES 2016 GLOBAL STATUS REPOR**  
[http://www.ren21.net/wp-content/uploads/2016/06/GSR\\_2016\\_Full\\_Report.pdf](http://www.ren21.net/wp-content/uploads/2016/06/GSR_2016_Full_Report.pdf)
3. **Grid Integration of Solar Energy Workshop, U.S. Department of Energy.**



**Thanks a lot  
for your kind attention**

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