CERTIFIED EXECUTIVE TRAINING ON GREEN ECONOMY

WGEO EXECUTIVE TRAINING COURSE
ON SCALING UP TRANSITION TO
A GREEN ECONOMY ON A PATH TOWARDS
IMPLEMENTING THE UNITED NATIONS
2030 SUSTAINABLE DEVELOPMENT AGENDA

MODULE DELIVERED BY

INTERNATIONAL SOLAR ALLIANCE

# FOSTERING GREEN INNOVATION

## MODULE "FI"

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**COHORT ONE**
**11-12 June 2019**
**Bangkok, Thailand**

WORLD GREEN ECONOMY ORGANIZATION

Empowered lives. Resilient nations.

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**Paris Declaration:**

Launched at COP 21 as a India’s proposal for a common platform for cooperation among solar rich countries lying fully or partially between the Tropics of Cancer and Capricorn.

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# Vision & Mission

To provide a global platform for cooperation among solar resource rich to help achieve the common goals of increasing the use of solar energy in a safe, convenient, affordable, equitable and sustainable manner.

## Governance

- Assembly of the ISA; President-India; Co-President-France
- Eight Committees of the ISA:

i. Standing Committee
ii. Programmes; General and Legal; and Finance Committee
i. Four Regional Committee- Asia and Pacific; Latin America and the Caribbean; Africa; and Europe and others

- 6 Taskforces and 2 Working Groups
- Corporate Partners

## GOALS

- Lowering **cost of financing** while scaling-up volumes of financing
- Mobilize more than **USD 1000 billion** of investments by 2030
- Bringing **reliable and affordable solar energy** to all

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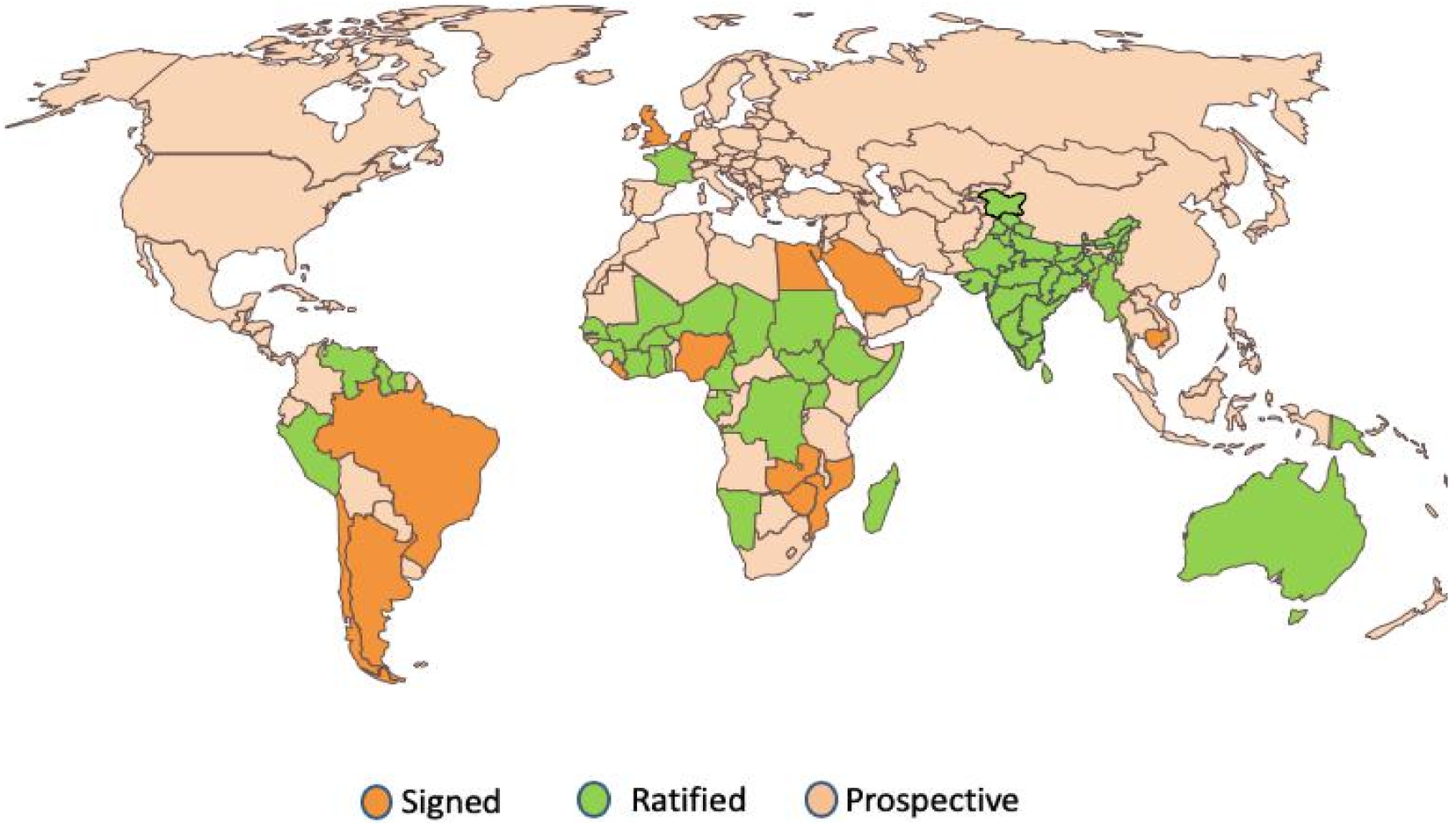
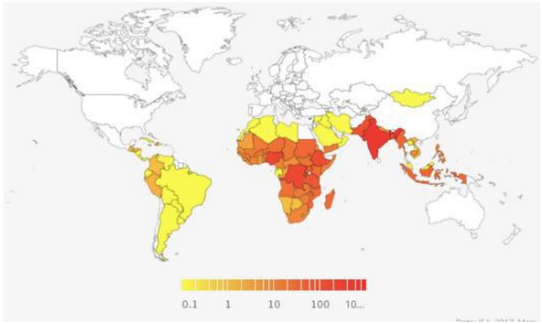
# Our Presence




**Population without Access to electricity**




**75** Signatory Countries
**54** Countries Ratified

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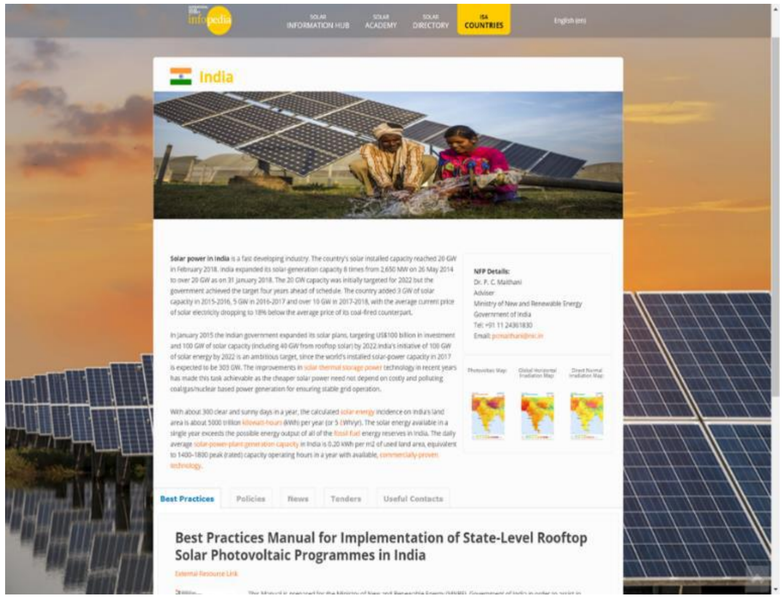
# Infopedia

An **online platform** dedicated to the dissemination of information, best-practices and knowledge on Solar Energy:

- To be completed by June 2019

- Launch in October 2019

- Supported by the **European Union**




**Country counters :** A dedicated space on the Online Platform for each Member Country to present the most complete solar energy profile

**Solar Information Hub ;** Aggregating solar projects in a central database for best practice sharing among Member countries

**Solar Academy:** A full-fledged Learning Management System allowing ISA and its partners to create and host courses on solar technology

**ISA Communication Tools :** Tools and methodologies to facilitate communication among Member countries

**Solar Directory:** An self-registration directory for the Solar Industry, NGOs, Research Centers and Financing institutions

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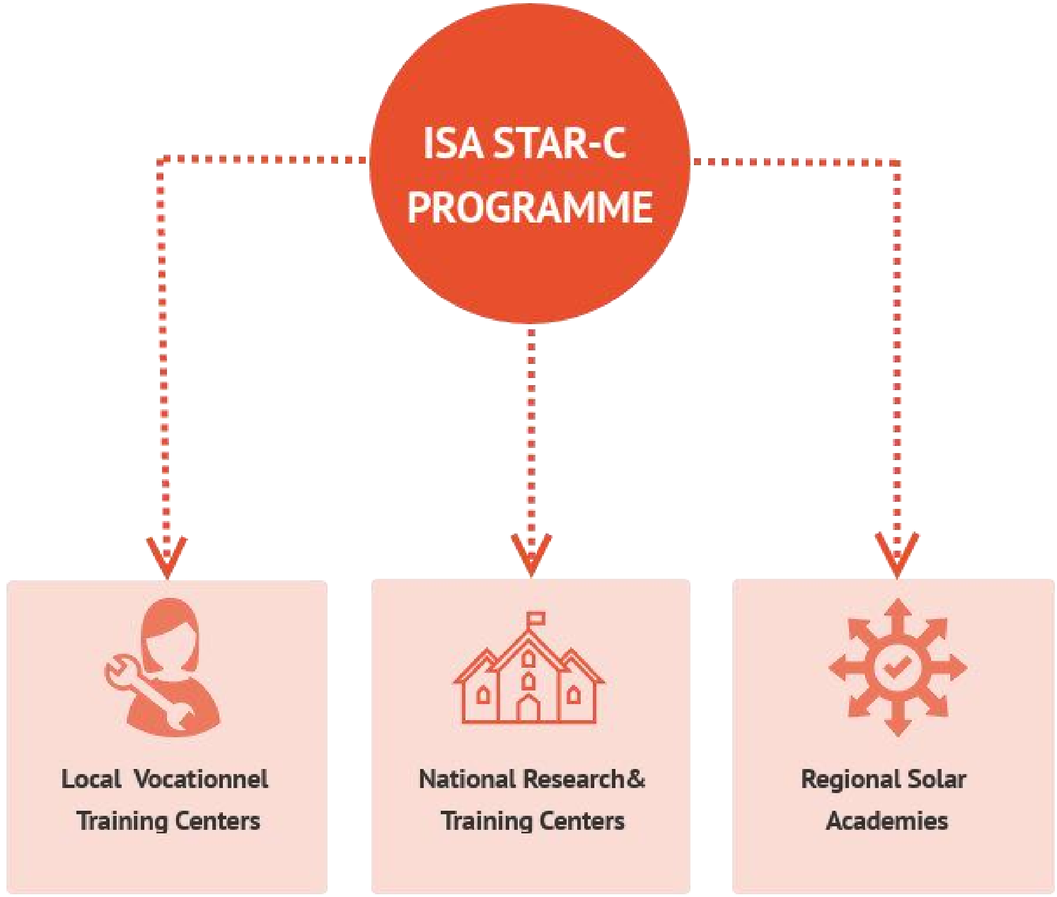
# Star C

**The goals of STAR-C include the following**:

- To build a network of training / R&D / standardization / Entrepreneurship STAR-centers working on solar energy
- To develop and disseminate training programs (online and in-personne) for all solar energy stakeholders (technicians, master trainers, project developers, engineers, policy makers, etc), via STAR-Centers & Regional Solar Academies (UNIDO centers for EE & RE)
- To provide testing and technical certification capabilities to key STAR-centers



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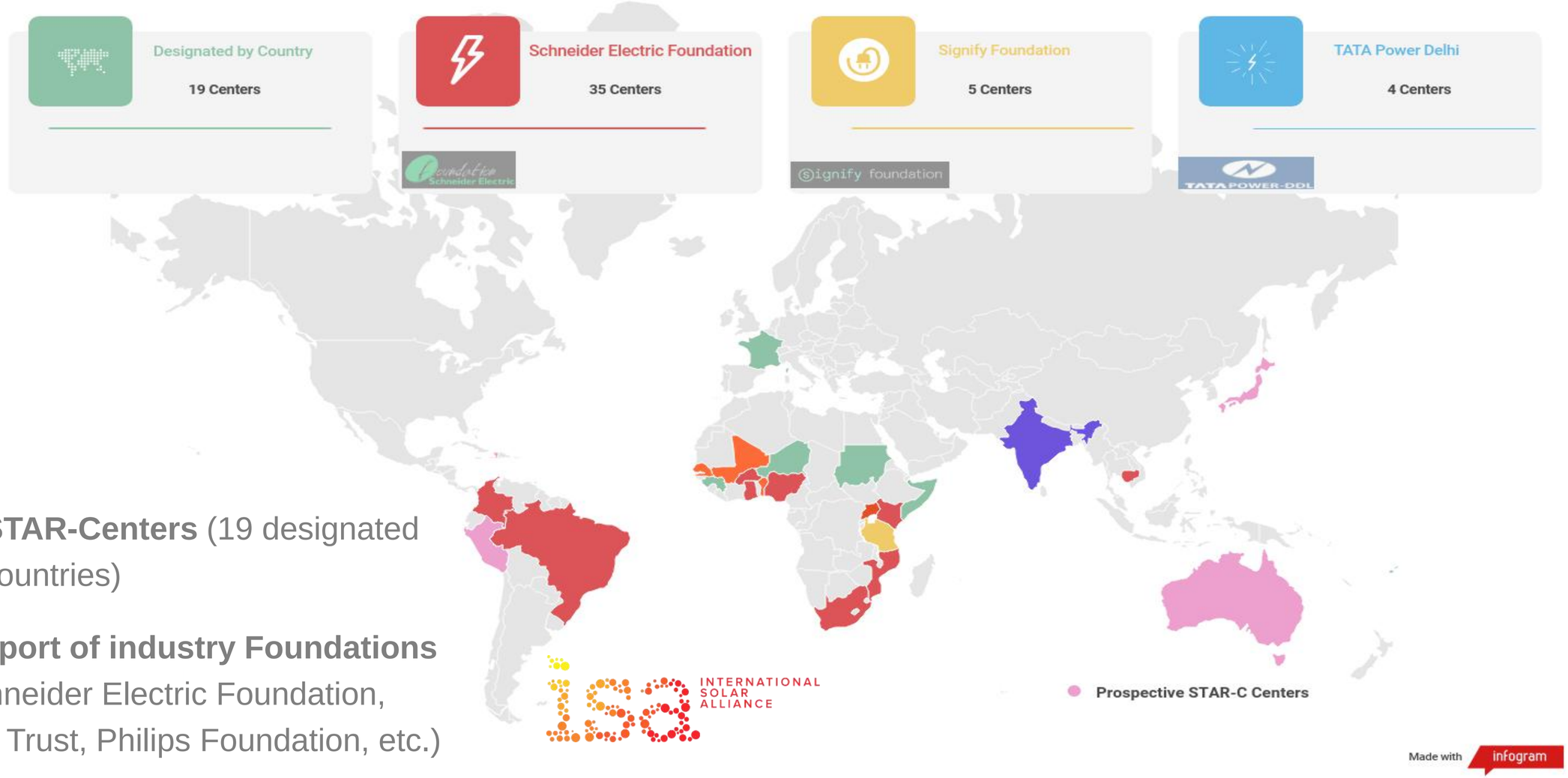
# Star-C network




- **65 STAR-Centers** (19 designated by countries)
- **Support of industry Foundations** (Schneider Electric Foundation, Tata Trust, Philips Foundation, etc.)

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# Setting the context of solar energy

Potential

Markets

Costs

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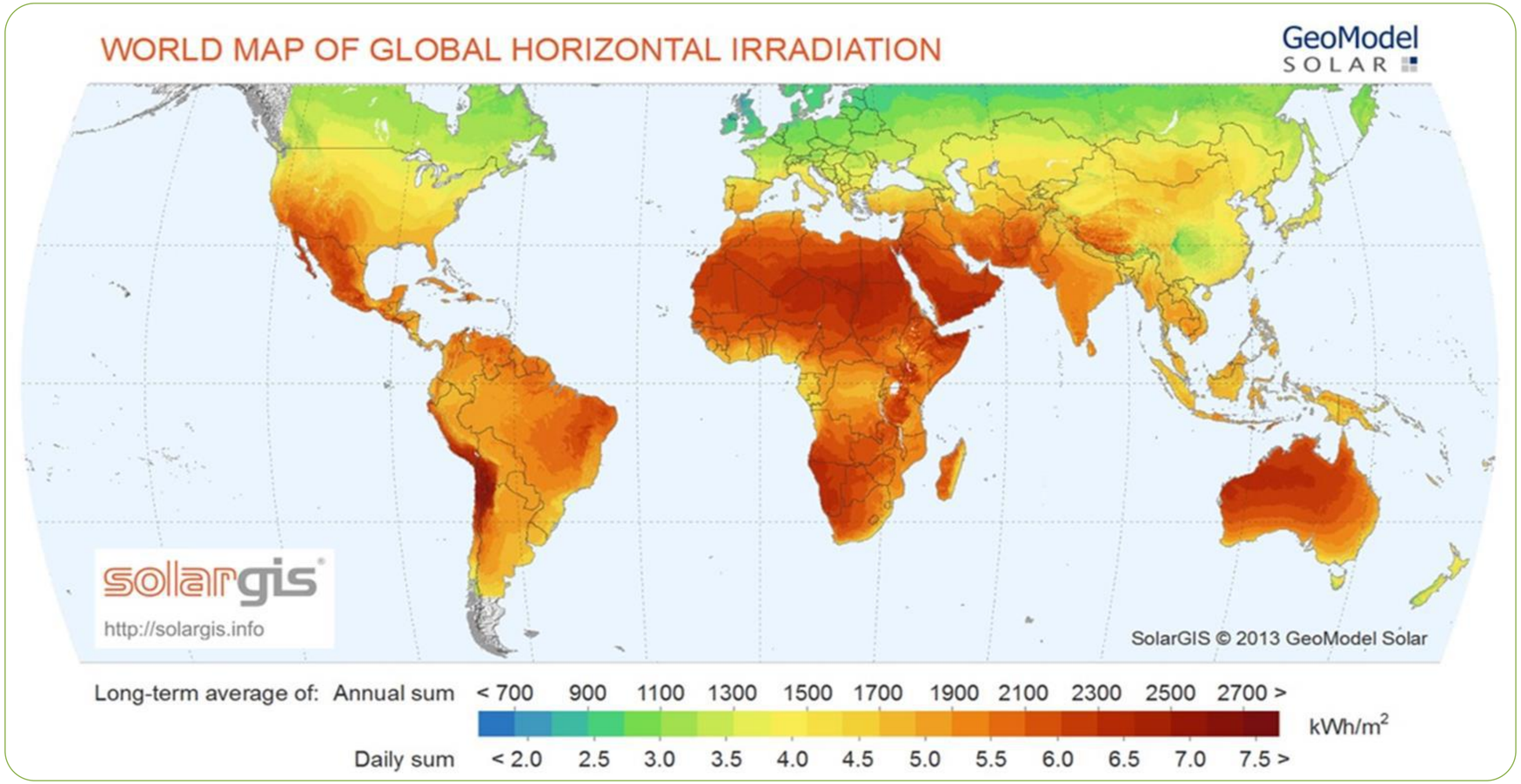
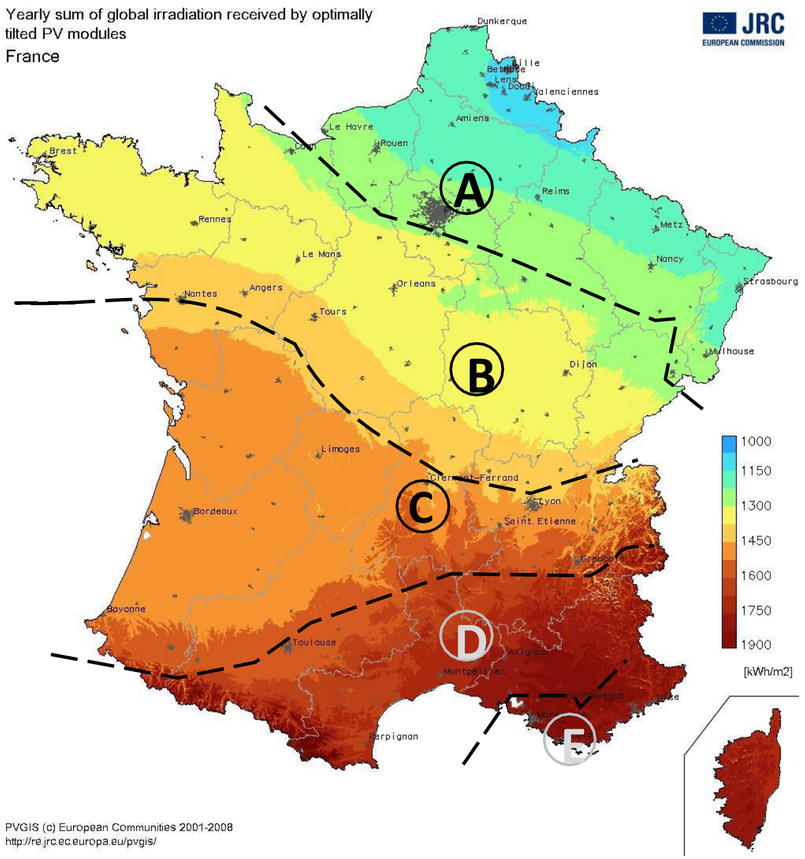
# Solar energy is available everywhere

A maximum ratio of 3 between « sun-rich » countries and « no-sun countries »



# The energy output is proportional to the irradiation

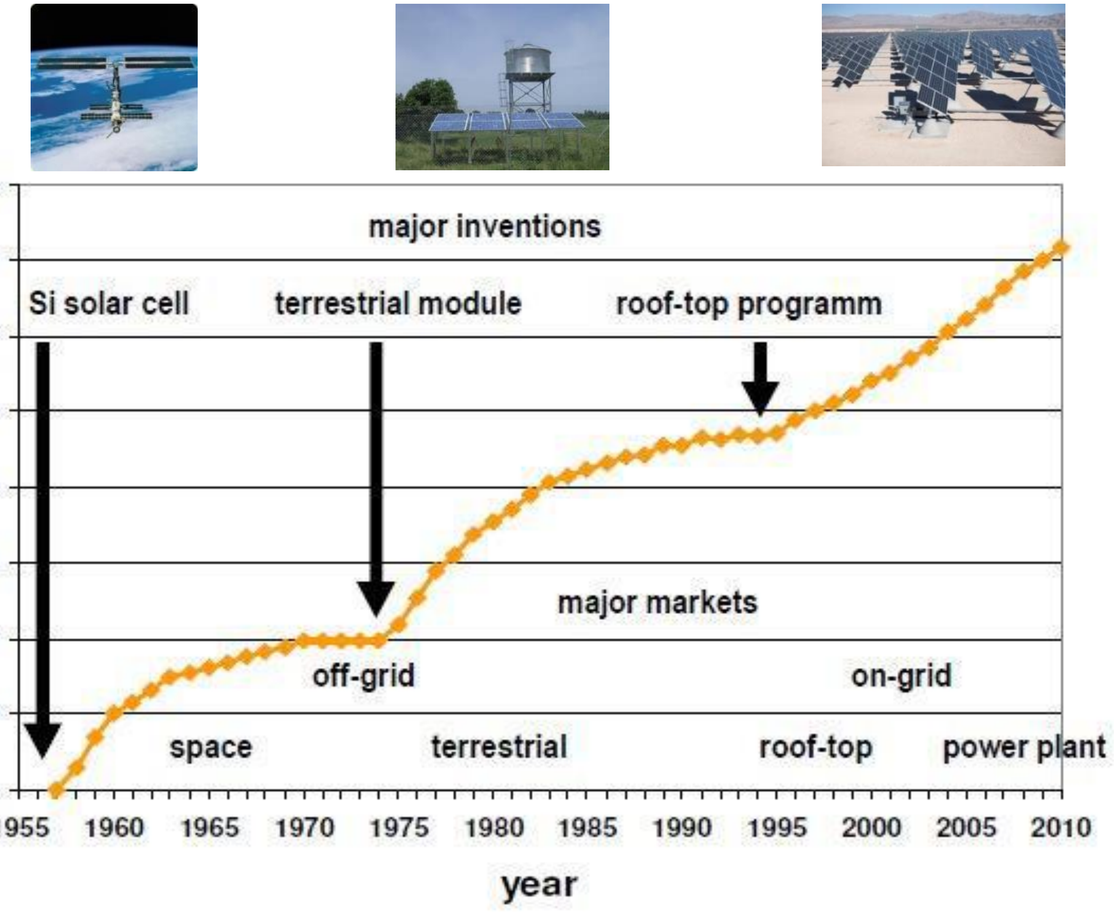



**Moyenne de l'ensoleillement annuel en France (orientation et inclinaison optimum) en kWh/m² par an**

## Production ? Irradiation

| [kWh/kWc]* | | [kWh/m²] | |
|---|---|---|---|
| 750 | | 1 000 | A |
| 900 | | 1 200 | B |
| 1 050 | | 1 400 | C |
| 1 125 | | 1 500 | D |
| 1 275 | | 1 700 | E |
| 1 425 | | 1 900 | |

# A gradual market penetration with various applications




(Source : http://www.q-cells.com/uploads/tx_abdownloads/files/11_GLOBAL_OVERVIEW_ON_GRID-PARITY_Paper.pdf)

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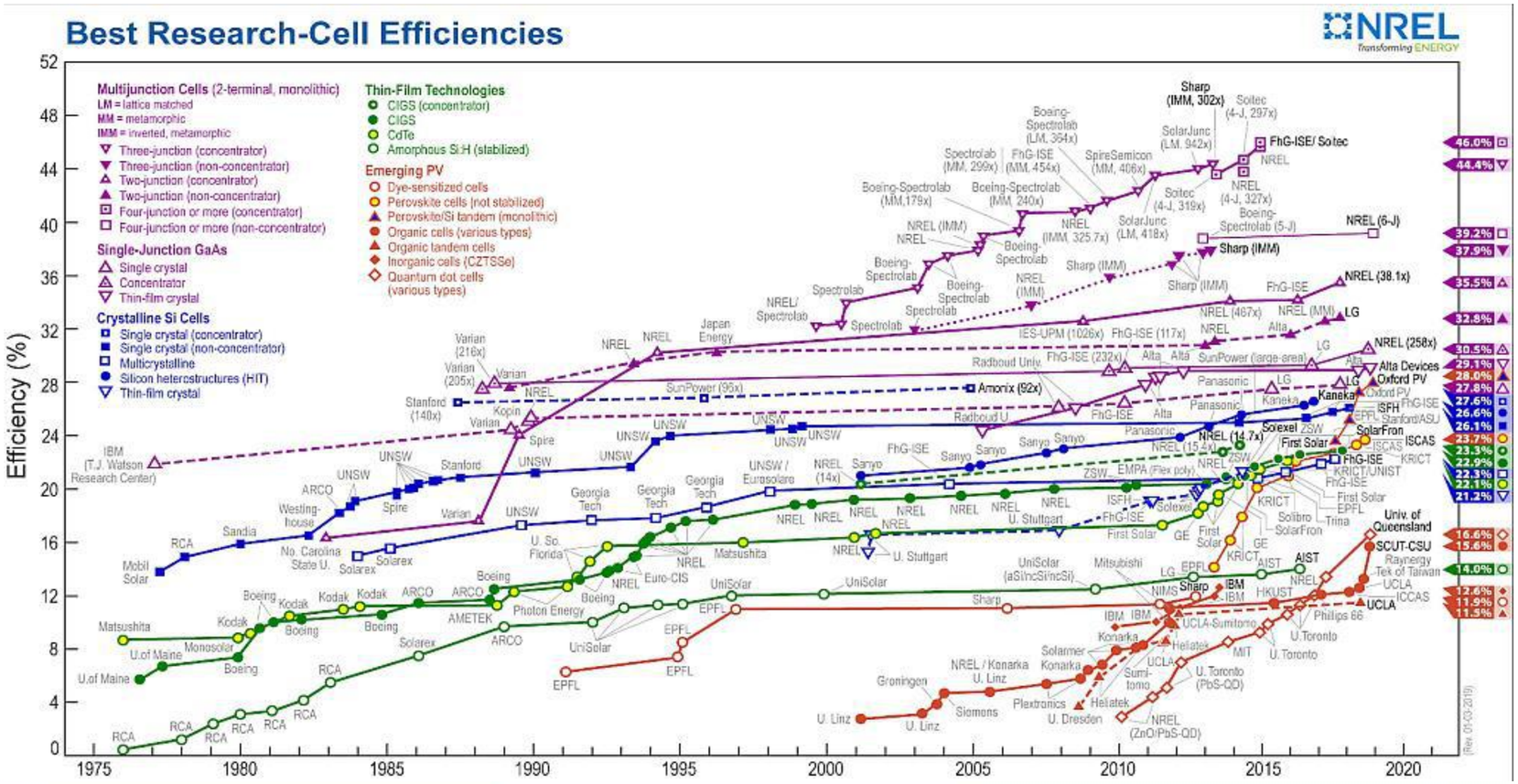
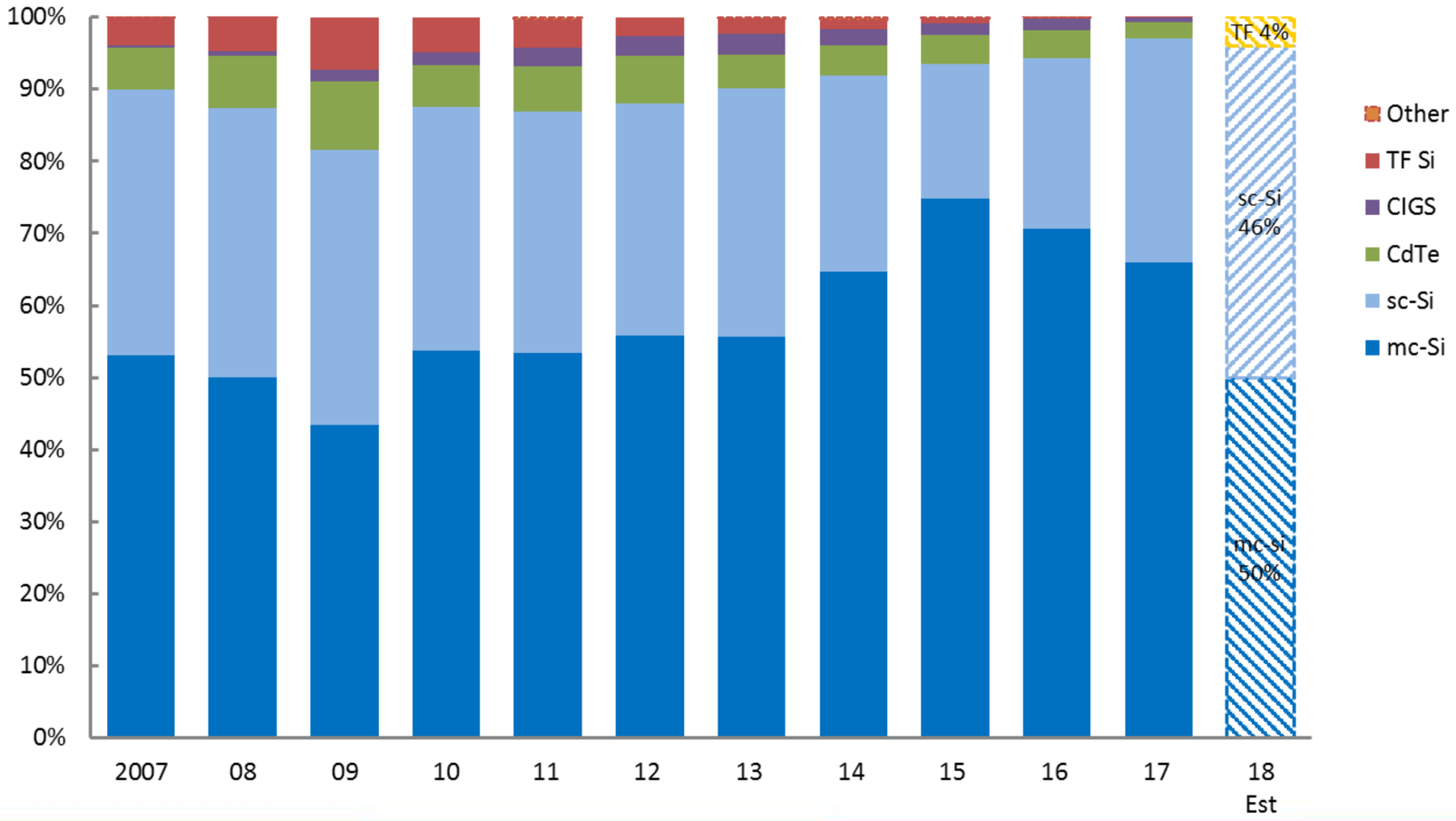
# A technology with many potential materials and designs, all under progress

Four decades of gradual efficiency improvement:



# PV module production by technology

From the market side, silicon technologies are dominating all others



# The silicon technology value chain

From silicon to modules and systems

| Silica | Purified Silicon | Ingot | Wafer | Cell | Module | Systems |
|---|---|---|---|---|---|---|
| | Various processes | Cast or Cz | Sawing | Surface treatment | Lamination | Mounting, wiring |

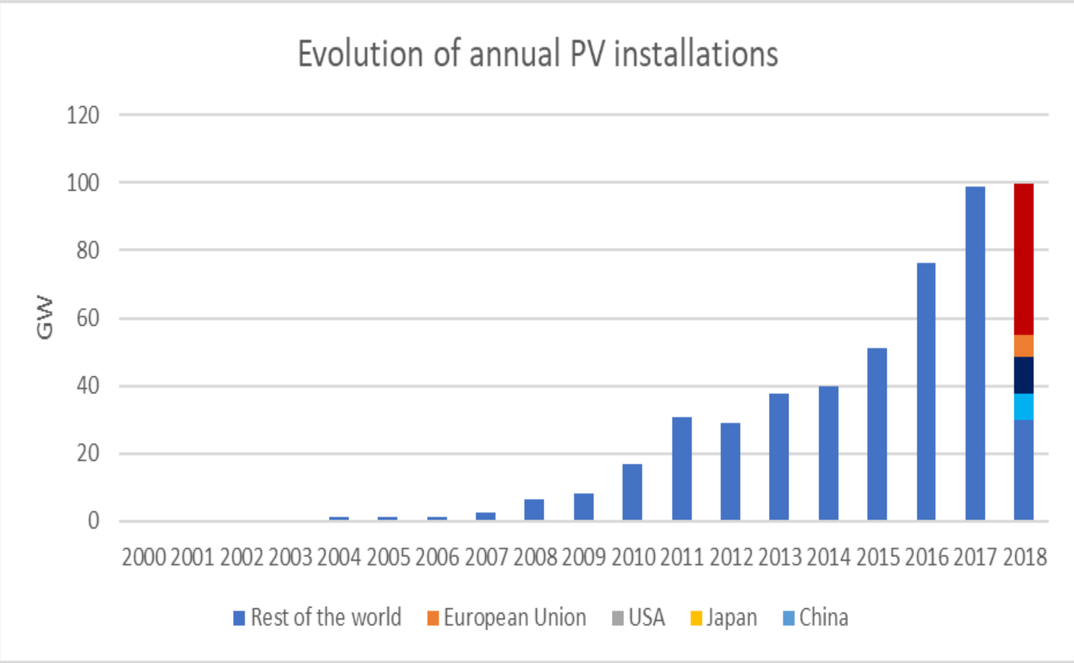
Silica is the second abundant material on earth, (28%) after oxygen (47%).
Around 900 000 tons of silicon are used by industry.

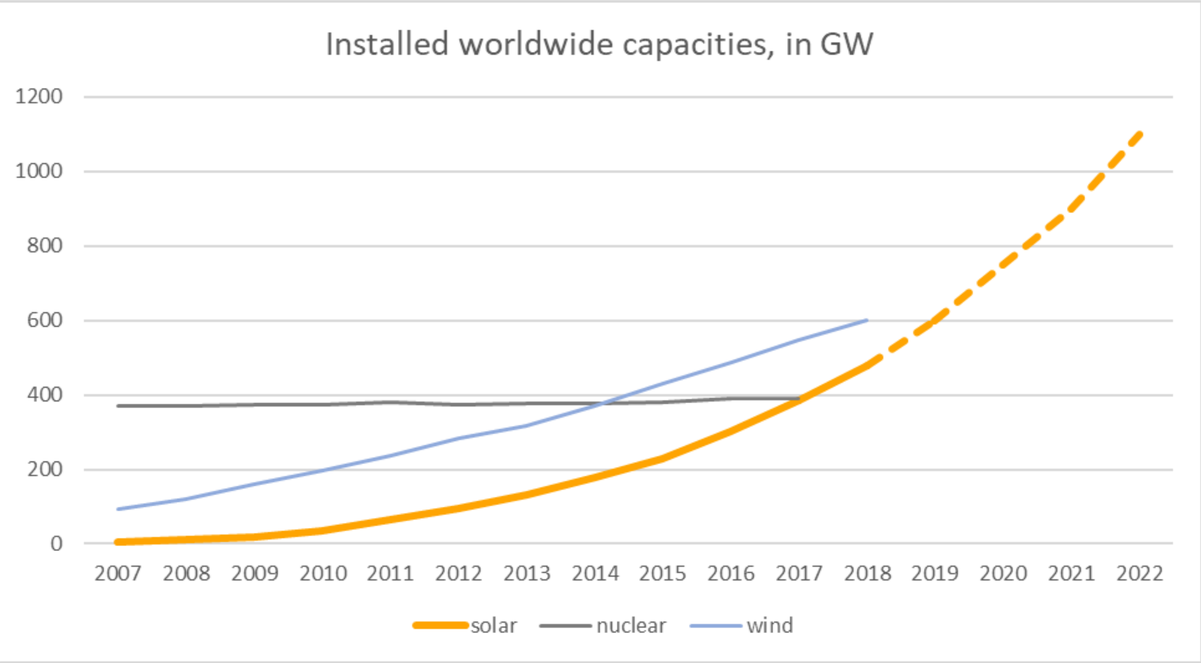
# Worldwide market

The largest growth among renewable, with an annual market of 100 GW

On the way to 1 TW installed capacity within 3 to 4 years

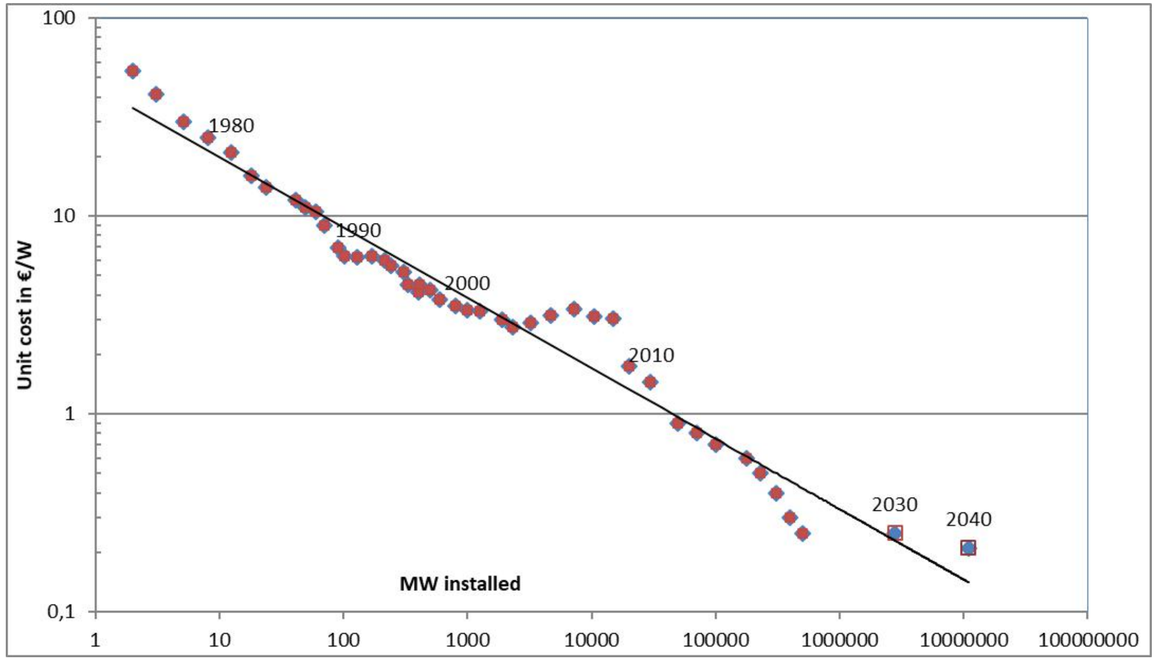
A potential of 30 to 60 TW



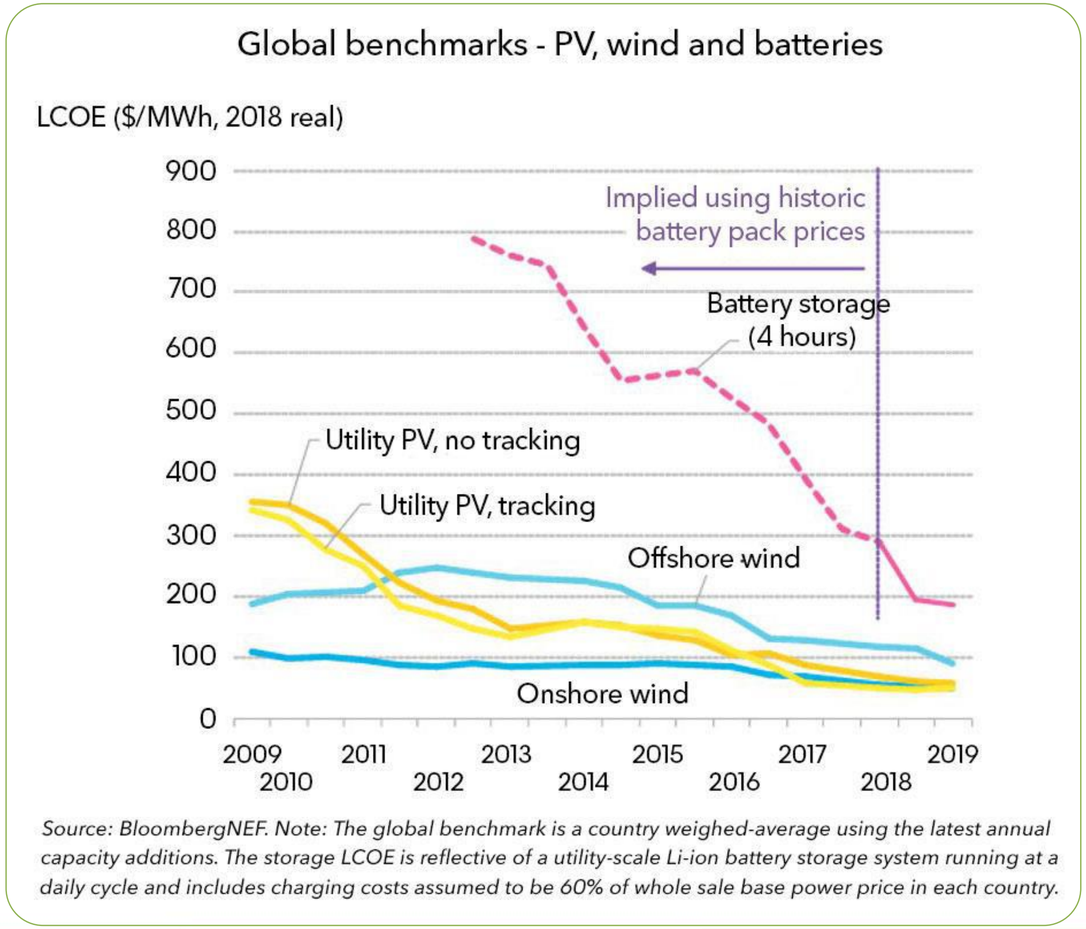



# Costs of PV modules and PV power : an impressive decreasing trend

The PV module learning curve




Levelized Cost of Electricity (LCOE)




**The LCOE is now the cheapest one :**

- 2c/kWh in sun-rich countries (Chile, UAE, etc.)
- Up to 5c/kWh in other countries (Germany)

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# 2. Technical Review Overview of Solar Applications

**Solar Applications**

**1. Utility Scale Solar PV**

- Solar Farms
- Large solar projects
- Floating solar

**2. Distribution level Grid Connected**

- Solar Rooftop
- Canal top solar

**3. Decentralized Applications**

- Village electrification
- Solar Lighting
- Solar pumps

**4. Heat Applications**

- Solar water heaters
- Solar cookers
- Process heat applications








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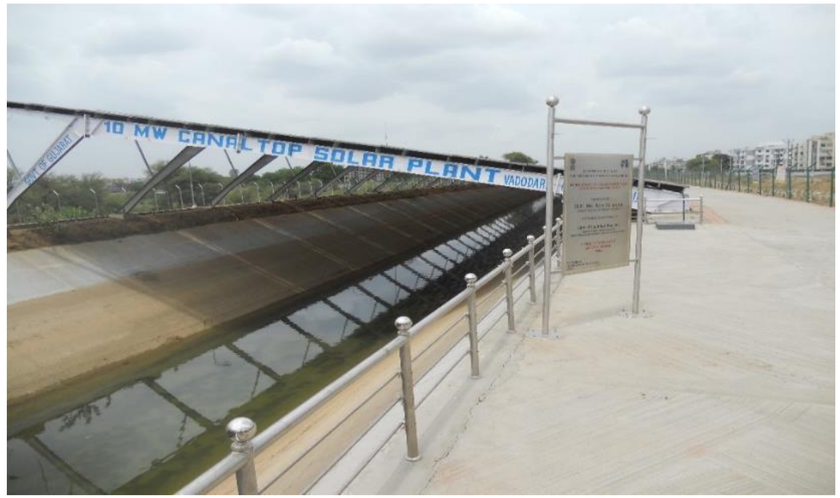
# Canal Top and Canal Bank Solar Power Projects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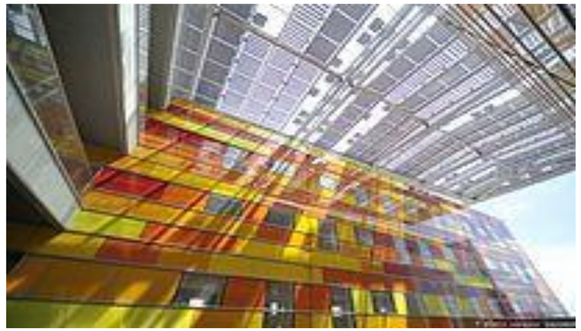
# Future Applications



Distributed PV share will gradually increase

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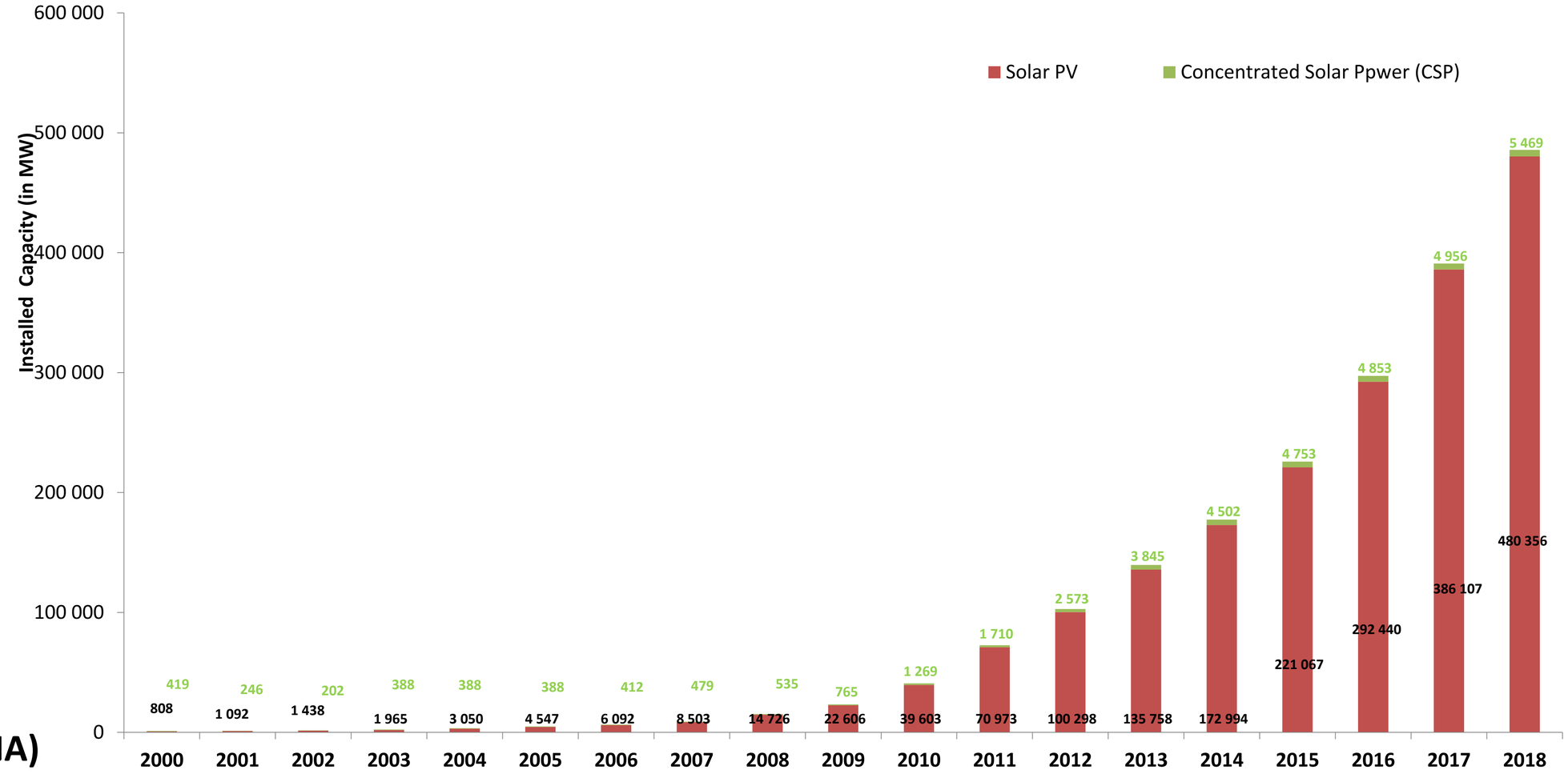
# Solar Growth Trajectory




(Ref.: IRENA)

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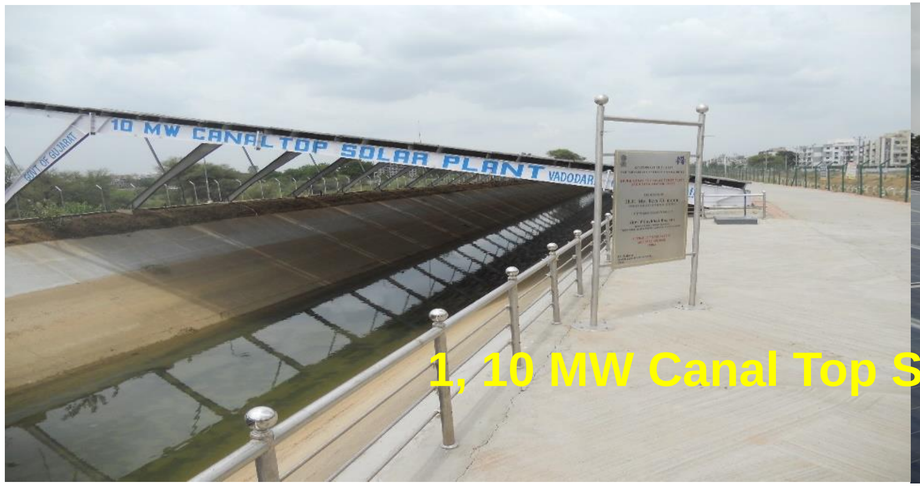
# Solar Growth Trajectory


1 MW Canal Top SPV Power Project in Karnataka




1, 10 MW Canal Top SPV Power Project in Gujarat

Solar Energy Corporation of India

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# 648 MW Solar PV Power Plant in Tamil Nadu, India

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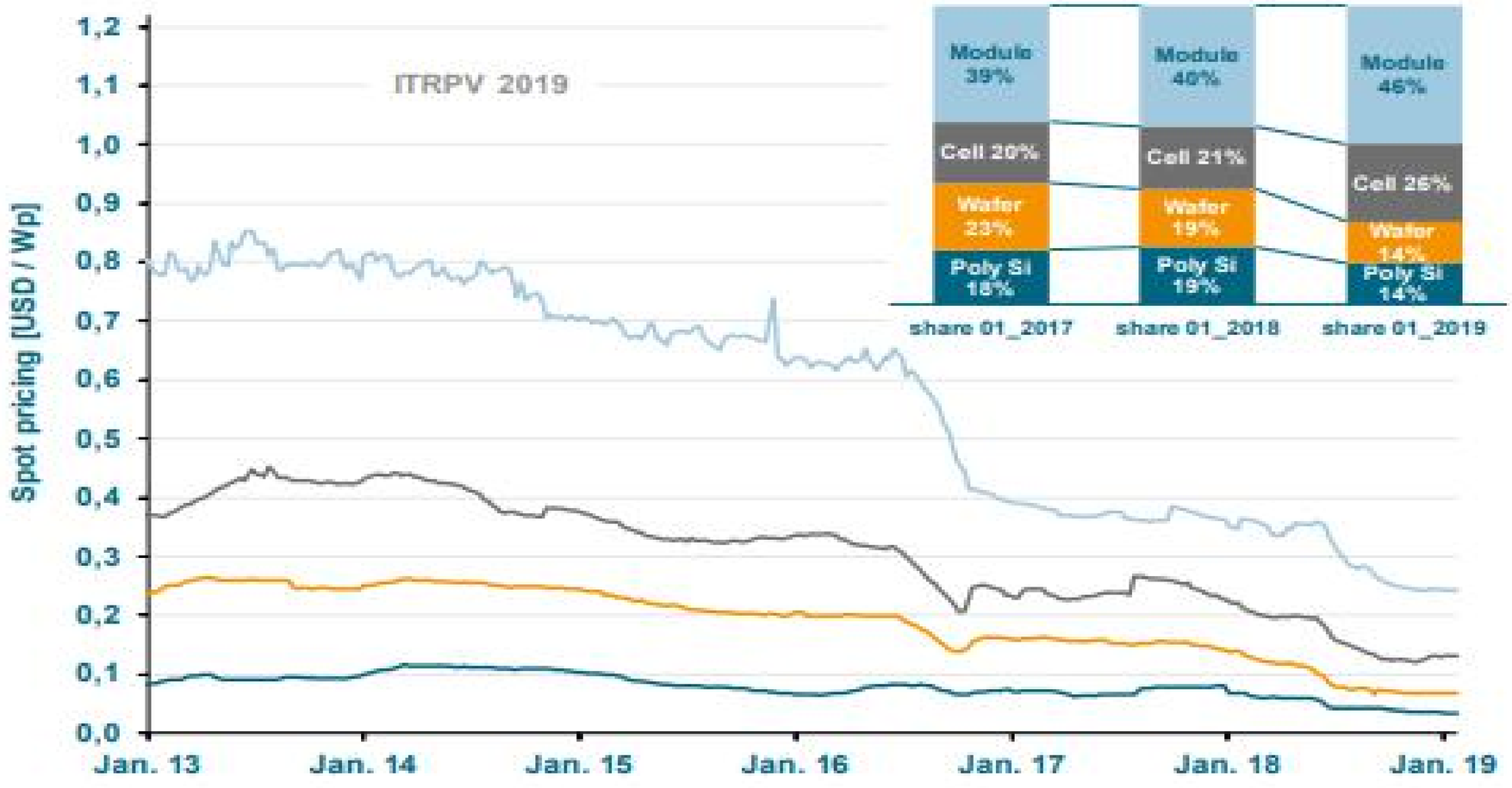
# Price Trends for c-Si Modules




Avg. Price (US$/Wp)

- 0.35 at 2017 end
- 0.24 at 2018 end

**(Ref.: ITRPV 2019)**

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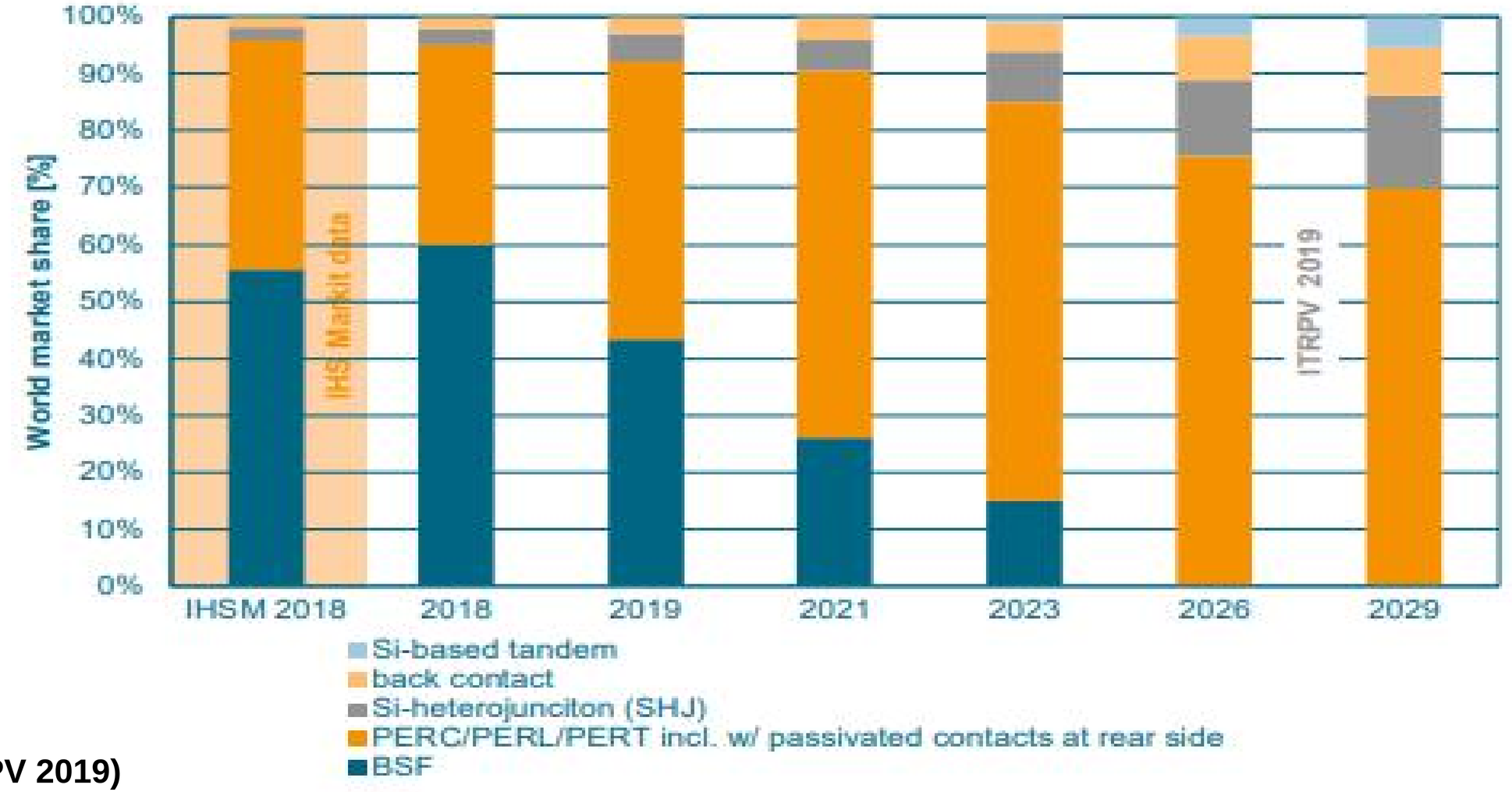
# Technology Trends (Solar Cell)

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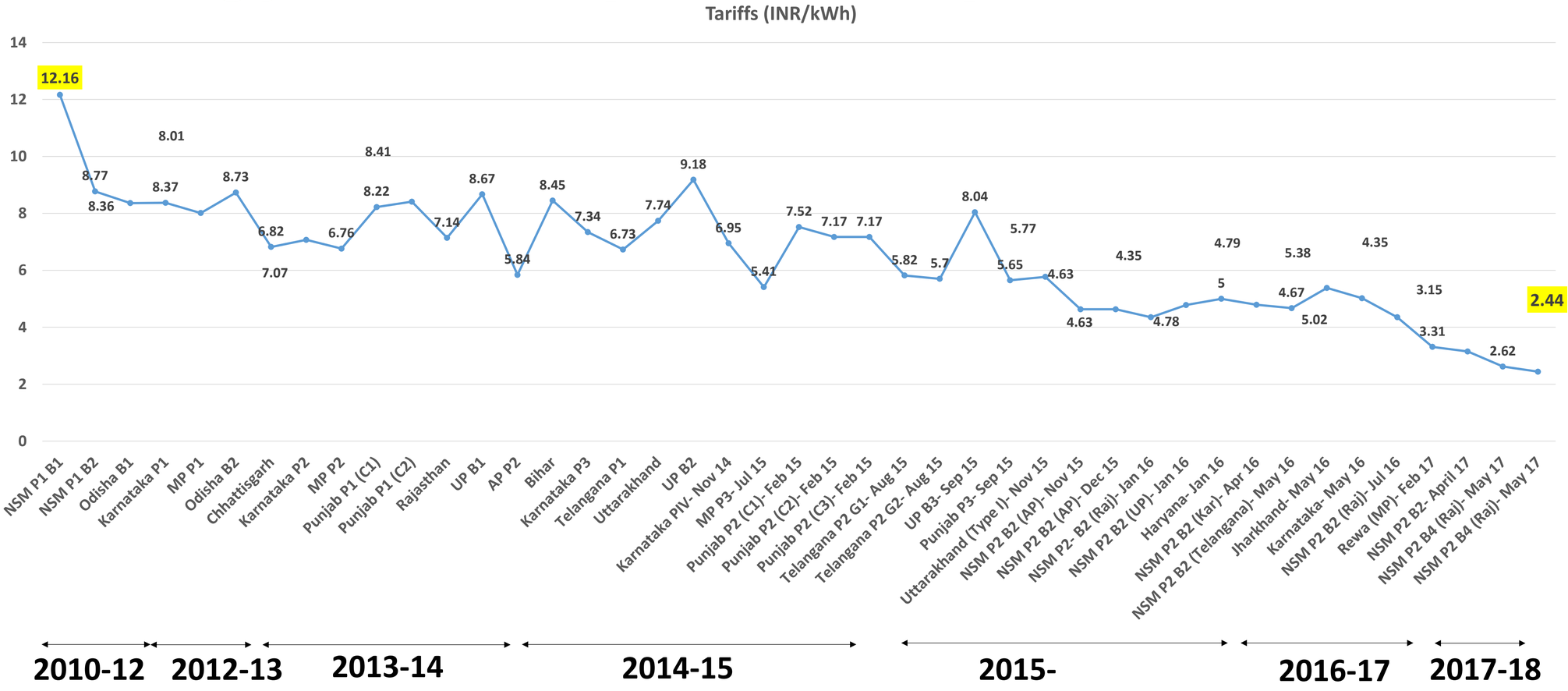
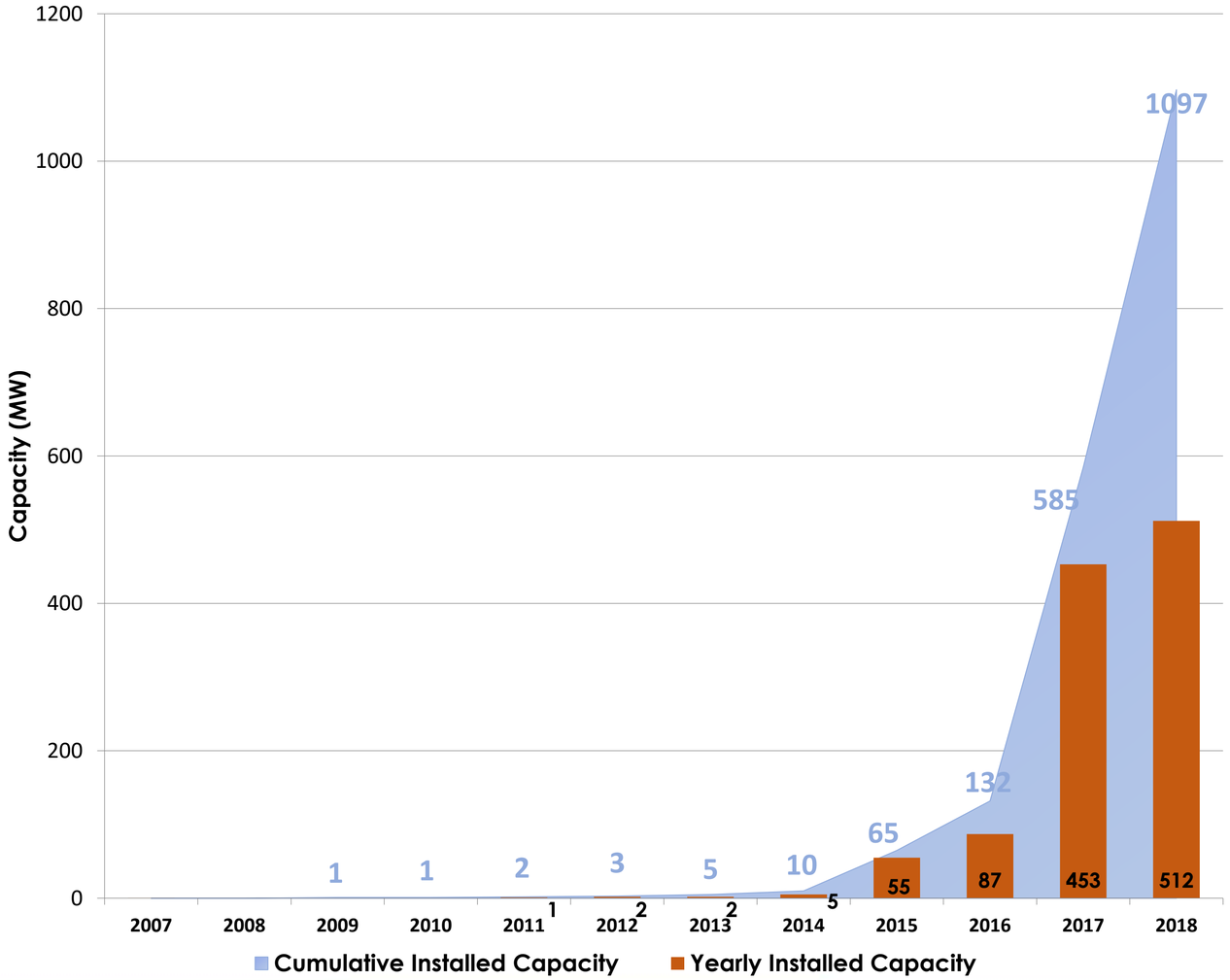


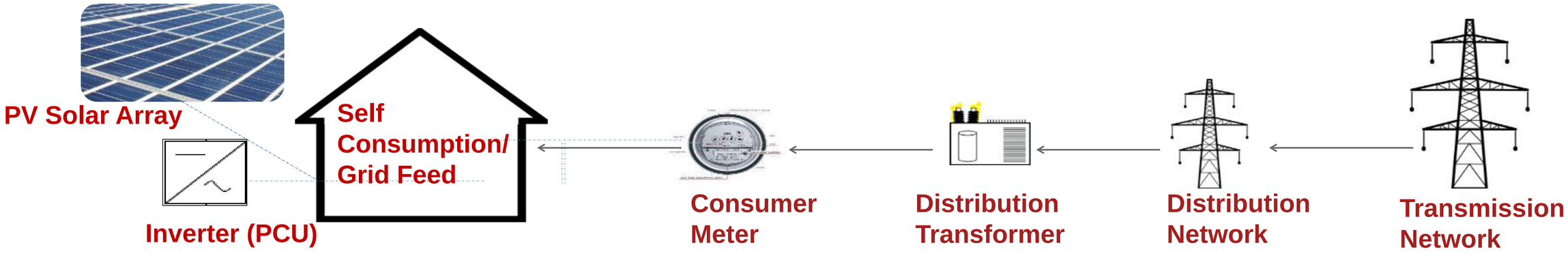

INR 12.16 = US$ 0.174
INR 2.44 = US$ 0.035
1 US$ = INR 69.67

# Floating Solar PV




***World's largest 150 MW plant in China***

# Rooftop PV  Arrangement




- Rooftop PV is an arrangement to utilize the vacant roof space to generate electricity.
- The electricity generated can be utilized for ***self-consumption and/or grid feeding***.
- Different types of inverters/PCUs are used for this purpose viz. Off-grid, Grid-tied and Hybrid.

**Required Policy Framework**

- Connectivity Norms
- Metering Policy
- Solar Tariff Policy

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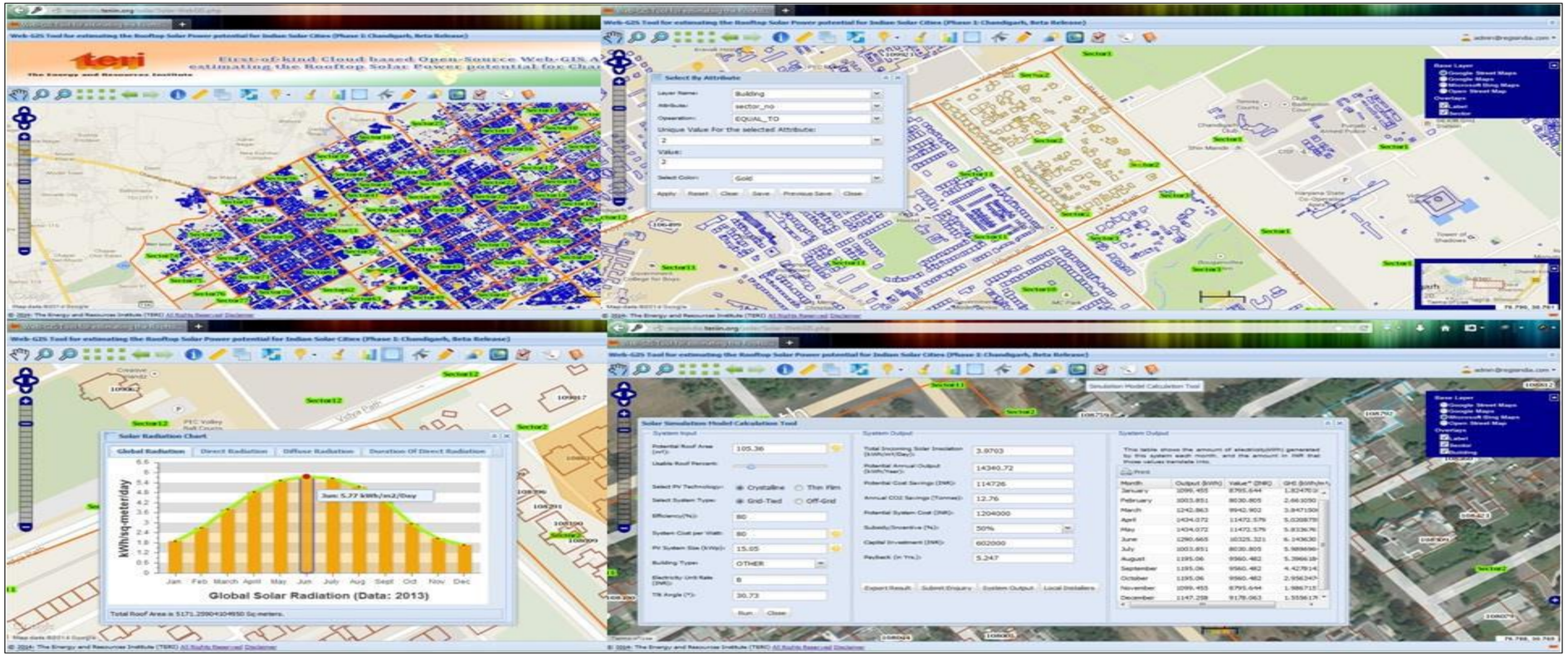
# Rooftop Solar Web-GIS Tool for Chandigarh

Survey Time – 15 days, Buildings evaluated physically – 14000, Buildings evaluated digitally – 110,000



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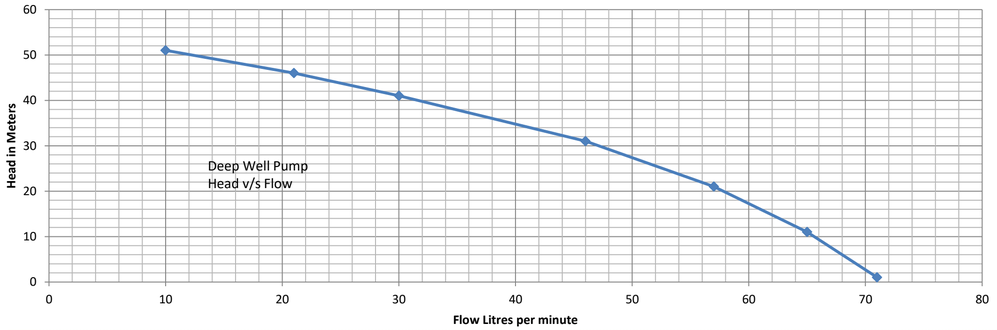
# 400 kWp Plant : Chinnasawamy Stadium, Bangaluru


PV Modules On PF-2 (Middle)
Katra Railway Station

# Off-Grid Applications: Solar Pump

**For Irrigation and Drinking Water applications**

- Major components: PV module array of capacity ranging from 200 Wp to about 10 kWp, a DC/AC surface mounted/floating motor pump set/submersible pump set, electronics and an ‘on-off’ switch.
- Surface pumps (both AC & DC) are used with canals, open wells, lakes, other shallow sources (up to 15 m depth)
- Submersible pumps (both AC & DC) with number of stages can be used to lift the water from the ground, from the depths up to 150 meters or more.



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# Containerized Solar Solution


## Uses:

Doctor’s clinic • Health screening by para medics • Cold storage of milk, vegetables and fish before collection • Vaccination centre • Centre for disaster management • Water purification systems

## Specifications:

- Solar Panels: 4 – 8 kWp
- Inverter Rating: 6 – 12 kVA Hybrid
- Battery: Tubular gel, 3 – 4 hr at 60% Load
- Standard  20’ marine container, 6 m x 2.45 m
- Free Area= 8 sq. m.
- Walls/Roof: Insulated with PUF

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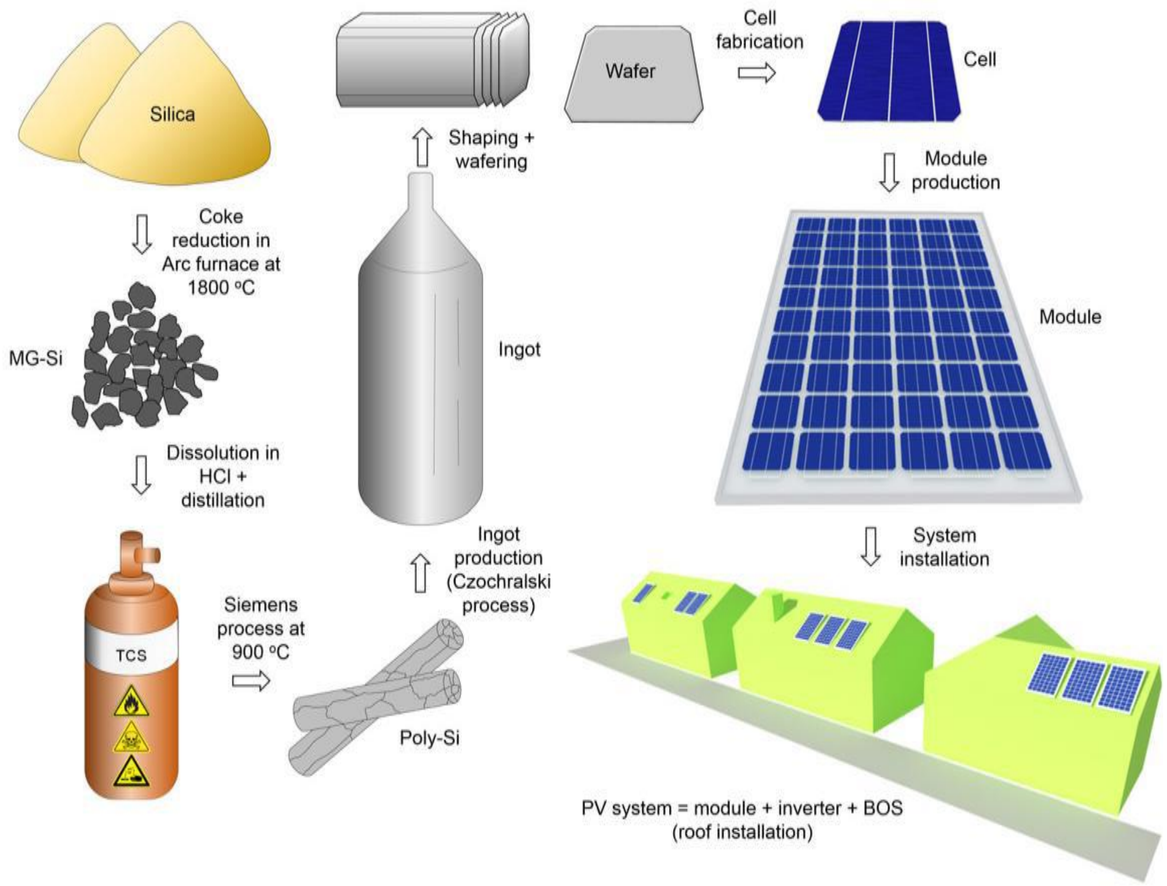
# Overall Eco-system Requirement

- Manufacturing facilities for solar
- Manufacturing of silicon ingots, wafers and cells at competitive prices is a challenge
- Availability of balance of system (inverters, cables, structures)
- System designers and EPC Contractors
- Installers
- Capacity building



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# Testing and Quality Assurance

Laboratory infrastructure is required for certification testing. International Standards for testing protocol are

**PV modules**

- Crystalline Silicon Terrestrial PV Modules **(IEC 61215)**
- Thin Film Terrestrial PV Modules **(IEC 61646)**
- Salt Mist Corrosion Testing of Photovoltaic (PV) Modules **(IEC 61701)**
- Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating **(IEC 61853 Part 1)**

**Inverters**

- Safety of power converters for use in photovoltaic power systems Safety compliance (Protection degree IP 65 for outdoor mounting, IP 54 for indoor mounting) (IEC 62109-1, IEC 62109-2)
- Photovoltaic Systems – Power conditioners: Procedure for Measuring Efficiency (10%, 25%, 50%, 75% & 90-100% Loading Conditions) (IEC)

**Cables**

- General test and measuring method for PVC (Polyvinyl chloride) insulated cables (for working voltages up to and including 1100 V, and UV resistant for outdoor installation) (IEC 60227, IEC 60502)

# 3. Policy Innovation

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# Energy Transition Pathways: Technological Disruption

- Stagnation in coal based power capacity additions is observed.
- Renewable energy (solar and wind) is on logarithmic growth trend in view of falling tariffs
- PLF of coal based plants is falling due to policy/regulatory measures.
- Technological solutions are being worked out for their flexible operations and minimum impact on conversion efficiencies at reduced loads.
- Dispatchability of RE power is a challenge.

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# Energy Transition Pathways: Economic and Social Factors

## Economic Factors

- Substantial reduction in tariffs requires funds at reduced costs to make projects financially viable.
- Development of market based risk mitigation mechanisms including dynamic evolution of power purchase agreements is required.
- Reduced power requirement from private sector coal plants has made them unable to service debt purely on the basis of fixed component of tariff. Some of these projects could become NPAs.

## Social Factors

- Coal linkages has substantial growth of employment. Restricted growth in coal mining has job creation implications
- Arguing that RE sector also has substantial potential for employment generation, skill development/ capacity building activities assume further importance.

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# Energy Transition Pathways: Opportunities

- **Continued reduction in electricity tariffs** from solar energy (through technology innovations and risk mitigation strategies) on sustainable basis would further scale up capacity additions.

- **Setting up Solar power plants in rural areas** has multiple merits in *strengthening voltage at tail-end grid* and also to *reduce T&D losses* and *grid failures* due to long evacuation and transmission lines.

- **Developing sustainable business models** (may be involving DISCOMs) for roof top solar systems and micro-/mini-grid systems can *enhance reliability of electricity* supply for poorly served households.

- **Capacity building** of Stakeholders in simulation and analysis of grids, smart technologies for grid management, and Regulators for appropriate regulatory provisions.

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# Policy Prescription for Promoting Solar

| | |
|---|---|
| **Feed-in tariffs** | Solar power is procured at feed-in tariff. |
| **RPO and REC** | Mandatory RPO targets to create demand. Provision of REC for resource poor entities for compliance. |
| **GBI** | Solar Power developers get a fixed sum per unit energy generated in addition to tariff. |
| **Tax Benefits** | Accelerated Depreciation, Tax holidays, etc. |
| **Concessional Import duties** | Concessional duty on import of solar power equipment |
| **Subsidies and VGF** | Capital grants from the govt. to make solar projects viable |
| **Waiver on evacuation charges** | Exemption from Open Access charges, Wheeling & Banking charges, UI charges etc. |
| **Assured offtake** | Solar plant is provided must-run status and exempted from the merit order dispatch. |

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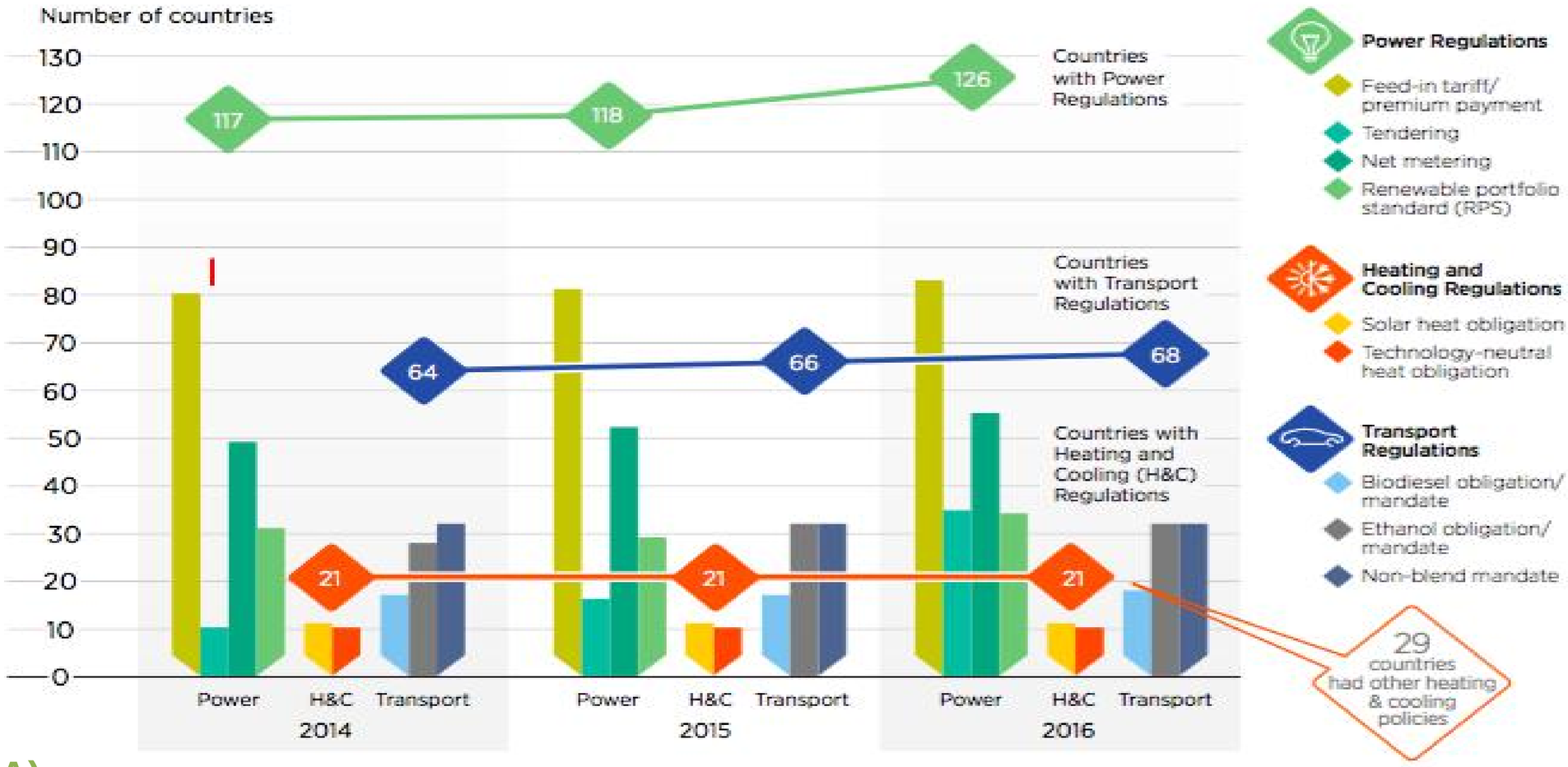
# Policy Status – Global




(Ref.: IRENA)

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# Policy Example: Indian National Solar Mission

- Selection of projects through Competitive Bidding
- **Solar Park scheme by Government of India**
- **Promotion of off-take of solar power**
  - *8% of electricity consumption excluding hydro power, mandated from solar energy by March 2022. (**Solar RPO**)*
  - ***Renewable Generation Obligation (RGO):** New coal/lignite based thermal plants after specified date to also establish/ procure/ purchase renewable capacity*
- Policy on the concept of ***"Polluter should pay";*** levied cess on each tonne of coal purchased by generating companies to create ***National Clean Energy Fund*** .
- **Regulatory Provisions**
  - *Exemption from the requirement of environmental clearance*
  - *Must-run status in merit order dispatch of power*
  - *Exemption for wheeling charges on Central Transmission Utility*
- **Payment security mechanism**
- **Development of Standard Bidding Guidelines**

# Solar Parks: Concept and Approach

- Solar Parks aim to achieve solar targets through
  - providing well characterized and properly infra-structured land provided with transmission and evacuation facilities, and
  - thereby ***minimizing the risk as well as the permitting process***.
- SOLAR PARKS are established jointly by Central and State governments.
- Land area by the State Governments and support to setting up infrastructure by the Central Government (***up to 30% of the project cost subject to INR 20 lakhs/MW***).
- Solar Park may hold several solar power plants each developed by separate or the same groups/promoters.
- Filling up of Parks through solar projects under Government's schemes; generated power could be procured by any of the States. Host State to buy at least 20% of the capacity of solar park.

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# 4. Organisational Innovation

- Project Management
- Capacity Building
- Quality Assurance
- Technology Transfer
- Socio-economic Impacts

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# Project Management

Long-term objectives at the country level are necessary :

- To help in the alignment of all stakeholders within implementation programmes
- To make each project implementation easier

The project management should cover all the steps from the need survey to the long-term operation of the various systems, including recycleability and sustainability aspects


The goal of the procurement phase may be :

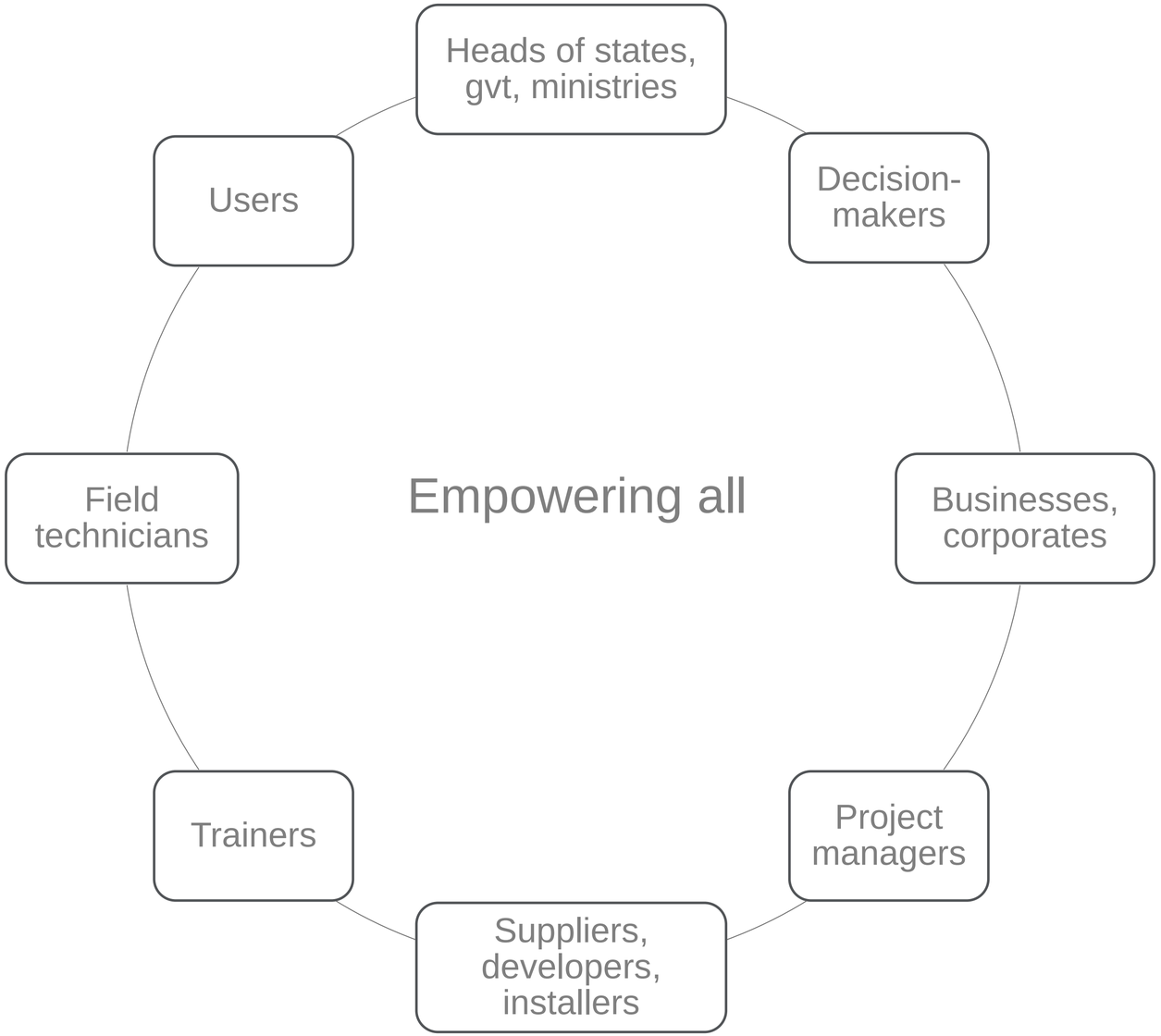
to provide equipment and systems,

service-oriented over a long period to ensure customer satisfaction

# Capacity Building

Of all stakeholders, in a coherent manner, in order to increase :

- The number of programmes and projects,
- The local content,
- The overall quality, therefore the end-user satisfaction

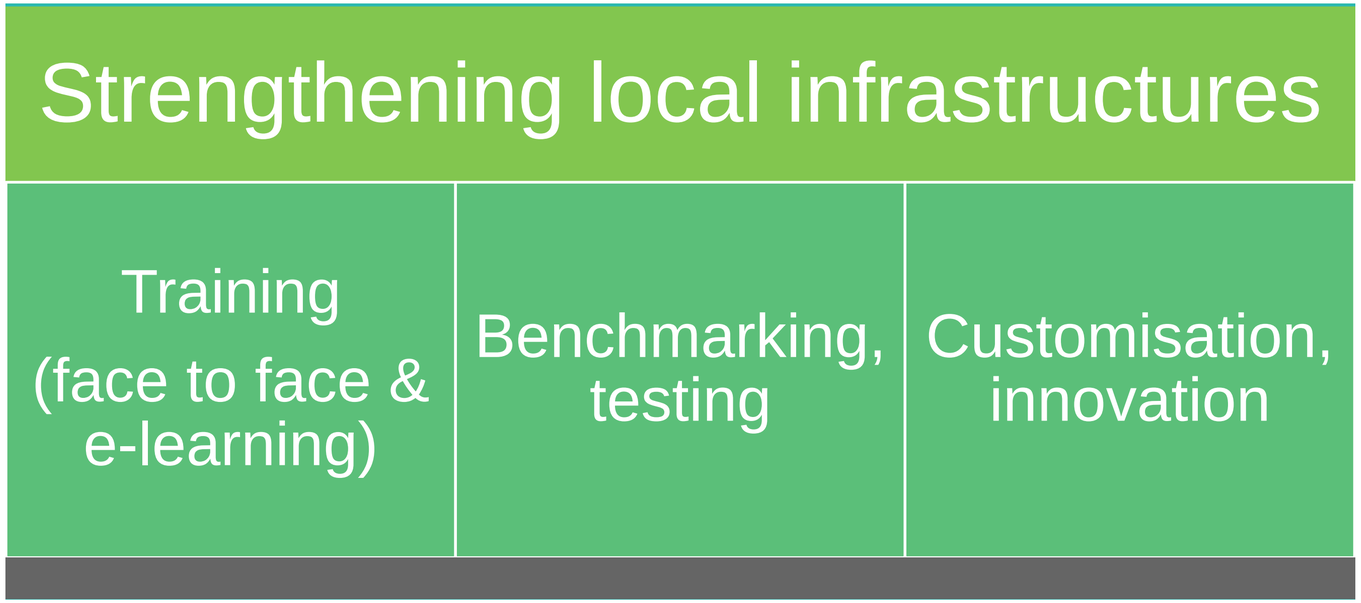


# Capacity Building

The ISA' STAR C programme is designed to address all of these activities

Bundling these activities on a regional level could speed up the learning process :

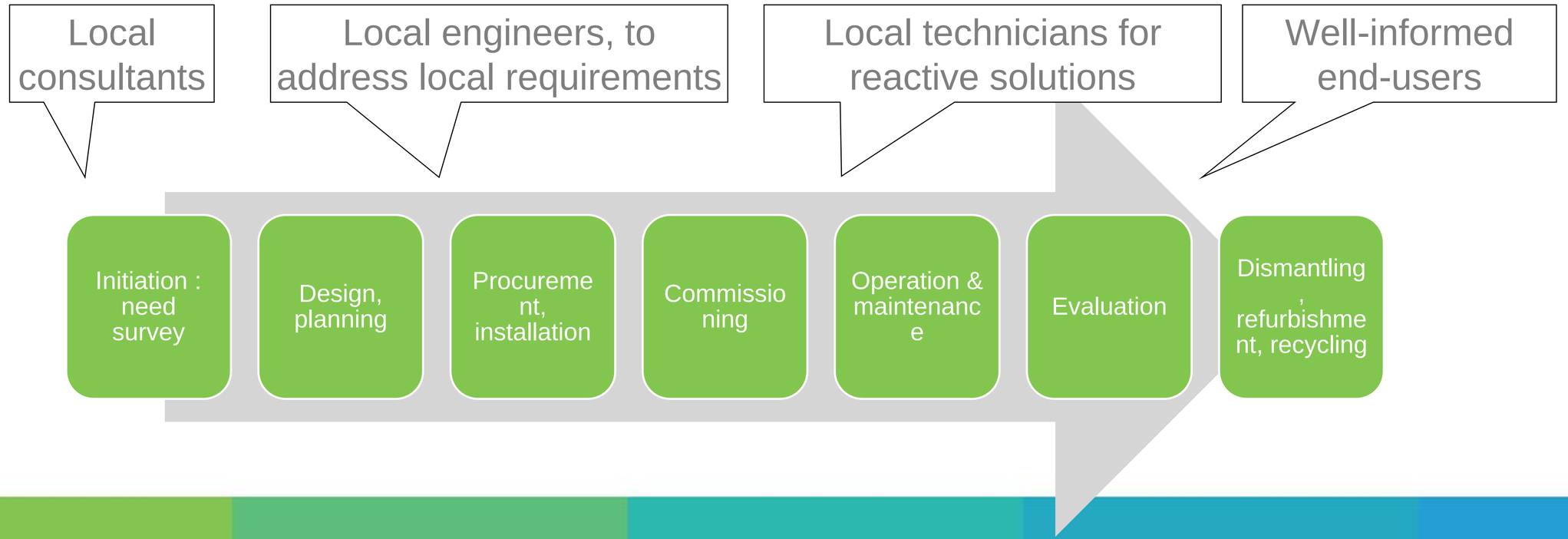
- Exchange of practices
- Reuse of existing training material



# Quality assurance

Quality is of utmost importance in order to avoid user dissatisfaction, poor image and increased overall costs (Buy « cheap stuff », buy twice).

It should be ensured at all stages of project implementation, with skilled project managers, acting with well-trained stakeholders :



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# Technology transfer, local content

**Specific criteria and compliance to some standards in calls for tenders may help to address specific issues :**

- Need for high efficiency modules
- Non use of toxic materials, minimisation of the CO2 content, recycling, etc.
- Durability under specific climate conditions

**Local content requirements may also be added :**

- Training / employment of local workforce
- Use of local materials (foundations, supporting structures, wiring, etc.)

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# Socio-economic impacts, in general

1. For all end-users, reduction of the electricity cost, for an improved purchase power

2. At the country level :

- **Reduction of the balance of payment deficit, when fossil fuels are imported**
- **Job creation :**

i. Cell and module manufacturing (when available)

ii. Related to local content activities : supporting structures, wiring, module customisation, etc.

- **Installation and maintenance**
- **On the long-term, access to the cheapest power supply to energy-intensive industries**

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# Socio-economic impacts: energy access

Changing lives by bringing light, water, telecommunications, and productive uses

Therefore reducing rural-urban migration and negative impacts of growing slum areas

# Job development

- The Solar PV industry sector is currently the largest employer among renewables, especially in China and India.

- almost 3.4 million jobs
- up 9% from 2016 to 2017


*Source: IRENA jobs database.*

*Note: The numbers shown in this Figure reflect those reported in past editions of the Annual Review.*

*a Includes liquid biofuels, solid biomass and biogas*

*b Other technologies include geothermal energy, hydropower (small), concentrated solar power (CSP), heat pumps (ground-based), municipal and industrial waste, and ocean energy.*

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# Job development

## Which positions ?

Installer

Construction

Design, sizing

O&M

Technician


Teacher / researcher

Bank, financing

Insurance

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# 5. Financing

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# Financing the solar revolution in emerging economies

***Opportunities, Risks and Ways Forward***

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# CEEW – Among South Asia's leading policy research institutions

Energy Access

Renewables

Power Sector

Industrial Sustainability & Competitiveness

Low-Carbon Pathways

Technology, Finance, & Trade

Centre for Energy Finance

Risks & Adaptation

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# What’s the end game?

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# Four energy transitions

- From traditional energy to access to modern energy
- From rural to urban-centric energy demand
- From relative autarky to deeper integration into global energy markets
- From growth to sustainable growth

SOURCE: Ghosh (2019); Bery, Ghosh, Mathur (2017)

# Driver 1: Ambition

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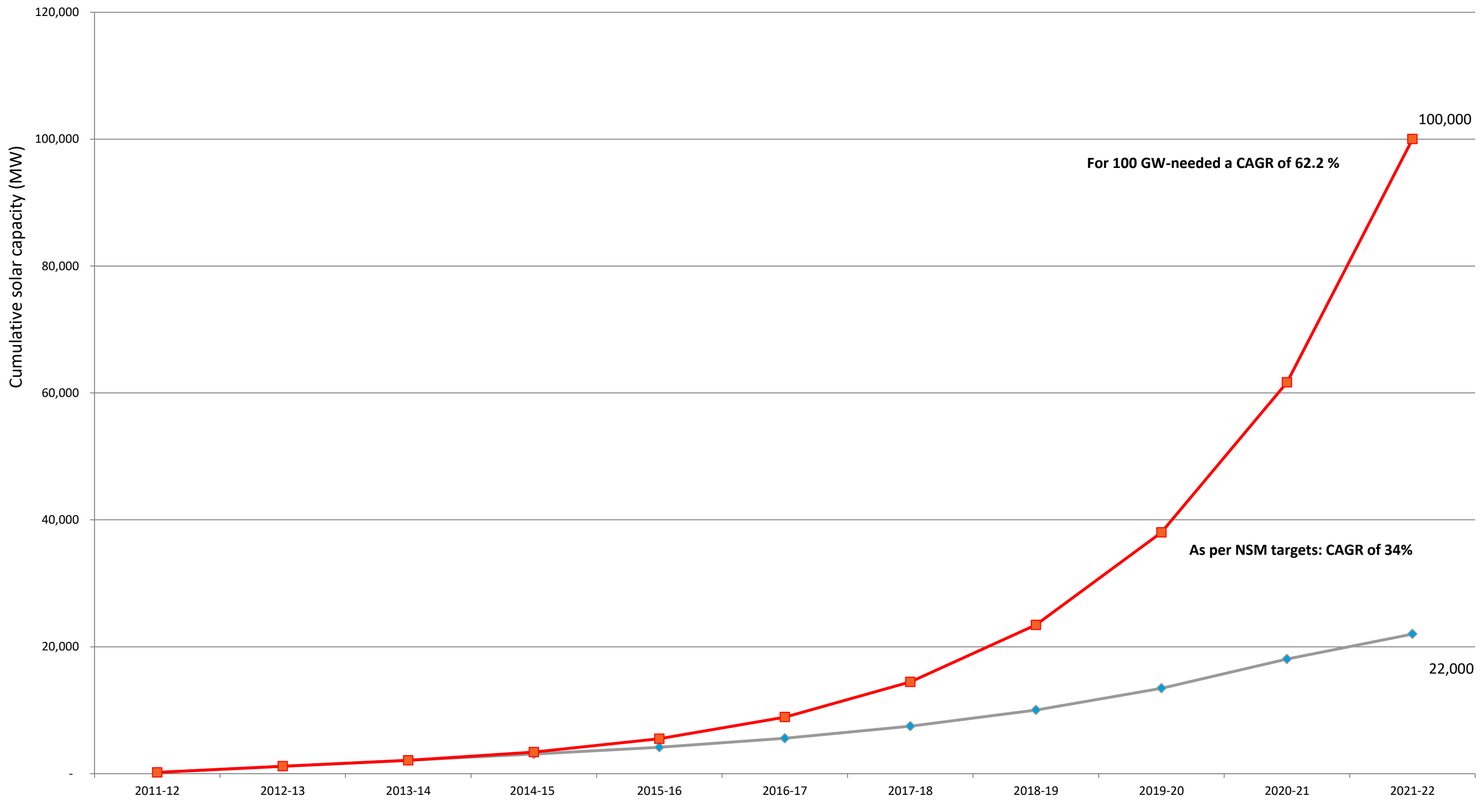
# Tapping every ray of the sun

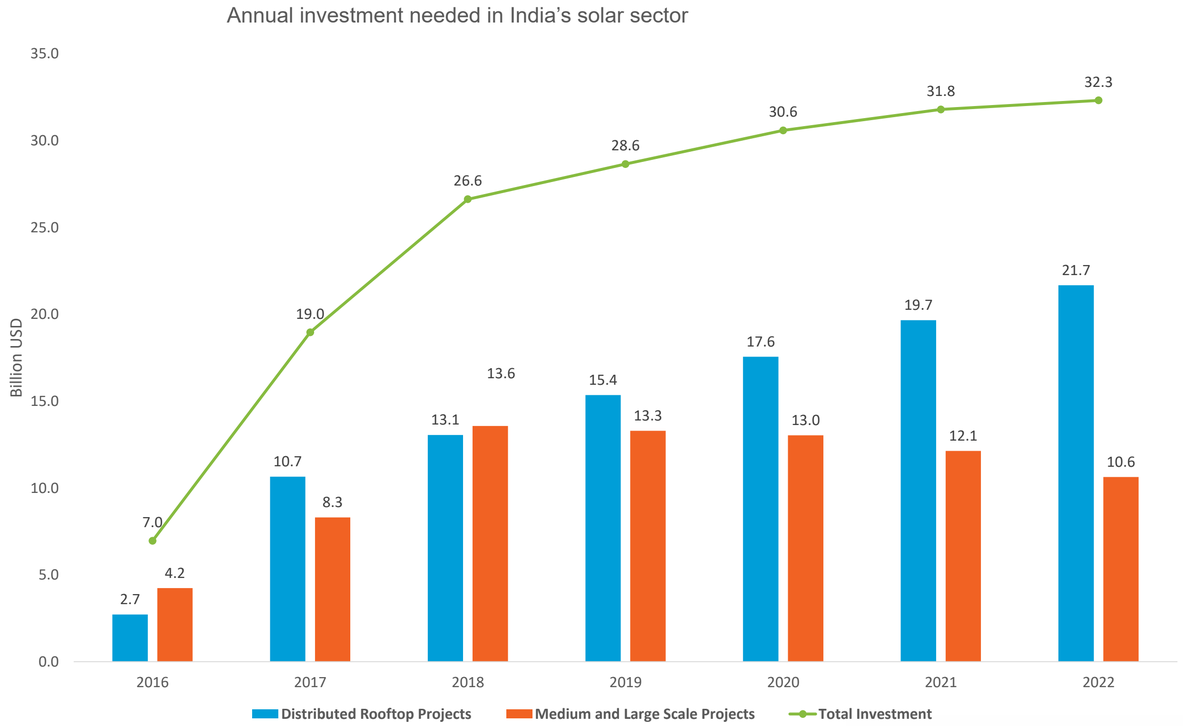



- In getting to 100GW of solar capacity, the required CAGR of 62.2% will mean cumulative installed capacity doubling every 18 months.

SOURCE: CEEW (2014)

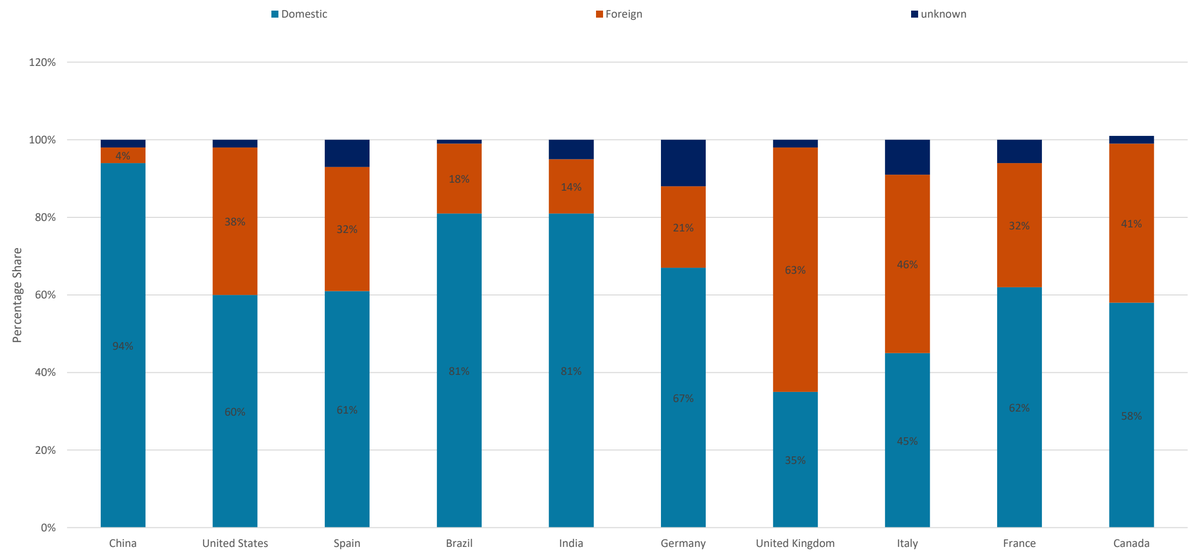
# Investment requirements... to fund a revolution

| RE Investment Flows | Average 2013-2017 (USD Billion) | 2017 (USD Billion) |
|---|---|---|
| India[1] | 10.0 | 10.9 |
| Global[2] | 321 | 334 |




- 1 Source: BNEF (2018); Chawla (2016)
- 2 Incudes large hydro investments

# Emerging economies receive only a small share of foreign funding




SOURCE: Ghosh and Chawla (forthcoming); BNEF (2016)

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# Driver 2: Taxation

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# What role can a carbon price play?

- Factoring in central and state levies
  - For gasoline – the tax rate is effectively 50% of the market price of the commodity
  - For diesel – the tax rate is ~ 45% o the market price of the commodity
  - In addition there's a levy of 75 US cents on every tonne of crude
  - 20% excise duty on domestically produced crude
  - Royalties, pollution taxes and other cesses are not included in this list
  - Latest cuts in petrol and diesel duties could result in loss of USD 1.13 billion of tax revenue by end-FY19
- Do we really need more taxes to control the demand for these fuels?
  - The income inequality in India dictates that even at these levels, these are still within the reach of the average Indian you will run into at any COP
  - It will be irrational to impose any more taxes in the name of pricing carbon
  - The existing pool of money goes to a consolidated fund / the treasury. How can it be channelled to promote low carbon development?

- SOURCE: CEEW; Ghosh (2018)

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# Driver 3: Perception

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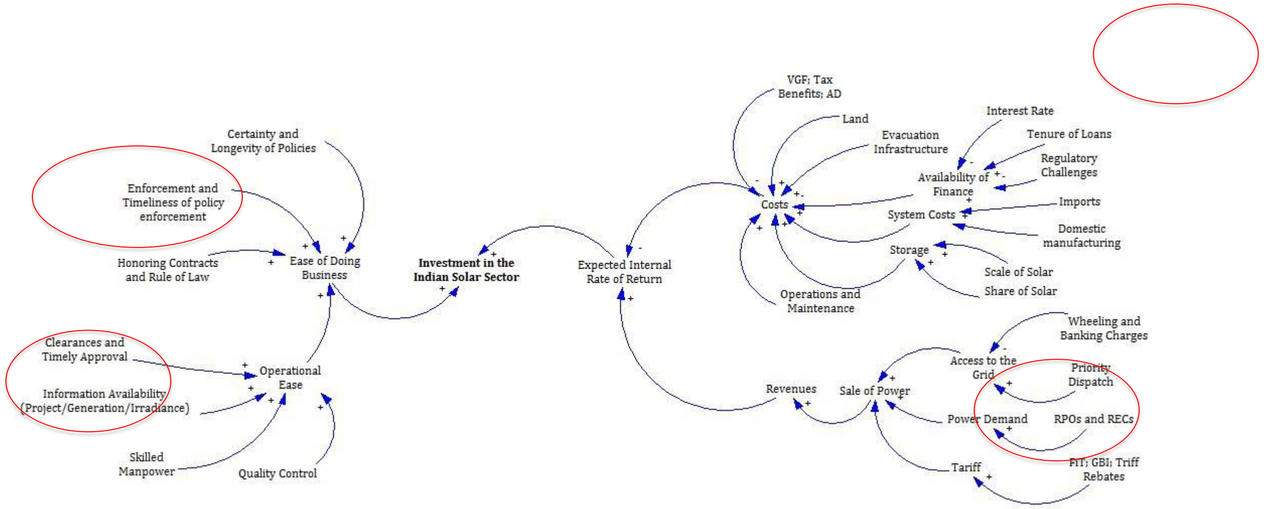
# Factors determining returns on RE investments




- Source: CEEW Analysis

# Anatomy of an RE tariff: risk perceptions determine costs of finance

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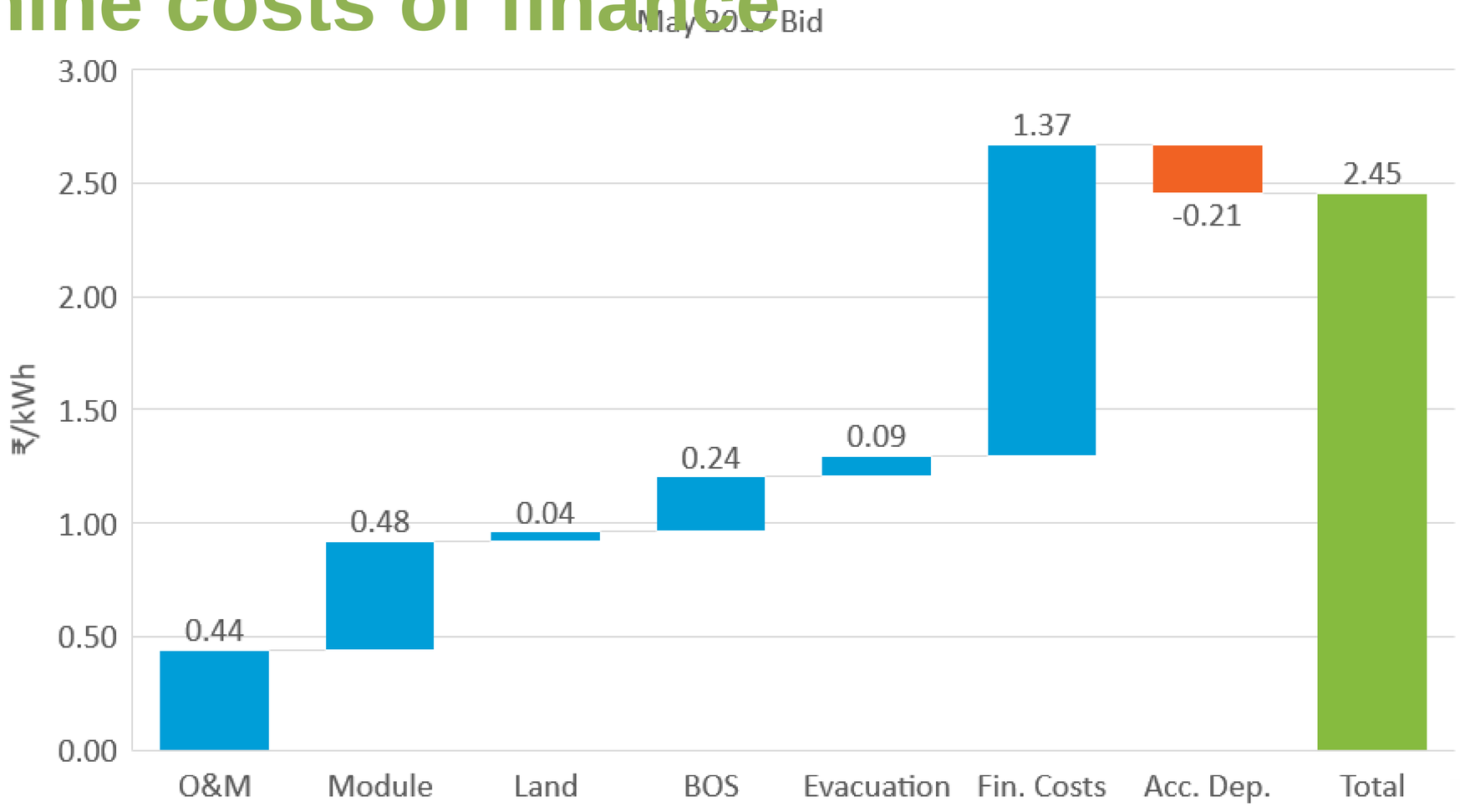


SOURCE: CEEW (2017)

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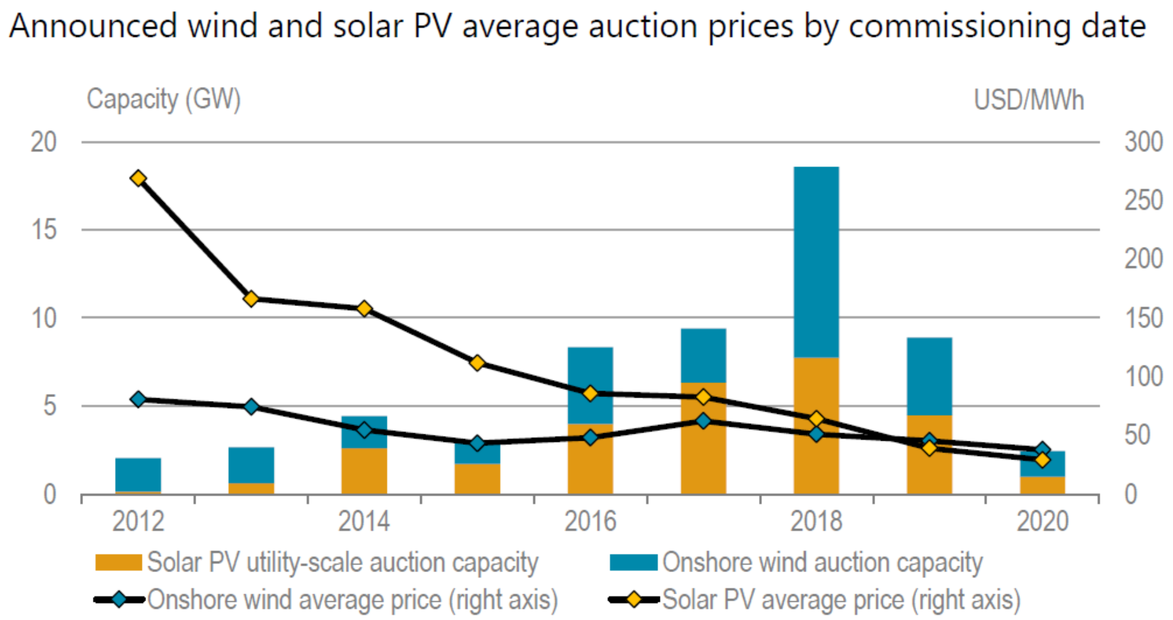
# Risks identified by the market

- Offtake Risk (Delays or defaults in payments)
- Curtailment risk
- Foreign exchange risk
- Land acquisition and construction risk
- Policy uncertainty and change in law risk

- Source: Authors

# Dramatic cost reductions in the prices of solar and wind energy

- Price discovery through reverse auctions have reduced prices along the value chain for solar and wind energy
- There is a learning curve of finance, similar to the learning curve of the technology, which declines rapidly as the familiarity with the sector grows

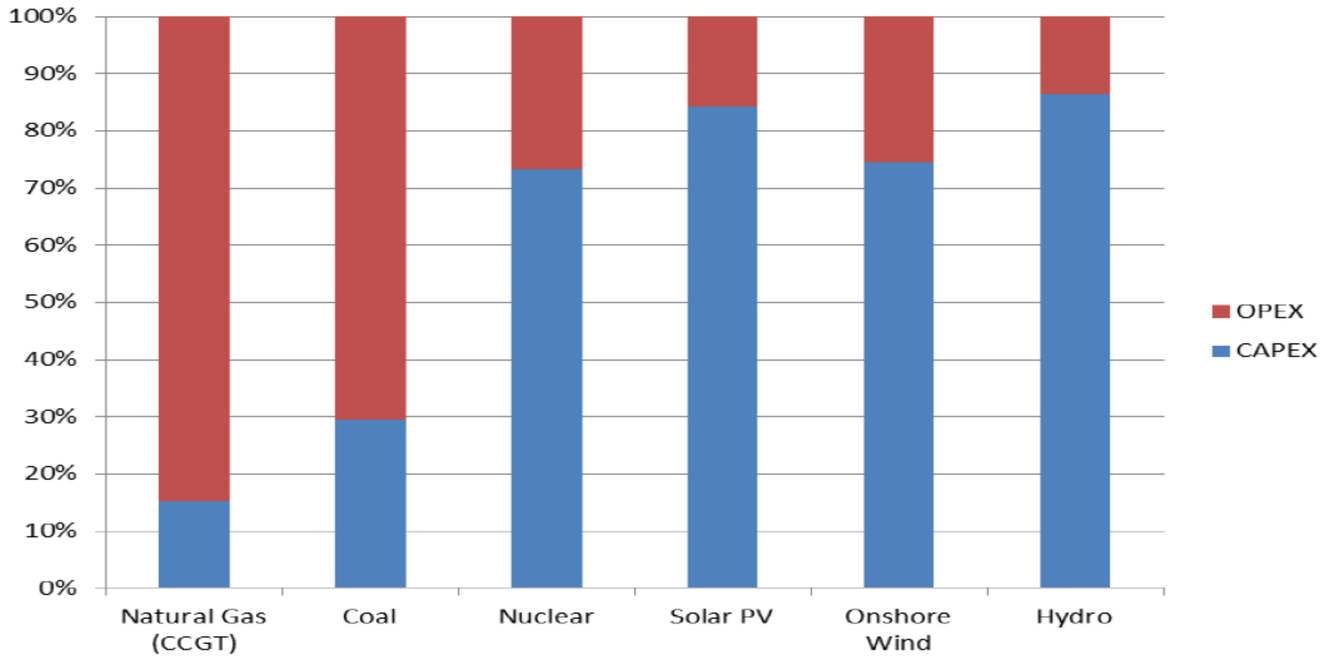



- Source: IEA; CEEW

# Renewables are more capital intensive than other energy sources

- The upfront cost of solar projects is significantly higher than of thermal and gas projects, even as per unit of electricity solar is now competitive with other sources of power in most economies
- The large upfront capital requirements makes the total costs more vulnerable to risks

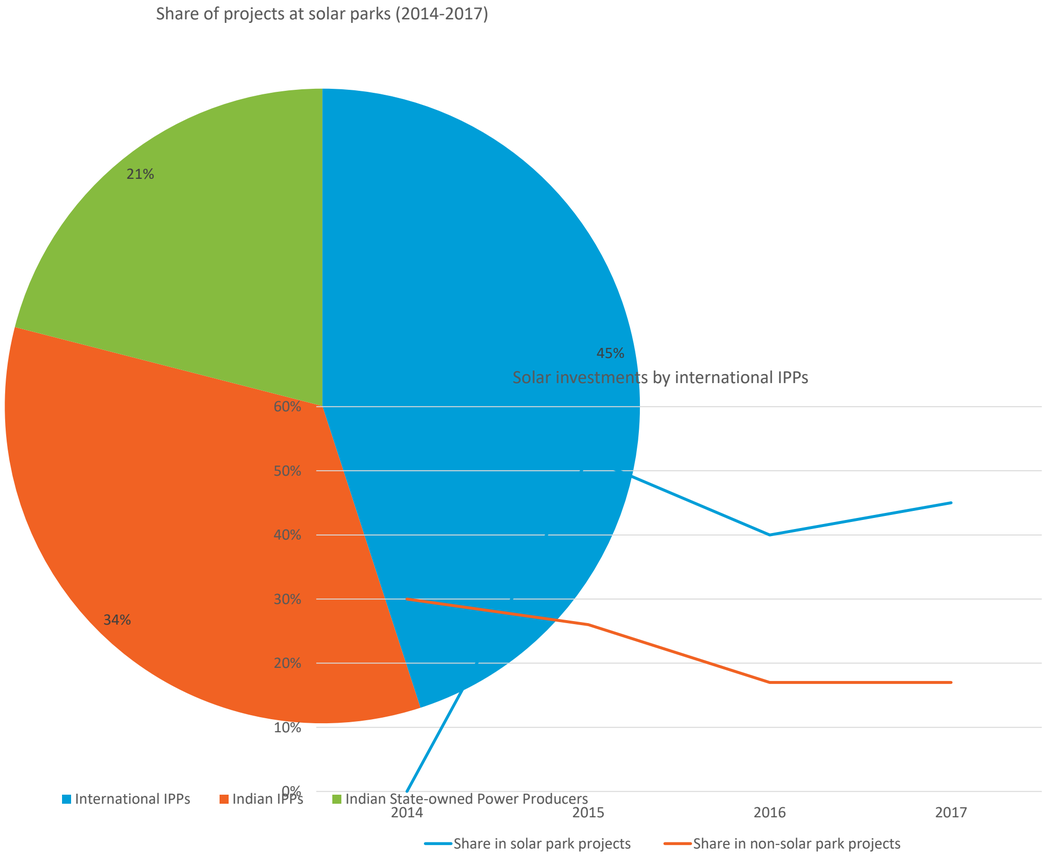
Typical shares of capital expenditures and operating expenditures in the levellised cost of generation for




Source: IEA; CEEW

# The role of solar parks in addressing risks and attracting capital

- Over half of solar PV projects sanctioned in India in 2017 were based on solar parks
- Share of solar parks in overall projects sanctioned in India rose from 38% in 2015 to 54% in 2017



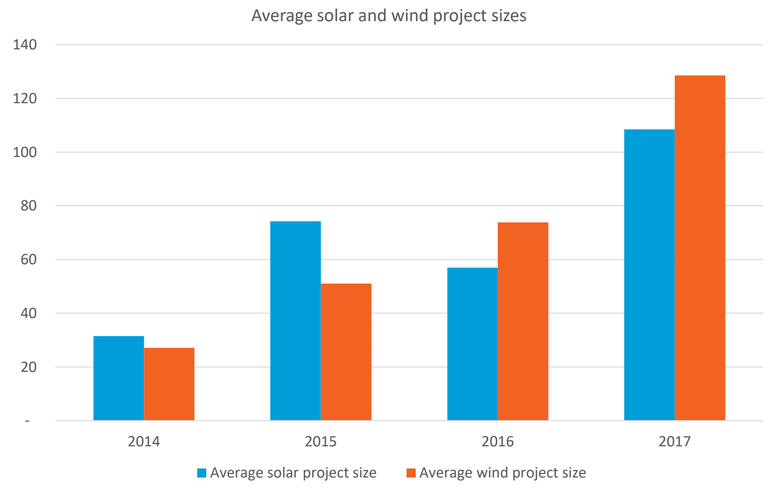

- Source: CEEW and IEA, Clean Energy Investment Trends Report, June 2018

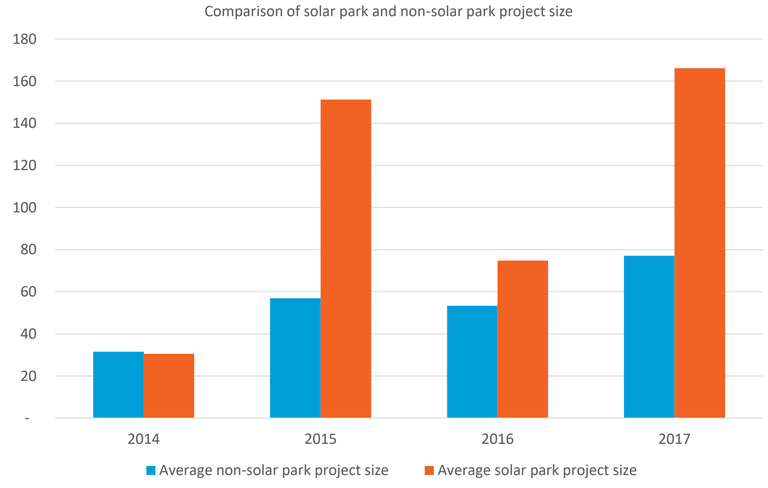
# Ambitious targets and support policies have enabled bigger project sizes

- The tendering of larger capacities and an overall supportive policy framework has helped drive an increase in average project size for both solar and wind energy

- Challenges in acquiring contiguous land with high solar/wind potential could limit future growth in project sizes

Source: CEEW and IEA, Clean Energy Investment Trends Report, June 2018

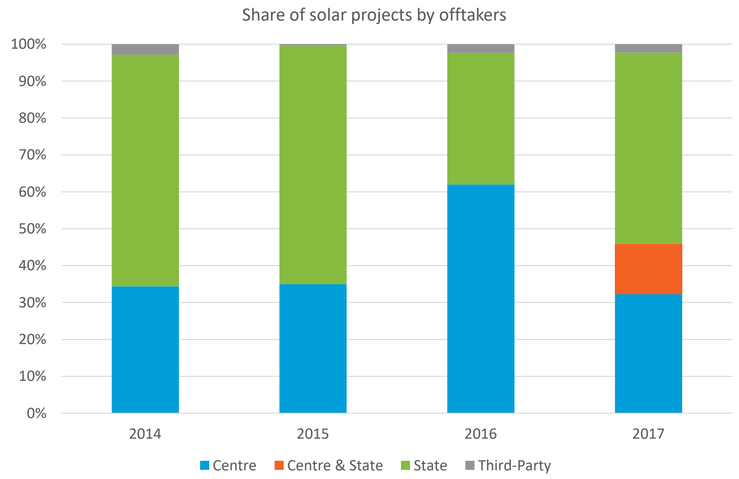


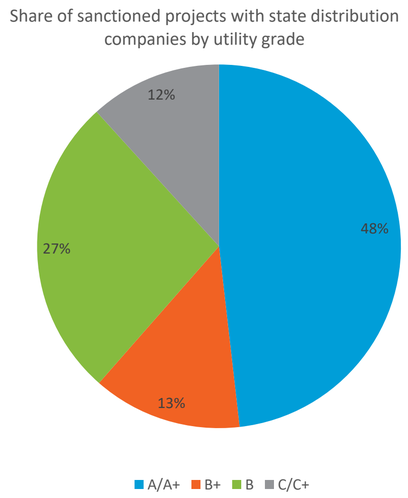



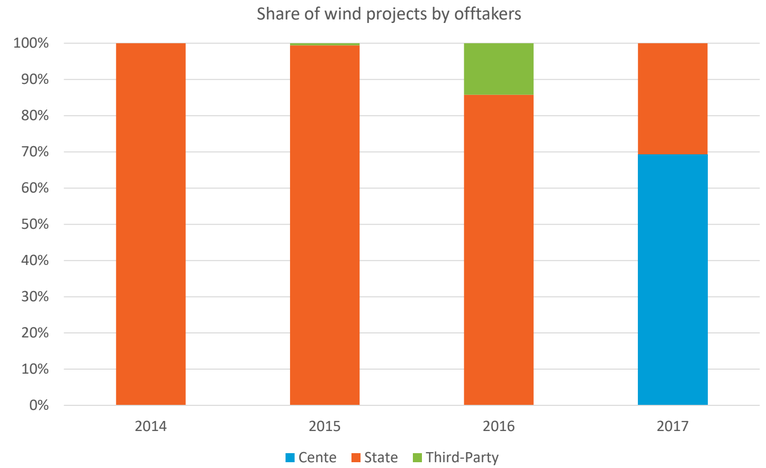

Source: CEEW and IEA, Clean Energy Investment Trends Report, June 2018

# Creditworthiness of offtakers strongly impacts investment

- Preference for creditworthy central offtakers for solar and wind projects
- Creditworthy state DISCOMS account for the majority of state offtakers




- As per Ministry of Power's Fifth Annual Integrated Rating for State DISCOMs, 2017

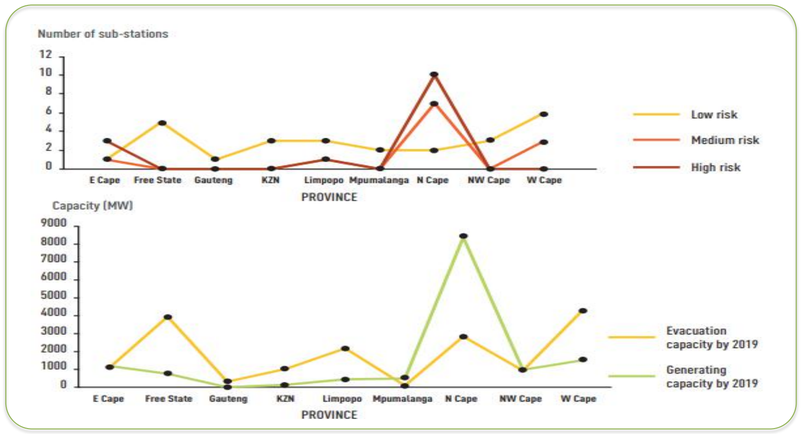
# Indonesia: The importance of market design and policy certainty

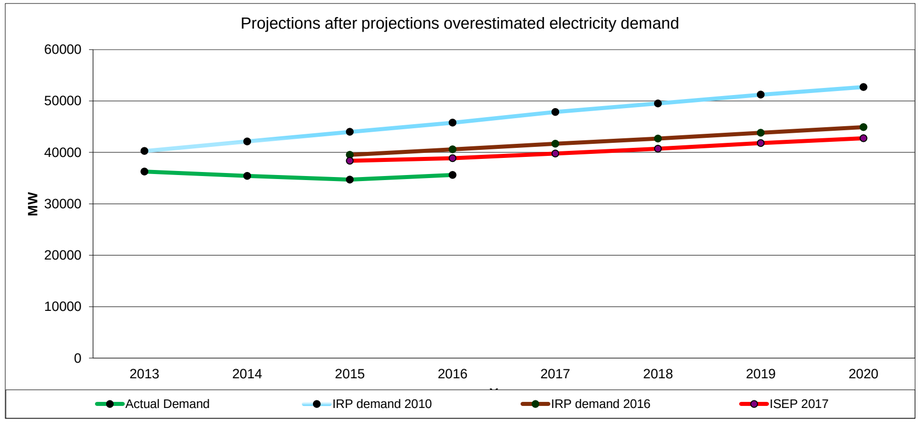
- Demand risk
  - Average demand growth of 4.6% from 2013 to 2018
- Policy risk
  - Cancellation of tenders
- Regulatory risk
  - BOOT Scheme
- Grid integration risk
  - 10% capacity cap
- Land acquisition risk
- Forex risk
- Source: CEEW Analysis

| Assumption/target | 2017 RUPTL | 2018 RUPTL | 2019 RUPTL |
|---|---|---|---|
| Electricity demand growth | 8.3% | 6.9% | 6.42% |
| Overall capacity addition | 78 GW | 56 GW | 56.4 GW |
| Solar capacity addition | 87 MW | 1045 MW | 908 MW |
| Wind capacity addition | 465 MW | 589 MW | 855 MW |

# South Africa: The importance of market design and policy certainty

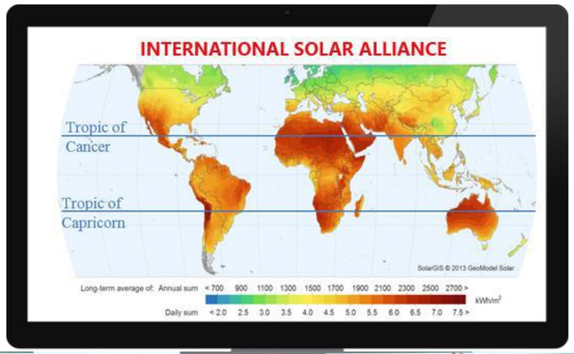
- Political risk
- Demand risk
- Offtake risk
  - ESKOM credit rating
- Grid integration risk




- Source: CEEW Analysis, ESKOM

# International Solar Alliance:
# A new kind of energy partnership

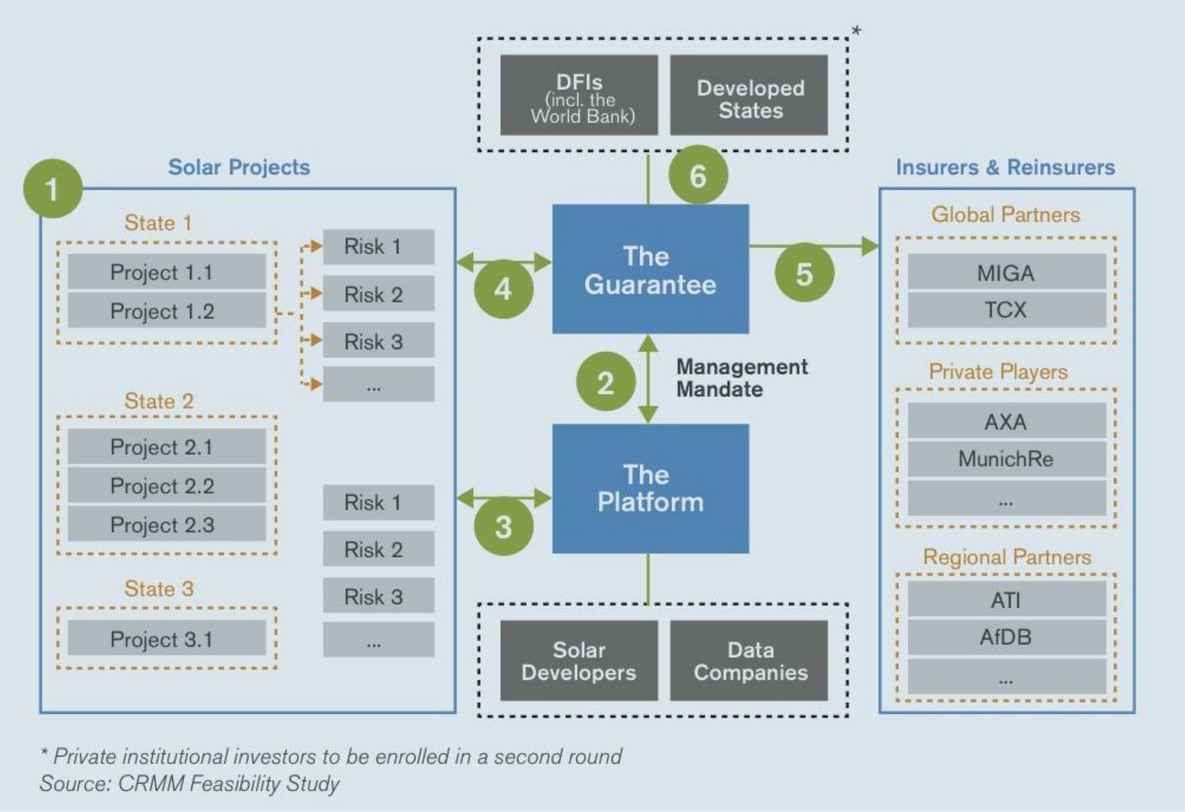



*Recognizing that sustainable development, universal energy access, and energy security are critical to the shared prosperity and future of our planet, and acknowledging that clean and renewable energy needs to be made affordable for all, we do hereby declare our intention to support India's proposal to launch an international solar alliance as a common platform for cooperation among solar resource rich countries lying fully or practically between the Tropics of Cancer and Capricorn.A*

- SOURCE: PTI; www.isolaraliiance.org

# Designing a silver bullet…

- Common Risk Mitigation Mechanism (CRMM)
  - For mitigating non-project specific risks (currency, offtaker, and political risk)




Source: CRMM Feasibility Study (2017)

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# Solar energy & the green economy

Some take aways regarding solar energy :

- Four decades of gradual and impressive improvement, allowing energy access and reaching grid parity everywhere.
- However solar energy is only at the beginning of a peaceful revolution, in which solar energy will be key to implement a green economy in most countries
- We need finance, speed, scale and therefore skills for the required large-scale implementation, and that’s what ISA is dedicated to.

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KEEP CALM AND GO SOLAR

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