CLEAN ENERGY MINISTERIAL

Accelerating the Transition to Clean Energy Technologies

# ROUNDTABLE 6: Mini-Grid Development

Session Structure for the Public-Private Roundtable

Clean Energy Ministerial
16:15-17:45
17 April 2013
New Delhi, India

## OVERVIEW

Solutions to the limitations of rural energy access around the world require use of both centralized and decentralized power systems. In 2010, the International Energy Agency estimated that, "to achieve universal access to electricity, 70% of the rural areas that currently lack access will need to be connected using mini-grid or off-grid [decentralized] solutions." Mini-grids and other decentralized solutions may be more attractive than larger, centralized solutions in rural areas for a number of reasons. First, they can often be deployed more rapidly than grid solutions. Second, they do not rely on extending grid-connected generation capacity, a much larger, resource intensive and longer term effort. Third, mini-grid solutions provide local business development and job creation opportunities. Importantly, they are also customizable to local contexts and needs. Even in areas with the prospect of future power system development, mini-grids can play an important role of providing near-term electrification. Once the grid extends to these areas, the installed mini-grids can provide reliability and ancillary services to the grid-connected regions.

Emerging mini-grid research and deployment, particularly renewable energy powered mini-grids, has demonstrated the benefits of these technologies. Consequently, there is substantial interest in different aspects of mini-grids such as innovative business models, financial and tariff models, the integration of smart grid technologies and load management, and technology performance and standards. While fossil fuels play a major role in on-grid electricity generation, renewable sources are likely to dominate in mini-grid and decentralized solutions (IEA, 2012). Still, barriers to scaling up remain. A CEM roundtable on mini-grids offers an important opportunity to synthesize the lessons-learned from this history, and bring together practitioners and policymakers to cooperatively identify the barriers to further scaling up mini-grids, and also discuss potential solutions to addressing these barriers, as a key component of achieving universal energy access.

Stakeholder meetings were held in preparation for this roundtable to discuss different factors affecting mini-grid installations, which helped inform the scope of the roundtable.

## DISCUSSION TOPICS

- What are the market barriers for the scale up of mini-grids? What are viable business and financing models for mini-grids that provide energy access with and without the prospect of grid-connection in the future?

- What are the policies and regulatory frameworks that are required to support commercially viable mini-grids, in particular the renewable generation based mini-grids?

- Are there technologies, load management approaches, standards, or other enabling factors that would create cost-effective mini-grids for both consumers and installers?

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## OBJECTIVE

The objective of the roundtable is to provide decision-makers with an understanding of the technical, economic and policy issues and opportunities with rural "mini-grid" systems especially in Developing Countries, as well as to provide a menu of options that accelerate scaling-up in their deployment. The discussion will equip national, regional and local policymakers and investors with perspective, solutions, and inspiration on how to develop sustainable energy strategies utilizing mini grids that can be carried forth through public-private collaboration within the context of the Clean Energy Ministerial.

## FORMAT

The session will be a moderated discussion among ~25 participants from both the public and private sectors. Although guided by the moderator, the roundtable is meant to be an unscripted and free-flowing conversation that allows for a candid exchange of information and ideas. In order to signal a desire to speak, participants should raise their name plates. The session will follow the discussion topics outlined above.

This will be a private discussion held under the Chatham House Rule. [1]

The roundtable is to be 90 minutes long, beginning promptly at 16:15 and ending promptly at 17:45. Participants are asked to please limit individual comments to 2 minutes each. These time limits will be strictly enforced by the moderator.

## MODERATOR

- **Gauri Singh**, Director of Country Support and Development, IRENA

## GOVERNMENT REPRESENTATIVES

- **India: Farooq Abdullah, Minister of Renewable Energy, Ministry of New and Renewable Energy**
- **Japan: Isshu Sgawara, State Minister of Ministry of Economy, Trade and Industry**
- **United Kingdom: Phil Marker, Head of Joint HMG Climate Unit, UK Department for International Development**
- **United States: William Hammink, Mission Director, US Agency for International Development**

## OTHER PARTICIPANTS

- **Anshu Bharadwaj, Executive Director, CSTEP**
- **Pramod Deo, Chairperson, Central Electricity Regulatory Commission**
- **Jamshyd Godrej, Chairman and Managing Director, Godrej Group**
- **Bazmi Husain, Country Manager of India, ABB**
- **David Jhirad, Professor, John Hopkins University**

[1] When a meeting, or part thereof, is held under the Chatham House Rule, participants are free to use the information received, but neither the identity nor the affiliation of the speaker(s), nor that of any other participant, may be revealed.

- **Richard H. Jones, Deputy Executive Director, International Energy Agency**
- **Yashraj Khaitan, CEO, Gram Power**
- **Takemitsu Kunio, Senior Vice President, NEC**
- **Peter Lilienthal, CEO, HOMER Energy LLC**
- **Terry Mohn, CEO, General Microgrids**
- **Gyanesh Pandey, CEO and CTO, Husk Power Systems**
- **Jeeva Perumalpillai-Essex, South Asia Manager for Sustainable Business Advisory, International Finance Corporation**
- **Neeraj Prasad, Manager, Climate Change Practice, World Bank**
- **Sairam Prasad, CTO, Bharti Infratel**
- **Anil Raj, CEO, OMC Power**
- **Sandra Retzer, Managing Director, Younicos**
- **Rahul Sankhe, Managing Director (India), SunEdison**
- **Ajay Sharma, Managing Director, Entura India**
- **Moch Sofyan, Head of Renewable Energy, PLN Indonesia**
- **Frans Vreeswijk, General Secretary and CEO, International Electrotechnical Commission**

## SESSION STRUCTURE

**16:15-16:25: Moderator's Opening Remarks and Scene Setting**

Moderator will describe the scope for the discussion, set expectations on the time limits for individual comments, provide an overview of the three segments for open discussion, and articulate the goals for the roundtable.

**16:25-16:45: Discussion on Business Models**

*Relevant Discussion Topic:*

- What are viable business models for mini-grids that provide energy access with and without the prospect of grid-connection in the future?
- What are key financing requirements and successful financing models for mini-grids that provide energy access with and without the prospect of grid-connection in the future?

**16:45-17:05: Discussion on Policy and Regulatory Drivers**

*Relevant Discussion Topic:*

- What are the policies and regulatory frameworks that are required to support commercially viable mini-grids, in particular renewable generation based mini-grids?
- What public mechanisms can be created for surfacing and disseminating market information and location-specific demand characteristics to develop robust markets?

**17:05-17:20: Discussion on Technologies and Standards**

*Relevant Discussion Topics:*

- What technologies, load management approaches, or technology standards would create cost-effective mini-grids for both consumers and installers?

- What measures can the public sector take to promote these technologies, load management approaches and standards? E.g., Investment in research and development of storage technologies, load-side product competitions.

**17:20-17:40: Discussion on Public-Private Cooperation**

The moderator will direct the discussion toward potential follow-on actions, which may follow pathways that have opened up during the discussion, involve ideas developed by participants in advance, and/or include discussion of ongoing activities or those that could benefit from international collaboration.

**17:40-17:45: Moderator's Closing Remarks**

Moderator will summarize salient points, emerging consensus areas, and follow-on actions.

CLEAN ENERGY MINISTERIAL

Accelerating the Transition to Clean Energy Technologies

# Mini-Grids

## Pre-Read for Public-Private Roundtable

**Clean Energy Ministerial**
**17 April 2013**
**Taj Palace**
**New Delhi, India**

# OUTLINE

1 **Objective**

2 Current Landscape

3 Barriers

4 Potential Solutions

5 Opportunities for Progress

# Objective

**Clean Energy Ministerial (CEM) 4 Roundtable:** Provides an important opportunity to synthesize the lessons learned from history, and to bring together practitioners and policymakers to cooperatively address the barriers faced today, including technical, regulatory, financial, and policy issues.

**Presentation:** Provides background information on the current state of mini-grids, and outlines challenges and potential solutions to further scaling-up mini-grids as a key component of achieving universal energy access.

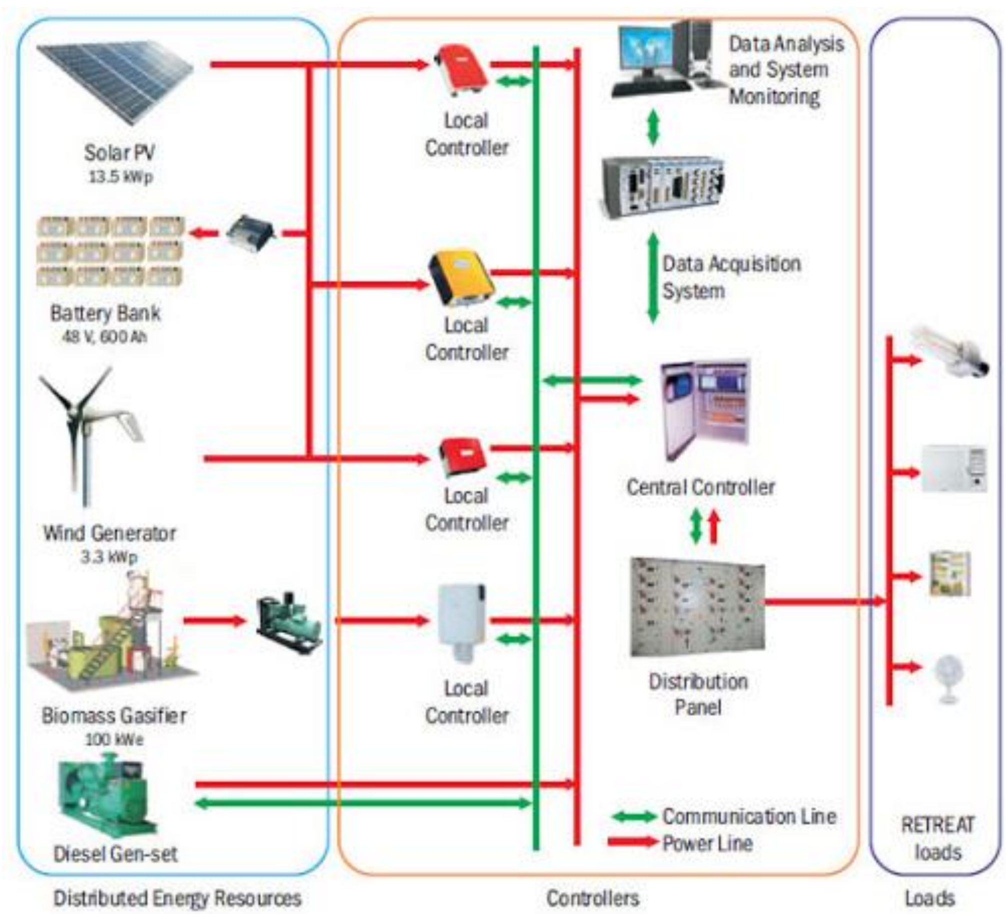
The information in this presentation is based on the work conducted by the CEM Clean Energy Solutions Center Initiative and the National Renewable Energy Laboratory (NREL), in collaboration with other organizations.

**The time is ripe for scaling-up mini-grids in alignment with the provision of universal access to modern, clean-energy services.**

# Scope of Roundtable

**Mini-Grid:** An integrated energy system consisting of interconnected loads and distributed energy resources—including generators and energy storage devices—which, as an integrated system, can operate in parallel with the utility grid or in an intentional islanding mode.

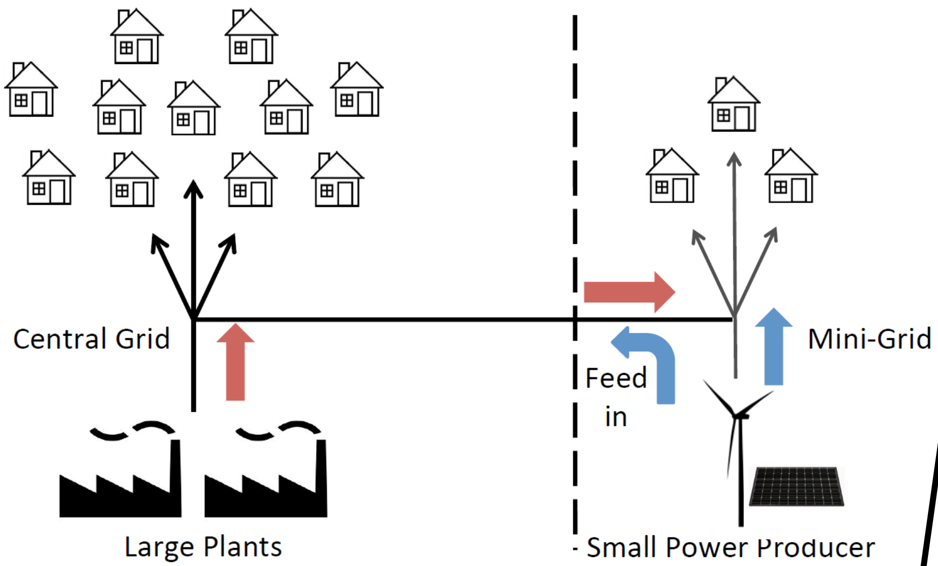
- A modern mini-grid can include renewable and fossil-fuel based generation, energy storage facilities, and load control.
- A modern mini-grid is scalable, so that additional generation capacity can be added to meet growing loads without compromising the stable operation of the existing mini-grid.




Source: "Smart Mini-Grid, A TERI Initiative." (Undated). TERI The Energy and Resources Institute. Accessed February 26, 2013: http://www.teriin.org/events/SmartMini_Grid_Brochure.pdf

# Scaling-Up

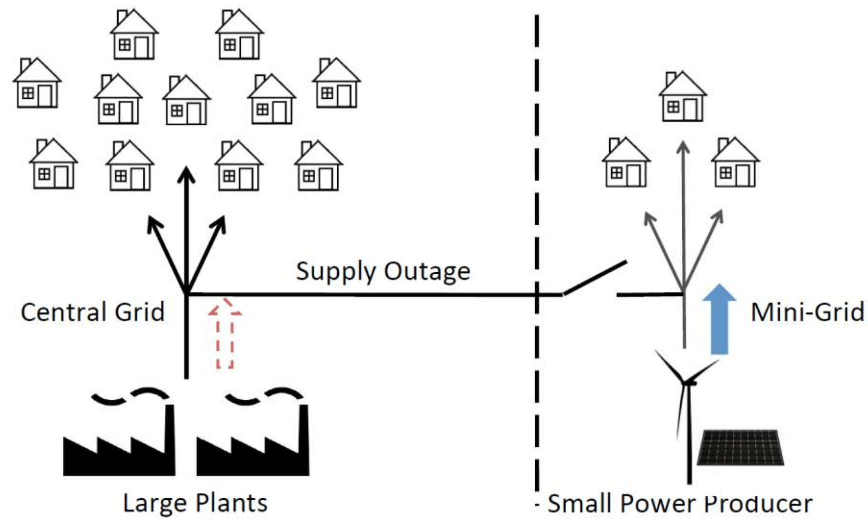
Grid interconnection and feed into central grid




- Mini-grid and central grid both supply power to the local community. Excess power from the mini-grid is fed back into the central grid.

- Mini-grid supply is uninterrupted during central grid supply outages.

Islanded mini-grid operation during interrupted central grid supply






Source: Lawrence Berkeley National Laboratory, Schatz Energy Research Center at Humboldt University

# Renewable Energy/Hybrid Mini-Grids

**Renewable energy mini-grids offer possibilities for improved energy generation and access.**

- Displace expensive diesel-based generation.
- Utilize local renewable energy resources in the system design.
- Graduate from household solar systems and off-grid lighting devices.
- Provide power for commercial and agricultural applications (not just for residential use).
- Create local jobs.
- Provide environmental benefits.

Source: Lawrence Berkeley National Laboratory, Schatz Energy Research Center at Humboldt University

# History of Mini-Grid Development

- During the past few decades, a diverse array of mini-grid research and deployment has demonstrated the benefits of mini-grids.
- Substantial interest exists for different aspects of mini-grids, such as technology performance and standards, integration of smart-grid technologies and load management, financial and tariff models, and innovative business models.
- Research includes more than 30 years of experience in developing mini-grids and improving mini-grid capabilities on islands and in rural areas and military facilities.



Sources: Don Buchanan; Andy Walker, NREL; Warren Gretz , NREL; Professor Vijay Modi, Columbia University.

# CEM4 Roundtable Concept

- In 2010, the International Energy Agency estimated that,

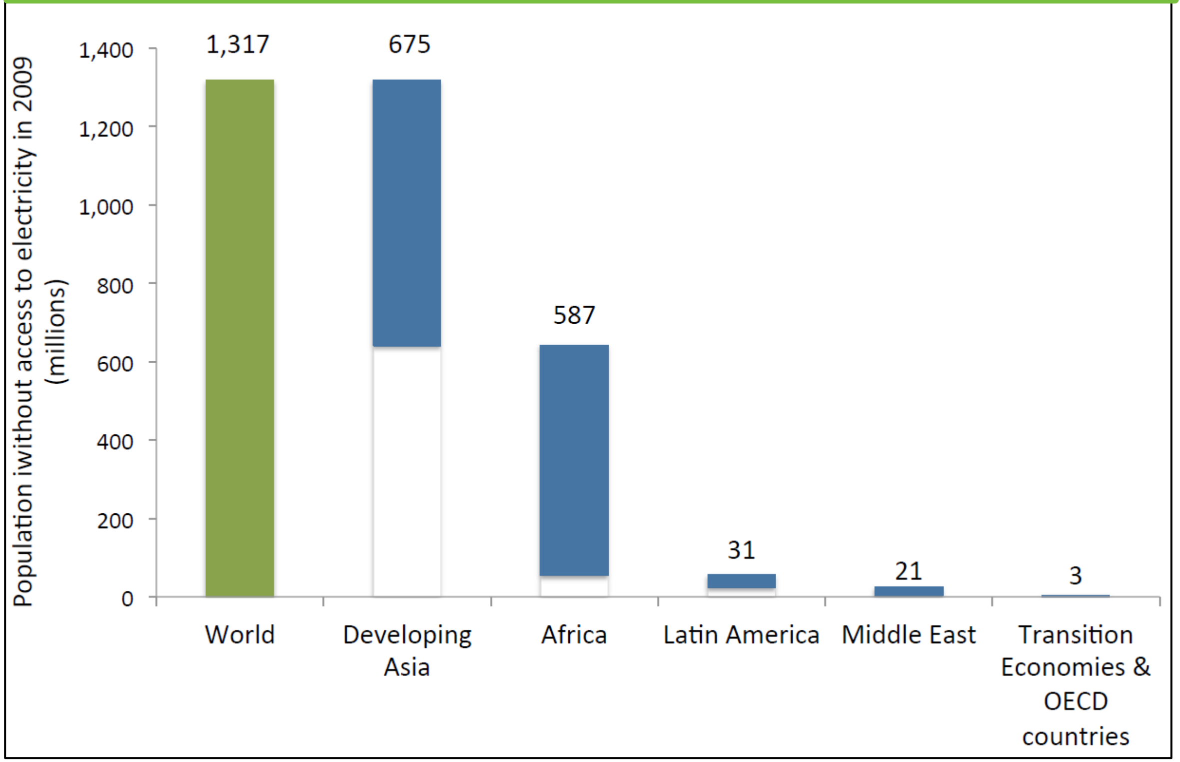
  "To achieve universal access to electricity, 70% of the rural areas that currently lack access will need to be connected using mini-grid or off-grid solutions."

- The roundtable is focused on the scale-up of clean energy services through mini-grids. Participants will address key questions:
  1) What are viable business and financing models for mini-grids that provide energy access with and without the prospect of grid connection in the future?
  2) What are the market barriers for the scale-up of mini-grids?
  3) What are the policies and regulatory frameworks that are required to support commercially viable mini-grids, in particular the renewable generation based mini-grids?
  4) Are there technologies, load-management approaches, and smart-grid technologies, standards, or other enabling factors that would create cost-effective mini-grids for both consumers and installers?

# OUTLINE

# BACKGROUND

**More than 1.3 Billion People Lack Access to Electricity**

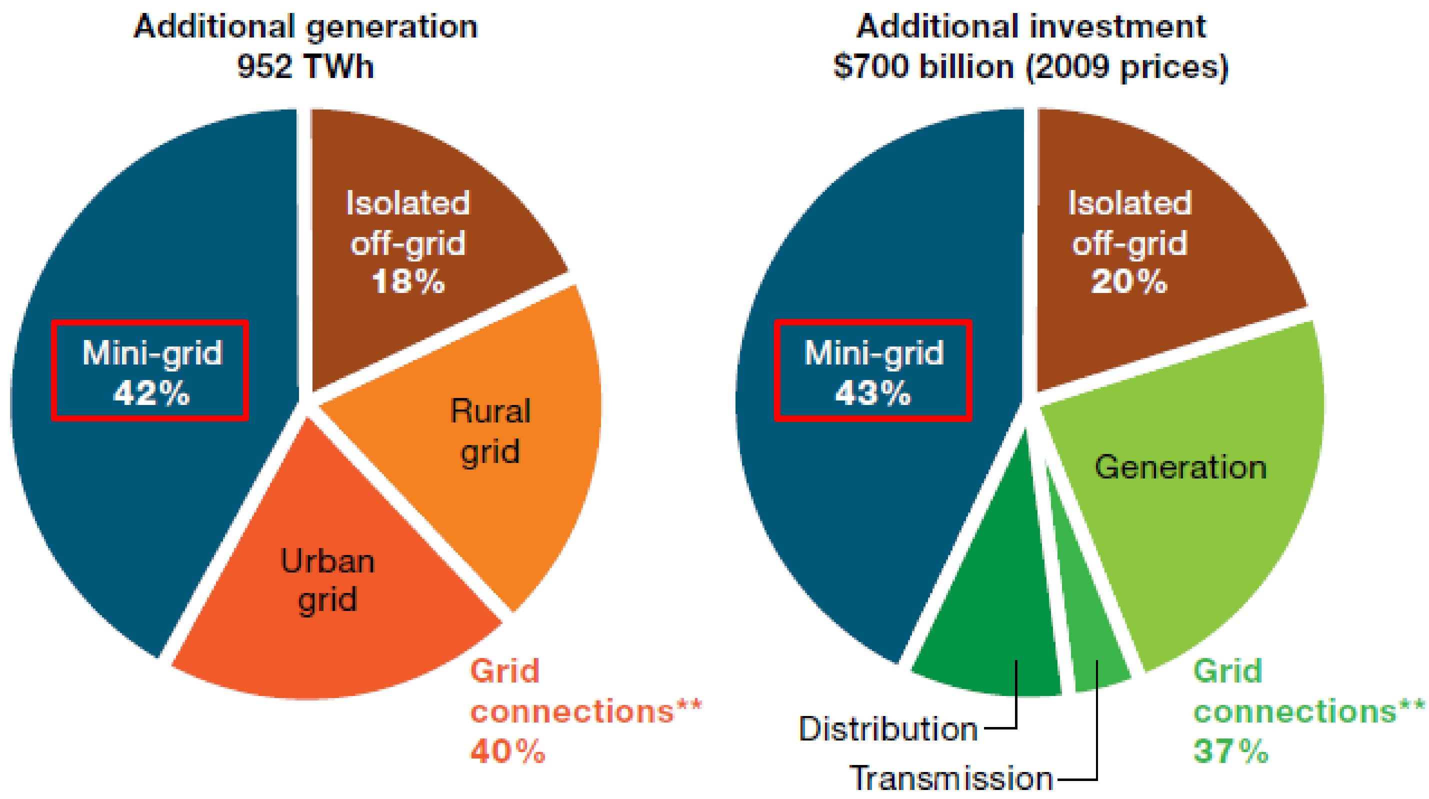



The IEA, in its “2010 World Energy Outlook,” states:

> **Decentralised options have an important role to play when grid extension is too expensive, and will probably provide the bulk of the additional connections over the project period to 2030.**

# The Importance of Mini-Grid Solutions

**Incremental Electricity Generation and Investment in the Universal Modern Access Case*, 2010-2030**



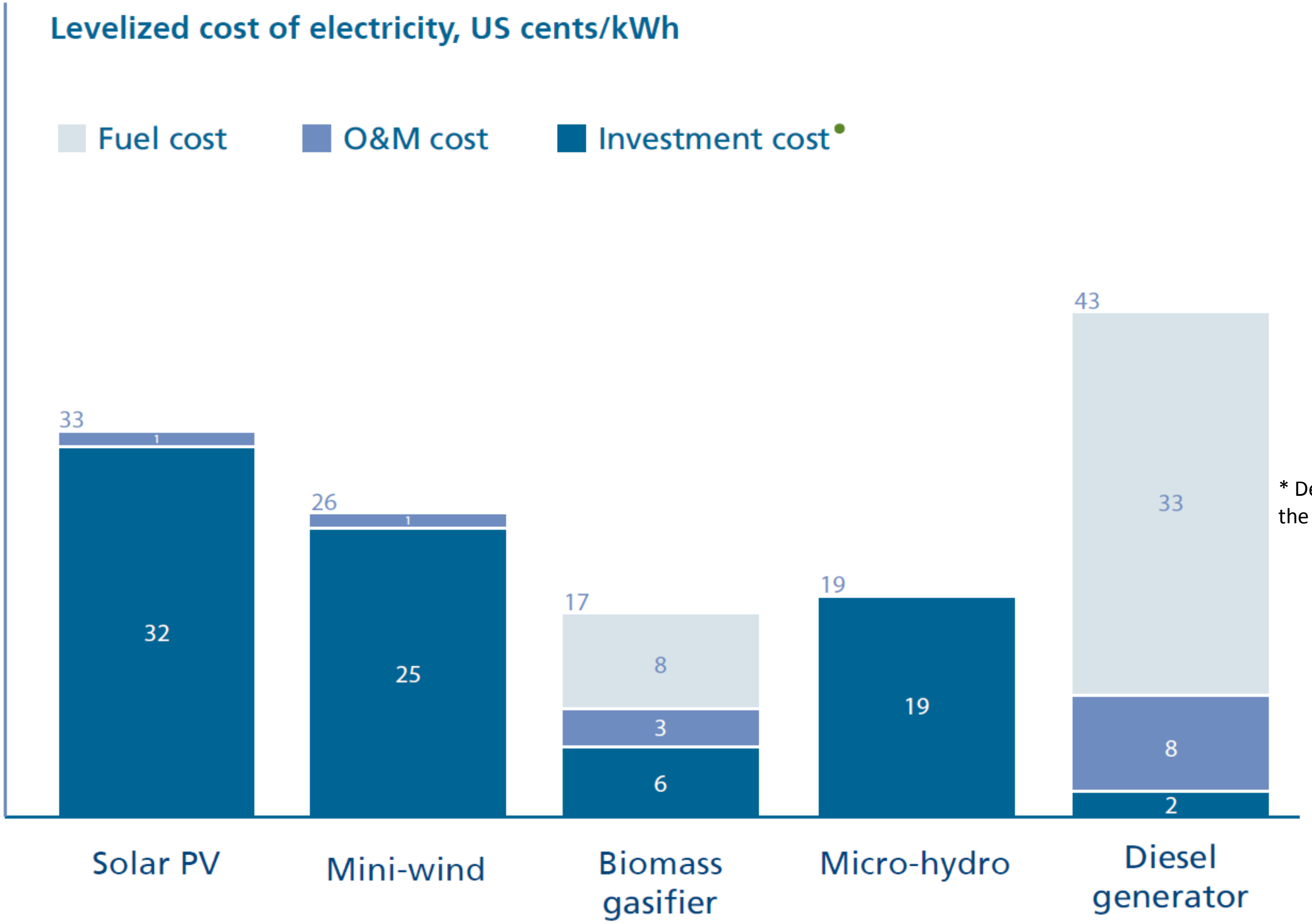

*Compared with the New Policies Scenario

**includes generation, transmission and distribution for both urban and rural grids



Source: IEA (2010), World Energy Outlook, p.257.

# Global Levelized Cost of Energy for Mini-Grid Systems




* Dependent upon the price of diesel

- Capacity factors, fuel costs, and access to credit influence overall cost.



Source: ESMAP –World Bank, McKinsey analysis. 2011.

# Current Status of Mini-Grids

- There is need for more data on the number and type of current mini-grid installations at the regional, country, and global levels.
- The majority of current efforts are pilot efforts, or initial first steps.
- Mini-grids are becoming more efficient and growing in size as demand rises with falling generation costs and cheaper, easier system maintenance.
- As integration of automatic control technology in micro-grid systems improves, known as "smart-grids", many governments are investing in them at various scales as clear alternatives to grid extension.



Sources: Renewable Energy Policy Network for the 21st Century

# Current Status of Mini-Grids

- Mini-grids have grown to provide power for small industry uses in addition to households and small businesses, thereby stimulating economic development in rural areas.
- While mini-grids typically provide about 100 kW of maximum power, in 2012 several supported up to 500 kW and even 1,000 kW.
- The Economic Community of West African States (ECOWAS) region of Africa has developed many such mini- and micro-grids to expand access to electricity in rural areas; for example, a PV and wind powered micro-gird in Santiago, Cape Verde provides power for 117 rural households.



Sources: Renewable Energy Policy Network for the 21st Century

# Outline

1. Objective
2. Current Landscape
3. **Barriers**
4. Potential Solutions
5. Opportunities for Progress

# Barriers

- Technical
- Financial
- Policy
- Regulatory

# TECHNICAL BARRIERS

| Technical Factors | Impact on Mini-Grids |
|---|---|
| • Significant fuel costs, lack of fuel availability, and variable renewable energy production all reduce the reliability of power generation. | ➢ Technical expertise often is difficult to find at the rural local level. This poses a challenge in maintaining the mini-grid and ensuring its reliability. |
| • The use of intermittent renewable energy—such as wind and solar—requires energy storage | ➢ Energy storage technology—such as batteries—is expensive and can increase the cost of mini-grid projects. |
| • Diesel engines are the primary power source for many rural communities due to a lack of technical expertise in other technology opportunities. | ➢ Renewable energy and other power resources are often ignored for traditional, familiar diesel systems. |
| • Operation and Maintenance (O&M), poses a challenge and can threaten the continuity of the operation and the reliability of power supply. | ➢ Hybrid mini-grids are utilized to improve the reliability of power generation, but add complexity and cost to the system. |
| • Mini-grids are custom made for each rural location. | ➢ Resource assessments and accurate load analysis of the hybrid mini-grid require upfront analysis and site-specific designed systems that can be technically challenging, costly, and not easily replicable, and also can prevent scaling-up. |

# FINANCIAL BARRIERS

International Finance Corporation
World Bank Group

| Financial Factors | Impact on Mini-Grids |
|---|---|
| • Greater initial cost of renewables. | ➢ The initial capital cost of renewable energy compared to the cost of a diesel generator can act as a barrier to energy transition. |
| • Lack of financially sustainable business models, plus banks' preference to lend to large projects especially those that are grid connected. | ➢ Mini-grid developers are forced to rely on government subsidies and grants from donors. |
| • Greater system design costs due to custom designed mini-grids with renewable energy sources. | ➢ Hybrid mini-grids typically use renewable energy sources and have custom designs that can be complex and act as a barrier to system design cost. |
| • Greater upfront capital costs, fuel costs, and maintenance costs increases the power supply costs of mini-grid utilities. | ➢ Small scale operation raises power supply cost of mini-utilities and can exceed U.S. $1 per kWh. Many mini-grids close down after only a couple of years because financial sustainability is not achieved. |
| • Mini-grids are often considered transition solutions due to their lack of an anchor customer or grid connection. | ➢ Mini-grids are not seen as reliable for providing productive economic services. Mini-grids are viewed only as temporary solutions. |

# Policy Barriers

| Policy Factors | Impact on Mini-Grids |
|---|---|
| • Existing policies do not address the multiple methods for achieving rural and remote electrification. | ➢ Electrification is achieved primarily through central grid extensions, even when this is not cost effective. Current policies encourage this approach and deter mini-grids. |
| • There is a shortage of information in the public domain on process issues, and a lack of consumer awareness and access to information. | ➢ Information is needed for both large global corporations and very small local players to evaluate entering the market. |
| • Subsidy policies, such as capital subsidies, are aimed at short-term performance. | ➢ Short-term subsidies are not effective or efficient in promoting long-term performance. |
| • There is a lack of government support for rural electrification institutions or programs. | ➢ Countries lack institutions that fully understand the electricity needs of rural and remote populations. Many state-level governments lack the capacity to properly address rural electrification needs. |
| • Subsidy policies follow a "bigger is better" approach. | ➢ Subsidies for renewable energy often encourage large projects, such as hydro or multiple-megawatt wind facilities. This subsidy framework does not encourage small mini-grid renewable energy projects. |

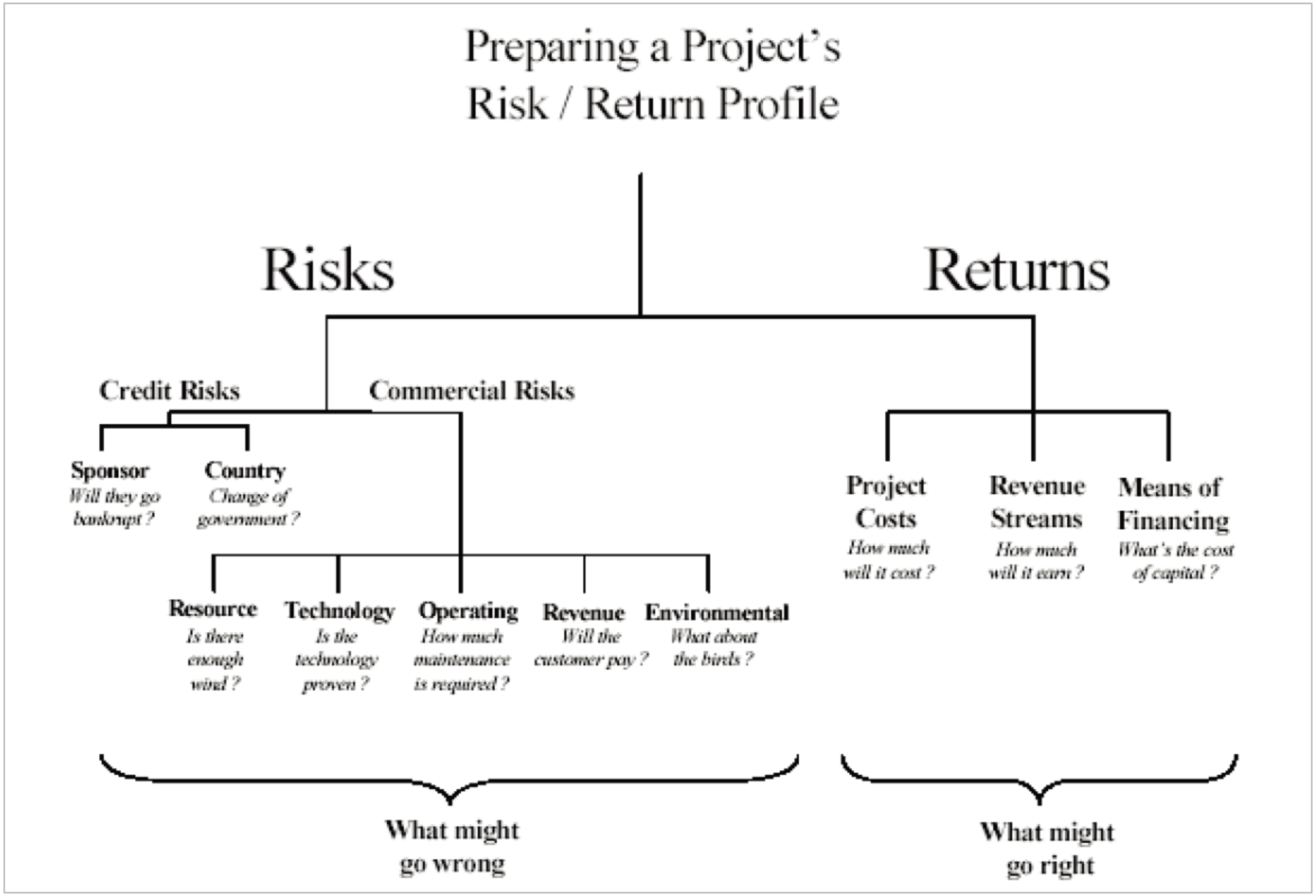
# Policy Barriers

| Policy Factors | Impact on Mini-Grids |
| --- | --- |
| • Policies do not exist for setting the tariff on electricity fed back into the grid. | ➢ Mini-grid development is discouraged due to uncertainty over the impact of eventual scaling-up to the central grid. |
| • Regions lack clarity on where the grid will be extended. | ➢ The absence of policies on grid extension plans creates uncertainty over market prospects for mini-grid development and the fear of decreased demand due to future scaling-up. |
| • Lack of policies and information on the process and clearances required for mini-grid development. | ➢ Uncertainty over the mini-grid development process and permitting procedure adds costs and perceived risk to projects. |

# Regulatory Barriers

| Regulatory Factors | Impact on Mini-Grids |
|---|---|
| • Lack of understanding of the culture and capacities of rural and remote regions makes it difficult to estimate electricity demands, establish appropriate payment infrastructure, and select suitable technologies. | ➢ Regulations make mini-grid options unaffordable and do not address the unique needs of rural and remote regions, such as operation and maintenance challenges. |
| • No standard operating procedures, quality standards, or health and safety standards exist for setting up mini-grids. | ➢ The lack of standards results in a high-risk perception that discourages private investment, which limits funding opportunities. Demand for electrification through mini-grids decreases due to uncertainty about the quality of service, accurate billing, and safety. |
| • Existing regulations act as an umbrella for all regions and technologies. | ➢ Mini-grids differ based on the region, customers, and the available resources. Umbrella regulations can discriminate against certain technologies, system management, or tariffs. It is not cost-effective for mini-grids to provide electricity at the same price for all grids and customers. |
| • Lack of protection for developers when mini-grid served areas become grid connected. | ➢ Developers and investors are unlikely to support mini-grids if the region is likely to be connected to the grid in the future. |

# Need to Reduce Project Risks for Private Investors




Source: "Risk and Return Profile, " ARE Working Group on Legal and Policy frameworks, Anjali Shanker, IED, 2009. http://www.ruralelec.org/fileadmin/DATA/Documents/07_Events/WG_Legal_Framework/IED.pdf

# OUTLINE

1. Objective
2. Current Landscape
3. Barriers
4. **Potential Solutions**
5. Opportunities for Progress

## Technical

# Technical Solutions

**Hybrid Smart Mini-Grids**

- **Hybrid smart mini-grids** can overcome many of the barriers challenging 100% diesel systems, which are created by high diesel prices and low fuel availability.
- **The combination of renewable energy technology with a genset** makes the hybrid power system less dependent on fuel availability and affordability and allows the system to provide 24-hour power. Solar and wind power can be substituted for diesel power and reduce diesel fuel use.
- **Local involvement and training** is essential for a successful reliable power system. Training and scheduled O&M services can increase the life and reliability of the system.
- **Adding batteries** to hybrid power systems that have variable renewable energy ensures that electric power is available and can provide frequency and voltage stability.
- **Resource assessments and accurate sizing** of the hybrid mini-grid is key to providing quality power and meeting future load requirements.

# Technical Solutions

**Smart Mini-Grids**

- Many **load management** technologies exist—including GridShare—that enable grid managers to limit power demand during peak hours and to encourage conservation.
- **Smart grid** advances could enable developing countries to leapfrog elements of traditional power systems in terms of both technology and regulation.
- **Improved power consumption of household appliances**, such as energy efficient light bulbs, televisions, and refrigerators, can allow a small amount of low-cost power supplied commercially to go a long way to improving the access picture.

# Technical Solutions

**Mobile Towers**

- New **machine to machine (M2M) module design**—technologies that allow both wireless and wired systems to communicate with other devices of the same ability—could unlock high-volume growth.
- Combining mini-grids and information and communication technology (ICT) allows **remote monitoring and asset management.**
- Mini-grids provide **reliable power** for phones, towers, links, and datacenters.
- ICT may provide **control** of generation resources and interruptible loads.
- ICT may provide **feasible metering and billing** solutions.

# Load Management Technologies

**Load management technologies can significantly improve the level of energy access through off-grid mini-grids.**

**Simple and smart load limiters better manage supply and demand.**


- **Metering encourages conservation.**
- **Prepaid metering enables payment in small increments.**

Bushlight India
http://catprojects.squarespace.com/bushlight-india

SharedSolar
www.sharedsolar.org

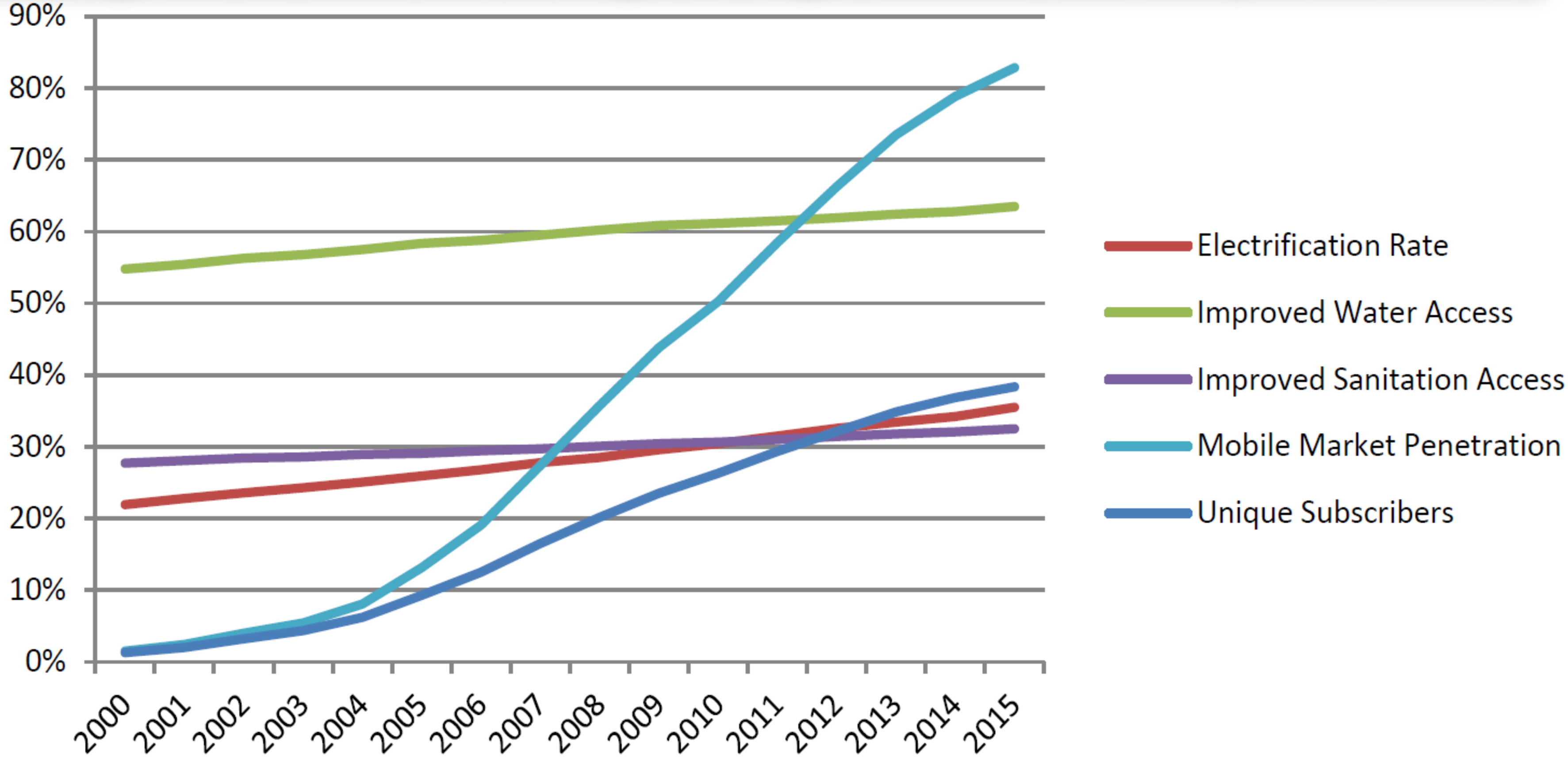
**Centralized communication facilitates monitoring and management.**



Source: Lawrence Berkeley National Laboratory, Schatz Energy Research Center at Humboldt University

# Mobile Phone Penetration Versus Energy, Water, and Sanitation Access in Sub-Saharan Africa

**Pairing communication technology with mini-grids will allow mini-grids to take advantage of high mobile market penetration.**




Source: GSMA, World Bank, IEA 2012

# Finance

# Financial Solutions

**Financial Models**

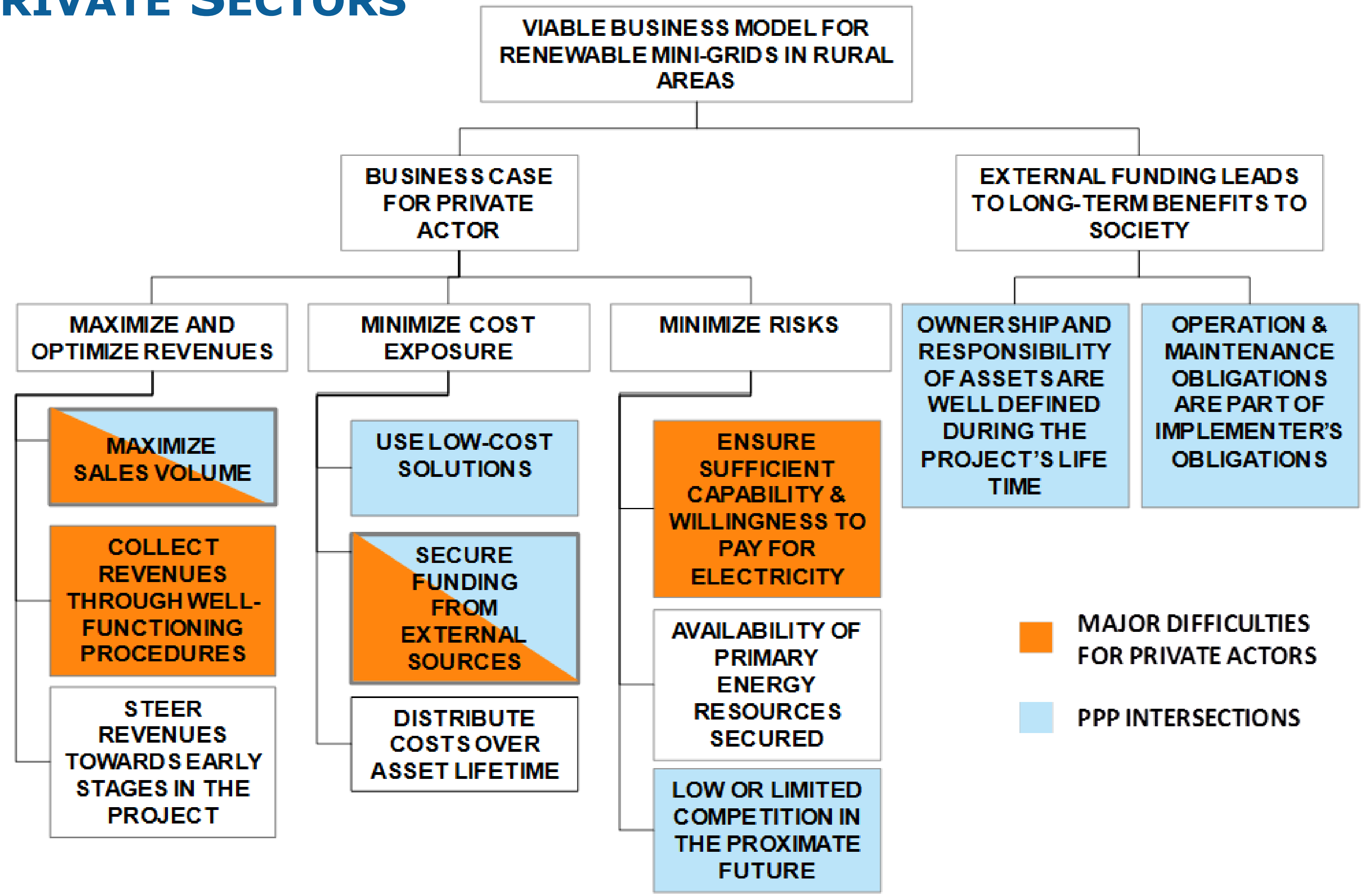
- **Encourage cluster-based mini-grid development** to ensure bankability and commercial viability.
- **Long-term financial support** in the form of subsidies, loans, grants, and investment in renewable energy service companies.
- **Facilitate consumer financing** through M2M connectivity.
- **Easier access to bank finance:** Encourage capacity building of financial institutions and local banks.
- **Consider the long-term investments in renewable hybrid mini-grids.** Hybrid mini-grids typically are the least-cost solution among mini-grids for most locations and natural-resource conditions over the long-term. Also, technology is evolving rapidly and initial costs are decreasing for many renewable  sources of power.

# Financial Solutions

**Financial Models**

- **Involve the local community** through financial participation, such as binding service contracts that secure revenues.
- **Consumers must pay for the service**, including operations, maintenance, and replacement costs.
- Provide "**lifeline tariffs**," or minimal affordable rates, to those who cannot afford the full cost of energy. Subsidized rates can be removed as economic growth increases consumers ability to pay.
- Support parallel **creation of productive economic services** within the project. Productive uses can help to ensure financial viability, long-term project sustainability, and revenues.

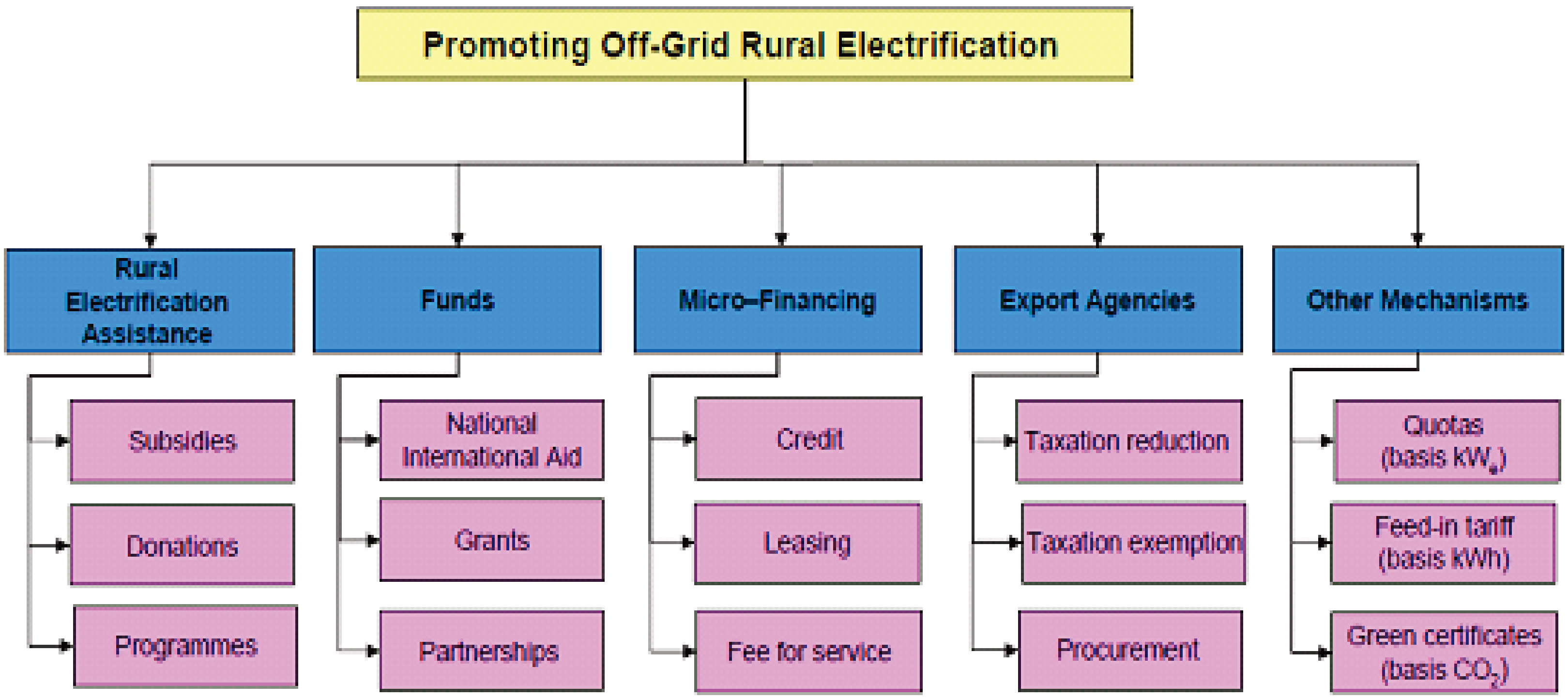
# KEY FINANCIAL REQUIREMENTS FROM THE PUBLIC AND PRIVATE SECTORS






Source: Clean Energy Hybrid Mini-Grids in Remote Areas: An Investment Opportunity. United Nations Environment Programme (UNEP). Draft, 2012.

# Financial Instruments to Support Renewable Energies and Rural Electrification






Source: "Concepts for Hybrid PV Village Grids to Make their Operation a Local Business". B. Ortiz, M. Vetter, S. Gölz, G. Bopp, Fraunhofer ISE, 2007.

# Policy

# Policy Solutions

**National Policy Approaches**

- Encourage public participation from the beginning. Public participation increases energy literacy among the public, provides a sense of ownership over mini-grid projects, and increases the success of projects.
- Do not specify the technologies to be used. All technology options should be made available to allow for the selection of the most efficient and appropriate based on the region’s characteristics.
- Establish a clear set of rules for scaling-up to the central grid. This is critical for assuring mini-grid operators and customers that they will be properly compensated if and when the centralized grid becomes available.
- Support productive use/enterprise development to increase local abilities to pay for energy, thus increasing demand.

# Policy Solutions

**Financial Policies**

- Provide risk guarantees, tax cuts, or other market incentives to private investors.
- Divert international assistance funding from large energy-infrastructure projects and invest it into mini-grid projects.
- Remove excess subsidies for traditional fuels and the centralized-generation paradigm.
- Support access to carbon markets and carbon finance.

# Mini-Grid Policy & Regulation Solutions

## INSTITUTIONAL

- Defined Roles: Ownership, Deployment, Operations and Maintenance
- Regulations and Licensing
- Community Involvement and Capacity Building
- Monitoring and Verification

## TECHNICAL

- Standards: Quality of Equipment, Construction, and Service
- Grid Interconnection and Islanding: Mini-Grids As Part of the Larger System
- Resource Surveys and Potential Site Studies

## FINANCIAL

- Public Support: Capital and Ongoing Subsidies and Incentives
- Financing: Loans, Banking, Channeling Aid and Grants.
- Revenue Streams: Retail and Wholesale Tariffs

Source: Lawrence Berkeley National Laboratory Solar Energy Research Center

# Enacting Policy Solutions Through Rural Electrification Institutions

**Government institutions focused on rural electrification must be created to implement many of the policy solutions.**

**Funding for the institutions should be long-term and reflect a commitment to rural electrification.**

**Roles and Responsibilities:**

- *Assess* the specific needs, resources, and markets of rural areas.
- *Create* a step-by-step process for mini-grid development and each agency involved.
- *Determine* the best technology options, management, and payment infrastructure for mini-grid projects.
- *Select* the best projects for funding and divert funding to those projects.
- *Educate* rural areas about mini-grids, increase capacity and expertise.
- *Establish* regulations for mini-grids based on local characteristics.
- *Encourage* public participation.

# Regulation and Standards

# Regulations and Standards Solutions

**National and International Regulations**

- **Regulation should be light-handed and simplified.** Support streamlined permitting, clearances, and application procedures.
- **Establish realistic and affordable quality standards.** Standards should address power quality, service quality, and commercial quality that allows new connections and accurate billing.
- **Establish basic international standards** for micro- and mini-grids.
- **Vary regulations** based on the system type.
- **"Devolved regulation."** Delegate mini-grid regulations to an established rural electrification institute. Allow regional or local regulatory bodies to set their own tariffs and subsidy levels that are appropriate for local circumstances.

# POTENTIAL INTERNATIONAL STANDARDS ORGANIZATIONS FOR MINI-GRIDS

| | |
|---|---|
| Product/System Standards | Institute of Electrical and Electronic Engineers (IEEE), International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), GIZ, Photovoltaic Global Accreditation Project (PVGAP), American National Standards Institute (ANSI), Lighting Africa |
| Installation Certification | North American Board of Certified Energy Practitioners (NABCEP), International Commission on the Rules for the Approval of Electrical Equipment (IECEE), American National Standards Institute (ANSI), International Renewable Energy Certification Organization (IRECO) |
| Training Workforce | Institute of Sustainable Power (ISP), International Accreditation Forum (IAF), ANSI |


Source: Energy Access Practitioner Network: Towards Achieving Universal Energy Access by 2030. Sustainable Energy for All, United Nations Foundation. 2012.

# International Electrotechnical Commission in Support of Scaling Up

- IEC 62257: Recommendations for small renewable energy and hybrid systems for rural electrification
  - General introduction to rural electrification
  - From requirements to a range of electrification systems
  - Project development and management
  - Prepared jointly by committees on PV, win technology, electrical installations, safety, and others
- IEC in support of scaling up
  - Quality and performance guarantees, for investors
  - Renewables and their technical integration
  - The control problem: State-of-the-art solutions
  - Certification: IEC schemes
  - A single international solution, no country or supplier is privileged

# Selected Case Studies

- Smart Power for Environmentally-sound Economic Development (SPEED); India and East Africa
- OMC Micropower Plants; Uttar Pradesh, India
- Load Management; Rukubji, Bhutan
- Solar Based Mini-Grids; Chhattisgarh State, India
- Husk Power Systems; Bihar, India
- Solar PV Mini-Grids; Sundarbans, India

# Smart Power for Environmentally-sound Economic Development (SPEED); India and East Africa

Mobile phone masts can create additional local loads.

Source: SPEED, 2011

**Mini-Grid Project:**

SPEED aims to leverage the power needs of cell-towers in electricity-starved regions as an anchor load to create a cleaner power infrastructure.

**Lessons Learned**

- The sector character enables raising of capital, including patient capital.
- SPEED highlighted the importance of additional stimulation to the local economy by actively promoting productive uses, such as capacity building of micro-enterprises, etc.
- Mobile payment-collection mechanisms play an important role.
- Scale is possible through SPEED ESCOs, and is rapidly replicable once the business model is proven.

**What Worked:** SPEED uses mobile phone towers as a key anchor load, proposing that the towers that have become ubiquitous in unelectrified regions could serve households, and creates a viable business model.

# OMC Micropower Plants; Uttar Pradesh, India


**OMC Business in a Box.**
Source: Sustainable Energy for All (undated)

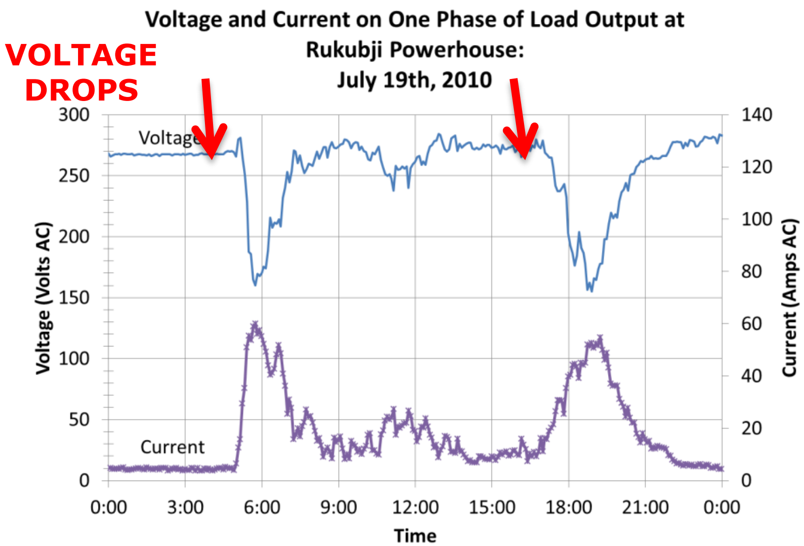
**Mini-Grid Project:**
OMC builds, operates and owns Micropower Plants™ that extract clean energy from sun, wind and biogas.

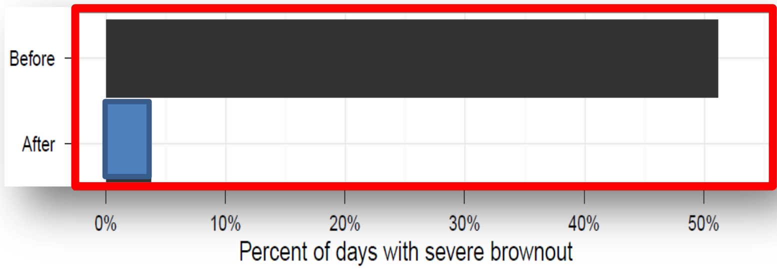
**Lessons Learned**

- For telecom consumers, OMC runs a power cable from the Micropower Plant to the telecom base station and power is provided on a kilowatt-hour-consumed basis.
- For communities within easy reach of telecom base stations serving as "anchor tenants," power is sold on demand through a local entrepreneur that rents out lanterns, power boxes, and other power utility products.

**What Worked:** Micropower Plants™ extract clean energy from the sun, wind, and biogas and include battery banks and diesel generators for backup, and a power management system for optimal energy efficiency and remote access.

# LOAD MANAGEMENT; RUKUBJI, BHUTAN





**Mini-Grid Project:**

GridShare load management technology was developed by the Humboldt State University team to prevent brownouts.

**Lessons Learned**

- The device is intelligent enough to detect rice cookers, and keeps them turned on for people to finish cooking their rice.
- Electrical data indicated a reduction of more than 90% in severe brownouts.
- Reduced spoiled rice, and residents stated that, “the grid is more predictable.”

**What Worked:** Smart load management through GridShare, installed in each household, limits household load only during a brownout or voltage drop.



Source: Lawrence Berkeley National Laboratory Solar Energy Research Center

# Solar Based Mini-grids; Chhattisgarh State, India

**Solar PV power plant.**
Source: credacg.org 2009

## Mini-Grid Project:

A state renewable energy agency (CREDA) has provided electricity access to 35,000 households by operating and managing mini-grid systems.

## Lessons Learned

- A successful example of using both AC and DC solar-PV based mini-grids.
- Subsidies at the same level as grid-connected consumers are justifiable.
- Technicians have been trained at a local level to handle preventative maintenance.
- State entities can also efficiently provide and maintain energy systems.

**What Worked:** State subsidies were necessary to supply energy to the poorest members of society, which were not commercially viable to reach.

# Husk Power Systems; Bihar, India

**Filling a gasifier plant with rice husk, Tamkuha, Bihar.**

Source: Ashden.org, 2012

## Mini-Grid Project:

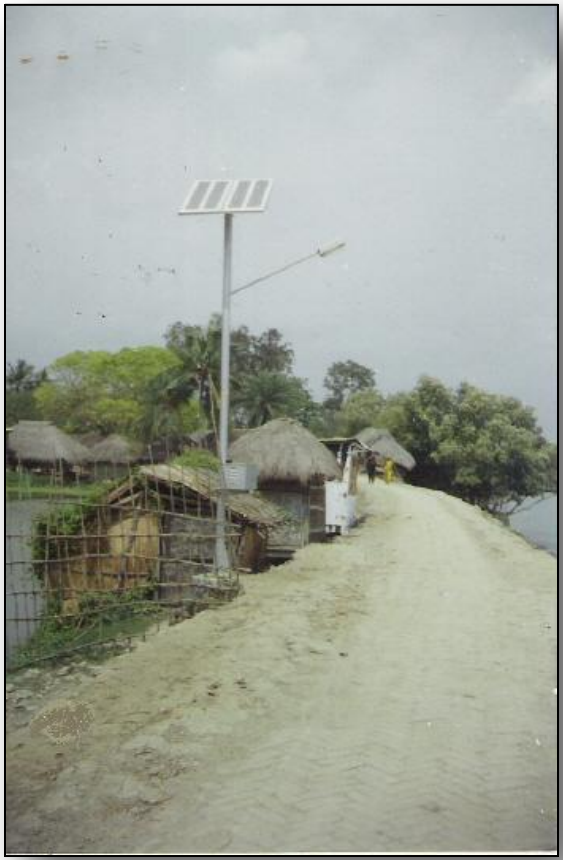
A for-profit company that provides electricity through gasifying waste rice husks in more than 65 power plants (with 10 in development) and delivers electricity to more than 100,000 customers.

## Lessons Learned

- The solution should be entrepreneur-led, not model- or community-led.
- Any organization which provides energy for the poor must make that mission its first priority.
- Quality of the technology matters, but is secondary to the quality of the delivery channel.

**What Worked:** Building local employment through training and education of local people creates local ownership and opportunities for scaling.

# Solar PV Mini-grids; Sunderbans, India



**Solar street lighting.**
Source: WBREDA.org 2012

## Mini-Grid Project:

A mix of central- , state- , and local-level developmental funding, community financing, and public-private local community partnerships has enabled 15 years of mini-grid operation and has provided inspiration for similar projects elsewhere.

## Lessons Learned

- Rural communities are willing to co-finance electrification.
- Sustainable supply can be organized through a cooperative system, including the local people.
- After sales service, revenue collection has been helped by accountable government/community institutions.
- The tariff was set according to existing diesel generation tariff.

**What Worked:** Quality power (not just for lighting) supplied to consumers for 6 to 8 hours increased the community's willingness to pay, and was enforced by local community agencies.

# Lessons Learned in Real World Mini-Grid Experiences

- Mobile phone towers can be used as key anchor loads.
- Technologies such as GridShare can facilitate load Management.
- State engagement and capacity can provide energy to the poorest customers.
- Training and education of the local population creates local ownership and opportunities for scaling-up.
- Quality power increases customer willingness to pay.

# Outline

1. Objective
2. Current Landscape
3. Barriers
4. Potential Solutions
5. **Opportunities for Progress**

# Leveraging Partnership with CEM

Transition to significant scaling-up of mini-grids requires excellence, innovation and smart regulations, and financing by sustained public- and private-sector collaboration. Different aspects are being supported by the CEM through the following:

| | |
|---|---|
| **ISGAN** | International Smart Grid Action Network |
| **MSWWG** | Multilateral Solar and Wind Working Group |
| **CHP** | Combined Heat and Power Working Groups |
| **SEAD** | Super-Efficient Equipment and Appliance Deployment |
| **GSEP** | Global Superior Energy Performance Partnership |
| **CESC** | Clean Energy Solutions Center |
| **21CPP** | $21^{st}$ Century Power Partnership |

# Illustrative Ongoing Activities

**Many parties are taking action to move the mini-grid agenda forward.**

| | |
|---|---|
| **UK DFID** | Initiating a process with an initial focus on Africa, it intends to run a series of consultations, research, analysis, and modeling activities with a view to making a concept recommendation in 2013. |
| **UNEP** | Looking closely at business models for renewable mini-grids in rural areas in Africa, it recognizes that public funding will play an important role in developing physical infrastructure. |
| **ARE & USAID** | Released a report on hybrid mini-grids in 2011 with USAID support, noting that electricity mini-grids can power households and local businesses. Members of the Alliance for Rural Electrification (ARE) have been involved in the implementation of hundreds of mini-grid projects around the world. |

# Illustrative Ongoing Activities

| | |
|---|---|
| **EU Energy Initiative** | Providing technical assistance related activities, with a focus on mini-grids, being supported by the Africa-European Union Renewable Energy Cooperation Program (RECP). The activities started in early 2013, recognizing the important role for mini-grids in enhancing energy access and the use of renewable energy in Africa. |
| **SE4ALL & UNF** | Is working on mini-grids through the Practitioners Network. The network is helping to make global connections with like-minded organizations intent on increasing access to clean-energy solutions. The Network currently hosts more than 500 individuals and organizations from the private sector. |
| **Australian Gov.** | The Australian government has been working on rural and remote mini-grids for decades through work at the University of New South Wales and elsewhere. Through the Bushlight program and Community Energy Planning Model (CEPM) the Australian government has been supplying and designing solar and renewable energy systems for indigenous homelands and outstations. |

# Illustrative Ongoing Activities

| | |
|---|---|
| **IFC** | Is supporting mini-grid companies in India through investment and advisory services. IFC invested in HUSK Power Systems in 2010 and provided advisory support to HUSK for the development of a Management Information System for better data management. Under the Lighting Asia - India program, IFC is supporting mini-grid companies including SunEdison Energy India Pvt Ltd, Minda NextGen Tech Ltd, and a payment solutions company - Simpa Networks through its advisory services to help business scale-up and large scale replication. IFC is also providing research on market and business opportunities for growth, and assessments of barriers and solutions related to regulatory, policy and technical issues. |
| **NREL** | There is ongoing technical work in the areas of islands (such as NREL's Island Partnerships), Indonesia, military use (for bases and installations in theater), hybrid system design (such as RE/diesel, batteries), and analytical tool development (such as HOMER). Extensive smart-grid, load-management controls testing is being incorporated in the new Energy Systems Integration Facility (ESIF). |
| **Columbia University** | The Earth Institute has established a network of 16 mini-grids in Uganda and Mali using innovative pre-paid metering coupled with smart controls. That work is bringing in much needed data sets around economics, technical issues, and behavior. |

# Potential Areas for Collaboration between Companies and Organizations, both Private and Public

## Analysis

- For identifying and optimizing renewable energy integration into the hybrid mini-grids.
- For improved renewable energy resource and cost data.
- For establishing risk finance instruments at scale.

## Mini-Grid Management Tools and Strategies

- Pursue international standards or best practices for forecasting, market design, and data sharing.
- Address hybrid power system design and distributed generation in parallel.
- Develop and share successful business models that keep minigrids going long-term.
- Document best practices and create peer exchange forums for mini-grid management of variable renewables.
- Train and educate people and create good institutions.

# Potential Areas for Collaboration

- **Research & Demonstration Projects**
  - Data collection, validation, and management, including renewable energy resource assessments, mini-grid sensor data, and demand response resource assessments.
  - Expand collaboration and sharing of experiences with high renewable energy integration with islands and other isolated systems (building on Energy Development in Island Nations [EDIN] and related programs).
  - Demonstrate battery and energy-storage technologies especially for larger scale utilization.
  - Integration at a broader-scale: Full systems interface of electricity, fuels, storage, and end-use technologies.
- **Enhancing Capacity and Exchange Programs**
  - Implement and empower national and regional action plans that support renewable energy, energy efficiency, and rural electrification

# International Catalytic Interventions

- **Information Sharing**
  - Establish an international forum on mini-grids, building on existing work, possibly launching this as an initiative tied to both CEM and SE4ALL.
  - Create a global knowledge share platform - through CESC/CEM initiatives.
  - Design and create an international development facility.
- **Technology**
  - Run competitions to improve the energy efficiency and efficacy of demand side devices such as pre-paid meters, lighting, TVs, etc.
  - Invest in storage technologies.
- **Financial**
  - Create a dedicated funding mechanism for mini-grids.
- **Policy & Regulation**
  - Engage at the country level for planning support with the CEM initiatives (CESC, ISGAN, 21CPP, etc.).
  - Develop international standards that are flexible enough to accommodate local conditions.

**Gauri Singh**
***Director of Country Support and Development***
***International Renewable Energy Agency***

**Gauri Singh** joined the Indian Administrative Service, in 1987, as a career bureaucrat.

Has held various policy positions in the field of finance, foreign direct investment, and renewable energy, in the Government of India and Government of MP. Has also led the implementation of large World bank supported livelihood and poverty alleviation projects.

Joined The International Renewable Energy Agency (IRENA) in January, 2011. As Director, Country support and Partnerships (CSP), am responsible for supporting member countries of IRENA, in the development and implementation of national and regional renewable energy strategies. The division assists countries with their Renewables Readiness Assessments (RRAs), advises on follow-up actions and supports key capacity-building efforts. Large regional initiatives like the Geothermal project with Andean countries, Clean energy corridor in Eastern and Southern Africa are being led by the CSP division.

Was the Joint secretary in the Ministry of New and Renewable Energy, Government of India, from 2006 to January, 2011 and was responsible for policy formulation, planning and International cooperation. In this capacity, led major initiatives in renewable energy policy, during this period.

**Anshu Bharadwaj**
***Executive Director***
***Center for Study of Science, Technology, and Policy***

**Dr. Anshu Bharadwaj** is Executive Director of Center for Study of Science, Technology and Policy (CSTEP), a not for profit research corporation based in Bangalore. The think tank directs its research with the vision: 'T*o enrich the nation with technology-enabled policy options for equitable growth'*. Dr. Bharadwaj was among a small group of people that started the organization in 2005. CSTEP has grown from a fledgling organization into a professional policy research think tank of repute with over 50 research staff and an annual budget of about $ 3 Million.

Prior to joining CSTEP, he was a member of the Indian Administrative Services (IAS) and worked with Government of Karnataka in various capacities. He acquired rich experience of working in rural areas in diverse fields such as implementing rural development schemes in housing, education and rural energy; law and order maintenance, providing relief in natural calamities, and conducting State and National elections.

His research interests are in examining low carbon technology policy options. He has led projects in assessment of wind power potential in Karnataka and the engineering economics of solar power generation technologies. He is the Thrust leader for Solar Energy Integration in Indo US Joint Clean Energy Research and Development Center (JCERDC). He is also a member of Planning Commission's committee on Low Carbon Inclusive Growth and is the convener of the Power Sector.

His undergraduate education is in Mechanical Engineering from Indian Institute of Technology, Kanpur and he holds a Masters in Business Management from Indian Institute of Management, Kolkata.

**Pramod Deo**
*Chairman*
*Central Electricity Regulatory Commission*

**Dr. Pramod Deo**, Chairman, Central Electricity Regulatory Commission, is the longest serving (10 years) electricity regulator in India.

Deo has 30 years of experience in the energy sector at policy, regulatory and project management levels. He has worked with two international institutions namely UNEP Risoe Centre on Energy, Climate and Sustainable Development (URC), Denmark and Asian Institute of Technology, Bangkok.

He is a recipient of World Wind Energy Association's Award 2005 for his outstanding achievement in the dissemination of wind energy. He has co-authored three books on decentralized energy planning, energy management and regulatory approach to green power.

**Jamshyd N. Godrej**
*Chairman of the Board*
*Godrej & Boyce*
*Manufacturing Company*
*Limited*

**Jamshyd N. Godrej** is the Chairman of the Board of Godrej & Boyce Manufacturing Company Limited. He graduated in Mechanical Engineering from Illinois Institute of Technology, USA.

Mr. Godrej is the Chairman Emeritus of Aspen Institute India. He is the Trustee and President Emeritus of World Wide Fund for Nature – India. He is the Chairperson of the Board of Directors of Shakti Sustainable Energy Foundation and Chairman of India Resources Trust. He is a Director of World Resources Institute, USA; Director of ClimateWorks Foundation, USA and Director of Global Footprint Network, USA. He is also a Trustee of the Global Board of the Asia Society, USA. He is a member of the Toyota Motor Asia Pacific Regional Advisory Committee. He is the Past President of Confederation of Indian Industry and also the Past President of the Indian Machine Tool Manufacturers' Association.

Mr. Godrej is the Chairman of the CII Sohrabji Godrej Green Business Centre. The Centre is housed in a LEED Platinum demonstration building which is the first green building in India and the greenest building in the world at the time when it was rated. The Green Business Centre is a Centre of Excellence for green buildings, energy efficiency, energy conservation, non-conventional energy sources, water policy, water conservation, etc.

Godrej and Boyce Mfg. Co. Ltd. manufactures and markets refrigerators; washing machines; air conditioners; office furniture; home furniture; security equipment for banks (such as safes, strong room doors, bank lockers, etc.) and for commercial establishments and homes; locks and latches, forklift trucks and warehousing equipment; process equipment for chemical, petrochemical, refineries and allied industries; precision tools for sheet metal, zinc, aluminum; real estate development.

The Godrej group are leaders in home appliances, consumer durables, office equipment, industrial products, consumer products and services.

**Bazmi Husain**
*Country Manager and Managing Director*
*ABB Ltd., India*

**Bazmi Husain** is the Country Manager and Managing Director of ABB Ltd, India. In this capacity, he is responsible for the overall strategic direction and results of the company. ABB operations in India include 14 manufacturing facilities with over 8,000 employees. Customers are served through an extensive countrywide presence with more than 23 marketing offices, 8 service centers, 3 logistics warehouses and a network of over 550 channel partners. ABB in India is headquartered in Bangalore.

Bazmi joined ABB India in 1981 as an R&D engineer and has worked all over the world. For 10 years, Bazmi led teams at ABB's operations in Singapore contributing to the growth of the automation businesses throughout the Asia Pacific region through strong customer relationships and the development of innovative technology solutions. During his stint as head of the automation segment in India from 1998-2000, he orchestrated a business turn-around resulting in double-digit growth which helped to make ABB the largest B to B vendor base in the country.

Bazmi was appointed the head of the global research center in Bangalore in 2002 wherein he scaled up operations of the center, which today is the largest research center for ABB globally. From 2005 through 2009 he was director of ABB's corporate research center in Vasteras, Sweden and also led ABB's global automation technology research, leading the development of many automation solutions currently on the market today.

Before his appointment as the Country Manager and Managing Director of India in January 2011, he headed the global Smart Grid industry segment initiative out of Zurich, Switzerland. While leading the industry segment, Bazmi was instrumental in pioneering agreements with partners such as General Motors and Deutsche Telekom which have helped to make ABB a leading name when it comes to providing Smart Grid solutions.

Bazmi is an electrical and electronics engineer from BITS Pilani and holds an MS in Physics.

**David John Jhirad**
***HRH Prince Sultan bin Adbul Aziz Professor of Energy and Environmental Policy, and Director, Energy Resources and Environment (ERE) Program***
***Johns Hopkins University School of Advanced International Studies***

**Dr. David John Jhirad** is a Professor and the Director of the Energy, Resources and Environment (ERE) Program at Johns Hopkins University School of Advanced International Studies in Washington, DC. He holds the HRH Prince Sultan bin Abdul Aziz Professorship in Energy and Environmental Policy.

Dr. Jhirad is a global leader in the field of energy and power technology innovation, infrastructure investment, science and policy, focusing on resilient and sustainable solutions to climate stability, energy security and poverty reduction. He was the Vice President of Research and Evaluation and the Special Adviser on Energy and Climate Change at the Rockefeller Foundation. Prior to this appointment, Dr. Jhirad served as Vice President for Science and Research at the World Resources Institute, a highly regarded environmental think tank based in Washington, D.C. During the Clinton Administration, Dr. Jhirad was the deputy assistant secretary for International Energy Policy, Trade and Investment, and the senior adviser to the Secretary of Energy. He led U.S. bilateral relationships with all major energy producing and consuming nations, and represented the United States as vice chairman of the Governing Board of the International Energy Agency in Paris and as the lead delegate to the Asia-Pacific Economic Cooperation (APEC) Energy Working Group. As senior energy and science adviser to USAID, he designed and implemented bilateral programs in India, Sub-Saharan Africa and Latin America on energy science and technology innovation, sustainable infrastructure investment, and poverty reduction. Dr. Jhirad has been a Professor and Senior Scientist at Georgetown University’s School of Foreign Service, Brookhaven National Laboratory, and the California Institute of Technology Jet Propulsion Laboratory.

Dr. Jhirad holds a Ph.D. in Applied Physics from Harvard University, where he won the Bowdoin Prize for excellence in research, and a B.A. and M.A. in Theoretical Physics from Cambridge University.

**Richard H. Jones**
***Deputy Executive Director***
***International Energy Agency***

**Richard H. Jones** took up his duties as Deputy Executive Director of the International Energy Agency on 1 October 2008. Ambassador Jones, a former American diplomat, brings to the IEA over thirty years of diplomatic and policy experience on issues ranging from Middle East politics to trade negotiations and energy security. He served as the American Ambassador to four countries: Israel (2005-2008), Kuwait (2001-2004), Kazakhstan (1998-2001) and Lebanon (1996-1998). He also acted as the US Secretary of State's Senior Advisor and Co-ordinator for Iraq Policy from February-August, 2005.

In the energy field, Richard H. Jones has a wide range of policy experience. As Ambassador in Kuwait, he led talks with the Minister of Petroleum on production-sharing proposals. In Kazakhstan, he was the key liaison with the Presidency on the Baku-Ceyhan pipeline and other energy issues.

***Yashraj Khaitan***
***Co-Founder & CEO***
***Gram Power***

**Yashraj Khaitan** completed his undergraduate degree in Electrical Engineering and Computer Science from University of California - Berkeley, and opted out of his postgraduate program to start Gram Power in India. He co-developed the company's core technology after doing extensive research in understanding the challenges associated with bringing reliable power to rural India. In the past, he's worked on solar cell research in Lawrence Berkeley National Labs, Space Sciences Lab, was a founding member of Engineers Without Borders chapter at UC-Berkeley, and has 5 years of prior work experience in his family business in India. At Gram Power, he today leads product and business development and partnership building to scale the company's operations.

Gram Power is an energy technology company out of University of California – Berkeley, providing cutting edge Smart Grid technology to address the electrification challenges in India. Their Smart Microgrid technology creates access to reliable, on-demand AC power for remote rural communities for as little as $3/month, while ensuring 100% payment collection and theft-proof electricity distribution. Their end-to-end solution to manage last mile power distribution holds the potential to save over $10Billion/year of losses to DISCOMs, while creating access to reliable power for the hundreds of millions currently living without it. NASA too selected the company's technology among the top 10 cleantech innovations from around the world.

**Takemitsu Kunio**
***Senior Vice President***
***NEC Corporation***

**Dr. Takemitsu Kunio** is senior vice president, who heads the Smart Energy Business Unit at NEC Corporation. At the Smart Energy Business Unit, Dr. Kunio is responsible for electrodes for automotive lithium rechargeable batteries working together with Nissan Motor Co., Ltd., cloud based charging systems, Home Energy Management System (HEMS), and ICT system for Utilities.

Previously, Dr. Kunio served as Associate Senior Vice President responsible for the Central Research Laboratories at NEC. Before serving as the head of the Central Research Laboratories and managing its operation, Dr. Kunio engaged in research in the field of semiconductor devices for nearly 20 years since joining NEC in 1982.

Dr. Kunio holds a doctorate degree in Engineering from the Keio University of Japan, which he received in 1982. He is also the Fellow member of Japanese Society of Applied Physics.

**Peter Lilienthal**
***President/CEO***
***HOMER Energy***

**Dr. Peter Lilienthal** is the President/CEO of HOMER Energy. Since 1993 he has been the developer of the National Renewable Energy Laboratory's HOMER hybrid power optimization software, which has been used by over 86,000 energy practitioners in 193 countries. NREL has licensed HOMER Energy to be their sole world-wide commercialization licensee for distributing and enhancing the HOMER model.

Dr. Lilienthal was the Senior Economist with the International Programs Office at NREL from 1990 - 2007. He has a Ph.D. in Management Science and Engineering from Stanford University. He has been active in the field of renewable energy and energy efficiency since 1978. This has included designing and teaching courses at the university level, project development of independent power projects, and consulting to industry and regulators. His technical expertise is in utility modeling and the economic and financial analysis of renewable and micro-grid projects. He was the lead analyst and one of the creators of NREL's International and Village Power Programs.

**Terry Mohn**
***Chief Executive Officer***
***General MicroGrids, Inc.***

**Terry Mohn** is Chief Executive Officer of General MicroGrids, Inc, an end-to-end solution provider for renewable energy technologies and transformational microgrid construction. General MicroGrids uses intelligent energy management systems that dispatches clean power and resource control systems for campuses, industrial complexes, electric cooperatives, communities, villages and distribution utilities.

Terry is also Managing Partner at CleanSource Energy Partners, LLC. It is a multi-national company that delivers large renewable energy production in domestic and global markets, with offices in San Diego, Nairobi and Kampala.

Terry is also Project Director for the Global Microgrid Center (a non-profit organization), which is a test and certification, R&D and innovation facility focused on advancing microgrid supplier capabilities to address the changing energy market. The Center is designed to test and certify electric energy equipment, software, construction and project delivery. It is a partnership between Santa Fe Innovation Park, Santa Fe Community College, US Laboratories, multi-national corporations, researchers, work force developers and global non-governmental organizations.

Terry also serves as chairman of the United Nations Foundation MicroGrid Work Group focused on "Sustainable Energy for All", that provides a global platform for practitioners to identify and address market and other barriers to the effective delivery of clean, affordable energy services for the globe by 2030.

Terry is also an appointed Federal Advisor to the Dept of Commerce's NIST agency, providing the agency direction in its smart grid-related programs and activities as they lead a nationwide effort to expedite the development of interoperability standards for the smart grid. He continues advising the US Dept of Energy and California Energy Commission for research and emerging technologies. He worked closely with many DOE laboratories developing future energy standards. He was a co-founder of OpenAMI and UtilityAMI, now part of OpenSG, to develop requirements and standards for consumer access to the smart grid.

Terry was previously VP Innovation of BAE Systems energy business and Chief Technology Strategist for the Sempra Energy utilities. He served two terms as Vice Chairman of the GridWise Alliance, Chief Technology Officer for an international broadband media company and founder of two Internet companies.

**Jeeva Perumalpillai-Essex**
***Manager, Sustainable Business Advisory, South Asia Region***
***International Finance Corporation***

**Jeeva Perumalpillai-Essex** has over 30 years of development experience of which 20 years is with the World Bank Group working in Africa and Asia. Since 2000, she has been a leader of the World Bank's sustainable business practice in Africa, East Asia and South Asia.

In Africa, she was responsible for rural development and infrastructure project lending in Southern and Eastern Africa. In East Asia Region she led the World Bank's sustainable lending and advisory activity in South East Asia. Jeeva recently moved to India and is South Asia Regional Manager for IFC's sustainable business, managing a growing program of advisory activities with private sector companies in the five countries.

Jeeva previously worked for the Asian Development Bank, Australia's EXIM Bank and the Government of Sri Lanka before joining the World Bank in 1990. She has an Honors B.A in Economics from UK's London School of Economics and an MSc in Agriculture Economics from Australia's University of New England.

**Neeraj Prasad**
***Manager, Climate Change Practice***
***World Bank Institute***

**Neeraj Prasad** is the Manager for the Climate Change Practice in the World Bank Institute, which is focused on supporting capacity development for energy access, governance issues in development and climate change, climate-smart agriculture, and innovations in carbon markets/climate financing. Before joining the World Bank in 1996, he was a member of the Indian Administrative Service for eighteen years, working as a development administrator in the North-Eastern Indian hill state of Meghalaya, followed by an assignment with the federal Finance Ministry, and finally as Assistant to the Executive Director for India in the International Monetary Fund. In the Bank, he has supported and led Environment sector operations in the South Asia and East Asia & Pacific regions, and was team leader of the China HFC-23 project, which remains to date the single largest Carbon Finance transaction ever undertaken by the Bank. He also supported the management of the Carbon Finance Unit in the Environment Department for two years.

Mr. Prasad has Masters' degrees in International Commerce & Policy (George Mason University) and in History/Asian Studies and Political Thought (University of Delhi). He has co-authored a number of climate change analytical pieces and handbooks, and has spoken on the topic at seminars and workshops across the world.

**Sairam Prasad**
***Chief Technology Officer and Head of Operations Bharti Infratel Limited***

**Sairam Prasad** is the “Chief Technology Officer and Head of Operations” at Bharti Infratel Limited. He has over 20 years of rich experience in the areas of Telecom Network Rollouts, Network Planning, Technology and Operations. He held key leadership roles across reputed telecom organizations like Tata Cellular - Bell Canada International, Birla Tata AT&T, Idea Cellular and Tata Teleservices (WTTIL).

At Bharti Infratel, he is responsible for leading technology needs and applications, while driving technical innovation initiatives. He has lead Infratel's pioneering “P7 Green Towers project”, of adopting clean technologies for power generation and energy efficiency at its tower sites, through options like the Solar Photo Voltaic. This first-of-its-kind initiative is credited as one of the largest solar power rollout in the world by a passive infrastructure company.

These Innovative Green Power and Energy Efficiency efforts have earned prestigious Awards for Bharti Infratel from

- “CNBC TV 18 Infrastructure excellence award,
- GSMA Global Mobile Award and
- CII National Energy Efficiency award”.

Mr. Sairam has also lead major network deployments across multiple circles, which were instrumental in launching services for major operators in the country. He has formulated and driven cost reduction programs on Capex, Opex and Energy Costs in GSM, CDMA and Tower Infrastructure Businesses. He is an electrical engineer with certifications in various Leadership and Management programs, Project Management & Six Sigma.

He is also credited as being highly valued Key Speaker in various industry forums on Wireless Telecom Networks, Telecom Infrastructure, Backup Power Industry and Renewable Energy Sectors. He is a key working Group Member in GSMA Green Power for Mobile Program and Member in TAIPA Energy Committee.

**Anil Raj**
***Chief Executive Officer***
***OMC Power***

**Anil Kumar Raj** is a veteran of the telecom industry with roots tracing back to the earliest days of mobile telecom. Anil was the start-up CEO of Hutchison in India and launched the country's very first mobile network. He started his career at Ericsson where he held a number of senior leadership positions in Sweden and in Asia Pacific.

As Head of Ericsson's Smartphone business, he was responsible for launching the world's first smartphone and first Bluetooth product. He also headed Ericsson's businesses in India and Indonesia establishing the company as the market leader in mobile infrastructure. While at Ericsson he also spearheaded the merger of Ericsson's and Sony's handset businesses into Sony Ericsson and went on to forge the Symbian mobile software initiative where he also served as Chairman.

**Sandra Retzer**
***Managing Director - Asia Pacific***
***Younicos AG***

**Sandra Retzer** is the Managing Director Asia- Pacific of Younicos AG, a German company specialized in the management of energy storage technologies and systems for a stable power supply from renewable sources. The company also advises several European governments and international financial institutions on energy policy and strategic investments in the renewable energy sector.

In the past 19 years- after getting a diploma in Business Studies as well as a diploma in Chinese language studies- Mrs. Retzer has been living in Germany and China working for different transnational companies in infrastructure projects. She has also been working as a Senior Consultant for GIZ (Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH) in China in the field of climate change, green investment and environment as well as economic and structural reforms and innovation policy.

Currently, Sandra Retzer is the Chair of the smart grid working group of the European Union Chamber of Commerce in China, Beijing.

**Rahul Sankhe**
***Managing Director—Indian Operations***
***SunEdison Energy India Pvt Ltd***

**Rahul Sankhe** is the Managing Director, Indian Operations for SunEdison.

Rahul Sankhe has an extensive background in cleantech and climate change, having played an important role in defining the National Solar Mission policy for India.

Rahul joined SunEdison in 2010 as Business Development Director for South Asia and Sub-Saharan Africa. He played an instrumental in setting up Indian Operations, and drove the expansion of SunEdison's footprint to Thailand, Malaysia and South Africa.

Prior to SunEdison, Rahul Sankhe was a senior engagement manager with McKinsey & Company Mumbai, where he advised leading Indian corporations on strategy and operations and also led the climate change practice for India. Rahul Sankhe also has semiconductor industry experience, having worked in semiconductor R&D in silicon valley for several years, where he worked on next generation process technologies for LSI Logic Corporation.

Rahul Sankhe holds a B Tech from Indian Institute of Technology, a MS from University of Texas at Austin and an MBA from Indian School of Business, Hyderabad.

**Ajay Sharma**
***Managing Director***
***Entura India***

**Ajay Sharma** is the Managing Director of Entura's India operations in New Delhi. He has around 20 years' experience in the renewable energy industry, predominantly with engineering and project management roles in hydro power development projects. In his current role, leading the India operations, Ajay is responsible for strategy development and implementation; business development, sales and account management; human resource management and project management. During his tenure with various consultant firms, Ajay has also been actively involved in project designs, feasibility studies, project management, business development and project management, bringing a strong understanding of renewable energy project development. Ajay is a civil engineer, also holds Diploma in project management and a Masters in Business Administration.

**Frans Vreeswijk**
*General Secretary*
*International Electrotechnical Commission*

**Frans Vreeswijk** became International Electrotechnical Commission (IEC) General Secretary and CEO on 1 October 2012, having served as Deputy General Secretary since 1 March 2012. Prior to joining IEC Central Office, he worked for 30 years for Philips in the Netherlands, Austria and the USA, notably in research, healthcare and consumer electronics areas. Previously he was President of the Dutch National Committee of the IEC (NEC) and has served on the IEC CB and SMB as well as representing the Netherlands in CENELEC.

The General Secretary is the Chief Executive Officer of the Commission and is responsible for its day-to-day operations.