INTERNATIONAL RENEWABLE ENERGY AGENCY

IRENA

International Renewable Energy Agency

Renewable Energy Technology for Rural and Remote/Island Areas

Global Perspective

Bangkok, 21 June 2016

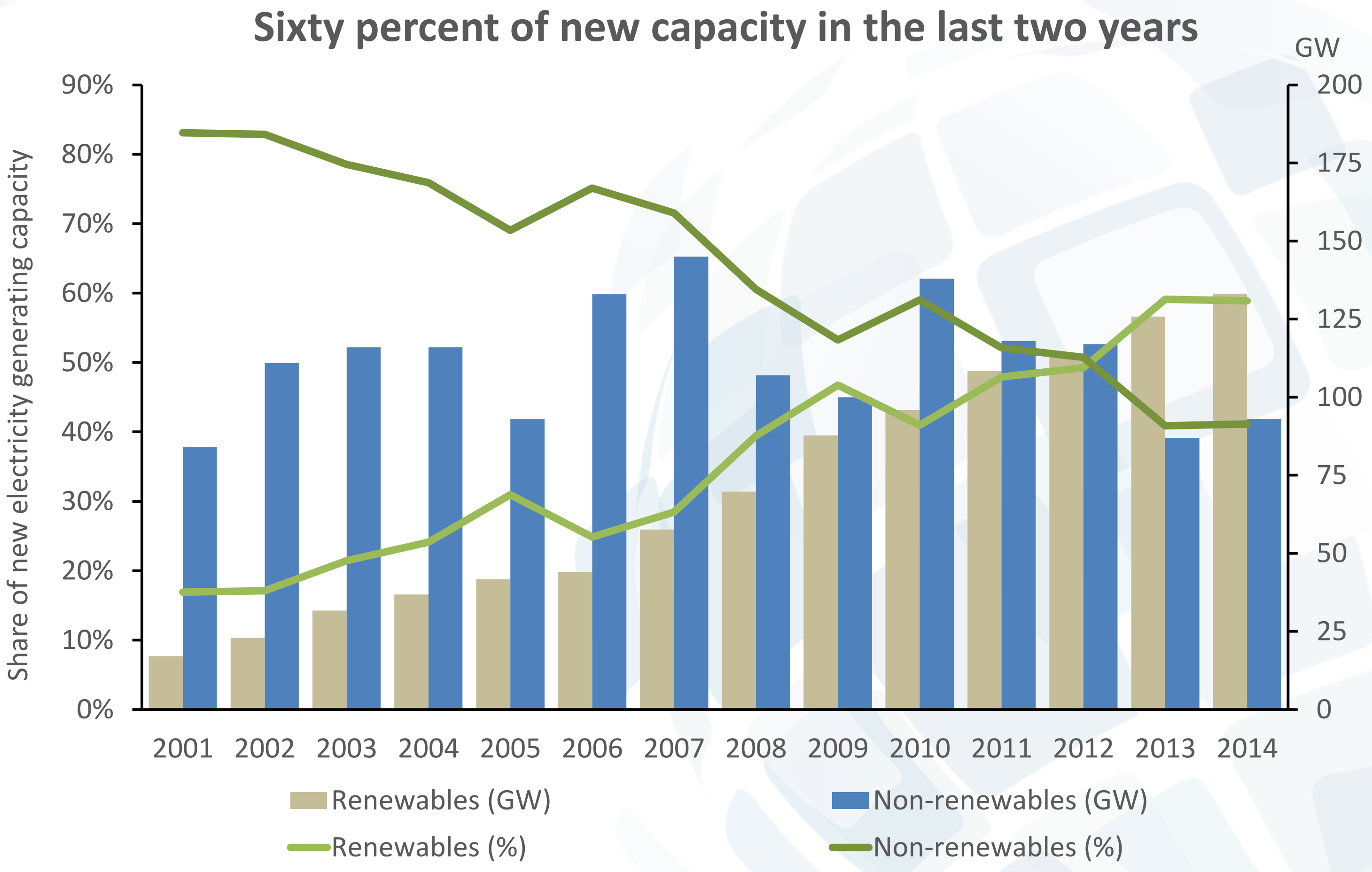
Global Trend
Renewable Energy Development

2015: a record year for renewables

- **156 GW of renewable energy capacity** added, including **51 GW PV, 64 GW wind power,** representing more than half of the global added power generation capacity
- Investment into renewables, excluding large hydro, has risen from USD 55 billion dollars in 2004 to **more than USD 285 billion in 2015**, at an annual growth of over 16%
- Solar **PV USD 29/MWh** in Dubai; **wind USD 40/MWh** in Egypt
- The wide adoption of the **Paris Agreement**
- **Emissions from the energy sector trends to flatten out** largely attributable to the increased use of renewables

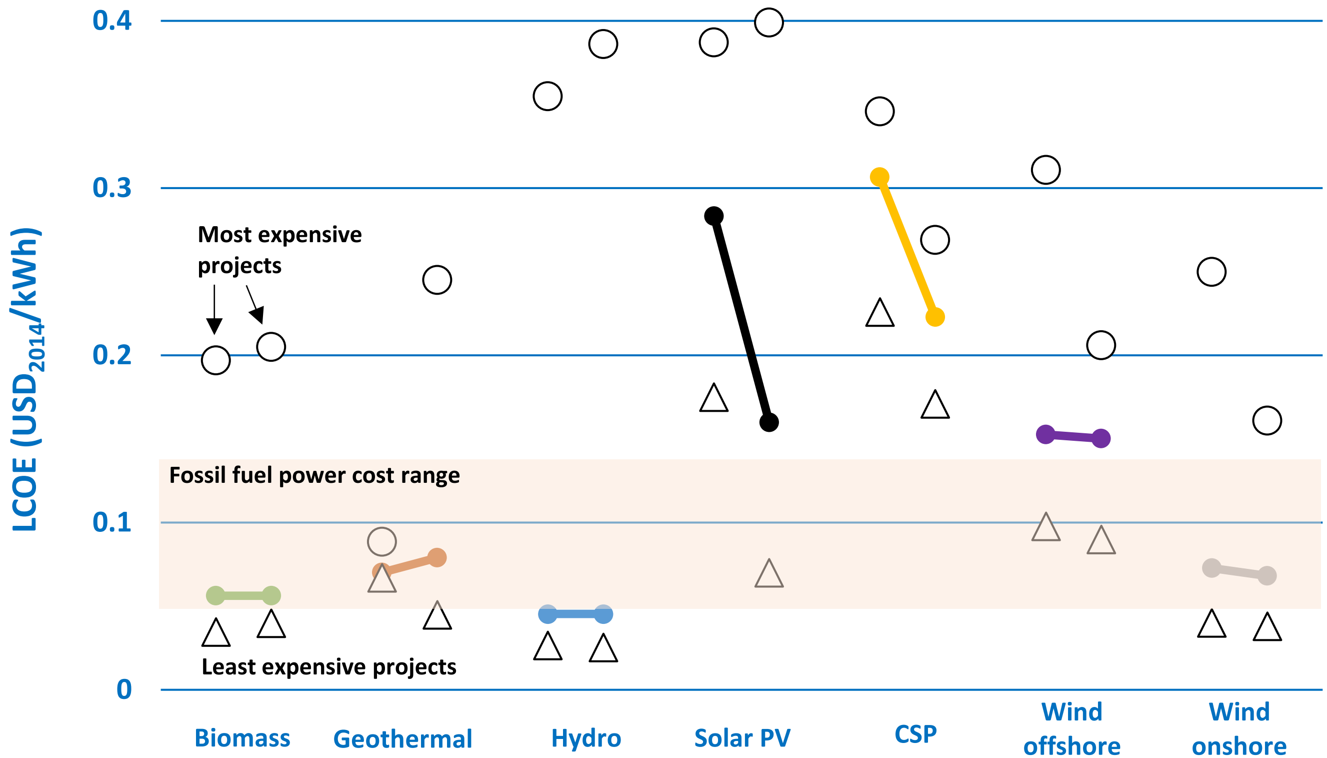
Renewables investments have overtaken non-renewables

#REmap



2015 record year in installations of solar PV (51 GW) and wind (64 GW)

Falling costs of renewables



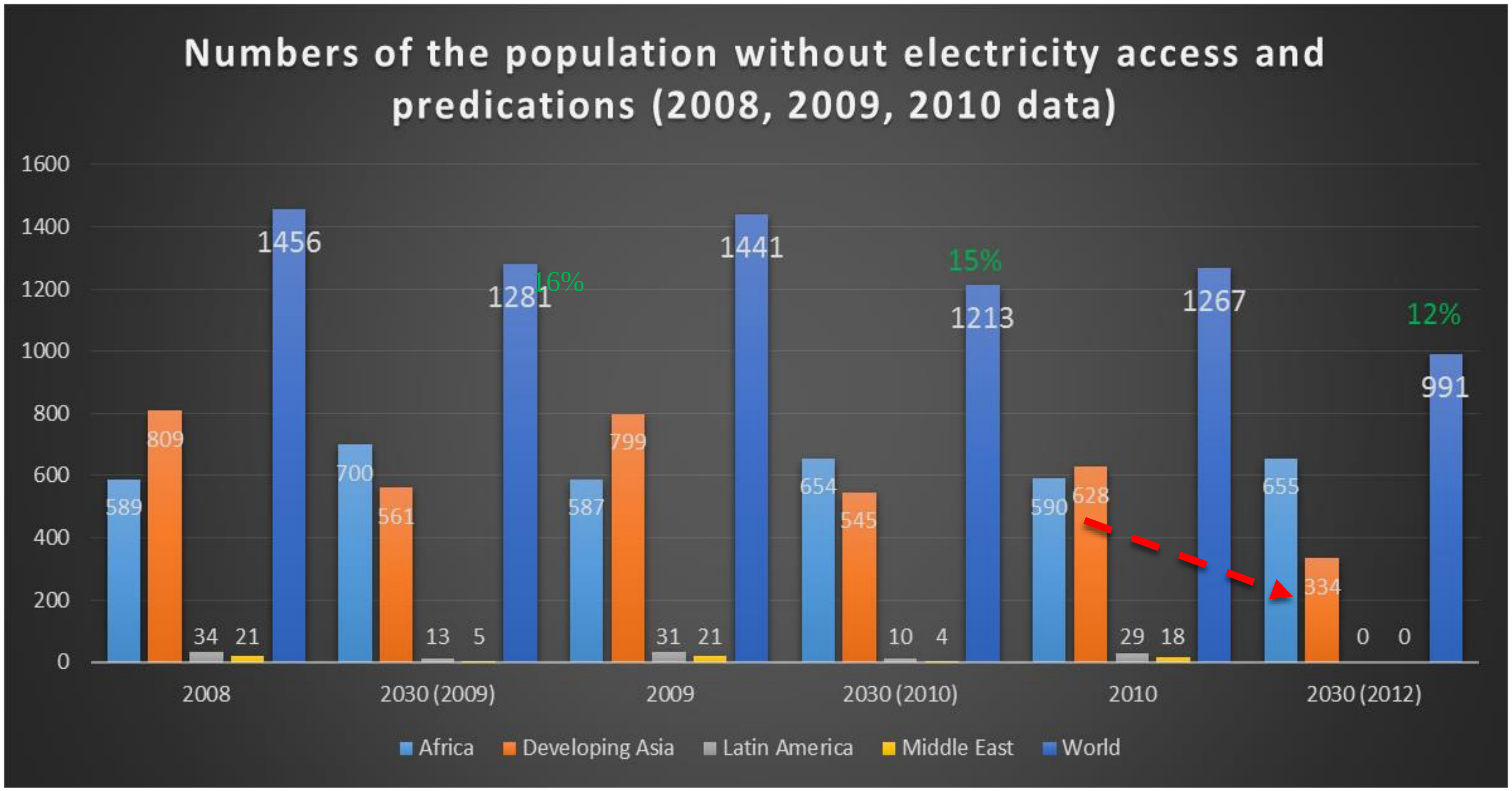
Left side: 2010
Right side: 2014

Solar PV module prices have dropped by more than three-quarters since 2010, while global wind turbine prices have declined by around 30% since the same year

What does it mean to rural and remote areas?

The Challenge

- By 2030, despite of 1.7 billion of new electricity users, still about 1 billion people without access to electricity
- By 2050, energy demand is set to more than double



The Main Grids

Power grid extension sometimes means differently to different people

Renewable Energy Solutions

Off-grid renewable energy systems now represent the most cost-effective solution to expand electricity access in many rural areas

Energy supply by renewable resources providing more than just renewable energy sources

Islands are moving forward…

Vanuatu Wind Farm

Tonga Solar Farm

Solar Power in Nauru

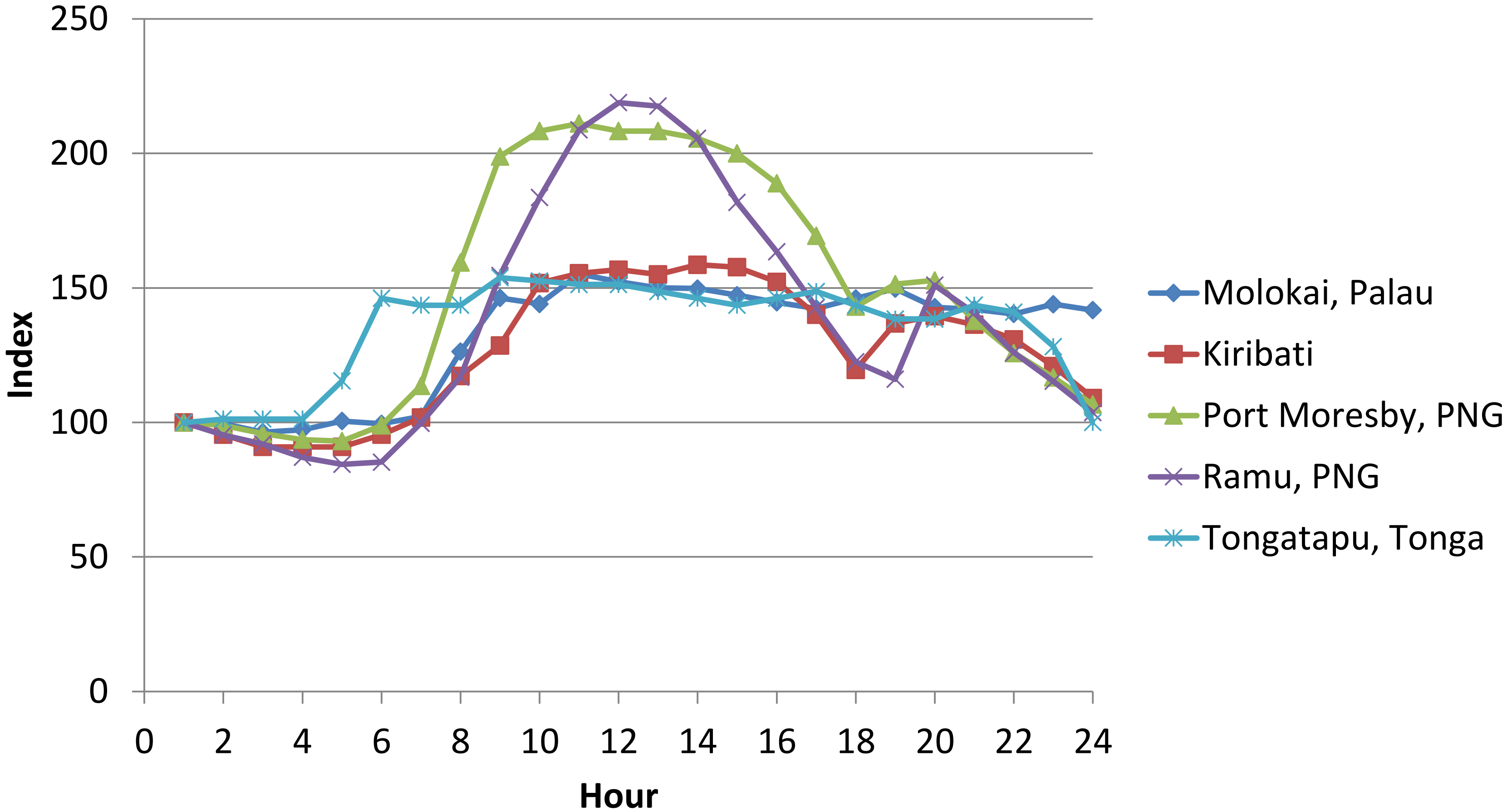
Pacific Leaders Energy Summit, Tonga 2013:

- Need for co-ordination between donor offers & national needs
- Need to work fast & maintain momentum
- Need to work holistically & consider interlinks with other sectors (tourism, water, etc.)

Kiribati PV Drives PC

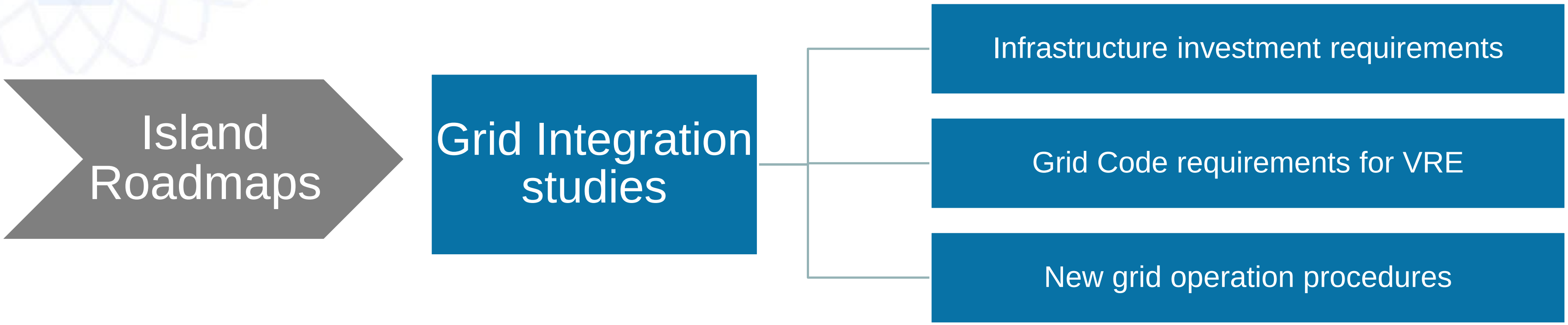
Solar PV electricity matching demand well in some cases

Pacific load curves *Day peak fits well with PV, yet grid integration is a growing challenge*



Source: IRENA, 2012

Grid integration studies



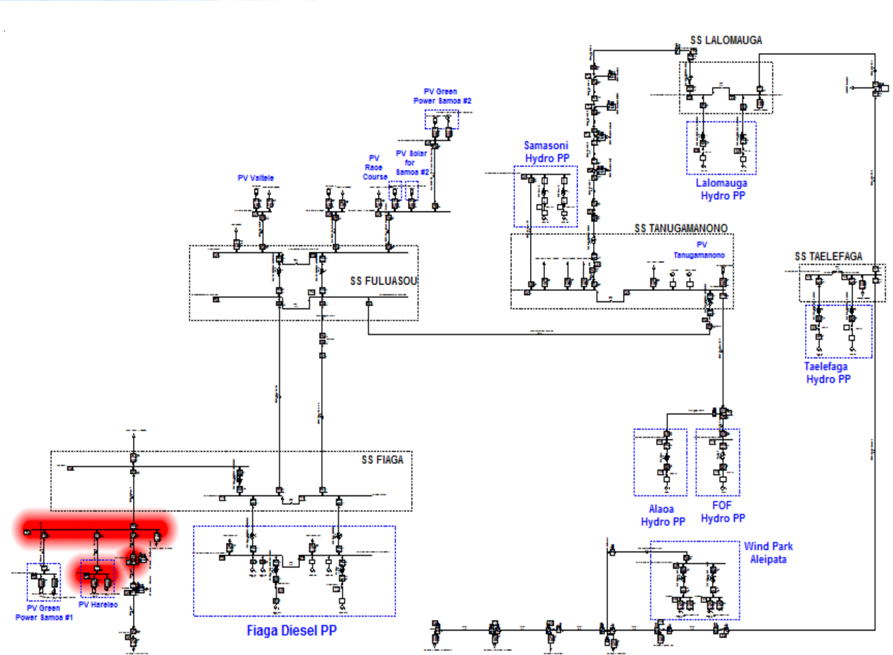
Facilitate coordination between long-term, policy-driven RE targets and their actual deployment in the grid

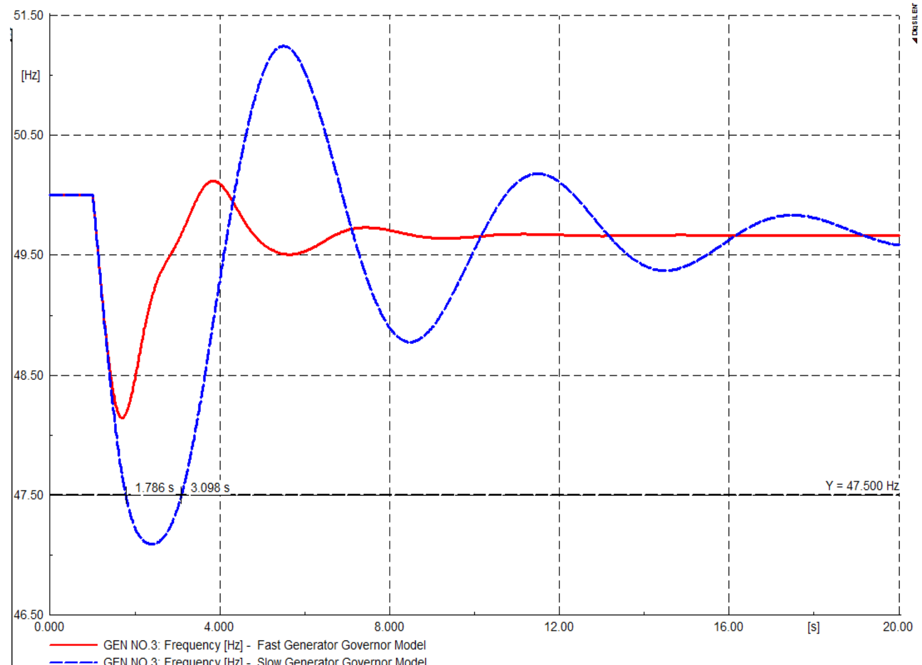
Assessment of reliability and security of the system with planned penetration levels of VRE through statistical analysis and electricity grid modelling & simulation

Identification of technical solutions to maintain reliable grid operation

Provision of technical assistance and online access to simulation software DIgSILENT PowerFactory to do grid studies with local human capacities

IRENA Grid integration studies

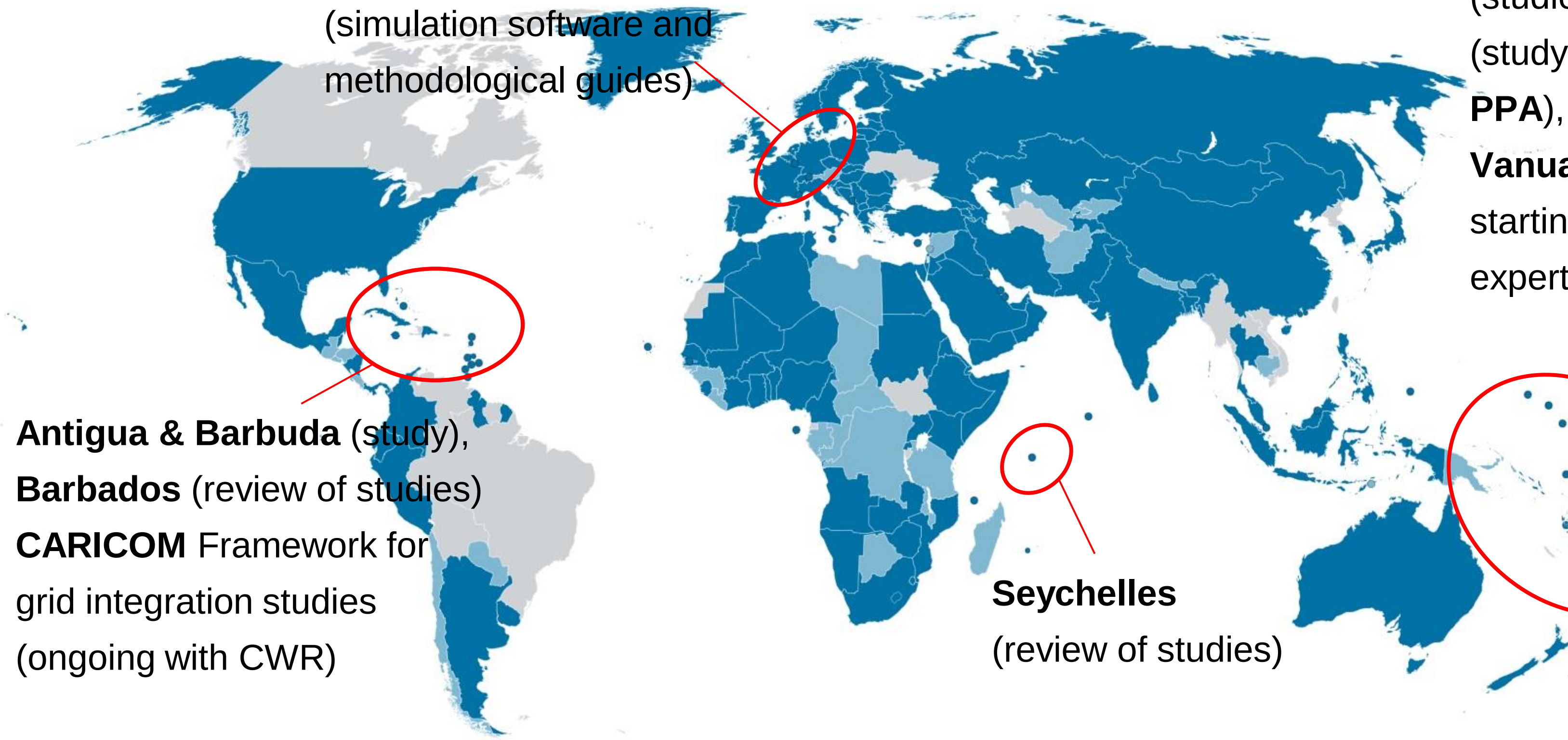




- Detailed electrical grid modelling
- Assessment of reliability and security of the system with planned penetration levels of RE
- Identification of technical solutions to maintain reliable grid operation
- IRENA's support provides technical assistance and simulation software to do grid studies with local human capacities

Grid integration studies

Cooperation with decision makers, network operators and technical experts at a global level supporting exchange of experiences on grid operation & expansion



DIgSILENT, TU Darmstadt, TRACTABEL-ENGIE (simulation software and methodological guides)

Samoa, Cook Islands, Palau (studies), **Kiribati** (study ongoing with **PPA**), **Fiji & Vanuatu** (studies starting), Regional expert meetings

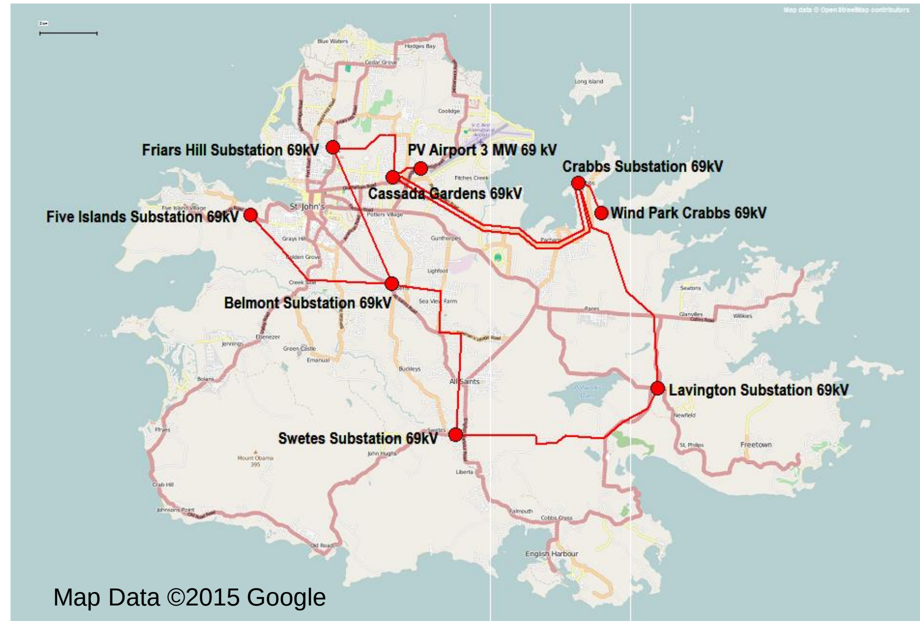
Antigua & Barbuda (study), **Barbados** (review of studies) **CARICOM** Framework for grid integration studies (ongoing with CWR)

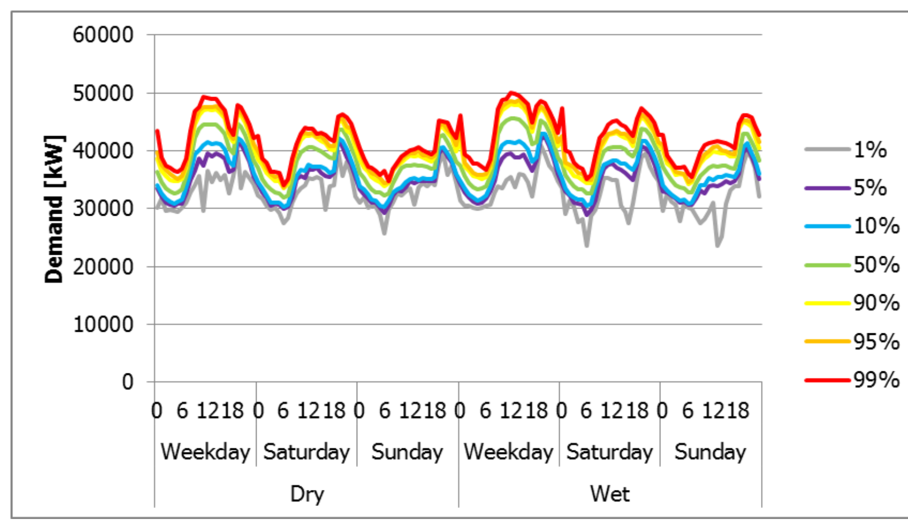
Seychelles (review of studies)

Case study Antigua - background

Antigua

- Peak load around 50 MW
- Annual electricity consumption around 350 GWha
- Over 100 MW of installed diesel capacity
- 160 GWha purchased under PPA
- Assessment impact of 9 MW of PV and 18 MW of wind (government projects)
- Identification of maximum capacity of the network to host PV systems





Study case Antigua – findings

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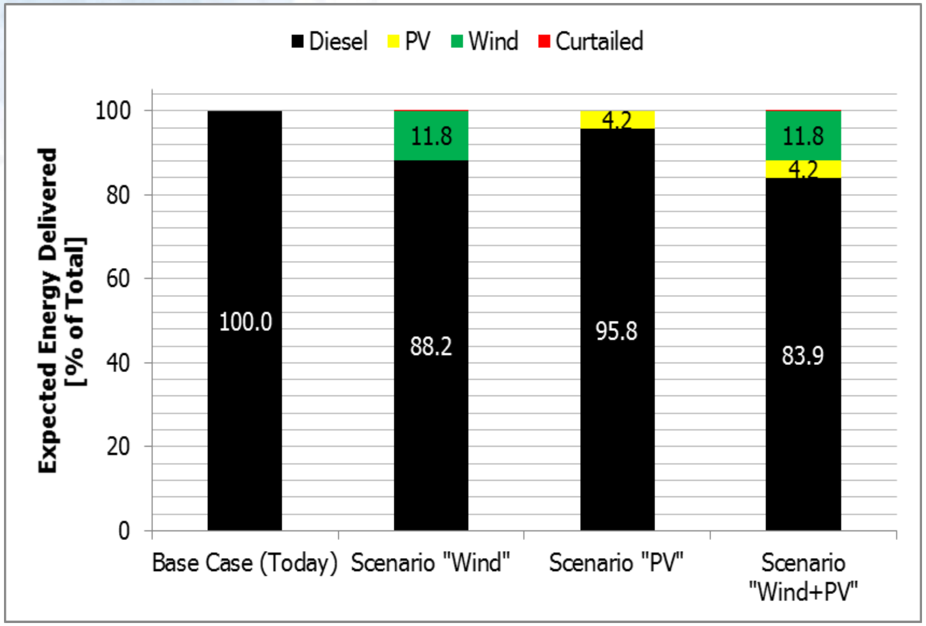
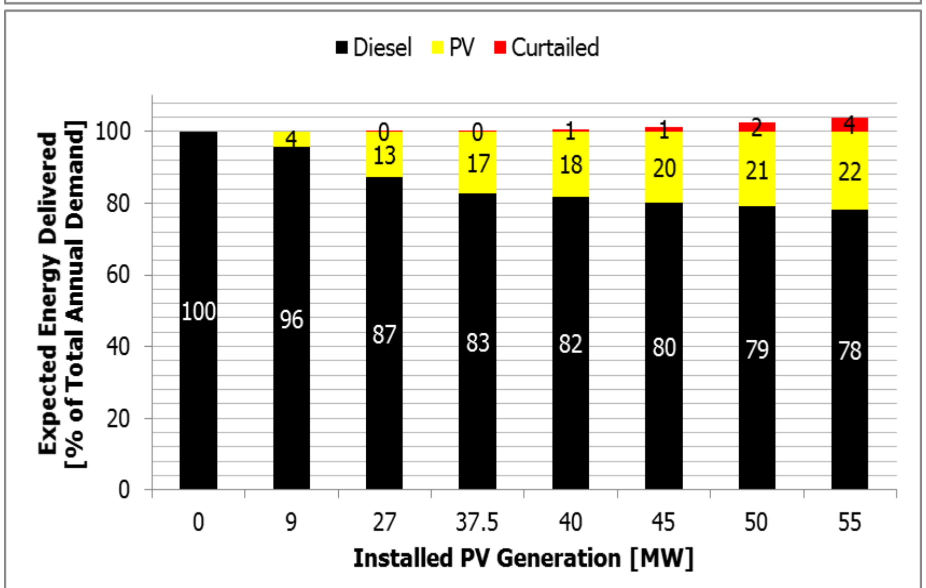




- Performance criteria fulfilled without major updates in the grid
- Changes in reserve allocation practices required
- Utility not willing to allocate contingency reserves
- Stability of the system relays on load shedding scheme
- Grid support functions provided by utility scale PV and wind are crucial: Reactive power control capability, FRT, Over
- frequency response
- Frequency range of operation of utility scale PV and wind must be the same from protection settings of diesel generators
- Automatic generation control recommended

Lessons learned in Island cases

- IRENA’s approach has evolved from “grid stability studies” to **grid operation planning**
- The deployment of high shares of variable renewables is a **long journey**
- **Each island is a unique case**. Particularities define approach required for assessments
- Grid integration assessments are a **continuous / iterative process**
- **The biggest challenges** are data collection and communication of messages

Mini-grid innovation & technology outlook

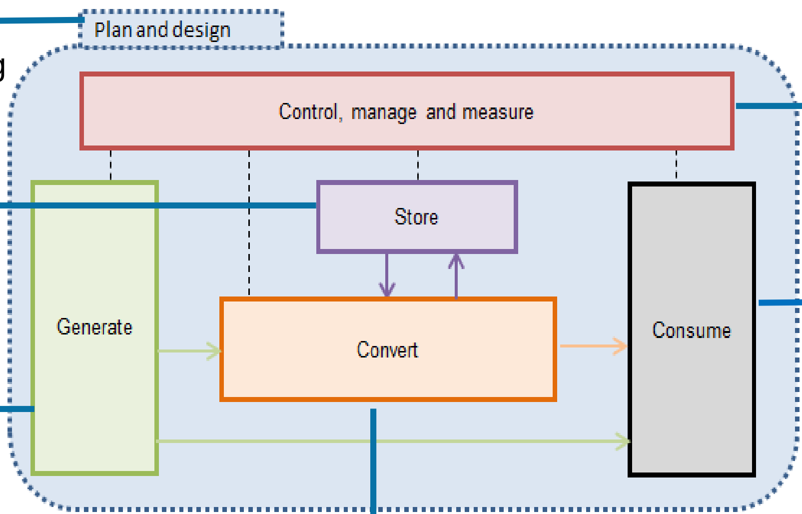
This report evaluates technology innovations renewable energy based mini-grids:

- Autonomous basic and full service
- Interconnected for community and industrial applications

Mini-grid design
Resource and load planning

Electrochemical
Mechanical
Thermal
Chemical
Electrical

Photovoltaic
Wind
Hydro
Biomass
Technologies

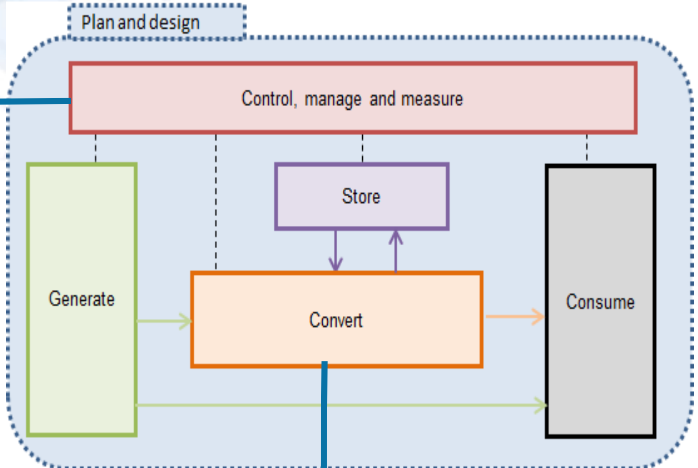


Controls
Data communication and standards
Metering and monitoring
Interoperability and interconnection

DC appliances and DC grids
Demand-side management
Energy efficiency

Grid-following inverters
Grid-forming inverters
Dual mode inverter
DC-to-DC conversion

Innovation & technology outlook: Technology Research Opportunities



Control, Manage and Measure

Indicators	2015	2025	2035
Cost of controls	Specialized and expensive	Increasingly modular, lower cost	Low cost modular
Control intelligence	Non-economic, non-predictive	Economic based controls	Economic and predictive
Plug and play capability	Moderate	Increasingly modular	Seamless
Utility acceptance of REBMGs in grid	High interest, limited to pilots	Increasing number of commercial projects	Standard interconnection
Communication and Standardization	Numerous competing standards	Increasingly standardised	Common, open-source
Prediction of renewable resources	1-2 hours with high accuracy	Several hours with high accuracy	Day-ahead with high accuracy

Grid-forming converters

Indicators	2015	2025	2035
Cost (USD/kVA)	500 – 1200	400– 1000	300 – 800
Efficiency -DC to AC (%)	85 – 90%	87 – 93%	90 - 95%
Efficiency -AC to DC (%)	90 – 95%	92 - 97%	95 - 98%
Lifetime (years)	5 - 10	7-12	10-15

Grid-following converters

Indicators	2015	2025	2035
Cost (USD/kVA)	110 - 170	100-150	100-150
Efficiency -DC to AC (%)	95 - 98%	95 - 98%	95 - 98%
Efficiency -AC to DC (%)	N/A	N/A	N/A
Lifetime (years)	5 - 10	7-12	10-15

Dual-mode converters

Indicators	2015	2025	2035
Cost (USD/kVA)	650 – 2500	520 – 2000	450 – 1600
Efficiency -DC to AC (%)	93% - 96%	94 – 97%	95 - 98%
Efficiency -AC to DC (%)	87 - 92%	91 – 5%	95 - 98%
Lifetime (years)	5-10	7-12	10-15

Innovation & technology outlook: REBMG Innovation Prospects

The Renewable Energy Based Mini-grid of the Future

	2015	2025	2035
Ease of deployment	Custom engineering based on local needs and resources	Planning tools with increasingly modular and scalable technologies	There are standard off-the-shelf products available and low-cost robust planning tools for easy deployment of REBMGs
RETs penetration	Low-penetration RETs considered in autonomous mini-grids	Autonomous and more economical mini-grids with low cost storage, generation and intelligent controls	Interconnected mini-grids considering higher penetrations of RET for cost-effective resilience
Commercialisation	Mostly pilots, some commercial autonomous REBMGs for basic service	Commercial autonomous REBMGs for basic service. Some commercial autonomous REBMGs for full service	Commercial autonomous REBMGs for basic and full service. Some commercial interconnected REBMGs for community and industrial applications

The role of policy makers: Economic, educational, regulatory and market policies

The role of private sector investors:

- Undertake fundamental research
- Implement pilot projects
- Deploy REBMNGs
- Transfer technology
- Develop standards and build relationships

ProSPER: Promoting a Sustainable PV Market in the ECOWAS Region

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Objective:

Development of a sustainable market for off-grid PV applications by:

strengthening and developing local capacities of **policymakers**, **regulators and utilities, financial institutions** and renewable energy **entrepreneurs.**

ECOWAS Renewable Energy Entrepreneurship Support Facility

<u>Objectives:</u>
Assist entrepreneurs in specific requests for improving their business operations.
Provide mentorship and technical support to existing entrepreneurs.
Provide advisory services upon request.
Refine entrepreneurs' Project proposals to bankable levels.

<u>Subject to External Funding:</u>
Established fund to support entrepreneurs in obtaining seed funding and testing the viability of their ideas.
Increased demonstration of pilot projects.

2iE

Certification project for solar PV installers in ECOWAS

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Trained and Certified Technicians

International Certification Accreditation
(e.g. ANSI, ISO/IEC 17024)
Verifies that certification providers adhere to international standards

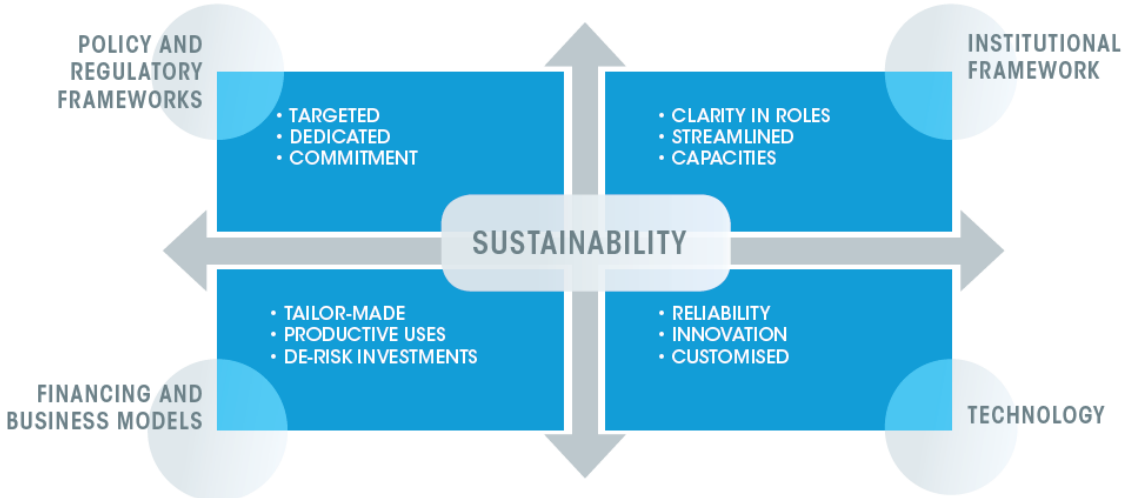
National or Regional Training Accreditation
(e.g. IREC, with IREC Standard 01023)
Accredits training programmes, academic institutions under international standards

National or Regional Education Providers
(e.g. local universities, technical colleges, vocational training centres)
Prepare curricula and training course content based on JTA

Regional Certification Provider
(e.g. NABCEP)
Develops technical guidelines (JTA) for renewable energy and designs exams

- IREC: Inter-State Renewable Energy Council
- NABCEP: North American Board of Certified Energy Practitioners
- JTA: Job Task Analysis (Technical guidelines, competency standards)

Enabling environment for off-grid RE deployment



Source: IRENA, 2012

1. **Moving away from a project-by-project approach** towards a market-based approach where scale up in off-grid RE can occur sufficiently enough to meet 2030 targets.

2. **Ensuring sustainability in energy access efforts** wherein all elements of the energy service delivery model contribute to reliability and cost-effectiveness.

3. **Leveraging local enterprises and capacities** to expand electricity access in rural areas, rapidly and sustainably, and to maximise value creation.

Scaling-up off-grid renewable energy deployment : IOREC Platform

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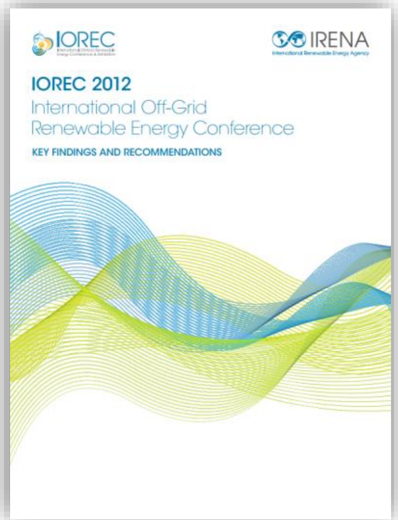
IOREC
International Off-Grid Renewable Energy Conference & Exhibition

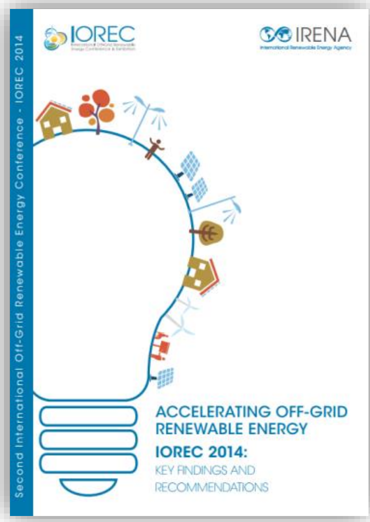
Objective

- Identify key barriers and drivers for stand-alone and mini-grid RE system deployment
- Platform to share experiences, lessons learned and best practices

IOREC 2012 : Accra, Ghana



IOREC 2014 : Manila, Philippines



Conference outcome papers available at: www.iorec.org

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SAVE-THE-DATE

IOREC
International Off-Grid Renewable Energy Conference & Exhibition

3rd International Off-grid Renewable Energy Conference and Exhibition (IOREC)

30 Sept – 1 Oct 2016; Nairobi, Kenya

REPUBLIC OF KENYA
MINISTRY OF ENERGY AND PETROLEUM

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Alliance for Rural Electrification
Shining a Light for Progress

More information and registration soon on: www.iorec.org

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Thank You!