INTERNATIONAL RENEWABLE ENERGY AGENCY

IRENA Innovation and Technology activities on renewable-energy based mini-grids

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Abu Dhabi, 3 November 2016
IRENA mini-grid activities

International Off-grid Renewable Energy Conference & Exhibition (IOREC)*

Policy frameworks and business models

Analysis, design and project development

Regional and national implementation

*www.iorec.org
Mini-grid Planning and Design Process

NREL’s: Continuously Optimized Reliable Energy (CORE) Microgrids Concept

Evaluation
- Energy planning
- Objective setting
- Asset inventory
- Management systems

Data gathering
- Grid infrastructure
- Generator specs
- Demand profile
- Grid operations
- Cost estimates

Design analysis
- Detailed electricity model
- Power flow models
- Controls & communication
- Financial analysis
- Optimisation

Installation and monitoring
- Request for proposal
- System integration selection
- Construction oversight
- Verification and validation

Source: http://www.nrel.gov/docs/fy13osti/57744.pdf

Tariff Studies
Island and Mini-grid Roadmaps
Mini-grid Innovation & Technology Outlook
Smart Grids + Energy Storage Outlook

Mini-grid Costing Analysis
Grid Studies
Project Navigator
Valuing Energy Storage
1. Mini-grid and Island Roadmaps

IRENA’s renewable energy roadmaps for islands can support private sector engagement in mini grids deployment by offering:

• Options for policies, regulations and market structures that support private sector involvement in RE mini grid deployment, e.g. net-metering and feed-in-tariffs, power purchase agreements (PPAs), etc.

• Identification of technologies that are specifically suited for minigrids deployment in tourism facilities (e.g. off-grid resorts)

• Successful pathways based on best practices for transition from diesel-grids to mini grids with large share of renewables

• Analysis that helps potential investors to understand which technologies and services are most valuable to mini grid deployment

• The roadmap process encourages governments to engage all energy sector stakeholders including customers, IPPs, installers, project developers, etc.
Mini-grid and Island Roadmaps

**Goal:** develop a comprehensive, quantitative, action oriented plan supporting a transition to renewable energy for islands and mini-grids

- Country driven process: focus varies depending on country’s needs
  - The whole country (national) or specific islands or off-grid resorts
- Analysis that helps potential investors to understand which technologies and services are most valuable to mini grid deployment
- Different quantitative tools used, depending on approach, sectoral focus, data availability, etc. (e.g. HOMER, MESSAGE, PLEXOS, LEAP, etc.)
- Provides specific recommendations to policy makers for implementation

**Progress to date:**
- Roadmapping Baseline Report for Pacific SIDS
- Four Renewable Energy Roadmaps completed, two ongoing
- Roadmap deployment support for three islands
- Assessment of the impact of RE deployment in both technical and economic terms
- Explore the impact of different assumptions to develop policies resilient to external shocks
- Direct link with the technical assessment of grid operations with the identified generation mix
2. Innovation Outlook: Renewable mini-grids

44% in North America
5% in Europe
47% in Asia Pacific
3% in Latin America
1% in Africa and Middle East

12 GW of mini-grids installed worldwide
50 - 250 GW of diesel mini-grid hybridisation potential

Source: Navigant (Asmus and Lawrence, 2015)
Deployment today

<table>
<thead>
<tr>
<th>Region</th>
<th>Autonomous Basic</th>
<th>Autonomous Full</th>
<th>Interconnected Community</th>
<th>Interconnected Large Industrial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada and USA</td>
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<td>🟠</td>
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<tr>
<td>Caribbean, Central America, Mexico</td>
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<tr>
<td>South America</td>
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<td>Europe</td>
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<td>North Africa</td>
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<tr>
<td>Sub-Saharan Africa</td>
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<tr>
<td>Central and North Asia</td>
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<tr>
<td>East and South Asia</td>
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<tr>
<td>Middle East</td>
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<tr>
<td>Oceania</td>
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<tr>
<td>Antarctica</td>
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Opportunities for innovation

<table>
<thead>
<tr>
<th>Plan and Design</th>
<th>Impact</th>
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<tbody>
<tr>
<td>Cost</td>
<td>Reliability</td>
</tr>
<tr>
<td>---</td>
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</tr>
</tbody>
</table>
| 1 Standardised planning and design | ★★★★★ | ★ | ★★★★★ | ★

Control, manage, measure (CMM)

| 1 More intelligent controls | ★★★ | ★★★★★ | ★★★★★ | ★
| 2 Improved communications and standards | ★★ | ★★★★★ | ★★★★★ | ★
| 3 Improved metering and monitoring | ★★ | ★★★ | ★★★★★ | ★★★
| 4 Simplify connecting equipment together | ★★ | ★ | ★★★★★ | ★

Convert

| 1 Lower capital costs of converters | ★★★★★ | ★ | ★ | ★
| 2 Combine diverse function into inverters | ★★ | ★★★ | ★★★★★ | ★
| 3 Improve efficiency, particularly at partial load | ★★ | ★ | ★ | ★★★
| 4 More converter options for diverse renewable mini-grid markets | ★★ | ★★★ | ★★★★★ | ★

Consume

| 1 Increased commercial availability of efficient end-uses | ★★★★★ | ★ | ★ | ★★★★★
| 2 Better user tools for adapting consumption to energy supply (DSM) | ★★★★★ | ★★ | ★★★ | ★★★★★

Innovation making renewable mini-grids competitive

Unsubsidised cost ranges for renewable mini-grids from 2005 to 2035 for a 100% renewable energy community system
## 3. Energy Storage + Smart grid Outlook

<table>
<thead>
<tr>
<th></th>
<th>Pumped hydro</th>
<th>Lead-acid</th>
<th>Li-ion</th>
<th>Flow battery</th>
<th>Molten salt</th>
<th>Fly-wheel</th>
<th>Supercapacitor</th>
<th>CAES</th>
<th>Hydro-gen</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output (MW)</strong></td>
<td>250 -1000</td>
<td>0.01 - 10</td>
<td>0.01 - 30</td>
<td>0.01 – 30</td>
<td>1 – 200</td>
<td>0.01 – 10</td>
<td>0.1 – 10</td>
<td>110 - 290</td>
<td>10 –100</td>
</tr>
<tr>
<td><strong>Depth of discharge (%)</strong></td>
<td>100</td>
<td>50</td>
<td>80</td>
<td>70 – 90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>100</td>
</tr>
<tr>
<td><strong>Discharge time</strong></td>
<td>hrs</td>
<td>min - hrs</td>
<td>min - hrs</td>
<td>hrs</td>
<td>hrs</td>
<td>sec - min</td>
<td>sec</td>
<td>Min - Hrs</td>
<td>Hrs</td>
</tr>
<tr>
<td><strong>DC Efficiency (%)</strong></td>
<td>70 – 80</td>
<td>70 – 80</td>
<td>90</td>
<td>75 – 80</td>
<td>75 – 85</td>
<td>90</td>
<td>95</td>
<td>40 - 70 (A)</td>
<td>70 – 80</td>
</tr>
<tr>
<td><strong>Cycles</strong></td>
<td>&gt;50 000</td>
<td>300 - &gt;800</td>
<td>1000 - &gt;5000</td>
<td>&gt;10000</td>
<td>&gt;10000</td>
<td>&gt; 50000</td>
<td>&gt; 50000</td>
<td>&gt; 50000</td>
<td>&gt; 50000</td>
</tr>
<tr>
<td><strong>Investment (USD/kW)</strong></td>
<td>2000 – 4000</td>
<td>500 - 1500</td>
<td>1500 - 5000</td>
<td>2000 - 4000</td>
<td>4000</td>
<td>300 - 1000</td>
<td>1500 – 2500</td>
<td>850 - 2000</td>
<td>650 - 2300</td>
</tr>
<tr>
<td><strong>Storage costs (USD/kWh)</strong></td>
<td>50 –150</td>
<td>150 –600</td>
<td>600 - 2000</td>
<td>500 – 850</td>
<td>500</td>
<td>4000 - 6000</td>
<td>100 - 1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cycle costs (USD/kWh/C)</strong></td>
<td>0.06 –0.15</td>
<td>0.2 – 0.5</td>
<td>0.15 – 0.50</td>
<td>0.1 – 0.25</td>
<td>0.06 – 0.12</td>
<td>0.05 – 0.11</td>
<td></td>
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</tr>
</tbody>
</table>
4. Solar PV in Africa: Costs and markets

“KEY FINDINGS”

Latest proposed utility-scale solar PV projects are targeting competitive installed cost levels that are comparable to today's lowest-cost projects.

The installed costs of solar PV for mini-grids span a wide range, but recent and planned projects show examples of competitive cost structures.

Solar home systems in Africa are providing better-quality energy services at the same or lower cost as lighting from kerosene lanterns in off-grid situations.

A sub-regional analysis for Africa could help identify the reasons for cost differentials, map out strategies to reduce them, and identify roles and responsibilities.
PV mini-grid system costs by system size in Africa, 2011-2015
5. IRENA 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 guides and assistance and online access to simulation software DIgSILENT PowerFactory to do grid studies with local human capacities
Cooperation with decision makers, network operators and technical experts at a global level supporting exchange of experiences on grid operation & expansion – Until now focus on small isolated systems

- **Seychelles** (review of studies)
- **Samoa, Cook Islands, Palau** (studies)
- **Kiribati** (support in realisation of study)
- **Fiji, Vanuatu** (on-going studies, technical workshops)

**DIgSILENT, TU Darmstadt, TRACTEBEL-ENGIE**

(Access to simulation Software, technical guides)

**Dominican Republic, Antigua & Barbuda** (study), **Barbados** (revision of studies), **CARILEC** (technical workshops)
Objectives

» Increase the bankability of projects by:
  » Strengthening the project development base
  » Enhancing the quality of project proposals
  » Reducing costs and mitigating risks through proper planning and efficient use of funds
  » Facilitating effective implementation

Learning Section

» Project development and technical guidelines
» Best practices
» Tools, templates, examples
» Case Studies

Start a Project

» Personal and private workspace
» Stepwise approach
» Track your progress
» Export documents

Financial Navigator

» Information on multiple funds
» Filter by region and technology
» Information includes fund types, requirements and contact details among others.
Technical Content

- The project consists of 5 aspects:
  1. Minigrid definitions and conceptual guidelines, introduction and background information
  2. Minigrid project development guidelines, detailed guidance on each of the 9 project development steps in the Project Navigator
  3. Microgrid operation and financial evaluation tool, prove the financial feasibility of the project
  4. Project case studies, lessons learned for different types of microgrids and locations
  5. Set of practical tools for project developers, guiding and structuring the process to develop a bankable and successful proposal.
Financial evaluation tool

**Microgrid components:**
- Grid connection
- Solar PV
- Wind turbine
- Generic base load RES
- Battery storage
- CHP
- Diesel generator
- Boiler
  - Different fuels:
    - Diesel, biodiesel, biomass, natural gas

**Resources:**
- Irradiance
  - automated import of location specific hourly profiles (PVGIS)
- Wind speed
  - automated import of location specific monthly average (NASA)
  - Generate hourly values
  - Define turbine power curve

**Loads:**
- Electricity & heat
- Yearly or monthly input data
- Normalized hourly profiles (standard or custom)

**Microgrid Operational Calculation**

**Dashboard:**
- Financial parameters
- Results summary

**Cash flow Calculation & Detailed results**

**Financial KPI’s:**
- NPV, IRR, LCOE, Return on Investment, Payback Time, Minimum DSCR

**Operational KPI’s:**
- #customers
- Heat demand (GJ)
- Electricity demand (GWh)
- Local/renewable/fossil generation (MWh and %)
- Grid import (MWh and %)
- Battery storage (MWh)
- RES curtailment
- Demand not met (MWh and %)

**Cost-Benefit KPI’s:**
- Subsidy per connected customer
- Cost of CO2 emission reduction
7. Valuing energy storage

- Integrate variable renewables
- Reduce fuel consumption
  - Price at which the power generated is sold
  - Reduction of generation operating costs

- Increase distributed generation self-consumption
- Reduce demand charge and/or time shift energy consumption
  - Reduction of energy bills

- Lower need for flexibility due to lower variability
  - Control the frequency of the grid
  - Alleviate congestions
  - Reduction of grid operating costs
  - Reducen of grid operating costs
  - Reduction of energy losses
Get in touch!

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Project Navigator