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Upscaling Mini-Grids Conference for Least Cost and Timely Access to Electricity Services

Islanded Generation-Distribution Systems: Implementation & Integration Challenges

NRECA International

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Islanded Generation-Distribution Grids: An Old Concept Presenting Many Challenges

- Power systems in all countries started with series of islanded generation-distribution systems serving population centers
- Many countries in Latin America and in remote areas of North American used islanded generation-distribution systems through the late 1990s. Parts of Brazil, Bolivia, Peru, Colombia, and Alaska still use islanded power systems
- Many small power systems were designed with lower voltage levels such as 3.3 kV, 7.2 kV and 10 kV medium voltage systems in Latin America. Interconnection sometimes required complete reconstruction of these systems

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Isolated Power System Characteristics

- In the past smaller power generators lacked more advanced synchronizing capabilities, and many smaller systems had limited fault controls
- For this reason, interconnection most often meant retiring old equipment
- In the 1990s, NRECA participated in interconnecting approximately three dozen islanded mini-grids into regional grids
  - Consolidated generation into central stations (2-5 MW)
  - Replacement of distribution infrastructure using 34.5 kV
  - Improved services, distribution transformers
  - Lower tariffs using natural gas-fired power stations

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Power System Characteristics in SSA

- Most rural systems use three phase, 22 or 33 kV medium voltage distribution
- Rural systems are often fused by do not use line reclosers. Fault protection is normally installed at substations and on fused distribution transformers
- Feeder lengths exceeding best design practice are quite common. Voltage levels in rural areas can get quite low
- There is growing recognition that master planning is needed, but master plans are uncommon and when they exist they are rarely followed

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Regulatory Environment

- There is growing recognition of a need for service quality standards for rural service, however:
  - Specific quality standards have been developed by the World Bank and other agencies, but have not yet been adopted in many regulatory agencies governing rural and off grid service
  - Mini-grids with limited service hours require specific standards vis-à-vis regulation of outages
- Licensing procedures and provisions
  - Needed for clarity and transparency
  - Where they exist, they often do not yet address geographic protection against grid intrusion
  - Clarity is needed with regard to process of grid integration
- If a license with territorial protection is awarded, what happens to tariffs when grid service approaches?

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Challenges with Islanded Utilities

- **Governance challenges**
  - Business ownership model is extremely important
  - Balance community engagement with focus on business management
- **Business challenges**
  - Achieving scale: selling sufficient energy/service to balance operating costs
  - Operating capital: need cash flow support to get through first few years
  - Customer subscription – getting consumers to connect and keeping them connected
- **Operational challenges**
  - Availability of qualified personnel
  - Supply chains (fuel & spares)
  - Expertise for major maintenance

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Alaska Village Electric Cooperative

- Cooperative model requires lower rates of return and includes significant consumer engagement – sense of ownership
- AVEC includes/serves 56 communities, only one of which is accessible by road
- Generation modality: diesel generation and in some cases, wind-diesel hybrids
- Fuel supply is a major challenge
- Centralized management, engineering, and financial control with localized operational control
- Highly standardized power system solutions that are extremely robust to operate in unforgiving environment

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Haiti Electric Cooperative

- Formed two years ago serving Coteaux, Roche-au-Bateaux, and Port-au-Piment in southwest Haiti
- 240 kW diesel & 140 kW DC solar array feeding 23 kV three phase backbone distribution system
- System commissioned in October, 2015
- 2400 potential consumers, 1100 enlisted members with 790 connected consumers at present
- Pace of consumer connections and slow load growth created load balancing and reactive power challenges

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- **Community organization and communication has been an on-going challenge**
  - **Expectation that power costs should be as low as grid costs (and these are highly subsidized)**
  - **Training board members and cooperative members to take responsibility for their energy business has been a continuing challenge**
  - **Appreciation for power quality and reliability is there, but tariff sensitivity hasn't gone away**

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Valles Cruceños (Santa Cruz)

- Interconnected 18 islanded generation-distribution systems in 1993 approximately 120 miles from city of Santa Cruz
- Centralized power generation with natural gas-fired medium speed internal combustion engines
- Reduced tariffs from ~$0.30-0.35/kWh to $0.16/kWh
- Within three years, community members began to petition for tariff equalization

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Implementation Timelines

- Developing individual projects without specific market information is time consuming and can be expensive
- Project preparation consists of market analysis, system design and project cost analysis, financial analysis, risk analysis, licensing, securing finance, and implementation
- Project implementation consists of final design, procurement, delivery, construction and commissioning
- For a typical project, the project preparation period where license agreements are not required can take between 6-9 months after a project has been identified
- Project implementation normally takes an additional 6-9 months

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Scaling Up and Implementation Timelines

- **Twelve to twenty-four months for each project is a very long time. Scaling up off-grid implementation implies:**
  - **A need for wide-scale project identification through a master planning process**
  - **Market characterization performed on a board scale to provide general and specific market information to developers**
  - **Grouping projects in tranches so they can be implemented in parallel instead of on a piecemeal basis**
  - **Developing financing and PPP mechanisms that are well-defined, transparent and investor/program friendly**

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Lessons Learned

- **The need for off-grid power systems in SSA is real and will continue for many years to come**
- **Experience with conventional islanded generation-distribution systems seems to show us that tariff and grid integration issues will have similar impacts on renewable mini-grids**
- **Finding the means to centralize higher management and operational support functions is worthy of evaluation**
- **Planning, market characterization and information sharing are needed to speed up implementation**
- **Evaluating how to achieve partnerships between rural electrification agencies and off-grid service providers is a necessary step to scaling-up mini-grids**