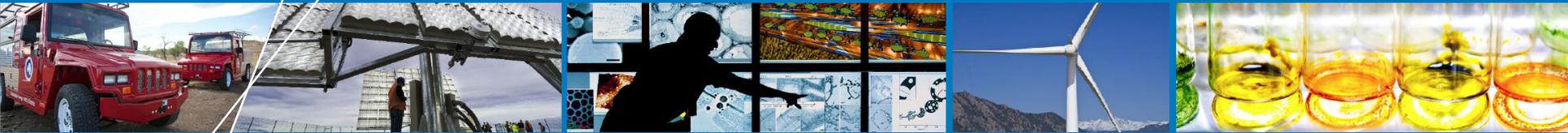


# Smart Hybrid Microgrid Clean Energy Models For Improving Life Quality of Underserved / Remote Communities in Africa



**Energy Africa**

**Colorado School of Mines**

**By: Ravi Vora**

**29 October 2015**

# Motivation

Access to clean, affordable energy and basic services are essential to better quality of life

Absence or inadequate/expensive energy (e.g. diesel, kerosene) adversely affect

- Education and literacy rates
- Sanitation, health and hygiene
- Communications and information access (internet and cellular phone service)
- Social stability and community harmony
- Natural and living environment through harmful pollutants

## **Rural community issues:**

- Limited or no electricity/power supply; use of expensive polluting diesel/kerosene
- Excessive irrigation water use and water waste resulting from “unmetered” free power for irrigation from the local grid
- Inadequate energy/power for community needs
- Use of dirty fuels for back up generation

## **Urban slum community issues:**

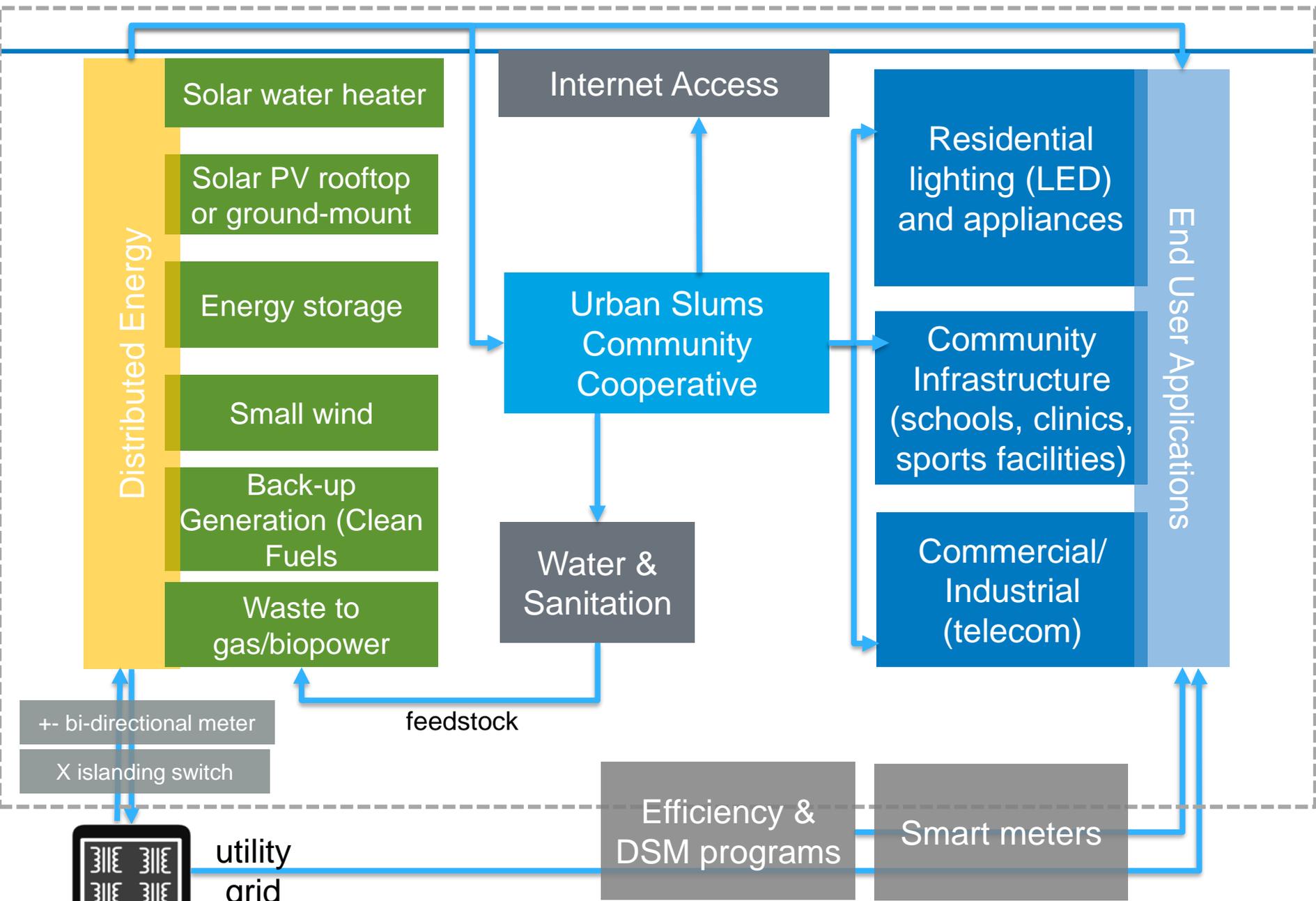
- Unreliable power supply with frequent outages
- Absence of community ownership and stake, conducive to rampant power theft or may have socially disruptive influence in the communities
- Use of dirty fuels for back up generation

# Objectives

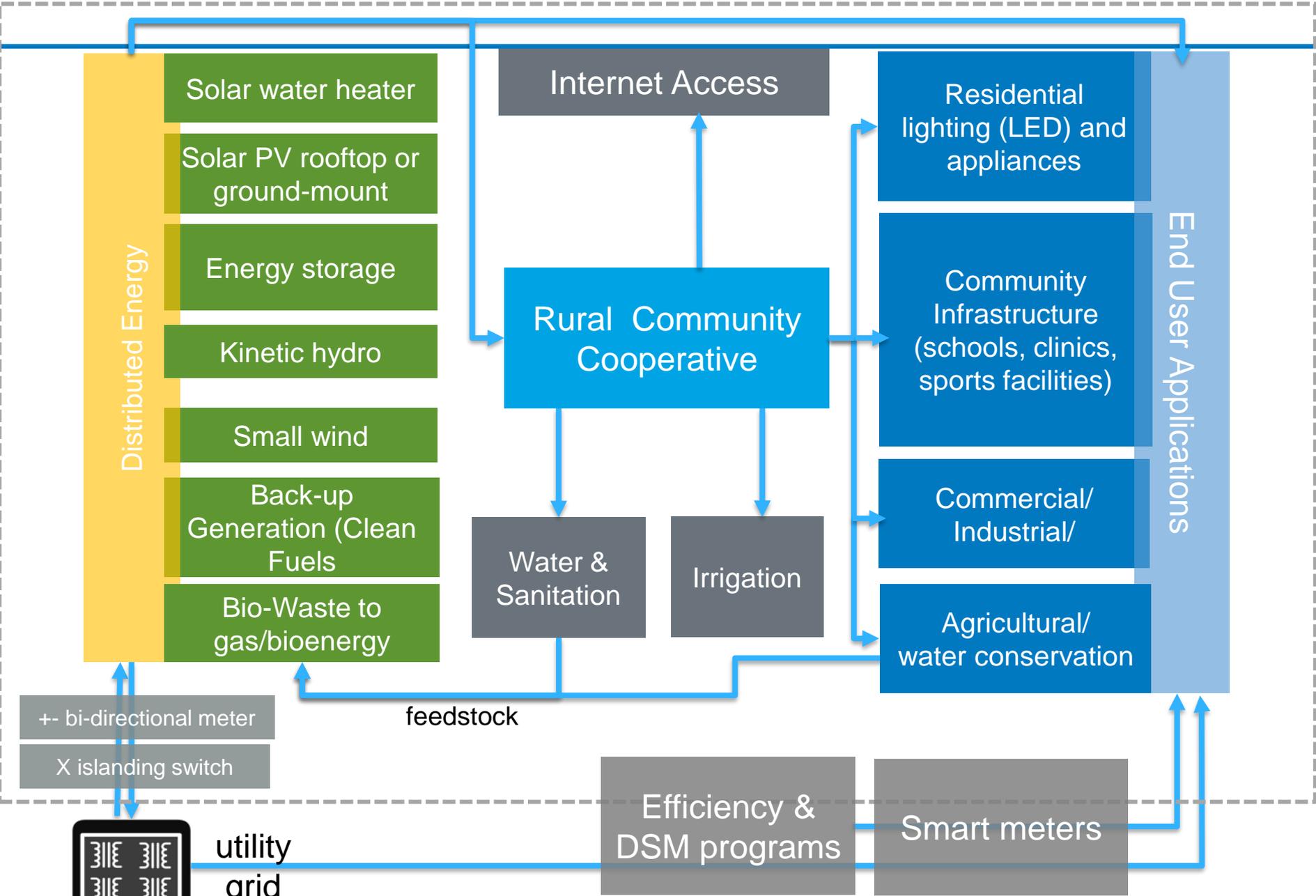
**Create template projects** for clean, smart, and reliable energy & other **services** solution for disadvantaged communities:

- **Tailored to community needs** for cost-effective cooking, heating, electrical end uses, **internet connectivity, and** clean water, sanitation/hygiene.
- **Supporting utility goals** by leveraging smart technologies to prevent power theft and real time monitoring to deter power theft and criminal activities
- **Leveraging best-in-class intelligent technology integration adapted to local community needs** to achieve energy efficiency, demand side management, and sufficient-reliable-affordable services
- **Supporting bankability and community ownership** through management and financing business model for both the rural community and urban slums (**e.g. Community Cooperatives**)
- **Supporting irrigation water conservation** by taking existing irrigation power off-grid with distributed solar PV/ energy storage.

# Smart Hybrid Microgrid Conceptual Model: Urban Slums



# Smart Hybrid Microgrid Conceptual Model: Rural Communities



# Energy Sources: Role & Challenges

- **Majority of African countries have abundant but vastly under-utilized renewable energy resources:**
  - Abundance of Sun; Bio-resources (including Bio-fuels),
- **Majority have little or no clean fuels (natural gas, natural gas liquids) and are expensive**
  - Opportunity: Import of low cost and abundant supplies of NGLs (use existing infrastructure) and LNG (requires major import terminals), especially from USA with low long term hedged prices
- **Fuel infrastructure is limited, often inefficient and expensive; clean fuel infrastructure tied to export.**
- **Clean fuels are essential to maximizing the use of renewable energy to back up variable generation from RE resources.**
- **Grid Scale vs. Distributed generation with smart micro grid will disrupt the market**

# Target Countries & Markets

---

- **Most African Countries are potential targets**
- **Most are facing insurmountable problems with improving quality and economic success of “Bottom of pyramid” communities**
- **Affordable energy for all remains a dream; let’s ensure it does not become a mirage and none are left behind**
- **Countries like South Africa, Nigeria, Kenya and or Tanzania can set the stage.**

# Core Stakeholders:

---

- **Brain trust (led by NREL)**
- **Capital for Start up to first 2 to 3 successful pilot projects**
- **Local community champions, social services**
- **National Utilities and Municipalities**
- **Funding seed capital to reach first Pilot Project (Approx. \$1+/- Million)**
- **Corporate/Industry Champions and strategic partners from USA, & Africa sought**
- **Foundations, NGOs, Government Aid agencies, World Bank ESMAP, UK and German Aid Agencies**
- **Local community champions**

---

**INTERESTED? CURIOUS? BETTER  
IDEAS? ENTHUSIASTIC?**

**Contact:  
Ravi Vora**

**Email: [ravindra.vora@nrel.gov](mailto:ravindra.vora@nrel.gov)**

**Phone: 001-303-408-4912**

# Questions?



---

BACK UP SLIDES

**NREL BACKGROUND:  
NATURAL GAS & RENEWABLE ENERGY  
INITIATIVES IN SOUTH AFRICA**

# NREL Capabilities

## POWER SYSTEM OPERATIONS

- Operational strategy modeling
- Operating reserve requirements
- Operations of emerging resources (e.g. DR, storage)
- Integration studies.

## GENERATOR MODELING

- Generic wind and solar models
- Three phase and positive sequence
- Validation using PMUs
- New frequency, voltage, damping controls.

## POWER SYSTEM PLANNING

- Solar and wind resource assessments
- Resource adequacy with renewables
- Transmission expansion planning
- Policy and regulatory issues
- Flexibility needs of the future.

## STAKEHOLDER ENGAGEMENT

- UVIG, IEA, NERC IVGTF, FERC, IEEE PES, international, utility TRCs.

## EQUIPMENT TESTING

- Wind/solar frequency/voltage
- Controllable grid interface.
- **Energy Storage Test bed**

## WHOLESALE ELECTRICITY MARKET DESIGN

- Flexibility market designs
- Revenue sufficiency
- Ancillary service market designs, primary frequency response market.

## OPERATIONAL FORECASTING

- Error characteristics of wind, solar, load forecasts
- Economic and reliability metrics of forecasts
- Probabilistic forecasts.
- **RE Forecasting integration in System Operations**

## Founding Institutions

- U.S. Department of Energy's National Renewable Energy Laboratory
- University of Colorado-Boulder
- Colorado School of Mines
- Colorado State University
- Massachusetts Institute of Technology
- Stanford University.

# Opportunities for Synergy Between Natural Gas and Renewable Energy in the Electric Power and Transportation Sectors (December 2012)

- Part I of this paper offers nine platforms for dialogue and partnership between the natural gas and renewable energy industries, including development of hybrid technologies, energy system integration studies, analysis of future energy pathways, and joint myth-busters initiatives.
- Part II provides a brief summary of recent developments in natural gas and renewable energy markets.
- Part III, on the electric power sector, discusses potential complementarities of natural gas and renewable energy from the perspective of electricity portfolio risk and also presents several current market design issues that could benefit from collaborative engagement.
- Part IV, on the transportation sector, highlights the technical and economic characteristics of an array of alternative transportation technologies and fuels. Opportunities for natural gas and renewable energy transportation pathways are discussed, as are certain relevant transportation policies.

# Exploring the Potential Business Case for Synergies Between Natural Gas and Renewable Energy (February 2014)

- This paper attempts to address the question, “Given near- and long-term needs for abundant, cleaner energy sources and de-carbonization, how can more compelling business models be created so that these two domestic forms of energy work in greater concert?” This paper explores revenue opportunities that emerge from systems-level perspectives in “bulk energy” (large-scale electricity and natural gas production, transmission, and trade) and four “distribution edge” subsectors: industrial, residential, commercial, and transportation end uses.