Design and Development of a Microprocessor based Monitoring and Control System for developing country mini-grids integrating small scale wind

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Problem Statement

3.6 billion people around the world suffer from lack of electrical energy out of which 1.2 billion have absolutely no energy access. Significant part of these people live in rural areas where providing grid extension is not possible. The solution to the problem is an off-grid electrification.

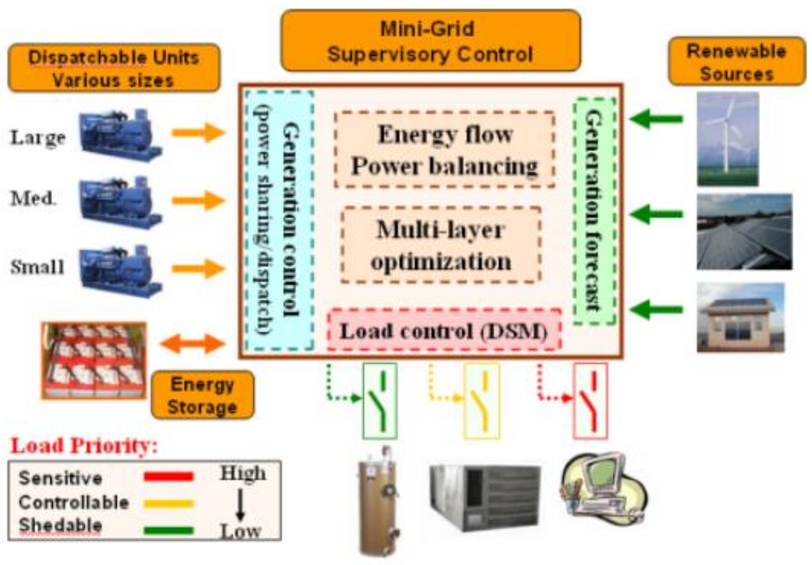
Most off-grid systems operating in developing countries are heavily based on diesel generation. In order to generate power it is required to import energy sources (mainly oil) from distant countries. As a consequence the cost of energy is high. Implementation of renewable energy systems could significantly reduce the cost of energy for communities living in rural areas of developing countries.

Tasks for the Mini-Grid Controller

- Match Demand and Supply for systems based on RES
- Improve reliability of supply
- Reduce number of brownouts/blackouts
  - Case Study from Nepal: blackouts for 16h/day during dry season
  - Case Study from India: blackouts for 14-16h/day
- Maximize Contribution from RES to general energy mix
- Reduce CoE resulting from expensive Diesel Generation (equivalent to 2 euro/kWh)

Mini-Grid Based on Centralized Generation

- Centralized controller dispatching diesel generation according to network needs
- Short/Long term balancing provided
- Capability to overcome power fluctuations introduced by wind turbines and solar panels
- Maximize renewable energy generation
- Possible load control



Aspects to think about before designing a Controller

- LV power networks are more resistive than inductive – different power flow methods than for large, interconnected grids
- Networks with a high degree of RES significantly modify voltage profiles within the network
- In interconnected power network there is no need to analyse frequency stability. For mini-grids this aspect has to be considered in order to provide safe power distribution
- DC vs. AC for the power distribution

Targets and Objectives

- SE4ALL – Sustainable Energy for All, program initiated by UN. Targeting to electrify 500 million people before 2030. Estimated cost – $ 50 billion/year
- Enable people to use simple electrical devices such as lights, refrigerators and heating systems.
- Improve air quality as a consequence of replacing kerosene lamps by light bulbs.
- Improve quality of education by providing reliable lightening systems.
- Grater industrial development and business productivity.

Types of Mini-Grid Controllers

Centralized	Decentralized
Maximizes Renewable Energy Systems Input to the network	Less Complex and cheaper solution
Applies Optimal Power Flow Algorithms	Failure of one Controller does not have Catastrophic Impact on the Whole System
Provides Secondary Control of the power network (frequency, voltage restoration)	Easy while expanding the system
Can provide optimal load shedding	No need to use communication Systems
Optimal for meshed power networks	Easier to Upgrade (no need to tune and test it)
Controller Requires Tuning while Expanding the Grid and Installing new Energy Sources – testing needed	Not always applicable to mini-grid installation – good for radial power networks but not for meshed AC with bi-directional power flows
Failure/Attack on the Controller would be catastrophic for the whole system	Optimal Power Flow not possible
	Effective in mini-grids with a single, centralized generation

Swarm Power Network – Decentralized Control

- System operating mainly on Solar Home Systems (SHSs), solar kiosks and hybrid standalone systems based on wind turbines and PV generation
- Many standalone power systems produce more energy than it is consumed
- By introducing ability to sell surpluses of energy new type of power network can be developed where each prosumer (producer and consumer) is seen as a single cell in the power network
- Each user operates at sell/buy mode

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