Microgrids for Rural Electrification

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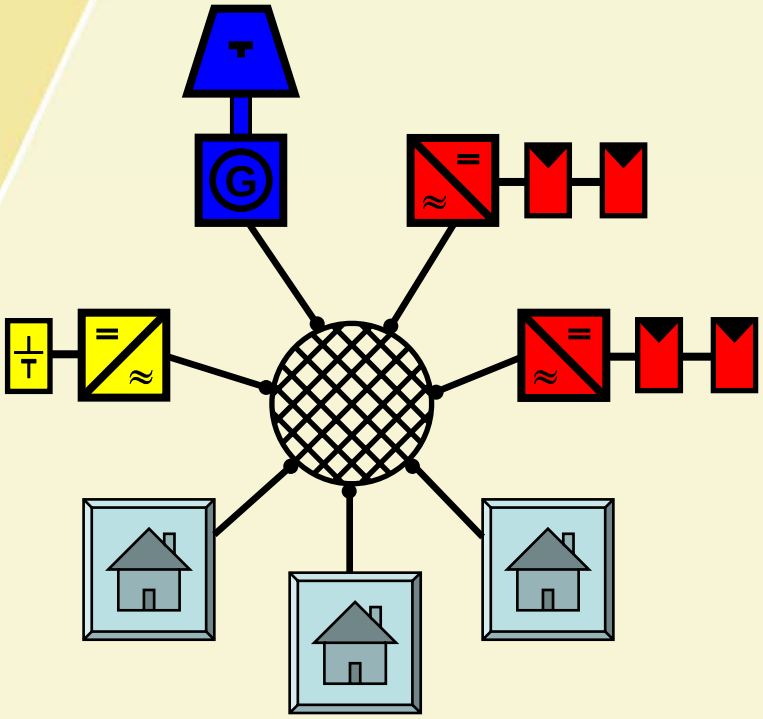
Presentation Outline

- Microgrids for Rural Electrification
  - Hybrid systems
  - Microgrids
- Bulyansungwe System
  - Bulyansungwe, Uganda
  - Hybrid Microgrid
- Load Side Management
  - Bulyansungwe Water Pumping
  - Other options

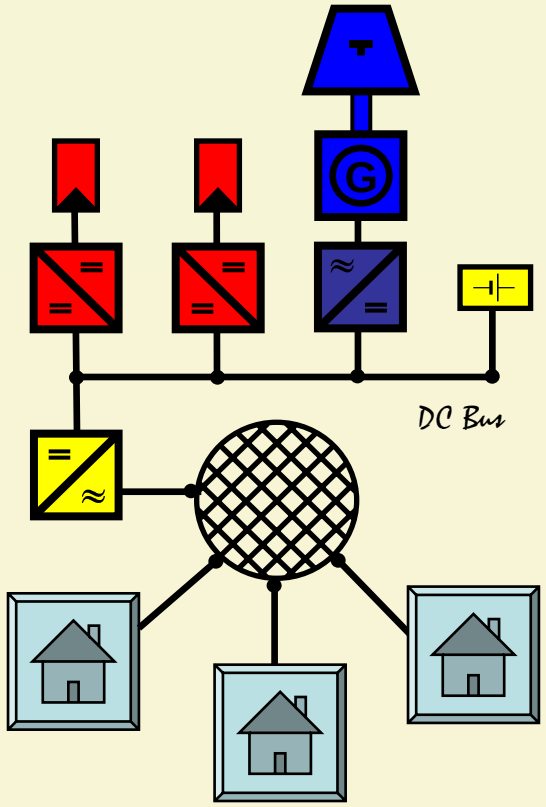
Hybrid System

- Remote electrification
- Security of supply
  - Accommodate for statistical nature of RE's
- Diversity of sources
  - One or more renewable sources
  - Energy storage (batteries, fuel cells)
  - Dispatchable sources (motor generators)

System Architectures



Microgrid
(AC Coupled)



DC Coupled System

Microgrid Philosophy

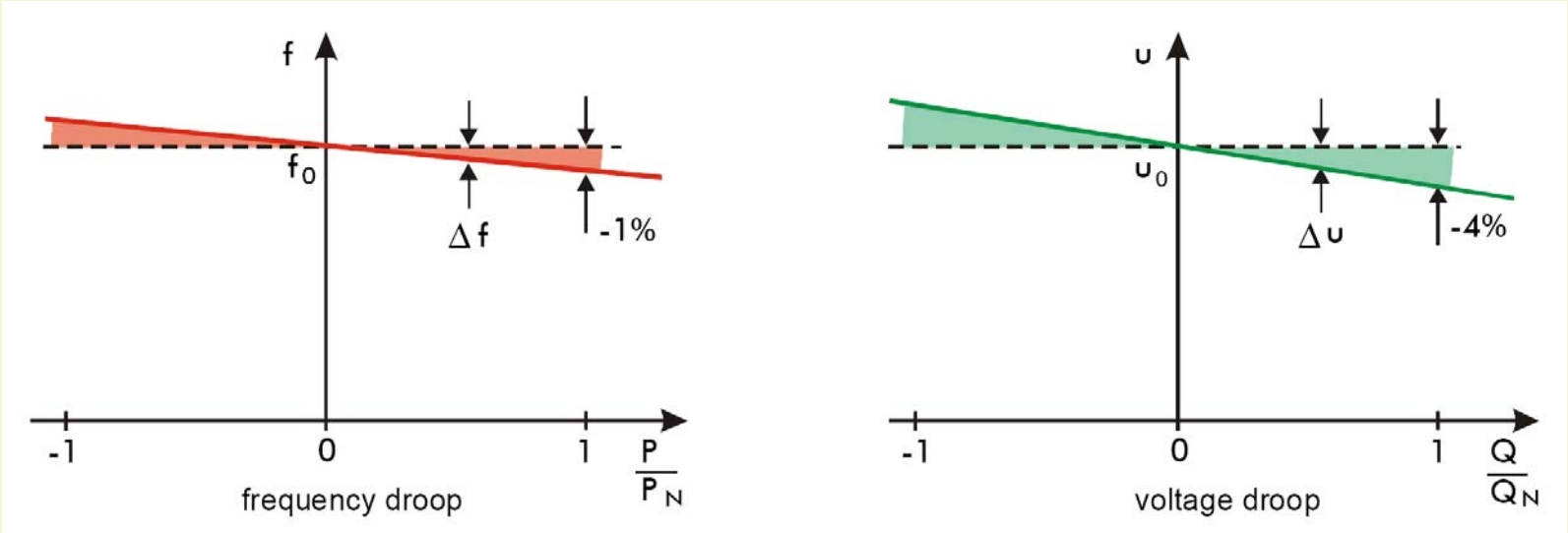
- Modularity
- Expandability
- Redundancy of suppliers
- Existing standards
- Simplified interconnection

Microgrid Implementation

- Requirements
  - Coordination of voltage sources
    - Voltage, frequency and phase
  - Load sharing
  - No high speed communication
- Solution
  - Variable voltage, variable frequency sources
  - “Droops method”

Droops Method

- Used by utility grid
- Frequency & real power
- Voltage & reactive power
- Sunny Island battery inverter



Bulyansungwe, Uganda

Typical Bulyansungwe Home

Typical Bulyansungwe Home

Bulyansungwe School

Bulyansungwe Hybrid System

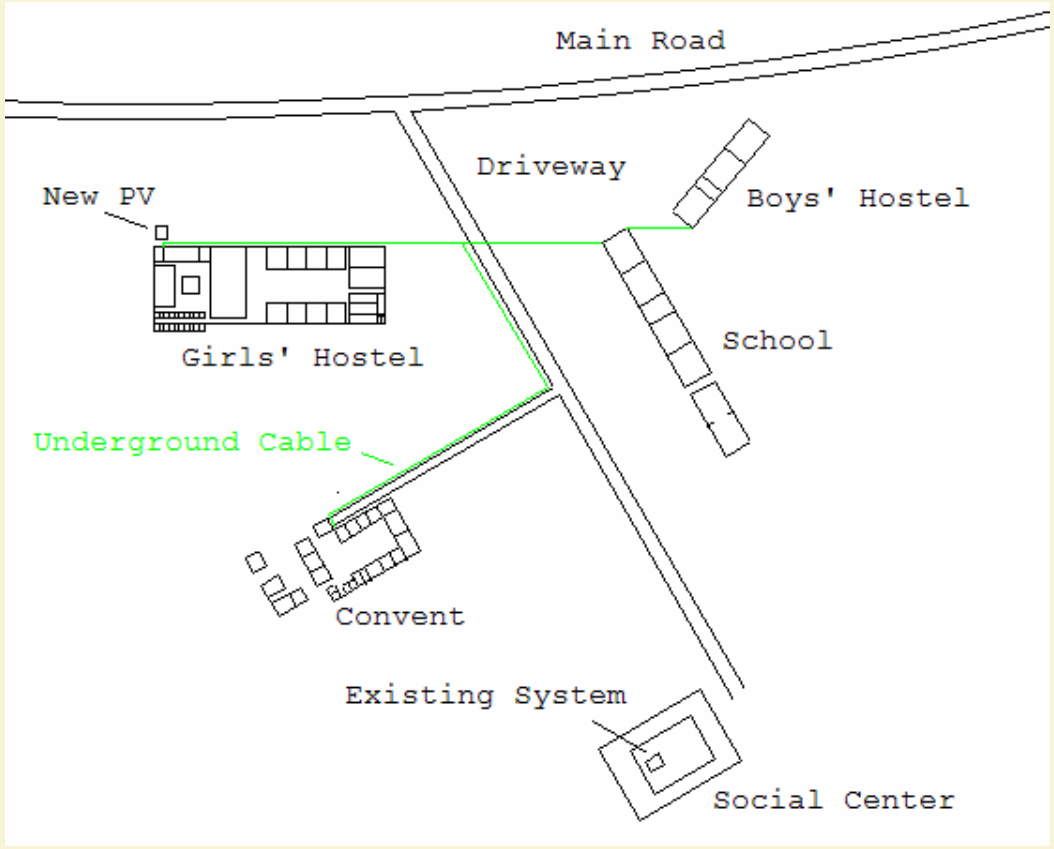
- 3.6kW$_p$ photovoltaic array
- 2 x 1.7kW Sunny Boy PV inverters
- 21.6kWh battery bank
- 3.3kW Sunny Island battery inverter
- 4.6kW 3-phase gasoline generator

PV Tower

Inverters

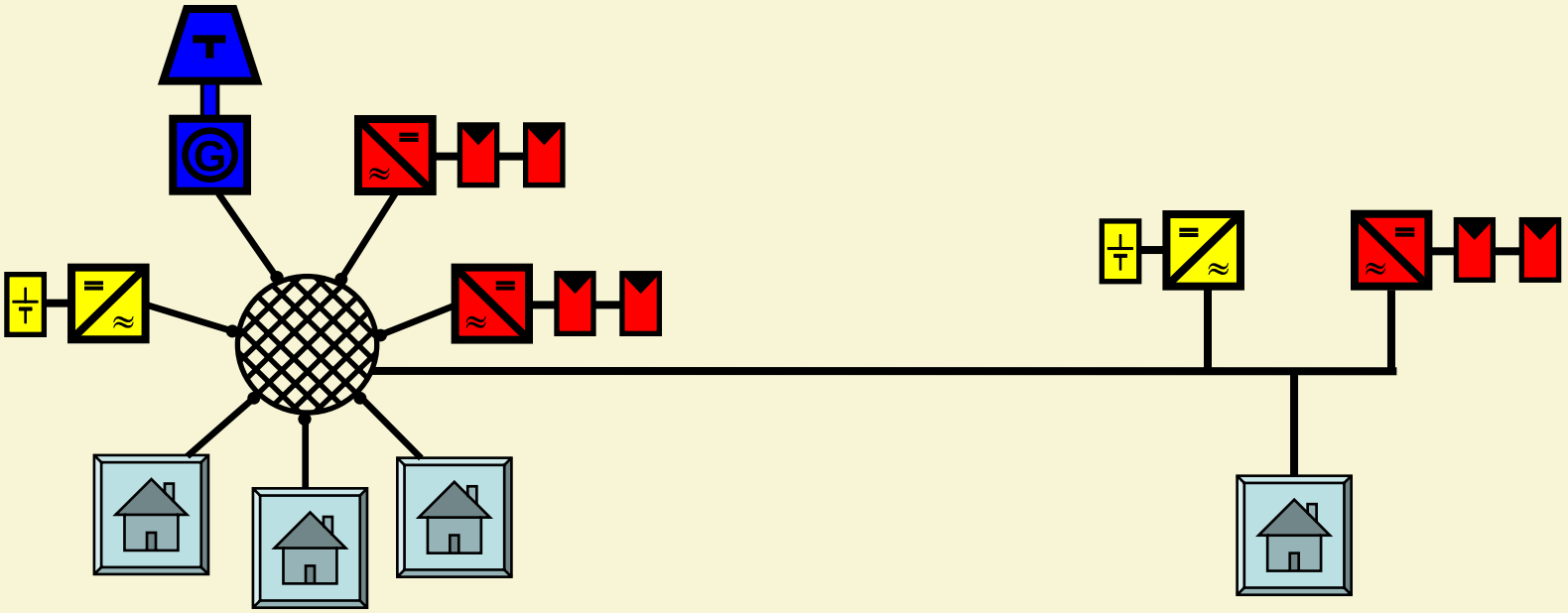
Electrical Distribution

- Girls' hostel
- School
- Boys' hostel
- Convent



Future Expansion

- Health clinic in social center
- Integration of existing system into microgrid

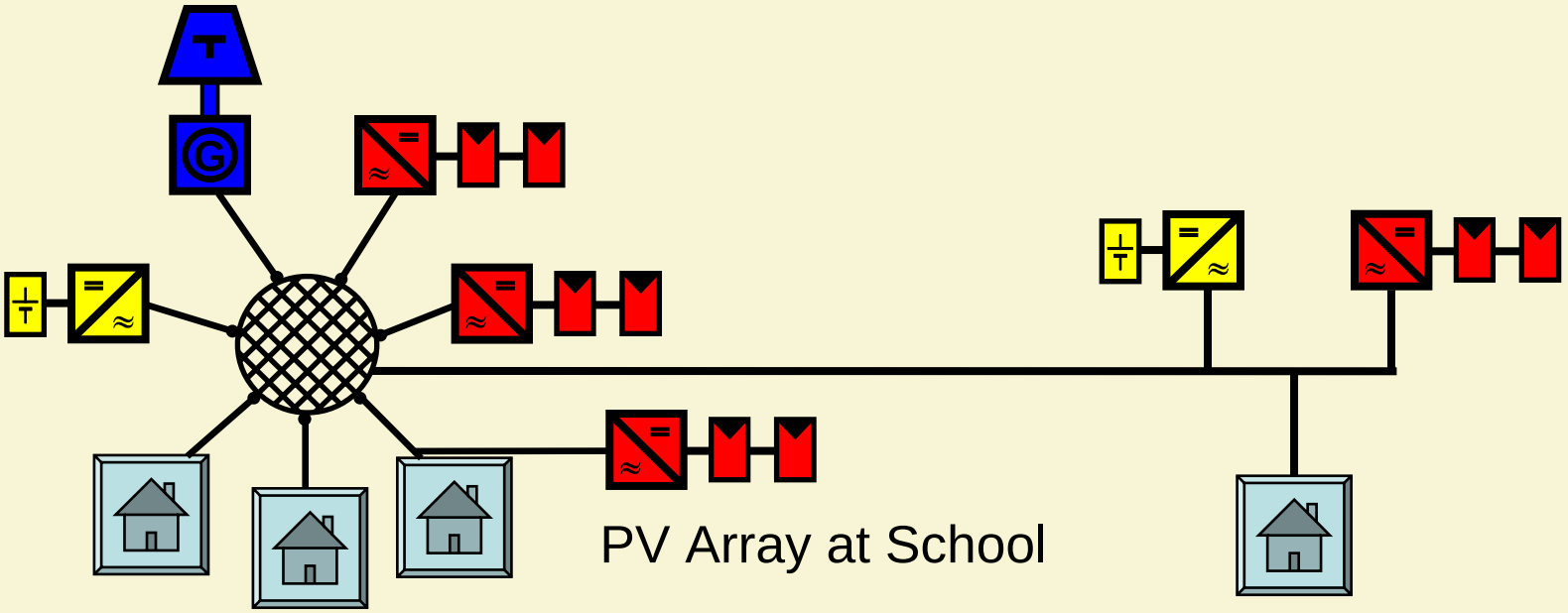


Current AC Mini-Grid

Extension to Social Center

Future Expansion

- Computers in the school
- Localized production, no new storage



Demand-Side Management

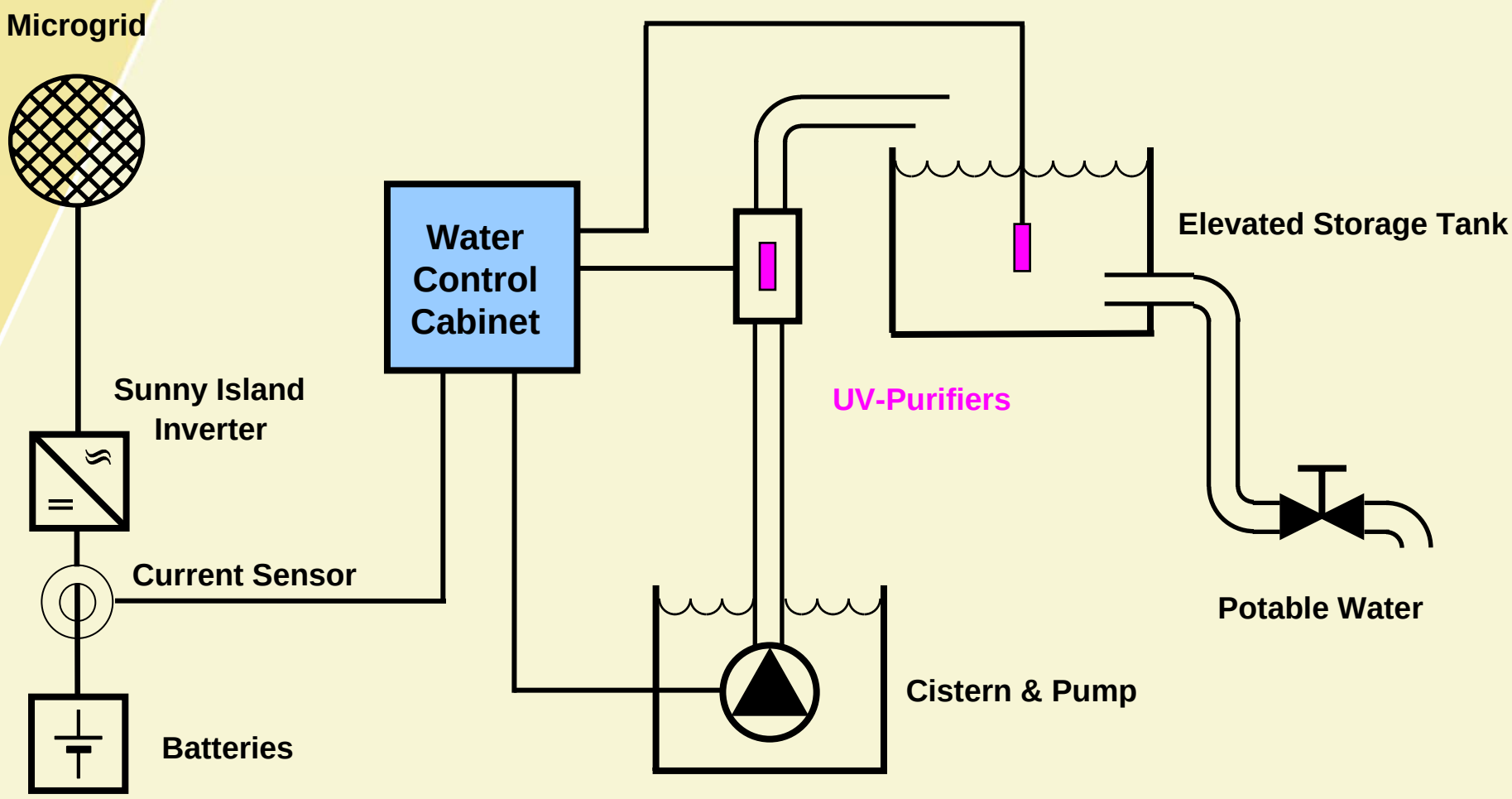
- Match demand to supply
- Use energy before it is stored
  - Reduce battery cycling
- Use all available energy
- Bulyansungwe pumping system

Pump Operation Strategies

- Tank level
  - Simple
- Time of day
  - Peak production hours

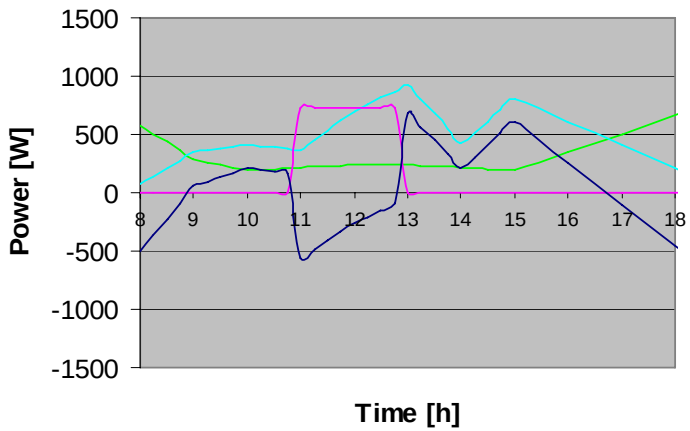
- Charge skimming for battery conservation
  - Active control based on energy available
  - Does not draw energy from batteries

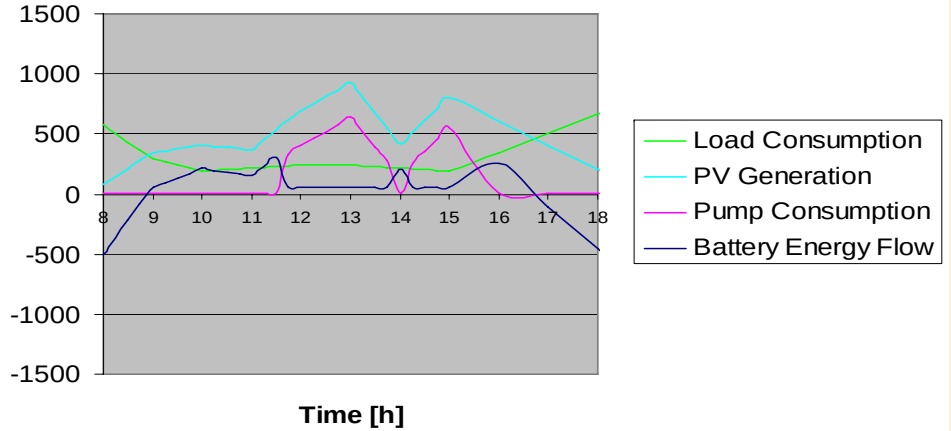
Pumping System Architecture



Battery Conserving Pump

- Simulation
  - Time regulated pump drew 29kWh/year from batteries
  - 1.67 full battery bank cycles





Future DSM

- Use all available energy
  - SMA Smart Load
    - Heat only

- Real-time adjustment of demand to supply
  - Intelligent Loads
    - Frequency based load adjustment like price based
  - Reduce load during energy shortage
  - Increase load (store energy) during excess
    - Elevated water, refrigeration, heat

Questions?