



HYBRID DIESEL/PHOTOVOLTAIC DISTRIBUTION SYSTEMS

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AGENDA

- Distribution System
- Diesel System
- Grid Interactive Photovoltaic System
- Putting it all Together - Diesel/Photovoltaic Hybrid Distribution System
- Design Improvements

CHARACTERISTICS

- 23 kV lines connected directly to the power plant (low technical loss design)
- Radial with 3 phase backbone and single phase side taps (low cost design)
- Remotely located
- Small industrial, commercial and residential load only
- System peak load less than 2 MW
- %50 to %60 load factor



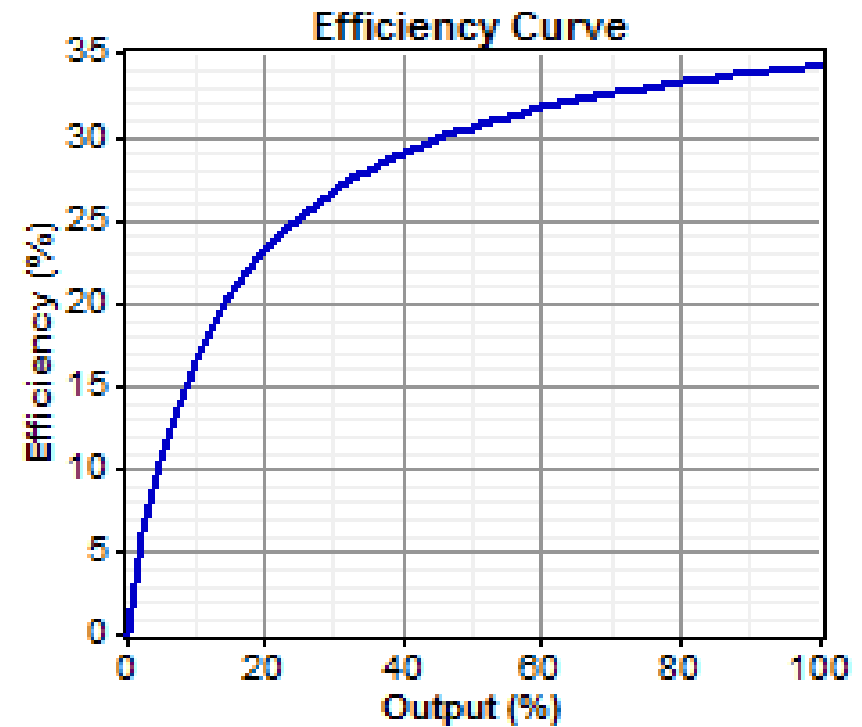
CHARACTERISTICS

- Dispatchable
- Stable frequency and voltage output over its designed operating range
- Requires routine maintenance that can result in downtime
- Requires skilled operator to be present at site daily



EFFICIENCY

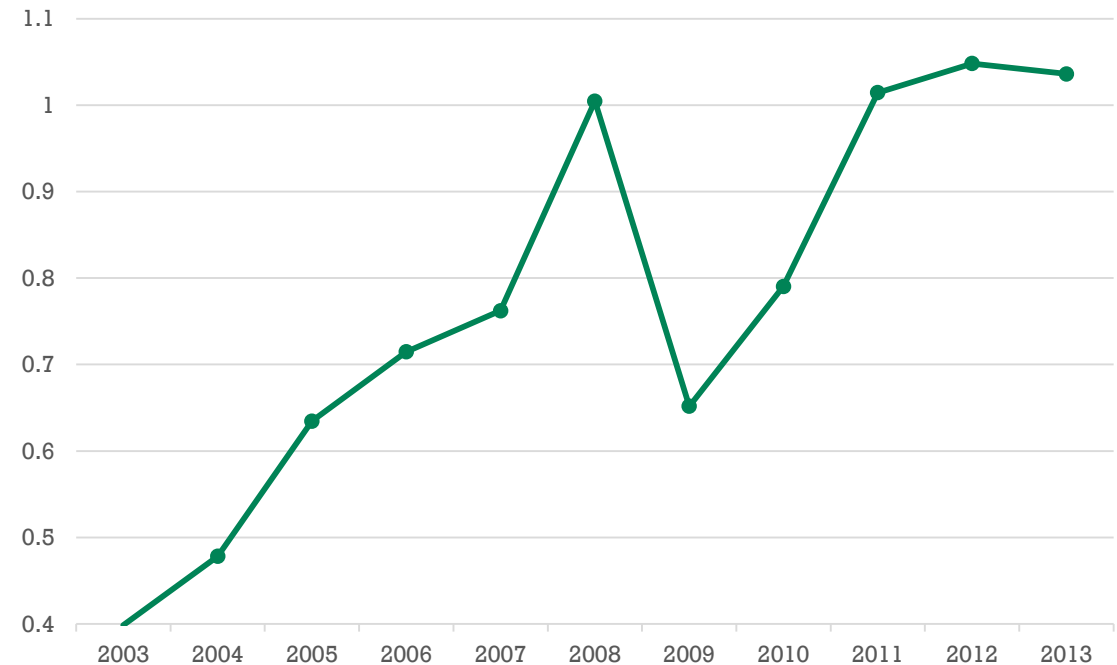
- Maximum thermodynamic efficiency of 35%
- Typical efficiency of 30% or less depending on the load profile and the system stability requirement
- O&M based on run hours not kWh produced leading to higher energy prices in low load factor systems



COST

- Installed capital cost, typically less than USD\$1000/kW
- Typical lifespan is relatively short
 - 25,000 hours for high speed diesel
- High O&M cost due to:
 - High fuel cost and low efficiency
 - Delivery cost of fuel and maintenance material at remote sites
 - Repeated scheduled maintenance requirements and the need for a skilled operator

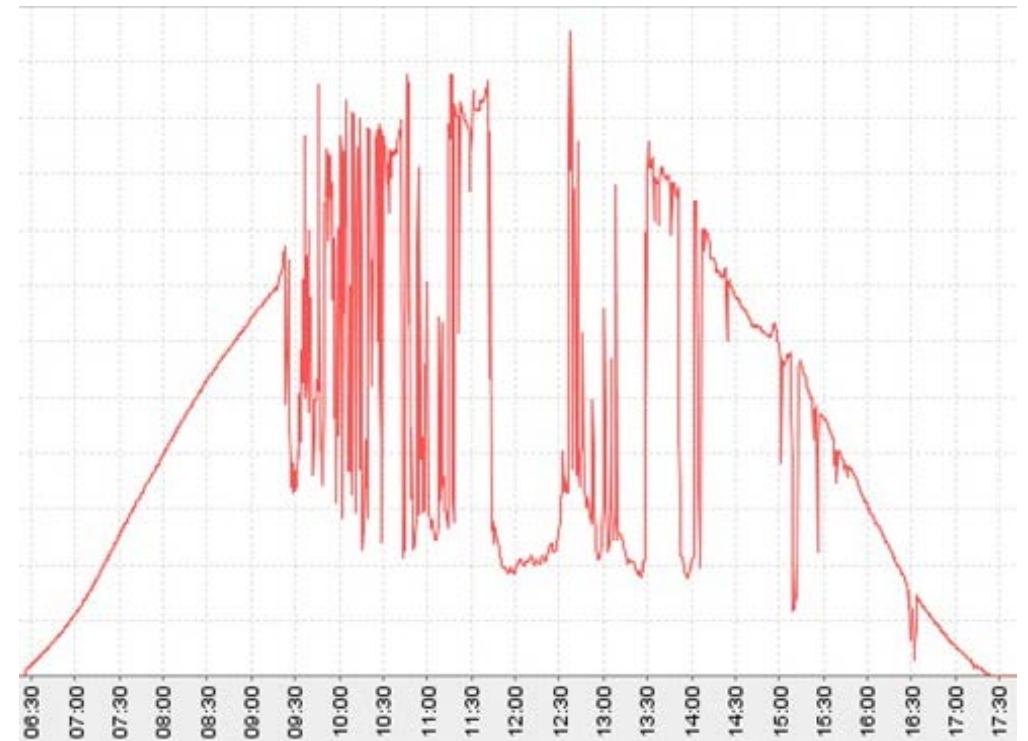
U.S. No 2 Diesel Retail Prices (USD/L)



GRID INTERACTIVE PHOTOVOLTAIC SYSTEM

CHARACTERISTICS

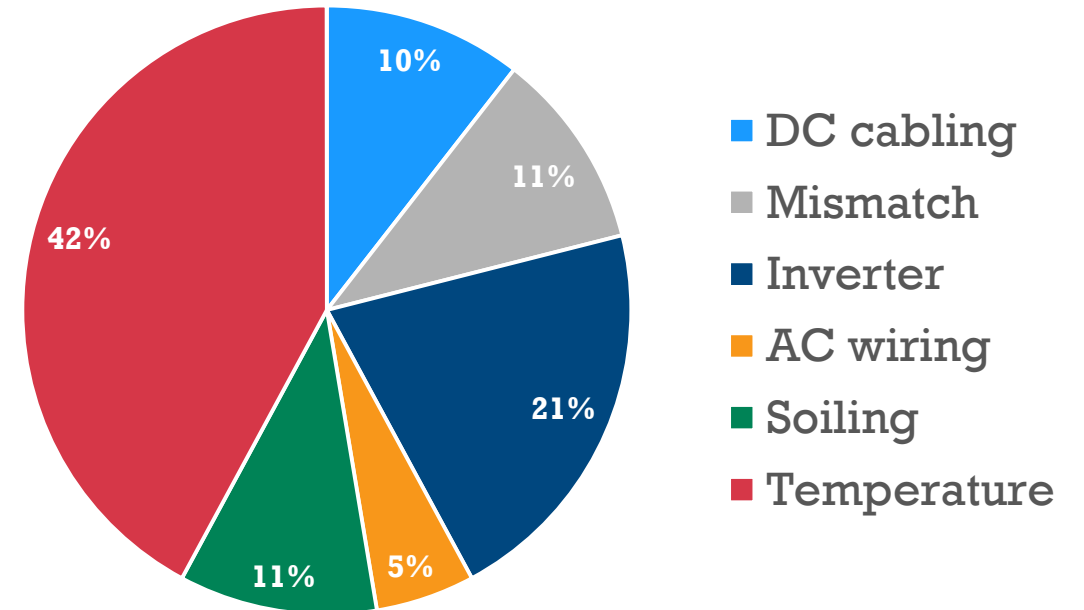
- Highly variable and intermittent output
- Requires another power source on the grid to function
 - Follows frequency of other source
 - Act as a current source and produce higher voltage at the point of connection to the grid
- System output can drop by 70% in 3 seconds
- Only available during the daytime hours



GRID INTERACTIVE PHOTOVOLTAIC SYSTEM

EFFICIENCY

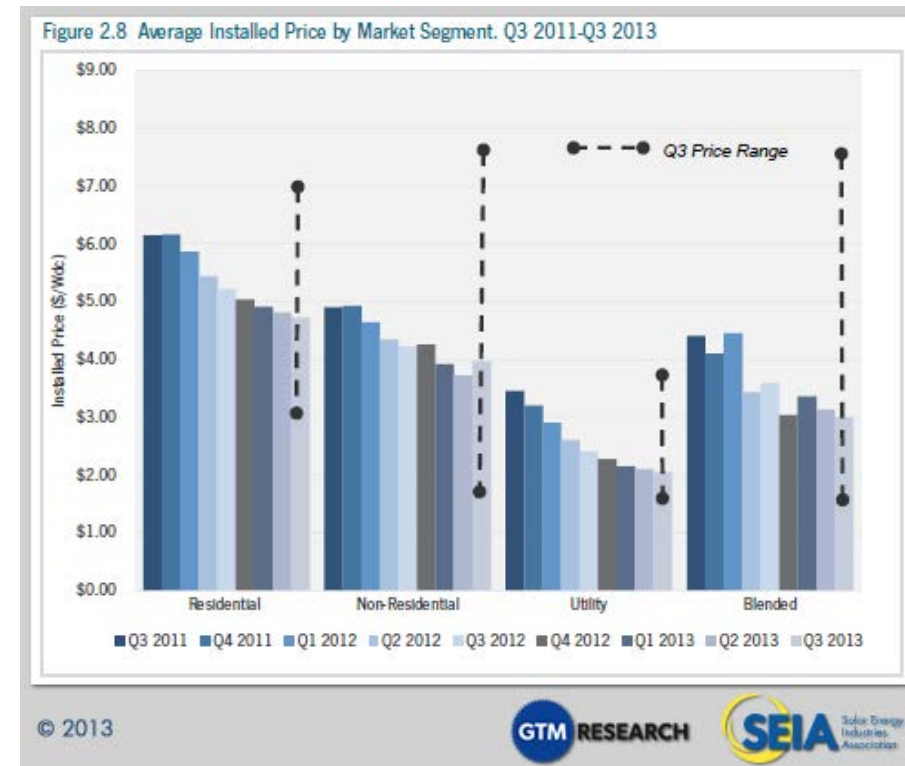
- Typical efficiency of the PV panel 17%
- Panel output efficiency decreases over time
 - 90% of the initial maximum power after 10 years
 - 80% of the original maximum power after 25 years.
- Typical efficiency of inverters 96%
- Typical grid interactive photovoltaic system is 80% of the rated STC DC output of the PV panels



GRID INTERACTIVE PHOTOVOLTAIC SYSTEM

COST

- Installed capital cost, typically USD\$4/W_p STC.
This includes:
 - Photovoltaic panels and mounting brackets
 - AC and DC wiring
 - Inverters
- Longer system lifespan
 - Inverters 15 years
 - Panels 25 years
- O&M is very low, around USD\$20/kW



DIESEL/PHOTOVOLTAIC HYBRID DISTRIBUTION SYSTEM

HOW?

- KISS - No changes required to the typical diesel plant and distribution system. Low PV penetration
 - Based on historical load or forecasted loads install an off grid interactive PV systems smart – oversize PV
- Smart – Using a separate communication link and strategically placed controllers to control the grid and balance power production with the load.



DIESEL/PHOTOVOLTAIC HYBRID DISTRIBUTION SYSTEM

WHY?

- Reduced fuel consumption results in a reduced cost of energy over the lifespan of the power plant.
- Hedge against future cost increase of fossil fuel
- Reduce carbon emissions
- Battery technology is still more expensive than diesel generation
 - Typical price USD\$0.5/amp-hr (DC)
 - High losses in charging and discharging batteries ~40%
 - Limited lifespan 10 years or less



IMPROVING THE ENERGY SUPPLY

- Distribute the PV plant geographically
 - Reduce intermittency
 - Improve efficiency
- Orient panels to produce higher outputs at different time of day
 - Reduces efficiency and increase stability
- Invest in other small renewable energy technologies
 - Wind
 - Run of river hydro
 - Biogas



ADDING ACTIVE DEMAND SIDE MANAGEMENT

- Using time of use to shift some of the night load to peak PV energy production time. Ex:
 - High energy household shores
 - Water pumping
 - Battery charging
- Integrating smart meters into the distribution grid and providing customers with an interruptible tariffs to actively manage demand





Q&A

PHOTOS OF THE DISTRIBUTION SYSTEM IN THE NORTH OF HAITI
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