Performance Optimization with Grid-tied Storage
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To be a power management leader, it helps to have a 100 year head start

- Founded in 1911
- 2014 sales of $23B
- >50 years on the S&P 500
- Innovation centers in regions around the world
- Customers in more than 175 countries
- More than 100,000 employees worldwide
- 50% of sales outside the U.S.
Energy Storage Balance of System for Utility installations
New generation: intermittency the major player

- The power generation landscape in the US is changing dramatically
  - Nukes are being shut down (4 announced so far)
  - Coal cannot be permitted due to high emissions
  - Low natural gas prices and ample supply make natural gas more attractive than ever
  - Solar becoming increasingly price competitive and now a major player in new generation

US New Generation 2012-2015 (GW)

- Natural Gas 40%
- Solar 36%
- Wind 15%
- Coal 9%
- Nuclear 0%

Source: US EIA
US Solar market snapshot (MW)

- Solar has a huge head-start over storage
- Many shared lessons to be learned

Source: IHS Q4’13, PV Inverter Market Data
3 Categories

- Performance
  - Efficiency of the system including ancillary loads
- Price
  - Turn-key installation and optimal design
- Packaging
  - Optimized for the application
Performance Matters

• Unlike solar, power losses are “round trip”
  • Inverter, transformer, cabling losses all get doubled
• In some cases, inefficiency is compounded
  • Inefficient batteries require more air-conditioning
  • Inverters inside containers sometimes need air-conditioning
• Operating conditions are complex
  • Measuring efficiency can be more complicated.
Performance: Efficiency

- Complex and battery-dependent for the inverter
- Straightforward for the transformer

![Efficiency Graph](image-url)
Performance: Connections

- Direct bus connections to reduce line losses
Price

• Price is more than just the equipment cost
  • Excavation
  • Pads
  • Equipment placement
  • Connections
Benefits of Compactness

• Compact solutions save solution costs in several ways
  • Excavation costs
  • Pad costs
  • Shipping costs
Modularity
Modular Designs

- Modularity reduces custom engineering work
Inverter Packaging

• Early solar inverters often started as VFD drive units and were typically NEMA-1 rated
• E-houses became a necessity
  • Temp control: drives often can’t handle high and low temps
  • Environmental contaminants: air cooled drives often pulled in lots of debris and needed physical protection
Inverter Packaging

- Ehouses tend to have flat roofs and do not shed snow.
- Snow can pile up and block doors and impede entry.
- Snow or debris can get sucked in by air intakes.
- Piled snow can melt and then drip through low vents.
Packaging: Outdoor Designs

- Does not impede airflow to the inverter
- Inverter “breathes” normally and does not let exhaust air mix with intake
- Intake and exhaust high off the ground where air is clean
- Easy access to unit on all sides for comfortable working space
Remember the 3 P’s

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- Price
  - Turn-key installation and optimal design
- Packaging
  - Optimized for the application