Microgrid Power Systems

Lowering the LCOE of Hybrid Systems
LCOE Drivers and Challenges for Hybrid Systems

- Maximizing renewable penetration
- Grid stability trade offs
  - Frequency control
  - Spinning reserve requirements
  - Storage solutions still expensive
  - System complexity
  - Curtailment

- Fixed Speed GENSET challenges
  - Minimum load (>30%)
  - Low efficiency at low loads
  - O&M Impact at low loads

Maximizing Renewable Penetration

Fixed Speed Generators (FSG)
How to adapt to challenges?
Fixed Speed Generator (FSG) Hybrid Challenges

Low efficiency at low loads

High Penetration Renewables drive GENSETS to operate at low loads

Frequency control with rapid load transients

Frequency Instability
**Decouple Engine Speed from Frequency & Load**

### Fixed Speed Generator
- Generator speed fixed regardless of load.
- Generator speed: 1800 RPM.
- Average Load: 1600 RPM.
- Peak Load: 2000 RPM.

### Innovus Variable Speed Generator
- Generator speed mirrors the load.
- Signal from Generator varies as electric load varies.
- Signal is converted to smooth AC output.

### Innovus VSG Decouples Engine Speed from Frequency & Load
- Engine controller:
  - Piston Engine
  - Generator
- DemandGenius Controller:
  - Piston Engine
  - Permanent Magnet Generator
  - Inverter
  - Active rectifier
- 3 Phase AC output.
Innovus VSG Delivers Higher Fuel Efficiency at All Loads

Operating Range for High Penetration Renewables

As Renewables reach higher penetration, VSG fuel burn remains low
With stability controlled, Renewables can increase to 100% of Peak

**Fixed Speed Generator (FSG) based Power System**

**Innovus Variable Speed Generator (VSG) based Power System**

High penetration Renewables can be realized without adding costly assets
Innovus Microgrid Platform Solves the Cost Challenges

High Penetration Renewables Can Be Realized at Lower Cost
400kW Hybrid System LCOE Case Study - Australia

Current - Utility Connection
- Average load 400 kW
- 2,808,321 Annual kWh Usage
- Large annual utility rate increases
- AVG $0.32 kWh

EPC's “Standard” Solution
- FSG-Solar-Batteries-Converter
- Non Solar Capex $1.6M
- AVG LCOE $0.25 kWh

Innovus Solution
- VSG-Solar-Energy Buffer
- Non Solar Capex $ 1.4M
- AVG LCOE $0.18 kWh

$394,000 per year savings
- No Storage
- High efficiency VSG at low load
- Stable frequency control
Innovus FSG Solution Enables

- High renewable penetration with grid stability
- Efficiency at low loads
- Efficient spinning reserves
- 100% penetration without storage
- Stable frequency control
- Integrated generation/control
The New Backbone for Distributed Power

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FSGs cost rise with high renewable penetration

Levelized Cost of Energy (LCOE)

Fixed Speed Generator (FSG)

Cost increase assets are added to stabilize Grid

Maximum penetration without stability issues

LCOE of Renewables Plus Dispatchable Fixed Speed Generator (FSGs)

100% fossil fuel power

Increasing Renewables

100% Peak Power from Renewables
Innovus Microgrid Platform deploys the lowest cost power

Interchangeable Rack Mount Power Converter Modules Allow for Easy System Configuration

DemandGenius Controller

Active Rectifier → DC Bus → Inverter

PowerBridge

Stabilizing Load

Hybrid Energy Storage

AC Load → AC
Customer Case Study: Wind-Diesel Application

Current situation with FSG based System

- Wind power severely curtailed due to stability issues
- Savings 52% below plan

Projected results with Innovus System

- Wind capacity can be fully deployed
- Additional energy available for heating
- 53% reduction in diesel cost

Grid operator will save $525,000 per year in fuel

*Wind turbine in operation since 2012
The only way to maintain constant 60 Hz ‘AC’ power frequency was fixing the speed of generators.

System turns at 1 speed at all loads

Prime Mover → Generator → AC Power

The Synchronous ‘Fixed Speed’ Generator

Fixed Speed Generators (FSGs) have serious challenges

- Limited ability to handle large and frequent load changes
- Limited ability to handle rapid changes in renewable generation
- Rapid decline in fuel efficiency as loads decrease
- Must be run at high minimum loads to prevent reliability issues
Innovus Power at a glance

**Background & Other**
- Founded in 2013
- Key IP and asset acquisition in 2012
- Marine Diesel Electric Propulsion since 2002
- Robust patent portfolio and proprietary technologies
- Based in Fremont, CA. near San Francisco

**Products**
- Microgrid Power Systems from up to 25 MW
- Only Variable Speed Generators above 100 kW

**Target Markets**
- Microgrids
- Grid Load Defection
- Mining
- Grid Stabilization
- Oil & Gas
- Military
- Construction
- DE Generation

Fremont, CA Headquarters