Microgrid Power Systems

Lowering the LCOE of Hybrid Systems

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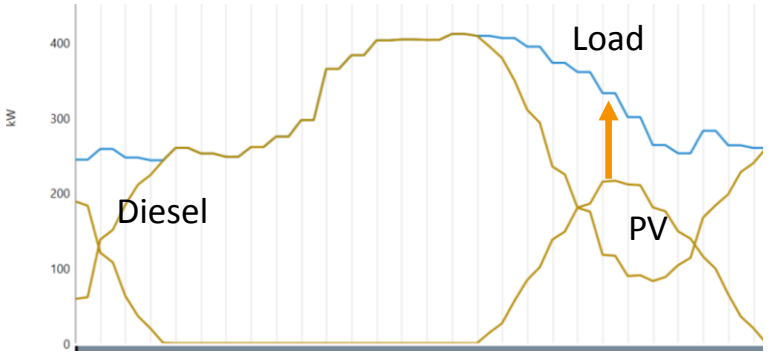
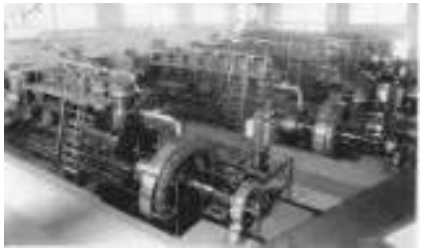
LCOE Drivers and Challenges for Hybrid Systems

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



Maximizing Renewable Penetration

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



Fixed Speed Generators (FSG)
How to adapt to challenges?

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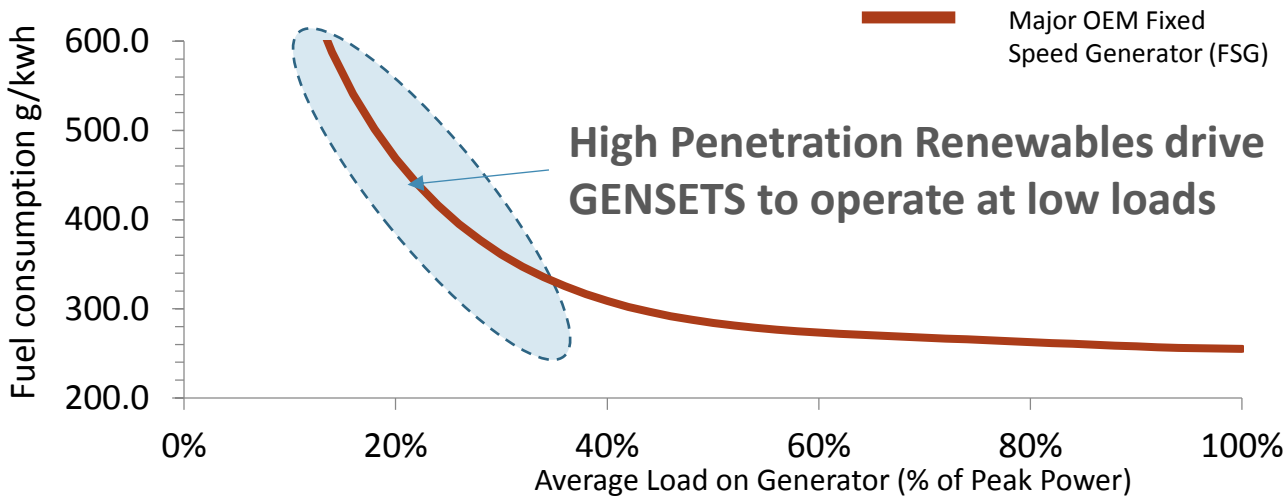
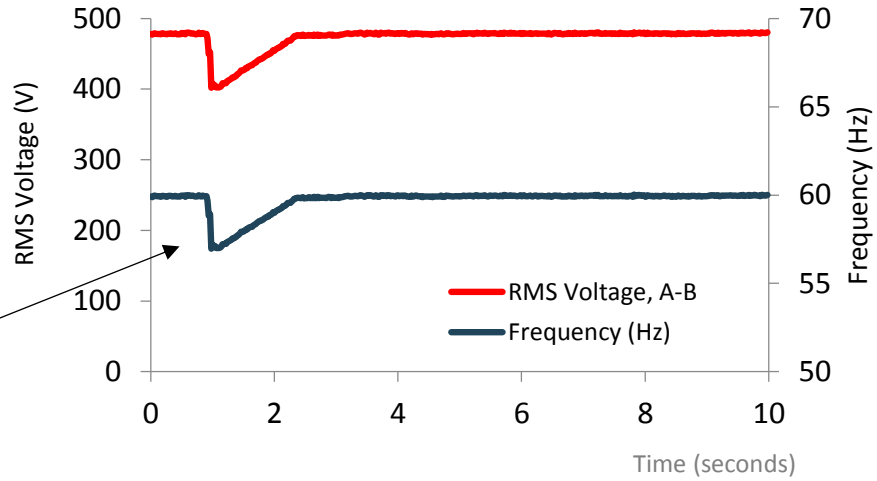
Fixed Speed Generator (FSG) Hybrid Challenges

Low efficiency at low loads



Frequency control with rapid load transients

Frequency Instability



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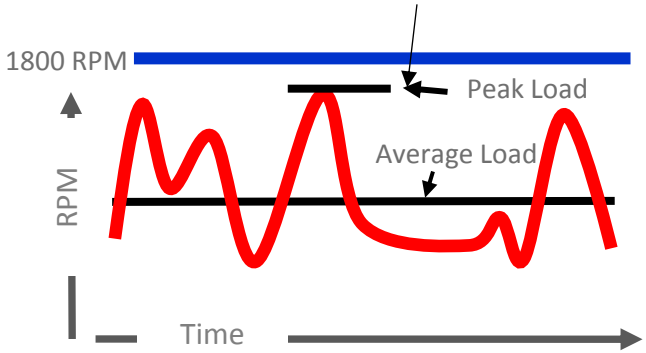
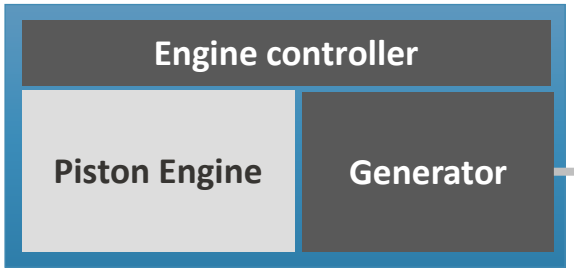
Decouple Engine Speed from Frequency & Load

Fixed Speed Generator

Generator speed fixed regardless of load



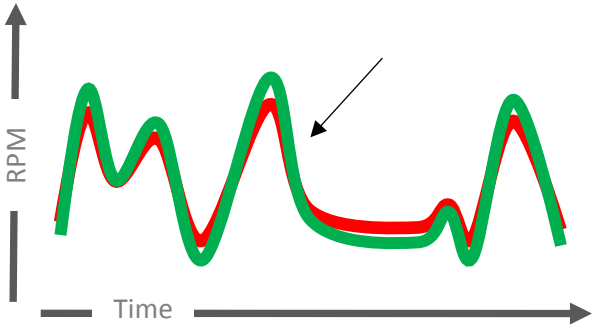
Generator Speed
Power Load



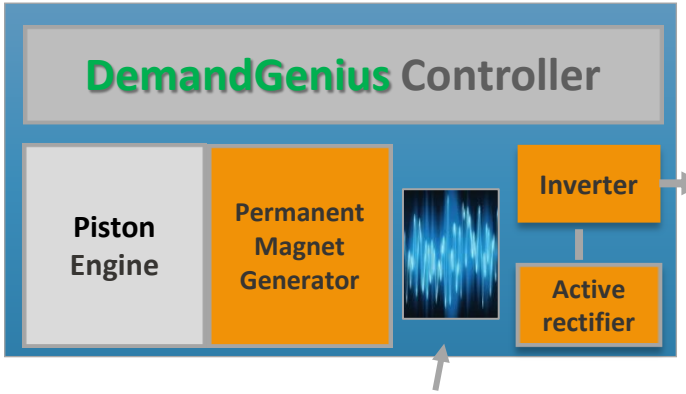
3 Phase AC

Innovus Variable Speed Generator

Generator speed mirrors the load



Generator Speed
Power Load



Innovus VSG Decouples Engine Speed from Frequency & Load

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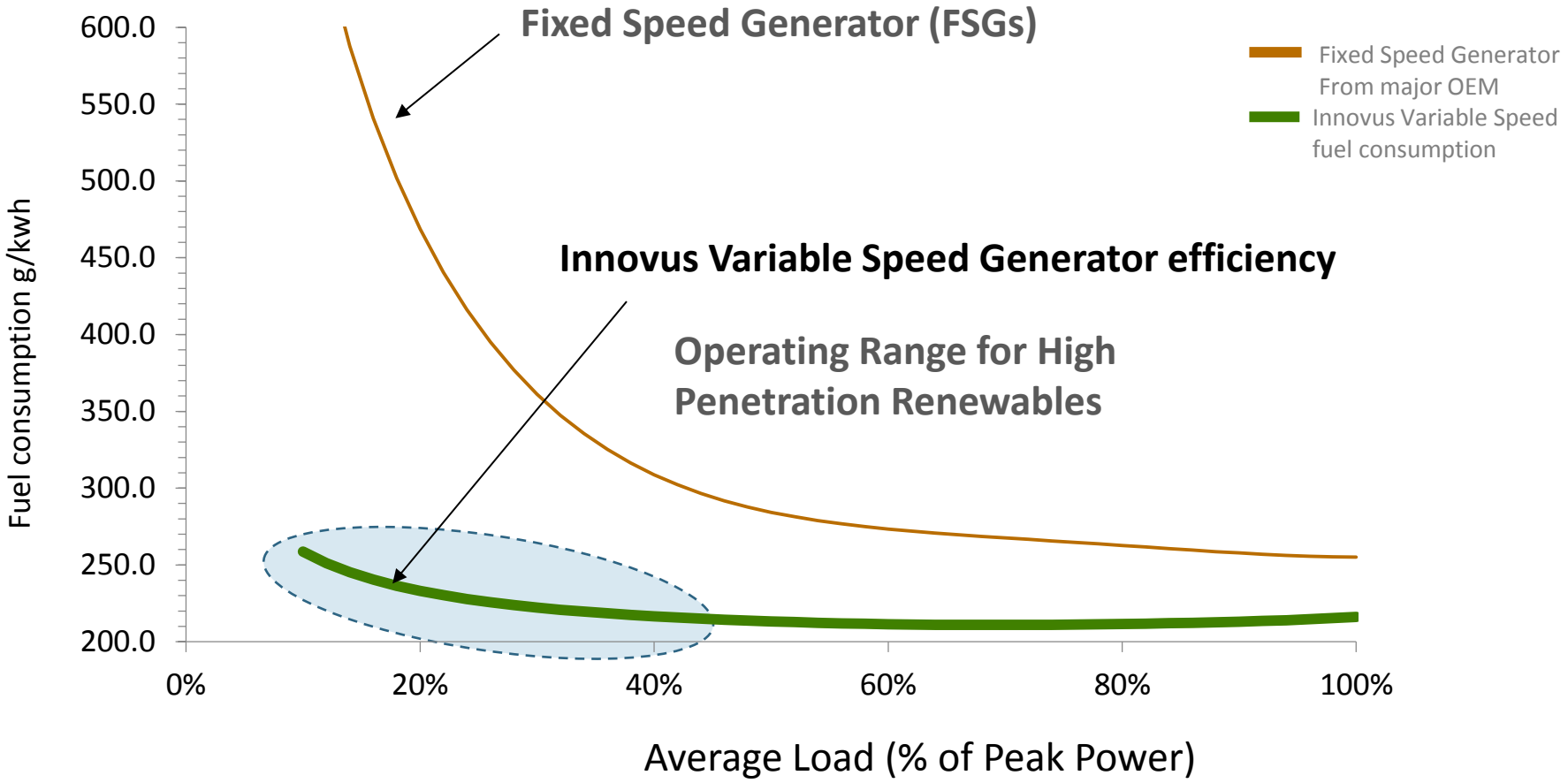
Innovus VSG Delivers Higher Fuel Efficiency at All Loads



As Renewables reach higher penetration, VSG fuel burn remains low

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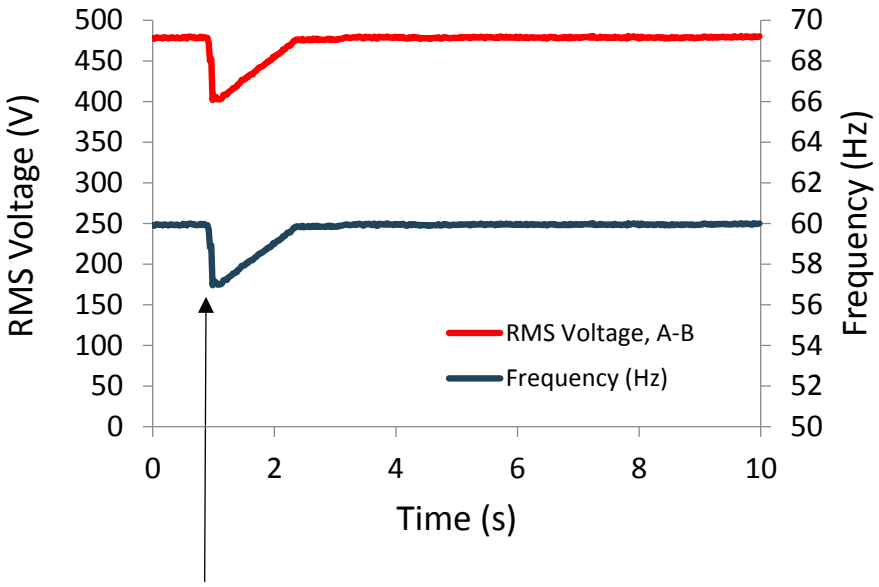
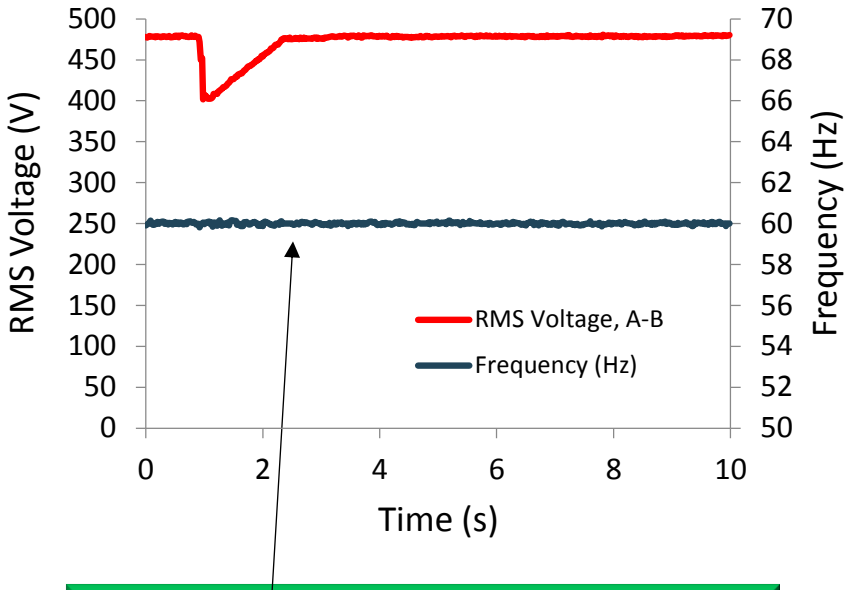
With stability controlled, Renewables can increase to 100% of Peak

Fixed Speed Generator (FSG) based Power System



Frequency variability

Innovus Variable Speed Generator (VSG) based Power System



Fixed frequency leads to stable Grids

High penetration Renewables can be realized without adding costly assets

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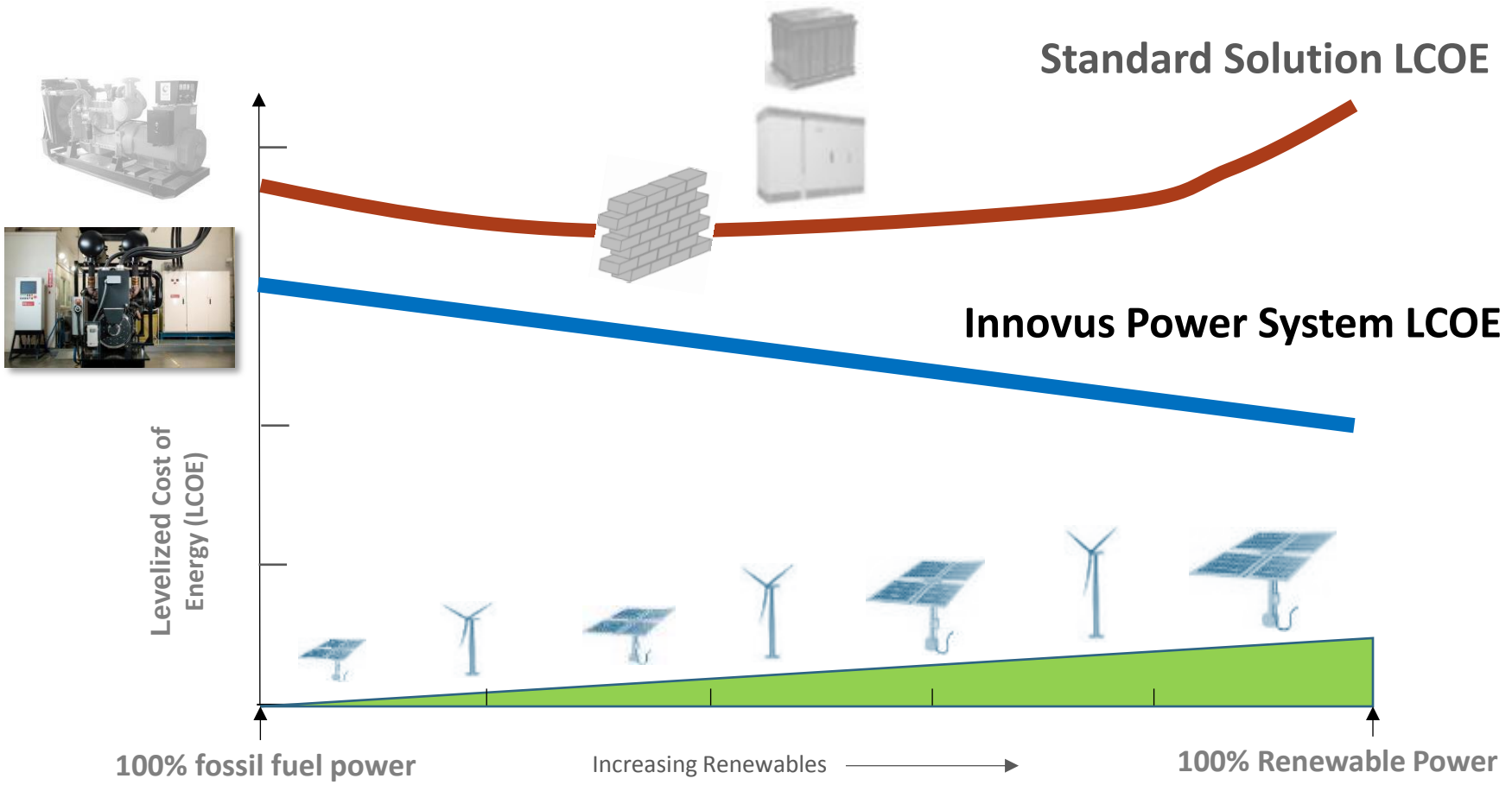
Innovus Microgrid Platform Solves the Cost Challenges



High Penetration Renewables Can Be Realized at Lower Cost

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400kW Hybrid System LCOE Case Study - Australia

Current - Utility Connection

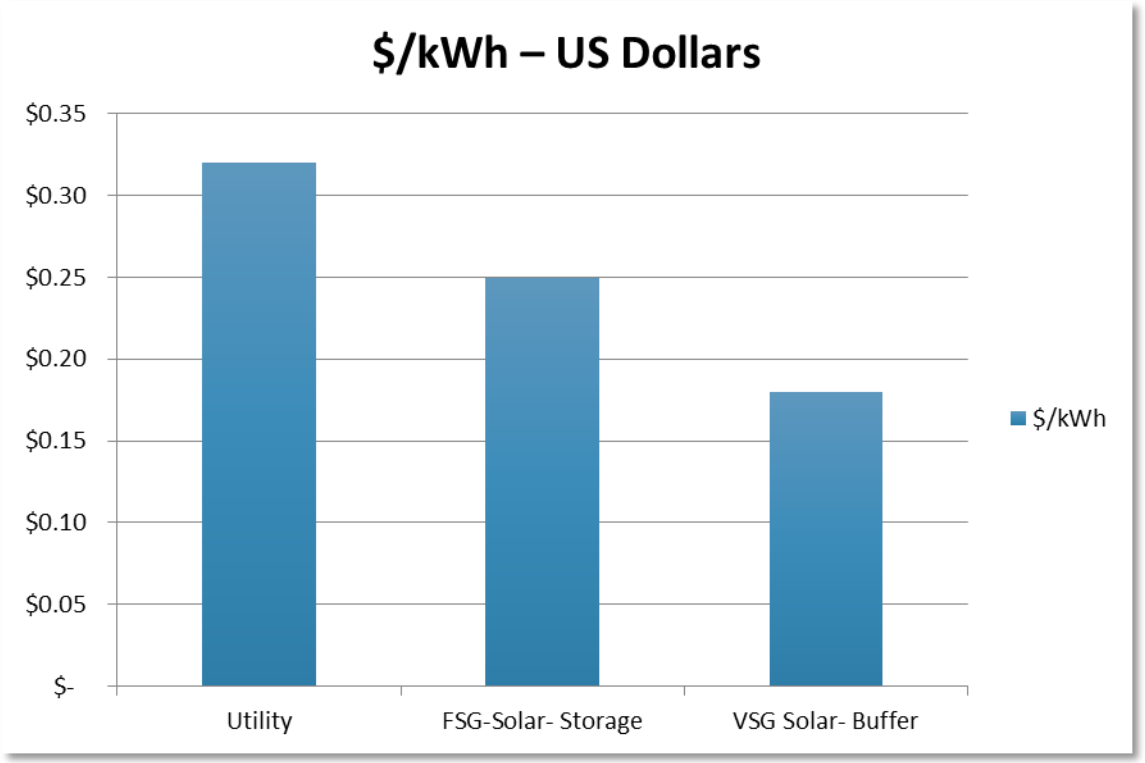
- Average load 400 kW
- 2,808,321 Annual kWh Usage
- Large annual utility rate increases
- AVG **$0.32** kWh

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

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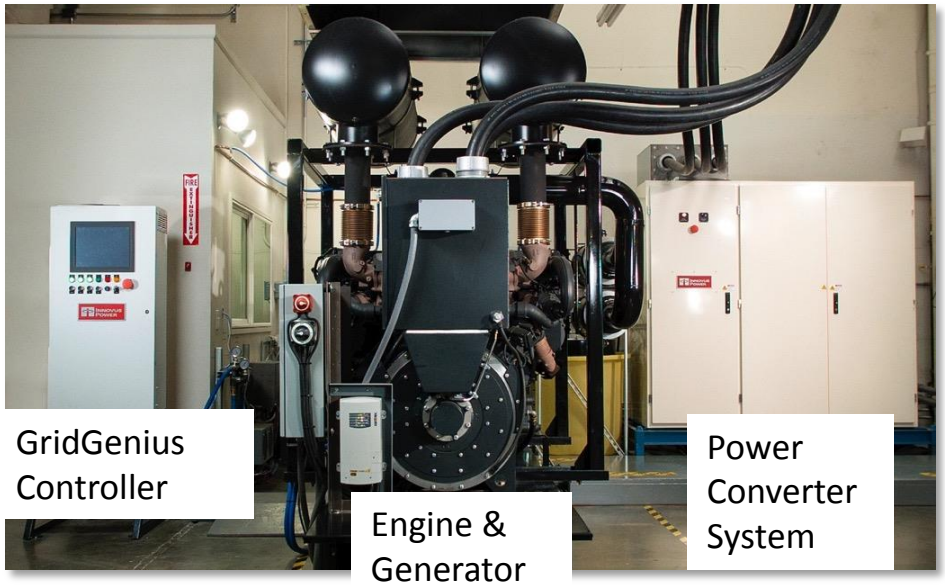
Innovus Microgrid Platform Enables Lower LCOE

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



Innovus Microgrid Platform

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The New Backbone for Distributed Power

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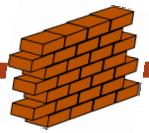
FSGs cost rise with high renewable penetration

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)

Levelized Cost of Energy (LCOE)

100% fossil fuel power

Increasing Renewables

100% Peak Power from Renewables

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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

AC

AC Load

Stablizing Load

PowerBridge

Hybrid Energy Storage

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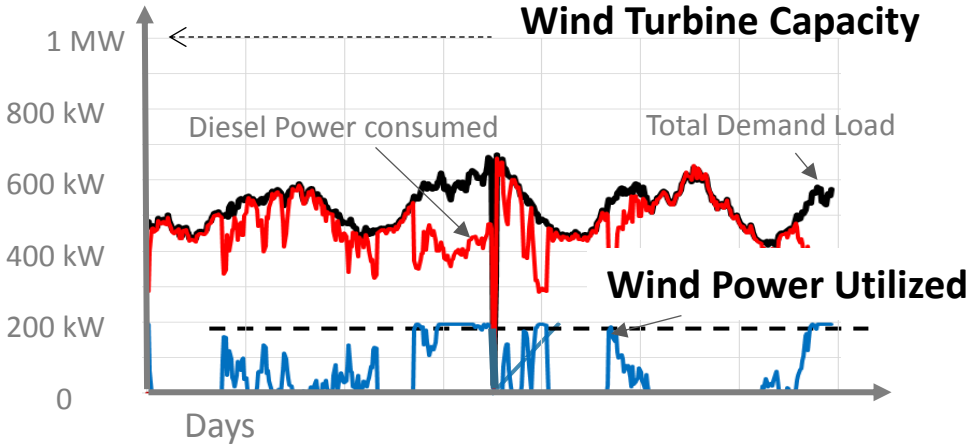
Customer Case Study: Wind-Diesel Application

Current situation with FSG based System

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

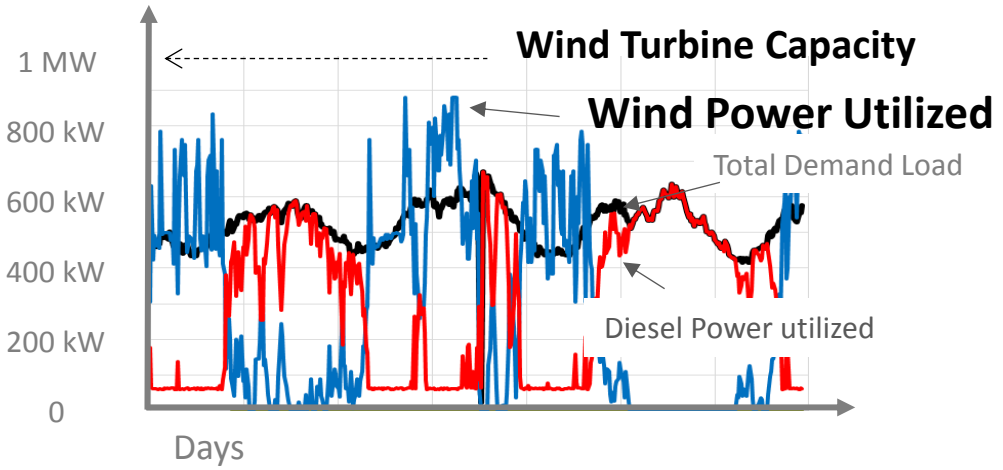
Current- Energy by power source*



Projected results with Innovus System

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

With Innovus- Energy by power source



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

*Wind turbine in operation since 2012

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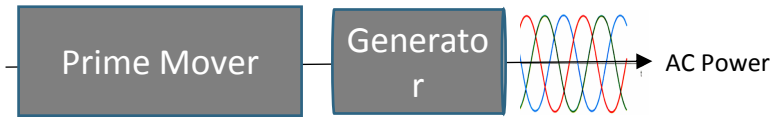
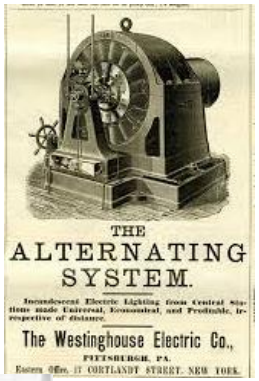
Fixed Speed Generators were invented 125 years ago

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



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

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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

Fremont, CA Headquarters

Target Markets

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

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