IPS Connect Maui 2018

The Innovus Power Microgrid Platform

Software driven Converter Based Integrated Variable Speed Generation Solutions

Software and Electronics for Power Generation

Wind

SolarPV

Battery Storage

- Low Cost
- High reliability
- Extremely efficient
- Proven & Bankable
- Programmable and controllable

- Transient response
- Grid Support

Why Not for Fossil Fuel Generation?

- Variable Speed Engine operation
- Enables Highest Engine efficiency
- Integrates 100% renewables
- Programmable and controllable
- Components Proven & Bankable

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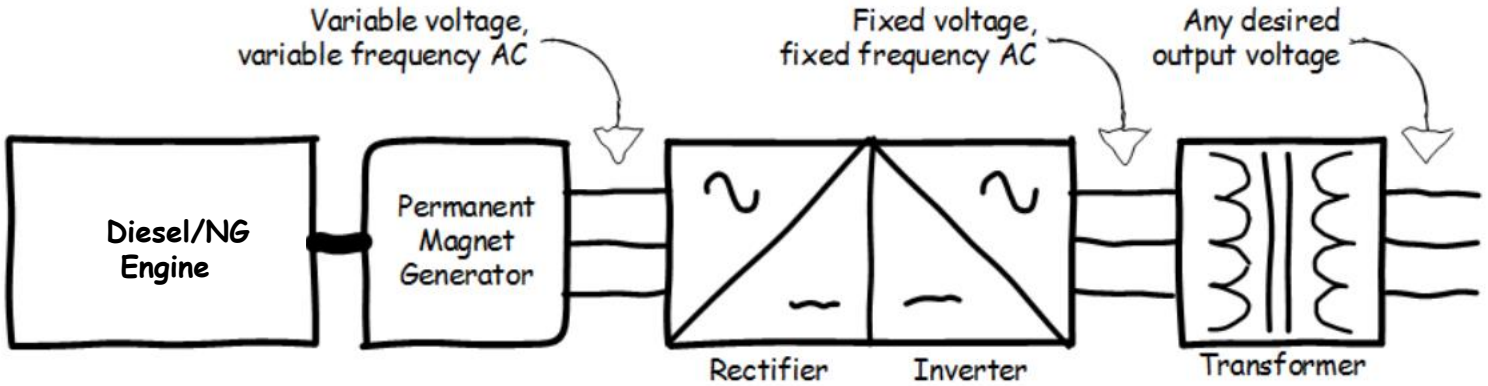
INNOVUS POWER

Innovus Architecture- Converter Based VSG

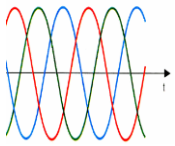


MTU/Cat/Siemens Diesel/NG/Propane

Permanent Magnet Generator

Variable RPM Frequency/Volt

Power Hub



50/60 Hz AC

- **Decoupling** Engine Speed and generator through Back to back conversion process fundamentally changes the characteristics of fuel based energy production
- Significantly **improved response capabilities** of the prime mover- predictive- not reactive

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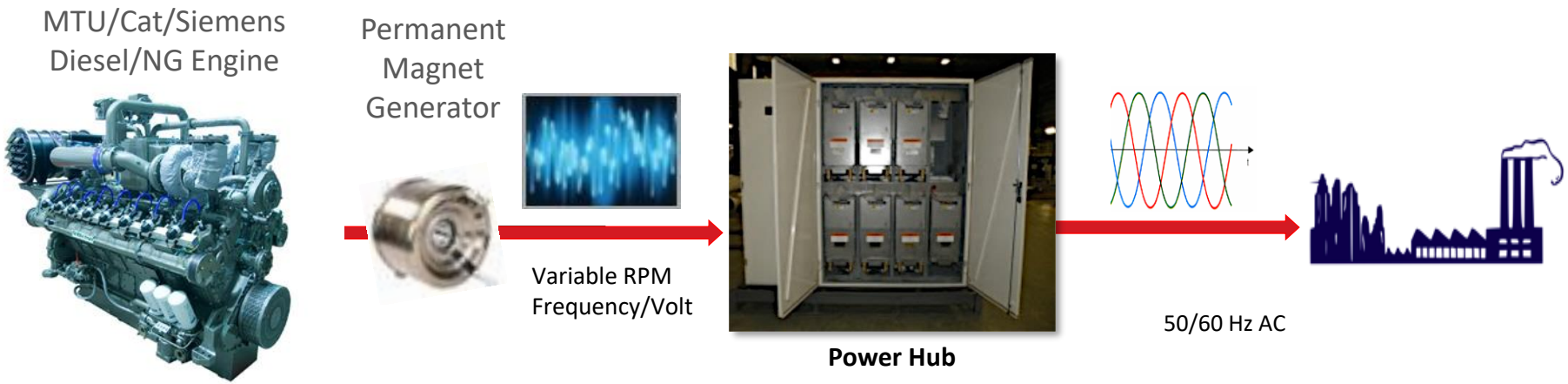
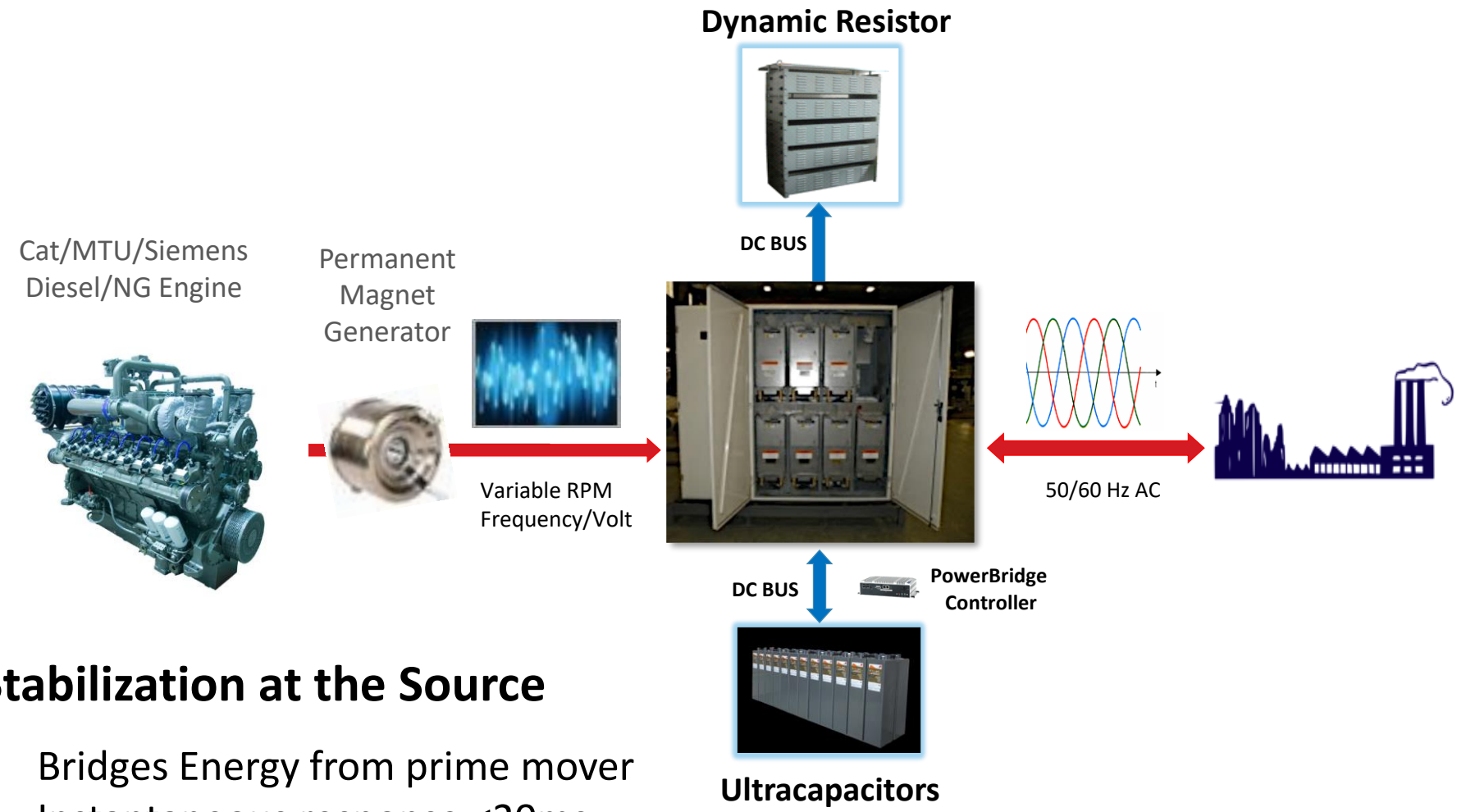
Inverter based Generation- Unlocking Benefits



- Converter provides Grid **Support Features**
  - **Generation Stability without Storage**
  - **Transient response**
  - **Frequency Regulation**
  - **VAR Support-100%**
  - **Virtual Spinning Reserve**
  - **Engine off operation**

- **Healthy LOW LOAD** operation typical **10%**
- **Dispatchable + Renewable Firming 24/7/365**
- **Cost effective transition Grids to 100% renewable with fossil back up**

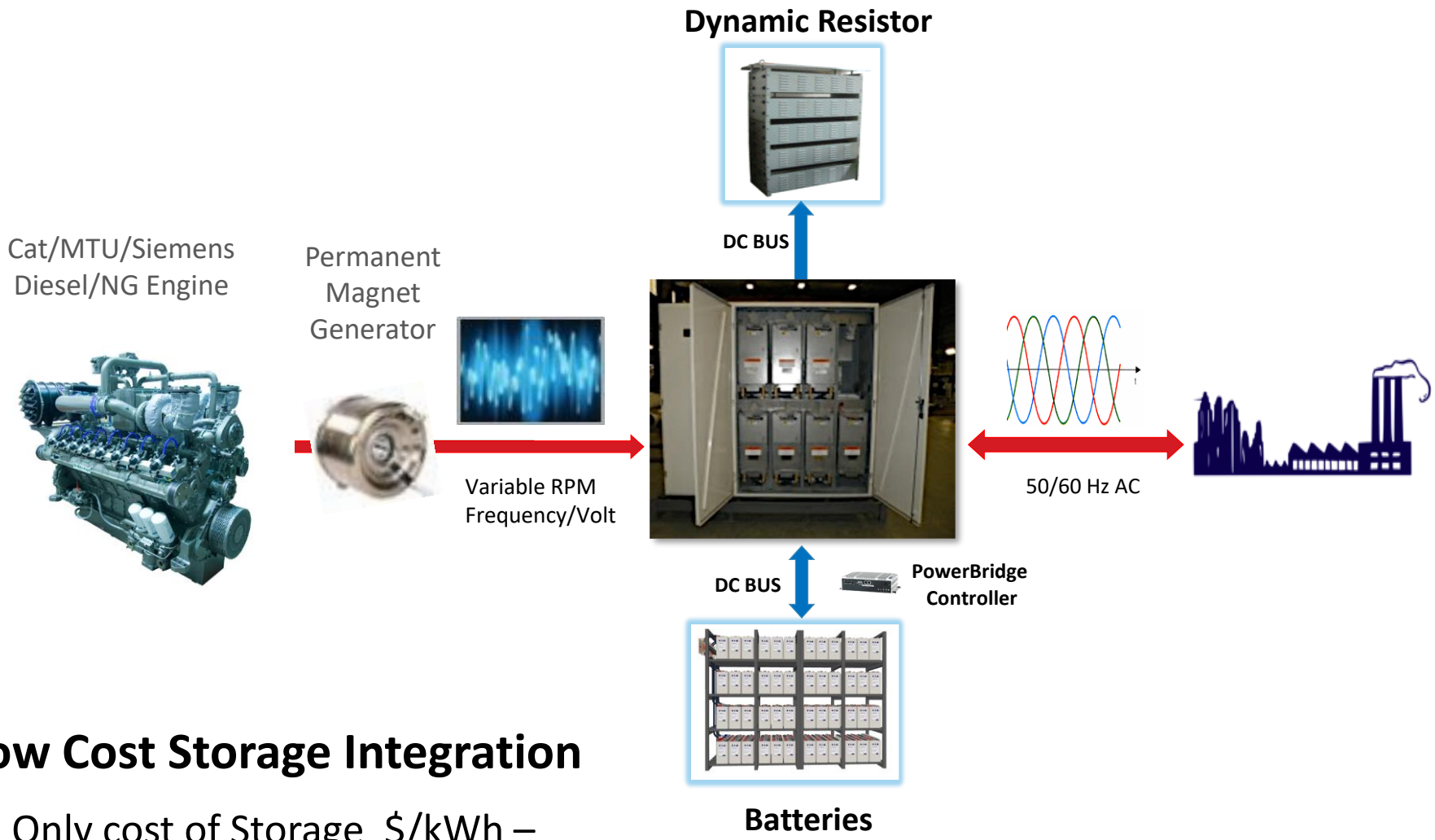
PowerBridge- An Innovus Integrated Solution



Stabilization at the Source

- Bridges Energy from prime mover
- Instantaneous response <20ms
- Seamless Power Supply/Engine off
- UPS response

Low Cost Storage Integration



Low Cost Storage Integration

- Only cost of Storage $/kWh –
- $250-$300/kWh-
- eliminates $/kW for Power Electronics

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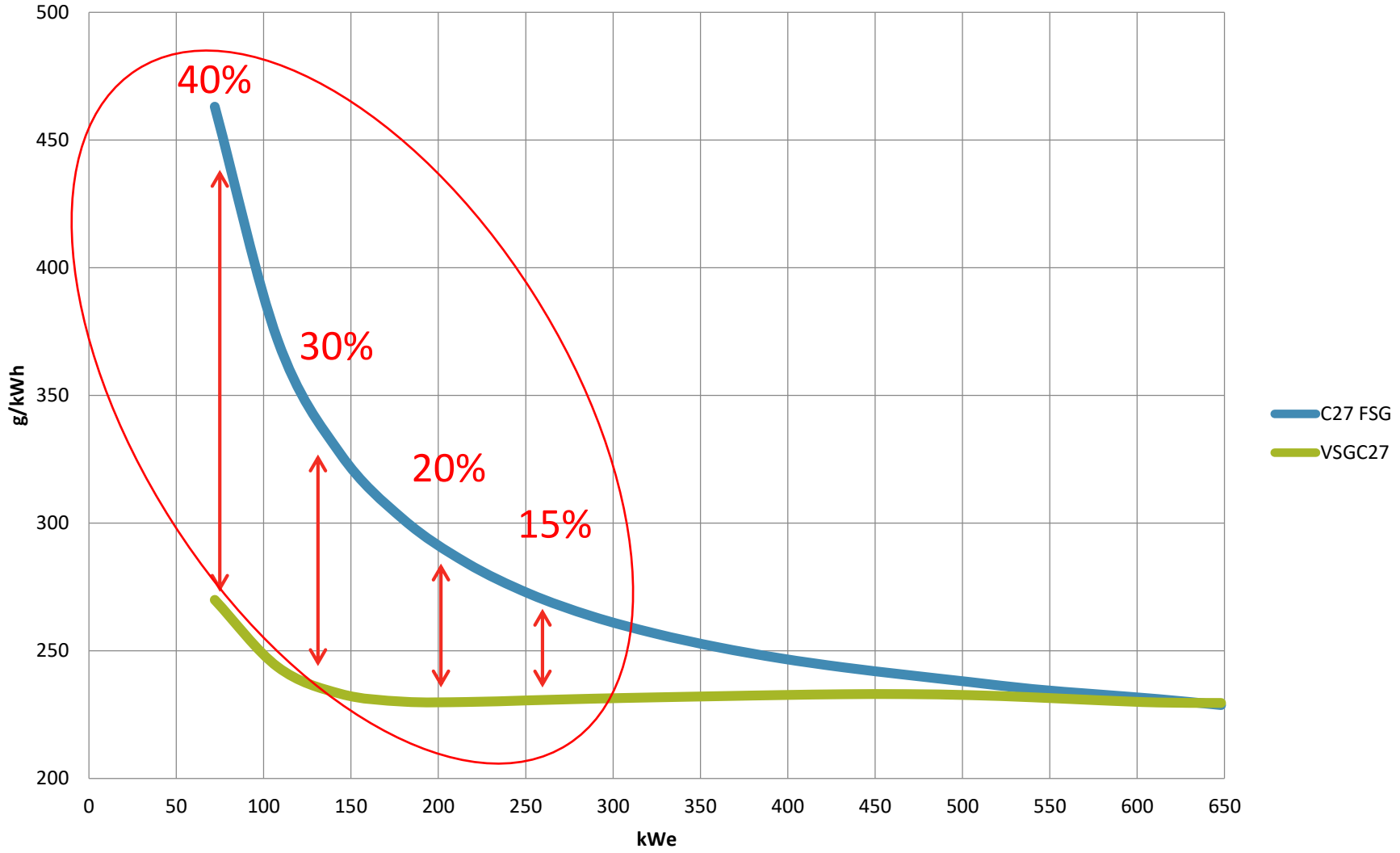
Disruptive Efficiency & Load Range



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INNOVUS POWER

Aklavik, NT An NTPC Project

Population: 590~

Households: 300

Access: Airport, road-Barge, Ice Road

Fuel savings: 80,000 litres/year

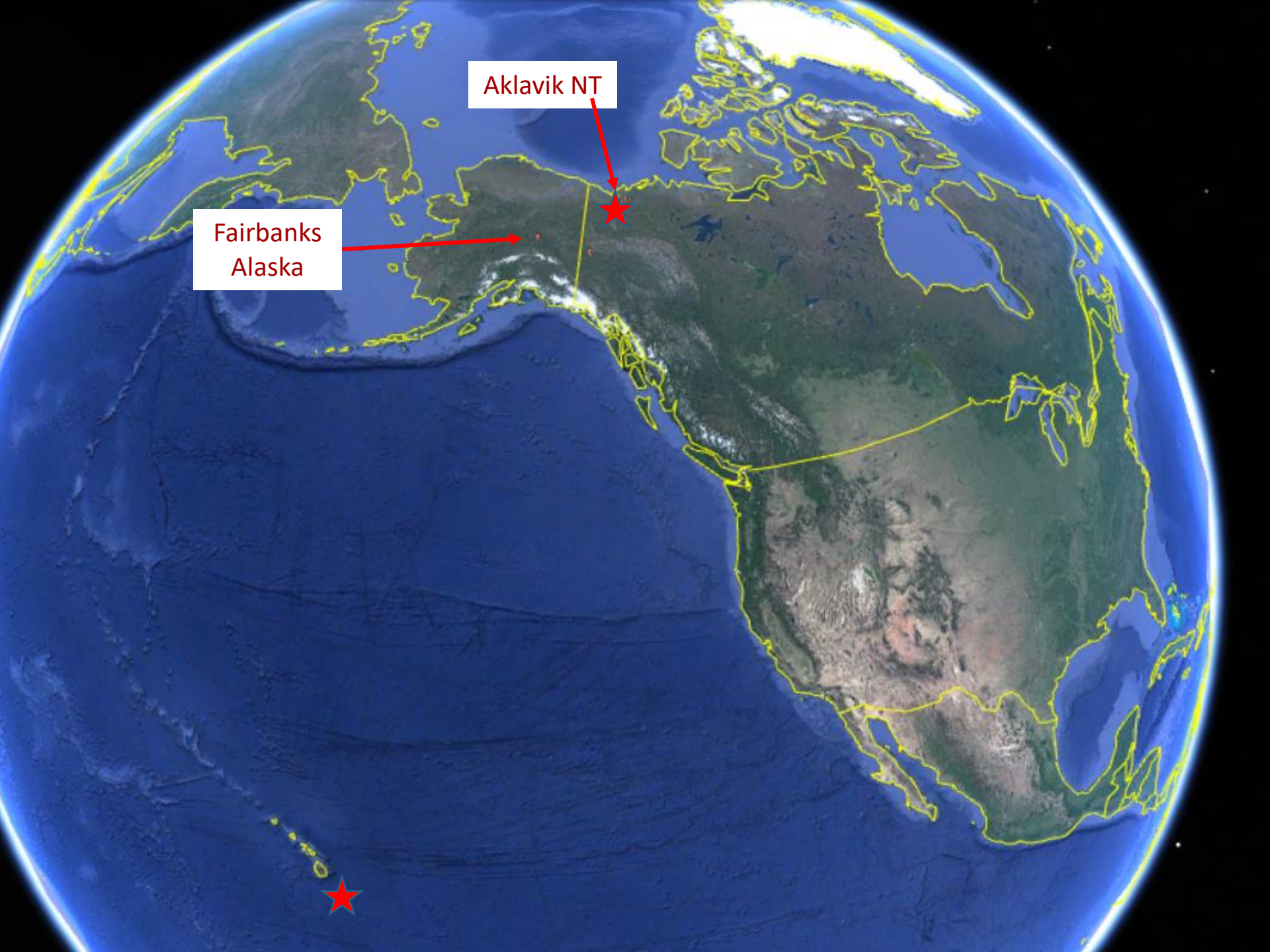
Emissions: 210 Tonnes GHG reduction

Peak Rating: VSG 590 kW Prime Power

System Configuration: Diesel Generation with Solar

Solar: Low Penetration 1st Phase-55kW

LT Goal: High penetration Renewables


Aklavik NT
Fairbanks
Alaska

Climate data for Aklavik/Freddie Carmichael Airport [hide]													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high humidex	10.5	2.0	8.1	16.6	27.8	35.7	35.5	33.8	26.5	16.4	4.3	5.5	35.7
Record high °C (°F)	6.7 (44.1)	9.4 (48.9)	11.0 (51.8)	14.2 (57.6)	25.0 (77)	31.8 (89.2)	33.9 (93)	31.9 (89.4)	27.6 (81.7)	17.0 (62.6)	6.7 (44.1)	10.0 (50)	33.9 (93)
Average high °C (°F)	−22.3 (−8.1)	−21.7 (−7.1)	−16.4 (2.5)	−6.7 (19.9)	4.6 (40.3)	16.5 (61.7)	18.4 (65.1)	15.0 (59)	7.6 (45.7)	−4.9 (23.2)	−17.0 (1.4)	−20.9 (−5.6)	−4.0 (24.8)
Daily mean °C (°F)	−26.3 (−15.3)	−25.7 (−14.3)	−21.7 (−7.1)	−12.5 (9.5)	−0.1 (31.8)	11.4 (52.5)	13.9 (57)	10.9 (51.6)	4.4 (39.9)	−7.6 (18.3)	−20.7 (−5.3)	−24.7 (−12.5)	−8.2 (17.2)
Average low °C (°F)	−30.2 (−22.4)	−29.8 (−21.6)	−27.0 (−16.6)	−18.2 (−0.8)	−4.8 (23.4)	6.2 (43.2)	9.4 (48.9)	6.8 (44.2)	1.2 (34.2)	−10.2 (13.6)	−24.2 (−11.6)	−28.4 (−19.1)	−12.4 (9.7)
Record low °C (°F)	−51.0 (−59.8)	−52.2 (−62)	−48.9 (−56)	−42.2 (−44)	−25.6 (−14.1)	−6.7 (19.9)	−11.1 (12)	−3.9 (25)	−14.0 (6.8)	−35.1 (−31.2)	−45.6 (−50.1)	−47.8 (−54)	−52.2 (−62)
Record low wind chill	−59.8	−61.5	−52.8	−46.0	−31.5	−11.4	0.0	−6.0	−16.4	−41.1	−49.7	−56.4	−61.5

Factory Tested, Modularized

Containerized or Skidded Solutions

600kW, 1.2MW, 1.8MW

SIMPLE ON SITE CONNECTIONS

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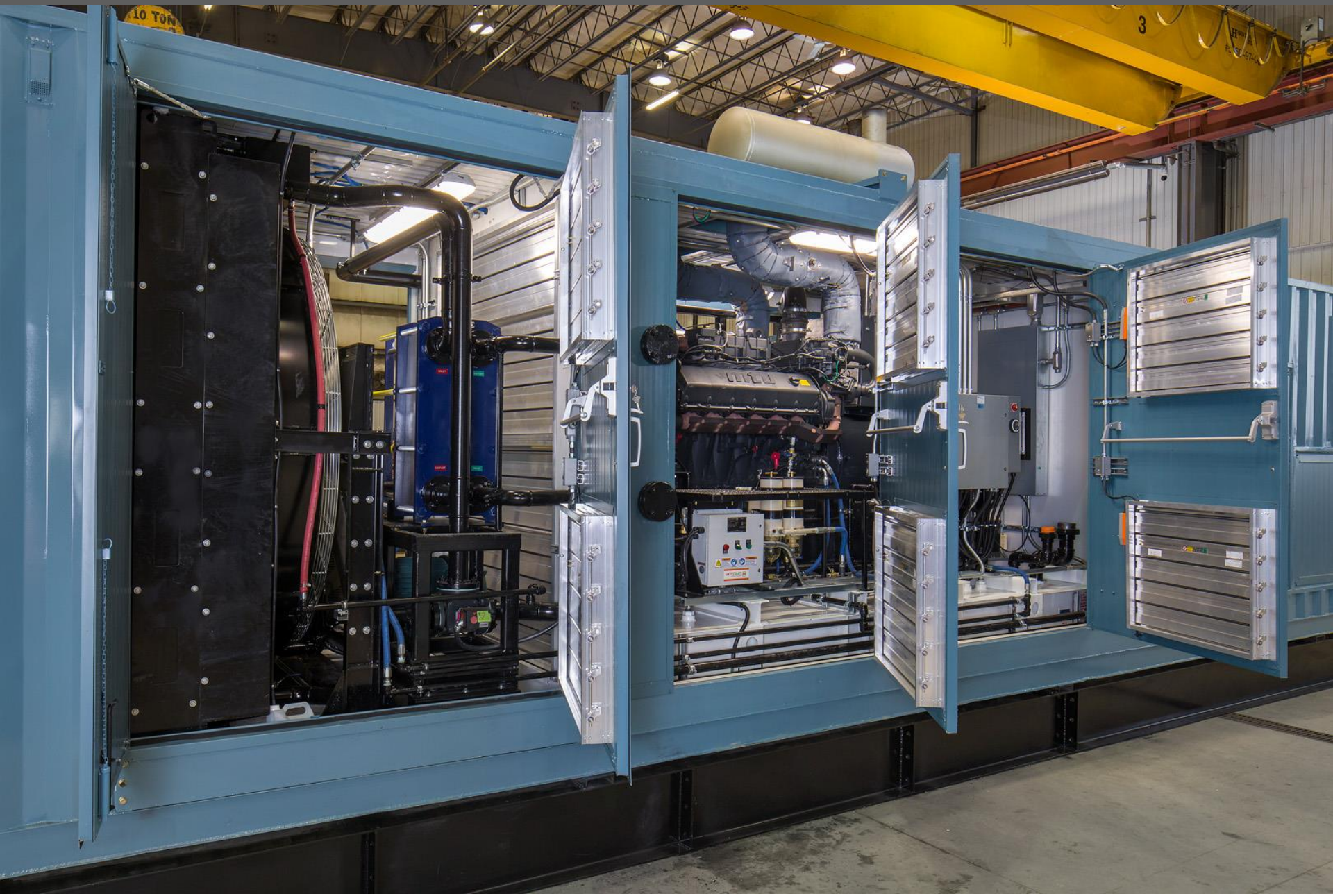

Interior Arctic Containerized Package for NTPC-with subbase tank, roll end skid, plate frame heat exchanger

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Interior Electronics Room- Arctic Containerized Package for NTPC- Converter, and exterior mount HMI

Aklavik NWT- VSG Independently Powering Entire Community

Status: Commissioned January 2018

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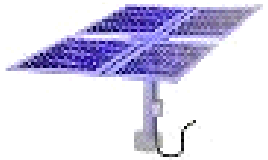
NTPC Aklavik NWT- N+3 Generation Architecture

590kW VSG

Power Converter

55kW Ground Mounted Solar



DD Series 60
320kW
Qty 4

Aklavik Isolated Grid
550kW Peak
180kW min
350 Ave Load

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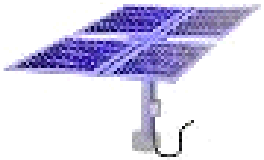
NTPC Aklavik NWT- Control Architecture

590kW VSG

Power Converter

Isochronous Frequency

Droop Voltage



55kW Ground Mounted Solar

Innovus MCU

Droop/isoch mode

Woodward on/off

VSG on/off

PLC

Woodward Load Share

DD Series 60 320kW Qty 4

Aklavik Isolated Grid

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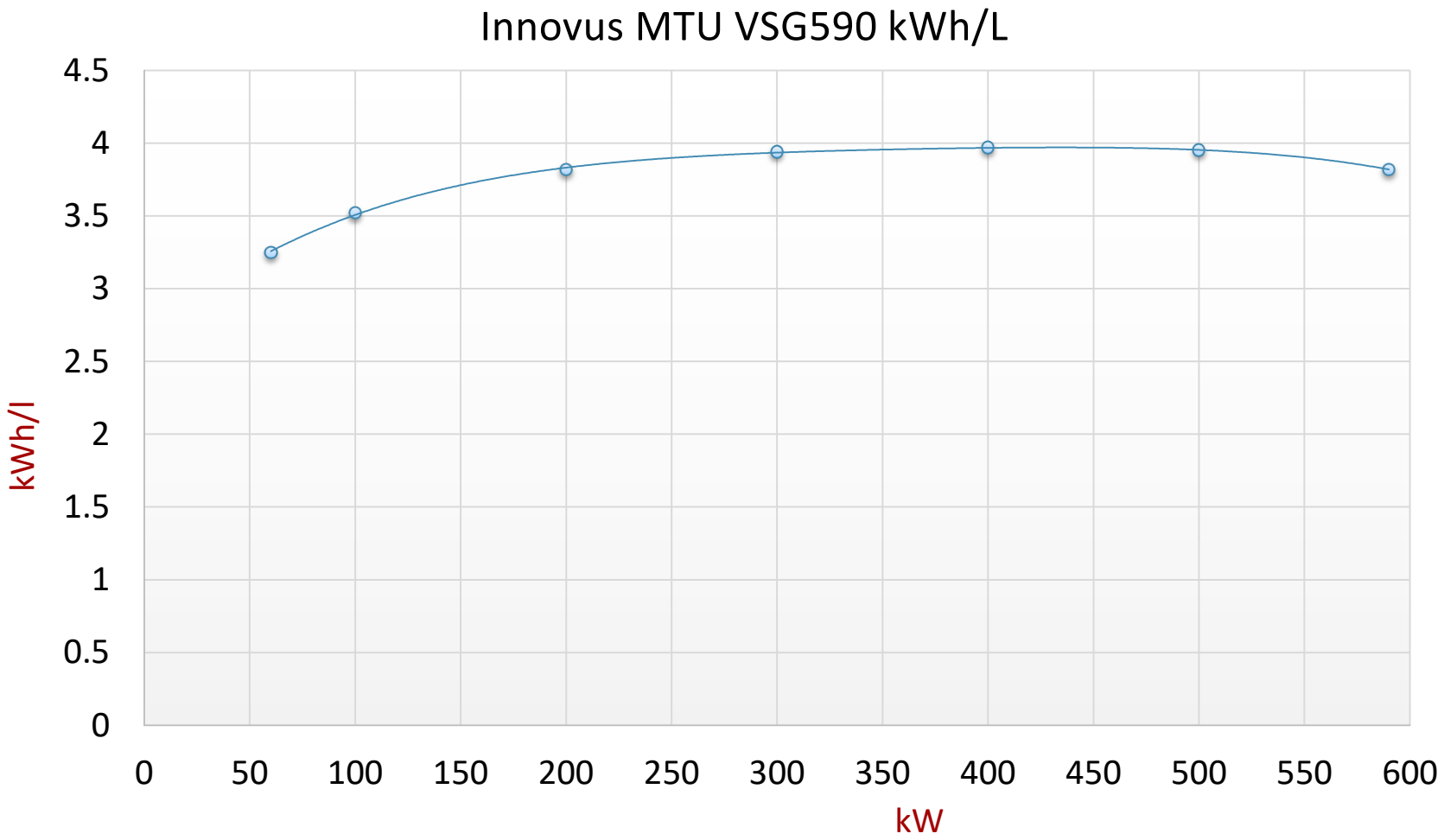
Aklavik NWT- Innovus Efficiency



<u>Frequency Stability</u>: Less than 0.5% deviation

- **during normal operation AND solar ramp periods**

INNOVUS POWER

Mahalo !

The Future of Microgrid Distributed Power

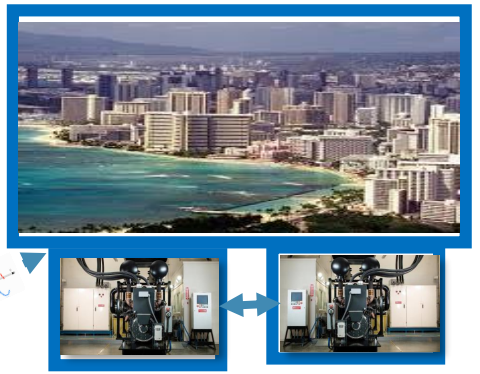
Paul Pauze, P.Eng

705-760-4466

Transforming the Grid for today's Needs- **Fully Optimized CG and DG**

Distributed Generation 'DG'

Central Generation 'CG'



Power Grid

- CG runs Base load increasing efficiency
- DG runs with CG efficiency and assures
  - Grid Resilience
  - High Quality Power
  - Renewable Optimization

DG Renewables

CG-DG Dispatchable Primary Power

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