

**UNCLASSIFIED**

# ***High Power Density Turbine Based Generation Systems***



**NDIA**

***Joint Service Power Expo***

***Myrtle Beach, SC***

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***Candent Technologies, Inc.  
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***Presented by:  
Hernando Munevar***

# ***Candent Company Background***





# About Candent Technologies: A lean, experienced, and expert team of technical, program management, and business development personnel.

*Each member has 20 or more years experience in the design, development, qualification/certification, management, production and support of all types of gas turbines, but particularly small and low cost turbine engine systems, having been involved in the design and/or development of more than a dozen successful engines.*

## Sampling of Candent Team's Engine Experience

Allison Model 150



*Low Cost - High Performance Turbojet designed and on test in 22 weeks*



*Under Armor APU for the M1A2 Tank*



*Low Cost Expendable Engines for Missiles and UAV's*



Model 250



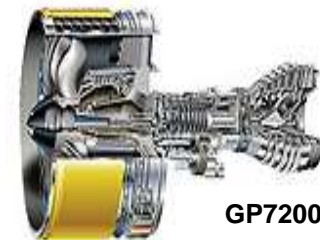
T800



T56/501



T406/AE1107/2100



GP7200

**Strong background and knowledge base including small engines**

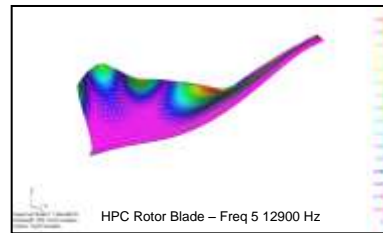
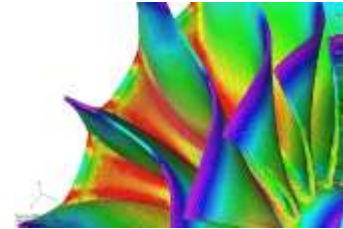
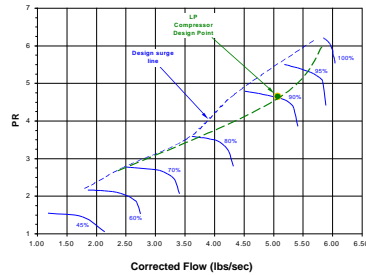
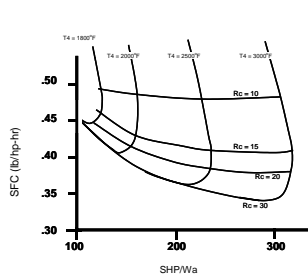


# About Candent Technologies

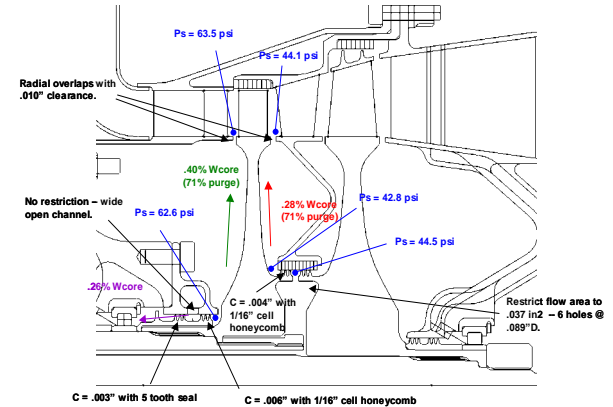
- **Who we are:** *A lean, highly experienced, and expert gas turbine engine team, based in Mt Comfort, Indiana*
- **What we are doing:** *Presently developing high efficiency, low cost, small gas turbine engines, for military and civil power generation and propulsion systems*
  - *Simple Brayton Cycle systems from 350 kW to 2,250 kW in size*
  - *Specific fuel consumption 20-35% better than state of the art small turbine engines (<1,000 kW size) and competitive with similar size diesels*
  - *Microturbine systems, recuperated and simple cycle, from 10 kW up to 350 kW*
- **Current DOE Projects:** *Phase II SBIR program, started September 2011, to design and test critical components for an advanced technology, high efficiency, low cost gas turbine powered genset*
  - *Simple cycle system with a Rankine “Bottoming Cycle” steam system to recover exhaust waste energy*
  - *Turbine shaft direct drive, high speed generators*
  - *Capable of producing 1,500 kW*
  - *High thermal efficiency goal set at 50%*
- **Current DOD Projects:** *Navy (NSWC-CD) Phase I SBIR program to define a main gas turbine exhaust waste heat recovery system, started March 2011*

**Using available and proven technology – no inventions required**

# Candent Technologies Technical Capability



Static and Dynamic Structural Analysis



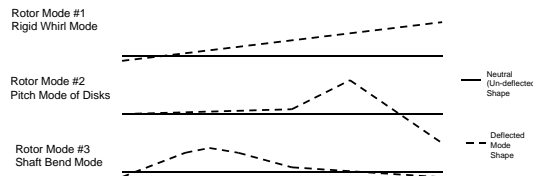
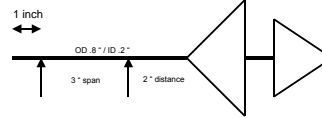
Secondary Flow and Heat Transfer

Gas Turbine Performance, PD, Detail Design and CAD Modeling Capability



Aerodynamic Design and CFD Analysis

Simplified HP Rotor Configuration



High Speed Shaft Dynamics



Sea Level Test Cell Facility

**State of the art system and component design and analysis capabilities**

# ***High Power Density: The Gas Turbine Solution***





# ***Increased Deployment of Modern Warfare Systems Will Require More Power Generation Capability***

- The sophistication of current and future weapon systems will continue to increase the requirements for electrical power
  - Individual Warfighter size
  - Tactical force size/land vehicle/tactical naval craft mounted
  - Base size/large vehicle/naval vessel
- While modern systems are more efficient, they are more numerous
- Logistics support for power generation systems is also increasing
  - Fuel Stocks Inventories
  - Transportation
  - Maintenance
- Power generation design continuously driven to
  - Higher Power density
  - Improved Mobility
  - Higher Efficiency
  - Higher Reliability
  - Improved Maintainability
  - Lower Cost

***More high power density generation needed by deployed units***



# ***Turbines Provide Very High Power Density Efficiently and at Cost Effective Rates***

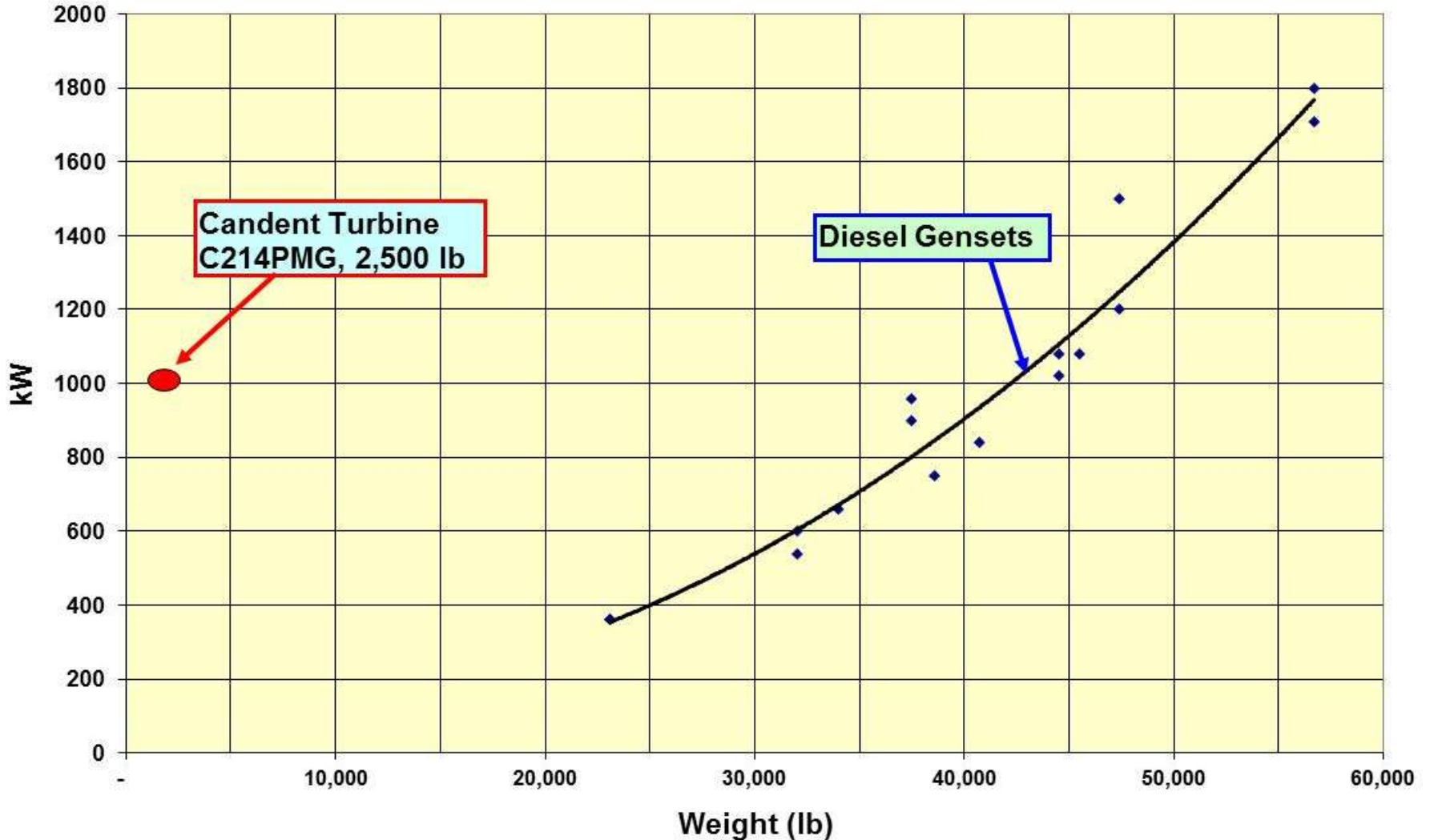
- Gas turbine specific power is much higher than similarly power rated reciprocating engines
  - Lighter overall system weight by an order of magnitude
  - Smaller volume by factor of at least 4 to 5 vs. piston engine genset
- Candent advanced technology gas turbine has fuel efficiency comparable to diesels of same power
- High speed generators at turbine output shaft speed eliminate need for heavy gearboxes, minimize system complexity
- Multi-fuel capability of gas turbines easily allows great flexibility in use of available fuels, i.e. diesel, jet, kerosene, bio fuel, natural gas, propane, methane, etc.
- Gas turbine MTBO much longer than piston engine gensets, typically in excess of 20,000 hr
- Gas turbine has lower life cycle cost than comparable piston engine
  - Significantly less scheduled and unscheduled maintenance
  - Longer MTBO
  - Similar acquisition cost as diesels

***Advanced Technology Gas Turbines Offer Viable Solution***



# Gas Turbine Power to Weight Advantage

Power vs Weight: Power Generation Module



# ***Gas Turbine Large Mobile Power Genset***





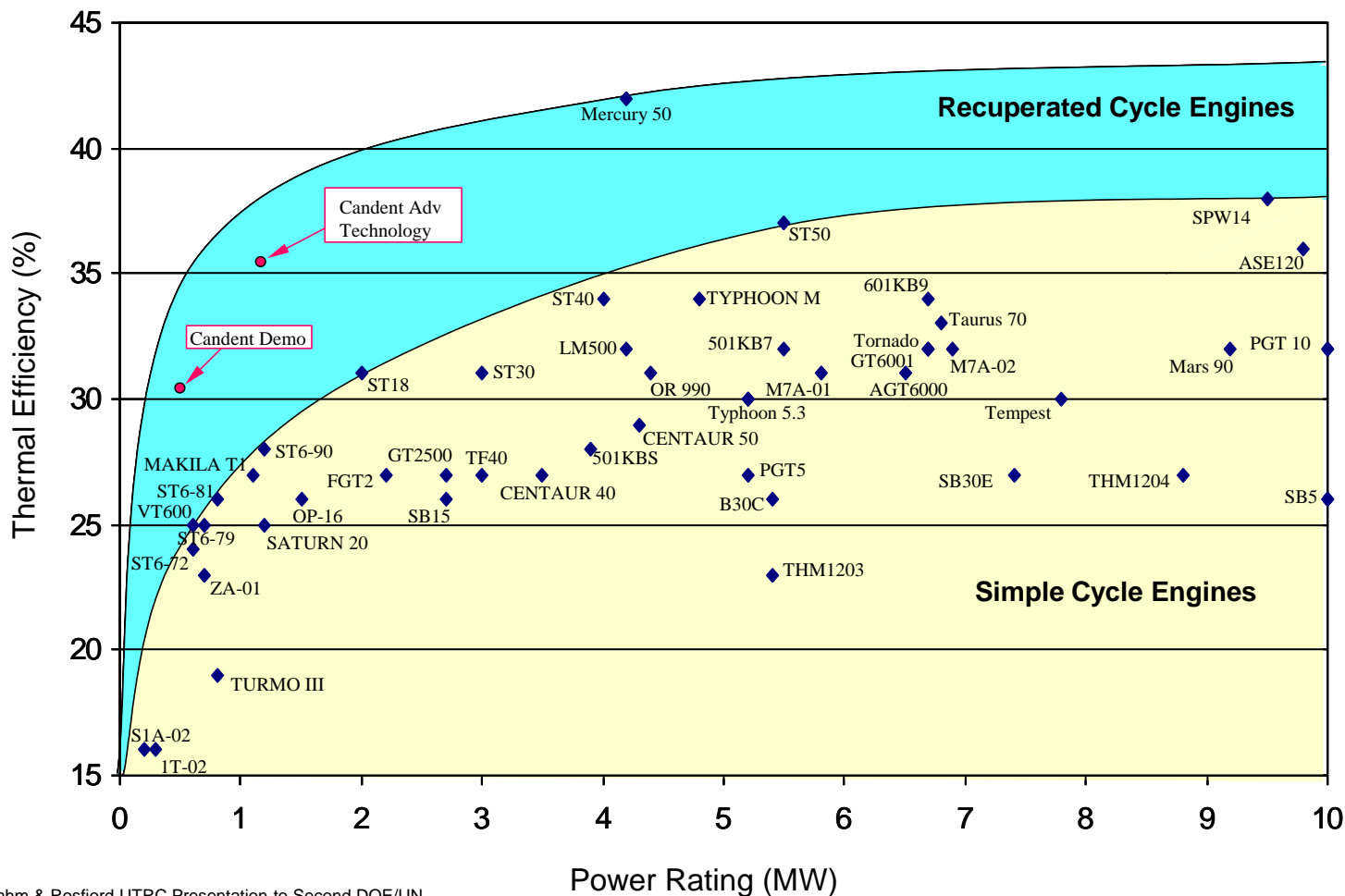
## ***Candent Advanced Technology Impact***

- Larger gensets, 350kW-2.0MW would also greatly benefit from Candent's advanced technology gas turbines
  - High pressure ratio provides higher efficiency
  - Fuel burn comparable to similar power rated diesels
  - Inherently more reliable
  - High power density minimizes weight and size, provides highly enhanced mobility
  - Longer MTBO than diesels, by at least 100%
  - Lower Scheduled and Unscheduled maintenance
- Candent is developing more efficient gas turbine under DoE sponsorship
  - Engine core testing scheduled for 1Q12
  - System thermal efficiency goal is 50%
- Larger gas turbines use state of the art technology hot section airfoil and cooling designs, achieve competitive fuel burn

***Candent's advanced technology enables genset high power density with competitive fuel consumption and system costs***

# Candent Comparison versus Current Technology

Candent simple cycle engines have fuel consumption consistent with heavier recuperated engines

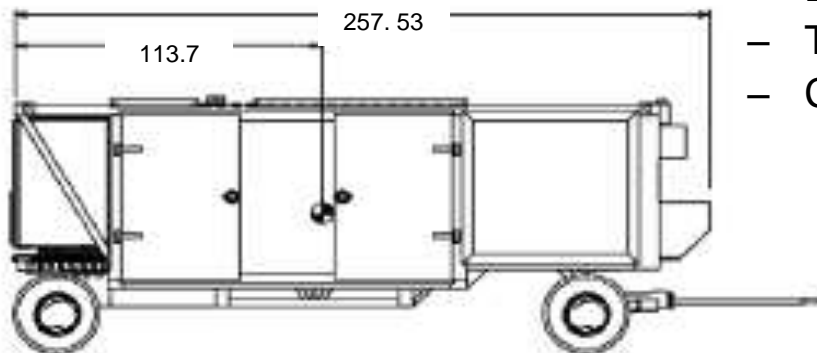


Data for graph from Sahn & Rosfjord UTRC Presentation to Second DOE/UN, International Conference and Workshop on Hybrid Power Systems, 17 April 2002

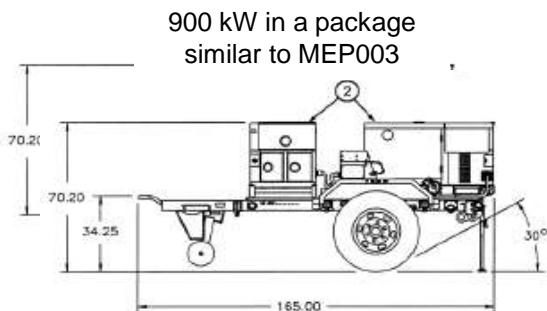
**Higher Pressure Ratio Provides "Big Engine" Performance**

# Large (900kW) Mobile Power Genset Application

Used in USAF Harvest Eagle and Harvest Falcon Base Base Operating Kits



- Current Power Genset: MEP-PU-810A
  - Power 840 kW
  - Weight - 25,600 lbs
  - Length - 21.1 ft
  - Thermal Efficiency ~ 33%
  - C-130 Transportable



- Candent Turbine Power System
  - Power 900 kW
  - Weight - 2,500 lbs (est.)
  - Length - 12 ft
  - Thermal Efficiency ~ 33%
  - Competitive first cost, lower LCC
  - Transportable in C-27, C-130, V-22, UH-47



Designed to be easily Mounted on 1-1/2 Ton Trailer, M103A3

***Smaller, lighter, more easily transported system with same fuel consumption as diesel MEP- PU-810A***

# ***Microturbine Based Tactical Genset***



# Microturbine Genset Solutions

- The standard military 30kW genset is the MEP 805/815
  - Diesel Powered
  - 30kW, 110 VAC, 60 Hz, 3 Phase
  - 88 cu ft
  - 3,000 lb
  - The MEP 815 is the 400 Hz version
- Candent has designed a microturbine genset to the requirements of the MEP805/815
  - Utilizes turbine hardware previously designed and tested under Army contract to Candent
  - Adds recuperator system to enhance efficiency
  - Uses high speed (turbine output shaft rpm) generator
  - Under 200 lbs (minus fuel tank) and 9 cu ft
  - Small and light enough to install in HMMWV, or MRAP
  - Small enough to install in tactical and SOC riverine or naval craft, 21 ft and up, including new vehicles such as CCM and USSV

***Current systems are effective but are NOT high power density designs***



# **20-40 kW Marine/Land Generator Specifications**

***Candent Technologies design is a microturbine based, 20-40 kW Advanced Marine/Land Generator system:***

## **Generator Specifications**

- **Power Rating:** 20-40 kW (50 kW de-rated to 40 kW)
- **AC Power:** 20-40 kW, 110/208 VAC, 3 Phase, 60 Hz
- **DC Power:** Optional 10 kW, 24 VDC, with 10-30 kW AC
- **Speed:** 75,000 rpm
- **Shock Loads:** 25g (40g peak)
- **Materials:** Capable of surviving marine environment

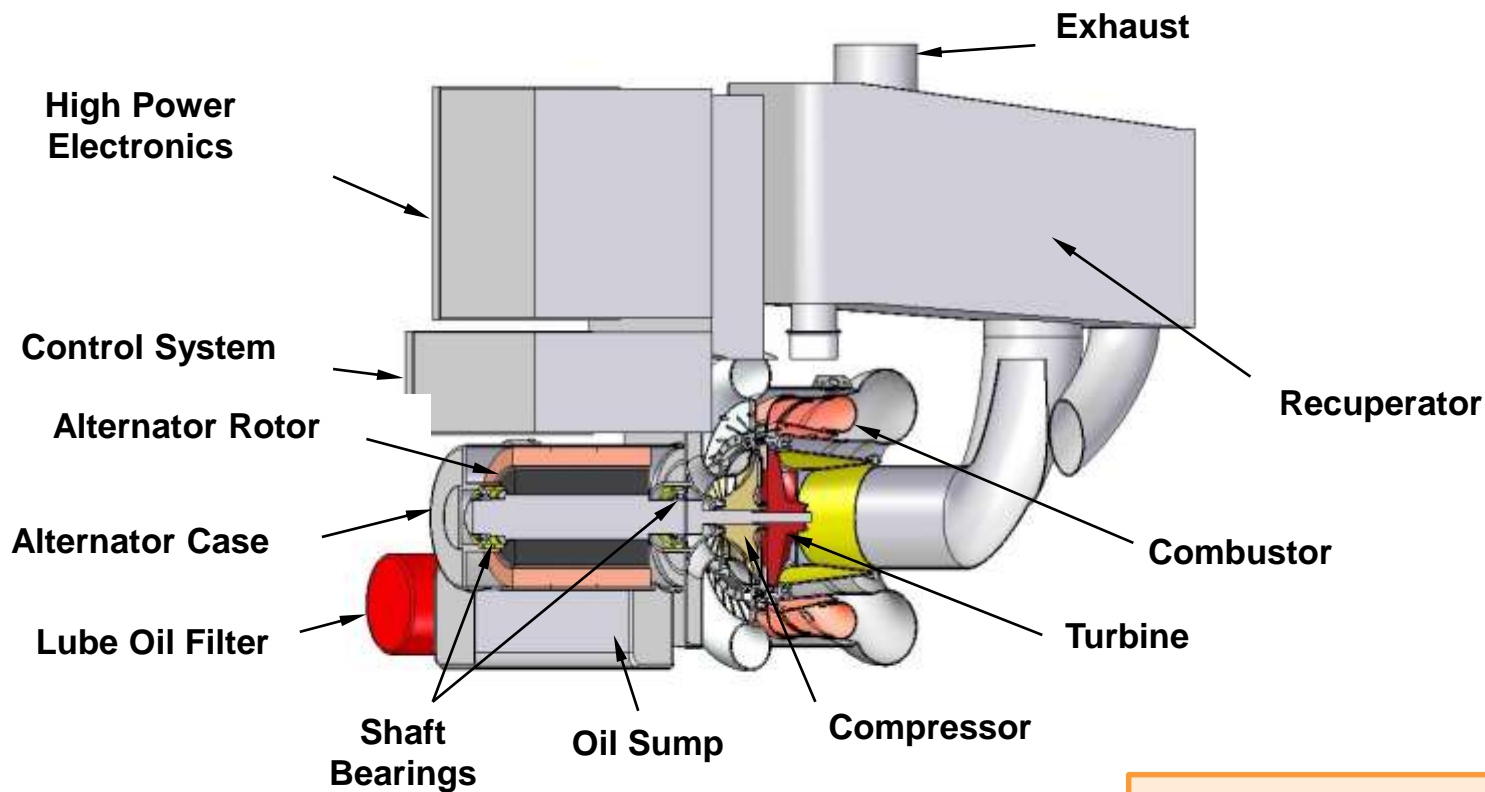
### **Other:**

The generator will also be used during the start mode for engine starting using a 24V battery.

***A high speed generator means lower weight and volume***



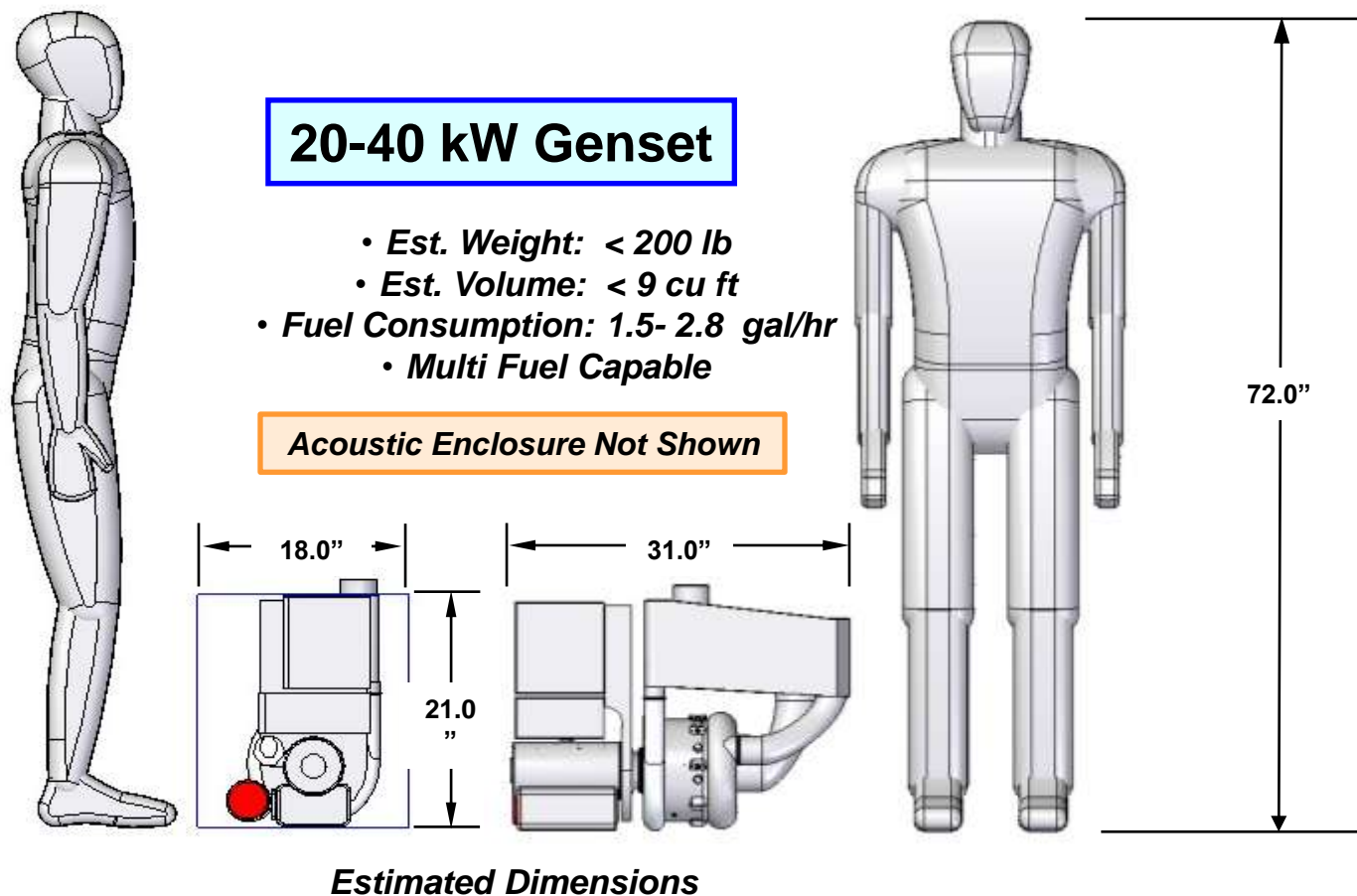
# Microturbine Genset Components



*Acoustic Enclosure Not Shown*

***Microturbines with recuperator and high speed generator provide highly efficient power in a very small package***

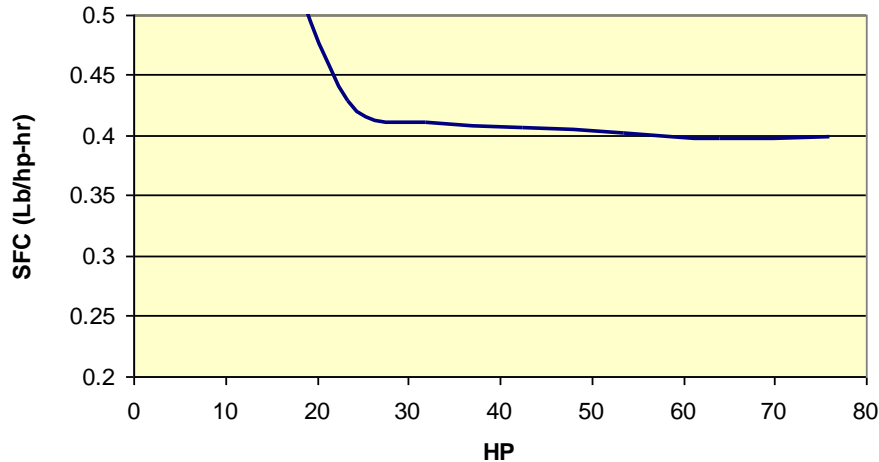
# High Power Density 20-40 kW Microturbine Genset



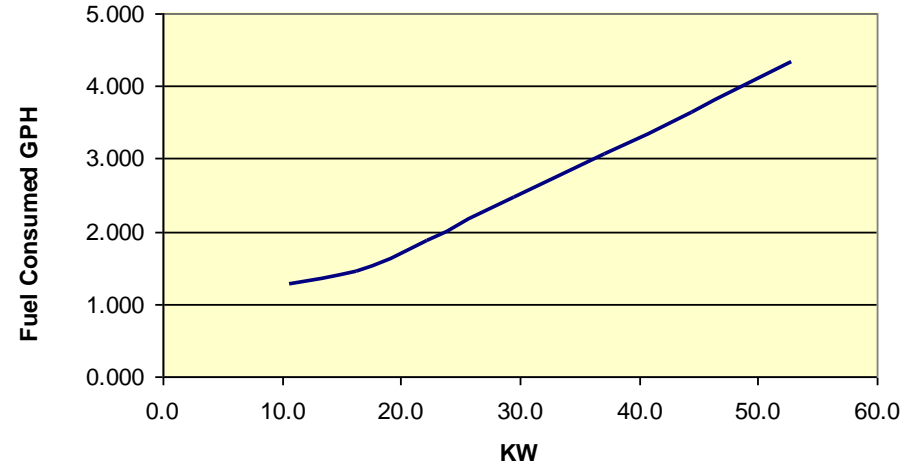
**Compact and reliable power generation system**

# Fuel Consumption Same as Similar Size Diesel

HP vs SFC



Fuel Consumption GPH vs KW Output



- Flat SFC curve down to 30% power
  - Allows system to be oversized and have greater capability for minimal weight penalty
  - SFC and GPH are about the same as similar sized diesel
  - Power off-load capability of up to 40 kw even on a hot day

# ***Microturbine Genset Advantages***

- Smaller, lighter more mobile power
  - At least 80% lighter than conventional diesel system
  - Smaller logistics transportation footprint
  - Transportable in more aircraft types, including smaller rotorcraft
- Rugged design
  - Capable of being used in high shock environment, i.e. off the road, or in high speed boats, or shocks due to explosive detonations in water or land
- High reliability and low maintenance
  - No oil change interval, top up as required
  - Long life, over 40,000 hrs.
  - Minimal on location maintenance
    - Air filter cleaning when prompted by system
- Fuel consumption on par with diesels of similar size
  - No increase in fuel logistics tail required for fuel stocks

***High power density in a smaller, more mobile package***

# ***Summary and Conclusions***



# Summary and Conclusions

- ***Increased deployment of modern warfare systems will require more power generation capability in the field to support the Warfighter***
  - Candent's advanced turbine technology provides viable solutions
    - Lighter, smaller, highly mobile systems
    - Multi-fuel capable systems provide high flexibility
    - Cost effective and competitive
- ***Technology is applicable to microturbine sizes from 20kW to 350kW, and in larger sizes up to 2.25MW***
- ***Physical size enables installation in :***
  - Small land vehicles such as the HMMWV or the MRAP
  - Small boats such as the 11m RIB / CCM, SOC-R, USV, or Mark V / CCH types, or similar sizes
  - Large naval vessels
- ***Candent gas turbine technology is cost effective and competitive***
  - Acquisition costs competitive with similar power diesel systems
  - Turbine system Life Cycle Cost is lower due to longer TBO's and substantially lower scheduled and unscheduled maintenance costs
  - Turbine system substantially enhances maintainability, supportability and readiness

***Gas turbine based gensets offer viable, highly reliable, highly mobile, cost effective high power density solutions***

# Contact Information



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