# Man-Portable Tactical Power

# Report on Efforts

A Presentation Prepared for

**NDIA 2011 Joint Service Power Expo**

**May 2 – 5, 2011**

Myrtle Beach Convention Center, Myrtle Beach, SC

by

**S. Paul Dev, President, D-STAR Engineering Corporation**

4 Armstrong Road, Shelton, CT 06484

Ph : 203 925 7630 x 101;  Mobile : 203 915 3166

Fx : 203 925 7631;  em : SPaulDev@DStarEngineering.com

# Outline

1. **Company Background**
   0.1 – 100 hp Heavy Fuel Engines, Turbine Engines, Hybrid Power Systems

2. **Need for Portable Power Solutions :** Light-Weight Heavy-Fuel Gen-Sets
   Example : ONR Goals for a 500 W – 1000 W Power System

3. **Problems with Conventional Generator Sets**
   Size, Weight, Noise, Wet-Stacking
   Challenges in Developing Small, Heavy Fuel Engines

4. **Light-Weight Power Solutions by D-STAR Engineering**
   Strategies for Developing Light-Weight Heavy-Fuel Engines
   Examples of D-STAR Heavy Fuel Power Systems
   Business and Teaming Strategies (Beneficial to the Government and Others)

5. **Conclusions**
   Technologies have been Developed and Validated
   **TRL 5 Prototype Has Been Demonstrated, Delivered, Tested by the Govt.**
   Teaming Opportunities are in Discussions, but are Currently Open

# **D-STAR Engineering** Experience Base

## 0.1 – 100 hp Heavy Fuel Engines, Turbine Engines, Hybrid Power Systems

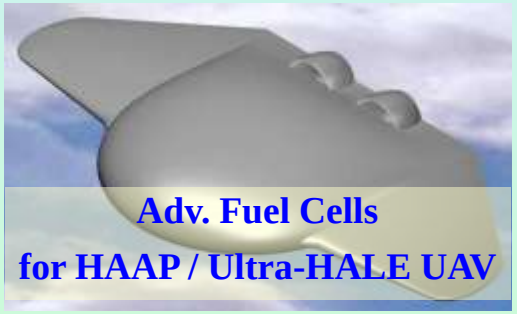
**0.1 hp HFE**

**0.6 hp M-COTS HFE**

**1.5 hp HFE**

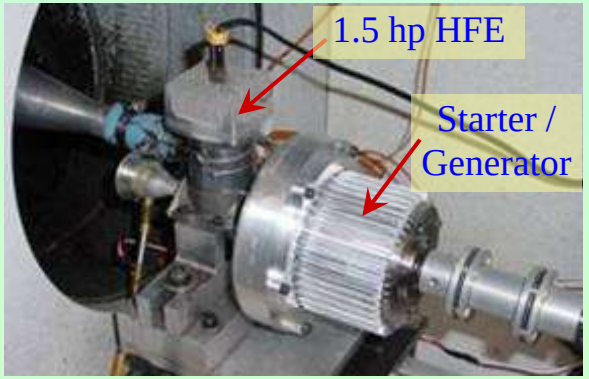
**6 hp Class 4-stroke M-COTS HFE**

**Miniature Turbine Engine**



**Adv. Fuel Cells for HAAP / Ultra-HALE UAV**

**Mini-FADEC for 1.5 hp HFE**

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## ONR BAA 06-023 : Original Goals and D-STAR Prototype Capabilities

6.1 Desired Capabilities

The ideal single-person portable JP-8-fueled generator would incorporate as many of the following features as possible:

1) Provide **500-1000 Watts** power at 28VDC through a commercial grade two-wire connector output interface : **700+ Watts Demonstrated.**

2) Operate directly on **JP-8 fuel** : **Yes. Straight JP-8. No Additives.**

3) Weigh ≅ **15 pounds** : First Prototype is Heavier, Production Item can be Lighter.

4) Be highly compact, about **the size of a small lunch-box**, and able to fit in a Marine Corps backpack : First Prototype is Larger, Production Item can be Smaller.

5) **Start up in less than 10 minutes** : **Yes. < 1 minute. Often < 10 seconds.**

6) Provide **power quality** comparable to current tactical generators. **Yes.**

7) Have an acoustic signature < 70 dB at 7 meters : **Yes,** 67 – 69 dB (First Prototype)**.**

8) Operate over a broad temperature range : **Yes.** Tested to 32 F, Range to be Expanded.

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6.1 Desired Capabilities (Continued)

9) Be able to operate from a remote standard 5 gallon military fuel container with the capability to pump fuel from that container : **Yes.**

10) Be **water neutral to the greatest extent possible** (i.e., operation should not require more than a minimal amount of water to be added to the system initially if needed, and no additional external water should be required after start-up.) : **No Water.**

11) Be able to operate for **at least 1 hour on internal fuel** : **Yes.**

12) Be able to **operate in a range of battlefield environments** (i.e., salt water atmosphere, diesel fumes, dust) : **TBD**

13) Be able to operate for **600 hours** before any major maintenance : **Expected.**

14) **Simple & highly reliable** : **Push-Button Start, Auto. Control & Optimization**.

15) Be a **cost effective** technology : **To Be Optimized.**

16) Able to be started without significant special training and can be operated by the average Marine : **Yes.**

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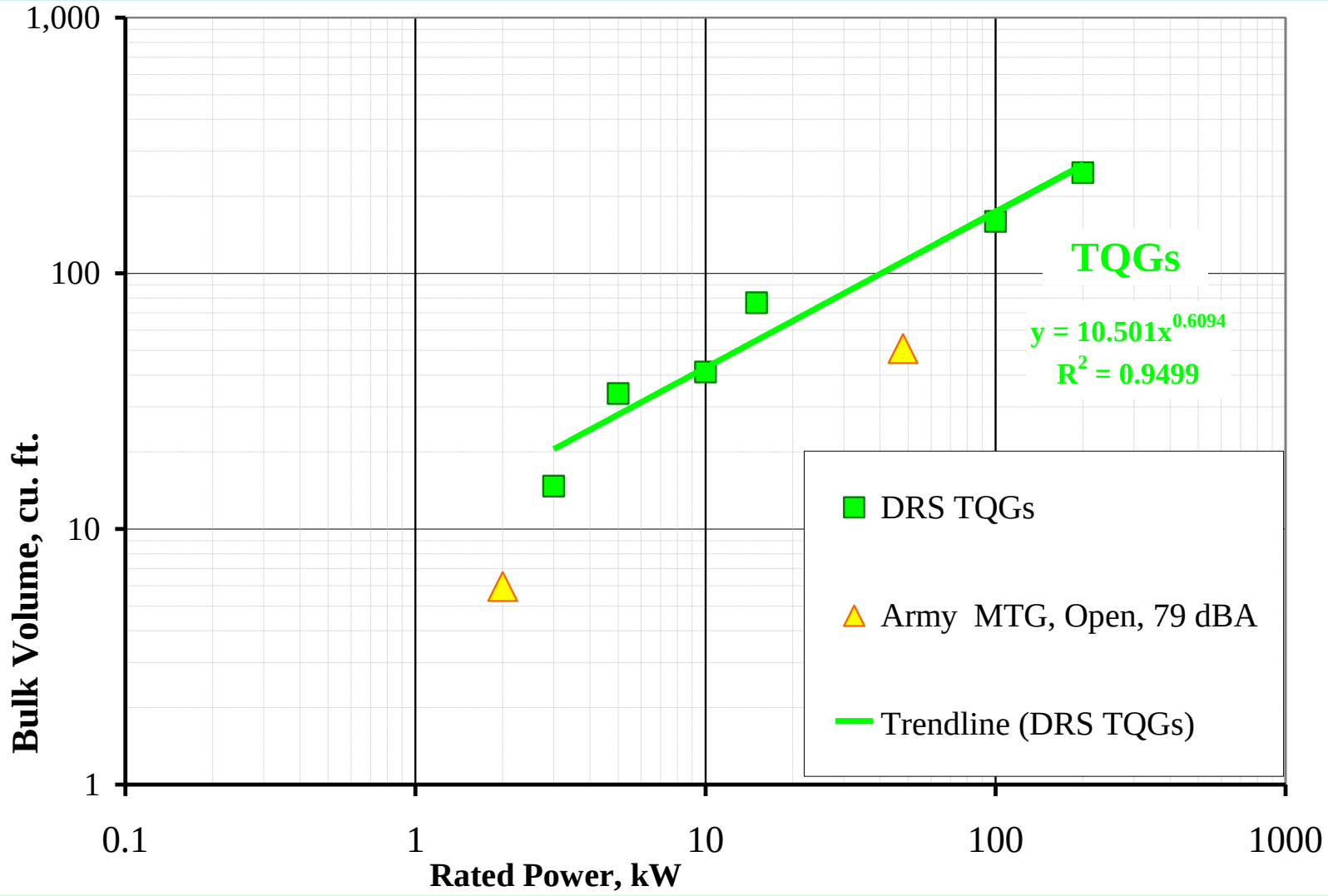
## Size : Military Generator Sets are Too Large



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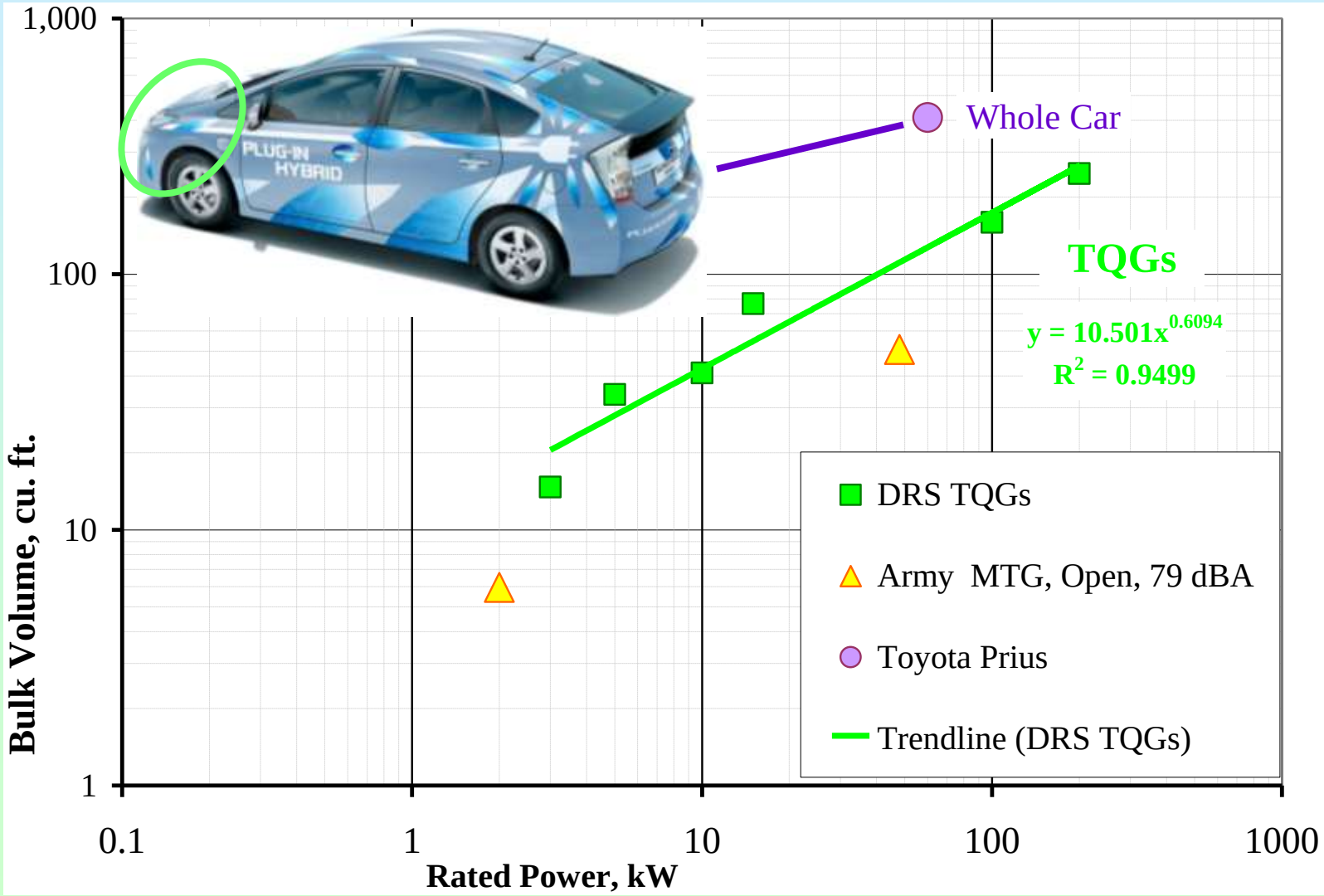

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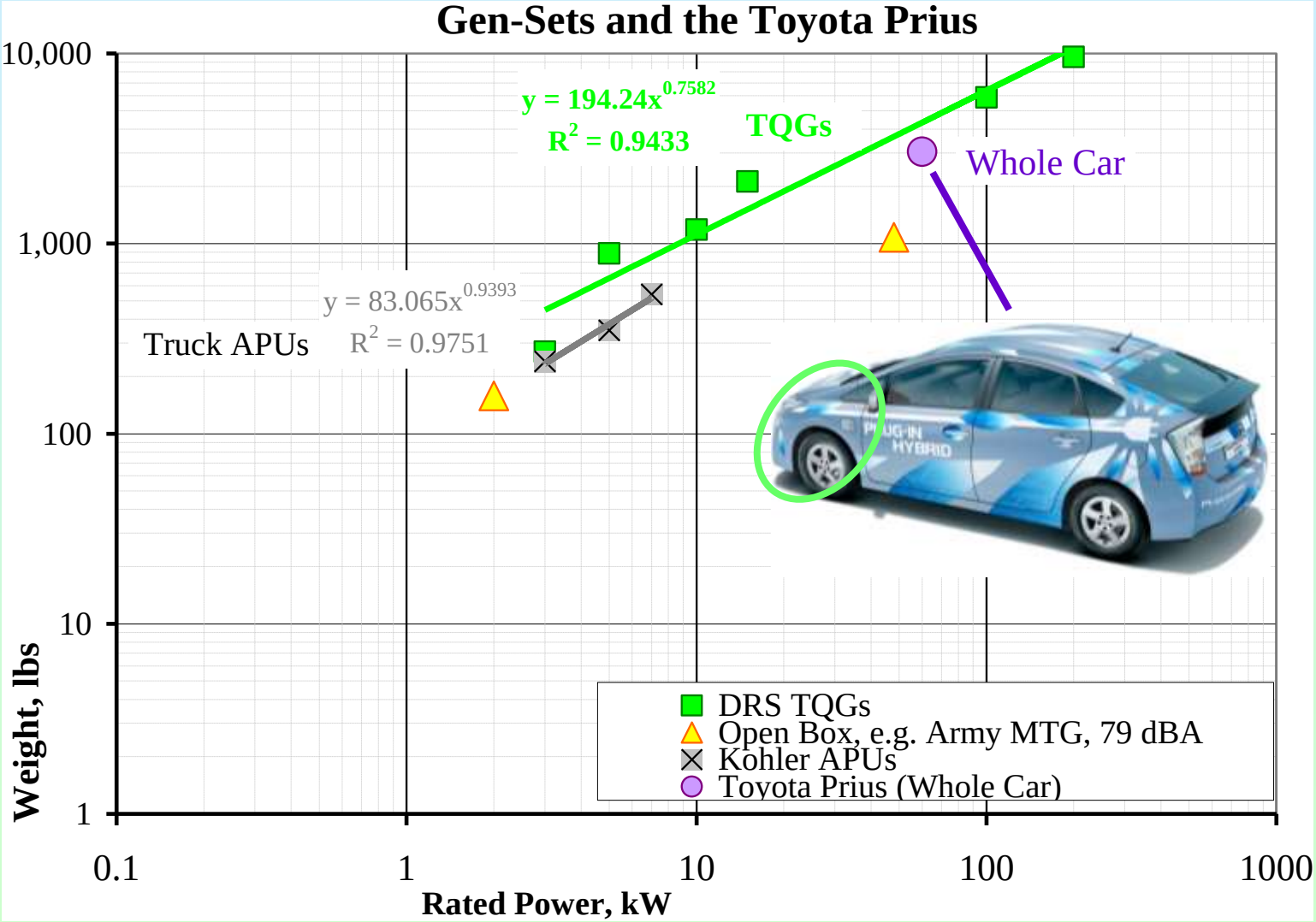

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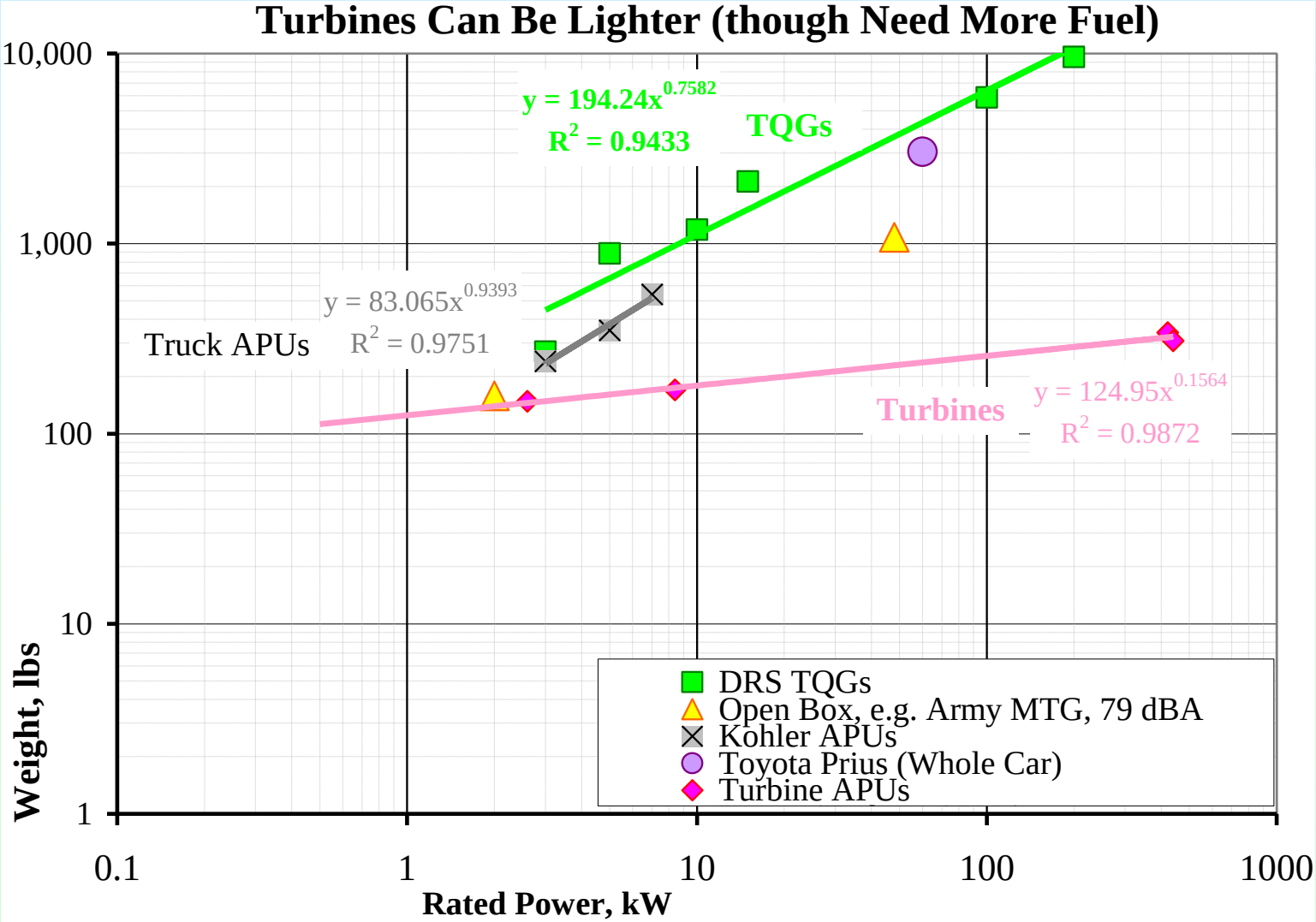

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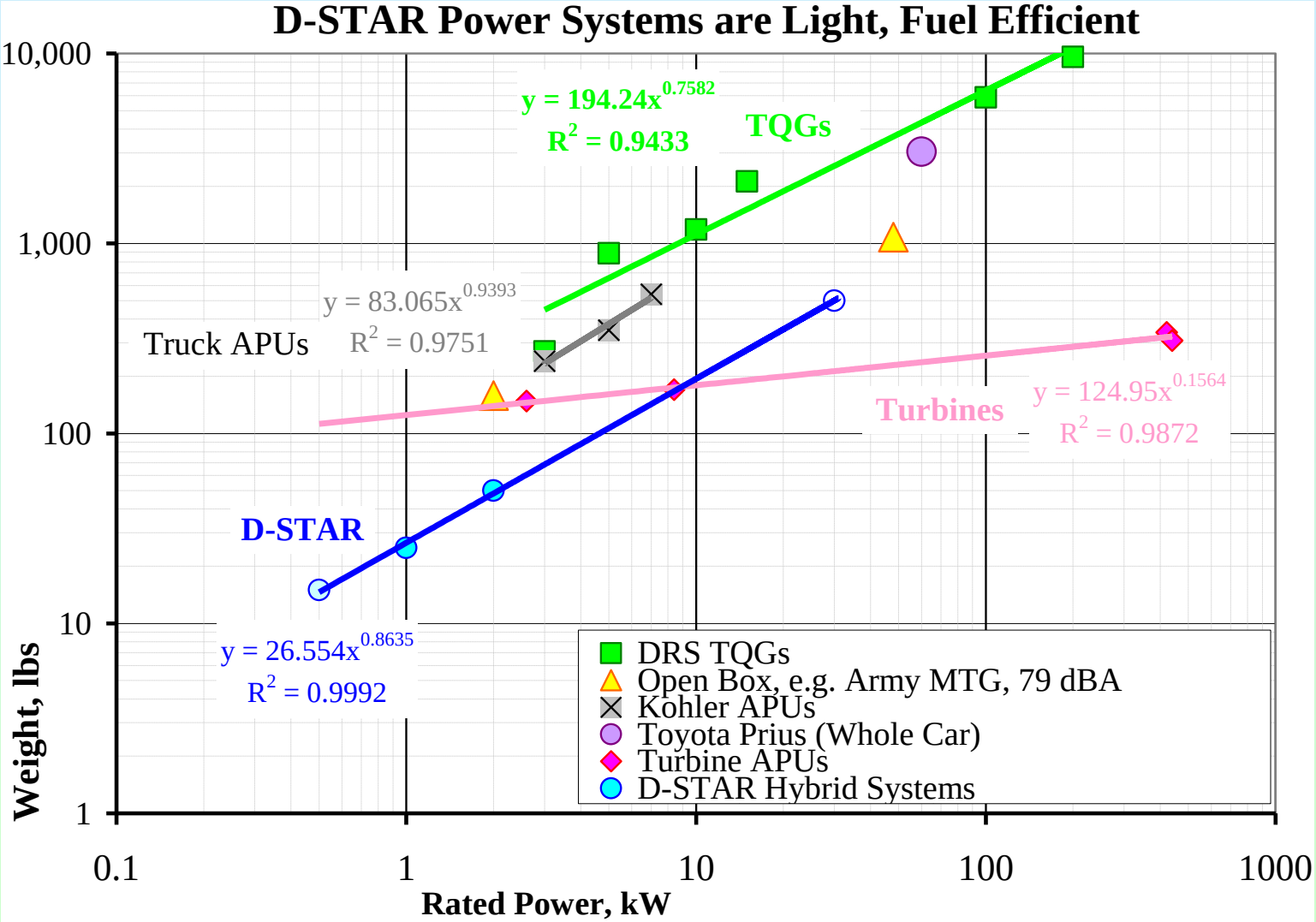

## Problems with Conventional Generator Sets

**Noise : The Enemy of Stealth and Military Success.**

The 2 kW MTG Makes 79 dB at 7 m

TQGs Achieve 70 dB, but are 2x Heavier (per kW) than MTG.

**Wet Stacking : Maintenance Problems with Exhaust Systems.**

Can be Avoided by Variable Speed Operation.

## Key Handicaps of Conventional Diesel Generator Sets and APUs

**Large Size :** Large, Low Speed Engine, Large Generator

**Heavy Weight :** Large Diesel Engine
Low Speed
Low Air Utilization, Low BMEP
Heavy Construction
High Peak Combustion Pressures

**High Cost :** Large Size & Weight, Greater Cost

**High Noise :** Combustion Shock Noise
Low Frequency Noise Difficult to Attenuate.

**Exhaust Emissions :** Stratified Charge Produces Smoke
High Peak Combustion Temperature Produces NOx.

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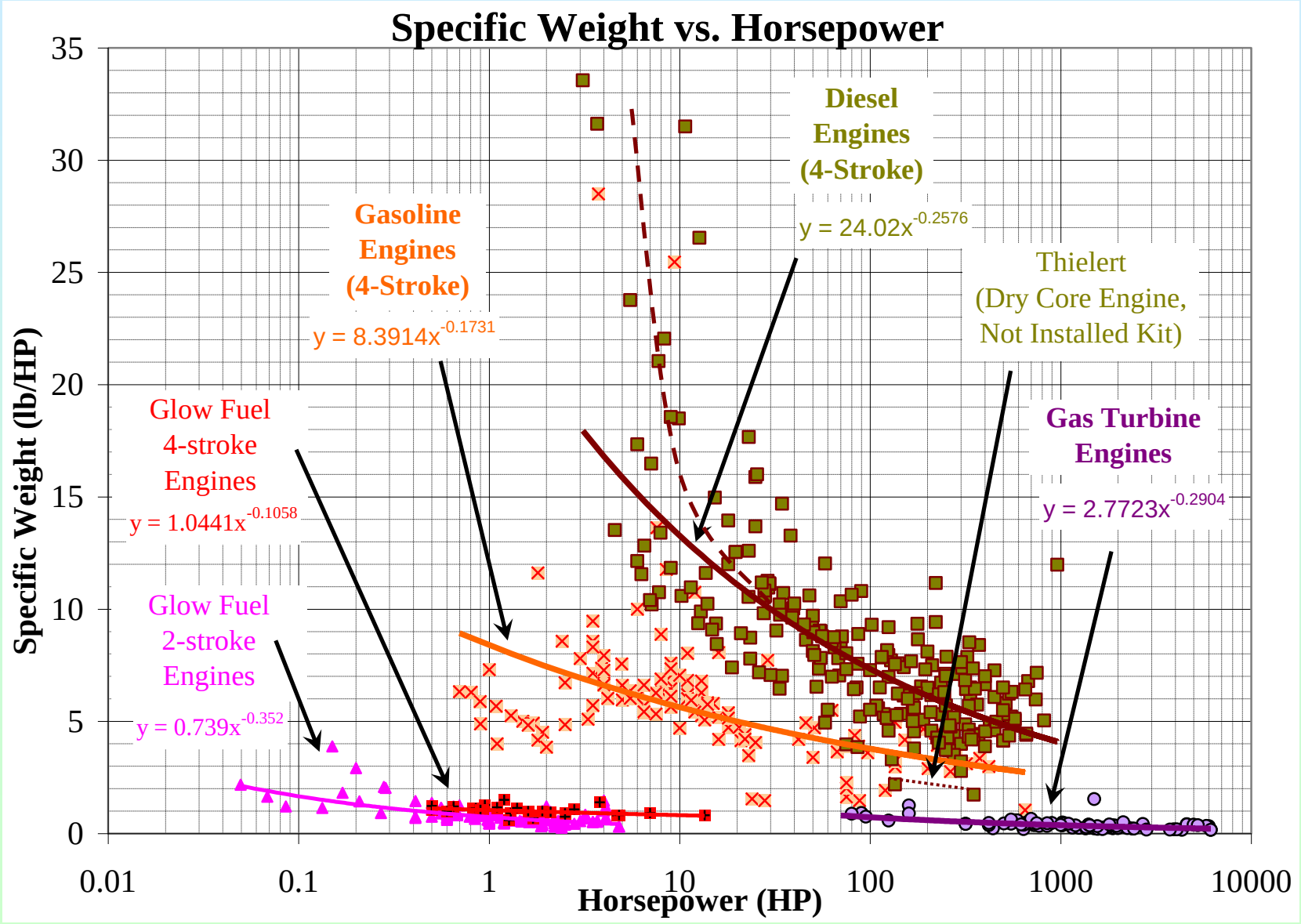
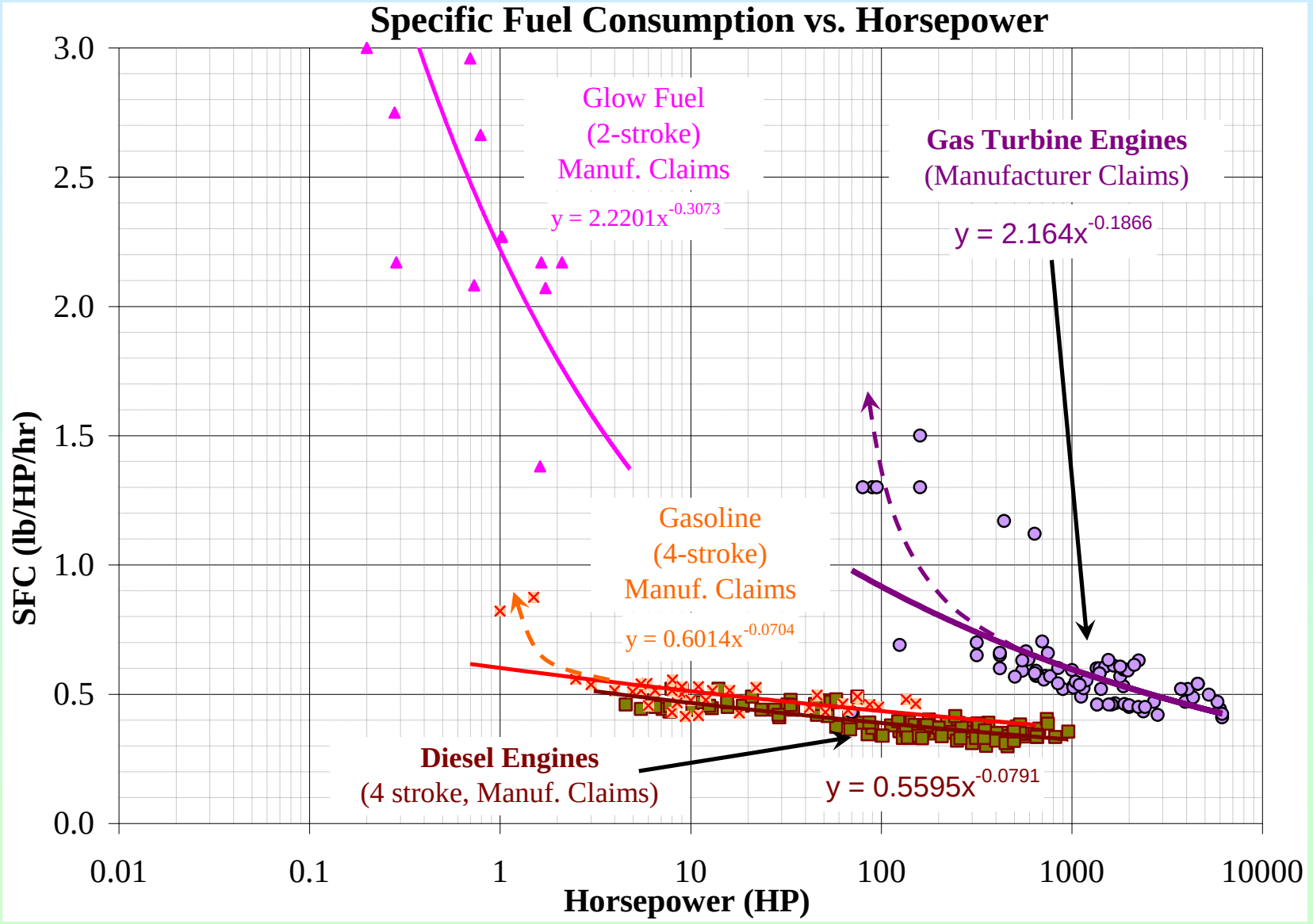
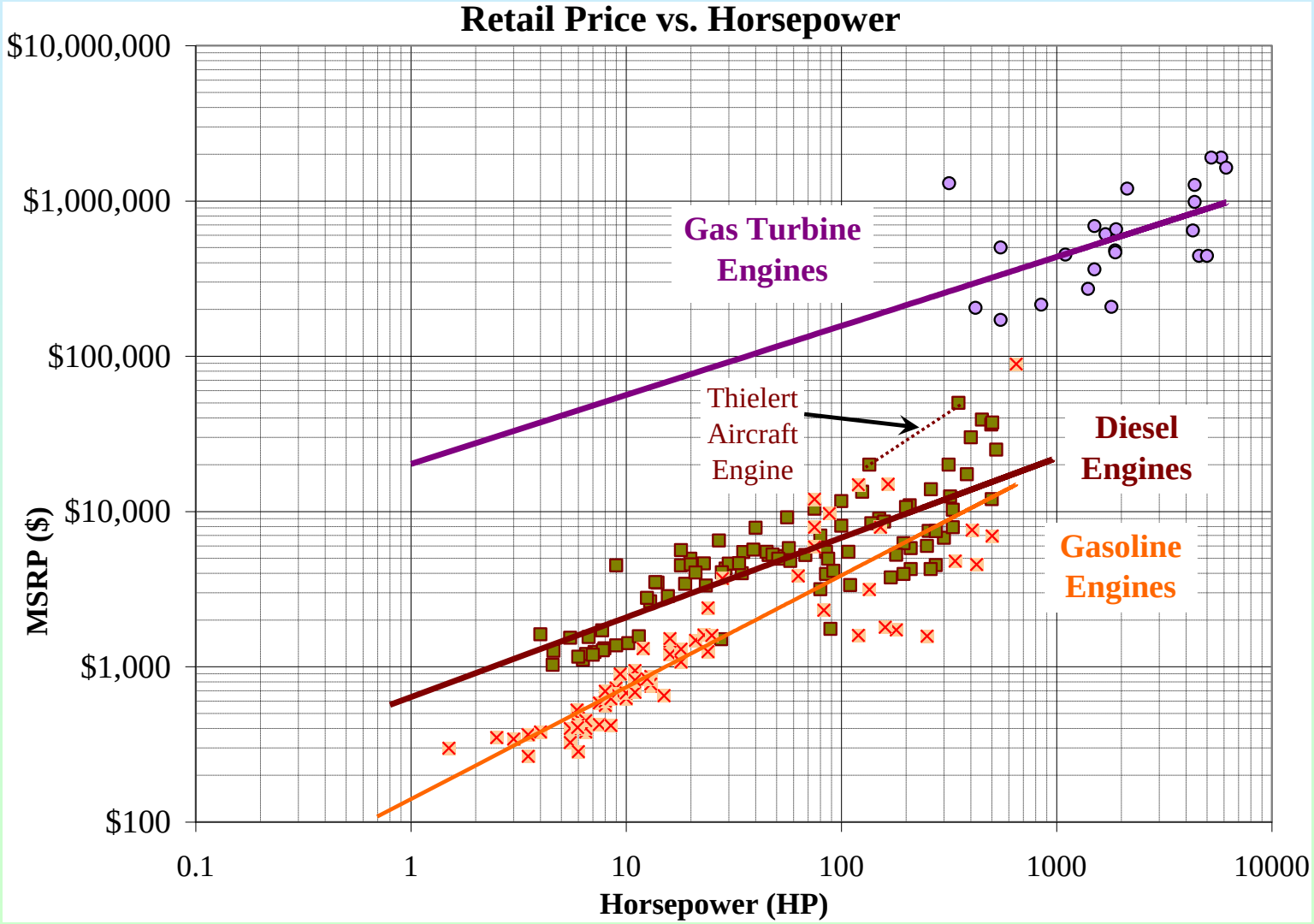
# Handicaps of Conventional Heavy Fuel Engines : Weight



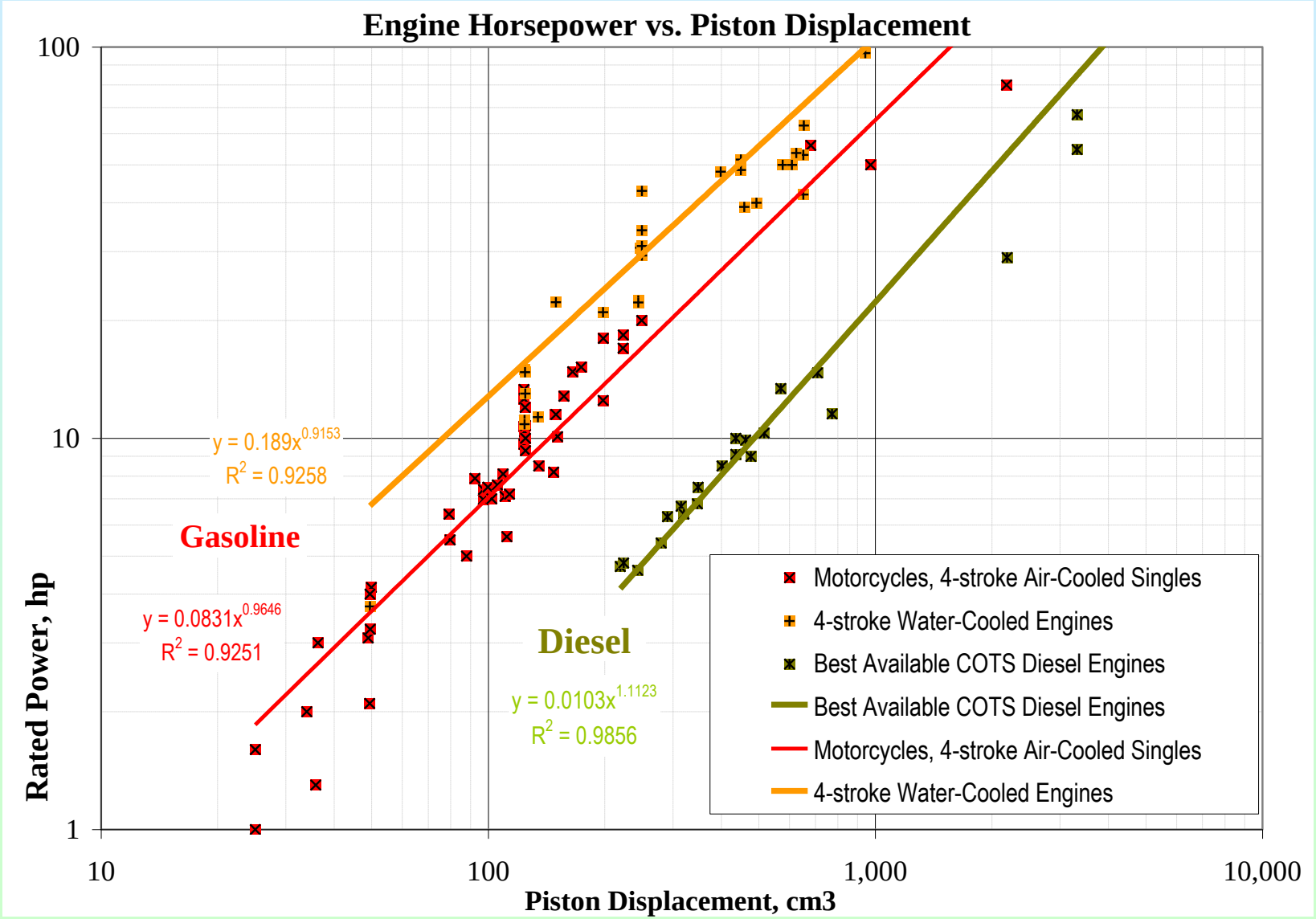
# Turbine Engines Weigh Less, but Small Turbines have Excess Fuel Use



# Heavy Fuel Engines are 2x – 3x More Expensive Than Gasoline Engines
# Turbines are 10x – 20 x More Expensive than Diesel Engines

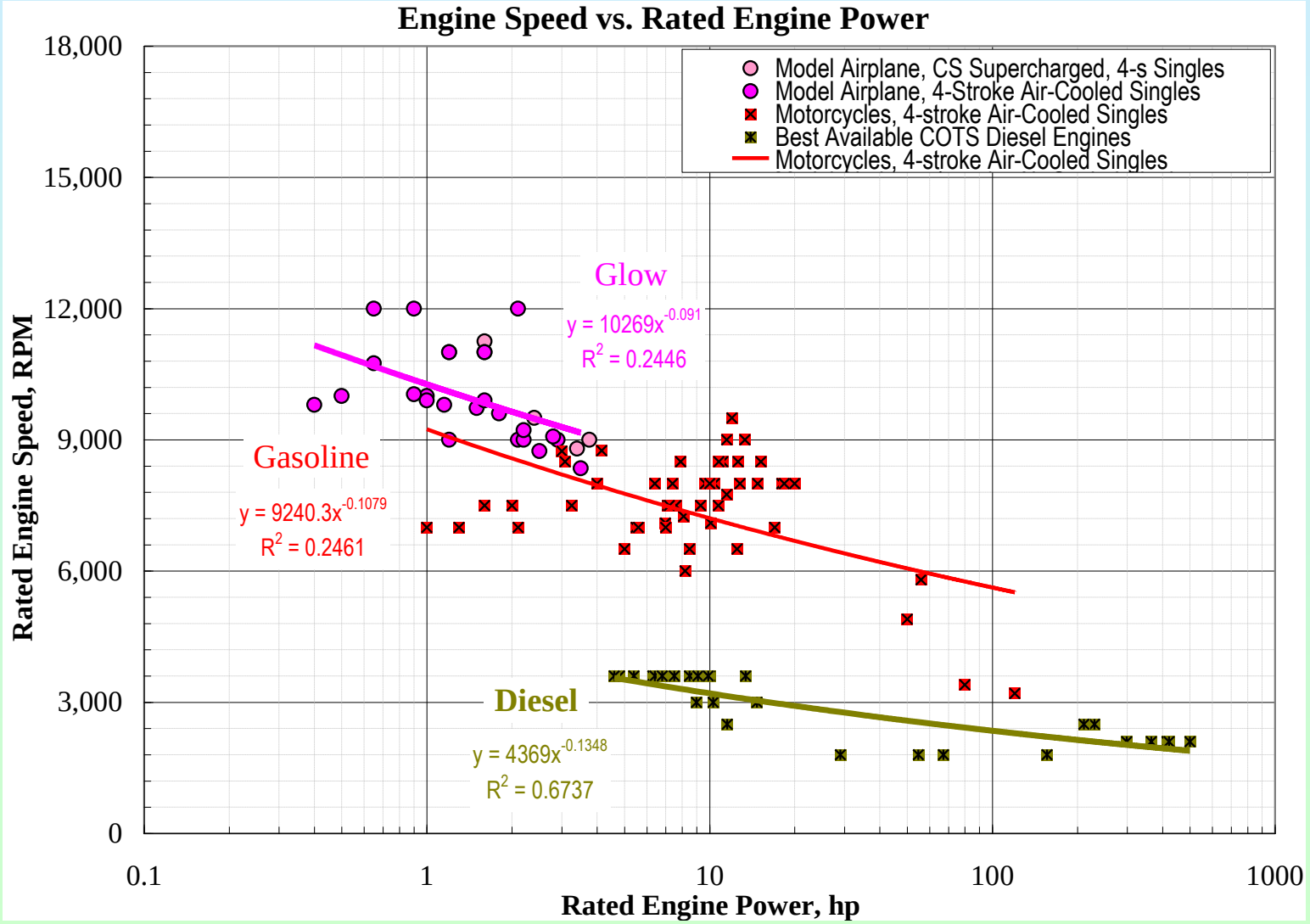


# Heavy Fuel Engines Need to be 5x Larger Than Gasoline Engines



# Why Do Heavy Fuel Engines Need to Be Larger than Gasoline Engines?

## Low Speed and Low Air Utilization



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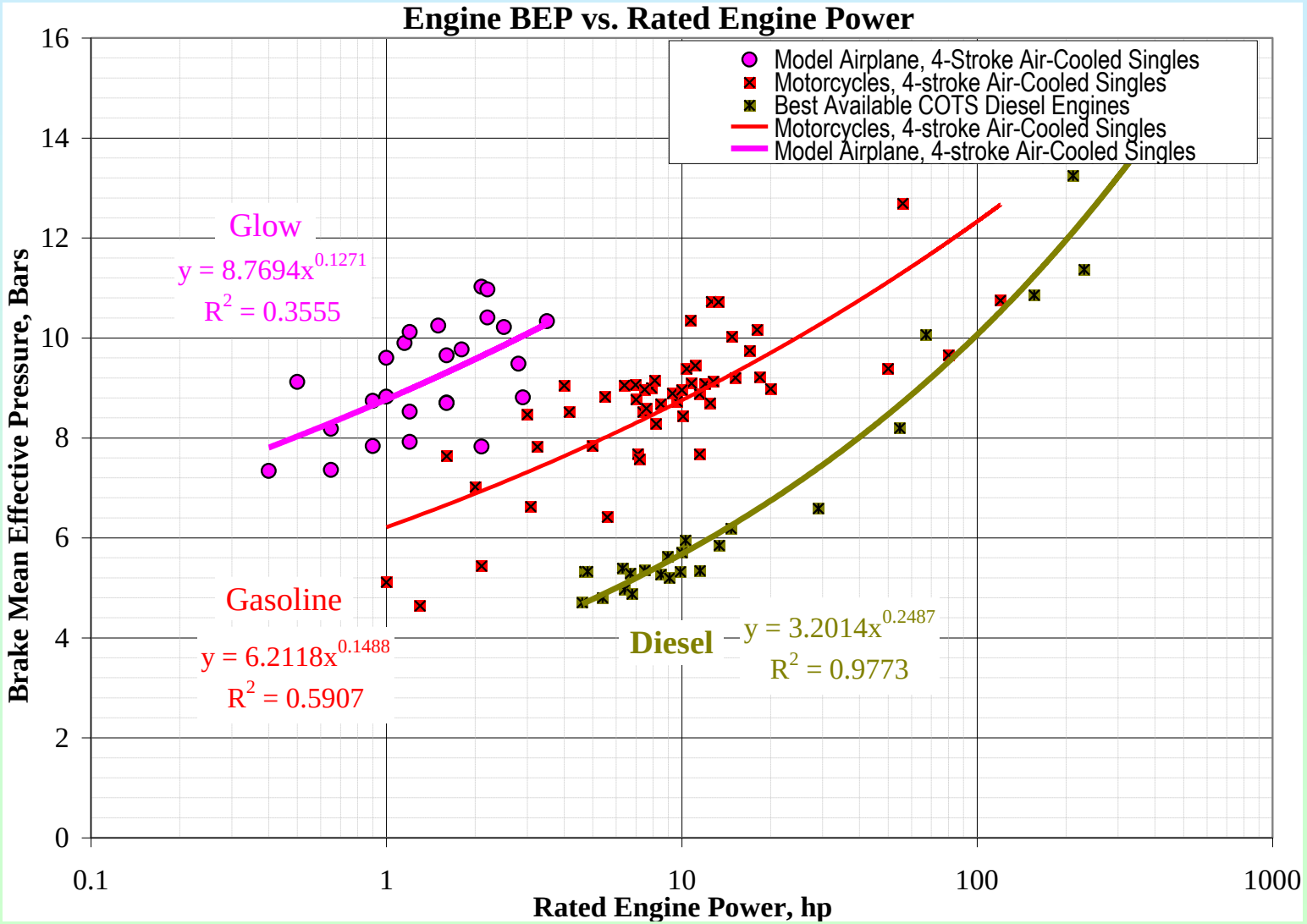
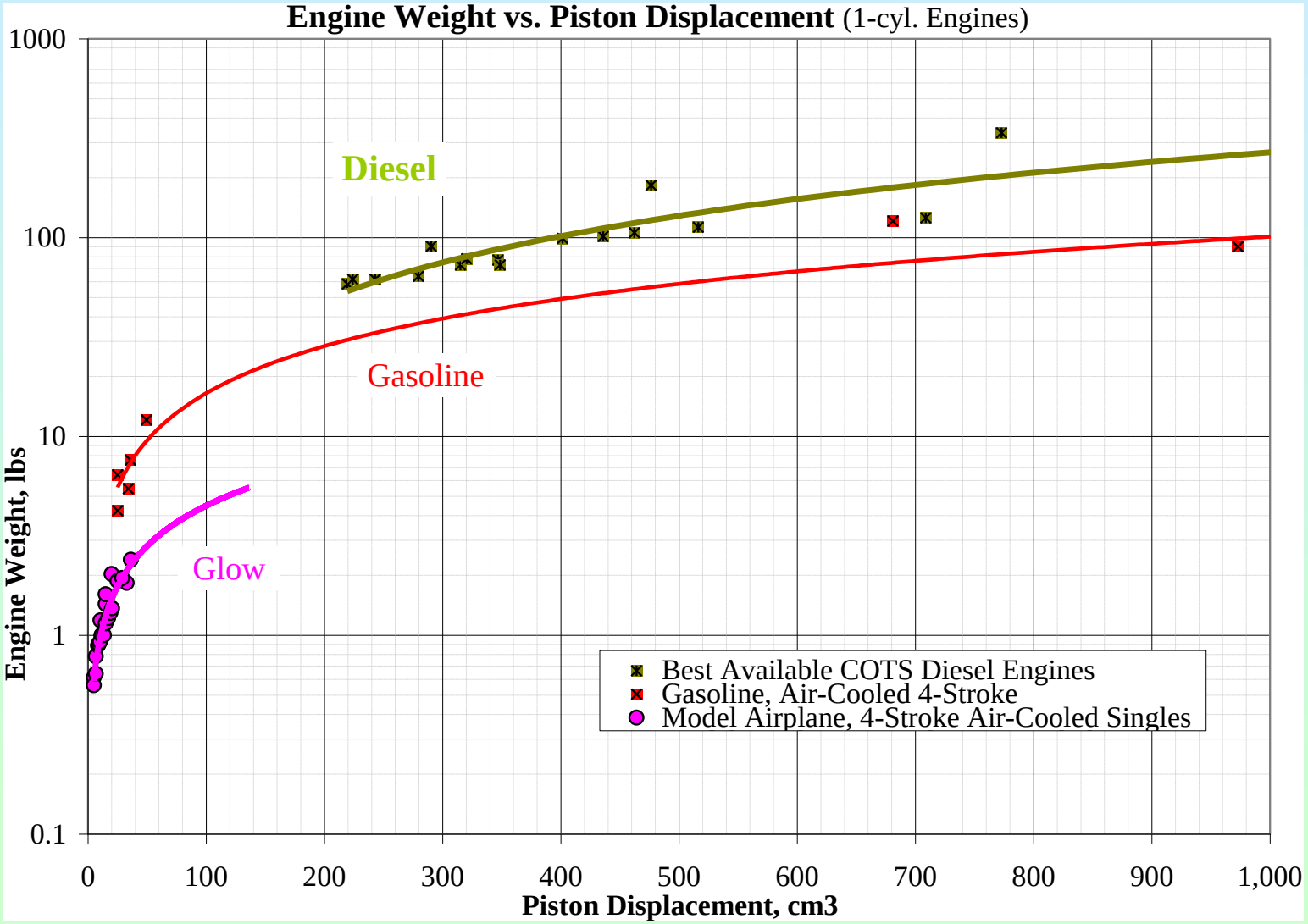


# Even at Equal Size, Diesel Engines Weigh More
# Because of High Compression Ratios, Very High Peak Pressures.



## So, Diesel Engines are Large and Heavy Because of Low Speed, Low Air Utilization, High Peak Pressures.

## What Can Most Improve Heavy Fuel Engines?
## Lower End (Mechanism) or Upper End (Combustion)?

**Piston-Rod-Crank System is**

- ✓ **95% Efficient, Very Light Weight**
- ✓ **Has 100-year History, $100 Billion R&D Investment**
- ✓ **Sealing, Lubrication and Heat Transfer Problems are Well Understood, Solved.**

**'Barrel' Engines, 'Butterfly' Engines, 'Cat-and-Mouse' Engines (real names) ...**

- ✘ **Are Not More Efficient, Not Much Lighter**
- ✘ **Have Large Challenges of Sealing, Lubrication and Heat Transfer.**

**Improving the Upper End (Combustion) Can Enable**

- ✓ **Faster Operating Speeds for Higher Power Density**
- ✓ **Greater Air Utilization (BMEP) for Greater Power, Greater Efficiency.**
- ✓ **Reduced Peak Pressures for Lighter Weight, Lower Friction.**

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# D-STAR Strategies for Developing Light-Weight Heavy-Fuel Engines

1. **Enable High Speed Operation**, even with Heavy Fuels (e.g. JP-8)
   Conventional Diesel Engines Operate at < 3600 RPM
   D-STAR HFEs Operate at 6,000 – 18,000 RPM.

2. **Enable Full Air Utilization**
   Conventional Diesel Engines Operate at Phi < 0.6 (Smoke Limit)
   D-STAR HFEs Operate at Phi up to 1.0 (without Smoke).

3. **Enable Combustion at Low Pressures**
   Conventional Diesel Engines Operate at High CR, High Pmax.
   D-STAR HFEs Operate at Lower CR, Much Lower Pmax

4. **Ensure Active Optimization** of Engine Operating Parameters **(mini-FADEC)**

5. **Reduce Cost** Through Use of Gasoline Engine Components Where Feasible.
   Use Custom Components Where Needed.

# Examples of D-STAR Heavy Fuel Power Systems

**Current 2 kW Generator Set**
**Used by Army, Others**
**AC Only**
**158 lbs**

**D-STAR / Army 2 kW**
**✓ Power Core Demonstrated**
**50 lbs**

**D-STAR / ONR 1 kW**
**✓ Power Core Demonstrated**
**✓ Endurance Test Completed**
**✓ Prototype Delivered**
**✓ Performance Verified by Govt.**

**D-STAR / Army 500 W**
**✓ Phase 2 in Process**
**15 lbs**

**D-STAR / Army 300 W**
**✓ Selected for Phase 1**

# D-STAR / ONR / USMC 500 W – 1000 W

✓ **Power Core Demonstrated, ≅ 50 lbs. Demonstrated 1600W Cont., 1800 W Peak**


Potential

for

2+ kW

# D-STAR / ONR 500 W – 1000 W

**Phase 2.0 : Ended September ’09 : Technology Validation & Down-Selection**

✓ **Heavy Fuel Engine Demonstrated, Technologies Down-Selected.**

**Phase 2.1 : Nov. ’09 to Apr. ’10 : Demonstrate Power Cores, Endurance Ability**

✓ **Power Core Built, Straight-JP8 to 1080 Watts DC Achieved (2 hours non-stop)**

**Phase 2.2 : July ’10 to Jan. ’11 : Build Laboratory Prototypes of Generator Set**

✓ **Endurance Testing (100+ Hours) Successfully Completed (> 700 Watts Avg.)**

✓ **Fully Integrated Desktop Unit Built and Tested, with All Systems Operational**

✓ **First Prototype Delivered, Successfully Tested by the Government.**

**Phase 3 : Support Testing of Prototype + In-House Testing**

**Phase 4 : EMD / SDD**

Engineering & Manufacturing Development / System Development & Demonstrations

## ✓ Endurance Test Done, ✓ Prototype Delivered, ✓ Performance Verified by Govt.

## ONR BAA 06-023 : Original Goals and D-STAR Prototype Capabilities

6.1 Desired Capabilities

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# ONR BAA 06-023

II. AWARD INFORMATION [As Planned]

Anticipated Award Information is as follows:

Total Amount of Funding Available for the Program: $16.5M over 4 years

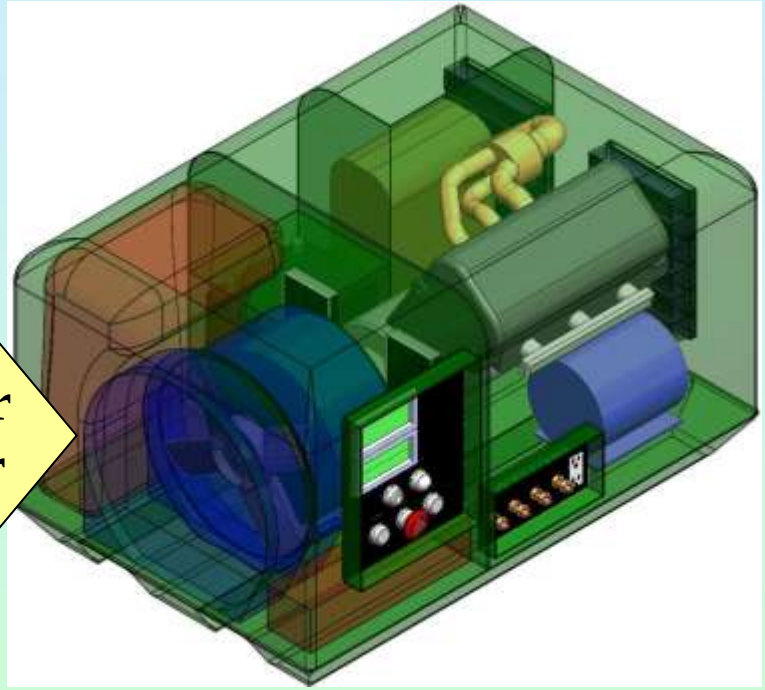
Total Amount of Funding Available for each Award:

| | | |
|---|---|---|
| Phase 1 (Base) : | $200-300K | **Successfully Completed** |
| Phase 2 (Option 1) : | Up to $3M | **On-Time, On-Budget** |
| Phase 3 (Option 2) : | Up to $200K | **Teaming** |
| Phase 4 (Option 3) : | Up to $4.5M | **Under Consideration** |

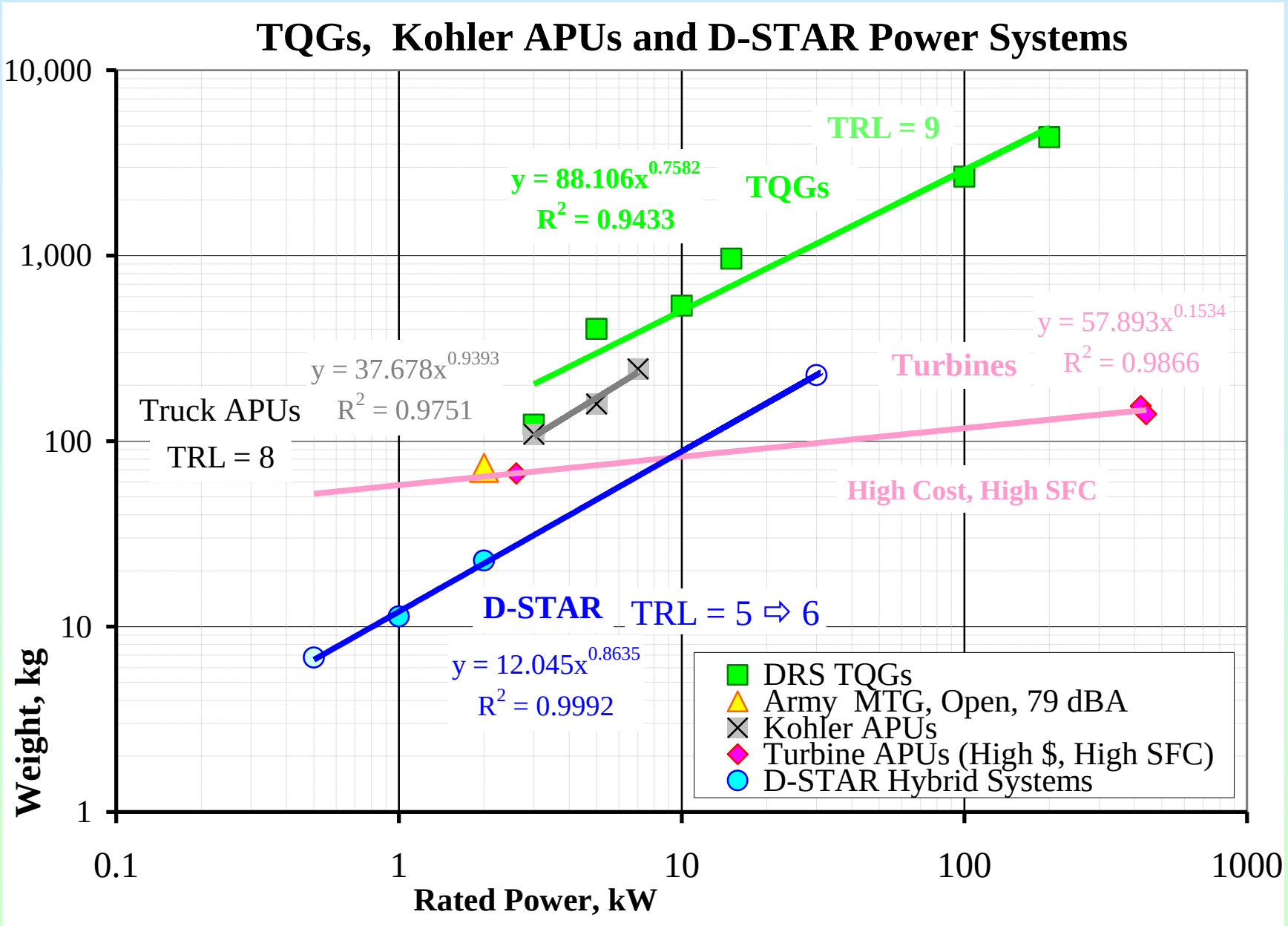
# 30 kW Heavy Fuel Power System : Conventional vs. D-STAR Technology

In-service 30 kW Gen-Set
80” L x 36” W x 55” H
**3015 lbs** basic
70 dB(A) @ 7m

**6 x Smaller**
**6 x Lighter**



Future 30 kW Gen-Set
by D-STAR Team
42” L x 28” W x 24” H
**≅ 500 lbs** basic
67 dB(A) @ 7m



## D-STAR Business and Teaming Strategies

Open to Teaming with Any and All ‘Good’ Candidates.

Potential Team Mate Must Bring Value Added to the Table.

**The Goal is to Maximize Benefits**

**for All Three Stakeholders :**

**ONR / USMC / Government** (Large Cumulative Investment)

**D-STAR Engineering** (twenty years of expertise and investment)

**Potential Team Member** (for their Investment).

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# Portable Power Solutions

by

## D-STAR Engineering Corporation

- ☆ **Extensive Prior Experience with Engines and Power Systems**
- ✓ **Delivered First Prototype for ONR 1 kW Portable Gen-Set, On Schedule, On Budget (BAA). Successfully Tested by the Government.**
- ✓ **Demonstrated 2 kW Power Core (limited by SBIR Funding)**
- ✓ **Developing a 2 hp HFE. Can be Basis of 0.5 kW, 15 lb Gen-Set**
- ✓ **Selected for a 300 – 500 Watt Hybrid Power System (10 lb Gen-Set)**
- ✓ **Designed a 30 kW, 500 lb Gen-Set.**
- ☆ **We Specialize in Light-Weight Heavy Fuel Power Solutions.**

**D-STAR has Developed Key Enabling Technologies**

**for Lighter, More Portable Generator Sets / APUs that can**

- **Use Diesel / JP-8 / Jet-A and Other Heavy Fuels**
- **Offer a Potential for Reduced Fuel Consumption**
- **Offer a Potential for Reduced and Cleaner Exhaust Emissions**
- **Offer a Potential for Cost Reduction.**

**D-STAR Would Like to Team with a Larger Company**

**to Bring its Products to Market**

**Starting with the U.S., Expanding Globally.**