How to Triple the Work Produced From A Pound of Fuel

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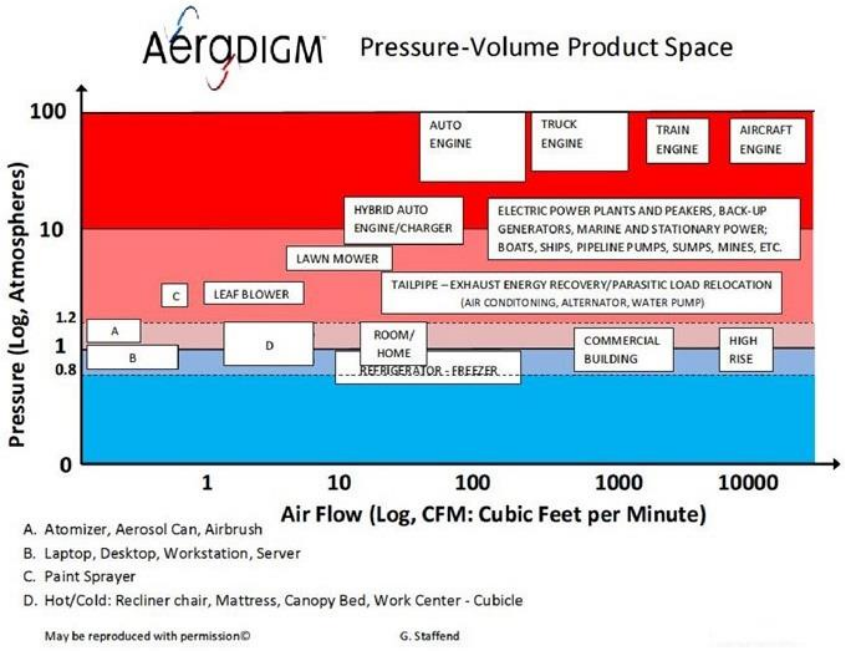
Technical Category: 2_B-Engines for Transportation, 4_B-Engines for Power Generation
Proposed Funds: Fed: $500,000/ Cost Share: $125,000/ Total: $625,000
Project Duration: 2 years

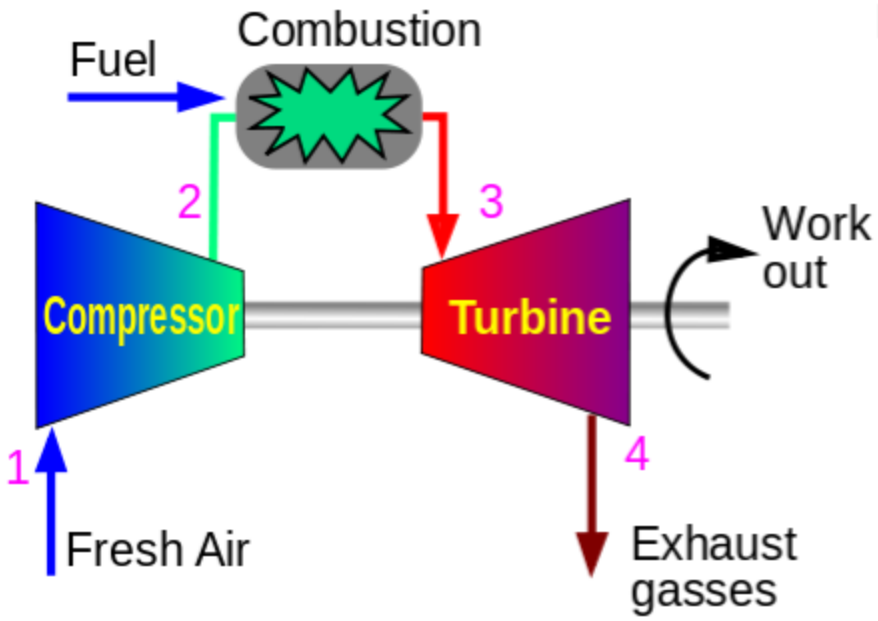
1. CONCEPT SUMMARY

AeraDIGM, the new paradigm for Getting All The Work Out (GATWO), introduces unprecedented mechanisms to maximize the work obtained from a unit of fuel. Rather than maximizing power (i.e., "power = work/time" Power is the amount of work obtained within a unit of time.) AeraDIGM shifts the focus to maximizing the amount of work obtained from any given unit of fuel. Noxious byproducts of combustion are correspondingly reduced or eliminated altogether. The ambient air stream itself becomes the only energy-efficient refrigerant choice. An avalanche of new mechanisms and methods invite research and development throughout the entire Pressure vs. Volume Product Space.



2. INNOVATION AND IMPACT

- Both piston and turbine engines maximize power by compressing a maximum amount of air into the combustion space where fuel is introduced. At 70MPH an automobile engine typically turns 3,000 RPM. That allows a little less than 7 milliseconds to inject fuel, burn fuel, and extract all the work before dumping 85%-95% of the power out the tail pipe. The combustion losses are similar in turbine engines as well although their tail pipe losses are not as severe. Consider the constant-pressure heat engine that AeraDIGM uses to recover work equal to 40% of heat transferred in convective systems, as shown on the next page.



- AeraDIGM's innovation proposes to Get All The Work Out (GATWO) by using positive displacement mechanisms for compression and expansion. Unlike the piston engine, however, the fuel will be allowed time to be burned completely at a lower pressure, perhaps catalytically assisted. Most importantly by far is the confidence with which tail pipe losses can be reduced if not eliminated entirely by numerous well documented GATWO proposals.
- Many mechanisms will capture work from more complete adiabatic expansion. Many mechanisms will burn fuels without noxious byproducts. Many are described in detail with the certification of the US Patent office that none of these have been investigated commercially or academically to date. US7556015 US7621167 US7650754 US8424284
- The patented technologies deliver 3 times the work of the best turbines and 5 times the work of the best piston engines. They are also far less costly to manufacture.
- ARPA-E will lead the world to understand how work is different from power. Increasing efficiency, reducing emissions, and reducing imports to lead the way to carbon neutral.
- Table of Metrics comparing concept to current and emerging by Technology Category

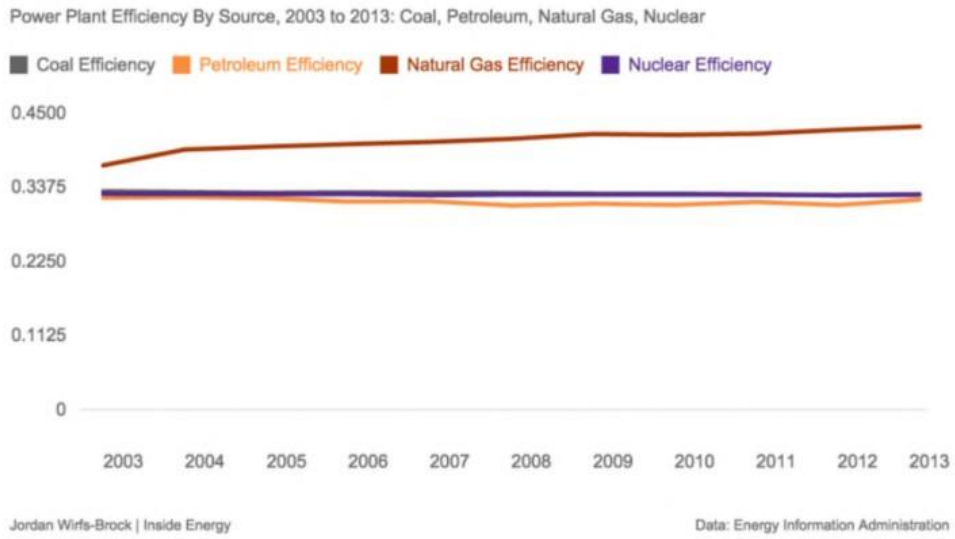
Technology Category from I.D of FOA	Metric for GATWO/current and emerging
2_B_Engines- Transportation	Greater than 5 fold increase
4_B_Engines – Power Generation	Greater than 3 fold increase
7_E_Data Centers and Computation	Greater than 3 fold increase
3_B_Building Heating and Cooling	Greater than 2 fold increase

3. PROPOSED WORK

- Funding of this project will deliver an engine capable of generating electricity on a scale needed to keep the battery of a plug-in hybrid vehicle fully charged. Because such an engine

will avoid grid losses while generating electricity at least three times more fuel-efficiently than present power generation, such a "stationary generator" will be economically attractive even while mounted in a vehicle. (The dead weight of the automotive transmission will be eliminated as well, along with significant weight reductions for both engine and battery.) Moreover, it will economically motivate enormous environmental savings while the US is on the way to "Carbon Neutral".

Energy lost in power plants: About 65%, or 22 quadrillion Btus in the U.S. in 2013



- The GATWO tools comprise a set of flexible methods providing for final products to be tuned specifically to match a task. As with Fan Replacement™ our patented transmission may equip any given product with easy adjustment of compression/expansion ratios. In the case of power generation, the exact match of a chosen fuel to burn at an ideal temperature and pressure may be determined in advance and then fixed to match the most advantageous adiabatic expansion volume. With no variability needed or wanted. The product may then be sized to match the expected battery charging needs of any chosen vehicle.
- Details of the GATWO tools applicable for engines in transportation or power generation will be found in their patents. US7556015 US7621167 US7650754 US8424284
- The experts consulted in the fields of engines, formability, transmissions, and pumps have insisted that "it will not work", yet they have failed to identify their objections. No new developments appear to be needed, so the risk is acceptable. GATWO engine demonstration can be performed as shown in the animation available at www.aeradigm.com. In fact the plan is to measure work recovery from fuel input in exactly the manner shown in the animation. The same test apparatus planned for on the AeraDIGM demonstration of building heating and cooling will be used for the demonstration of generating electricity following precisely the methods shown in the website animation.
- Techno-economic challenges have more to do with groundless yet entrenched commercial resistance to new ideas. Belief systems override data. The data is clear. It will take a product that cuts the cost of energy by a factor of three to gain acceptance. For a plug-in hybrid vehicle, GATWO can deliver more.

4. TEAM ORGANIZATION AND CAPABILITIES

- Management: Dr. Kashif Nawaz, ORNL; Gilbert Staffend, AeraDIGM
- AeraDIGM: Overall responsibility for this project including external interactions
- ORNL: Thermal Analysis and prototype testing, analysis of results, and final report
- Centrepolis C3 Accelerator, Lawrence Technological University; coordination of design, build, control activities and securing matching funds from State of Michigan and other sources.
- Munro Associates: Potential Design and Build activity
- Dr. Kashif Nawaz serves as Group Leader for Multifunctional Equipment Integration and Senior Research Scientist for the Technology Directorate: Buildings and Transportation Science. His laboratories include testing HVAC Systems and components. Dr. Nawaz continues to serve as Chairman of the ASHRAE Technical Committee on Thermodynamics and Psychrometrics. Dr. Nawaz was PI for a similar DOE proposal with AeraDIGM in 2017. It was not funded.
- Gilbert Staffend has 8 patents detailing GATWO features extensively. Previously responsible for engineering and manufacturing systems and their improvement at Ford (including Climate Control, Engines, Computer Centers), Honeywell Computer Integrated Manufacturing across all divisions, and AlliedSignal (including Garrett TurboChargers).
- Dan Radomski, now Director of LTU's C3 Accelerator has supported the evolution of AeraDIGM concepts in many roles, initially as a Manager at NextEnergy.
- Jim Newman is Owner and Managing Partner of Newman Consulting Group, LLC, an EPA Energy Star(r) and Rebuild Michigan(r) Partner. He is a Certified Energy Manager, a LEED Accredited Professional, an Operations and Performance Management Professional, a Building Energy Assessment Professional, and a Fellow of the Engineering Society of Detroit (ESD) and of ASHRAE. He has more than 50 years of experience in HVAC design and manufacturing.