BRASH Air-Steam Hybrid Technology for Combined Heat and Power (CHP)

A Solution for Home Heating and Electrical Generation

BACKGROUND:

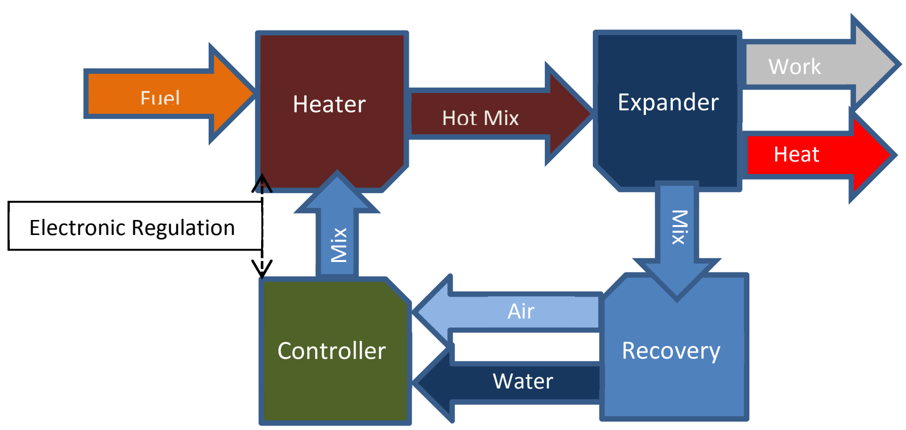
Only one third of the energy consumed for electrical power generation in the US reaches the consumer as useful power. Two thirds of that energy is lost to the inefficiency of the power generation cycle or to line and switching losses between source and user.

Demand for electricity continues to grow in the US at a rate of 1.1% per year for the residential market (and 1.5% per year for the commercial/industrial market). While many utilities have been aggressively replacing coal-powered plants with cleaner-burning natural gas, residential customers resist the siting of new power plants in their communities. Meanwhile, world electrical demand is expected to increase by 87% over the next 25 years. Conventional centralized power production and distribution simply cannot meet such demand quickly enough as well as cleanly and efficiently.

BRASH Engines, Inc. proposes an alternative: a decentralized power generation system in which individual combined heat and power (CHP) units not only produce electricity and usable heat locally, but also contribute to overall utility network capacity.

HOW WILL BRASH TECHNOLOGY WORK IN A CHP?

The BRASH CHP system involves four conceptual building blocks: air/water heater, expander, water/energy recovery unit, and process controller.



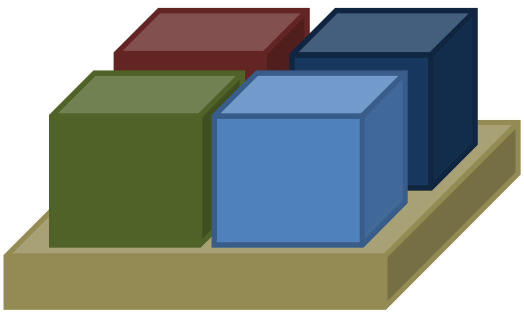
BRASH is a Binary Recovery Air-Steam Hybrid Engine: an external combustion engine that combines air and water to provide immediately available power, with much greater fuel economy than conventional steam or internal combustion engines.

The compressed air fraction provides a safe and consistent flow pressure into the hot section. A small fraction of water, once heated to working steam temperature, results in a far more robust working fluid, than air alone.

The hot mixed working fluid is injected into the expander, moving a piston and converting heat to motion. The expanded working fluid drops to condensing temperatures, allowing the water portion to fall to a sump for pumped return to the injector. The expanded air fraction is recompressed for return to the injector.

The use of an air fraction allows for immediate injection of work-appropriate amounts of water into the hot section, without a boiler, steam under pressure, or fuel wasted heating steam for no immediate purpose. The use of a water fraction (and proportional fuel flow) allows for variable power from a constant temperature system. The binary (air plus steam) propellant allows for a closed-loop, condensing recovery system, extending range and economy.

These four building blocks can be translated into physical modules, potentially removable and replaceable by the homeowner for upgrade or repair. The inter-connections between modules, and connection meters, utility-supplied fuel and customized home heating components could be accomplished through connection to a base pallet and installed by a utility-qualified contractor.



Combining air and steam in a single engine type is expected to yield economies between 35% and 65% over conventional small diesel generators.

In a BRASH CHP, conductive loss could be used to heat living space or hot water, increasing combined efficiency to 75-80%.

HOW WILL THE BRASH CHP WORK?

The BRASH generator system can easily be automatically controlled.

- Low indoor temperature (per thermostat), or low battery bank voltage (by voltmeter) prompts the controller to initiate low air and fuel flow, increasing temperature and pressure in the heater, which in turn begins expander rotation,
- Once the heater achieves proper operating temperature, water flow and increased fuel flow commence. Due to the small quantity of water required, the resulting immediate steam pressure causes increased expander rotation, thereby increasing generated electricity and available heat.
- The hot air and steam mix expands and the expanded mix condenses the water fraction, thereby transferring heat to the room or water tank.
- A small parasitic load from the electrical generator recompresses the small air fraction to reinjection pressures.
- Power generation and heat transfer to the living space continue until thermostat/voltmeter thresholds are restored to set value. System then returns to quiescent state by reducing water and fuel flow to air only operation; then air flow stops, awaiting the next ON cycle.
- During wintertime operation, thermostatic operation dominates. The excess power generated during each cycle would be reverse metered to the utility. During summertime operation, power generation dominates. The excess heat would be shunted to outside the home.

The BRASH Engine combines **compressed air** with **steam**, providing a powerful alternative to the conventional internal combustion engines without a heavy, hard-to-manage boiler and with greater power than air can supply alone.

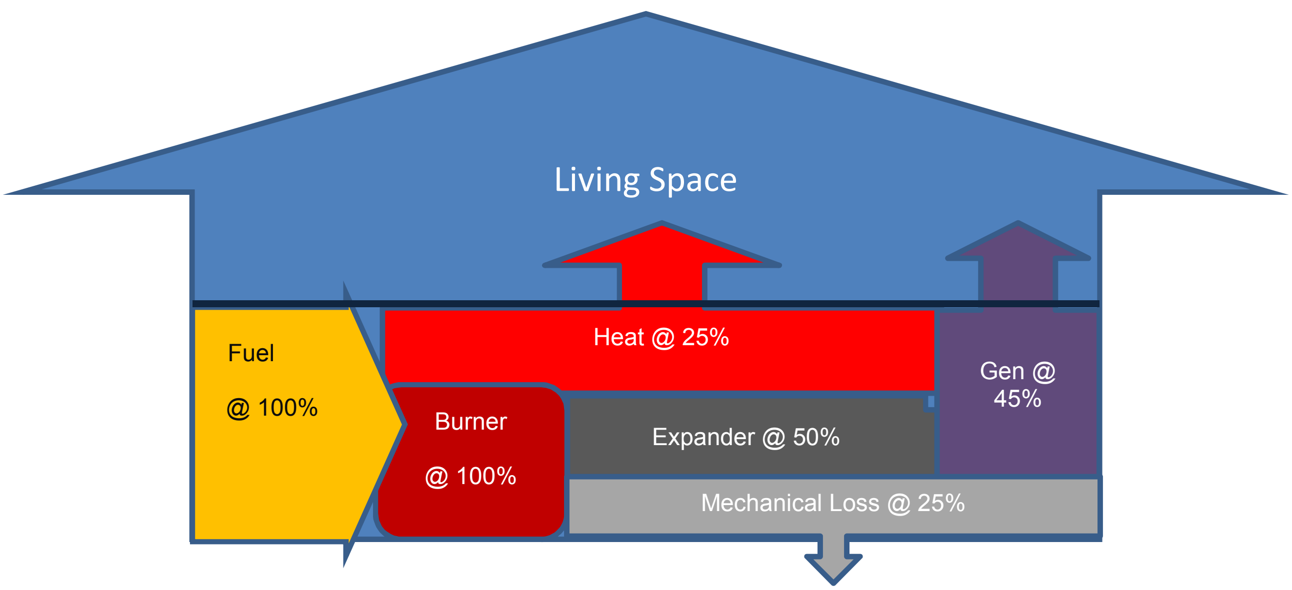
With BRASH, fuel is consumed in direct proportion to the water fraction to maintain the heater at a near-constant temperature. The heat required to maintain "hot air" temperatures is a small fraction of the heat required to maintain steam temperatures.

HOW MUCH MIGHT A TYPICAL BRASH CHP INSTALLATION SAVE?

US Department of Energy (EIA) estimates average home energy demand at 11MWh/home/year, or 1.28 KW steady state. Estimated peak demand of 2 KW equals 2.7 HP shaft power, derated by an approximate 50% thermal efficiency to 6 HP Boiler HP.

6 HP fuel burn is equal to 250 BTU/minute, which equates to 3.2 gasoline gallon equivalents (GGE) per day. At $3/gal, the cost for heat and power for the average American home would be under $10 per day ($300/month). If natural gas was used, with a cost of $1.6/ GGE, the cost would be roughly half that $10, or $150 per month. If the homeowner operated the BRASH CHP at the time weighted average rate of 1.28 KW, then the monthly fuel cost would be $100.

The overall energy flow model for this system is shown below:



WHAT OTHER ADVANTAGES DOES THE BRASH CHP OFFER?

Heat and power in the footprint of a furnace: A homeowner can install BRASH CHP in the same space as an oil- or gas-fired furnace, and derive the same heat, but also electrical power.

Built upon simple, reliable components: BRASH is built upon proven 200 year old technology, updated with robust electronic controls. Once installed, BRASH should require no more maintenance than the furnace it replaces, and last just as long, or longer. The same HVAC technician maintaining current furnaces will be able to maintain BRASH CHP.

Field supportable and upgradeable: BRASH CHP can be separated into four modules in anticipation of further technology enhancements in electronics, customer changes in power demand, or other post installation enhancements. The modular design will permit removal and replacement of whole modules to reduce the effective cost of upgrading.

BRASH system monitoring and smart update: For the benefit of the homeowner and the supporting utility, BRASH CHP will report specific fuel burn and heat and power generated to assure optimal performance. Wi-Fi-enabled reporting can recommend modifications to system settings to shift heat/power ratios or day time cycles for maximum performance and comfort.

(A good example of monitoring benefit would be average cycle time. Too short an operating cycle would indicate either too narrow a thermostatic range, or too small a battery bank. Remedies would include increased hot water reserves or increased battery capacity.)

For the sponsoring utility, monitoring can permit remote operation and control for maximum community benefit from a reliable and always available power source. Grid power could remain in place as backup.

Instant on/Instant off: As demonstrated on website videos, BRASH has the benefit of instant-on (2-3 second) startup, consistent with homeowner expectations for a furnace replacement.

Clean burning/ multi-fuel capable: Early configurations will operate on one specific fuel (natural gas, propane or fuel oil) depending on availability.

A better backup power supply: Some customers may install BRASH CHP for only intermittent backup use. Instead of a noisy, gasoline-powered generator, BRASH can be installed in a standby capacity to sense line brown-out or black-out and instantly switch to backup mode.

Cost competitive: BRASH CHP is derived from off the shelf components, so initial development through to higher scale production can be managed cost effectively and with a minimum of risk. Utility support, in the form of rebates or other forms of cost-sharing would reduce barriers to market entry.

Easily integrated: A BRASH CHP system could be integrated with other renewable sources, like solar and wind power, to further improve system efficiency. Alternatively, it could provide reliable local power in case of sustained cloudiness or lack of wind.

HOW REAL IS BRASH?

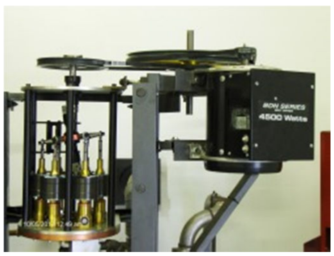
With the support of the US Department of Transportation and University of Connecticut, BRASH has been successfully demonstrated in a small transport vehicle. This proven vehicular application is far more complex than stationary power generation. The preliminary data supports projections of two- to three-fold improvement in fuel economy for engines of comparable torque.

Video recordings of the BRASH vehicle demonstration runs can be viewed at www.brashengines.com The demonstration vehicle operates “open cycle” without recovery of expanded air or steam as visual verification of the instant steam generation capable from the BRASH design. The vehicle development program is continuing with the migration of the technology to a small S-10 pickup truck with enhanced controller logic and air/water recovery.

HOW REAL IS BRASH CHP?

The combined heat and power version of BRASH, in development now at University of Connecticut, presents fewer design and operating challenges than were faced in the vehicle demonstration. Vehicle installed systems have to operate over extremes of temperatures, under highly variable loads. All components, including fuel, must fit within vehicular weight, size, and configuration limitations, meet constantly changing output requirements, and withstand impact tests safely. In contrast, CHP systems can be installed inside a larger, structurally stable, temperature-regulated space, and operate with less variation.

The current BRASH CHP development effort is a bench-mounted 20 HP (15KW) propane system. Propane was selected for simplicity of analysis: cylinder weight before and after testing provides a direct measure of fuel consumed. Virtually any other fuel could be used.



The expander in this phase is a modern 6 cylinder steam engine design with a displacement of 53 cubic inches and is capable of sustained 15-25 HP operation. This expander will drive an alternator/generator in the manner shown at left to measure effective work output in Watts, as well as provide sufficient power to satisfy the system's parasitic loads of battery recharge, exhaust air recompression, and all other pump and valve operations

Static pressure for the water column will still be supplied via compressed air cylinder, but the dynamic air flow will be supplied by an oil-less air compressor. A 24 VDC, 0.5 HP compressor will recompress the recovered air exiting the expander to 40-60 psi pressure and support flows of 3-4 cubic feet per minute (cfm).

The expander, generator and compressor are off the shelf components, but custom engineering of a more powerful and efficient heater; integration of electronics; and design and fabrication of the recovery and recompression components remain as tasks before the first iteration of the CHP system is complete.

All expander operations will be measured for power and work. Once the bench version is in control, data analysis will lead to scale modeling for smaller and larger systems for specific customers and markets.

The issuance of the BRASH technology's foundational U.S. Patent has two important consequences for this project. First, it serves to validate the underlying technology: the combination of air and steam in an external combustion engine is better than steam or air alone, and potentially also far superior to conventional internal-combustion power units. Second, it provides a strong basis for full and open discussions with government agencies and commercial interests in the transportation and power sectors.

BRASH Air Steam Hybrid technology is protected by Patent #7,743,872. BRASH is a registered trademark of Averill Partners, LLC. BRASH is a joint venture of Averill Partners, LLC of Branford CT and BKi of Oakland CA. BRASH Engines, Inc. is a Connecticut corporation, based in Branford CT.

We welcome the interest and participation of partners, customers, and investors. Please visit our website: www.brashengines.com and follow the links provided to indicate your interest.