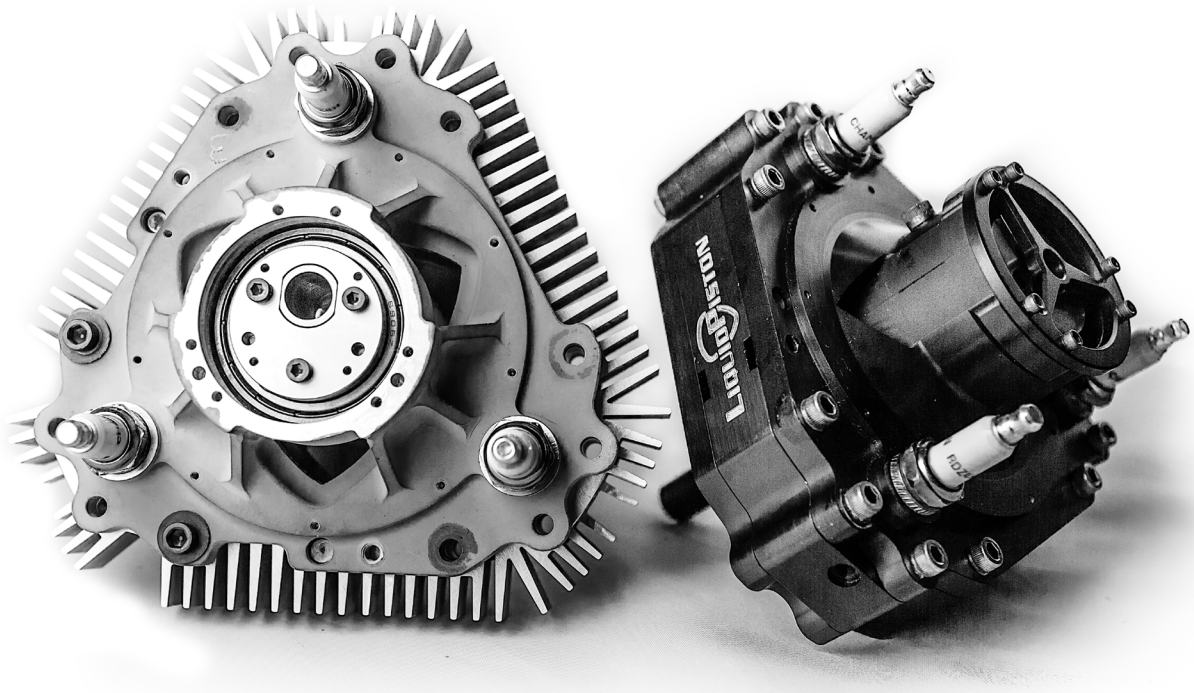
Power Reimagined

Compact, Quiet, Low-Vibration, High-Efficiency Rotary Engines



X Mini 70cc 4-stroke SI engine

LiquidPiston develops advanced rotary engines based on the company's patented HEHC thermodynamic cycle and engine architecture. LiquidPiston engines are designed to be:

Lightweight and Compact

- High power density - up to 1.5 hp/lb (2.5 kW/kg)
- 30% smaller and lighter for spark-ignition (SI) gasoline engines
- Up to 80% smaller and lighter than compression-ignition (CI) piston diesel engines

Quiet

- No poppet valves
- Exhaust turbulence minimized by over-expansion; no muffler required

Low-Vibration, Low-maintenance, Reliable

- Only two primary moving parts, optimally balanced / near-zero vibration

High-Efficiency

- 50% decrease in fuel consumption possible for SI gasoline engines
- 30% decrease in fuel consumption possible for CI diesel engines

Multi-Fuel Capable (Spark Ignited), or Heavy Fueled (Compression Ignited)

- Diesel, gasoline, natural gas, Kerosene / Jet-A / JP-8.

Scalable

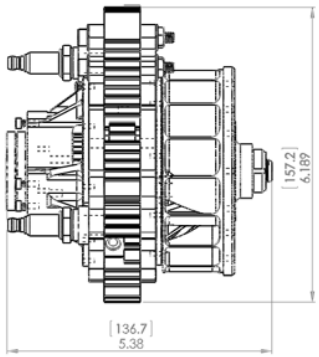
- From 1 hp to over 1000 hp

Specifications

Model	X Mini Alpha Prototype	X Mini Beta Prototype	Mature Design
Type	70cc SI-HEHC cycle air-cooled rotary engine		
Fuel	Port injected, multi-fuel (Gasoline, JP8, Kerosene, etc.)		
Compression Ratio	9:1		
Power (hp) / RPM	3.0 hp / 10 k	3.6 hp / 9 k	5 hp / 14 k
Dimensions	6.6"x6.2"x5.4"= 221 in^3	6.6"x6.2"x5.4"= 221 in^3	6"x6"x5"= 180 in^3
Dry Weight ++	5 lb.	4.5 lb.	4 lb.
Peak Efficiency SFC (g/kW-hr)	18% 460 g/kWh	22% 378 g/kWh	25% 333 g/kWh
Specific Power	.6 hp/lb.	` .8 hp/lb.	1.2 hp / lb.
Time between overhaul	30+ hours	150 hours	1000 hours

++Engine core, excluding fuel / ignition / cooling systems

X Mini Engine



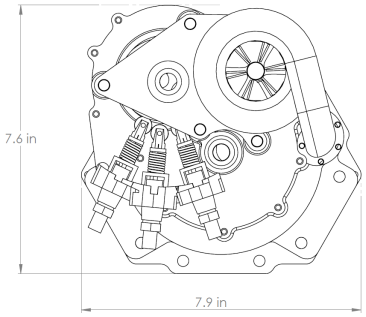
Specifications

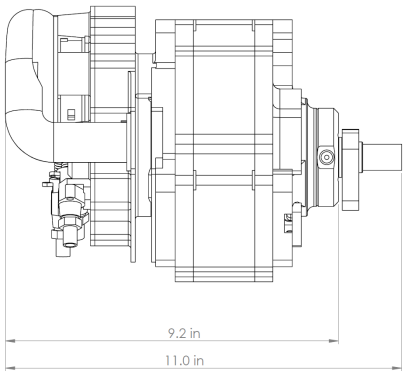
Model	X4 Alpha Prototype	X4 Beta Prototype	Mature Design
Type	750cc CI-HEHC naturally-aspirated liquid-cooled X engine		
Fuel	Common Rail Direct Injection, Diesel / Heavy Fuel		
Compression Ratio	16:1 up to 26:1		
Power (hp) / RPM	40 hp / 7 k*	40 hp / 7 k	50 hp / 7k
Dimensions	14"x17"x19"= 2.6 ft^3	11"x11"x15"= 1 ft^3	11"x11"x11" = .77 ft^3
Dry Weight ++	110 lbs. (steel test rig)	60 lbs.	40 lbs.
Peak Efficiency SFC (g/kW-hr)	40%* 210* g/kWh	40% 185 g/kWh	45% 185 g/kWh
Specific Power	NA	` .9 hp/lb.	1.2 hp/lb.
Time between overhaul	NA	150 hours	1000 hours

++Engine core, excluding fuel / ignition / cooling systems

* On Net Indicated Basis

X4 Engine





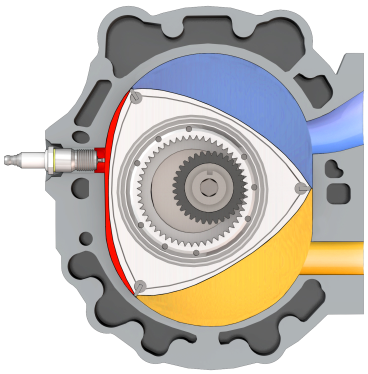
Technology

LiquidPiston's X Engine architecture is a non-Wankel rotary embodiment of the company's innovative High Efficiency Hybrid Cycle (HEHC). The X Engine has few parts and three combustion events per rotor revolution, resulting in high power density. The X Engine's parts consist of a rotor (the primary work-producing component) and an eccentric shaft. Except for ancillary parts such as injectors, fuel pumps, and oil pumps, there are no other moving parts, making the X Engine extremely simple and elegant. LiquidPiston's X Engine architecture geometry allows for standard materials manufacturing techniques.

To see an animation of how the engine works, go to: www.liquidpiston.com

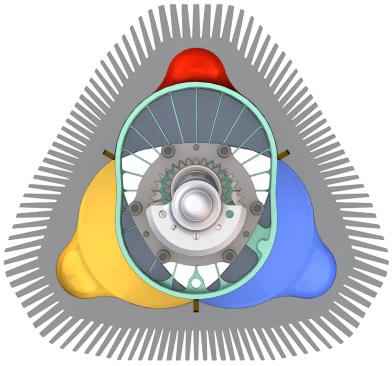
Not a Wankel

Wankel Engine



- Low compression ratio
- No constant-volume combustion
- No over-expansion

LPI X Engine



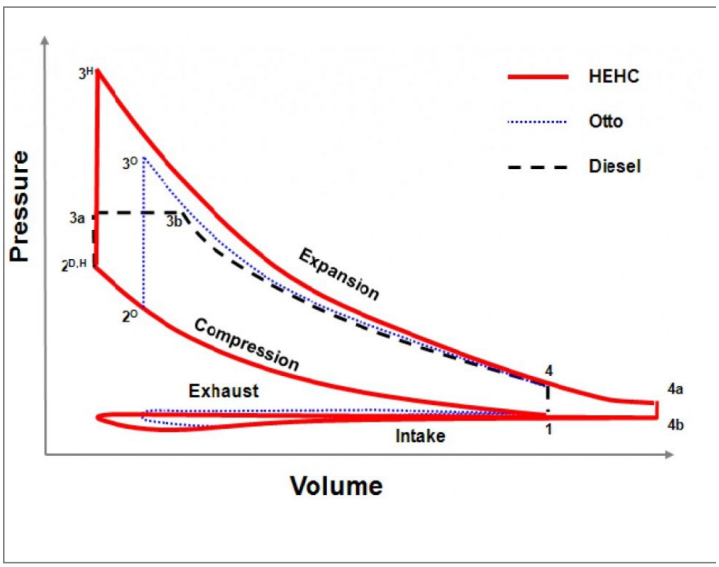
- High compression ratio
- Constant-volume combustion
- Over-expansion

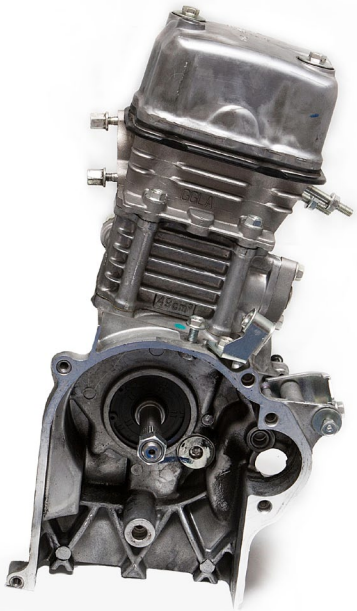
LiquidPiston's X engine can be thought of as an "inverted" Wankel engine. The X engine operates on a new thermodynamic cycle, and solves the Wankel challenges in sealing, cooling, lubrication, emissions and efficiency!

High Efficiency Hybrid Cycle (HEHC)

LiquidPiston's HEHC is a patented thermodynamic cycle that combines the advantages of Diesel, Otto and Atkinson thermodynamic cycles. The cycle elements include:

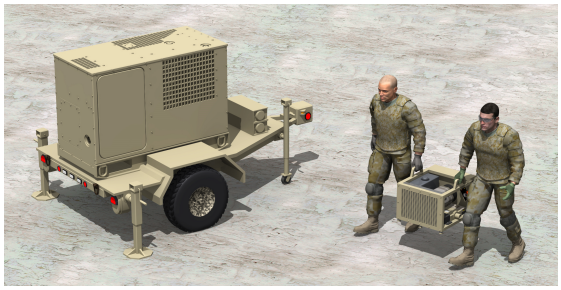
1. Compression: For maximum efficiency, air is compressed to a high compression ratio, fuel is injected and compression ignited (CI-HEHC). The X Mini utilizes a spark-ignition (SI-HEHC) version of the cycle with a lower compression ratio standard for gasoline engines.
2. A dwell near top-dead-center forces combustion to occur at nearly constant-volume conditions.
3. Combustion products are over-expanded using a larger expansion volume than compression volume, as in the Atkinson Cycle.
4. Cycle-skipping power modulation allows high efficiencies at low power settings while simultaneously cooling the engine's walls internally and providing partial heat recovery.
5. Water may be injected to internally cool the engine. Some of this cooling energy is recuperated, as the water turns to steam, increasing the chamber pressure.





LiquidPiston's 3-5 hp X Mini 70cc engine prototype (right) next to a 49cc Honda Metropolitan moped engine

LiquidPiston Overview

Disruptive combustion engine technology	LiquidPiston develops and licenses advanced rotary engine technology based on the company's patented thermodynamic cycle and engine architecture. The **X Mini** engine demonstrator is a Spark-Ignited (multi-fuel) 79 cc, 4 stroke, air-cooled, rotary engine prototype that is designed to be power-dense, virtually vibration-free, quiet, and low-cost. The **X4** is a TRL-4, 40 HP, high-efficiency Compression-Ignited (CI) engine.
Initial capability of engine proven	LiquidPiston's X Mini 79cc multi-fuel 4-stroke engine prototype is designed for high-power density, low-vibration, and quiet operation. The X Mini prototype, undergoing development, has demonstrated 3.6 HP at 10,000 RPM, continuously. With further development, the engine is expected to produce 5 HP at up to 14,000 RPM, weighing only 4 lbs, and be >30% smaller & lighter than piston 4-stroke gasoline engines. The Company has also demonstrated the 750cc Compression-Ignited X4 engine, funded by DARPA, to demonstrate the high efficiency capability of the engine on heavy fuel. The program ultimately targets 45% brake thermal efficiency at an unprecedented 1 HP/Lb. The engine has run both gasoline and diesel fuels.
Markets	LiquidPiston's engines scale from 1 to over 1000 HP and can address most combustion engine markets. Initial markets for the engines include: • Generators and auxiliary power units • Unmanned Aerial Vehicles (UAVs) • Range extenders • Handheld outdoor power equipment • Mopeds / small vehicles • Lawn and garden equipment • Robotics  30 kW Diesel generator - today (left), vs. with an X4 engine
IP portfolio	LiquidPiston has 51 patents, issued or applied for, that include the company's High Efficiency Hybrid Cycle thermodynamic Cycle (HEHC), X-engine architecture, and enabling technologies e.g., sealing, cooling, lubrication, and control strategies.
Licensing opportunities	LiquidPiston is soliciting strategic partners to co-develop engines targeted for specific end markets and license the technology for manufacture and use.
Experienced engine team	With decades of combined experience, LiquidPiston's technical team provides expertise in engine design and program management, with technical backgrounds in physics, mechanical design, modeling, and optimization.
Financing	Building on $30M (VC and govt. funding) invested into the development of the cycle and engine.

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