Reasons for the high efficiency of the Z-Engine, over 50% BTE

1. Very rapid HCCI-combustion at right moment, triggered with spark and ignition injection
2. New type of high voltage ignition system: spark ignition possible at very high pressures
3. No NOx- or particulate filter need: lower exhaust gas backpressure, better efficiency
4. Ignition at lower temperature than negative temperature coefficient regime: no knock
5. No self- ignition possible because of low TDC temperature: high compression ratio possible
6. HCCI-combustion at all loads: no radiation from combustion flame, lower heat losses
7. Water injection: lower compression work and lower TDC – and combustion temperature
8. Water from exhaust gases: FEV, etc.
9. Lower TDC temperature: lower max. combustion temperature and lower heat losses
10. 2-stroke engine: lower heat losses as work at every piston stroke, no intake cycle
11. 2-Stroke engine: lower friction losses as less cylinders, no intake cycle
12. Fully valve controlled gas exchange: no short circuit between intake- and exhaust gases
13. High expansion (compression) ratio, 25:1: better efficiency, especially at part load
14. High intercooling rate, two inter cooler: lower compression work, better efficiency
15. Water cooled piston compressor: high isentropic efficiency, no hot surfaces inside cylinder
16. Piston compressor after turbo: high intake air pressure at all loads possible
17. Early intake valve close mass flow control in compressor: no throttling, better efficiency
18. Air-fuel ratio control possible without throttling: better efficiency
19. Camshaft controlled poppet valves in compressor: high flow efficiency in compressor
20. Short compression in work cylinder: less heat transfer to gas and lower TDC-temperature
21. Pintle type fuel injection nozzle: small spray penetration - and SMD, no wall wetting
22. Evaporation of fuel in hot waste exhaust gases in cylinder: higher heat value of the fuel
23. CFD optimized high speed intake flow: good gas exchange efficiency
24. High speed intake flow: high turbulence in cylinder, good mixing and homogenous mixture
25. Extra turbo bypass exhaust valve: control of pressure in cylinder during fuel injection
26. Extra turbo bypass exhaust valve: control of amount of IEGR and TDC temperature
27. Active radicals in IEGR lower activation energy of air-fuel mixture: easier to ignite
28. Active radicals lower CO and HC amount in exhaust gases: better combustion efficiency
29. LPEGR: control of TDC-temperature, condense water from intercoolers
30. No waste gate in turbo: better turbocharger efficiency
31. Heat isolation of exhaust channel: more power from turbo, better efficiency
32. Steel piston: small crevices, better combustion efficiency
33. Steel piston: better mechanical efficiency
34. High max. BMEP (35): higher part load mechanical efficiency (downsizing, Golloch)
35. Downsizing: better part load operation point (Golloch)
36. Down speeding (N max 2600 rpm): better mechanical efficiency

A big river is born from small rivers