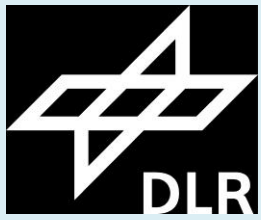


LIBERTINE

LINEAR POWER SYSTEMS

‘Free Piston Engines’ entering mainstream R&D



Sandia
National
Laboratories



FPE advantages

- Low cost
- High efficiency
- Low emissions
- Compact format
- Low maintenance
- Fuel-flexibility
- Low vibration
- Low noise
- Oil-free

Libertine’s ‘Linear Power Systems’: Linear e-machines and free piston devices

Benefits for FPE developers

1. Libertine’s research engine hardware addresses the major challenges of FPE control, system losses and complexity
2. ‘Developer toolkit’ library of lab-validated simulation tools available for electromechanical and thermal optimisation
3. Proven electrical machine architecture, integrated into a free piston expander system
4. Compact, flexible, modular design is readily scaled to suit client research applications



R&D resources freed up to focus on high value combustion development

Free piston research engine for PETRONAS



*UNIVERSITI TEKNOLOGI PETRONAS is evaluating the use of Libertine’s Linear Power Systems to help us **accelerate our pioneering Free Piston Engine combustion research***

Deputy Vice Chancellor, UTP



Evolution of combustion engine control

	1960s	1970s	1980s	1990s	2000s	2010s	2020s
Ignition	Mechanical (Distributor)			Analogue (EI)		Digital (Via ECU)	
Fuelling	Mechanical (Carburettor)			Analogue (EFI)		Digital (Via ECU)	
Air	Mechanical (Cam driven valves, turbochargers)				Variable valve lift/timing		Digital (e-valves, e-superchargers)
Motion	Mechanical (Crankshaft)						FPE 'digital piston motion'

New possibilities for future powertrains

- **Variable compression & expansion ratios**
 - Flex-fuel (Ethanol / gasoline)
 - Start-up
 - Transient
 - Lean-burn & EGR optimisation
- **Advanced combustion cycles**
 - HCCI
 - Split cycle FPE
- **Heat recovery integration**