The Dearman Engine

COMPANY

Fostering SME Innovation and Investment Opportunities in the UK

Introduction to DEC

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- A British company developing a novel zero-emission engine
- Uses “Liquid Air” as fuel
- Concept proved in vehicle and lab tests (academic / engineering due diligence)
- Technology will be cheap and robust
- Multiple applications and global market
- 20 month commercial development programme

Current Status

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2010-11	UK University research & review + due diligence with Ricardo
Q1 2012	Series A funding completed
2012-13	Engine development (by Ricardo)
2013	Demonstration engine built & tested
2013	Commercial discussions commence

"Numerous practical applications for the technology… The low cost and simplicity would benefit.. penetration… likely to compete with hydrogen fuel cell and battery electric systems in zero emission applications"

Ricardo Plc 2012

Drivers and Characteristics

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Zero Emission Drivers

Now

- Operational
  - e.g. Enclosed environments
- Legislative
  - General and local

Longer Term

- Environmental concerns
- Rising fossil fuel costs
- Decreasing off-peak energy costs

Characteristics

- Capital cost – ICE Comparable
- Energy density – Comparable to advanced batteries
- Refueling – minutes
- Infrastructure – low cost
- Lifetime/Maintenance – ICE comparable
- Tolerates harsh environments
- Converts heat (e.g. from IC engines) to power
- "Free" air conditioning and cooling

Dearman Drivers:

Technology is targeted at addressing applications and markets where EV and Fuel Cell technology characteristics are sub-optimal in the short to medium term

Liquid Air as a “Fuel”

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- Good energy store for time shifting energy.
- Globally available infrastructure - manufactured and distributed in all industrialised economies
- Cheap to store - requires insulation not high pressure
- Safe:
  - Non-combustible
  - Non-toxic
- Simple & fast re-fuelling

Technology

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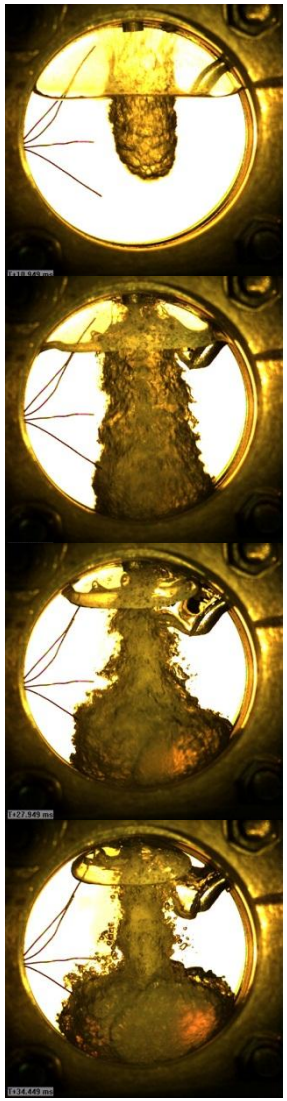
Process

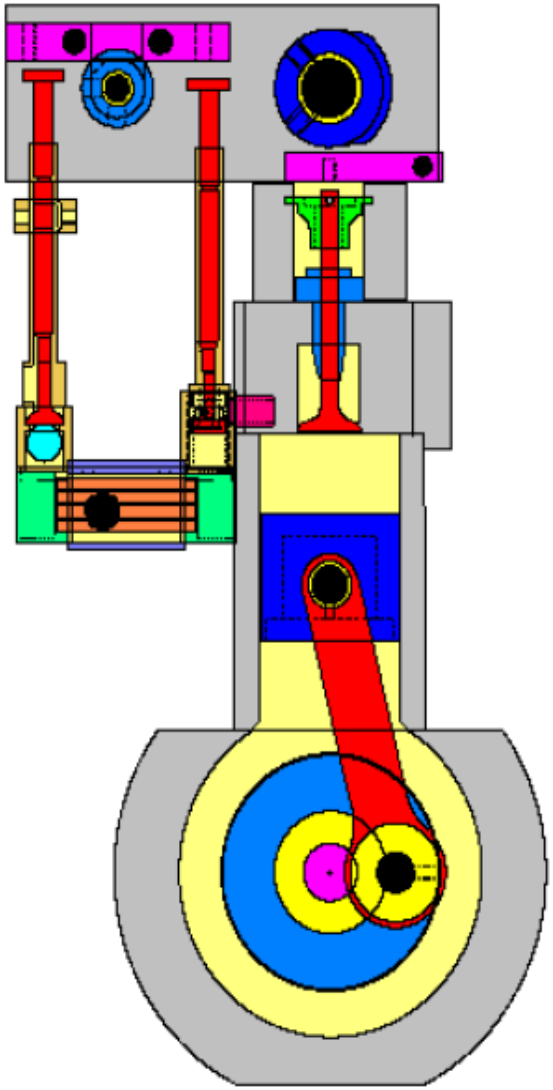
Engine operates by boiling liquid air to produce high pressure gas that can be used to do work.

Inventive Step

Boiling takes place inside cylinder through direct contact heat exchange with a heat exchange fluid – ***patent granted***

- No high pressure heat exchangers
- Rapid expansion
- High pressurisation rates
- Near isothermal (constant temperature) expansion
- Non combustive





Applications

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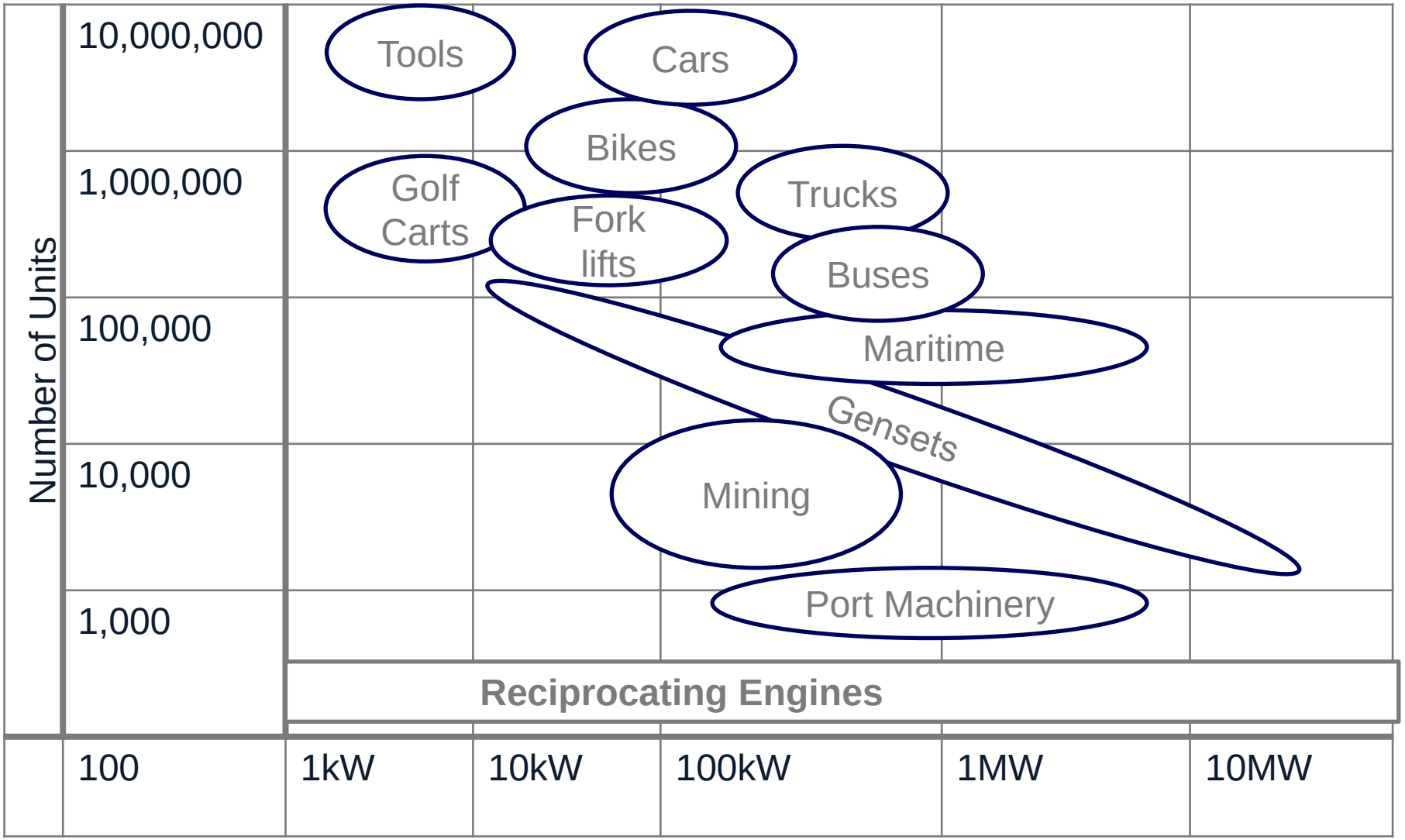

Unique Capabilities

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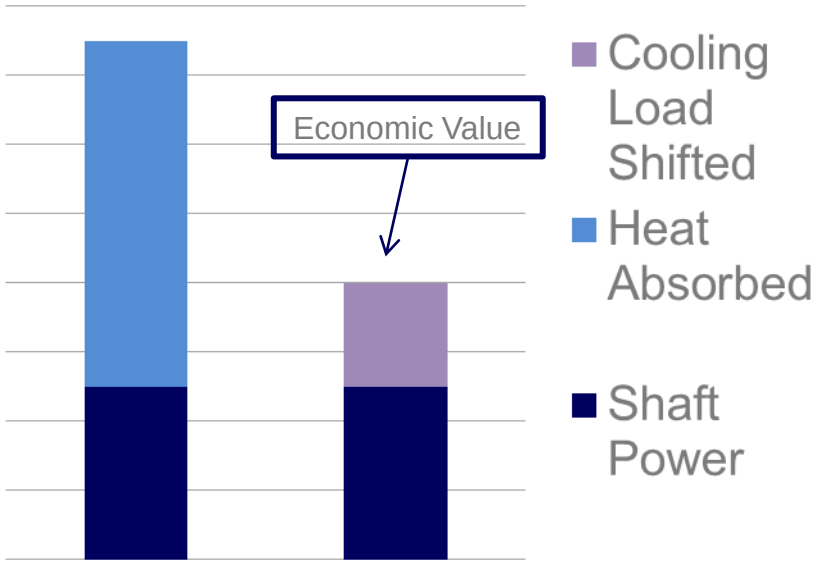
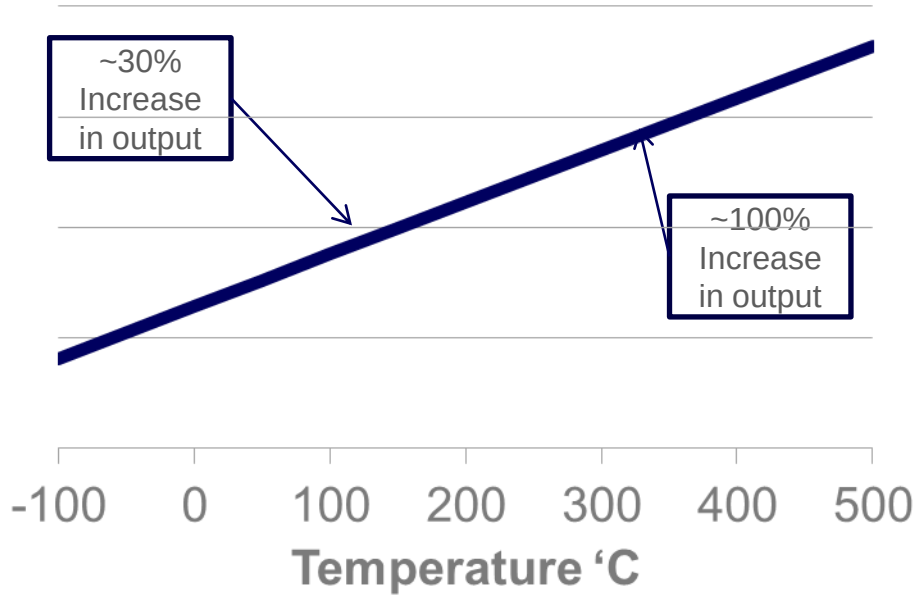
Combined Cold and Power:

- Engine absorbs heat as shaft power generated
- Engine can be used as a heat sink or cooling system
- Useful for chilled delivery vehicles

Heat to Power:

- Low starting temperature means liquid air can convert heat into power efficiently
- Energy availability increases with peak temperature
- IC Engine hybrids are a big opportunity





Team

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- Company employs a small focused team, supported by a network of advisors and consultants
- Technology development executed by Ricardo
- Advisory panel for peer review and supply additional unique expertise
- Commercial team brings together extensive strategic and market perspectives

Technical:

RICARDO

University of Brighton

Loughborough University

UNIVERSITY OF LEEDS

Queen Mary University of London

Science & Technology Facilities Council

Commercial:

RICARDO

BDO

Programme

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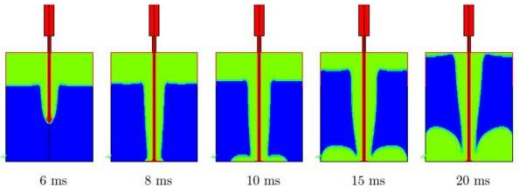
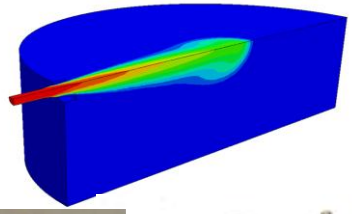
Previous:

- Proof of concept work
- Academic test and validation
- Independent technology review and engine feasibility study



Now (2012-13):

- Commercial and technical development
- Next generation test engine



Next (2014):

- Potential exit for early investors
- Field demonstrations
- Relationship with volume reciprocating engine manufacturer

UK environment (1)

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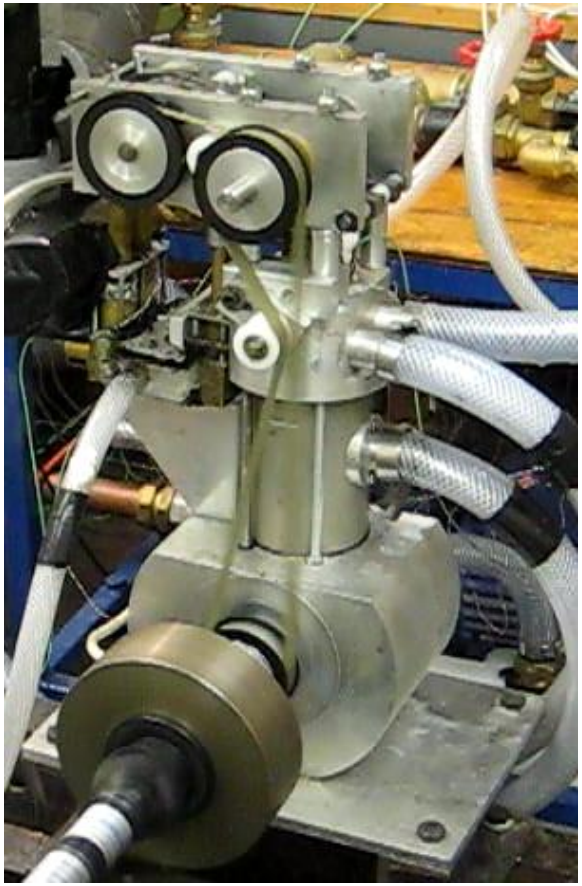
DEC Experience:

- Classic, British “garden shed” invention
- High quality, flexibility and industry focus of UK academic institutions
- Allows first stage validation and progress to be made with limited resources.
- World class engineering expertise in thermal reciprocating engine development, validation and design.
- Through the British Cryogenic Cluster, one of the densest groupings of cryogenic expertise anywhere.
- Support of trade organisations e.g. SMMT



BRITISH CRYOGENIC CLUSTER

UK environment (2)

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DEC Experience:

- Early stage funding dominated by networks of HNWI's
- Favourable tax environment for early stage investment.
- Government and institutional funding focused on policy road map leaving great opportunities for outside investment into early stage, transformational technologies
- UK has significant existing engine manufacturing capability and substantial first stage deployment opportunities

Summary of DEC

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DEC has patented an engine which runs on liquid air. The exhaust is cold air.

Key advantages within the zero-emission market

- Low Capital Cost
- Durability - uses existing components
- Competitive Energy Density (similar to Lithium Ion)
- Rapid re-fuelling

Work to date

- Proof of concept test engines delivered positive power (inc. 4 year PhD programme)
- Inventor – modified and drove cars at 30 mph
- Ricardo - independent due diligence & analysis of market potential

20 month commercial development program

- deliver an optimised demonstration engine;
- generate and own additional IP;
- develop first commercial applications and markets;
- engage with appropriate Original Equipment Manufacturers.

The Dearman liquid air engine - “a truly clean, cool technology”

for further information

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