Unlocking the Low Carbon Vehicle Supply Chain

A survey of SME clean-tech innovators looking to make it big

LowCVP
low carbon vehicle partnership

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Introduction

Background

This report outlines the experiences of UK SMEs developing clean-tech automotive components and bringing these to market. The findings are used to suggest possible interventions to support these businesses and help to unlock parts of the UK's automotive supply chain.

Undertaken by the Low Carbon Vehicle Partnership, the study involved a detailed survey of 20 leading UK clean-tech automotive SMEs. These companies, from a range of backgrounds, are developing technological solutions to reduce greenhouse gas emissions. The study:

- Examines the proposed routes to market and customer readiness of technology developers for low carbon automotive products;
- Explores the common challenges faced by technology developers and identifies common gaps in their capability and needs at different stages of customer readiness;
- Investigates the extent and nature of engagement between technology developers and prospective OEMs and Tier 1 customers and how this can be facilitated.

Survey Objectives

The work is designed to help inform policy makers, intermediaries and the automotive industry to understand the specific issues facing UK clean-tech automotive SMEs and how these might be addressed by the wider UK industry and Government.

The evidence was assembled through questionnaires completed during April 2011, providing both qualitative and quantitative responses. The questionnaire utilises LowCVP's previous work[1] that defined standards for assessing automotive Technology Readiness Levels (TRLs) and Manufacturing Readiness Levels (MRLs). These scales convey the development status of technologies as they move from a researched concept to a validated product that has been designed for scale manufacturing.

Routes to Market

For developers of clean-tech automotive products there are potentially three high-level routes to market; manufacture yourself and sell direct to an OEM or Tier 1, outsource your manufacturing and sell direct to an OEM or Tier 1, or licence your IP to an OEM or Tier 1 for them to manufacture/sell your technology (either globally or in specific markets). The companies surveyed indicated a broad mix of intended routes to market, with some focusing on one or other route and many others leaving two or even all three options open. About half the companies were also considering growing their company with a view to it being acquired.

The companies surveyed

The type of products being developed by the companies surveyed (see back cover for full listing) are highly integrated and technology-driven. They are bought by OEMs or Tier 1 suppliers on the basis of the innovation they provide in improving fuel economy and reducing CO_2 emissions. They enable OEMs to differentiate the performance of their vehicles and help achieve regulatory requirements. These engineering led products must be priced competitively relative to alternative products that meet similar requirements. To succeed, suppliers thus require a competitive strategy and business model focused on technology leadership and their future customers.

[1] *Automotive Technology and Manufacturing Readiness Levels, A Guide to Recognised Stages of Development within the Automotive Industry*, Automotive Council, January 2011

Readiness Levels

Technology Readiness Levels		
Research	**TRL 1**	Paper studies and scientific experiments have taken place; Performance has been predicted;
	TRL 2	Application specific simulations or experiments have been undertaken; Performance predictions have been refined;
	TRL 3	Performance investigation using analytical experimentation and/or simulations is underway;
Demonstration	**TRL 4**	The technology component and/or basic subsystem have been validated in a laboratory or test house environment;
	TRL 5	The component and/or basic subsystem have been validated in a relevant environment, e.g. via a mule or adapted current vehicle;
	TRL 6	A prototype of the system or subsystem has been demonstrated within a test house, test track or similar operational environment;
	TRL 7	Multiple prototypes have been demonstrated in an operational, on-vehicle environment;
Product readiness	**TRL 8**	The technology has been proven to work in its final form and under expected conditions;
	TRL 9	The technology has been successfully applied in its final form and under real-world conditions;
	TRL 10	The technology is successfully in service in multiple application forms, vehicle platforms and regions;

Technology Readiness Levels

Technology Readiness Levels (TRLs) convey the development status of a technology to deliver its function. These range from desk based research to demonstration and validation to a product proven for mass market adoption.

Manufacturing Readiness Levels

Manufacturing Readiness Levels (MRLs) communicate the maturity of a product to be produced. These range from proof of concept through prototyping to volume production, deployable globally and to appropriate quality levels.

Manufacturing Readiness Levels		
Proof of concept	**MRL 1**	Basic manufacturing implications have been identified;
	MRL 2	Manufacturing concepts and feasibility have been determined and processes have been identified;
	MRL 3	Experimental hardware has been created, but is not yet integrated or representative; Supply chain requirements determined;
Prototypes	**MRL 4**	Capability exists to produce the technology in a laboratory or prototype environment; Design optimised for production;
	MRL 5	Capability to produce prototype components in a production relevant environment;
	MRL 6	Capability to produce integrated system or subsystem in a production relevant environment;
	MRL 7	Capability to produce systems, subsystems or components in a production representative environment; Procurement plans made;
Low & high volume production	**MRL 8**	Initial production is underway; An early supply chain is established and stable; Manufacturing processes have been validated;
	MRL 9	Full/volume rate production capability has been demonstrated; Major system design features are stable and proven;
	MRL 10	Full Rate Production is demonstrated; Lean production practices are in place and continuous process improvements are on-going; The manufacturing capability is globally deployable;

The tables above summarise the various levels – a full definition was provided to survey respondents, and was as set out in the 2011 Automotive Council/LowCVP paper.

Attainment & Ambition

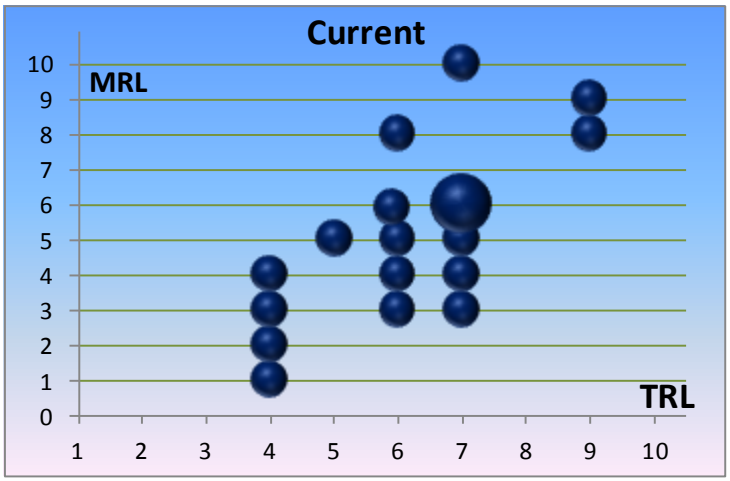
"a generally high level of ultimate ambition but a wide range of short-term expectations of progress"

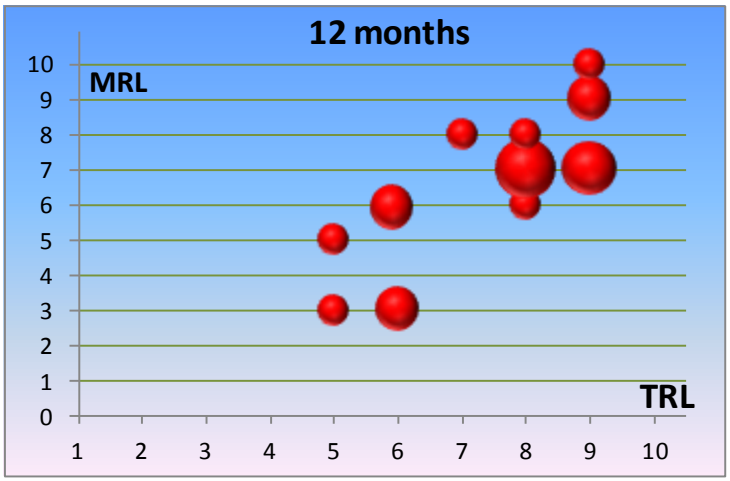
Respondents were asked to rate their current TRL and MRL, where they expect to be in 12 months time and where they ultimately intend to get to. The results show a generally high level of ultimate ambition but a wide range of short-term expectations of progress. In the charts (right), each bubble represents one or more company at that combination of TRL and MRL; the bigger the bubble, the more companies represented.

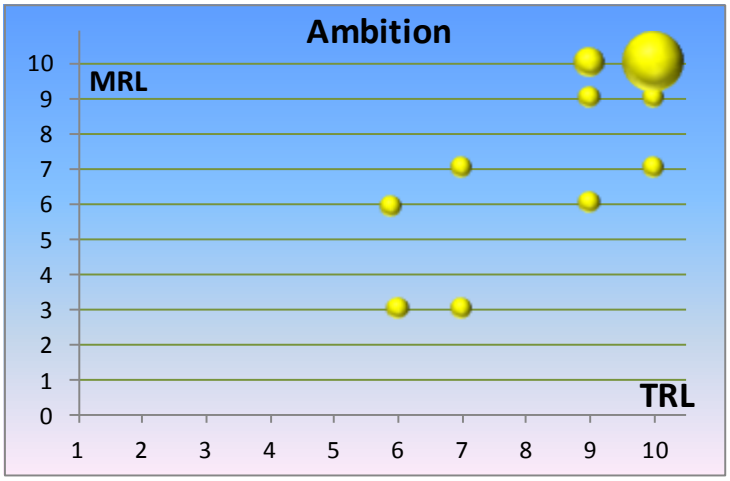
No respondents are currently still in the research phase, and most are in the demonstration phase (TRLs 4-7). Only two respondents (10%) considered themselves to be at product readiness (TRLs 8-10). There is more variation, however, in MRLs, with at least one company at each level. Five companies rate themselves at proof of concept stage only, with a further four at the volume production stages. Most (over 50%) are in the prototyping stages. With a few exceptions, MRLs generally lag behind the TRLs.

Ultimately, the clear majority intend to be at full readiness or very close (TRL and MRL of 9 or 10). A sizeable minority (one third), however, have no manufacturing ambition beyond prototyping and some of those (10% overall) wish to go no further than proof of concept. All but four respondents aim for product readiness (TRLs 8-10), the remainder going only to the advanced demonstration stages (TRLs 6 or 7).

Respondents generally see the situation in 12 months time as being between their current levels and future ambitions. Some companies expect to make much more rapid progress through the MRLs than the TRLs – 20% of respondents expect to move up at least 3 MRLs in the next year, while only 10% expect the same progress in TRLs. This may reflect the low starting MRLs of some companies and their confidence in being able to move rapidly through the prototyping stages. Most (two-thirds) of the respondents expect to progress by 1 or 2 TRLs in the next year with only four companies not expecting to progress beyond their current TRL.







Challenge & Opportunity

Challenges faced

Respondents were asked to describe any specific challenges they have faced, or anticipate facing, in progressing up through the TRLs (performance validation) and MRLs (production viability).

A wide range of individual issues were identified with regard to performance validation, but some common themes emerged:

- **Data issues**. One company incurred additional costs because vehicle data obtained from one client could not be shared with others, while another could not get full results from tests performed on their technology by OEMs. Others had problems with establishing the true customer requirements and their diversity across different OEMs.
- **Cost/resource issues**. Companies mentioned funding for limited run pre-production systems, the costs of validation to required standards and the burdens placed on small companies to overcome the natural cautiousness of OEMs and Tier 1s.
- **Design issues**. One company mentioned the challenge of balancing their needs for a common core design to minimise initial pilot/niche application costs against OEM requirements for highly customisable designs. Another mentioned vehicle integration with existing architecture.

There was markedly less diversity of issues raised for MRL progression and the validation of production viability. Of those companies that described specific challenges, most mentioned the costs and risks in demonstrating production capability, perhaps involving investment in assembly equipment prior to high-volume customer commitment.

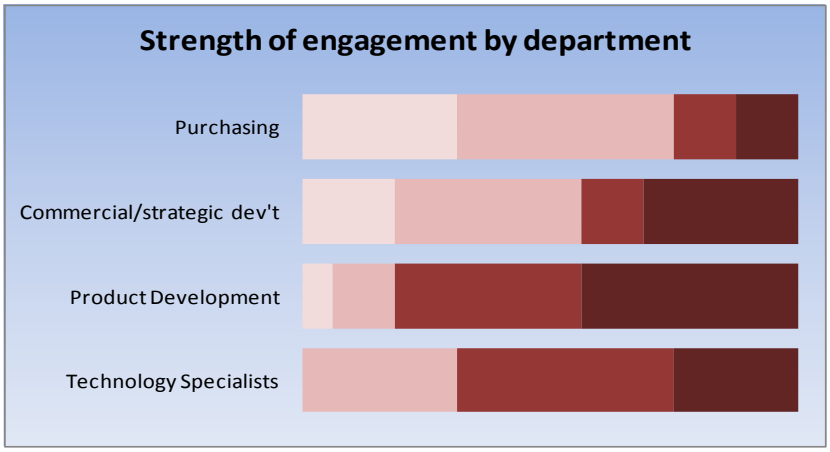
Engagement opportunities

The companies surveyed were asked to describe the types of participation from OEMs or Tier 1s that would help them progress through the different stages of technology and manufacturing readiness.

The table below summarise the main opportunities respondents perceive for help from OEMs and Tier 1s at the different development stages.

How can OEMs & Tier 1s help with TRLs?	
Research (TRL 1 - 3)	Ideal spec development; market guidance; test data verification; access to facilities & engineering expertise
Demonstration (TRL 4 – 7)	TSB projects; cost, weight, size and durability targets; IP protection; closer engagement with engineering expertise and test facilities; mule vehicles; support finance and financial commitment; component manufacture; prototype testing; access to trial customers
Product readiness (TRL 8 – 10)	Fleet trials and in-use validation; demo vehicles; vehicle programme selection; support finance; volume manufacturing capability; partnership agreement; commitment to realistic volumes and ramp-up; professional services; quality control
How can OEMs & Tier 1s help with MRLs?	
Proof of concept (MRL 1 – 3)	Expertise on related components; future production volume info; quality & cost targets; detailed launch plan (timing/volume); finance; production sample development
Prototypes (MRL 4 – 7)	Design for manufacture help; tooling commitments & demand for prototypes; pre-production requirements; process development; technology road map; validation data; licence technology; cost analysis; commercial agreement and commitment; realistic pricing of prototypes (i.e. more than mass production prices); access to quality systems
Volume production (MRL 8 – 10)	QMS, lean manufacture & 6-sigma expertise & validation; partnership agreement; investment support; agreement on run/rate capabilities; early visibility of appropriate schedule; production process sign-off; finance; orders!

Customer engagement



Who to engage

Respondents were asked to specify the level of engagement they had with four separate departments/functions within their target OEM or Tier 1 customer organisations; technology specialists, product development, commercial or strategic development, and purchasing. Engagement was rated on the following scale:

0 – No engagement
1 – Initial contact made
2 – Early discussions held
3 – Frequent contact
4 – Strong engagement

The results are shown in the figure above – the wider and darker the shaded bands, the more respondents reported higher levels of engagement with that function/department. It is evident that there is much greater engagement with the technical areas than with the business and procurement areas.

When to engage

No clear trends emerged when examining responses by current TRL or MRL, with companies reporting engagement levels varying between 1 and 4 almost regardless of their existing readiness.

The two companies rating themselves at product readiness (TRL 8-10) did both, however, also report greater engagement with the commercial and purchasing functions than was often the case with companies at TRLs 4-7.

Companies generally expressed the view that strong engagement with customers was vital for them to progress beyond the demonstration stage (TRL 7) into final, mass production.

How to engage

Respondents were also asked to describe how their contacts in the various customer functional teams had first been made. The answers to these questions tended to highlight the importance of networking, in various forms, including:

- Via a key contact within the customer organisation, e.g. a project manager or advanced engineering team member;
- Via involvement in collaborative R&D projects, e.g. TSB or FP7;
- Via conferences, PR activities, websites etc.

Resources & barriers

Resource needs

The relative importance of different business needs will vary between companies and with time. A snap-shot of the resource priorities of the surveyed companies is shown in the pie-chart below. The feedback identifies broadly equal importance given to support from:

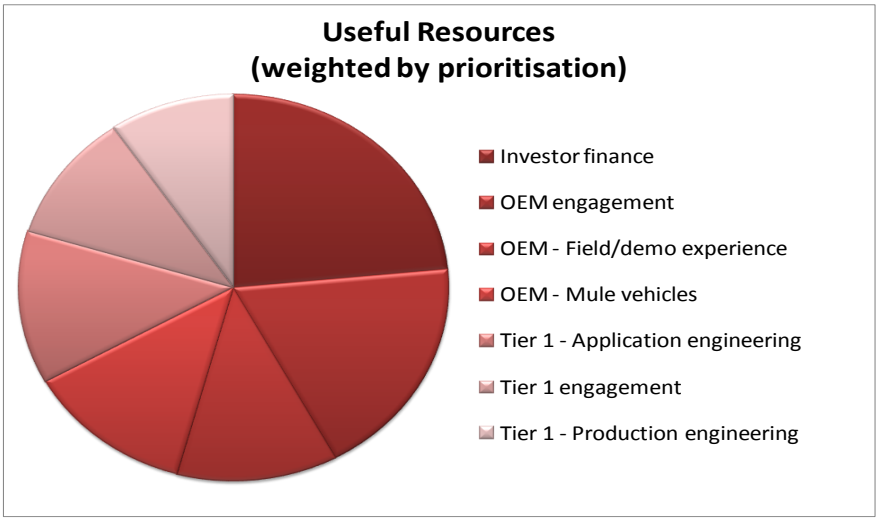
- Investors – for finance;
- OEMs – as prospective customers and for demonstration assistance, including the supply of mule vehicles;
- Tier 1s – for application and production engineering to progress through the MRLs.

Barriers

At the end of the questionnaire, respondents were asked a series of open-ended questions about the barriers they face in commercialising their low carbon automotive technologies.

Perhaps unsurprisingly, the companies surveyed came up with a diverse and varied set of issues that they perceived either as current or potential future barriers. Most responses, though, can be categorised into one of five key areas:

- **Market barriers**. This includes concerns about UK market size, e.g. relative to the EU and USA, the UK's high labour and other costs compared to Asia and its lack of prototype suppliers. Perceptions were expressed that the UK supply chain is more focused on low volume for motor racing than medium volume for mainstream automotive, and of weak manufacturing infrastructure;
- **Customer barriers**. Respondents mentioned the hurdles they perceive are placed in their path by OEMs or Tier 1s. These include risk aversion, unrealistic expectations and validation criteria, the lack of future commitment, mentoring and engagement, and that many UK-based OEMs are controlled from parent organisations outside the UK;
- **Investor barriers**. Concerns here include the availability of funds, due diligence/business accreditation issues and the lack of investor confidence in UK manufacturers;
- **Governmental barriers**. Some respondents felt that there was a lack of funding programmes geared to 'pull through' technologies into production (rather than support R&D). The USA was held as an example of where this is done more effectively (high tech purchasing). Several companies also mentioned legislative barriers and bureaucracy burdens facing them as SMEs;
- **Internal barriers**. A small number of respondents also mentioned how they themselves sometimes hinder their own progress. Issues here include their product costs and other limitations, being overly protective of their IP, not talking to the right people early enough and being too focused on technical minutiae rather than the bigger picture.



A big "Thank You" to the companies surveyed...

Aeristech: fully electric, single-stage turbocharger, eliminating turbo lag, providing smooth, computer-controlled boost through every stage of engine operation.

Amberjac Projects: develops advanced, custom, large format Lithium ion battery systems for the electric and hybrid vehicles and stationary energy storage markets.

Antonov Automotive Technologies: has developed a compact, high performance, high efficiency 3-speed power-shift transmission for electric vehicles.

Artemis Intelligent Power: research, development, and technology licensing associated with hydraulics and other innovations in fluid power control and transmission.

Ashwoods Automotive: producer of hybrid-electric vans, hybrid drive systems and a leading developer of other innovative low carbon vehicle technologies.

Axon Automotive: designs and manufactures light weight, high performance, low cost vehicles and vehicle structures based on patented carbon fibre technology.

Bowman Power Group: a world leader in Energy Recovery Systems that convert waste heat into electrical energy to save fuel, increase power and reduce emissions.

Controlled Power Technologies: evolutionary CO_2 reduction powertrain products based on switched reluctance electric motor technology.

EVO Electric: develops and manufactures advanced electric machines, hybrid drive trains and generator sets for transportation and mobile power applications.

Flybrid Systems: developing high-speed flywheel based kinetic energy recovery systems for motor sport and road vehicles, including cars, trucks and buses.

Libralato Engines: is developing an 'eco-engine' for the 21st century - exceptionally compact, powerful, efficient, clean and quiet.

Magnomatics: has developed an ultra-compact, high torque, high efficiency traction motor/generator for wheel hub or inboard electric drive applications.

Mechadyne: researches, develops and licenses advanced valve train systems for internal combustion engines, making them greener and more efficient.

Oxford YASA Motors: commercialising IP developed at Oxford University, the YASA motor has high specific torque and efficiency and low cost manufacturing options.

Oxy-Gen Combustion: specialises in engine pre-treatment systems for emissions control and engine optimisation, without the use of exhaust after-treatment systems.

Pi-Innovo: is an expert in vehicle electronics from concept to manufacture, offering system design and electronics design engineering services.

RDS Europe: the UK-based provider of the Regenerative Drive System (RDS), a hybrid hydraulic technology for retro/aftermarket fitment to rigid heavy goods vehicles.

Torotrak: is the world leader in full-toroidal traction drive technology, developing main drive transmissions and variable speed drives for flywheel-based mechanical hybrids.

Xtrac: this transmission specialist has now produced more than 140 prototype transmissions and drivelines for evaluation in innovative hybrid and electric road cars.

Zeroshift: a novel, patented bi-directional dog based transmission system and NVH solution providing instant, seamless, silent shifts for EVs and hybrids.

Report prepared by TRL (the UK's Transport Research Laboratory) for the Low Carbon Vehicle Partnership.