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Promoting tomorrow's technologies today: an insight into the UK Technology Strategy Board's innovation landscape

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Abstract

The Low Carbon Vehicle Innovation Platform (LCVIP) at the Technology Strategy Board to date has funded 110 projects with total project costs approaching £250m. The LCVIP has brought hundreds of vehicles onto the UK's roads in real-world demonstrator trials. This paper discusses how a strong emphasis on encouraging challenge-led innovation, supported by technology development, will tackle the barriers and enable the development of new solutions, business models and ways of thinking. This involves careful consideration of the variety of stakeholders involved in the automotive industry as well as how companies and projects at different stages have varying needs – whether for ideas, capital, partners, suppliers or customers.

This paper provides an analysis of the innovation landscape in the UK and how this can be applied for the benefit and the advantage of businesses across the automotive and adjacent sectors. It also demonstrates how targeting the appropriate funding mechanisms and structuring an adaptive intelligent portfolio can inform future direction to aid in the creation of exploitable intellectual property and jobs.

Commercial, communication, market, policy, promotion

1 Introduction

This paper provides an understanding of the UK's innovation landscape and how it might be used for the advantage of businesses all across the automotive and adjacent sectors. The Technology Strategy Board is a publically funded, executive non-departmental public body (NDPB). It is sponsored by the Department for Business Innovation and Skills (BIS) and works to stimulate research and development in the UK by leveraging public money against industry investment to stimulate advanced step change technology development. The board encourages and facilitates partnerships across government, business and the research communities by removing the barriers to innovation, bringing organisations together to focus on opportunities, and investing in the development of new technology-based products and services for future markets. The vision is for the UK to be a global leader in innovation and a magnet for cutting edge industries which can apply technology rapidly, effectively and sustainably to create wealth and enhance quality of life.

Founded in 2007, the board has worked with thousands of businesses from industry leaders to SMEs in order to deliver over £2bn of investment in innovation across a wide range of disciplines, including stratified medicine, sustainable agriculture and food, and low carbon in the areas of vehicles, aerospace, buildings, energy and manufacturing. Much of the work around sustainability and the reduction of carbon emissions is not only because it is necessary, but also because it offers major business opportunities for the future. Projects that are funded assist UK businesses in bringing new ideas and technologies to market faster, or that

would not ordinarily have been undertaken in the first place. This paper specifically looks at Low Carbon Vehicles, where to date the Technology Strategy Board has funded over 110 projects. The projects have been funded on a competitive basis aligned to a competition scope document. Each project proposal is independently assessed and awarded grant on a quality basis. They are primarily collaborative (a business lead and at least one other partner from business or academia) in nature. The total portfolio project costs are currently approaching £250m.

The Low Carbon Vehicles Innovation Platform (LCVIP) has three key goals:

1) Contribute to the growth of the UK automotive sector, facilitating the development of exploitable intellectual property and a sustainable supply chain of systems and components that will be required by the vehicle manufacturers.

2) Increase and accelerate the introduction of vehicle-centric technologies to the LCV market. One of the ways this is achieved is by integrating the science base with the UK automotive R&D activities.

3) Support the UK's contribution to the achievement of national and international Green House Gas reduction targets, by reducing road transport CO_2.

The key stakeholders, the project portfolio and the opportunities for businesses are central to understanding how the LCVIP is delivered. It is important to consider how these three elements work together to position the UK as a major player within the new emerging low carbon vehicle market.

2 The players

Three key groups work in partnership in shaping and delivering the innovation landscape as it relates to the Technology Strategy Board's LCVIP: industry, government and academia. For the sake of this paper, these three groups are dealt with broadly below.

2.1 Industry

The main players in the global automotive industry are well known. The ways in which the industry engages at the national and local levels often reflects geographic size and location, population density, heritage, dedication to R&D, skill base and cost base. For the LCVIP, the stakeholders representing industry are distributed across the sector and include vehicle manufactures, tier suppliers, research organisations and industry bodies.

The UK automotive industry is vibrant and an important element of the UK economy, overall employing nearly 740,000 people [1]. There are eleven of the world's volume vehicle manufacturers, supported by 19 of the world's top 20 suppliers. There is a strong regional spread of manufactures and tier suppliers.

The automotive sector is the UK's number one manufactured export sector, with almost 78% of output exported, bringing £29 billion into the UK economy. Around £1.3 billion is spent every year on automotive R&D by UK companies [2]. The UK is the number one gateway to Europe, with easy access to the 500 million people in 27 EU member states. Approximately 1.4m passenger cars were produced in the UK in 2010 including Nissan, BMW/Mini, Jaguar Land Rover, Honda and Toyota with over 120,000 commercial & off-highway vehicles produced annually including GM, Ford, Leyland/DAF, JCB and Wrightbus [3]. There is a particularly strong powertrain sector with over 2.4 million engines produced annually [4].

The UK has strong premium and niche sectors, such as Rolls Royce, Bentley, Aston Martin, McLaren Morgan and Lotus. It is home to eight of the Formula One racing teams, supported by more than 300 specialist motorsport companies in leading edge technologies, employing nearly 50,000 people [5].

The industry is supported and promoted by the Society of Motor Manufacturers and Traders (SMMT) both at home and abroad. In order to assist the UK motor industry to fulfil its potential, SMMT addresses the major issues that impact on the automotive sector: environment, competitiveness, legislation, consumer protection, new technology, globalisation, and education and training.

The past two years have seen a number of high-profile announcements regarding investment in the UK automotive sector. These have amounted to the creation of 7,400 new jobs, the safeguarding of over12, 000 jobs and

investments in production expansion and new models worth over £3.9 billion [6].

2.2 Government

In order to successfully deliver the LCVIP, different levels of government are involved. These are central and local levels, and the devolved administrations of Scotland, Wales and Northern Ireland, as well as arms length government agencies. Central government plays a key role as it can directly stimulate areas of the economy, provide incentives, encourage innovation, impose or relax taxes and provide many other incentives. Examples of incentives that have been put into place are grants to stimulate the purchase of electric vehicles, R&D tax relief and the stimulation of innovation through the Technology Strategy Board.

The Technology Strategy Board works with other levels of government to build connections and collaborations between industry and government. The LCVIP works closely with central government primarily the Department of Business, Innovation and Skills (BIS), the Office for Low Emissions Vehicles (OLEV), the Department for Transport (DfT) and the devolved administrations to create connections and align funding.

OLEV plays a particularly important role in the area of low carbon vehicles. With a budget of over £400m to 2015, it focuses on incentives, infrastructure, industry and innovation to place the UK at the global forefront of ultra-low carbon vehicle development, demonstration, manufacturing and use. The office works across government organisations aligning BIS, DfT and the Department for Energy and Climate Change (DECC).

Growth is one of the government's top priorities. Almost everything that BIS does – from investing in skills to making markets more dynamic and reducing regulation, and from promoting trade to boosting innovation and helping people start and grow a business – helps drive growth. This is also shared by the Technology Strategy Board.

The formation of the UK Automotive Council, the body that works towards bridging the gap between industry and government, is co-chaired between BIS and the industry. The creation of the council has been seen as a positive step within the industry. It brings together the UK to identify and tackle challenges such as building a stronger more competitive supply chain, develop strategies to best exploit the industry's many strengths and to maintain a continuous conversation between government and the automotive industry in the UK.

The UK Research Councils (RC's) invest around £3 billion in research each year, covering the full spectrum of academic disciplines from the medical and biological sciences to astronomy, physics, chemistry and engineering, social sciences, economics, environmental sciences and the arts and humanities. The Engineering and Physical Sciences Research Council (EPSRC) is the main UK government agency for funding research and training in engineering and the physical sciences. The LCVIP has developed a relationship with EPSRC that has resulted in co-funding to help support academia develop projects towards industry goals and importantly provides a feedback loop with academia back into industry.

2.3 Academia

The UK academic field generates groundbreaking research that complements the industry and government efforts in overcoming some of the key technical barriers related to the emerging low carbon vehicle market.

The higher education sector in the UK is recognised globally as exceptionally strong. "While the UK has far fewer researchers than larger countries such as the US and China, as a country, it is far more efficient in terms of output per researcher: of the top five research nations (based on article output in 2010: US, China, UK, Japan, Germany), UK researchers generate more articles per researcher, more citations per researcher, and more usage per article authored as measured by global downloads of UK articles" [7]. Using data published by the Times Higher Education (THE) list 2011 [8], the UK along with the US dominate the top 10 in terms of the best universities in the world.

Research in the area of low carbon vehicles is of particularly high calibre. Mechanisms put into place by the LCVIP in conjunction with EPSRC have helped to ensure that this research can be transferred into practice and does not remain as blue sky ideas. The academic landscape mainly covers the university institutions, but there is a strong link back to government through the research councils. The LCVIP has worked

closely with industry, academia and the research councils facilitating an open dialogue. This has resulted in academia providing feedback to the industry about the more disruptive ideas it is working on and for industry to help scope the funding opportunities with academia increasing the likelihood this potentially disruptive research will make it into production.

2.4 The benefit of the LCVIP collaborative approach

By adopting an approach that involves government, industry and academia, the LCVIP has developed ground breaking innovations encompassing both market need and major societal issues, with need and demand as powerful mechanisms for pulling innovation through to commercial reality [9]. The Technology Strategy Board and the LCVIP place a strong emphasis on encouraging challenge-led innovation, supported by technology development that will enable the development of new solutions. To tackle the barriers to innovation, businesses need to adopt a collaborative approach working with supply chain partners, universities and research institutes, government departments, funders and investors - sharing perspectives and working towards common goals. By bringing organisations and individuals together, and adding support and investment, it is possible to make things happen which otherwise would not.

The strong automotive sector coupled with some of the best universities in the world and excellent motor sport pedigree including the home of eight Formula One racing teams, creates a test bed for growing and developing highly innovative technology solutions for the new emerging low carbon vehicle market. Along with the very strong premium and niche sectors, this provides a great platform to test out these technologies in a less commercially constrained environment. This learning and up skilling has lasting benefit as it positions UK companies to hold the technology developments in the UK and also allows longer term technology knowledge transfer and adaption to the growing volume requirements.

Collaborations within government has meant that the LCVIP has brought together multiple funding sources from across government and the research councils, facilitating the opportunity for more innovative research and to begin to build a larger, more consolidated portfolio of projects. When this funding is leveraged against the industry funding, with the aligned goals, a hot bed for innovative R&D is created that can position the UK ahead of its global competitors. One example of this is the launch of hundreds of electric cars onto the UK's roads in real-world demonstrator trials. By bringing together manufacturers, the supply chain, government bodies (local and central), and universities, and by co-funding the technology development and the trials with industry, the LCVIP and its partners in the programme have facilitated an important step forward by the automotive industry demonstrating how low carbon vehicles perform in real life and informing future development.

The success of this collaborative approach towards innovation has been recognised explicitly by the industry. Nissan stated, "Through initiatives like the Technology Strategy Board's Low Carbon Vehicles Innovation Platform, the UK Government has demonstrated a vision of zero-emission mobility which is very much in line with our own; and played a significant role in our decision to base the production of the 100% electric Nissan LEAF and batteries in Sunderland.

3 The portfolio

The LCVIP has a diverse project portfolio. This reflects the commitment of the platform and the Technology Strategy Board as a whole to engage with and support businesses of all sizes.

3.1 The portfolio inputs

The LCVIP employs an upfront dynamic portfolio management approach to maximise the use of its funding.

Managing the projects under the LCVIP as a portfolio brings a number of key benefits. The portfolio has an overall strategic aim and each competition or programme has specific deliverables that can attribute to the overall strategic goal of the portfolio and platform. Analysing strategic alignment, level of innovation, business benefits, CO2 impact, costs, level of knowledge exchange, risk of delivery and return on investment, helps to grow the portfolio by targeting specific gaps and providing more efficient use of funding to

address the key strategic areas that could provide potentially higher benefits in the long term.

The LCVIP is technologically agnostic. A broad range of technologies are targeted that can meet the programme goals. What has been found is that the technologies defined and funded under the portfolio align well with the technologies that the industry through the automotive council has subsequently defined as strategic for the UK. These areas of strategic importance, known as "Sticky Technologies", are internal combustion engines, energy storage and energy management lightweight vehicle and powertrain structures, electric machines and power electronics and intelligent transport systems. This alignment brings credence to the LCVIP's project portfolio and the method by which competitions/programmes are designed and scoped. Furthermore, by applying this portfolio model, the potential return has been maximised.

It is important to consider some of the inputs that are utilised by the LCVIP stakeholders to make decisions on the next competition for funding. When defining the portfolio, the segmentation and categorisation are crucial so as not to inadvertently skew the portfolio. The LCVIP portfolio has been broken down into 16 different key elements, looking at various categories, characteristics and outcomes. In order to make the most robust decisions, clear accurate data and a clear definition of the categories to be segmented is essential. This needs to be carried out specifically with the strategic vision of not just the portfolio but also of the organisation as a whole.

3.1.1 – Analysis of company size

Figure 1 shows that when the projects are categorised by company size, there are a similar number of Small and Medium Enterprises (SMEs) and large companies engaged in LCVIP programmes. There is a strong representation of the academic sector, partially driven by a partnership with EPSRC who have funded over £12m into the platform to help seed basic research.

This balance of companies and academics is an important indicator of the skills that are being developed through knowledge exchange on the projects. By having a healthy mix of companies the knowledge exchange potential increases and different ways of thinking within the project can stimulate more robust innovative solutions to challenges and can generate new exploitation opportunities.

This seeding work with the research councils and alignment to the automotive industry priorities is very important when linking the industry back to the science base. The result is highly innovative fundamental research ideas having a greater chance of success. Funding research at the earlier technology readiness levels is relatively inexpensive compared to products that are closer to market, but the risk is much higher, as the chances of the product getting the whole way through the innovation chain is a tricky road to travel.

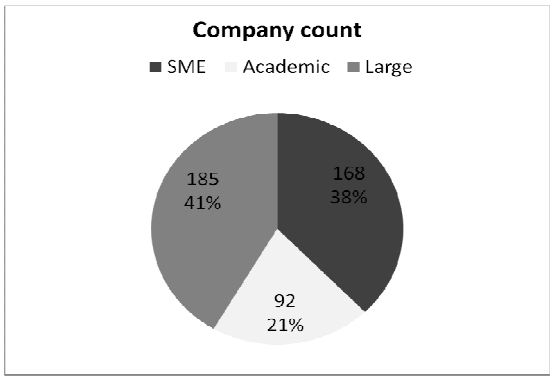

Figure 1 – Company count

This balanced company count starts to tell a great story for the UK. The developing trend is that large companies are acting as hosts to the smaller companies. This is beginning to reverse the hollowing out effect of the supply chain that has taken place within the industry. Typically, the large companies are taking on some of the higher material and capital costs. They are in a position to do this as they are usually in a stronger commercial position to match fund. The larger companies are often supporting and mentoring their smaller company partners, for the benefit of the wider consortium. This has significant benefits for the supply chain and UK economy as a whole.

3.1.2 – Analysis of technological spread

Each project has multiple technology barriers being addressed and advanced to the next level of technological evolution. Figure 2 shows the funding being aligned to addressing these technical barriers.

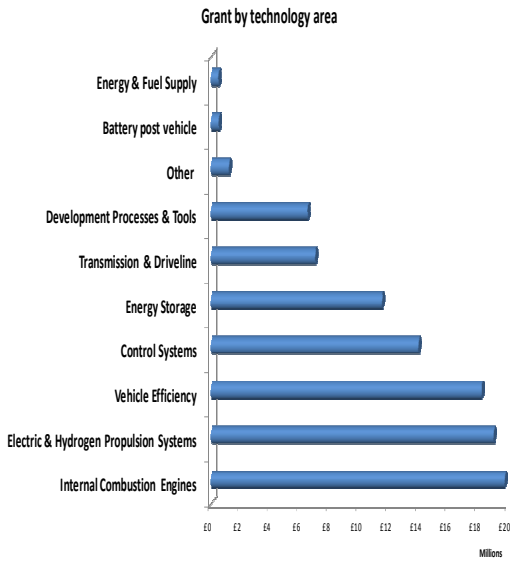

Figure 2 – Funding by technology category

The technologies across the portfolio have been segmented into eight main categories.

The majority of the funding to date has gone into internal combustion engine (ICE) development. This is a key strength of the UK auto industry with almost twice as many engines manufactured compared to vehicles. To maximise the use of the funding, it needs to be strategically aligned towards specific technology obstacles. If the technology development is broken down to a level seen in Figure 3, over 26 individual technology areas are receiving in excess of £1m of grant. When match funded by the industry, this means that at least £2m of R&D activity is happening on each of these technical areas.

The past four years have seen a growing number of battery and battery management system projects and developments around power electronics. There are also a number of technologies relating to ICE's mainly focusing around downsizing with boosting. The trend in ICE technology is the increase in the projects looking at thermal energy recovery. It is also interesting to note that there has recently been an increase in the number of projects utilising advanced process tool as an enabler to reduce the development times and accelerate the projects to market.

The constant factor across all of the projects is a strong interest towards lightweight vehicle and powertrain structures. This complements the UK's potential to be a global leader in this area and overall strong capability in the short medium and long term.

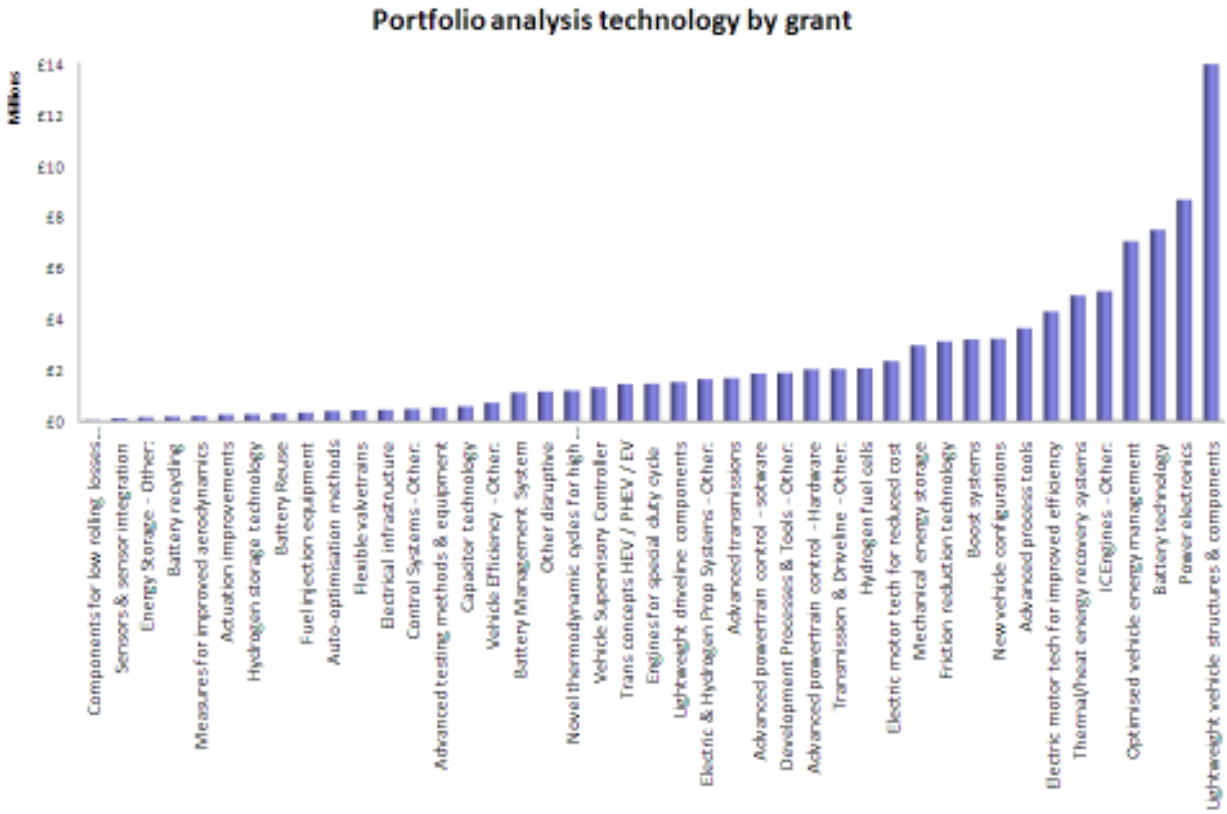

Figure 3 – Funding by technology sub-category

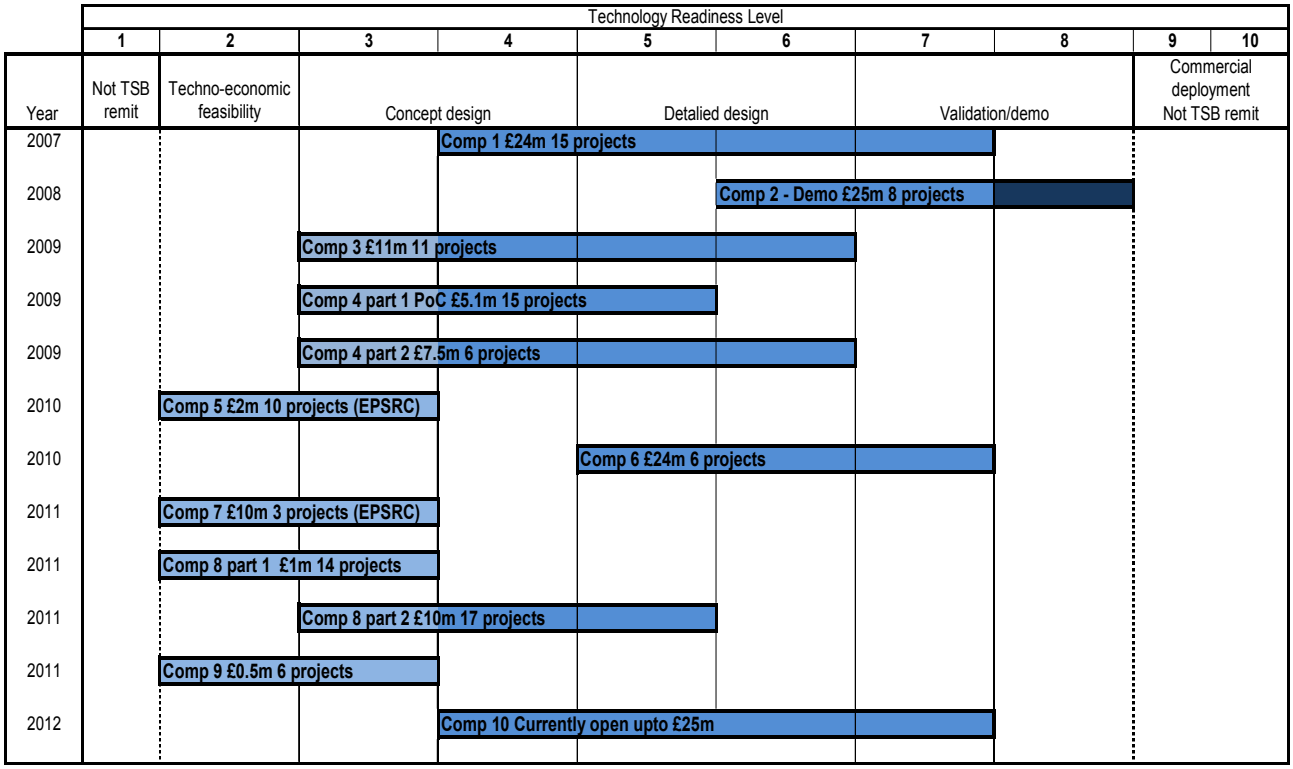

Figure 4 – The programmes/competitions aligned to TRL

3.1.3 – Overview of technology readiness

The importance of managing the risk level of the portfolio is a critical element of each the projects. The assessment of risk can be quite complex and is dependent on a number of factors including: the complexity of the project, the technology barriers being overcome, the number of consortium members, the types of members (SME, Large, multiple Large, non auto sector), the strength of the project management team and planning, the support within each company organisation, the surrounding intellectual property, the financial stability of companies and the distance the technology is from market entry. All these factors together can be managed in different ways. Mechanisms are in place to make sure that any potential failure is identified early and the appropriate support is provided to overcome the obstacles. For example, if a technology barrier cannot be overcome, the LCVIP will work with the consortia to determine if there is a potential change in the base project scope that could result in delivery of different but equally beneficial results. Although this is rare, in the instances where this has happened, the end result has been far greater than the original benefits expectations. In certain instances, a variation in scope can open up a whole new market.

The technology distance from market is a simple indicator that can be used to identify the potential risk of a portfolio. In order to encourage a step change in the technology, it is important to balance risk and innovation by weighing the potential for a higher return on investment against the development of lower risk projects that are more likely to succeed and make it to market giving more modest returns.

If the portfolio is assessed against the technology readiness levels (TRL) (i.e. the distance the technology is from market entry), what can be seen is that moving up the TRL typically reduces the level of technological risk in a project but also increases the amount of cost to move it to the next level.

Figure 4 above demonstrates the breakdown of each of the competitions that have been run to date, with the grant and the number of projects overlaid against the TRLs. The competitions that have a smaller number of projects for a higher level of grant are primarily focused on moving up the TRLs towards validation and demonstration, where the challenges are often

around technology integration. The earlier TRLs are focused on challenges that are based on the fundamental development of a new technology where the ideas/projects can be developed through feasibility, into the lab and then into early proof of concept, for a relatively small amount of grant.

One of the key goals is that by utilising the additional grant funding, the consortia can take on riskier projects and accelerate the technology through these readiness levels allowing market entry earlier than their competition, providing a better competitive advantage for the consortium. On average, the LCVIP projects see advancement in TRL of nearly 2 levels per year.

3.2 The results

An independent study of the portfolio shows that the median potential return on investment across the short, medium and long term is 39:1; for every £1 of public money invested the median return is £39.

By developing an adaptive portfolio strategy, each competition can be established to balance the portfolio and maximise the overall potential return for the UK. Making sure the right inputs are fed into the stakeholder base means the scoping of the future interventions will be more robust and attract the best potential return while making sure the overall balance of the portfolio is aligned to provide the best return for the UK plc. As outlined below, it is also important to note that the collaborative research and development tool is just one such mechanism in the tool box.

4 Support mechanisms

Looking at the range of players in innovation, with multiple organisations and initiatives, it can sometimes seem fragmented and difficult for businesses to navigate. Companies and projects at different stages have differing needs – whether for ideas, capital, partners, suppliers or customers. To realise the potential of an idea, the appropriate support needs to be available at the right time.

New technology in a market can disrupt existing supply chains and business models, requiring new partnerships and multiple innovations at different readiness levels; this is difficult for individual businesses, particularly smaller firms.

The most successful UK businesses and innovations are those with a global, rather than a local market. Research shows that two-thirds of UK private sector productivity growth between 2000 and 2007 was the result of innovation [10] and a separate worldwide study confirmed that innovation is central to growth in developed countries [11]. It is also vital for competition. In a global market, the competitive advantage of UK businesses will depend on effective knowledge management, rapidly commercialising technologies and focusing clearly on higher value-added goods, services, and industries.

In order to provide targeted and effective support for competitive and innovative business, the Technology Strategy Board has developed a range of support through funding and collaborative activities and programmes. These are based on the position that if businesses can find innovative solutions then they can, especially during an economic downturn, increase their potential return far beyond day to day gains.

4.1 Funding mechanisms

The LCVIP funds a variety of projects from small proof of concept grants and feasibility studies through to large multi-partner collaborative R&D and demonstration projects.

The businesses that receive support represent a wide range from pre start-up, start-up and early stage micro businesses, to large multi-nationals. In order to successfully work with diverse projects and project partners, there are different funding models depending on the specific needs of companies, sectors and technologies.

These include:

1. Grant for R&D known as “Smart”– this single company scheme is open to applications at any time for pre start-ups, start-ups, micro businesses and SMEs.

2. Feasibility studies and collaborative R&D – these competitions are open to applications from single companies and business-led consortia for innovative projects in specific technology areas or

to meet particular challenges identified as a priority for the UK.

3. Demonstrators – these competitions invest in business led projects to demonstrate new products or services in the real world and at scale.

Technology and innovation centres, called Catapults, are centres which are partially funded by the Technology Strategy Board, with the aim to create a critical mass for business and research innovation by focusing on a specific technology where there is a potentially large global market and a significant UK capability. They allow businesses to access equipment and expertise that would otherwise be out of reach, as well as conducting their own in-house R&D.

It is worth noting that the Technology Strategy Board is not bound by the above mechanisms. The appropriate tools need to be developed and enhanced to meet the many needs of the diverse industry sectors that are being stimulated.

4.2 Support activities: Networks and programmes

The LCVIP and the Technology Strategy Board actively participate in organising networks, programmes and activities that provide support to industry. These forms of support represent a range of effective ways in which businesses can accelerate innovation. The intention is to create a coherent package of support activity with clear routes to enable businesses to move more rapidly towards marketable products and services.

A number of support initiatives take place. Key ones of note include:

- SBRI (Small Business Research Initiative): This initiative provides public sector procurement contracts to business for R&D to develop new products and services. The business gets financing to develop its ideas in conjunction with a potential purchaser and the public sector gets more innovative solutions to deliver better services.
- Missions: Trade missions, in which the pick of innovative UK companies travel to for example the United States to make new connections and meet potential investors, suppliers and customers.
- Networking events: Networking and partnering events are organised to bring businesses, researchers, innovators and funders together. The Technology Strategy Board's flagship one day event, *Innovate,* brings 2,000 delegates together. *Collaboration Nation* events for companies that have received funding are facilitated to showcase the results of the projects to industry with a view of finding new partners to collaborate with and new sources of funding.
- Knowledge Transfer Networks (KTNs): These represent a dynamic resource for individuals to enable business innovation by sharing knowledge, ideas and opportunities with and between specific sectors. There are also special interest groups set up to work across KTNs on specific tasks.
- Knowledge Transfer Partnerships: This programme stimulates business innovation by drawing on the expertise in UK universities and colleges. Companies work with recently qualified individuals on challenging projects which transfer knowledge into companies.

4.3 European and international activities

The Technology Strategy Board and the LCVIP recognise that innovation extends beyond the UK borders and work with UK Trade & Investment and the Science and Innovation Network to align activities and provide support for companies seeking to expand and co-operate abroad. By accessing the EU, business can gain further innovation support. This can bring UK companies new R&D funding, the chance to collaborate with other world-class companies and institutions, and reach into the world's largest 'home' market. An important role of the Technology Strategy Board is to help business to take advantage of these opportunities through collaboration with other EU bodies and tapping into the R&D funding available from the Framework Programme 7.

4.4 Support in practice

By using the right tool at the right time and designing competitions aligned to the industry requirements and challenges, the stimulation of innovation can be created in line with the overall strategic view of supporting UK plc. As an example, in 2010 funding support was announced with the specific goal of growing and maturing some of the smaller companies in the UK supply chain so that they can be ready to supply volume production and maximise returns from the new emerging global market. To help stimulate the UK supply chain, several appropriate tools were identified. The collaborative funding mechanism was used, with the intent that large companies would lead the projects supporting and mentoring the smaller companies. The support mechanisms of the KTN to find the right people and networking events to get the right people talking to each other were also put into place.

As a result of this, significant global companies worked together to support and mentor the UK supply chain. Over £24m was invested in six consortia which in turn stimulated over £50m R&D that would not have been carried out otherwise. An example of one project is the collaboration between Jaguar Land Rover, Nissan and Lotus. This represents the first time three vehicle manufactures have collaborated in this manner to mentor and support a large range of companies across the supply chain such as Evo electric, Xtrac and Axeon.

5 Conclusion

This is an exciting time in the auto industry with new technology challenges and a huge market opportunity. It is important that a single technology approach is not taken. The larger vehicle manufactures are developing multiple technology options and are keeping their overall strategy towards an end game dynamic and fluid. As new technologies emerge, prices in existing technologies fall and different final solutions become more attractive. This creates great opportunities, for businesses of all sizes, to make significant commercial gains. It also opens up a window for smaller businesses to build relationships and gain recognition from larger companies, where in the past there was sometimes little prospect to build such relationships.

The Technology Strategy Board aims to use the links into different parts of industry and government to create new connections and collaborations and to catalyse these with investment in innovation and new technologies.

Strong collaboration is vital for delivery and can put a project ahead of the game. Bringing companies together that would not normally have worked closely before, or from different sectors, has shown that new business models and ways of thinking can emerge within the project. A study of the LCVIP portfolio revealed that over 80% of the funded projects stated that the collaboration element of the project was one of the key factors for success.

The UK premium and niche sector has created a strong position for technology to be developed, trialed and marketed, as these sectors are less price sensitive. This is ultimately positions the UK to have a knowledge and skill base that will have a lasting effect as the knowledge is transferred from these sectors into more mainstream automotive applications. This strength, supported by demonstration programmes, helps to bridge the gap between the industry view and the end customer view.

The LCVIP experience has confirmed several key principles that have helped generate exploitable intellectual property, stabilise the industry and create jobs. These are: understanding the landscape, targeting the right funding mechanisms, structuring an adaptive intelligent portfolio to inform future direction and pushing projects to think about their market at the right entry point, aligned with robust exploitation plans. With all of these considered in parallel, the Technology Strategy Board is able to support the UK auto industry in a way that generates significant returns on investment.

Some of the biggest returns that have been gained by projects have been when the technology has been exploited outside the sector. This has created economies of scale for the base technology opening up a larger, more cost competitive market for the on vehicle technology. It has also generated revenue for the company, strengthened its commercial position and placed it in a strong position to exploit the technology in the market for which it was originally intended.

The move to a low carbon economy has real opportunities for many businesses. However, it also poses some potential threats as it is one of the biggest change projects the world has seen. If it is not handled properly and attacked aggressively enough to reduce the point of the emissions peak, then this could pose as a threat to many economies. It is doubly important therefore to consider how to best capitalise on the opportunities, as individual companies as well as countries and economic areas.

One of the most significant outcomes of the LCVIP approach to innovation is that it is helping to create a lasting foundation for the UK automotive industry. This will serve to attract and hold these new technologies for the long term and continue to foster innovation in the future.

Although overall economic recovery is still uncertain, the industry forecast looks positive and major companies have shown their commitment to the UK through new vehicle programmes and expansion of their existing facilities. The industry and government are working more closely together with excellent exploitation of academic based ideas and research. There are a wider range of incentives and funding opportunities that can help stimulate significant tangible and intangible benefits stimulating and allowing the automotive industry to grow.

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