MANUFACTURING SECURING SCOTLAND'S FUTURE.

Institution of MECHANICAL ENGINEERS

Improving the world through engineering

This report focuses on the manufacturing sector in Scotland (taking into account the current world economy as well as the challenges of competing) and how well placed it is to compete in a global marketplace. It makes recommendations on how Scottish manufacturing can be preserved, equipped and adapted to take advantage of future opportunities. This report has been produced in the context of the Institution's vision of 'Improving the world through engineering'.

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EXECUTIVE SUMMARY

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Manufacturing in Scotland has long been a major contributor to the economy, in terms of output, employment and exports. However, with the emergence of cheaper foreign labour markets, the number of people employed in the Scottish manufacturing sector has halved over the last 25 years. Today, Scotland is unable to compete on the basis of unit manufacturing cost alone. The current economic crisis exacerbates the challenge for the manufacturing sector. In light of this, the Institution of Mechanical Engineers commissioned this report. It offers recommendations to the Scottish Government on strategies to ensure that Scotland's manufacturing sector adapts. Confident leadership now can position the sector to take advantage of significant future opportunity.

Based on research and interviews with industry stakeholders, this report:

- Considers trends within the Scottish manufacturing sector
- Identifies strategies for success for a modern manufacturing enterprise
- Outlines Scotland's intrinsic strengths and weaknesses and their perceived importance for future markets
- Makes policy recommendations based on the above.

Despite the gloomy headlines, manufacturing still plays an important role in Scotland. Manufacturing typically stirs up images of shipbuilding and the steel industry. However, such traditional manufacturing has migrated to the Far East. Successful Scottish manufacturing enterprise today has already adapted to this change, taking a much broader view of manufacturing than just simply manufacturing the product. Understanding and broadening this adaptability is vital to develop successful strategies – manufacturing in Scotland is not essential to be a Scottish manufacturer. Discussions with industry stakeholders identified a number of themes common to successful manufacturers in Scotland today. All related to a move away from traditional manufacturing (making the product) to higher added-value activity. This included Research and Development, design, procurement, integration, construction and inservice support. These themes were analysed against a systems engineering framework to identify six generic strategies for success. They are:

- Go creative innovate
- Go clever high value design and procurement
- **Go large** traditional manufacturing of products with prohibitively high transport costs
- Go local in-situ construction of nonmobile assets
- **Go French** mandate local manufacturing content
- **Go canny** understand and manage throughlife risk by the provision of in-service support

Key to these strategies for success are skills, size of product, economic policy and understanding the risks associated with the whole lifecycle of the product. These are areas that the Scottish Government can positively influence with good policy. However, economic policy that perpetuates a status quo by mandating the use of local supply chains is unlikely to be a long-term route to sustainable economic growth. Hence, the Institution's policy recommendations focus on skills, size of product and understanding risk.

The policy recommendations have been formed by coupling the strategies for success with a consideration of Scotland's intrinsic strengths and weaknesses. They are also forward-looking, to ensure sustainable economic growth. Accordingly, the Institution offers the following four policy recommendations to the Scottish Government, to help Scotland's manufacturing enterprise adapt and thrive in the modern global market.



RECOMMENDATIONS

- Skills Matter Support Commercialisation
 of R&D through the Creation of a
 Prototyping Centre of Excellence. Innovation
 is a high added value activity in the product
 lifecycle that plays to the strengths of
 Scotland's universities. A prototyping centre
 would help commercialise Scotland's great
 R&D ideas by developing knowledge of
 product performance and adapting designs for
 manufacture. It is envisaged that the centre
 would be a collaboration of existing facilities.
 The Scottish Government's role would be both
 facilitative (selling the concept locally and on
 the global stage) and financial (to share some of
 the one-off costs associated with prototypes).
- **Skills Matter Create a Route Map for** National Infrastructure Investment to Create a Stable Demand for Skills. One of Scotland's strengths is the quality of the engineering workforce. This must be maintained. However, future demand for these skills is hard to predict and companies are reluctant to invest in recruitment and training. There is a danger that Scotland may not have the skills to service future opportunities such as the development and deployment of low-carbon energy technologies. The Scottish Government can help create a stable, growing demand for skills by preparing a route map of national infrastructure investment. This will ensure continuity of market pull for engineering talent and ensure Scotland has the skills to play its role in engineering the future.
- Size Matters Work with Westminster to Build a Carbon Capture and Storage (CCS) Demonstrator in Scotland. The skills and resources for carbon capture and storage are resident in Scotland today. However, the size of a CCS demonstrator project is large and should be pursued as a UK project. The Scottish Government should work closely with Westminster to build a CCS demonstrator on the east coast of Scotland.
- Risk Matters Encourage Competitive In-Service Support of the Emerging Renewables Sector by Funding a Reliability Data Centre. The use of engineering knowledge to manage the risks of asset ownership is a source of competitive advantage. In particular, understanding the reliability of the emerging renewable technologies such as wind, wave and tidal allows competitive in-service support to be offered. The Scottish Government should sponsor the formation of a renewables reliability data centre to allow Scottish companies to offer global in-service support to renewable asset owners.

INTRODUCTION

Scottish manufacturing has been a significant contributor to the Scottish economy for over two centuries. Traditional manufacturing was focused around heavy industries such as steel, shipbuilding, locomotives, and more recently the construction of offshore oilrigs and platforms. However, competition from lower cost producers in foreign countries has lead to a downturn in manufacturing in the last 30 years, in terms of importance and contribution to the economy. Despite this trend, manufacturing still plays an important role in Scotland, currently employing in excess of 218,000 people¹ and generating approximately 13% of Scotland's Gross Domestic Product (GDP)², equal to more than £12 billion³.

With the current global financial crisis, prospects for the global economy appear to be worsening; the world is experiencing an economic slowdown and many countries are entering recession. This economic slowdown has now caught up with the Scottish manufacturing industry and is presenting significant challenges for businesses that must be overcome.

The aim of this paper is to build up a picture of Scottish manufacturing industry, the challenges it faces competing in the global economy and to develop impartial policy recommendations to address these challenges for the Scottish Government. Specifically, the objectives are to:

- Provide a brief overview of trends within the Scottish manufacturing industry
- Identify the key challenges and opportunities for the Scottish mechanical manufacturing industry
- Identify what strategies best address these challenges and ensure Scotland's manufacturing enterprise is best placed to exploit any opportunities
- Develop policy recommendations for the Scottish Government to help facilitate these strategies.

The scope of this study is restricted to that part of Scotland's manufacturing industry with significant mechanical engineering content. Manufacturing industry with a predominantly electrical or process engineering content is excluded from the scope of the study.

This report was written following desktop research and a series interviews with industry stakeholders, listed in Annex A. The strategies, strengths and weaknesses discussed within are themes drawn from these interviews.

STEPHEN TETLOW MBE FIMECHE CHIEF EXECUTIVE

KEY FACTS

- Manufacturing is still a vital component of Scotland's economy, employing 218,000 people and contributing 13% of GDP (£12bn)
- This report recommends policies that will strengthen the position of Scottish manufacturing in a changing global economy and enable it to exploit future opportunities.

THE HISTORICAL PERSPECTIVE AN INDUSTRY IN DECLINE OR TRANSITION?

TRADITIONAL MANUFACTURING HAS MOVED EAST

Manufacturing has long been an important contributor to Scotland's economy in terms of output, employment and exports. In Scotland's industrial heyday, prosperity was primarily as a result of highly successful heavy industries such as coal, steel, shipbuilding and construction of offshore oilrigs and platforms. However, as with other developed countries, manufacturing has suffered a steady decline in output and employment in the last 30 years or so.

In 1981, manufacturing employed over 475,000, representing 23% of total employment in Scotland³. The structure of Scottish industry has gradually shifted, with a reduction in Scotland's manufacturing industry and the number of people it employs, **Figure 1**. The latest data from the Office for National Statistics (ONS) provides an employment figure for Scottish manufacturing of 218,300, approximately 9% of total employment in Scotland. Much of this decline can be attributed to job losses in labour-intensive industries such as shipbuilding and the steel industry; these activities have instead shifted to cheaper foreign labour markets, such as the Far East, as shown in **Figure 2**. However, during the same period the total number of jobs in Scotland has increased by almost 300,000 despite the losses in the manufacturing sector. This illustrates the adaptability of the Scottish workforce, which is a strength in a changing world.

Figure 1 is also a reflection of the fact that Scotland cannot compete in the global market purely on the basis of labour or business costs; the average Scottish salary is ten times the average Chinese salary⁴. Put simply, **unit manufacturing costs cannot be a driver**. Furthermore, the Far East has invested heavily in manufacturing infrastructure, on a scale unimaginable in a small nation such as Scotland. For example, Korea has some of the world's largest shipyards, currently housing seven of the world's top ten shipbuilders occupying about 40% of the global shipbuilding market.

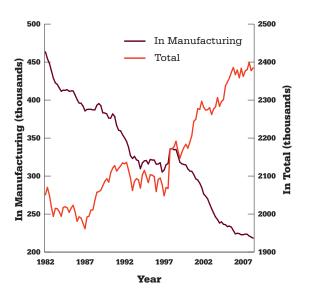


Figure 1: Number of Employees in Scotland 1981 to 2008

(Source: Quarterly Employee Jobs Series, Scottish Government, June 2008 series)

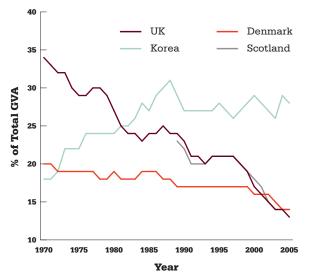


Figure 2: Comparison of % Contribution of Manufacturing to Total GVA

(Sources: EU KLEMS Growth and Productivity Accounts: March 2008 Release. Data for Scotland is from Office for National Statistics, Regional, subregional and local gross value added, December 2008)

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RECESSION ACCELERATES THE TREND

It is widely recognised that the global financial crisis has led to recession in the real economy and that manufacturing has been hit hard. However, headline trends can mask differing impacts within a sector. Many of those interviewed during the preparation of this report were relatively upbeat about the future prospects for their businesses. The underlying issues appeared to be that:

- Those that are best positioned have a focus on national infrastructure and assets, such as power plants or defence projects, rather than consumer products
- Service markets, which rely on getting the best out of existing assets, are more stable than the manufacturing of new products
- Small and Medium Enterprises (SMEs) are more affected than large businesses, in part because of a shorter forward order book.

These findings are broadly compatible with recent findings by Scottish Engineering and Scottish Enterprise, discussed below.

Scottish Engineering is a major support and lobbying organisation for the manufacturing engineering industry in Scotland and carries out quarterly reviews of the industry. The most recent quarterly review⁷ provides a number of indicators that the Scottish manufacturing industry is feeling the effects of the global economic slowdown:

- significant downturn in order intake and output volumes
- a stall in recruitment, reduction in employment in SMEs
- reduction in training and capital investment
- significant effect on business optimism.

These findings are supported by conclusions from the January 2009 Economic Commentary from Scottish Enterprise⁸ which highlighted access to finance as an additional concern. The majority of these effects are being felt by SMEs, with fewer than 500 employees, with larger companies not experiencing difficulties of the same magnitude. However, it is important to appreciate that difficulties currently being experienced by small companies, especially those that play critical roles in supplying specialist products, will eventually filter up the supply chain and create problems for larger companies.

HOWEVER THE MANUFACTURING SECTOR ADAPTS TO CHANGE

The migration of traditional manufacturing from West to East has been ongoing for many years. The Scottish manufacturing enterprise has gradually adapted to that change and today's successful manufacturing companies have a much wider focus than simply manufacturing the product. Manufacturing in Scotland is not essential to be a Scottish manufacturer.

A consistent view emerged from the stakeholder interviews, that to be successful in Scotland today the focus should be on R&D, design, niche markets, construction/integration and in-service support. The scope of this report is restricted to manufacturing with a significant mechanical content. Such manufacturing tends to lend itself to such diversification into the wider product lifecycle. For instance ships, power plant and sub-sea equipment all require significant through-life support. This can be contrasted with other parts of the manufacturing sector which do not lend themselves to such diversification. One example relevant to Scotland is the textiles, footwear, leather and clothing industry which has suffered a much more severe drop in employment of 54% in recent years².

It can be concluded that the wider mechanical manufacturing enterprise in Scotland has a brighter future than headlines may suggest. However, to understand this it is necessary to move away from some deeply engrained notions of what manufacturing actually is.

KEY FACTS

- The manufacturing sector currently employs 9% of the Scottish workforce
- Through-life costs of assets are often far greater than just build costs. For example, the new Royal Navy Queen Elizabeth Class aircraft carriers will cost £4bn to build but their total life-cycle cost is likely to be in the region of £18bn
- Many successful Scottish manufacturers have adapted, choosing to focus on high value-added tasks such as design, system integration, procurement and in-service support
- Due to this adaptation a wider definition of manufacturing is required: 'creating and making; the entirety of the process, incorporating research and development, design, supply, production, software, services, distribution, delivery and aftercare'⁶.

A MODERN DEFINITION OF MANUFACTURING

For many people in Scotland, manufacturing stirs up images of heavy industry and shipbuilding; in the past, manufacturing was focussed on the production process. Indeed, the data presented in **Figure 1** and **Figure 2** is based upon the UK Standard Industrial Classification (SIC) of manufacturing, which does not include the majority of construction, servicing and repairing.

As discussed, many manufacturers today take a broader view of manufacturing, focusing on the whole product lifecycle. Rather than attempting to compete with cheaper manufacturers elsewhere, successful Scottish manufacturers have chosen to focus more on high value-added tasks; design, system integration, procurement, assembly and inservice support. These tasks typically involve more complex engineering, allowing lower-value tasks to be carried out in foreign markets.

Figure 4 below presents the structural change experienced in the last decade; a shift in activities from production-focussed manufacturing to a broader definition of manufacturing, which focuses on the whole product lifecycle, against the generic CADMID product lifecycle (Concept, Assessment, Demonstration, Manufacture, In-service and Disposal). The reasoning behind such a shift is apparent when considering the build costs against the through-life costs for a large asset, such as the new UK aircraft carriers. Although each aircraft carrier will cost approximately £2 billion to build, the through life costs are estimated to be many times greater in the region of £18 billion.

As more "service sector" tasks, such as servicing, repairs and R&D are undertaken by manufacturers, the boundary between manufacturing and services becomes less clear and a wider definition of manufacturing becomes necessary. The Scottish Manufacturing Steering Group reports Created in Scotland⁵, and later Nurturing Wealth Creation⁶, developed and adopted a more encompassing definition of manufacturing:

"...creating and making; the entirety of the process, incorporating research and development, design, supply, production, software, services, distribution, delivery and aftercare."

It is this wider definition of manufacturing that will be used throughout the remainder of the report.

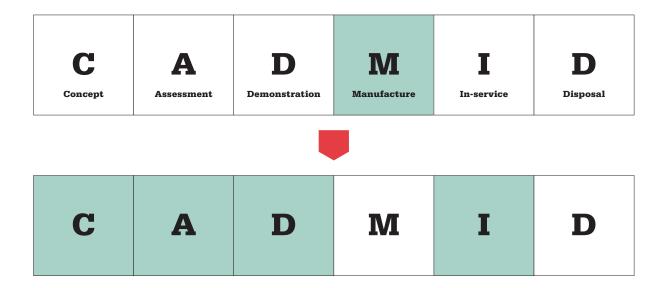


Figure 4: Structural Change of Manufacturing in Scotland

FORWARD LOOKING SCOTLAND A BROADER VIEW OF THE MANUFACTURING ENTERPRISE

STRATEGIES FOR SUCCESS

Scotland cannot compete in a global market on the basis of unit cost alone. Successful Scottish manufacturers have already very substantially diversified across the full product lifecycle. Hence, to analyse strategies for success in a modern manufacturing enterprise, it is necessary to adopt the wider definition of manufacturing given in the previous section. A range of industry stakeholders were interviewed to form a view of general strategies for success for a modern manufacturing enterprise against this wider definition of manufacturing.

From the interview process the following consistent themes emerged:

- Focus on R&D, commercialising university research and supporting start-ups
- Nurture engineering excellence in high valueadded design, management and integration
- Manufacture large components that have prohibitively high transport costs close to the end user
- Construct, and decommission, non-mobile assets
- Participate in large UK-based projects, through the Government mandating the use of local manufacturers eg. defence projects
- Provide in-service support throughout asset lifecycle.

Interpreting these themes in the context of systems engineering allows for generic strategies for success to emerge. Each of the themes above has been evaluated against the CADMID product lifecycle, identifying the stages of the lifecycle over which it has the greatest influence. The output of this evaluation is presented in **Figure 5**. The six generic strategies for success identified in **Figure 5** are expanded below:

- **Innovate**; focussing on research and development, assisting to commercialise university research and supporting technology start-ups and demonstrator projects.
- **High value design & procurement**; focussing on the high value added areas of the product lifecycle, allowing the low value areas to be supplied from the global market.
- **Too big to transport**; manufacturing components that have prohibitively high transport costs close to the end user e.g. large ship stabilisers and steering gear or wind turbine towers.
- **Because it's here**; construction, and decommissioning, of non-mobile assets is intrinsically in-situ e.g. power stations (both conventional and nuclear).
- **Go French**; mandate local manufacturing content – supporting industries through favouring goods and services that are produced locally and therefore stimulate economic activity.
- **Manage through-life risk**; providing in-service support throughout the asset lifecycle, selling support services with the asset and therefore reducing the risk of ownership.

MECHANICAL ENGINEERING SKILLS ARE VITAL TO SCOTTISH MANUFACTURING, BUT DOING MANUFACTURING IN SCOTLAND IS NOT.

	C Concept	A Assessment	D Demonstration	M Manufacture	I In-service	D Disposal
INNOVATE	Focus on R&D commercialising university research and supporting start-ups.					
HIGH VALUE DESIGN & PROCUREMENT		high added wanagement and i competitive compe	ring excellence in value design, ntegration. Procure onent manufacture supply base.		SKILL M	ATTERS
TOO BIG TO TRANSPORT				Manufacture components with very high transport costs close to end user.		
BECAUSE IT'S HERE	····· S	IZE MATTER	S	Construction of non-mobile assets is intrinsically in-situ.		Decommissioning of non-mobile assets is likewise intrinsically in-situ
GO FRENCH	ECONOM	IIC POLICY M	IATTERS	Mandate local manufacturing content.		
MANAGE THROUGH LIFE RISK	R	ISK MATTER	s		In service support throughout asset lifecycle. Reduce risk of ownership.	

System engineering lifecycle

Figure 5: Strategies for Success

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These generic strategies for success provide an insight into potential policy areas; skills, product size, economic policy and risk. Although Scottish Government influence in any of these policy areas is likely to be effective in the short term, not all fully align with the Scottish Government's overall objective of sustainable economic growth. Consideration of **Figure 5**, with a longer-term view and Scottish Government's principal objective in mind, leads to the following conclusions:

- Skills Matters creating and maintaining skills is critical to sustainable economic growth in Scotland. Given that Scotland cannot compete on labour costs alone, focus should be given to the high value-added stages of the product lifecycle. By nurturing engineering excellence, encouraging R&D and commercialising university research, Scotland's skilled workforce will be able to adapt and remain at the forefront of emerging technologies.
- **Size Matters** other than the defence sector, the primary forms of "traditional" manufacturing being carried out in Scotland are due to prohibitively high transportation costs and hence local construction. Other non-mobile assets, such as power stations and oil & gas platforms/wells, provide decommissioning or 'reverse engineering' tasks. Carrying out this type of manufacturing can and does sustain a number of manufacturers. Whether it can provide sustainable economic growth in the future depends on the market for such products; offshore wind or Carbon Capture and Storage (CCS) may represent such an opportunity.
- Economic Policy Matters although economic policies could influence the mandatory use of local manufacturing, this is viewed as a relatively short-term solution. This approach is visibly applied only in a single area within the UK, the defence sector. Despite this solitary application, it provides substantial business for Scottish manufacturing. However, there is little point in attempting to perpetuate a status quo based on historical infrastructure if there will be no demand in the future. Additionally, mandating the use of local manufacturing has the potential to remove competition along with any benefits. Hence, it is considered unlikely that mandating the use of local industry would provide sustained economic growth and it even has the long-term potential to damage by encouraging inefficiencies and dependency upon Government projects.
- **Risk Matters** by providing in-service support throughout the asset lifecycle, the risk of ownership can be reduced. Furthermore, the provision of in-service support is generally dependent on the cumulative production of a product, whereas manufacturing is dependent on the immediate demand for a product. Hence, in-service support is more stable. Such support can take a number of forms, including: provision of warranty, contracts to maintain assets and infrastructure or selling operating time rather than the asset itself. One highly successful example of this, indicating the extent to which this process can be applied, is Rolls-Royce (RR) which invested in a 'global operations' room in Derby⁹. This centre collects data and continually assesses the performance of 3,500 jet engines around the world. Equipped with data that fully characterises the performance of their products, RR is able to sell their aeroengines 'by the hour', thus encapsulating design, manufacturing and servicing in a single package. It is concluded that the provision of in-service support provides high added-value, stable opportunities that can be designed to provide significant competitive advantage and hence sustainable economic growth.

KEY FACTS

- Successful Scottish manufacturers have already diversified across the full product lifecycle
- Creating and maintaining skills is critical to economic growth
- Providing in-service support can provide significant competitive advantage and sustainable economic growth.

SCOTLAND HAS SOME OF THE WORLD'S BEST WIND AND MARINE ENERGY RESOURCES.

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IDENTIFYING NATIONAL STRENGTHS AND WEAKNESSES

A number of generic strategies for success, from an industry perspective, were developed in the previous section. However, to allow for policy recommendations to be formed this needs to be coupled with an understanding of Scotland's intrinsic strengths and weaknesses. The following is a summary of viewpoints and experience drawn from the stakeholder interviews and supported by research.

Strengths:

- **Traditional Resources** Scotland has a history of excellent resources in coal, oil and gas. However, energy policy is moving towards secure, sustainable supply from low carbon sources. Hence these traditional resources may become less important in the future.
- **Renewable Resources** Scotland has some of the world's best wind and marine renewable energy sources. This strength should be exploited where possible, showcasing Scotland.
- **Historical Infrastructure** Scotland's has significant infrastructure from its historical heyday as a traditional manufacturing powerhouse. However, as discussed in this report, the days of traditional manufacturing in Scotland are over.
- Educated Workforce Scotland has a number of excellent universities. As highlighted in previous sections, maintaining and creating skills are vital to the success of the broader definition of manufacturing. An educated workforce is one of Scotland's strengths that must be maintained and exploited.
- Ideas in Universities Scottish universities carry out excellent research and design in a number of areas. This is one of Scotland's strengths that must be supported.

Weaknesses:

- **Commercialising Ideas** the ideas from universities must be supported in order to take them out of academia and into industry. This is currently viewed as one of Scotland's weaknesses.
- **Major PLC Base** Scotland is lacking a major base of PLCs. Given the size of the Scottish economy, it is difficult to attract major PLCs to Scotland. This is a weakness of manufacturing in Scotland.
- **Labour Cost** Scotland cannot compete purely on labour cost and this is an intrinsic weakness of manufacturing in Scotland. Given that it is simply not possible to close the gap on labour costs with other countries, the importance of labour costs should be reduced.
- **Infrastructure** good infrastructure is essential to supporting manufacturing in Scotland. It is important to ensure good transport links within the country. Scotland currently has a number of issues with transport infrastructure, e.g. the M8, airport rail links and the Aberdeen bypass. The importance of infrastructure is dependent upon the types of manufacturing undertaken and their location within Scotland.
- **Route Map** the ability to anticipate demand is vital for the success of many manufacturers. With no clear route map for future infrastructure investment, industry cannot anticipate demand for resources and hence cannot carry out the necessary preparation today for the requirements of tomorrow.

KEY FACTS

- An educated workforce is one of Scotland's great strengths. This must be maintained and exploited
- Scottish universities excel in research but are less successful in commercialising ideas
- No clear route map for future infrastructure investment has been developed. Such a route map would help manufacturers plan and ensure correct resources are in place.



These strengths and weaknesses have been qualitatively plotted against perceived importance for future markets in **Figure 6**. This figure has been segregated into four distinct zones, providing an indication of what action, if any, should be taken:

- **Status Quo** (Challenge) although these are current strengths of Scottish manufacturing, they may be of less importance in the future.
- Priority for Action (Maintain/Exploit)

 Scotland's key strengths that already provide a competitive advantage for Scottish manufacturing. These strengths must be maintained and exploited.
- **Priority for Action** (Develop or Reduce Importance) – areas that are important for a strong manufacturing enterprise but which are currently judged to be weaknesses in Scotland. These weaknesses must be improved or their importance to Scottish manufacturing reduced.
- **Ignore** (Not Sustainable) areas that are weaknesses but which are unlikely to be important in the future. These should not be the focus of development, as they will not play a significant role in Scottish manufacturing.

Figure 6 also indicates opportunities to improve Scotland's strengths or to reduce the importance of its weaknesses. Arrows indicate potential opportunities. For instance, Scotland's traditional resources could be given a new lease of life through CCS technology, or the lack of major PLCs could be made less important through building a strong network of SMEs, such as Germany's Mittelstand.

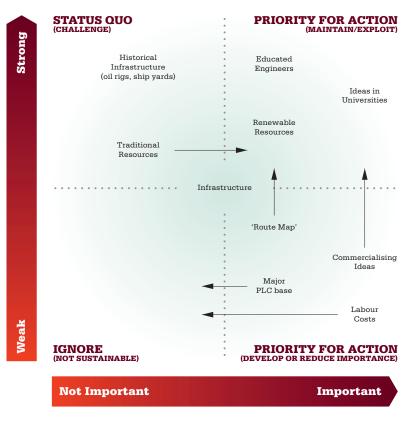


Figure 6: Scotland's Strengths and Weaknesses

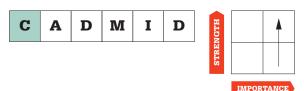
THE NEW MANUFACTURING POSITIONING SCOTLAND IN A GLOBAL ECONOMY

Any policy recommendations should:

- Be based on the strategies for success identified in **Figure 5**
- Draw on, or augment, Scotland's national strengths as identified in **Figure 6**
- Be forward-looking, to ensure sustainable economic growth

With this in mind, the following policy recommendations are offered to the Scottish Government and other stakeholders. For each recommendation, the stages of the CADMID lifecycle and the relationship to Scotland's strengths are graphically highlighted.

SKILLS MATTER SUPPORT COMMERCIALISATION OF R&D THROUGH THE CREATION OF A PROTOTYPING CENTRE OF EXCELLENCE



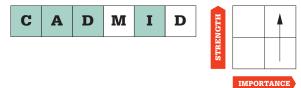
From the analysis undertaken, it is clear that early stage R&D is a high added-value activity that Scotland is well placed to undertake. **Figure 5** identified "innovation" as one of the strategies for success. **Figure 6** identifies the ideas created by Scottish universities as a strength, but the commercialisation of these ideas as a weakness. Much has already been done to strengthen the commercialisation of Scotland's ideas, for instance the formation of the Intermediary Technology Institutes (ITIs). However, more should be done. In particular, IMechE proposes that the Scottish Government supports the creation of a prototyping centre of excellence.

The objective of such a centre would be to support Scotland's manufacturing enterprise in the prototyping of new technologies. Prototyping is a one-off manufacturing exercise and unlikely to be commercially attractive in its own right. An example would be the manufacture of first-generation marine energy devices. However, the knowledge gained through the prototyping experience creates valuable knowledge in terms of both product performance and design-for-manufacture.

Such a centre could be 'virtual', in that it could be a collaboration of existing manufacturing facilities. The Scottish Government's role should be both facilitative (through the creation of the network of existing manufacturers and showcasing the strategic importance of prototype investments in terms of future markets) and financial (by providing some grant aid to recoup one-off costs of investment in prototype tooling). The centre should be marketed globally, increasing Scotland's exposure to global product technology innovation.

IT'S ABOUT PRODUCT TECHNOLOGY INNOVATION AND GLOBAL RELATIONSHIPS.



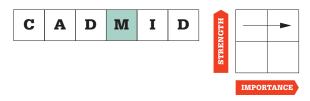


From the analysis undertaken, it is clear that one of Scotland's great strengths is the quality of the engineering workforce, both professional engineers and technicians – Scotland's education system is working well. Figure 5 identified "high value design and procurement" as one of the strategies for success. Figure 6 identifies educated engineers as a strength. However, industry has expressed concern that the future demand for skills is difficult to predict because of a lack of clarity over the timing of national infrastructure investments. At worst a 'boomand-bust' cycle could occur, with major projects such as aircraft carrier construction and power station upgrades occurring simultaneously followed by a period of sharply reduced demand. This uncertainty, compounded by the economic downturn, means that there is a lack of recruitment and training investment from businesses. This presents a real risk that skills necessary for effective recovery from recession may be inadequate or absent. Some skills take years to develop, so it is important to prepare now for future requirements - new industries will not establish themselves and then wait for the necessary labour force, they will simply emerge somewhere else.

Hence, IMechE proposes that the Scottish Government creates a route map for national infrastructure investment. Such a route map would plan national infrastructure investments alongside major projects such as aircraft carriers and offshore wind construction to create a stable, growing demand for skills. This should be coupled with outreach to schools, universities and industry to ensure they understand and sympathise with what is required to deliver the route map. Creating stable domestic demand will ensure that Scotland maintains the quality of its engineering workforce and hence is well placed to undertake high-value design, procurement, construction and in-service support.

LAT IT'S HARD TO REPLICATE EXCELLENT ENGINEERS.

SIZE MATTERS WORK WITH WESTMINSTER TO BUILD A CARBON CAPTURE & STORAGE DEMONSTRATOR IN SCOTLAND

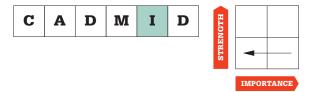


From the analysis undertaken, it has emerged that manufacture of equipment that is too big to transport, and the construction of non-mobile assets are both strategies for success (see Figure 5). Furthermore, Figure 6 suggests that creating new purpose for Scotland's traditional resources (oil and gas, coal) would strengthen the nation's competitive position. Developing CCS technology fits these strategic aims. It is a new technology for the low-carbon economy that complements Scotland's existing power generation skills base and has global reach. Existing North Sea skills, companies and infrastructure can be used to transport and store carbon dioxide. Furthermore, the size of equipment may lend itself to local manufacture and certainly to local construction.

The size of investment required to develop a CCS demonstrator is large (of order £1 billion) and the technology would be deployed throughout the UK. Energy policy is also reserved to Westminster. For these reasons, a CCS demonstrator should be pursued as a UK project. Hence, IMechE recommends that the Scottish Government works closely with Westminster to find a politically positive position from which a CCS demonstrator can be built on the east coast of Scotland.

THE SKILLS AND RESOURCES FOR CARBON TRANSPORT AND STORAGE ARE RESIDENT IN SCOTLAND TODAY.

RISK MATTERS ENCOURAGE COMPETITIVE IN-SERVICE SUPPORT OF THE EMERGING RENEWABLES SECTOR BY FUNDING A RELIABILITY DATA CENTRE



A consistent theme from stakeholder interviews is the move from traditional manufacturing to in-service support. A global example of this is the current trauma being experienced by US car manufacturers - a sharp downturn in new car sales is good news for garage mechanics. Accordingly, Figure 5 identifies the management of through-life risk as a strategy for success. This is complemented by **Figure 6**, which notes that the importance of labour cost in Scotland must be reduced to compete in a global economy. The message is clear – for long-term success, manufacturing enterprise must avoid dependency on traditional nationally sponsored manufacturing projects and use engineering knowledge to manage the risks of asset ownership. This can take many forms: provision of a warranty; contracts to maintain assets and infrastructure; selling operating time rather than the asset itself. The latter is illustrated by Rolls-Royce, which sells its aero-engines 'by the hour' and hence encompass design, manufacture and servicing in one commercial package. It was able to take this risk through investing in a data centre to characterise fully the performance of its products.

Hence, the IMechE recommends that the Scottish Government sponsors the formation of a data centre to fully characterise the performance of renewable technologies (onshore wind, offshore wind and marine), particularly in regard to reliability and maintainability. Such a data centre would enable Scottish companies to provide competitive in-service support to renewable asset owners, based on the best knowledge of product performance.



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Scottish Engineering www.scottishengineering.org.uk

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The Scottish Government www.scotland.gov.uk

GLOSSARY

CADMID Concept, Assessment, Demonstration, Manufacture, In-service and Disposal

CCS Carbon Capture and Storage

GDP Gross Domestic Product

 $\ensuremath{\textbf{GVA}}$ Gross Value Added

IMechE Institution of Mechanical Engineers

ITIs Intermediary Technology Institutes

ONS Office for National Statistics

SIC Standard Industrial Classification

 ${\bf SMEs}$ Small and Medium Enterprises

ANNEX A STAKEHOLDERS INTERVIEWED

Martin Anderson General Manager, Neptune Deeptech

Archie Bethel Chief Executive Officer, Babcock Marine

Mike Farley Director of Technology Policy Liaison, Doosan Babcock Chair, Industrial and Power Association

Peter Hughes Chief Executive, Scottish Engineering

Bill McDiarmid Manager – Engineering & Technology, Motion Control, Rolls-Royce

Robin Steel Engineering Manager, Oil Industry, Clyde Pumps

> FSC Mixed Sources Product source for wet-Hamaged forests and other controlled sources www.fc.org 0 1996 forest Stewardship Council

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