JONES, H. and BOTHA, N. Accelerating the fuel cell Industry in South Africa. *The 6th International Platinum Conference, 'Platinum–Metal for the Future'*, The Southern African Institute of Mining and Metallurgy, 2014.

Accelerating the fuel cell Industry in South Africa

*H. JONES and †N. BOTHA
**CarbonTrust*
†Orion Innovation

South Africa could participate in the fuel cell industry as both a major PGM producer and a potential fuel cell deployment hub, with potential opportunities for manufacturing, systems integration, and ancillary services. This paper sets out the steps that the South African government, industry, and other players need to take, in principle, in order to accelerate the development of the fuel cell industry in South Africa.

Background

This paper is based on research and field work carried out by Carbon Trust and Orion Innovations on behalf of Anglo American between 2011 and 2013, the key findings of which are reproduced here.

Role of fuel cells

The role that fuel cells may play in South Africa's future energy infrastructure, industrial policy, and economy has been open to debate for a number of years. This is evidenced by the development of specific South African hydrogen and beneficiation strategies alongside the adoption of fuel cells for early industrial use in sections of the South African economy. The fuel cell debate invariably covers needs such as energy security, access, storage, and efficiency, but also potential barriers such as technology cost and uncertainty, as well deployment issues including fuel supply. Is there a real prospect for South Africa to play a material part in the global provision of fuel cells and fuel cell expertise, as well as to use their deployment to solve some of its own energy security and sustainability issues, and if so, what is the window of opportunity to realize this?

This paper responds to the need to identify enablers to accelerate the fuel cell industry, and also to test these enablers 'on the ground' in South Africa.

Initial research

Fuel cell development

We found in research carried out in 2011 that fuel cells and related technologies are developing ever faster and the case for their use is strengthening. They offer efficiency, versatility, and scalability benefits that make it likely that they could become – on a 20 to 30 year view – an important element of the global energy infrastructure for a broad range of applications, including motive power and both on- and off-grid energy generation. Their suitability as a source of dispatchable power, utilizing a range of different fuels, also enables them to co-exist with other power sources in various applications.

Fuel cell shipments

Fuel cell unit volume shipments have increased steadily, and our projections show that assumed trends could lead platinum volumes to increase first through stationary fuel cells, then through vehicle fuel cell applications. These trends and projections, shown in Figures 1 and 2, contribute towards the potential for fuel cells to be an attractive proposition area for South Africa with its extensive platinum reserves.

Figure 1 indicates that recently the fuel cell industry has grown steadily, but not spectacularly.

Figure 2 indicates that while long-term market predictions for platinum in fuel cells are driven mainly by transport applications, in the short term stationary applications could have an equal weighting.

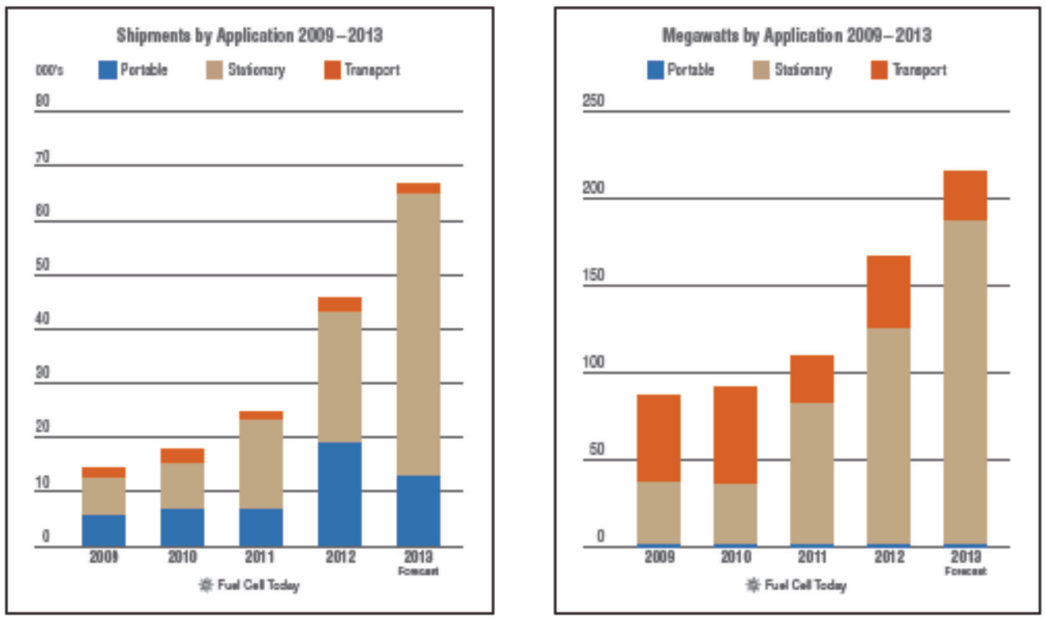
Fuel cell costs

Capital costs for fuel cell systems are prohibitively high for most applications due to the small scale of manufacturing at present, but the predicted scale curve as the fuel cell industry grows is expected to address this issue within a few years. For example, there could be significant fuel cell cost reductions through:

- Improvements in design, e.g. removing components; operating at a higher temperature in order to simplify the units
- Different use of materials, e.g. reduced platinum use; using alloys and smart catalyst structure; mitigation of fuel cell degradation.
- Improvements in production technology – moving from batch to continuous production patterns; solvent-free (dry processes) with high throughput
- Economies of scale.

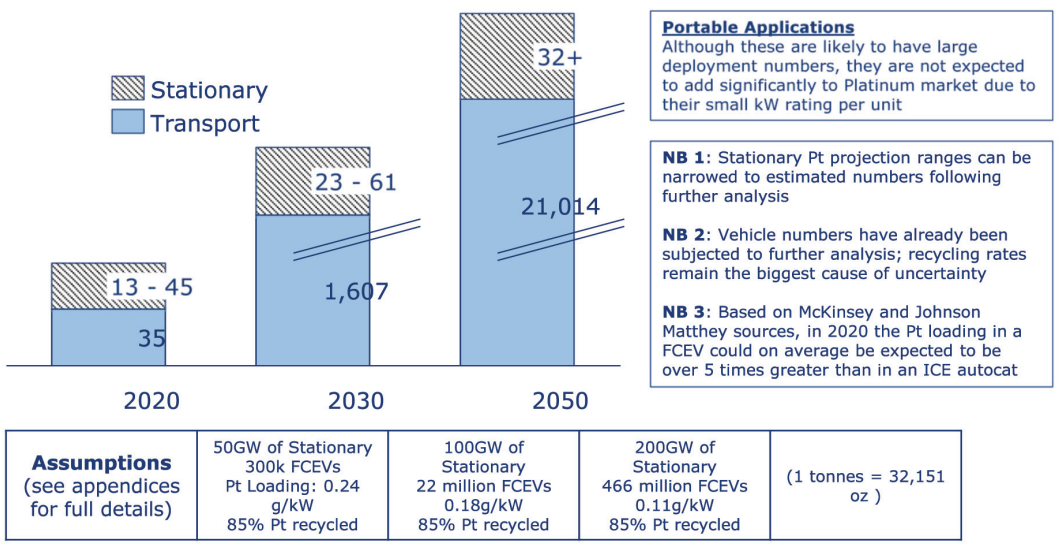
Some projections on fuel cell and hydrogen costs are shown in Figures 3 and 4.

The global market has arguably reached a stage of development that creates a window of opportunity for South Africa to establish a presence in an international and high-value industry.



Source: Fuel Cell Today, 2013

Figure 1. Recent fuel cell shipments



Source: Carbon Trust and Orion Innovations research, 2013

Figure 2. Estimated cumulative platinum market size (thousands of troy ounces) based on unit (number) and capacity (kW) deployment

Figures 3 and 4 indicates that fuel cell costs, as well as hydrogen costs, could decrease significantly in the medium to long term.

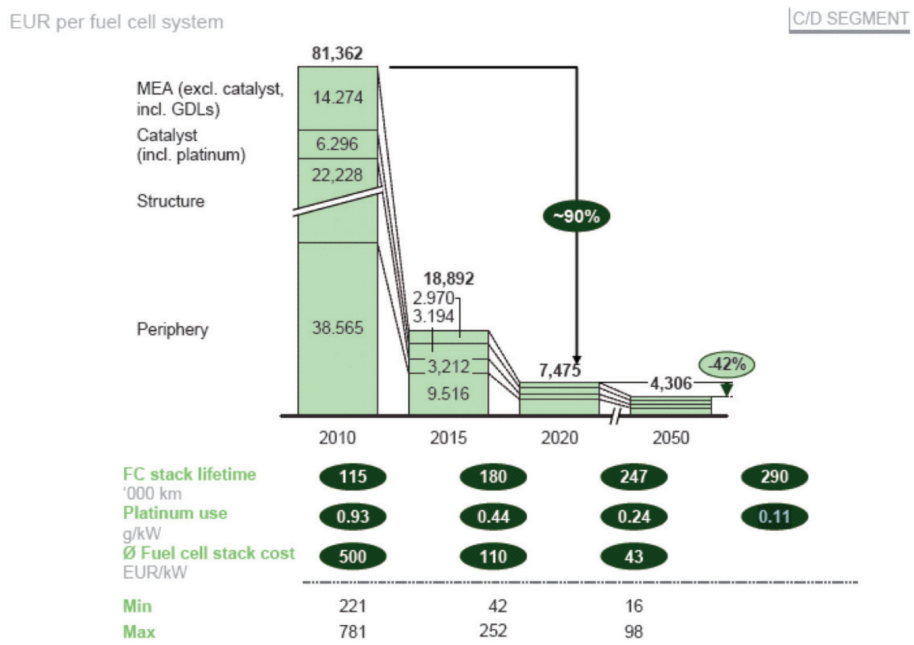
Hydrogen strategy

The South African government's hydrogen strategy (HySA) is already aimed at exploiting this opportunity by addressing elements of fuel cell innovation that are likely to provide valuable opportunities for global industry participation. However, creating the knowledge, skills, and infrastructure to seize this opportunity will depend not only on continued funding and direct research, but also on investigating commercialization opportunities and creating a viable local industry by encouraging local deployment in key applications. Evidence for the relevance of this approach can be seen in concentrated industrial clusters, which combine supply and demand in a competitive local environment and result in competitiveness on the international stage, in terms of productivity, innovation, and new business formation.

Without this broadening of focus towards deployment, the commercialization of research that comes out of the HySA initiatives may be hampered by an absence of local industry. If South Africa lags behind in deployment, this will also allow fuel cell value chains to be established elsewhere, leaving South Africa with a smaller fraction of the available value chain, not only internationally, but also for local deployment and operation.

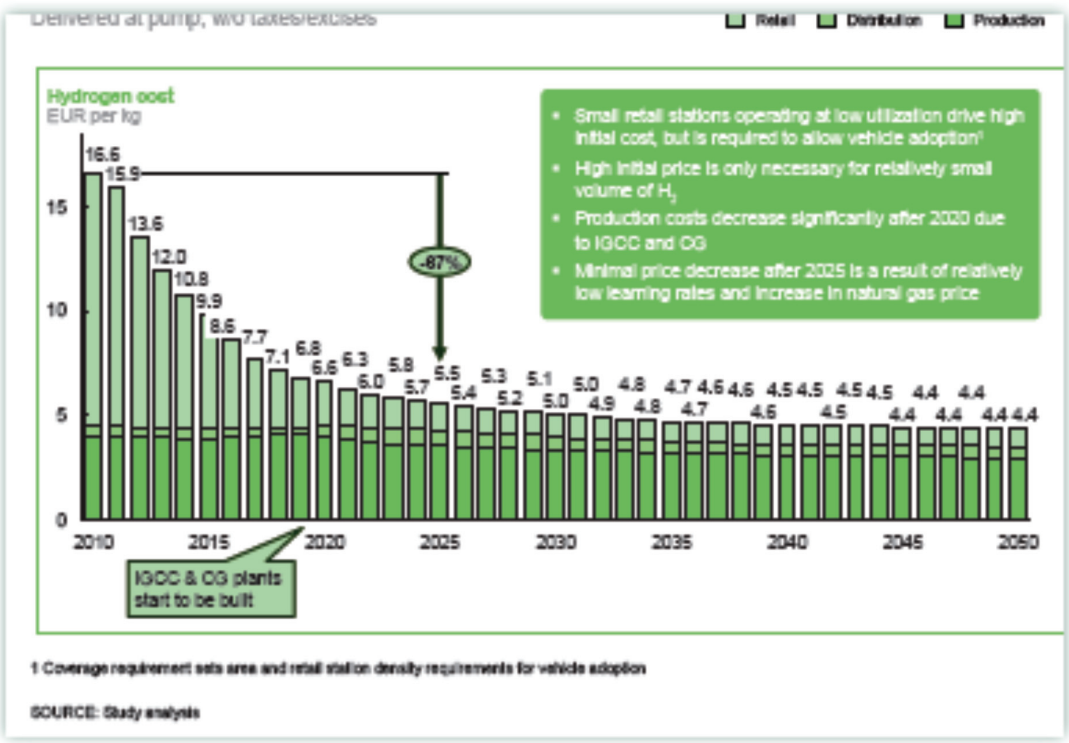
Potential benefits

If South Africa embraces this opportunity, the benefits could be significant and far-reaching, and include:



Source: McKinsey & Co., A Portfolio of Power-Trains for Europe, 2011

Figure 3. Projected fuel cell system cost curve, potentially decreasing 90% by 2020



Source: McKinsey & Co., A Portfolio of Power-Trains for Europe, 2011

Figure 4. Projected hydrogen cost curve, potentially decreasing 70% by 2025

- Improved on-grid energy security and quality, and greater access to energy for off-grid communities
- Significant deployment in both stationary and mobile applications, with conservative deployment estimates of between 3.0 and 5.0 GW in stationary and up to 80 GW in mobile applications by 2040
- Substantial job creation in knowledge-based industries, with estimates of potentially in excess of 500,000 by 2040
- The attraction of international fuel cell technology players to South Africa as well as substantial foreign direct investment (FDI)
- Beneficiation of key South African resources in catalysts, membranes, and other fuel cell-related technologies
- Potential export of knowledge, components, sub-

assemblies, or packaged products.

The actual scale of these benefits and the pace at which they are realized will depend to a significant extent upon the degree to which the South African government embraces and accelerates the development of the sector within the region.

South African advantages

In terms of fuel cell deployment, it is suggested that South Africa is particularly suited to lead in the development of specific applications that meet the needs of the country in the short term. These are primarily stationary applications that reduce requirements to extend or enhance the grid, or protect against grid disruption. South Africa has a number of advantages that should enable it to benefit from this opportunity. These include:

- Existing political commitment to meet beneficiation and energy provision and security challenges
- An established national innovation system
- An existing hydrogen strategy (HySA)
- Experience in demonstration and deployment of fuel cells in a range of applications, and in development and testing of fuelling technologies
- A diversified manufacturing base, supported by government productivity initiatives
- Access to the southern hemisphere and African markets
- Technical and engineering knowledge and skills in relevant sectors, and the presence of businesses that could adapt their services to the fuel cell sector.

New market development

Nevertheless, challenges remain to the successful fulfilment of South Africa's potential within the global fuel cell industry. We used a Carbon Trust model of new market development to provide a framework for the identification of these challenges and their potential solutions: this model is based on four pathways that need to be travelled for an industry to emerge and stabilize:

- Technology and product development:
  - The need for manufacturing at the scale needed to reduce costs
  - The need for further technology R&D to reduce material costs and improve performance
- Participant development:
  - A risk-averse culture and lack of entrepreneurship
  - Competition for access to fuel supply from incumbent infrastructures
  - The need for significant investment in fuelling infrastructure
- Market development:
  - Lack of awareness of fuel cells
  - A reluctance to use whole life costing in purchasing decisions
  - Current free access to a base level of electricity
- Regulation and standards development:
  - Absence of visible coordination between government departments in setting priority levels, strategic objectives, and implementation plans for fuel cells
  - A lack of long-term certainty and regulatory incentives to stimulate the market
  - Barriers to entrepreneurship created by a complex regulatory environment
  - A subsidized rural electrification programme that does not currently apply to all alternative power delivery mechanisms.

Challenges

The challenges are not all exclusive to South Africa. Those within the technology and product development pathway, in particular, are faced by the global industry as a whole. At a macroeconomic level, South Africa also experiences relatively low labour and total factor productivity. However, several government initiatives exist that encourage productivity growth, and there has been success in attracting FDI to other sectors, such as automotive manufacturing.

Local experience

Local observations

We tested some of these concepts in a South African province, focusing on a municipality facing a number of economic challenges including high levels of unemployment and poverty, and poor access to rural electrification. Our obsevations include:

- The dominance of the regional mining industry within the local economy, specifically associated with globally significant platinum group metal (PGM) reserves, points to the need for regional beneficiation, specifically around job and skills creation
- The international fuel cell industry is gaining momentum, and on the basis of significant investment being made by the national government and international companies, South Africa is well positioned to play a key role. Currently no individual region, organization, or technology is in a market-leading position
- Consultation with key stakeholders supports the view that the province could act as key location for early deployment of fuel cell systems within South Africa, with the potential to capture associated supply chain activities
- Initially these would focus on field support activities where long-term job creation opportunities could be significant. There may also be potential to capture future incremental manufacturing opportunities
- The region has a number of key assets and resources that could be leveraged in support of the initiative; and the provincial government could play a key role using public procurement to support early deployment activities, e.g. associated with game lodges, schools, and clinics.

Local objectives

In addition to progressing a Department of Trade and Industry (DTI) Special Economic Zone application which is under consideration, the province defined a number of strategic objectives. These would be realised by the creation and commercial exploitation of a sustainable regional model for rural economic development and commerce, enabled through fuel cell deployment and supply chain beneficiation:

- Beneficiation of platinum and PGMs at source and along the value chain
- Inward investment
- Localization of supply chain activities where it can make commercial sense
- Job creation (both manufacturing and the knowledge economy)

- Deployment of affordable, secure power to rural communities
- Increased local commerce and number of rural micro-enterprises
- Creation of an export hub (regional and international sales).

Local benefits

A sustainable regional fuel cell model is attractive because:

- Electrification in the province remains a key priority for economic development
- Opportunity for platinum/PGM beneficiation in the local area is a key national and regional priority
- Alongside mining, the local area has a diverse and fragmented business base that is heavily impacted by electricity outages and price hikes
- Fuel cells have the potential for dual economic benefits:
  - o Provision of secure and reliable power to off-grid communities and applications that require security of supply
  - o Development of related supply chain capabilities with associated investment and job creation
- Across South Africa 1.3 million rural homes have no grid connection and grid connection is deemed to be uneconomic for about 600 000 people
- It is estimated that up to 16 000 schools and 5 000 clinics have no access to electricity
- The potential 'sweet spot' for cost-effective deployment for rural electrification is focused on communities less than 150 households located between 5 and 14 km from the grid (depending, among other factors, on terrain and ease of access)
- Fuel cells are cited as having competitive advantages relative to photovoltaics, relating to lack of intermittency, lower cost of capital, and reduced risk of theft
- In the province, there are significant numbers of homes, schools, clinics, small and micro-businesses, farms, and game lodges, all of which will benefit from new or improved electrification, and additional applications and upgraded opportunities in telecommunication base stations and chilled produce transport.

Deployment pathway

Early deployment of fuel cell systems could stimulate local supply chain development (see Figure 5):

- The province takes the lead in South Africa as an 'early adopter' of fuel cell technology, providing a national reference site for commercial deployment of fuel cells in rural, off-grid applications (primarily distributed generation and remote power)
- Early deployment develops regional know-how and skills relating to field logistics, service support (and fuelling), and development of appropriate business/commercial models (e.g. application of pre-payment mechanisms and community ownership models)
- The province remains technology 'agnostic', deploying the best currently available solutions, exploiting (and inputting into) ongoing innovation in new technology and services, until the market is mature
- The province captures critical, high-value know-how associated with the practical deployment of fuel cells
- As the deployment volumes increase, works with OEMs to put in place supply chains for regional sub-assembly (including component supply e.g. inverters and controls), and subsequently incremental manufacturing opportunities encompassing MEA, stack manufacture, and the knowledge economy.

Deployment pathway benefits

There are several key benefits from this approach:

- PGM beneficiation via local jobs/skills creation and rural access to electrification
- Development of know-how and early showcasing of commercially viable business models
- Provision of (national) skills training programmes in support of system deployment
- Raising the international profile of the region and encouraging inward investment
- In the longer term, export of commercial know-how and systems/components to the rest of South Africa, sub-Saharan Africa (and the rest of the world).

Figure 5 illustrates that while there are a number of opportunities for value creation along the supply chain, the early-stage ones are likely to be in installation and maintenance. It should be noted that this diagram was created in 2013, so the opportunity timings could now be set back by one year, given delays in deployment since 2013.

Job creation

It should be noted that the future job creation opportunities will be greatest in field deployment services.

- Once the fuel cell industry reaches maturity (in terms of thousands of units deployed), the majority of jobs will be associated with field support services (a function of cumulative installed capacity)
- For example, assuming 500 x 10 kW systems are manufactured and installed over a 5-year period, there could be (estimated) 10 FTEs in manufacturing, and approximately 20-50 for field deployment support. This differential would increase significantly with the total number of units deployed (Figure 6).

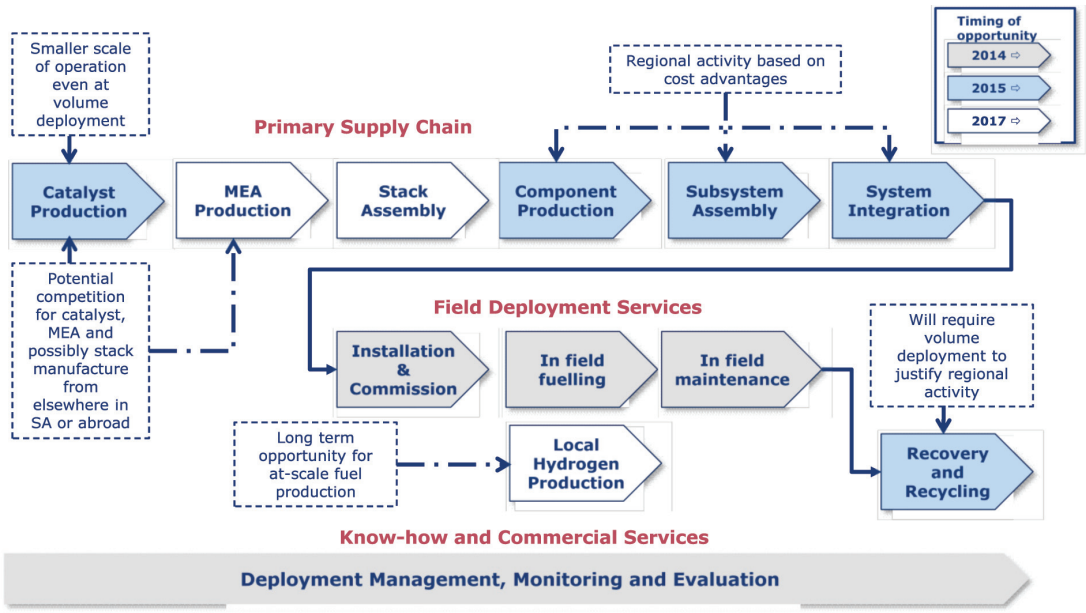
Figure 6 indicates that the majority of fuel cell jobs are likely to be created in field deployment services rather than manufacturing, and that the difference in the respective rates of growth is likely to increase over time as cumulative volumes increase.

Recommendations

Recommended actions

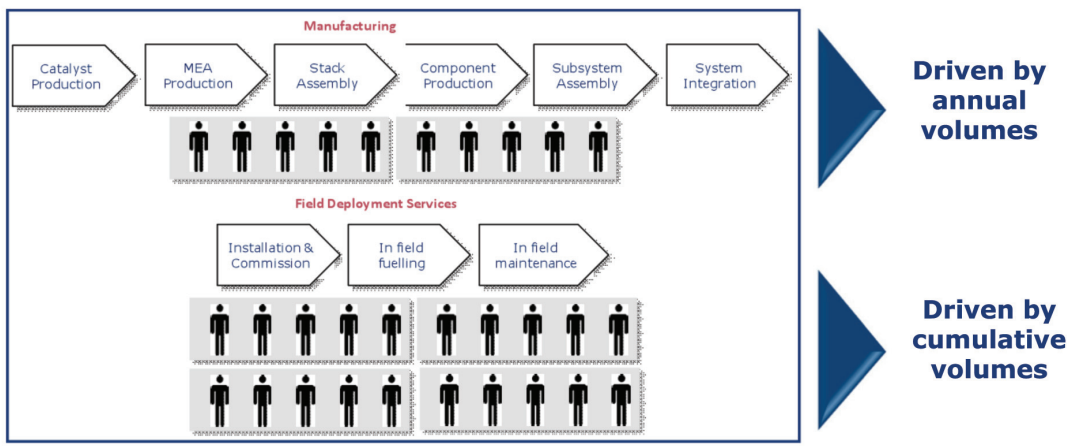
A number of actions are recommended. These are based on the premise that certain pre-conditions are required for South Africa to accelerate the development of its fuel cell industry, namely:

- Clear articulation by the government of its commitment to long-term investment in the sector
- A 'step-change' vision for fuel cells that is endorsed by both government and industry stakeholders
- The appointment of a governmental 'champion' – a minister or other senior appointment – to drive action
- Governance structures that can ensure alignment of actions across government, industry, and academia
- The commissioning of further detailed work on fuel cell prospects, future economics and competitiveness, and employment impacts, informing a decision to back fuel cells or not.



Source: Carbon Trust and Orion Innovations analysis, 2013

Figure 5. Potential opportunities from supply chain participation



MEA = Membrane Electrode Assembly

Source: Carbon Trust and Orion Innovations analysis, 2013

Figure 6. Potential employment opportunities from supply chain participation

Recommendations for 2015–2016

With this achieved, the following goals should be set for 2015–2016:

- Engagement with energy generators and suppliers, large energy consumers, and other key stakeholders in order to develop a Vision to 2030 and supporting roadmap for the economic development of the fuel cell sector
- Engagement with key stakeholders to identify and support the promotion of an appropriate governmental champion for the industry
- Identification of short-term actions and interventions to 'kick-start' the sector, for instance distributed generation subsidies and public procurement programmes
- Development of a supporting plan for FDI and the engagement of key international businesses that are potential investors, in order to understand their perspectives, options, and decision criteria
- Establishment of governance structures that ensure integrated planning and ongoing coordination of action across government (including between different spheres of government), business, and academia
- Pursuit of international financial assistance from programmes that have, or will have, a fuel cell agenda.

Further recommendations

The Vision to 2030 and supporting roadmap should be accompanied by a suite of interventions that could include some or all of the following in the near term (2 to 5 years):

- Government: fiscal incentives to underwrite early market adoption (including incorporation of fuel cells in feed-in-tariffs); public procurement of fuel cells to create demand; provision of market intelligence;

development of standards and product certification; development and realization of grid connection policy
- Industry: advanced procurement programmes; definition of target specifications; showcasing of new solutions; sponsorship of local enterprises to provide product support; and training/upskilling of work forces
- Academia: collaborative research with international suppliers; creation of clusters of interest and expertise; and commercial exploitation of R&D.

Research methodology

This document was researched and written by Carbon Trust and Orion Innovations (UK) Ltd., with assistance from Enerleq and Eco Limited, on behalf of Anglo American Group. The methodology for the research into this topic was three-fold and included: extensive research into existing studies and papers; structured interviews with a wide array of experts in the innovation and development, fuel cell, and energy fields; and two workshops exploring the full scope of this report in depth. One of these workshops was held in South Africa and one in London, allowing the team to access both local and international participants. The contents have not previously been published externally, though some of them have been presented and communicated internally.

Acknowledgements

The authors and sponsors of this report are grateful to individuals and organizations that participated in the research effort for this report. In addition to contacts within the province where the concepts were tested, the organizations contacted during the research includes:

- Acal Energy
- AFC Energy
- Air Products
- Ballard Power Systems
- Carbon Soft
- Council for Scientific and Industrial Research (CSIR)
- Department of Energy
- Department for Trade and Industry
- Eskom International
- Eskom Research and Innovation Centre
- Frontier Advisors
- Fuel Cell Markets Africa
- GVEP International
- HySA Catalysis Centre of Competence / University of Cape Town
- HySA Systems Centre of Competence / University of Western Cape
- IFC
- Impala Platinum (Implats)
- Intelligent Energy
- Johnson Matthey
- Logan Energy
- North-West University
- Optimal Energy
- P&M Intellectual Capital
- Pike Research
- Powertech IST
- Samancor
- South Africa Central Energy Fund (CEF) / iGas
- South African National Energy Research Institute (SANERI)
- Standard Bank
- Technology Innovation Agency (TIA)
- The Linde Group
- Vaal University of Transvaal

References

FUEL CELL TODAY. 2008 Large Stationary Survey. August 2008 .

MCKINSEY & COMPANY 2010. A Portfolio of Power-Trains for Europe - A Fact-Based Analysis: The Role of Battery Electric Vehicles, Plug-in Hybrids and Fuel Cell Electric Vehicles.

GERMANY TRADE & INVEST. 2009 H2 Mobility Initiative: German Hydrogen Infrastructure in Place by 2015. Press release, September 23.

US DEPARTMENT OF ENERGY. 2011. 2010 Fuel Cell Technologies Market Report. June.

US DEPARTMENT OF ENERGY Fuel Cells & Infrastructure Technologies Program. 2006. AC Transit Demos Three Prototype Fuel Cell Buses. May 2006

PIKE RESEARCH. 2011. Fuel Cells for UPS, Residential, and Large Stationary Applications: Market Analysis and Forecasts. Q2 2011.

GOVERNMENT OF CANADA. 2008. Canadian Fuel Cell Commercialization Roadmap Update. December 2008.

GREENPEACE / UNIVERSITY OF TECHNOLOGY, SYDNEY. 2010. South African Energy Sector Jobs to 2030.

SOUTH AFRICA GOVERNMENT. 2007. National Hydrogen and Fuel Cell Technologies Research, Development and Innovation Strategy. May 2007.

OECD. 2010. OECD Economic Surveys. South Africa 2010. July 2010.

Hugh Jones

MD, Advisory, Carbon Trust

Hugh is a senior sustainability professional with experience of working with multiple corporates and policy makers in the fields of climate change and resource efficiency.
Hugh is Managing Director of Carbon Trust Advisory, providing advice and sustainability services to businesses and the public sector. These services have included corporate sustainability strategy and target setting, water impact, supplier engagement and supply chain energy efficiency.
Before joining the Carbon Trust, Hugh worked at both IBM and PwC Consulting in sales and client service positions. Hugh graduated from Cambridge University in Modern Languages, and also holds an Environmental Technology MSc from Imperial College.

Noel Botha

Director, Orion Innovations (UK) Ltd

Noel is an entrepreneurial business manager and innovation specialist with a track record of success in realising commercial value from innovation.
Noel is a Founding Director of Orion Innovations, where he has acted as mentor, interim manager and consultant in order to successfully guide new businesses through start-up and early stage development, and helped to turn-around and grow established businesses through market diversification, new ventures creation, and acquisition. Noel has worked with academic and public sector research bodies, businesses, government bodies, NGOs and innovation agencies to foster and accelerate innovation and growth.
Prior to joining Orion Innovations, Noel was a founding member and Senior Manager of fuel cell technology business, Intelligent Energy, and previously held senior positions in leading international consulting firms, A.T. Kearney, KPMG and Chem Systems. Noel holds a Bachelors degree in Chemical Engineering from Birmingham University, a Masters degree in Organisational Behaviour from Birkbeck College, University of London, and an MBA from the London Business School.