



## Employment-oriented Industry Studies

### Resource-based Technology Innovation in South Africa:

#### Multotec Process Equipment - dense medium cyclone for materials separation

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# **RESOURCE-BASED TECHNOLOGY INNOVATION IN SOUTH AFRICA:**

**Multotec Process Equipment - dense medium cyclone  
for materials separation**

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## Contents

Tables.....	3
1. Introduction: background on Multotec.....	3
2. Overview: the innovation.....	6
2.1 Cyclones.....	6
2.2 Product lifecycle and ongoing innovation.....	7
2.3 The innovation.....	7
3 Incentives and drivers of innovation.....	9
3.1 Motivation for internal capabilities.....	9
3.2 The Support Programme for Industrial Innovation (SPII).....	10
3.3 The coal spiral case as a comparison.....	11
4 Gains from commercialisation and the competitiveness of the firm.....	13
4.1 Market shares and growth.....	14
4.2 Competitiveness.....	15
4.3 Potential.....	16
5 The role of institutions.....	17
5.1 IDC/SPII.....	17
5.2 The CSIR.....	18
5.3 Universities.....	20
6 Conclusions.....	21

## Tables

Table 1 – Multotec Process Equipment: turnover and R&D expenditure .....	4
Table 2 – Estimated sales for the cyclone division of MPE.....	13

## 1. Introduction: background on Multotec

Multotec Process Equipment (MPE) manufactures various types of machinery for the separation of different media, such as ores and coal. Its largest area of operation is the manufacture of cyclones. These machines use centrifugal force coupled with fluid dynamics to separate media of different densities. MPE is a leader in the development of cyclones, and, in addition to dominating the local market, it also exports a substantial proportion of its output. The research and development that is the focus of this case study relates to two activities. One is the product development which has placed it in a leading position. The second is its construction of a full testing facility, which received financing from the SPII.

MPE is an interesting case, partly because it has used the SPII twice, once with a successful development and once with a development which did not meet its goals. The successful development is the testing facility for cyclones for dense-medium separation. The unsuccessful development is also for materials separation, but this time related to a new spiral for the processing of coal. The manufacture of spirals and the manufacture of cyclones fall under separate divisions. As will be seen, the SPII support for the spiral did have positive spin-offs despite not ultimately meeting its main objective.

Multotec Process Equipment is part of a large group, which has majority German ownership (though MPE is not integrated into the German firm).<sup>1</sup> It has several divisions, including the one that manufactures cyclones. Seventy-five people are employed in MPE overall, with 31 employed in developing and manufacturing cyclones. Of the turnover, 64% is from cyclones.<sup>2</sup> (Seven hundred people are employed globally by the German parent company.) MPE's total turnover has grown strongly in most years (Table 1), reflecting its strong position in the local market, and growth in its exports.

**Table 1 – Multotec Process Equipment: turnover and R&D expenditure**

	1999	2000	2001	2002	2003	2004*
R&D Exp. (Rth)	439	660	960	560	450	550
Turnover (Rth)	56,343	70,892	60,800	65,300	82,000	90,000
Turnover growth, %		25.8	-14.2	7.4	25.6	9.8
R&D, % of turnover	0.7	0.9	1.5	0.8	0.5	0.6

\* projection

<sup>1</sup> Multotec Pty Ltd is 66% owned by Stafag Holdings AG and 34% owned by local shareholders. Stafag Holdings and Multotec Pty are each 50% owners of Multotec Manufacturing, which in turn holds 75% of Multotec Process Equipment Pty Ltd.

<sup>2</sup> Calculated from 2002 data, which are given in Table 2 for cyclone sales.

MPE's main motivation for developing firm-specific capabilities and making ongoing innovations is the local demand from industries, principally mining, for equipment to meet their specific needs. This demand has provided the base for export capabilities. At present, approximately 30% of output is exported. The main markets are Norway, Russia and Australia. The firm is also looking at breaking into the South American market.

Although MPE does not have a separate R&D division, a significant proportion of its resources, efforts and people are directed towards research, and it has good links with institutions such as universities. Although R&D expenditure has remained at 1.5% of turnover or less (Table 1), this does not include the expenditure on the testing facility supported by the SPII. The money spent on R&D also does not include the salaries of MPE staff who are responsible for ongoing product development and customisation of products to meet the needs of users. Altogether, MPE employs seven qualified process engineers.

Despite the apparent success of MPE on the back of quite low levels of R&D, its experience nevertheless raises a key issue concerning the need for more responsive facilities able to undertake or support shorter-term research to complement fundamental research. This directly talks to the need identified by Department of Science and Technology to define and take forward a new R&D vision and follow through to commercialisation of the outputs.

## 2. Overview: the innovation

### 2.1 Cyclones

A cyclone is a machines used for separating materials according to density through the action of centrifugal force as they are fed into a cylinder at velocity (created by pressure). A strong vortical flow is created within the cyclone, resulting in the heavier material being moved outwards towards the wall, and downwards in a spiral path to the lowest point, where it is discharged. The lighter material is taken upwards by the reverse vortex created and is removed through an outlet at the top.

Cyclones have generally been used for separating a little waste from a majority of 'good' material. The important thing that makes the high-density cyclone different is that it separates a majority of waste from a small amount of 'good' material. This makes it useful, for example, for the reprocessing of mine dumps, where a large amount of waste material has to be sifted through.

The challenge of processing large amounts of waste with a cyclone is that the exit at the bottom for the higher-density waste material constrains the speed of operation, as the great majority of material now has to exit via this route rather than from the top. The cyclones developed by MPE experiment with faster exits at the bottom of the cyclone, including a side exit.

The innovation and product development in cyclones requires a combination of advanced computer modelling capabilities together with the ability to test different designs. The manufacturing of the cyclones themselves has to meet specifications, but does not require especially advanced manufacturing capabilities in itself.

Most of the cyclones made by MPE are for use in the mining of gold, platinum, diamonds and coal, although some are used in the processing of chemicals. There are also potential applications in areas such as separation of foodstuffs. The materials to be processed largely determine what the cyclone is made of. Cyclones are mainly made of steel, and lined to be more abrasion-resistant, although MPE also makes some cyclones out of polyurethane (this is set to develop further).<sup>3</sup>

The cyclone division has been engaged in a series of incremental, and more radical, developments to the cyclone, driven largely by the lead process engineer, who was until 1994 head of Iscor's research and development section. The development involves computational fluid dynamics – applying advanced mathematics in computer modelling, experimentation and testing.

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<sup>3</sup> The research programme on the spirals involved experiments in casting polyurethane. These techniques are now being applied to cyclone manufacture.



## **2.2 Product lifecycle and ongoing innovation**

The product (the cyclone) lasts for two to three years and the life-cycle of the technology is estimated to be around five to eight years. Small changes in the specifications of the cyclone can have quite large impacts on the efficiency of its operations, which have potentially very large returns for customers processing valuable metals. This means that customers are going to be continually looking for the best specifications.

These factors together mean that ongoing product development is crucial for the success of the firm. This is also reflected in profit margins, which are very good relative to the material input costs of making cyclones.

Multotec's two main competitors are a South African subsidiary of the major USA manufacturer, Krebs, and a second firm, Linatex, which has used the Krebs designs and empirical results in its own manufacturing.<sup>4</sup> Linatex produces almost entirely for the local market and sees itself to be mainly competing in terms of price, as it does not have ongoing R&D related to cyclones. Krebs undertakes extensive R&D work in its USA home base.

## **2.3 The innovation**

Rather than one single innovation, it is MPE's ongoing capabilities in product development which are evaluated here, including the radical innovations in the design of the shape and structure of the cyclone. In recent years these have changed the shape of the cyclone to increase velocity and lead to a better flow. As explained in the introduction to this section, a side exit at the bottom has also been introduced for the heavy material.

For the SPII, Multotec's key innovations are those that advance the dense-medium separation capabilities, precisely because of the potential linkages with the reprocessing of mine material. The development supported by the SPII is the construction of a full on-site testing facility. The test rig was completed towards the end of 2003 and is the only one of its type in southern Africa. It stands three storeys tall and enables controlled testing of different types of cyclone, changing variables such as pressure and flow. It will enable Multotec to develop a new generation of more efficient cyclones.

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<sup>4</sup> Linatex is a subsidiary of a UK-listed firm, with operations in several other countries. Its technological strengths in process equipment are focused on the manufacture of screens for sorting ores. Its other main operation is the manufacture of high-quality rubber, which is used to line the cyclones, giving it a specific edge.

The R&D expenditure, at around 1% of turnover, consists of approximately R100,000 per annum on experimental work, and R600,000 per annum on the modelling of computational fluid dynamics, which is mainly conducted at the CSIR. In addition to these expenditures, there is the construction and operation of the testing facility. The construction cost was R540,000 (half of which was financed by the SPII under matching finance arrangements).

## 3 Incentives and drivers of innovation

### 3.1 Motivation for internal capabilities

As will be seen in section 4 below, the commercial returns to MPE's investment in R&D capabilities appear to be very good. Obviously, financial returns are an important driver for innovation. Yet firms differ greatly in their success in innovating and the path followed in developing their production capabilities. In the case of MPE, analysed here, financial returns do not provide a strong explanation of why innovation was pursued and was successful. Rather, there are particular salient factors which have underpinned MPE's decisions.

Although MPE's commercial returns have been very good, they also partly derive from the relatively low production costs in South Africa. Several competitors produce under license or are local subsidiaries of international firms like Krebs. These firms have a fixed range of products and do not undertake the same level of in-house design (in South Africa) and ongoing development as MPE.

The key motivation for local in-house capabilities has been the specific demands of South African mines. MPE has emerged as the leader in making customised products to order rather than 'off-the-shelf' products. This itself requires design capabilities. Ongoing innovation has therefore been mainly driven by MPE's objective of building and then maintaining its domestic market position, based on in-house capabilities.

The innovative dimension, however, did not originate as an explicit firm strategy determined by senior management. Rather, it derives from the group of people employed and their backgrounds. Instead of a defined research function, the development of an engineering team was motivated by the strategic decision to provide extensive after-sales support to customers. This team became involved in R&D as a natural consequence of solving customers' problems.

MPE did not identify R&D as a separate function until recently, and had no R&D division or section, nor did it have a development manager. Development tasks were assigned on an *ad hoc* basis. The R&D spend is no higher than 1.5% of turnover, but 10% of employees in the cyclone division are involved in R&D (most of the skilled/professional staff), and in MPE as a whole there are seven qualified process engineers. Recent appointments also include an engineer with a PhD. Staff involved in research and ongoing innovation therefore represent a significant proportion of the total, given that a good many of MPE's activities are fairly routine manufacturing

functions. R&D expenditures are therefore higher than the 1.5% of turnover the firm itself identified.<sup>5</sup>

At an individual level, the senior process engineer, who has now been appointed development manager, was more experienced than might have been expected for a firm of this size. This was as a direct result of the declining R&D spend in large South African companies during the 1990s, which has been widely observed. Until 1994 the MPE development manager was the head of Iscor's Research and Development department. When Iscor was restructured, its research activities were dramatically cut back, enabling MPE to attract a very experienced research manager.

The evolution of research capabilities can therefore be seen as a combination of 'push' influences internal to MPE and demand-side 'pull' factors from mining in particular. Each of these influences implies the importance of testing facilities. Such facilities are required for the customisation of designs to different customers' specific needs. The internal employee-driven interest in R&D also requires testing facilities in order to progress. Before the testing site was constructed in 2003, the lack of suitable facilities meant that prototype cyclones had to be tested *in situ* (generally in a mine), following the computer modelling. The identification of a specific development path around capabilities of design and customisation led to MPE's plan to construct their own testing facility and the application to the SPII concerning this.

Demand for the testing facilities is indicated by the fact that MPE already has more than a year of testing planned, in the form of 12–15 potential projects, even before the testing facility is complete.

### **3.2 The Support Programme for Industrial Innovation (SPII)**

In interviews the availability of SPII funding was reported as a major motivation for the testing facility that MPE required in order to build its innovative capabilities. Questions about the counter-factual remain, however, as the returns appear to justify investment in a facility by the firm itself (i.e. without support from the SPII or other programmes). But the size of the investment, and uncertainty about the quantifiable benefits, plausibly suggest that without the SPII support it would have taken much longer to realise the testing facility. In MPE's case, therefore, the SPII programme appears to have played a reinforcing and encouraging role.

MPE's SPII application for the cyclone testing facility was made in September 2002 and provisionally approved in December 2002. The last milestone (the operation of the testing facility) was reached at the end of 2003. The provisional acceptance of the proposal by the SPII was conditional on the ending of the unsuccessful SPII-

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<sup>5</sup> And, for example, the manager of the spiral division estimated internal and external R&D spend to be equivalent to 4.5% of turnover when the salaries of research-related staff were included.

supported development of a new spiral column for the processing of coal (see section 3.3 below). This had been overly ambitious and had failed to progress as expected.

There are four elements for qualification for a SPII grant:

- The project must be innovative (either in its products or its processes), and marketable;
- It must be financially viable. The company must fund both its own portion of the project and the SPII portion, as the SPII grant is made retrospectively;
- The firm must show that it has the necessary technological and human resources, including managerial ability in product development; and
- The research project must be designed to serve more than one customer (as the research cannot be for within-group purposes, nor can it be basic research which is not targeted at commercial projects).

Crucial to the success of MPE's application for the testing facility was the fact that it would allow the development of dense-medium cyclones suitable for reprocessing mine dumps. The financial viability and firm capabilities were well established, and the research was clearly directed towards products that would serve more than one customer.

The SPII rationale of supporting risk-taking means that failures are expected. As the case of MPE's spiral development programme demonstrates, the failure of a project also does not prevent a firm accessing SPII funding for other innovative ventures.

### **3.3 The coal spiral case as a comparison**

Spirals are used to separate heavy minerals from shales and sort them into different sizes. While the principle is relatively simple – that if a mix of material is churned the smaller sizes will move towards the centre and up the spiral – the effectiveness depends on the exact profile of the spiral itself. Multotec conducts ongoing research in order to refine its spirals, and it patents its incremental improvements. It is a major producer, rating itself the second-largest supplier of heavy-mineral spirals in the world, and the largest supplier of coal spirals. Exports are approximately 35% of output.<sup>6</sup>

The spirals are currently manufactured by spraying polyurethane onto a metal mould. The polyurethane spiral, once hard, is wound off the mould by hand and fibreglass is applied to the back of it to give it greater strength and rigidity. Some polyurethane is lost in the spraying process, and the application of fibreglass is time-consuming and

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<sup>6</sup> This does suggest that they may be overstating their relative size internationally.

labour-intensive. It is these two concerns which motivated a programme of research into the possibility of casting the polyurethane with a fibreglass core inside a closed-mould system.

The SPII application supported the process – mainly in the form of building prototype moulds and part-funding the development time required. Progress was slower than initially expected: the SPII schedule was not always met, and in the meantime the firm also worked out a way of applying the fibreglass by using an automated process (thereby greatly reducing the benefits obtained from the research). For these reasons, the project was terminated.

It should be noted, however, that the firm and its German supplier benefited from learning about the moulding of polyurethane, and about adapting different grades of polyurethane. This knowledge has been applied in MPE's manufacture of polyurethane cyclones. The firm is also continuing, although more intermittently, with experiments in moulding spirals.

It is possible to draw conflicting conclusions from the experience with spirals. One interpretation is that the obstacles to success should have been more clearly foreseen in the evaluation of the SPII application, and that the projected gains to the firm did not appear particularly large in the event of success. The SPII grant essentially supported the firm in research activity which it was going to undertake anyway, albeit more slowly perhaps. The alternative interpretation is that the SPII programme supported research which relates to the firm's core production capabilities and that, as such, the knowledge can be transferred to other operations. The early termination of the programme shows the effectiveness of the monitoring and evaluation.

Furthermore, while the particular step envisaged was not achieved, the project did not entirely fail, as may appear at first sight.

Each of these interpretations is consistent with the experience. Research that is not aimed at radical change is nevertheless still uncertain and risky. The SPII's rationale, therefore, is that it was supporting innovative activity of an incremental nature like the development of the spirals, although questions still remain as to the initial evaluation undertaken.

## 4 Gains from commercialisation and the competitiveness of the firm

MPE is highly profitable and appears to have a strong platform for continued growth. Profits are approximately 30% of sales – a very healthy margin. This figure is based on production costs of approximately 50% of sales revenue and fixed costs of a further 20% of revenue. Based on estimated sales of cyclones (Table 2), the returns easily reward the investments in R&D and in the testing facility in particular. Indeed, it could be argued that the firm may still be under-investing in R&D even on relatively narrow and short-term commercial criteria.<sup>7</sup> While the projected sales growth is steady and incremental, the financial rewards from this growth are substantial relative to the R&D spend.

**Table 2 – Estimated sales for the cyclone division of MPE**

	2002	2003	2004	2005
Local market (R-million)	30	35	40	42
International market (R-million)	12	15	16	18
Total	42	50	56	60

The low R&D spend (relative to its apparent returns) and the development of production capabilities reflects a number of influences on the strategic direction of the firm. Historically the firm (through its owners) did not see itself as R&D-focused, as is suggested by the lack of a specifically defined R&D function. In the 1990s, however, it was decided to provide customers with a very strong service function. This entailed having an engineering capability that would provide customers with support and problem-solving as they needed it. In this the company differed from its main competitors, including the operations of its main multinational competitor in South Africa (Krebs).

Luck (or at least coincidence) played a role at this point, as the availability of good engineers due to retrenchments in the big upstream industries like Iscor meant that MPE could build up an engineering team who were able to move forward with development and design improvements, which effectively amounted to R&D. A belated recognition of the value that this accorded to the firm led to the identification of R&D as a key driver of the firm's commercial success. The low recorded R&D spend therefore belies the capabilities built up. Valuing the time of the engineering team as partly R&D would increase the spend, while their success has led to recognition of the importance of technology.

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<sup>7</sup> However, the low R&D spend is partly a question of certain activities not being identified as research.

## **4.1 Market shares and growth**

The commercial imperatives of R&D reflect the mixed basis of the firm's competitiveness. On the one hand, MPE has built its dominance of the local market on its responsiveness to the needs of South African mines in processing gold ore, platinum ore, and diamonds and coal. For this reason, one of its major concerns is to be defensive, so that it can protect its local market from other firms, both local and international, that seek to copy it and customise products as it does. Only by maintaining ongoing improvements can MPE ensure that it stays ahead. The company estimates it has an 85% share of the market in its particular product areas, and the remainder is largely supplied by imports.

On the other hand, there is the more growth-oriented focus on building export markets. Exports account for approximately 30% of output. The export markets have developed gradually, aided by the internationalisation of South African mines. The next target is to break into South American markets, including the copper market, as well as the processing of iron ore in existing markets such as Australia (where the South African firm Kumba has a mine). Export markets therefore involve new product niches in the sense of different minerals, as well as straightforward expansion of existing production. There is ready capacity for expanded production. At present MPE only runs one shift, with overtime as required. It can also quite easily contract out some of the work (such as casting) and so greatly increase throughput with existing facilities. Its competitiveness in international markets depends on being able to customise its main models, which in international terms can be viewed as 'mid-range' in terms of design and effectiveness, to the needs of different customers.

With the completion of the new testing facility in late 2003, Multotec is working on a new range of cyclones, which, due to better modelling and design, will have significantly better production efficiencies and enable the company to build a stronger brand and market share internationally.

The cost competitiveness of manufacture can be viewed as militating against an R&D-oriented strategy, as firms can manufacture relatively standardised products under license. In the South African context, two factors make a price-and-cost-based competitiveness strategy difficult. These are economies of scale and the needs of local customers. First, the size of the South African market means that firms cannot do the large orders and production runs that are required in order to use installed machinery most efficiently. This pushes firms towards a focus on product niches with small runs to particular specifications, which require many changeovers and are not so price competitive. Second, such a focus is reinforced by the gains to the local buyers of having customisation to particular needs.

It is the interaction with local buyers, and the ongoing learning-by-doing resulting from it, that appear to have been crucial in MPE's move towards an R&D-oriented competitive strategy. We now briefly discuss the firm's competitiveness in more detail.



## 4.2 Competitiveness

The competitiveness of South African manufacturing costs can be seen in relation to those of the main international manufacturers, in the USA, the European Union and Australia. Despite abundant local materials (largely iron and steel), the import parity pricing and relatively high local scrap prices (scrap being used for much of casting) mean that South Africa does not have a significant materials cost advantage. The cost competitiveness derives instead from labour and other costs including electricity, land and additional fixed costs. Despite being ‘knowledge-intensive’ in the design and development phases, the manufacturing of cyclones is quite labour-intensive. Labour accounts for between 35% and 40% of production costs. In South Africa the costs of the semi-skilled labour required in production are very low compared with those in industrialised countries such as the USA.

Perhaps more surprisingly, MPE reported that the ‘computing power’, mainly skills and capabilities of people employed in modelling and product design, was both readily available and cheap in South Africa. Again, the international comparisons that are used are important here. Presumably, other industrialising and developing countries like India and Malaysia have similar or cheaper skills in this area, but the nature of the product being made and the demand from mining have meant that the main competitors are in industrialised countries in Europe and North America. This still represents a threat in that multinational cyclone manufacturers are able to locate production functions in countries where these skills are even more cheaply available – India, for example – as firms in other industries have already done.

While it draws on these sources of cost competitiveness, which ensure a healthy profit margin, non-price sources of competitiveness are going to be increasingly significant for MPE. These encompass continued technological capabilities together with design and customisation. As noted above, in the case of MPE the design and customisation functions have led the development of technological capabilities. The availability of skills in process engineering preceded the establishment of a defined R&D function.

The importance of the demand-side stimulus to design and research, in the case of MPE, suggests that the weak R&D expenditure of South African firms in general is related to the lack of a deliberate mission or focus in supporting new industries. The apartheid government support for the then new chemicals and defence industries (and earlier, the iron and steel industries) evidently stimulated R&D and technological capabilities. Without such a demand-side motivation from industry, coupled with appropriate support measures, the natural barriers to R&D inhibit the development of capabilities. Similarly, the decline in R&D activity in the now ‘old’ industries has meant available skills for firms such as MPE, but without new skills development this aging (and white) skills base is too narrow for a prolonged expansion of industry founded on improved technological capabilities.

### **4.3 Potential**

MPE itself has considerable potential. The possible returns from a ‘lateral migration’ of cyclone technology to applications in chemicals and food products (e.g. cleaning starch) have also yet to be properly explored. Mintek is reported to be involved in some of these developments, which are still at an early stage. Exploiting such potential will also rest on computational power and ability to design and test cyclones. It will also benefit from further use of other materials such as plastics, which MPE is already developing with polyurethane cyclones.

## **5 The role of institutions**

The fundamental factors which inhibit research and innovation – appropriability, positive externalities and risk – all require institutions to undertake initiatives that are in the collective interest, as such initiatives may not be taken by individual firms or, if they are, will not be shared.

Multotec has relatively well-developed links with the various institutions responsible for supporting research and innovation. The case illustrates the roles of these institutions and suggests where there are overlaps or gaps. As discussed above, the Support Programme for Industrial Innovation was an important consideration in their decision to move ahead with the testing facility. In interviews, the role of the CSIR was also explored in some detail, and so too were links with universities.

### **5.1 IDC/SPII**

It is important to note that the SPII's successful operation is partly due to its being housed within the IDC. This gives it a measure of autonomy, including the ability to draw on a pool of consultants and industry experts to appraise projects and monitor their progress.

The SPII is intended to fill a gap in government support between basic research and programmes and incentives to support capital expenditure. Therefore SPII applicants cannot get other government funding for the same project. The SPII evolved in 1993 from the Innovation Support for Electronics Scheme, which the DTI introduced in 1989. It is managed by the IDC on behalf of the DTI.<sup>8</sup>

There are two schemes under the SPII, the Matching Scheme and the Partnership Scheme.

#### *5.1.1 The Matching Scheme*

This provides a non-repayable grant of 50% of the actual direct qualifying costs incurred and paid for in development activity, up to a maximum grant of R1.5 million per project.

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<sup>8</sup> Note that firms are required to provide data for three years after the end of a SPII grant, so there is an important database of firms which could be drawn on in assessing innovative activity.

### *5.1.2 The Partnership Scheme*

This provides a conditional grant of 50% of the actual direct qualifying costs incurred and paid for in development activity, with a minimum grant of R1.5 million per project. The grant is repayable upon successful commercialisation of the project, in the form of a levy on sales. Should the project be unsuccessful, the conditional grant is converted into a non-repayable grant.

In 2002/03 there were 61 approvals under the Matching Scheme, with an average grant of R910,000, and three approvals under the Partnership Scheme, with an average grant of R7.9 million. This represented a slight fall in the number and value of approvals from the previous year. The constraint on the growth of the scheme is the number of good applications rather than the availability of funds. This suggests either that the scheme is not being marketed effectively, that it is not useful to firms, or that factors other than finance inhibit innovative activity. The requirement for firms to fund the activity initially, before being reimbursed under the matching scheme, was not reported to be an obstacle to potential applicants.

Disbursements are made in three tranches as performance milestones are achieved. This means that firms are reimbursed as they make measurable progress. As the SPII is meant to fund high-risk projects promising high returns, repayment is not required. The use of three tranches enables projects to be terminated if thorough investigation proves it to be no longer viable. Thirty consultants are used for the evaluation of proposals and the progress of projects.

## **5.2 The CSIR**

The CSIR has been a key player in technological development – especially in the case of energy and coal. Its role in the support of related research has gone through several stages. It is useful to understand these stages, as they provide an insight into the way public institutions work together with private interests; they also provide the background to the specific current situation of the main source of energy in South Africa, coal.

In the past (up to 1990) there was a levy on coal exports. The funds raised went to the National Energy Council (NEC) so that it could undertake and fund research. In addition, a test facility was constructed in Pretoria West. The levy was essentially part of the very large state role in the coal industry. With the 1990 Coal Act, which deregulated the coal industry, the levy fell away. This led to a fragmentation of research, with firms having to conduct more in-house research (with duplication of research), and the CSIR conducting research on a contract basis. The testing facility was also closed down. Much of the testing, both in the past and the present, has been driven by health and safety imperatives. Improving equipment to make it safer is clearly very important; however, it is necessary to distinguish this from innovations intended to improve the performance of the machinery or equipment in terms of the job it is required to do.

Problems with the declining level of research as a result of there being no structure and funding for collective research stimulated the design of the Coaltech 2020 plan. There are similar plans for gold ('Goldmine') and platinum ('Platmine'). The nature of the plans differs according to the stage of the industry and the requirements of different mining operations. In general, gold and coal are more mature industries, and the initiatives are engaged in supporting ongoing and incremental research and development. In particular, Coaltech 2020 is motivated by cooperation between Sasol and Anglo-American, two of the biggest coal miners and processors.

Coaltech 2020 is a collaborative research programme for which each of the following provides one-third of the funds: the CSIR (from its parliamentary grant), the FRD through the Technology and Human Resources for Industry Programme (THRIP), and the coal industry. In 2001 the budget totalled R12 million.

Support had been given to a total of 37 students by 2002, of whom six were registered for PhDs and 19 for Master's degrees. 12 students were black and 12 were female.

Coaltech 2020 has six research areas:

- Open-cast mining;
- Underground mining;
- The surface environment;
- Geology and geophysics;
- Coal processing and distribution; and
- Human and social aspects of mining.

Proposals are invited for projects, which are led by CSIR scientists under each of these main areas. In addition, Coaltech 2020 is funding a PhD student at the University of Pretoria; this student will use the Multotec facility.

Under coal processing the main thrusts have been economic agglomeration of fine coal and beneficiation of fine coal.

The proposed new projects in 2002 were:

- Smokeless fuel;
- Kroosh screening technology;
- Control and management of dust;
- Real-time plant efficiency measurement; and
- Hydraulic pumping of ROM coal.

It appears as if, as in the past, the institutional agenda for research support is relatively narrow; it does not seek to develop linkages. The Coaltech programme is very much focused on mining.

More broadly, firms' assessment of the CSIR's activities is that, although the CSIR has been moving towards business development and an emphasis on export orientation, it is still more suited to fundamental research. A key gap that was mentioned both by those inside and outside the CSIR is the lack of capabilities for more responsive research linked to incremental development. At present there is a pool of consulting expertise, including people who have been retrenched from defence research, but there is a need for coordination and management of expertise to support industry's needs.

Closely associated with more short-term and responsive research is the need for testing facilities. The Multotec facility is an example of the type of facility which enables ongoing research for improved products. However, its use remains limited to one company, and for others to do similar tests will require duplication of the facility.<sup>9</sup> Mathematical modelling is very important in design, but testing of prototypes is also required. Testing cannot be effectively done on site, and so the development of competing local manufacturers requires joint access to a testing facility. Conversely, to the extent to which the main competitors are subsidiaries of multinationals that conduct research and testing in their home base, the lack of open access may be viewed as the support of a 'national champion'.

### **5.3 Universities**

Multotec has strong and ongoing links with universities, including Pretoria, Stellenbosch and Wits. These links include Multotec funding of Master's students through bursaries and funding for their research projects. A PhD graduate from Wits has also recently joined Multotec to increase its own in-house research capabilities.

Although there has been an increasing emphasis on the commercial value of research, it still appears as if much of universities' research funded through programmes like THRIP is very science-driven and the links with business development are not made at the research stage.

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<sup>9</sup> One interviewee from the CSIR believed that the SPII funding will mean that the Multotec facility will be more widely available. But there appear to be no grounds for this. While Multotec may be happy to have a PhD student using the facility for research linked to its own needs, there is no reason why it should make the facility available to other firms wishing to undertake testing.

## 6 Conclusions

The MPE case reinforces the importance of particular local demand patterns in stimulating technological capabilities. In particular, the needs of mining have underpinned the development of firm capabilities, and the case is illustrative of the underlying dynamic driving much of South African industrial development, which Fine and Rustomjee (1996) have termed the ‘minerals–energy complex’. It is, however, also an example where capabilities appear to be transferable to the separation and processing of other materials (and so lateral migration is feasible).

At the level of the firm, the development of technological capabilities does not appear to have been driven by clear strategic decisions, and R&D expenditures have been relatively low, especially given the high levels of profit being made.

Instead, the developments have partly been driven by the core group of technical employees within MPE, who have pursued a research-oriented approach under the guidance of the senior process engineer. The firm’s decision to provide customers with support, linked to their production of customised cyclones, led to the development of an engineering team and the capabilities to innovate.

The case therefore illustrates the importance of broad economy-wide factors – the significance of mining and energy in particular – along with the need to understand internal and firm-specific considerations related to production capabilities and firm strategy. The demand-side pull has underpinned ongoing development of the expertise required for what are arguably world-class capabilities in the necessary activities, including computer modelling.

The importance of mining and energy has not, however, been developed into a coherent strategy to develop wider linkages, and this pattern appears to be replicated in the recent initiatives like Coaltech 2020. These initiatives followed a decade in which the role of the public sector in supporting research was rolled back, but the plans are still quite narrowly focused on mining.

The SPII support given to MPE essentially built on existing activities and did not mean that a different path was followed as a result of the intervention. Support for the test facility appears to have encouraged MPE to take a more research-intensive approach, which in effect had already been embarked upon.<sup>10</sup>

The challenges facing MPE are to accelerate and better plan R&D activities, given the threat from multinational companies and the ability to overcome barriers to exporting.

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<sup>10</sup> This also does not provide a solution to the need for shared facilities, especially for small and medium firms

There is also great potential to broaden the applications for which cyclones are manufactured, especially with the shift to different materials such as polyurethane. MPE's steps in this regard are encouraging; and coincidentally they were supported by the SPII grant for the unsuccessful coal spiral development.



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## **List of interviews**

Pieter Neveling, Process Engineer, Cyclones, MPE

Rohan Biddulph, Factory Manager – Spirals, MPE

Stewart Douglas, Process Engineer, Linatex

George Ashworth, Miningtek, CSIR

Johan de Korte, CSIR, coal division.

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