ACARP - Research that makes a Difference

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INTRODUCTION

Coal exports are forecast to grow strongly, so that coal is likely to remain very important to Australia for the foreseeable future. However there is no sign that prices or profitability will rise of their own accord. Therefore the intense squeeze on costs will continue for the foreseeable future. This will mean lower manning, more outsourcing and probably an increasing rate of company attrition. As well, the political pressure from the greenhouse debate is only going to intensify and the pressure on the Federal Government after Kyoto is likely to be irresistible.

The next one to two years therefore will see the industry caught in a nutcracker of intense political pressure on the one hand to help the country meet its political obligations, while on the other there is the relentless pressure of zero profit margins. Answers will be demanded that require research at the same time that cost pressures are reducing companies' ability to fund it. It is timely therefore to consider what it is that the industry is getting from its research levy and to see whether it really is making a difference.

AUSTRALIAN COAL ASSOCIATION RESEARCH PROGRAM (ACARP)

In December, 1992 the Australian Coal Association took over the program of coal related research, which had been run under the National Energy Research Development and Demonstration Program (NERDDP). Under the former program approximately A$167 million dollars was spent from 1978 to 1992, with expenditure largely funded from a levy of 5c/tonne on black coal production. The Australian Coal Association now fully directs the research program, called ACARP and since June 1993 has taken over voluntary collection of the coal research levy.

ACARP's charter has recently been extended for another two year period and will now run until at least the year 2000. This good news is a significant vote of confidence in the program from Australian coal producers

So far under ACARP, approximately A$41 million dollars of levy funds have been committed to research projects with a total value of about A$100 million. The additional funds come from ACARP cooperation with other funders of research such as the BHP Special Research Program, the NSW State Energy Research Fund, manufacturers of mining equipment and individual coal mining companies which support specific projects over and above their research levy contribution. The levy of 5c/tonne on black coal production, is currently generating about A$ 9.9 million per year.

ACARP has committed funding to 294 projects so far. Of these about 105 have concluded, 155 are in various stages of completion and the rest are under contract negotiation prior to starting. An additional 56 projects have just been selected to which a further $8.6 million will be committed when the necessary contracts have been finalised.

ACARP ANALYSIS

About two thirds of ACARP's research effort is on mining related activities reflecting the fact that funds are drawn from coal producers which have to remain world competitive in selling price and at the same time cope with increasing production difficulties in terms of deepening pits and increasing environmental pressures. Table I shows the distribution of project findings during the period 1992 – 1996

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Table 1 - ACARP 1992-96

CATEGORY	No of PROJECTS	ACARP $ million	OTHER $ million	TOTAL $ million	LEVERAGE
Underground	139	16.6	26.9	43.5	2.6X
Open Cut	60	11.7	12.4	24.1	2.1X
Coal Preparation	54	7.2	8.0	15.2	2.1X
Coal Utilisation	41	5.8	13.8	19.6	3.4X
TOTAL	**294**	**41.3**	**61.1**	**102.4**	**2.5X**

This table demonstrates that a useful degree of leveraging continues to be achieved on project funding. In the round just completed, ACARP's $8.6 million allowed entry into nearly $19 million worth of projects.

THE ACARP VISION

In a recent review of its vision for ACARP the joint Research Committee looked at where ACARP currently is and where it would like to be.

Where is ACARP

- ACARP is an effective program of research with runs on the board;

  Around $20 million per year of projects are funded;

- Second most influential coal research funder in Australia after BHP;

- Strongly networked with research providers;

- A strong inter-company technical communication forum;

- An effective industry response capability

- Provides much needed commercialisation support;

- International links are strengthening;

- Still flexible and developing;

- Constrained by the need for short term results;

  CEOs not fully convinced;

- Minesite support about 50/50 (could be 80:20). Coal Prep 80:20 already; and

- More integration of different program segments is needed;

What is needed

A clear vision for the future;

A clear strategy

Sufficient time;

The current issues and problems clarified;

The right program formulated / the right projects selected;

Superb communication, marketing;

Support from all stakeholders (to be recognised as essential to the industry);

A credible cost - benefit analysis mechanism established;

Collaborative funding maintained or strengthened;

The research community focussed to the industry's best advantage;

Efficient paths to commercialisation, implementation in place;

- Improved alliances with manufacturers (domestic and overseas

MAKING A DIFFERENCE

If we achieved this challenging agenda how would this make a difference to our stakeholders? Well let us look at some examples of what ACARP is doing.

Safety

An important area in which ACARP is definitely having an effect is in safety. Significant work is being supported in six categories as shown in Table 2.

Table 2 - Major Incident Safety

		ACARP $	OTHER $	TOTAL $
23 Proj	(i) Strata control	2463	3418	5881
	(ii) In-seam drilling	2310	3702	6012
18 Proj	(iii) Detection and prevention of fires and explosions	2412	2955	5367
15 Proj	(iv) Gas monitoring, drainage and control	1288	2474	3762
10 Proj	(v) Outbursting	969	1105	2074
5 Proj	(vi) Escape and rescue	1185	708	1893
	Total	**10627**	**14362**	**24989**

Strata control

As you can see from the table the biggest area of effort has been in strata control. There is no doubt that the reason for this strong ACARP support is because strata control is not only a safety issue but a key production issue as well. The safety aspects are well demonstrated of course by the Joint Coal Board funded project at the University of NSW on improving pillar design. This work can clearly be shown to have saved lives and reduced serious injuries. ACARP is funding the UNSW group to extend this work into understanding the support capacity of irregularly shaped pillars and into soft strata environments and also to improve the design and performance of timber chocks.

ACARP has put considerable effort into trying to understand and implement pretensioning of roof bolts because of the promising results of early work in this area. Seminal work by ACIRL and Ripu Lama has been followed up by Barrett Fuller and Partners in their work on the Flexibolt and by Strata Engineering. Results to date are very encouraging. The UNSW is also looking, in conjunction with ANI Arnall, at the effect of pretensioning as a means of improving rib support.

Another consistent strand within ACARP funded work has been to improve monitoring techniques and instruments for strata control since this is a key to early warning of impending trouble. Work with the CSIRO, Strata Control Technologies and Mincad has been very successful in this regard. The safety benefits of some of this work have recently been well demonstrated by Pacific Power in the successful management of their windblast problem. Early warning was the key to removing personnel from danger before windblast events.

ACARP recently funded an exchange of data with South Africa whcih has some very graphic examples of the danger to life and limb posed by major strata collapses and their experience is a clear reminder of why ACARP supports efforts by every significant strata control group in the country to improve the theory and practice of strata control.

In- seam drilling

The main technological developments in in-seam drilling since the commencement of ACARP have been made by mine operators and contractors, with assistance from suppliers, to alleviate current problems . ACARP funded research has resulted in prototypes which have either been completed or will be completed over the next two years and which will take in-seam drilling technology in to the next generation. This is a very well thought out and coordinated program aimed to lift in-seam drilling to a new level.

The value of this work can be estimated by considering whether any South Coast mine which is unable demonstrate adequate gas drainage through a well conducted in-seam drilling program, is likely to be allowed by the inspectorate to remain open. It has also been of major value to Dartbrook in helping that that pit cope with its high carbon dioxide levels and the Central Queensland mines now starting to cope with hydrogen sulphide.

By monitoring and coordinating individual projects and acting as the technical transfer link between researchers, pits, drillers and equipment suppliers this task force has been part of a very significant upgrading in the industry's capabilities in an area which threatens the ability of many pits to continue mining. Those operations which are actively participating in this program are deriving very considerable value from it.

Some achievements are:

- Development and demonstration of the rotary drill rig monitor by BHP Research for detection of structures while drilling.(Awaiting commercialisation).

- Development and IS approval of a 486 computer by BHP Research, for safe data collection underground. Combined with the M&G high speed modem, which has also received IS approval, this is a very important breakthrough in data collection and analysis. (Modem on sale, IS computer awaiting commercialisation.)

- The AGA consortium has developed technology to enable monitoring of drilling parameters behind the bit, thus facilitating future detection of potential outburst structures while drilling long holes. (Undergoing surface testing prior to underground demonstration)

- A borehole pressurisation system has been developed by AGA which will facilitate future geophysical logging of holes. In conjunction with this, Sigra has developed a device for analysing the virgin gas content of drill cuttings while drilling, for a better assessment of outburst potential. (Undergoing surface testing prior to underground demonstration)

- Development of radar and radiometric tools by the CMTE for use during long hole drilling to detect proximity of the bit to roof and floor and for detection of adjacent structures. These probes have been partly funded by ACARP. (Prototypes still being tested)

- Development by AGA (privately funded) of an inexpensive electronic `measure-while-drill' survey tool for use initially in rotary and later in long holes either as a component of other tools or as a separate item. This tool should be available in late 1997

- Initial trials with the CMTE developed water-jet assisted drill are very encouraging for drilling straight gas drainage holes which go where they are aimed. (Trials continuing).

Unfortunately there is not time to go into the details of what is being developed but only to say that we expect to have the capacity shortly, to drill holes more rapidly with an accuracy that will guarantee safe drainage and to have the means of gathering information both during and after the drilling which will accurately locate and define any structures which have dangerous outburst potential.

Gas monitoring, drainage and control and outbursting

Although these are categorised separately of course they are all of a piece with in-seam drilling as part of improving the industry's ability to safely control gas emissions of whatever type. Two projects in the Outbursting category for example, could just as easily be put into in-seam drilling. One is a project to pressurise boreholes. This device if successful will allow a wider range of geophysical tools to employed for detecting outburst structures. This class of tools requires a fluid filled hole to be effective. Another is a project to develop a new geophysical tool for the detection of outburst structures in boreholes.

As with strata control, improved monitoring is a key area of importance, for early warning of a dangerous gas build up or changes in the make up of gases being emitted which could signal danger. Many facets of monitoring are being investigated. Attempts are being made to improve real time monitoring in working areas, during drilling, in goafs and in return areas. A prototype of a new meter for measuring gas make from drainage holes has been developed and is awaiting testing. And in response to the Moura Inquiry two different prototype valves for shutting off drainage gas in the event of an explosion have been developed and are also awaiting trial. Hopes are high that these will help prevent the secondary explosions which are the most damaging events after an initial incident.

Detection and prevention of fires and explosions

There are four main strands to ACARP work in this area.

The first is electrical safety where we have five projects looking at ways of preventing dangerous ignitions particularly from high voltage electrical equipment underground.

The second is on improving the design and efficiency of dust and water explosion barriers. This work is to be added to in the latest ACARP round by further efforts to improve seals and stoppings. In this regard one of the highlights of the recent ACARP funded exchange of data with South Africa was the revelation of a new and apparently highly effective stone dust barrier, recently developed there.

The third and probably most costly in dollar terms was support for the recent inertisation trials using the GAG jet engine and the Thomlinson Boiler. Both these trials were very successful, leading to the purchase by the Queensland Government of a GAG inertisation system for their State and further development of low flow systems.

The fourth is the understanding and control of spontaneous combustion, which clearly is still a major issue with the industry. From ACARP's point of view it is not only a danger to underground mining but also an environmental problem for open cut mining and a possible hazard in transport and handling. The projects in these other areas reinforce the work done for underground miners. For example, an ACARP project which is attempting to control spontaneous combustion in an open cut spoil pile by the injection of a fly ash slurry, could well be applicable to creating a grout curtain in an underground situation.

The fifth area, where there is only one project, is to develop an improved method of testing and classifying the flammability of conveyor belting, since underground belt fires are becoming an increasing concern. Related to this, but not categorised as a Safety project, is a device developed under ACARP by Vipac (and recently commercialised by them) to rapidly detect, faulty idler bearing rollers prior to failure. The failure of these rollers is a major cause of belt fires.

Escape and rescue

In spite of the very high cost involved, a number of mines have gone ahead with the purchase of oxygen self rescuing equipment. The South African experience with oxygen self rescuers, revealed on the recent exchange visit to South Africa, has been very enlightening in this regard. Not only is it clear that some equipment is better than others, it is also clear that introduction of oxygen self rescuers needs to be in conjunction with a system of monitoring the devices to ensure that they are always in satisfactory working order. This realisation is currently being digested by the state rescue services and will certainly lead to further ACARP work to help develop the necessary capability.

ACARP inherited the Numbat from NERDDP and has continued work to both improve its capability and to use it as a test bed for a possible Mine Rescue Vehicle. A very imaginative proposal has been put forward to develop a mine rescue vehicle based on the ANI Ruwolt man transport vehicle. It is proposed that the vehicle have a self contained air supply for both personnel, and the engine, so that it is isolated from the mine atmosphere. It would carry the Numbat sensing package. A proof of concept project will be undertaken to test the feasibility of such a design.

BENEFITS FROM ACARP

Passive benefits

Levy payers benefit both passively and actively from what ACARP does.

Some benefits which the industry receives accrue to the coal industry generally. They are real but difficult to quantify in value because they tend to be preventative in nature.

A good example is what happens after there is a serious incident in a coal mine in which either multiple lives were lost or a disaster was narrowly avoided. The subsequent inquiry plus union reaction almost always leads to massive pressure on the industry and the regulating authorities to make a significant response. There is a strong tendency for draconian legislation to be introduced which is ultimately unproductive.

That the counter productive effects of this sort of knee jerk reaction can last for decades is well illustrated by the banning of the use of aluminium alloys in British and Australian underground collieries on the basis of what in hind sight looks like an extraordinary reaction to an incident in a British coal mine in 1962. In spite of how odd this decision now appears and the scientific and metallurgical progress made since it was imposed, it may never be possible to get the ban lifted in Australia. A study being undertaken by ACARP which documents the background to the decision and more importantly the lack of incidents attributable to the use of aluminium alloys in US coal mines, however does offer some hope.

More importantly, as demonstrated in the aftermath of the recent Moura Inquiry, the existence of ACARP funding and the ACARP committee structure provides an effective and above all a credible response mechanism to the technical questions raised by the Inquiry. There is no doubt that this response played a part in a producing a productive outcome for the industry rather than a purely negative one.

Levy payers who are not actively involved in the Inquiry response or in ACARP, still benefit if the industry is protected from inappropriate legislation. Other examples of where the industry has an improved defence from negative judgements because of ACARP assistance, are related to environmental or community problems e.g., mine site rehabilitation or reduced pollution from coal utilisation

In these cases a bad image created at one place can easily produce problems for every operator and it is politically essential for the coal industry to be seen to be taking effective action to combat the problems.

Another passive benefit is the way ACARP helps to keep public research at the universities and the CSIRO focused on industry problems. Over time the benefit of this work accrues to all operators in the improved understanding of problems such as pillar design or rock mechanics. Additionally, research infrastructure is maintained which is available when a pit needs help and an improved flow of better trained graduates results.

Active benefits

Clearly the operators who benefit most from ACARP are those who actively participate by offering staff for selection committees and project monitors and their mines as demonstration sites. When a research project relieves a serious problem at a particular mine site and at the same time demonstrates a technique which is useful industry wide, the benefits are immediate at the demonstration site and valuable over time for the rest of the industry.

The recent 'Coal Loss' project which demonstrated how to reduce coal losses in open pit mines is an excellent example of this. The demonstration sites gained additional coal worth several million dollars a year while industry wide there are now demonstrated techniques available for pits with similar problems.

Here are some examples where pits, through participation in ACARP have recorded significant gains:

Westcliff (NERDDP)	**Electricity generation from mine gas drainage**
Angus Place, Ellalong	**Flexibolt** (significantly improved roof support)
Gordonstone, Tower, Teralba, West Wallsend	**Pre-tensioning of roof bolts** (as above)
Appin, Tower	**Improved gas drainage/drilling for greater effectiveness at lower cost)**
Tahmoor, Dartbrook,	**Real time gas monitoring**
South Bulga, Appin, North Goonyella	**Improved understanding of ground behaviour around longwall faces**
Tahmoor	**Remote control outburst driveage**
Wyee, Cooranbong, Tahmoor	**Use of the Coal Auger for drilling cut throughs**
Gordonstone	**Improved timber chock constructions**
Howick, Warkworth	**Reduced coal loss for higher mine yield**

Many innovations have come from this work which will benefit the industry, but the companies that get the most benefit and the first use of these and will be those which actively participated in their development through ACARP.

Other than just providing specific solutions ACARP has a role in encouraging pits to develop a culture of innovation. Innovation allows an operation to be in charge of events rather than just reacting to a harsh external environment such as worsening mining conditions (do they ever get better?), falling prices, loss of markets, customer dissatisfaction, inspectoral edicts, environmental pressures, company takeovers, rising workers' compensation premiums, etc, etc.

These are just a few examples of the gains pits have made through active participation at mine sites, mostly from the underground sector.

For open cut mining the major effort has been to improve overburden removal efficiency. In Australia this effectively means trying to improve dragline efficiency. Mainly through company efforts, but definitely assisted by ACARP, this has been a notable success story. There have been major gains in efficiency. The levy payers have received full value from the research which has made a recognisable difference at their individual pits.

Some of you may have seen the recent report by Tasman Asia Pacific which was commissioned by Rio Tinto entitled "The Scope for Productivity Improvement in Australia's Open Cut Black Coal Industry" which made very unfavourable comparisons between USA coal mine productivity and Australia. The one bright spot where we are way ahead is in the productivity of Queensland draglines. I have no doubt that ACARP is partly responsible for this.

Unfortunately time precludes further examples but allow me to say that one of the key indicators of the success of the program is that at last count, 68 mine sites were actively hosting ACARP projects. Under the previous government regime, project selection tended to be researcher driven. Under ACARP it is operator driven and increasingly the pits themselves are becoming the research laboratories. We believe that this is a sure sign that the program is making a difference.

Communication

ACARP provides a communication network through committee meetings, newsletters and various types of workshops and seminars and will soon be augmenting these efforts through the Internet and by publishing our total research output on CD-ROM so that it is rapidly searchable for data of relevance to a levy payer's problem. While all new knowledge has value, its usefulness is vastly increased by being easily accessible and its true value is often only apparent when its relevance to a current problem is recognised. Superb communication is vital to ensure that the full value of research is realised.

THE ENVIRONMENT

Maintenance of a healthy coal mining industry for the community means above all means the maintenance of high paying jobs.

However those not involved in coal mining object, at times strenuously, to the by-products of mining:

- visual pollution;
- nuisance noise and dust;
- increased heavy truck traffic near ports;
- subsidence over long wall mines affecting ground and surface water, buildings and roads, scenic rock formations etc;
- interference with alternative rural land uses; and
- salination of streams.

Whether it realises it or not, the community of course gains significantly from the provision of cheap electricity based on coal. However this is not without concerns in regard to:

- NOx, SOx and particulate emissions;
- Greenhouse emissions causing climate change;
- Effluent pollution of streams e.g., selenium poisoning; and
- Disposal of fly ash.

It is pretty clear then that if the community can comfortably enjoy the economic and life style benefits that coal mining undoubtedly brings, while having the side effects reduced or maintained within tolerable limits, then that would make a considerable difference to how the coal mining industry was perceived by the community.

It is difficult to see how the technical issues related to community concerns could be tackled in a more cost effective way than through a system such as ACARP.

The following are some of the environmental projects which ACARP has supported which are making a difference to the mining industry:

- Projects to improve the stability and drainage of spoil piles left by open cut coal mining;
- Projects to improve revegetation of spoil piles with native grasses, shrubs and trees;

- Projects to improve the quality of water in final voids;
- Projects to reduce noise and dust from open cut mining; and
- Projects to reduce the effects of mine subsidence.

MARKETING OF AUSTRALIAN COALS

Coal preparation

Some of the best results which ACARP has achieved have been in coal preparation research. This success makes a difference for the levy payer through:

- improved recoveries leading to higher mine yields;
- reduced risk of incurring penalties for being outside specifications for ash, and moisture;
- lower transportation charges; and
- reduced handling problems.

The customer also benefits through getting a consistent and improved product with lower ash, lower moisture, reduced impurities and better blends which improve such properties as coke strength, combustion efficiency and coal handling.

Coal utilisation

Work in this category is by definition highly customer oriented. The aim is to make Australian Coals work better, more cleanly and efficiently in whatever application they are used. If this happens the customer benefits and also the environment. If the environment benefits the adverse community pressure on the use of coal at all levels is reduced, whether it be in a prefecture in Japan, a local community in Australia worried about air toxics or the Federal Government trying to secure a slightly less unfavourable outcome for Australia from greenhouse treaty negotiations.

Much good work has been done s in many areas, such as:

1. improved combustion;
2. reduced NOx emissions;
3. reduced particulate emissions;
4. improved measurement and control of trace elements; and
5. improved coal grinding.

CONCLUSION

A research program such as ACARP not only has to add value for all its stakeholders, it must be clearly seen to be doing so.

Its primary focus must be on meeting the needs of the coal companies who pay the levy which funds it.

They get value by

- having their operational problems relieved by site based research;
- by keeping their key staff abreast of the latest technology;
- by the cross fertilisation of good ideas and by exposure to best practice;
- by being able to respond to community concerns in a systematic, coordinated and visible way;
- by being able to respond to government concerns in systematic, coordinated and politically effective way;
- by the maintenance of a core of talent in research establishments who can respond as needed where problems arise
- by helping attract and train good students who will enter the coal industry preferentially
- by helping to develop and sustain a local service and manufacturing response capability which can provide customised output for the local industry;
- by helping to maintain the public image, credibility and prestige of the coal industry.

This last point is more important than most people think. When coal companies think of competition, they think of other coal mines, either in Australia or overseas, which are competing for sales in Japan or Taiwan or Europe. They tend not to give full recognition to the primary competition within Australia for the very right to exist.

Coal companies compete for access to land against rural interests and the tendency to declare an increasing portion of the country national parks. They compete for finance and the best university graduates and they compete for public favour in the way business taxation is levied.

Consider these recent examples

- If a prospective coal mine planning to export A$100 million worth of coal a year, is competing with a small vineyard likely to produce wine worth less than one million dollars a year, which will have the most public sympathy?
- If the government is planning to take away a tax rebate on diesel fuel and it has to choose, which is it more likely to take it from, the grain growing industry or the mining industry?
- If you are a brilliant high school student what will you tend to study at university: law, accounting, medicine or mining engineering?

Public perception and political good will play a major role in decisions such as these and having an active research program which can ameliorate or prevent problems is not only good business sense, it can be very good PR. Coal mining is Australia's premier export industry. It is vital to the economic health of the country yet it has low public esteem, minimal political support and attracts few of the top graduates. Anything which adds to its prestige adds value.

In meeting the needs of the levy payers the research program is automatically adding value for the other stakeholders because coal mining does not occur in isolation. Coal mining will only be funded if its financiers believe they will get value; its products will only be saleable if its customers get value; it will only be the preferred land use option if the community feels that this use adds more value than alternatives and it will only get from its work force a profitable response if they feel it adds value to their lives. In all these interactions, a well managed and targeted research program can be a cost effective means of value addition for all the stakeholders.

ACARP has all these attributes and is certainly making a difference.

APPENDICES

Underground category

Major incident safety

Table 3 -Gas monitoring, drainage and control

		ACARP	OTHER	TOTAL
3029	Improved technology for maintaining hole integrity during gas drainage	25,000	25,000	50,000
3030	Real time monitoring of gas emissions	150,000	197,000	347,000
3034	Development of a general purpose hydrogen monitor	80,000	0	80,000
3076	Real time return gas monitoring for outburst and gas drainage assessment	91,163	171,164	262,327
3077	Gas detection technique to continuously monitor gas in drill fluid	45,000	15,000	60,000
4033	Stimulation of gas make from horiz in-seam drain holes by hydraulic fracturing	122,535	130,096	252,631
4040	Development of a hydrogen monitor for use in coal mines	139,253	220,000	359,253
5030	Development of a gas flow drainage meter	99,000	0	99,000
5036	Hydrofracture modelling to assess potential improvements to mine gas drainage	24,408	24,408	48,816
6020	Mine gas control	25,000	975,000	1,000,000
6021	Automatic shut-down valve for UG gas drainage lines (under vacuum)	40,000	15,000	55,000
6022	Automatic shut-down valve for UG gas drainage lines (positive pressure)	93,250	20,000	113,250
6031	Maximising coal production in the presence of H_2S seam gas	162,000	591,000	753,000
13 Proj	**TOTAL**	**1,096,609**	**2,383,668**	**3,480,277**

Table 4 -In-seam drilling

3070	In-seam drilling and bit location system	235,000	200,000	435,000
3071	Calliper probe for logging in-seam bore holes	41,680	28,000	69,680
3072	Borehole pressurisation system	135,290	40,000	175,290
3073	Bit, torque, load and RPM sensors	59,620	20,000	79,620
3074	Standards for in-seam drilling equipment	11,130	0	11,130
3075	In-seam drilling project coordinator	40,000	0	40,000
4035	Co-ordination of in-seam drilling research	44,000	0	44,000
4036	In-seam drill monitoring and bit location system stage 2	250,000	230,000	480,000
4037	Sensing and logging for in-seam boreholes	210,000	1,337,000	1,547,000
4038	Electronics for bit torque, load and rpm sensors (bitor electronics)	20,000	0	20,000
4039	Testing of drill rod joints for long hole drilling	90,000	20,000	110,000
5027	Co-ordination of in-seam drilling research	44,000	0	44,000
5028	Water jet assisted drilling	195,000	950,500	1,145,500
5029	Development of a new borehole survey tool	234,100	54,700	288,800
6027	Co-ordination of in-seam drilling research	44,000	0	44,000
6028	Longhole water jet assisted drilling	240,000	484,000	724,000

6029	Development of an intrinsically safe drill monitoring system Stage 3	75,000	55,000	130,000
17 Proj	**TOTAL**	**1,968,820**	**3,419,200**	**5,388,020**

Table 5 - Outbursting

3035	Improved remote control and monitoring of outburst mining equipment	170,000	248,000	418,000
3079	Workshop on management and control of outbursts in underground coal mines	25,000	20,000	45,000
4034	Outbursting scoping study	50,000	0	50,000
5034	Development of a borehole pressurisation tool for outburst assessment	156,850	53,150	210,000
5035	Prediction of outbursts using the occurrence of radon gas	79,500	78,000	157,500
5037	Degassing of methane and carbon dioxide	116,371	165,000	281,371
6023	Intercomparison of `quick crush' techniques used to measure gas content of coal	76,250	41,200	117,450
6024	Modelling of outburst mechanisms	100,000	266,000	366,000
6025	Detection of gas emission events precursive to outbursting using seismic	65,000	123,250	188,250
6026	Bore hole dielectric probe to detect mylonite zones and other structures	130,000	110,000	240,000
10 Proj	**TOTAL**	**968,971**	**1,104,600**	**2,073,571**

Table 6 - Detection and prevention of fires and explosions

3022	Reduction in earth fault currents by improved earthing reactor use	54,000	0	54,000
3083	High voltage cable test apparatus	35,000	0	35,000
4030	Design and efficiency of dust and water explosion barriers in modern Australian mines	65,410	0	65,410
4031	Research into the failure of 11kv plugs and adaptors used in underground coal mines	164,000	233,000	397,000
4032	Study of safety aspects of sheet metal IP55 enclosures in high fault level mines	118,000	18,000	136,000
5031	Development of better indicators for spontaneous combustion	166,747	143,920	310,667
5032	Further research into failure of 11KV plugs and adaptors in underground coal mines	75,000	0	75,000
5033	Improved flammability test methods for conveyor belting material	214,150	111,000	325,150
5430	Design and efficiency of dust and water explosion barriers in modern Australian mines	22,535	0	22,535
6001	Improved prediction of spontaneous combustion	172,000	176,144	348,144
6002	Demonstration of sealing and monitoring during low flow goaf inertisation	238,000	100,000	338,000
6018	Design and efficiency of dust and water explosion barriers Stage 2	161,525	0	161,525
6019	Demonstration & evaluation of jet engine inertisation techniques	432,512	515,100	947,612
13 Proj	**TOTAL**	**1,918,879**	**1,297,164**	**3,216,043**

Table 7 - Strata control

3025	Field trials flexible roof bolt project	120,000	0	120,000
3027	Improving reinforcement design	120,000	0	120,000
3032	Improved roof stability through pre-tensioned roofbolting	100,000	0	100,000
3059	Rib mechanics and support systems	70,000	70,000	140,000
3067	Roof and goaf monitoring for strata control in longwall mining	120,500	427,500	548,000
3068	Cost effectiveness of various timber chock constructions for longwall tailgate support	25,000	10,462	35,462
3069	Determination of stress relaxation axes in drill core using laser micromertry	90,000	306,000	396,000
3104	Rib bolting commissioned study	17,400	0	17,400
3105	Underground thick seam rib support	0	60,000	60,000
4024	Testing of roadway roof integrity	90,000	60,000	150,000
4025	Prestressing of strands to improve cable support performance	195,000	0	195,000
4026	Engineered mine design in soft strata environments	292,888	585,091	877,979
4027	Detection of incompetent mine roof (Stage 2)	50,000	18,000	68,000
5021	Post grouting technology to reduce bolting cycle times	163,500	200,000	363,500
5022	Early prediction of catastrophic roof failure	90,000	20,000	110,000
5023	Improved reinforcement techniques for weak roof	165,000	205,000	370,000
5024	Measuring the strength of irregular shaped and rectangular pillars	21,700	17,768	39,468
5025	Improved monitoring system for better roof management	125,000	120,000	245,000
6030	The dynamics of windblasts in UG coal mines	165,000	153,000	318,000
6033	Improving the up-time efficiency of roadway development units by reduced primary bolting densities and routine secondary support	200,000	800,000	1,000,000
6034	Improving safety and performance of chock construction	71,080	20,120	91,200
20 Proj	**TOTAL**	**2,292,068**	**3,072,941**	**5,365,009**

Table 8 - Escape and rescue

3078	Numbat upgrade approval and demonstration	60,000	110,000	170,000
5039	New self contained self rescuer	110,000	10,000	120,000
	Numbat upgrade approval and demonstration	530,000	0	530,000
3 Proj	**TOTAL**	**700,000**	**120,000**	**820,000**

OH & S general

		ACARP	OTHER	TOTAL
3 Proj	(i) Improved systems for capturing incidence and causality data particularly in relation to permanent disablement	0	0	0
3 Proj	(ii) Dust control	0	0	0
5 Proj	(iii) Reduced musculo-skeletal injuries	0	0	0
1 Proj	(iv) Reduced noise induced hearing loss	87,650	45,350	133,000
1 Proj	(v) Reduced injuries due to vibration and jarring	77,820	43,350	121,170
2 Proj	(vii) General	80,000	0	80,000
		245,470	**88,700**	**334,170**

OH&S general

Table 9 - Improved systems for capturing incidence and causality data particularly in relation to permanent disablement

3046	OH&S commissioned study	27,773	47,140	74913
4044	OH&S commissioned study	15,000	0	15,000
6032	Improved incident reporting and analysis	20,000	0	20,000
3 Proj	**TOTAL**	**62,773**	**47,140**	**109,913**

Table 10 - Dust control

3082	Reduction of dust in return roadways of longwall faces	42,500	231,500	274,000
4041	Electrostatic enhancement of water sprays for dust suppression	88,000	177,250	265,250
5019	Improved longwall dust suppression	35,000	242,000	277,000
3 Proj	**TOTAL**	**165,500**	**650,750**	**816,250**

Table 11 - Reduced musculo-skeletal injuries

3031	On-board rib bolting	100,000	0	100,000
3038	Development of a compact semi-automatic roof bolter	208,000	0	208,000
3060	Extension of compact autobolter project	175,000	0	175,000
3066	Application of light alloys and alternate materials in underground coal mines	104,350	0	104,350
5366	Application, risk and benefits of using aluminium in UG coal mines	10,000	0	10,000
5 Proj	**TOTAL**	**597,350**	**0**	**597,350**

Table 12 - Reduced noise induced hearing loss

4043	Adapting active noise control headsets for the coal mining industry	87,650	45,350	133,000
1 Proj	**TOTAL**	**87,650**	**45,350**	**133,000**

Table 13 - Reduced injuries due to vibration and jarring

5040	Development of test procedure for assessing whole body vibration	77,820	43,350	121,170
1 Proj	**TOTAL**	**77,820**	**43,350**	**121,170**

Table 14- Reduced exposure to diesel exhaust

3033	Improved diesel engine performance with lower emissions	317,000	174,000	491,000
3080	Evaluation and control of employee exposure to diesel exhaust emissions	223,000	0	223,000
3081	Effects of diesel fuel quality on exhaust emissions of U/G mining engines	87,000	0	87,000
3 Proj	**TOTAL**	**627,000**	**174,000**	**801,000**

Table 15 – General

5038	Development of a standard underground approval system	30,000	0	30,000
6058	Exchange of OHS data with South Africa	50,000	0	50,000
2 Proj	**TOTAL**	**80,000**	**0**	**80,000**

Open Cut Category

Table 16 - Open cut vehicle and equipment

Projects		ACARP	OTHER	TOTAL
4013	Intelligent dumper and hauler suspension systems	125,000	20,000	145,000
5041	Reflective material for improving night time driving on haul roads	66,000	45,000	111,000
5413	Intelligent dumper and hauler suspension system	29,500	0	29,500
6007	Intelligent dumper and hauler suspension systems (Stage 3)	140,000	77,000	217,000
6008	Development of a whole body vibration dosimeter	96,850	43,650	140,500
5 Proj	**TOTAL**	**457,350**	**185,650**	**643,000**

Table 17 - OH&S General

4012	Multifactorial back damage intervention study	209,500	0	209,500
4014	Emissions from spoil-pile fires	154,000	25,000	175,000
2 Proj	TOTAL	363,500	25,000	**384,500**