

# Coal – Energy for Sustainable Development

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## Key messages

Coal is the most widely available fossil fuel resource. It forms the backbone of the world's electricity supply, providing more than 40% of our electricity needs. It is also a key component in the production of steel and concrete; vital materials in building sustainable societies.

Energy is critical to sustainable development - to building stronger communities with hospitals and schools. It supports business and industry so that they can deliver sustainable employment and economic growth.

Across the world there are 1.3 billion people without access to electricity. International action is needed to change this. It is predicted that by 2035, unless action is taken, around one billion people will still be living without electricity.

The world needs an energy access target to provide energy to those who need it most.

Coal will be the bedrock on which energy access is built. International Energy Agency projections show that it will provide more than half of the 'on-grid' electricity needed to deliver energy for all.

Clean coal technologies, such as advanced coal-fired power generation and carbon capture and storage, can enable the world's coal resource to be used in line with environmental and climate objectives.

Coal mining provides more than seven million jobs worldwide and in 2010 the industry invested more than US\$7 billion in capital expenditure in developing countries.

## Part 1

### The global energy challenge

In 1992 the first Rio Conference took place. But after twenty years of action to address the challenges of sustainable development, billions of people across the world still live in poverty. For so many, living in poverty means living with unfulfilled potential. It is brought about by a lack of opportunity, of economic and educational advantages and a lack of access to energy. Poverty leads to poor health outcomes and premature death because people are unable to access clean water, nutrition, health care, education, clothing and shelter.

Access to energy is essential to addressing the problems that cause poverty. After food and shelter, energy is one of the fundamentals of modern society. Without energy, people cannot access the opportunities provided by the modern world.

A life lived without energy, is a life lived in poverty.

The world must take action. Before we can meet the myriad development challenges faced by those most in need, we need to provide access to energy. Growing, dynamic economies are essential prerequisites to addressing the environmental challenges that confront us this century.

#### Global energy poverty and its impact

Today there are 1.3 billion people across the globe without access to electricity and 2.7 billion people who don't have clean cooking facilities. The problem is spread across the developing world, but it is particularly severe in sub-Saharan Africa and developing Asia, which together account for 95% of people in energy poverty.

At 89%, the Democratic Republic of Congo has the highest percentage of population lacking access to electricity.

Without targeted global action, the International Energy Agency (IEA) estimates that in 2035 there will still be one billion people without access to electricity and 2.7 billion without access to clean cooking fuels.

Without a commitment to achieve universal energy access it has been estimated that by 2030, there will be an additional 1.5 million premature deaths per year caused by household pollution from burning wood and dung and through a lack of basic sanitation and healthcare. Modern energy sources are essential to meeting these challenges.

There are examples that show the impact that dedicated action can have. China doubled its energy output from 1990 to 2005 and electrification increased to just over 99%. The level of electrification in South Africa rose from 36% in 1994 to 75% at the end of 2009.

While there are many points of comparison and contrast between these examples, it cannot be ignored that both have benefited from ease of access to large reserves of coal (see figure 2).

**Figure 1. Global energy poverty**



Source: International Energy Agency, World Energy Outlook 2011

However, the challenge remains immense. The latent demand for electricity is huge. An estimated 400 million people in India still lack access to electricity. By 2030 this is only expected to fall to 300 million.

Beyond households and individuals, energy access is also critical to the broader economy and society.

Businesses and industries are major consumers of electricity. Globally, industrial use of electricity accounted for around 42% of consumption in 2008. Economic growth through the expansion of business and industry will be the only way that poverty can be eradicated in developing countries. Business and industry needs reliable base load electricity in order to expand. In the developing world, economic

expansion will provide secure employment. Without this, hundreds of millions of people will remain in poverty, particularly in urban areas.

Other essential social services are also heavily reliant on a modern, reliable electricity supply. Hospitals and schools cannot function effectively without access to electricity and in many developing countries the lack of electricity compounds the problems of disease and poor education.

This is why improving access to modern energy in the developing world is so important. The world needs to adopt targets for energy access that will support residential, industrial and social access to electrical services.

Without targeted global action, the IEA estimates that in 2035 there will still be one billion people without access to electricity and 2.7 billion without access to clean cooking fuels.

**Figure 2. Electrification and coal reserves**

Country	Electrification rate (2009)	Coal reserves (million tonnes)	% coal from electricity (2008)
China	99.4%	114,500	79%
South Africa	75%	30,156	93%

### Energy access targets

The world currently lacks an internationally agreed global target to improve access to electricity. The targets that do exist lack ambition.

The IEA's World Energy Outlook 2011 provides a definition of what its own energy access targets would deliver in terms of electricity for domestic use. In rural areas their targets would support "use of a floor fan, a mobile phone, and two compact fluorescent light bulbs for about five hours a day. In urban areas, consumption might also include an efficient refrigerator, a second mobile phone per household and another appliance, such as a small television or a computer." Critically, the definition also states "some other categories are excluded, such as electricity access to business." Other international agencies use similar definitions.

The targets also focus on the need to provide clean cooking fuels. This is vitally important because the burning of wood and dung reduces air quality in the home. It is also a major cause of respiratory disease. The daily forage for fuels of this type can leave people physically and emotionally depleted and with little spare time to devote to their economic and social advancement. Alongside providing small-scale, off-grid renewable power sources, providing clean cooking fuels will be important in the short to medium term in addressing the health challenges caused by energy poverty. However, targets based solely on providing for these minimal requirements ignore the true scale of effort needed to eradicate poverty – and the energy needed to match that ambition.

A recent study<sup>1</sup> considered the current situation in sub-Saharan Africa. It looked at the expansion of electricity that would be needed on an economy-wide basis to comprehensively address energy access. To reach what the study described as "moderate access" to energy, where electricity generation capacity is around 200-400MW per million of population, the region would need a total of around 374GW of installed capacity. That's about 12 times the capacity that exists in sub-Saharan Africa today.

To achieve that level of capacity, the study estimated that an annual growth rate in electricity of around 13% would be needed for the next 20 years. In the past 20 years the average has been only 1.7%. This demonstrates the significant challenge faced in providing a genuine level of energy access.

To consider this issue in context, South Africa currently has around 800MW of installed capacity per million people, and yet this country still faces its own significant challenges in providing energy to its population. India currently has an installed capacity of around 130MW per million people while in the United States and Europe the figures are around 2826MW and 1733MW respectively.

The scale of that challenge is shown in Figure 3. Current debates about providing universal energy access often assume that access brings people in developing countries to a level at least broadly comparable to that which exists in the developed world. But in reality, even to provide basic energy access, in line with a middle income country, would require a dramatic transformation of the electricity supply in these countries.

### Achieving energy access

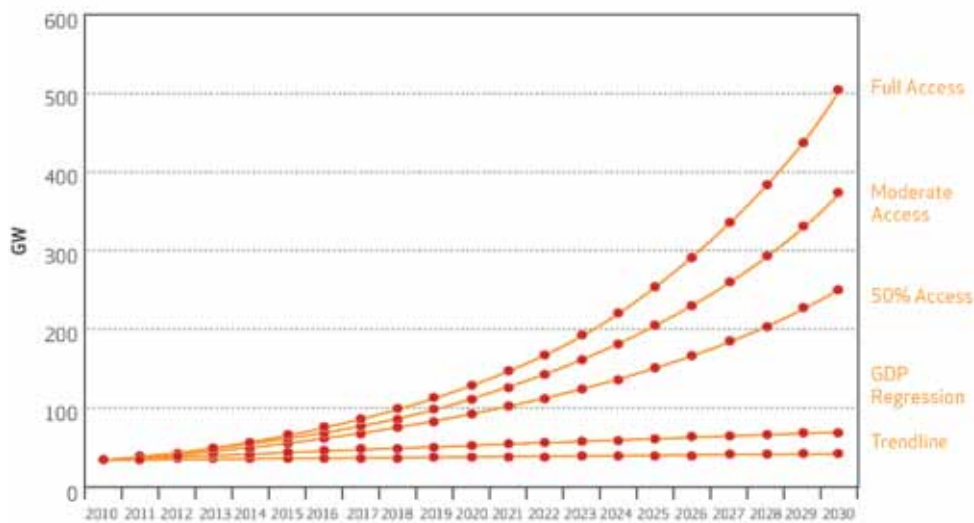
Despite the many challenges, there is nothing preventing the provision of energy to those who currently lack it. With ambitious action these challenges can be overcome. The technology already exists. National electricity grids are in place and can be further developed to ensure electricity is dispersed across countries. However, significant investment in electricity grids is required in many of the least developed countries. Strong grid structures are essential to even out peaks and troughs in the generation of renewable electricity and they can very effectively distribute centralised base load electricity.

All energy sources have some role to play in feeding those grids, including nuclear, hydro and the provision of renewable energy. However, base load power generation through the use of fossil fuels, and especially with coal, is the only way to provide affordable, safe and reliable electricity at the scale

► *The world currently lacks an agreed global target to improve access to electricity. The targets that do exist lack ambition.* ◀

<sup>1</sup> Bazilian, et al, "Energy access scenarios to 2030 for the power sector in sub-Saharan Africa"

**Figure 3. Scenarios and projections for installed power capacity in sub-Saharan Africa (excluding the Republic of South Africa) 2010-2030**



Source: Bazilian, et al, "Energy access scenarios to 2030 for the power sector in sub-Saharan Africa"

that is needed to achieve genuine access to modern electricity services. Coal is, and will continue to be, the backbone of global electricity generation. It will be fundamental to expanding generating capacity in many developing countries.

Along with the ambition to achieve real energy access in the developing world, three elements are necessary to help realise this vision:

**1** The right **policy frameworks** must be put in place, both on a national and international basis, to support effective energy institutions and business models that support the deployment of a comprehensive energy infrastructure where it is needed most.

**2** These frameworks will **encourage access to finance** from all sources, public and private, domestic and international. This will provide the right level of investment to build the energy infrastructure that is so badly needed.

**3** It must be recognised **that all sources of energy are necessary** to meet the vast potential demand for electricity. It is important to understand that different sources of energy will suit different countries and different environments. To ensure that energy reaches those who need it most, there cannot be a political preference for one technology over another. The decision must be based on what is most effective in meeting the energy need.

**The role of coal in providing energy access**

Coal resources exist in many developing countries, including those with significant energy challenges. Coal will therefore play a major role in supporting the development of base-load electricity where it is most needed. Coal-fired electricity will be fed into national grids and it will bring energy access to millions and support economic growth in the developing world.

The World Energy Outlook 2011 highlights that “coal alone accounts for more than 50% of the total on-grid additions” required to achieve the IEA’s Energy for All case. This clearly demonstrates coal’s fundamental role in supporting modern base load electricity. Many countries with electricity challenges are also able to access coal resources in an affordable and secure way to fuel the growth in their electricity supply.

As nations develop, they seek secure, reliable and affordable sources of energy to strengthen and build their economies – coal is a logical choice in many of these countries because it is widely available, safe, reliable and relatively low cost. This has been demonstrated in Vietnam, in China, in South Africa, and many other countries. Many developing countries have significant, untapped coal reserves.

The fact that coal is expected to account for more than 50% of total on-grid additions demonstrates coal’s continuing role as the backbone of our global electricity supply. Coal met around half of the incremental growth in global primary energy demand in the decade 2000-2010. These figures demonstrate coal’s central role in supporting increasing electricity demand in the future, particularly in a world where more than a billion people live in energy poverty. If the world is to be ambitious beyond current energy access targets, then coal will be needed to meet a significant proportion of that latent demand.

There is a huge opportunity to ensure that modern and clean coal technologies can be part

of addressing the challenge of energy poverty. National and international policy frameworks and financing mechanisms must support the deployment of the most efficient and cleanest coal technology. If these frameworks are not in place, then less efficient technologies with greater environmental consequences are likely to prove more attractive on a cost basis than more expensive but also more efficient and cleaner technologies.

**Energy and climate change**

In the face of global action to address climate change, it has been argued that the expansion of energy access could threaten international climate ambitions which aim to cap atmospheric CO<sub>2</sub> at 450 parts per million and keep global warming less than two degrees above pre-industrial levels. Developing countries have been concerned that requiring them to reduce emissions will threaten achievement of their legitimate development priorities.

However, an effective and sustainable climate response must integrate environmental aims with energy security and economic development. The world’s least developed countries need access to low cost energy, but they are also the most vulnerable to the impacts of policies aimed at reducing greenhouse gas emissions.

As demand for energy increases, affordable and sustainable sources of energy are essential to addressing the challenge of reducing greenhouse gas emissions whilst achieving access to energy. Without first addressing the challenge of poverty, developing economies will not have the capacity to focus their attention on reducing their greenhouse gas emissions.





While addressing climate and energy challenges together seems contradictory to some, the reality is that they must be considered as integrated priorities.

Importantly, energy needs can be met without impacting climate ambitions. The World Energy Outlook 2011 highlights that achieving the Energy for All case would only increase CO<sub>2</sub> emissions by 0.8% while avoiding the premature deaths of 1.5 million people. As has been noted above, achieving the Energy for All case includes significant coal-fired additions to national electricity grids. So the choice of energy sources for bringing electricity to those who need it will make almost no impact on climate action. This means that in reality there is no climate-based reason to limit the fuels from which energy can be sourced. Renewable sources have a large role to play but there is no climate-based reason to weigh energy access efforts strongly towards renewable energy sources.

The focus needs to be on ensuring that energy is delivered to those who need it. Rather than focussing on particular low-carbon sources of energy, they should all be made available, leaving national governments to choose what is most suitable for their circumstances.



## Part 2

### Coal and clean energy

Coal is the backbone of modern electricity. Coal currently supplies around 30% of primary energy and 41% of global electricity generation. Coal use is forecast to rise over 50% to 2030, with developing countries responsible for 97% of this increase, primarily to meet improved electrification rates.

Between 2000 and 2010 it is estimated that coal met around half of global incremental energy demand (see figure 4). Despite the rapid deployment of renewable energy technologies, particularly in the context of debates about climate change, it has been coal that has accounted for the largest increase in energy demand among the range of energy sources. The growth in coal usage, in both volume and percentage terms, was greater than any other fuel.

Coal has met this significant growth in energy demand because of its status as a reliable, widely distributed and affordable fuel. Coal is also the least subsidised of all fuel sources. According to the IEA, "...consumption subsidies to coal worldwide are small and diminishing, compared with those to oil products, natural gas and electricity, accounting for only 0.7% of these subsidies".

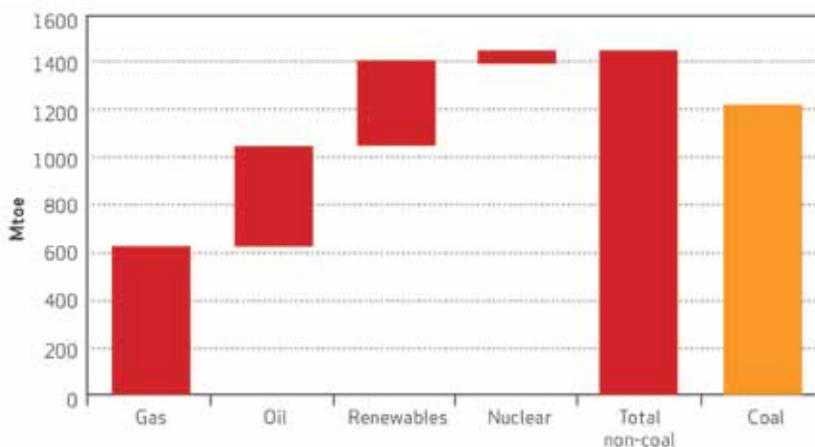
Coal will also play a major role as a complement to renewable energy sources. It will be one of the key sources of energy to address gaps in wind and solar powered electricity, both of which include risks of intermittent supply.

The World Bank recognises the significant role that coal energy plays in securing energy supplies, especially in developing economies. This was demonstrated by the decision in 2010 to provide funding for the development of the Medupi power station in South Africa where the President of the World Bank stated that, "Coal is still the least-cost, most viable, and technically feasible option for meeting the base load power needs required by Africa's largest economy".

This is also recognised by the IEA. In its World Energy Outlook 2011, it highlighted that coal will play an important role in underpinning the increase in power generation that is needed to provide electricity to the 1.3 billion people that currently do not have it, stating, "more than half of the ... increase in on-grid electricity generation capacity is expected to be coal-fired."



Figure 4. Incremental world primary energy demand by fuel, 2000-2010



Source: IEA, WEO 2011

### The coal resource

Coal is the most widely available fossil fuel energy resource. Unlike gas and oil it is widely distributed, both geographically and in terms of resource ownership. Its abundance provides energy security to many countries because its supply will last significantly longer than gas or oil. It is predicted that coal will continue to play a very significant role in world primary energy demand well into the future.

It has been estimated that there are over 860 billion tonnes of proven coal reserves worldwide. This means that there is enough coal to last us at least 118 years at current rates of consumption. In contrast, proven oil and gas reserves are equivalent to around 46 and 57 years at current consumption levels. However, reserve estimates vary. Worldwide, potential coal resources dwarf proven reserves and many analysts believe that coal could last considerably longer. Some deposits

are estimated to have as much as 400 years of production remaining and new technologies for utilising coal resources, such as underground coal gasification, are likely to boost coal's future role in energy supply even further.

Coal reserves are available in almost every country worldwide, with recoverable reserves in around 70 countries. The largest reserves are in the USA, Russia, China and India.

Importantly, many countries with significant energy poverty challenges also have significant coal reserves. The ability to utilise domestic coal reserves to address problems of energy access reduces reliance on imported energy, particularly oil and gas which are often sourced from unreliable and unstable markets. Utilisation of coal to complement renewable energy sources, particularly wind, reduces the risk of an intermittent supply.

Many African countries have coal reserves; however, South Africa has by far the most abundant reserves and has already developed a significant coal industry. Furthermore, a number of southern African states believe they have significant coal reserves that have not yet been properly assessed. This could significantly increase the potential role for coal in the African region.

**Figure 5. Proved recoverable reserves of coal in sub-Saharan Africa at end-2008 (million tonnes)**

Country	Total reserves
Botswana	40
Central African Republic	3
Congo (Democratic Republic)	88
Malawi	2
Mozambique	212
Niger	70
Nigeria	190
South Africa	30,156
Swaziland	144
Tanzania	200
Zambia	10
Zimbabwe	502

Source: World Energy Council, Survey of Energy Resources 2010

While the reserves in other sub-Saharan countries are dwarfed by those of South Africa, many have sizeable deposits that could supply secure and reliable energy to help grow their domestic economies.

South Africa obtains over 90% of its electricity from coal and has developed extensive coal conversion projects, especially coal-to-liquids (CTL). Currently around 30% of South Africa's gasoline and diesel needs are produced from indigenous coal.

South Africa's considerable coal reserves also make it a key member of the Southern African Power Pool, which establishes a common power grid and a common power market across countries in the Southern African Development Community.

These resources allow South Africa to export electricity to a number of countries in the area – including Botswana and Namibia – both countries where over half the population has no electricity. This means South African coal could play a significant role in expanding energy access in the region.

In Asia, coal reserves are more widely dispersed. China, India and Kazakhstan all have reserves greater than South Africa and a further five countries have well over a billion tonnes of available reserves.

**Figure 6. Proved recoverable reserves of coal in Asia at end-2008 (million tonnes)**

Country	Total reserves
Afghanistan	66
Armenia	163
Bangladesh	293
China	114,500
Georgia	201
India	60,600
Indonesia	5529
Japan	350
Kazakhstan	33,600
Korea (Democratic People's Republic)	600
Korea (Republic)	126
Kyrgyzstan	812
Laos	503
Malaysia	4
Mongolia	2520
Myanmar (Burma)	2
Nepal	1
Pakistan	2070
Philippines	316
Taiwan, China / Chinese Taipei	1
Tajikistan	375
Thailand	1239
Turkey	2343
Uzbekistan	1900
Vietnam	150

Source: World Energy Council, Survey of Energy Resources 2010

▶ South African coal could play a significant role in expanding energy access in the region. ◀

Many of the countries with significant coal reserves also have substantial coal production. However, there are a number of countries whose coal reserves are yet to be utilised at a large scale. This provides both economic opportunity for countries such as Indonesia, Mongolia and Pakistan, amongst many others, to further develop their coal extraction industry and a great potential for a secure and affordable domestic energy supply using their indigenous coal resource.

Coal mining plays a significant role in many national economies. Developing economies rank highly among the world's major coal producing nations. In the cases of China, India, South Africa and Kazakhstan much of this is utilised for domestic electricity generation. However, these countries also have large coal export markets which create valuable foreign investment. Colombia and Indonesia both earn considerable export revenues from coal production industries that are heavily export-focused.

**Figure 7. Top Ten Hard Coal Producers (2010e)**

PR China	3162Mt	Russia	248Mt
USA	932Mt	Indonesia	173Mt
India	538Mt	Kazakhstan	105Mt
Australia	353Mt	Poland	77Mt
South Africa	255Mt	Colombia	74Mt

Source: IEA 2011

Coal plays a vital role in electricity generation worldwide. Coal-fired power plants currently fuel 41% of global electricity. In some countries, coal fuels an even higher percentage of electricity.

**Figure 8. Coal in electricity generation**

South Africa	93%	Israel	63%
Poland	92%	Czech Rep	60%
PR China	79%	Morocco	55%
Australia	77%	Greece	52%
Kazakhstan	70%	USA	49%
India	69%	Germany	46%

Source: IEA 2010

The importance of coal to electricity worldwide is set to continue. In the IEA's central New Policies Scenario, coal is still expected to provide around 33% of global electricity generation in 2030. However, that scenario requires implementation of all policies currently planned by governments and therefore comes with considerable uncertainty. It also does not include the very significant increases in electricity needed to reach targets beyond the IEA's Energy for All scenario to provide even greater electricity in the developing world – which will likely see an even greater role for coal in securing those energy supplies. It is thought that this scenario would bring coal's share in future electricity generation more in line with the IEA's Current Policies Scenario forecast for 2035 of around 43%.

To meet the huge global demand for energy, all energy sources will be needed. Different sources of energy will suit different countries and different environments. Depending on the availability of natural resources, a decision may be taken between coal and gas as the most viable means of powering base load electricity. In many cases both will have a role to play. Nuclear technology may be available in some countries and not others. Renewable energy will have a particular role to play in providing off-grid electricity and in meeting peak demand. In countries where there is a significant coal resource, it is likely to be the preferred fuel for supplying base load electricity. In many cases this will be a matter of affordability and security.

### Energy efficiency

Efficiency in coal-fired power generation will play an important role in the future production of electricity. This is particularly the case with the potential for high efficiency power generation to reduce CO<sub>2</sub> emissions.



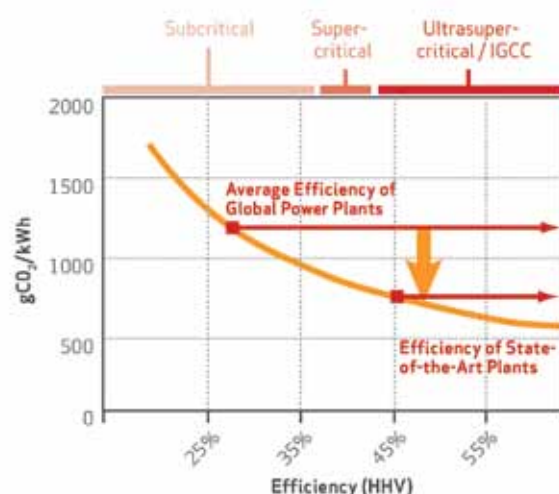
Improving efficiency levels increases the amount of energy that can be extracted from a single unit of coal. Increases in the efficiency of electricity generation are essential in tackling climate change. A single percentage point improvement in the efficiency of a conventional pulverised coal combustion plant results in a 2-3% reduction in CO<sub>2</sub> emissions. Highly efficient modern supercritical and ultra-supercritical coal plants emit almost 40% less CO<sub>2</sub> than subcritical plants.

Efficiency improvements include the most cost-effective and shortest lead time actions for reducing emissions from coal-fired electricity. This is particularly the case in developing countries and economies in transition where existing plant efficiencies are generally lower and coal use in electricity generation is increasing.

The average global efficiency of coal-fired plants is currently 28% compared to 45% for the most efficient plants (see figure 9). A programme of repowering existing coal-fired plants to improve their efficiency, coupled with the newer and more efficient plants being built, will generate significant CO<sub>2</sub> reductions of around 1.8 gigatonnes annually. Although the deployment of new, highly efficient plants is subject to local constraints, such as ambient environmental conditions and coal quality, deploying the most efficient plant possible is critical to enable these plants to be retrofitted with CCS (carbon capture and storage) in the future.

Improving the efficiency of the oldest and most inefficient coal-fired plants would reduce CO<sub>2</sub> emissions from coal use by almost 25%, representing a 6% reduction in global CO<sub>2</sub> emissions. By way of comparison, under the Kyoto Protocol, parties have committed to reduce their emissions by “at least 5%”. These emission reductions can be achieved by the replacement of plants that are < 300 MW capacity and older than 25 years, with larger and markedly more efficient plants and, where technically and economically appropriate, the replacement or repowering of larger inefficient plants with high-efficiency plants of >40%.

**Figure 9. Reducing emissions through efficiency improvements**



Source: IEA "Focus on Clean Coal" (2006)

Note: 1% increase in efficiency = 2-3% decrease in emissions

The role of increased efficiency as a means to CO<sub>2</sub> mitigation is often overlooked in discussions about climate and energy. As is noted in World Energy Outlook 2011 (WEO), "If the average efficiency of all coal-fired power plants were to be five percentage points higher than in the New Policies Scenario in 2035, such an accelerated move away from the least efficient combustion technologies would lower CO<sub>2</sub> emissions from the power sector by 8% and reduce local air pollution". It is also important to note that the cost of avoided emissions from more efficient coal-based generation can be very low, requiring relatively small additional investments. This is especially the case when compared to the cost of avoided emissions through deployment of renewables and nuclear.

### Carbon capture and storage

Carbon capture and storage technology will be a key technology to reduce CO<sub>2</sub> emissions, not only from coal, but also natural gas and industrial sources. Figures in the IEA's WEO 2011 report estimate the potential for CCS to contribute 22% of global CO<sub>2</sub> mitigation through to 2035. Further



analysis by the IEA in their Energy Technology Perspectives 2010 report also shows that climate change action will cost an additional US\$4.7 trillion without CCS.

Like all new low emission energy technologies, CCS will cost significantly more than conventional technology and requires extended development time. While available on a component-by-component basis, CCS has not yet been commercially proven on an integrated basis or at the scale required to meet global greenhouse gas concentration targets. Once demonstrated, CCS will enable countries to rely on secure and affordable energy sources such as coal without compromising their environmental ambitions.

Further investment is needed to fast-track CCS demonstration and allow for the necessary cost reductions that will support the future large scale deployment of CCS. Along with the significant investments already being made by governments in developed economies and China, an important aspect of CCS deployment in developing countries

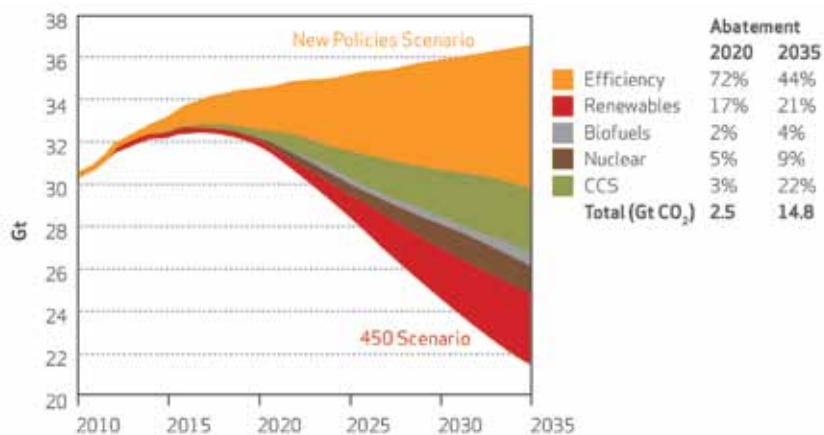
will be the recent inclusion of CCS in the Clean Development Mechanism; an important step for its inclusion in other future climate financing instruments, such as the Green Climate Fund.

### Utilising captured CO<sub>2</sub> to secure energy supplies

Another technology of growing importance in securing national energy supplies is carbon capture, utilisation and storage (CCUS). It provides a pathway to two important energy goals of many countries – producing reliable and affordable electricity from coal power plants while reducing greenhouse gas emissions and producing more oil to meet growing demand and enhance national security. Utilising the CO<sub>2</sub> from the consumption of fossil fuels is a crucial step in economically reducing greenhouse gas emissions.

About two-thirds of a reservoir's original-oil-in-place remains untapped after primary and secondary operations because it is too difficult or expensive to extract. With evolving technology, however, significantly more of the reservoir's remaining oil can be produced. Injecting CO<sub>2</sub>

Figure 10. Key technologies for reducing CO<sub>2</sub> emissions



Source: IEA Energy Technology Perspectives 2010

underground to produce such ‘stranded’ oil is known as enhanced oil recovery (EOR). Over 110 projects using this established technology are currently producing about 280,000 barrels of oil per day in the United States alone and the technology is also being developed in many other oil-producing nations.

EOR would support the deployment of CCS and create a revenue stream for CCS projects as the CO<sub>2</sub> captured becomes an economic resource. Deployment of this technology at a global level requires further investigation. However, early studies demonstrate that there is significant capacity for storage of CO<sub>2</sub> in under-utilised oil fields.

The process of EOR will stimulate economic growth and create jobs not only in local areas, but regionally and nationally as well. The capture of former “waste” CO<sub>2</sub> will create a valuable resource that can be used for EOR where supplies of CO<sub>2</sub> are now inadequate. Further, as University of Texas researchers have pointed out, utilisation of greater amounts of CO<sub>2</sub> for EOR will provide a commodity value that can be used to reduce the cost of capture and the financial burden on power consumers such as families and businesses.

With higher oil prices predicted for the future, securing and enhancing oil supplies should be a major international priority. The IEA has indicated that the world needs to invest over US\$10 trillion in oil infrastructure over the next two decades, EOR should be one of the technologies utilised to improve global oil supplies.

### Clean fuels from coal

In addition to improvements in the efficiency of coal-fired power stations and the deployment of CCS for electricity generation, the world’s significant coal resources can also be deployed to support other energy needs.

### Coal to liquids

Converting coal to a liquid fuel – a process referred to as coal liquefaction – allows coal to be utilised as an alternative to oil.

CTL is particularly suited to countries that rely heavily on oil imports and have large domestic reserves of coal.

South Africa has been producing coal-derived fuels since 1955 and has the only commercial coal to liquids industry in operation today. Not only are CTL fuels used in cars and other vehicles, but South African energy company Sasol’s CTL fuels also have approval to be used in commercial jets. Currently around 30% of the country’s gasoline and diesel needs are produced from indigenous coal. The total capacity of the South African CTL operations stands in excess of 160,000bbl/d.

Fuels produced from coal can also be used outside the transportation sector. In many developing countries, health impacts and local air quality concerns have driven calls for the use of clean cooking fuels. Replacing traditional biomass or solid fuels with liquefied petroleum gas (LPG) has been the focus of international aid programmes. LPG, however, is an oil derivative – and is thus affected by the expense and price volatility of crude oil. Coal-derived dimethyl ether (DME) is receiving particular attention today as it is a product that holds out great promise as a domestic fuel. DME is non-carcinogenic and non-toxic to handle and generates less carbon monoxide and hydrocarbon air pollution than LPG.

### Underground coal gasification

Underground coal gasification (UCG) is a method of converting unworked coal - coal still in the ground - into a combustible gas which can be used for industrial heating, power generation or the manufacture of hydrogen, synthetic natural gas or diesel fuel.

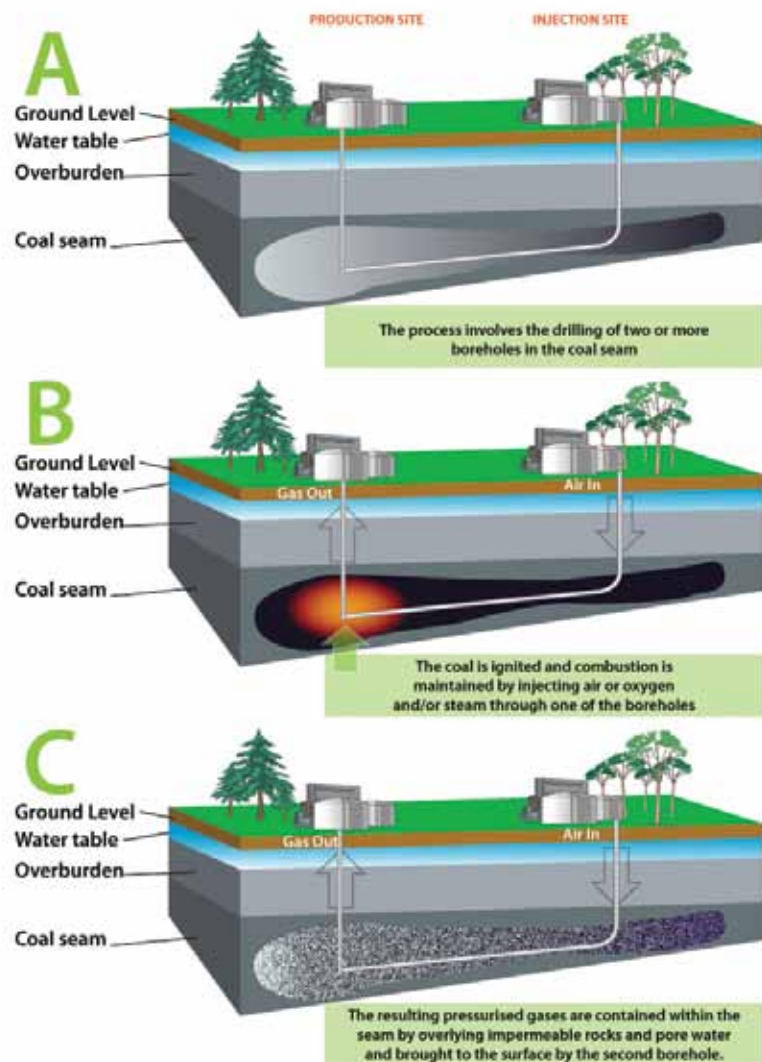
▶ Coal-derived dimethyl ether (DME) is receiving particular attention today as it is a product that holds out great promise as a domestic fuel. ◀



In the last few years there has been significant renewed interest in UCG as the technology has moved forward considerably. China has about 30 projects using underground coal gasification in different phases of preparation. India plans to use underground gasification to access an estimated 350 billion tonnes of coal.

South African companies Sasol and Eskom both have UCG pilot facilities that have been operating for some time, giving valuable information and data. In Australia, Linc Energy has the Chinchilla site, which first started operating in 2000. Demonstration projects and studies are also currently under way in a number of countries, including the USA, Western and Eastern Europe, Japan, Indonesia, Vietnam, India, Australia and China, with work being carried out by both industry and research establishments.

**Figure 11. How underground coal gasification works**



Source: UCG Association

## Part 3

### Coal and sustainable development

In addition to its direct role as an energy resource, coal plays a significant global role in sustainable development.

Coal mining is a critical contributor to many economies. From providing employment, export and royalty revenues through to local services and the development of infrastructure, coal mining makes a substantial contribution to improving the livelihoods of many. This is especially true in developing countries where coal mining makes a major contribution to national economies allowing them to grow stronger and address the challenges of poverty and development.

Coal is also a key component of important industrial processes such as steel and cement manufacturing – both of which are central to building the essential infrastructure of growing economies.

#### **Economic benefits of mining**

Coal directly provides more than seven million jobs worldwide and supports many more millions. Coal production is the key economic activity in many communities. In 2010 the coal industry invested more than US\$7 billion in capital expenditures in developing countries.

The presence of coal mining supports economies in many ways. At the most basic level coal mining provides employment for local communities. These employers often invest in improving the skills of their workforce – skills that can be transferred to other employers and other industries. Employment provided by coal mining does not only benefit the men and women employed at the mine and their families. These jobs support the wider community when the employees' income is spent on goods and services.

Coal mining often occurs in rural and remote areas requiring significant infrastructure development – particularly the development of transportation links such as road and rail. Mining often brings increases in other infrastructure services such as electricity. Improved infrastructure due to mining activity can also support broader economic development within the region.

Mining operations also bring revenues to governments. Companies pay taxes at both the local and national levels and can contribute royalties which help governments fund other services, such as health, education, welfare and security. In cases where coal is surplus to domestic energy needs, coal produced is exported to other countries, earning valuable export income and supporting national foreign exchange reserves. These benefits can be critical to often fragile developing economies.

Many companies also look to invest in the communities within which they operate – well beyond the needs of their mining operations. There are many examples of coal mining companies making sizeable investments in health and education services in their local communities. Some of these are considered on pages 20 – 27.

#### **South Africa**

Coal is a key contributor to South Africa's economy. While the rest of sub-Saharan Africa labours under an electrification rate of only about 10%,

South Africa has managed to more than double its electrification rate in just over a decade to 75% on the back of a power sector fuelled more than 90% by coal. The economic and social contrasts between South Africa and many of its neighbours are obvious. While coal addresses the domestic electrification challenges in South Africa, more than a quarter of coal mined in the country is exported, mostly through the Richards Bay Coal Terminal. After platinum and gold, coal is South Africa's third largest source of foreign exchange.

Employment in the South African coal mining industry totals more than 12% of the mining workforce in South Africa – that is more than 65,000 workers. It has been estimated that the coal industry in South Africa pays more than US\$1 billion in wages to its workforce each year. Workers in the coal mining industry are required to be skilled to a higher level than the other mining sectors mainly due to the need for specific training in the technical, mechanical, health and safety - and related fields of operation and engineering. Much of this training is provided through employment within the industry.

The impact that these employment benefits have is spread widely across the communities at large. The typical rural or low-skilled African family structure is often complex and multi-faceted. The impact of one employee's salary in the mining industry has been estimated to feed and clothe the equivalent of ten people, including children and the elderly.

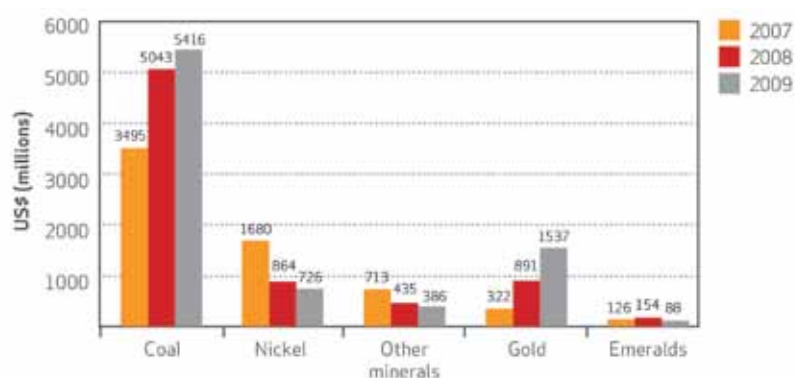
### Colombia

It has been estimated that in 2009 Colombia earned more than US\$5 billion in export revenue from coal – roughly two-thirds of total mining export revenues. Exports of coal have played an increasingly significant role in Colombia's economy, as demonstrated in figure 12.

Mining plays a key role in the Colombian economy, which has led to billions of dollars in foreign investment in recent years.

The coal mining sector plays an important role in contributing to government revenues both at national and regional levels. Royalties received by regional governments in Colombia for coal mining in 2008 were about US\$597 million, providing key revenue to support essential social services

**Figure 12. Colombian mining export revenues**



Source: National Association of Employers of Columbia – Mining Chamber

such as schools and hospitals and assisting the development of key economic infrastructure.

### Responsible mining

Coal is found in 70 countries and actively mined in around 50 countries by companies of varying sizes. Many companies are very small operations, in some cases even family-owned. Other companies operate in many countries and some also operate in other commodity sectors.

All companies have an obligation to act responsibly when mining for natural resources. Companies must consider their impact on the environment, the health and safety of their workforces and the communities within which they operate. Different locations have other issues that need to be addressed in different ways.

Many companies also learn from the experience of others and there are many positive stories to tell about the contribution that coal mining makes across the globe.

World Coal Association members place a high priority on responsible mining and commit, as part of their membership, to encourage improvements in mine health and safety and practice corporate social responsibility.

## Cerrejón land rehabilitation programme

### Colombia

**Colombian mining complex Cerrejón has developed a comprehensive land rehabilitation programme that is now being held up by environmental authorities in Latin America as a model of best practice.**

The result of over 20 years' observation, innovation and research, Cerrejón's award-winning programme has helped it rehabilitate over 2800 hectares of land to date.

A priority for all coal mining companies should be to protect the local environment and community around their mines. The soil is key, as within it is held the local biodiversity of the land alongside natural resources such as water and air. Through careful planning and land management, before and after mining takes place, the industry can help ensure a sustainable and responsible future for mining.

### Restoring the natural balance

Over the last two decades, Colombian mining and transportation complex Cerrejón - jointly owned by BHP Billiton, Anglo American and Xstrata - has developed a unique and award-winning land rehabilitation programme. Part of a much wider focus on sustainability and environmental management, the programme has already restored more than 2800 hectares of land - with over half of that covered by forests containing more than 140 native plant, shrub and tree species. It is recognised across Colombia and Latin America as an example of best practice in land rehabilitation, winning an Environmental Responsibility award from the Siembra Colombia Foundation and the British Embassy in 2009.

Head of the Programme, Ramón Gualdrón, explains how the methodology has developed: "We created an action plan based on sound principles and criteria, and we continually test it to prove our assumptions and apply the lessons we learn".



"We monitor progress by carefully tracking how the treated soil evolves, and comparing this with how the untouched lands develop over the same period."

### A six-part journey

Land rehabilitation begins before the mining stage, with the removal and preservation of soil banks. This natural resource is irreplaceable and essential to the process. Fauna is another vital component of the land being rehabilitated. It's important as a transformation agent in the vegetation cycle, helping to create favourable growing conditions without external assistance. Protecting fauna, and the Cerrejón fauna centre, are both integral parts of the cycle, even though they are not considered a part of the land rehabilitation programme.

#### Stage 1: Reshaping the mining deposits

The first stage in the process is to even out, till and reshape the deposits of waste rock (tailings) from old pits, dump areas and abandoned support areas, and add a layer of loose soil which has been stored in soil banks and which will be restored through an accelerated rehabilitation process.

#### Stage 2: Merging the deposits and the new soil

Mild rainfall then binds the old deposits and the loose soil together, and this is tilled again - flatter land by plough, slopes by oxen - before the onset of the



heavier rainy period in the second half of the year.

### Stage 3: Sowing the seeds

Buffel grass seeds are then hand-sown and mixed with fresh soil - which ensures an even distribution and incorporates microorganisms in the earth for when the first plants germinate.

### Stage 4: The first plants arrive

The first generation of green plants start growing, along with other, younger ones from the seeds in the soil, and these rapidly produce vegetation that protects the soil against erosion. Carbon is added to the soil to help it retain rain water and nutrients. This creates better conditions for the trees which will later grow there.

### Stage 5: Bringing nitrogen into the soil

When the grasses have used up the soil's nitrogen reserves, they become less competitive and allow trees and foliage from the leguminous plant species to grow. Essential to the rehabilitation process, these produce more nitrogen and convert it to ammonia - a process known as 'fixing' - which creates an environment where other species can grow.

### Stage 6: New growth and new species arrive

Gradually, the vegetation grows and stabilises, generates new resources and creates a host environment for more complex and demanding species of plants. As this happens, animals start to inhabit the land, and the human intervention becomes less and less - until the rehabilitation process is complete.

### A model for sustainable mining

Land rehabilitation is the process that closes the mining cycle, so mining companies must have expertise in this area. Cerrejón's methodology is now accepted as an effective way to rehabilitate land after mining - and the site has become a stop for visiting academics within agriculture, biology and environmental sciences.

Cerrejón Environmental Manager, Gabriel Bustos, explains why it has been such a success: "The Cerrejón programme's biggest impact has been to reduce the cost and improve the efficiency of the rehabilitation process. It has done this by optimising the way soil is used in the process".

The team already shares best practices, and their personal experiences, with other local initiatives that Cerrejón promotes in rural communities. Their ambition is to help improve land rehabilitation practices within the wider industry, and help make coal mining a more sustainable process for the future. No one is better equipped to do this than a team who can fully relate to the needs of mining, not only conscious of the sectors needs, but also of its local, regional and intergenerational obligations.

# 2800

hectares of land restored. Over half of that covered by forests containing more than 140 native plant, shrub and tree species.





## Community Engagement

### Brazil

**Coal mining companies in Santa Catarina State (Brazil) established the Santa Catarina Philanthropic Association (SATC) in 1959. The state had been experiencing difficulties in recruiting qualified labour to work in coal mines and established SATC to assist in raising awareness of coal mining and encouraging and training people to work in the industry.**

In 1963, SATC inaugurated the 'Male Industrial School' and in 1969, 'General Oswaldo Pinto da Veiga Technical School' started its first technical courses. Since this time, SATC has continued to grow and create further opportunities for learning.

The SATC campus is located in the 'Universitário' suburb, in Criciúma, covering an area of 550m<sup>2</sup>. The campus includes classrooms, laboratories with advanced technical equipment, a library, an ecological hiking site, and sports complex with two covered gymnasiums, two soccer fields and a running track. The work of SATC continues to focus on education and technology to help people from less fortunate communities have a better life. SATC offers 2000 scholarships and 700 students have free education.

#### Education

SATC Educational Technical School has more than 5000 students, covering primary school to high school level students, as well as offering professional qualification courses for high school and undergraduate level students. Every year, around 700 students from the school graduate.

SATC College offers graduate and post-graduate courses focused on technology. There are about 1200 students enrolled in SATC's higher education courses in the areas of technology, engineering, design and communication.

SATC extension courses (SATCTEC) cover executive education, business skills, distance learning and the further development of social skills, serving the community and assisting companies with the qualifications and skill base of their workforce. SATC extension courses cover a number of areas, including mechanics, electrics and computing. It



has a language centre, with English as the main language, and an internship programme that helps to place students in work. SATC also runs a 'SATC for Everybody' programme, whose goal is to help develop new professionals from less fortunate communities, creating job opportunities and offering free courses to obtain professional qualifications.

SATC also provides dental health care to students and psychology assistance to students and families, as well as a trainee apprentice programme.

#### Technology

The SATCTEC has three certified laboratories (NBR ISO 9001:2000) which offer technical support to companies and institutions through work on metrology, coal analysis and testing and also chemical and environment analysis. In 2009, the work of SATC in the technical field included:

- The Clean Coal Research Center (CTCL) that works in the areas of mining, geology and the environment. The main focus of the centre is the development of production technologies and the technologies to improve the environmental impact of the use of coal, which is vital for the development of the coal sector in Brazil.
- Technology-based Pre-incubator (PRINTEC) which will provide institutional support tools to business proposals and ideas which have market feasibility.

Through PRINTEC, entrepreneurs in various sectors will be able to access training and support to put their business plans into action.

### **Environment & Social Work**

SATC has made improvements in its environmental management system, which in 2008 led it to become certified with ISO 14001, making SATC the first educational institution in Santa Catarina to be certified and only the fourth in Brazil.



## Emalahleni Water Reclamation Plant

### South Africa

**The eMalahleni Water Reclamation Plant – situated in the Witbank coalfields of South Africa’s Mpumalanga province – has turned a major liability into a valuable asset that has created far-reaching benefits for the environment, the local community, and its feeder collieries.**

The award-winning project is a public-private partnership that was jointly undertaken by Anglo Coal South Africa, BHP Billiton Energy Coal South Africa (BECSA) and the eMalahleni Local Municipality, and has been described as a “world class initiative and an exemplary model for development”.

Approximately 130 million m<sup>3</sup> of water is stored in Anglo Coal’s underground workings, a figure that is rising by over 20 megalitres per day. A wide range of options to manage this water has been maximised and exhausted over a considerable period; the company therefore undertook extensive research into various treatment solutions, with desalination being one of them.

Following over a decade of research and development, Anglo Coal entered into a R300 million joint initiative with BECSA and a bulk supply agreement with the water stressed eMalahleni Local Municipality. The result was two competing global resource companies coming together to solve a common problem and provide a sustainable solution that benefits the communities that reside around their mining operations.

Commissioned in 2007, the plant desalinates rising underground water from Anglo Coal’s Landau, Greenside and Kleinkopje collieries, as well as from BECSA’s defunct South Witbank Mine. By doing so, it prevents polluted mine water from decanting into the environment and the local river system, while also alleviating serious operational and safety challenges.

Using the latest in water purification technology, it is currently desalinating record production volumes of 23 megalitres of water to potable quality per day, 18 megalitres of which is pumped directly into



the municipality’s reservoirs, meeting some 20% of its daily water requirements.

The plant’s all-time record of 25.8 megalitres in one day was achieved in September 2008, while a weekly record of 169 megalitres and an all-time best output of 632 megalitres in one month were accomplished in August of that year.

Additional water is piped to Greenside, Kleinkopje and Landau collieries as well as various nearby Anglo Coal service departments for domestic use and for mining activities, such as dust suppression. These operations are now self-sufficient in terms of their water requirements, which eases the serious supply problems of the local municipality.

The plant will also supply eight megalitres of potable water per day to Zondagsfontein, an Anglo Inyosi Coal greenfield project, BECSA’s Klipspruit mine and the Phola coal washing plant, a joint venture between the two mining houses.

### Critical need for water

The eMalahleni Local Municipality has long grappled with supply and demand problems to cater for the water needs of an area experiencing considerable industrial, commercial and residential growth. The plant is also aiding the provincial government in meeting its Millennium Development target to ensure that no household goes without a potable, reliable and predictable water supply by the end of 2008.





Apart from benefiting the local community by supplementing the low domestic water supply, it has created a number of job opportunities. During the construction phase, between 650 and 700 temporary jobs were created, while 40 permanent positions were created for the running of the plant. Eighty-six percent of the workforce comprises Historically Disadvantaged South Africans, while 91% have been sourced from surrounding communities in an area of high unemployment.

#### **Enterprise development**

During 2007, Anglo Zimele, Anglo American's enterprise development and empowerment arm, created a black empowered enterprise that utilises some of the plant's water for the retail bottling industry. Known as the White River Beverage Company, the business markets a brand known as 4Life to the South African bottled water market, which is growing by approximately 15% per annum and enjoys a turnover of in excess of R850 million per year. So far, the enterprise has created jobs for seven people. Only a very small percentage (<0.01%) of the water produced at the plant is currently bottled.

#### **Zero waste facility**

The plant operates at a 99% water recovery rate and the ultimate goal is for it to be a zero waste facility through the 100% utilisation of its by-product. The 100 tonnes of gypsum it produces daily is not only costly to dispose of, but is an environmental and post-closure liability.

Anglo Coal has launched two R16 million research and development projects that may offset the cost of the water treatment facility and reap further financial and environmental benefits.

The first study, which is being co-funded by the National Research Foundation's Technology and Human Resources for Industry Programme, is looking into the conversion of waste gypsum into sulphur, limestone and magnesite.

The second is investigating the by-product's use in the production of usable mining and building

products. The local banking sector has been mandated by government to provide assistance in eliminating the country's massive backlog in housing, which has spurred them into seeking alternative building materials.

The boom in the construction industry has caused conventional resources such as bricks and cement to be in short supply, and has driven up the cost of housing. As part of this study, the company has built a three-bedroom house constructed almost entirely out of gypsum-based building products.

It is currently undergoing a range of tests to prove its quality and social acceptance, and should the project be successful it is envisaged that a black empowered entity will be created to manufacture and market gypsum building products on a mass scale.

#### **Future developments**

Phase two of the plant means the facility can desalinate 50 megalitres (with a maximum capacity of 60 megalitres) of water per day.

The project has been designed to take into account the remaining 20-25-year life of contributing mines, and to cater for post closure liabilities which will require the desalination of mine water in excess of 30 megalitres per day. The plant will continue to run post mine closure.

## Anglo American HIV/AIDS programme South Africa

**By taking responsibility for the health of its workforce, multinational mining company Anglo American showed that providing healthcare isn't just the right thing to do – it's also a good investment.**

Between 1990 and 1998, the prevalence of HIV in South Africa rocketed from less than 1% to more than 22%. In August 2002, Anglo American announced that it was making antiretroviral therapy (ART) available to its entire southern Africa-based workforce. Even the architect of the scheme, Chief Medical Officer Dr Brian Brink, described it as “a leap of faith”.

However, by July 2010, it was clear that the benefits of the ART programme far outweighed the costs. Providing ART to one worker for one month cost Anglo \$126 but resulted in savings of \$219.

### Testing and treatment

Anglo American's HIV/AIDS programme is based on an ambitious target of three zeroes: zero new infections; zero employees falling sick or dying from AIDS; and zero babies born HIV positive in employees' families. UNAIDS, the Joint United Nations Programme on HIV/AIDS, has now adopted these same targets.

A cornerstone of the programme is voluntary counselling and HIV testing (VCT). In 2003, less than 10% of southern Africa-based Anglo American staff took advantage of VCT, but by 2010, 94% of employees were checking their status every year. This means Anglo can calculate the prevalence of HIV and the incidence of new infections more accurately than ever before.

As soon as an employee tests HIV positive they can enrol in the HIV Wellness Programme, which provides ongoing counselling and immune-system monitoring. When the monitoring indicates the time is right, they can start receiving ART.

In 2010, about 12,000 employees were HIV positive and about 4000 of those were receiving ART.



The programme is also available to workers' dependents – a complex exercise, given that many are scattered around southern Africa, often in remote villages with little access to healthcare. About 400 dependents are currently enrolled in the HIV Wellness Programme, and 75% of them are receiving ART – though estimates indicate that there are still many more in need.

People do drop out of ART, but Anglo is working to improve long-term adherence to treatment. Fewer than 20% of those enrolled dropped out in 2010, compared to more than 40% in 2004.

The prevalence of HIV in southern Africa is linked to a rising incidence of tuberculosis (TB). People enrolled in the HIV Wellness Programme are also offered TB prevention therapy, which has reduced AIDS mortality by 50%, and Anglo American also administers a TB control programme based on similar principles to the HIV/AIDS programme.

### Healthier communities

For Dr Brink, the programme has demonstrated that HIV can be contained and AIDS can be managed. Yet he is still concerned with the bigger picture.

“It is increasingly evident that a standalone response to HIV/AIDS will never succeed unless it is supported by a broad-based strengthening of the health system”.

In 2003 the company launched the Anglo American Community HIV/AIDS Partnership Programme, which supports youth programmes, clinics and other initiatives, and engages in public/private partnerships. These include the building of a community health centre at Lillydale in the Bushbuckridge municipality, Mpumalanga province, and a clinic in Kathu township, Northern Cape province – both of which provide access to life-saving ART.

Anglo is also sponsoring the writing of a business plan to revitalise primary healthcare in four sub-districts of the Eastern Cape, an area that many of its workers and their dependents call home. The plan will set clear targets for improving the basic indicators of health, including HIV/AIDS, TB and maternal and child health.

The broad-based strengthening Dr Brink envisages will require better health information systems, using modern technology to make data accessible even in remote areas. Anglo American's Thermal Coal business has developed such a system, the HealthSource, which is currently being piloted in two impoverished areas. The Eastern Cape Department of Health has also shown an interest.

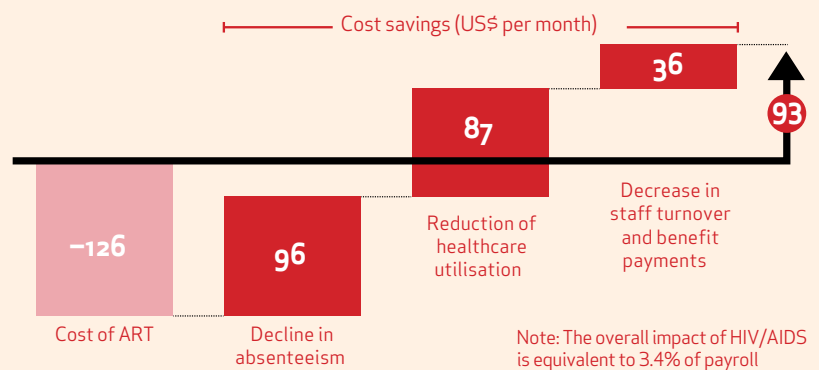
#### Setting an example to industry

Anglo American's next target is to encourage other companies to follow in its footsteps. Dr Brink wants the private sector to become one of the top ten donors to the Global Fund to Fight AIDS, TB and Malaria.

At the G20 Business Summit in Seoul, Chief Executive of Anglo American Cynthia Carroll pledged £1 million a year to the Fund for the next three years.

The company has demonstrated a clear business case for this sort of investment. "All that is required," says Dr Brink, "is the leadership and the will to get the job done."

#### Effects of Anti-Retroviral Therapy (ART) at an individual level – the Anglo American experience



# 33%

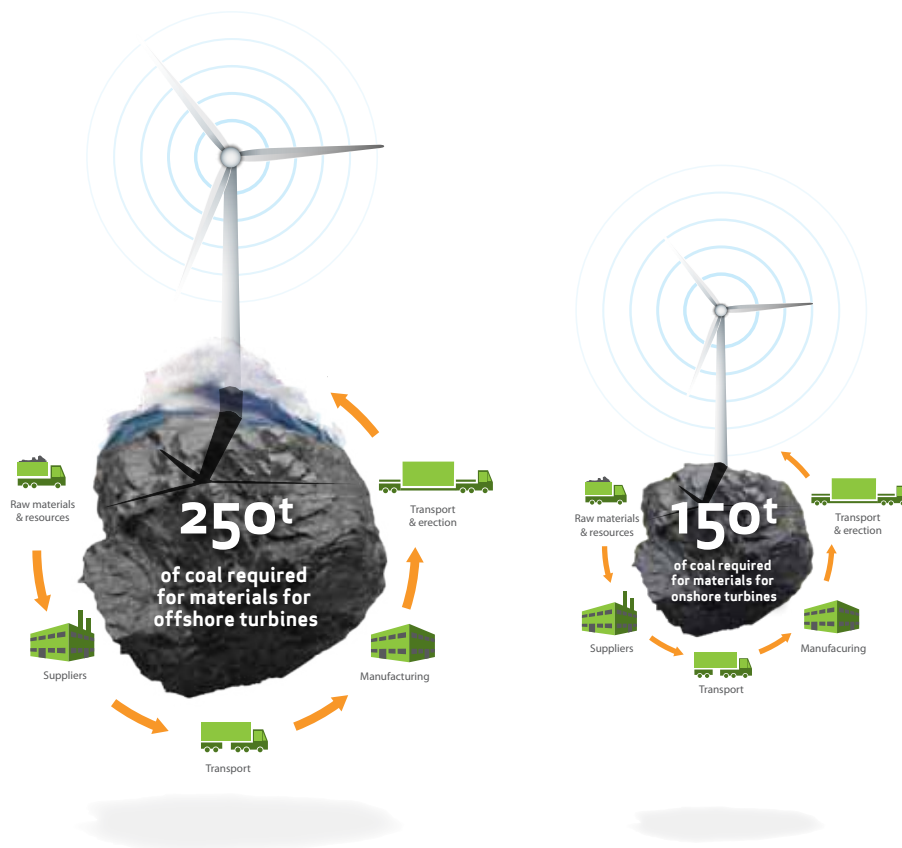
Percentage of the world's population that is currently infected with the tuberculosis bacillus – it can lie dormant for years, with people only becoming sick when their immune system is weakened

# 1%

Percentage of tuberculosis infections among Anglo American's South Africa-based employees in 2010



► **Figure 13. Coal's role in sustainable energy**



Source: [www.vestas.com](http://www.vestas.com). Key: t = metric tonnes

### Steel production

Coal is an important component of global steel production. According to recent statistics issued by the World Steel Association, there was an increase in global steel production in 2010 up to 1413.5 million tonnes from 1230.9 million tonnes in 2009. Coking coal is an essential element in blast furnace steel production, making up 70% of total steel production (the remainder is produced from electric arc furnaces using scrap steel). World crude steel production was 1.4 billion tonnes in 2010, involving 721 million tonnes of coking coal in its production.

Steel is an essential material for modern life. Manufacturing steel delivers the goods and services that our societies need – healthcare, telecommunications, improved agricultural practices, better transport networks, clean water and access to reliable and affordable energy. It is fundamental to a more sustainable world, helping to build lighter, more efficient vehicles, new highly efficient power stations and in the construction of smart electrical grids. Steel is a critical component in the construction of transport infrastructure and high energy efficiency residential housing and commercial buildings.



Steel also has a significant role in delivering renewable energy; each wind turbine requires 260 tonnes of steel made from 170 tonnes of coking coal and 300 tonnes of iron ore.

China is by far the world's largest steel producer followed by Japan, the United States, India and Russia. There has been a significant shift towards China in global steel markets over the past 10 years. China's share of global production increased from just over 15% in 2000 to more than 44% in 2010, during a period where global steel production grew by two-thirds. Likewise China's share of steel use (measured by finished steel products) increased from more than 16% to just under 45% of global use.

However, other developing economies in Latin America, Asia, Africa and the Indian sub-continent, where steel will be vital in improving economic and social conditions, are also expected to see significant increases in steel production. In these regions, according to the World Steel Association, more than 60% of steel consumption will be used to create new infrastructure.

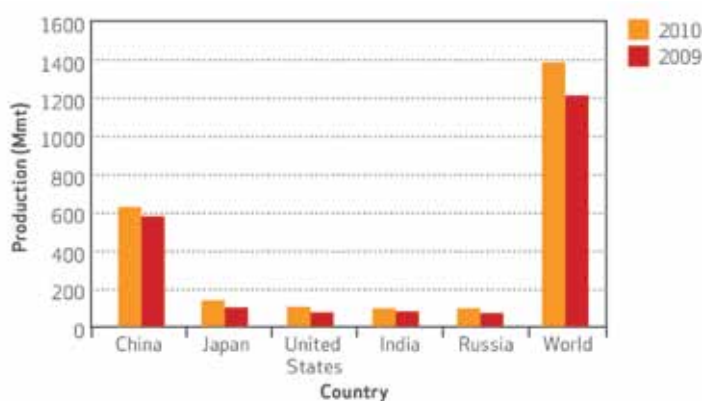
With world steel production expected to continue to grow, the outlook for the coking coal sector will also be strong. With average annual growth of more than 5% per annum during 2000 – 2010 and with the continuing increased demand from China, indications are that the marked growth in steel production is likely to continue well into the future.

### Cement production

Cement, like steel, plays a major role in the construction industry. Cement is used to combine aggregates to form concrete. Few construction projects take place without using cement. Together cement and steel play a significant role in building emerging economies and supporting socio-economic development.

Concrete has an essential role in modern society. It is used to build schools, hospitals, homes, and key public infrastructure such as bridges, tunnels, dams, sewerage systems, pavements, runways, roads and more.

► **Figure 14. Global steel production**



Source: World Steel Association, World Steel in Figures 2011

Concrete is in fact the most used man-made material in the world and is integral to the construction of longer-lasting energy-efficient buildings. According to the World Business Council for Sustainable Development, three tonnes of concrete are used annually for every individual on the planet.

Coal is used as an energy source in cement production. Large amounts of energy are required to produce cement. Kilns usually burn coal in the form of powder and consume around 450g of coal for about 900g of cement produced.

► **Figure 15. World cement production (in thousand metric tons)**

Country	2009	2010
United States	64,900	63,500
Brazil	51,700	59,000
China	1,629,000	1,800,000
Egypt	46,500	48,000
Germany	30,400	31,000
India	205,000	220,000
Indonesia	40,000	42,000
Iran	50,000	55,000
Italy	36,300	35,000
Japan	54,800	56,000
Korea, Republic of	50,100	46,000
Mexico	35,200	34,000
Pakistan	32,000	30,000
Russia	44,300	49,000
Saudi Arabia	40,000	45,000
Spain	50,000	50,000
Thailand	31,200	31,000
Turkey	54,000	60,000
Vietnam	47,900	50,000
Other countries (rounded)	466,000	520,000

Source: US Geological Survey

Coal combustion products, such as fly ash, also play an important role in cement manufacture and more generally in the construction industry. Coal combustion products (CCPs) can play an important role in concrete production. CCPs are the by-products generated from burning coal in coal-fired power plants.

### Coal and water

In addition to energy security, water security is expected to be a major challenge in the coming decades. According to the OECD 2.8 billion people, or almost half of the world's population, live in areas of high water stress. This number is expected to increase by 39% within the next two decades. By 2030, the global demand for water could outstrip supply by 40% if current consumption trends are not changed.

### Water in energy generation

Energy generation is usually associated with high water consumption. Cooling systems represent the highest proportion of water consumption in energy generation. This makes water an essential element of the energy generation process. In fact, the higher the reliance on water for cooling purposes, the higher the risk that power generation output might be affected during hot summers or droughts. Reports by the IEA and the World Policy Institute (WPI) show that hydro, geothermal, nuclear and concentrated solar power are the most water intense among the existing electricity generation technologies. Generating electricity in coal-fired power plants also requires a significant amount of water for cooling purposes.

Using integrated gasification combined cycle (IGCC) technology at coal-fired power plants can reduce water consumption by half. IGCC plants consume around the same amount of water as natural gas plants; that is four times less than solar thermal and seven times less than geothermal energy.

► *Steel delivers the goods and services that our societies need – healthcare, telecommunications, improved agricultural practices, better transport networks, clean water and access to reliable and affordable energy. It is fundamental to a more sustainable world.* ◀

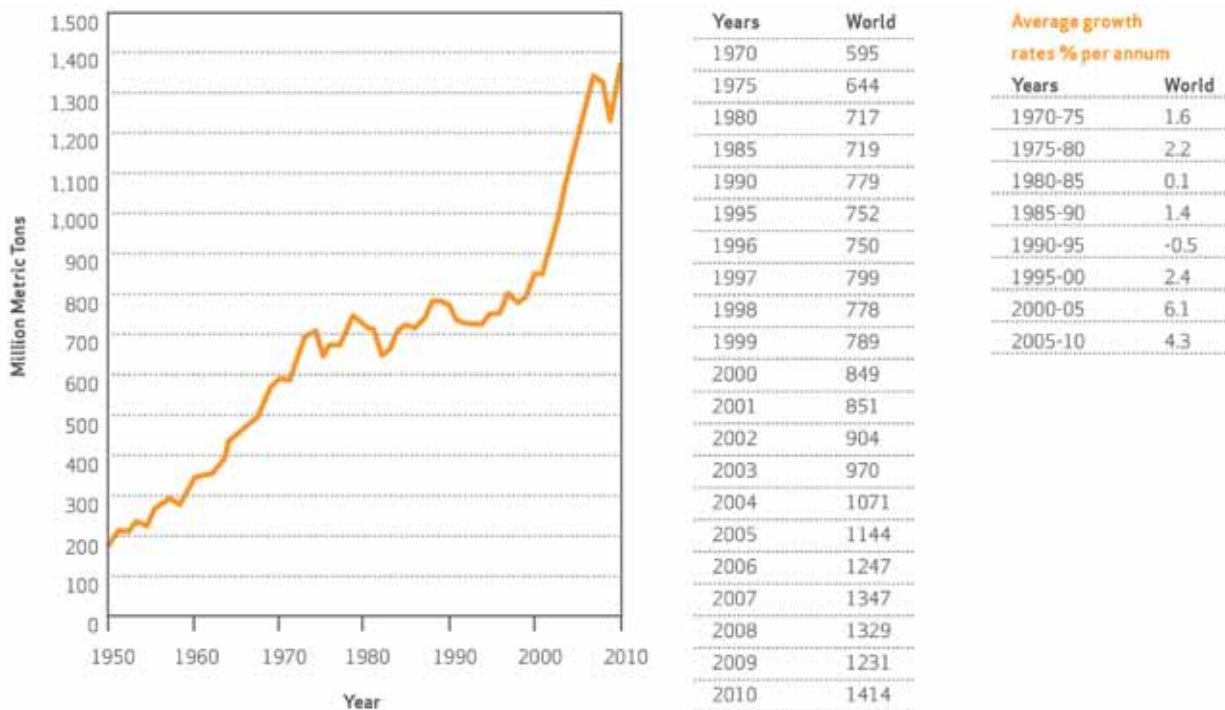
### Water in mining

Mining coal is responsible for around a tenth of water consumption across the chain of energy production and electricity generation.

Water reclamation and careful management techniques are critical to managing water resources. The coal industry has already made significant contributions to this effort. Self-sufficiency in water consumption plays a key role in reducing the impact of coal mining on local communities and reclamation can also allow for increased water supply in areas with limited resources.

Mine operations work to improve their water management, aiming to reduce demand through efficiency, technology and the use of lower quality and recycled water. Water pollution is controlled by carefully separating the water runoff from undisturbed areas, from water which contains sediments or salt from mine workings. Clean runoff can be discharged into surrounding water courses, while other water is treated and can be reused in activities such as dust suppression and in coal preparation plants.

► **Figure 16. History of world steel production**



Source: World Steel Association, World Steel in Figures 2011



## Part 4

### Time for action

Delivering sustainable development is a significant global challenge. There is a multiplicity of issues, which must be addressed as integrated challenges, not as isolated problems. Ensuring access to electricity and supporting economic growth is essential to global efforts to eradicate poverty and support human development. Addressing global CO<sub>2</sub> emissions is essential to mitigating the impacts of climate change. Managing our environment is essential to conserve biodiversity.

These challenges require coordinated and integrated international action.

#### Energy and the Millennium Development Goals

At the Millennium Development Summit in 2000 world leaders adopted eight goals to be achieved by 2015. These were aimed at eradicating extreme poverty, improving access to education, improving health outcomes, such as reducing child mortality, and fighting epidemics such as HIV/AIDS.

As one of the fundamentals of modern society, access to energy is a key component to achieving these goals (see table on pages 34-35). Without access to modern energy, hospitals and schools cannot function effectively. Women and children suffer disproportionately the effects of burning wood and dung in the home.

Yet there is no energy access target in the Millennium Development Goals.

If there is to be effective global action to address poverty, then addressing energy poverty must be a major priority. An ambitious energy access goal would not just alleviate extreme poverty but would also support more ambitious development objectives. This would enable global economic and social development to be accelerated. A recent study indicated that a “moderate access” scenario (see Figure 3 of this report) that would support the needs of business and industry requires an electricity capacity of around 200-400MW per million population. Electricity scenarios at this level, while ambitious, would deliver genuine economic and social development.

#### Action for Energy

#### Our recommendation

**An ambitious target for global energy access must be adopted. This target needs to be one that will**

**support the eradication of poverty, the growth of businesses and industries and true economic and social development. National governments and global institutions should work towards an energy target of at least 400MW of installed electrical generation capacity per million of population.**



### Advanced coal technologies

All energy sources and all energy technologies will be needed to meet the global challenge of providing energy access for all. Renewable energies, gas, nuclear, coal and cleaner coal technologies all have a role to play in meeting global energy needs. There are a range of modern coal technologies that will support the deployment of energy while also supporting climate and greenhouse gas mitigation objectives.

There are two major technologies that must be backed by the international community for deployment to support international energy and climate objectives:

- Advanced power generation – supercritical and ultra-supercritical technologies – each percentage point improvement in coal power efficiency reduces greenhouse gas emissions by 2-3 percentage points.
- Carbon capture and storage – a global climate mitigation energy portfolio with coal and CCS is estimated by the IEA to be 70% less expensive than a portfolio without coal and CCS. This potentially could release more funding for investment for poverty eradication.

There should also be more investment in other technologies that support the use of coal resources:

- Underground coal gasification – UCG is emerging as a technology to utilise otherwise unrecoverable coal resources with fewer greenhouse gas emissions, potentially unlocking a cleaner source of energy for generations to come.
- Coal to liquid fuels and synthetic natural gas – CTL and SNG provide reliable sources of liquid fuels when demand is high or prices are high. They also provide increased opportunities to deliver clean cooking fuels in the developing world.

These technologies will be applicable in different contexts and some may suit one location more than another. However they will all be part of a future global energy mix that supports both energy access and climate objectives.



### Our recommendation

**National governments and international institutions must support the rapid deployment of all advanced**

**coal technologies, particularly improved efficiencies at power stations and CCS.**

### Financing cleaner coal

International support is needed to finance cleaner coal energy solutions because all sources of energy will be needed to support economic and social development and the eradication of energy poverty in the developing world. National governments are entitled to assess which sources of energy are most suitable to their own needs and their own resource availability. Decisions on which energy sources should be utilised to further national development plans should be made by national governments and not by international institutions. It is the role of international institutions to support national governments in their decision-making and implementation processes.



### Our recommendation

**International financial institutions must adopt policies that will allow national governments**

**to determine which energy solutions are appropriate to their needs and support those decisions with the appropriate financial backing.**

## Annex

### Coal and the Millennium Development Goals

Millennium Development Goal	Importance of Energy	Coal
Eradicate extreme poverty and hunger	Energy inputs such as electricity and fuels are essential to generate jobs, industrial activities, transportation, commerce, micro-enterprises and agriculture outputs. Most staple foods must be processed, conserved and cooked, requiring heat from various fuels.	<ul style="list-style-type: none"> <li>• Over 40% of the world's electricity comes from coal, providing secure energy.</li> <li>• The rapid electrification in South Africa, India and China has been heavily dependent on affordable coal.</li> <li>• Coal directly provides seven million jobs worldwide and coal production is the key to economic activity in many communities.</li> </ul>
Achieve universal primary education	To attract teachers to rural areas electricity is needed for homes and schools. After dusk study requires illumination. Many children, especially girls, do not attend primary schools in order to carry wood and water to meet family subsistence needs.	<ul style="list-style-type: none"> <li>• In addition to providing reliable affordable electricity, many coal companies provide education and facilities within their communities.</li> <li>• The Brazilian Coal Association has worked with companies in the Santa Caterina area to develop a unique educational and skills training centre, meeting the needs of children and adults alike.</li> </ul>
Promote gender equality and empower women	Lack of access to modern fuels and electricity contributes to gender inequality. Women are responsible for most household cooking and water boiling activities. This takes time away from other productive activities as well as from educational and social participation. Access to modern fuels eases women's domestic burden and allows them to pursue educational, economic and other opportunities.	<ul style="list-style-type: none"> <li>• Coal provides reliable and affordable electricity, with more than 1 billion people gaining access via coal in the past two decades.</li> <li>• Converting coal to ultra clean liquid fuels for domestic use can make an enormous difference to women's lives, as well as to children and the elderly who are disproportionately affected by indoor air pollution.</li> <li>• Liquid fuels from coal can significantly reduce pollutants that impact local air quality such as nitrogen oxides and particulates. Liquid fuels from coal are sulphur free.</li> <li>• China has, with financing from the International Finance Corporation (the private sector arm of the World Bank), set up the first Coal-to-Liquids plant to provide ultra clean fuels for domestic use.</li> <li>• If CTL fuels are produced using carbon capture and storage, CO<sub>2</sub> emissions can be reduced by as much as 20% over the full fuel cycle compared to conventional oil products.</li> </ul>
Reduce child mortality	Diseases caused by unboiled water, and respiratory illness caused by the effects of indoor air pollution from traditional fuels and stoves, directly contribute to infant and child disease and mortality.	
Improve maternal health	Women are disproportionately affected by indoor air pollution and also by water and food-borne illnesses. Lack of electricity in health clinics, illumination for night time deliveries, and the daily drudgery and physical burden of fuel collection and transport all contribute to poor maternal health conditions, especially in rural areas.	

Millennium Development Goal	Importance of Energy	Coal
Combat HIV/AIDS, malaria and other diseases	Electricity for communication such as radio and television can spread important public health information to combat deadly diseases. Health care facilities, doctors and nurses, all require electricity and the services that it provides (illumination, refrigeration, sterilisation etc) to delivery effective health services.	<ul style="list-style-type: none"> <li>• Affordable and reliable electricity from coal can play a direct and major role in combating deadly diseases – by powering communication, equipment and services.</li> <li>• Coal companies also play a direct role in health care provision, often ahead of state services.</li> <li>• In South Africa, coal companies have been operating major HIV/AIDS treatment programmes, providing free antiretroviral drugs.</li> <li>• In Colombia, coal companies work with local organisations to provide 'health brigades' to indigenous peoples. Recent activities include widespread vaccination against yellow fever.</li> </ul>
Ensure environmental sustainability	Energy production, distribution and consumption have many adverse effects on the local, regional and global environment, including indoor, local, and regional air pollution, local particulates, land degradation, acidification of land and water, and climate change. Cleaner energy systems are needed to address all of these effects and to contribute to environmental sustainability.	<ul style="list-style-type: none"> <li>• Coal is facing up to its environmental challenges and promotes the use of clean coal technologies which reduce local, regional and global impacts.</li> <li>• Gasification of coal can reduce emissions of particulates, sulphur oxides and nitrogen oxides by up to 99%.</li> <li>• CCS must be included in any portfolio of mitigation options where significant reductions in CO<sub>2</sub> emissions are to be achieved.</li> <li>• CCS is recognised as reducing the costs of overall mitigation by 30% or more and global storage capacity is immense.</li> </ul>
Develop a global partnership for development	The World Summit for Sustainable Development called for partnerships between public entities, development agencies, civil society and the private sector to support sustainable development, including the delivery of affordable, reliable, and environmentally sustainable energy services.	<ul style="list-style-type: none"> <li>• FutureGen is an international public-private partnership to build a commercial scale, coal-fuelled, near-zero emissions power plant using coal gasification and carbon capture and storage.</li> <li>• Coal companies participate in the Carbon Disclosure Project - the world's largest institutional investor collaboration on the business implications of climate change.</li> <li>• Members of the coal industry also participate in the Global Reporting Initiative - an international collaborative network for reporting on economic, environmental and social performance.</li> </ul>

## Glossary

**Base load electricity** – is the minimum level of supply needed on an electricity grid network. Base load power sources are those plants which can generate dependable power to consistently meet demand. Base load generation will operate 24 hours a day, 7 days a week.

**Carbon capture and storage (CCS)** – a group of technologies used to reduce CO<sub>2</sub> emissions from large CO<sub>2</sub> sources (such as fossil fuel or biomass power generation) and industrial processes (such as cement, iron and steel and fertiliser manufacturing). Following capture, CO<sub>2</sub> is transported and stored in specifically selected and characterised geological formations over 1000 m below the ground. (IEA)

**Clean Development Mechanism (CDM)** – allows emission-reduction projects in developing countries to earn certified emission reduction (CER) credits, each equivalent to one tonne of CO<sub>2</sub>. These CERs can be traded and sold, and used by industrialised countries to meet a part of their emission reduction targets under the Kyoto Protocol. The mechanism stimulates sustainable development and emission reductions, while giving industrialised countries some flexibility in how they meet their emission reduction limitation targets. (United Nations Framework Convention on Climate Change)

**Coal-to-liquids** – refers to the transformation of coal into liquid hydrocarbons. It can be achieved through either coal gasification into syngas (a mixture of hydrogen and carbon monoxide), combined with Fischer-Tropsch or methanol-to-gasoline synthesis to produce liquid fuels, or through the less developed direct-coal liquefaction technologies in which coal is directly reacted with hydrogen. (IEA)

**Energy poverty** – means a lack of access to modern energy services. These services are defined as household access to electricity and clean cooking facilities e.g. fuels and stoves that do not cause air pollution in houses. (IEA)

**Enhanced oil recovery (EOR)** – also known as tertiary oil recovery, follows primary recovery (oil produced by the natural pressure in the reservoir) and secondary recovery (using water injection). Various EOR technologies exist, such as steam injection, hydrocarbon injection, underground combustion and CO<sub>2</sub> flooding. (IEA)

**Installed capacity** – is the maximum amount of electricity that a power plant can generate at any given point in time. Across an economy the installed capacity includes all points of power generation.

**Millennium Development Goals (MDGs)** – global commitments to eradicate extreme poverty. They were agreed by all the world's countries and all the world's leading development institutions in September 2000.

**Off-grid** – refers to electricity generation that is not connected to an economy-wide, national or major transmission system. Definitions of off-grid usually include both stand-alone generating systems and mini-grid systems. Off-grid electricity generation usually occurs in remote or rural areas and in countries where there is limited access to electricity.

**On-grid** – refers to electricity generation that is connected to an economy-wide, national or major transmission system.

**Original-oil in place** – is the total hydrocarbon content of an oil reservoir before the commencement of production.

## Further reading

**International Energy Agency**

[www.iea.org](http://www.iea.org)

**IEA Clean Coal Centre**

[www.iea-coal.org.uk](http://www.iea-coal.org.uk)

**International Year of Sustainable Energy for All**

[www.sustainableenergyforall.org](http://www.sustainableenergyforall.org)

**United Nations Conference on Sustainable Development 2012 (Rio+20)**

[www.uncsd2012.org](http://www.uncsd2012.org)

**UN-Energy**

[www.un-energy.org](http://www.un-energy.org)

**United Nations Framework Convention on Climate Change**

[www.unfccc.int](http://www.unfccc.int)

**United Nations Global Compact**

[www.unglobalcompact.org](http://www.unglobalcompact.org)

**United States Energy Information Administration**

[www.eia.gov](http://www.eia.gov)

**World Bank**

[www.worldbank.org](http://www.worldbank.org)

**World Coal Association**

[www.worldcoal.org](http://www.worldcoal.org)

**World Energy Council**

[www.worldenergy.org](http://www.worldenergy.org)

**World Energy Outlook**

[www.iea.org/weo/](http://www.iea.org/weo/)

## World Coal Association

The World Coal Association is a non-profit, non-governmental association.

Membership is open to coal enterprises and stakeholders from anywhere in the world. The WCA has more than 40 members spread across the globe. Our membership includes many of the world's largest coal producers and includes mining equipment manufacturers, national coal industry associations and coal research bodies. Member companies are represented at Chief Executive level. The WCA is the only international body working on behalf of the coal industry worldwide.

### Mission

WCA and its member companies engage constructively and openly with governments, the scientific community, multilateral organisations, non-governmental organisations, media, coal producers and users, and others on global issues, such as CO<sub>2</sub> emissions reduction and sustainable development, and on local issues including environmental and socio-economic benefits and the effects from coal mining and coal use.

### Objectives

The coal industry, including both internationally traded and domestic coal, needs to present a united front to the challenges it faces this decade and beyond. The orthodoxy that views coal only as a CO<sub>2</sub> emitter – without regard to its role in economic and social development, essential to electricity generation and steel manufacture – may be at a turning point. However, the industry needs to cooperate to ensure that this turning point occurs. For that reason, the WCA has adopted a forward looking strategy that aims to position:

- coal as a strategic resource that is widely recognised as essential for a modern quality of life, a key contributor to sustainable development, and an essential element in enhanced energy security; and
- the coal industry as a progressive industry that is recognised as committed to technological innovation and improved environmental outcomes within the context of a balanced and responsible energy mix.

The strategy can only be achieved with the commitment of leading coal producers and stakeholders.

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