Comments on the Kentucky Pioneer IGCC Draft Environmental Impact Statement

Will Herrick
4859 Flat Mary Rd
Campton, Ky 41301

January 22nd, 2002

Table of Contents

Mr. Roy Spears
U.S. Department of Energy
National Energy Technology Laboratory
3610 Collins Ferry Road
Morgantown, WV 26507-0880

Sir,

I have the following comments on the Kentucky Pioneer (KP) Integrated Gasification Combined Cycle (IGCC) Draft Environmental Impact Statement (DEIS).

There are manifest virtues to the promotion of our national understanding of advanced power generation technologies. However, significant flaws and omissions in the DEIS negates both the DOE assessment that this plant meets DOE's stated needs and the conclusion that it should be funded. The DEIS lacks critical information about the plant design that makes it impossible to assess the environmental impact of the Trapp facility.

The DEIS needs repair and a new round of public review before any Federal dollars are released.

The Federal issues of concern in this DEIS are:

- Weak argument: 'Purpose and Need for Agency Action.'
- Compromised demonstration of 'Clean Coal'
- Flawed premises: 'No Action Alternatives'
- Failure to consider other sources of power.
- Likely failure to get local permits.
- Conflict with state law.
- Intent to disregard the outcome of the research.
- Unreliable partners, private funding delays, inadequate planning & past failures.
- Disregard for social justice and environmental issues.
- Inadequate design data.

Weak Argument: 'Purpose and Need for Agency Action.'

The need for agency action is not well supported by the DEIS. As well, goals described as the basis for the proposed actions may have already been met without investment of Federal dollars.

The need for a successful demonstration of a largely coal fired IGCC facility using Federal funds, as stated in the DEIS section 2.2, is already satisfied by available information. Global Energy is building an MSW fired IGCC plant identical to Trapp, but for the fuel cell, in Lima Ohio without Federal monies.[1] The National Coal Council has said 'The technology has been successfully demonstrated at commercial scale in the U.S. and worldwide.'[2] Existing facilities include Wabash River,

1 RA Bailey, Sr VP Global Energy, Panel Discussion, Oct 9, 2001 www.gasification.org/98GTC/GTC01030.pdf
2 Appendix I:

Tampa Electric's Polk Plant, the Netherland's Buggenum, plants in Germany, Scotland, Singapore & South Africa and Spain's Puertollano plant. Global Energy already has several commercial IGCC projects under development based on using BGL Gasification Technology to gasify solid hydrocarbons for power production (Appendix E, Introduction, paragraph 2). The National Coal Council reported in May 2001: 'Based on the success of the BGL process at the Schwarze Pumpe GmbH plant in Germany, Global Energy is building two plants in the U.S. The 400-MW Kentucky Pioneer Project and the 540-MW Lima Energy Project will both use BGL gasification of coal and municipal solid waste to produce electric power.'[3]

The fuel cell demonstration at Trapp is more about MSW than Clean Coal. When presenting their Trapp proposal at a national coal conference, the company providing the fuel cell technology to Kentucky Pioneer Energy(KPE) said: 'Fuel cell systems operating on coal have been studied extensively in past years.'[4](p.3) Later in the paper they go on to say of the Trapp facility: 'The project will feature Advanced Fuel Technology briquettes made of Kentucky coal and Municipal Solid Waste (MSW) as fuel in the gasification process...'(p.5). These facts indicate that the purpose of the demonstration is not the already well researched coal powered fuel cell but, in fact, the MSW powered fuel cell where coal is being removed from the feedstock to favor MSW. This fails to satisfy the expressed goal of DEIS section 2.2 for: '...technologies that will help alleviate pollution problems from coal utilization.' Alleviating coal pollution problems by not using coal is not what DOE & CCT are about.

The national interest in MSW as a non-competitive alternative to other fuels for energy production is at cross-purposes to the CCT effort at Trapp. The Office of Integrated Analysis and Forecasting of the Energy Information Administration reported in April of 1997: 'MSW-produced power is viewed [primarily] as a byproduct of a community`s waste disposal activities and only secondarily as a competitive alternative to other fuels for energy production.'[5] The waste at Trapp is not a byproduct of that community's waste disposal activities, and the MSW is competing with local coal.

---

www.nationalcoalcouncil.org/Documents/May2001report-revised.pdf P. 32

3 Appendix I: www.nationalcoalcouncil.org/Documents/May2001report-revised.pdf P. 28

4 Appendix C. Steinfeld Ghezel-Ayagh, Sanderson, & Abens: IGFC Demonstration Test. FuelCell Energy Inc, 25th International Technical Conference on Coal Utilization and Fuel Systems, March 6th, Clearwater FL.

5 DOE/EIA-M069(97) Model Documentation Renewable Fuels Model of the National Energy Modeling System, URL: tonto.eia.doe.gov/FTPROOT/modeldoc/m06997.pdf

At what point does the presence of coal become token? Please make a specific answer to that question as it is the sole basis for DOE CCT's investing in the Trapp facility. KPE has said that they intend to use only 20% coal in the feedstock in the long run, 50% or less initially. 'Operation will commence on 100% coal with slowly increasing levels of RDF throughout the demonstration. This method will allow the development of a database of plant performance at various levels of RDF feed.'[6] Using Clean Coal monies for research on MSW/RDF diverts those dollars from their intended purpose.

The Wabash IGCC facility in Terre Haute, operating since 1996, has demonstrated most of the retrofit, repowering, coal, sulfur and NOx related features of Trapp with a similar gasifier from KPE's parent, Global Energy. BG/L facilities are in place in Europe, Singapore and elsewhere. They already offer a wealth of technical, environmental and financial data. A 1988/2000 NETL report, entitled 'British Gas/Lurgi Gasifier IGCC Base Cases', reports the Cost of Energy for IGCC BG/L facilities on pages 25-40[7].

Kentucky already has the lowest energy prices in the nation. From a Federal point of view, siting this plant anywhere else makes more sense in terms of meeting needs. If, (as described in the DEIS page S-3, 'Purpose and Need for Agency Action' paragraph 2), the goal is to 'significantly reduce electric power costs...', it may be most effective to look at sites for this facility where electricity rates are higher.

While Kentucky has the lowest energy costs in the nation, there are many other providers seeking to offer base and peaking capacity in the EKPC market area, to wit: the EKPC Mason County Spurlock Plant proposal introduced above (and many others). Neglecting to consider these other energy sources and providers is a serious omission in the Section 2 of the DEIS, Purpose and Need for Agency Action.

EKPC has proven in the past to seriously miscalculate their power needs. That is how the Trapp site was originally prepared and then mothballed for 20 years. EKPC is adding base capacity outside of this initiative (the Spurlock facility in Mason County), as are others. EKPC's pursuit of the Mason County Spurlock facility (Appendix D) appears to, for the near run, address their '1998 Power Requirements Study', cited as the energy demand component of the 'Need for Agency Action.'

---

6 P.2 Advanced Electric Power Generation Program Update 2000. May 17th, 2001 URL: www.lanl.gov/projects/cctc/factsheets/updates/documents/advelecigcc_2000_all.pdf

7 www.netl.doe.gov/coalpower/gasification/system/bgl3x_20.pdf

All the power plant interest in the Commonwealth bodes well for access to capacity in the long run. The base energy demand cited by DOE as justification for Trapp has not been well established, and would not compare well to most other sites where electricity rates were higher.

The case for spending Clean Coal dollars and the need for agency action has not been well made. The fact that the Lima facility is being built without Federal dollars undercuts the argument that the American power industry needs Federal funds to assess the potential of BG/L IGCC systems. There is an abundance of financial information already available. Little regarding coal powered IGCC systems will be learned at Trapp. Trapp is really about MSW, not CCT. Scarce tax dollars should not be spent, as the goals of the Clean Coal program described in the DEIS are already reasonably well met without Federal support, and are not well addressed by the Trapp proposal. Coal pollution abatement by not using coal defeats CCT goals.

Compromised Demonstration of 'Clean Coal'

Throughout the Introduction and Background section of the DEIS, the Federal goal is defined. The basis for funding, and the declared purpose stated there is demonstrating clean coal technology.

The summary page S-3's synopsis bundles the MSW derived fuel into the project goals. The inclusion of MSW & it's derivatives are not documented as a goal in the body of the DEIS, however. The entire background section details the chronology of the CCT program and DOE's interest in demonstration facilities. Nowhere is there mention of MSW or RDF fuels.

As presented in the DEIS,there is no Federal mandate for DOE's CCT program to demonstrate a waste-to-energy facility using clean coal monies. It seems disingenuous to label it a coal demonstration when so little coal is involved and in fact coal tonnage is being displaced by MSW. That is entirely contrary to the stated goals.

As designed, this facility is not going to demonstrate 'clean coal'; it is going to demonstrate a waste-to-energy technology. KPE has declared their long-term intention of using only 20% coal in the feedstock, with the rest being derived from distant sources of Municiple Solid Waste (MSW). DOE should justify how Clean Coal monies should be spent on MSW issues that remove coal from the feedstock.

I wrote the following to researchers at the University of Kentucky Center for Applied Energy Research: 'The questions that I have involve the phase states of the constituents as they transport through the gasifier, the gas cleaner, the sulfur recovery process and the turbine combustion. I am specifically trying to follow the transport and chemistry of metals and their oxides, the fate of chlorinated compounds in the feedstock,and the technology applied to clean the synthesized hydrocarbons.' Dr Burt Davis <davis@noah.caer.uky.edu> replied on Tue Jan 8 17:02:18 2002: 'I assume that you are referring to the facility that has been proposed by Global. If that is the case I have a general understanding of what is proposed. Many of the issue[s] that you raise are very complex and would in many cases be specific to the specific facility.' The results of the research cannot be directly applied other BG/L IGCC facilities that do not use MSW. The constituency of the feedstock, the combustion chemistry, the gas cleaning processes, and the resultant exhaust gases and slag will all vary significantly from facilities that just use coal. The value of Trapp as a research facility for Clean Coal is questionable.

DOE has acknowledged that it is normally responsible for a comprehensive review of alternative sites, and that by choosing to partner with Global Energy, the parent company of KPE, they feel relieved of that responsibility. There are several points to be addressed, however. In addition to the comments below, please consider the *Unreliable Partners* section.

Global Energy has other sites in various stages of construction using BGL based IGCC technology[8]. They are a CCT partner in a nearly identical IGCC plant burning coal since December 1995 in Indiana. They are putting an IGCC plant identical to Trapp in Lima Ohio.

To not consider these sites is improper-it is the same partner. The alternate sites appear to satisfy all stated goals of DOE & the CCT projects. Some may use 100% coal which makes them more valuable as CCT demonstrations sites than one that only uses 20% coal. There may well be other sites as well: DOE & the CCT program have IGCC partners as far away as Kazahkstan.

The fuel cell component of the Trapp demonstration is a fraction of 1% of the total energy production. It has already been demonstrated using sulfur-cleaned coal-based syngas. It is a modular technology that could be added to practically any current IGCC facility, and certainly to the Lima plant.

If MSW derived materials are to comprise 80% of the feedstock, sites closer to the source of the MSW need

8 Appendix E. APPLICATION OF BGL GASIFICATION OF SOLID HYDROCARBONS FOR IGCC POWER GENERATION
2000 Gasification Technologies Conference
San Francisco, California
October 8-11, 2000
Presented by:
GLOBAL ENERGY INC.
Richard A. Olliver

consideration. Energy prices are higher anywhere else in America, offering a better reward for siting elsewhere.

Without a thorough site review, it is impossible to establish whether the advantages offered by EKPC at Trapp are the best deal for the DOE & the public, or if Federal money is even needed to accomplish the goals presented by the DOE & EPA.

DOE and their current partners may better achieve their mandated goal of demonstrating CCTs at a different BG/L IGCC facility. They should be compelled to make that review. More importantly, DOE may be able to avoid spending taxpayers' dollars altogether while still managing to demonstrate coal based CCTs. It is a serious omission of this DEIS to neglect that opportunity.

Flawed Premises: 'No Action Alternatives'

There is good evidence provided by testimony before the PSC that the DEIS' Alternative 2 needs repair. EKPC's commitments, both present and future, are not accurately established. In the event that they are not as represented in the DEIS, the DEIS needs revision & subsequent public review.

Page S-8 describes the three alternatives analysed under this DEIS. The action described as Alternative 2 has been challenged by at least two documents. As well, personal communication with residents of the community of Trapp suggest that Alternative 2 may already be under construction, changing it's status from 'option' to fact.

On July 11, 2001, East Kentucky Power Co-Op (EKPC) amended its permit application before the Kentucky Public Service Commission (PSC) because KPE had not met its financial closing deadline of June 30, 2001. Due to the delay in KPE's financing, East Kentucky 'decided that it cannot reasonably rely on that project to satisfy its future power supply needs.' Therefore, EKPC has concluded that it should proceed to construct a 250 MW coal-fired generating unit at the Hugh L. Spurlock power station in Mason County, Kentucky[9]. This facility should be included as part of the DEIS Alternative 2.

The original NOI from DOE for Trapp includes the following: 'Under the no-action alternative, DOE would not provide partial funding for the design, construction, and operation of the project. In the absence of DOE funding, the Kentucky Pioneer IGCC Demonstration Project probably would not be constructed.'[10] Together, the two

9 Appendix D, Minutes of the Kentucky Public Service Commision, Case # 2001-053, September 26, 2001

10 DEPARTMENT OF ENERGY Notice of Intent To Prepare an Environmental Impact Statement for the Kentucky Pioneer Integrated Gasification Combined Cycle Demonstration Project, Trapp, KY and Notice of Floodplain Involvement. 10th day of April, 2000. David Michaels, Assistant

citations above suggest that all derived components of the DEIS that address Alternative 2 need to address the 250 Mw Mason County facility, and perhaps exclude the alternative as it is now written.

There may or may not be a natural gas fired power island at Trapp already under construction. This may be construction of some peaker units, however. If it is a fact that EKPC has already committed to building the power island, then it is not an 'alternative' but instead, an extant facility and should be dropped from the alternative section of the DEIS and added to the Cumulative Impacts. The residents of Trapp maintain that some construction is already underway.

The Proposed Action section may also need review. EKPC's commitment to the KPE IGCC facility is still contingent on future agreements, and that the DOE's Cooperative Agreement with KPE may be undone in the future by disagreements between KPE & EKPC & the PSC. In September, EKPC testified before the PSC that even 'In the event that KPE is able to secure project financing, East Kentucky stated that certain provisions in the existing purchase power agreement would have to be revised and any renegotiated contract will be resubmitted to the Commission for its prior approval.'

The alternatives offered to the public in the DEIS and scoping process do not represent the real alternatives before them. A revision of the DEIS & a new round of scoping and public comment after the DEIS is repaired is needed.

Likely Failure to get Local Permits

Over the last 15 years, Kentucky has bootstrapped itself into an enviable body of Solid Waste legislation. KRS 224 requires planning and management at both the state and county level for Municiple Solid Waste (MSW) production, reduction, and disposal. This statute provides the legal foundation for local permits. It also defines MSW and Refuse Derived Fuels (RDF).

The MSW being proposed as a feedstock does not qualify under KRS 224 as an RDF, as most of the recyclables (paper & plastics) have not been recovered. See the section *Conflict with State Law* below for more discussion of MSW vs RDF in Kentucky. Further, under KRS 224 there is a 15% limit on RDF in the feedstock before the facility is a waste-to-energy plant requiring local permits.

The language voiced inside the state of Kentucky that has been used to describe the facility differs from that used in the Federal dialog by DOE's corporate partners EKPC and KPE. One wonders if the goal of this contradiction

---

Secretary, Environment, Safety and Health. [FR Doc. 00-9301 Filed 4-13-00; 8:45 am] is to avoid Kentucky law and the requisite permits from local Clark County government.

The DEIS supports the designation of Waste-to-Energy. On page 3-21, section 3.2.2.1, 'Pellet Manufacturers', it states 'Historically, the waste-to-energy industry has used RDF pellets as a means of assuring effective co-feeding at conventional power plants.' The implication is clear: using RDF is waste-to-energy.

KPE's staff are arguing that they are not burning or combusting the 2500-4000 tons/day MSW derived fuel[11] that comprises 50% to 80% of their plant's feedstock, and that the MSW they are using is no longer solid waste once they have removed only the glass and metals. They are leaving most recyclables in the waste stream for their BTU content, preferring to burn rather than recycle them[12].

It is clear to me that they are burning the fraction of MSW that vaporizes at 3200 degrees Fahrenheit, the syngas. DOE's documents frequently refer to the integrated combustion stage that drives the turbines in IGCC facilities: "...(3) **combustion** {emphasis mine}of the clean syngas in a turbine generator to produce electricity...". As well, it is clear that the facility is a waste-to-energy plant: "The briquettes would be made from high-sulfur coal (at least 50%) and refuse (municiple solid waste)" [13]

Outside of Kentucky, Global has no problem describing the process as combustion. For example, in a description of the industrial process they state: '...sulfur recovery units prior to combustion in the gas turbines, resulting in exceptionally low SO2 emissions. '[14] Please compare this with Mike Musulin's (President of KPE) published

---

11 As proposed, KPE will transport as much as 4000 tons of municiple solid waste (MSW) per day from the East Coast to fuel the waste-to-energy facility in Trapp, Kentucky. This is an amount equal to approximately one half of Kentucky's own MSW production.

12 The sample provided by KPE for public inspection at the EPA EIS hearing on 12/11/01 in Trapp was a 10x50 mm compressed bolus made almost entirely of white paper. A rough guess is that particular sample was at least ¾ recyclable content.

13 DOE's Notice of Intent to Prepare an Environmetal Impact Statement for the Kentucky Pioneer IGCC Demonstration Project, Trapp KY

14 Page 5, Appendix E, APPLICATION OF BGL GASIFICATION OF SOLID HYDROCARBONS FOR IGCC POWER GENERATION
2000 Gasification Technologies Conference
San Francisco, California
October 8-11, 2000
Presented by:
GLOBAL ENERGY INC.
Richard A. Olliver

remarks where he says "It is not a combustion process."[15] KPE also plans to use an 80% MSW briquette after the 50% demonstration phase.[16]

The most obvious explanation for the strained language is that KPE needs to make these arguments in order to avoid the application of Kentucky law. If they are a Waste-to-Energy facility, then they are required to conform to the solid waste plan of Clark County Kentucky.

As of today in Clark County, the majority of the governing body, the County Attorney and the state Representative are publicly pursuing their county's right to require and enforce the permit. If KPE resorts to the courts to avoid the local permitting regulations, a significant delay is certain, and outright failure likely.

KPE has not applied for a permit from Clark County for their proposed facility. Their long standing denial of the need to get such a permit has turned public sentiment in the county against them.

Please see Appendix G, Kentucky Air Quality Permit. Further, under KRS 224, failure to get the required local permit disqualifies the state's right to permit the facility.

Conflict With State Law

The following section is an excerpt from the Kentucky Resource Council's comments on the EPA's draft EIS for the Trapp site.

" The proposal to thermally treat and to combust the volatile fraction of one million tons or more per year of treated municipal solid waste falls squarely within the type of facility intended by the General Assembly to be scrutinized under the solid waste planning process.

KRS 224.40-315 mandates that:
No permit to construct or expand a municipal solid waste disposal facility shall be accepted for processing by the Cabinet unless the application contains a determination from the governing body for the solid waste management area in which the facility is or will be located concerning the consistency of the application with the area solid waste Management plan.

The scope of this statute and the requirement for a determination of consistency with the approved solid waste plan is defined by the term municipal solid waste disposal facility, which is defined in KRS 224.01-010(15)

---

15 Op-Ed page, 7/23/2001, Lexington Herald-Leader, Lexington, KY

16Pers Comm: Dwight Lockwood, 12/10/01 c. 7 pm, manager of Regulatory Affairs, Global Energy Inc, Suite 2000, 312 Walnut St, Cincinatti OH 45202 to include:

Any type of waste site or facility where the final deposition of any amount of municipal solid waste occurs, whether or not mixed with or including other waste allowed under subtitle D of the Federal Resource Conservation and Recovery Act of 1976, as amended, and includes, but is not limited to, incinerators and waste-to-energy facilities that burn municipal solid waste, . . .

Because the material is not a refuse derived fuel under KRS 224.01-010(23) in that it has not been subject to extensive separation of municipal solid waste including the extraction of recoverable materials for recycling the processing of the municipal solid waste stream to create the pelletized fuel does not make the material a recovered material under KRS 224.01-010(20). The proposed gasification step in the process and the cleaning of the volatile fraction of the waste for combustion does not make the facility a recovered material processing facility so as to exempt it from the definition of a municipal solid waste disposal facility or to avoid the obligation to be consistent with the local solid waste plan.

Even assuming that the partially processed waste fell within the ambit of refuse derived fuel and the 15%[17] limitation on RDF didn't limit the applicability of recovered material even as to RDF, the proposed facility is not a recovered material processing facility since it proposes to combust the gases created by the thermal and pressure treatment of the waste and is not storing and processing for resale or reuse.

Reuse, as that term is used by the General Assembly does not include use of wastes as a fuel with or without heat recovery. The latter concept is resource recovery and is a term distinct from reuse of solid waste. See: KRS 224.43-010 (3) which sets reuse of solid waste as a priority below reduction, and above recycling, composting, and resource recovery through mixed waste composting or incineration."

The resolution of the conflicting interpretations of KRS 224 will likely require adjudication. The Federal Government should immediately temper it's affinity for the Trapp facility and recognize that it is bankrolling a project that, at best, violates the spirit of Kentucky voters, and at worst will be killed by failing to get a local siting permit after an ugly court fight. Given the visible statutory issues, this project deserves a time-out, not Federal dollars. By funding the Trapp facility, DOE & EPA help undermine the basis for much of the recent

17 Under Kentucky law, only 15% of the material processed by the facility creating the pellets could be credited as RDF.

solid waste planning & management in the state of Kentucky.

Intent to Disregard the Research Results

The DEIS, on page 3-24, Section 3.4.2 'Proposed Actions' states at the end of the second paragraph, 'Data generated during the first-year demonstration would be used to determine if the coal and RDF pellet co-feed would continue after the first year of operation.'

KPE president Musulin has publicly rejected that premise and stated the KPE intends to operate the plant without a new round of permit reviews based on the outcome of the DOE funded research[18].

In regards to the review, who will make the determination to continue the RDF/coal co-feed? The DEIS is sorely inadequate in this area. Absent of any details of the review, no estimation can be made of the quality of environmental protection afforded by the review. The details of the review need to be developed and presented to the public immediately. The state of Kentucky has already issued an Air Quality permit for five years. If the proposed action described in the DEIS to review the data is to occur, then DOE and EPA will have to be the ones to require it.

Given KPE's clear intent, it is reasonable to require DOE to contractually obligate the review, publish it's full details, seek a bond to secure the agreement, and require Occurance class insurance to assure the intended levels of safety. In the face of evidence to the contrary, the cooperation of KPE cannot be presumed, and must be contractually required. Trusting KPE to volunteer for review and abide by the results can no longer be an option. This contract should also be part of the DEIS, and deserves public comment and review.

DOE's notice of intent to prepare the EIS states clearly that the project is "designed for at least 20 years of commercial operation...", and that "Upon completion of the demonstration, the facility **could** (my emphasis) continue commercial operation."[19] KPE has said "Kentucky Pioneer Energy will furnish Kentucky residents with low-cost power, high-quality jobs, and a cleaner environment for years to come."[20]

---

18 pers comm, Mike Musulin, President KPE, 12/11/01 9 pm, just after the close of the formal EPA EIS hearing "If we did that, nothing would ever get built." This comment was made to me, the Lee County Solid Waste Co-ordinator Ms. Neely Back, to Clark County resident, John Maruskin, and others.
19 DOE's Notice of Intent to Prepare an Environmetal Impact Statement for the Kentucky Pioneer IGCC Demonstration Project, Trapp KY
20 Op-Ed page, 7/23/2001, Lexington Herald-Leader, Lexington, KY

One of two things can be drawn from these facts: either there should be a mandated public review and re-permit at the end of the demonstration because the outcome of the research and the safety of the waste product are uncertain, or that the outcome is certain and does not deserve Federal research monies.

In the event that DOE does fund the R&D facility, it should require, by contract and bond, a new round of public review and a new round of state permits predicated on the results of the test period. The absence of details about the how the data from the first year would be used to determine the continued use of coal/MSW/RDF is a significant omission in the DEIS.

Unreliable Partners, Private Funding Delays, Inadequate Planning and Uncertainties

KPE & EKPC are having trouble already (see Appendix D, the PSC September 11th hearing). The public pronouncement by KPE that they intend to run the facility without regard to the outcome of the first year flies in the face of the text of the DEIS and challenges the notion that they are a good partner for DOE, EPA, and the public. As well, the determined effort to avoid the local permitting requirements calls into question their commitment to public partnership.

Many of the features of the KP IGCC DEIS are founded on the DOE's partnership with Global Energy, KPE & EKPC. The failure to consider other sites, the inclusion of MSW derived fuels instead of coal, and the reliance on old studies from EKPC's prior EIS's are among those features. The appropriateness of DOE's relaxed efforts is predicated on the quality of their choice of partners. There is evidence that these partners have failed to measure up and casts doubt on their ability or willingness to deliver.

KPE missed it's financial closing deadline of June 30th, 2001. In testimony before the Kentucky Public Service Commission, KPE's partner EKP stated "However, due to the delay in KPE's financing, East Kentucky (EKP) decided that it cannot reasonably rely on that project (Trapp) to satisfy its future power needs."[21]

The Trapp facility had originally been planned as a Duke Energy subsidiary (Ameren) project in southern Illinois, but that encountered siting difficulties and was canceled.[22]

---

21 Appendix D. Commonwealth of Kentucky Public Service Commision case 2001-053, report on the hearing of 8/18/01, "Application of East Kentucky Power cooperative, Inc for a certificate of public convenience..."
22 Robert W. Gee,Assistant Secretary for Fossil Energy,

EKPC failed to send representatives to either of the December 2001 DEIS public comment meetings in Kentucky. KPE has neglected to apply for a critical permit from Clark County. They failed to apply due diligence in the review of applicable law and instead maintain that they are not operating a waste-to-energy facility, preferring a court battle over accommodating the local public.

The Federal Government should not risk public dollars on a project that, by DOE's own admission, may be poorly located, has a track record for last minute siting problems, and is anticipated to fail by it's own corporate partners. The quality of the partnership itself has become suspect in light of facts presented in these comments and appendices.

Disregard for Social Justice and Environmental Issues

Unlike New York, Kentucky has addressed our solid waste disposal problems. 4000 tons a day is a lot of trash. It is nearly half of what Kentucky produces each day. If folks in Trapp Kentucky can afford proper garbage disposal, New Yorkers can too. We have 23 other power plants awaiting permits. None of them want to incinerate 4000 tons of trash a day.

KPE has not offered any incentives to Kentucky. From Kentucky's view it's a clear loss. KPE is an Ohio company. Most jobs and all the profits leave the state. KPE will act to the advantage of it's parent, Global Energy, not EKPC or the Commonwealth. Since no local permit has been sought, there has been no discussion in Clark County of a 'Host Agreement', the contract of mutual benefits imposed on permit holders. Hence, there are no local benefits to offset any undesirable impacts from the facility. The Commonwealth's air quality is more excessively burdened by the metals and other contaminants in the imported MSW/RDF than if KPE burned Kentucky coal. From the Commonwealth's point of view KPE should be demonstrating 100% Kentucky coal. Kentucky already has the lowest energy costs in the nation: there is little demonstrated need for the power generated at Trapp.[23] A facility would be better located nearer it's feedstocks and high rate energy markets than at the proposed Trapp site.

If the Federal Government choses to fund the Trapp facility, many public bads (as opposed to public goods) will occur: Kentucky will see an escalation of landfill costs; elimination of new business opportunities due to increased scarcity of clean air and water; significant,

---

U.S. Department of Energy, before the Subcommittee on Interior and Related Agencies Committee on Appropriations, on March 14, 2000.

23 http://www.kentuckyconnect.com/heraldleader/news/121601/statedocs/16electricity-plants.htm

yet avoidable, public health issues due to metals, carcinogens, CO, CO2, NOx, and other pollutants in the air, soil and water; abuse of the will of Kentuckians and our laws. All this for a tiny handful of jobs. All this just to demonstrate cheap energy in the state with the cheapest energy, and a solid waste disposal solution in a state that solved that problem 10 years ago.

The environmental virtues of IGCC are offset by the MSW costs: massive chronic train loads of trash, importing hazardous metals and organic compounds as garbage, failing to recycle paper and plastics from 4000 tons/day of MSW, using local landfill space for 500 tons/day of heavy metal laced waste, competition with one of Kentucky's largest cites for scarce water, and burdening the air with a wide array of degrading elements.

Inadequate Design Data

Critical plant design components are missing from the DEIS. The fate of Mercury is a good example-some will be captured as particulates just after the gasifier, and some in the de-sulfurization step, but without the design data, no-one can more than guess what the capture rates are. Congress has mandated the reduction of Mercury, yet there is no visible effort or data in the DEIS to that end. The same can be said for other toxic metals.

Water use is not well documented. A typo in Figure 3.1.1-1 on page 3-14 of the DEIS shows untreated steam being piped to the turbines. The technologies for cleaning the gasification products are ambiguous, and the fate of water used to clean and cool the gases is not clear. The nature and degree of contamination of the 'aqueous effluent' is not detailed. The margin of additional risk to water quality and quantity from the transportation and use of MSW/RDF vs coal cannot be reasonably measured by information in the DEIS. The Trapp site is immediately upstream from the primary water source for the second largest city in the state.

In the absence of information like that shown below, no analysis can be made about the fate of constituents. It is bordering on travesty that DOE published a DEIS absent of the essential design information needed to make any estimate of environmental impact.

The environmental impact of an IGCC plant is a function of the thermal and chemical character of the facility. Section 3.1.2 should address the temperature profile of the pyrolytic products. Examples of the types of information missing are offered below:[24]

24 P. 51 www.nrel.gov/docs/fyosti/29952.pdf and British Gas/Lurgi Gasifier IGCC Base Cases PED-IGCC-98-004 Rev June 2000. pp3-4 URL: www.doe.gov/coalpower/gasification/system/bgl3x_20.pdf

Example process diagrams:

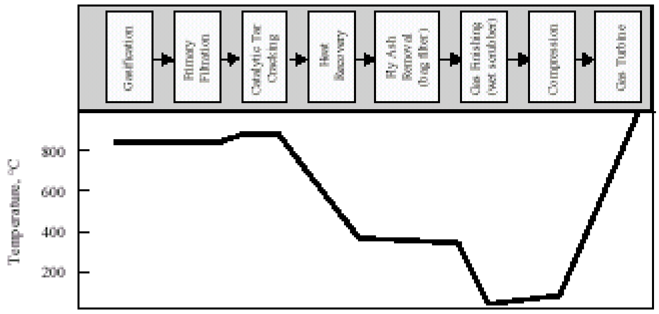
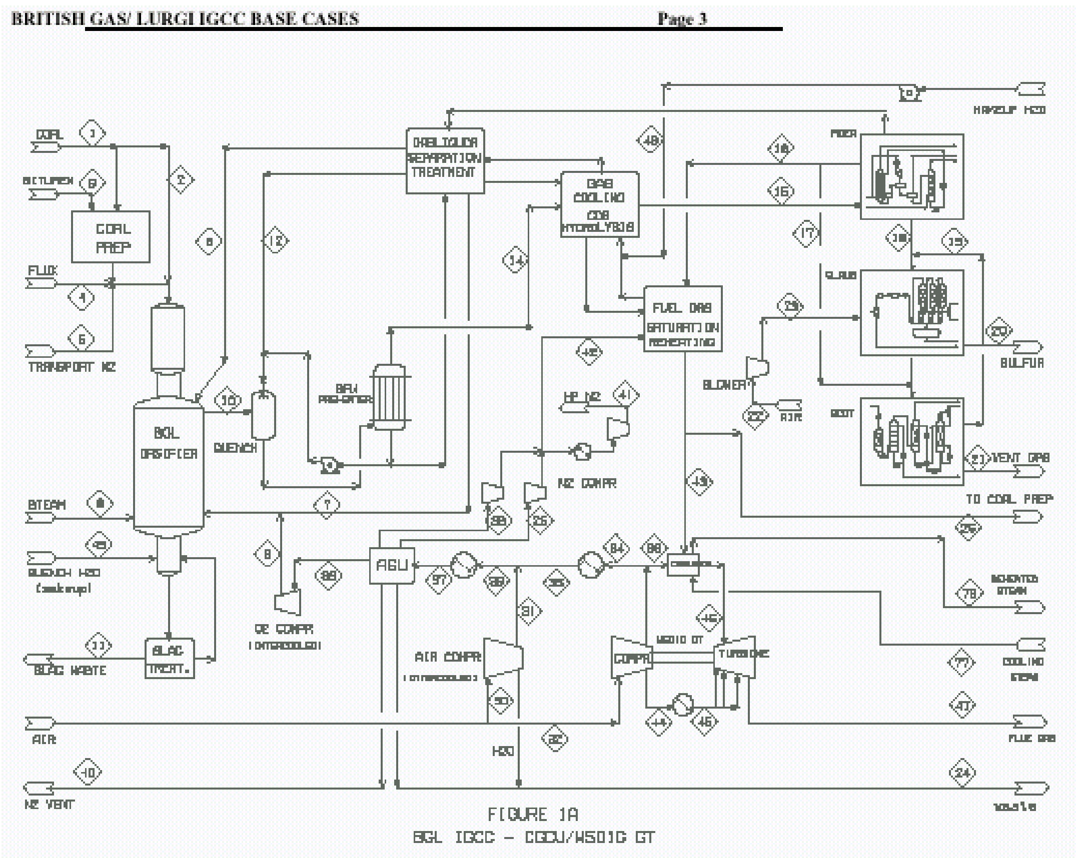


Figure 4.4 **Temperature Profile of ARBRE Gasification System**



Example flow rate and temperature regime diagram.

BRITISH GAS/ LURGI IGCC BASE CASES **Page 4**

FIGURE 1B

BGL IGCC - CGCU / W501G GT

SUMMARY:

POWER	MWe	EFFICIENCY:	%
GAS TURBINE	272.6	HHV	45.3
STEAM TURBINE	133.4	LHV	47
MISCELLANEOUS	19.5		
AUXILIARY	11.6		
NET POWER	374.9		

STREAM	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
FLOW (LB/HR)	237527	178146	4228	10076	9661	9019	8841	75006	124519	446254	35011	279000	9019	712236	388806
TEMPERATURE (F)	59	59	302	59	110	160	160	684	303.6	986.4	140	176	299	299	100
PRESSURE (PSIA)	14.7	14.7	14.7	14.7	420	395	395	500	464.1	395	14.7	435	392	392	371
H (MM BTU/HR)	-281.3	-211	-1.8	-52.3	0.1	3	3.1	-413.7	3.1	-751.4	-78.5	-1858.5	3.5	-2666.1	-713.5

STREAM	16	17	18	19	20	21	22	23	24	26	30	31	32	33	34
FLOW (LB/HR)	368010	7078	15010	1101	5880	29370	13172	13172	2992	2241	261884	260756	4320000	3517529	261884
TEMPERATURE (F)	116	116	144.2	70	285	70	59	161.2	67.6	550.7	59	204.2	59	813.5	813.5
PRESSURE (PSIA)	376	376	18.5	17.5	14.7	17.5	14.7	25	14.7	335	14.7	280.4	14.7	282.4	282.4
H (MM BTU/HR)	-668.1	-12.8	-37	-3.6	0.3	-73.7	-0.5	-0.2	-20.4	-3.8	-10.9	4.4	-180.3	512.2	38.1

STREAM	35	36	37	38	39	25	40	41	42	43	44	45	46	47	48
FLOW (LB/HR)	261884	522630	522630	124519	126005	25654	244597	14492	137166	573255	527109	527109	4090792	4617902	71442
TEMPERATURE (F)	460	333	179.4	60	62	60	62	112.8	303.8	550.7	813.5	600	2583	1124.1	59.8
PRESSURE (PSIA)	280.4	280.4	280.4	92	91	265	91	425	360	335	282.4	276.8	268.5	15.2	375
H (MM BTU/HR)	14.6	18.9	-0.9	-0.6	-1.4	-0.2	-2.7	0	3.3	-983.5	76.8	47.9	-510.8	-2215.5	-491.8

STREAM	49	77	78
FLOW (LB/HR)	6793	70000	70000
TEMPERATURE (F)	59	606.2	1055.4
PRESSURE (PSIA)	14.7	350	342
H (MM BTU/HR)	-46.8	-388.6	-371.8

Significant research is needed to characterize the effluents from a coal fired IGCC facility compromised with low ratios of coal to MSW/RDF. Kentucky will bear the risk of insufficient research.

Please find attached a (very) preliminary bibliography (Appendix A) that suggests both a paucity of peer-reviewed research specific to our case and confounding results.

The titles in that list suggest that nearly all the available literature is on MSW and Incineration technologies. The Trapp feedstock is a relatively heterogeneous coal and MSW/RDF mix, and the IGCC facility is not an incinerator, hence little of the available literature is necessarily applicable.

Largely absent from the list are independent peer reviewed assessments of ICGG produced fritted slag from mixed coal MSW/RDF feedstocks. There is little in the literature to reassure the public that BG/L IGCC facilities & frit are unfailingly environmentally benign, or that all the heavy metals in the feedstock are effectively sequestered.

The DEIS has not adequately addressed the short & long-term character of the fritted slag. There is some question as to the efficacy of metal sequestration in the frit. MSW/RDF has a highly variable metal and energy content compared to coal. It is possible that the metal concentrations in the vitreous waste will also be more variable, making the specific character and safety of the 500 ton/day of solid effluent harder to characterize. The DEIS should detail how & by whom the frit will be assessed.

The public cannot measure the risk created by the Trapp facility without additional review and research. In the face of such uncertainty, it is reasonable to require an Occurance class insurance policy sufficient to remediate potential long term damages. Unless DOE and the EPA bind KPE & EKPC to a new round of permits to review the results of the one year demonstration, or a long term occurance insurance policy that can cover any damages, the facility should not be funded.

In Conclusion

There are significant flaws and omissions in the Trapp facility DEIS. These demand repair and a new round of public review.

While it is not the Federal Government's job to enforce Kentucky law, the Feds should not facilitate the avoidance of Kentucky law nor reward the good environmental management efforts of Kentucky by dumping New York's trash on us.

The determination that there are no significant environmental or social justice issues is not supported by the facts. Many genuine environmental questions remain about the use of MSW/RDF. It is clear that Kentucky would be better off using 100% coal at Trapp.

It is patently unfair to reward a poor state that has afforded itself a safe means of disposal of its own MSW with almost a volume half again it's own, just to lower the cost in a far more affluent state. It is an injustice to unecessarily risk the physical and economic health of that poorer state for the sake of experimentation when there are no local benefits.

Kentucky doesn't have a waste disposal problem, so we cannot benefit there. Our costs will inevitably rise to compensate for the demand on our landfill space for the frit and other waste from East Coast waste. Our costs for health care will inevitably rise to repair the damage from heavy metals that could be avoided. The quality and quantity of water available to the second largest city in the state is unecessarily threatened, risking it's economic growth. Using MSW/RDF denies a long term market for Kentucky coal.

The decision to not consider other sites is not supported: partners already have IGCC facilities to demonstrate the fuel cell component. Failing to include the Lima, Ohio plant is a clear sign of the inadequacy of the DEIS site selection effort. Electricity demand and price are higher anywhere else in the country. Trapp may be one of the worst sites available. Given the long distances from the MSW source material, sites to the north and east deserve consideration.

EKPC should have attended the December DOE/EPA hearing at Trapp. KPE has proven unreliable at acquiring funding. EKPC has interjected a PSC decision into their commitment to DOE. EKPC & KPE relations are visibly suffering. The current partners are not working well with the public or each other. DOE should not use them as the basis to deviate from a full site review.

The Federal Government should not invest in a project at such risk of foundering in a permit fight.

The Federal Government should not invest in a project that cannot acquire timely and reliable private funding.

DOE & EPA need to justify the use of research dollars on a facility that intends to ignore the research outcome.

The DOE CCT program should not divert scarce Federal funds to research that is outside the realm of Clean Coal. Using CCT monies for research on MSW/RDF diverts those dollars from their intended purpose. DOE CCT's mandate is to make coal clean to use, not to remove coal from the energy production cycle.

The Lima, Ohio Global Energy facility undercuts the basis for Federal investment. The goals of DOE & CCT can be met without Federal funding.

The Mason County Spurlock plant now seeking permit from the Kentucky PSC by EKPE addresses the base electrical needs stated in the DEIS without Federal funding.

The lack of design information in the DEIS makes it a dysfunctional document-one cannot estimate the environmental impact of the proposal from what is included in the DEIS.

There is overwhelming evidence that the DEIS needs repair. The document does not detail the environmental impacts of the Trapp facility, nor defend the need for agency action. The DEIS, as presented, is more a dogmatic tract asking for the public's faith than a fact-filled document presenting the environmental impact of the proposed facility. Please mend the document and offer it again for public review.

Will Herrick
4859 Flat-Mary Rd
Campton, KY 41301

Appendix A-IGCC Frit & MSW Title Search Results

The Dialog © search terms used here are : LURGI OR BG/L OR IGCC OR INTEGRATED()GASIFICATION OR FRIT OR SLAG)(S)(MSW OR GARBAGE OR RDF OR REFUSE)

As is evident from the titles below, nearly all the available literature is on MSW and Incineration technologies. The Trapp feedstock is a relatively heterogeneous coal & MSW/RDF mix.

As DOE's partner, KPE, has repeatedly informed us, the IGCC facility is not an incinerator, and RDF mixed with coal is not MSW, hence little of the available literature is necessarily applicable.

While a case by case review seems neccessary to determine whether the available publications are germane and their impact on the goals of the DEIS, what is largely absent is independent peer reviewed assessments of ICGG produced fritted slag from mixed coal MSW/RDF feedstocks. There is little in the literature to reassure the public that BG/L IGCC frit is unfailingly environmentally benign and that all the heavy metals in the feedstock are effectively sequestered there.

The first citation below is not part of the Dialog search.

Bibliography

5. "Destruction of Toxic Organic Substances in a Slagging Gasifier Including Determination of Heavy Metals in the Slag" Distefano, R. P., Eberle, D.J. *et al.*, Columbia University Account Number 5-20270, Final Report for U.S. EPA Office of Research and Development July 15,1983.
===
2/6/1 (Item 1 from file: 10)
Application of refuse slag in concrete for agriculture (Cinders). 18092
Onderzoek naar de toepassing van afvalverbrandingsslakken-beton
1980
AGRICOLA 70-2001/Dec (c) format only 2001 The Dialog Corporation
===
2/6/2 (Item 2 from file: 10)
472238 739228213
Einfluss steigender Gaben an Mullschlacke auf die Ertragsbildung und den Gehalt an Spurenelementen im Weizen; Influence of increasing amounts of refuse slag on yield of wheat and its content of trace elements
1973
AGRICOLA 70-2001/Dec (c) format only 2001 The Dialog Corporation
===
2/6/3 (Item 3 from file: 10)
429320 739188394
Die Verwertung von Mullschlacke fur landwirtschaftliche Zwwcke; Use of garbage slag for agricultural purposes [Fertilizing]
1972
AGRICOLA 70-2001/Dec (c) format only 2001 The Dialog Corporation
===
2/6/4 (Item 1 from file: 5)
09173740 BIOSIS NO.: 199497182110
PCDD/PCDF formation and destruction during co-firing of coal and RDF in a slag forming combustor.
1994
Biosis Previews (R) 1969-2001/DEC W4 (c) 2001 BIOSIS
===
2/6/5 (Item 2 from file: 5)
08124468 BIOSIS NO.: 000042105091
FIXATION OF RESIDUES FROM SPECIAL HAZARDOUS WASTE INCINERATORS FOR SHALLOW LAND DISPOSAL
1992
Biosis Previews (R) 1969-2001/DEC W4 (c) 2001 BIOSIS
===
2/6/7 (Item 2 from file: 50)

00969969   CAB Accession Number: 802407952
Study of the use of refuse slag concrete.
Original Title: Ondersoek naar de toepassing van afvalverbrandingsslakken-beton.
Publication Year: 1980
CAB Abstracts 1972-2001/Nov (c) 2001 CAB International
==
2/6/8   (Item 3 from file: 50)
00313886   CAB Accession Number: 751915099
Effect of increasing amounts of town- refuse slag on yields and trace-element contents of wheat.
Publication Year: 1973
CAB Abstracts 1972-2001/Nov (c) 2001 CAB International
==
2/6/10   (Item 5 from file: 50)
00233560   CAB Accession Number: 750330246
Preliminary trials with refuse slag as a material for the drainagelayer in turf sports grounds.
Original Title: Vorversuche mit Mullschlacke als Dranschicht-Baustoff fur Rasensportflachen.
Publication Year: 1974
CAB Abstracts 1972-2001/Nov (c) 2001 CAB International
==
2/6/12   (Item 1 from file: 203)
00921338
Plant uptake of heavy metals (pots and mini plots), D: Trace metals in solid waste materials, plant availabilities in soil mixtures at varying pH, pot experiments [sandy-loam, green house, Italian ryegrass, sludge, garbage , compost, sludge-pyrolysis slag , incineration slag , incineration fly ash, manganese, copper, zinc, nickel, lead, cadmium, pH] (Spormetaloptag i planter (kar- og rammeforsoeg), D: Spormetaller i affaldsmaterialer, plantetilgaengelighed ved jordindblanding ved varierende pH; karforsoeg)
1981
[Agricultural use of sewage, 3: Report sections] (Slammets jordbrugsanvendelse, 3: Delrapporter)
AGRIS 1974-2001/Oct Dist by NAL, Intl Copr. All rights reserved

==
2/6/14   (Item 1 from file: 8)
05776764
Title: Fundamental tests on application of MSW direct melting slag as soil improvement material
Publication Year: 2000
Ei Compendex(R) 1970-2001/Dec W4 (c) 2001 Engineering Info. Inc.
==
2/6/15   (Item 2 from file: 8)
04918884
Title: Muellschlackenbehandlung in der MVB Hamburg-Borsigstrasse
Title: Refuse incineration slag treatment in the Hamburg-Borsigstrasse refuse incineration plant
Publication Year: 1997
Ei Compendex(R) 1970-2001/Dec W4 (c) 2001 Engineering Info. Inc.
==
2/6/16   (Item 3 from file: 8)
03883223
Title: Mechanische Aufbereitung von Schlacke aus Muellverbrennungsanlagen mit dem Schwerpunkt Schrott
Title: Mechanical processing of refuse incinerator slag with special emphasis on refuse incinerator scrap
Publication Year: 1993
Ei Compendex(R) 1970-2001/Dec W4 (c) 2001 Engineering Info. Inc.
==
2/6/17   (Item 4 from file: 8)
02801727
Title: Beurteilung der Umweltvertraeglichkeit vonMuellverbrennungsschlacken im Strassenbau.
Title: Evaluation of the environmental compatibility of using slag from refuse incineration in road construction.
Publication Year: 1989
Ei Compendex(R) 1970-2001/Dec W4 (c) 2001 Engineering Info. Inc.
==
2/6/18   (Item 5 from file: 8)
00578330
Title: Refuse Slag Melting: Experiences and Expectations.
Title: MUELLSCHLACKENSCHMELZE -- ERFAHRUNGEN, ERWARTUNGEN.
Publication Year: 1976
Ei Compendex(R) 1970-2001/Dec W4 (c) 2001 Engineering Info. Inc.
==
2/6/20   (Item 7 from file: 8)
00242360
Title: Conclusions drawn from operating experience of a refuse slag sintering plant.
Title: Folgerungen aus den Betriebserfahrungen mit einer Muellschlackensinteranlage.
Publication Year: 1971
Ei Compendex(R) 1970-2001/Dec W4 (c) 2001 Engineering Info. Inc.

==
2/6/26   (Item 1 from file: 34)
09513461   Genuine Article#: 412VM   Number of References: 3
Title: Melting and stone production using MSW incinerated ash (ABSTRACT AVAILABLE)Publication date: 20010000
SciSearch(R) Cited Ref Sci 1990-2001/Dec W5 (c) 2001 Inst for Sci Info
==
2/6/28   (Item 1 from file: 40)
00398899   ENVIROLINE NUMBER: 92-09432
Slag   and Fly Ash from   MSW Incineration Plants Characterization and Reuse
Sep 91
Enviroline(R) 1975-2001/Dec
==
2/6/29   (Item 1 from file: 41)
254352   98-09586
Assessment of the long-term behavior of MSW incinerator slag
Pollution Abs 1970-2001/Nov (c) 2001 Cambridge Scientific Abstracts
==
2/6/30   (Item 2 from file: 41)
035545   75-02666
Using slag from refuse incinerators as a building material.   Publ.Yr: 1974
Pollution Abs 1970-2001/Nov (c) 2001 Cambridge Scientific Abstracts
==
2/6/31   (Item 1 from file: 51)
00109885   76-02-m0224   SUBFILE: FSTA
Effect of increasing doses of incinerated household refuse   slag on yield and trace element content of wheat)
Einfluss steigender Gaben an Muellschlacke auf die Ertragsbildung und den Gehald an Spurenelementen im Weizen.
1973
Food Sci.&Tech.Abs 1969-2001/Feb W1 (c) 2001 FSTA IFIS Publishing
==
2/6/32   (Item 1 from file: 63)
00793584   DA
TITLE: HOUSEHOLD- REFUSE INCINERATION SLAG IN ROAD ENGINEERING - THE FRENCH EXPERIENCE
PUBLICATION DATE: 20000000
DATA SOURCE: Transport Research Laboratory (TRL)
Transport Res(TRIS) 1970-2001/Nov (c) fmt only 2001 Dialog Corp.
==
2/6/33   (Item 2 from file: 63)
00179992   DA
TITLE: REFUSE INCINERATION SLAG IN ROAD CONSTRUCTION; AFVALVERBRANDINGSSLAK IN DE WEGENBOUW
PUBLICATION DATE: 19771000
DATA SOURCE: Transport and Road Research Laboratory Institute for Road Safety Research State Road Laboratory, Netherlands
Transport Res(TRIS) 1970-2001/Nov (c) fmt only 2001 Dialog Corp.
==
2/6/34   (Item 1 from file: 65)
03253636   INSIDE CONFERENCE ITEM ID: CN034393904
Household- refuse incineration slag in road engineering -the French experience'
CONFERENCE: European conference on mineral planning; Mineral planning in Europe-2nd (199910)
Inside Conferences 1993-2001/Dec W4 (c) 2001 BLDSC all rts. reserv.
==
2/6/35   (Item 2 from file: 65)
02311981   INSIDE CONFERENCE ITEM ID: CN024211210
Processing and utilisation of slag from refuse incinerators
CONFERENCE: International mineral processing congress Vol 5; Wastetreatment, recycling and soil remediation-20th (199709)
Inside Conferences 1993-2001/Dec W4 (c) 2001 BLDSC all rts. reserv.
==
2/6/36   (Item 3 from file: 65)
02090225   INSIDE CONFERENCE ITEM ID: CN021901112
Actual Data Report of Residue and Fly Ash Melting, and Slag   Recovery in the MSW Incineration Plant
CONFERENCE: ISWA international congress-7th (199610)
Inside Conferences 1993-2001/Dec W4 (c) 2001 BLDSC all rts. reserv.
==
2/6/37   (Item 4 from file: 65)
00721397   INSIDE CONFERENCE ITEM ID: CN007033692
Chlorine, Sulfur, and Soluble Slag Extraction with Energy Density Improvements of a MSW Slurry
CONFERENCE: Coal utilization and fuel systems-19th International technical conference (199403)
Inside Conferences 1993-2001/Dec W4 (c) 2001 BLDSC all rts. reserv.
==
2/6/38   (Item 1 from file: 68)
00432246 Environmental Bibliography Number: 2101077
Slag and fly ash from MSW incineration plants characterization and use
PUBLICATION YEAR: 1991
Env.Bib. 1974-2001/Nov (c) 2001 Internl Academy at Santa Barbara
==

2/6/39   (Item 1 from file: 73)
03992928   EMBASE No: 1989161924
Evaluation of the environmental compatibility of using slag from
refuse incineration in road construction
BEURTEILUNG DER UMWELTVERTRAGLICHKEIT VON MULLVERBRENNUNGSSCHLACKEN IM
STRASSENBAU
1989
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/40   (Item 2 from file: 73)
03804900   EMBASE No: 1988254340
Effect of boiler ash on quality of slag from refuse combustion
EINFLUSS DER KESSELASCHE AUF DIE QUALITAT VON MULLVERBRENNUNGSSCHLACKE
1988
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/41   (Item 3 from file: 73)
02659723   EMBASE No: 1984128682
Slag and fluegas of refuse incineration
1984
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/42   (Item 4 from file: 73)
02633069   EMBASE No: 1984152027
Slag and fluegas of refuse incineration plants
1984
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/43   (Item 5 from file: 73)
02619833   EMBASE No: 1984188791
Slag and stack ash from refuse burning installations
1984
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/44   (Item 6 from file: 73)
01618842   EMBASE No: 1980176512
Method for preparation of auxiliary building material from slag and ash
from refuse burning installations
VERFAHREN ZUR HERSTELLUNG EINES ZUSCHLAGSTOFFES FUR BAUMATERIALIEN AUS
ABFALLSCHLACKE UND FILTERASCHE AUS MULLVERBRENNUNGSANLAGEN
1980EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/46   (Item 8 from file: 73)
00997764   EMBASE No: 1978126091
Slag from refuse burning installations used in roadmaking
1977
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/47   (Item 9 from file: 73)
00338014   EMBASE No: 1975110372
Preliminary trials of refuse   slag as drainage layer construction
material for turfed sport felds
VORVERSUCHE MIT MULLSCHLACKE ALS DRANSCHICHT BAUSTOFF FUR
RASENSPORTFLACHEN
1974
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/48   (Item 10 from file: 73)
00118950   EMBASE No: 1974109052
Influence of increasing amounts of refuse   slag on yield of wheat and
its content of trace elements
EINFLUSS STEIGENDER GABEN AN MULLSCHLACKE AUF DIE ERTRAGSBILDUNG UND DEN
GEHALT AN SPURENELEMENTEN IM WEIZEN
1973
EMBASE 1974-2001/Dec W4 (c) 2001 Elsevier Science B.V.
==
2/6/49   (Item 1 from file: 77)
4619049
Supplier Accession Number: 01-07421   V29N06
Metal release from MSW molten slag in single batch leaching test
Conference Papers Index 1973-2001/Nov (c) 2001 Cambridge Sci Abs
==
2/6/51   (Item 1 from file: 94)
04870860   JICST ACCESSION NUMBER: 01A0500927 FILE SEGMENT: JICST-E
Utilization of Slag Produced by Pyrolysis Gasification and Melting
Process of MSW . , 2001
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/52   (Item 2 from file: 94)
04613997   JICST ACCESSION NUMBER: 00A0211677 FILE SEGMENT: JICST-E
Ground Improvement. The Fundamental Tests on Application of MSW Direct
Melting Slag as Soil Improvement Material., 2000
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/53   (Item 3 from file: 94)
04434305   JICST ACCESSION NUMBER: 00A0013173 FILE SEGMENT: JICST-E
Application of melt slag from garbage incinerated ash to fine aggregate

for concrete and solidification material for cement., 1999
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/54 (Item 4 from file: 94)
04434304 JICST ACCESSION NUMBER: 00A0013172 FILE SEGMENT: JICST-E
Utilization of melt slag (crystallization slag)from garbage
incinerated ash to coarse aggregate for concrete., 1999
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/55 (Item 5 from file: 94)
04434298 JICST ACCESSION NUMBER: 00A0013166 FILE SEGMENT: JICST-E
Effective utilization of slag made by thermal decomposition and melting
process from the refuse . Part 1., 1999
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/57 (Item 7 from file: 94)
04292933 JICST ACCESSION NUMBER: 99A0871943 FILE SEGMENT: JICST-E
The experimental examination on the utilization of the garbage
incineration ash liquid slag., 1999
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/58 (Item 8 from file: 94)
04258401 JICST ACCESSION NUMBER: 99A0852498 FILE SEGMENT: JICST-E
Utilization of Melted Slag of MSW for Asphalt Mixture., 1999
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/59 (Item 9 from file: 94)
04236453 JICST ACCESSION NUMBER: 99A0814872 FILE SEGMENT: JICST-E
Stady on effective utilization of liquid slag from fly ash in garbage
incinerator., 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/60 (Item 10 from file: 94)
04193265 JICST ACCESSION NUMBER: 99A0730572 FILE SEGMENT: JICST-E
Development of Technology for Effective Utilization of Refuse
Incineration Ash and Melting Slag . , 1999
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/62 (Item 12 from file: 94)
04188843 JICST ACCESSION NUMBER: 99A0588879 FILE SEGMENT: JICST-E
Trial manufacture of concrete secondary product using refuse liquid slag
fine aggregate., 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/63 (Item 13 from file: 94)
04150439 JICST ACCESSION NUMBER: 99A0600616 FILE SEGMENT: JICST-E
Material property of sintered garbage slag fine aggregate of different
production method., 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/64 (Item 14 from file: 94)
04150429 JICST ACCESSION NUMBER: 99A0600605 FILE SEGMENT: JICST-E
Possibility of utilization of sintered garbage slag fine powder as
alternative cement material., 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/65 (Item 15 from file: 94)
04026340 JICST ACCESSION NUMBER: 99A0378178 FILE SEGMENT: JICST-ETechnology
development in the Ministry of Construction Technology Office
114. On the basic research and test on the possibility of the reuse as
a civil engineering material of the melting solidification (the
non-industrial wastes refuse melting slag) The Touhoku Technology
Office., 1999
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/66 (Item 16 from file: 94)
03976483 JICST ACCESSION NUMBER: 99A0271560 FILE SEGMENT: JICST-E
Manufacturing of glass and glass ceramics from sludge slag and garbage
-incinerated ash 1995 - 1997 (Ministry of Education S)., 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/67 (Item 17 from file: 94)
03907441 JICST ACCESSION NUMBER: 99A0195152 FILE SEGMENT: JICST-E
The Variance in the Physical Properties of MSW Incineration Ash & Slag .
, 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/69 (Item 19 from file: 94)
03857283 JICST ACCESSION NUMBER: 99A0070883 FILE SEGMENT: PreJICST-E
Technology of strengthening garbage incineration fly ash molten slag .
, 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/70 (Item 20 from file: 94)
03792718 JICST ACCESSION NUMBER: 98A0990764 FILE SEGMENT: JICST-E
Study on Refuse Incineration Ash Slag Aggregate Concrete., 1998
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)

==
2/6/71   (Item 21 from file: 94)
03256817   JICST ACCESSION NUMBER: 98A0104167 FILE SEGMENT: PreJICST-E
Utilization of liquid slag of incinerated ash from the municipal refuse
to the road sub-base. , 1997
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/72   (Item 22 from file: 94)
03252627   JICST ACCESSION NUMBER: 98A0081040 FILE SEGMENT: PreJICST-E
A few consideration on the application of the surface melting style
garbage incineration ash slag to fine aggregate for concrete. ,
1997
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/73   (Item 23 from file: 94)
03109521   JICST ACCESSION NUMBER: 97A0196193 FILE SEGMENT: JICST-E
Environment and waste processing, and electric heating. Melting of plasma
type garbage incineration ash and resource recycling of slag . ,
1997
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/74   (Item 24 from file: 94)
02853686   JICST ACCESSION NUMBER: 97A0164865 FILE SEGMENT: PreJICST-E
A study on stabilization of refuse incineration residue molten slag .
, 1996
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/75   (Item 25 from file: 94)
02841414   JICST ACCESSION NUMBER: 97A0070899 FILE SEGMENT: PreJICST-E
Application of garbage incineration ash fused slag to asphalt concrete.
, 1995JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/76   (Item 26 from file: 94)
02753809   JICST ACCESSION NUMBER: 96A0347617 FILE SEGMENT: JICST-E
Practice of environmental countertechnologies. Recycling technology of
garbage incineration ash molten slag . , 1996
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/77   (Item 27 from file: 94)
02725770   JICST ACCESSION NUMBER: 96A0291249 FILE SEGMENT: JICST-E
Utilization of garbage incinerated ash liquid slag to asphalt mixture.
, 1996
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/78   (Item 28 from file: 94)
02663597   JICST ACCESSION NUMBER: 96A0060040 FILE SEGMENT: JICST-E
Resource recycling of slag by plasma-type garbage incineration ash
fusion furnace. , 1995
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/79   (Item 29 from file: 94)
02628384   JICST ACCESSION NUMBER: 95A0851395 FILE SEGMENT: JICST-E
Study of Recycling Ash of Burnt Refuse (Part 3). Application of Slag
Result from Melting Ash of Burnt Refuse for Ceramics Products., 1995
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/80   (Item 30 from file: 94)
02577671   JICST ACCESSION NUMBER: 95A0851394 FILE SEGMENT: JICST-E
Study of Recycling Ash of Burnt Refuse (Part 2). Application of Slag
Result from Melting Ash of Burnt Refuse for Aggregates., 1995
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/82   (Item 32 from file: 94)
02550518   JICST ACCESSION NUMBER: 95A0578969 FILE SEGMENT: JICST-E
Study on the Chemical Components of Slag Prepared from Oota Refuse
Incineration Plant., 1995
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/85   (Item 35 from file: 94)
01520428   JICST ACCESSION NUMBER: 92A0335287 FILE SEGMENT: JICST-E
Melting Treatment of MSW Incinerator Ash and Slag Utilization., 1992
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/86   (Item 36 from file: 94)
01342483   JICST ACCESSION NUMBER: 91A0525830 FILE SEGMENT: JICST-E
Efffective utilization of melting slag from refuse incineration. (2nd
Report)., 1991JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/87   (Item 37 from file: 94)
01342481   JICST ACCESSION NUMBER: 91A0525828 FILE SEGMENT: JICST-E
Investigation on scattering of melting slag from refuse incineration.,
1991
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/88   (Item 38 from file: 94)
01249669   JICST ACCESSION NUMBER: 90A0903543 FILE SEGMENT: JICST-E
Effective utilization of the slag . Paying attention to weight reductio of

refuse incineration residue by high temperature melting, because of
the diffeiculty in securing reclamation land., 1990
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/89   (Item 39 from file: 94)
01141255   JICST ACCESSION NUMBER: 90A0665583 FILE SEGMENT: JICST-E
Effective utilization of melting slag from refuse incineration., 1990
JICST-EPlus 1985-2001/Nov W3 (c)2001 Japan Science and Tech Corp(JST)
==
2/6/90   (Item 1 from file: 98)
02517550   H.W. WILSON RECORD NUMBER: BGSI93017550
Garbage in, gravel out: plasma torches transmute waste into harmless
slag .
May '93 (19930500)
General Sci Abs/Full-Text 1984-2001/Nov (c) 2001 The HW Wilson Co.
==
2/6/91   (Item 1 from file: 103)
04251714   DE-97-0GJ061; EDB-98-009078
Title: Refuse incineration slag treatment in the Hamburg-Borsigstrasse
refuse incineration plant
Original Title: Muellschlackenbehandlung in der MVB Hamburg-Borsigstrasse
Publication Date: Oct 1997
Energy SciTec 1974-2001/Sep B2 (c) 2001 Contains copyrighted material
==
2/6/92   (Item 2 from file: 103)
04028442   EDB-96-112202
Title: Integrated   gasification and brick-making process for treatment
of MSW
Title: Twelfth annual international Pittsburgh coal conference:
Proceedings. Coal -- Energy and the environment
Conference title: 12. annual international Pittsburgh coal conference
Publication Date: 1995
Energy SciTec 1974-2001/Sep B2 (c) 2001 Contains copyrighted material
==
2/6/93   (Item 3 from file: 103)
03981630   NEDO-95-930346; EDB-96-065390
Title: Study of recycling ash of burnt refuse . Part 2. Application of
slag result from melting ash of burnt refuse for ceramics products
Original Title: Toshi gomi shokyakubai no sairiyo ni kansuru kenkyu. 3.
Shokyakubai yoyu slag no yogyo kenzai eno tekiyo
Publication Date: 1 Sep 1995
Energy SciTec 1974-2001/Sep B2 (c) 2001 Contains copyrighted material
==
2/6/94   (Item 4 from file: 103)
03925074   SWD-95-007617; EDB-96-008834
Title: Corrosivity of flue gas slag in refuse fueled boilers -
Background and slag synthesis
Original Title: Korrosivitet hos roekgasslagg i avfallspannor - Bakgrund
och slaggsyntes
Publication Date: Mar 1995
Energy SciTec 1974-2001/Sep B2 (c) 2001 Contains copyrighted material
==
2/6/95   (Item 5 from file: 103)
03719132   CLA-94-100748; EDB-94-135098
Title: RDF -pulverized coal co-firing in a slag combustor. Combustion tests at the
Coal Tech facility
Title: Second international conference on combustion technologies for a
clean environment
Conference title: 2. international conference on combustion technologies
for a clean environment
Publication Date: 1993
Energy SciTec 1974-2001/Sep B2 (c) 2001 Contains copyrighted material
==
2/6/96   (Item 6 from file: 103)
03620671   DE-94-0G1696; EDB-94-036637
Title: Mechanical processing of refuse incinerator slag with special
emphasis on refuse incinerator scrap
Original Title: Mechanische Aufbereitung von Schlacke aus
Muellverbrennungsanlagen mit dem Schwerpunkt Schrott
Publication Date: Dec 1993
Energy SciTec 1974-2001/Sep B2 (c) 2001 Contains copyrighted material
==
2/6/97   (Item 7 from file: 103)
03423561   DE-92-013630; EDB-93-002437
Title: Possibilities of using refuse combustion slag
Original Title: Verwertungsmoeglichkeiten von Muellverbrennungsschlacke
Publication Date: Sep 1992
Energy SciTec 1974-2001/Sep B2 (c) 2001 Contains copyrighted material
==
2/6/98   (Item 8 from file: 103)
01410897   ERA-09-031119; EDB-84-108697
Title: Characterization of slag and fouling residues from co-combustion
of powdered refuse -derived fuel with residual oil and comparison with
coal and RDF residues
Title: Resource recovery from solid wastes
Conference title: Conference on resource recovery from solid wastes
Publication Date: 1982

==
2/6/100 (Item 1 from file: 110)
00110787
Assessment of the long-term behavior of MSW incinerator slag
(1997)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/102 (Item 3 from file: 110)
00081383
Baustoffgemisch zur Herstellung von Form- und Fertigteilen sowie Verfahren zur Herstellung der Baustoffgemische. (Building material mix based on activated waste, preferably slag and ash from refuse incineration or power station and brick and concrete debris and waste) (In German)
(1992)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/103 (Item 4 from file: 110)
00077666
Process and device for cleaning slag from refuse incinerators(1991)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/104 (Item 5 from file: 110)
00072401
A method for incineration of refuse - including recycling fly ash to convert it to slag and adding agent to reduce emissions of acid gases and/or dioxin(s)
(1989)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/105 (Item 6 from file: 110)
00024367
Characterization of slag and fouling residues from co-combustion of powdered refuse -derived fuel with residual oil and comparison with coal and RDF residues
(1982)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/106 (Item 7 from file: 110)
00011329
LEACHING TESTS ON SLAG AND ASHES FROM HOUSEHOLD REFUSE COMBUSTION - RESULTS AND CONCLUSIONS IN VIEW OF WATER PROTECTION. (IN GERMAN).
(1974)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/107 (Item 8 from file: 110)
00004456
THE OXYGEN REFUSE CONVERTER - A SYSTEM FOR PRODUCING FUEL GAS, OIL, MOLTEN METAL AND SLAG FROM REFUSE .
(NA)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/108 (Item 9 from file: 110)
00003856
USING SLAG FROM REFUSE INCINERATORS AS A BUILDING MATERIAL.
(NA)
WasteInfo 1974-2001/Jun (c) 2001 AEA Techn Env.
==
2/6/109 (Item 1 from file: 118)
0481140 ICONDA Accession Number: 1999(07):1001569 ICONDA
Bautechnische Aspekte der Waesche von Muellverbrennungsschlacken
Engineering aspects of rinsed slag from garbage incineration plants
PUBLICATION DATE: 19990000
ICONDA-Intl Construction 1976-2001/Jan (c) 2001 Fraunhofer-IRB
==
2/6/110 (Item 2 from file: 118)
0479753 ICONDA Accession Number: 1999(07):1000131 ICONDA
Muellverbrennung und Muellverbrennungsrueckstaende in Wien
Refuse incineration processes and residual slag in Vienna
PUBLICATION DATE: 19980000
ICONDA-Intl Construction 1976-2001/Jan (c) 2001 Fraunhofer-IRB
==
2/6/111 (Item 3 from file: 118)
0408131 ICONDA Accession Number: 1996(05):1300010 ICONDA
Des machefers d'incineration d'ordures menageres pour le chantier de la deviation de Malzeville
HRIS (household refuse incineration slag) for the Malzeville diversion project
PUBLICATION DATE: 19950000
ICONDA-Intl Construction 1976-2001/Jan (c) 2001 Fraunhofer-IRB
==
2/6/112 (Item 4 from file: 118)
0363249 ICONDA Accession Number: 1993(10):1000376 ICONDA
MVA-Schlacken verglasen. Die Forderungen an die Auslaugbarkeit werden strenger - neue Verfahren und Einsatzgebiete
Clinkered slag from refuse incineration plants. The demands on leachability are becoming stricter - new methods and areas of application

PUBLICATION DATE: 19930000
ICONDA-Intl Construction 1976-2001/Jan (c) 2001 Fraunhofer-IRB
==
2/6/113 (Item 5 from file: 118)
0252372 ICONDA Accession Number: 1997(07):1000753 ICONDA
Emissionspotential einer Muellverbrennungsschlacken-Monodeponie fuer Schwermetalle
Emission potential of a refuse incineration slag monodump for heavy metals
PUBLICATION DATE: 19950000
ICONDA-Intl Construction 1976-2001/Jan (c) 2001 Fraunhofer-IRB
==
2/6/114 (Item 6 from file: 118)
0199167 ICONDA Accession Number: 1988(02):1300030 ICONDA
Scories d'ordures incinerees comme granulat pour beton
Slag of household refuse incineration used in place of aggregatein concrete
ICONDA-Intl Construction 1976-2001/Jan (c) 2001 Fraunhofer-IRB
==
2/6/115 (Item 7 from file: 118)
0191256 ICONDA Accession Number: 1994(11):1000219 ICONDA
Schlacken und staeube verglasen. Aus MVA-Rueckstaenden werden isolierende Glaswolle, Fasern, Schaumglas oder Gussglas hergestellt
Vitrification of slag and dust. Insulating glass wool, fibres, foamed glass or cast glass made from the residues of refuse incineration plants
PUBLICATION DATE: 19930000
ICONDA-Intl Construction 1976-2001/Jan (c) 2001 Fraunhofer-IRB
==
2/6/116 (Item 1 from file: 144)
12448286 PASCAL No.: 96-0105697
Des machefers d'incineration d'ordures menageres pour le chantier de la deviation de Malzeville
(HRIS (household refuse incineration slag) for the Malzeville diversion project)
1995
Pascal 1973-2001/Dec W4 (c) 2001 INIST/CNRS
==
2/6/117 (Item 2 from file: 144)
12118447 PASCAL No.: 95-0348877
Valorisation en structure routiere du machefer d'incineration d'ordures menageres de l'usine de Lyon-Sud
(Upgrading of Lyon-South incineration plant household refuse slag in road structures)
1995
Pascal 1973-2001/Dec W4 (c) 2001 INIST/CNRS
==
2/6/118 (Item 3 from file: 144)
07516738 PASCAL No.: 87-0018306
Scories d'ordures incinerees comme granulat pour beton
(Slag of household refuse incineration used in place of aggregate in concrete) 1986
Pascal 1973-2001/Dec W4 (c) 2001 INIST/CNRS
==
2/6/123 (Item 1 from file: 305)
217021
PCDD/PCDF (polychlorinated dibenzo-p-dioxins and dibenzofurans) formation and destruction during co-firing of coal and RDF (refuse -derived fuel) in a slag -forming combustor.
PD- Jan 1994 ; 940100|
Analytical Abstracts 1980-2001/Dec W4 (c) 2001 Royal Soc Chemistry
==
2/6/124 (Item 2 from file: 305)
033555
Analysis of effluents of an urban solid refuse incinerator: study of methods of extraction and analysis for quantitative determination of polychlorodibenzo-p-dioxins.
PD- 1981 ; 810000|
Analytical Abstracts 1980-2001/Dec W4 (c) 2001 Royal Soc Chemistry
==
2/6/125 (Item 1 from file: 583)
05871685
\genFirmennotizen: ML Entsorgungs- und Energieanla
NETHERLANDS: LURGI /LENTJES GARBAGE INCINERATION
08 Jul 1993
Gale Group Globalbase(TM) 1986-2001/Dec 26 (c) 2001 The Gale Group
==
2/6/126 (Item 1 from file: 636)
02257514 Supplier Number: 44325726 (USE FORMAT 7 FOR FULLTEXT)
Converting Garbage to Glassy Slag
Jan, 1994
Word Count: 196
Gale Group Newsletter DB(TM) 1987-2001/Dec 27 (c) 2001 The Gale Group
==
2/6/127 (Item 2 from file: 636)
01098044 Supplier Number: 40764100 (USE FORMAT 7 FOR FULLTEXT)
Lurgi spots promise in RDF cofiring
April 24, 1989

Word Count: 556
Gale Group Newsletter DB(TM) 1987-2001/Dec 27 (c) 2001 The Gale Group
==
2/6/128 (Item 4 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Melting furnace with stable discharge of slag in waste treatment
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/129 (Item 5 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Study on development of application of municipal waste-incineration slags. Development of concrete products using crystallized slag as fine aggregatesCA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/130 (Item 6 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method and equipment for treatment of waste garbage by gasification and melting to produce slag byproduct
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/131 (Item 7 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Content and internal distribution of heavy metals in roots of plants grown at alkaline pH on slag from municipal solid waste incineration
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/132 (Item 8 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for careful selection of raw material in producing melting slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/133 (Item 9 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Shaft furnaces for melting of trash with continuous discharging of molten slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/134 (Item 10 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Hydraulic activity of eco-cement made by using slag from municipal solid waste incinerator fly ash
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/136 (Item 12 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Manufacture of porous sintered body by using molten slag of municipal waste and sewage sludge
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/138 (Item 14 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Chemical speciation of waste compounds in inorganic residues - A basis for geochemical long term assessment
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/141 (Item 17 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.Manufacture of chlorine-free slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/144 (Item 20 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Process and molten slag incinerator for treating urban domestic refuse
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/145 (Item 21 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Process integrated treatment of slag from municipal refuse incineration
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/146 (Item 22 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Long-term behavior of slag from heat treatment of municipal wastes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/147 (Item 23 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for gasification treatment of organic waste with recycle of gas and wastewater and particular slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/148 (Item 24 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Effect of post-combustion chamber conditions in refuse combustion equipment on the quality of crude gas and slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==

2/6/150   (Item 26 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Operation of fluidized-bed incinerator for industrial wastes or municipal refuse treatment
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/154   (Item 30 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method and device for suppressing generation of minute algae in water by using incinerator slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/155   (Item 31 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for treatment of solid waste having large water content to be molten slag with purification of flue gas
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/157   (Item 33 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Newest developments and long-term experiences in fluidized-bed combustion technology.
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/158   (Item 34 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
System for gasification of waste garbage and melting fly ashes with improved slag discharge
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/159   (Item 35 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Elaboration of a MSWI fly ash solidification stabilization process: use of statistical design of experiments
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/161   (Item 37 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Municipal refuse treatment for recovering valuable materials while detoxicating waste gases
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/162   (Item 38 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Treatment of slag from ashes from incineration of municipal refuse and wastewater treatment sludge
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/165   (Item 41 from file: 399)DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Gasification and smelting system using oxygen blowing for municipal waste
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/166   (Item 42 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Plant for incineration of garbage and melting slag and its structure
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/167   (Item 43 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Environmental properties of vitrified fly ash from hazardous and municipal waste incineration
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/172   (Item 48 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for melting municipal refuse incineration residue without increasing viscosity of slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/175   (Item 51 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Melting and burning apparatus for dry distillation and thermal decomposition of wastes and capable of recovering granulated slag with little heavy metal contamination
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/179   (Item 55 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Hydraulic compositions obtained from incinerator ash and their hardened products
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/180   (Item 56 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Melting treatment of incinerator residue containing salts for slag recovery as aggregate

CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/182 (Item 58 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
System for gasification and melting treatment of waste garbage with improved slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/183 (Item 59 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Apparatus treatment of melting slag from ash melting treatment in garbage treatment facility to reduce lead content
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/184 (Item 60 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Production of granulated slag with smooth surface
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/185 (Item 61 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Calcium silicate compositions containing incinerator ash molten slag for forming construction materials
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/186 (Item 62 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Characterization and assessment of refuse incinerator slag from 15 refuse incinerators with different technology
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/187 (Item 63 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for reducing heavy metals leaching from municipal refuse incineration ash and/or slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/188 (Item 64 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Valorization of LD slag with treated urban wasteCA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/189 (Item 65 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Combustion melting furnace for waste garbage with improved slag discharge
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/190 (Item 66 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Manufacture of high-strength rock wool from molten slag of municipal refuse incineration ash
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/191 (Item 67 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Ground strengthening material from garbage incinerator ash-based slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/192 (Item 68 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Metal recovery from slag generated by melting wastes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/193 (Item 69 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Pavement test of asphalt admixture with molten slag of municipal solid waste incineration ash
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/194 (Item 70 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for operation of combustion melting furnace in waste treatment apparatus with control of slag temperature
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/198 (Item 74 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for separation of molten salt and molten slag in melting incinerator ashes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/199 (Item 75 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Manufacture of tiles from garbage incineration ash slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/200 (Item 76 from file: 399)

DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Refuse incineration slag treatment in the Hamburg-Borsigstrasse refuse incineration plant, GermanyCA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/201 (Item 77 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Method for preventing lowering of fluidity of molten slag in plasma melting furnace for treatment of municipal refuse incineration ash.
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/202 (Item 78 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Separation of pollutants from waste gases from municipal incinerators using furnace ash and/or slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/203 (Item 79 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Process for separation of copper and heavy metals from incinerated garbage residue and slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/204 (Item 80 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Actual data report of residue and fly ash melting, and slag recovery in the MSW incineration plant
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/206 (Item 82 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Behavior of slag derived from DIS (special industrial wastes) and used for road building. Comparison with slag from incineration of domestic waste (OM)
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/207 (Item 83 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Modification of steelmaking slag by utilization of noncombustibles in city garbage
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/208 (Item 84 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Serial batch tests performed on municipal solid waste incineration bottom ash and electric arc furnace slag, in combination with computer modeling
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/209 (Item 85 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Melting of incinerator ash and fly ash in slag discharge type rotary kiln
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/210 (Item 86 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Coloring of molten slag from garbage incineration
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/211 (Item 87 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Heat-treating process for combustible material-containing waste solids
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/212 (Item 88 from file: 399)DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Molten slag from municipal refuse for pavement
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/213 (Item 89 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Processing slag from incineration of municipal wastes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/214 (Item 90 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Processing of municipal and other wastes in molten slag bath
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/215 (Item 91 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Treatment process for residues in refuse incinerator plants
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/216 (Item 92 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Incinerator flue gas cleaning with milled slag sorbents
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY

==
2/6/217   (Item 93 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
The influence of combustion bed temperature during waste incineration on
slag quality
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/218   (Item 94 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Fusion of slags by the HSR process
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/219   (Item 95 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Logistics and management of mechanical slag beneficiation
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/220   (Item 96 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Slag processing and utilization by an association for disposal and use of
waste (GfA) in the Geiselbullach waste incinerator power plant (Germany)
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/222   (Item 98 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Mechanical slag beneficiation technologies and mechanical equipment of
the system KHD Humboldt Wedag AG
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/223   (Item 99 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Slag beneficiation through aging and leaching
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/224   (Item 100 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
DBA-roller grate-direct current firing for optimization of slag qualityCA SEARCH(R)
1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/225   (Item 101 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Criteria and acceptance questions for slag utilization in Switzerland
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/226   (Item 102 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Quantity, quality, and utilization possibilities of waste incinerator
slags - general review
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/227   (Item 103 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
VS Combi reactor of Kuepat AG firm for melting of wastes and combustion
residues
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/228   (Item 104 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
A study on the behavior of PCDDs/DFs in a municipal refuse fly-ash
melting experiment
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/229   (Item 105 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Vitrification of slags and dusts (from refuse incinerators)
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/230   (Item 106 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Statistical analyses of control parameters for physicochemical properties
of solidified incinerator fly ash of municipal solid wastes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/232   (Item 108 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Study on transformation of Cr6+ in codisposal of chromium slag and
domestic garbage
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/233   (Item 109 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Manufacture of melting slag from incinerator ashes from municipal refuse
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/234   (Item 110 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Manufacture of high grade materials from molten slag and low temperature

sintered articles therefrom
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/237 (Item 113 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Melting process of ash from municipal incinerators by plasma arc heating
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/238 (Item 114 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Development of an MSW ash melting system of low running cost
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/239 (Item 115 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Ecologically clean technology for processing of municipal wastes in a
Vanyukov furnace
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/240 (Item 116 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
The presence and distribution of heavy metals in municipal solid waste
incinerators
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/241 (Item 117 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Melting furnaces for waste solid treatment
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/242 (Item 118 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Recovery of vanadium pentoxide by chlorination in hydrochloric acid
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/243 (Item 119 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Utilization of refuse incineration slags after conventional processing.
Part 1
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/244 (Item 120 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
The use of waste materials in civil engineering. AVI slag can replace
gravel in concrete production
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/245 (Item 121 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Wastes, combustion, and then? Qualitative and quantitative aspects of
residues from combustion plants
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/246 (Item 122 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Effect of additions of refuse-incineration-plant (MSZ) slag and a
plasticizer on cement structure
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/247 (Item 123 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Development of municipal solid waste (MSW) ash melting system of IHI
rotary stoker type incinerator
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/248 (Item 124 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.A method for
incineration of refuse
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/249 (Item 125 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Multielement analysis of city waste incineration ash and slag by
inductively coupled plasma atomic emission spectrometry
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/250 (Item 126 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Slag from refuse-incinerating plants for cement concretes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/251 (Item 127 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Solidification materials for solid wastes and soils
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/252 (Item 128 from file: 399)

DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Short-term release of slag and fly ash produced by incineration of municipal solid waste
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/253 (Item 129 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Use of ash and slag from the processing of solid refuse
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/254 (Item 130 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Mortar containing municipal refuse incineration ash fused slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/255 (Item 131 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Concrete plates from municipal refuse incineration ash fused slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/256 (Item 132 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Process for removal of flue dust and/or slags from municiple refuse incinerators
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/257 (Item 133 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Discharge control of fused slag of municipal incinerator ash
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/258 (Item 134 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Optimization of waste combustion plants with the goal of decreasing air pollution
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/259 (Item 135 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Process for waste decomposition
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/260 (Item 136 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Emissions arising during the combustion of high calorific industrial wastes in a municipal incineratorCA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/261 (Item 137 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Leaching behavior of residues from waste incineration plants. 2. Exemplified by the Grossmehring refuse landfill
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/262 (Item 138 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Leaching behavior of residues from waste incinerators, as illustrated by the Grossmehring landfill. (Part 1)
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/263 (Item 139 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Treatment of liquid wastes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/264 (Item 140 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Structure of ceramics produced with slag from city solid refuse
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/265 (Item 141 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Fusion and leaching of dust from waste incinerators
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/266 (Item 142 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Fertilizers from city garbage
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/267 (Item 143 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Melting of ashes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/268 (Item 144 from file: 399)
DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.

Treatment of municipal waste leachate by granulated slag
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/269   (Item 145 from file: 399)

Molten iron bath incinerator for solid wastes
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/271   (Item 147 from file: 399)

Leaching of incinerator slag from municipal waste
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/273   (Item 149 from file: 399)DIALOG(R)File 399:(c) 2001 AMERICAN CHEMICAL SOCIETY. All rts. reserv.
Refractory tamping, spraying, and casting masses for coating slag-tap and cyclone furnaces of power plants and refuse incinerators
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/275   (Item 151 from file: 399)

Leaching experiments on the slag from refuse incineration
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/276   (Item 152 from file: 399)

Refuse slag fusion - experiences and expectations
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/277   (Item 153 from file: 399)

Leaching tests on slag and ashes from household refuse combustion - results and conclusions in view of water protection
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/278   (Item 154 from file: 399)

Leaching tests on slag from refuse combustion - results of Swiss studies
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/280   (Item 156 from file: 399)

Effect of increasing doses of refuse slag on the yield and on the content of trace elements in wheat
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==
2/6/281   (Item 157 from file: 399)

Preparation of raw slag of refuse incineration plants
CA SEARCH(R) 1967-2001/UD=13601 (c) 2001 AMERICAN CHEMICAL SOCIETY
==

Office of Fossil Energy, U.S. Department of Energy • DOE/FE-0215P-39 Issue No. 39, Spring 2000

CLEAN COAL TODAY

A Newsletter about Innovative Technologies for Coal Utilization

Project News Bytes

In December 1999, George Rudins, DOE Office of Fossil Energy Deputy Assistant Secretary for Coal and Power Systems, was named 1999 winner of the **Washington Coal Club's Achievement Award**. The membership of the Washington Coal Club comprises private sector and government representatives working on coal issues and, for the past 20 years, has annually recognized members of Congress, industry, labor leaders, and government officials. Rudins was cited for his leadership in advancing clean coal technologies, as well as promotion of innovative concepts for pollution control, climate change mitigation, and carbon sequestration. He is also the author of FE's Vision 21 plan for a futuristic, virtually non-polluting fossil fuel energy plant.

See "News Bytes" on page 3...

In This Issue

Wabash Completes Fourth Year of Commercial Operation

One of the world's pioneering commercial-scale coal gasification-based power facilities, Wabash River's Integrated Gasification Combined-Cycle (IGCC) plant, has successfully completed its fourth year of commercial operation and processed over one-and-a-half million tons of coal. A winner of *Power* magazine's 1996 Powerplant Award, as well as other honors, Wabash River is one of the cleanest coal-fired facilities in the world, and has contributed greatly to the commercial potential of this advanced coal-based power generation technology. Gasification is already in wide use for syngas-to-chemical production, and under the DOE Office of Fossil Energy Vision 21 initiative, coal-based IGCC is expected to coproduce power and high-value chemicals and clean transportation fuels.

The 262-MWe Wabash River IGCC project repowered an existing facility.

DOE selected Wabash River in September 1991 as a Clean Coal Technology (CCT) Program Round IV demonstration project, and the Cooperative Agreement between the industrial participants and DOE was signed in July 1992. Commercial operation began in December 1995. The Cooperative Agreement ended in January 2000 after a four-year commercial demonstration, and the plant continues in commercial operation.

The original Participant was the Wabash River Coal Gasification Repowering Project Joint Venture, formed in 1990 by Destec Energy, Inc. of Houston, Texas and PSI Energy, Inc. of Plainfield, Indiana. Destec owned and operated the gasification facility, and PSI Energy owned and operated the power generation facility. In 1997, Houston-based Dynegy, Inc. purchased Destec. A final transfer took place last December when Global Energy, Inc. purchased Dynegy's gasification assets and technology. PSI Energy remains the owner and operator of the generating facility.

Major Repayment Made to DOE

Global Energy plans to market and license the Destec Gasification Process under the name: "E-GAS Technology™." Dynegy has repaid DOE $550,000 — $300,000 for the facility and $250,000 for the technology. Global Energy

See "Wabash" on page 2...

...Wabash continued

will promote commercialization of the technology, and make repayments on future equipment sales or licenses for a 20-year period.

THE PROJECT

The project is located at PSI's Wabash River Generating Station near West Terre Haute, Indiana. PSI repowered a 1950s vintage steam turbine and installed a new syngas-fired combustion turbine while continuing to utilize locally mined high-sulfur Indiana bituminous coal. The repowered steam turbine produces 104 MWe that combines with the combustion turbine generator's 192 MWe and the system's auxiliary load of 34 MWe to yield 262 MWe (net) to the PSI grid.

GASIFICATION PROCESS

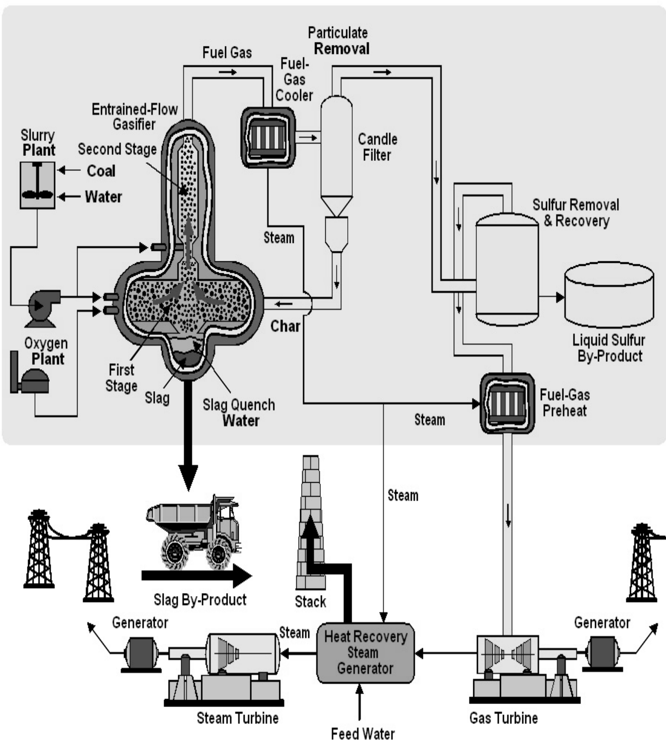
The Wabash Project features the integration of the E-GAS process with an advanced General Electric MS 7001 FA high-temperature gas turbine. The E-GAS process features an oxygen-blown, two-stage entrained flow gasifier capable of operating on both coal and petroleum coke, with continuous slag removal.

As illustrated in the schematic, syngas is generated from gasification of a coal/water slurry with 95 percent oxygen in a reducing atmosphere at 2,600 ^oF and pressure of 400 psig. The syngas produced from coal comprises 45.3 percent carbon monoxide, 34.4 percent hydrogen, 15.8 percent carbon dioxide, 1.9 percent methane, and 1.9 percent nitrogen, and has a higher heating value of 277 Btu per standard cubic foot (dry basis). The ash melts and flows out of the bottom of the vessel as a vitrified slag (frit) by-product. Additional coal/water slurry added to the second gasification stage undergoes devolatilization, pyrolysis, and partial gasification to cool the raw gas and increase its heating value. The syngas flows to a heat recovery unit, producing high-pressure saturated steam that is superheated and used to drive a steam turbine. Subsequently, the particulates (char) in the raw gas are removed with a hot/dry candle filter and recycled to the gasifier where the remaining carbon is converted to syngas. After particulate removal, the syngas is water-scrubbed for chloride removal and passed through a catalyst that hydrolyzes carbonyl sulfide to hydrogen sulfide. The hydrogen sulfide is removed using methyldiethanolamine absorber/stripper columns. The syngas is then burned in a gas turbine that produces electricity. Gas turbine exhaust heat is recovered in a heat recovery steam generator to produce steam that drives the steam turbine to produce more electricity.

Over its four years of operation, the plant has demonstrated an impressive record of continually increasing reliability and syngas production, with 2.7 x 10^{12} Btu in 1996, 6.2 x 10^{12} Btu in 1997, and 8.8 x 10^{12} Btu in 1998. Overall, plant availability has increased from 56 percent in 1997 to 72 percent in 1998 and 79 percent in 1999. Thermal efficiency (HHV) is 39.7 percent on coal and 40.2 percent on petroleum coke compared to the 33–35 percent figure for conventional pulverized coal-fired plants. The greater the thermal efficiency, the less coal is needed to generate a given amount of electricity, thereby reducing both fuel costs and carbon dioxide emissions.

Emissions from Wabash River's IGCC facility are 0.1 pounds of SO_2 and 0.15 pounds of NO_x per million Btu of coal input. This SO_2 emission rate is less than one-tenth the emission limit set for the year 2000 by the acid rain provisions of the Clean Air Act Amendments of 1990. Particu-

E-GAS PROCESS

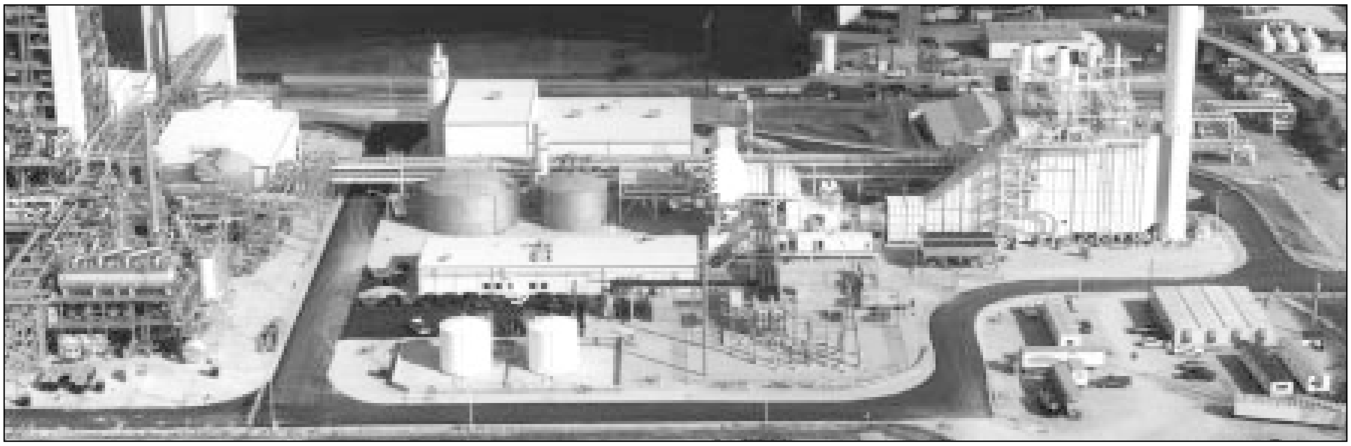


late emissions are less than the detectable limit set by EPA-approved emission measuring methods.

Another major environmental advantage at Wabash is the production of useful by-products. From startup through the end of 1999, Wabash has recovered and sold 33,888 tons of elemental sulfur (99.99 percent purity) for agricultural applications.

The IGCC technology demonstrated at Wabash River is an ideal candidate for repowering the more than 95,000 megawatts of existing U.S. coal-fired utility boilers that are more than 30 years of age, and for meeting the needs of a burgeoning foreign power generation market.

For more details on this and other CCT Program Demonstration Projects, please visit the Clean Coal Technology Compendium web site at http://www.lanl.gov/projects/cctc/.



Award-winning Wabash River IGCC plant continues in commercial operation after four years of successful demonstration.

....News Bytes continued

ENCOAL assets and responsibilities assumed by SGI International. SGI International (SGI) has purchased all ENCOAL plant assets from AEI Resources, which includes assuming full responsibility for marketing and repayment obligations to DOE. SGI has been actively securing customers for the plant's products in order to support the re-start of the mothballed demonstration plant. The company is adding new partners to share plant operating costs, and anticipates re-start by mid-2000. In a related action, SGI International has signed a long-term agreement with American Electric Power (AEP) to transport upgraded coal from the ENCOAL Demonstration Plant near Gillette, Wyoming to AEP's Cook Coal Terminal at Metropolis, Illinois for further barge delivery to various SGI customers, including AEP. This agreement provides a valuable incentive for SGI to restart the plant as well as move ahead with a larger commercial plant.

Fuel cell subcontract approved for Kentucky Pioneer IGCC Project. DOE has reviewed and approved the subcontract between Fuel Cell Energy (FCE) and Kentucky Pioneer L.L.C. FCE is planning to build and operate a 2-MWe molten carbonate fuel cell (MCFC) on a slipstream of clean syngas from the 400-MWe plant. FCE will scale up the design of their module from an existing 250-kW test facility. The FCE activity will cost about $34 million, of which DOE will fund 50 percent. The IGCC project is planned for an existing power plant site in eastern Kentucky and is currently in the design and permitting stage. When completed, this will be the largest commercial-scale IGCC and MCFC facility to operate on coal-derived syngas.

Rosebud SynCoal reorganizes to better align interests. Western SynCoal Co., Montana Power's research and development arm for enhanced coal technologies and products, has reorganized to reduce administrative costs and better align its interests with those of Western Energy Co., an affiliated coal mining company. Under the new structure, Western SynCoal and two other entities, SynCoal Inc. and the Rosebud SynCoal Partnership, will form Western SynCoal LLC, a limited liability company. Western SynCoal was the operating entity of the partnership formed in 1992 between subsidiaries of The Montana Power Company and Northern States Power Company (NSP) to enhance low-quality coals by improving their heating values while removing moisture, sulfur, and ash through an Advanced Coal Conversion Process (ACCP). Over the years, Western SynCoal bought out NSP's interest.

INTEGRATED GASIFICATION FUEL CELL (IGFC) DEMONSTRATION TEST

George Steinfeld, Hossein Ghezel-Ayagh, Robert Sanderson, Sandors Abens

FuelCell Energy, Inc.
3 Great Pasture Road
Danbury, CT 06813-1305

Introduction

Power generation in the United States relies heavily on coal with 56.3% of the power or 1807 billion kilowatt-hours generated using coal in 1998 as shown in Figure 1. As total U.S. coal consumption increases from 1043 to 1279 million tons a year between 1998 and 2020, the average annual increase is projected to be 0.9 percent. About 90 percent of the coal consumed in the U.S. is used for power generation. In the next 20 years, coal is expected to remain the primary fuel for power generation, although its share of total generation declines between 1998 and 2020 as natural gas increases its share[2].

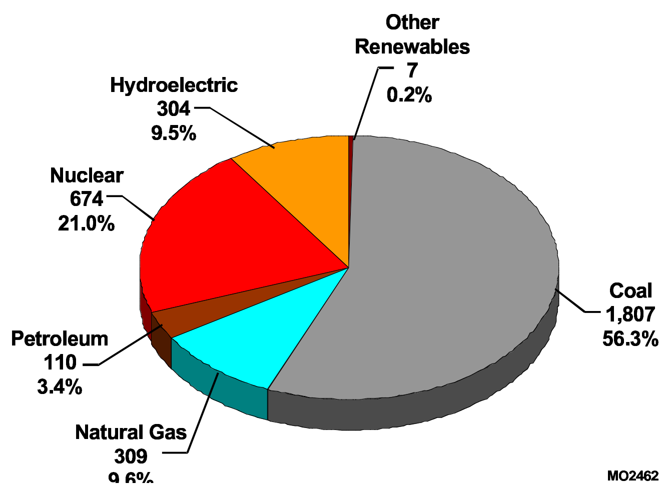


Figure 1

1998 U.S. Electric Generation by Fuel Type (Billion Kilowatt-hours)[1]

Source: U.S. DOE/EIA "Annual Energy Review 1998" (Data for U.S. Electric Utilities)

As concern about the environment generates interest in ultra-clean energy plants, fuel cell power plants can respond to the challenge. Fuel cells convert hydrocarbon fuels to electricity at efficiencies exceeding conventional heat engine technologies while generating extremely low emissions. Emissions of SOx and NOx are expected to be well below current and anticipated future standards. Nitrogen oxides, a product of combustion, will be extremely low in this power plant because power is produced electrochemically rather than by combustion. Due to its higher efficiencies, a fuel cell power plant also produces less carbon dioxide. Fuel cells in combination with coal gasification, are an efficient and environmentally acceptable means to utilize the abundant coal reserves both in the United States and around the world.

To demonstrate this technology, FuelCell Energy Inc. (FCE), is planning to build and test a 2-MW Fuel Cell Power Plant for operation on coal derived gas. This power plant is based on Direct Fuel Cell (DFC™) technology and will be part of a Clean Coal V IGCC project supported by the US DOE. A British Gas Lurgi (BGL) slagging fixed-bed gasification system with cold gas

25th International Technical Conference on Coal Utilization and Fuel Systems
March 6-9, 2000 in Clearwater, FL
Sent on January 24, 2000

clean up is planned as part of a 400 MW IGCC power plant to provide a fuel gas slip stream to the fuel cell. The IGCC power plant will be built by Kentucky Pioneer Energy, a subsidiary of Global Energy, in Clark County, KY.

This demonstration will result in the world's largest fuel cell power plant operating on coal derived gas. The objective of this test is to demonstrate fuel cell operation on coal derived gas at a commercial scale and to verify the efficiency and environmental benefits.

Fuel Cell Power

The carbonate fuel cell derives its name from its electrolyte, which is made up of potassium and lithium carbonates. Figure 2 shows a simplified flow schematic of the carbonate fuel cell power plant. Syn-gas from the gasification plant clean-up system is cleaned up further and moisturized. The moisturized syn-gas is fed to the anode side of the fuel cell where methane is internally reformed and CO is shifted to CO_2 and H_2. Spent fuel exits the anode and is further oxidized in the anode exhaust oxidizer to supply oxygen and CO_2 to the cathode. The resulting reactions in the fuel cell anode and cathode produce DC output which is inverted to AC. The cathode exhaust supplies heat to the fuel clean-up, steam boiler and co-gen system as it is vented from the plant.

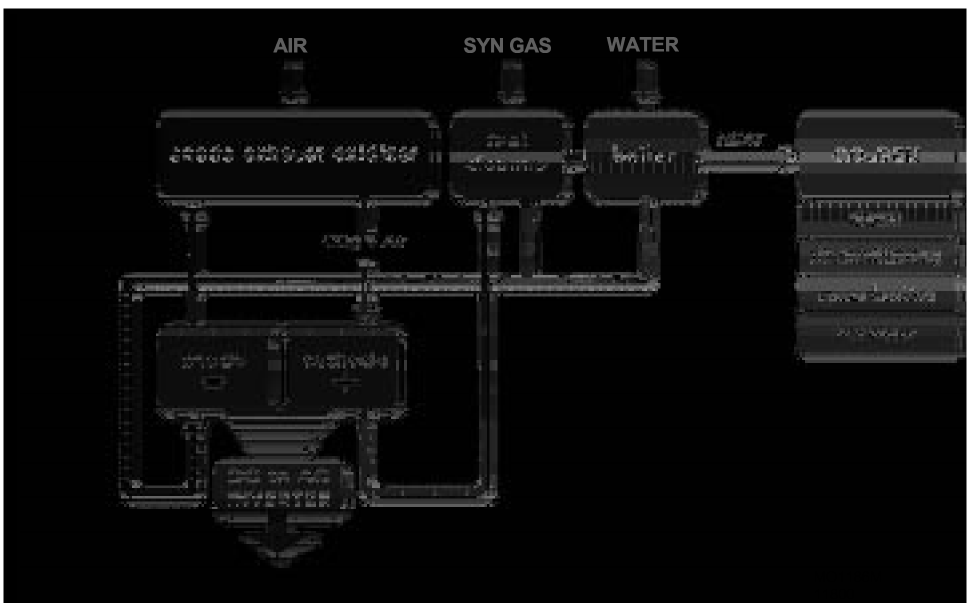


Figure 2.
Fuel Cell Power Plant Simplified Process Schematic

A 3-MW fuel cell power plant designed to operate on natural gas, shown conceptually in Figure 3, will be the basis for the power plant operating on coal derived gas. Two fuel cell modules, each housing four fuel cell stacks, produce the DC power. An inverter converts the DC power to AC. The balance of plant equipment includes thermal management, water treatment, switchgear and controls.

Figure 3
3-MW Fuel Cell Power Plant for Natural Gas

System studies

Fuel cell systems operating on coal have been studied extensively in past years. A simplified block diagram of a fuel cell power plant system is shown in Figure 4. Gasification is used to convert the solid fuel to a gas which is processed to remove sulfur compounds, tars, particulates, and trace contaminants. The cleaned fuel gas is converted to electricity in the fuel cell. Waste heat from the carbonate fuel cell is used to generate steam required for the gasification process and to generate additional power in a bottoming cycle.

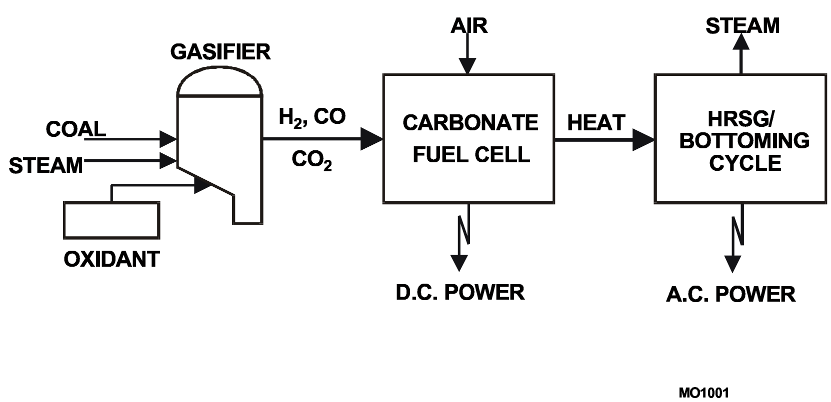


Figure 4
Integrated Gasification Fuel Cell System Simplified Block Diagram

At a 200 MW scale, past studies[4,5,6] indicated that using conventional gasification and clean-up technologies, a heat rate of 7379 (46.3 % HHV efficiency) can be achieved with IGFC utilizing BGL gasification and low temperature clean-up. This plant would require 1800 tons/day coal and generate a net output of 205 MW. Later studies[7,8,11] indicated that higher efficiencies, 51.7% –53.5%, can be achieved with higher methane producing gasifiers and by using hot gas clean-up. More recently[12], studies of hybrid fuel cell/turbine systems have shown that LHV efficiencies of 70% can be achieved on natural gas. This system utilizes a gas turbine as a bottoming cycle to the fuel cell, as shown in Figure 5. This concept can be applied to coal gas systems as well.

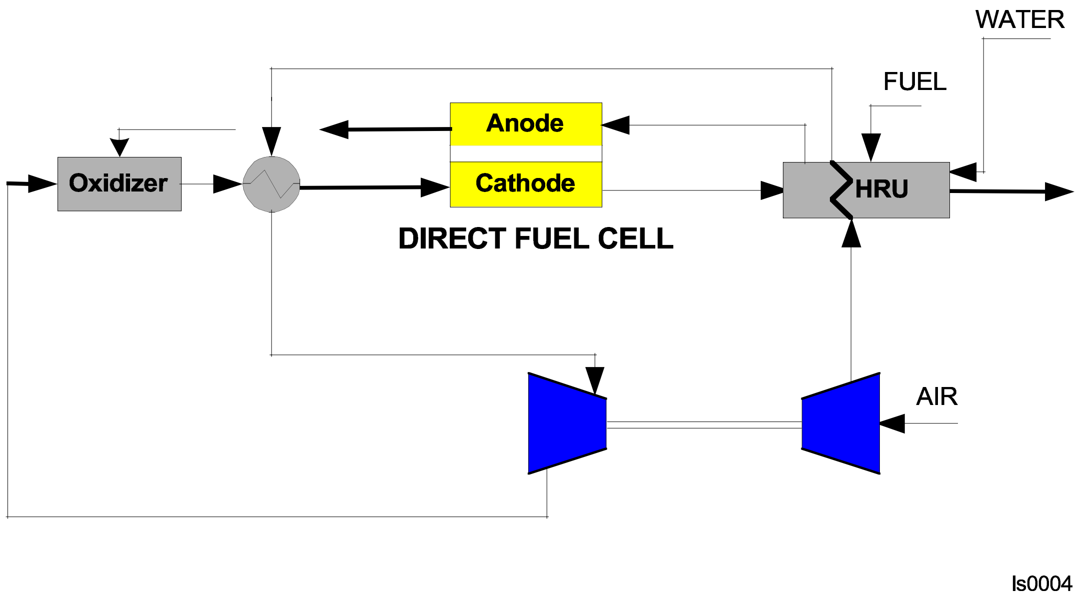


Figure 5
High Efficiency Hybrid Fuel Cell/Turbine Power Cycle

Emissions from this plant would be extremely low and below any current or anticipated future standards. Figure 6 compares the combined SOx, NOx, and solid waste emissions of existing commercial technologies, IGCC and IGFC. IGFC technology achieves the lowest levels of pollutant emissions in addition to lower CO_2 emissions and make-up water requirements. The CO_2 emission is 1.54 lb/kWh and the make-up water requirement is 6.8 GPM/MWh.

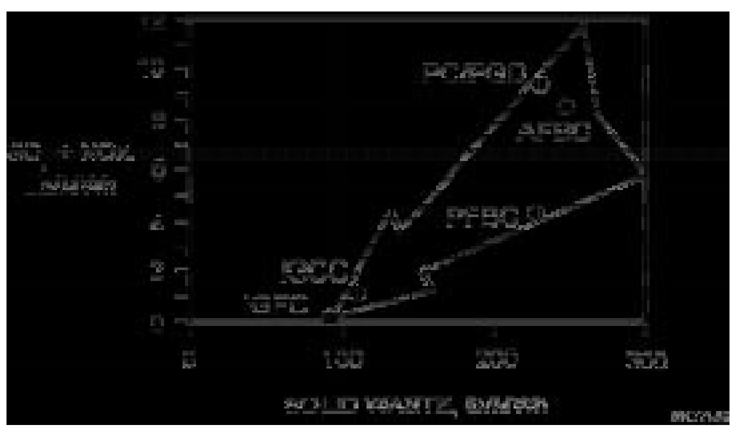


Figure 6
Environmental Impact Comparison of IGFC and Other Technologies

Experimental testing

Figure 7
20 kW Carbonate Fuel Cell Test at the LGTI Gasification Facility

Experimental testing of a 20 kW sub-scale fuel cell stack was conducted[9] at Louisiana Gasification Technology Inc. (LGTI) in 1993-4 by Destec as shown in Figure 7. This was the world's first test of a carbonate fuel cell on coal derived gas. Gas from the entrained flow Destec gasifier was further cleaned-up after bulk gas clean-up by the fuel cell test facility and supplied to the fuel cell. The fuel cell operated on syn gas from the gasifier and inter-changeably with natural gas providing normal perform-ance and stable operation. After completion of the test, the fuel cell was disassembled for post-test inspection. Analysis of the components indicated no evidence of degradation and no detectable accumulation of coal gas borne contaminants in the fuel cell electrolyte or in the hardware. These results paved the way for a larger scale demonstration test.

Clean coal demonstration test

FuelCell Energy is planning to build and test a 2-MW carbonate fuel cell power plant as part of the Kentucky Pioneer Energy Project by Global Energy. The plant will be located in Trapp, KY and will be operational in 2003. This project, supported by DOE as part of the Clean Coal Technology Program will include a 400-MW Integrated Gasification Combined Cycle (IGCC) and a 2-MW fuel cell power plant (Integrated Gasification Fuel Cell, IGCF) as shown in Figure 8. The project will feature Advanced Fuel Technology briquettes made of Kentucky coal and Municipal Solid Waste (MSW) as fuel in the gasification process, adding a renewable fuel component to the project. The use of municipal solid waste as fuel reduces fuel cost to the power plant and provides low cost waste elimination. British Gas/Lurgi (BGL) gasification technology and General Electric advanced turbine power generation will be utilized for the IGCC.

As shown in Table 1 emissions from this plant will be significantly lower than conventional coal fired plants using PC boiler, atmospheric fluidized bed, and pressurized fluidized bed technologies.

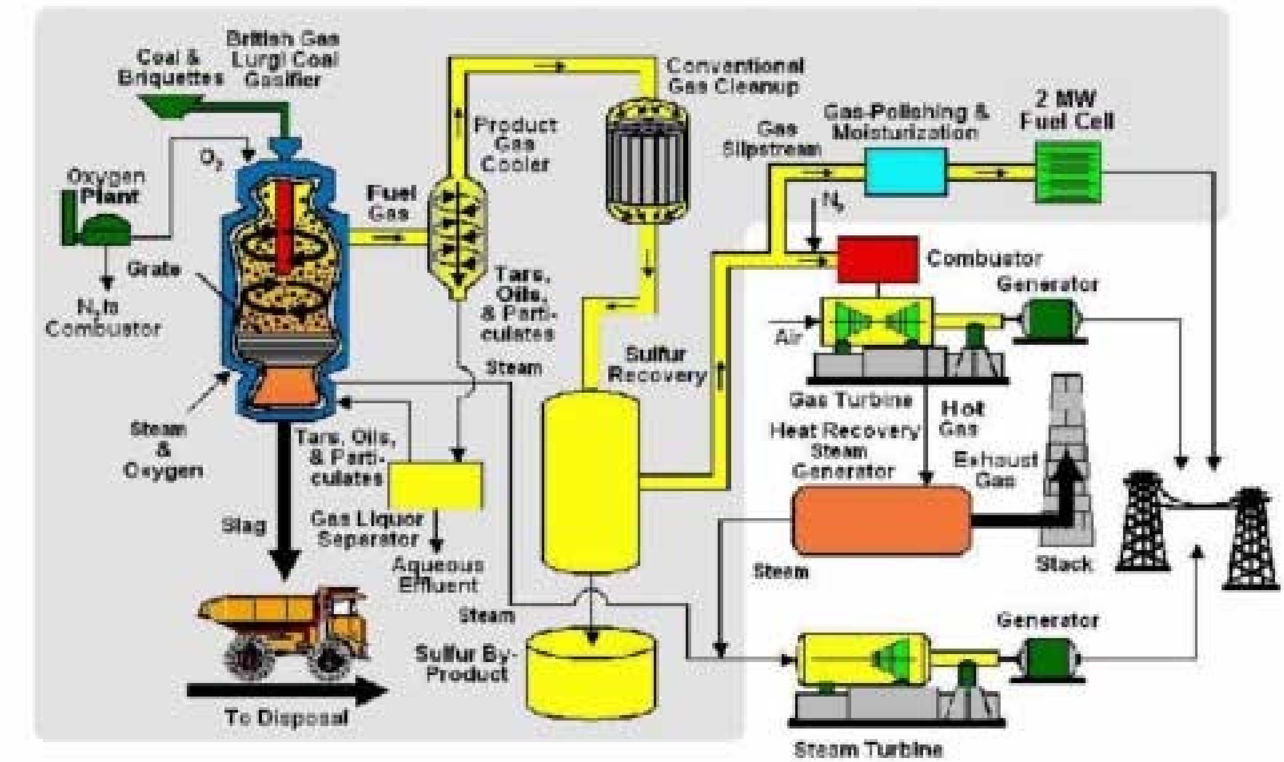


Figure 8
400-MW IGCC and 2-MW Fuel Cell Power Plant Process Flow Diagram[14]
Source: DOE Project Fact Sheet (Modified)

Table 1
Typical Emission Levels and Waste from Coal Based Power Plant Types

2.5% SULFUR EASTERN COAL *Source: EPRI With Adjustments By Duke Energy*				
PLANT TYPE	SO_2 EMISSIONS LB/MWH	NO_x EMISSIONS LB/MWH	SOLID WASTE (DRY) LB/MWH	CO_2 VENT GAS LB/MWH
Pulverized Coal (PC w/ESP Only)	35.7	11.2	136	1871
Pulverized Coal with FGD and LNB (90 percent S Removal, NO_x Control	3.6	5.8	232	1908
Atmospheric Fluidized Bed Combustion (AFBC)	3.6	4.9, 0.5 (SNCR)	249	1975
Pressurized Fluidized Bed Combustion (PFBC)	3.3	0.9	230	1826
Integrated Gasification combined cycle (IGCC) (99 Percent S Removal)	0.3	0.9	123	1695
BGL IGCC (99 Percent S Removal, 15 PPM NO_x)	**0.3**	**0.4**	**115**	**1585**
BGL IGFC	**0.25**	**0.18**	**90**	**1540**

References:

1. U.S. DOE/EIA "Annual Energy Review 1998".

2. U.S. DOE/EIA "Annual Energy Outlook 2000".

3. Graves, H., Global Energy Inc., Personal Communication, December 1999.

4. Farooque, M, G. Steinfeld, G. McCleary, S. Kremenik, "Assessment of Coal Gasification/Carbonate Fuel Cell Power Plants", Topical Report to DOE/METC, June, 1990, DOE/MC/23274-2911. NTIS/DE90015579.

5. Sander M.T., et al, Fluor Daniel, G. Steinfeld, Fuel Cell Energy, "Cost and Performance Analysis for a 220 MW Phased Construction Carbonate Fuel Cell Power Plant", 11th Annual Conference on Gasification Power Plants, EPRI, October 1992.

6. Sandler H.S., and S.J. Meyers, "Integrated Coal Gasification in Carbonate Fuel Cell Power Plants" 11th Annual Conference on Gasification Power Plants, EPRI, October 1992.

7. EPRI, AFPS Developments, Gasification/Fuel Cell Study Projects Very Low Heat Rate, Winter 1990 Issue 6.

8. Meyers S., Fluor Daniel, Advanced Molten Carbonate Fuel Cell Systems Using BGL Gasification, Presented at the 9th Annual Conference on Gasification Power Plants, October 16-19, 1990, Palo Alto, CA.

9. Rastler, D.M., EPRI, C.G. Keeler, Dow Chemical USA, "Slip Stream Test of a 20 kW Carbonate Fuel Cell Unit at Destec's LGTI GCC Facility", Presented at the EPRI Gasification Conference, Oct 1993.

10. Kluttz D.E., Duke Engineering & Services Inc., et al, "Proposed BGL CGCC Project for Clean Coal Technology Round Five Demonstration", Presented at the EPRI Gasification Conference, Oct 1993.

11. Steinfeld,G., W. Willson "Advanced Power System Featuring a Closely Coupled Catalytic Gasification Carbonate Fuel Cell Plant" Presented at the 17th Biennial Low-Rank Fuels Symposium, May 10-13, 1993, St. Louis, Missouri.

12. Ghezel-Ayagh, H., R. Sanderson, A. J. Leo, "Ultra High Efficiency Hybrid Direct Fuel Cell/Turbine Power Plant", Proceedings of Carbonate Fuel Cell Technology V, PV 99-20, page 297-305, 190th Meeting of the Electrochemical Society, Oct. 7-22, 1999, Hawaii.

13. DOE Fossil Energy TechLine, "Richardson Approves Federal Funding for High Tech, Ultra Clean Coal Plant in Kentucky", U.S. DOE Press Release issued November 15, 1999.

14. DOE Clean Coal Technology, Compendium, Project Fact Sheet, Advanced Electric Power Generation Integrated Gasification Combined Cycle, Clean Energy Demonstration Project.

Appendix D

COMMONWEALTH OF KENTUCKY
BEFORE THE PUBLIC SERVICE COMMISSION
In the Matter of:
APPLICATION OF EAST KENTUCKY POWER
COOPERATIVE, INC. FOR A CERTIFICATE OF PUBLIC
CONVENIENCE AND NECESSITY, AND A CERTIFICATE
OF ENVIRONMENTAL COMPATIBILITY, FOR THE
CONSTRUCTION OF A 250 MW COAL-FIRED
GENERATING UNIT (WITH A CIRCULATING FLUID BED
BOILER) AT THE HUGH L. SPURLOCK POWER STATION
AND RELATED TRANSMISSION FACILITIES, LOCATED IN
MASON COUNTY, KENTUCKY, TO BE CONSTRUCTED
ONLY IN THE EVENT THAT THE KENTUCKY PIONEER
ENERGY POWER PURCHASE AGREEMENT IS
TERMINATED
)
)
)
)
)
)
)
)
)
)
)
)
CASE NO.
2001-053
O R D E R
East Kentucky Power Cooperative, Inc. ("East Kentucky") filed its application on March 9, 2001 for a Certificate of Public Convenience and Necessity and a Certificate of Environmental Compatibility to construct a 250 MW coal-fired generating unit, referred to as "Gilbert," at the Hugh L. Spurlock power station ("Spurlock") and related transmission facilities in Mason County, Kentucky. The Gilbert unit was to be constructed only in the event that East Kentucky's prior agreement to purchase the output of a 540 MW generating unit proposed by the Kentucky Pioneer Energy, L.L.C. ("KPE") is terminated. The Attorney General's Office ("AG") and the Kentucky Natural Resources and Environmental Protection Cabinet, Department of Natural Resources, Division of Energy ("DOE") were granted intervention and a hearing was held on August 18, 2001..

On July 11, 2001, East Kentucky amended its application to eliminate the contingent nature of its request because KPE had not met its financial closing deadline of June 30, 2001. The amended application also revised Gilbert's output from 250 MW to 268 MW. East Kentucky has not terminated the power purchase agreement because the power will be sold at a very reasonable price and KPE has indicated that it believes it can obtain project financing by March 2002. However, due to the delay in KPE's financing, East Kentucky decided that it cannot reasonably rely on that project to satisfy its future power supply needs. Therefore, East Kentucky has concluded that it should proceed to build the Gilbert unit. In the event that KPE is able to secure project financing, East Kentucky stated that certain provisions in the existing purchase power agreement would have to be revised and any renegotiated contract will be resubmitted to the Commission for its prior approval.

East Kentucky submitted to the Natural Resources and Environmental Protection

Cabinet ("Natural Resources Cabinet") a statement of environmental compatibility for the proposed Gilbert unit. By letter dated May 23, 2001, the Natural Resources Cabinet

reported that East Kentucky's proposed Gilbert plant will be environmentally compatible.
East Kentucky determined that additional power will be needed to meet its future load requirements and it issued a request for proposal to utilities and power marketers on January 11, 2001. Several responses were received, but East Kentucky's analysis shows that the proposed Gilbert unit will have the lowest cost. Additional analyses were performed in response to the request of the AG. One of those analyses shows that adding one 93 MW combined cycle unit in April 2004 and waiting for the KPE project to develop will cost $114 million less than adding the Gilbert unit now and then relying on the KPE development. East Kentucky rejected this scenario, claiming that it should not place all of its new base load requirements at market risk, contingent on the development of the KPE project as a commercially viable plant.
The AG recommends that East Kentucky's request to construct the Gilbert unit be granted. However, if KPE achieves financial closure by the summer of 2002, the AG suggests that the Commission and the parties explore cancellation of the Gilbert unit.
DOE recommends that East Kentucky should complete a full and comprehensive study of the technical potential of demand-side resources and distributed generation in its service territory before proceeding to construct any new generation.
Based on East Kentucky's supply analyses, the uncertainty of the KPE project, and East Kentucky's need for additional power, the Commission finds that the construction of the Gilbert unit should be approved. Further, the Commission finds that when the KPE project achieves financial closure, East Kentucky should refile the power purchase agreement for review and approval by the Commission. The filing should include an analysis of the feasibility of the cancellation of the Gilbert unit and the substitution of a 93 MW combined cycle unit. In addition, the Commission finds that East Kentucky should continue to review the feasibility of demand side resources and provide a detailed analysis of its review in future filings related to generating capacity.
The Gilbert unit has the ability to burn not only coal but also wood waste and other biomass products due to the nature of a circulating fluid bed boiler. East Kentucky did not propose to include as part of the initial construction the handling facilities necessary to burn any of these other products. The AG recommended that the wood waste handling facilities be included in the unit design and that wood waste be.-4- considered as one of the primary fuels. East Kentucky acknowledged that the wood waste handling facilities would cost $2.5 to $3 million and have a relatively short payback. Due to the potential cost savings over time from burning biomass, the Commission finds that East Kentucky should conduct a detailed analysis of fueling the Gilbert unit with wood waste and other biomass products.
East Kentucky indicated that additional transmission facilities would be needed to maintain stability of the unit at the Spurlock station. A transmission line will be needed to connect to transmission facilities owned by Cinergy Corp. East Kentucky indicated that certain agreements are necessary between the utilities, and additional time will be needed to finalize those agreements. Because of the potential delay in finalizing the transmission agreements, East Kentucky proposed to delete the transmission portion of its application and proceed only with the proposed generating facilities. The Commission finds East Kentucky's proposal to be reasonable.
IT IS THEREFORE ORDERED that:
1. East Kentucky is granted a Certificate of Public Convenience and Necessity and a Certificate of Environmental Compatibility to construct the Gilbert unit, a 268 MW coal-fired generating unit with a circulating fluid bed boiler, at the Spurlock station at an estimated cost of $367 million.
2. East Kentucky shall conduct a detailed analysis of the benefits of fueling with wood waste and other biomass products and file that analysis upon completion.
3. East Kentucky's request to delete from consideration at this time the construction of needed transmission facilities is granted. Within 30 days of completing all analyses, including the selection of a final route for the transmission facilities and the.execution of all necessary agreements with other utilities, East Kentucky shall file a new

application for approval of the proposed transmission facilities.
Done at Frankfort, Kentucky, this 26 th day of September, 2001.
By the Commission

Appendix E

APPLICATION OF BGL GASIFICATION
OF SOLID HYDROCARBONS FOR
IGCC POWER GENERATION

2000 Gasification Technologies Conference
San Francisco, California
October 8-11, 2000
Presented by:

GLOBAL ENERGY INC.
Richard A. Olliver
With support from:
GENERAL ELECTRIC POWER SYSTEMS
John M. Wainwright
PRAXAIR
Raymond F. Drnevich.2

ABSTRACT

Since last year's GTC Conference, a considerable number of significant events have occurred in the gasification technology marketplace. New IGCC projects have come on stream with commercial operation, other new IGCC projects have been announced and started in development, environmental issues have gained emphasis, and energy prices, notably natural gas, have escalated dramatically. Directionally, all of these events appear to have created a more favorable atmosphere for IGCC projects.

Related to an ongoing IGCC project currently in development, a joint analysis has been performed by Global Energy, General Electric Power Systems, and Praxair to evaluate technical and economic elements for the performance of BGL Gasification Technology based on solid hydrocarbon fuel feed to an IGCC for power generation.

Results of the analysis provide a picture of the relative economics in today's environment for electrical power generation by conventional natural gas fired combined cycle power systems compared to using BGL Gasification Technology in an IGCC configuration..3

INTRODUCTION

Over the last few years there have been a number of new Integrated Gasification Combined Cycle (IGCC) plants placed in operation, under construction, or otherwise in development, representing numerous technologies and fuel applications. Typically, the new IGCC plants have utilized either solid or liquid hydrocarbons as feed, gasification methods including entrained flow, fixed bed or fluid bed technologies, and power blocks utilizing various gas turbine systems and manufacturers.

Global Energy has several commercial IGCC projects under development based on using BGL Gasification Technology to gasify solid hydrocarbons for power production. Coincident with these development efforts, several feasibility studies have been performed related to diverse applications of the BGL Gasification Technology. This paper deals with the application of BGL Gasification Technology fueled with coal and incorporating an Oxygen plant provided by Praxair and a Power Island using 7FA Gas Turbines provided by General Electric Power Systems.

MACRO-ECONOMIC BACKGROUND

The original concept for performing this particular analysis evolved from ongoing technical analyses and business discussions related to several IGCC projects currently in development by Global Energy. The origins of these projects considered site issues and microeconomics of project specifics; additionally Global Energy kept an eye on the fundamental macroeconomic issues that were driving the IGCC industry and furthering its growth.

The interesting event that occurred at the inception of this analysis was the dramatic increase in energy prices this year, notably in prices for electrical power and natural gas. Accordingly, the analysis shifted its focus to consider the position of BGL Gasification Technology in the IGCC industry, the economic status of a commercial BGL based IGCC relative to power from natural gas, and a consideration of other factors of note in the rapidly changing world of energy prices.

BASIS FOR ANALYSIS

For purposes of this analysis, a single design case was developed and analyzed for the BGL Gasification Technology application, essentially considering use of Pittsburgh # 8 coal as the solid hydrocarbon feed to the Gasification Island..4

OVERALL IGCC CONFIGURATION

As shown in Attachment C, the overall project configuration includes the Gasification Island, comprised of the BGL gasification units, ASU, and syngas cooling and cleanup units, and the Power Island, which consists of two General Electric 7FA gas turbine generators and HRSGs and one steam turbine, all optimized for firing on syngas, but capable of operation on natural gas. At site design, ambient conditions of 59ºF, 14.28 psia and 60% RH, Gross and Net Electrical Power Output are approximately 586MW and 538MW, respectively, and Net Heat Rate is 8072 BTU/KWh, HHV. Plant capital cost is assumed to be $1000/KW. The plant includes normal offsites, utilities and infrastructure required to support the main operating units.

GASIFICATION ISLAND

As shown in Attachment D, the BGL Gasification process is a fixed bed type gasifier that uses a lock hopper system to admit dry feed to the pressurized reaction vessel. The gasifier units are refractory lined and water jacket cooled. As the feedstock descends it is heated by rising high temperature gases. Moisture and volatile light hydrocarbons leave the coal soon after the feed enters the gasifier unit and exit the gasifier with the syngas stream. Oxygen and steam are injected near the bottom of the unit and react with devolatilized coal to provide thermal energy needed for the formation of syngas components. The high temperature also converts the inert ash content of the coal into vitreous frit or slag.

The vitreous frit is removed from the bottom of the gasifier via a lock hopper and is water quenched, thus capturing the inorganic content of the feedstock as a glassy silica matrix material resembling coarse sand. The vitreous frit is an environmentally benign synthetic aggregate material suitable for use as roadway base, roofing material and seawall construction.

The BGL Gasification IGCC system offers the following features:

- High gasification efficiency (carbon conversion), typically over 92%,
- Use of run-of-the-mine coal or other carbon-based feedstock,
- High thermal efficiency and simple heat exchanger for convenient heat recovery,
- High gasifier throughputs,
- Superior environmental performance, and
- A closed loop system with no primary stack and no ash residue.

The synthesis gas produced in this process is made up primarily of carbon monoxide and hydrogen (more than 85% by volume), and smaller quantities of carbon dioxide and methane..5

Hot syngas leaving the top of the gasifier is quenched and purified. Particulates and other impurities are removed in this initial gas processing stage. Heavier oils and tars will condense during cooling, and are returned to the gasifiers for reflux into the hearth zone.

Sulfur compounds in the feedstock are converted mainly to H_2S and smaller quantities of COS in the raw syngas. Over 99% of these are removed through acid gas cleanup and sulfur recovery units prior to combustion in the gas turbines, resulting in exceptionally low SO_2 emissions. The acid gas cleanup is accomplished using a selective solvent; the sulfur recovery is accomplished with the use of a process unit employing the Claus reaction to generate elemental sulfur. The elemental sulfur in these compounds is a commercially saleable product.

POWER ISLAND

The Power Island is based on a configuration of two trains of dual-fuel General Electric 7FA gas turbines with hydrogen-cooled generators. Each train is coupled to its own Heat Recovery Steam Generator (HRSG), which together will provide superheated steam for a single steam turbine generator. The system enables transfer to natural gas should syngas flow be interrupted. This provides for Power Island availability equal to that of conventional natural gas fired power plants.

Prior to entering the gas turbine combustor, the syngas is saturated with water and is then superheated. Additionally, nitrogen from the ASU is moisturized, superheated, and injected into the turbine combustor, effectively diluting the fuel to reduce NOx emissions. Saturating the syngas and the addition of saturated nitrogen also increases the mass flow to the gas turbine, resulting in increased electrical power generation.

Exhaust gas from each gas turbine is routed to a dedicated HRSG producing superheated steam. This steam is used to power a steam turbine generator and to meet the needs of the Gasification Island and the overall plant.

DESCRIPTION OF ANALYSIS

The analysis was aimed at an assessment of the economic considerations for power generation using solid hydrocarbon feed, specifically Pittsburgh # 8 coal, processed in an IGCC mode, which employed BGL Gasification Technology and General Electric 7FA gas turbines.

The analysis defined a specific IGCC plant configuration as noted, and accordingly, plant capital and operating costs were defined using estimated costs for fuel feed and other required support streams. The cost of electrical power was calculated based on those parameters, and further analyzed by calculating variations of power cost as a function of varied capital costs and gasifier feed costs..6

As a parallel evaluation, the analysis also looked at the cost of power generation from natural gas fired combined cycle plants of similar capacity, using varied prices for natural gas. A comparison was made between these two fuel scenarios to allow reflection on potential market opportunities.

RESULTS

The analysis results are presented in detail in the attachments and show that IGCC power generation systems with solid hydrocarbon feeds can be competitive with natural gas fired combined cycle (NGCC) systems. Results show equivalent Cost of Electricity (COE) for IGCC and NGCC Systems at certain natural gas and gasifier feedstock prices. For example, natural gas at about $3.75/MBTU and coal at $1.00/MBTU will both yield a COE of 4.90 cents/KWh.

While these electrical power prices are not likely to stimulate consideration of the large capital investment required to build a self-sufficient project financed power plant, rising prices for natural gas clearly make IGCC increasingly attractive as an option for power generation.

An important factor, which has the potential to directly improve today's IGCC economics, is the utilization of the BGL gasifier unit's ability to handle a wide variety of fuel (feedstocks), including Refuse Derived Fuel (RDF). For example, a mixture of coal at $1.00/MBTU and RDF at $0.00/MBTU at a ratio of 50/50 by heat content equated to a gasifier feedstock price of $0.50. This places electricity generated from a BGL based IGCC on par with electricity from a NGCC if the price of natural gas is $3.00, within the range of annual average fuel costs considered reasonable by developers motivated to build an electric power plant.

CONCLUSIONS

Macroeconomic forces have created an atmosphere today where use of gasification to produce power is a real and competitive alternative to natural gas. There are a number of Gasification Technologies that are commercially proven and in a state of readiness to establish new commercial projects based on IGCC concepts using solid hydrocarbon feeds. BGL Gasification Technology is one of those technologies, with its own unique attributes, and potential for further technical and economic enhancements through application of evolving Power Island technology, as well the as use of co-production scenarios, which provide additional impetus to favorable and improved project economics.

The specific results of the analysis performed indicate that:

- If high natural gas prices are sustained, IGCC will be the economic preference over NGCC in more future power generation projects; and
- Even if natural gas prices level off or decline slightly, the application of BGL gasification using a composite feedstock of coal and RDF will improve IGCC economics and make it.7 the technology of choice in more future power generation projects.

Furthermore, the following prospects have the potential to further improve IGCC economics:

- GE Power Systems technology developments such as the 7H and 9H Systems TM , rated in IGCC at 460 MW and 550 MW respectively, will further improve IGCC economics. The real cost of oxygen has historically dropped about 3% per year. Praxair's process, equipment, and systems development activities expect to provide similar improvements in the future.
- The co-production of materials such as hydrogen, methanol, ammonia, steam, plus Fischer-Tropsch generated liquid transportation fuel products will improve economics.
- Ongoing developments by Global Energy are also expected to contribute to further economic enhancements for IGCC projects. The know-how derived from these activities is expected to provide significant benefits to current and future BGL projects. There are three IGCC projects publicly announced by Global Energy in various stages of project development, each based on using BGL Gasification Technology in an IGCC scenario. Global Energy is also in the process of acquiring Berlinwasser's gasification co-production facility Sekundärrohstoff Verwertungszentrum Schwarze Pumpe GmbH (SVZ) Recycling Project in Schwarze Pumpe, Germany, as well as the right, title and interest in SVZ's proprietary gasification technology, including its gasification-related patents. The facilities also include a new BGL gasifier, further enhancing Global's knowledge of the BGL Gasification Technology.

A collective view of all of these ongoing events suggest that further significant improvements for IGCC economics are likely to occur, and that use of BGL Gasification Technology for IGCC projects can provide notable economic benefits to this rapidly growing market.

SUPPORTING CONTRIBUTORS TO PAPER

The companies supporting the analysis efforts include Global Energy, General Electric Power Systems, and Praxair. Each organization has significant involvement and presence in the rapidly growing IGCC industry as follows:

Global Energy

Global Energy Inc. is an international independent energy company with expertise in Gasification Technology, Alternative Fuels and Environmental Technology. The company is a founding member of the Washington, D.C.-based Gasification Technologies Council, together with General Electric, Texaco and 11 world-class companies. Global Energy is focused on Gasification Technology projects designed to improve environmental and economic results for the power, refining, chemical, steel, fuel cell, and pulp and paper industries. The company has.8 more than 5,000 MW of project activity in development, construction and operation in the Americas and Europe, with business development interests worldwide. The company is well aligned with the U.S. DOE's Vision 21 plan for Multi-fuel, Gasification Technology, Co-production systems.

General Electric Power Systems

GE Power Systems is one of the world's leading suppliers of power generation technology, energy services and management systems, with year 2000 revenue estimated at $14.5 billion. The business has the largest installed base of power generation equipment in the global energy business. GE Power Systems provides turnkey equipment, service and management solutions across the power generation, oil and gas, distributed power and energy rental industries.

Praxair

Praxair is a technology pioneer and global leader in the industrial gases industry. The company is the largest industrial gases company in North and South America, and one of the largest worldwide. Praxair is also a recognized leader in the commercialization of new technologies that bring productivity and environmental benefits to a diverse group of industries..9

SUPPORTING BACKGROUND REFERENCES

U.S. Department of Energy, "Clean Coal Technology - The Investment Pays Off", November 1999.

U.S. Department of Energy, "Clean Coal Technology Demonstration Program Project Fact Sheets", June 1999.

General Electric Power Systems, "Integrated Gasification Combined Cycle Gas Turbine Technology", 1999.

DePuy, et al., "From Coal or Oil to 550 MWe via 9H IGCC", Gasification Technology Conference, October 1999.

U.K. Department of Trade and Industry, “Gasification of Solid and Liquid Fuels for Power Generation - Technology Status Report”, December 1998.

U.S. Department of Energy, “Vision 21 - Clean Energy for the 21 st Century”, November 1998.

U.S. Department of Energy, “Focus - Energy Solutions for the 21 st Century”, September 1998.

U.K. Department of Enterprise, Coal R&D Report, “Integrated Gasification Combined Cycle Technology in the U.K. - Analysis of 300 MWe IGCC Power Plant”, November 1992.

Bellinger, et al., “Clean Power - The BGL Gasifier”, June 1987.

Scott, et al., “Application of the British Gas/Lurgi Slagging Gasifier for Combined Cycle Power Generation”, International Consulting Service - British Gas plc, November 1985..10

ATTACHMENTS

A. Energy Information Agency (EIA) – US Gas and Oil Prices

B. Energy Information Agency (EIA) – Fossil Fuel Prices to Electric Utilities

C. BGL IGCC Process Diagram

D. Schematic Diagram of BGL Gasifier

E. Basic Analysis Assumptions

Appendix F

Kentucky Revised Statute 224.010

(20) "Recovered material" means those materials, including but not limited to compost, which have known current use, reuse, or recycling potential, which can be feasibly used, reused, or recycled, and which have been diverted or removed from the solid waste stream for sale, use, reuse, or recycling, whether or not requiring subsequent separation and processing, but does not include materials diverted or removed for purposes of energy recovery or combustion except refuse-derived fuel (RDF), which shall be credited as a recovered material in an amount equal to that percentage of the municipal solid waste received on a daily basis at the processing facility and processed into RDF; **but not to exceed fifteen percent (15%) of the total amount of the municipal solid waste received at the processing facility on a daily basis;**

Appendix G

The below is the first section of the Air Quality Permit, please note the Section 1 language regarding local permits.

Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Department for Environmental Protection
Division for Air Quality
803 Schenkel Lane
Frankfort, Kentucky 40601
(502) 573-3382

AIR QUALITY PERMIT

Permittee Name:
Kentucky Pioneer Energy LLC

Mailing Address:
312 Walnut Street, Suite 2000, Cincinnati, Ohio 45202

Source Name:
Kentucky Pioneer Energy LLC

Mailing Address:
312 Walnut Street, Suite 2000, Cincinnati, Ohio 45202

Source Location:
12145 Irvine Road, Trapp, Kentucky 40391

Permit Type:
Federally-Enforceable

Review Type:
PSD, Title V

Permit Number:
V-00-049

Log Number:
51152

Application
Complete Date:
January 21, 2000

KYEIS ID #:
21-049-00053

SIC Code:
4911

ORIS Code:
5266

Region:
Bluegrass

County:
Clark

Issuance Date:
June 7, 2001

Expiration Date:
June 7, 2006

John E. Hornback, Director

DEP7001 (1-97)

Division for Air Quality

Revised 06/22/00

TABLE OF CONTENTS

SECTION A - PERMIT AUTHORIZATION

Pursuant to a duly submitted application which was determined to be complete on January 21, 2000, the Kentucky Division for Air Quality hereby authorizes the construction and operation of the equipment described herein in accordance with the terms and conditions of this permit. This draft permit has been issued under the provisions of Kentucky Revised Statutes Chapter 224 and regulations promulgated pursuant thereto.

The permittee shall not construct, reconstruct, or modify any emission units without first having submitted a complete application and receiving a permit for the planned activity from the permitting authority, except as provided in this permit or in the Regulation 401 KAR 50:035, Permits.

Issuance of this permit does not relieve the permittee from the responsibility of obtaining any other permits, licenses, or approvals required by this Cabinet or any other federal, state, or local agency.

References in this permit to regulatory requirements of 401 KAR 50:035 are based on the governing regulation which was in effect at the time the permit application was deemed complete. For future reference to the regulatory basis for permit conditions and for the purposes of implementation and compliance, the corresponding portions of the provisions of new permitting regulations in 401 KAR Chapter 52 (effective January 15, 2001) shall apply

Appendix H

Kentucky Resources Council, Inc.

Post Office Box 1070

Frankfort, Kentucky 40602

(502) 875-2428 phone (502) 875-2845 fax

e-mail FitzKRC@aol.com

December 13, 2001

Rob Daniell

Division of Waste Management By fax & e-mail only

14 Reilly Road

Frankfort, Kentucky 40601

Re: Global Energy, Inc.

Request for Determination Regarding Applicability

Of KRS 224.40.

Dear Director:

After a review of the position paper submitted by Global Energy to the state Division for Waste Management, and after review of the applicable statute and case law, I believe that the facility is subject to the solid waste regulations and is required to obtain a determination of consistency from the solid waste management governing body of Clark County before importing and disposing of the solid waste fuel through thermal treatment.

By letter dated October 9, 2000, Global Energy Inc., Suite 2000, 312 Walnut Street, Cincinnati, OH 45202, through its manager of Regulatory Affairs Dwight Lockwood, requested a determination from the Kentucky Division of Waste Management as to the applicability of KRS 224.40 to the proposed "integrated gasification combined cycle (IGCC) power plant project in Clark County."

The request letter from Global Energy (Hereafter Global) asserted that the proposed project was "exempt from waste regulations." The 2-paged letter contained an attached "Analysis of the Non-Applicability of KRS 224.40 to the Kentucky Pioneer Energy IGCC Project."

The determination of applicability of the waste regulations rests in the first instance with the Natural Resources and Environmental Protection Cabinet, subject always to review by the courts. KRS Chapter 224 is a statute that is remedial in nature and its protections are to be liberally with a view towards promoting the public and environmental protection goals of the statute. *Roland v. Kentucky Retirement Systems,* Ky.App.52 S.W.3d 579 (2001). Exemptions from its reach are to be narrowly construed.

The question of whether the proposed coal and waste-fueled facility is subject to the requirements of KRS Chapter 224 as a waste management and waste disposal facility is of significance to the residents of Trapp and of Clark County, since if exempted from the ambit of the term "municipal solid waste facility," the planned importation of processed municipal solid waste from northeastern states representing the equivalent of "roughly half of the residential waste generated in the entire Commonwealth of Kentucky" will not be subject to scrutiny and a determination by the local governing body of Clark County of the consistency with that county's approved solid waste plan.

When enacted in 1991, Senate Bill 2 substantially revised state and local solid waste management, requiring of local communities that they plan for the proper management of solid waste generated within their borders and promising, in return, that the local "governing body" responsible for solid waste planning would have the ability to control the manner and extent to which waste generated outside of the boundary of that planning unit would be managed and disposed of within the planning area.

The proposal to thermally treat and to combust the volatile fraction of one million tons or more per year of treated municipal solid waste falls squarely within the type of facility intended by the General Assembly to be scrutinized under the solid waste planning process.

KRS 224.40-315 mandates that:

> No permit to construct or expand a municipal solid waste disposal facility shall be accepted for processing by the Cabinet unless the application contains a determination from the governing body for the solid waste management area in which the facility is or will be located concerning the consistency of the application with the area solid waste Management plan [.]

The scope of this statute and the requirement for a determination of consistency with the approved solid waste plan is defined by the term "municipal solid waste disposal facility", which is defined in KRS 224.01-010(15) to include:

> Any type of waste site or facility where the final deposition of any amount of municipal solid waste occurs, whether or not mixed with or including other waste allowed under subtitle D of the Federal Resource Conservation and Recovery Act of 1976, as amended, <u>and includes, but is not limited to, incinerators and waste-to-energy facilities that burn municipal solid waste,</u> . . .

The term is broadly inclusive of all types of waste sites or facilities where the final deposition of any amount of municipal solid waste occurs. There can be no serious argument that the feed material to be combined with the coal is a solid waste, which is to say, that the material is "garbage, refuse, sludge and other discarded material." The waste is to be processed, according to the applicant, at a facility in a state other than Kentucky, where it will be manufactured from municipal solid waste by removing "large objects and white goods" as well as "glass and metal [.]" The remaining material, including chlorinated plastics, will be milled and shredded.

These "pellets" are municipal solid waste processed as an intermediate step in the thermal treatment of the waste to produce a gas for combustion. The proposed facility is utilizing a fuel stream comprised of partially separated, shredded and shaped municipal solid waste used as a fuel source, disposing of the waste through thermal treatment at high temperature to drive off the volatile fraction for combustion. As such, it is engaged in disposal of a municipal solid waste stream and falls within the ambit of a "municipal solid waste disposal facility" the siting and operation of which should be reviewed for consistency with local solid waste plans.

The applicant claims exemption for the waste fuel from the waste program as a "recovered material," yet the clearly better reading of the statute, and the intent to carefully regulate the disposal of solid waste by thermal treatment as well as other means, militates against the exemption of the material from regulation as a solid waste. The material is not a "refuse-derived fuel" notwithstanding the claim by the applicant to the contrary, since the applicant has indicated that it intends to retain the recoverable plastics in the waste (likely for the Btu value), and thus is outside of the ambit of "recovered material," since that definition specifically <u>excludes</u> "materials diverted or removed for purposes of energy recovery <u>or</u> combustion []" from being considered recovered material.

Assuming, for the sake of argument, that the waste <u>were</u> further processed over what is proposed, in order to meet the state definition of "refuse derived fuel" by removing all recoverable plastics and other recoverable material, such as mixed paper, corrugated paper and newsprint, the definition of "recovered material" still would not apply to exempt the entire waste stream from regulation since only 15% of the material processed by the facility creating the pellets could be credited as "RDF."

While the acceptance by the applicant of regulation under EPA’s Municipal Solid Waste Combustor standards makes it difficult to accept at face value the assertion of non-applicability of state "waste" designation, commenter concurs that the state law itself determines how this facility is to be characterized for purposes of state regulation.

Because the material is not a "refuse derived fuel" under KRS 224.01-010(23) in that it has not been subject to "extensive separation of municipal solid waste" including "the extraction of recoverable materials for recycling" the processing of the municipal solid waste stream to create the palletized "fuel" does not make the material a "recovered material" under KRS 224.01-010(20). The proposed gasification step in the process and the cleaning of the volatile fraction of the waste for combustion does not make the facility a "recovered material processing facility" so as to exempt it from the definition of a municipal solid waste disposal facility or to avoid the obligation to be consistent with the local solid waste plan.

Beyond the specific failure of the application to meet the criteria for an exempt "recovered material processing facility" because the waste feed will retain recoverable materials, including all plastics and paper, the *context* in which municipal solid waste disposal facilities are regulated under KRS Chapter 224 makes clear that the attempt to shoehorn this substantial waste-fueled energy facility into the category of a "recovered materials processing facility" is an ill-fit from a public policy standpoint. KRS 224.01-010, which contains many of the definitions for the chapter, is prefaced with the caveat "[a] s used in this chapter unless the context clearly indicates otherwise [.]" The statutory provision requiring a determination of local consistency for disposal facilities was plainly intended to cover thermal treatment of municipal solid wastes with and without energy recovery, and to segment the facility into the component processes in order to exclude from the application of KRS 224.40-315 a facility which uses a sequential process of thermal treatment followed by combustion of volatile gases, and which presents many similar concerns in management of air, water and solid waste byproducts from a heterogeneous fuel source such as municipal solid waste (even if homogenous in shape), is contrary to the intent of the statute and the public policy behind it.

In sum, the Council believes that the pelletized mixed municipal solid waste does not fall within the ambit of the state statutory definition of "refuse derived fuel" and is thus not a "recovered material." By definition, the facility is a "municipal solid waste disposal facility" under KRS 224.40-315(1), KRS 224.40-310 and KRS 224.01-010(15).

Commenter appreciates the Division’s consideration of these comments in making a final determination as to the applicability of the waste statutes to the proposed facility.

Cordially,

Tom FitzGerald

Director

Kentucky Resources Council, Inc.

Post Office Box 1070

Frankfort, Kentucky 40602

(502) 875-2428 phone (502) 875-2845 fax

e-mail FitzKRC@aol.com

BEFORE THE DEPARTMENT OF ENERGY

NATIONAL ENERGY TECHNOLOGY LABORATORY

COMMENTS CONCERNING DEIS FOR PROPOSED

KENTUCKY PIONEER ENERGY INTEGRATED GASIFICATION

COMBINED CYCLE DEMONSTRATION PROJECT

Dear Mr. Spears:

These preliminary comments are submitted regarding the proposed Kentucky Pioneer Energy IGCC Project Draft Environmental Impact Statement, and will be supplemented with extensive written comments concerning the project prior to the close of the comment period. As a preliminary matter, however, the Council was asked to address the relationship of the proposed project and the utilization of a shredded, milled and pelletized municipal solid waste fuel, to Kentucky's solid waste disposal statute and the requirement of maintaining consistency with local solid waste plans.

After a review of the position paper submitted by Global Energy to the state Division for Waste Management, and after review of the applicable statute and case law, I believe that the facility is subject to the solid waste regulations and is required to obtain a determination of consistency from the solid waste management governing body of Clark County before importing and disposing of the solid waste fuel.

By letter dated October 9, 2000, Global Energy Inc., Suite 2000, 312 Walnut Street, Cincinnati, OH 45202, through its manager of Regulatory Affairs Dwight Lockwood, requested a determination from the Kentucky Division of Waste Management as to the applicability of KRS 224.40 to the proposed "integrated gasification combined cycle (IGCC) power plant project in Clark County."

The request letter from Global Energy (Hereafter Global) asserted that the proposed project was "exempt from waste regulations." The 2-paged letter contained an attached "Analysis of the Non-Applicability of KRS 224.40 to the Kentucky Pioneer Energy IGCC Project."

The determination of applicability of the waste regulations rests in the first instance with the Natural Resources and Environmental Protection Cabinet, subject to review by the courts. KRS Chapter 224 is a statute that is remedial in nature and its protections are to be broadly construed consistent with the public and environmental protection goals of the statute. Exemptions from its reach are to be narrowly construed.

The question of whether the proposed coal and waste-fueled facility is subject to the requirements of KRS Chapter 224 as a waste management and waste disposal facility is of significance to the residents of Trapp and of Clark County, since if exempted from the ambit of the term "municipal solid waste facility," the planned importation of processed municipal solid waste from northeastern states representing the equivalent of "roughly half of the residential waste generated in the entire Commonwealth of Kentucky" will not be subject to scrutiny and a determination by the local governing body of Clark County of the consistency with that county's approved solid waste plan.

When enacted in 1991, Senate Bill 2 substantially revised state and local solid waste management, requiring of local communities that they plan for the proper management of solid waste generated within their borders and promising, in return, that the local "governing body" responsible for solid waste planning would have the ability to control the manner and extent to which waste generated outside of the boundary of that planning unit would be managed and disposed of within the planning area.

The proposal to thermally treat and to combust the volatile fraction of one million tons or more per year of treated municipal solid waste falls squarely within the type of facility intended by the General Assembly to be scrutinized under the solid waste planning process.

KRS 224.40-315 mandates that:

> No permit to construct or expand a municipal solid waste disposal facility shall be accepted for processing by the Cabinet unless the application contains a determination from the governing body for the solid waste management area in which the facility is or will be located concerning the consistency of the application with the area solid waste Management plan [.]

The scope of this statute and the requirement for a determination of consistency with the approved solid waste plan is defined by the term "municipal solid waste disposal facility", which is defined in KRS 224.01-010(15) to include:

> Any type of waste site or facility where the final deposition of any amount of municipal solid waste occurs, whether or not mixed with or including other waste allowed under subtitle D of the Federal Resource Conservation and Recovery Act of 1976, as amended, <u>and includes, but is not</u> limited<u> to, incinerators and waste-to-energy facilities that</u> b<u>urn municipal solid waste, </u>. . .

The term is broadly inclusive of all types of waste sites or facilities where the final deposition of any amount of municipal solid waste occurs. There can be no serious argument that the feed material to be combined with the coal is a solid waste, which is to say, that the material is "garbage, refuse, sludge and other discarded material." The waste is to be processed, according to the applicant, at a facility in a state other than Kentucky, where it will be manufactured from municipal solid waste by removing "large objects and white goods" as well as "glass and metal [.]" The remaining material, including chlorinated plastics, will be milled and shredded.

These "pellets" are municipal solid waste processed as an intermediate step in the thermal treatment of the waste to produce a gas for combustion. The proposed facility is utilizing a fuel stream comprised of partially separated, shredded and shaped municipal solid waste used as a fuel source, disposing of the waste through thermal treatment at high temperature to drive off the volatile fraction for combustion. As such, it is engaged in disposal of a municipal solid waste stream and falls within the ambit of a "municipal solid waste disposal facility" the siting and operation of which should be reviewed for consistency with local solid waste plans.

The applicant claims exemption for the waste fuel from the waste program as a "recovered material," yet the clearly better reading of the statute, and the intent to carefully regulate the disposal of solid waste by thermal treatment as well as other means, militates against the exemption of the material from regulation as a solid waste. The material is not a "refuse-derived fuel" notwithstanding the claim by the applicant to the contrary, since the applicant has indicated that it intends to retain the recoverable plastics in the waste (likely for the Btu value), and thus is outside of the ambit of "recovered material," since that definition specifically <u>excludes</u> "materials diverted or removed for purposes of energy recovery <u>or</u> combustion []" from being considered recovered material.

Assuming, for the sake of argument, that the waste <u>were</u> further processed over what is proposed, in order to meet the state definition of "refuse derived fuel" by removing all recoverable plastics and other recoverable material, such as mixed paper, corrugated paper and newsprint, the definition of "recovered material" still would not apply to exempt the entire waste stream from regulation since only 15% of the material processed by the facility creating the pellets could be credited as "RDF."

While the acceptance by the applicant of regulation under EPA’s Municipal Solid Waste Combustor standards makes it difficult to accept at face value the assertion of non-applicability of state "waste" designation, commenter concurs that the state law itself determines how this facility is to be characterized for purposes of state regulation.

Because the material is not a "refuse derived fuel" under KRS 224.01-010(23) in that it has not been subject to "extensive separation of municipal solid waste" including "the extraction of recoverable materials for recycling" the processing of the municipal solid waste stream to create the palletized "fuel" does not make the material a "recovered material" under KRS 224.01-010(20). The proposed gasification step in the process and the cleaning of the volatile fraction of the waste for combustion does not make the facility a "recovered material processing facility" so as to exempt it from the definition of a municipal solid waste disposal facility or to avoid the obligation to be consistent with the local solid waste plan.

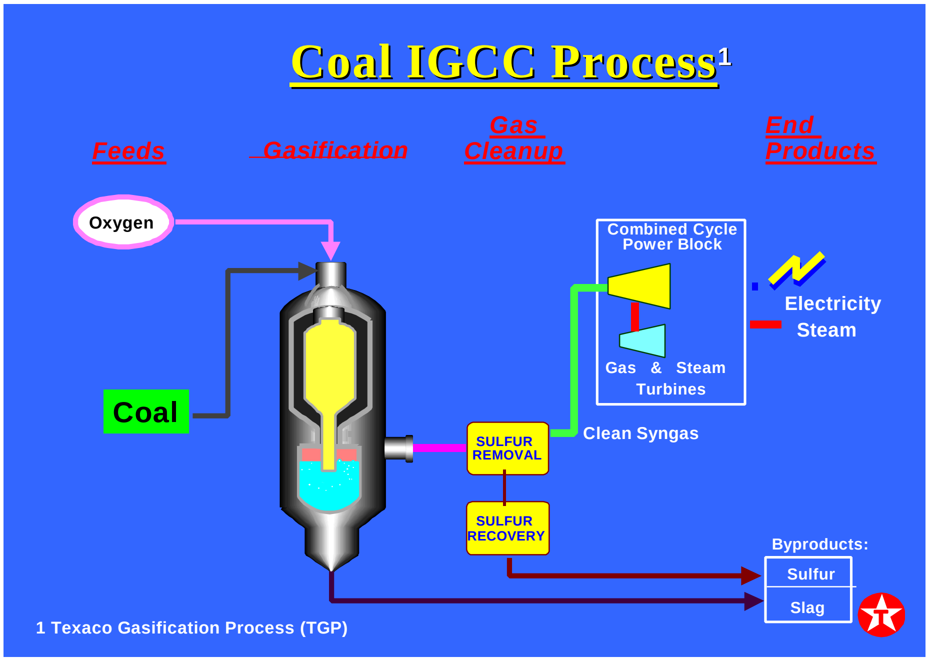
Beyond the specific failure of the application to meet the criteria for an exempt "recovered material processing facility" because the waste feed will retain recoverable materials, including all plastics and paper, the *context* in which municipal solid waste disposal facilities are regulated under KRS Chapter 224 makes clear that the attempt to shoehorn this substantial waste-fueled energy facility into the category of a "recovered materials processing facility" is an ill-fit from a public policy standpoint. KRS 224.01-010, which contains many of the definitions for the chapter, is prefaced with the caveat "[a] s used in this chapter unless the context clearly indicates otherwise [.]" The statutory provision requiring a determination of local consistency for disposal facilities was plainly intended to cover thermal treatment of municipal solid wastes with and without energy recovery, and to segment the facility into the component processes in order to exclude from the application of KRS 224.40-315 a facility which uses a sequential process of thermal treatment followed by combustion of volatile gases, and which presents many similar concerns in management of air, water and solid waste byproducts from a heterogeneous fuel source such as municipal solid waste (even if homogenous in shape), is contrary to the intent of the statute and the public policy behind it.

In sum, the palletized mixed municipal solid waste does not fall within the ambit of the state statutory definition of "refuse derived fuel" and is thus not a "recovered material." By definition, the facility is a "municipal solid waste disposal facility" under KRS 224.40-315(1), KRS 224.40-310 and KRS 224.01-010(15).

Commenter suggests that DOE undertake these actions in order to assure full compliance with applicable state laws prior to engaging in funding support for this project:

1. request and await final determination by the Natural Resources and Environmental Protection Cabinet as to the applicability of the waste statutes to the proposed facility;
2. assuming the applicability of the statutes, defer the funding decision until the applicant demonstrates the viability of the project by obtaining a determination of consistency from the governing body of the solid waste management area covering Clark County of the proposed importation and utilization of the solid waste material for the facility; and
3. extending to the Governing Body of that solid waste management area the opportunity to participate in the EIS review process as a cooperating agency.

Increasing Electricity Availability From Coal-Fired Generation in the Near-Term
May 2001



THE NATIONAL COAL COUNCIL

Increasing Electricity Availability From Coal-Fired Generation in the Near-Term

Chair: Mr. Steven F. Leer

Vice Chair: Mr. Wes M. Taylor

Study Work Group Chair: Ms. Georgia Nelson

The National Coal Council
May 2001

THE NATIONAL COAL COUNCIL

Steven F. Leer, Chairman

Robert A. Beck, Executive Director

U.S. DEPARTMENT OF ENERGY

Spencer Abraham, Secretary of Energy

The National Coal Council is a Federal Advisory Committee to the Secretary of Energy. The sole purpose of the National Coal Council is to advise, inform, and make recommendations to the Secretary of Energy on any matter requested by the Secretary relating to coal or to the coal industry.

NATIONAL COAL COUNCIL, INC.
1730 M Street, NW • Suite 907
Washington, DC 20036
PHONE: 202-223-1191
FAX: 202-223-9031

Website Address: nationalcoalcouncil.org

May 3, 2001

The Honorable Spencer Abraham
Secretary of Energy
United States Department of Energy
Room 7A-219
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Mr. Secretary:

On behalf of The National Coal Council I am pleased to submit the enclosed report entitled "Increasing Electricity Availability from Coal-Fired Generation in the Near-Term." This report was authorized by your predecessor then-Secretary Bill Richardson, on November 13, 2000 prepared, deliberated and recommended by the Coal Policy Committee at its meeting on April 3, 2001, and formally approved by The National Coal Council on May 3, 2001.

In his letter, Secretary Richardson requested that The National Coal Council conduct a study on measures, which the government or government in partnership with industry, could undertake to improve the availability of electricity from coal-fired power plants. His letter requested that the Council address improving coal-fired generation availability in two specific areas:

- Improving technologies at coal-fired electric generating plants to produce more electricity, and
- Reducing regulatory barriers to using these technologies.

The Council accepted Secretary Richardson's request and formed a study group of experts to conduct the work. The study group conducted its work at the direction of the Coal Policy Committee of the Council, which is chaired by Malcolm Thomas, Vice President of Kennecott Energy and a member of the Council. The study group itself was chaired by Georgia Nelson, President of Midwest Generation Company and a member of the Council.

The study was divided into two major sections: technologies and regulatory reform. The focus of the technologies section is on achieving more electricity from existing and new coal-fired power plants using technologies that improve efficiency, availability and environmental performance in the near term defined as the next 36 months.

However, unless there is a significant change in regulatory interpretation and enforcement regarding the installation of new technologies at existing power plants, it is not likely that any of this additional low-cost, low-cost emission electricity will be produced. The recent change in enforcement procedures by EPA, reinterpreting as violations of the Clean Air Act what had heretofore been considered routine maintenance at power plants, has had a direct and chilling effect on all maintenance and efficiency improvements, and clean coal technology installations at existing power plants. A return to the pre-1998 interpretation of this one regulation would allow plant operators the opportunity to install technologies discussed in the report.

Several other existing regulations seem to be in conflict with the country's attempt to maximize the use of domestic energy sources, as well. Environmental regulation should be harmonized with the energy and national security goals of the country.

The National Coal Council strongly recommends that the country, with the Department of Energy in the lead, develop a clear comprehensive energy policy that supports the maximum use of domestic fuel sources, continues to protect the environment by implementing strong but balanced environmental regulations, and harmonizes conflicting regulations affecting energy development and use. Government and the private sector should work in partnership to achieve the desired goals and remove those regulatory barriers that create obstacles to achieving those goals, while preserving environmental performance. The specific recommendations of the Council can be found in the Executive Summary of the report.

The Council appreciates being asked to provide this report and we stand ready to answer any questions you may have about it.

Sincerely,

Steven F. Leer

Steven F. Leer
Chairman

Enclosure

Abbreviations

AQRVs	Air quality related values
B&W	Babcock & Wilcox
BACT	Best available control technology
BGL	British Gas/Lurgi
Btu	British thermal units
Btu/kWh	British thermal units per kilowatt-hour
CAA	Clean Air Act
CFB	Circulating fluidized bed
CO_2	Carbon dioxide
COS	Carbonyl sulfide
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
FGD	Flue gas desulfurization
FLMS	Federal land managers
GADS	Generation Availability Data System
GW	Gigawatts (10^9 watts)
HHV	Higher heating value
HRSG	Heat recovery steam generator
IGCC	Integrated gasification combined cycle
kW	Kilowatt
lb/MBtu	Pounds of emissions per million Btu of heat input
LAER	Lowest achievable emission rates
LHV	Lower heating value
LNB	Low NO_x burners
MACT	Maximum achievable control technology
Mbtu	Million Btu
MDGC	Maximum demonstrated generating capacity
MW	Megawatts (10^6 watts)
MWH	Megawatt-hour
NAAQS	National Ambient Air Quality Standards
NCC	National Coal Council
NERC	North American Electric Reliability Council
NGCC	Natural gas combined cycle
NOVs	Notices of violation
NO_x	Nitrogen oxides
NSPS	New Source Performance Standards
NSR	New Source Review
O&M	Operating and Maintenance
OEM	Original Equipment Manufacturer
PPM	Parts Per Million
PSD	Prevention of significant deterioration
SCR	Selective catalytic reduction
SO_2	Sulfur dioxide
SO_x	Sulfur oxides
tpy	tons per year
UDI	Utility Data Institute
WEPCo	Wisconsin Electric Power Company

Table of Contents

Preface

The National Coal Council is a private, nonprofit advisory body, chartered under the Federal Advisory Committee Act.

The mission of the Council is purely advisory: to provide guidance and recommendations as requested by the United States Secretary of Energy on general policy matters relating to coal. The Council is forbidden by law from engaging in lobbying or other such activities. The National Coal Council receives no funds or financial assistance from the Federal government. It relies solely on the voluntary contributions of members to support its activities.

Members of the National Coal Council are appointed by the Secretary of Energy for their knowledge, expertise, and stature in their respective fields of endeavor. They reflect a wide geographic area of the United States (representing more than 30 states) and a broad spectrum of diverse interests from business, industry, and other groups, such as:

- large and small coal producers;
- coal users such as electric utilities and industrial users;
- rail, waterways, and trucking industries as well as port authorities;
- academia;
- research organizations;
- industrial equipment manufacturers;
- state government, including governors, lieutenant governors, legislators, and public utility commissioners;
- consumer groups, including special women's organizations;
- consultants from scientific, technical, general business, and financial specialty areas;
- attorneys;
- state and regional special interest groups; and
- Native American tribes.

The National Coal Council provides advice to the Secretary of Energy in the form of reports on subjects requested by the Secretary and at no cost to the Federal Government.

Executive Summary

Purpose

By letter dated November 13, 2000, then-Secretary of Energy Bill Richardson requested that the National Coal Council conduct a study on measures which the government or the government in partnership with industry could undertake to improve the availability of electricity from coal-fired power plants. His letter requested that the Council address improving coal-fired generation availability in two specific areas:

- improving technologies at coal-fired electric generating plants to produce more electricity; and
- reducing regulatory barriers to using these technologies.

The Council accepted the Secretary's request and formed a study group of experts to conduct the work and draft a report. The list of participants of this study group can be found in Appendix D of the report.

Findings

The study group found the following.

- Nationally, approximately 40,000 megawatts of increased electrical production capability is possible now from existing coal-fired power plants.
- Such increased electricity supply can be available through the installation of standard improvements and clean coal technologies. This will have the important effect of increasing efficiency and decreasing emissions per megawatt from such modified plants, thereby improving air quality.
- Such plant efficiency and increased electricity production capability may only be realized if a return to historic regulatory policy is made.
- Coal-based electricity will be important for many years into the future. Therefore, regulations and policies employed should encourage the clean use of this resource through accelerated installation of more efficient, cleaner technologies.

  The study was divided into two major sections: technology and regulatory reform. The focus of the technology section is on achieving more electricity from existing and new coal-fired power plants using technologies that improve efficiency, availability, and environmental performance. The discussion is divided into three subsections:

  a) achieving higher availability/reliability in the existing fleet of coal-fired plants;
  b) Increasing generation output of existing coal-fired plants; and
  c) Determining opportunities for repowering existing facilities with clean coal technologies as well as building new advanced clean coal technology generation facilities.

Analysis of the U.S. utility industry infrastructure of coal plants reveals a significant potential for increasing generation capacity by taking well-tested measures to improve the reliability/availability of older facilities. This effort, which will come mainly from improvements on the steam generators of these older plants, can create 10,000 MW of new capacity.

Techniques to recover lost capacity and increase capacity above nameplate have been collected from a combination of research studies by utility industry organizations such as EPRI and actual case studies which are detailed in the report. The nameplate capacity of coal units older than 20 years is approximately 220,000 MW; however, due to derating, the existing capacity is only about 200,000 MW.

This group of plants has the potential for both capacity restoration (about 20,000 MW) and/or improvement (about 20,000 MW). It is estimated that this increased capacity of 40,000 MW could be recovered within 36 months. This can allow the economy to grow while new generation facilities are sited, constructed, and brought into service.

For new coal-fired power generating capacity, Pulverized Coal Combustion in supercritical steam plants (a mature technology) is available with minimal emissions, high efficiency, and at very favorable total production cost.

Repowering of an old existing coal fired power plant with a single modern steam generating unit, equipped with commercially proven emissions controls results in significant reductions in the total amounts of emissions even while substantially increasing the total MWh output of the facility.

Integrated Gasification Combined Cycle (IGCC) has become a commercially available technology for both greenfield and repowering applications. IGCC is a clean, new technology option insensitive to fuel quality variation.

While natural gas will fuel the majority of new capacity additions during this time period there are currently about 321,000 MW of coal-fired capacity in service. While not all of this capacity can be targeted for the new technologies discussed in this report, it is estimated that 75% of it can be retrofitted with one of these technologies. This additional increase in capacity is estimated to be 40,000 MW and much of it could be brought on line in the next three years. This minimizes economic impacts while new generation facilities are sited, constructed, and brought into service without increasing emissions at existing facilities and, in some cases, lowering emissions. Approximately 25% of existing facilities can be targeted for repowering with much cleaner and more efficient coal-based power generation.

However, unless there is a significant change in regulatory interpretation and enforcement regarding the installation of new technologies at existing power plants, it is not likely that any of this additional low-cost, low emission electricity will be produced. The recent change in enforcement procedures by EPA (reinterpreting as violations of the Clean Air Act what had heretofore been considered routine maintenance at power plants) has had a direct and chilling effect on all maintenance and efficiency improvements and clean coal technology installations at existing power plants. EPA has brought legal action against 11 companies and 49 generation facilities since 1998 under the New Source Review section of the 1990 Clean Air Act. The companies involved believe that they were conducting routine maintenance needed to keep these plants in good condition. The result has been that no new efficiency, availability, or environmental improvement has occurred since 1998 when EPA changed its enforcement policy. A return to the historic interpretation of this one regulation alone would allow plant operators the opportunity to install technologies discussed in the report. If just a three percent increase in capacity could be achieved through reducing outages and increasing plant efficiency, it could result in over 11,500 MW of coal-based capacity being added to the current fleet while continuing the downward trend in emissions.

Several other existing regulations seem to be in conflict with the country's attempt to maximize the use of domestic energy sources. Environmental regulation should be harmonized with the energy and national security goals of the country.

Recommendations

The National Coal Council strongly recommends that the country, with the Department of Energy in the lead, develop a clear, comprehensive energy policy that supports the maximum use of domestic fuel sources, continues to protect the environment by implementing strong but balanced environmental regulations, and harmonizes conflicting regulations affecting energy development and use. Government and industry should work in partnership to achieve the desired goals and remove those regulatory barriers that create obstacles to achieving those goals while preserving environmental performance.

Specifically, the Council recommends that the Department of Energy take the following actions.

- Initiate and lead a dialogue with EPA, with the goal of returning to the traditional pre-1998 interpretation of the New Source Review section of the 1990 Clean Air Act.
- Promote accelerated installation of clean and efficient technologies at new and existing coal-fired power plants.
- Initiate and lead a dialogue with EPA to promote coordinated regulations for ozone attainment into a single compliance strategy.
- Initiate and lead a dialogue with EPA and electricity generators to establish credible and uniform emissions targets, which will provide regulatory certainty for a sufficient period in the future to assure electricity generators that they can achieve a return on investments for performance and environmental improvements.
- Lead the country's effort to develop a clear, comprehensive, and secure energy policy that maximizes the use of domestic fuels, including coal, while continuing the downward trend in emissions.

Achieving Higher Availability/Reliability From Existing Coal-Fired Power Plants

This section will focus on recommendations that will improve existing coal-fired power plants' reliability and availability to eliminate or reduce forced outages and extend the time between planned maintenance outages. This suggested availability improvement program is meant to restore the plants' infrastructure to a level that restores the original reliability of the plants. Implementation of these recommendations will allow the plants to increase generation output above recent historical output without increasing gross generating capability.

We will show from the use of industry sources on reliability (GADS/NERC) and generation capacity (EIA) that there is a significant opportunity for the utility industry to increase the generation output from our existing fleet of coal-fired power plants by restoring portions of the plant infrastructure to their original condition.

Analysis of the U.S. utility industry's coal-fired plant infrastructure reveals a significant opportunity for increasing electricity output from these plants by taking measures to improve the reliability/availability of the older facilities. Maintaining or restoring plants that are over 20 years old to a condition similar to plants that are under 20 years old can result in more reliable facilities that will be available to play an important role in supporting the increasing strain on our electrical system's reserve margins and electrical demand growth.

Specifically, our analysis has shown that this reliability improvement effort can create 10,000 MWs of equivalent generation capacity within our existing coal-fired fleet of plants. Of particular note is that over 90% of these MWs of capacity will come from component replacement and material upgrades of the boiler/steam generator at our facilities that are more than 20 years old. The U.S. EPA has focused on boiler/steam generator component replacement projects in its recent enforcement actions, applying New Source Review ("NSR") standards to repairs formerly considered routine maintenance, repair, or replacement. The potential regulatory consequences of the EPA's enforcement actions may prevent the utility industry from taking full advantage of this relatively inexpensive way to increase the availability of our national electric generating capacity, which could be implemented in a two to three year time frame.

The U.S. electric generating system's reserve margins have declined dramatically over the last 20 years. This situation has put pressure on the operators of our existing coal-fired fleet to restore, maintain, or improve the reliability and availability of their facilities to keep pace with the growing demand for electricity in the face of limited new capacity coming on line. The mandate for higher availability, lower forced outage rates, and longer time spans between planned outages is more critical today than ever in our history.

The causes of plant unavailability are well defined, and sound, technology-based solutions are commercially available to improve plant availability and help restore our historic reserve margins.

Causes of plant unavailability and recommendations for solutions have been generally categorized according to the magnitude of their impact on plant availability in the following list:

Area 1: Boiler/Steam Generator

The primary cause of unavailability of our coal-fired plants is the reliability of the boiler/steam generator. Severe duty on both the fire side and the water/steam side of the various heat transfer surfaces in the boiler/steam generator cause frequent unplanned outages and lengthening of planned outages to repair failures to these critical components of the power plant. Replacement of these components will significantly reduce outages and increase the facility's availability and total generation output capability. Examples of our recommendations for improving the availability of the boiler/steam generator are:

a. furnace wall panel replacements;
b. reheater component replacements;
c. primary superheater component replacements;
d. secondary superheater component replacements;
e. economizer replacements;
f. various header replacements;
g. furnace floor replacements;
h. cyclone burner replacements; and
i. incorporation of improved materials of construction for items a-h.

This area represents between 50% and 70% (depending on age, design, and operating history of the unit) of all lost generation from our coal-fired fleet. The industry data sources referenced above indicate that if improvements to the boilers/steam generators on our plants that are older than 20 years can be made to restore these facilities to the condition of plants that are under 20 years, we will benefit from an attendant improvement in reliability/availability. To help quantify this finding, plants older than 20 years are, on average, currently experiencing nearly 10% loss of achievable generation due to problems in the boiler/steam generator. This compares to approximately 5% loss for plants that are less than 20 years old. If we can recover only this differential through restoration of the boiler/steam generator, we will be taking advantage of nearly 9,000 MWs of available generation capacity in our existing coal-fired generating fleet. This figure is expected to increase significantly as our older generating units are dispatched more often to meet the growing demand for electricity considering the less than adequate new capacity coming on line.

Although the implementation of any (or all) of these recommendations will significantly increase plant availability, recent regulatory treatment of previously routine repairs, maintenance, and replacement as modifications by the EPA discourages utilities from pursuing these kinds of projects in their future plans for availability improvement for fear of triggering NSR with accompanying permitting and modeling requirements. NSR can radically undermine the economic feasibility of these projects, preventing recapture of lost generating capacity or increased reliability.

Area 2: Steam Turbine/Generator

Problems with the steam turbine/generator represent the second largest source of reduced generation capability in coal-fired plants. This area represents a 3% loss of generation compared to up to 10% for the boiler/steam generator. An interesting finding from our analysis is that the data sources referenced above show very little difference in loss of generation capability due to turbine/generator problems between plants older than 20 years and plants younger than 20 years. This phenomenon may be due to the regimented safety and preventative maintenance program typically mandated by turbine manufacturers and followed by plant owners for the steam turbine/generator.

Section 2 describes turbine/generator improvements (e.g., uprating) that can change gross plant outputs without changing the turbine/generator's relatively good track record on availability. In addition to turbine uprating, some of the general improvements that have occurred in steam turbine design will also improve the availability/reliability of existing steam turbines. Recommendations include:

a. turbine blading replacements with improved shapes (CFD modeling) and materials of construction to increase turbine efficiency and reliability;
b. implementation of measures to reduce or eliminate droplet formation and the resultant blade erosion preserving turbine reliability and performance; and
c. turbine/generator inclusion in plant diagnostic and data acquisition system for predictive maintenance (reference area 7c below) to reduce unnecessary maintenance and associated outage time.

<u>Area 3: Plant Auxiliaries</u>

This area focuses on plant auxiliaries including the air heater, feedwater system, cooling water systems, electrical systems, etc. Plant auxiliaries cause approximately 1-2% of lost megawatt-hour (MWh) generation from our coal-fired plants over 20 years old. This can be improved to under 1% with restoration of critical components in this area of the plant. Some examples of recommendations for improved reliability and increased operating efficiencies in these areas are:

a. air heater or air heater basket replacement with the attendant modern sealing systems;
b. improved air heater surface design and cleaning system installation to address fouling;
c. feedwater heater retubing or replacement with upgraded materials to reduce failure rates; and
d. cooling tower fill improvements.

<u>Area 4: Environmental (Focus on Electrostatic Precipitators)</u>

Precipitator performance has the fourth largest impact on loss of plant availability. This problem almost always manifests itself in the form of load curtailment caused by the potential for opacity excursions. To exacerbate the problem, these curtailments typically occur at very critical capacity supply situations such as periods with high load requirements. Recommendations for mitigation are:

a. collection plate and electrode upgrades and/or replacement;
b. collection surface additions (new fields);
c. various flue gas treatment system installations;
d. addition of modern control system installations; and
e. general correction of leakage and corrosion problems.

<u>Area 5: Fuel Flexibility</u>

Many utilities have expanded their coal purchase specifications to leverage the variability in the cost of coal as a means of providing low-cost electricity to their customers. This practice, however, can have an adverse affect on plant reliability due to stress on the plant. It should be noted that although this area is not statistically recognized as a cause of loss of plant availability, fuel related problems are a major part of loss of availability from Area 1 "boiler/steam generator" due to such phenomena as boiler slagging/fouling, limited pulverizer throughput, reduced coal grindability, inadequate primary air systems, etc. Recommendations to reduce or eliminate these limitations are:

a. coal handling system upgrades to accommodate lower Btu coal;
b. mill upgrades to accommodate reduced grindability of coal;
c. ash (bottom and/or fly) system upgrades to accommodate higher ash coal or different ash classes;
d. additional furnace-cleaning equipment to mitigate different slagging and fouling characteristics of the coals;
e. draft system upgrades including FD fans, ID fans, combustion air temperature, and related electrical systems to accommodate higher gas volume flow rates; and

f. precipitator upgrades to accommodate changes in fly ash resistivity and/or quantity.

Area 6: Boiler Water Treatment

This issue goes hand-in-hand with Area 1 described above. Performance of boiler heat transfer surface is highly dependent on the chemistry of the water/stream that keeps the surface cool. Upgrades of the boiler water treatment system should be coordinated with the upgrades described in Area 1. An added benefit of higher water purity standards is faster plant start-ups; and, therefore, a unit can come on-line more quickly and ramp up generation faster resulting in a higher overall generation output. In addition, water purity has a cascading effect increasing the reliability of feedwater heaters and turbine blades and improving condenser performance.

Area 7: Controls and Plant Diagnostic Systems

Modern digital control and diagnostic systems can improve heat rates (generation efficiency), lower emissions, reduce plant startup times, and provide valuable information for outage planning. Recommendations in this regard include:

a. replacement of outdated analog control with advanced digital control systems;
b. replacement and/or addition of instrumentation for better control of the unit over a wider range of loads and improved monitoring of critical system components for outage planning;
c. installation of plant diagnostic and data acquisition systems to perform predictive maintenance reducing unplanned outages and extending on-line time durations between planned outages; and
d. installation of turbine bypass system hardware and controls to facilitate lower load capabilities, faster unit start-ups and faster ramp rates increasing overall unit productivity.

Area 8: Plant Heat Rejection

For many plants, the highest capacity requirements of the year occur at the same time that they experience severe heat rejection limitations. Summertime cooling lake and river temperatures/water levels can cause load curtailments. Recommendations include:

a. water intake structure modifications to provide more flexibility during low water levels;
b. cooling tower additions to provide an alternate heat rejection mechanism; and
c. cooling lake design modifications (additional surface, redirected flow path, etc.) to increase heat rejection capability.

Summary

Restoration of our 20+-year-old coal-fired plants to a condition similar to those that are under 20 years through the recommendations described in these eight areas can create approximately 10,000 MWs of additional availability from existing assets. We would expect this number to grow significantly as we increase utilization of our older plants to meet growing demand. Without implementing these recommendations, the forecasted increases in utilization will accelerate failures in these older facilities increasing the need for the recommendations we have identified here.

Of particular interest is that 90% of the increased availability identified will come from component replacement and other projects involving the boiler/steam generator. The boiler/steam generator has been the focus of the EPA's allegations in its recent reinterpretation of the New Source Review program as part of its power plant enforcement initiative.

Increasing Generation Output of Existing Units

The maximum demonstrated generating capacity (MDGC) of coal units older than 20 years, as identified above, is conservatively estimated to total approximately 220,000 MWs. The existing operating capacity is estimated to be 200,000 MWs (due to deratings). This group of plants has the potential for both capacity restoration (20,000 MWs) and/or capacity maximization (20,000 MWs). Thus, the total amount of potential increased MW output of this existing group of units is approximately 40,000 MWs. This increased capacity could be achieved within 36 months.

If all existing conditions resulting in a derating could be addressed, approximately 20,000 MWs of increased capacity could be obtained from regaining lost capacity due to unit deratings. This increase would be achieved using the approaches and techniques in Table 1 below.

Approximately an additional 20,000 MWs of capacity could be gained if it were possible to increase heat input and/or electrical output from generating equipment while still maintaining the acceptable design margins and allowable code ratings of the equipment. The approaches and techniques would be similar to those for regaining capacity, as indicated in Table 1.

These approaches and techniques could only be logically pursued by the facility owners if it was clearly understood that the increased availability and/or electrical output would not trigger New Source Review (NSR) and if repowering or construction of new clean coal technologies would be subject to the streamlined permitting authorized by the 1990 CAA Amendments.

The techniques to recover lost capacity and to increase capacity above MDGC have been collected from a combination of research studies by utility industry organizations (such as EPRI) and actual case studies (such as those outlined below) which had benefits for plant owners. They are summarized in Table 1 below.

TABLE 1
Techniques and Approaches for Coal-Fired Power Plants Capacity Restoration and Increase

Capacity Increase Method	Capacity Restoration	Efficiency/ Capacity Increase	Fuel Conversion/ Repowering
Installation of improved air pollution control equipment	X	X	X
Steam turbine modernization improvements and upgrades	X	X	
Coal washing	X	X	
Coal switching	X	X	
Repowering with CFB technology			X
Consolidation of multiple, smaller inefficient units to larger, more efficient units		X	X
Operating above the nameplate but within the plant design	X	X	
Control system improvements	X	X	
Plant efficiency improvements	X	X	

The techniques and approaches listed in Table 1 have been implemented with proven results. The following highlights are from case studies.

- *SCR and FGD emissions control equipment was installed on a coal- fired generating station to reduce emissions of SOx and NOx. In order to offset the increased auxiliary load (16 MWs) of these new systems, an upgrade of the original 500-MW (nominal rating) steam turbine was performed. The upgrade consisted primarily of a new high-efficiency, high-pressure rotor with increased number of stages and an optimized steam path. The upgrade resulted in an output increase of approximately 15 MWs, almost offsetting the auxiliary load increase from the new emission controls.*
- *Turbine upgrades were completed on two 400-MW rated units to obtain an additional 25 MWs per unit. No additional steam was required from the boiler. No changes were made to the boiler. A more aerodynamic steam path through the turbine was designed and installed.*
- *Turbine upgrades were incorporated into another unit, nominally rated at 500 MWs achieving an additional 25 MWs. In this case, more steam had to be generated in the boiler and the steam turbine was upgraded.*
- *Coal cleaning is a process whereby a coal that is high in ash and sulfur is "washed." As a result, the coal is lower in both ash and sulfur content and higher in thermal value. The method consists of a multi-circuit wet process where water is used for screening and separation. Coal cleaning is a cost-effective means of separating ash and sulfur from coal, which in turn reduces opacity and SO_2 emissions. This enables one facility to continue to use local, lower cost, higher ash and sulfur coal and meet environmental limits. Without this coal cleaning process, the facility's load would be limited by approximately 10% due to opacity restrictions.*
- *Coal switching is an alternative to coal cleaning. In some cases where coal has been switched to reduce SOx emissions, the capacity may be impaired unless fuel handling systems are upgraded to allow efficient use of lower sulfur fuels.*
- *Repowering with CFB technology is an alternative to installing NOx and SOx emissions equipment. The use of this technique is highly site and fuel specific.*
- *Capacity increases can be accomplished by taking a brownfield site with several smaller old units, and repowering the site with a single large unit. This will require the full environmental permitting*

process. It is a technique that is highly site specific and economically driven. To make the economics attractive, it is important that the units are running at low dispatch levels, so income losses are minimized, and the site can be readily cleared for construction of the larger unit.

- *Control system improvements can increase capacity in older plants. Modern control systems can improve efficiency and reduce emissions by optimizing the combustion process. General improvements to plant efficiency can be obtained by improved operating and maintenance practices along with targeted equipment improvements.*

Note: The additional 20,000 MW that can be achieved by capacity restoration described in this section includes the 10,000 MW of capacity that can be recovered due to deteriorated availability described earlier in the report.

Opportunities for Greenfield Sites and Repowering Existing Facilities with Pulverized Coal Power Generation

As a result of ongoing technology development, new and retrofitted pulverized coal power plants have achieved outstanding emissions performance for NOx, SOx, and particulates. Similarly, continued advances in the steam cycle continue to provide higher net plant efficiencies. As a result, new pulverized coal-fired power plants are now commercially available with minimal emissions and with very favorable total production cost. Repowering of an old existing coal-fired power plant with a single modern generating unit equipped with commercially proven emissions controls results in significant reductions in total tons of emissions, even while substantially increasing the total megawatt-hour output of the facility. A case study of repowering an actual old coal-fired plant with a unit utilizing current technology showed a 32% higher design capacity, achieving triple the total electrical output, an 87% reduction in tons of NOx and SOx up the stack, and a 42% reduction in total electricity production costs.

Pulverized Coal Technology Options

The configuration of today's state-of-the-art pulverized coal power plant is primarily dependent on the sulfur quantity of the coal to be utilized.

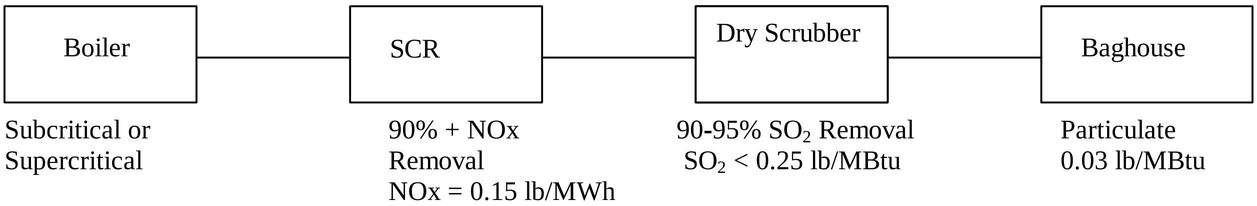
Low sulfur coals will most economically utilize a dry scrubber and baghouse for SO_2 and particulate control. Wet scrubbers can also be utilized with the benefit of producing a useful byproduct (gypsum).

Higher sulfur coals will utilize a wet scrubber and precipitator or baghouse for SO_2 and particulate control.

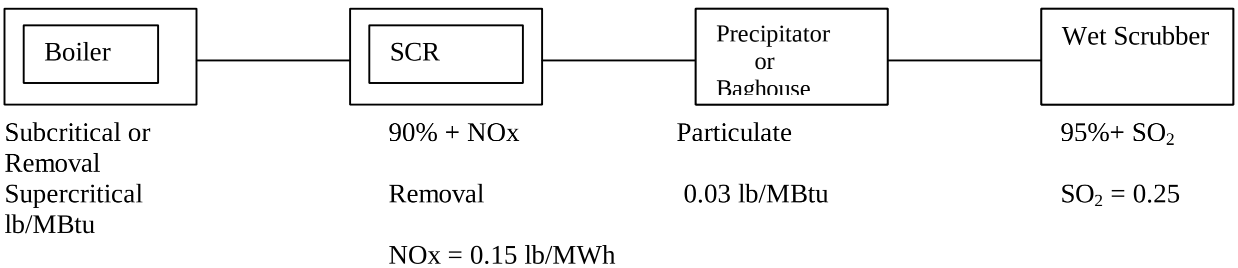
NOx emissions will be controlled by both Low NOx Burners (LNB)and Selective Catalytic Reduction (SCR).

The boiler/turbine steam cycle will vary from a standard subcritical cycle to an advanced supercritical cycle depending on project requirements and fuel costs.

Example: Low Sulfur Coal Configuration with representative emissions performance.

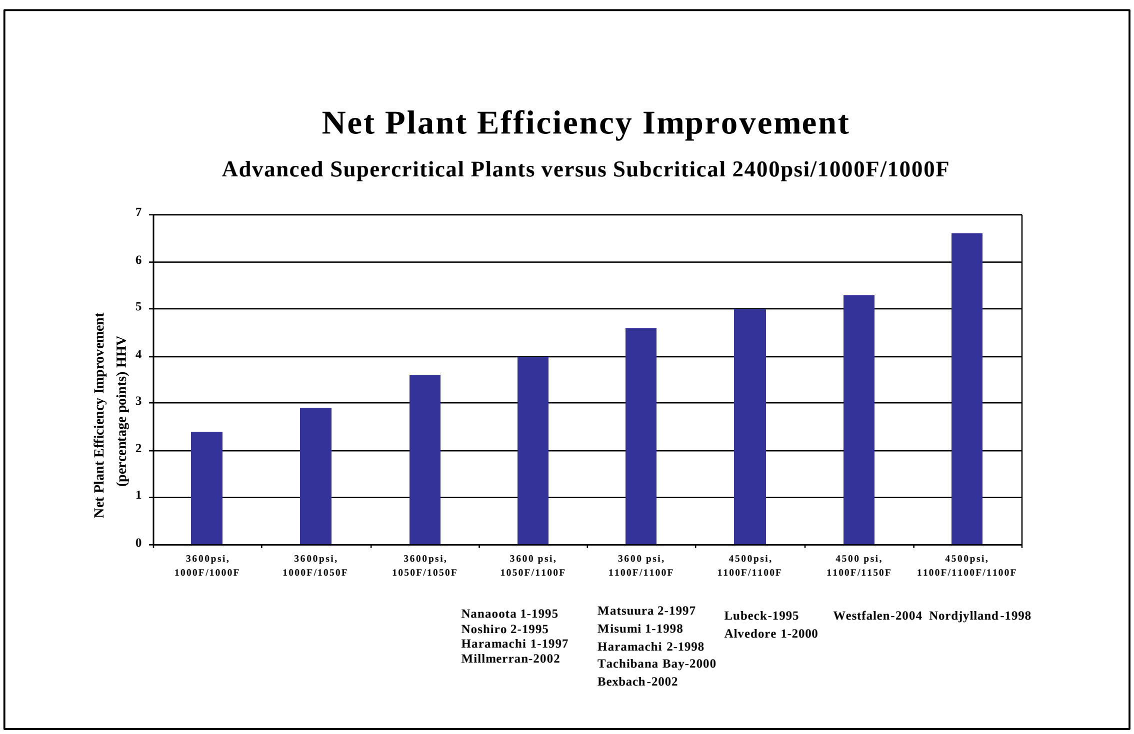


Example: High Sulfur Coal Configuration with representative emissions performance.



Heat Rate

Over the last 10 years, higher efficiency pulverized coal plants have been placed in commercial operation. The higher efficiencies are due not only to advanced pressure and steam cycles, but also to improvements in turbines and reductions in auxiliary power requirements. Pulverized coal power plant heat rate improvements versus steam parameters are shown below. (The actual operating plants have steam parameters close to the examples under which they are listed.)



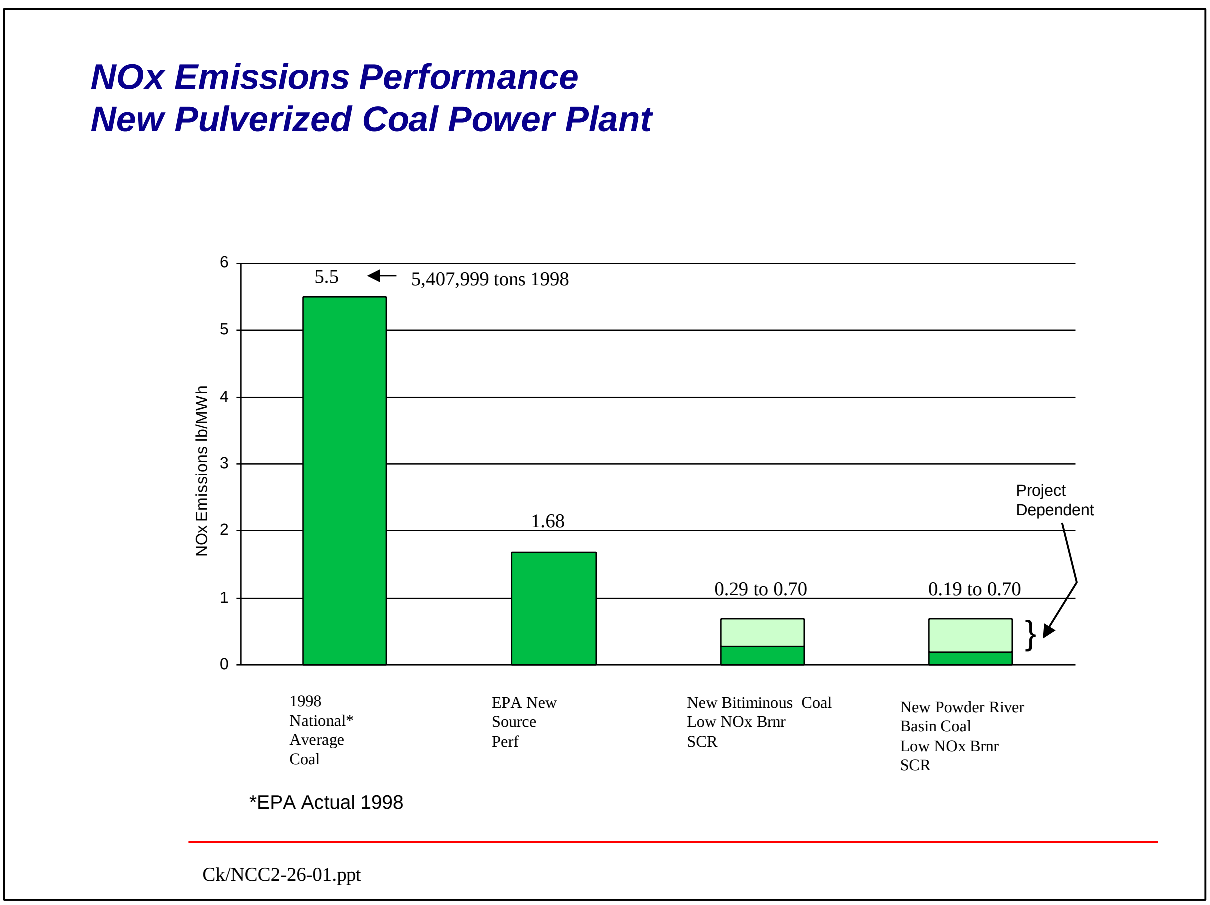
The summary point is that higher efficiency cycles are now being demonstrated with commercially required availability/reliability. Higher efficiency cycles will reduce the production cost by reduced fuel consumption and will result in a lower capital cost for all of the environmental equipment (on a $/kW cost basis). The ambient air emissions levels (NOx, SOx, particulate, and mercury) will primarily be a function of the emissions control devices installed (SCR, scrubber, baghouse, etc.). More efficient plants will provide an emissions reduction as well. For the U.S. market, the economically optimum cycle efficiency will be very project specific. However, today's advanced cycles have been demonstrated commercially and can be applied where project economics dictate.

Emissions Performance

NOx

Significant improvements in NOx emissions are being achieved in pulverized coal-fired power plants today. This is through both advances in Low NOx Burner Combustion technology and advances in Selective Catalytic Reduction systems, both of which are being widely applied. Low NOx Burner Combustion technology has resulted in combustion NOx levels being in the range of 0.15 to 0.30 lb/MBtu, depending on the coal. Selective catalytic reduction systems are in operation with NOx removal efficiencies up to 90-95%. An existing plant retrofit this year with an SCR will result in NOx emissions of approximately 0.30 lb/MWh, (approximately .03 lb/MBtu which is lower than the best natural gas combined cycle unit utilizing dry Low NOx Combustion, according to the most recent EPA actual operating data).

New pulverized coal power plants, through the application of commercially demonstrated Low NOx Burners and SCRs, can achieve NOx emissions as shown in the table below. In order to compare NOx emissions with natural gas-based power generation, the performance is reported in lb NOx per MWh.

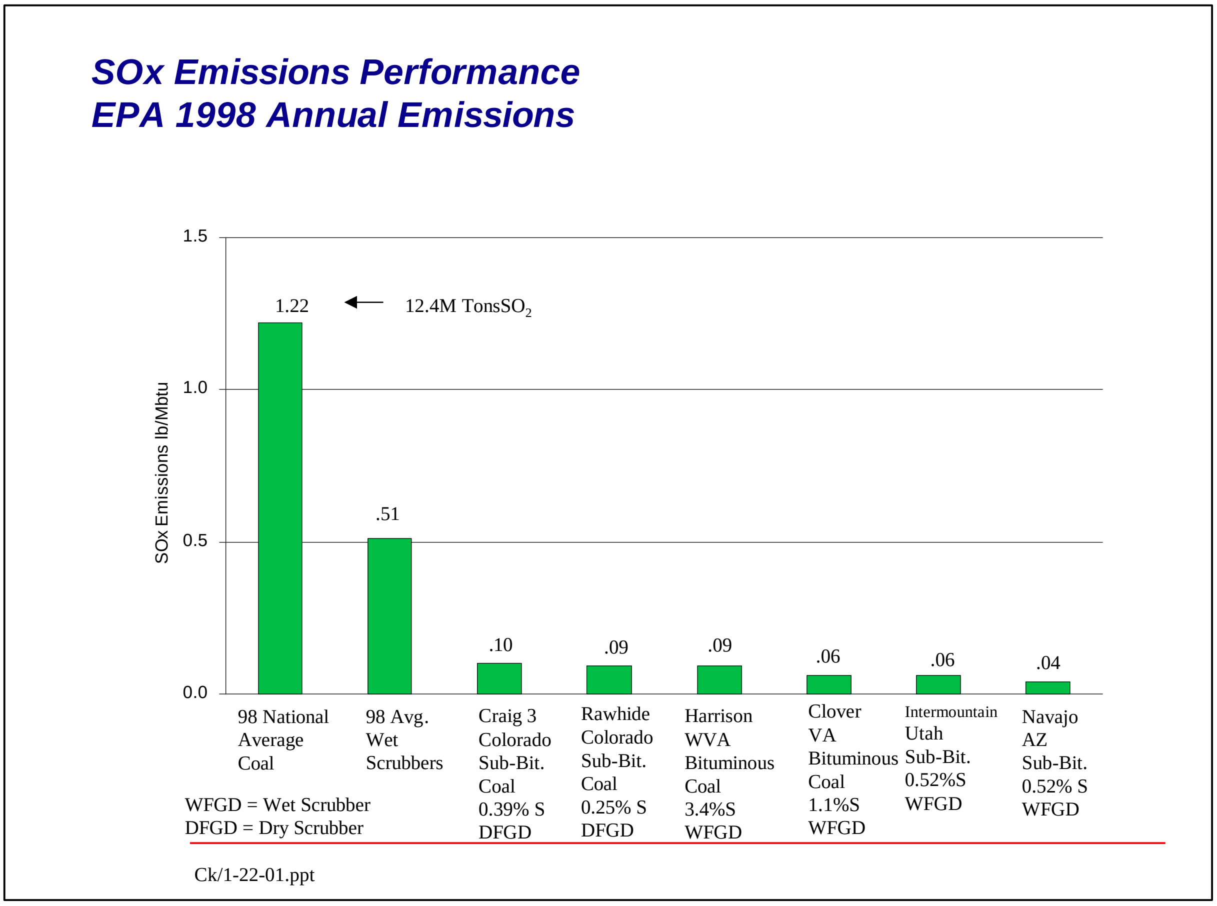


The NOx emissions performance represented in this section of the report and in the two case studies is derived from applying the state of the technology, Low NOx Burners, with the state of the technology Selective Catalytic Reduction Controls. These are applied to representative Eastern and Western coals and typical project parameters. The actual NOx emissions that can be obtained from a given new coal-fired project will depend on the analysis of the actual coal to be burned. It will also depend to some extent on the local ambient air conditions and condenser water availability and temperatures, which will impact the available heat rate of the cycle. The actual achievable NOx emissions rate for a given project can only be determined after the specific project and fuel parameters have been defined.

It should also be noted that this section of the report only addresses new, coal-fired generating plants. Whereas significant NOx reductions can be achieved from retrofits to an existing coal-fired generating unit, in many cases constraints from the original furnace design or other project constraints that cannot be modified will result in it not being possible to achieve the same NOx reductions on a retrofit as will be available for a greenfield generating unit that has maximum design flexibility for the boiler and environmental equipment.

SOx

Similarly, outstanding performance is being demonstrated on low SOx emissions technology, from a number of pulverized coal-fired power plants ranging from high sulfur Eastern bituminous coals to low sulfur Western coals. The graph shown below reflects actual SOx emissions from a number of coal-based power generating facilities as reported in the EPA 1998 Annual Emissions. In summary, the technology is available and is being commercially demonstrated to achieve extremely low SO_2 emissions.



Particulate
High efficiency precipitators and baghouses are routinely achieving particulate emissions levels under .020 lb/MBtu.

Mercury
Significant mercury removal research from pulverized coal power plants has been underway over the last 10 years. In 2001, this will culminate in plant demonstrations for Advanced Mercury Removal Systems at Alabama Power's Gaston Station, Michigan South Central's Endicott Station, and Cinergy's Zimmer Station. These demonstrations are aimed at positioning coal-fired power plants for the announced future regulation of mercury emissions. Additionally, aggressive research and plant demonstrations are underway to substantially reduce mercury emissions.

Pulverized Coal Power Plant Applications

Following are two cases, which illustrate the impact of building new pulverized coal power generation plants.

1. Greenfield site or addition of a new generating unit to an existing power plant. This case shows typical plant efficiencies, emissions levels, electricity produced, and production costs for new pulverized coal power plants for both a low and high sulfur coal options.

2. Repowering of an old existing pulverized coal-fired power plant.

This case examines the performance emissions and production cost of repowering an entire old, coal-fired power plant consisting of multiple old, low-efficiency units that have high emissions rates with a single modern pulverized coal-fired generating unit.

Case 1

This case examines the efficiency, emissions performance, and production cost for adding a new coal-fired generating unit, either to a Greenfield site or to an existing power plant. Performance is shown for both an eastern bituminous coal and a Powder River Basin Coal Plant.

TABLE 2
New Pulverized Coal Power Plant

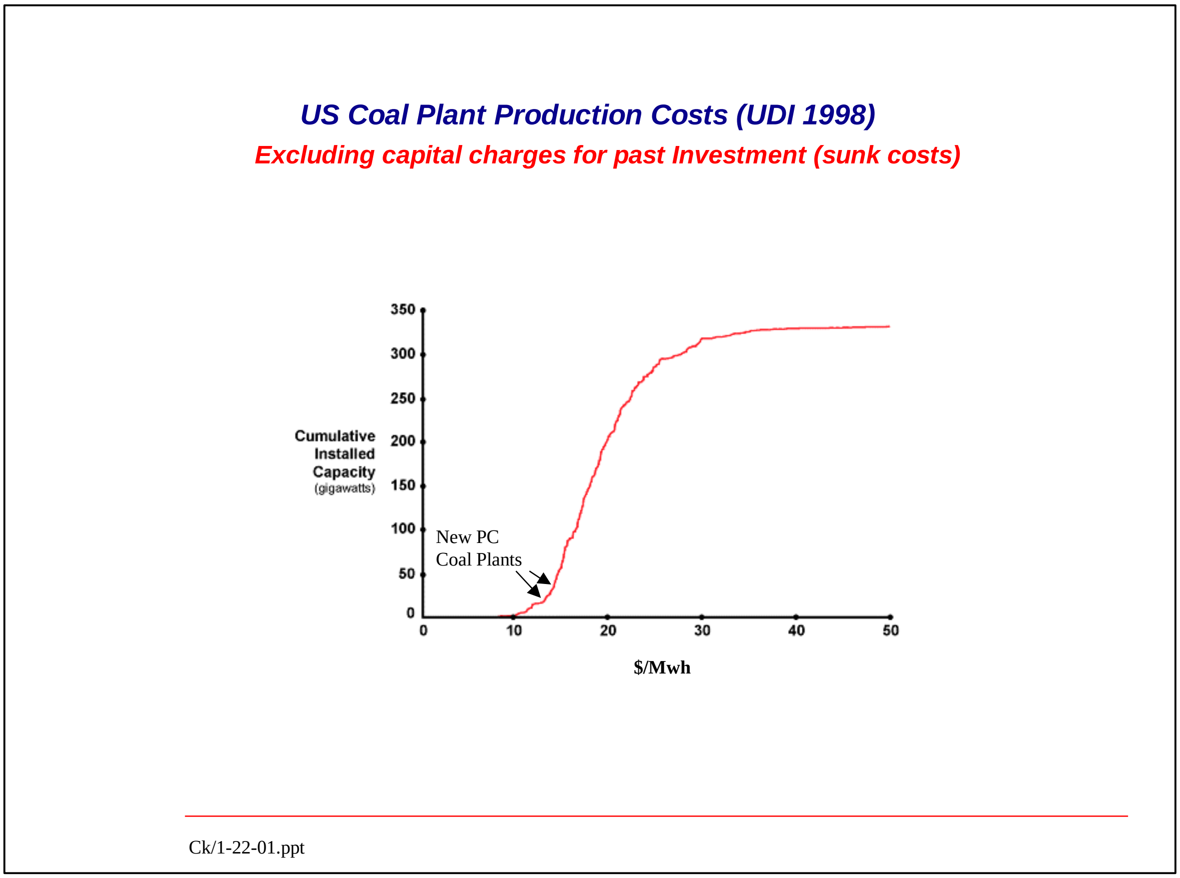
		Low Sulfur PRB Coal		High Sulfur Bit. Coal	
Coal Heating Value	Btu/lb	8,000		12,500	
Coal % Sulfur	%	0.4		3.5	
Steam/Turbine Cycle		Supercritical	Subcritical	Supercritical	Subcritical
Net Plant Heat Rate	Btu/kWh	8900	9600	8500	9200
Net Plant Efficiency	HHV	38.3%	35.6%	40.1%	37.1%
Net Plant Efficiency	LHV	41.6%	39.8%	42.2%	39.0%
Emissions - Ranges					
Combustion NOx	lb/Mbtu	0.20 to 0.40	same	0.40 to 0.50	same
SCR % NOx Removal	%	80 to 90	same	85 to 92	same
Outlet NOx	lb/Mbtu	0.020 to .080	same	0.032 to .075	same
Outlet NOx @ 3% 0_2	ppm	14 to 58	same	23 to 54	same
Outlet NOx @ 15% 0_2	ppm	5 to 20	same	8 to 18	same
Outlet NOx	lb/MWh	.18 to .70	.19 to .75	.28 to .66	.29 to .69
Uncontrolled SO_2	lb/Mbtu	1.0	same	5.6	same
Scrubber % SO_2 Removal	%	90	same	95	same
Outlet SO_2	lb/Mbtu	.10	same	.28	same
Outlet SO_2	lb/MWh	.89	.96	2.38	2.58
Coal Cost	$/MBtu	1.22	1.22	1.22	1.22
Fuel Production Cost	$/MWh	10.86	11.71	10.37	11.22
Non-Fuel O&M Cost	$/MWh	3.50	3.50	3.50	3.50
Total Production Cost	$/MWh	14.36	15.21	13.87	14.72

Total Production Cost
The curve below shows the variable production cost (Fuel + O&M, excluding capital investment costs) for all the coal-fired power plants in the U.S. in 1998 (UDI data).

The curve is a plot of the variable production cost of every coal-fired power plant, ranked from the lowest to the highest. It only shows the fuel and O&M cost, and not the sunk capital costs. This would also indicate the relative order of competitive dispatch.

Also shown on the curve is the variable production cost for the two plants discussed in the case studies. This shows that the total production costs for a new pulverized coal plant will be significantly lower than most of the existing coal fleet and will assure high capacity factors.

Case 1



Total Emissions Level
The total NOx and SOx emissions are significantly lower than what is being achieved in the existing coal-fired power plants today.

Total Emissions Performance
Table 3 (below) places a value on the total NOx and SOx emissions based on assumed allowance values for the examples in this case. To illustrate the low emissions level, the total outlet NOx and SOx emissions are given a monetary cost based on assumed allowance costs. When the emissions costs are stated as a production cost in $/MWh, it can be seen that these do not change the very favorable total production cost of electricity.

TABLE 3

		Low Sulfur PRB Coal		Eastern Bituminous Coal	
		Supercritical	Subcritical	Supercritical	Subcritical
NOx Allowance Value (assumed)	$/ton	1000	1000	1000	1000
Outlet NOx	lb/MWh	.18	.19	.28	.29
NOx Allowance Cost	$/MWh	.09	.10	.14	.15
SOx Allowance Value (assumed)	$/ton	200	200	200	200
Outlet SO_2	lb/MWh	.89	.96	2.38	2.58
SOx Allowance Cost	$/MWh	.09	.10	.24	.26
Total Emission Allowance Cost	$/MWh	.18	.20	.38	.41

Case 2: Coal Power Plant Repowering

This case considers the repowering of an existing Eastern U.S. coal-fired power plant, burning low sulfur Eastern bituminous coal. The plant consists of six generating units that were built between 1949 and 1956, with a composite average net plant efficiency of 29.4%. The total gross generating capacity from all six units is 387 MW. The plant has no emission controls for NOx and SOx except for Low NOx Burners on one of the units.

The plant is repowered by replacing the boiler and turbine islands for all six units with a single 506-MW supercritical boiler/turbine, with an average net plant efficiency of 38.8%. The plant's coal receiving and handling, ash disposal, and electrical distribution infrastructure is retained where possible. The repowered unit is redesigned for the same heat input as the original six units; Low NOx Burners, an SCR, a dry SO_2 scrubber, and baghouse are added. The same coal is used in the repowered unit as is currently being burned.

Table 4 shows the actual operating performance from this plant for 1998 and the projected repowered performance in 2004.

In summary, with the plant repowered at the same heat input, it will now be rated at 31% higher megawatt output and operating efficiency. Both the NOx and SOx emissions will be reduced by 87% of the actual 1998 emissions in tons. The total production cost per megawatt-hour will be reduced 42%. Because of the low production cost, the unit will be base loaded with a high capacity factor, which will result in more than triple the actual megawatt hours produced during the year.

TABLE 4
Case 2
Repowering Existing Coal Plant

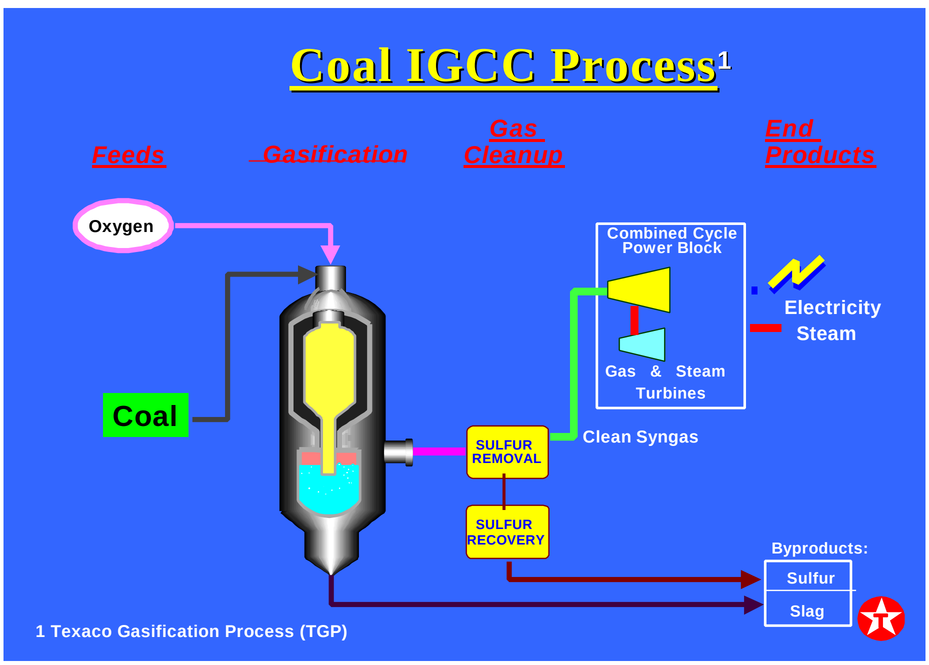
	Existing Plant 1998 Actual Operating Data	Repowered 2004 Performance	Improvement %
Design Plant Total Heat Input MBtu/hr	4140	4140	
Nameplate MW	387	506	
Total # of Units	6	1	
Total Actual MWh	1,082,180	3,544,296	+327%
Total Actual Capacity Factor	31%	85%	
Heat Rate – Annual Average Btu/kWh	11,594	8,800	
Average Plant Efficiency HHV	29.4%	38.8%	+32%
Average Plant Efficiency LHV	30.9%	40.8%	
NOx Tons – annual	3536	468	-87%
NOx Emission Rate lb/MBtu	0.509	.03	
NOx Emissions Rate lb/MWh	5.9	0.26	
Coal % S	1.08	1.08	
SOx Tons Annual	12,881	1565	-88%
SOx Emissions Rate lb/MWh	23.8	0.88	
Fuel Cost $/MBtu	1.05	1.05	
Fuel Production Cost Annual Avg $/MWh	12.18	9.26	
Non-Fuel (OEM) Production Cost Annual Average $/MWh	9.87	3.57	
Total Production Cost $/MWh	$22.04	$12.83	-42%

Opportunities for Greenfield Sites and Repowering Existing Facilities with Coal-Based Power Generation

When considering coal-based technologies for both greenfield applications and repowering of existing facilities, utilities have several primary options to consider. In addition to the modern pulverized coal technologies described earlier, integrated gasification combined cycle (IGCC) has become a viable, commercially available technology. With successes from the Clean Coal Technology Program in both new and repowered projects, much has been learned about IGCC performance, heat rate, cost, and emissions performance. This information, which has been widely published, has become an important tool for evaluation of this technology by electric utilities.

IGCC Technology Options

The diagram below shows a typical IGCC plant. The coal gasification process replaces the conventional coal-burning boiler with a gasifier, producing syngas (hydrogen and carbon monoxide) that is cleaned of its sulfur and particulate matter, and used as fuel in a gas turbine. The power generation cycle is completed through the use of the Heat Recovery Steam Generator (HRSG) and steam turbine, just as in a natural gas-fired combined cycle (NGCC) plant, offering the high efficiency and continual advances achieved with this equipment configuration.



The two primary technologies which have had the most success in the U.S. are Texaco's oxygen-blown, entrained-flow gasifier (Tampa Electric Company's Polk Power Station, a greenfield plant) and the Global Energy E-Gas (formerly Destec) oxygen-blown, entrained-flow gasifier (Cinergy/PSI Energy's Wabash River Station, a repowering project at an existing power plant).

In the Texaco gasification process, a down-flow slurry of coal, water, and oxygen, are reacted in the process burner at high temperature and pressure to produce a medium-temperature syngas. The syngas moves from the gasifier to a high-temperature heat recovery unit, which cools the syngas while generating high-pressure steam. The cooled gases flow to a water wash for particulate removal. Molten ash flows out of the bottom of the gasifier into a water-filled sump where it is forms an inert solid slag. Next, a COS hydrolysis reactor converts COS into hydrogen sulfide. The syngas is then further cooled in a series of heat exchangers before entering a conventional amine-based acid gas removal system where the hydrogen sulfide is removed. The sulfur may be recovered as sulfuric acid or molten sulfur. The cleaned gas is then reheated and sent to a combined-cycle system for power generation.

The Global Energy E-Gas process uses a slurry of coal and water in a two-stage, pressurized, upflow, entrained-flow slagging gasifier. About 75% of the total slurry is fed to the first (or bottom) stage of the gasifier. All the oxygen is used to gasify this portion of the slurry. This stage is best described as a horizontal cylinder with two horizontally opposed burners. The gasification/oxidation reactions take place at temperatures of 2,400 to 2,600^{o}F. Molten ash falls through a tap hole at the bottom of the first stage into a water quench, forming an inert vitreous slag. The hot raw gas from the first stage enters the second (top) stage, which is a vertical cylinder perpendicular to the first stage. The remaining 25% of the coal slurry is injected into this hot raw gas. The endothermic gasification/devolatilization reaction in this stage reduces the final gas temperature to about 1,900^{o}F. The 1,900^{o}F hot gas leaving the gasifier is cooled in the fire-tube product gas cooler to 1,100^{o}F, generating saturated steam for the steam power cycle in the process.

Particulates are removed in a hot/dry filter and recycled to the gasifier. The syngas is further cooled in a series of heat exchangers. The syngas is water scrubbed to remove chlorides and passed through a COS hydrolysis unit. Hydrogen sulfide is removed in the acid gas columns. A Claus unit is used to produce elemental sulfur as a salable by-product. The clean syngas is then moisturized, preheated, and sent to the power block.

In Europe, Global Energy has successfully used the British Gas/Lurgi (BGL) gasification process. In the BGL process, the gasifier is supplied with steam, oxygen, limestone flux, and coal. During the gasification process, the oxygen and steam react with the coal and limestone flux to produce a raw coal-derived fuel gas rich in hydrogen and carbon monoxide. Raw fuel gas exiting the gasifier is washed and cooled. Hydrogen sulfide and other sulfur compounds are removed. Elemental sulfur is reclaimed and sold as a by-product. Tars, oils, and dust are recycled to the gasifier. The resulting clean, medium-Btu fuel gas is sent to a gas turbine. Based on the success of the BGL process at the Schwarze Pumpe GmbH plant in Germany, Global Energy is building two plants in the U.S. The 400-MW Kentucky Pioneer Project and the 540-MW Lima Energy Project will both use BGL gasification of coal and municipal solid waste to produce electric power. The Kentucky project is being partially funded by DOE.

Heat Rate

DOE reports the Polk Power Station heat rate to be 9,350 Btu/kWh, with Wabash River at 8,910 Btu/kWh. These equate to about 38.4% and 40.2% (LHV) respectively. Overall IGCC plant efficiency of 45% LHV is likely to be demonstrated with the enhancements developed from the Clean Coal Technology Program projects and continued advances in gas turbine technology. As part of its Vision 21 Program, DOE has set a 2008 performance target of 52% on an HHV basis (about 55% LHV) for IGCC.

Emissions Performance

With gas becoming the fuel of choice for most new units, permitting agencies and environmental groups have become used to seeing very low emission limits for new units. Further, they have come to expect that repowering existing units should also meet those same low levels, regardless of economics or fuel choice. IGCC can approach the environmental performance of natural gas-fired power plants, opening the door for its application in new and repowered plants. As part of the Vision 21 Program, DOE has set a

2008 performance target of 0.06 lb/mmBtu for SO_2, 0.06 lb/mmBtu for NOx, and 0.003 lb/mmBtu for particulate matter.

Conventional power plants that are candidates for repowering are typically 40-50 years old. Historically, the small upgrades and modifications that were made to maintain capacity or increase efficiency did not subject the utility to the New Source Review (NSR) process. With EPA's coal-fired power plants enforcement activities, many utilities are under enforcement pressure to meet very strict NSR limitations for SO_2, NOx, and particulates. Compliance with these limitations usually means retrofit with flue gas desulfurization (FGD) for SO_2 control, selective catalytic reduction (SCR) for NOx control, and possibly even upgrades to the electrostatic precipitator for increased particulate control. With such units being near the end of their economically useful lives, adding additional controls may not make economic sense for a unit that may be shut down in a few years.

Repowering with IGCC allows the utility to maintain or increase capacity, while significantly improving environmental performance and producing low-cost power. The coal gasification process takes place in a reducing atmosphere at high pressures. In the gasifier, the sulfur in the coal forms hydrogen sulfide, which is easily removed in a conventional amine-type acid gas removal system. The concentrated hydrogen sulfide stream can then be recovered as elemental sulfur or sulfuric acid, and sold as a commercial byproduct, eliminating the need to dispose of large amounts of combustion byproducts. The clean syngas is sent to the gas turbine to be burned. With the addition of nitrogen into the turbine for power augmentation, the combustion flame is cooled, minimizing NOx formation and eliminating the need for SCR.

Many existing coal-fired plants are also affected by the NOx SIP call, and utilities are facing the installation of SCR on these existing units in order to comply. With changes in utility regulation, and the age of the units, the economics of these retrofits presents a challenge to continued operation of the units. Further, the possibility of stricter limitations on SO_2 or other emissions in the next few years presents another layer of economic decisions. While the unit may still be economic to dispatch following the installation of SCR, the addition of FGD may not allow that to continue. In that case, the utility would face the stranding of its SCR assets after only a few years of operation. Repowering with IGCC would provide the utility with the ability to maintain or even increase capacity, meet NOx limitations, and prepare for stricter SO_2 emission limitations.

While the retrofit of emission controls reduces emissions, it leads to secondary environmental issues, such as the large amounts of land needed to dispose of the new FGD byproduct and groundwater protection. The SCR system raises issues regarding local exposure to risks of accidental release of ammonia and disposal of the SCR catalyst.

In the gasifier, the ash in the coal melts, and is recovered as a glassy, low permeability slag which can be sold for use in making roofing shingles, as an aggregate, for sandblasting grit, and as an asphalt filler. With the sulfur also recovered as a commercial byproduct, repowering with IGCC can eliminate the solid waste issues that utilities might face when retrofitting conventional coal-fired plants with FGD and SCR.

With EPA's recent determination to regulate mercury emissions from coal-fired units, utilities will face additional potential requirements for the retrofit of control equipment. With the reducing atmosphere, and by operating a closed system at high pressures, IGCC releases of mercury are minimized. Initial information from EPA's mercury-based Information Collection Request shows promising results for IGCC, with as much as 50% of the mercury in the coal feedstock reduced or removed, much of it bound in the slag and sulfur byproducts.

Another issue that utilities will potentially face in the near future is the need to reduce CO_2 emissions. The existing coal-fired fleet in the U.S. is responsible for about one-third of all of the CO_2 emissions. While automobiles and other industries make up a large portion of U.S. CO_2 emissions, coal-fired power plants are an easier target to identify, measure, and control. Due to its high overall efficiency, repowering an existing coal-fired power plant with IGCC can reduce CO_2 emissions by as much as 20%.

Overall, repowering with IGCC provides a utility with significant increases in environmental performance. By reducing SO_2 and NOx emissions, minimizing solid waste disposal issues, and addressing potential near-term emission limitations for mercury and CO_2, repowering with IGCC allows the utility to move forward with the knowledge that it has addressed environmental issues effectively. For capacity additions and repowering over the next five years, IGCC is an option that utilities can seriously consider.

IGCC Power Plant Applications

Recent History and Applications

Coal gasification technology has been used for over a hundred years. The production of town gas worldwide is a simple form of gasification. Coupling this proven technology with efficient combined cycle technology was seen as a way to enjoy the advantages of using low-cost coal with the high efficiency of combined cycle technology. The 100-MW Cool Water IGCC project, which went in service in 1984, was the first commercial-scale demonstration of IGCC. That project was done in a consortium of EPRI, Southern California Edison, Texaco, GE, Bechtel, and others. The plant operated for more than four years, achieving good performance, low emissions, and developing a base of design for full-scale IGCC plants.

Since then, IGCC technology has improved greatly through DOE's Clean Coal Technology program. The Wabash River IGCC Project and Polk Power Station IGCC Project are in operation as a part of this program. Installations in other countries include the Buggenum plant in the Netherlands and the Puertollano plant in Spain. IGCC performance and reliability continues to see significant improvements. In the fourth year of operation of Tampa Electric's Polk Power Station, the gasifier had an on-stream factor of almost 80%, a considerable improvement over previous years. This project no longer suffers from the serious problems encountered over the first three years, including convective syngas cooler pluggage, piping erosion and corrosion, and sulfur removal problems. The on-going pluggage problems in the convective syngas coolers have been resolved by modifying start-up procedures to minimize sticky ash deposits, and by making configuration changes in the inlet to the coolers to reduce ash impingement at the tube inlets. In the fourth year, the coal gasification portion of the plant became so reliable that the leading cause of unplanned downtime was not there, but rather in the distillate oil system for the gas turbine (problem has been addressed).

Reliable performance has also been achieved at the Wabash River plant. During 2000, the gasification plant reached 92.5% availability, with the power block at 95%. In fact, the gasification technology caused no plant downtime at all. Other areas of the plant, such as coal handling and the air separation unit were available more than 98% of the time.

IGCC for New and Repowered Plants

These examples show that IGCC has met the challenges of the Clean Coal Technology program. Further, with almost 4,000 MW of IGCC in operation worldwide, and another 3,000 MW planned to go into operation over the next four years, this technology is commercially proven and ready for the repowering market.

The U.S. now has about 320,000 MW of coal-fired power plants, just over one-third of all installed capacity. These coal-fired power plants generate over half of all of the electricity in the U.S. Many of these plants are over 30 years old, with some over 50 years of age. With a growing need for additional capacity in many parts of the country, and rising operation and maintenance costs on existing units, many utilities are looking hard at repowering with technologies that can increase capacity, while decreasing operation and maintenance costs.

Repowering with IGCC can meet those challenges. Repowering older, less efficient generating units with IGCC, results in capacity increases, lower production costs, higher efficiency, and environmental compliance. Since the IGCC plant uses coal as its feedstock, much of the existing coal-fired plant's coal handling and steam turbine equipment and infrastructure can be utilized, lowering the overall cost of repowering. With greater than 95% of the sulfur emissions removed, and further improvements in combustion turbine low-NOx burner technology, emissions of SO_2 and NOx now approach the performance of NGCC plants. By using low-cost and/or low-quality coals, the cost of electricity generated from a plant repowered with IGCC technology can meet or beat that produced by NGCC plants.

One of the key efficiency advantages comes with oxygen-blown IGCC technology. In this type of gasification system, air is first separated into its main constituents: oxygen and nitrogen. The oxygen is used in the gasifier, and the nitrogen is injected into the gas turbine, where it increases the mass flow through the gas turbine, increasing power output, and minimizing NOx formation during combustion. Efficiency increases through further integration can be realized by using extraction air from the gas turbine in other areas of the plant. Since this extraction air leaves the gas turbine at high temperature and pressure, it can be used to preheat boiler feed water. After the heat is removed, the cooled air, still at high pressure, is used to feed the air separation unit, reducing the amount of energy expended there to compress air.

A typical method of repowering an existing unit is to remove the coal-fired boiler and replace it with a gas turbine, re-using the steam turbine in combined cycle mode. In a combined cycle plant, the steam turbine usually provides about one-third of the total output. In a recent study conducted for DOE, a large number of plants with twin 150 MW units were identified as good candidates for repowering. There, the utility could repower one of the units with two 170 MW natural gas-fired gas turbines. The steam produced by the HRSGs for these units would power the existing 150 MW steam turbine, for a total of almost 400 MW.

A typical F class gas turbine produces about 170 MW when firing natural gas. At high ambient temperatures, output may fall to only 150 MW. In an IGCC plant, the syngas is fired in the gas turbine along with the nitrogen, providing significantly higher overall mass flow over a wide range of ambient temperatures. When firing syngas, this same F class gas turbine produces about 20% more output, reaching 190 MW or more. This additional capacity from firing syngas is valuable when additional peaking power is needed during hot, summer days. The additional exhaust flow results in more steam production in the HRSG, making up for steam uses in the gasification area. By firing syngas, the overall capacity is increased to almost 550 MW, more than tripling the capacity of the unit. Repowering the twin 150-MW unit could increase the overall capacity from the original 300 MW to almost 1,100 MW.

While the typical repowering study targets coal-fired boilers, existing NGCC units also provide a technical and economic opportunity for repowering with IGCC. In the case of NGCC units presently firing natural gas, rising fuel costs have lead to increases in the cost of producing electricity. This typically results in a lower capacity factor, and the unit generates fewer MW-hours and revenues. Given the inherent high efficiency of the gas turbines, and the ability to utilize low-cost coal, repowering with IGCC can turn an NGCC unit with a high dispatch price into a unit that dispatches at a much lower cost. As described above, the additional 20% capacity gained from firing syngas instead of natural gas can have significant economic value in areas where there is insufficient peaking power capacity.

IGCC technology has become a more attractive option for new capacity because:

- the technology has been successfully demonstrated at commercial scale in the U.S. and worldwide;
- the enhancements made by the companies operating these IGCC plants, as well as by the technology suppliers, have decreased the cost and complexity of IGCC, while at the same time substantially improving the efficiency and reliability; and
- the price differential between natural gas and coal has risen sharply over the last year.

Economics

The ability to repower units and gain the capacity increases noted in the previous section is a major economic driver for repowering with IGCC. Another advantage of repowering with IGCC is the ability to reuse a significant amount of the existing infrastructure at the plant. Areas such as buildings, coal unloading, coal handling, plant water systems, condenser cooling water, transmission lines, and substation equipment can be incorporated into the repowered IGCC plant This helps to minimize the time for repowering and can reduce the overall cost by about 20%.

With uncertainty in the pace and extent of utility industry restructuring, as well as with changes in environmental regulations, utilities have been reluctant to make large capital expenditures for new capacity. Almost all of the capacity installed over the last few years has been natural gas-fired gas turbines and NGCC. With ongoing decreases in the cost per kW for NGCC technology, along with forecasts of low natural gas prices, NGCC has been the choice for almost all of the new planned baseload capacity in the U.S. Most of this new generation has been built and is being planned in states that have completed their electric utility industry restructuring, making for easier entry into power markets. Unfortunately, the greatest needs for new generation have been in California and the Southeast where deregulation has either been incomplete, inconsistent, or delayed.

With recent increases in the price of natural gas, and stability or even decreases in coal costs, the electric utility industry has renewed its interest in coal-based technologies. Announcements by Tucson Electric Power and Wisconsin Electric Power to build the first coal-fired power plants in years puts coal back in the picture for new capacity. One important result of the improved performance of existing IGCC plants has been an overall decrease in second-generation IGCC plant capital costs. If the current differential price between coal and natural gas continues or grows larger, the economics for repowering with IGCC will become even more attractive.

In the paper "EPRI Analysis of Innovative Fossil Fuel Cycles Incorporating CO_2 Removal," various power generation technologies were analyzed with and without CO_2 removal systems, in a study performed by Parsons. The allowable capital costs were analyzed to determine a break-even cost of electricity based on a range of gas prices. For IGCC, the break-even point with $5/mmBtu gas was found to be about $1,200/kW, dropping to about $1,000/kW with $4/mmBtu gas prices. As IGCC plant costs continue to decrease, it will become an even more serious choice for repowering. If CO_2 removal is required in the future, the costs shown in the study for CO_2 removal and the cost of producing electricity from IGCC will be competitive with NGCC at gas prices of only $3.70-4.00/mmBtu.

Reducing Regulatory Barriers

The Clean Air Act ("CAA") imposes a number of regulatory burdens on the expansion of electric generating capacity. EPA's recent interpretations of several existing laws have led to confusion and perhaps additional burdens. Formally proposed EPA revisions to existing CAA programs may impose further burdens if they are adopted. These burdens impact three activities that increase U.S. generating capacity: (1) the construction of new units; (2) efficiency and availability improvements at existing units; and (3) the repowering or reactivation of existing units.

New Construction

The CAA provides two main programs to control emissions from new coal-fired sources: New Source Performance Standards ("NSPS") and New Source Review ("NSR"). Both programs are intended to require the adoption of controls at the time it is most economical to do so – when a new unit is designed and built.

A utility wishing to construct a new coal-fired generating station must comply with NSPS. NSPS require new sources to meet numerical emissions limitations based on the best technology that EPA determines has been "adequately demonstrated." EPA revises these standards periodically to reflect advances in emissions control technology.

In areas that are in attainment with National Ambient Air Quality Standards ("NAAQS"), a new major source also must comply with prevention of significant deterioration ("PSD") requirements. PSD rules require new sources to adopt the "best available control technology" ("BACT") and to undergo extensive pre-construction permitting. This includes air quality modeling and up to one year of air quality monitoring to determine the impact of the new source on air quality. EPA or state permitting authorities determine what type of control constitutes BACT on a case-by-case basis. BACT may require control beyond NSPS for that source category, but may not be less stringent than applicable NSPS.

A company that constructs a new major source near a "Class I" attainment area must satisfy additional requirements. Class I areas include most national parks, and federal land managers ("FLMs") are charged with protecting air quality in these areas. PSD rules require that FLMs receive copies of PSD permit applications that may impact air quality in Class I areas. In cases where the new source will not contribute to emissions increases beyond allowable levels for the attainment area (*i.e.*, beyond the PSD "increment" for that area), the FLM may still object to issuance of the permit based on a finding that construction of the source will adversely impact "air quality related values" ("AQRVs") (including visibility) for that area. The FLM bears the burden of making that adverse impact demonstration. If the state concurs with the determination, then a permit will not be issued. In cases where the new source would contribute to emissions beyond the PSD increment, the company must satisfy both the FLM and the permitting authority that the unit will not adversely impact any AQRVs, before the permit may be issued.

A company that constructs a new major source in a nonattainment area must satisfy NSR requirements similar to, but more stringent than, PSD requirements. Instead of adopting BACT, the source must adopt control as needed to meet the Lowest Achievable Emission Rate ("LAER") for that source category. LAER is based on the most stringent emissions limitation found in the state implementation plan ("SIP") of any state, or the most stringent emission limitation achieved in practice in the source category, whichever is more stringent. A new major source in a nonattainment area also must demonstrate that any new emissions caused by the source will be offset by greater emissions reductions elsewhere.

In July 1996, EPA proposed changes to these new source programs that would increase the burdens on the construction of new generating stations. EPA's proposal would give FLMs the authority to require companies to perform AQRV analyses even where their new units would not cause exceedence of the PSD increment. A company's PSD application would not be considered complete until it had completed these analyses. EPA's proposal also would transfer authority from EPA to FLMs to define AQRVs and determine what qualifies as an "adverse impact" on those values. These changes, as a whole, would increase the ability of FLMs to control the timing and eventual issuance of PSD permits. EPA also would require state and federal permitting authorities to adopt a "top down" method for determining BACT. Under this method, a PSD applicant must adopt as BACT the most stringent control available for a similar source or source category, unless it can demonstrate that such level of control is technically or economically infeasible. The effect of the policy is to make BACT more similar to LAER in the stringency of control required. The proposed rule is now under review by the Bush EPA.

Following another recent EPA determination, new sources may be required to meet technology-based emission limitations for mercury and other air toxics. On December 20, 2000, EPA indicated that it would regulate emissions of mercury and possibly other air toxics from coal- and oil-fired utilities under the CAA's maximum achievable control technology ("MACT") program. Depending on the basis for the determination, state and federal permitting authorities may be required to impose unit-specific MACT limits on new coal- and oil-fired units until a categorical federal standard is promulgated in 2004. As its name implies, MACT would require units to meet a numerical emissions limitation consistent with the use of the maximum control technology achievable for regulated pollutants.

New source permitting is a lengthy process. The permit must be issued within one year of the filing of a "complete" application. Developing a "complete" application, however, can take another year or longer, as a source negotiates with the permitting authority, FLM, and others regarding modeling, monitoring, control technology, AQRVs, and other issues. If the proposed revisions to the NSR rules are finalized and if case-by-case MACT determinations are required, this permitting process for new sources will take even longer. Even without these proposed revisions, it will be important to consider how this permitting process can be streamlined and expedited.

Efficiency/Availability Improvements at Existing Units

Utilities have many opportunities to increase electrical output at existing units without increasing fuel burn by improving efficiency or reducing forced outages through component replacement and proper maintenance. In some cases, utilities do so as a reaction to unexpected component failures (reactive replacement). In others, utilities replace worn or aging components that are expected to fail in the future or whose performance is deteriorating (predictive replacement). In some cases, utilities replace components because more advanced designs are available and would improve operating characteristics at the unit. Such component replacement can restore a unit's original design efficiency or, in some cases, improve efficiency beyond original design.

Babcock & Wilcox ("B&W"), industry experts on the construction, operation, and maintenance of coal-fired boilers, identify a number of components that electric generating stations typically replace or upgrade during their service lives to maintain or improve operations. These include economizers, reheaters, superheaters, furnace walls, burner headers and throats, and other assorted miscellaneous tubing. In their book Steam, the B&W authors identify predictable ages for the failure of these components and offer a variety of upgrade options to be incorporated as replacement parts. Other components that utilities frequently replace or upgrade include fans, turbine blades and rotors, feed pumps, and waterwalls.

NSR rules apply to "modifications" of existing facilities that result in new, unaccounted for pollution. For the first 20 years of these programs, EPA identified only a handful of "modifications." In 1999, however, EPA sued several major utility companies for past availability and efficiency improvement projects like those described above, characterizing them as modifications subject to NSPS and NSR. EPA has further indicated that it will treat innovative component upgrades that increase efficiency or reliability without increasing a unit's pollution-producing capacity as modifications as well. EPA's current approach to these projects strongly discourages utilities from undertaking them, due to the significant permitting delay and expense involved, along with the retrofit of expensive emission controls that are intended for new facilities. This is the greatest current barrier to increased efficiency at existing units.

NSR rules define a modification as a physical change or change in the method of operation that results in a significant increase in annual emissions of a regulated pollutant. However, the rules exclude activities associated with normal source operation from the definition of a physical or operational change, including both "routine maintenance, repair, and replacement" and increases in the production rate or hours of operation.

For more than a decade following the establishment of these programs, EPA made very few determinations that projects triggered NSR as "modifications." These determinations involved sources that: (1) added new capacity beyond original construction, for example by adding an entirely new generating unit; or (2) reactivated a long-shutdown unit.

In 1988, EPA concluded that a collection of component replacements intended to extend the lives of five Wisconsin Electric Power ("WEPCo") generating units that had been formally derated and were at the end of their useful lives triggered NSR. Pointing to the project's "massive scope," unusually high cost ($80 million spent on five 80-MW units) and "unprecedented" nature, EPA concluded that the project was not "routine," and calculated an emissions increase for purposes of NSR.

Following the WEPCo decision, utility companies and the Department of Energy asked EPA to clarify the impact of its ruling for common component replacement projects in the industry. Through a series of communications with Congress and the General Accounting Office, EPA assured utilities that "WEPCo's life extension project is not typical of the majority of utility life extension projects, and concerns that the agency will broadly apply the ruling it applied to WEPCo's project are unfounded."

In 1992, EPA issued regulations that confirm the historical meaning of the modification rule and provide special guidance on the application of the rule to electric utilities. Under the 1980 rules, the method used to determine an emissions increase for NSR purposes depends on whether a unit is deemed to have "begun normal operations." The preamble to the 1992 rule states that units are deemed not to have begun normal operations only when they are "reconstructed" or replaced with an entirely new generating unit. Units deemed not to have begun normal operations must measure an emissions increase by comparing pre-change actual emissions to *potential* emissions after a change. Since few facilities operate at full capacity around the clock before a change, this test – if applied to existing sources -- nearly always shows an apparent emissions increase (even where emissions in fact decline after the change). Sources that have begun normal operations may compare actual emissions before the change to a projection of actual emissions after it. For utilities, the 1992 rule allows a comparison of past actual to "future representative actual emissions," a term defined to allow elimination of projected increases in utilization due to demand growth and other independent factors (provided that post-change utilization confirms the projections). Other units make a more generic comparison of pre- and post-project emissions holding production rates and hours of operation constant.

In the decade following the WEPCo decision, utilities continued to undertake the replacements described above without incident. In November 1999, however, EPA commenced a major PSD enforcement initiative against seven utility companies and the Tennessee Valley Authority alleging violations of PSD provisions. In complaints and notices of violation ("NOVs"), EPA alleged that replacements of deteriorated components undertaken at these units over the past 20 years were non-routine and triggered emissions increases under NSR rules. The complaints and NOVs target component replacements common in the industry, including economizers, superheaters, reheaters, air heaters, feedwater pumps, burners, turbine blades and rotors, furnace and water wall sections, and other components. EPA has since expanded the enforcement initiative to cover more than 20 companies, with plans to add more.

EPA's claim that these projects are now non-routine has left utilities highly uncertain about the coverage of the modification rule. In particular, EPA now suggests that it has discretion to classify projects as non-routine for several new reasons, including the fact that the replacement restores availability, improves efficiency, or involves a major component. At the same time, EPA has raised the stakes for a finding that a project is non-routine by assuming an emissions increase from all non-routine projects. Specifically, in contrast to the NSR rule, EPA now asserts that any non-routine change makes a unit into one that has not "begun normal operations" – necessitating use of an "actual to potential" emissions increase test that the unit is sure to fail. This is true even where such units have an extensive past operating history that would allow reliable predictions of future actual emissions.

A utility considering projects similar to those targeted in the complaints and NOVs must confront the fact that EPA has claimed broad discretion to classify availability and efficiency improvement projects as non-routine modifications subject to NSR. NSR requires the retrofit of BACT technology, which can cost hundreds of millions of dollars, and can delay projects by several years while permits are obtained and/or controls installed. Accordingly, EPA's actions strongly discourage utilities from undertaking projects that improve efficiency, and thereby increase generation without any increase in pollution.

B&W's <u>Steam</u> suggests the scope of projects blocked by EPA's current approach to modification. In order to reach a standard 55 to 65 year operating life, B&W estimates that a typical utility will replace its superheaters and burners at least twice, its reheaters at least once or twice, the economizer and lower furnace at least once, and all other tubing at least three times. Turbine blades are replaced more frequently still. Industry-wide, this means thousands of major component replacements may be prevented or delayed by EPA's approach, as well as other categories of projects EPA has not yet addressed but may find non-routine under its new discretion.

Moreover, EPA has extended its approach to innovative component upgrades that improve unit efficiency and other operating characteristics. In a letter dated May 23, 2000, EPA concluded that a plan by the Detroit Edison Company to replace worn turbine blades with new, improved blades was non-routine. Detroit Edison proposed to replace existing blading with a new, more durable blading configuration that would increase the efficiency of two turbines by 4.5% each. This would allow these units each to produce 70 additional megawatts of power with no increase in fuel consumption, or to continue producing at past energy levels while reducing fuel consumption by 112,635 tons of coal per year, SO_2 emissions by 1,826 tons per year ("tpy"), and NO_x emissions by 1,402 tpy. This would also allow an incidental 259,111 tpy reduction in CO_2 emissions – a compound that EPA currently lacks authority to control. The company estimated that widespread adoption of the upgrade at compatible units would allow CO_2 reductions of approximately 81 million tpy, with correspondingly large reductions in NO_x and SO_2. EPA based its finding of non-routineness in part on the fact that the project made use of new, upgraded component designs. EPA reached a similar conclusion in 1998, finding that a proposed blade replacement project at a Sunflower Corporation power plant could not be routine because it involved redesigned/ upgrad[ed]" components. Accordingly, utilities contemplating innovative upgrades of turbine and other components to improve efficiency face a known risk that EPA will classify them as non-routine modifications based on their use of advanced technology. Although the exact numbers of innovative projects blocked by EPA's approach is difficult to quantify, the example of Detroit Edison suggests that the losses in generation and pollution reduction from these efficiency gains is substantial.

In sum, EPA's new approach to its NSR rules presents a significant regulatory barrier to projects at existing sources that would otherwise be undertaken to improve availability and efficiency. This barrier can be expected not only to prevent significant gains in generating capacity at existing units, but also to actively reduce availability of these units by preventing needed maintenance. As a related matter, this barrier also can be expected to inhibit development of more efficient generating technologies, reducing the amount of energy that may be produced from existing units, and to encourage prolonged reliance on units operating at lower efficiencies.

Repowering and Reactivation

Replacing a coal-fired boiler with a more efficient generating technology, such as fluidized bed combustion, or an integrated gasification combined cycle, or state-of-the-art pulverized coal technology, can increase generation at an existing facility. This process is commonly known as "repowering." Title IV of the CAA grants special treatment to utilities that meet the acid rain requirements of that title through repowering. A project that qualifies as "repowering" for Title IV purposes also gains exemption from NSPS requirements if the project does not increase the unit's maximum achievable hourly emissions. Such projects almost certainly require PSD review, but are granted expedited review under the Act. EPA has yet to implement these expedited review procedures. Additional uncertainties for permitting these facilities are created by EPA's proposal to "reform" the new source permitting process discussed above.

Reactivation of shutdown existing units presents another means for utility companies to increase generation. A source that has been shutdown for an extended period may be subject to NSPS and/or NSR when it is reactivated. Early determinations on this topic are often unclear or inconsistent as to whether the reactivated unit is subject to NSPS or NSR because it is deemed to be a new unit, or because it is deemed to be an existing unit that has undergone a "modification." In its most recent determination on the subject, EPA has suggested that a unit could be subject to NSPS/NSR for either reason – making for a stricter, two-part standard. Clarification of EPA's reactivation policy, and streamlining of NSR requirements for reactivated facilities, would contribute capacity needed to respond to demand peaks.

Solutions

EPA's proposed rule on NSR would impose significant additional burdens for new sources if it is finalized in its current form. EPA's recent listing of coal- and oil-fired electric utility steam generating units as major sources of hazardous air pollutants could require additional, extended pre-construction review for new and reconstructed facilities. EPA's recent reinterpretation of the modification rule with respect to routine repair and replacement, calculating emissions increases, and source reactivation imposes additional burdens that discourage projects that increase unit availability and efficiency or reactivate shutdown units, including cases where shutdown was never intended to be permanent. EPA should return to its historic interpretation and application of these rules.