Vice President Richard Cheney  
The White House  
1600 Pennsylvania Avenue NW  
Washington, DC 20500

Dear Vice President Cheney:

Allow me to express my appreciation for your recent efforts to develop the much-needed and long-awaited national energy policy. Judging by all that I have read, the Administration understands the critical importance of developing the nation’s domestic energy resources, including oil, natural gas and coal. I strongly support this emphasis and commend you for keeping it foremost in your policy development.

I am writing to reiterate the role that coal can and should play in meeting the United States’ energy demands. In addition, I wanted to offer my assistance to you and President Bush in promoting coal and our other natural resources as key components in a national energy policy. If there is any way I can help in making the case for your energy initiatives, please feel free to put me to work.

It is appropriate that the President is coming to Minnesota on Thursday to address energy issues. Much of Minnesota’s electricity is generated in North Dakota by coal-fired power plants. The lignite industry represents a significant part of our state’s economy, and of course, we would like to develop it further in the coming decades.

The advantages of coal as an energy source are numerous, and from your years in Wyoming and Texas, I know you are well acquainted with the industry. Let me highlight coal’s advantages as seen from a North Dakota perspective.
Supply – The lignite-bearing regions of western North Dakota and eastern Montana have more than a 1,000-year supply of lignite that is currently economically feasible to recover. (Based on 35 billion tons with the current production rate of 30 million tons per year.) Energy independence clearly should be a central goal of a national energy policy; given the abundant supplies, coal will help anchor that independence.

Cost – Although the price of coal has recently faced upward pressure, it remains a comparatively inexpensive source of energy in the United States. America’s competitiveness benefits greatly from low-cost energy supplies, and coal is well-equipped to fill the economy’s needs.

Environmental friendliness – Coal-generated electricity and clean air are certainly compatible. North Dakota’s industry has been a leader in reducing emissions, and even with our healthy energy sector, our air ranks among the cleanest in the country. I applaud the President’s commitment to developing clean-coal technologies, including his budget proposal to spend $2 billion on the coal-related environmental initiatives over the next 10 years.

Versatility – Our coal industry is not limited to electrical generation. More than 13.5 percent of North Dakota’s lignite is used to generate synthetic natural gas, at the only such plant in the United States. This technology holds tremendous potential for the future. (The Great Plains Synfuels plant is operating profitably, I would note.) In addition, about 7.5 percent of lignite is used to produce fertilizer products, such as anhydrous ammonia and ammonium sulfate.

North Dakota’s commitment to coal is serious and long-term. Working in a partnership, the state and lignite industry recently launched the Vision 21 project, intended to lead to the establishment of at least one new coal-fired power plant. The 500 megawatt plant is estimated to require three million tons of coal a year while adding 1,300 new jobs.

In light of this goal, I am pleased to see reports that the President’s energy strategy calls for regulatory steps that would expedite approval of new power plants.
By all accounts, the President’s comprehensive energy strategy will strike a balance, encouraging conservation while promoting the wise development of all of our energy resources. While I am certainly an advocate for coal, I also support this balanced approach. Oil exploration and development should remain a priority, and there is an important place for renewable sources such as wind and bio-fuels.

The absence of a comprehensive, national energy policy has hampered our economic growth and contributed to the supply shortfalls and sudden price swings. The result is understandable political pressure to take short-term action that may, in fact, be counterproductive.

It is to the Administration’s credit that you have sought to develop a long-term strategy with the appropriate emphasis on supply. I congratulate you for the effort, and stand ready to assist the President and you in whatever way would be helpful.

Sincerely,

[Signature]

John Hoeven
Governor

cc: Secretary Spencer Abraham, Department of Energy

38:27:41
Dear President Bush:

I was interested to read your comments reported in the national press last week about the national energy policy you are developing. A national energy policy is a terribly complex undertaking, but we in the Pacific Northwest now know all too well how vital this work is to our regional and national economies. I look forward to working constructively with the Administration as this work goes forward.

While the City of Seattle may respectfully disagree with some of the directions you appear to be considering, I am intrigued by the comments you made about the role of energy conservation. The City of Seattle has aggressively pursued energy conservation for at least twenty years. Our citizens enthusiastically support our investments in energy efficiency; perhaps in part, because it is the right thing to do, but much more importantly because they know that each conservation investment must prove its worth in relation to the comparable cost of acquiring new energy generation. Energy conservation on this basis is just as good as any new generation plant development. While there are some administrative costs associated with our approach, they are nothing in comparison to the costs and difficulties incurred with new plant construction.

After twenty-plus years of “buying” conservation in our community on this basis, you might think that we must have been getting close to exhausting the supply. We have just completed a detailed assessment of the conservation potential remaining in our community, and I was a little surprised but pleased to see that we can not only continue the program, but we can also double the level of accomplishment — with only a modest increase in costs.

Conservation alone is not going to solve this country’s energy problems. Conservation based on “doing without” is certainly not a reasonable part of the national energy approach. But real energy efficiency investments should be featured prominently in the Administration’s plan. I was pleased to hear your comment last week that you recognized the value of real energy efficiency investments. I fear that you may be underestimating the amount of energy these investments might produce in a short time if we properly encourage them. I hope the Administration will continue to support federal incentives that can help make conservation an even bigger success.

Seattle City Light, our very successful municipal electrical utility, has a great deal of expertise with energy conservation. We offer our assistance to your task force in any manner you might find useful. Good luck with the national energy policy endeavor; we look forward to working with you.

Very truly yours,

Paul Schell
Mr. Walter L. Adams, Jr.
2221 Old Comfort Highway
Trenton, North Carolina 28585

Dear Mr. Adams:

Thank you for your recent letter to the Secretary of Energy expressing your support for the revival of the nuclear option for electrical power generation within the United States and for other energy production options.

One of President Bush’s first acts was to create a National Energy Policy Development Group, headed by Vice President Cheney, to help the private sector and government at all levels promote dependable, affordable, and environmentally sound production and distribution of energy for our country. This group includes the Secretary of Energy, as well as the Secretaries of the Treasury, Interior, Agriculture and Commerce Departments, the heads of the Federal Emergency Management Agency, the Environmental Protection Agency, the President’s Deputy Chief of Staff for Policy, and the Assistants to the President for Economic Policy and Intergovernmental Affairs. The National Energy Policy Development Group is considering ideas and recommendations of consumers, businesses, states and independent experts on how best to address the broad range of energy issues now facing the Nation. Your specific suggestions will be passed on for their consideration.

The Department of Energy (DOE) is working to ensure that nuclear power remains a viable energy alternative for power generators in the future. For this to happen, it is vital that existing nuclear power plants continue to operate economically and safely. In addition, future plants will depend on investments we make today in nuclear power plant safety, reliability, and economic competitiveness. We are actively pursuing a number of means for stimulating new investments in nuclear power generating capacity.

The Department is making steady progress on the geological repository for high level wastes. The President has committed to ensuring that sound science governs the site characterization activities being conducted by the Department in support of a possible recommendation to continue development of a potential
repository at Yucca Mountain in Nevada. As for reprocessing, the Department is taking a fresh look at the nuclear fuel cycle to be sure that Government policies do not unnecessarily close off important energy options to the private sector.

Thank you for writing.

Sincerely,

Margot Anderson
Acting Director
Office of Policy
May 15, 2001

The Honorable George W. Bush
President of the United States of America
The White House
1600 Pennsylvania Avenue
Washington, D.C. 20500

Dear Mr. President:

We, the undersigned members of the Maine House of Representatives, are concerned about the United States' domestic supply of energy and are concerned that there has been no comprehensive, forward-looking energy plan created over the past several years. These concerns stem from the following facts: demand for oil is projected to grow one-third by 2020; the U.S. produces 39 percent less oil today than it did in 1970; by 2020, the U.S. will produce approximately half of what was produced in 1970; the U.S. imports 57 percent of its oil and it is projected that by 2020, imports will grow to 64 percent; not one new refinery has been built in the U.S. in over 25 years; and since 1980 the number of refineries has been cut in half.

Energy prices are too high, demand is great and the supply is limited. This is causing great apprehension and difficulties for American consumers. Therefore, we support any federal efforts to develop a national comprehensive energy plan with short-term and long-term solutions that will help increase domestic supplies of energy. Such a plan may include:

- Reviewing exploration on federal land so there can be energy development on federal lands;
- Increasing refining capacity through regulatory relief;
- Increasing pipeline transportation through FERC and DOE policies;
- Developing clean coal technology; and
- Re-licensing hydro projects.

We encourage you to continue to work with the Congress, the Department of Energy, the Environmental Protection Agency and the Department of the Interior to develop and implement a national energy plan. We appreciate your attention to this matter of vital importance to the citizens of the State of Maine and the entire United States of America.

Sincerely,
The Undersigned Members of the Maine House of Representatives

cc: The Honorable Olympia Snowe, United States Senator
    The Honorable Susan Collins, United States Senator
    The Honorable John Baldacci, United States Representative
    The Honorable Thomas Allen, United States Representative
    The Honorable Spencer Abraham, Secretary of Energy
    The Honorable Christie Whitman, Administrator, Environmental Protection Agency
    The Honorable Gale Norton, Secretary of the Interior
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Obtained and made public by the Natural Resources Defense Council, May 2002
May 15, 2001

The Honorable Richard Cheney
Vice President of the United States
The Old Executive Office Building
Washington, DC 20501

Dear Mr. Vice President:

I am disturbed by early reports that the Energy Task Force recommendations fail to recognize the need to include a path forward for assuring that this country is capable of providing a reliable and economic source of nuclear fuel for commercial nuclear reactors. As you know, nuclear power is the second largest supplier of electricity generation in the country. Unfortunately, it is not unreasonable to expect that the U.S. could have an OPEC-like dependency on foreign sources of nuclear fuel supplies in the near future. To prevent such a situation, the U.S. needs to deploy cost competitive uranium enrichment technology or we will rely on foreign supplies to meet nearly one quarter of our electricity needs.

There have been adverse consequences to the nation’s energy security as a result of the privatization of the United States Enrichment Corporation (USEC) in July 1998. USEC is the only domestic supplier of uranium enrichment services in the U.S. When it was privatized, USEC operated two gaseous diffusion plants located in Piketon, Ohio and Paducah, Kentucky. However, last June, USEC made the decision to cease operations at the Piketon Gaseous Diffusion Plant (GDP) ignoring the advice of the Departments of Energy and Treasury. The targeted date for turning the key to the “off position” is June 1, 2001.

A Department of Energy report issued on January 19, 2001 describes the need for the U.S. “to be able to reliably meet the continuing demand for approximately 11 million separative work units (SWU) per year.” However, the Paducah plant can only produce approximately 4.5 million SWU per year in an economic manner. The balance of requirements comes from 5.5 million SWU derived from blended down weapons grade uranium imported from Russia under the U.S.-Russia HEU Agreement and some European supplies. It is evident that the operation of a single enrichment plant in the country, coupled with a history of five interruptions in the delivery of enriched uranium under the Highly Enriched Uranium Purchase Agreement with Russia, raises questions about the vulnerability of the U.S. to a disruption in the supply of enriched uranium.
The Honorable Richard Cheney
May 15, 2001
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The need for a secure, domestic uranium enrichment supply is underscored by the fact that nuclear power is enjoying improved operating economics and increased average efficiency of reactors. Demand is likely to remain stable or grow, as approximately 40% of the domestic nuclear reactors are currently seeking license renewals. During a hearing on nuclear power before the Energy and Air Quality Subcommittee on March 27, 2001, there was discussion about building the next generation nuclear reactors in the not-so-distant future. These next generation reactors will require 8-10% U-235 enrichment, compared with the 4-5% levels required for the current generation of boiling water reactors. It is troubling that USEC is closing the Piketon facility which is the only U.S. enrichment plant that is licensed to enrich uranium to 10% assay, when there is a trend toward higher assay fuel.

During the March 27, 2001 Energy and Air Quality Subcommittee hearing, testimony was offered which stated:

"USEC utilized only about 25% of its nameplate GDP capacity in 2000, and over the next year will supply a majority of its customers needs from Russian and U.S. HEU blending." (Testimony of John R. Longenecker, former USEC official).

Mr. Longenecker further states:

"USEC is finding it more profitable to operate as a trader of blended HEU rather than as a primary producer. This approach appears to lead inevitably to USEC exiting the market as a primary producer. As a result, constructing replacement enrichment capacity in the U.S. should be the key focus for the decade ahead."

In addition, during a June 8, 2000 hearing before the Commerce Subcommittee on Energy and Power, testimony was submitted stating that the front end of the nuclear fuel cycle is endangered:

"Since 1998, expenditures for uranium exploration and mine development have declined by 59%; three uranium processing facilities have closed during 1999 (two in Texas and one in Louisiana); employment in U.S. uranium exploration, mining, milling and process has decreased by almost 30%. Last year, production at ConverDyn, the sole remaining uranium converter in the U.S. was cut back by 25% and employment was reduced by over 12%." (Testimony of Mr. James Graham, President and CEO of ConverDyn).

If this nation’s energy policy is going to place a greater emphasis on nuclear power, it must do so in a comprehensive fashion. An energy policy that ignores the reliability of the front end of the domestic nuclear fuel industry falls short of assuring needed energy security in this country. I urge you to carefully consider the needs of the entire nuclear fuel cycle as you prepare...
The Honorable Richard Cheney
May 15, 2001
Page Four

to issue your recommendations for a national energy strategy. I know you will agree that Americans would find it unwise and unacceptable to depend on foreign sources for the second largest supplier of U.S. electricity generation, nuclear power.

Thank you for your attention to this important matter.

Sincerely,

Ted Strickland
Member of Congress

cc: The Honorable Spencer Abraham
The Honorable Bob Taft
The Honorable Mike DeWine
The Honorable George Voinovich
The Honorable W. J. "Billy" Tauzin
The Honorable John Dingell
The Honorable Joe Barton
The Honorable Rick Boucher
May 15, 2001

The Honorable Spencer Abraham
Secretary of Energy
United States Department of Energy
Washington, DC 20585

Dear Secretary Abraham,

As a result of our book Coal Burning Issues [Green ed. 1980] and my appointment to the National Coal Council (NCC) by past Secretaries Herrington, Watkins, O’Leary, Peña and Richardson I have been advocating utilization and co-utilization of all domestically available fuels and conducting R&D on such possibilities. Since your office is in the process of re-examining National Energy Policy I thought I should send to you some material related to my considerations that may now be timely. These include

1) A 2 page statement on the national need for domestic fuel co-utilization.
2) A 2 page description of my R&D and missionary efforts on co-utilization.
3) Another missionary effort on advanced methods of co-utilization.
4) A 1994 statement on the need for a National Solids Fuel Council that I submitted when the NCC was reconsidering its charter. It had little effect.
5) A suggestion to past Secretary of Interior Bruce Babbitt on co-utilizing the understory fuel in national forests that did not get a favorable response
6) Two layman articles describing European Union advanced co-utilization efforts.

The USA that now consumes about 100 quads could probably make fairly near term use of some 10 extra quads of waste and cultivated biomass with substantial environmental benefits. This, however, would require the fresh and fossil biomass sectors to work together closely yet somehow our infrastructure does not lend itself to such co-operation. While item 4 was a suggestion to deal with this problem perhaps more politically and economically astute methods can be implemented during your administration.

Hopefully these considerations can be helpful to you in formulating a sensible National Energy Policy. I can assemble more technical material that support the national benefits of co-utilization of domestic fuels if so requested.

Respectfully Yours

[Signature]

Alex E. S. Green

Ps. A 7th attachment is also included.
THE NEED FOR SENSIBLE CHANGES IN NATIONAL ENERGY POLICY

In addressing national energy-environmental (EE) problems and policy changes that might mitigate them each fuel sector might now look beyond its typical "turf". Thus the coal sector could well look beyond its traditional domain from anthracite to lignite into peat and various forms of biomass, the precursors of peat. The biomass sector might well consider co-utilization of coal and other domestic fuels to help overcome the "recalcitrant" properties of biomass as a fuel. Such co-utilization of domestic fuels can significantly reduce national reliance on imported fuels while mitigating NOx, SOx, CO2 and other undesirable emissions. Co-firing of coal and biomass for steam turbine power generation is a near term co-utilization approach that can make use of existing coal facilities with relatively minor modifications. However, co-gasification and co-liquefaction by providing fuel for more efficient combustion turbine systems including combined cycle, co-generators and fuel cells have much greater EE potential. In particular the development of optimum thermo-chemical (TC) co-conversion systems can be advanced by fostering cooperation between the biomass sector that enjoys a good environmental image, the coal sector that carries the nation's main electricity load as well as premium fuel sectors (petroleum and natural gas).

To illustrate the need to develop cross-cutting national interest type solutions for problems mired in political controversy let us examine in greater detail the transitional problem of reducing greenhouse gas (GHG) emissions with a minimum disruption of our domestic economy. In such an effort the USA, the coal industry, coal based utilities, forestry and agriculture could significantly benefit by cooperative endeavors. Essentially coal can benefit by life extensions of coal based facilities using small proportionate (~10%) co-firing with biomass and using the sequestering potential of trees. At a low density fuel biomass cannot economically be transported over distances much greater than 50 miles. However, locally available biomass can be brought closer to the competitive domain by blending with coal in existing coal facilities. To alleviate our excessive dependence on imported oil, the major source of fossil fuel CO2 emissions today, biomass could become a CO2 neutral source of liquid transportation fuels. By fuel blending in gasifiers biomass could become a source of renewable fuel in electrical generation using highly efficient gas turbines and fuel cells. Given below is a summary of possible joint programs and mutual benefits of making greater co-use of our domestic energy resources.

I. What can Biomass do for Coal?

A. Cofiring Biomass with Coal
   1. Lower CO2, SO2 and NOx (reburn) emissions
   2. Extend life of coal facilities

B. Cogasifying Biomass with Coal
   1. Biomass + coal,
      (a) agricultural residues, (b) waste paper, (c) yard waste
      (d) fuel in forest understory (e) energy crops
   2. Municipal sludge + coal (waste disposal and reduce methane generation)
   3. MSW + coal (waste disposal and reduce methane generation)

C. CO2 Sequestration
   1. Federal land reforestation
   2. New national parks
   3. Interstate highway plantings
   4. Urban forests (new elms)
   5. Wood buildings and products
   6. Restoration of mined lands
   7. Phytoremediation of superfund sites
   8. Extra-territorial reforestation

II. What can Coal do for Biomass?

A. Overcome obstacles to biomass - energy
B. Lower capital cost of near term biomass utilization (co-firing)
C. Foster biomass use in efficient electric generation (co-gasifying)
D. Foster production of liquid fuels (co-liquefying)
E. Foster production of charcoal, activated carbon, humic acid, useful chemicals

III. What can Serious Cooperation do for the U.S.A.?

A. Reduce oil imports, (1) transportation fuel (2) industrial fuel
B. Lower CO2 and CH4 emissions
C. Develop useful environmental agents
D. Buy time to develop long range measures

The solid fuels: coal, biomass and large components of municipal solid waste (MSW), in common, have useful energy content but cannot directly fuel reciprocating internal combustion engines, gas turbines or fuel cells. Because of higher hydrogen/carbon and oxygen/carbon ratios, biomass is significantly more volatile than coal and generally requires fewer thermal steps in conversion to combustible gases or liquids. However, in view of the seasonal nature of biomass availability, its low energy density, diverse physical properties and limitations on economic transport distances it is prudent to develop co-utilization technologies with coal, a compact, more storable high energy fuel abundantly available in the USA.
Gas turbines have higher efficiencies than steam turbines and when used in combined cycle or cogeneration modes can convert much more of the fuel value of the feedstock to useful energy. Gasification also offers three extra pollution prevention stages for minimizing pollutant or toxic emissions from thermal plants. In addition to front end sorting to avoid toxic forming materials, blending dolomite, lime rock or other high temperature sorbents in the reactor itself can reduce sulfur emissions. A gas clean up system following the gasifier but before the turbine combustor protects the turbine and reduces final particle emissions. The fact that the volume of gas to be cleaned before combustion is much less than the volume to be cleaned after combustion has many advantages. It could, for example, be useful in reducing toxins such as mercury, arsenic or other volatile toxic metals in coal or in biomass. Co-gasification has been pursued in the EU, as a part of a transitional CO₂ reduction and oil back-out strategy. It could also serve in the USA to help ease adjustments of the coal industry, nurture the infant biomass industry and buy time to resolve many controversial greenhouse issues. Here the "closed loop" policy in current legislation on biomass support might be modified until a biomass fuel infrastructure is developed.

Fast pyrolysis biomass liquids are under intensive development in Europe and Canada and are a complementary path to gasification, since the liquids in principle, can more easily be stored. While the EU is investing in thermo-chemical liquefaction technologies the major approach to satisfying the USA's need for liquid transportation fuels has been to generate ethanol via fermentation processes. Clearly the US should develop a broader liquid fuels program that considers thermo-chemical (TC) processes that are much faster than bio-chemical processes. Conversion by TC processes is more natural for utilities and the co-use of carbonaceous fuels.

A change in government policy is needed in which the government focuses more of its "R&D on projects with high potential payoffs for society as a whole. Such projects frequently would not be on topics that that industry would support based upon expected short term returns. Recent practice of the DOE has been to emphasize developments that require substantial industrial cost sharing which generally favors short term low risk non-innovative projects. There is also a large and long overdue need to strengthen the Applied Energy R&D effort of the Department of Energy. To facilitate this need the DOE could transfer "fundamental" R&D that fails to show reasonable energy linkage, to NSF or other national agencies with fundamental science missions. Then the primary role of the Department of Energy to ensure "readily affordable supplies of energy" for the USA would be clear to the public. This would support the importance of energy and energy R&D to the nation's future.

The current DOE organizational structure almost parallels the divisions of the domestic fuel industry and has tended to reinforce the fuel competition that has plagued the USA since WW II. At this time DOE should provide strong support for programs that foster the overall national energy interests and the optimal environmental and economic use of all domestic energy sources even when they require fuel sector cooperation instead of the traditional fuel sector competition. For example, in addition to co-firing coal DOE should encourage R&D on co-gasification and co-liquefaction and middle term cross cutting options in which coal, petroleum, or petroleum coke, natural gas or nuclear provide the heat to thermally liquefy biomass into suitable transportation fuels. The existing fuel sectors are unlikely to support dual or multiple energy sector technologies. Accordingly, a policy shift with changes of organizational structure by DOE would be helpful.

One frequently sees the phrase "the United States must maintain its leadership in the science and technology of energy supply and use". On the other hand many leading US companies in power generation have already been sold to foreign companies, e.g. Combustion Engineering -> ABB (Swiss Sweden); Babcock & Wilcox Nuclear -> Framatome (France); Allison Motors -> Rolls Royce (Great Britain); Westinghouse -> Siemens (Germany) etc... Japan and Germany have long been leaders in the commercialization of fuel efficient vehicles. Japan, starting with USA developed nuclear technology, is showing leadership in pursuit of advanced nuclear reactors. Scandinavian countries, close to the Arctic Circle, have shown far more leadership in advancing the use of biomass for energy than the USA even though we have many regions with more favorable rainfall and sunlight. The EU is also showing more leadership in R&D on fuel blending in gasifiers and liquefiers. These historic trends suggest that the USA might already have lost its former leadership in power generation technology and its associated environmental technology. This is probably due to the fact that European countries and Japan have long placed high end-use values on energy which provide strong market incentives for the energy efficient products that are mostly absent in the USA. This serious problem should be addressed by policy changes. With trade debts approaching a half trillion dollars per year, in part due to energy imports, the USA should begin to find policies that recognize the intrinsic value of energy before our country's debt approaches our net worth.

Most national policies have been consistent with the phrase "the USA works best by the free market". However, with the OPEC cartel clearly in control of the price of some 55% of our liquid energy and deregulation policies not working in California some sensible policy changes are needed. This, of course is mainly the political domain but quantitative technical persons should be encouraged to developed options that are sensible and feasible.
ICAAS was established in 1970 as an interdisciplinary community of scholars seeking advanced solutions for anthropogenic emission problems. Early ICAAS studies contributed to the recognition of the stratospheric ozone depletion problem, the climate change problem and the development of pollution prevention as applied to thermal processes. In "Coal Burning Issues" [UFL Press, 1980] ICAAS concluded that many energy-environmental problems could be mitigated by co-combustion of domestic fuels. This strategy led to the book "An Alternative to Oil, Burning Coal with Gas" [UFL Press, 1981] and the formation of the Clean Combustion Technology Laboratory (CCTL). CCTL's goals were to reduce pollutants from industrial and utility boilers and increase our national reliance on domestic fuels, such as coal, natural gas biomass and municipal solid waste. In 1988 the CCTL received a National Energy Innovation Award and a Florida Governor's Energy Award for co-firing R&D carried out at an industrial scale at the steam plant of Tacachale, a nearby state institution.

Since 1990 most CCTL studies have been on gasifying or liquefying domestic solid fuels by indirectly heated conversion systems (IHCS) to prepare them for use in energy efficient gas turbine systems or fuel cells. As a result of papers presented and panel sessions organized for International Gas Turbine Institute (IGTI) conferences the CCTL has developed a unique position among academic institutions in the USA in its pursuit of fuel blending in thermal gasifiers/liquifiers. With energy costs so low in the USA the CCTL is also investigating additional services that IHCS, capable of handling many types of energy containing inputs, can perform (see conceptual diagram below). Thus the CCTL is seeking IHCS that are omnivorous as to their inputs but yields clean gaseous or liquid fuels as well as useful chemicals and chars as outputs. In recent papers we describe the potential application of such IHCSs: for converting biomass with coal and other domestic fuels into liquid or gaseous fuels suitable for gas turbines or fuel cells, for the disposal of plants used for phytoremediation, for solid waste disposal on long space missions and for using or sequestering CO₂. Currently funded CCTL studies are:

| Cogasification of Solid Waste | A. Green PI | Mick A. Naulin Foundation |
| Arsenic Phytoremediator Disposal | Lena Ma, PI | National Science Foundation |
| Systematics of Pyrolysis | A. Green PI | Green Liquids and Gas Technologies |

Figure 1. Omnivorous Feedstock Converter
Veteran Who Found Japanese Fleet Now Fights For Alternative Fuels

By Randolph Fillmore

"Don't trust anyone under 70! That's my motto," says Alex Green, Ph.D. "And even then, don't trust them unless they were willing to lay down their life for their country!"

In 1945, Green was willing to lay down his life to find the Japanese fleet. Today he is willing to stake his professional life on his work aimed at reducing the nation's dependency on foreign oil by developing alternative, renewable fuels.

During the war, Green developed slide rules for flight engineers to gauge their fuel consumption. More than 50 years later, he is still concerned with fuel usage.

"A Tragedy"

"It's a tragedy that the U.S. is not leading the world in developing alternative fuels," said Green, who was surrounded by furnaces and test equipment in a crowded corner of his research lab on the campus of the University of Florida. "The Finns and the Swedes are way ahead of us. We need to make greater use of renewable energy sources and do it cooperatively. The country as a whole has been neglectful in paying attention to this issue."

Green received a masters degree from the California Institute of Technology before Pearl Harbor. Putting his knowledge of physics to work for the nation in WWII, he served as an operations analyst in the China-Burma-India and Pacific theaters where he developed slide rule computers for ship identification, flight engineering, range estimation, bomb plotting and other technical combat needs.

I performed two operations analyses while serving with the 30th Bomber Command in the CBI area," said Green. "I analyzed combat issues during the last 25 missile launches and assessed the performance of the remote gunnery system. I also devised a device that, when used with the gunnights, could compute the length of ships. The device proved its worth when we discovered the Japanese fleet in March 1943."

Medal Of Freedom

Green was on the B-29 photo reconnaissance flight, piloted by Capt. Alvin Cox, that Gen. Curtis LeMay called "one of the longest and most hazardous reconnaissance flights of the war." Green used his slide rule to identify the remaining Japanese fleet at another before the invasion of Okinawa. He received the Medal of Freedom for his role in that memorable flight.

According to Adm. Chester Nimitz, the ships' discovery helped the U.S. Navy destroy or damage half the Japanese warships in Hiroshima Bay and Kure Anchorage.

One of Green's slide rule computers was aboard the Enola Gay, the B-29 that dropped the atomic bomb.

After the war, Green received a doctorate in physics from the University of Cincinnati. He has been a graduate research professor at the University of Florida since 1963 and is in mechanical and nuclear engineering for the past 15 years.

Biggest Concern

Green said his biggest concern over the last two decades has been that the U.S. is not leading the way in developing alternatives to imported oil. An ardent supporter of using "biomass" to stretch non-renewable fuels such as coal, Green's crowed lab rocks pleasantly of pine bark smoke as he seeks the most combustible wood gas.

"Biomass is plant matter. It can be sugar cane, wood, vegetation, non-toxic products of the paper and pulp industry or just waste paper," said Green. "Whether growing wild or cultivated, biomass is a storehouse of solar energy. It is a renewable resource. Biomass is simply stored energy. Unlike fossil fuels, biomass is carbon dioxide-neutral. Burning biomass does not contribute to the greenhouse effect. Use of biomass can cut our dependency on fossil fuels and cut our air pollution."

"Biomass is widely available. It has been used by humankind for hundreds of thousands of years to generate heat and light. We're wasting valuable biomass by putting it in landfills when it could be used for fuel."—Alex Green

"We're conserving more than half of them, at most half of them. The loss is enormous, but it is not as great as it seems. We could be "cooks" biomass at high temperatures and analyze the resulting gas. The higher the temperature, the better the fuel. He implied that searching for the best combinations of biomass to blend with domestic fuels is not unlike searching for the Japanese fleet. You have to look.

"Biomass is widely available. It has been used by man for hundreds of thousands of years to generate heat and light. We're wasting valuable biomass. By putting it in landfills when it could be used for fuel," said Green. "Biomass was the dominant energy source until fossil fuels took over in the industrial world. Blending two or more types of fuel in a single combustor or gasifier can be more than efficient than using a single fuel and can reduce emissions."

Green easily draws a parallel to his wartime service as an operations analyst and his research into biomass as an alternative fuel.

"Sympathy. Biomass is a form of stored solar energy, and we're wasting it rather than using it as a renewable fuel."

The headline by Star and Stripes gives me too much credit. Eleven other men shared the hard work of this mission that found 77 warships in Hiroshima Bay and Kure Anchorage. On March 18th the pilots of Hornet and the Wasp carriers hit these ships and sank almost half of them. Since Americans did not take to banzai assignments the statement "lay down" in the second and third sentence should have been replaced by "risk" or "take."

28148

Obtained and made public by the Natural Resources Defense Council, May 2002
Panel Session on “Coal-Biomass Blending in Gasifiers/Liquifiers”. April 30, 2001

The Final Program is being produced for ASME IGTI-Turbo Expo and should reach you soon. Our panel session for the technical congress organized by the Coal Biomass and Alternatives Fuel (CBAF) Committee is listed for Wednesday afternoon June 6. I have requested that the title be changed to the above. Professor Rafael Kandiyoti, one of the world’s leading authorities on thermo-chemical conversion has kindly agreed to chair the session in addition to serving as a panelist. Dr. Donald Erbach of ARS-USDA has kindly agreed to serve as the first panelist, to give a USDA perspective on this topic. He replaces Michael Valenti Senior Editor of Mechanical Engineering who could not make it. The persons on the platform and the scheduled panelists will be:

Chairman : Professor Rafael Kandiyoti, , Department of Chemical Engineering and Chemical Technology, Imperial College University of London, Prince Consort Road, London SW7 2BY; r.kandiyoti@ic.ac.uk; 0171-594-5604 (fax)

Session Organizer and Co-Chairman Alex Green. Graduate Research Professor, College of Engineering, University of Florida Gainesville FL, 32611-2050, Tel 352-392-2001, Fx 352-392 2003, email aesgreen@ufl.edu.

TE01CBAF06-01 Dr. Donald Erbach, National Program Leader Engineering/Energy, Agricultural Research Service, US Department of Agriculture, 5601 Sunnyside Avenue, Rm4-2234, Beltsville Maryland20705-5139, Tel 301-504-4610, Fax 301-504-6191, email dce@ars.usda.gov

TE01CBAF06-02 Professor Rafael Kandiyoti, (see above)

TE01CBAF06-03 Robert Beck Executive Director National Coal Council


R.Beck82851@aol.com

TE01CBAF06-04 Dr. Evan Hughes, Manager Biomass Programs EPRI

650-855-2179 (tel.); 650-855-2002 (fax); ehughes@epri.com

TE01CBAF06-05 Dr. Fatma Karaca Prof. Esen Bolat, Department of Chemical Engineering, Yildiz Technical University Esenler-Istanbul, Turkey, T 90 212 449 1722, F 90 212 449 1895; karaca@yildiz.edu.tr

TE01CBAF06-06 Prof. Alex Green, (see above)

The website URL for the registrations, hotels and other Turbo Expo information is: www.asme.org/igt/ev/index/te2001/register.html

Cc Paul Pillsbury, CBAF Point Contact, Siemens Westinghouse Power Corporation, Emerging Technology, 4400Alafaya Trail MC-381, Orlando FL32826-2399 USA, Tel 407-736-2817, Fx 407-736-5014 email paul.pillsbury@swpc.siemens.com.

Prof. Dillip Ballal E-mail ballal@udri.udayton.edu

Bill Koch Congtemp@asme.org

Please acknowledge receipt of this e-mail. If you have any questions please don’t hesitate to ask.

Alex
ON THE NATIONAL NEED FOR A SOLID FUELS COUNCIL.

1) Our nation is heavily dependent on imported oil whereas we have abundant domestic sources of energy in the solid forms: coal, biomass and municipal solid waste.

2) There are commonalities in the combustion properties and characteristics of solid fuels that make it possible to use similar clean combustion technologies to harness their energies.

3) There are many efficiency and environmental benefits obtainable by cofiring domestic solid fuels together or domestic solid fuels with domestic natural gas.

4) Aeroderivative gas turbines in combined cycle systems are now the highest efficiency electricity generation systems and the dominant additions to the national electrical network. Most new installations use natural gas, however, gas produced from solid fuels, coal, biomass and MSW could also provide the fuel input to gas turbines. Thus Integrated Gasifier Combined Cycle (IGCC) systems with biomass or MSW as the fuel can proceed along the same lines as Coal Gasifier Combined Cycle systems, one of the most promising Clean Coal Technologies.

5) Gas from coal, biomass and MSW gasification could also provide gas for Carbonate Fuel Cell another promising high efficiency method of producing electricity.

6) European and Asian industrial countries are recognizing the commonalities of solid fuels technologies. While the USA has led the world in environmental regulations and environmental control technologies it is losing its leadership to Japan and Germany who factor their national interests more closely into national policy and are aggressively pursuing environmental policy and products using overall systems approaches.

7) The American Petroleum Institute advises the Secretary of Energy on the use and supply of liquid and gaseous fuels on behalf of the Petroleum and Natural Gas industries. A Solid Fuels Council could better advise the Department of Energy by considering the totality of domestically available solid fuels.

8) Our country can substantially reduce its dependence on imported oil if domestic fuel competition were replaced by some domestic fuel cooperation and greater use of domestic fuels became a part of a national job creation policy.

9) The Secretary of Energy would be subject to fewer manifestations of special interests and exaggerated technical claims if the solid fuels communities worked together in formulating advice as to our national energy interest, particularly on making best use of what we have. Our national interests would thus best be served if the Secretary of Energy had direct access to a Solid Fuels Council (SFC).

10) The National Coal Council is the closest advisory body to a Solid Fuels Council and broadening its scope would be a practical and rapid way to establish a SFC.

My perspective in compiling the above comes from 8 years of service on the National Coal Council, service as chairman of the Executive Committee of the Fuels and Combustion Technology (FACT) Division of the American Society of Mechanical Engineers (ASME), from working separately with the gas, biomass, coal and waste industries and in large part from service as an operations analyst with the 20th Air Force in WWII when strategic systems approaches and commitment to the national interests were uppermost. More detailed information is given in the attachments submitted on May 18th to Joseph W. Craft III, Chairman and James F. McAvoy, Executive Director, of the National Coal Council.

Alex E. S. Green
Graduate Research Professor

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28150

Obtained and made public by the Natural Resources Defense Council, May 2002
April 23, 1999

Dear Secretary Babbitt:

You might remember the first question following your talk in Gainesville on Tuesday, April 20 at the Forestry Association meeting. In essence I asked "Have you considered the pros and cons of an alternative form of controlled burning (CB) that might be called controlled burning industrially (CBI)"? Specifically CBI would involve gathering up the understory biomass and chipping it for use as a renewable supplementary fuel in a nearby fossil fuel burning plant or plant for biomass conversion to gaseous or liquid fuels or chemicals. The organic carbon is replaced from a nearby source of treated municipal sludge.

SOME CBI PROS
(1) a greater reduction in the risk of catastrophic fires and threats to nearby urban areas
(2) avoidance of smoke generation from CB's that can reach health threatening levels
(3) reduction of the fire threat to wildlife
(4) reduction of net greenhouse gas emissions, since biomass is a greenhouse neutral fuel
(5) reduction of carbon monoxide emissions that indirectly damage the stratospheric ozone layer
(6) promotion of the development of biomass to energy technologies.
(7) reduction of our almost 60% dependence on imported liquid fuels
(8) helping USA's agricultural community work towards energy farming
(9) improving the accessibility of our forest lands to supplement our crowded public parks
(10) reducing the costs of maintaining a large wildfire control infrastructure
(11) reducing the disposal costs of municipal sludge
(12) providing challenges for USA's remaining "hands-on, can-do" engineers

SOME CBI CONS
(1) costs of versatile small scale biomass chipping, gathering and transportation systems
(2) costs of adapting fossil fuel plants to accommodate small fractions of biomass.
(3) loss of fire based seed releases (however, desirable seeds could be artificially assisted)
(4) reduced disinfection by fire (could be overcome by increased sunlight or sludge disinfectants)

There are probably other pros and cons that should be weighed after considering that nature's way, the wild fire, did not allow for current human populations. On balance, I believe that CBI using advanced co-utilization technologies warrants serious consideration. I will be in Washington on May 18 and 19 to attend a meeting of the National Coal Council, an advisory council of the Secretary of Energy. If you wish, I could, while there, brief you or your concerned staff further on CBI.

Very sincerely yours,

Alex E. S. Green
Graduate Research Professor
Syngas Europa
United Europe explores technology to get more power and less pollution from its coal. By A. J. Minchener

EUROPE WILL NEED NEW POWER GENERATION PLANTS within 20 years. More than 80 percent of the energy that is consumed in the European Union countries comes from fossil fuels. Coal accounts for over 40 percent of the power, and that comes almost entirely from conventional pulverized-fuel-fired boilers linked to a conventional steam cycle. Such systems have modest efficiencies and contribute to a large extent to the global emissions of nitrogen oxides, sulphur oxide, carbon dioxide, and particulate matter.

The European Commission is supporting a wide range of clean coal technology research and development initiatives, including those known as APAS (Activité de Promotion, d'Accompagnement et de Suivi) and Joule (after the 19th-century British physicist James Joule).

APAS, a two-year multiple-partner program, was set up to evaluate gasification processes using biomass, sewage sludge, and other wastes as co-feedstocks with coal. For example, Rheinbraun AG of Germany and the British Coal Corp. of the United Kingdom have examined the use of sewage sludge in combination with different types of coal. Rheinbraun AG studied the use of sewage sludge and loaded coke as co-feedstocks with dried brown coal in the high-temperature Winkler gasification process. Various tests were conducted in a demonstration plant that operates on 30 metric tons per hour of dried brown coal. The plant works continuously on an industrial scale and has full final gas treatment and water pretreatment stages.

During 11 individual test campaigns, a total of 504 metric tons of sewage sludge and 32 metric tons of loaded coke were co-gasified at feeding rates varying between 0.3 and 5 metric tons per hour. These tests took about 70 hours and were accompanied by a detailed analysis program to monitor such aspects as operability, conversion efficiency, syngas contaminants, solid residue characteristics, and emissions.

Emissions were well below the limits. For both sewage sludge and loaded coke, conversion efficiency and syngas yield were adequate. An increase in the benzene and naphthalene concentrations in the crude gas was noted.

Thus, a commercial application would require additional gas treatment.

An application was approved to operate the demonstration plant with a co-gasification rate of up to 15 metric tons per hour of waste materials. Wastes selected included dewatered sewage sludges, loaded rotary hearth furnace cokes, and processed packaging plastics. A number of plant modifications were made to accommodate these feedstocks. Recent trials have included the gasification of 800 metric tons of plastic wastes.

COMMERCIAL VIABILITY

Rheinbraun concluded that co-gasification of sewage sludge or loaded coke with dried brown coal offered significant potential for disposing of these wastes without impairing plant efficiency and emissions. The commercial viability was demonstrated by an assessment study that included major aspects such as feed rate, total investment, and methanol price in order to establish the criteria for the use of sewage sludge in the high-temperature Winkler gasification process.

In a complementary study at its Coal Research Establishment, British Coal Corp. examined the use of sewage sludge as a partial feedstock with hard coal.

Preliminary testing with coal and pelleted sludge on an atmospheric fluidized bed gasifier rig was followed by more extensive trials on a pressurized unit. This unit had a thermal input of 2 MW and comprised a spouted bed gasifier, cyclone, hot gas filtration unit, and fuel gas combustor. Test programs involved adding sewage sludge up to 25 percent (dry weight basis), increasing the peak bed tem-
Alchemy is present in medieval Europe, where the philosopher's stone was believed to enable them to transform lead into gold.

Today, their descendants in Italy and Germany are converting the carbon in oil-refining tar, plastic wastes, and steel-furnace gas into a synthesis gas that provides electricity, process steam, and valuable chemical feedstock.

The modern version of the fabled philosopher's stone is gasification, a process typically used to convert high sulfur coals into a synthesis gas, or syngas, that can be burned cleanly. Basically, the coal is prepared and fed into a reactor, or gasifier, where it is partly oxidized with steam under pressure. By simultaneously reducing the presence of oxygen in the gasifier, the carbon in the coal is converted into a gas that is 85 percent carbon monoxide and hydrogen, with smaller portions of carbon dioxide and methane.

Sulfur is removed from the gasified coal and is sold in its elemental form, or as sulfuric acid. Inorganic materials such as ash and metals drop out as slag, which is typically used for construction materials.

When coal is gasified to generate electricity, it is typically consumed in an integrated gasification combined cycle, or IGCC, configuration, to improve the energy efficiency of gasification plants, which are inherently more expensive than conventional coal-fired power plants. In the combined cycle, gas is burned in turbines to produce electricity, and exhaust is recovered to produce steam in a boiler that powers another turbine to generate additional electricity. The plant may provide process or heating steam as well.

While mechanical engineers work to make IGCC plants more economical, they tout the environmental advantages of burning syngas, a cleaner-burning fuel than coal. The same ecological benefits underpin the Italian and German plants, which convert waste materials containing carbon into gas turbine fuel.

All of these plants rely on heavy-duty gas turbines that the General Electric Co. in Schenectady, N.Y., has been modifying for IGCC service since 1984, when the first IGCC plant, the Cool Water Demonstration Project in the Mojave Desert in California, came online.

"We've accumulated 320,000 hours of syngas-fueled power generation worldwide since Cool Water," said Douglas Todd, a chemical engineer and manager of process power plants at GE. "We joined Cool Water to demonstrate how the advantages of combined cycle costs could be applied to fuels other than natural gas. We believe that 30 percent of the world's power plants to be built in the next 10 years will be designed to consume coal or oil. IGCC can make them cleaner and lower the costs of the electricity they produce."

Other economics are spurring the development of waste-fueled IGCC plants. "When we built Cool Water, the IGCC technology generated electricity at a cost of $2,000 per kilowatt. Since then, we have got the cost of IGCC-generated electricity down to less than $1,000 per kilowatt. Using waste fuels helps to reduce the cost of electricity even further," explained Todd.

This is particularly true for the wastes generated by oil refining, such as petroleum coke. "Most of GE's orders for IGCC turbines are for petroleum coke plants, most recently, under construction in France, Spain, and the United States," Todd said. "For example, the Delaware Star refinery in Delaware City, Del., was recently converted to gasify solid-waste petroleum coke to power four GE 6FA gas turbines."

General Electric's experience is underscored by the first World Gasification Survey conducted by SFA Pacific Inc. of Mountain View, Calif., in 1999. This survey was supported by the U.S. Department of Energy and member companies of the Gasification Technologies Council in Arlington, Va. The survey identified 160 commercial gasification plants operating, being built, or planned in 28 countries around the world.
FEATURE FOCUS

TRASH AND BURN

Synthetic gases derived from industrial and municipal wastes fuel cogeneration plants in Europe.

By Michael Valenti, Senior Editor

Obtained and made public by the Natural Resources Defense Council, May 2002
temperature from 980 to 1,000 and 1,020°C, and reducing limestone addition from a Ca:S of 2:1 to 1:1:1 and 1:1.

The feeding and handling properties of the dried pelleted sewage sludge selected for study compared favorably to those of crushed coal. Co-firing sewage sludge with coal for extended periods of time, and with sewage sludge additions of up to 25 percent (dry basis), did not adversely affect the gasifier operability or process performance, provided that the input ratio of carbon in the fuel to oxygen in the fluidizing air remained constant. The fuel gas calorific value was typically 4.2 megajoules per cubic meter (wet, net, purge-free basis) and fuel conversion efficiency 78 percent (dry ash-free, mass basis). The sulfur retention efficiency attained during co-gasification, with limestone addition, was high, typically 92 percent. This efficiency was attributable partly to the sulfur retention properties of sewage sludge.

Sustained operation without the agglomeration of ash was attained for all test conditions, including operation at a bed temperature of 1,015°C, co-firing with 10 percent sewage sludge. There was no evidence of an increase in the elutriation of fines or the formation of tars as the co-firing ratio of sewage sludge and coal was increased.

Compared to coal, sewage sludge has higher levels of the more volatile heavy metals, and there were concerns that they could harm downstream components. However, most of the trace elements were partitioned into the solid stream at the hot gas filtration stage.

**British Coal Studies**

To support the technical work, British Coal carried out various techno-economic studies. Two biomass feedstocks—sewage sludge and straw—and two process technologies—oxygen-blown integrated gasification combined cycle (IGCC) and an air-blown gasification combined cycle (ABGC)—were selected. A wet feed IGCC process was used for sewage sludge and a dry feed process for straw. Plant sizes of 350 to 500 MW of electricity were dictated by the size of the large gas turbines used in most commercial power plants. Biomass feed rates within a range of 0–25 percent of the coal feed were modeled, based on an analysis of the likely availabilities of straw and sewage sludge within a reasonable radius of a plant.

Plant performance was predicted by CRE Group Ltd. (formerly part of British Coal) using the Archimedes process flowsheet modeling computer package (an in-house package available for contract consultancy applications). Adding 25 percent straw to an IGCC plant was predicted to reduce the low heat value efficiency by 1.5 percentage points if lock hoppers were used. It should be possible to virtually eliminate this penalty if an advanced feeding system could be developed. Even using lock hoppers, there should be no efficiency penalty from feeding straw in the ABGC, provided the gasifier bed temperature does not have to be reduced substantially for the low melting characteristics of straw ash.

Feeding 25 percent sewage sludge to an ABGC plant would increase the low heat value efficiency by 1.5 percentage points, but reduce the high heat value efficiency by 1.9 percentage points. If cold gas cleaning was required for removal of ammonia and heavy metals, the LHV efficiency would increase by 0.7 percent instead. Adding 25 percent sewage sludge to an IGCC plant would have very little effect on the LHV efficiency.

**Joule Initiatives**

The Joule 3 co-gasification initiative was designed to aid European industry to address the technical issues for fluidized bed co-gasification applications.

Part of the Joule project, a program to develop and design coal-biomass systems components, was undertaken by VTT Energy and Carboma of Finland, Schumacher of Germany, British Coal, Technical University of Delft in the Netherlands, and Nuovo Pignone of Italy. The work investigated the effect of mixed feedstock properties on co-gasification processes, and resulted in improved hot gas filtration technologies, increased overall carbon conversion, and reduced emissions. It was also confirmed that, with modifications, it was possible to fire turbines on the gas generated.

A separate part of the program, coal-biomass environmental studies, undertaken by CRE Group Ltd and Imperial College of the United Kingdom, and TPS Termiska Process AB and Kung Tekniska Hogskolan of Sweden, concentrated on the use of laboratory-scale experimental techniques to study the influences of several fuels on...
gasification behavior. The studies found that when coal and biomass or wastes were co-gasified, the overall level of tar generated was lower than for coal alone; the concentration of hydrocarbons in the range of C₃ to C₅ was increased, and product gas yields increased and char levels decreased, with co-gasification chars being significantly more reactive. In addition, the heightened char reactivity resulted in increased conversion of NO and NH₃ to N₂.

Technical and economic studies by the Energy Research Centre of Ulster found that in nearly all cases, the gasifiers could operate on a range of coals and generate gas of sufficient calorific value to be combusted in a gas turbine.

The strategic studies concluded that in markets where natural gas is available, new coal plants will be unable to compete directly until the gas price doubles. For coal-fired plants, unless credit is given for lower levels of emissions, pulverized fuel and pressurized fluidized bed combustion technologies will remain the least expensive options.

The Joule 2 project for the enhancement of the efficiency of coal-fired power generation systems was undertaken by Siemens and the University of Essen in Germany, and Babcock and Wilcox España in Spain. It used the oxygen-blown Puertollano IGCC power plant in Spain, with good-quality coal feedstock as the base case. The project considered ways in which plant performance could be improved, with particular emphasis on efficiency and environmental impact.

Replacing the conventional wet gas cleaning stage with a dry, high-temperature system increased the plant efficiency of the base case by 0.8 percentage point to 49 percent. Increasing the clean gas temperature before the gas turbine combustion chamber from 330°C to 510°C enhanced the net efficiency by another 0.9 percentage point.

Further studies examined the effect of increasing the inlet temperature of the gas turbine. The gas turbine was modeled as a unit using the Aspen Plus power plant process flowsheet modeling package, suitably tailored, available commercially from AspenTech of Cambridge, Mass. It was assumed that the inlet temperature was 1,190°C, the compressor ratio was 17.0, air compressor polytropic efficiency was 91.5 percent, and the turbine isentropic efficiency was 89.5 percent.

The influence of increasing the inlet temperature from 1,150°C to 1,400°C was investigated over a range of compressor pressure ratios. The studies indicated that raising the inlet temperature to 1,400°C would lead to IGCC net efficiencies (LHV) of 53.2 percent.

Studies confirmed that IGCC systems fired on a variety of fuels can realize increased efficiency, reduced emissions, and lower cost of electricity using proven technology within existing designs. Further developments in the fields of hot gas cleaning, gas turbine technology, and materials would have further positive effects.

In the Joule 3 project on advanced cycle technologies, the University of Essen and four partners have investigated measures to reduce costs, enhance efficiency, and provide a basis for an advanced design. The studies also included co-gasification of coal and biomass in an entrained-flow gasifier suitable for IGCCs.

The study concluded that, based on proven materials, components, and processes, in the near term, coal-fired IGCC technology is competitive with a modern pulverized coal steam power plant. It is expected that with the gas turbine inlet temperature operating at elevated temperature, IGCC net plant efficiency (LHV) would be approximately 31.5 percent, compared to a modern pulverized coal plant's 45 percent. There are a number of other IGCC developments in hand that could ultimately increase efficiency to levels approximately 58 percent or more.

The study also investigated the use of coal/biomass combinations for IGCC applications. Findings confirmed that as much as 10 percent biomass in an oxygen-blown entrained flow gasifier was technically feasible. Net electrical efficiencies were lower as a consequence of the higher internal energy consumption required for biomass pre-treatment and process compressors. However, by using an optimized and integrated process, and by pressurization of the pyrolysis/gasification pre-treatment stage, the overall decrease could be limited to 0.5 percentage point LHV.

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A Gain in Spain

THE BENCHMARK IN EUROPE for IGCC is the 300 MWs combined-cycle power plant at Puertollano in Spain. The process uses an oxygen-blown Pradelino entrained-phase coal gasifier, followed by extensive coal gas cleaning stages and low NOx combustion in the gas turbine. Once fully operational, it is expected that the process will have a net efficiency of 45 percent.

A three-year demonstration phase began in 1997 with the first production of gas from coal occurring in December of the same year. Following this, an extensive assessment was carried out and a series of plant modifications made. Gas turbine operation on coal gas was achieved in March 1998. However, initial runs showed the need for a number of other modifications. These were carried out and trouble-free steady operation was achieved in October 1998. By the end of the year, some 56 gasification runs had been done, amounting to a total of 800 hours of operation. Ten gas turbine runs using syngas had been completed.

With increased fuel diversification in Europe, gas-fired power stations are currently the preferred option for new capacity. Nevertheless, coal will continue to have a role to play in power generation in the future. The technology of choice will not be the conventional pulverized coal plant; rather, it will be either an advanced PF plant, with higher efficiency steam conditions and ultra-effective gas cleaning, or one of the new, advanced, clean coal technologies that will offer integral pollutant control plus optimized gas turbine and steam cycle systems.
The survey showed that in the 1990s, gasification capacity fueled by petroleum-based materials, including residual oil, petroleum coke, and tar, was approximately 60 percent of coal-fueled capacity. However, the survey found that refining industry economics, stricter environmental regulations, and electricity deregulation that enable oil refineries to generate power and compete in open energy markets would increase the use of petroleum material gasification. The study forecast that after the current year, petroleum-based gasification capacity would grow almost twice as fast as coal-based gasification capacity.

**Turning Tar into Sardinian Power**

The survey's findings are supported in the world's largest IGCC power plant, recently constructed by a consortium including Snamprogetti S.p.A. of Milan and GE Power Systems of Schenectady on the Italian island of Sardinia. The IGCC plant is located at the Saras Oil Refinery in Sarroch, the second largest European refinery. The plant has been running on syngas since August, and produces 551 megawatts of electricity, 285 metric tons of process steam for the refinery, as well as 30 million standard cubic feet a day of hydrogen feedstock. The Sardinian facility is owned by Sarlux S.p.A., a joint venture formed by Saras Raffinerie S.p.A. of Milan and Enron Corp. of Houston.

The Sarlux IGCC plant gasifies the tar-like residue produced by vacuum visbreaking at the Sarroch refinery.

Vacuum visbreaking is a form of thermal cracking of petroleum that dates back to the 1930s. Visbreaking involves subjecting heavy crude oil to pressure and heat to physically break its large molecules into smaller ones to produce lighter fuels, such as gasoline and diesel fuel. Originally, the visbreaking tar at Sarlux was incinerated in boilers to make electricity for ENEL, the national Italian power company. By 1990, environmental regulations prohibited the practice. IGCC was already an ecologically viable alternative, so GE and its Italian partners worked to get the laws revised to allow refining companies to sell power, and assisted legislation that would set a competitive price for electricity generated by waste-derived fuels.

The visbreaking tar is a thick liquid that is pumped to the gasifier unit, which is licensed from Texaco Inc. in White Plains, N.Y., and was originally used in the Cool Water program.

Oxygen is added to the gasifier to partially oxidize the tar under pressure. This causes the carbon and the oil in the tar to change to carbon monoxide rather than carbon dioxide, and the hydrogen present to become gaseous hydrogen, rather than water. The plant then separates the elemental pure hydrogen that Sarlux uses to upgrade all its finished fuel products, such as gasoline. The remaining syngas is sent to the turbines to make power.

There are three GE 109E, single-shaft combined cycle systems built by GE and its subsidiary, Nuovo Pignone of Florence. Each GE STAG (steam and gas) system consists of a GE MS9001E gas turbine, a GE 109E condensing steam turbine, a double-end generator, and a heat recovery steam generator.

The turbines are started up by distillate oil, are injected with steam to control nitrogen oxide formation, then are switched over to syngas. Distillate oil also serves as the backup fuel for the Sarlux turbines.

"We designed the turbines to handle syngas with 40 percent moisture, and a heating value one-sixth that of natural gas. The combustor design has to handle six times the amount of syngas compared to natural gas. This means the fuel delivery system must deliver the higher volume and be explosion-proof, due to the hydrogen fuel," said Todd, who added that these proprietary modifications grew out of GE's Cool Water experience.

Each Sarlux turbine produces up to 186 MW of electricity while meeting Italian emission levels of 30 parts per million for nitrogen oxides and sulfur oxides. GE adds the 40 percent moisture to the fuel to reduce NOx formation. Noise levels must be less than 85 decibels at the equipment.

The Sarlux IGCC plant will generate about four billion kilowatt-hours of electricity annually that will be sold to ENEL. This energy will be distributed throughout Sardinia's electrical grid. Sarlux will also generate fresh water.

**We Gasify Anything**

In Spreeviit, Germany, north of Dresden, Sekundarstoff-Verwertungszentrum Schwarze Pumpe GmbH operates an IGCC facility that converts an eclectic mix of 450,000 metric tons of solid waste, and 50,000 metric tons of liquid wastes, into electricity, steam, and methanol feedstock. SVZ was founded in 1995 as an independent subsidiary of Bethanwa Wasser Holdings to operate the Spree...
which was originally designed to gasify brown 1960. The company has spent more than $250 million in an ongoing effort to modernize the plant with a variety of solid and liquid wastes.

Materials treated at Spreewitz include plastic bag from junked railroad ties and telephone cable sludge, old tires, and household garbage. Metals are ground up, pelletized, mixed with water, and sent into four solid-bed gasifiers made by a va-riety of manufacturers. The reactors process up to 15 tons of waste hourly.

SVZ will sell 30 tons of mixed solid waste and coal per hour into the double airlock of the BGL gasifier. Steam and oxygen are injected into the gasifier, heating the mixture to 1,600°C while pressurizing it to 25 bar. Syn-gas is drawn off, while molten solid residues are shocked-cooled by quench to form a vitrified, granular slag for later disposal.

Beiträgerwasser Holdings recently agreed to sell SVZ to Global Energy Inc. of Cincinnati. The Ohio company sponsors the development of gasification technology, and has more than 4,000 MW of projects in development, under construction, or operation in Europe and the Americas.

FURNACE GAS FUELS TARANTO

Steel mills can be reconfigured as sources of waste-fueled syngas because they already produce hydrocarbon gases from their furnaces and coke ovens that can be burned as turbine fuel after some solid and liquid contaminants are removed. This is being done at the Ilva Sistemi Energetica cogeneration project, which uses process gases generated at the Ilva steelworks in Taranto, Italy, to fuel turbines and produce 520 MW of electricity for ENEL, and 150 metric tons per hour of process steam.

The Taranto plant is the buckle on Italy's steel belt, producing nine million tons of steel plates and pipes. The plant previously relied on two conventional coal-fired steam plants to meet its steam and electrical requirements, but
their combined electrical efficiency was less than 37 percent. Among the changes Ilva management instituted to raise the Taranto plant's efficiency was building a power station, called the CET3, to recover furnace gases to fuel three combined cycle units to produce steam and electricity.

The CET3 power plant at Ilva/Taranto was built by a joint venture, including Ansaldo, based in Genoa, and GE-Nuovo Pignone, headquartered in Florence. The power plant is fed with blast furnace gas, oxygen steel-furnace gas (also known as converter gas), and coke oven gas. All three hydrocarbon gases are chemically similar to syngas, but the blast furnace and converter gas streams are laden with dust, and the coke oven stream is laden with liquid hydrocarbons, which require the gas streams to be treated.

The two furnace gas streams are directed through two electrostatic precipitators that remove the dust particles. The coke-oven gas is sent through three electrostatic precipitators that will remove tar particles. The gas streams are then mixed and sent through a final electrostatic precipitator before being used as fuel.

Each combined cycle unit is built around an MS9001E gas turbine manufactured by Nuovo Pignone, with each turbine capable of generating 140 MW. These turbines were modified to burn low calorific value gases, such as furnace recovery gases supplemented by natural gas, by using the GE's syngas combustion system.

The 9Es at Taranto are single-shaft machines that burn the syngas to simultaneously drive a generator and a fuel gas centrifugal compressor to pressurize the recovery gases. Each turbine is linked to a horizontal waste heat boiler that produces steam at two pressure levels, 93 and 25 bar. The boiler reheats the low-pressure steam before routing it back into a steam turbine that operates a second electrical generator that has an output of 68 MW. The high-pressure stream is used as process steam.

Both the gas turbines and waste heat boilers at CET3 can burn natural gas, recovery gas, or a mixture of both to provide fuel flexibility. The net electrical efficiency of CET3, including the power absorbed by the gas compressor and the steam cogenerated, ranges from 41.5 to 42 percent.

An additional benefit of IGCC power plants is their ability to stay online due to their fuel flexibility. GE has developed co-firing capability that allows the power plant to produce full electrical load on the backup fuel, providing electric power availability up to 95 percent. According to Todd, this has helped make IGCC more acceptable in its early developmental stages.

Todd noted that waste-fueled IGCC plants are being built in countries other than Italy and Germany. Asian petrochemical plants are also bullish on waste-fueled IGCC. GE is working with Exxon in Singapore to gasify the residues from steam cracking operations at a major olefins plant in the island nation. In addition to providing power and steam, gasification will produce all the hydrogen feedstock the plant needs for olefin processing when it begins operating later this year.