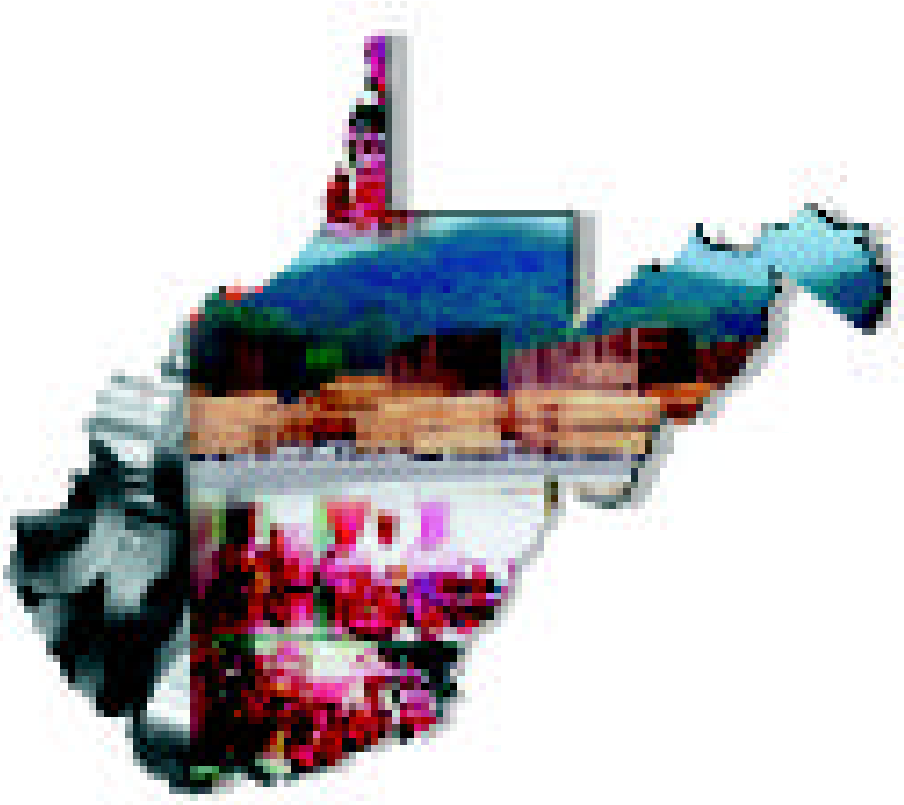
1999 Symposium Proceedings

Industries of the Future–West Virginia
IOF–WV



A program of the U.S. DOE Office of Industrial Technologies,
the West Virginia Development Office, and West Virginia University

Days Inn Convention Center – Flatwoods, West Virginia
November 17-19, 1999

In memory of the life, personal integrity,
and achievements of Louis "Lou" Minehardt IV

August 14, 1943 - December 16, 1999

President and cofounder of HK Castings, Weston, WV

American Foundry Society

Board of the WV Manufacturing Extension Partnership

Industry Advisory Council of the Robert C. Byrd Institute

Chair of the IOF-WV Metal Casting Group

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Preface

Welcome to the proceedings of the third IOF-WV Symposium held November 18, 1999 in Flatwoods, West Virginia. There are gems of insight, foresight and hindsight in these proceedings that reflect some of the impacts of globalization, consolidation, and new technologies on West Virginia's IOF industries.

In his symposium keynote address, Gerry Meyers, CEO of Century Aluminum, suggests that the U.S. government should consider limited protection and incentives to help threatened industries improve their global position. Americans, he says, are not ready to accept an America without the capability to produce steel, aluminum, chemicals, and wood products.

The heart of the IOF-WV program is development of projects and acquisition of technologies that will benefit West Virginia's IOF and manufacturing companies. Karen Price, President of the West Virginia Manufacturers Association, inspired the industry groups to "let their imaginations run wild" and to "think out of the box" in order to make West Virginia a global industry leader. The status of on-going projects and plans for the future presented by eight industry spokespersons are reproduced in the section on IOF-WV Industry Sector Updates.

Governor Underwood has participated in all three IOF-WV symposia. In his luncheon speech, he eloquently endorsed the IOF concept, drawing enthusiastic applause. The transcript of his speech contained in these procedings includes his assertion that established businesses should receive attention and incentives comparable to those offered to prospective new investors.

Earl Beaver's speech from the afternoon session on successes from the national IOF program confirms WVU President David Hardesty's opinion that the IOF process itself can be as important as actual results from funded projects. Beaver's talk describes how the chemical industry was highly motivated by participation in the IOF Vision/Technical Roadmap process to undertake energy and environmental efficiency reforms – without waiting for government project money.

Robert DeSaro, president of Energy Research Co., observes in his talk that the Industry Technology Roadmaps developed in the IOF program are like having highly paid consultants for free. Talks by Richard Brent and Brent Blalock address technologies and real-world experience with on-site and distributed generation. Arel Weisberg and Tim McIntyre presented new, advanced sensor technologies incorporating laser optics and spectroscopy for in-situ, real-time measurement of temperatures and melt constituents, Their comments are included in these proceedings.

We were extremely fortunate to have had Dr. Bruce Merrifield as the symposium dinner speaker. The transcript of his talk is a brilliant, thought-provoking essay on technology developments and economic transitions. It is essential reading for all who are working to make things happen in West Virginia.

Thank you for reading these proceedings. Your suggestions on the IOF-WV program are welcome and we look forward to your participation in future IOF-WV projects and programs.

Carl Irwin
June 2000

IOF-WV Symposium Agenda

Wednesday, November 17, 1999

12:00 Wood Products Working Group meeting

6:00 Symposium reception

7:00 Rapid mold making by spray technology for the plastic, polymer, metal and glass industries
— Kevin McHugh, Idaho National Engineering Laboratory

7:30 Steel Industry Working Group dinner meeting

Thursday, November 18, 1999

8:30 Welcome and Introductory Comments
— Allen Cogley, Dean, WVU College of Engineering and Mineral Resources
— Jeff Herholdt, Manager, WVDO Energy Efficiency Program
— Jim Quinn, Head, OIT States IOF Team

9:00 Keynote Address
— Gerry Meyers, President, Century Aluminum Company
Introduced by David C. Hardesty Jr., President, West Virginia University

9:45 Industry Sector Caucuses
Charge to the breakout groups by Karen Price, President, WV Manufacturers Association

10:30 Industry Sector Updates
Session Chair: Fred Cutlip, Director, Community Development, WVDO

Aluminum	Ric Love
Steel	Howard Snyder
Glass	Tom Fenton
Chemical/Polymers	Charles Sobrero
Wood/Forest Products	Joe McNeel
Metal Casting	Pat Minehardt
Distributed Generation	Muhammad Choudhry
Carbon Foam Commercialization	Libby Kraftician
Mining	Syd Peng

12:15 Lunchtime Address
— Governor Cecil H. Underwood
Introduced by Sam Tully, Director, Governor's Office of Technology

1:30 Showcase of Four Success Stories from the National IOF Program

Session Chairs:

— Denise Swink, U.S. DOE Deputy Assistant Secretary for Industrial Technologies

— Bill Parks, U.S. DOE Associate Deputy Assistant Secretary for Power Technologies, Office of Power Technologies

— Scott Richlen, Supervisory General Engineer, U.S. DOE Office of Industrial Technoloies

Case Studies of Waste Utilization in the Chemical/Polymer Industry

— Earl Beaver, Practical Sustainability, Inc.

***In-situ*, Real-Time Measurement of Melt Constituents and Temperatures**

— Robert DeSaro, & Arel Weisberg, Energy Research Co.

3:00 Break

3:30 Resume National IOF Showcase Session

On-Site Generation for Combined Heat and Power

— Richard Brent, Solar Turbines, Inc.

— Bruce Hedman, Onsite Sycom Energy Corp.

— Brent Blalock, B.A. Mullican Lumber and Manufacturing Co.

Remote, Real-Time Temperature Measurement in Galvanneal Furnaces, Rolling Lines, and Processing Vessels

— Tim McIntyre, ORNL

5:00 Small group discussions on OIT showcase technologies and exhibits – featuring demonstration of laser cutting technology for glass production

6:00 Symposium Reception and Dinner

After dinner comments by Bruce Merrifield, CEO, Pridtronics

Introduced by Rudy Henley, Senior Managing Director, McCabe-Henley Properties LP

IOF-WV Short Courses Schedule

Friday November 19, 1999 — 8:00 a.m. – 12:30 p.m.

A-1. Internet Opportunities for WV companies
— Roger Duckworth, Program Manager, Virtual Company,
WV High Technology Consortium Foundation

A-2. How and Why of E-Commerce
— Bonnie Morris, Associate Professor of Accounting, WVU
— Jeff Tucker, Senior Software Engineer, DN American

A-3. Checklist for Y2K Compliance
— John Frazer, Y2K Champion and Industrial Hygienist, WV
Manufacturing Extension Partnership

B-1. Initiatives to Improve Safety and Reduce Workers' Compensation Premiums in the Forest Products Industry
— Dick Waybright, Executive Director, WV Forestry Association

B-2. Workforce Training Programs
— David Lieving, Director, Governor's Guaranteed
Work Force Training Program, WVDO

B-3. Status of Electric Industry Restructuring
— David Ellis, Director, Utilities Division,
Public Service Commission of WV

C-2. Effective Business Networks to Cut Costs and Build Opportunities
— Tom Mahoney, Director, WVU Industrial Extension,
WV Manufacturing Extension Partnership

C-3. NICE^3, Inventions and Innovations, and SBIR Proposal Planning Session
— B. Gopalakrishnan, Associate Professor, WVU, and
Associate Director, WVU Industrial Assessment Center
— Judith Dyer, Chief Program Manager,
Energy Efficiency Program, WV Development Office

IOF-WV Symposium Exhibitors

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Steve Woodruff of the U.S. DOE National Energy Technology Laboratory, discusses the laser glass cutting and finishing machine developed by a joint WVU, NETL, and glass industry research team. (WVU photo by Rita Beaty)

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Welcome & Introductory Comments

Allen Cogley, Dean, WVU College of Engineering & Mineral Resources

Thank you for attending the third Industries of the Future – West Virginia symposium. Our main job at the WVU College of Engineering and Mineral Resources is to educate people so we will have successful industries in the future. Universities like WVU organize themselves into colleges and departments, and grant specialized degrees in many disciplines. We work very hard to make sure we do not build walls around individual departments.

In Chemical Engineering, we offer B.S., M.S., and Ph.D. degrees. In Civil and Environmental Engineering, we have B.S., M.S., and Ph.D. degrees, and in Computer Science and Electrical Engineering we have a B.S. in Electrical Engineering, a B.S. in Computer Engineering and a B.S. in Computer Science as well as a Master of Science in Software Engineering, something that is very vital for the information age. In Industrial and Management Systems Engineering, we have a B.S. in Industrial Engineering, and we have a Master of Science in Occupational Hygiene and Safety. As you know, safety and occupational safety are vital to industry. They affect your bottom line. If you truly practice safety, you are going to save money. We have specialized M.S. degrees in Safety and Environmental Management. And we have M.S. and Ph.D. degrees in Industrial Engineering. Mechanical and Aerospace Engineering has a B.S. in Mechanical Engineering, a B.S.Ae. in Aerospace Engineering, and a M.S. and Ph.D. degrees in both of these areas. Mining Engineering has B.S., M.S., and Ph.D. degrees, and Petroleum and Natural Gas Engineering offers B.S., M.S., and Ph.D. degrees.

We are a comprehensive engineering college. We also have Extension in the college. This is where we work directly with West Virginia companies. Mining Extension focuses on work force development more than anything else we do. We work with miners and certify their skills for the mining industry. Industrial Extension is involved in economic and work force development. We have nine agents throughout the State who work directly with industry. The extension agents are really facilitators for business in their region. They do not deliver all the services themselves; rather, they contact companies, talk with them, do assessments, and frequently use third parties to deliver the services and resources. Extension is another door to the College that you should be aware of.

I encourage you to work with us, and I will be glad to help facilitate that. The entire faculty here will be glad to help facilitate that. We want to learn how you work so we can share our resources, share our capabilities, and maximize the economic development of the State. I hope you have a very good conference and that you will develop new ways to work with the resources we have, not only in the College of Engineering and Mineral Resources but within the entire University, because we are a unique asset for economic development and job creation.

Jeff Herholdt, Manager, West Virginia Development Office Energy Efficiency Program

The West Virginia Energy program operates within the Community Development Division of the West Virginia Development Office. One of the principal things we have been involved with recently has been securing funds through the OIT's State Energy Program to help support West Virginia's IOF activity.

The IOF program is one of our ways of working with existing West Virginia companies to help them modernize their operations. The Development Office is highly motivated to help the State maintain its manufacturing base.

The drivers for West Virginia are international competition, environmental regulations, and emerging technologies. One of the responses we sometimes get in the Energy Efficency Office is "Well, I really don't have much of an energy problem, so how can we participate?"

Our feeling is that anything you do to improve production at your facility is going to have a positive impact on your bottom-line energy costs. You are going to reduce the BTUs required per unit of product produced. Likewise, by improving your environmental performance, you will also have similar impacts.

Some of the technologies for the glass industry we have worked with include heat recuperators, automated motors, sensors and controls, CO_2 laser cutters, oxy-fueled systems, fluid dynamics and simulation control software, and improved refractory materials.

In addition to the IOF program, my office works with the Student Energy Intern program, which places about 75 students in 15 industries a year to identify process improvement opportunities. We also have a Glass Industry Assistance program, a Wood Industry Assistance program, and we provide support to the Industrial Extension program that Dean Cogley referred to.

It has been a pleasure working with many of the small companies here today, and I am looking forward to many new projects with the IOF-WV team.

Jim Quinn, Head, Office of Industrial Technologies States IOF Team

The OIT office is well represented here this morning and we are happy to be part of the IOF-WV effort. Just a few introductions - Valeri Robinson for Forest Products, Scott Richlen for Steel, Denise Swink is our boss, Bill Parks for Cross-Cut Technologies, Harvey Wong for Metal Casting, Rolf Butters for Glass, and Charlie Russamano for Chemicals. Mary Ann Daniels from our Philadelphia Regional Office is also here. These people can answer your questions and give you more information about the various OIT programs.

Over the past year, the chemicals IOF team has developed a number of road maps to guide our work over the next few years. They plan to do additional road maps and to conduct workshops. The forest products implementation plan was completed. A gasification

solicitation should be issued in this area pretty soon. For the glass industry, a showcase is planned for next year in Amarillo, Texas. There was also a new compact for glass signed in February at the 1999 Expo. In aluminum, the inert anode study was done and the SECAT Center for advanced technology was established at the University of Kentucky. Subodh Das is here from Kentucky. He has done a terrific job and is the guy to talk to if you want to find out how to do things quickly. He raised $8 million in the last year or so for this center. In steel, we have a technology showcase scheduled for Pittsburgh in May 2000. We also signed a new compact with the steel industry in February 1999. In metal casting, we had an excellent showcase event a couple of weeks ago at Lester Die Casting in Cleveland, Ohio. I hope that some of you were able to be there. The petroleum industry has now completed a vision. It is not released publicly yet, but will be soon. A compact-signing will be held in early 2000. An agriculture industry group has done a Technology Road Map in Plant-Crop-Based Renewable Resources that was completed in the last year. We also have a new bio-energy initiative that DOE is putting together. In mining, the first road map for cross-cut technologies was completed, and we have issued a first and a second solicitation in mining.

So, very briefly, those are a few highlights of the national IOF program. Now for state programs. Recall that two years ago there was just one state doing a state IOF – West Virginia. In Fiscal Year 1998, we had about 20 states that were working on this and in Fiscal Year 1999, we have grants to 26 states for developing IOF programs. Some states have carryover from last year, so there are a total of 31 states that are now actively working on Industries of the Future activity. The model has been West Virginia. Many people are using a great deal of the material that was compiled in West Virginia, so we really would like to applaud West Virginia for leading the nation in this area.

One of our goals within OIT is to integrate the way we provide services to customers, to provide the right information to the right people at the right time. The idea is to meet the needs of the customer, not to provide too much information or too little or to provide it at the wrong time. One of the ways we are doing that is with something called "best practices." Now, you may recall we had things like motor challenge and steam challenge and a couple of other challenges. What we are trying to do is put much of this material together so that a plant manager can select from various technologies and processes for cleaner, more productive, more energy-efficient and lower-cost operations.

I mentioned the upcoming Pittsburgh Regional Steel Technology Showcase. This is an excellent opportunity to learn about new technology and on-going steel industry projects, meet suppliers, meet trade group people, and visit plants. The Weirton plant is one of those chosen for site visits in West Virginia. We hope you will join us in May 2000 for this exciting event!

And last, but not least, Expo 2001. We have our Symposium and Expo event every other year, and we invite all of our industry customers. We had over a thousand people attend Expo 1999. We are planning to expand substantially in 2001 with more exhibit space and we expect about twice the attendance. So please put that on your calendar.

Symposium Keynote Address

Gerry Meyers, President, Century Aluminum Company

Introduction:
David C. Hardesty Jr., President, West Virginia University

I've been privileged to have had two careers in which I could observe first-hand various elements of society. In both of the jobs – one being a corporate lawyer, representing businesses like yours, and the other being a college president – I've had the opportunity to be a part of so many different things, and have taken great joy in meeting people from so many different walks of life. I was just thinking this morning that it was in one of those situations that I first met this morning's speaker.

Before I introduce him, I'd like to just say that I'm glad to be here with Denise Swink. Denise is the queen mother of the IOF program. I was once invited to a garden party in the presence of the Queen Mother, and so I'm here now in the presence of the queen mother of the IOF program. She has taken a personal interest in West Virginia and our university, and I appreciate it very much.

I'm also happy to be here with representatives of state government and our university and our federal delegation. And I want to reiterate what Carl said about Dean Allen Cogley. Our metrics are moving in the right direction, and so many good things are happening on the campus and in the College of Engineering and Mineral Resources. I congratulate you; you're doing a fine job.

The IOF program comes at a very good time, and some of you who went to school in the '60s, like me, remember Marshall McLuhan and his book *The Medium is the Message*. This format comes at a very good time, and maybe the format is as strong as the content. I'm sure that the content may help to transform the economy, but the collaboration that has arisen out of the IOF program is really quite significant. Our national economy is in transition, and there is no question that we all have to change. Our university is not exempt from that.

There's a certain downsizing in corporate R&D departments going on. There's a need for higher education to come out of its ivory tower and collaborate with business, and there's a need for all of us to reach out and touch other institutions in the society. It's an industry-led, vision-based, applied research and development program that brings us all together and IOF is a great vehicle for that. It's sponsored by the Energy Department and looks at work on various programs and projects at the Century plant in Ravenswood, which is one of the finest aluminum production facilities in the world. The projects that we've done with Century have given our faculty and our students an opportunity to work with West Virginia's aluminum industry in a meaningful way, and it's been really healthy for our university.

Century has also been an enthusiastic participant in the IOF program. They are part of two multimillion-dollar projects involving a significant cost-share on their part and participation by many in this room. These projects lead to jobs for our graduates, and I see them from time to time during the year. Also, several of our faculty are working with the IOF programs at Century.

So there's a long and growing partnership of which we are very proud, and I'm absolutely delighted that Gerry could be here today. He's a Canadian, graduated from the University of Toronto as a metallurgical engineer. Before joining Century, he held various positions of increasing responsibility across his career at Alcan and Logan Aluminum.

He became president and chief operating officer of Century at a tough time. The aluminum industry is a commodity business, and a cent on the pound can make a huge difference. That is partly why energy savings are of such importance to that company. It was also a facility that's gone through several series of owners, and those of you that know West Virginia know that he came at a time when there were some raw nerves there. With the force of his personality and his integrity and his savvy management, he and a very competent team of others rallied that plant to make it productive. Recently part of the facility was sold to Pechiney, which will now invest, as Gerry described it, north of a hundred million dollars – maybe south of $200 million in the rolling operations. I know Jack Burlingame is in the audience, and he will tell you that that is a happy end of a long questioning period as to the future of that plant. And it is because of its productivity and finding the right owner and having the right touch that this was able to occur. So this announcement is good news for the state of West Virginia. It's good news because they are partners with West Virginia University, and it's probably good news for the aluminum industry as Pechiney and Century work to become more productive and more competitive in the world market.

Gerry is an industry leader who understands the fortunes of his company are linked to the fortunes of the state. When he lived here, he worked hard developing an interface with government, with other organizations and with higher education to make this a better place for all of us to do business.

So I thank you, Gerry, for all you are doing for the economy of our state and for coming to talk to us today. I know your time is precious, and I hope everyone will join me in giving a very warm welcome to the president of Century Aluminum, Gerry Meyers.

An attentive audience for Gerry Meyers' symposium keynote address, Thursday morning, Nov. 18. (WVU photo by Rita Beaty)

Survival In An Age Of Business Consolidation

Gerry Meyers

As Groucho Marx once said: "Before I speak, I have something important to say." First, I am a West Virginia booster. My wife and I lived here for three very happy and rewarding years. In fact, we lived here long enough to master West Virginia usage of the term "Y'all." We figured out that "Y'all" is singular. "All y'all" is plural. "Your'all's" is singular possessive. And -- "All your'all's" is plural possessive. My vocabulary has changed, but the Canadian accent remains. And after living in ten different locations, we feel West Virginia has much to offer in terms of lifestyle, living standard, and economic opportunity. Better still, the state appears to be on the verge of an economic renaissance - thanks, among other things, to the progressive leadership of the Caperton and Underwood administrations, and, of course, the enduring and strong support of Senator Byrd. That renaissance is being generated mainly through industrial development, growing tourism, and infrastructure improvements. At the same time, educational institutions, led by WVU, are using teaching and applied research in ways that could have very profound and positive effects on social and economic fabric of the Mountain State.

Second, let me briefly tell you about Century Aluminum. For the past seven years we have owned and operated the large primary aluminum plant and aluminum rolling mills at Ravenswood that were built by Kaiser in the late 1950s. We recently sold the rolling mill portion of the plant to Pechiney, a big French aluminum company. That sale came after about five years of intensive effort and some $100 million in new investment that shifted the plant from being a producer of commodity sheet products, such as sheet for beverage cans, to a leading producer of premium products for the aerospace and transportation markets. The sale allowed Century to capture for shareholders the value of our efforts and investments. It also put the ownership of the rolling mills into the hands of a highly respected company with the financial and technical resources to make the plant truly world class in the highly competitive rolled products business. With the proceeds from the sale we intend to grow and enhance our position in the primary aluminum business well beyond the 500 million pounds of capacity that we control at Ravenswood and at a plant in South Carolina.

With those personal and business credentials stated, let me now turn to main body of my talk, which addresses the unprecedented period of global competition and consolidation that world business is in. No industry sector is untouched, from financial institutions to meat packers to big oil to drug makers. Through the end of September, worldwide M &A transactions were a record $2.2 trillion, up thirty-five percent from $1.6 trillion in the same 1998 period. I would like to discuss five major aspects of this consolidation:

- What is driving the trend
- How it is changing the way we conduct business
- The vicious competitive environment it is creating
- How it affects Century and other businesses in West Virginia
- And what we must do to insure that our opportunities to survive and prosper are not lost

What's Driving Global Consolidation?

First of all, we are capable of consolidating! There is explosive growth in the availability of broad-scale technology to reduce costs and manage assets on a global basis. Second, equity ownership has never been greater. Everyone is demanding corporate earnings growth. Companies recognize that top line growth comes faster from acquisitions than from internal sources alone. Revenue growth and cost cutting are two paths to higher profits. Third, there is a quantum shift toward specialization - the opposite of the diversification fad seen in the 1970s and 1980s. This "stick to your knitting" approach promotes consolidation in two ways:

- When companies spin off non-core assets, they generally become another company's core assets
- Companies with a dominant domestic market share in their specialty realize that the only way to grow revenues and earnings is by expanding beyond their national borders

Fourth, M & A financing is being facilitated by the availability and easy movement of huge pools of investment capital, and by the relatively cheap currency of bull market inflated equities - even though targets are not cheap. Fifth, the privatization of state-owned assets is producing giants in such former state monopolies as telecommunications, energy, basic materials, and others. The sixth factor promoting consolidation is the increasingly tolerant anti-trust policies of governments that recognize that the global reach of today's transnational corporation is a near guarantee of competition within domestic markets.

All of this, of course, raises a very fundamental question: By eliminating the number of competitors, is consolidation also reducing competition? Let me give you an aluminum-specific example. In our industry, intended mergers have recently been announced between the world's largest aluminum company (Alcoa) and the world's number three aluminum company (Reynolds). At the same time, the world's second largest aluminum company, Alcan, has announced its intention to merge with the world's number four aluminum company, Pechiney, and another large competitor, Alusuisse. Calculate Alcoa and Reynolds' primary aluminum capacity in North America and you'll find that together they would control forty-seven percent of it — a frightening figure from an anti-competitive perspective.

Primary aluminum is a global commodity that is priced twice-a-day on the London Metal Exchange. The combined share of Alcoa and Reynolds is a smaller and more tolerant nineteen percent. Let's look at some effects of this consolidation. First, there is tremendous emphasis on scalability, which forces the second and third tier suppliers into consolidation - a trend that is especially visible in the auto industry, and, for that matter, in the aluminum industry too. Second, with the marketplace filled with deep-pocketed, technology-rich competitors, we can expect a quickening pace of improvement and pressure to raise product quality and service. Third, is the issue of trade. As industry fragmentation gives way to global consolidation, economic interdependence grows and free-trade zones thrive. The "sucking sound" predicted by Ross Perot for the NAFTA treaty has turned out to really be the energetic hum of economic progress on both sides of our southern border. With the evident economic strength, particularly in employment, in Mexico and the U. S. since the signing of the NAFTA, we have

learned that free and fair trade is not a zero-sum game.

However, that is not to say that there aren't victims in this process of free trade. While total jobs in the U. S. have grown and jobs in high tech and service have exploded, jobs in textiles, steel, and other more basic industries have disappeared. Steel companies in West Virginia, for instance, have been heavily punished by imports. Is this fair? No. Is it an inevitable reality? Probably.

What is the government's role as this shakes out?

First is to help the victims. Second is to make this transition process as slow and gradual as possible. That may mean providing some limited protection to threatened industries and offering incentives to improve their global position, if possible. Third, and maybe more philosophically, government must look, at least to some degree, at industries needed to maintain some level of self-sufficiency for national security -- even though it appears to be a relatively friendly world at present.

I don't think Americans are ready to accept an America without the capability to produce steel, aluminum, chemicals, and wood products. Globalization and consolidation should also heavily impact the agenda of our universities by increasing demand for global minded managers. In today's job market the global perspective that you carry is more valuable than the passport you carry. Bottom line, I believe globalization will produce tougher and tougher competition, and more satisfied, if not more demanding, customers. I strongly believe that we will continue to face a tougher and more competitive business environment with the "bar being raised higher and faster" on quality, delivery, and cost. In turn, this will lead to many changes and innovations that could not have been imagined 10 years ago. Let me give you one example pertaining to relationships between customers and suppliers and among multiple suppliers to a single customer.

Boeing, a big-time buyer of aluminum, recently told suppliers that it will establish more partnerships with them for mutual prosperity. Boeing wants to be the preferred customer to suppliers that embrace new partnerships in which the goal is cost reduction that leads to price reduction. Boeing will set performance expectations and provide accurate, realistic, and timely design requirements. Suppliers will be expected to deliver fewer parts and more assemblies. Suppliers will be asked to work with Boeing and other suppliers to deliver high-level assemblies. For instance, an effort on the 777 landing gear reduced the number of parts Boeing handled from 1,850 to three. Now that's a new way to do business.

How does global consolidation relate to Century and West Virginia?

To answer that, I would like to discuss how it is impacting Century, what the effects might be, and how relatively small players like Century can navigate this tidal wave of mergers and acquisitions. I think my thoughts apply to all of you because we are all in the same competitive boat. First, let's look at what is propelling this consolidation. Many commodities are in ample supply or even over-supply. This puts downward pressure on prices. Sound familiar? All metals, including aluminum, are recent examples. A number of factors are promoting

oversupply and increasing capacity. One is the application of new technology to existing facilities. This adds incremental capacity at a relatively modest cost. For instance, Century has added about 2.5 million pounds per year to our primary capacity since taking over management of the Ravenswood plant in 1993. Industry wide, we estimate that about 350,000 metric tons of world primary aluminum capacity will be added in the next several years through this so-called capacity creep. 350,000 metric tons happens to be equivalent to the output of two more plants the size of the Ravenswood plant.

Another factor promoting over capacity is the proportionately high ratio of fixed costs to truly variable costs for the production of many metals including aluminum. In aluminum, for example, cost savings from cutting production are quite low. This means that even with relatively low aluminum prices a smelter loses less money by operating at unnecessary capacity than by shutting that capacity down. Also promoting consolidation are the large blocks of government controlled capacity that are being privatized. The best current example is in Venezuela where the government is attempting to privatize its 630,000 tons of primary aluminum capacity. Talk about potential for improving efficiency. I have visited these plants. The staffing levels in them are about triple those in a typical U. S. aluminum plant. In the decade of the 1990s alone, governments in the Soviet Union, France, Spain, Italy, Australia, and Venezuela have privatized or are planning to privatize nearly five million metric tons of primary aluminum capacity, or nearly a quarter of the world's total output.

Also applying consolidation pressure, as I mentioned before, is the unyielding pressure to grow earnings and to create shareholder value. In this environment of oversupply, prices come under pressure and profit margins tend to fall. In turn, producers focus on cutting costs to protect margins, making consolidation and the elimination of duplicate costs an extremely attractive proposition. In aluminum, this global economic metamorphosis is expected to create through mergers over the next six months two $20-billion-a-year companies that together will control about forty percent of the world's primary aluminum capacity.

So consolidation in aluminum, and presumably most other industries, is inevitable as industries

- Synergize to reduce costs
- Balance production capabilities
- Attempt to develop better access to world markets, to reduce shipping costs respond to customers that demand that their suppliers have global reach

Consolidation helps quench the thirst for corporate expansion and earnings growth, and finally is being facilitated by technology. What will be the effects on the consumer? Or, more specifically, what will be the effect on aluminum prices? There is inevitable concern about prices shifting higher when there are fewer players in any industry. But in the environment that I have attempted to describe, where market shares must logically be viewed globally, does it sound like a less competitive world to you? It sure doesn't feel like it to me so far. Longer term, our view is that lower costs from efficiencies and technical leverage will actually accelerate the trend to lower real prices, and maybe there will be less commodity price volatility as larger producers make more "responsible" capacity decisions. After all, the long-

term price behavior of any commodity is based on the price at which new production capacity yields an acceptable return.

Real prices for primary aluminum, stated in 1998 dollars, have actually fallen in the past twenty years from about $1.00 a pound in 1978 to about $0.70 a pound in 1999 as technology and efficiency have allowed new capacity to be justified at lower prices for the metal. Incidentally, before 1886, when today's processes for making primary aluminum were discovered, aluminum was a precious metal prized for its potential to lightweight the armies of Western Europe. And the Washington Monument, built in 1884, is capped with a block of aluminum supplied by Tiffany's. Beyond pricing, what might this aggregation of metal control mean to Century or to any enterprise in the midst of this global corporate urge to merge? The first is painfully obvious. We must control costs. No, I think it is better said that we must be obsessed with cost control. In fact, the other day our site manager at Ravenswood asked our technical manager, Ric Love, who is here today, for Ric's input on a complex metal issue. Ric said that he would start work on the problem as soon as he could get the company pencil from the other guy who was using it.

Seriously, we have to take every single advantage and opportunity that we can, and programs such as Industries of the Future are critical to all of us. At Ravenswood we are working on two IOF projects to improve efficiencies in our reduction plant. The first involves the addition of boron oxide to the carbon lining of the production cells. This can improve cell life, reduce energy consumption and make the process more environmentally friendly. Cost savings could be as much as $5,000 per cell per year. At Ravenswood, that would represent total savings of $3.3 million a year. The second project, which was recently approved, will examine the use of expert computer systems and artificial intelligence to improve the operational efficiencies of the reduction cells. Our participation in projects using innovative technology is not new, however. In 1993 we were presented with a demand from the West Virginia DEP to change the way we dispose of waste water and oil emulsion.

Who did we call? We called WVU . . .

Together our engineers and their experts and students searched for the best technology to dispose of the waste oil. They helped us select the optimum system, designed it, implemented it, and operated it. Our state-of-the-art plant for processing waste oil emulsions is now the benchmark for the industry. One of the great lessons of that experience, though, was learning not to argue with an engineer. Arguing with an engineer is a lot like mud wrestling a pig. After a few minutes you find out that he actually likes it! Beyond cost control, we absolutely must maintain, in fact, increase our dialogue with all levels of government, both as individual companies and in concert with others. This is my key point today. We must insure that we are competing efficiently and fairly with our off-shore and out-of-state competitors.

Specifically, we must deal with our governments to remove unnecessary cost burdens that make doing business inefficient and uncompetitive. Here's an example. Worker Compensation costs in West Virginia are the highest in the U. S. They average $893 per year per worker, versus a national average of $378. This is a serious competitive disadvantage for our plant against competitors that are often below the national average. The West Virginia

Worker Comp system must be fixed so that costs don't disadvantage West Virginia business. Second, we need to deal with our governments to insure that our business playing field is level. For example, primary aluminum may be imported into the U. S. from anywhere in the world duty free. However, if we wanted to export our primary aluminum to Europe, it would be subject to a 6% tariff. Another example of a non-level playing field is the Kyoto Global Climate Treaty. It imposes strict limits on carbon dioxide and other greenhouse gas emissions in North America, Europe, and other developed regions, while excusing so-called developing nations.

According to Argonne Labs, here are the possible dire consequences for a treaty that promises no overall reduction in greenhouse gases, and only shifts the sources of them from one part of the world to another:

- Twenty to thirty percent of the U. S. chemical industry will move to developing countries within fifteen or twenty years.
- All U. S. primary aluminum smelters will close by 2010.
- A thirty percent decline in the number of steel producers at a cost of 100,000 jobs.
- Domestic paper production will be displaced by imports.
- Petroleum refinery output will be reduced by twenty percent.
- Twenty-three to thirty-five percent of cement industry facilities will close. This is significant because many cement plants are major employers in small communities.

Simply put, new rules, taxes, and regulations have to balance the benefits with the costs. This balance must be based on scientific assessments of the costs and benefits. Beyond cost control, we must innovate and we must manage smarter. We must use every advantage we can get.

I mentioned Century's participation in the Industry of the Future program and with WVU. I would also like to mention the role Touchstone Laboratories, based near Wheeling, played in Century's rolling business at Ravenswood. Touchstone provided a technological jump-start to our own talented people at Ravenswood to enable us to develop a market-niche strategy in our rolling business. As mentioned earlier, Century stopped producing the low-value-added, highly competitive product of can sheet that had ten to fifteen desperate competitors. We migrated toward higher value-added, technologically demanding transportation products, such as heat-treated plate for aircraft and brazing sheet for making radiators for cars and trucks.

Beyond managing smarter, we need a clear and realistic corporate strategy. If you weigh 98 pounds, it is probably smarter to challenge Mike Tyson to a game of chess than to an ear-biting contest. In terms of strategy, Century intends to be a competitive player in primary aluminum business – a business with many big and deep-pocketed players. How can we compete in this arena? First of all the technology is mature. This means that no huge investments are required in technology to provide the customer with a product that he wants.

We enjoy very low corporate overhead. We understand the market dynamics. And we believe that the mid- to long-term fundamentals for primary aluminum are very positive based on growing world demand and limited amounts of new capacity coming on stream.

Let me now try to wrap up this rambling dissertation. By the way I can blame David Hardesty and Woodrow Wilson for my ramblings. That's because Wilson once was asked how long it took him to write a speech. He said, "That depends. If I am to speak ten minutes, then I need a week to write it. If it's fifteen minutes, I need three days. If it's a half-hour, two days. If it's an hour, I am ready now." Well, Dave asked me to speak for up to an hour. Seriously, I think my message and my views are that we are entering a truly golden age.

- Many people on our planet are being freed from age-old tyrannies.
- People are tasting informational and entertainment freedoms from sources as narrow and personal as the Internet and as broad and universal as CNN and MTV.
- With these freedoms comes economic freedom – freedom to expect improvements in education, health care, infrastructure, nutrition, housing, and quality of life.
- Each of these needs and desires represents a direct or indirect market demand for business – your business, my business.
- The consolidation of businesses occurring to fill these demands is formidable, but the market potential is still more formidable.
- Consider this: Per capita consumption of aluminum in the world is a little more than eight pounds per person, versus seventy-five pounds per person in the U.S.

If global consumption grows to only one third the rate in the U.S., the world's aluminum capacity would have to triple. That's like adding 200 more Ravenswood smelters!

And there's a direct correlation between aluminum consumption and the maturity and wealth of a nation's economy. As living standards in underdeveloped countries improve, so will the fortunes of those of us who survive in the aluminum business. I'm sure other commodities and products have similar opportunities. Even though growth of this magnitude is unlikely in your industry and mine any time soon, the fact remains that unfilled demand for goods and services in the world is enormous and growing larger. It has the potential of fueling an unprecedented period of economic expansion and prosperity for most of the world's population. The challenges for business, education, and government are to

- Understand the increasingly competitive and global nature of business — particularly industry
- Ensure that we work together within our state, region of operation and country to create an environment in which our businesses can compete "toe-to-toe" with the best in the world.

Someone will be around to service and profit from the exploding demand growth of developing nations. Let's be sure that it's us.

Thank you.

IOF-WV Industry Sector Caucuses

Charge to Breakout Groups

Karen Price, President, West Virginia Manufacturers Association

It's good to be here this morning and to be able to tell you that manufacturing is up in West Virginia. That's something that I'm very pleased about, because manufacturing is a major force that drives the economy of West Virginia.

The work that you're doing here is extremely important. You've heard from Mr. Meyers of Century Aluminum about some projects they're undertaking, and I know that steel is doing some things, as is the Polymer Alliance Zone. These are, I hope, leapfrogging West Virginia not only over other states but over other countries in the world. I think it's time that we recognize that we are perhaps in a crisis and we have to think globally. We used to talk about competing with other states in the Southeast. We don't do that any more. We are part of the global economy, and we need to let the world know who we in West Virginia really are. I would like for other states and other countries in the future to look to West Virginia and our companies for what we're doing in technology and information systems.

I am reading a book right now called The Lexus and the Olive Tree, and it's a very good book about globalization. I'll just give you one brief quote. "Globalization is not a phenomenon and not just a passing trend. It is the international system that replaces the Cold War system. It is the integration of capital, technology, and information across national borders that has created a single global market, and to some degree, a global village. The symbol of the Cold War was a wall which divided everyone; the symbol of globalization systems is www, which unites everyone."

Albert Einstein said, "Imagination is more important than knowledge." Knowledge is limited, but imagination circles the world. And I think that's what we've got to do here today. The charge to you is not to say, "I don't think that can be done." Rather go forward and try new imaginative things, think out of the box!

I will leave you with one last thought. "Imagination has brought mankind through the Dark Ages to the present state of civilization. Imagination led Columbus to discover America; imagination led Franklin to discover electricity. Imagination has given us the steam engine, the telephone, the talking machine, and the automobile. These things had to be dreamed of before they became reality. So I believe that dreams, daydreams, you know, with your eyes wide open and your brain machinery whizzing, are likely to lead to the betterment of the world. The imaginative child will become the imaginative man or woman who is most apt to invent, and therefore to foster civilization." L. Frank Baum said that in The Wizard of Oz. I charge you to go out today and let your imaginations run wild.

Thank you very much.

IOF-WV Industry Sector Updates

Session Chair: Fred Cutlip, Director, Community Development, West Virginia Development Office

Aluminum Industry Update

Ric Love, Technical Manager, Century Aluminum of West Virginia

There's been a continuous increase in the amount of funding through the national IOF program to the aluminum industry, and West Virginia has done a fairly good job over the past three years of picking up a share of that. The national aluminum IOF program will have a budget of a little over $11 million if everything gets approved next year. This is not a lot in the total scheme, but it is a significant amount for making progress on our highest-priority needs.

Recently, there has been a lot of activity in the aluminum IOF program, including inert anode road maps and automotive applications road maps. All of this is made possible through the assistance of OIT. The Science and Engineering Center for Aluminum Technology at the University of Kentucky has been established with a budget of $8 million. The Northwest Regional Aluminum Alliance is promoting applications for aluminum interests. The aluminum industry road map will be updated in 2000, and we're working with the Aluminum Association on putting together a joint meeting with the ceramics group.

There are some OIT funding activities going on inside West Virginia, but one thing you notice is there's a fairly small group involved, and that was our concern this morning. If the IOF-WV aluminum industry group is to be effective, we've got to find ways to include other companies, smaller companies that are not present here today. How do we do that? We decided that we would have a meeting in January, and we have a few people who have volunteered to work on a committee with the objective to try to start interacting with some of the smaller companies and bringing benefits that are available in the OIT program. A lot of things developed through OIT programs could be very beneficial to smaller companies that may not have the funding, the background, or the knowledge of opportunities in the IOF program.

We have a working group of about five or six people representing diverse interests — the university, the government, Century, and other businesses such as Touchstone Labs. We will focus on expanding the West Virginia aluminum interest group and on continuing to add value to West Virginia's aluminum industry. Century cannot complain about what has come out of these meetings. We recently announced a $2.3 million cooperative agreement that was the direct result of people meeting through IOF-WV and creating the partnerships. We want to find ways to open up those opportunities to more people in West Virginia, and that's our main purpose for the January meeting.

One thing that we didn't get a chance to discuss, but I want to mention because it is on my personal agenda, is the educational process. When I look out at this group and recognize the wide range of interests and companies, I think we've got a major cross-cutting concern. As an overall group, how do we generate the people capable of doing the things that we're working so hard to develop? That's a major challenge, and IOF-WV might be a good forum from which to work on these concerns.

Steel Industry Update

Howard Snyder, Manager, Corporate Total Quality & Compressible Costs, Weirton Steel

Scott Richlen (right) was one of several U.S. DOE Office of Industrial Technologies team leaders participating in the symposium. (WVU photo by Rita Beaty)

I want to briefly cover the five projects developed last year. The first was hot-dipped galvanized pot equipment. The purpose was to develop materials for improved corrosion resistance. The galvanized pot contains 140 tons of molten metal at about 890 degrees. It has an assortment of rollers, bearings, and blushings, and we have continuous maintenance nightmares with them. In the last year people have experimented a lot with stellite. It's probably tripled the life of the bath equipment, but we're trying to take it to the next step. We submitted a proposal to the DOE, but it wasn't granted. We have to make revisions — document the energy savings and address environmental issues. We would like to see some revisions to the steel industry road map and will be working with the AISI on that one. Our next step is to have a workshop in February of 2000 with all the manufacturers of galvanized steel. There are over 50 producers of galvanized produts out there, and we want to include them all on the next proposal. The first proposal was just for the West Virginia steel producers.

The second project shape-casting technology. Tim Duke and Steel of West Virginia basically developed that at their own expense, but right now it's not in production due to business issues. But that process is developed and we're considering that project complete.

The third project is non-chromium treatment to prevent formation of rust on hot-dipped steels. Every galvanized producer currently uses chrome passivation to prevent rust during transit until the steel gets to the customer. Right now most producers use a valence-6 chrome, it provides the best protection but it's potentially an environmental issue. Some current galvanizers use a non-chrome product and the results are acceptable, but it's definitely not as good as a chrome-based product. So we're going to continue work on this one.

The next topic was to hold a workshop for steel industry energy teams. This has not been held yet, but we had some good discussion the last day and a half here. There are Energy Matters, Steam Challenge, Motor Challenge, energy audits by the DOE, and energy assessments by WVU. I don't think the steel industry uses these opportunities very effectively. Every steel company has an energy program, since energy is upwards of 30-40 percent of our cost per ton of steel produced. We've discussed these programs with Scott Richlen and we're trying to get some things going with assessments and audits.

Next is a workshop on process control sensors. A galvanic temperature measurement sensor was implemented at Weirton Steel. That project is basically complete, but there are some modifications that need to be made.

Glass Industry Update

Tom Fenton, Vice President, Fenton Art Glass

The glass industry committee had a good meeting. In West Virginia, we have an active glass industry group, which has been in place for several years. It includes the West Virginia Development Office, West Virginia University engineering, members of the Society for Glass Science and Practices, which is primarily a group of hand-glass manufacturers and other glass manufacturing interests.

We have four projects currently in place, three of them very active, and I'd like to give you a summation of where we are on each. First, we have the laser cutting project, which is being funded, and we're looking forward to a second year of funding. This is a piece of equipment which is being worked on by Steve Woodruff at FETC's lab in Morgantown in collaboration with WVU doctoral engineering students, Pilgrim Glass, Fenton Glass and Davis-Lynch Glass. This project is going well. Mr. Woodruff has brought us up to date. He's to the point where he now needs a more powerful laser than the one he started with. We have very thick things as well as thin things to cut, so he has his next steps planned out and he's awaiting funding for next year. The laser cutting machine will be demonstrated in the lobby later today.

A second project that has been very active, led by Fred Kang at West Virginia University, is the simulation of combustion atmosphere inside a glass melting furnace. And he is adapting software to better predict what someone might expect in a particular furnace in a particular situation. I believe much of that software and research has been developed for larger, more continuous operation furnaces, and this one is being adapted for batch-type furnaces.

We have not been as directly involved with the third project. Ray Dalton, a member of our committee, has organized a company to reprocess and reuse the waste cuttings from fiberglass plants. I think we have three fiberglass plants in West Virginia. Ray is now in the process of starting up a business to make useful products from the fiberglass waste. We also learned that another member of our committee is involved in a national-level effort with several fiberglass companies to work on the same problem. Ray credits the IOF-WV glass industry group as having been a good opportunity for networking and helping him move his endeavor along. I'm hoping that his research and his accomplishments can also be used on a national level to try to solve the same problem.

The fourth item is refractory materials. Most people know the performance of refractory materials is a big issue in glass and other industries. We're formulating a project on this topic at the West Virginia level. The next IOF-WV glass industry group meeting is April 26, 2000.

Chemical/Polymer Industry Update

Charles Sobrero, Lab Director & Technology Manager, DuPont Washington Works

I am relatively new to West Virginia and to the IOF-WV process. My predecessor at DuPont, and the previous DuPont representative to IOF-WV was Bob Cook. I think some of you know and work with Bob. The good thing is, it leads to very interesting job assignments. The down side is that we lose continuity in forums like this, so this symposium has been an exciting learning experience for me.

Most of what I'm going to talk about this morning is a bit different from what we've heard so far, in the sense that the chemical and polymer sector hasn't had an OIT-funded proposal yet. What I'll talk about this morning is work in progress aimed at putting some proposals together.

I can certainly relate to the challenges facing industry that we have heard about this morning. There are two areas receiving a lot of attention right now. One is zero discharge to the environment, a big topic for the chemical and polymer industry, and the other is energy conservation, which is also a significant issue for us.

Just to give you an idea of the sort of environment we're working in, DuPont is a huge consumer of energy. A DuPont corporate vice president a few months ago in a talk to the Pew Center articulated some new goals that we have in the corporation around energy. One of the goals is to reduce the atmospheric emissions of global warming gases as defined by the Kyoto protocol by 65% from 1990 levels. The other challenge is to keep the total use of energy flat as we continue to grow our business. The third challenge is to source 10% of our energy use from renewable resources. So that gives you some idea of the environment that we're operating in and the challenges we face.

A particular proposal that we're putting together is aimed at waste elimination in our operation here in West Virginia, in our Parkersburg plant, which is actually in Washington, W.Va. We landfill several million pounds of waste polymer each year coming out of that site. Back in 1991, when we started looking at waste reduction at that facility, we were actually putting over 15 million pounds of polymer waste in landfills every year. The material just couldn't be sold because it was contaminated and mixed with other things. Over the years, we've been able to hack away at that, and we're now down to the last few million pounds. So we've done all the easy things, or relatively easy things, and are now facing some fairly tough challenges.

The particular waste material that I'm describing here comes from transitioning from making one type of polymer to another type. You go through a transition period where you start with 100% of A and end with 100% of B, but in between you've gone through this period where you've made a mixture of things. Separation is one of the key things that are being looked at to help turn that transition material into usable materials.

The most obvious advantage is landfill reduction, but there are significant energy savings also. We put a lot of energy into making this material, and now we're just junking it. If we can separate and recover the polymers, I see some demand for them.

This work is in partnership with some other folks. Argonne National Lab actually developed the separation technology that's being looked at. It's something that's familiar to anyone who knows the flotation technology for ore enrichment. We take the polymer mixture, grind it up very finely, and then use density or surface characteristics to do physical separation of the polymer stream. West Virginia University has been very active. We're working with Rakesh Gupta at WVU to help characterize the products from the separation process. The Polymer Alliance Zone is looking at how to scale up the process, and we at DuPont have been basically supplying the junk polymers mix, the raw material that needs to be recycled, but also looking at how to use what comes out of the process for commercial use.

That's the basis of one of the proposals that we hope to submit to OIT. DuPont itself has been fairly active with OIT, but not here in West Virginia. We are involved with a number of OIT-funded programs through the national IOF program.

Before our breakout, Karen Price very energetically charged us to be imaginative and broaden our thinking, but frankly we had a little bit of a tough time doing that in just a 30-minute period. Certainly the whole concept of zero-discharge is one that we do want to pursue. A lot of advances have been made over the years, but we're a considerable distance from achieving the zero-discharge vision.

We also talked about treatment of dilute aqueous waste streams, another common characteristic of chemical and polymer industries. Another topic is "smart" materials – the development of new materials that are not just inert, but that actually react to changes in the environment. We talked about advanced extruder technology. We do a lot of that in the plastics industry, and that technology is one where there's ground for improvement.

These are some of the ideas we're working on, and I hope that next year when we're back here again we can talk about some of the great programs that we have with the IOF program.

Wood/Forest Products Industry Update

Joe McNeel, Director, Division of Forestry, West Virginia University

I'm fairly new at WVU, and this is my first year to be involved with Industries of the Future. During that year, we have been working with the West Virginia wood industry, the OIT, and the USDA Division of Forestry to assess R&D opportunities for hardwoods and solid wood products in the IOF program.

In fact, just yesterday we had a short workshop that reviewed the funding structure that exists within DOE to see how the hardwood industry can be better incorporated. We hope to continue these efforts, and I think the workshop yesterday provided a number of good insights for our hardwood industry on mechanisms for future opportunities through the IOF program.

We do have Agenda 2020 in place, and it identifies six areas of focus that IOF is working with through the American Forestry and Paper Association. These include sustainable forestry, environmental performance, energy performance, capital effectiveness, recycling, and sensors and controls. I'm going to briefly go over some project areas that we think are opportunities for us in the next couple of years.

In sustainable forestry, we see some real potential for improved growth and quality issues within West Virginia's hardwood forests, such as improvement of soil productivity for our forest soils. In terms of energy performance, we need better boiler efficiency in mills, wood gasification improvements, co-generation for complete utilization of wood waste – which already exists in the state, but we'd like to see improvements, primarily the reduction of electrical demands by various mills.

We're also looking at pellet fuel manufacturing for utilization of green sawdust. Lori Hamer of Hamer Lumber said there are four mills in West Virginia that are putting these

pelletized wood fuel products into the market. Pellets and other forms of wood wastes are renewable fuels that can be used for co-firing with coal.

Sensors and controls is another area where we see a tremendous interest by industry. Log-scanning technology has not yet reached the hardwood industry or the pine industry that much, but we're hoping to develop some projects on this particular topic that we can get funded through DOE. Lumber scanning technology has been introduced, but grading is still a significant hurdle for us.

We have seen scanner technology in the form of an edger-optimizer introduced into two mills in the state. It seems to increase yields – i.e., revenues – about five to ten percent. We think there are tremendous opportunities for industry-sponsored research through crosscut technology funding with DOE on this. We'd like to see it pushed further into trim-saw scanning and grading using video.

Finally, there is an interest in a non-destructive testing study to determine engineering characteristics of existing structures such as bridges. Dick Bowlby with Burke-Parsons-Bowlby is one of our industry experts on that topic.

Environmental performance – yesterday we visited a Weyerhaeuser-engineered wood products mill with Valri Robinson of the OIT and several other workshop participants. One of the topics that came up was volatile organic compounds and how the engineered wood-products mills in some parts of the state do have problems with VOC emissions. We think there are opportunities for us to start looking at environmental performance issues under Agenda 2020.

Our present focus falls into four categories. We'll go over those very briefly.

We have a funded project to develop a thinner saw blade that dissipates built-up heat energy better than existing systems. The potential for improvements in the industry using this technique is really tremendous. Many mills still use conventional surface saws. We feel that as soon as the technology is proven in testing and is competitively priced, we will see many mills adopt this new technology.

Another project area is geographic information systems. Remote sensing is one of AF&PA's major research pathway areas within sustainable forestry. We feel that many forest products companies in West Virginia do need to adopt this technology at some level. West Virginia University will continue to work with IOF to promote research funding for application of GIS in the hardwoods industry.

At lunch today, a number of companies indicated that they need to improve the safety of harvesting timber. We have a worker's compensation rate of about $46 per hundred dollars of wages. It holds the industry down substantially, and we are working a couple of different options. Increased mechanization is an alternative approach; also, more safety training, such as the West Virginia Forestry Association's Logger Safety Initiative, will help reduce rates. We hope there will be funding opportunities through the Capital Effectiveness pathway of AF&PA.

In conclusion, the hardwood industry must make a greater effort to develop research

opportunities with AF&PA and the DOE. We think there are many opportunities and we've just begun to scratch the surface with IOF.

Metal Casting Industry Update

Industry Representative: Pat Minehardt, General Manager, HK Casting Inc.

I have been a foundryman for forty-two years, and for thirty of those years I've been married to Lou here who is also a foundryman. We're very excited to be part of IOF-WV and to help the metal casting industry get organized, as were the other participants in our meeting this morning.

The metal casting group is a bit behind the other groups, because we formed a little over a year ago. We have a small but active meeting on a monthly basis, currently at WVU. We're a very diverse group, with brass, bronze, and ductile iron as the metals produced, as well as three different methods of casting, which are sand casting, investment casting, and centripedal casting. Each of these methods and each of the metals has its own needs and problems. But we have found areas where we could join forces to make a difference.

One problem facing some of us is the need to find beneficial ways to reuse the excess spent foundry sand currently going into regulated landfills. Such a beneficial reuse is not permitted in West Virginia. We are greatly encouraged by me§etings that we were able to hold at WVU that were attended by senior members of the West Virginia Legislature, the governor's administration, University officials, DOE representatives, and members of the West Virginia Development Office. We received their commitment to getting regulations in West Virginia comparable to what is being done in other states to use that material in a beneficial use.

WVU President David C. Hardesty Jr. and Professor Robert Creese of the WVU Department of Industrial and Management Systems Engineering discuss the IOF–WV program during the break-out session. (WVU photo by Rita Beaty)

One such reuse is in flowable fill as part of a slurry of cement and water to fill service line trenches where water and sewer lines are being installed. Some Ohio counties will only use that material, since they've determined the advantages that it makes possible. It's solid but flowable fill that can be easily cut out if repair or replacement should be done. In our small operation, this will have a great impact, as it will with other companies that are using sand in the molding process. We're all facing increased landfill fees above what we already

spend, so this project has an urgent timeline. Finding suitable reuses means money can be spent to expand our businesses and create jobs, not to mention avoiding putting material in landfills that really doesn't need to be there.

Our group has explored how we might be able to join as a unit to increase our purchasing power so we could obtain better rates on raw material purchases, freight rates, and other supplies. In some areas, we're also exploring a joint marketing and sales effort. None of us in this organization compete with each other in the market. We have different products, and we do find that many customers have multiple needs for casting.

A problem that was identified by one of the non-ferrous companies in our group is to find a more suitable mold coating material. One of the most significant costs in metal casting is the cost of energy to process the molten metal. Thus, maximizing the yield from a batch and reducing the cost of heat energy is very critical to staying competitive in the worldwide market that we have to sell in. We have increased that yield in our foundry with specialized filtration methods that increase the good products up to twenty percent over conventional molting methods.

The metal casting group will continue to monitor the exciting development of carbon foam technology. We think it will have an application in the foundry industry, we're just not yet sure how. The IOF-WV program gives us – who are all small companies, some very small – a forum to find solutions that would be difficult or impossible to address as individuals. We value that participation.

Thank You.

Carbon Foam Commercialization Update

Libby Kraftician, CEO, Touchstone Research Laboratories, Ltd.

I am Libby Kraftician, CEO of Touchstone Research Labs. I would like to take a moment to introduce our company to you. We are located just off I-70 outside of Wheeling, W.Va., and occupy two buildings in the Millennium Center. The first one looks like a Stealth bomber, and we have a third of the next building. We are anticipating expanding by another third this year in order to build a manufacturing facility. We've been described by the Small Business Association and by 3M, with whom we worked for several years, as a fast turnaround, efficient facility. We work hard to keep that reputation with our customers and our project partners. We're here by invitation of Carl Irwin to talk about an agreement we signed at last year's IOF-WV symposium to begin to commercialize carbon foam technology developed at WVU.

Carbon foam has some amazing properties. I also have a small piece of carbon foam to circulate. It has outstanding compressive strength, and it weighs about the same as a Styrofoam cup. We're hoping that it will become very inexpensive – possibly in the realm of the cost of plywood for 4' x 8' sheets. It also doesn't burn – it just kind of graphitizes on the edges. And it's stealthy material – radar doesn't pick it up.

As part of our efforts, we work with potential end users to decide what their potential needs are. We then determine what their criteria are so that we can match the material

specifications. We're also looking at the potential market size. We're working with aerospace companies, shipbuilding companies, and even construction industries for applications of carbon foam materials.

Carbon foam can be made from coal-based precursors. A larger coal extraction unit to make the slurry precursor material has recently been built at WVU. At this point, they're able to make around ten pounds of precursor per day. Besides carbon foam, there are other products that can be made from the precursor: fibers, specialty graphites, binder pitches, etc.

We have electron microscopes, mechanical testing, fatigue testing, and parts of chemical analysis laboratories devoted to the development of this material. We're going to be adding some other pieces of equipment very shortly. We are putting in place a foamer, which will be activated in 60 days, and we should then be able to start making 2 foot by 3 foot panels of this material. That material then would be used for engineering samples to be passed out to end users for them to do their own testing.

This covers some of our work with carbon foams. We are looking forward to a bright future for the WVU/Touchstone partnership.

Mining Industry Update

Syd Peng, Chair & C.T. Holland Professor, WVU Mining Engineering

The Industries of the Future mining program is in its second year. This program focuses on projects that apply not only to coal but also to hard rock, salt, industrial minerals, etc. The selection process goes through two steps. One is a technical panel review, which includes university professors, coal and hard rock operators, and equipment manufacturers. The second level is more or less policy and program priorities. In the first year, all the proposals were submitted through national laboratories.

There were 26 proposals submitted, and eight were awarded in the $2 million program. We at mining engineering in the College of Mineral and Energy Resource got one. In fact, I am the co-principal investigator.

The title of our project is "Characterization of Geologic Anomaly Ahead of Mining." The technology actually is not new. Storrar Horizon in New Mexico developed it. The idea is to send radio waves through the rock. The intensity is attenuated, so maybe we can figure out what type of rock or coal or mineral is there. It is a radio tomography technology. We will do the analysis of all that data. The actual experiments will be conducted at Consol Energy 84 mine in Pennsylvania and at a copper mine in Utah.

The funding requested for 2000 is $3 million. As of the deadline – August 9, 1999 – 62 proposals had been submitted. Now they are in the proposal evaluation stage, and their target date for awards is early 2000. We have two proposals to work with in characterization title, but we work with Fletcher, Rupolder in Huntington and also companies in Colorado, Ohio and West Virginia.

Symposium Luncheon Address

Cecil H. Underwood, Governor, West Virginia

Introduction:

Sam Tully, Chief Technology Officer, Governor's Office of Technology

It is my great pleasure this afternoon to introduce the Governor of West Virginia. He is an individual whose career has very much been characterized by honesty, integrity, and dedication. He said that it is more important for the people of West Virginia to hear what they need to hear, and not what they may want to hear. He said that West Virginia needs better government, not bigger government. He said that creating and maintaining jobs in West Virginia is a top priority because employment fuels the economic engine that drives the education infrastructure. He has also said that he will be wherever he needs to be, do whatever he needs to do, and say whatever he needs to say to serve the best interests of the state of West Virginia. I recently asked him who he supported among the presidential candidates, and he said, "Whoever can do the most for West Virginia." I also asked him how he maintains the incredible schedule that we all know he does. He says he just does not stop.

Ladies and Gentlemen, it is my great pleasure to introduce the Governor of the great state of West Virginia, the Honorable Cecil H. Underwood.

West Virginia Governor, Cecil H. Underwood

President Hardesty, Secretary Swink, we're glad to have you back in West Virginia, and we appreciate the leadership you've given to the Industries of the Future concept. We are especially pleased with the cooperation and support you've given us here in West Virginia.

I'm sure that every speech you hear begins, "As we stand on the brink of a new millennium . . ." We are here, we have the opportunity to take stock of where we are now as a state, as a nation, and a world, and where we want to be in the coming century. And so a turning point gives us reason to focus more accurately than perhaps we would otherwise.

We know the truths of our past. We know the great successes and achievements of our scientists, of our corporate leaders. We also know that knowledge is like money. To be of value, it must be circulated. And when it's circulated, it can increase both in quantity and value. Our successes have improved medical care for millions of people beyond anything dreamed of at the beginning of this century; increased our farmers' capacity to provide foods for people around the world; developed new materials to clothe and house people in this nation and abroad. And by the way, Libby, I'm very excited about the new carbon foam material that you reported on this morning. I think that has tremendous potential for our state, and I'm delighted to see your leadership in this development.

At the same time, however, the media and certain interest groups are eager to remind us, always, of industry's shortcomings. It's become fashionable in West Virginia, as elsewhere, to

Governor Cecil H. Underwood
(WVU photo by Kathleen Cullen)

criticize industry, to complain about how it handles its workplace practices, how it refuses to be a good community citizen and how it disregards its impact on the environment. A new day is here. Those of you who are involved in the Industries of the Future program recognize that your companies' future and our state's economic future depend on conducting business in new ways.

As governor, I have the responsibility to promote the general welfare of the state. And it's an exciting challenge and one that I welcome on a daily basis. I've tried to work nonstop since 1997 to promote an environment in West Virginia that encourages investment, that encourages the expansion of our economy; an environment that will lead to a stronger, more diverse economy to weather changes in market conditions and shifts in technology.

Last June 30, in the wake of no new mining permits from Washington, a very soft coal market internationally, and new competition from western coal, we experienced an $18 million shortfall in coal severance tax from the level of collections the previous June 30, 1998. In earlier years, as tightly as we budget, an $18 million shortfall was a grave problem. Our constitution does not permit us to operate in a deficit position. And the governor has the unhappy responsibility, if tax collections fall below budget appropriations, to get the paring knife and prune across the board. I've had that experience 40 years ago, and it's not a very pleasant one. But this year our total tax collections generated a surplus of $26.5 million. And so you add the two figures together, and you have a $45 million spread. What does that tell us? It tells us that we are succeeding in diversifying our economic base, and while coal and the extractive industries will be extremely important in the future, we are not completely tied to the fortunes of the coal industry. And I think we make every effort to try to continue this diversity so that we have a more stable economic base, a more stable tax system and tax structure to support the services of government.

Your work is extremely important and essential to the future as we look in new directions. I want to see the baseline industries of West Virginia prosper and remain a part of our economy in the next century and well beyond. I'm very pleased that the U.S. Department of Energy has recognized the importance of our traditionally energy-intensive industries.

As you know, six years ago DOE began working on the Industries of the Future program. It certainly has found many enthusiastic participants here. I believe this is our third annual symposium, and it's great to see so many of you here and to see it growing and expanding.

Our energy-intensive industries have played, and continue to play, very strong roles in the economy. They are positioned to compete and succeed in the global economy if each industry takes advantage of emerging technologies that cut costs, improve efficiencies and at the same

time protect the quality of our environment. And I can think of no other state better positioned to be an environmental laboratory than West Virginia. Small in size, a long history of extraction, a long history of environmental problems caused by extraction, and now we are in a position to do research to develop new environmental technologies, to fix the problems of the past; more importantly, to prevent them in the future. It's a wide-open world market, and one that I think has great potential for the companies represented here today.

We recognize the efficient use of energy as critical in the operations of companies, especially manufacturing companies. Many of you – I'm sure more than half of you in this room today – represent private companies, the private sector. Some of you have already succeeded in changing your process to achieve greater efficiencies and cleaner production. You've heard from Century Aluminum this morning. They've made great strides, great investments in environmental control. Weirton Steel, in spite of all the problems they face, is working hard to develop and implement new technologies, cooperating with West Virginia Northern College as well as with WVU. Fenton Glass and all of the companies that made presentations this morning have explored new technologies and are always looking for ways to improve efficiency. Industries of the Future teams are working with West Virginia's chemical/ polymer companies to achieve zero discharge, another goal that means a cleaner environment and more efficient production.

The Industries of the Future program is a convenient vehicle to narrow the focus and apply it directly. I'm sure you will agree that IOF is an evolving process. It's a moving target, one that considers challenges that affect specific industries as well as the broad issues that affect our overall economy. Our development office has been involved in the program in a number of ways, including providing work force training assistance to companies that have invested in new technologies. Yours is a partnership that involves private sector companies and higher education as well as state, local, and federal agencies. And one thing that I have been extremely impressed by is the level of cooperation among all levels of government, education, and the private sector. I think it's at the highest level it has ever been in our state. And I think the success we've had in attracting new investments and creating new jobs confirms the wisdom of that approach.

Your work is forward-looking. It has many visionary aspects. A program in itself that demands cooperation and communication. When we were in Germany to open the new trade office in Munich in September, we spent a couple of days in Berlin. I was fascinated to see no evidence, ten years after the fall of the Berlin Wall, no evidence that it ever existed. One has to be told where it is, except in one isolated area. And it wasn't the power of military might that tore down the wall. It was the power of information, free-flowing information across the wall, because information does not recognize boundaries. And I can remember in 1959, forty years ago, the executive committee of the National Governors' Conference spent a month in Russia. And at that time, they were very proud, and they spoke boastfully that their number 1 goal was to wipe out completely illiteracy in all of the Soviet Union. I was asked to report to the governors' conference when I returned on the educational aspects of our visit. And I recounted that goal and made the prediction, in 1959, that if they were successful in wiping out illiteracy they would succeed in the downfall of communism, because the two cannot exist in the same environment. An educated public will overthrow communism, and I think we've lived to see that happen.

And so information, free-flowing information, exchange of ideas, working together, is what you are doing, and that's why your work is so important to the state. In a real sense, you're writing a new script for business practices in the future, a script that recognizes business decisions today can have enormous implications for tomorrow and beyond. Business leaders are always caught in the competitive forces of bottom-line profits for their stockholders now verses investments for the long-range future that make them much safer and more profitable in the future. Those of us in political life have the same competing forces. We think in four-year cycles, and we always have to have enough success in a four-year period to be able to stay. And at the same time, we know that planning and thinking way beyond the next four years is extremely important. And I've been very impressed to see that change in thinking in the governors' conferences now as compared to 40 years ago. Every governor is focusing on balancing environmental protection with job protection and moving both along together. The states have taken leadership and the initiative in many important things, particularly in education and economic development. And that by itself forces governors and legislatures to think more long-range about the future. Your stockholders and neighbors and employees certainly will appreciate your foresight because you have rewarded or will have rewarded them with stronger companies to compete in a global economy, to sustain high levels of employment and to preserve the quality of life for employees, customers, and for the communities in which you are located.

Without question, industry always has had its share of forward-thinking executives – those who've created new products to improve the lives of people around the world. But events during the last half of this century have triggered creative thinking and generated new disciplines within industry.

It's incumbent, I think, upon government to get in step in developing public policies that recognize the emergence of new business protocols in the private sector. All of us know that the only job government creates is a government job, and we've done very well with that in West Virginia. But the public policies enacted in statutes by the Legislature, administered through the power of permitting and regulation by the executive branch of government, and the judicial review from the courts of our state all have measurable impact on job creation or the discouragement of jobs. And, therefore, government needs to be in step all of the way with public policies that encourage and support growth. We must not punish companies that are committed to making this critical transition. When you go in for a permit for a new process in your plant that's been here for a long time, there's always the tendency for the bureaucracy on the other end to say, "Well, we've never done it this way." We've got to get out of that mindset.

I believe governments surely must encourage transition wherever possible and reward those companies that have taken bold steps to ensure their futures and at the same time encourage the growth and diversification of our state economy deep into the next millennium. My administration supports the abilities of West Virginia businesses eager to embrace new cooperative approaches to problem-solving, companies that want to accomplish their important goals but in new ways that have the support of shareholders, employees and society at large.

With that in mind, I've asked our state Tax Department to review in depth the possibility of broadening our tax incentive program to include companies that make investments in their West Virginia operations as a part of the Industries of the Future program. And I'm not a wild

enthusiast about tax incentives, but I think that incentives in economic development are an important part of the program that we can offer industry. And we're very enthusiastic about going into great detail about what we can do for a prospective investor coming here. To me, it's logical that we do the same thing with companies that are taking new directions with well-established businesses already here.

I see this as one small way state government could help our baseline industries to invest in new technologies that improve productivity and improve our environment all at the same time. We want to do all we can to encourage companies to do the right thing, to invest in their own future, because their success and their future spell success for our state.

There are critics out there who will say that West Virginia is ill-prepared to diversify or to strengthen its economy. They say we're too committed and locked into the base industries, especially coal, which historically has served as a foundation of our economy. I think we've already demonstrated that we are moving out of that mold. That doesn't mean we throw away the mold; we make it better, we add to it.

We're striving to develop our work force with our work force training program. And now we have the marvelous new opportunity with the Work Force Investment Act, to be implemented by next July, 1 to combine resources at the federal and state level and to have a program that is driven by the needs of people and not by what providers have to offer. A dramatic change in direction. And we certainly want to harness and team with the federal program in our already nationally recognized work force training program and make sure that we get full advantage of those resources. We're trying to be very careful, make sure that we build a structure that is sound, that does take full advantage of these new resources and at the same time provides new training opportunities that we've never had before.

We're building more roads, developing more water and sewer systems, all of which are essential building blocks for development in the future. They all have very high priority. As we move into the twenty-first century, your commitments to finding new ways to do your business contradicts the critics who say that we're not prepared to compete in the new millennium. By participating in this critical march to the future, you've set the stage for success – for building durable companies that satisfy shareholders, customers, employees, and the communities where you operate. Your companies already have expressed your commitment to secure a solid, bright future in which company owners, employees, customers and neighbors can benefit. I'm proud to have been a part of your activity for these past three years. I believed in it three years ago and I believe in it more than ever now because I think you've made a solid promise.

I've been a strong advocate for the use of technology, an advocate for business development and economic diversification, and for collaboration rather than confrontation. And the Industries of the Future program very much reflects the commitment to those very important goals. And so for that reason, I salute you. I am eager to identify new opportunities and new challenges that you can deal with over the next year.

Thanks very much.

Showcase of Four Success Stories from the National IOF Program

Session Chair: Denise Swink, Deputy Assistant Secretary, U.S. DOE OIT

It is a wonderful pleasure to be here with you. West Virginia has really been on the forefront of all the developments that we have at the state level. The gentleman here from Louisiana is watching and Subodh Das is here from Kentucky. As Jim Quinn mentioned earlier, we have lots of states that are interested, but what you have actually accomplished is really what it is all about. Not only the investments and the accomplishments that you have made over the past few years, but the visions that you presented before lunch. Talking about where you want to go from here is really wonderful. I just want to emphasize with all of you that we have been here from the beginning with you and you can count upon us being with you all along the way.

For two reasons, first my voice, but also because I think the rest of the OIT team should have a chance to communicate with you up here, I am going to pass the microphone over, but I will tell you that I was just thrilled with the governor's announcement about the tax incentive. I just cannot wait to bring that back to the office. That is really wonderful!

I'm looking forward to the rest of the afternoon and I'll be here through dinner. I hope I get a chance to talk to everyone. I particularly thank the folks in our partnership that came to donate their time, such as Earl Beaver, Bob DeSaro, Bruce Hedman, Tim McIntyre, and Richard Brent. You're going to hear them speak this afternoon and they are happy to share some experiences. And one last thing, George Keller just received a prestigious award from the American Institute of Chemical Engineers. George, would you stand up? You have a very important person here in West Virginia that has been highly recognized by the Chemical Industry.

Symposium participants (left to right) Ric Love of Century Aluminum and Migri Prucz of WVU College of Engineering and Mineral Resources network with with Beri Fox of Marble King, Inc., and her son Michael. (WVU photo by Rita Beaty)

Case Studies of Waste Utilization in the Chemical/Polymer Industry

Earl Beaver, Practical Sustainability, Inc.

In preparing for this talk, I was asked to identify real success stories in the chemical industry from Technology Vision 2020. The vision was actually issued less than five years ago, and the road mapping sessions took place after that. Proposals were requested and funded, and then the research started. You can see that it is very hard to identify actual cases that are there. What I have done is identify real pollution prevention, real waste elimination, and real energy improvement cases that were done in parallel with the vision/roadmap process and were heavily influenced by the Industries of the Future program.

I mentioned earlier that we have a series of steps that we undertake in the IOF program which include establishing a vision for that industry. That is in fact the strategic part of the sequence. It is followed by a series of technology road maps that represent the tactics — what will be done, when, and in what order. And finally, there is an implementation phase, which is actually achieving results.

There is nothing of value in creating another binder to set on your shelf. George, I don't know what you went through when you left Union Carbide. I suspect it was very similar to what I went through when I left Monsanto. And that is through a veil of tears when you have multiple decades of work that you have got all of the binders from every conference you have ever attended and a lot of documents sitting there. It is the ones that turn into reality that really do something that count. And those are the ones that you keep and take home, right?

With the Industries of the Future Program, a whole series of workshops can be held and many can be developed. When you exam all nine of the industry areas and look at the road maps there are issues that cross-cut. There are things that are important to multiple industry sections. In fact, I am certain that the issue of separations is quite crucial, both in terms of removing the things that you don't want in there, and also getting the good out that you do want. Separation is important for everything from forest products to glass to aluminum to chemicals and is indeed a cross-cutting issue. Fresh water use, reuse, and release is crucial for all of the industries, as is energy consumption, resource consumption, modeling of processes, and sustainable development.

In many cases, sustainable development is viewed as some subset of it, whether it is environment or pollution prevention, or eco-efficiency. In fact, if you look at sustainable development, which is the entire large circle, it includes such things as social and cultural factors that we have not gotten very good at quantifying. So we find ourselves, many of us relying on this little gray circle inside here, which is pollution or waste reduction, and in some cases we are able to extend it to eco-efficiency and think about resource depletion, energy use, water use, and so forth.

There is one additional circle that I would like for you to carry away from here, and that is effectiveness. What does the product or the service that you deliver actually contribute to society? Is it worth the waste? Is it worth the resource depletion? Is it worth the toxins that are dispersed?

Now, back when we were thinking about Vision 2020 for the chemical industry, in the Monsanto company these were the original goals that pertain to pollution prevention. There was a stated goal of reducing air toxics by ninety percent within a five year period. We had enrolled as a corporation in the EPA 33-50 program to reduce releases by thirty-three percent by 1992 and fifty percent by 1995 from a database of seventeen priority materials. The corporation also adopted a voluntary program to reduce releases to all media of toxic chemicals by seventy percent, and to get off the list of bad guys all around the world.

One of the reasons that we were on the list of bad guys was that people on the outside looked at us and judged us by our public numbers. So they would take the amount of pounds of toxins that were released by the company and divide by sales revenue. The higher you were on this list, the worse you were. That makes CEOs and corporate spokespersons quite uncomfortable.

We established a whole series of projects, and many of these were put in place in parallel with the Vision 2020 process for the chemical industry. I have a series of examples to show you that match for various parts of Chemical Industry Vision 2020. In the first case, this particular material is an intermediate in the manufacture of the herbicide Roundup. The technology was developed while we were thinking about Vision 2020 road mapping exercises in the areas of Catalysis and Alternative Pathways. When this particular project was completed and implemented in commercial practice, it eliminated ten million pounds of wastes annually and reduced the use of hazardous raw materials, including hydrogen cyanide, formaldehyde, ammonia, and hydrochloric acid. One hundred and fifty people at Corporate R&D worked on it and it was installed for very modest capital.

Another example is a technology that was developed to take the waste of dibasic acid stream from a typical acid production and produce an ester from it. Eighteen million pounds a year of dibasic acid were being wasted, but for a very modest capital investment it was upgraded into a non-chlorinated paint stripper that in many cases was superior to the product that was being intentionally produced. Once again it had matches into the Vision 2020 process of catalysis and separation.

One of our more popular and publicly espoused improvements that occurred in the same time frame as Vision 2020 is the improvement in our process to produce an antioxidant that is used to make rubber tires last longer. The original process created a number of different waste streams which were quite difficult to manage. The new process eliminated seventy million pounds per year of waste, ninety-four percent of the waste that was in the original process, and it does not use chlorine.

When you look at the ways that companies have historically reduced their waste under the pressure of regulation and public scrutiny, you get sort of a sobering story. The sobering story is that much of the reduction was done in ways that we as technologists wouldn't think too much of. For example, five percent of the reduction came from finding out that it is too expensive to fix it, so you shut it down. Twenty-five percent came from trying to burn up the waste, and another eight percent from doing the same thing, but getting heat recovery. An additional thirty-five percent comes from either consolidating operations into a modern facility

or selling it to somebody else so they get to report the waste treatment. That is not very high technology. A good part of the effort that has been undertaken in the chemical industry, in terms of the Vision 2020 process, is to forge new processes or modify old processes that allow you to recover or recycle materials.

In 1993, if you looked at Monsanto's toxic relief inventory report, something would jump out and grab you. Nearly half of the waste was ammonia. In this case the ammonia was part of a very complex mixture that was going down the injection well. It was going down the injection well because it was part of a combination of salt, organics, and aqueous stream. It was relatively dilute but there was a lot of it. The company actually offered an award of a million dollars to develop solutions for these relatively dilute streams. I have to tell you that in neither case, neither the first or the second challenge, was the final technology development actually implemented. A very intractable problem, very difficult. The approach that needed to be taken was one of working together with a critical mass of people. But the focus in the million dollar challenge was to look at separations and alternative processes. This focus is right in the heart of Vision 2020.

The reason Monsanto was driven to offer one million dollar prizes to solve these problems is that once you told your employees what you were going to accomplish, they could find ways with zero capital of actually reducing the waste. Another thing I would like for you to note is that by the time you get two-thirds of the waste eliminated about sixty-six to seventy percent of it is starting to get expensive very fast. In the chemical industry today, for large volume commodity chemicals, you invest a dollar in capital for each annual pound of production of your desired product. So, when you have reduced your waste by seventy percent you are starting to pay more in capital for waste reduction than you paid in capital to produce the product in the first place.

In early 1999, a workshop chronology was laid out. To develop technologies related to separations for use in the chemical industry. The first workshop was in February 1998 and focused on membrane separation reactors and absorption. The second workshop was in May 1998 and focused of crystallization, distillation, and extraction. Those first two workshops were summarized in the summer of 1998 separations roadmap, which is available for shipping costs or off the web. We subsequently held two additional workshops, one on bioprocess separations and one on dilute solutions.

A series of projects on total cost assessment is being funded in part by the Department of Energy. For that I am quite grateful. It takes all of the environmental accounting methodologies that are available and combines the best parts of each to produce a workable tool that allows you to make the best decisions in terms of environmental stewardship, share holder value, reducing your insurance premiums, and making the correct R&D decisions.

This tool is now available. It is funded by the Department of Energy and twelve companies to lead you through the process of estimating the cost in each of those areas and to consider both the magnitude of the cost and the probability they will occur. For example, what is the expected future cost for emitting a ton of nitrous oxide or a ton of carbon dioxide? Within the model you get to select what you think the scenario is and look at your future

emissions cost. You can re-examine past pollution prevention or waste elimination projects as well as make proper choices for the future.

This total cost assessment effort that we are doing will lower corporate staff costs and provide higher curb appeal. This terminology is one of growing use in the chemical industry. It means how do you look to someone when they are at your curb. High stacks decrease your curb appeal, a plume decreases your curb appeal, an odor decreases your curb appeal, and all those things are worth something. Lessening public concern is a big issue that allows you to have greater freedom to operate. You lessen the impact on real estate values.

I really appreciate you listening to me this afternoon, especially since I am not of good voice. What I have tried to convey to you is that the Industry of the Future process is alive and well in the chemistry industry and elsewhere. Frankly, it is doing a lot of good that doesn't show on the surface. There are cross-cutting issues that are plentiful. Sustainable development is a high priority, even if it isn't necessarily spelled out. There are projects underway today to help you make the right decisions on a monetary basis as to which projects to implement. Open calls are being made for specific proposals by the Department of Energy, and funds are flowing from the OIT for research, but frankly, folks, companies that are involved in the visioning process and technology road mapping are doing projects on their own rather than necessarily waiting for the whole process to work its way out. These are some of the examples I have tried to show you today. Companies are implementing vision related projects on their own.

Thank you very much for your attention.

In-situ, Real-time Measurement of Melt Constituents & Temperatures:

A Joint Presentation by Robert DeSaro & Arel Weisberg

Robert DeSaro, President, Energy Research Company

Our talk will be on in-situ, real-time measurements of melt constituents in the various IOF industries using Laser-Induced Breakdown Spectroscopy (LIBS). The participants in this project include the U.S. DOE's Office of Industrial Technologies, Oak Ridge National Laboratory, Mississippi State University, Textron, and my company.

There has been wide industry interest in the LIBS technology, even though we're probably two or three years away from commercialization. When we first looked at the problem of identifying the constituents in a melt, we thought about using a more difficult technique, Raman scattering spectroscopy, a technology that we're also developing. I talked to industry, and they said, "Well, we don't really care about that level of detail. Just tell us what the elements are, rather than the compounds." And so that's when we changed focus to using Laser-Induced Breakdown Spectroscopy. And that one conversation probably saved us three or four man-years of effort. So the industry support and interest that we've had has been really very useful.

We also took a hard look at the industry road maps developed in the IOF program. This is like having a very high-paid consultant for free! The industries have poured out their hearts on these road maps, and looking through them, it became very clear to us what industry was really interested in. We looked very carefully at them to see where our technologies could apply.

I'd like to just very briefly discuss some of the projects that we have in the metals industry, because it does show that developing the laser technology really is applicable to a wide audience. Our vertical floatation melter project is being funded by the Department of Energy. In it we are melting scrap aluminum, but we're doing so at energies about a third of what a conventional reburn furnace can do, with metal yield pretty much equivalent to that of an electric melter. We are concluding the pilot phase at about a thousand pounds an hour and will soon be moving into a full-scale demonstration.

A technology funded by DOE as well as by NYCERTA, a New York state agency, is a dryer for a secondary aluminum smelter. This is also a very successful technology that's being deployed now full-scale. It's removing organics and things of that nature from scrap metal in a form that's energy-efficient and environmentally friendly.

A recuperator that we developed—actually, we developed coatings, along with Brookhaven National Labs, to be high-temperature corrosion resistant. With DOE and NYCERTA funding, we did a pilot-scale test and we are now in partnership with Alcoa to put a full-scale system in their plant.

I'm going to follow up at the end of the presentation to give some specific applications of

the LIBS technology, and now I'd like to turn the floor over to Arel Weisberg to talk about some of the details of LIBS.

Arel Weisberg, Program Manager, Energy Research Company

Let's start with the problem that this technology is meant to address. Essentially, the way many scrap melters now formulate an alloy in a furnace is to dump a whole lot of scrap in, and they try to modify that mixture or that recipe so that the final alloy is what they're looking for. There are a number of inefficiencies in the process that's currently being used. And this project is aiming to address those inefficiencies. For example, the first one is excessive melting times. Right now, as I said, they put a lot of different scrap into the furnace, and then with a ladle or some other instrument they remove a sample, send it out to the lab, and wait for results to come back, evaluate the mixture and then either put more scrap in or other chemicals that will change the composition of the melt. All that time is dead time, while waiting for the results to come back from the lab, and during the whole time, of course, the furnace is running, keeping the melt in its molten state. Another problem with this method is quality problems, because the spatial distribution of elements inside the melt may not be uniform. So with the ladle taking a sample from one corner of the furnace, it may not be representative of the composition in the furnace as a whole. This can be especially true when remelting glass, because of the large eddy currents that exist in glass furnaces.

The next item is wasted feedstock. Well, this basically is a trial-and-error process where you melt down the scrap and sample out, have it tested, add some more scrap, change the composition, and go through this iterative process back and forth until the right composition is achieved. This is not the most efficient way. It would be much better to put all the right ingredients in at the beginning rather than tinker with the formula later. All this results in increased energy use and emissions, and wasted products as well.

The goal of our project is to identify the elements and constituents in metal and glass melts during the alloying process – to be able to operate continuously. We'd rather not stop the alloying process in midstream. Our instrument has to be able to be inserted into the melt. It's going to evaluate the composition of the melt in multiple locations inside the furnace. It will take real time, continuous measurements, obviating the need to stop and send out samples to the lab. And of course the cost of this instrument needs to be in line with what the industry is willing to spend.

The technology we propose to use is known as LIBS, which is an acronym for Laser-Induced Breakdown Spectroscopy. This process involves taking a laser beam and tightly focusing it on the material. The result is a small vaporized amount of material that emits a plasma. This plasma emits ultraviolet light, which is collected through a lens system and passed along to a spectrometer. The spectrometer analyzes the ultraviolet light, and when you look at the output from the spectrometer, you see the contribution from individual elements in the melt. I'll show you examples of that shortly.

The advantage of the LIBS process is that it's fast. Using commercially available lasers, we can take ten to twenty measurements per second. It's certainly fast enough for the process

that we are targeting. It's very accurate. You can measure concentrations at a fraction of a percent, which is very important for certain alloying elements. You can apply this to metals and glass; in addition, it can be applied to liquids or gases. It's a very wide-ranging technology, and it's proven. This has been in development, I believe, since the late 1960s.

One advantage of applying it to metal melts and glass melts is that it can be used as a tool to check computer codes. If you want to be able to predict furnace performance, then you need to be able to take measurements at different locations in the furnace to be able to validate those codes. And the LIBS process enables us to do that. We can identify the constituents anywhere in the melt at any point in time. Another advantage I'll point out to you shortly is that the electronics involved in this instrument can be placed far away from the furnace, so it's outside the harsh operating conditions in a melting facility. It's fairly inexpensive and will lead to reduced energy use, as I pointed out earlier, as well as increased production.

An important point is that through the use of fiber optics, we can keep the expensive laser and spectrometer far away from the operating environment of the furnace.

In actual data from the spectrometer, each of the spikes in the spectrum is labeled with the element that's responsible for it. All the different elements that cause these spikes can be identified, and we can use the high signal-to-noise ratio line in the spectrum to measure the concentrations in the melt. We've actually taken some data on molten glass as it was being poured from a laboratory furnace. There was some rather high noise due to the fact that while the melt is being poured there were surface ripples on top of the melt. Presumably if it were poured a little bit more slowly that noise could have been eliminated.

We've developed a thermal model of the probe, and based upon that model we've come up with a mechanical design that's currently being fabricated. The laser system and the lenses that focus in the fiber optics have been completed at Mississippi State University. We've done some preliminary testing at Oak Ridge National Laboratory, and we expect to do a lab-scale melt at the beginning of December.

In addition, we've seen a lot of interest in applications for LIBS technology for scrap sorting. There is a desire for the collectors of scrap aluminum or steel to separate the scrap into different alloys. It's actually highlighted in the aluminum road map. It's difficult to do by sight, and a lot of mistakes are made. Putting the wrong type of scrap into the furnace can ruin an entire melt. We can apply the LIBS technology to this problem. One way we envision using it is simply placing the scrap on a conveyor belt and passing it below the LIBS laser. The light would be collected, and the spark that's generated on the piece of metal is passed along to a spectrometer for analysis.

Robert DeSaro

Another application is online alloying. As a pour is being made, we look at what's coming out. There may be one or two elements that you might have an interest in, let's say magnesium, and online – on the fly, you can adjust the pour to get the magnesium content exactly where you would like it. And that gives you a lot of savings in terms of the chlorine, for ex-

ample, that you have to use to adjust the magnesium. It's a very easy way of doing things.

The probe is in-situ, it's real time, it can be placed anywhere in the melt, and you can get a reading of the exact constituents at that particular point. A semi-continuous furnace would be operated just the way it is today except that you would not have to send samples over to the lab to see if they are within spec. You could do that in real time instantaneously, so what you would save would be the amount of time that the furnace idles while you're trying to get it into spec.

We've already talked about scrap alloy separations and diagnostics with computer modeling. There has been a lot of modeling in the glass industry on what's going on in a furnace in one of the glass tanks. LIBS can provide a lot of data that just do not exist now. We can measure the exact elemental constituents at any point in the furnace, and that information can then be fed back into a model to validate it or to modify it.

Automobile manufacturers are very concerned about the high value of lost alloys. They should be recycled, but they are not being recycled properly because there's no way to tell the difference between a raw and a cast alloy. So both alloys then get thrown into the furnace and they're not available for the automobile manufacturers. So DOE, the Aluminum Association, and the aluminum industry have formed a partnership to develop scrap sorting to such an extent that you can in fact separate the high-value raw alloys that can then go back into automotive applications. That is something that we are looking at very carefully.

Waste glass monitoring — if you vitrify a hazardous waste, you need to be sure the glass is in spec so that in fact you do completely encapsulate the hazardous or radioactive wastes. Sealing glasses that have very critical thermoexpansion coefficients, and therefore very critical compositional tolerances, is another application for LIBS.

Through the various applications of LIBS, there is a total potential energy savings of 60 to 88 trillion BTUs per year. This is significant and if you can use it in a feedback loop to help actually control the feed process, even more benefits are possible.

In conclusion, the LIBS feasibility has been proven. We've done preliminary tests that show we can measure in these kinds of environments. Our development has proceeded with industry guidance and we have identified a large number of markets, some of which were previously not identified. For example, scrap sorting was something that we realized we could do, but didn't really understand the importance until we started listening to people in industry.

On-site Generation for Combined Heat and Power

Richard Brent, Director, Government Affairs, Solar Turbines, Inc.

A portion of the presentation today will discuss distributed generation. You will hear some associates talk about combined heat and power later on. I was very interested in Jim Quinn's suggestion that as capacity exceeds demand in our commodity industries it drives the prices down. It is not only important to do what we can to be energy efficient, but we need to be just as concerned about the cost of the energy we are using. We can get double savings by working with programs like the IOF to reduce the cost of energy consumed and also reduce the amount of energy that we consume. That really becomes the double edged sword that allows us to compete in the competitive marketplace. I also believe that as we look at this we can really start to think about where distributed generation fits into all of this.

We in the distributed generation community believe that we can fit as a cross-cutting technology with all the vision industries. We want to work hard with you on energy cost reduction as well as on reducing the amount of energy that you use.

How many of you are familiar with the term distributed generation? (This is heartening!) How many of you are looking forward to deregulation in the state of West Virginia? How many of you are looking forward to reregulation in the state of West Virginia? There is a technical definition for distributed generation power plants, and I think Dr. Choudhry mentioned it earlier, that is generation located near or at the load center itself. Supporting the grid in many cases because it has an ease of interconnect — usually at distribution level voltage which is 138KV for most companies. So it has the ability to augment the grid that the local utility has in place to serve you as industry. That is the technical definition. The market has a definition as well.

Perhaps most importantly, consumers see it as a tool to lower the cost of energy and enhance the reliability. Microturbines — a technology that is being invested in by the Office of Industrial Technologies — are being seen almost as an insurance policy. The utilities, interestingly enough, are seeing distributed generation as a way to enhance their system reliability and improve their asset utilization. Rather than putting in a transformer at a particular substation because for fifty hours out of the year there is a spike and they do not have quite enough capacity, they are going out to some of you in industry and saying they will put a small generator in your yard and ask you to dispatch it so they do not have to put the transformer in. You have, in fact, lowered the amount of static equipment needed at that feeder station and improved the utilization. The utilities are talking quietly amongst themselves about taking distributed generation to their customers rather than have customers do distributed generation on their own. Certainly, the emerging energy service industry sees distributed generation as a tool to really broaden the product offerings that they have to reduce energy consumption.

Distributed generation complements the central station. It does not supplant the central station. We are going to need that base load power. There is no doubt that reserve margins, as Dr. Choudhry mentioned, are in a decline. We need to be able to boost that up. Is it smart to put in a one gigawatt power plant, or is it smarter to put in small, more highly efficient, one

megawatt power plants near or at that load center? We see new technologies that are improving the cost effectiveness and improving the performance. The OIT program has a number of us working on technologies for a fifteen percent improvement in the efficiencies of electrical generation.

Say for example that you are paying five cents for electricity. If you have a piece of distributed generation hardware inside your fence that makes electricity at 5.3 cents, no matter what time of year, when that peak price starts to go up you can economically dispatch the distributed generation technology and forever cap the price that you pay for electricity.

"Well, what is the cost?" someone said. That is site-specific and we will talk to contractors and people who supply the technology and try and tailor that to your specific requirement. Let's say as a general statement that we can produce electricity, not counting the steam or heat value yet, for less than five cents a kilowatt hour. I would be interested. What is the average price of an industrial user here for energy? I am assuming that you may not want to answer because you have your own deal with your utility. Wholesale prices in the United States on average are running around four and a half cents. Retail prices are around seven to seven and a half cents. In California we pay considerably more, and depending on what area of the country you are in you pay more, or in some cases like West Virginia, you pay less. The marginal cost to produce electricity with the advanced turbine system Mercury fifty engine is less than three cents. If you can buy electricity for less than 3 cents you are doing well. If you can buy the electricity and can buy the gas or coal to run the boiler to make the steam for less than three and a half cents, you are doing extremely well. I would encourage you to keep with it. If you are not, there are technologies coming up that can provide that.

I was delighted to hear Dr. Beaver say that more and more companies, customers, and users want technology inside their fence that looks, acts, and feels like it has a conservation benefit. If you can get real conservation benefits out of it, that is the best way to go. You want to be seen today especially as being eco-friendly and being ecologically and environmentally responsible. This kind of technology, or some of it, can do that for you.

I'll bet that some of you in the aluminum industry say, "wait a minute, I am in the aluminum industry, not the energy business. I do not necessarily want to get into the energy business." So that becomes a real distraction for distributed generation. It takes you away from your core focus, and we understand that. We also know that it competes for capital. If I have a depreciation cycle for a milling machine of seven years, and I have a depreciation cycle for thirty years for a cogeneration system, which one is the accountant or the CFO going to let you purchase first? If that milling machine affects your core business, which one are you going to purchase first? It distracts and competes for capital. It increases some risk–you may not be equipped to handle and manage distributed generation technologies and many feel that the environmental permitting process certainly in many states is long, arduous, and difficult. That is not my core business, so I will leave it alone. However, people are talking distributed generation to the market, and frankly, that market is those people who do not want it because it is not their core business. We find investor owned utilities, municipal utilities, and others are buying distributed generation technologies and negotiating with some of their larger customers to put that technology inside their fence. Natural gas companies have a vested interest. They

would like to see more gas sold. Base load distributed generation gives them a great opportunity and they would like to be able to service that customer who already has that kind of gas infrastructure in their yard. Later you will hear from Dr. Bruce Headman, with an energy service company, talking about how they take distributed generation the next step up the value chain from folks like Solar Turbines, Caterpillar, and Fairbanks.

Lastly, the engineering procurement construction firms and even the manufacturers themselves will bring distributed generation to the market place. There are a couple of different ways that distributed generation technology can be managed. It can be done through a third party or you can do it by yourself. You can rely on somebody else to come in, provide the financing, the equation, service the operation and maintenance of that technology, provide the fuel management for backup, and provide the backup electricity or the backup capacity. Many times distributed generation will be based around the heat requirement. Again, it supplements the system. Where do you buy that additional electricity that you need, and what is the best price? If the nine month average is at the spot price, who do you get it from and how do you wheel it? Again, it may not be your core business, but there are energy service companies that are able to do it for you.

We've seen in more than 280 sites in the U.S. that there are many people who have used distributed generation themselves. They are self reliant and want to operate it, maintain it, control it. They want to be responsible for all aspects of it. Solar Turbines has been in this business for a number of years. We find that the customer has a number of specific needs. They want it easily sited. They want a low maintenance cost. They would like to have a low capital cost and would like to be able to see lower emissions — lower environmental signatures.

The gas turbine advantage over some of the other technologies we see in the market place today is that they are in the smaller sizes — between one and twenty megawatts — and relatively easy to install. They can generally be done in less than ten months. The permitting, depending on the area you are in and the technology that is deployed for pollution prevention, will also shorten up a little bit of the permitting time. We have literally thousands of gas turbines in the world that are gas compression stations. No one is sitting there operating the system. They operate remotely. On a dollars per kilowatt basis, they generally have a relatively low capital cost, and in partnership with the DOE we hope to get even lower emissions.

When we started working with the DOE and the Office of Industrial Technology, gas turbines were around thirty to thirty-four percent thermally efficient. The reliability was good. The availability was reasonably good and they were bought based on a continuous duty, life-cycle cost basis. What we are finding today, again with some good research, development and demonstrations, is forty percent thermal efficiency for electricity only, at the terminals. Gas turbines are generally rated at a fifty-nine degree day. We took on the position that this is a machine that needed to be rated at an eighty degree day. The important statistic here is that it is forty percent efficient at the terminals, not at the shaft, and on an eighty degree day when you really need it, and not on a fifty degree day when you are probably turning on your boiler and producing heat instead of electricity.

We are using technologies for pollution prevention such as catalytic combustion or ultra-

lean pre-mixed combustion and we are seeing environmental signatures. In NO_x production, which is were we get measured pretty regularly, we are seeing production at less than nine parts per million. Today, most gas turbines are rated at twenty-five parts per million. We have recently had a demonstration at Malden Mill in Massachusetts where we are demonstrating fifteen parts per million. There has been quite a drop in the price of the installed capacity. We have been quite grateful for our partnership with the Department of Energy. When we started the program, we did not realize where distributed generation was going. Today we see this as one of the most important the new programs in the United States. The culmination of that program is the Mercury fifty system in a cogeneration mode. There is a description in your book under one of the success tabs about how the system works in a cogeneration application.

In closing, we think the IOF Program is an exciting opportunity for new technologies. We think there is a tremendous market potential. We put a lot of time into looking at the vision industries. We see that most importantly the user gets benefits of reducing their energy costs, minimizing their environmental impact and increasing utilization of their assets.

Thank you for the opportunity to participate in the IOF-WV Symposium.

Bruce Hedman, Vice President, On-Site Sycom Energy Corp.

What I am going to talk about is combined heat and power (CHP). Because of the efficiency and emissions benefits you gain from simultaneously producing power and thermal energy on site, it really is the crown jewel of distributed generation—the broader topic that Richard just talked about.

I will briefly discuss the potential for CHP in industry, and focus particularly on the role CHP currently plays in the Industries of the Future program and the expanded role it can play in the future for IOF companies.

Let me start by briefly telling you about the company I work for. It is On-site Sycom Energy Corporation. We are an independent, nationally acredited energy service company. We are a full service company, meaning we do everything from changing lights in hospitals to implementing process changes in industrial plants. We have offices in California, Illinois, Texas, New Jersey, Washington state, and Washington, DC, where I am located. We differ a little bit from the ESCOs that are out there in that our company really has its origins in cogeneration and power generation. One of our original companies, On-site Energy, started in 1982 actually installing, owning, and operating small co-gen systems in California. Since that time we as a company have remained active in distributed generation and combined heat and power both from a developer perspective and also from being involved and active in the policy and strategy debates that are going on at the federal and state level.

What I will do is go through some statistics on CHP and use them to make a couple of points. If there is one major point that wraps it all together, I would say it is that the market for CHP is on the verge of opening up as it never has before, for a number of reasons. Richard touched on some of these. Certainly access to the electric grid system has the potential to open up with all the state restructuring activities that are going on. There is a potential for

onsite generation to level the playing field in many of these states as it has never been leveled before. I think customers have a greater awareness of what electric costs are in that restructuring process — not only the commodity costs but the costs that were never unbundled before, such as reliability and power quality. Customers and industrial users are beginning to realize what those costs are. They are beginning to understand what options are out there as alternatives to purchasing directly from the utility. I think a very significant change in the landscape is from technology improvements which are enhancing performance and the economics of CHP, particularly in smaller systems of below 10 megawatts. The DOE has been extremely important in funding many of these advances such as the advanced turbine system that Richard just talked about.

Also on the list of what is changing, there are new ways to get these technologies to the market — energy service companies. Energy service providers are out there with innovative ways of packaging the project, integrating an overall management strategy with access to financing that I think will make this market open up in a way that has not happened before.

One of the reasons the federal government has become interested in CHP is the potential to reduce the environmental impact of the energy industry. The amount of CO_2 or carbon equivalent produced can be reduced by up to ten percent by avoiding power losses due to transmission and distribution of electricity.

Let's look at how CHP has been used on a national-level by IOF companies. Electricity is the largest energy expenditure in manufacturing. It accounts for over fifty percent of the almost seventy billion dollars spent for purchase of fuel and energy. This is from the 1994 manufacturers' energy consumption survey. Given these data, it is not surprising that CHP is an important power source for many industries today. Again, going back to that 1994 MEC survey, CHP represented about fourteen percent of the power consumed by manufacturing. NUG is non-utility generators. Most of that is small power production use, but not in CHP mode. Of the existing capacity, we estimate that at the beginning of this year there was about 50,000 megawatts or fifty gigawatts of CHP capacity. To put it in perspective, that represents about seven percent of total generating capacity in the US. Seventy-five percent of the existing CHP capacity has been put in by IOF industries. Chemicals, forest products, refining metals, and other IOF industries have large power demands and large steam demands. The CHP technologies out there have been quite sufficient for them.

Just to get a snapshot of what CHP looks like today, gas turbines dominate the capacity, both in combined cycle and single cycle mode. There is also a significant amount of boiler steam turbine capacity out there. Most of that is boilers burning solid fuels such as coal, wood, petroleum coke, or waste materials. All together, there are over 2,000 CHP sites out there.

There appears to continue to be an enormous opportunity for additional CHP out there. Most of the CHP that has gone in today has been relatively large, certainly greater than ten megawatts, and many in the fifty to one hundred megawatt range. GE believes there is still significant opportunity in that size range and that there is a huge untapped market in the smaller size range. A lot of the technology improvements are being focused on this area, and I think there will be enormous changes in what the CHP market looks like ten years from now.

We have examined this market for DOE, and we estimate that the CHP potential in the existing industries is about eighty gigawatts. That's about twice what is in place now. Again, most of this potential is in the IOF industries: chemicals, forest products, refining, and metals. We have also verified that indeed there is a large potential in the smaller size range of less than twenty megawatts. In the past, the technology available has made a lot of those installations marginal. I think the technology improvements you see, both in the systems like the Solar Mercury and in the smaller microturbines, are really going to work that market up in the future. If you are down in that size range you should start thinking about the potential for CHP.

We estimate that installation of eighty more gigwatts of CHP in existing manufacturing industries would save users eight billion dollars a year and energy costs of almost sixty million metric tons of carbon equipment.

I did a "back of the envelope" look at what the CHP potential might be for West Virginia. This is preliminary, but there could be a technical fit for CHP in about 500 West Virginia plants, 400 in the IOF area. Many of these would be in the small size range facilities needing less than ten megawatts. The CHP potential for West Virginia could be as high as 1500 megawatts, a relatively significant impact in terms of energy efficiency and emissions improvements.

So what is the future of developing that potential here and elsewhere? Richard talked about this, so I'll be brief. CHP does offer industrials a chance to manage their energy costs, to increase their flexibility with energy, and also to understand or address energy costs that in the past they may not have realized. As electricity becomes unbundled, they are going to realize that reliability, power quality, and flexibility all cost money. There may be more cost effective alternatives to produce these. Beyond the technology, there are other barriers across the country to further CHP development. In the past utilities have viewed on-site generation and CHP as a threat and have put practices in place to keep it down. These include high standby backup power costs, overly strict interconnect requirements, and things like that. These are all beginning to be looked at to see how they can at least be leveled in the playing field.

Permitting is an issue with CHP. Right now, the way permitting guidelines are set up, the full environmental benefits of CHP are not fully recognized. Whenever you put in a new technology you compete with old technologies that are already in and depreciated, with their emissions grandfathered in. There is quite a hurdle to go over on environmental permitting. DOE is working closely with EPA, and I think they're making some progress understanding these issues. The federal government has taken a critical leadership role in recognizing the environmental and efficiency benefits of CHP. DOE and EPA have jointly issued a challenge to double the amount of CHP in the United States to roughly 100 gigawatts by the year 2010. The Office of Industrial Technologies has taken a leadership role, not only in the technologies, but in raising of awareness of the benefits of CHP within the federal government and DOE.

The Office of Industrial Technologies has also conducted a number of state outreach programs, which are helping states understand the potential benefits and barriers for CHP in their particular regions. They are raising the awareness among state regulators, the financial community, and users that there is something new here with benefits for everyone, and that there are some issues that need to be addressed.

State restructuring legislation is moving along in most states. As time goes on, the states that are looking into it now are becoming more favorably disposed toward on-site generation. In some states there have been specific provisions put in where CHP is exempt from transition costs, standard charges, and such things. The industry itself is organizing to support the CHP agenda. At the end of last year, a U.S. CHP Association formed. It has worked now with the DOE and has developed a vision for the CHP industry. The U.S. CHP Association is now in the process of developing road maps through a series of regional road mapping meetings. It is an organization where manufacturers, users, and developers are coming together to try to understand what the potential is, what the issues are, and to work some of these issues out. If anyone is interested in more information about the association, they certainly could talk to me or Richard Brent. We will be happy to pass the information along to you.

What is the customer's perspective? There are still many hurdles and risks to consider in reaping the benefits of CHP. Sure, you want the lower cost, reliability, power quality, and more flexibility in your energy costs. You are also concerned about where your electric rates are going, particularly with restructuring and the promises you heard of lower rates. Where are our fuel prices going? There are regulatory uncertainties, permit headaches, performance risks, and technology questions. Do you want to staff up for increased O&M if you are putting in a system where you may not have a boiler house now? There are a whole series of concerns, I think, that still make it very tough for a customer to go forward with CHP, even in this new environment.

Despite all this, there is a new avenue out there. I think it will be a significant avenue in developing this market. There are energy service providers ESCOs like myself, and a lot of other companies that can work with you to reduce these risks, and in some cases take them off of your shoulders completely. They often will integrate CHP or distributed generation into a broader energy management program that really looks at the entire energy procurement structure, management, and use. These companies can also provide access to financing as well as innovative approaches such as performance contracting, where they actually finance the CHP installation and pay the service through savings achieved with CHP. There are even companies out there that will own and operate the system and let you outsource your steam and electric needs.

Again, I stress that I think we are in a changing environment for CHP. It is something to be looked at again and it is going to make a significant impact on the market.

Thank you for listening!

Brent Blalock, Safety and Environmental Compliance Manager, B. A. Mullican Lumber and Manufacturing Company

I need to give you just a little bit of background on B.A. Mullican Lumber and Manufacturing. Our facilities in Roncevert, WV are scrutinized by just about every government agency there is because we are on a twenty-nine acre island in the middle of a protected river. We have environmental concerns and a number of other problems with this site. On one end of the island we have a wood flooring manufacturing plant of approximately 80,000 square

feet. We have eight kilns constituting about 702,000 board feet capacity. On the upper end of the island we have a double band hardwood sawmill. There is a lot of activity on on this island, and we have to spend a lot of time making sure that everything is happening efficiently.

Our plans are to expand the facility. We need an additional million board feet capacity in the kilns. Right now we have a single 500 horsepower woodburning boiler. It is supporting the 702,000 board feet kiln space and also provides heat to the flooring plant. The natural tendency is to think, "Okay, you ought to do electric co-generation because you already have the steam." By the way, I would echo what Mr. Hedman said a few minutes ago, and that is, if you visited co-generation before and for some reason rejected it, now is a very good time to go back and take a look at it again. A lot of things have happened in the industry, in the technology, and there are many turbines out there now that are sized for the smaller generator.

Actually Mullican had considered co-generation about ten to twelve years ago and they rejected it for all the probably legitimate reasons at the time. You cannot say, "well, I ought to be cogenerating electricity because I have steam - I have a boiler - I have capacity," and on down the line. You have to take a look at a few other things first. The very first thing you have to do is a well conceived, properly conducted energy survey of your property. You have to know what you have, how efficient it is, and how is the best way to resolve problems that may be presented by that facility. We did that. We turned to the WVU Appalachian Hardwoods Center, and through a DOE grant program they had a couple of years ago, we got a very well conceived, very well done energy survey. As a matter of fact, it was conducted by Dr. Larry Banta of West Virginia University. We learned a lot of things from this survey. When I sat down with Larry, he recommended an analysis of all of our energy consumption on a very detailed basis. We took a look at a lot of things and have made a number of changes.

You must assess your situation and see what really makes sense, and what you need to do to generate power. In our particular situation, I felt that probably the most important thing for us was to always be able to maintain the drying process. The key to maintaining the drying process is the boilers. Our plans are to do a number of things on this site. One is to more than double the kiln drying capacity. Another is to expand the plant, replace a great deal of equipment inside that plant, and go from one eight hour shift to two eight hour shifts five days a week at the facility. To do all of that we will have to expand the boiler operation. That becomes the key. One thing we really know is that electricity co-generation will not make us the money. What we wanted electric cogeneration to do, once we really begin to analyze this thing, was to protect the most important portion of our operation, that is, the boiler and kiln operations.

Why do we need protection? We have a very reliable power source and dependable power company in this area, but we do have a high rate. The problem we have is that we will have on the average three power interruptions each year. Last year in 1998 the shortest one was seven hours. The longest one was nineteen hours. The other one fell somewhere in between. That doesn't sound too bad unless you are curing lumber. If you are curing lumber in kilns and you lose power for seven hours, that is a very expensive proposition.

So we began to look at it and we said "Okay, if we are going to lose power, let's make sure that we do not lose power to this kiln operation. When the power company gets power

back on we can go back on the production side." That was the very first thing we looked at from the perspective of electric co-generation.

B.A. Mullican is owned by a New York company, as many of you know, by the name of Bailey Forest Products. Before we can make a decision, or very early in the decision process, we have to look at the return on investment. That is very, very important and we have to find that out up front. We are not going to be able to spend a whole lot of time theorizing on something unless we can say "Yes, there is a postive return on investment that works for us."

Reliability of power was our major concern to those kilns. We are at this particular point in time probably doing the best job we have ever done in selling the material that is in the kiln. What we have to do, if the material is in the kiln, is bring it out somewhere between seven and nine percent moisture content, and then we have to turn it into wood floor material, and have to ship to the customer. As you can see, we do not have a lot of time here for error. We want to be sure we can guarantee that reliability.

One of the major things that will impact this decision, and you do need to know this, is that maintenance of a turbine system to generate power for electric co-generation is almost negligible. The turbine equipment is out there now that will not require an operator. You are not talking about something that requires you to become an expert in power, unless you want to get into distributing power back into the power grid, which we certainly did not feel like we wanted to do it. I thought that Mr. Brent made a good point a few minutes ago when he asked who is looking forward to deregulation and who is looking forward to reregulation. When you really look into it you do not know where it is going. We do not want to be in the business of competing with our power company. We want to protect our kilns and be in the business of wood flooring manufacturing. This to me is a very easy extension of the boiler and kiln operation. It does not involve any more technology than we already have on site.

We went to a company in the Atlanta area – the smallest of five engineering consultant firms we interviewed. They came up with a couple of novel concepts. One was that we could go ahead and start generating power today. In fact, we could do everything we were looking to do in the expanded project in the initial phase using existing facilities. That took me by surprise. Frankly, when Dr. Banta and I sat down and originally talked about this, I didn't think we could even consider electric co-gen until we had the complete plant expansion on line.

Some of you know about the wood business and some of you don't. I know of four ways to dry wood. You can do it with water based kilns, and I know very little about that. You can do it with high pressure steam kilns. You can do it with low pressure steam kilns. And I understand from my friends at Oak Ridge that we are fairly close to being able to do it with microwaves – I know nothing about that.

The bottom line is at Roncevert, WV we have a combination of high pressure and low pressure kilns. I very much prefer low pressure kilns. They are more efficient and they are better for the boiler operation. We have an existing 500 horsepower woodburning boiler and we could go in there right now with a phase one, add a turbine and generate sufficient power to support the existing kilns and the boiler itself. That is an option for us.

I am really interested in what happens when we expand this plant. I will have not only the existing 500 horsepower boiler but I would also have its brother sitting beside it, which will actually be a 600 horsepower boiler. This gives us a lot of flexibility in what we do with the steam. It does not impact what happens with the cogeneration portion at all. The only things that the turbines are doing is that we are taking steam off of the boiler and patching it through the turbines. I asked the question, if we wait and develop it as one project why would we maintain two turbines? Why wouldn't we just set one with larger capacity in there. After sitting for about a half a day and listening to the engineers talk, I came out understanding that, in fact, the two smaller turbines would serve us more efficiently.

Not only has this study convinced us this makes sense for us in Ronceverte, WV, but we are taking bids next Wednesday, the day before Thanksgiving, on a very large expansion of a facility we have in Smyrna, NY. We are sizing all of that to also allow for the addition of electric co-generation. We are also expanding the facility in New Bern, NC. We are upgrading the boilers and are also planning for electric co-generation there.

Our upgrades make a lot of sense for us because we have a fuel cost of zero. We have a marginal market for dry wood waste, so we use it as our boiler fuel. The facility cannot be expanded unless we add the second boiler anyway. That will also increase the amount of wood waste. Those two quantities are going to go up together. This will makes sense for us all the way through. In today's market, we do not see a good opportunity in the dry wood waste market. We do realize there are good possibilities for green wood waste when the next revisions to the Clean Air Act come out because of the co-firing. I do not think they will change that. I think the co-firing concept will stay and that will be the green dust market. We do not burn green dust in our boilers.

This is an overview of what our experience has been to that point. This project is hopefully going to get back on line within the next thirty to forty-five days. We are hoping to see project develop in the year 2000. I want to advise you to be sure you get the engineering right in the beginning and stay with it all the way. Otherwise you can get in a lot of trouble.

Thank you.

Remote, Real-time Temperature Measurement in Galvanneal Furnaces, Rolling Lines, and Processing Vessels

Tim McIntyre, Sensors & Controls Program Manager,
Oak Ridge National Laboratory

What I would like to share with you today is a neat technology called phosphor-based temperature measurement, or galvanneal temperature measurement as we have called it on this IOF steel project. This was just a laboratory curiosity a few years ago when we got started, but, as I am going to try to show you, we now have a commercial product that is very inexpensive and quite effective at measuring temperature in a plant environment.

Many disciplines went into developing this technology. We did everything from developing the fine ceramic powder — the fluorescence medium that we use to make the measurement — all the way through the digital electronics and instruments that help us actually process and display the information.

Just to give you a feel for one particular application, we deposit a very small amount of ceramic powder on a steel strip just as it is coming out of the zinc pot on the galvanizing line. The steel strip at that point still has a molten layer of zinc on the surface. The powder sticks and up it goes into the annealing furnace. You then hit the powder with a laser, which excites the atoms in the fine powder. The atoms decay and you collect that decay florescence signal that is the essence of the measurement.

As I mentioned before, this was really just a laboratory curiosity when we got started, so there was quite a bit of development to do. The phosphor material we developed can be used to measure temperatures ranging from 4° K to more than 3000° K. You just have to be careful what material you pick. You customize the material for the temperature range you are interested in. If you do that carefully, you can get measurement accuracies on the order of a few milli degrees.

The Weirton Steel folks are working very closely with us on phase two, which aims to shrink the footprints and reduce the cost of the system, so that it will be easier to deploy in a plant environment. Earlier in the project, Bethlehem Steel, Tomkin Steel, National Steel, and the University of Tennessee all made significant contributions. Our commercialization partner, Bailey Engineers out of Pittsburgh, is now working with us at Weirton. They will soon be bringing the technology to market and selling this instrument to whoever is interested.

In addition to developing phosphors, optics, lasers, and various micro electronics, we had the challenge to box this thing up and package it so that it would actually function and survive in a real steel plant. We had some trials and tribulations along those lines. When we tested our first prototype of the phase two device in Weirton, we plopped that thing on top of the furnace, turned it on, and it shot up to 450° C. We got back a box that looked like it had charcoal briquettes inside. Clearly, that wasn't the way to deploy this thing, so we live and learn. The steel industry is a challenging place to work!

So what is this phosphorus or florescence thermometry and how does it work? The fine

granular ceramic powder for this particular application is the ceramic YAG (Yttrium, Aluminum, Garnet) and you dope the YAG with chromium. If you hit chromium dope YAG with a red laser, it flouresces. You are exciting the outer electrons in that chromium material to an excited state, and they decay by either throwing a photon out or by passing energy to the lattice of the ceramic. There are two competing processes of decay that you actually measure — the florescence and the non-radioactive decay. Because these two processes are taking place at the same time, in a certain ratio that is a function of temperature, you get a very nice temperature descriptor. As I mentioned before, if you are very careful, you can make nice temperature measurements with milli degree accuracy.

The key thing is that the decay constant (i.e., the flourescence lifetime decay) changes as a function of temperature — that is the essence of the idea. So all you have to do is develop a measurement system to measure that florescence decay very accurately and you can then determine the temperature.

The beauty of this instrument is that it is completely emisivity independent. It is based on atomic physics from first principles i.e., exciting electrons and watching florescence. It has been used on aluminum sheets, on paper sheets, on textile sheets, and on steel sheets. It has been used on turbine blades in an operating jet engine. So it can be a versatile technique for measuring temperature in really nasty places were emisivity could be an issue.

The actual measurement head is about the size of a brick. We surrounded it with some high thermal BTU blocks, ceramic insulation , and then we surrounded all that with double wall stainless steel to keep any electromagnetic interference from getting into the device - for applications that might be in an induction furnace. So it is magnetic stainless on the outside.

We developed an optical detection system that could be very small and compact and in with the same box with the rest of the measurement head. We minimized the phosphor consumption by having a very sensitive phase lock detection measurement schemes so now instead of having a three foot long strip of phosphor we can get away with about three inches. We would be depositing on the order of micrograms of phosphor rather than grams. We are using this very sensitive phase lock detection rather than a curve fit exponential curve capture type of approach. And our early laboratory test show that the system should be very robust. But we learned already that it is not as robust as it needs to be for steel applications where it can be very hot. The bottom line is that the initial system would cost you forty to fifty thousand dollars to purchase and replicate. To purchase it now is probably on the order of about two to three thousand dollars. We are doing further trials at Weirton, but up the road we think we have addressed most of the temperature issues and it is ready to go on the market.

Again, thanks to all the contributors to this technology development – and thanks for inviting me to talk about it.

Symposium Dinner Speaker
D. Bruce Merrifield, CEO, Pridtronics

Introduction:
Rudy Henley, Senior Managing Director, McCabe-Henley Properties LP

I'm really pleased to be here and to introduce our speaker, who's a great friend. A few years ago when I chaired the Economic Development Transition Team, a friend of mine, Dr. Paul Franke, called me and said, "You've got to meet Bruce Merrifield, he's a good friend of mine and has great ideas on technology and economic development." Well, it's been just a fantastic four years or so of friendship, talking on the phone, actually creating some initiatives and just being able to share some ideas and thoughts.

Dr. Merrifield has very deep West Virginia roots, having raised his family in the Kanawha Valley in the late '50s and early '60s. He is a graduate of Princeton University and holds master's and doctoral degrees in physical organic chemistry from the University of Chicago. He's presently chief executive officer of Pridco Research Firm and also serves as professor emeritus at the Wharton School of Business.

Dr. Merrifield was assistant secretary of commerce in the Reagan administration, and actually served, I think, in two different roles both as assistant secretary for technology as well as undersecretary for economic affairs. In that role, he was on the first trade trip to China. Dr. Merrifield is widely recognized as the person responsible for the Cooperative Research and Development Act of 1984, as well as the Technology Transfer Acts of '84 and '86. His office was responsible for initiating the Quality Productivity Award, now named the Malcolm Baldridge Award. He's a former director and president-elect of the Industrial Research Institute. He's a member of the advisory board of the Binational Research and Development Foundation and is a member of the visiting committee for research at MIT and at Boston University.

In West Virginia particularly, we really do have tremendous opportunities. What used to be obstacles are now opportunities for us. We're a small state, but that makes us mobile in a time when you need to be mobile. We have more facilities, more opportunities, and more energy than I think we know we have, and the key is for us to get organized. Organizations like IOF definitely help, and Dr. Merrifield is the perfect person to help us figure out how to harness all these energies and point them in the right direction.

Dr. Merrifield has been not only a brilliant observer of economic transitions and a predictor of technology impacts, but also a catalyst and a stimulating, thought-provoking participant. In a crowd like this where there's a can-do attitude, he has not only a can-do attitude, but also the has-done experience to back it up. I am very pleased and honored to introduce him. Please welcome Dr. Bruce Merrifield.

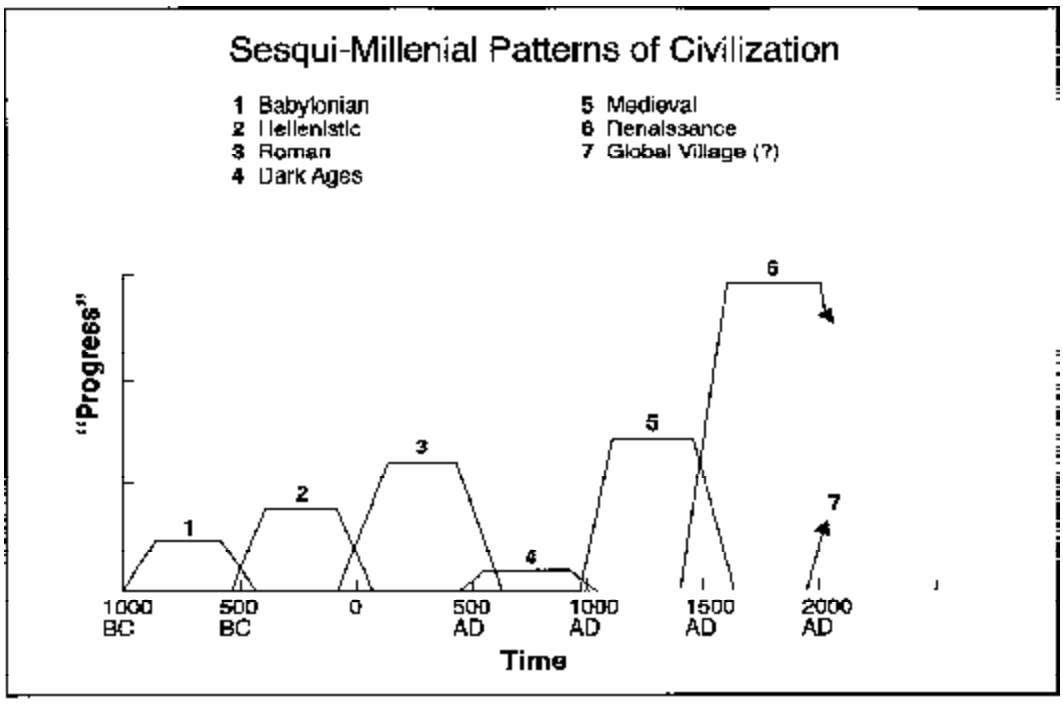
Economic Development: Patterns of Change

The Honorable D. Bruce Merrifield

This is a period of massive change. Tremendous discontinuities and trauma accompany it, and we have to understand that this is a period that we've lucked into. What we're really seeing now is the demise of the nation-state system. As the economic and financial sovereignty of the nation-state system erodes, we enter into something of a global village without borders. We can now bring education to every corner of the earth, and capital and information now flow at the speed of light anywhere. It's an opportunity that West Virginia must take advantage of, and I'll come back to that.

Forces of Change

I think a little perspective might be helpful. In 1908, a Benedictine monk wrote a book called *The Great Thousand Years*, in which he pointed out that starting in 1000 BC, there have been six 500-year epochs, and at the end of each epoch an old order is destroyed and a new order is generated. For example, in 1000 BC the Babylonians were running the Western world, and did so for about 500 years. In about 650 BC, Philip of Macedonia and his son Alexander the Great conquered the world, and the Greeks ran things up until the birth of Christ. Then Julius Caesar came along and conquered the world and the Romans ran it for the next 500 years, and then the Huns and the Vandals and the Visigoths swept in and ran everything in chaos for the next 500 years, the terrible period of the lost ages. Then in 1000 AD, the Christians swept down from the north again and conquered the world and thus initiated the medieval period for the next 500 years, and then of course the last period in which we are living started with the Renaissance when the printing press was invented, and we have now had the nation-state system for about the last 500 years.

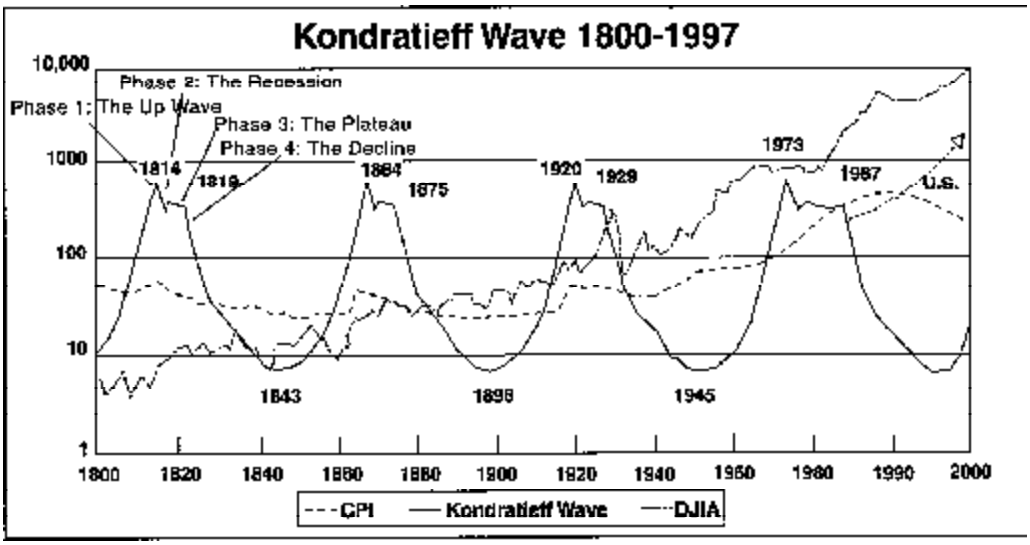


The book points out that the last century in each of these epochs is a period of great turbulence, trauma, and discontinuity. The Benedictine monk predicted that the 20th century would be the worst of all. And it has been. The interesting thing about this is that none of these major order changes have occurred except at the end of each of these 500-year epochs. We're now at the end of the sixth epoch and basically, we've had two world wars, the demise of 16 colonial empires, the 1930s Great Depression, Korea, Vietnam, the Gulf Wars, a 50-year Cold War, nine major recessions and many economic downturns in the process, the Asian melt-down only a couple years ago, and currently Kosovo and Timor and 5,000 ethnic minorities all of whom want economic or political recognition.

Twentieth Century Turmoil
Disruptions and Discontinuities

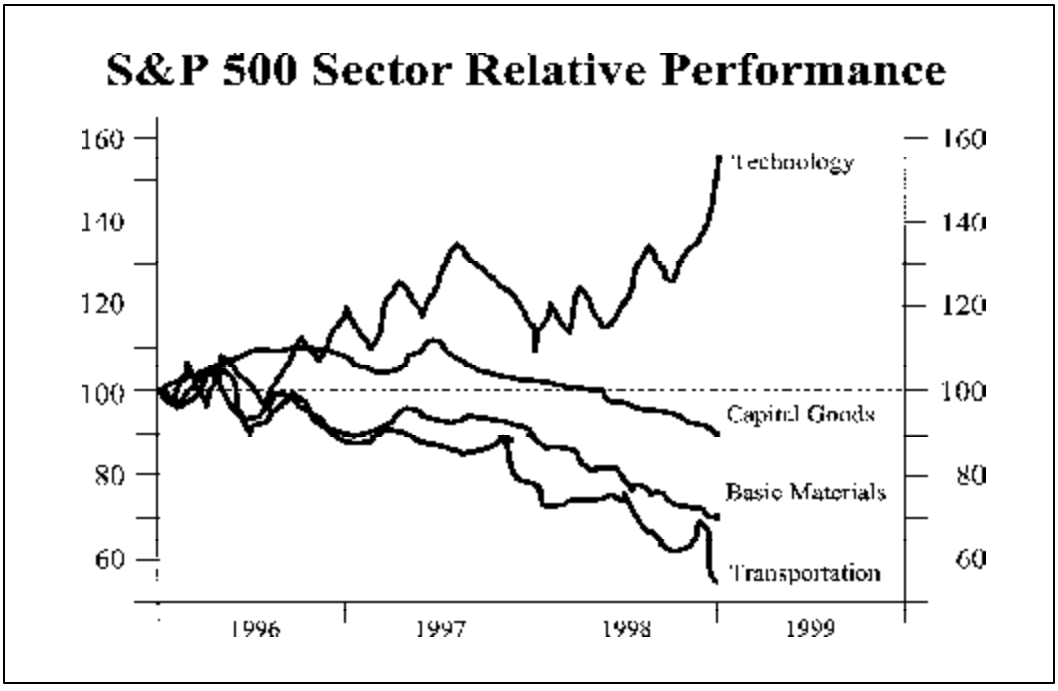
- Two devistating World Wars
- The demise of sixteen colonial empires
- The Great Depression (25% unemployment)
- The Korean, Vietnam, and Gulf Wars
- A fifty-year Cold War
- Nine major recessions and many economic downturns
- The "Asian Meltdown"
- Rapid erosion of the economic and financial soverienty of the nation-state system and the emergence of the global village without borders

The second great concurrent event is the end of the fourth and the very last of the Kondratieff, long waves. Kondratieff, a very bright Russian back in the early '20s, told Marx and Lenin that capitalist countries don't crater, they just shoot themselves in the foot every fifty years and then come back again. Well, of course this had been going on for about 150 years, and it wasn't exactly the party line in Moscow, so they put the poor guy in a salt mine in Siberia and he died there in 1937. He predicted the next Great Depression in the '30s, which actually came right on schedule. Well, 1930 and 1980, there's 50 years, and basically we have just entered into the last stage of the fourth and very last of the Kondratieff long waves.

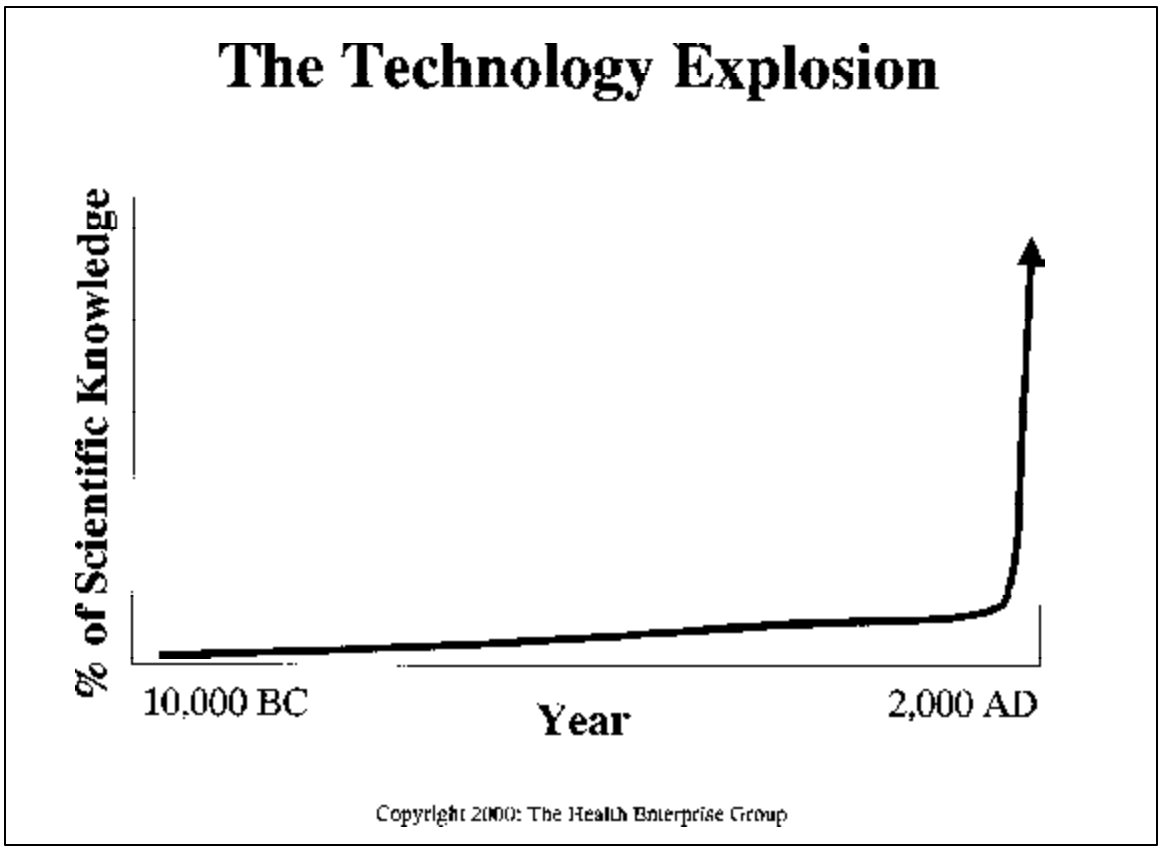


There are four stages in this thing. The first is the fifteen year period of collapse, in which obsolete, over-capacity industries get written down, restructured, and go into Chapter 11. Then a twenty-year period of reinvestment, building new technology, and a third period in which we overbuild capacity again, a fourth period of economic turbulence, and then the next cycle. Since the early 1980s, we have written down, as you know, tremendous numbers and restructured many of our older obsolete businesses. And I'll come back to that in a minute, because it's awfully important. But the point is there'll never be another fifty year life for anything. Software lives are about six months or so, and two to three years is normal in many industries. So we'll never see a fifty year life again, and we're now seeing the destructive end of the last of the Kondratieff long waves. We started in 1984 or 1982 or so, and we're pretty well advanced on this. But Europe and Japan and the rest of the world are not. They're in big trouble. Japan has thirty percent idle capacity, which they haven't written down yet. Europe is also in bad shape. There's a major restructuring process ahead for them. In the meantime, we are well advanced now on our twenty-year rebuilding cycle, i.e., the second stage where we are using our advanced technologies, and I'll show you in a minute why that's so critical.

By the way, here's an illustration of what's happening: technology sectors are going up like a big balloon and all the old commodity businesses are going down the tubes. There's an enormous excess capacity worldwide in almost all the commodity businesses, like steel, textiles, and shoes. Those industries are not going to come back again, because the competition is so great. But the new technology-driven systems are going to continue to rise, and already are more than offsetting the decline of the older industries. It's an important fact, and I'll show you some data on that in a second.



The third great concurrent force of change is the explosion of technology. This graph is one of my favorite ones. Basically it goes from 10,000 BC to the present day and is supposed to indicate that about ninety percent of everything we know in the sciences has been generated – guess what – since 1970, and will double again in the next fifteen years. That's important. Ninety percent of everything we know in the sciences – that's the great force of change driving us now, and we have the leading edge on every one of those areas.



Back in 1945, Vannevar Bush wrote his report to the president calling research the endless frontier. He captured the euphoria of the moment. We had just detonated the atomic bomb and built a bazillion planes, and ammunitions. Around that time, we started the National Science Foundation, and since then we've pumped about a trillion dollars into our academic community here in the United States. A trillion dollars. And that capability now spends about thirty-five billion dollars a year in basic research. That's more than all the rest of the world put together. No other country can match this in any reasonable period of time. We have the leading edge in almost every area of technology and it's explosive, we are going to outrun the rest of the world now beyond belief. This is the symbol of our time, this explosion of technology.

The last of that sixth 500-year epoch, the last of the Kongradyev long waves, and this tremendous explosion of technology which has reduced industrial life cycles from decades to just a few years are the great forces of change that are going to change our world forever.

The American Miracle

In 1981 the Economic Recovery Tax Act was passed. It reduced taxes by about $500 billion over the next four years, but the most important thing was that it reduced the capital gains tax on industry, which had been seventy percent in early 1980, to twenty percent. That created about thirty-five billion dollars almost overnight in venture capital and jump-started the formation of new businesses. Since about 1984, we've been creating 800,000 new businesses every year, and two to three million net new jobs in those businesses. The important thing to understand is that since 1982, we've created eleven million new businesses, eighty million new jobs, and ninety percent of those jobs have been in companies of less than twenty people. Not the big companies, the little companies.

The "American Miracle"

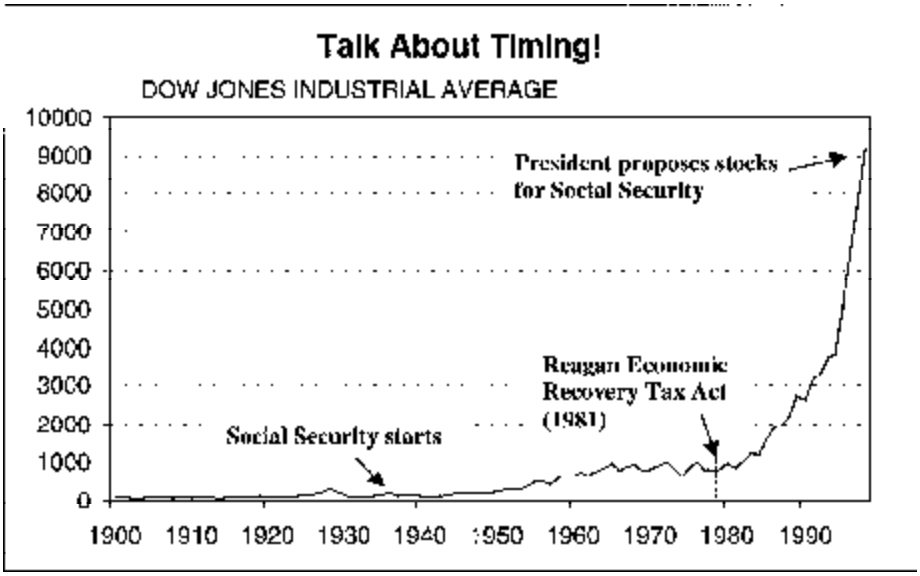
Since 1982 . . .

- Ten Million New Business have Incorporated
- Seventy-five million New Jobs (>50% High Paying and 70 - 90% in the New Businesses)
- Forty Million Jobs Lost ("Downsizing & Reengineering")
- Thirty-five Million Net
- Seventy percent of the originial Fortune 500 Companies are no longer listed

This is the story of the entrepreneurial revolution, the American miracle in the United States, as the French call it. In the same period of time, big companies have lost forty million jobs in downsizing and restructuring, the end of the Kondratieff long wave. And if we hadn't had this entrepreneurial process going, we'd now be in the worst depression the world's ever seen and we'd drag the whole rest of the world with us. The political instability would be unbelievable. Right now we are the lead engine of the whole world, and we'll maintain that. Basically, remember, forty million jobs lost, eighty million jobs created, we've netted out at over forty million now, and most of these jobs have been created in these new small businesses. By the way, over seventy-five percent of the companies that were originally listed in the Fortune 500 are no longer there, and many more will not be there in the next decade. Well, that's okay. That's called creative destruction, and it's a positive effect in the long run. This is part of the change that we have to understand, we have to manage, and we can do that. We have created eighty million jobs in the United States; why hasn't West Virginia created more jobs? We can create jobs anyplace, anytime. The models for doing it are here and we don't have to reinvent that wheel, we know how to do it, we've just got to do it.

Here's another great example of what's happened since 1980. This is the Dow Jones average going back to 1900. As you can see, it hardly moved, and then in 1982, when the Economic Recovery Tax Act was implemented, it went gone up like a rocket. And this is the index, the measure of the technology revolution that we are involved in. And the potential is here for West Virginia, and the rest of the United States.

The basic reality is that every industry will continuously restructure from now on. That is a given. And management is now the management of continuous change, and we have to



restructure to manage continuous change. But most important, wealth will no longer be measured in terms of ownership of fixed physical assets that could be obsolete in a few years, but rather in terms of knowledge-intensive, high-value-added technology-intensive operations. That's the future for West Virginia, the future for the rest of the world, and the United States will be the leader in this area.

Basic Realities

- Major forces of change will continually restructure all world economies
- Management now is the management of continuous change, requiring all organizations to resturcture to manage change
- Wealth no longer will be measured by ownership of rapidly obsolescing fixed physical assets, but in terms of Knowledge-intensive, high value-added, technology-intensive proprietary systems

The Technology Explosion

The technology explosion has created a number of critical technologies. These are in the areas of material sciences, electronics and the communication sciences, the biosciences, engineering, energy systems, and manufacturing sciences. I put this chart together when I was in the Commerce Department, and there are half a dozen critical technologies in each of these areas. They are so powerful, they're going to restructure almost every industry now over the next decade and dominate the twenty-first century.

Critical Technologies

Electronics & Information

- Microprocessors & Logic Chips
- Lasers & Meteor Burst Communication
- Digital Imaging, Compression
- Fiber Optics & Optoelectronics
- Magnetic Storage
- Neural Networks

Material Sciences

- Structural Ceramics
- Metal Matrix Composites
- High Temperature Superconductors
- Diamond Films
- Engineering Plastics & Composites
- Catalysts, Nanotechnology

For example, in the area of material sciences, take superconductivity. That was invented or discovered in 1986 in a Zurich IBM laboratory. Fifteen years later we still don't have applications in commercial operations, but we will soon. It is important to understand the significance of this. For example, motors, generators and fault current limiters and so forth are going to be commercialized within the near future. I've been working with the Department of Energy to develop these systems.

But probably the most important application is for the transmission of electricity, because superconducting cables transmit electricity with almost zero loss for any distance. North Dakota supposedly has enough wind energy to supply forty percent of all the electric industry in the United States, if we can only get it to where it's needed. I have a vertically integrated consortium working on superconducting. The first pilot project, about a half-mile cable, will be going into test shortly, initially in the inner cities where you want more capacity, but eventually, for tying the whole grid together and for accessing energy wherever it is. You know, in Siberia there are three major gas fields bigger than all our known reserves, shut in because there's no way to get the gas to where it's needed. In the Middle East there are tremendous resources of natural gas that, instead of putting it through pipelines to other places, you generate electricity right at the well head, or as in the case of coal, at the mine mouth, and put it into the grid for transmission to any home or business in the world. This is the kind of thing that will totally restructure the utility industry over the next decade as this technology is further advanced.

There are engineering plastics, composites, and metal technologies. We can now move individual atoms around and create new materials. For example, a cluster of thirteen silicon atoms behaves differently from twelve, and it looks like a new material. Tremendous changes or differences at that level, and tremendous advances and developments coming out of such technologies.

Well, there are many things I could go into. You're much more familiar perhaps with the electronics revolution. We haven't seen anything yet in terms of explosively growing bandwidth and costs falling - essentially cheap communication anywhere in the world. As I mentioned earlier, capital and information flow with the speed of light anywhere in the world, and we can begin to access anything, anywhere — even from the mountaintops in West Virginia. Well, digital imaging, compression, and fiber optics are all contributing. They're all tremendous

advances that will continue to increase our capabilities.

For the first time in history, we can now bring education to every corner of the earth. There's no excuse for us not doing that – reading, writing, and arithmetic around the world. There are four billion people in developing countries who need this, and West Virginia University has the capability to help supply it.

In the area of biosciences, as we sequence the human genome and identify where those thousands of genetic defects are, we'll begin to correct some of them. That work is beginning already, it's in the exploratory stage and it has profound consequences for healthy, long productive lives. In fact, my immunologist friends tell me they're going to wipe out all the viral diseases in the next few years. Remember Barney Clark, that first heart transplant? He had three different viruses that destroyed his heart. Never even knew he had them. As we wipe out viral diseases, the life span will be very significantly extended. My friend says "Bruce, you know, you could live to be 120 or 140." Well, I don't know that I want to, but this is a consequence that is coming out of these things.

Stem cell research – this is a spectacular field where we can grow new tissues of any kind. Recently somebody grew a thumb from a man's own cells and put it back on him. We can grow all sorts of organs – then we really will be bionic people.

In the area of energy systems, I mentioned super-conducting cables, but there are also fuel cell systems, fusion technology, hypervelocity propulsion, and other developments in this area. I wish I could go into more of them because of their relevance to West Virginia.

Have you heard of meteor burst technology? There are thousands of little meteors that come into our atmosphere every second. Basically little grains of sand that burn up in the atmosphere, leaving a trail a mile, or half mile long, and lasting for thirty to sixty seconds. The military is bouncing signals off of those now. They can get about a five-second interval now, but they think a quarter of a second would be okay for voice as well as data. So what do you need satellites for? Who would ever think of bouncing signals off of little grains of sand in the atmosphere? Well, these are the kinds of things that are happening. They happen continuously, and will continuously change our lives and economies.

Agents of Change

The point I want to make here is that we are the agents of change. As agents of change, we have the responsibility and we have the knowledge. Knowledge represents responsibility, responsibility for making things happen. We have to be the change agents in West Virginia now that brings this incredible, spectacular, historically unprecedented opportunity to make jobs and higher quality of life to all our people in West Virginia. We can do it. We don't have to reinvent the wheel, the wheel has already been invented, we just have to identify what's best for us and clone that here in West Virginia.

The point is that we know how to do this sort of thing now. It's a highly disciplined process. Not a catch-as-catch-can process. For example, we have developed screening methodolo-

gies that get eight or nine out of ten successes instead of the normal two or three out of ten. We can't afford to waste effort and time and money on things that don't have a high probability of working to begin with.

What do we do? Basically, it's a catalytic function. Rudy and Carl mentioned this. We need to put together vertically integrated collaborative efforts, because hardly any company alone can do the major developments again. No single company can develop high-temperature superconductivity by itself. It takes a vertically integrated collaborative effort. And it's this kind of collaborative analytic function we need to establish here in West Virginia, to begin to identify, screen and then develop these new opportunities.

Of course it needs seed funding to get them started and it's a key responsibility of the federal and the state governments to provide those seed funds. I started the Advanced Technology Program because I didn't have enough money in Congress to do anything, really. But that's just a miniscule thing, it probably funds one in a hundred viable opportunities. Entrepreneurial activity and initiative exists everywhere, if they are allowed to surface. We need tax incentives for these new start-up businesses, and loans, and of course the continuous skilling and reskilling process. Please hear me now. Any set of skills, yours and mine, can be obsolete in five to ten years. We have to continually reskill ourselves. The great frontier of education now starts at age twenty-two, instead of stopping there. We have to take that responsibility and our companies have to take that responsibility to continuously go about reskilling their own employees.

Agents of Change

- There now exists a rising tide of opportunity that is historically unprecedented
- This opportunity will result in increased wealth and quality of life for all peoples
- Major forces of change are driving this process
- You are the agents of change who must manage the process - take responsibility for leadership

West Virginia: Capabilities and Challenges

West Virginia has tremendous capabilities to work with, for example, natural resources. When I was in the Commerce Department, I started several hundred joint ventures and collaborative efforts in incubators all over the country. One of them was in Minneapolis — the Greater Minnesota Corp., now called Minnesota Technology Corp. One of the things we started up there in Duluth was the Natural Resources Research Institute, NRRI. It has a budget of about twelve million dollars a year now, and has created hundreds of new small businesses all over Minnesota. For example, in a small town on a beautiful lake, we gave a couple of entrepreneurs some seed funding to convert an old defunct creamery to an aseptic pasteurization process for all sorts of cheeses that are shelf-stable without refrigeration. They now employ about a hundred people in that little company, and the town has grown to a thousand people

with all the support functions and services required. That's what happens when you create these new small businesses.

They have a short growing season in Minnesota, but they developed a hybrid poplar tree that matures in about twelve or thirteen years, and now the major plywood and composite systems companies were taking that soft wood pulp and making it into material that they then surface with mahogany and oak veneer.

In West Virginia, there are thousands of people working in the forest products industry. We have incredible hardwood forests and wood technology centers all around the state. Instead of shipping our hardwood to Japan or North Carolina and then watching it come back as fine furniture, we need to be making it ourselves here in automated facilities. We could do it; we know how to do it. By the way, technologies in NRRI are available under license or even free. I would suggest that West Virginia ought to look at places like NRRI, and there are hundreds of other examples around the country from which we can copy what already exists and already works.

At one time I had fifteen divisional laboratories and a central research laboratory in the Kanawha Valley. I would go around visiting all those division laboratories and find very interesting technologies that had been partially developed and then put on the shelf for some reason or another. Maybe it didn't look like it was big enough or important enough, or the general manager had changed and didn't like it, or whatever. Those could have been spun off into new businesses, small businesses. And in fact, Carbide and DuPont, I'm sure, have hundreds of these on their shelves that could be sources for new business operations. Just given seed funding and support capabilities for entrepreneurs, I think we could spin off a lot of new businesses in the Kanawha Valley.

West Virginia Resources

- Universitities (Basic Research, Entrepreneurship)
- Kanawha Valley Technology Base
- Natural Resources
  - Fossil Fuels
  - Wind
  - Hard Wood Forests

Another thing I want to point out is that the big companies, or the high-growth companies, like America Online, SYSCO, E-Bay, and Microsoft are not growing from internal research. They do internal research, but they're growing by buying little companies that are high-growth opportunities. There's an incredible explosion of new things. It's unbelievable. We don't have to invent everything ourselves. They're there, and they need seed funding, they need management, they need the special skills that we and some of our bigger companies can provide.

There are different models of growing businesses and creating jobs, we get to look at all of these different models and choose the ones that will work for us.

In summary, let me remind you that all nations compete in world markets now. The Asian meltdown was a good example of the fact that tremendous overcapacity has been building in the commodity businesses. It'll take five to ten years to write that down. In the meantime, those businesses aren't going anywhere. We are in direct competition worldwide with them, and the major forces of change that I mentioned are going to continually restructure everything we do from now on, not only companies, but also universities. The challenge, then, is to manage continuous change.

But let's not forget that we have incredible advantages. We have the world's most advanced technology, critical technologies in which we have the leading edge in almost every one. No country can even begin to match this capability. We have an incomparable industrial infrastructure, seventeen million companies in every area of opportunity that exists, to translate new ideas into useful things. Our entrepreneurial culture that has no fear of failing and trying again. In Europe, you fail and you're through. In Japan, it's hard to do things because you might lose face if you fail. Well, we don't have those problems. We have this incredible entrepreneurial can-do culture which is so powerful and the world's most available capital development capability. If we just harness it effectively, the world's largest market with a common language. We have everything in spades. All we have to do now is get together and work out what we want to do, identify what's best for us, put it in place and make it happen. It can happen right here in West Virginia as it has already happened all over the United States. I challenge you now to go do it.

Thank you very much.

Lori Hamer of Hamer Pellet Fuel, Denise Swink, U.S. DOE Deputy Secretary for Industrial technologies, Carl Irwin of WVU's NRCCE, and other symposium participants enjoy Bruce Merrifield's dinner presentation. (WVU photo by Kathleen Cullen)

Appendix A
IOF-WV Symposium Short-Courses

Internet Opportunities for West Virginia Companies

Roger Duckworth, Program Manager, Virtual Company,
West Virginia High Technology Consortium Foundation

Roger Duckworth discussed the tremendous opportunities that are out there for West Virginia by using the internet as a selling and promotional tool. An excellent example of that is the new Mountain Made website that Governor Underwood just announced. West Virginia companies can talk to the world by simply using the internet.

How and Why of E-Commerce

Bonnie Morris, Associate Professor of Accounting, WVU
Jeff Tucker, Senior Software Engineer, DN American

Bonnie Morris and Jeff Tucker taught a short-course on how to go about conducting business on the internet. They discussed why the internet is such an important tool for businesses to get their product noticed outside of their state or region. They showed how to use the many opportunities that are out there for West Virginia companies by simply using the internet as a selling tool.

Checklist for Y2K Compliance

John Frazer, Y2K Champion and Industrial Hygienist
WV Manufacturing Extension Partnership

John Frazer discussed the pitfalls to avoid with the advent of the year 2000 and the many computers out there that were not Y2K compliant. He discussed how to avoid falling into the Y2K trap, what the potential consequences were for companies if they failed to heed the warnings, and what to do if your company was affected by Y2K.

Initiatives to Improve Safety and Reduce Workers Compensation Premiums in the Forest Products Industry

Dick Waybright, Executive Director, West Virginia Forestry Association

A cooperative effort between the West Virginia Forestry Association (WVFA), the WV Workers' Compensation Division (WVWCD), the WV Division of Forestry (WVDOF), and The WVU Appalachian Hardwood Center (WVU/AHC) to promote employee safety in the timber industry. The purpose is to provide members of the logging industry with state of the art

logging safety and management training performance monitoring. Timber safety will be improved resulting in fewer injuries to employees in the industry. Rates will be reduced through fewer claims and lower claims cost.

The program begins July 1, 1999 and participation is on an annual basis. The program is open to any employer regularly engaged in timbering that is properly classed and in good standing with the Workers Compensation Division. Employers & employees must actively participate in training and assure compliance, or they will be removed from the program.

Workforce Training Programs

David Lieving, Director, Governor's Guaranteed Work Force Program, West Virginia Development Office

David Lieving discussed the Governor's Guaranteed Work Force Training Program which is administered through the West Virginia Development Office. The goal of the program is to provide all industries in West Virginia, both traditional and cutting-edge, with work force training and development. He also discussed the various workforce training programs that exist throught the state. These programs give businesses the advantage of having a pool of trained potential employees to hire from.

Status of Electric Industry Restructuring

David Ellis, Director, Utilities Division, Public Service Commission of West Virginia

West Virginia, like many other states, is in the process of investigating the impact of deregulation of the electricity industry. Dave Ellis discussed the current status of deregulation in West Virginia, what actions have been taken, the status of other surrounding states, and where West Virginia hopes to end up. He also discussed the issues and concerns that companies have brought to light in the investigation of what the impact would be on the state and the positions that various companies, organizations, and individuals have taken on the issue.

Effective Business Networks to Cut Costs and Build Opportunities

Tom Mahoney, Director, WVU Industrial Extension West Virginia Manufacturing Extension Partnership

Tom Mahoney discussed what benefits there were for companies to be involved in business networks. How they cut costs and build opportunities. He discussed why this issue is so important for a state such as West Virginia, where companies can work together to achieve success by building networks.

NICE³, Inventions & Innovations, & SBIR Proposal Planning Session

B. Gopalakrishnan, Associate Professor, WVU Industrial & Management Systems Engineering, and Associate Director, WVU Industrial Assessment Center
Judy Dyer, Chief Program Manager, Energy Efficiency Program,
West Virginia Development Office

B. Gopalakrishnan and Judy Dyer gave a detailed discussion on how to submit a successful NICE³, Inventions and Innovations, and SBIR proposal. They showed how important it is for a proposal to be clear, concise, and accurate in order to be successful. They also showed how companies can go about obtaining funding for research programs and what they need to include in their proposal for it to be funded.

Professor B. Gopalakrishnan of WVU's Department of Industrial and Management Systems Engineering and Judy Dyer of the WV Development Office plan their short course on preparing NICE³, I&I, and SBIR proposals. (WVU photo by Rita Beaty)

Appendix B
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