Papers:

All papers can be found in the conference proceedings: Global Conference on Sustainable Product Development and Life Cycle Engineering. 2004. Berlin, Germany: Uni-Edition. ISBN 3-937151-21-4

Breakout Session Group reports:

Although initially four breakout groups were held on Thursday, it was decided to change the Friday (Day 3) breakout group structure from two to five breakout groups in order to synthesize the Thursday (Day 2) discussions into a more coherent form. A fifth group on analyical tools was added due to the issues surrounding Life-Cycle Assessment (LCA). The following five groups reported their findings in terms of probems/gaps and actions/strategies to overcome these gaps:

- 1. Technology and Process Development
- 2. Analytical Tools
- 3. Remanufacturing and Reuse
- 4. Design
- 5. Education and Dissemination

Group 1: Technology and Process Development

This group synthesized their gaps and actions in terms of product life cycle phases and focused on the information, energy, material and tools issues in each life-cycle phase. Their summary is given in the table below. The entries in bold represent their highest priority actions/strategies that they recommended.

	Material Creation	Manufacturing	Use	End of Life
Information	- Providing information on new materials and recovered materials	 Storage of information on disassembly, on maintenance Product architecture for end of life Improving efficiency of manufacturing 	- Acquiring, distributing and assessing of information	- Collect and interrogate - RFID Tags, Sensors
Energy	- Minimize embodied energy	- minimize material usage	 usage of new energy sources 	- recover embodied energy
Material	- Micro and Macrostructured Material - Develop new and renewed materials	 Novel and modified robust processes Better control of the process 	 Interaction with nature (battery recharged through sound) 	- New separation processes - Reduce losses
Tools	Models (cultural, ecological, economical, social)	Modeis ()	Models ()	Models () and hardware tools

Group 2: Analytical Tools

The problems and gaps identified by the Analytical Tools group were as follows:

• Lack of integration of tools and analytical methods including: uncertainty, data gaps, and impact factors

- Lack of cooperation between disciplines
- Lack of tools for design for remanufacturing and disassembly
- Problems of bringing LCA into decision space
- Inability to meet designers language and integrate into their tools
- Problem with misuse of tools
- Impact factors needed for more chemicals

The recommended actions and strategies of this group were:

- 1. Develop an international database
- 2. Need to communicate LCA needs
- 3. Solid decision rules/tools such as
 - -Should I remanufacture/reuse/recycle/energy/dispose
 - Optimal life time of systems
- 4. Roadmaps
 - for LCA needs
 - for integration of LCA into technology roadmaps
- 5. Tools for different amounts and types of information
 - extract product group design guidelines
- 6. Meta analysis of
 - standard method for new LCAs
 - evaluation for existing LCAs

The group identified expected impact from these actions as follows:

- leverages past work
- results more reality based
- would help organize the activities in the field
- a common language for collaboration
- international understanding of issues improved
- wider practice of LCA

Group 3: Remanufacturing and Reuse

The problems and gaps identified by the Remanufacturing and Reuse group were as follows:

- There is a lack of understanding of consumer preferences for green products and remanufactured goods.
- There is a lack of understanding of the impacts of government policy and regulations on "incentivizing" markets for green and remanufactured products.
- There is a lack of financing mechanisms for green products; there is an investment gap due to characteristics of green products (often with longer term, life-cycle payoffs).
- There is not enough reliance on small and medium enterprises (SMEs) for the development of green and remanufactured products and services.

The recommended actions and strategies of this group were:

- Conduct a cross-national study to assess consumer preferences
- Investigate relationship between consumer wants, needs, and impact on the environment for various green and remanufactured goods
- Conduct a cross-national study of policy mechanisms to help determine the effectiveness of such mechanisms
- Explore how or if policies in one country can be applied other country contexts; conduct historical analysis

- Develop ideas for new mechanisms (e.g., eco-points, market based regulations, etc.)
- Develop training programs to encourage local SMEs to engage in remanufacturing business (builds trust at local market level)
- Conceive methods to encourage local level remanufacturing industry
- Facilitate networking and information sharing among SMEs
- Research local level supply chain feasibility to identify those products that would succeed using local SME capabilities

Group 4: Design

The problems and gaps identified by the Design group were as follows:

- Need for new paradigm for sustainable products
 - Clear design requirements
 - Clear criteria definitions
 - Design assessment tools of future impacts
 - Information systems support
 - Integrated tools
 - CHECKLISTS
- Lessons learned incorporated into the design process
 - Develop criteria from successfully remanufactured products
- Training
 - Middle management first
 - Then designers

The recommended <u>actions and strategies</u> of this group centered around what was phrased a "New Design Paradigm" in the design process, which should include the following aspects:

- Customer need
 - Incorporate sustainability into needs
 - Ask about sustainability goals
- Specifications
 - Translate into measurable goals: Economics, Social and Environment needs, Legislation, NGO's contributions
 - Assessments of specs
- Concept development
 - Inspired designers
 - Incorporate sustainability in the design statement of work
- Concept evaluation and selection
 - Checklists for sustainability
 - Quantitative evaluations
 - Customer evaluation
- Engineering analysis
 - Must use LCA
 - Add economic and social needs analysis
- Prototyping
 - Virtual prototyping that includes sustainability
- Testing
 - Testing of the sustainability goals
 - Remanufacturing and recycling tests
 - What can be added to make more sustainable
- Final design selection
 - Trade offs analysis

- Global optimization
- Design package development
 - Localization needs definitions
 - Environmental impact assessment
- Process planning
 - Sustainable processes
 - Energy minimization
- Quality planning
 - assurance of sustainability items
- Facilitization
 - Considerations come into effect
 - Social safety issues
- Production planning and scheduling
 - Insure materials from sustainable sources
 - Insure schedule does not adversely impact sustainability
- Production
- Distribution
 - Supply chain management issues
- Usage
- Service and warranty
- Maintenance
- End of service
 - Reuse
 - Remanufacture
 - Recycle
 - Discard

It was noted that this could already be done by a concurrent engineering/collaborative engineering design team.

Group 5: Education and Dissemination

The problems and gaps identified by the Education and Dissemination group were as follows:

- The need for modular tool kits for the different disciplines teaching fitting the needs of the students
- Training of the professor for teaching multidisciplinary courses
 - Professors need to learn how to teach!
 - Methods of Instruction
- Motivating the student to learn multidisciplinary content
- Mechanisms for sharing information
- Business oriented education of engineers (engineer as an entrepreneur)
- Participation of Africa

The recommended actions and strategies of this group were:

- Develop education material
 - Table of contents for areas of information
 - Assess current studies
 - Delegate to fill in the blanks
 - Create network for exchanging materials
 - Create thesis databases

- Continue to enhance the international CIRP (Communitee International de Research Production) website
- Create an international studies course which includes learning to understand and motivate the customer
- Support international student projects
 - Creating multinational student team projects which focus on sustainable campus systems
 - What is in common,
 - What are the differences
 - Expansion of GDP
- Create international sustainability design competition

Central Themes and Questions:

During the conference, the following central themes and research questions emerged:

- Technology and Process Development
 - What technologies are needed to advance EBDM?
 - What standards are needed for technologies, processes, or techniques?
- Market Development
 - How do we connect market signals with design?
 - How do government policies affect markets for green products?
 - How do we develop the appropriate supply infrastructures for reman/reuse?
- Analytical Tools
 - What improvements are needed in LCA and design tools?
 - How best can we bring LCA or other tools into the designer's workspace?
- Education
 - How can information be best disseminated to consumers, producers, and designers?
 - How can sustainability concepts best be integrated into academic curricula?
- Metrics
 - How do we measure sustainability?
 - How do we measure the value of reman/reuse?
- Design
 - How can we best feedback from reman/recycling into design process?

Conclusions:

The following conclusions from this conference were as follows:

- International collaboration in the EBDM area can be very beneficial and lead to standardization
- Many collaboration opportunities have been identified. As a direct result, researcher from RIT and University of Michigan teamed on developing a NSF MUSES proposal that has recently been awarded.
- Science and technology can guide policies and influence industry and consumers if message is credible and unified
- US and EU share many objectives, however, have varied motivations and approaches
- The needs and objectives of other continents such as Asia, South America, and Africa are not clear in light of many challenging conditions
- A unified approach to EBDM challenges should accommodate varied local conditions

It was recommended to extend and continue the Berlin conference model to encourage collaboration, information sharing, and sound understanding of issues and challenges. A 2005 conference held in China and a 2006 conference held in Brazil were direct results of this conference.

1 Conference Objectives

Following the outcomes from the Alabama EBDM conference and the prior study on Environmentally Benign Manufacturing (Gutowski et al. 2001; Allen et al. 2002), a joint EU-US conference with the Technical University of Berlin focused around the theme of Sustainable Product Development and Life Cycle Engineering was organized. The overarching objectives were to:

- Facilitate open in-depth discussions on how researchers in multiple disciplines can work constructively on EBM product manufacturing.
- Identify the areas / research issues for funding and future work on integrative approaches to manufacturing.
- Broaden the knowledge base and awareness of the participants about how various disciplines implement EBM research, technologies, and tools.
- Provide international networking opportunities and potential for future collaborations.

The conference program can be found online at: .www.gpe.tu-berlin.de/Global Conference/index.php.

The conference proceedings were published under "Global Conference on Sustainable Product Development and Life Cycle Engineering", Berlin, Germany: Uni-Edition, 2004, ISBN 3-937151-21-4.

2 Conference/Workshop Structure (Topics & Program)

The conference program took longer to develop than expected, primarily due to different perceptions of what "workshops" are in the US and Europe. However, after a 2 day face-to-face meeting in Berlin with the German prior to the conference, the structure as discussed in the following sections was adopted and followed. All presentations were accompanied by papers that were published in the conference proceedings..

2.1 Conference Day 1 - Wednesday

Welcome Speeches:

The objective of this session was to share with attendees the objectives of the conference and inform them about the various initiatives in the United States and Europe in the Environmental Benign Design Manufacturing (EBDM) area.

- Chair: Prof. Dr.-Ing. G. Seliger, Technical University (TU) Berlin, Germany
- Dr. D. Durham, National Science Foundation (NSF), USA
- Dr. J. Kunze, Deutsche Forschungsgemeinschaft (DFG), Germany

Keynote Speeches

The objective of the keynote presentations was to provide an overview on each focus area related to the conference theme. Discussion of the state-of-the-art in this area, major challenges, opportunities, and best practices will also be covered. The goal is to provide the attendees with a comprehensive view of the different areas to stimulate and to guide the follow on panel discussions.

- Chair: Prof. Dr.-Ing. G. Seliger and Prof. Dr.-Ing. K. Mertins, Technical University (TU) Berlin, Germany
- Prof. Dr. L. Alting, Technical University of Denmark (DTU) "Architecture of Life Cycle"
- Prof. Dr. B. Bras, Georgia Institute of Technology, USA "Challenge of Education in Sustainability"

- Prof. Dr. N. Nasr, Rochester Institute of Technology (RIT), USA "Remanufacturing From Technology to Application"
- Prof. Dr.-Ing. G. Seliger, Technical University (TU) Berlin, Germany "Global Sustainability A Future Scenario"

Presentation: Results from the EBM Study

The objective of this session was to show the results of the environmentally benign manufacturing (EBM) study sponsored by the National Science Foundation and published in January 2001. This study reviewed the current status of EBM research, development, and applications in the United States, Japan, and Western Europe. It attempted to identify new strategies the research community could employ to improve the future position manufacturing industries with respect to environmental issues. It also assessed current international collaborative activities and identifies opportunities for new approaches and topics for international cooperation in this field.

- Chair: Prof. Dr. B. Bras, Georgia Institute of Technology, USA
- Dr. D. Bauer, Environmental Protection Agency (EPA), USA
- Prof. Dr. T. Gutowski, Massachusetts Institute of Technology (MIT), USA
- Prof. Dr. J.W. Sutherland, Sustainable Futures Institute, Michigan Technological University (MTU), USA

Presentation: Results from the 2001 Ypsilanti and 2003 Alabama Workshops

Environmentally Benign Manufacturing (EBM) workshops were held in Ypsilanti, Michigan and Birmingham, Alabama, in 2001 and 2003. The National Science Foundation sponsored these workshops. In particular, the workshops were focused on discussions regarding the system-level issues of EBM. Therefore, the workshops aimed to bring together a group of researchers and practitioners from a variety of disciplines, rather than from a single technical area. It was hoped that this might lead to an expansion of interdisciplinary personal networks for novel multi-disciplinary research and EBM approaches in academic and industrial contexts. Results of these workshops were presented in this session.

- Chair: Prof. Dr. N. Nasr, Rochester Institute of Technology (RIT), USA
- Prof. Dr. M. Overcash, North Carolina State University (NCSU), USA
- Prof. Dr. J. Isaacs, North Eastern University (NEU), USA
- Prof. Dr. W. Olson, University of Toledo (UT), USA
- Prof. Dr. B. Bras, Georgia Institute of Technology, USA

Panel Discussion: Trends, Drivers and Policies for Sustainability

The objective of this session was to identify and highlight the needs in the EBDM area as seen by governments and industry. Environmental trends and challenges were presented and assessed as drivers for varied initiatives and policies as well as future directions and opportunities for collaborations.

- Chair: Prof. Dr.-Ing. G. Seliger, Technical University (TU) Berlin, Germany
- Dr. D. Durham, National Science Foundation (NSF), USA
- Dr. D. Bauer, Environmental Protection Agency (EPA), USA
- Prof. Dr. R. Dekker, Erasmus University Rotterdam, The Netherlands
- Klaus Hieronymi, Hewlett Packard (HP), Germany

- Prof. Dr. R.P. Gouvinhas, Federal University of Rio Grande do Norte (UFRN), Brazil
- Prof. Dr. F. Kimura, The University of Tokyo, Japan

Evening Event

The conference participants attended the 100th Anniversary Event in the PTZ Lab (Figure 1).



Figure 1: PTZ Lab

2.2 Conference Day 2 - Thursday

Parallel Presentations on Global State-of-the-Art and Future Perspectives, Part 1 and 2

The objective of the parallel presentations was for each participant to introduce her or himself, present what their main area of interest is, and what they are working on. Each participant was given 10 minutes plus a few minutes for Question and Answers. Parallel sessions were designed based on the abstracts received. Papers accompanying the presentations were included in the conference proceedings. The session topics as well as session Chairs and Synthesizers are shown in Tables 1 and 2. The role of the synthesizer was to take notes and observe any crosscutting themes for the next day breakout sessions.

Table 1 - Lalanel Session Lare 1	Table :	- P	arallel	Session	Part 1
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	Life Cycle Technology	Reverse Logistics, Recycling, Disassembly	Sustainable Design	Life Cycle Assessment
Chair:	Prof. Dr. J. Lee, University of Wisconsin Milwaukee (UWM), USA	Prof. DrIng. G. Seliger, Technical University (TU) Berlin, Germany	Prof. Dr. B. Bras, Georgia Institute of Technology, USA	Prof. Dr. H. Kaebernick, University of New South Wales (UNSW), Australia
Synthesizer:	Prof. Dr. J. Hu, University of Michigan (UoM), USA	Prof. Dr. R. Dekker, Erasmus University Rotterdam, Netherlands	Prof. Dr. S. Skerlos, University of Michigan (UoM), USA	Prof. Dr. M. Overcash, North Carolina State University (NCSU), USA

Table 2 – Parallel Session Part 2

	Life Cycle Technology	Remanufacturing	Sustainable Design	Education
	PTZ Room 210	PTZ Room 307	PTZ Room 001	PTZ Room 507
Chair:	Prof. Dr. J. Isaacs, North Eastern University (NEU), USA	Prof. Dr. N. Nasr, Rochester Institute of Technology (RIT), USA	Prof. Dr. J.F.G. Oliveira, University of São Paulo (USP), Brazil	Prof. Dr. ir. J. Duflou, Katholike Universiteit Leuven (KUL), Belgium
nthesizer:	Prof. Dr. T. Gutowski, Massachusetts Institute of Technology (MIT), USA	Prof. Dr. P. Gu, University of Calgary, Canada	Prof. Dr. F. Kimura, The University of Tokyo, Japan	Prof. Dr. W. Olson, The University of Toledo (UT), USA

Discussion of Workshop Objectives

The objective of this session was to set the focus for the upcoming work in breakout groups, and to answer the question: *What is this all about*? The speakers were:

- Prof. Dr.-Ing. G. Seliger, Technical University (TU) Berlin, Germany
- Prof. Dr. B. Bras, Georgia Institute of Technology, USA
- Prof. Dr. N. Nasr, Rochester Institute of Technology (RIT), USA

Breakout Groups

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The goal of the breakout groups was to assess the needs in each assigned area followed by the identification of state of-the-art, and the assessment of gaps. Prioritized recommendations were then compiled outlining opportunities for collaboration and future work based on potential impacts. The breakout group topics and facilitators are shown in Table 3.

Table 3 - Breakout Groups and Facilitators

Life Cycle Technology	Remanufacturing and Re-Use	Sustainable Design	Education and Dissemination
Prof. DrIng. G.	Prof. Dr. N. Nasr,	Prof. Dr. B. Bras,	Dr. D. Bauer,
Seliger, Technical	Rochester Institute of	Georgia Institute of	Environmental
University (TU)	Technology (RIT),	Technology, USA	Protection Agency
Berlin, Germany	USA		(EPA), USA

Report and Discussion

The objective of this session was to report and discuss the results of the breakout groups by volunteers from each group.

Evening

An evening social event was attended at the SORAT Hotel.

2.3 Conference Day 3 - Friday

Discussion: Identify Potential Multinational Collaborative Projects

The discussion in two groups focused on the following topics:

- Identify cross-cutting themes
- Identify implementation challenges
- Identify commonalities and differences in different regions
- Identify criteria for multi-national cooperation
- Identify criteria for leading/ground-setting projects
- Identify examples/recommendations for specific projects
- List and prioritize potential opportunities

The outcome of this discussion was a number of prioritized opportunities for multi-national cooperation.

Reports and Discussion, Comments

The objective of this joint session was to report and discuss the results of the previous discussion.

Networking, Collaboration Discussion and Poster Session

The final session aimed at the identification of networking opportunities and gave a chance for discussion in smaller groups. The posters were presented in the PTZ Lab.

References

- Allen, D. T., D. J. Bauer, B. Bras, T. G. Gutowski, C. F. Murphy, T. S. Piwonka, P. S. Sheng, J. W. Sutherland, D. L. Thurston and E. E. Wolff (2002). "Environmentally Benign Manufacturing: Trends in Europe, Japan and the USA." <u>ASME Journal of Manufacturing</u> Science 124(4): 908-920.
- Gutowski, T. G., C. F. Murphy, D. T. Allen, D. J. Bauer, B. Bras, T. S. Piwonka, P. S. Sheng, J. W. Sutherland, D. L. Thurston and E. E. Wolff (2001). Environmentally Benign Manufacturing. Baltimore, MD, International Technology Research Institute, World Technology (WTEC) Division.