FINAL REPORT

Technology Gaps Recycling Workshop

MTL 2001-13(OPJ)

Organized by

Materials Technology Laboratory - CANMET
Natural Resources Canada

in Partnership with
Industry Canada
Environment Canada
National Research Council
Process Research ORTECH Inc. and
Canadian Association of Recycling Industries (CARI)

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ABOUT THIS WORKSHOP

MTL-CANMET in co-operation with Policy-NRCan, organised a Technology Gaps Recycling Workshop in partnership with Industry Canada, Environment Canada, National Research Council, Process Research ORTECH Inc. and the Canadian Association of Recycling Industries (CARI). The workshop was held on March 1-2, 2001 at Sheridan Park Conference Centre, Mississauga, and its objective was to discuss technology gaps and identify technology innovations for improving the recycling in four sectors:

1. *Automobile:* impurities in metals (steel, aluminum, magnesium), auto shredded residuals, EAF dust, slags (ferrous and nonferrous), etc.

2. *Construction:* fly ash, slags (ferrous and nonferrous), concrete, wood, gyprock, plastics/vinyl, etc.

3. *Plating:* sludges containing nickel, zinc, chromium, cadmium, etc.

4. *Electronic scrap:* metals, plastics, glass, etc.

A total of 53 leading specialists from industry (34), government (17) and academia (2) discussed concerns and issues related to technology gaps in recycling. Recognition and appreciation is extended to the workshop participants who volunteered their time to contribute valuable expertise to this effort. Specific technologies such as separation, refining, and monitoring were identified to enhance resource recovery and provide a basis for future R & D work; recyclable product design, data generation, and life-cycle assessment were also discussed. This final report includes the outcomes of the workshop and recommendations for future work.

Amjad Javaid and Elhachmi Essadiqi from MTL-CANMET, in co-operation with Mike Clapham from Policy-NRCan, organised this Recycling Workshop in partnership with Joseph E. Cunningham Industry Canada, Duncan R.W. Bury from Environment Canada, Michael Barré from National Research Council, Lucky Lakshmanan from Process Research ORTECH Inc. and Leonard Shaw from the Canadian Association of Recycling Industries (CARI).

Elhachmi Essadiqi from MTL-CANMET, Duncan R.W. Bury and Peter Paine from Environment Canada and Michael Rich and Mike Day from National Research Council led the four product groups and prepared position papers.

Frank Harrison from Stelco, Nabil Bouzoubaâ from NRCan, Duncan R.W. Bury and Peter Paine from Environment Canada summarized the key points of discussion from each product area during the plenary session.

This workshop was facilitated by SUMMUM Consultants, and this document constitutes an "as it was said" report of the deliberations recorded on flip charts throughout the workshop prepared by Louise Mantha and edited by four product group leaders and Amjad Javaid.

TECHNOLOGY GAPS

RECYCLING WORKSHOP

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EXECUTIVE SUMMARY

On March 1-2, 2001 stakeholders from government, industry, and academia met in Toronto to discuss technology gaps in recycling in four sectors: automobile, construction, plating, and electronic scrap. Keynote addresses on the state of recycling and of recycling technologies were given by Lucky Lakshmanan from ORTECH Inc., and by Roger Yates from Hatch.

Workshop participants met in facilitated break-out sessions to identify what recycling practices are working well in their respective sectors, and what are not. They subsequently addressed solutions that might 'fill in' the technology gaps, and factors that might help, or hinder, achievement of these solutions.

The plenary discussion indicated common weaknesses in recycling technology across all sectors, such as: lack of separation technologies; non-existence of scaled-down economically viable technologies for small companies; lack of refining technologies; missing instrumentation technologies such as on-line sensors, and lack of cost-effective resource-recovery technologies.

Other non-technological recycling issues that were dealt with include: the fact that recycling does not seem to be considered at the design stage; regulatory burdens; lack of markets for waste materials or by-products; intellectual property; lack of awareness and education; cost of recycling technologies; lack of government co-ordination or R&D funding; lack of expertise in life-cycle analysis in Canada.

The group made a number of recommendations for follow-up to the recycling workshop, including:

- clearly articulate the rationale or drivers for improving recycling technologies and define the ultimate goal: do we mean closed loop recycling? or the creation of new products from recycled materials? or just don't put it in the land-fill?
- urge industry to input into changes in regulations and to develop an integrated communication strategy
- promote the establishment of a "Life-cycle Analysis and Management Centre of Excellence" as an independent research facility
- gather data on what <u>needs</u> to be recycled in Canada and why: what we can afford to dispose of and why? what are the volumes and what are their impacts on the environment? and what are the economic benefits?
- create a virtual centre of excellence on recycling, and develop a R & D strategy to find solutions for efficient recycling
- identify government and industry champions for recycling

Participants expressed their satisfaction with the way the meeting was conducted, and appreciated the varied interests represented as well as the position papers distributed in advance of the meeting. They would have liked greater representation from provincial governments, and from post-consumer packaging. This document constitutes an "as it was said" report of the deliberations recorded on flip charts throughout the workshop.

A. AUTO GROUP

1. In our industry what is <u>working well</u> with regard to recycling?

- Steel recycling is working
- There is a built-in infrastructure in place
- Easy separation for steel
- There are markets for the materials (most of the time)
- Infrastructure is in place to facilitate reuse and recycling (battery/catalyst lives, etc.)
- There is non-ferrous stream that is recycled (improved through separation) - adding current
- Shredded residues are being reprocessed
- There is a good copper stream and aluminum and magnesium
- Magnesium parts are more and more used - there is a high potential
- The auto manufacturers are actively involved in the process
- There are some trials in Texas regarding shredding of fluff
- Regarding auto wreckers, the infrastructure for reuse and recycling is well established
- The price of non-ferrous metal makes it profitable to dismantle them even manually
- Some car manufacturers put an ID stamp on the plastics
- The recycling process is energy efficient
- ASR is working well in Germany where the process is developed better than in North America

2. In our industry, what is <u>not working so well</u> with regard to recycling and <u>needs improvement</u>

- Tires: process exists but regulations don't allow for using this kind of process
- Only a small percentage of tires are currently recycled
- Plastic: there are so many pieces of non plastics - dismantling and separation is almost impossible, too expensive, and there is a risk of contamination with a mix of the polymers
- As more plastic is being used instead of steel, it ends up in end residues
- PCVs: could result in contamination of shredded residue (chlorine)
- Paint on bumpers creates a contaminant for the plastics
- Recycling of the shredded residues is not working well
- EAF dust has to be handled in the steel recycling

- The technology is not adequate for the segregation of alloys
- The closed loop recycling of steel to steel is not working well
  - elimination of some residuals is not done
  - the end product quality is not as high as the original steel (although alternative markets are there)
- Quality goes down in the recycling process and recycling is difficult to sustain
- Detonators in air bags create some problems - they result in hazardous situations because they are left in cars
- It is very difficult to recycle aluminum alloys
- Poor quality of end products is an issue: we need to improve monitoring, control and separation technology at low cost
- Re: electronic chips, mercury in switches, etc.: the chances are low that all these components are taken off
- Mercury switches could be recycled or reused; the technology is there, but it is a design issue
- Changes that occur today won't actually occur in the recycling of cars before 10-15 years
- We don't design with recycling in mind as much as we should
- The auto is changing rapidly and the recycling industry is not always changing at the same pace
- A lot of electronic components are being used: the presence of copper could result in health issues (zinc cadmium)
- Approximately 25% of cars are not being recycled at the moment

3. What are the main <u>technology gaps</u> in the auto industry?

- Economical separation technology for ASR
- Need to develop technology to convert ASR into marketable products
- Need to develop marketable products from ASR (challenge is presence of PCBs in ASR... vs. tight regulations)
- We need the development of a more economical process to treat EAF dust (zinc, lead, cadmium): there is a need for a solid commercial demonstration of processes for recycling EAF dust
- We must decontaminate the steel to prevent contamination of EAF dust
- Need to change the coating on steel to avoid EAF problem
- Need a technology to eliminate trace material from liquid metal
- Need for low cost on-line impurity monitoring technology
- Need of adequate technology to separate aluminum and magnesium alloys from scraps

- Need for methods of handling more hazardous materials (mercury, etc.)
- Need to design materials for recycling, i.e., designing with recycling and easy dismantling in mind : redesign for the environment

KEY TECHNOLOGY GAPS IN THE AUTO INDUSTRY RECYCLING

- Separation process
- Dismantling process
- Product development
- Refining / upgrading technology
- Design with recycling in mind

POSSIBLE INNOVATIONS / SOLUTIONS
(NOTE: NUMBERS IN BRACKETS INDICATE THE PRIORITY GIVEN TO EACH ITEM THROUGH A GROUP VOTE)

DISMANTLING

- Do material identification (develop analysers) (7)
- Do reverse assembly line automation technology (3)
- Throw the whole car into the furnace and then focus on separation technology (2)
- Have a more integrated disassembly process (consolidation economy of scale) (1)
- Clean the car before shredding (1)
- Do material labelling
- Use fewer polymers
- Develop improved tools
- Use old technology car manufacturing process to dismantle cars
- Develop “mini-shredders” that could be easily moved to remote areas
- Maximize the utilisation of parts resulting from dismantling
- Develop cheap transportation technology to take cars to developing countries where labour is more affordable
- Improve storage and transportation processes

SEPARATION

- Do media separation based on specific gravity of materials (5)
- Develop a brand new process to replace shredding (5)
- Develop a better chemical and physical separation process (2)
- Change the shredding process - break out the auto differently (2)
- Offer government incentives (1)
- Do a better identification of materials including phase analysis
- Develop a better thermal separation process
- Use clean material
  - Car - plastics - various polymers
  - Car - metal - various metals
- Find a way to do aluminum / magnesium separation
- Find a mechanism to get rid of PCBs and other hazardous material (mercury, lead, etc.)
- Use air classification

PRODUCT DEVELOPMENT

- Find products that could be produced from co-mingled plastics (parking curbs and other uses) (7)
- Identify methods of converting ASR to fuels - gasifying these plastics? etc. (5)
- Use ASR for slag stabilization (3)
- Recycle tires into a higher value product rather than low value product (1)
- Co-mingle plastics (BTU potential is interesting for other uses...) (1)
- Develop product and markets for glass (1)
- Recycle the foam
- Look at reusing some of these materials instead of recycling to make a cheaper yet safe car
- Improve toxic leaches so that the car could be use as artificial reefs
- Find products for all the organic stream
- Develop markets for new products from recycling

REFINING / UPGRADING

- Develop an economical process for EAF dust, i.e., recover usable zinc from EAF dust (8)
- Do commercial-scale demonstration of existing technology for EAF dust and other applications (8)

- Upgrade steel scrap by removing zinc, cadmium, lead (8)
- Eliminate trace material from liquid metal (magnesium, aluminum, steel, beryllium) (7)
- Improve detection of trace elements in liquid metal (7)
- Develop new improved low-cost sensors for process automation (better inputs detection, reduce energy consumption and production cost and improve product quality) (7)
- Explore agglomeration of the EAF dust (4)
- A & S upgrading ASR for fuels (4)
- Find a way to separate MG from Al (3)
- Do economic iron recovery - energy (1)
- EAF: facilitate transportation through revised regulations
- More efficient decontamination removal of liquids (oil, glycol, HFCs)

DESIGN

- Improve the design of auto recycling (9)
- Increase the amount of recycled materials in new cars (5)
- Make a modular car for easy dismantling (4)
- Eliminate the use of hazardous materials (2)
- Increase the overall durability of the car: make a stainless steel car (1)
- Develop something like the toothpick in a club sandwich: magnetic fastening system or dissolvable fasteners (1)
- Look at the specs regarding new materials in cars
- Use fewer polymer standardizing of polymer composition
- Eliminate composite materials
- Use easily dismantable plastics
- Use easily "tearable" plastics
- Make a biodegradable car
- Use only reusable parts
- Ensure that recyclability is part of the design
- Develop alternative coating
- Package things differently in order to facilitate dismantling: easy access and easy removal
- Develop an upgradable car with a longer overall life
- Increase the repairability of parts

- Have a group of people design a car for improved recycling
- Conduct a recycling industry design exercise
- Standardize all the components

BEST OPPORTUNITIES FOR RECYCLING IN THE AUTO INDUSTRY

- Create a "Design for Recycling" consortium
- Demonstrate existing technologies (EAF dust and other materials)
- Develop EAF dust treatment process
- Removal of Zn, Pb, Cd from scrap
- Develop sensors for process automation (impurity/trace element detection, improve quality, reduce energy/cost)
- Find a process for converting ASR into fuel
- Make products from co-mingled plastics
- Identify methods for material identification and analysis

BARRIERS

- Lack of technology transfer between stakeholders
- Not enough communication and information exchange
- Low risk acceptance
- Regulations
- Lack of recognition of the issue by all stakeholders
- Cost
- Intellectual property regarding who owns the technology
- Lack of technical resources
- Consumer acceptance vis-à-vis recycled cars or car parts: perceived as dirty and old

ENABLERS

- Acceptance and management of risk
- Risk sharing between the various stakeholders, between industry and government
- Encouraging broad base implementation innovations (not only for isolated plants)
- Reinforcing of regulations
- Expanded producers' responsibility

- Financial incentives e.g., incentives for Research and Development
- Recyclables being considered as product
- Ban the use of word WASTE
- Improving procurement policies
- Establish green credit
- Setting up a recycling information exchange between various technology and sectors
- Create a consumer demand for recycled products: get them to request these products
- Public education - show the benefits of recycling
- Appropriate labelling of recycled/recyclable materials
- Address the intellectual property issue in order to facilitate information sharing
- Non competitive research model
- Improve partnership between Research and Development institutions and Industry
- By-product synergy concept

B. CONSTRUCTION GROUP

OUR DEFINITION OF TECHNICAL GAPS IN CONSTRUCTION:

- It is not a gizmo
- It is a process
- It could be a connection
- A system of technologies that already exists (the connection)
- It has to be economically viable

CURRENT RECYCLING SITUATION

1. What is working well?

- Recycling of steel and metal products as well as rubble and asphalt
- Traditional application of fly ash and ground slag in concrete-cement industry
- Manufacturing processes in-house / post-industrial
- Lumber into landscape material
- Paper going into laminates
- Sustainable forestry in Canada
- Wall-boarding industry if you are close to a recycler
- The sector is a good consumer of other industries by-products
- Acoustic tiles and some of the carpet industry are doing some recycling
- Roofing products are doing well in industrial production

2. What is not working well?

- Co-mingled material
- We don't have a clear indication of the problems that need to be solved

3. What are the recycling <u>technology gaps</u> in the construction industry?

- Low enough cost separation technology is a gap in technology
- There is a lack of single material products to fulfill properties delivered by co-mingled materials
- We don't think about designing for obsolescence (i.e., design for recycling)

- We need technologies that will enhance the end of life re-use and recycling of multi-material products
- We need a cost effective sorting of contaminants in multi-material products
- Technology gaps need to be divided according to the following sectors before we can begin to address any of the related gaps:
  (a) the construction industry as a consumer of other industries' by-products
  (b) the manufacturing of construction materials
  (c) the construction process itself
  (d) renovation / demolition of constructed structures
- Address materials handling / transportation issues by scalability of the process. The distance to the market is an issue, versus the current disposal costs

GENERAL CONCERNS

- We have a very diverse, disconnected playing field, e.g., 80% of the industry consists of companies with fewer than 10 employees
  - there is a lack of awareness of issues
  - there is a lack of dissemination of options
  - there is a fear of liability for innovation
  - there is a lack of regulatory flexibility, i.e., specification rather than performance driven
  - the specification bid culture discourages enhancing performance (end of life, environmental concerns and LCM)
  - construction has the lowest research and development investment of all major industries

SECTORS OF CONSTRUCTION

(A) THE CONSTRUCTION INDUSTRY AS A CONSUMER OF OTHER INDUSTRIES' BY-PRODUCTS

THE CHALLENGES

- Fly ash quality
- Resistance of fly ash concrete to salt scaling
- Early strength gain of concrete
- Evaluate fly ash in conjunction with other material and admixtures for specific applications

TECHNOLOGY GAP:

- How to reduce the carbon and NH3 content in fly ash at an acceptable cost

SOLUTION

- It is being resolved as we speak

(B) THE MANUFACTURING OF CONSTRUCTION MATERIALS

- mine tailings
- recycled paint
- slag
- incinerator ash
- pulp mill black liquidation
- gypsum
- cement kiln dust
- crumb rubber tires paper
- recycling sludges
- water treatment sludges
- alternatives to silica fumes

TECHNOLOGY GAP:

- There is a discrepancy between the lab tests and the data generated in the field

SOLUTION:

- Research and development, data collection, collaboration with the industry, analyse and share the data

TECHNOLOGY GAP:

- Economic technology that enhances early strength development of fly ash concrete

SOLUTIONS:

- Research and Development and funding from more sources to evaluate performance and performance gaps
- Include the life cycle costs of the final products in construction costs. Project evaluation must consider life cycle impact(s) and durability

TECHNOLOGY GAP:

- Actual lab and field validation of specific examples where concrete performance can be dramatically improved, e.g., Gardiner Expressway, bridges

SOLUTIONS:

- Collaboration between research and development resources and industry to identify potential improvements
- The renovation / demolition of constructed structures

TECHNOLOGY GAP:

- A cost effective sorting or separation of multi-material products
- Address materials handling and transportation issues by scalability of the process. The distance to the market is an issue versus the current disposal costs

SOLUTIONS:

- Design for the commissioning balanced with needs for operability and durability
- Research and development on separation and sorting techniques, and consider the scalability of separation techniques: development must consider small and medium size enterprises
- The manufacturing of construction materials

TECHNOLOGY GAP:

- Life cycle analysis and management knowledge (this notion applies throughout the sector)

SOLUTION:

- Awareness, education, skills development, data development
- Translate the data into comparison to feed the project design and material choice

(C) THE CONSTRUCTION PROCESS WAS NOT COVERED DUE TO LACK OF TIME

C. PLATING GROUP

CURRENT SITUATION

1. What is working well now?

- Nickel recovery for large companies, offsite
- Improved utilisation of the raw material; this reduces the need for recycling in some cases
- Large significant amounts of recoverable metal are being recycled
- Segregating the waste; in new installations it is easier than in older installations due to size and retrofitting factors
- Cost of raw materials (e.g. nickel)
- Recovery technologies
- Information from trade association dedicated to the MFI
- Large metal finishing industries are working well
- Some specialized factories focus on only 1 or 2 metals: it is easier to manage when other X metals have been eliminated
- Matching companies: 1 company's waste becomes another company's raw material
  - pro-active clearing house idea
- If large companies use a technology and can show results it will or could be used by a smaller producer

2. What is not working well?

- There is a fear of new technology and new by-products
- Large companies do process management but smaller companies do not
- There is no means of recycling large amounts of zinc sludge
- Unwillingness of large producing companies to thoroughly invest in recycling technology; economics don't allow for small volume input and for the contamination risk
- There is no system for segregating small amounts of contaminants
- If the material is non-hazardous there is less pressure to recycle
- Cost of technology versus the status quo
- Use of technology and removal are too costly for small companies: the paperwork is too cumbersome and it is easier to pay someone to take the material away

PLATING TECHNOLOGY GAPS

- The ability of large and small producers to deal with waste and by-products (it is a financial gap)
- Small companies produce mixed waste with a danger of contamination
- There is a lack of technologies which are economically viable
- Lack of ability to downscale technology for use by small producers
- Lack of exchange of information between manufacturing companies who are competitors, therefore a lack of reliable bench-marking
- Unwillingness of regulatory agencies to allow innovative use of technology: governments don't understand or encourage recycling (political or policy gap)
- Some companies don't believe in research and development; they are not working closely with their suppliers on research and development (economic constraint)
- Lack of selective separating technology for more metals and substances
- Regeneration of hydrochloric acid containing contaminants other than iron (e.g. zinc)
- There is no black box which will separate out everything in a recyclable form
- There are no economically viable smaller versions of separation and recovery technologies for small platers

PLATING STRATEGY: SOLUTIONS / INNOVATIONS

MIXED WASTE FROM SMALL COMPANIES - DOWNSCALING TECHNOLOGY

- Send mixed waste solutions to larger 'brother' (intermediate plater or other) with the ability to treat the solutions: i.e., concentrate the problem in fewer spots
- Improve the education of small companies on the dangers and impacts of contamination and potential cost savings from even low tech solutions - e.g., improved racking
- Downscale technologies - e.g., avoid mixing ion exchange with electrowinning; the technologies exist, small companies need to be educated
- Develop an education team separate from all companies to work with small companies to improve their processes and increase their understanding; this will allow new problems to be addressed
- Develop a technology to treat small concentrations in large volumes to fight dilution as a solution e.g. filter placed in the line which is sent away to a recycler at regular intervals

ECONOMICALLY VIABLE TECHNOLOGIES

- Investigate technologies used by other industries which may be usable or applicable to the plating industry

- Have greater incentives for research and development, e.g. direct funding from governments encouraging solutions for recycling
- Develop cost statistics on the production of waste, e.g., the recycling cost vs. impact of landfill

SELECTIVE SEPARATING TECHNOLOGY / BLACK BOX MAGIC SOLUTION

- Simple boxes (e.g., filter cartridge) on a stream so that groups of metals are filtered out: it could be a scavenger unit for physical separation or ion exchange separation
- Develop plasma systems which are ion specific
- Have a government team to investigate inter-industry synergies
- Investigate other uses of by-products
- Need to develop recycling facilities in Canada to deal with recycling zinc so that we can understand the volume and the constraints, and develop options

ENABLERS FOR PLATING RECYCLING TECHNOLOGY STRATEGY: WHAT MIGHT HELP?

- Money
- Having a marketable product
- Grants from governments
- Investments / venture capital
- Grants from industrial groups (AESF)
- Funds from individual companies that have a vested interest
- Licensing or royalties after development of a technology
- Clearly define the anticipated output of the black box(es): draw up an agreement among the players
- Long term incentives for the use of the technology: monetary subsidization, or legislated requirement
- Waiver of certain regulations (or at least greater flexibility in respecting them)
- Create a “Department of Recovery” at the federal government level
- Change legislation to reflect the need for re-use
- Reallocate resources at the federal level to address recycling process management
- Make annual environmental report by companies available to the public
- Develop a technology which will allow companies to be competitive globally (large companies primarily)
- Regulate land-fill sites but not recyclables

WHAT MIGHT HINDER?

- No money
- No agreed-upon definition
- No incentives
- Existing regulations (e.g. transportation)
- New regulations imposing more constraints
- Economic cycles i.e., price for recycled materials, or lack of demand for finished products
- This is a throw-away society
- Lack of education and caring among potential users

D. ELECTRONIC SCRAP GROUP

1. **In the "electronics" industry, what <u>is working</u> well with regards to recycling?**
(Note: The discussions relate to PCs and some peripherals. It was recognized that other electronics such as communication technology may have different issues associated with them. Design was felt to be more of an issue, which could be impacted in Canada as more of some electronics are made in Canada)

- A young, emerging refurbishing and recycling industry
- We are all coming to the table at same time, all voluntary recyclers, regulatory industry, NGO, Federal Ministry
- There is a good industry built up around electronic industry (business to business) because of economic incentives
- Relatively speaking, no large environmentally damaging legacy from past bad performance at the present time
- Packaging materials are being recycled in some large companies' e.g. Sony, HP, Xerox, IBM but not in SME's.
- Multi-stakeholder process to address issues is being established - IT industry is engaged (e.g. participating in work on waste management options)
- Canadian Council has struck a working rep to look at electronics
- Models for response to issues exist - Computers for Schools a major success story, a good understanding of Extended Producer Responsibility approaches, and concrete examples of programs
- Models have been developed (WDO Regulation, deposit return, blue box) that we can learn from
- There are some international models, particularly legislative
- The refurbishing side in Canada is very well organized, and some are national
- Some of the solutions and our relationships are good
- There is a rechargeable recycling battery corporation - for all small amounts we ensure that the end of life battery is recycled
- Life cycle environmental burden data as a help to future investments: it changes so quickly but quantity is validated by the environment. The quantity is based on sales and is a model, but a compositional study would be even more helpful
- Limited legacy (e.g. televisions) if we are aware at the earlier stages (e.g. CRT's)
- There is a market for scrap if we could get greater economies of scale with high end computers at this point in time
- Collaboration is the Canadian way to find solutions
- Large firms are committed to research and development investment in these issues.

2. In our industry, what is not working so well with regard to recycling?

- Economic sustainability isn't in place - concern about viability of emerging recycling industry and recovery infrastructure
- It would help sustainability if we could express what we are trying to do in monetary terms
- Emerging technologies seem to come and go: why are they not there and how can we support them?
- Disconnect between design and manufacture of equipment and the needs at end of life for such things as ease of disassembly, recyclability etc.
- There is little dialogue between design and recyclers, e.g., tell them to build a solder without lead: more dialogue is needed to see what materials are being used
- Manufacturers are small to medium sized and don't have ability to redesign for resource recovery or recycling technology
- Distances to markets for recovered materials - responses to issues in smaller scale markets and communities
- Transportation is a major issue for CRT's because there are few places that do it
- Our drivers encourage small operations
- "Mom and Pop" shops are a dying business of refurbishing
- CRT management and disposal - environmental and technical issues
- Increasing use of plastics in equipment and other composites - renders recycling difficult or impossible - plastics not identifiable
- It is a complex chains and many parts are contributing different parts of solutions
- Declining value of recovered materials - less value in newer equipment
- Today's value of electronics is low and who is going to pay to recycle? Consumers are not very willing to pay for it to be recycled
- We are trying to compete where it is very cheap so it goes to land-fill or offshore, e.g., stereos, phone, VCR
- It is an immature industry which is one reason why recycling is not cost effective: no one wants to take it on if it is not economical
- We need to connect more with corporations to get more years out of the product, or get a second use.
- Designing and investing in recovery, recycling equipment for continually changing equipment and waste streams is a major challenge - designing for new IT equipment but dealing with obsolete equipment
- Regulatory issues and hazardous waste definitions
- We are unwilling to invest in infrastructure due to economies of scale, and the cost of the regulatory regime is too high

- There is no market or regulations for recovery of some products today
- Serious health and safety issues regarding material also require more dialogue
- Poorly developed technology, knowledge transfer
- There is less recycling from consumers
- There is limited education on issues due to a number of drivers
- How do we get more research and development funding to look at these issues?
- Packaging separation needs improvement, particularly for the end of life phase
- Question: How national is this refurbishing business in the recycling business?
- We as an industry will develop technologies, but then we invest in the U.S.
- There is a flow of electronic scrap from Canada to the US where it is separated and then shipped back: this is inefficient.
- We are missing some cross-provincial representation
- There is a greater and more costly role for municipalities' demands, and for new investment

3. What are the recycling technology gaps in our industry?

- There are major technology gaps for recycling CRT's (monitors) and plastics
- There are gaps in the design and end-of-life stages
  - ➢ Ability to design for recoverability does exist but only in large companies, although there is some push down
  - ➢ we lack separation technologies at end of life stage
- CRT recycling technologies exist but they are expensive
- There is inconsistent supply - there is too much or too little at one point in time
- Separation technologies are not as developed as necessary - plastics a particular problem
- There are composite plastics in new products: right now they need to be separated into various grades
- There is an expectation problem with the use of plastics: design mixes the types of plastics or modular types together
- CRT's constitute a major recovery issue and may be a technology issue: e.g., the separation of the lead phosphor from the glass
- Cost effective technologies - the challenge of technically feasible, but economically unsustainable
- There are some solutions but they are not cost effective, i.e., vacuuming technology
- The product life cycle is very short so investing in some technologies may not be worthwhile
- There is a need to balance between recycling vs. energy use: what is the best solution is up for debate

- In the future, design technology is a major part of the solutions
- We are not sure how much technology work has really been done to recycle monitors economically
- Design for the environment - disassembly, recycling
- Need for flexibility in technology to address changes in equipment design and material components
- Existing technologies are often not suitable for small scale application
- Identification of materials
- Technology to manage workplace hazards i.e. beryllium, CRTs

GAPS AND POSSIBLE SOLUTIONS

- Front end design
- Design for environmental issues - e.g., recovery of reusable components, recoverability of the types of materials
- Collection is an issue because we are dealing with small items of little value
- Focus on consumer IT and telecom sector because it poses the most challenge - less is known about the larger scale, mainframe, telecom industry where Canada has more direct manufacturing - sense that there is less of an issue in this sector
- Improvements in front end design are a major necessity but have to be addressed by OEMs and at an international level
- Improvements in scientific knowledge about environmental and health effects of materials used in electronic equipment are needed
- Scalability of facilities needs investigation - development of technologies which are appropriate for smaller scale, smaller market/community application
- Separation technologies - R & D necessary, also related to scale issue
- Technology commercialization challenges - technology may be available but application a challenge
- Guidance on the right mix of capital and labour
- Regulatory and policy framework to encourage and enhance recovery - linkages to Environmentally Sound Management initiative

(A) SEPARATION ISSUES

- Facilities are not there due to scalability:
  - we do not know for sure what is available
  - recycling of some metals does not exist
  - is there a market?

- plastic side of the stream
- labour and capital considerations

- Technology and knowledge transfer is a cross cutting issue
- Technology transfer is a problem
- There is little sharing of information especially around separation interconnectedness: we have not built synergies
- We do not have a common definition of recycling
  - 75% of that which is captured in the waste is recycled in Canada
  - 95% of technology production is offshore
- Separation of CRTs and plastics is a key issue for electronic scrap: the real challenges exist around P.C.'s and peripherals
- Some technologies exist for various aspects of resource recovery, but not all are cost effective, and this is therefore a major technology gap.

(B) DESIGN FOR THE ENVIRONMENT

- Encourage upgradability
- Take a modular approach
- Need to drive some economic value into the design phase
- Impose a tax on land-fills: if manufacturers are responsible for life end, it drives the front end (We will get some benefits from European legislation because most components are imported, although it is not clear what materials will be banned and not)
- Define the risks associated with handling certain substances
- Establish a Round table concept
  - get everyone who has a stake in the life cycle voluntarily at the table, with a willingness to engage, and broad base representation
- Documents on the principles of design exist but none on how to implement them
- If barium gets into the PC it will be a serious problem: is there a Canadian role in regulating to ban substances?
- Is there a role that they (government) can play to provide economic advantage to make products more recyclable? OECD and UN levels do lots of work on substances: the solution may be about managing and not just banning
- Change the incentives for built-in design of environment considerations
- Regulation levels the playing field: we need to give a clear message
- Encourage designers to try something new.
- Increase focus of design for environment at the academic level and into circulation
- Encourage voluntary participation

PC DESIGN

- Needs to be addressed at the international level with the scientific knowledge being shared. Need to broaden scope and put DFE back in
- Need to use like plastics in one component which makes recycling easier (no separation required)

SEPARATION OF PC MATERIAL

- There has to be a social legitimacy to recover energy from plastics that we may not be able to separate or where we do not have a use for the by-product. This is a heightened problem in Ontario and therefore an opportunity
- We may need to move to better use of materials (e.g., metals) instead of plastics: designing for the environment is a move to fewer polymers because it is not economical to manually separate and some composites present problems
- We need better automated processes because volume will increase and labour is too expensive
- Determine who will pay for the technology to do the separation: we may still need to do it manually, but then decide on the capital investment to pull if reusable or remove if it is hazardous
- In Canada we have few electronic machines and it is harder to sort different types
- We need to mark the type of plastic being used (there is a move in this direction)
- American Plastic Council and European equivalents are active in separation technology. We need to take a new look at this and see if some incentives can be given to make the technology commercially viable
- Non desirable materials may exist in some components and we need technologies to identify if it exists
- Can there be a regulation so that other materials would be labelled like plastics?
- We need to consider special requirement regarding the disposal of monitors: the ways to recycle CRT's may not be optimal due to high cost: who will pay is the issue
- The priority is to invest in a regulatory policy framework to encourage recycling with industry involvement

HINDRANCES

- Inventory of materials
- Technologies are changing too rapidly: it is difficult to keep up with how to take the machines apart and then to sort them
- It is not clear what levels of contamination are acceptable

PLENARY DISCUSSIONS

COMMON RECYCLING TECHNOLOGY GAPS/ ISSUES ACROSS ALL FOUR SECTORS (auto, electronic scrap, construction, plating)

1. Separation technology
2. Scaling down technology for smaller companies (SME's) to make recycling economically viable
   - size of company
   - size of region/population
3. Initial design for ultimate recycling
4. Regulation changes
5. Constant change in materials used (materials become obsolete in short time)
6. There is not always a market for the waste or by-products because they are un-economical
7. There is a lack of a green procurement policy on the part of our governments
8. There are no technologies to improve the efficiency of existing technologies
9. How to create products out of the composite materials generated by recycling activities?
10. Lack of commercially affordable technologies
11. Low-cost, on-line, monitoring, control, and separation technologies
12. Application of technologies used in one sector to another sector
13. Lack of information exchange within each given sector and between companies
14. Look at the value-added in the management of materials
15. We need a clear understanding of life cycle analysis in each sector: there is a need for data

COMMON RECYCLING TECHNOLOGY THEMES

1. Separation technology
2. Design for the environment / Design for recycling
3. Scalability
4. Refining technology (e.g., removing impurities) - cleaning it up

5. Automation (automated processing)

6. Creating products out of recycled materials (e.g., composite plastics) and creating a market for these products

7. Instrumentation: on-line sensors to identify materials (hazardous materials)

8. Making more cost effective technologies

OTHER COMMON THEMES

1. Regulations issues

2. Information exchange (between/within disciplines, sectors, technologies)

3. Intellectual property (can stifle research)

4. (competitive) Cost and value

5. Education / raising awareness

6. Recognition: positive spin, whole new conceptual approach to recycling

7. Governance: co-ordinating a positive approach, promoting eco-communities

8. Infrastructure (e.g. transportation)

9. R & D funding (basic research for the future)

10. Risk Management and Partnerships

11. Collaboration , i.e., on research

12. Green credits: recognition and incentives

13. Life Cycle analysis

RECOMMENDED NEXT STEPS

1. Articulate the rationale or drivers for improving recycling technologies & activities

2. Get all industry associations to monitor the development of regulations and ensure industry input into any changes i.e., get on the Environment Canada mailing list

3. Develop an integrated communication strategy which takes into account such factors as, rapid response, association engagement, early warning, involvement in regulatory or legislative change
   - use government as the hub or the glue: get them to act as facilitator
   - each sector should set up an information exchange system

4. Define the ultimate goal or options: define what we mean by recycling: do we mean closed loop recycling? or the creation of new products? or just don't put it in the land-fill?

5. Promote the establishment of a "Life-cycle Analysis and Management Centre of Excellence" as an independent research facility

6. Gather data on what needs to be recycled in Canada and why: what we can afford to dispose of and why? what are the volumes and what are their impacts on the environment? and what are the economic benefits?
   - get copies of R-NET and access NRCan's website for this information

7. Create a virtual centre of excellence on recycling (e.g., look into separation technologies)

8. Unrepresented industry should get involved in the CSA and ASTM processes to develop standards where none exist

9. Develop an R & D strategy to find solutions for efficient recycling

10. Identify industry leaders to develop a vision for sustainable development
    - negotiate with regulators
    - look at various venues for exchange (e.g. the Thursday group)

11. Identify a government champion for recycling

12. Develop multi-party project proposals: write state-of-the-art papers to inform proposals, identify clear gaps

13. Find out what environmental impact the country is most interested in addressing

MEETING EVALUATION

WHAT DID WE LIKE / WHAT WENT WELL	SUGGESTIONS
• multi-industry groups • the facilitation was professional and helpful • we maintained the focus • being here • the facility and location • taking the initiative to have the meeting • size of the group • getting the position papers ahead of time	• be sure to have a follow-up • stay away from Fridays as a meeting day • stay focussed on the objective which is technology • pick Fridays • include representatives from post-consumer (e.g. packaging) • broaden the scope beyond technology • have an industry steering group to help design the agenda of follow-up meetings • include academic input • provide feedback to the organisers before the next meeting • involve more provincial counterparts and have them present at the meetings

APPENDIX A: WORKSHOP DESCRIPTION

Objective

To identify technology innovations for improving the recycling of various materials.

Description

CANMET held a workshop on recycling in partnership with Industry Canada, Environment Canada, National Research Council and the private sector on March 1-2, 2001 at ORTECH, Mississauga. ORTECH cosponsored the one and a half day workshop. Leading specialists from industry and government exchanged information and discussed concerns and issues related to recycling. The workshop was divided into four product groups of ten to fifteen people for a total of fifty to sixty. These product recycling groups were selected in consultation with industry.

The workshop identified improvements in processing, material structure and integrity, material recovery and sorting systems and product design. We identified technology gaps in the four products recycling streams containing multiple materials. Specific technologies were identified to enhance resource recovery and provide a basis for future R&D work. We focused on both primary and secondary processes of metals that have scrap feed as part or all of their material inputs:

1. **Auto:** impurities in metals (steel, aluminum, magnesium), auto shredded residuals, EAF dust, slags (ferrous and nonferrous), etc.

2. **Plating:** sludges containing nickel, zinc, chromium, cadmium, etc.

3. **Electronic scrap:** metals, plastics, glass, etc.

4. **Construction:** fly ash, slags (ferrous and nonferrous), concrete, wood, gyprock, plastics/vinyl, etc.

Day one we focused on the status of recycling specifically what works and what does not. Key areas in each of the product groups were identified for discussion in the day two of the workshop (i.e., identification of technology gaps).

A position paper was prepared (2-3 pages maximum) on recycling in each of the four product areas. The paper served as a basis for questions and discussions during day one. This paper was available before the workshop.

Day two we identified technology gaps including required R & D, realistic goals, priorities, incentives and obstacles. Options were tabled by the working groups, i.e., identify technology innovations and solutions.

Expected Outcomes

- Identify technology gaps and related costs and infrastructure short comings
- Identify R&D needs
- Identify synergies across four product areas
- Final report with recommendation on future work

There was no registration fee, but each individual was responsible for his/her own hotel costs and transportation to the meeting site. Continental breakfast, coffee, soft drinks, lunch and dinner were provided.

Directions and hotel information are provided in Appendix C. Please make your reservations as soon as possible.

If you have any questions, do not hesitate to call Dr. Amjad Javaid or Dr. Elhachmi Essadiqi.

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APPENDIX B: PRELIMINARY AGENDA

Technology Gaps Recycling Workshop

Time	*Session*
Thursday, March 1, 2001	
12:00 – 13:00	Registration and Lunch
13:00 – 13:15	**Introduction** • Purpose of the Workshop.......................…..E. Essadiqi, CANMET • Process.. SUMMUM Consultants
13:15 – 14:00	**Keynote Address** • Lucky Lakshmanan, Process Research ORTECH Inc. • Roger Yates, Hatch
14:15 – 15:30	**Current Recycling Situation** Participants representing each of the four product areas meet separately (assisted by a facilitator), and address the following questions and exchange their views. Each working group is asked to fill out a prepared work sheet on the current recycling situation in terms of: a) What is working well? b) What needs improvement? c) What are the technology gaps or issues? Day one of the workshop will primarily focus on what we know (i.e., what is the current recycling situation?), and identify key areas for discussion in the next phase of the workshop (i.e., identification of technology gaps).
15:30 – 15:45	Break
15:45 - 16:30	**Plenary** Each group reports on its' deliberations.
16:30 - 17:00	**Identification of Key Technology Gaps** Identification of key technology gaps for discussion during tomorrow's session.
17:30 - 20:30	Dinner

Time	*Session*
Friday, March 2, 2001	
7:30 - 8:30	Continental Breakfast
8:30 - 9:00	Recapitualtion and Instructions
9:00 - 11:00	**Working Groups** Focus on identification of technology gaps including required R & D, realistic goals, priorities, incentives and obstacles. Each group meets separately (assisted by a facilitator), and considers options such as, what is needed to achieve the goals and what technical solutions would address the issues? (i.e., identify technology innovations and solutions). Group agrees on key messages and select a rapporteur.
11:00 - 12:00	**Plenary** Each area reports on their key points. (15 min. each) Q'S & A'S to clarify
12:00 - 13:00	Lunch
13:00 - 14:15	**Overall Conclusions** Facilitator asks participants for common threads amongst the working groups, areas for potential technological synergy, lessons learned, etc.
14:15 - 14:30	Break
14:30 - 15:15	**Next Steps** Participants are asked to suggest actions to follow up on the workshop
15:15 - 15:30	**Closing Remarks** • Dr. Leonard Shaw, CARI (participants are asked to hand in an evaluation sheet)

APPENDIX C: RECYCLING WORKSHOP PARTICIPANTS

Auto - (Recycling through Primary and Secondary Metal Production)	
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APPENDIX D: POSITION PAPERS

CANADIAN CONSTRUCTION INDUSTRY

BACKGROUND

The Canadian construction industry, although a major factor in the national economy, is both regionally fragmented and divided into a number of sectors and disciplines. The principal sectors of the industry are commercial, industrial, institutional and residential, each having very significant and different needs and, for the already vast subject of sustainability, very different technical considerations. The construction industry is also very regional due to both the population distribution of Canada and the very different regional and climatic conditions to be identified and accommodated. Furthermore, the disciplines of architecture, engineering and research are usually focused on one or two specific sectors of the industry and rarely cross into the other disciplines. It is also very difficult to introduce similar recycling protocols across these sectoral boundaries.

COMMERCIAL AND INSTITUTIONAL

The commercial and institutional sectors of the construction industry have begun to identify opportunities to improve their performance in the fields of sustainability, performance and recycling - life cycle costing. The initial effort is often introduced by progressive owners who are interested in achieving improved long term performance from their new buildings and improved indoor environments in their refurbished or renovated properties. Excellent examples of both of these were demonstrated in the recent construction of a new commercial tower in downtown Toronto as well as the complete renovation of the existing 60 year old headquarters of the same company, Canada Life. Canada Life/Adason Properties used demanding performance specifications including “incorporated energy” for the windows of this restoration project. It is worth noting that Canada Life owns and operates a number of large commercial properties (e.g. Sherway Gardens, Etobicoke, ON). There remains a substantial opportunity to harness the efforts of complimentary sources of expertise to address any remaining “gaps” and other related subjects to improve the overall quality of commercial buildings

INDUSTRIAL

The use of recycled or otherwise waste materials in concrete has been an ongoing initiative involving the cement industry, consulting engineers, researchers and progressive contractors and suppliers. The concrete floor of a recently constructed large industrial plant (4,000 m^2) in Brant county Ontario utilized 25% fly ash in the concrete mix design. The steel supporting structure and roof joists were salvaged from a previous uncompleted project. This same plant produces concrete elements (floor slats, pens) for the hog industry and has been experimenting with numerous materials to improve the long-term performance of these concrete elements in a very hostile environment - hog barns. To date they have investigated fly ash, silica fume, rice hull ash (amorphous silica), slag and various geo-polymers. These experiments continue to involve a variety of diverse parties including researchers, engineers and suppliers. Much remains to be done to fill the "gaps" in attempting to optimize the performance characteristics of each of the manufactured elements of industrial buildings.

RESIDENTIAL

An increasing number of progressive residential builders in an otherwise conservative sector of the industry are introducing new, environmentally friendly practices and products into their developments and houses. In BC (improved building envelope/indoor air quality), New Brunswick (collective ground source heating), Ontario (new basement and framing technologies, interior versatility) and Quebec (new construction materials) there are increasing numbers of examples of sustainability, improved service life and better collective initiatives to incorporate better value in residential buildings. The residential sector is also the showcase of many new framing and finish products using re-cycled materials. Nonetheless, there remains much to be done since many of the new initiatives may have been commercially driven and could warrant better scientific evaluation vis-à-vis impact on indoor air quality.

CLOSING

The new Objectives-based National Building Code, presently soliciting comments from across Canada, will be a timely encouragement to the increasing efforts to find, develop and identify new and innovative solutions to the fundamental challenges of increasing our overall sustainability and recycling in the key sectors of the Canadian construction industry.

RECYCLING IN AUTOMOBILE INDUSTRY

Recycling of automobiles is an important component of sustainable development and energy conservation. Almost 75% of obsolete cars are recycled and the remaining 25% becomes landfill. It is a major challenge to reduce this percentage of obsolete cars going to landfill. In recent years the automotive industry, metal producers, automotive parts manufacturers, the recycling industry and governments have been working toward increasing the recyclability of cars. One of the issues that these players are facing is the identification of the recycling gap in the automotive industry.

"The recyclability of end-of-life vehicles (ELV) is limited by the lack of commercially proven cost-effective technical capabilities to separate, identify, and sort materials and components and by the lack of profitable post-use markets."

As cars increase in number and complexity, they will be posing more pressure and challenges on recycling infrastructure. Due to climate change pressure, the automobile of the future will use more lightweight materials (such as ultra-light steel, magnesium, aluminum, and plastics), and more complex parts. Therefore, new recycling technologies will be needed to improve the recyclability of obsolete cars.

MATERIALS RECYCLING STATUS IN THE AUTOMOTIVE INDUSTRY

Steel, which constitutes about 55% of cars, is easily recyclable. Aluminum is recyclable but not at the same quality as the primary metal. Recycling of magnesium is an issue for the future since its use in cars will increase under the continuing pressure to reduce weight in cars. Plastics and composite materials pose a real challenge. Improvements in plastic recycling will contribute substantially to the reduction of landfilled cars.

So far recycling was looked at the end of the ELV. To achieve sustainability, a holistic approach in the recycling of vehicles, and particularly at the early stages of car design, is required. It has to be integrated into the design as a key selection element. This approach will encourage:

1) Less complicated dismantling and separation of parts

2) Selection and design of materials that are easier to recycle

3) Evolution of the infrastructure of the recycling industry according to the advances in recycling technologies within automotive industries.

ISSUES TO BE ADDRESSED

- Removal of harmful residuals from liquid metals
- Recycled product with the same properties as the original one
- Recycling of EAF dust
- Reuse of slag
- Recycling of shredded residue
- Segregation of alloys; e.g., Mg and Al alloys
- Design of alloys and parts that are easier to segregate and recycle

CONCLUSION

The workshop participants in the auto group discussed the technology gap in the recycling of obsolete vehicles and identified what has to be done in this field to improve recycling of cars and minimize the percentage of vehicles going to landfill.

PLASTICS RECYCLING

Prepared by Michael Day
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Prepared for the Technology Gaps Recycling Workshop
Organized by Materials Technology Laboratory - CANMET
1 – 2nd March 2001, Toronto, Ont.

SOME BASIC FACTS

- Plastics currently only use about 4% of total oil consumption.

- Plastics play a key role in sustainable development;
  - plastics protect the environment and help save resources due to their light weight and design flexibility;
  - the industry contributes significantly to economic growth, with worldwide production continually outperforming growth in GDP;
  - plastics contribute to social well being, providing higher standards of living, better health care, and improvements in information technologies.

- Where does the plastic go?
  - 40% packaging (bottles, containers, bags, film, stretch wrap, foam, etc.);
  - 25% building and construction (windows, siding, flooring, pipes, etc.);
  - 10% automobile and transportation uses (ca.100 kg car, e.g.: bumpers, grills, body parts, hoses, covers, upholstery, seating, floormats, etc.);
  - 10% furnishings (appliances, housewares, tableware, mattresses, etc.);
  - 5% electrical components (sockets, connectors, telephones computers etc.);
  - 10% miscellaneous (adhesives, textiles, medical supplies, toys, CD's etc.).

- In North America and most countries around the world plastic materials represent a growing component of the solid waste being generated (e.g. in 1960 plastics only represented about 0.5% by weight of the total MSW; however, by 1996 this had grown to 12.5% and is still growing).

- This increase is due to plastic's great versatility, cost and light weight. Consequently in most applications, plastic products result in substantial energy and environmental savings during their useful life, making significant contributions to sustainable development.

- In North America in 1996, only 5.4% of the 19.8 million tons of plastic generated was actually recovered, the rest was landfilled or, in some cases, incinerated for energy recovery.

In Western Europe it is reported that about 75% of the plastics are landfilled, with a reported 25% being recovered (however this figure includes energy recovery).

RECYCLING OPTIONS FOR PLASTICS

There is a full range of recovery (recycling) options available for plastic materials with the choice being very much dependant upon such factors as quantities available, level of contamination, purity and polymer type. There are many different types and grades of plastics, each tailored for a specific application. Because these different plastics are frequently not compatible, mixing them together results in materials of poor mechanical properties. This means that for effective recycling of individual plastics extensive sorting, washing and separation is required.

Mechanical recycling takes advantage of the fact that most plastics soften on heating and can be reprocessed into new plastics products. However, because of the many different types of plastic wastes, this process is usually only applied to source-separated clean wastes with the material being incorporated with virgin plastic of the same type. However, there are some processes designed for use with commingled plastic wastes where the material is molded into products such as wood and lumber substitutes.

Thermal feedstock recycling is another form of material recycling particularly well suited to mixed plastics waste. These technologies (in which Canada has many experts) break the plastics down into their chemical constituents, which are then used in the production of new chemicals and materials.

Another variant of thermal feedstock recycling is the use of plastics as a chemical reactant in the production of steel. Here the plastics are used to produce reduction conditions while also contributing their calorific value. As with mechanical recycling, some pre treatment of the plastic waste may be required to ensure the specifications of the recycling process are met.

These technologies have been tested in North America, Western Europe and Japan, with some commercial plants currently in operation using post-consumer plastics as the feed.

Chemical recycling processes have been used with certain plastics to convert them back to the raw materials from which they were derived. Essentially they are depolymerization reactions in which polymers (usually a condensation polymer such as polyethylene terephthalate [PET]; Nylon, or Polyurethane) are chemically broken by a processes such as hydrolysis, glycolysis or methanolysis. The resultant chemical products are then be purified and reprocessed back to the polymer.

Energy recovery is the recycling process in which the high calorific value associated with plastics waste is recovered as energy in the form of heat or electricity. The use of waste plastics as a fuel base offers an attractive alternative to coal, for example, in the manufacture of cement or the generation of electricity in power plants.

Irrespective of the recycling process adopted, the following the elements are essential for a successful plastics recycling initiative:

- availability of reliable collection/sorting technologies and logistics at lowest possible cost;
- availability of an efficient reprocessing (recycling) operation;
- existence of one or more marketable outlets for the recycled material;
- in addition the process must be environmentally acceptable.

RECYCLING OF AUTOMOBILE PLASTICS

The recyclability of end-of-life vehicles (ELV) has long been regarded as one of the major recycling success stories, with a recycling rate of 75% associated with the recovery of the ferrous and non-ferrous metals by shredding operations. In the last two decades, however, there has been a slow but progressive decrease in the percentage of steel in a vehicle and an increase in the lighter-weight materials such as plastics and aluminum. This changing material composition of vehicles has resulted in the enactment in Europe of regulations to increase recycle rates to 80% by 2005 and 85% by 2015. In order to achieve these levels, greater responsibilities are being placed upon auto manufacturers to be responsible for their vehicles once they reach the end of their life.

Europe already has in place recycling schemes that address the following parts from ELVs: bumpers, wheel caps, grids, PU foam from seats, dashboards, fuel tanks and battery cases. However, these only represent about 8% of the total automotive plastic waste being generated. This figure will have to increase once the new regulatory requirements come into effect.

In response to these initiatives in Europe, North American automobile manufacturers have set up a collaborative program involving resin suppliers known as The Vehicle Recycling Partnership. This partnership is exploring cost-effective processes for the recovery of plastics from automobile shredder residue (ASR) while at the same time exploring options to facilitate the selective dismantling of automobiles once they reach the end of their life (i.e. Design for the Environment).

RECYCLING OF PLASTICS FROM ELECTRONIC EQUIPMENT

The reclamation of engineering thermoplastics used in business machines, appliances and computers is receiving worldwide attention especially in Europe and Japan. However, as with other recyclable commodities, collection of the material in sufficient quantites, at low costs and reasonably contamination free are the critical criteria for viable recycling operations. Currently in North America, several pilot projects have been set up by interested parties (producers, recyclers and regulators) to evaluate a variety of collection, sorting, and recycling processes.

The American Plastics Council (APC)—a national trade association of plastic resin producers—is currently conducting a number of research projects to better understand end-of-life electronics. This study essentially addresses such basic questions as:

- What plastics are used in the manufacture of electronic equipment?
- What types and quantities of plastics are available for recovery?
- What contaminants are present?
- What products can be manufactured with plastics recovered from end-of-life electronics?

According to the EPA, 23 separate commodities may be potentially recycled from post-consumer electronics. While half of this material generated is metal, plastics comprise about one-third of the total. Unfortunately only 25% of that plastic material is defined as clean plastic (i.e. free of contaminants). In view of the wide range of plastics used in the electrical and electronic sector (1995 data indicates approximately sixteen different generic plastic resins), it is clear that these materials need to be identified, separated, and collected in sufficient quantity if there is to be any chance of successful recycling.

RECYCLING OF PLASTICS FROM THE CONSTRUCTION INDUSTRY

PVC is one of the major resins used in the North American construction industry, finding applications in pipes and siding materials, etc. However, because of the long lifetimes associated with these materials which frequently are over 25 years, recycling is only just starting to be an issue, as these materials only now are starting to enter the waste stream. In order to address this issue, the Vinyl Industry is already starting to address the issue of recyclability of waste plastics.

For example recycling technology is available to recycle PVC into products such as hose core, car mud flaps, floor coverings and pipe fittings. In Europe, several collection and recycling operations already exist in several countries, and the PVC pipe and window frame sectors are committed to recycling 25% of the PVC waste collected by 2003 and 50% by 2005.

In addition because of PVC's unique physical and chemical properties, equipment and processes exist for the sorting and purification of PVC from other waste plastics. However, in view of the "Chlorine debate", the PVC industry has to support the development of suitable logistics, recycling technologies and reuse applications for all PVC products to ensure their recyclability.

PLASTIC RECYCLING ISSUES

Current plastic recycling levels are low for most applications such as those outlined above. However it is anticipated that recycling levels will rise due to progress in new design concepts, customer demand for "green" products, an increasing desire to use recycled materials and rising world petroleum prices.

However, there are several factors that constrain the growth in recycling plastics.

- Technical barriers such as:
  - Demanding technical specification for recycled products equal to new.
  - The color of regrind products are frequently dark limiting application to non-visible and non-aesthetically demanding parts.
  - It is essential that processing parameters are not significantly altered different to virgin material.

  - Increased wall thickness may be required resulting in a weight reduction conflict.

- Quality and quantity
  - Sufficient quantity of recyclate must be available.
  - The mechanical and physical properties of a regrind must be within acceptable limits (comparable to the virgin resins)
  - The quality of the recyclate has to be relatively consistent.

- Competition with virgin materials
  - The recycled plastics must offer a suitable price-benefit-ratio versus virgin material.
  - These prices need to reflect collection, cleaning and sorting costs.

- Image
  - Products made from recycled plastics are viewed as "seconds".
  - A lack of consumer acceptance leads to smaller markets potential.

- Evolving legislation
  - Potential liability associated with the failure of a recycled product could limit market penetration in some specific situations

PLATING - Recovery/Reuse of Metal Finishing Industry Sludges and Solutions

This paper discusses the current status of the recycling/reuse of value metals in sludges and solutions generated by the metal finishing industry (MFI). The discussion is in four parts:

1) The highlights of the SOP report (1997).

2) Canadian data

   a) The results of a brief survey of Southern Ontario MFI shops.
   b) NPRI

3) The National Centre for Manufacturing Sciences (NCMS) US study (2000)

   a) its approach to self evaluation;
   b) its treatment/recovery recommendations;

4) What next?

THE SOP REPORT (1997)

The MFI is one of five industrial sectors being addressed at this workshop on recovery/reuse. As you are aware, the Strategic Options Process (SOP) for the metal finishing industry conducted by Environment Canada in 1997 recommended that measures be taken to improve the environmental performance of the MFI; specifically to continue to reduce the release to the environment of chromium (particularly hexavalent chromium), nickel and cadmium.

The SOP concluded that the two major concerns were as follows:

1. The release of hexavalent chromium, particularly resulting from the elevated temperatures and prolonged plating times involved in hard chrome plating, to workplace air and to the ambient air should be reduced significantly.

2. Some of the 15-25% or so of nickel that was currently not being recovered from spent solutions and sludges should be targeted for recovery. The need for a minimum nickel content and the requirement for low contamination of the nickel sludge with chromium, were limiting nickel recovery by INCO and others to the 75-85% range. It was felt that further recovery was possible. Some of the barriers to this were cited as the difficulty of collecting low sludge volumes from small shops, contaminated sludges, and artificial barriers to recycling presented by some provincial hazardous waste regulations. It should be added that price is a factor in the feasibility of nickel recovery.

Beyond the more intense application of good housekeeping practices in metal finishing operations, the SOP identified no potential opportunities for recovering chromium or cadmium from spent solutions or sludges. In the case of chromium, the existing practice of reducing hexavalent chromium to the trivalent form, followed by precipitation as chromium hydroxide with landfilling of the resultant sludge, was considered adequate. The treated wastewater effluent generally complied with sewer regulations. No discussion was reported on the feasibility of the actual recovery of chromium. As for cadmium, Health Canada considered MFI uses to be relatively insignificant in the Canadian context.

CANADIAN DATA

RESULTS OF THE MINI-SURVEY

From 12 companies surveyed, 4 replies were received. While those who responded deserve credit (one reply came back the day the survey was sent out!) it is apparent that not enough time was allowed to contributors, either to come to grips with the requirements of the survey or to develop replies. The data received will be reconsidered following the workshop, and follow-up discussions will be held. Confidentiality requirements should allow provincial summaries of data to be provided.

NPRI

Records representing MFI reported releases were extracted from the National Pollutant Release Inventory (NPRI) for the period 1993 to 1998. The data represent releases by facilities identified as metal finishers, essentially job shops. Releases by companies with captive metal finishing operations are more difficult to associate with metal finishing, since NPRI releases are reported as facility, rather than process, totals. What can be done is to extract NPRI data showing all facilities reporting releases of chromium, cadmium, and nickel to air, water etc.

Another point to bear in mind is that only facilities that “handle” at least 10 tonnes of a given substance have been required to report to NPRI up to now, and only companies releasing more than a tonne of the substance have been required to report the environmental medium to which the release is made. There are a few exceptions. A summary of the data associated with metal finishing is shown in Table 1.

Finally, cadmium does not show in Table 1, because either the 10 tonne minimum criteria is too high, or captive shops that use cadmium in metal finishing have not been identified from the SIC code reported to NPRI. Further attempts will be made to extend the list of metal finishers identified in NPRI.

Table 1. MFI releases of selected chemicals expressed as kilograms per employee, as reported to NPRI over the period 1994-1998.

Chemical	1994	1995	1996	1997	1998
Chromium (and its compounds)	3.5	2.5	2.4	1.3	0.4
Methyl ethyl ketone	5.8	5.3	5.2	5.6	5.6
Methyl isobutyl ketone	6.4	5.4	3.8	3.6	3.0
Nickel (and its compounds)	0.003	0.003	0.003	0.281	0.101
Xylene (mixed isomers)	10.2	8.4	12.6	10.54	8.71

UNITED STATES FINDINGS – THE NCMS STUDY

Among several studies of metal finishing releases the most recent, as well as the most thorough, is reported in the National Center for Manufacturing Sciences (NCMS) report "*Benchmarking Metal Finishing, June 2000*." The NCMS study was based on a questionnaire about environmental practices of the US MFI – waste water volumes, dry sludge weights, organic solvent use, and electricity use. The questionnaire was sent to 1500 job shops; 132 replies were received; 58 replies were received to a more detailed follow up survey from the 132 original respondents.

THE POTENTIAL FOR RECOVERY

In order to estimate the value metal in the reported waste streams, NCMS focused on the top six reported activites, namely zinc plating, nickel plating, decorative chrome plating, electroless nickel plating, anodizing and hard chrome plating. A statistical treatment was applied to the results. The top six markets served were motor vehicles, machinery/industrial, other, other (non-toys) electronics, fasteners, and aerospace/aircraft. Table 2[1] (NCMS Table 1-10 modified) shows sludge generation rate by process type, for the top six activities. Table 3 (NCMS Table 1-11) shows the amount of hazardous wastewater treatment sludge going to land disposal, for each of the top six activities.

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[1] Permission to cite data from the NCMS "Benchmarking Metal Finishing. NCMS, Ann Arbor MI (2000)" was received from Paul Chalmer of NCMS.

NCMS Table 1-20 (not reproduced here) gives an interesting way of calculating the amount of sludge generated per dollar of sales, for each of 15 metal finishing activities. It works as follows: to compute a company's expected value for sludge per dollar of sales, take the share of sales accounted for by each of the 15 process categories listed in the table, multiply each share by the corresponding coefficient listed in the table and sum across the 15 activities. The result is a company's predicted sludge (dry) generation rate, in kilograms per dollar of sales.

Table 2. United States sludge generation rate, expressed as kilograms per 1,000 Canadian dollars of sales, for the top 6 metal finishing processes (NCMS Survey, 2000). Note that the negative value for anodizing is a statistical artifact.

Process	**Average Dry Sludge (kg/$1,000Can)**
Zinc plating – barrel	16.0
Zinc plating – rack	4.8
Nickel plating	1.9
Decorative chromium plating	2.4
Electroless nickel plating	1.4

Table 3. United States sludge disposed on land, expressed as kilograms per 1,000 Canadian dollars of sales, for the top 6 metal finishing processes (NCMS Survey, 2000).

Process	**Average Hazardous Sludge Land Disposal (kg/$1,000CAN)**
Zinc plating	7.2
Anodizing	5.5
Electroless nickel plating	3.3
Decorative chromium plating	1.6
Hard chromium plating	0.6
Nickel plating	0.4

TREATMENT/RECOVERY

Table 4 (NCMS Table 2-4) shows the result of combining the normalized measurements of wastewater discharge, sludge generation/disposal, electricity use and organic emissions into overall ranking scores for 37 responding companies. Only the top six and bottom six companies are shown in Table 4. The wide variation in scores between the top and bottom companies suggests that there is considerable scope for improvement. NCMS analyzed this as follows.

- Nickel plating wastewater: if the industry average were brought to the level of the top quartile in Table 4, an improvement of 75% over the existing average (volume/sales dollar) would result.
- Nickel plating sludge generation: a 73% improvement of the weight/sales dollar ratio would result.
- Decorative chrome plating wastewater: a 74% improvement would result.
- Decorative chrome sludge generation: a 71% improvement would result.
- Anodizing wastewater: 70%.
- Anodizing sludge generation: zero sludge generation may be attainable.
- Hard chromium plating wastewater: zero discharge may be attainable.
- Hard chromium plating sludge generation: virtually zero sludge generation could be attainable.

The question is How can these improvements, for example in reduced sludge to landfill, be accomplished?

Table 4. United States sludge disposed on land, expressed as kilograms per 1,000 Canadian dollars of sales, for the top 6 metal finishing processes (NCMS Survey, 2000).

Company ID	Overall Score	Wastewater Discharge %	Sludge Generation %	Electricity Use %	Organic Emission %
4	102.8	87.4	100.0	4.5	100.0
58	91.6	41.2	100.0	47.6	83.9
73	86.5	37.0	100.0	18.8	100.0
127	76.3	76.6	19.0	42.7	100.0
69	72.7	49.5	53.0	19.5	99.5
59	64.7	56.9	23.7	21.7	100.0
132	-23.5	-63.2	-54.8	-10.0	98.7
81	-29.9	48.6	-143.5	-69.6	100.0
36	-36.2	-3.2	-165.8	17.6	100.0
100	43.4	-169.8	0.0	-2.0	94.1
6	-48.5	-34.1	-110.9	-64.5	100.0
67	-49.4	-41.2	-157.2	12.2	100.0

Chapter 3 of the NCMS report discusses, in some detail, housekeeping and in-process treatment measures to reduce environmental impact. Many of the technologies described are discussed in the 1994 Hill Engineering report. In the NCMS study, very little on-site management of sludge is reported. A key to recovery of value metal from wastewater sludge is considered to be waste segregation. Wastewater treatment residuals from segregated wastewater streams may be amenable to metals recovery, unlike sludges from mixed streams.

The following treatment/recovery processes were advocated by one or more respondents to the NCMS survey.

ANODIZING

Use lead cathodes instead of aluminum.

For chromic acid use: acid sorption, diffusion dialysis, additives to lower surface tension, high current density electrolysis, porous pots in chromic acid anodizing, membrane electrolysis and ion exchange to remove dissolved aluminum.

CADMIUM PLATING

Many respondents were looking for alternatives to cadmium plating.

Some chemical recoveries recommended were: electrowinning, evaporative recovery and ion exchange.

DECORATIVE CHROME PLATING AND HARD CHROME PLATING

The only reference to recovery is the suggestion that chromium sludge should be recycled off-site.

NICKEL PLATING

Ion exchange recovery

Atmospheric evaporation

Vacuum evaporation

Electrowinning

Reverse osmosis

Electrodialysis

ELECTROPOLISHING

Close looped rinse system to maintain temperature of process tanks

Find end users for used electropolishing solution

Closed manufacturing loop to purify acidic rinse water

ORGANIC SOLVENT CLEANING

Alkaline cleaning is recommended as an alternative to solvent cleaning. Only 23% of US respondents said they were using solvents in 1998. The solvents used were mainly TCE and MEK. The NCMS study found that a shop's use of organic solvent per dollar of sales was unrelated to its size, process mix or any other identifiable shop characteristic.

WHAT NEXT?

Various generic treatments and procedures are mentioned in recent reports commissioned by Canadian and United States agencies, for reducing the amount of value metal in final sludges that go to secure landfill. However, throughout this literature few concrete proposals are made as to how metal recovery can be achieved. On the other hand, the analysis done by NCMS of Ann Arbor suggests quite clearly that there is scope for improving the performance of companies whose "environmental performance indices" put them in the lower half of the ranking system. What seems to be called for is an examination of how such a system could be applied in the Canadian MFI, with a view to diagnosing the operational differences that exist between strong and weaker performers.

Adapting the approach taken by NCMS in Canada should be relatively straightforward. A wealth of detail is provided in the Benchmarking report, to the extent that average US sludge disposal rates (weight of cadmium per dollar sales, weight of chromium per dollar sales, etc.) are available for Canadian companies to compare against their own disposal rates. However, there are other approaches. A similar survey could be carried out in Canada enabling individual Canadian companies to benchmark themselves; how are they doing compared with companies using similar processes with similar workpieces?

In addition to attempting to use an NCMS or equivalent system to locate sources of useful advice, it may also be prudent to think of initiating specific searches for practical technology for recovering metal value from sludges. This would complement the performance evaluation described above and could take the form of a certain number of site visits to compare general housekeeping procedures across the industry as well as specific measures taken to optimize the use of value metals or organic solvents (and electricity?), including the rate at which value metal is sent for ultimate disposal.

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ELECTRONIC SCRAP

EXECUTIVE SUMMARY

The *Information Technology (IT) and Telecommunication (Telecom) Waste in Canada* report was commissioned by Environment Canada to develop baseline estimates of the amount of IT and telecom equipment waste that is currently being generated in Canada. The study is also designed to provide a broad overview of how such products are handled and to estimate the amounts of these products and materials that will enter the waste stream in the next few years. These tasks were accomplished through the development of a Waste Flow Tool that was modified slightly for each of the main streams of IT and telecom waste that are addressed in this report.

Information Technology and telecommunication equipment waste is receiving increased attention for the following reasons:

- Rapid advances in technology result in IT and telecom equipment becoming obsolete at an increasingly rapid pace. This is resulting in an increase in the rate and quantity of IT and telecom equipment entering the waste stream;
- A piece of IT or telecom equipment was, or is, typically of high value both in terms of its component parts and the equipment itself;
- IT and telecom equipment commonly contains toxic materials, which are hazardous if not managed properly.

The specific waste streams addressed in the study include:

- personal computers,
- monitors,
- laptop computers,
- peripherals (e.g., printers, scanners),
- telephones,
- mobile telephones and
- facsimile machines

The study did not include mainframe computers and other large equipment, such as telecom switching stations.

The report includes a summary of the infrastructure that currently exists in Canada for handling IT and telecom equipment waste. Finally, the report also highlights experience in other jurisdictions, particularly in the U.S. and Europe, to assess how this material is addressed in other countries. Recommendations on additional areas of research are included in the last section of the report.

Separate waste flow tools were developed for four different types of IT waste (personal computers, monitors, laptop computers and peripherals) and three types of telecom waste (telephones, mobile telephones and facsimile machines). The waste flow tool for each type of equipment incorporates annual sales of the component in the Canadian market, assumptions on what percentage of the equipment is stored, reused, recycled or disposed at the end of its first useful life in Canada, and the weight of the component, in order to estimate the flow of that equipment type over a 13-year period (1992 to 2005).

INFORMATION TECHNOLOGY WASTES

Based on the Waste Flow Tool, it is estimated that in 1999, approximately 33,972 tonnes of IT equipment waste (including PCs monitors, laptops and peripherals, but excluding mainframes and other large equipment) was disposed, 15,592 tonnes was recycled, 24,507 tonnes was sent for reuse and 6,128 was put into storage. Some pieces of IT equipment which had been stored or reused in previous years entered the waste stream in 1999. Of the IT waste disposed, PCs and servers accounted for an estimated 10,833 tonnes, monitors accounted for an estimated 10,688 tonnes, peripherals (scanners, printers, etc) accounted for about 11,474 tonnes and laptops accounted for about 977 tonnes.

The Waste Flow Tools predict that approximately 67,324 tonnes of IT equipment waste (including PCs monitors, laptops and peripherals, but excluding mainframes and other large equipment) will be disposed in 2005, 47,791 tonnes will be reused, 11,948 tonnes will be stored and 43,428 tonnes will be recycled. Of the total IT waste that will be disposed, PCs and servers will account for an estimated 23,349 tonnes, monitors will account for an estimated 24,472 tonnes, peripherals (scanners, printers, etc.) will account for about 17,396 tonnes and laptops will account for about 2,107 tonnes.

Many of the materials contained in IT equipment can be potentially hazardous if improperly managed. For example, printed circuit boards contain heavy metals such as antimony, silver, chromium, zinc, lead, tin and copper. The lead oxide used in the cathode ray tubes (CRT) of computer monitors is of particular concern because it is in a soluble form. It is estimated that 1,356 tonnes of lead was contained in the PCs and monitors disposed in 1999 in Canada. This equipment also contained approximately 2.0 tonnes of cadmium and 0.5 tonnes of mercury. Based on the prediction that 47,821 tonnes of PCs and monitors will be disposed in 2005 and assuming that the average composition of this equipment will not change significantly by that year, the weight of lead, cadmium and mercury that will be disposed with this stream in 2005 will increase to 3,012 tonnes, 4.5 tonnes and 1.1 tonnes respectively.

INFORMATION TECHNOLOGY WASTE REUSE AND RECYCLING

There are a number of organizations, both for-profit companies and non-profit agencies, across Canada that are involved in IT equipment reuse. These organizations typically receive used IT equipment (large amounts from private companies in many cases), which they test to see if it can be easily reused. Repairs and minor modifications are often made to enhance the reuse potential of the equipment (e.g., adding memory to the hard drive, etc.). Where pieces of equipment cannot easily be reused, they are dismantled to recover valuable parts, which can be used in the operation or sold to other operations. Non-reusable pieces are sent for recycling. 'Reuse' companies pay for some components delivered, handle some for free, and sometimes charge a fee for handling the equipment, depending on its age. The age of equipment received by these organizations can range from less than one-year to 15-20 years old.

The IT equipment recycling infrastructure in Canada is far from uniform and has limited coverage. It is an immature business, with a relatively small number of companies across the country, but the numbers are growing. It is expected that the demand for this type of service will continue to grow as increasing quantities of IT waste enter the waste stream in future years. The infrastructure for computer recycling is more mature in the US than Canada, with a number of facilities across the country to handle IT waste from large leasing companies such as IBM, etc.

There are already a number of computer recycling companies across Canada. Some recycling companies use manual separation to dismantle and sort the IT equipment into its various components (sometimes into 40 separate categories) in order to get the highest market price for high quality material streams (i.e., wire, circuit boards, power bars, semi-precious and base metals etc.). There are also some automated computer recycling companies that provide secure destruction services for information contained on hard drives, that also recycle component materials. Many companies who recycle IT equipment also handle telecom equipment.

The most challenging component of the IT equipment to recycle is the monitor, which contains a cathode ray tube (CRT). The CRT poses a concern for recycling because soluble lead is incorporated into the frit. Recycling options for this component (if it cannot be reused) are to use the glass as a fluxing agent at a lead smelter, or recycling the component for use by CRT manufacturers.

TELECOMMUNICATIONS WASTES

The telecom sector Waste Flow Tools estimate that in 1999, approximately 2,961 tonnes of telephones, facsimile machines and mobile telephones were disposed, 2,256 tonnes were recycled, 2,253 tonnes were reused and 482 tonnes were put into storage in Canada.

In 2005, the Waste Flow Models predict that approximately 4,328 tonnes of telecom equipment waste (including telephones, fax machines and mobile phones) will be disposed in Canada, 3,729 tonnes will be reused, 786 tonnes will be stored and 4,087 tonnes will be recycled.

The infrastructure to handle telephones is relatively mature in Canada, because only a few companies operated the telephone business in the past. As the number of companies providing telecom services increase, more options are available for telephone discards, and recycling and reuse will likely be managed by a larger number of players.

OVERVIEW OF DEVELOPMENTS IN EUROPE AND THE UNITED STATES

The study provides a brief look at some U.S. programs and an overview of European IT and telecom waste diversion initiatives.

Although still immature, the infrastructure for collecting IT equipment for reuse and recycling is slightly more developed in the U.S. than it is in Canada. This may partly be due to the fact that the U.S. market is larger than the Canadian market.

There has been significant policy development activity in Europe to handle the burgeoning issue of IT and telecom equipment waste, both through the European Union (EU) and through its member states. The EU publicly released the most recent draft of their proposed Waste Electrical and Electronic Equipment Directive (WEEE) on June 13, 2000. This directive is intended to harmonize the EC's member states' national measures on WEEE in order to avoid obstacles to trade and to ensure the functioning of the internal market. Five years after the directive is adopted by member states, EEE (Electronic and Electrical Equipment) producers, including those outside of Europe, will be legally responsible to pay for reuse and/or recycling of their products at the ends of their lives.

The WEEE Directive requires an overall recovery rate of 4 kg/household/year by January, 2006 for all WEEE[2]. An IT and telecom recovery rate of 75% and a reuse and recycling rate of 65% is required by 2006. The recycling and reuse rate prescribed for equipment containing a cathode ray tube is 70%.

Conclusions and Recommendations

The study team recommends that more research be conducted to complete a comprehensive picture of the amount of IT and telecom equipment waste being generated in Canada and the amount of reuse and recycling that is currently occurring. The Waste Flow Tool developed in this study will then provide a more accurate account of the flow of IT and telecom waste in Canada.

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[2] WEEE includes large and small household appliances, IT and telecommunication, consumer and lighting equipment, electrical and electronic tools, toys, medical equipment systems monitoring and control instruments and automatic dispensers.