Statement of Work (SOW)

iNEMI Environmentally Sustainable Electronics TIG
Metals Recycling Project

Version #1.0

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Basic Project Information

Background/Context

Metals recovery from electronic product recycling is focused on high-volume and most valuable metals that are easily recoverable. Current and future electronics will contain small amounts of resources that are available for recovery but are not currently recovered in today’s recycling infrastructure.

Electronic product recycling today is focused on the recovery of the metals that constitute significant mass and/or significant metal value in a specific product. Steel, aluminum and copper make up the majority of a product’s weight (excluding plastics) and represent a significant share of its material value which can be recovered relatively easily. Gold, silver and palladium, on the other hand, are used only in small quantities, but are nonetheless a focus for recovery due to their very high value. Recovery of these precious metals is more difficult due to their low concentrations and interconnectedness with other materials in circuit boards and other components, which complicate their recovery during the preprocessing of entire devices, particularly when mechanical separation processes are used. When these metals do make it into appropriate material fractions for end-processing, however, they can be efficiently recovered through state-of-the-art processes.

Beyond these metals, however, there are a significant number of additional metals in various forms that are not fully recovered in some processes, or may not be recovered at all due to their low concentrations and insufficient economic drivers for recovery. These metals often provide cutting-edge functionality available in current and future electronic products and may be seen as a supply risk if their demand were to rise rapidly, due to known difficulties in increasing their supply from ores.

Recycling thus offers the potential benefit of securing an additional supply of metals, which often may be done at a great environmental benefit when compared to producing them from ores.
The current and future evolution of electronic products is not only characterized by an increasing number of elements used, but also significant changes in the types and characteristics of products themselves. The design of electronic products is continually adapting to consumer demands to become smaller, thinner, more portable and more durable, in addition to other trends. The impact of product evolution on today’s recycling infrastructure, which has been largely designed / developed for desktop PCs, CRT monitors and other products that are quickly evolving or even becoming obsolete, is largely unknown. It is anticipated, however, that a tablet PC will behave much differently than a desktop PC in today’s manual and mechanical separation lines, which is an indication that significant adaptations to the current recycling infrastructure may be needed to efficiently cope with the changes in electronic products and continue to have efficient material recycling and a circular flow of materials.

The significant number of largely unrecovered metals and the evolving characteristics of electronic products are urgent challenges that require an assessment of current recycling systems to see how they should be used or adapted to most efficiently recover the large number of metals in the electronic products of today, as well as tomorrow.

**Scope of Work**

(Phase 1) Conduct an analysis of the needs and readiness of current and future materials recovery, focusing on metal recovery, as it applies to consumer electronics, enterprise electronics and future ICT. The trend toward miniaturization to increase functionality and the introduction of new heterogeneous materials systems and technologies create new challenges with respect to materials supply, materials recovery, and electronics recycling. Understanding how these interact, and their impact on metals recycling will assist us in making materials and technology choices both now and in the foreseeable future.

1. Identify materials and future product technology trends that the recycling/recovery industry will be handling in the near future. This will permit an assessment of the readiness of the recycling industry for coming changes in materials and products.
2. Assess the current state of the recycling systems and technologies in use.
   a. Develop map of the existing recycling systems.
   b. Develop a high-level assessment of the roles of the economic actors in the life-cycle chain, including product designers, EoL collectors, processors, and treatment facilities, with an eye to future needs.
   c. Develop a decision tree for use along the supply chain on potential choices for systems to increase efficiency of material recovery.
3. Identify Gaps and provide recommendations of how to increase the readiness for future materials recovery.
   a. Develop projections regarding future demands for recovery of an increasing diversity of metals (metal species, processing and smelting technologies, metallurgy, etc.).
   b. Project future opportunities for and expectations of the recycling industry.
   c. Identify system needs to meet these opportunities and expectations.

Where applicable, case studies may be suggested by the team to be conducted as part of, or outside of, the team.

The output of the project will be, at a minimum, a public report; future phases of the project may be identified depending upon the findings of Phase 1.
Purpose of Project
The purpose of this project is to provide pro-active recommendations for increasing the ability of future recycling systems to meet demands for recovered materials in a sustainable way. To this end, the project will be considering several things:

- Reaching a quantitative understanding of the ability of current recycling systems to recover a wider range of metals, trending toward lower concentrations in the products.
- Assessing whether current recycling systems are suitable for processing the electronic products that are on the market today (and future).
  - Handling of future product types
  - Handling of future material usage in those products
- Determining what the roles of different economic actors are/should be in different parts of the entire life-cycle process.
  - What voluntary action should be expected?

IS / IS NOT Analysis

<table>
<thead>
<tr>
<th>This Project IS:</th>
<th>This Project IS NOT:</th>
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<tbody>
<tr>
<td>Focusing on Metals Recycling – some plastic contaminant optimization/handling for metal recovery</td>
<td>Developing smelter processes, or other end-processes, or pre-processing (sorting and separation processes)</td>
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<td>Developing a list of existing applicable literature, pilot studies and build upon this work. ID what activities are going on. - Recommendation of applicability to electronics industry</td>
<td>Assessing recycling of any other materials (plastics, paper, etc.), except for some plastic contaminant optimization/handling for metal recovery</td>
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<td>Developing a map of the recycling system - Recommendation of what elements to follow in the mapping activity (metal types, chemistry, etc.)</td>
<td>Attempting to identify or prioritize specific “critical” metals for recovery</td>
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<td>High-level Assessment of roles of different stakeholders in the life-cycle chain through the lens of future needs</td>
<td>Repeating existing work</td>
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<td>Metals recycling from consumer electronics, enterprise electronics, and future ICT</td>
<td>Developing Standards or Certifications</td>
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<td>Analysis of current state of the art of the recycling systems and technologies in use (Efficiency, Economics, etc) - Recommendations/Gap Analysis of how this relates to readiness for future materials recovery</td>
<td>Creating new implementation activities</td>
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<td>Guidance, Best Practices, Recommendations for manufacturers, electronic recyclers and other economic actors in the supply chain</td>
<td>Being proscriptive</td>
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<td>End outputs: Public report; iNEMI member-only recommendations for next steps (Phase 2+ or other)</td>
<td>Creating new tools or assessment methods</td>
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<td>High level assessment - User-friendly guide on ability for recovery</td>
<td>Judging effectiveness</td>
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<td>The project will assess how the widest range of metal recovery options can be realized through the EoL supply chain in order to permit market forces, future policy initiatives to determine what options are realized.</td>
<td>Developing product design criteria</td>
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**Business Impact**

The industry will benefit from this forward-looking, collaborative effort without investing a huge sum of money and resources individually. The business impact could be substantial in the following areas.

A. Project Team:
   - Experience gained in evaluation of recycling systems and stakeholders

B. iNEMI Membership
   - Increase in membership for iNEMI

C. The Industry
   - Provide assessment of current recycling infrastructure and readiness recommendations for current and future metals recovery

D. The Recycling Industry
   - Provide insight regarding product and technology changes that are occurring and how they will impact recycling operations

**Participating Organizations**

- Green Electronics Council/EPEAT
- IBM
- KXI
- NIST
- Purdue
- UC Berkeley
- Umicore

**Outcome of Project**

This iNEMI sponsored project proposes to understand the current and future readiness of the recycling infrastructure and provide recommendations throughout the entire life-cycle to better enable more efficient metals recovery.

**Previous Related Work (Initial List)**

- e-Stewards, R2, WEEE-LABEX
- STEP paper – what should be included in best practices of collection and processing in WEEE
- UNEP Resource Panel “Metal Recycling; Opportunities, Limits, Infrastructure”
- Academic Papers
  - Element distributions (steel) and mixing of different alloys in shredding process and implications on final material
- Close the gap in developing countries (best practices in dismantling)
- The Metrics of Material and Metal Ecology Harmonizing the resource, technology and environmental cycles

- OEM best practices/interactions in recycling/supply chain
- Sustainability Consortium
- EU best practice list for collection schemes (ERP)
- PACE recycling guidelines

**Prospective Participants**

At least one representative from the following economic actors:

1. Recycling chain
   - Collection schemes
   - Pre-processing
   - Electronic scrap end-processing
2. Academic
   - Material flows
   - Recycling/metallurgical process modeling
3. Electronics Manufacturer – Consumer, Enterprise, Future looking
   - Consumer electronics producer
   - Enterprise electronics producer
4. Electronics Supply Chain
   - PCB, Laminator producer

**Project Plan**

**Schedule with Milestones**

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NOTE: All changes to SOW must be approved by the Technical Committee for version control
Phase 1 – Detailed Information

Task 1: Review existing work and Develop baseline “vocabulary”
   - Need to define terms like “efficiency”
   - Identifying the product(s) in each sector (consumer electronics, enterprise electronics and future ICT) to model

Task 2: Develop map of existing recycling systems
   - Routes through which equipment goes
     o Inputs
     o Outputs
     o Qualitative evaluation

Task 3: Assess current state of recycling systems and technologies

Task 4: Develop high-level assessment of roles of the economic actors in the life-cycle chain

Task 5: Develop a decision tree for use along the supply chain on potential choices for systems to recover materials

Task 6: Identify Gaps and provide recommendations for future metals recovery

Task 7: Write and issue public report

Project Monitoring Plans

- Ensure open lines of communication among participants.
- Review all project requirements with participants before the project begins.
- Project participants will meet bi-weekly to review various aspects of the project and make plans for next phases of the project.
- Meeting minutes provided through e-mail.
- Follow-up with individuals on an as-needed basis.
- Provide any project specific monitoring or communications plans, e.g., multiple project meetings to cover multiple regions (EMEA, Asia, Americas).
- Workshops and face-to-face meetings as determined by the project team.
- Progress reports will be provided upon request for presentation at regularly scheduled iNEMI meetings (e.g., a short series of PowerPoint slides showing the work in progress at member council meetings).
- Track and document approximate man-months per quarter per team member (this will require the active members of the team to provide estimates).
- Track and document approximate number of people on the project per quarter (this can be tracked through iNEMI’s WebEx account).

General and Administrative

Guidelines for this project and all other iNEMI Projects are documented at http://thor.inemi.org/webdownload/join/gen_guidelines.pdf.