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Recycling Technology Validation

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Overview: *Recycling Technology R&D*

- **Timeline**
  - Start: FY ‘08
  - Finish: FY ‘10
  - Percent Complete: 30%
- **Budget**
  - Total project funding
    - DOE, $3275K
    - Cost-share, $7000K
  - Funding received in FY ‘08 and FY ‘09
    - FY ‘08, $800K and $375K capital equipment
    - FY ‘09, $1100K
- **Barriers Addressed**
  - Business case for recycling materials from shredder residue
- **Partners**
  - Interactions/Collaborations
    - Individual shredder
  - Project Lead
    - Argonne National Laboratory

Objectives: *Validate the costs and performance of the Argonne materials recovery process at full-scale*

"Economic use of advanced lightweight materials for automotive construction will be enhanced by both prompt recycling of scrap materials during manufacture, as well as recycling of end-of-life vehicles…"

- A shredder has accepted the risk of building this "first-of-a-kind" materials recovery facility
  - Commitment of $7 million; $5 million for capital and $2 million for operation
  - Risk---plant costs underestimated, plant performance overestimated, recovered product prices overestimated (commodity markets decline)

- Intermediate goals
  - Finalize the design, obtain quotes for the equipment, and for the installation
  - Complete the installation, testing of equipment, and start-up of the full-scale validation plant at the partner's site
  - Install and test the polyolefins upgrade system
  - Conduct laboratory and pilot plant tests when necessary to support or enhance validation plant operations
  - Confirm market opportunities and values for the recovered materials

FY 2008 Milestones

Major Milestones	Planned Completion Date	Status
Completed engineering designs and economic analysis of the process based on pilot plant data	3rd Qtr	Complete
Complete construction and shake down of the base recycling validation plant	4th Qtr	Revised completion 3rd Qtr of FY '09
Completed design of the upgrade system for separation of wood and rubber from the recovered polyolefins for the validation plant	3rd Qtr	Complete
Evaluation of recovered polymers from validation plant	4th Qtr	Revised completion 4th Qtr of FY '09

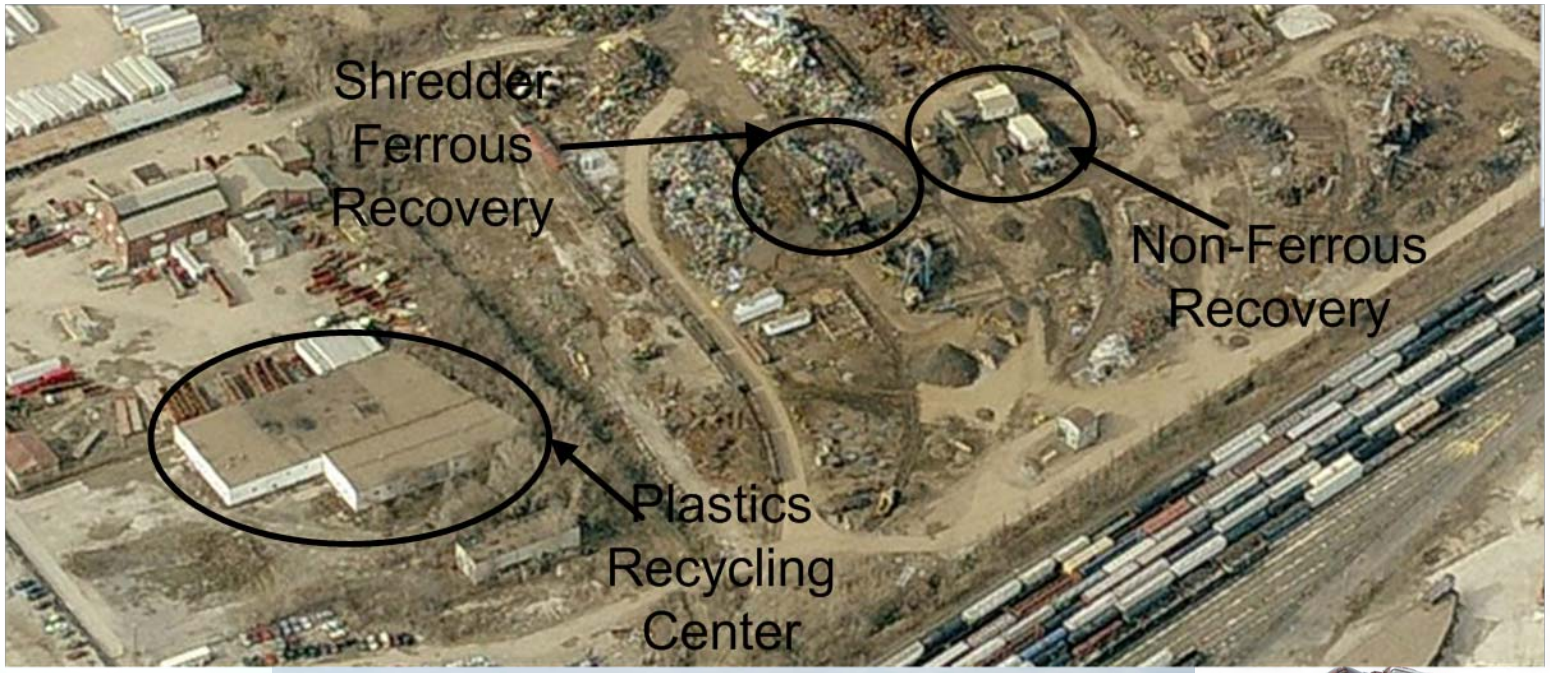
FY 2009 Milestones

Major Milestones	Planned Completion Date	Status
Complete validation plant equipment installation	2nd Qtr	Revised completion 3rd Qtr
Begin Production	3rd Qtr	4th Qtr
Determine physical properties recovered by validation plant	4th Qtr	4th Qtr

Approach: *Design, build and operate the validation plant*

- Design, install, start-up, and operate the validation plant
- Evaluate processing modifications, if necessary, to obtain recovery rates and qualities of the polymers and residual metals comparable to those obtained at the pilot-scale
- Determine the quality and properties of the recovered materials
- Install, start-up, and operate the polymer upgrade systems
- Confirm the continuous operation of the plant at design production rates
- Re-evaluate process design, costs and performance for commercial deployment at other facilities

Accomplishments: *Overview of the plant location*



Accomplishments: *Completed cost analysis of the Argonne process*

- Completed a detailed cost model for the Argonne process
- Capital cost estimates are based on quotes from equipment vendors
- Operating cost estimates are based on pilot plant operating experience
  - 150 tons of shredder residue from multiple shredders
- Revenue estimates:
  - Residual metals based on commodity pricing
  - Polymeric materials based on verbal quotes subject to product quantities and consistency

Accomplishments: *Economic analysis of the Argonne process -- Design capacity 20 ton/hour @ 2000 hours/yr August 2008*

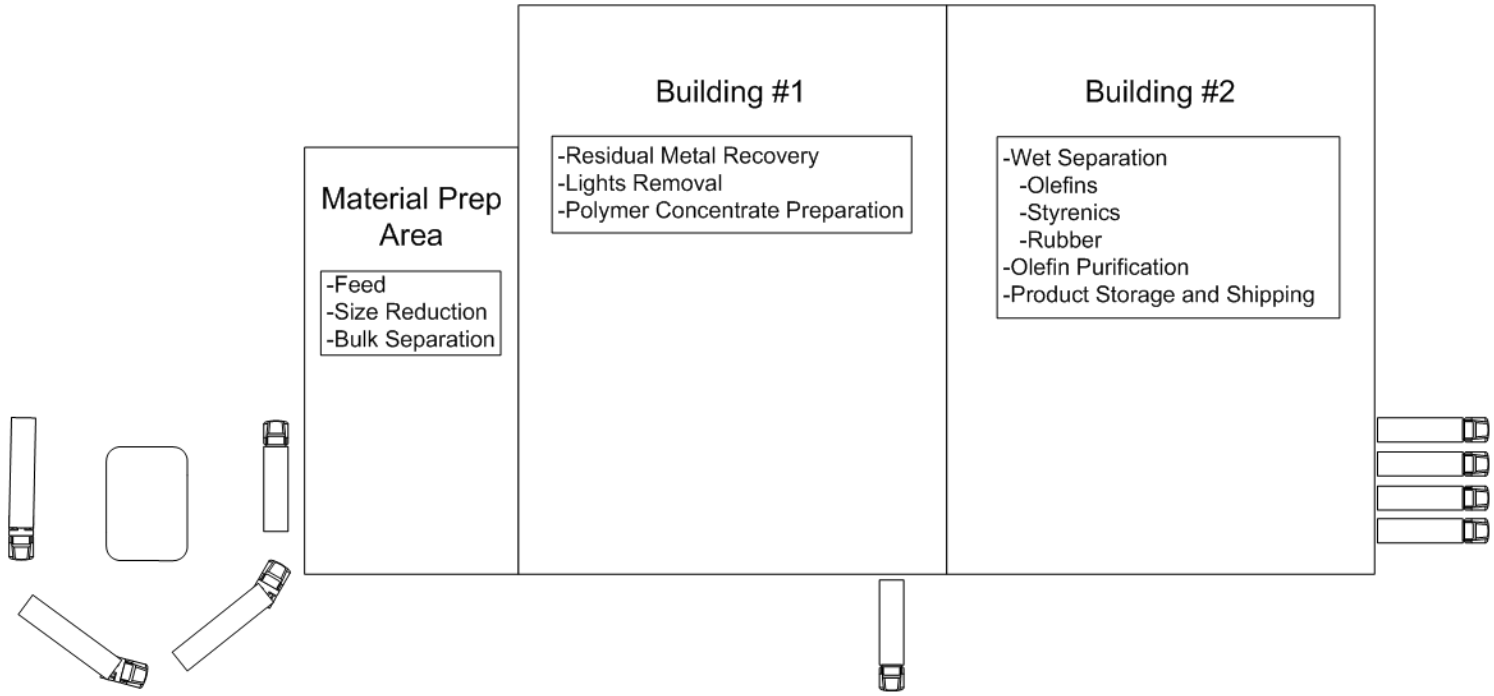
Equipment Costs ($1000)		
Mechanical Separation System Equipment (20 ton/hour)	$1,540	
Wet Separation System Equipment (10 ton/hour)	1,135	
PP/PE Upgrade Subsystem (3 ton/hour)	375	
SOC Removal Subsystem (budgetary estimate)	1,000	
Subtotal Equipment Costs		**$4,050**
Auxiliaries and Installation ($1000)		
Mobile Equipment and Auxiliaries	$550	
Plant Installation	500	
Subtotal Auxiliaries and Installation		**$1,050**
Land and Buildings		**$1,000**
TOTAL INSTALLED PLANT COST		**$6,100**
ESTIMATED ANNUAL OPERATING COSTS		**$1,600**
Potential Revenue ($1000/yr)		
Residual Metals (1.5 ton/hour @ $500/ton)	$1,500	
Polyolefins (1.1 ton/hour @ $500/ton)	1,100	
Styrenics (1.5 ton/hour @ $100/ton)	300	
Mixed Rubber (3.0 ton/hour @ $100/ton)	600	
Alternate Fuel (3.9 ton/hour @ $20/ton)	156	
Avoided Landfill Costs (11.0 ton/hr @ $20/ton)	440	
TOTAL REVENUE ($1000/YR)		**$4,096**

Accomplishments: *Economic analysis of the Argonne process -- Design capacity 20 ton/hour @ 2000 hours/yr March 2009*

Equipment Costs ($1000)		
Mechanical Separation System Equipment (20 ton/hour)	$1,900	
Wet Separation System Equipment (10 ton/hour)	930	
PP/PE Upgrade Subsystem (3 ton/hour)	370	
SOC Removal Subsystem (budgetary estimate)	1,000	
Subtotal Equipment Costs		**$4,200**
Auxiliaries and Installation ($1000)		
Mobile Equipment and Auxiliaries	$300	
Plant Installation	500	
Subtotal Auxiliaries and Installation		**$800**
Land and Buildings		**$1,000**
TOTAL INSTALLED PLANT COST		**$6,000**
ESTIMATED ANNUAL OPERATING COSTS		**$1,400**
Potential Revenue ($1000/yr)		
Residual Metals (1.5 ton/hour @ $500/ton)	$1,500	
Polyolefins (1.1 ton/hour @ $500/ton)	1,100	
Styrenics (1.5 ton/hour @ $20/ton)	60	
Mixed Rubber (3.0 ton/hour @ $20/ton)	120	
Alternate Fuel (3.9 ton/hour @ $10/ton)	78	
Avoided Landfill Costs (11.0 ton/hr @ $20/ton)	440	
TOTAL REVENUE ($1000/YR)		**$3,928**

Accomplishments: *Subsystem design timetable*

- Detailed layout design has been completed
- Electrical design completion expected 05/2009
- Plumbing design completion expected 05/2009



Accomplishments: *Validation plant construction progress*

- Building upgrades and utilities installation are 85% complete
  - Electrical
  - Natural gas
  - Steam
  - Water
  - Drain/sewer
  - Heaters
  - Fire suppression system

Accomplishments: *Equipment and installation timetable*

- Major equipment has been ordered, delivery in progress; equipment ordering to be completed by 03/2009
- Installation of the plant is anticipated to begin 05/2009
  - Equipment arrival and installation 02/2009 to 06/2009
    - *Polyolefin upgrade system arrival and installation 08/2009 to 09/2009*
  - Electrical installation 05/2009 to 06/2009
  - Plumbing installation 05/2009 to 06/2009
  - Plant startup and shakedown 06/2009 to 09/2009

Future Work

- For the remainder of FY ‘09 the major focus will be on building and starting up the validation plant
- Evaluate processing modifications if needed
- Determine recovery rates and qualities of the polymers and residual metals comparable to those obtained at the pilot scale
- Install, start-up, and operate the polymer upgrade systems
- Confirm the continuous operation of the plant at production rates
- Re-evaluate process costs and performance based on operating experience

Summary

- Development of cost-effective recycle technologies supports the deployment of advanced lightweighting materials

- The validation plant will confirm that the supply of recycled materials can be available to the automakers at a lower cost than their virgin counterparts