Recycling Infrastructure Stability: Transfer Pricing Anaysis

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Recycling Initiatives, Again

- In the Early 1990s, The German Recycling Initiatives Were Established
- A Wide Range Of Motivations Suggested
  - Landfill Use Reduction
  - Market Protection; Transplant Limitation
  - Rationalization of the Secondary Infrastructure
  - Part of a Recycling Sequence - Packaging, Electronics, etc.
- The Original Initiative Slowed By Other Political Events
- But, It Now Has Returned
  - European Commission Initiatives
  - Ultimate Objective - 95% Recycling Of The Automobile (varying timetables)

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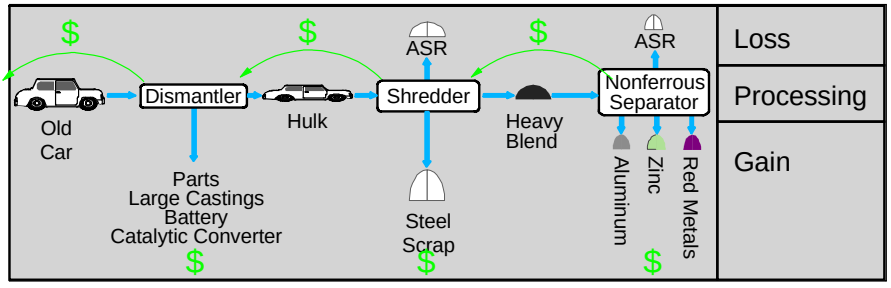
Consequences

- Automakers Are Confronted With A Slippery, But Potentially Onerous, Target
- Definitions Are Going To Make Or Break This Initiative
  - What IS "Recycling," Anyway?
- Current Political Pressures Keep Putting Off Implementation
- Aspects Of The California Electric Vehicle Initiative All Over Again

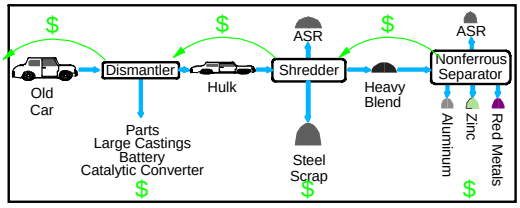
Automobile Recycling Infrastructure

- System is propelled solely by profitability of each business
  - NOT by government policy intervention
  - "Pushing a rope at each end"
- How robust is this system to pending changes in
  - Vehicle materials
  - Regulatory / economic constraints



Key Economic Drivers

- Shredder Extracts The Bulk Of Recycled Automobile Value
  - Ferrous Scrap
  - Non-Ferrous Blend
- Dismantler Extracts Parts
  - For Resale
  - For Remanufacture
  - For Material Recovery
  - For Regulatory Reasons



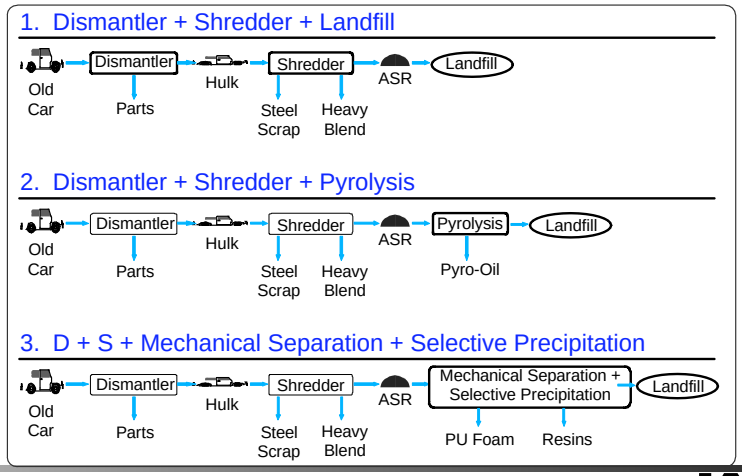
- Transaction Prices Are Key To Understanding System Stability To Change
  - Acquisition of Deregistered Vehicle — Cost(?) to Dismantler
  - Transfer of Hulk To Shredder — Income to Dismantler; Cost to Shredder
  - Sale of Recovered Metals — Income to Shredder
  - Disposal of ASR — Cost to Shredder
- Policies focus on the "ends of the rope" - deregistered vehicle cost and ASR

How Much Value Is In the System?

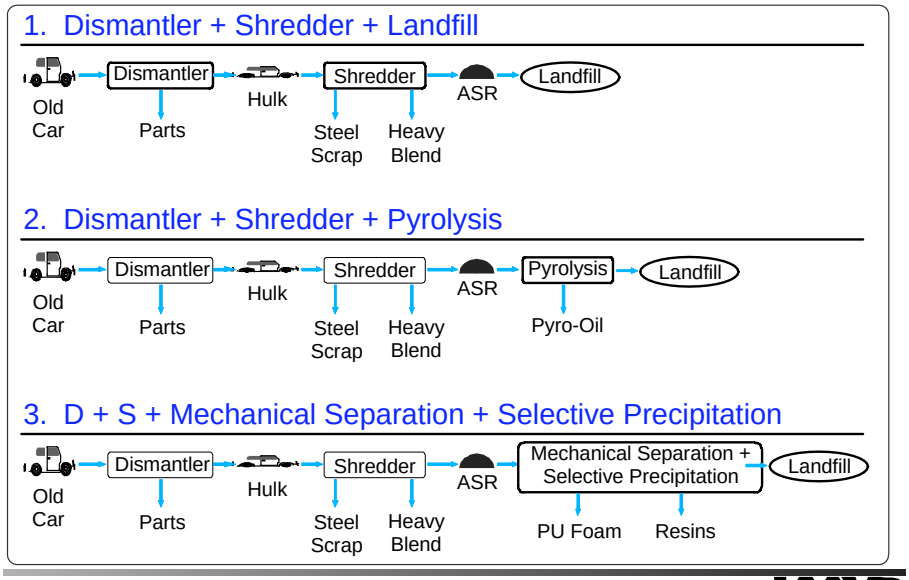
- Magnitude Determines Degree Of "Wiggle Room" For Policymakers and Industry
- Regulations Are Not Directed Toward Adding Value
- Issue Is Extent To Which Additional Costs Can Be Managed And Redistributed
- Examination Of Economics Depends On Assessment Of Transfer Pricing

Options To Increase Materials Recovery

- Technical Options Exist To Increase Recovery
- Costs and Their Distribution Key To Viability
- Modeling Issues



Key Systems Investigated For Improving Recovery



Dismantler Modeling Goals

- To what extent should a vehicle be disassembled
  - Dismantler attempts to maximize profits
    - *Part can be sold for revenue, but...*
    - *Parts cost to remove*

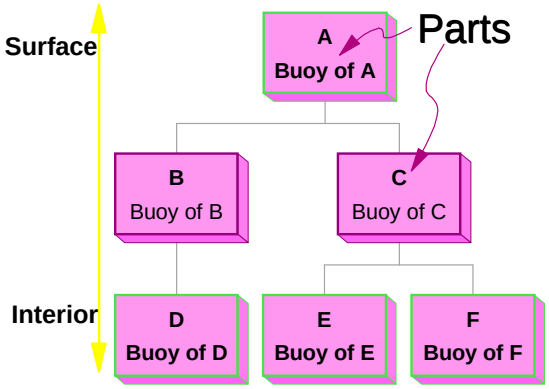
- A part is removed if
  - Value of $Part_i$ >Cost of Removing $Part_i$
  - $Value_i$ = Maximum of {Part sale price or Material value of part}
  - $Cost_i$ = Removal Labor + Sorting Labor - Value in the Hulk
    - *What is the "Value in the Hulk"*

- For convenience, define
  - Intrinsic Buoyancy$_i$ = B_i = $Value_i$ - $Cost_i$
  - Remove if ===> $B_i > 0$

Which Parts to Remove:
Sequence Matters

- Parts do NOT exist in isolation & are NOT randomly accessible
- Each part can only be reached by through certain paths

For example
- To get to D ==> A & B must be removed



Individual Model Results
Revealed Economic Drivers

- Each model reveals profit determining assumptions

Dismantler
Composition
Hulk Price

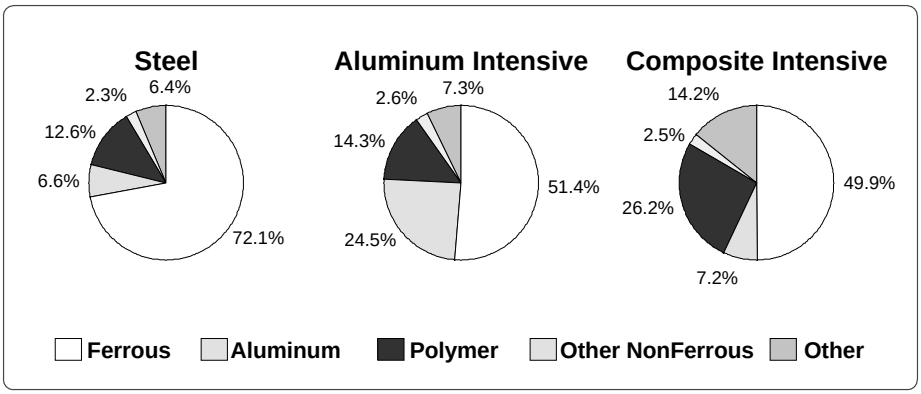
Shredder
Composition
Hulk Price
Landfill Price

Pyrolysis
Landfill Price
Capital Cost
Op. Volume

Mechanical Sep. Selective Ppt.
Landfill Price
Capital Cost
Op. Volume
Composition
PUF / ABS Price

Testing System Performance:
Vehicle Composition

- **Mixtures of three different vehicles designs were used**



System Model Results
Current Dismantler + Shredder System

- Current system profitable for most cases

	100% Steel	100% AIV	100% CIV	50% Stl. 50% AIV	50% Stl. 50% CIV	Three-way Split
Dismantler Profit ($/Vehicle)	**$ 13**	**$ 16**	**$ 11**	**$ 14**	**$ 12**	**$ 13**
Shredder Profit ($/tonProcessed)	**$ 14**	**$ 108**	**(4)**	**$ 57**	**$ 5**	**$ 37**
Amount Landfilled (tons)	30,000	31,000	57,000	30,500	48,000	39,000

- CIV loss could be covered by reduced hulk price
- How does hulk price / composition effect these two?

Extensive Disassembly
Hulk Price and Composition Effects

- Introducing more material value prompts disassembly
  - Shredders can respond through changing hulk prices

	AIV	AIV + Al Engine			AIV + Al Engine + Al Chassis		
Hulk Price (cents / kg)	**5**	5	1	**18**	5	18	**1**
Dismantler Profit ($/Vehicle)	**$ 16**	$ 105	$ 100	**$ 130**	$ 150	$ 199	**$ 110**
Shredder Profit ($/tonProcessed)	**$ 108**	$ 20	$ 15	**$ 39**	(25)	(64)	**$ 15**
Annual Hulks to fill Shredder Capacity	**125,000**	250,000	500,000	**125,000**	500,000	500,000	**500,000**

Adding ASR Processing
Pyrolysis - Current Situation

- Pyrolysis plants must operate near capacity
  - This does not match up one-to-one with all shredder outputs

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Dismantler Profit ($/Vehicle)	$ 13	$ 16	$ 11	$ 14	$ 12	$ 13
Shredder Profit ($/ton)	$ 14	$ 108	(4)	$ 57	$ 5	$ 37
Pyrolysis Profit ($ / ton ASR) at Full Utilization	**(10)**	**(10)**	**(9)**	**(9)**	**(10)**	**(9)**
ASR Landfilled (tons)	**7,200**	**8,200**	**24,300**	**10,700**	**7,500**	**10,800**
ASR Processed (tons) would have been Landfilled	30,000	30,000	45,000	45,000	30,000	45,000

Adding ASR Processing
Outlook for Pyrolysis

- Pyrolysis becomes profitable if landfill prices = $50 / ton
- For shredders this translates to
  - For metal cars - a $4 cost
  - For CIV - an $8 cost
- System can bear these except for the 100%CIV scenario
  - For 100%CIV, no surplus to offer final vehicle owner
  - Other schemes might prompt proper disposal

Pyrolysis promising for near term.

Conclusions

- The automobile recycling infrastructure
  - Resilient for compositions studied
  - Could accommodate pyrolysis
    - *Reduces landfill burden up to 75%*
  - High Al content would force restructuring
- Stability for Higher Recycling Rates Dependent Upon Recycling Definition
  - Not A Lot Of Profit To Redistribute, Unless Vehicles Become Intrinsically More Valuable
  - With Increased Value, Dismantler/Shredder Tension Will Influence What Recycling Means - Reuse or Recovery