

# Results from the SEES Project: Recyclability and Sustainability of Automotive Electrical and Electronic Systems

**Sebastian Alber<sup>1</sup>, André Greif<sup>2</sup> Julio Rodrigo<sup>3</sup>,**

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<sup>1</sup> CIMA.KFT

<sup>2</sup> Technical University of Berlin, Systems Environmental Engineering, Germany

<sup>3</sup> SIMPPLE / Universitat Rovira i Virgili, Spain



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# SEES Project & Partners

 Funded by the European Commission



(contract no. TST3-CT-2003-506075)

## Project full title:

Sustainable Electrical & Electronic System for the Automotive Sector (SEES)

## Project duration:

1 Feb 2004 – 31 Jan 2007

## Homepage:

[www.sees-project.net](http://www.sees-project.net)

The partners cover the entire life cycle of automotive electrics/electronics!



[www.sees-project.net](http://www.sees-project.net)

# Automotive Electrical & Electronic System (EES)



The **electrical system** and the **electronic systems** of a car are closely interlinked and become increasingly important in modern cars

→ **Electrical & Electronic System (EES)**

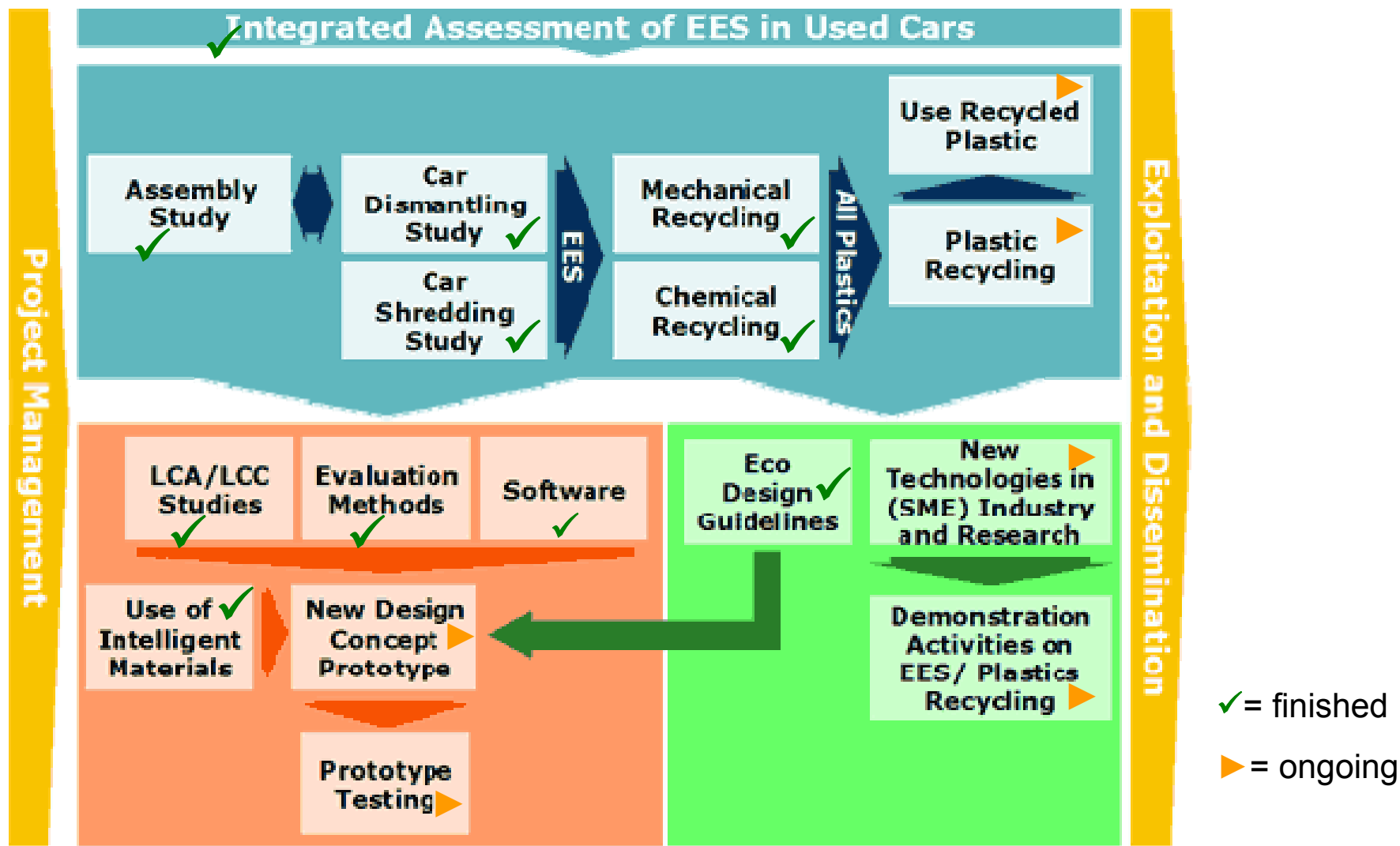
## WHAT does it contain?

- **Energy sources** (battery, alternator)
- **Wire harness** (power and signal distribution)
- **Sensors and actuators**
- **Passive and electronic junction boxes** and other control units
- **Different devices** (lights, motors, heatings, comfort and infotainment devices, safety devices, etc.)

## SEES Main Objective:

Development of prototypes and dismantling/recycling processes for a sustainable, clean, cost- and eco-effective EES in order to increase the recovery and reuse rate of vehicles

# SEES Work Structure




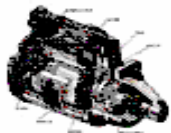












# Some Interim Results

- ▶ **Integrated EES assessment:** EES evaluation and classification according to their legal, environmental and economic relevance
  - ▶ → 14 representative groups of EES components
- ▶ **Disassembly & Shredding Studies:**
  - ▶ → Limited influence of Design for Disassembly on actual disassembly time
  - ▶ → Disassembly for material recycling is currently not cost-efficient for studied components
- ▶ **EES and plastic recycling:**
  - ▶ → Developed schemes for recycling of dismantled EES components, mixed materials from shredding residues and mixed plastics

# Integrated Assessment of EES

→ Public Report D1 on th SEES website

- ▶ Classification of EES components into 14 groups
- ▶ Collection of information about them (materials, future trends...)
- ▶ Integrated assessment of their legal, environmental and economic aspects

Sensors		Electr. motors and generators	
Actuators		Lighting devices	
Wire Harness and Cables		Heating Units	
Connection and protection devices		Displays	
Electronic Control Units		Entertainment devices	
Integ. Mechatronic Components		Comm. and navigation dev.	
Batteries		Other devices	

# Assembly, Disassembly and Shredding Studies

→ Public Reports D3+D6 on the SEES website

## ■ Disassembly Tests:

- New vs. end-of-life vehicles, different car segments and types, destructive vs. non-destructive approach, different tools  
→ Disassembly time and cost, logistics, optimisation



## ■ Shredding Tests:

- Whole vehicles vs. vehicles with dismantled EES  
→ Distribution of EES materials to output fractions, recovery/recycling potential, process optimisation



## Some Results:

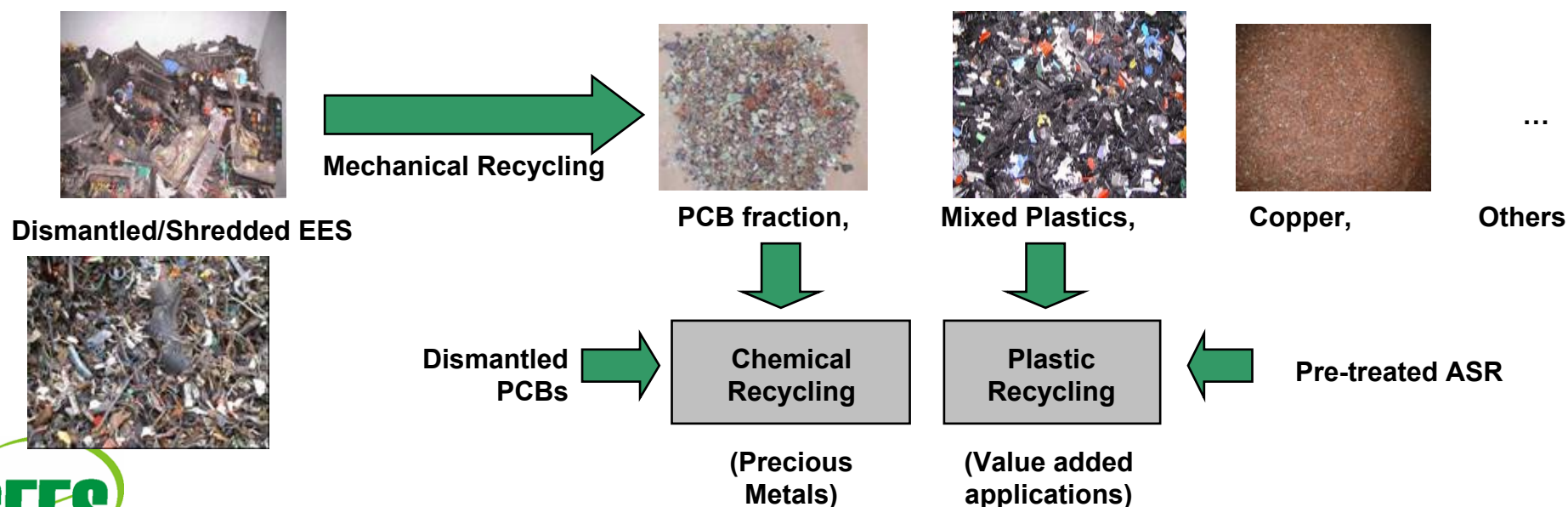
- ▶ Disassembly for material recycling is currently not cost-efficient
- ▶ Small portion of disassembly time can be addressed by Design for Disassembly
- ▶ Separation of copper from the ferrous shredder fraction (handpicking) is currently more economical than EES dismantling



# EES and Plastic Recycling

→ Upcoming Public Reports D4+D5

- ▶ Mechanical and chemical recycling of dismantled EES components, mixed EES materials and automotive shredding residues (ASR)
- ▶ Plastic separation/recycling of mixed plastic fractions from mechanical recycling and pre-treated ASR
- ▶ Identification of value added applications for recycled fractions



# Goal and Scope of LCA and LCC Studies

- Determination and comparison of potential environmental and economical impacts of alternative scenarios for EES → to assess the significance of improvement potentials in design and recycling.
- Components under study: Engine Wire Harness (WH) & Passenger Smart Junction Box (PSJB)
- Functional Unit: One component, assembled in a middle class Ford car model, assumed use phase 150.000 km in 12 years.
- Allocation of fuel consumption based on an incremental approach, diesel (44 %) and gasoline (56 %) mix.

# Environmental & Economic Studies

→ Public Report D7 available from the SEES website

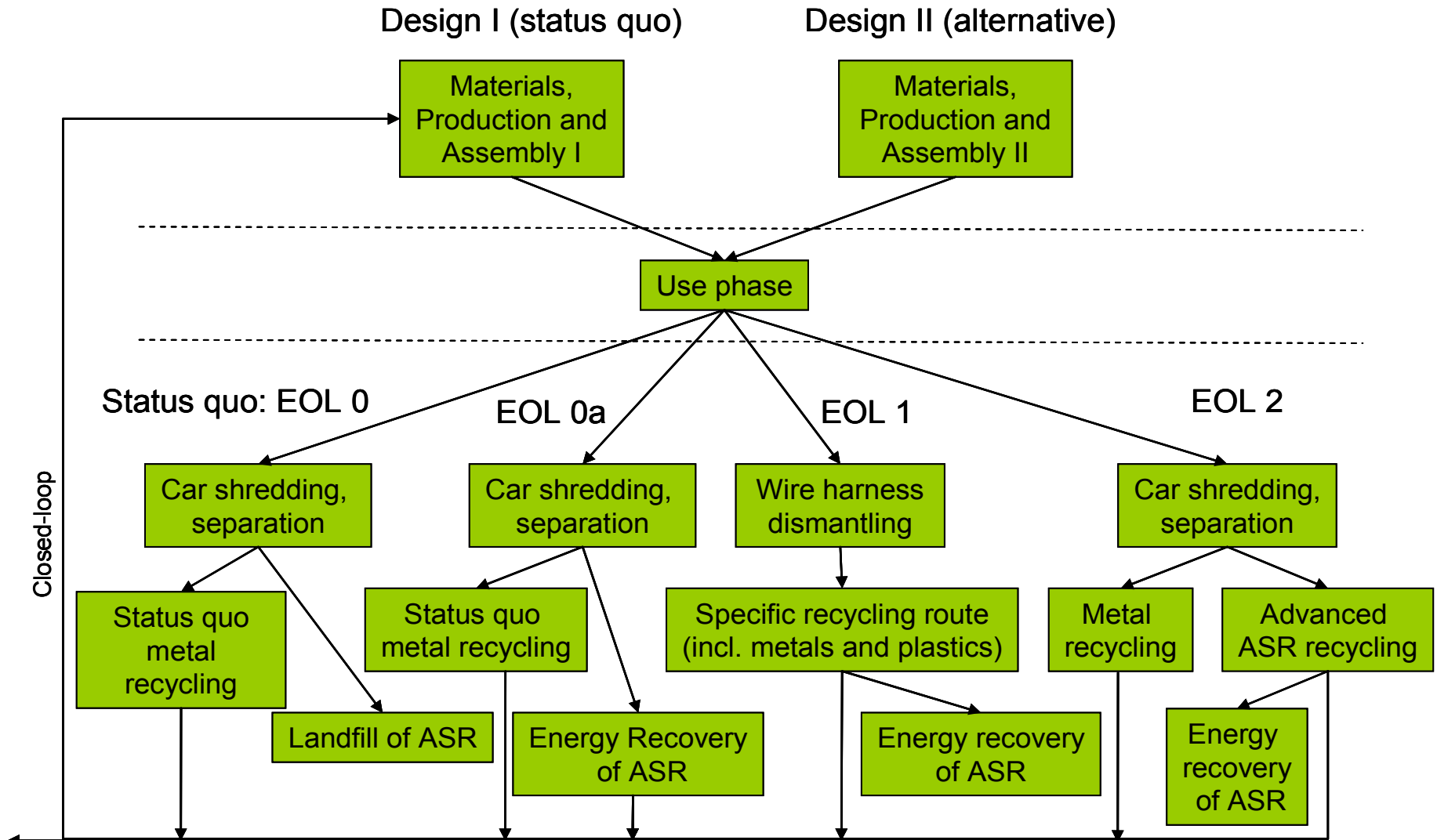
- ▶ Life Cycle Assessment (**LCA**) and Life Cycle Costing (**LCC**) case studies for a wire harness and a smart junction box
- ▶ Comparison of different **design alternatives** (lead-free solders; flat flexible cables; improved fasteners) and **end-of-life scenarios** (status quo car shredder; disassembly for recycling; post-shredder-recycling)

## Some Results:

- ▶ High relevance of the production phase (incl. material production) and the use phase in the total life cycle
- ▶ Improvement potential of design alternatives is higher than for different end-of-life scenarios
- ▶ Disassembly and post-shredder-recycling both perform better than status quo car recycling  
→ preferred option depends on component



# Schematic Representation of Design and EOL-Scenarios



ASR= Automotive Shredder Residue



## Results of LCA and LCC case studies for WH

- LCA results are dominated by the manufacturing (including material production) and use stage, LCC results are dominated by the manufacturing costs (90%).
- A clear environmental improvement in the case of Design II1 (FFC) due to reduced weight (-18%) for manufacturing and use stage, but with some increased costs.
- No significant environmental improvement in the case of Design II2 (hook-loop-tapes), but a slight cost reduction (< 1 %) which becomes more relevant for disassembly (EOL 1).
- Better LCA results for EOL 1 and EOL 2 due to higher credits given for material recovery.
- EOL 2 would be more recommendable, since in EOL 1 only partly disassembly of WH is possible.
- LCC results are better for EOL 2 and EOL 1 due to increased revenues and saved costs for reduced ASR amount.

# Structure of the SEES software

- ▶ The software is intended for use by EES designers and end-of-life operators for support in decision making.
- ▶ Using the software, a simplified model of a product can be created and process related aspects of the model can be analysed. In this way, different design and end-of-life scenarios can be quantitatively compared.
- ▶ The first part of the software covers product related analysis of recyclability, recoverability and disassembly effort to support EES designers. A product comparison shows the differences.
- ▶ The second part has additional functions like scenario management, process flow analysis of recycling process technologies, life cycle costing, life cycle phase analysis and process comparison.

# Software: Product Model Input

**Components of TEST CAR for SEES**

Components | Environmental Data

Used parts

Used parts	Mass [kg]
TEST CAR for SEES	1350
PSJ Junction Box	1.3279
Car for shredder	1250
Steel fraction	680
<b>Non ferrous heavy fraction</b>	<b>108</b>
Magnetic light fraction	110
Non magnetic light fraction	87
Depollution	50

Price specified in: [dropdown]  
 Min (per kg): 0  
 Max (per kg): 0  
 Average (per kg): 0  
 Validation date: 2005-10-17  
 Source: [dropdown]  
 Geographical Coverage: [dropdown]  
 Data collection method: [dropdown]

Revenue specified in: [dropdown]  
 Min (per kg): 0  
 Max (per kg): 0  
 Average (per kg): 0  
 Validation date: 2005-10-17  
 Source: [dropdown]  
 Geographical Coverage: [dropdown]  
 Data collection method: [dropdown]

Defined materials | View as Tree

- DECLARABLE SUBSTANCES
- OTHERS
- MODIFIED ORGANIC NATURAL M
- FLUIDS
- GLASS
- ELASTOMERS
- POLYMERS
- Metals

Used materials in component

Name	Share [%]	Mass [kg]
Aluminium, with iron c...	50	54
Copper (metallic)	35	37.8
Unknown others	14	15.12

Assembly taxonomy: Non ferrous heavy fraction [dropdown]

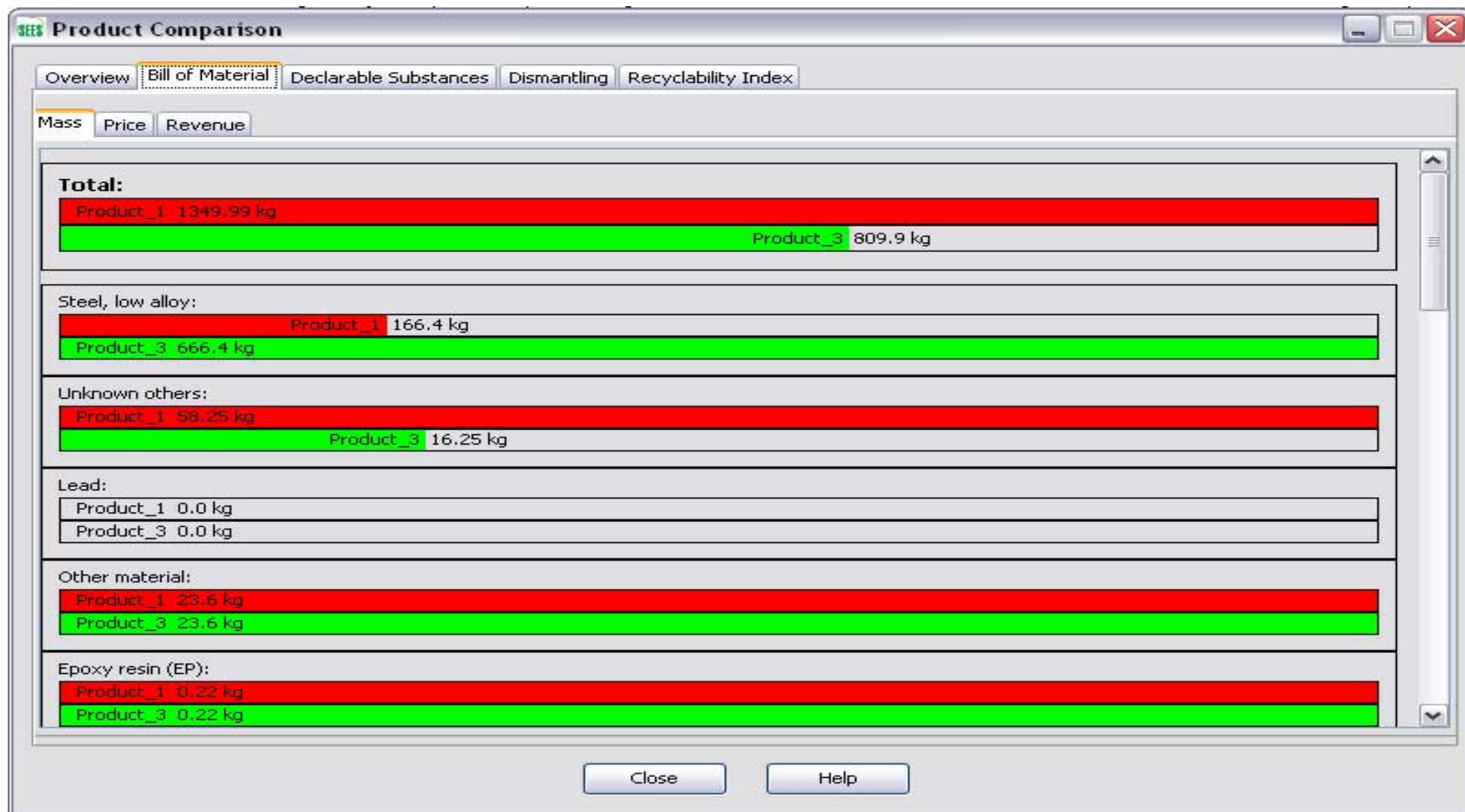
ELV Heavy Metals: B  
 Legal Duty Dismantling: B  
 Reuse Potential: B

Author: [dropdown]  
 Editor: [dropdown]  
 Input date: 2005-10-17  
 Editing date: 2005-10-17  
 Comment: [text area]

106.92 kg (99 %) Normalize shares

New Cancel  
Duplicate Undo  
Delete OK

# Product calculation (1/2)



**AG2**

In this screenshot you have large quantity of "unknown others" and "other material". Maybe you can show another list instead which shows more real materials.

André Greif, 9/1/2006

# Product calculation (2/2)

**SEES Product Comparison**

Overview | Bill of Material | Declarable Substances | Dismantling | Recyclability Index

Productname: Product_1				Productname: Product_3			
Name	Mass	Price	Revenue	Name	Mass	Price	Revenue
Fuse Cover	0,24	2	3	Fuse Cover	0,24	0	0
Car for shredder	1.035	13	18	Car for shredder	1.035	0	0
Non ferrous heavy fra...	108	2	1,4	Non ferrous heavy fra...	108	0	0
Depollution	50	5	8	Depollution	50	0	0
Electronic & quick cover	0,18	15	17	Electronic & quick cover	0,18	0	0
Missing parts	313,67	1.500	44	Missing parts	313,67	1.500	0
PCB1	0,55	4,5	6	PCB1	0,55	0	0
Non magnetic light fract...	87	0	0	Non magnetic light fract...	87	0	0
PCB2	0,18	0	0	PCB2	0,18	0	0
PSJ Junction Box	1,32	7	4	PSJ Junction Box	1,32	7	4
Isolator	0,03	0	0	Isolator	0,03	0	0
Power PCB	0	0	0	Power PCB	0	0	0
Electronic PCB	0,13	0	0	Electronic PCB	0,13	0	0
Steel fraction	680	0	0	Steel fraction	680	0	0

Close Help

**AG3**

Comparing "Product\_1" and "Product\_3" in this screenshot it is a little confusing that some parts, as e.g. the Fuse Cover, have a price and revenue defined in "Product\_1" but not in "Product\_3". Why? Change Screenshot?

André Greif, 9/1/2006

# Disassembly time/costs/revenue

Disassembly sequence structure

This is the Disassemblystructure for the selected assemblies !

additive view 10.0 change costunit

### TEST CAR for SEES

- Assembly
- Joining
- disassembling not recommended
- disassembling user decision
- disassembling recommended
- legal duty dismantling
- reuse potential
- ELV heavy metals

	disassemblytime (s)			disassemblycost (10.0 €/h)			desired time (s)			assembly revenue (€)			
	min	avg	max	min	avg	max	min	avg	max	min	avg	max	
<b>Rear fixations</b> (Fixation rear/Cutter)	1200,0 s	4800,0 s	9600,0 s	3,33 €	13,33 €	26,67 €	0,0 s	0,0 s	0,0 s				
<b>Car for shredder</b> B B B											30,0 €	45,0 €	90,0 €
<b>Missing parts</b> B B B													
<b>Dashboard cover 1</b> (Fixation yellow/Manually)	8,0 s	32,0 s	80,0 s	0,02 €	0,09 €	0,22 €	0,0 s	0,0 s	0,0 s				
<b>Dashboard cover 2</b> (Fixation rear/Cutter)	8,0 s	32,0 s	64,0 s	0,02 €	0,09 €	0,18 €	0,0 s	0,0 s	0,0 s				
<b>PSJ Junction Box</b> B B A											20,0 €	30,0 €	40,0 €
	<b>1216,00 s</b>	<b>4864,00 s</b>	<b>9744,00 s</b>	<b>3,38 €</b>	<b>13,51 €</b>	<b>27,07 €</b>	<b>0,00 s</b>	<b>0,00 s</b>	<b>0,00 s</b>	<b>50,00 €</b>	<b>75,00 €</b>	<b>130,00 €</b>	

cancel save and exit release other assemblies barcharts export help



# Process calculation (1/4)

**Enter amount settings**

Please enter amount settings for creation of resource flows report.

Amount:

Unit:

Amount in pieces:

Value type

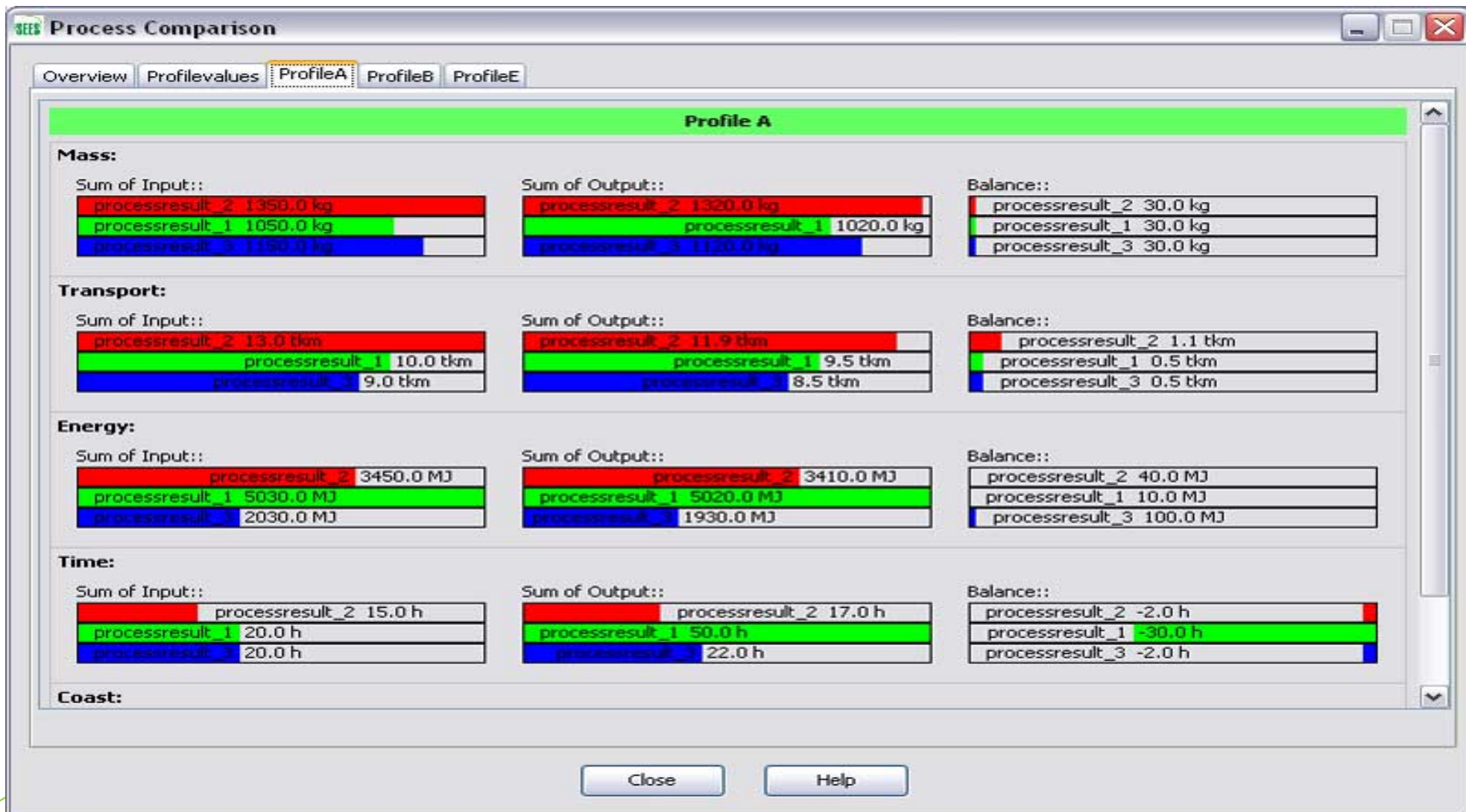
Minimum  Average  Maximum

**AG1**

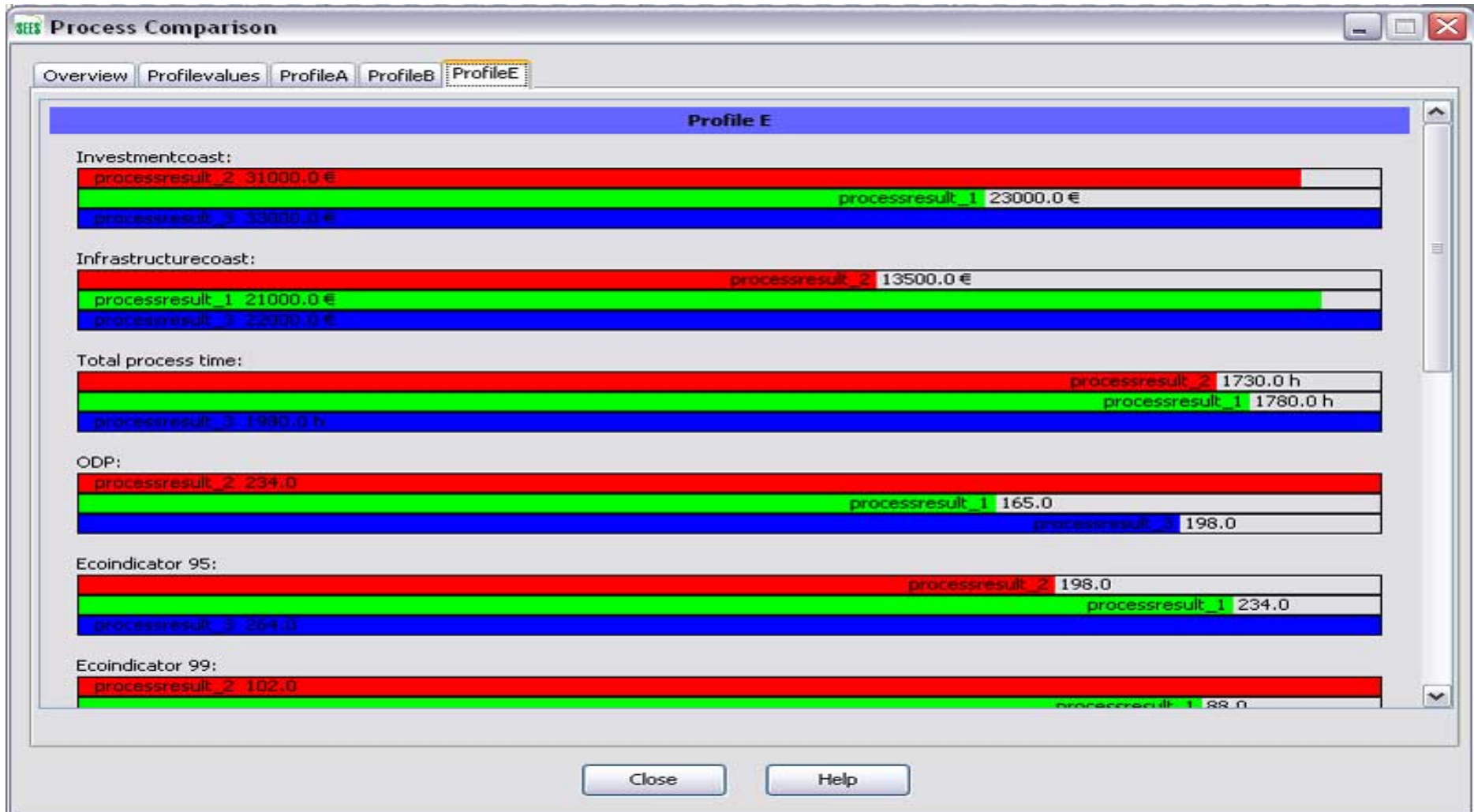
Not very meaningful screenshot here. I think, this slide could be left out in case you have to shorten your presentation. The results on the next slide are more interesting.

André Greif, 9/1/2006

# Process calculation (2/4)



# Process calculation (3/4)



# Process calculation (4/4)

SEES Process Comparison

Overview Profilevalues ProfileA ProfileB ProfileE

Processfilename: processresult_3				Processfilename: processresult_2				Processfilename: processresult_1			
Profile A				Profile A				Profile A			
Sum of	Input	Output	Balance	Sum of	Input	Output	Balance	Sum of	Input	Output	Balance
Mass:	1150kg	1120kg	30kg	Mass:	1350kg	1320kg	30kg	Mass:	1050kg	1020kg	30kg
Transport:	9tkm	8.5tkm	0.5tkm	Transport:	13tkm	11.9tkm	1.1tkm	Transport:	10tkm	9.5tkm	0.5tkm
Energy:	2030MJ	1930MJ	100MJ	Energy:	3450MJ	3410MJ	40MJ	Energy:	5030MJ	5020MJ	10MJ
Time:	20h	22h	-2h	Time:	15h	17h	-2h	Time:	20h	50h	-30h
Coast:	10000€	11000€	-1000€	Coast:	30000€	32500€	-2500€	Coast:	20000.6€	21000.6€	-1000€
Profile B				Profile B				Profile B			
Production:				Production:				Production:			
Sum of	Input	Output	Balance	Sum of	Input	Output	Balance	Sum of	Input	Output	Balance
Mass:	2756kg	2350kg	306kg	Mass:	2356kg	3340kg	16kg	Mass:	1356kg	1350kg	6kg
Transport:				Transport:	30tkm	20tkm	10tkm	Transport:	10tkm	9tkm	1tkm
Energy:				Energy:	3210MJ	3190MJ	20MJ	Energy:	2000MJ	2200MJ	-200MJ
Time:				Time:	13h	15h	-2h	Time:	44h	38h	6h
Coast:				Coast:	11500€	10500€	1000€	Coast:	20000€	15000€	-5000€
Use:				Use:				Use:			
Sum of	Input	Output	Balance	Sum of	Input	Output	Balance	Sum of	Input	Output	Balance
Mass:	2350kg	2350kg	0kg	Mass:	1650kg	1350kg	300kg	Mass:	1350kg	1350kg	0kg
Transport:	10tkm	20tkm	-10tkm	Transport:	1tkm	1tkm	0tkm	Transport:	20tkm	10tkm	10tkm

Close Help

# SEES Eco-Design Guidelines

→ Public Report D8 available from the SEES website

▶ SEES developed eco-design guidelines to improve the environmental performance of new EES designs

▶ Covered aspects:  
all life cycle phases from pre-production to end-of-life,  
EES product characteristics, EES design alternatives evaluation

1. Qualitative evaluation of available redesign options  
→ Recommendation
2. Determination of priority life cycle phases based on product type and its characteristics
3. Selection of appropriate guidelines for the priority life cycle phases

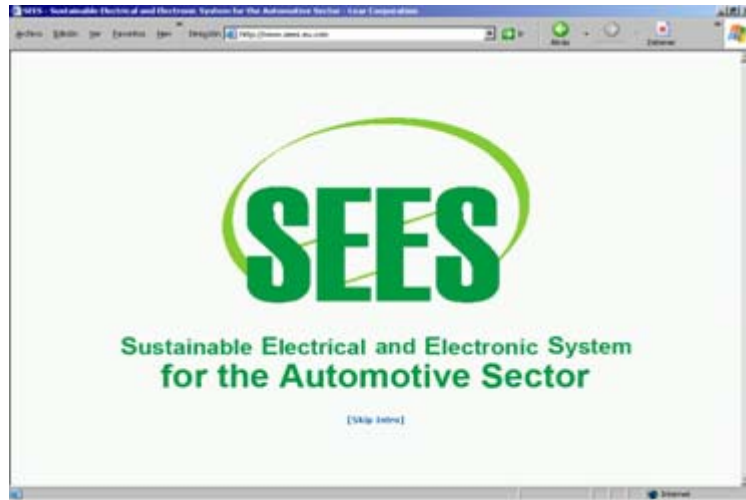
# Outlook on further SEES Activities

- ▶ Development of a new EES concept including prototyping of specific functions/parts (e.g. energy management system, natural fibers reinforced plastic covers)
- ▶ Testing and validation of the prototypes (technical/functional, environmental and economic aspects)
- ▶ Dissemination and exploitation of the results

(SEES workshop planned at the CARE Innovation Congress, Vienna, 13-16 November 2006)



# Thank you for your attention!



**SEES-Project Homepage:**

**[www.sees-project.net](http://www.sees-project.net)**

SEES project presentation, SEES flyer,  
conference papers/posters, upcoming events,  
newsletter registration

