Lifecycle Management Methodology using Lifecycle Cost Benefit Analysis for Washing Machine

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Introduction

EuP Directive Requests to Manufacturers of EuP:

- Ecodesign
- Life Cycle Thinking
- LCA (ISO14041,14044)
- Green Product Chane
- International Harmonization

→ Request for Internal Ecodesign control or Management system for Ecodesign

Problem:

- Relation of environmantal impact and cost unclarified
- Many kinds of environmental options
- Identify Priority of Options using Cost-Benefit Analysis

→Need a tool for Decision Making Support for Environmental Options and Communication

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Goal

- Develop LCCBA Method with Monetary value of environmental Impact using LIME, including LCT, LCA, LCC → CBA

- Develop EcoDesign Managing system According to EuP request

- Clearize Cost-Environmental Profile of Products and Process able to support for Decision making and Communication

- Achieve an Example of Washing Machine

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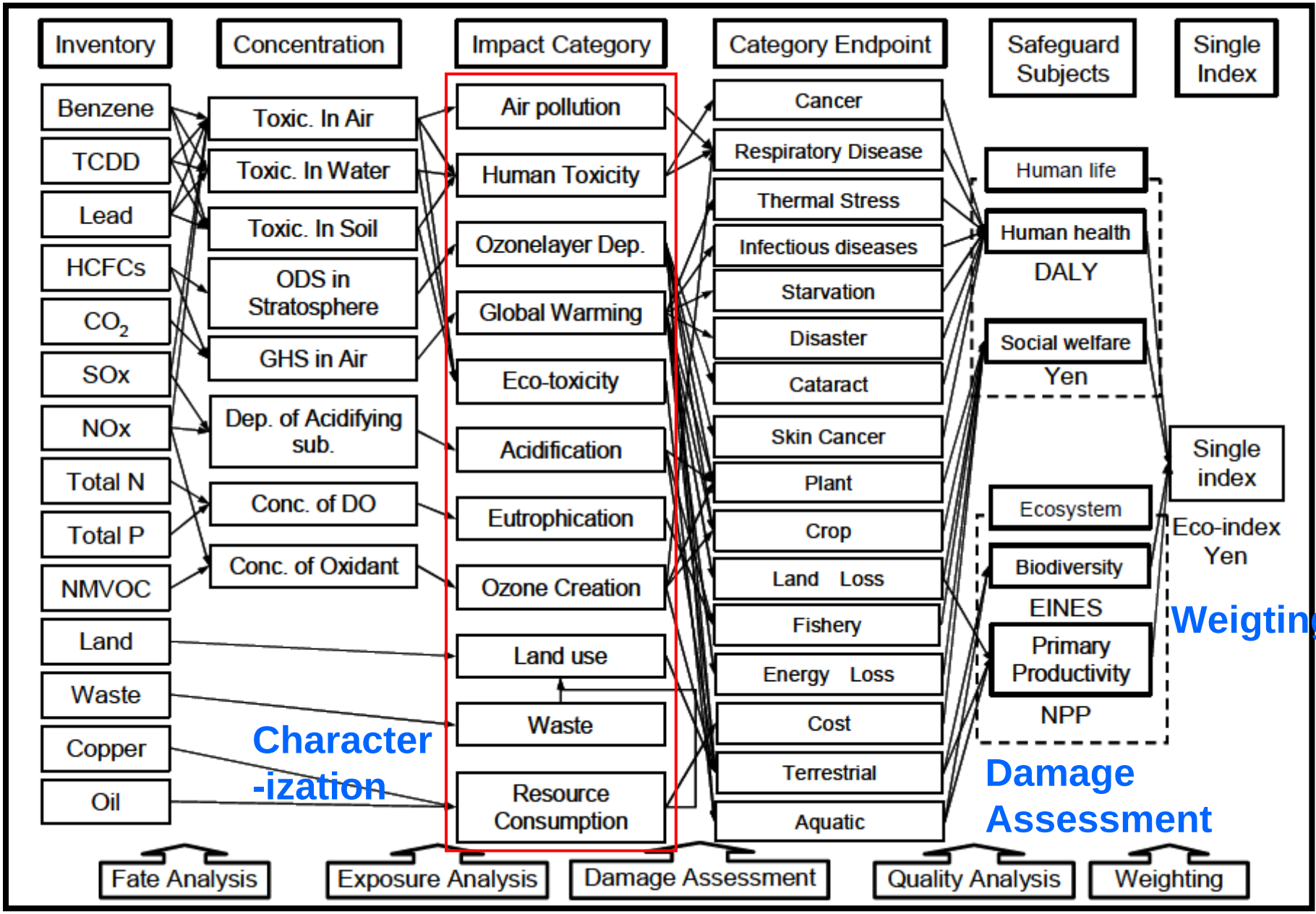

LIME (Life-cycle Impact assessment Method based on Endpoint modeling)

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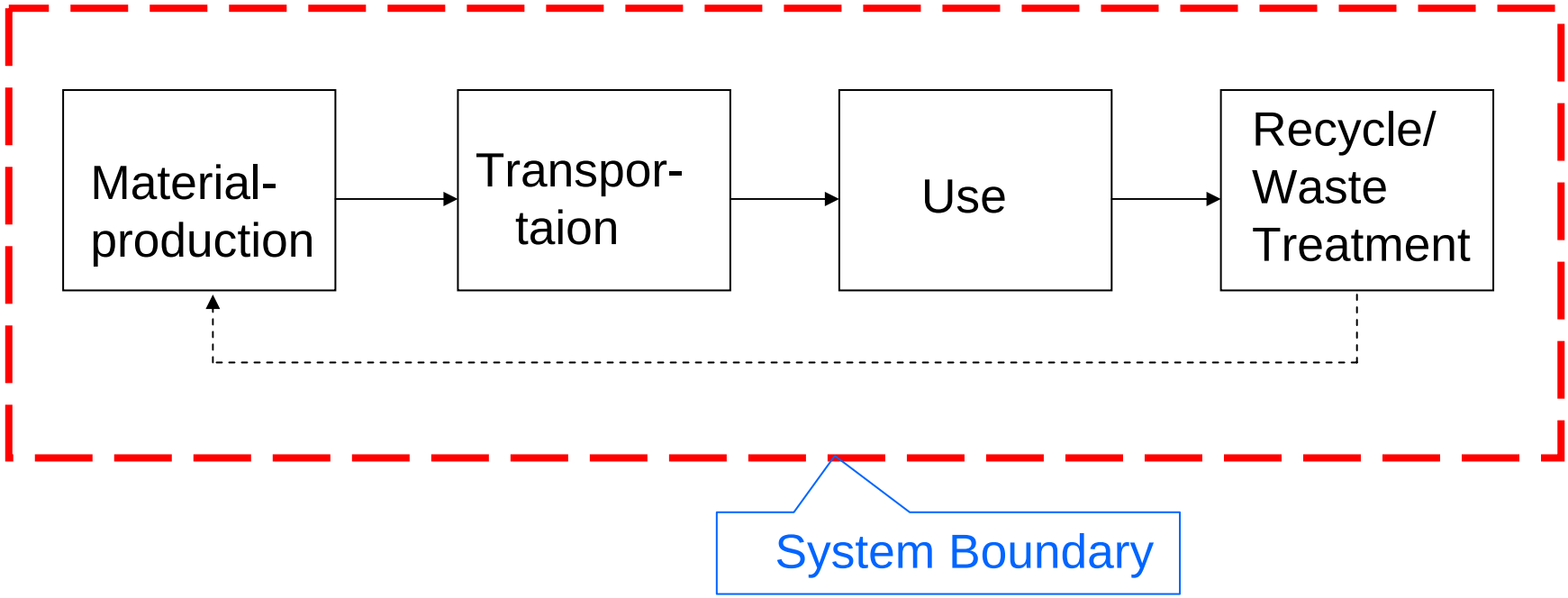
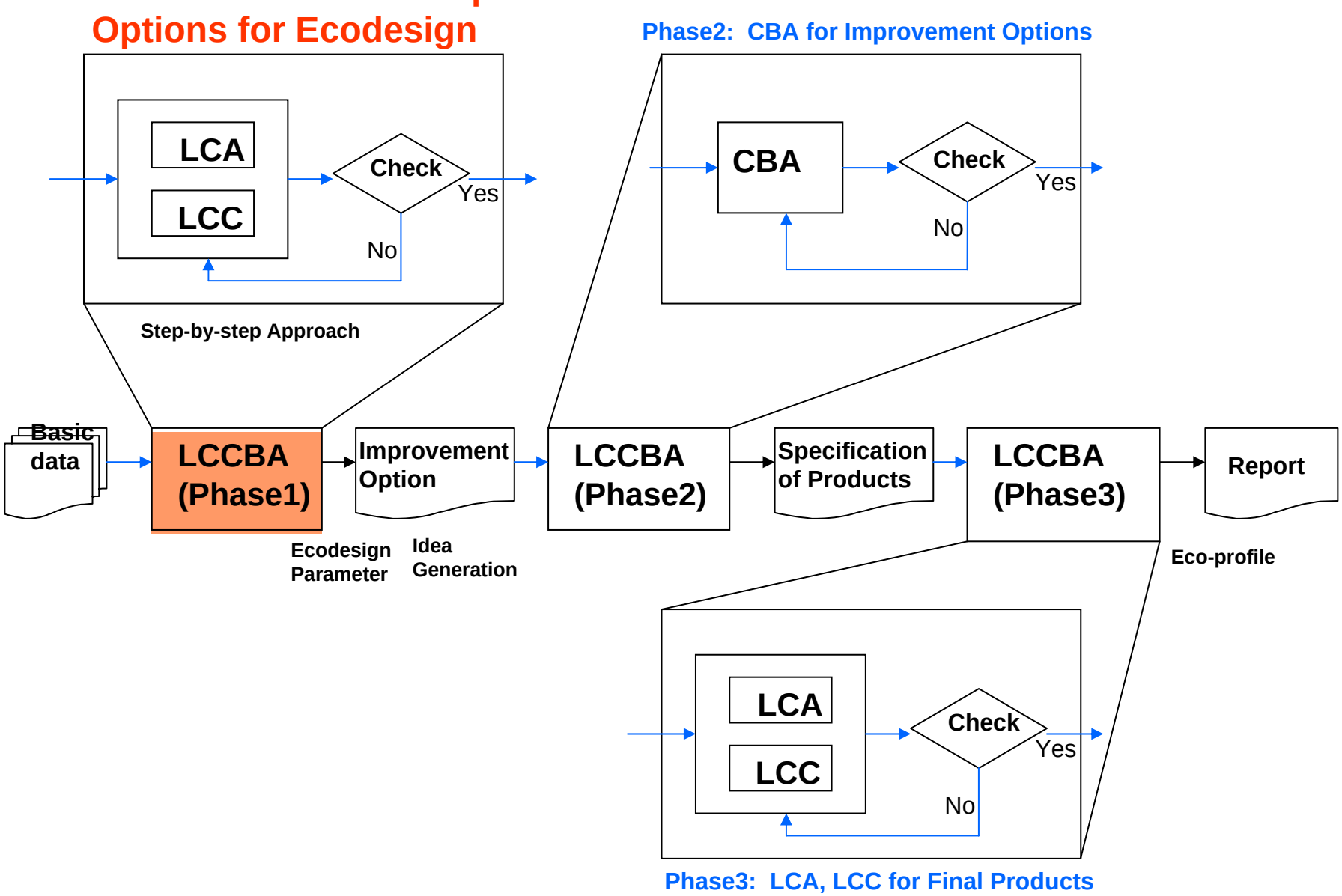
Target and Scope of Example

Target: Life cycle of a Washing Machine for home use (Laundry:8kg)

Scope:





Process Flow of LCCBA

Step1　LCA・LCC

- Analize for screening.
- Perform quickly using simple data.
- Extract the stage and process having large environmental impact and cost.
- Infer the ecodesign parameter.
- Check by criteria and go to the next step (Step2 or Phase2).

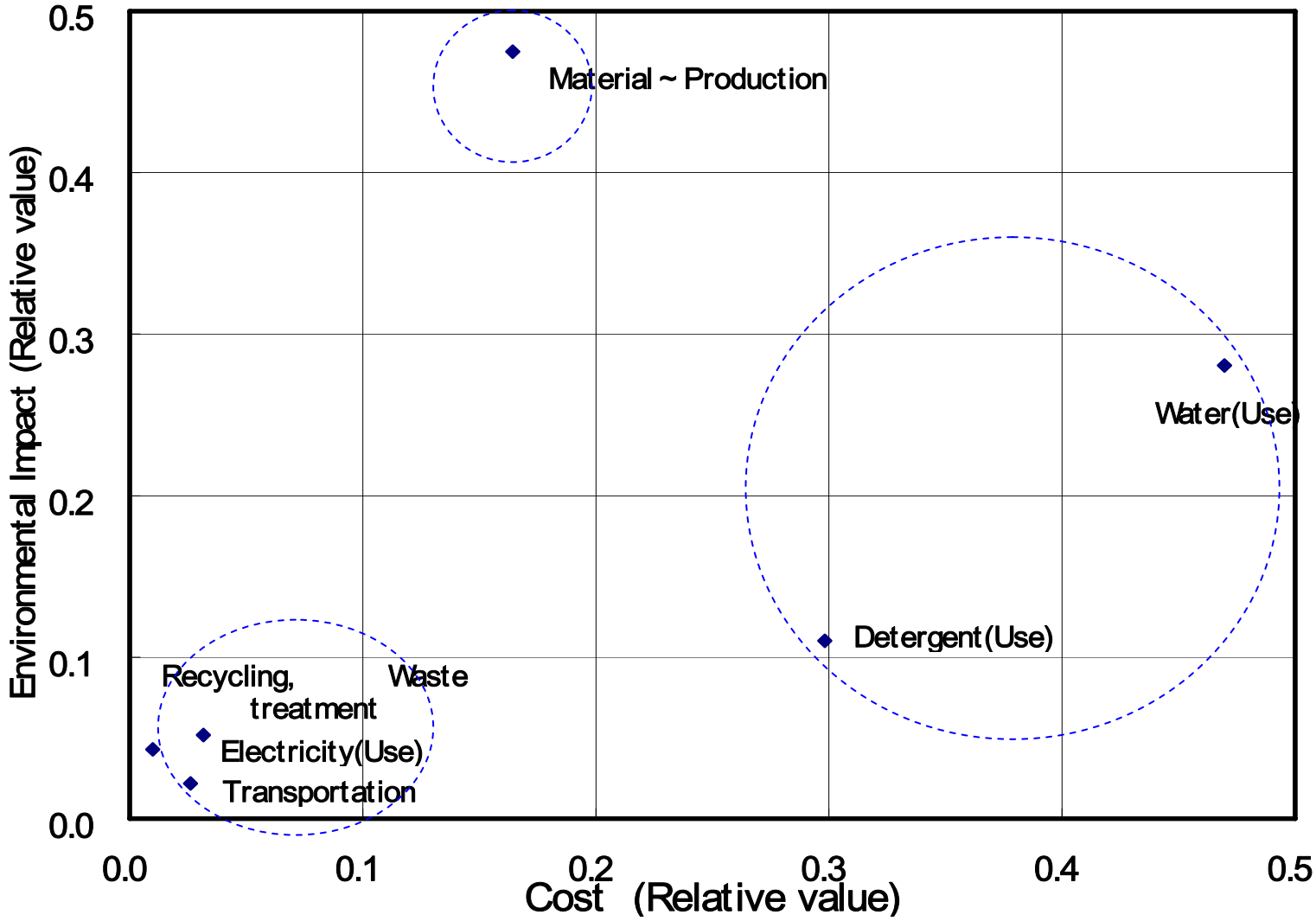
Step1 LCC· LCA Data

Stage	Item*	Amout*	LCC	LCA
Material-Producion	Steel Copper Aluminium Polypropylene. ABS	27.2kg 1.81kg 3.11kg 14.87kg 1.31kg	Washing Machine(IO)	ETH-ESU96 ETH-ESU96 ETH-ESU96 ETH-ESU96 APMA
Packaging Material	Cardboard EPS	5kg 0.5kg	× ×	BUWAL250 PRE
Use**	Electricity Detergent Tap Water Sewage System	377.2kWh 206kg 539kL 539kL	Av.unit pricie× Av. amount Av.unit pricie× Av. amount Av.unit pricie× Av. amount Av.unit pricie× Av. amount	AIST-LCA AIST-LCA IO AIST-LCA
Transpotation	truck (600km× 2)	78.6t·km	Av. Price	BUWAL250
Recycling/ Waste treament	Recycling of Steel Recycling of Copper Recycling of Aluminum Recycling of Polypropylene Landfill	27.2kg 1.33kg 1.76kg 15.87kg 11.84kg	Recycling Price for Washing Mashine by Recycling Law for Home Appliances	BUWAL250 PRE BUWAL250 BUWAL250 BUWAL250

* Value for Representative Washing Machine

** 365Wash× 11.5years

Step1 Cost and Environmental Impact for Stages (Relative value)



H. Yamaguchi, et al., Proc. 7th Ecobalance, p.409 (Tsukuba, 2006)

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Adequacy Check for the Step1

Identified Problem	Adequacy checking									Ecodesign Parameter to be improved (EuP Directives)	Improve-ment Option
	1st criteria		2nd criteria (ISO14044)								
	Possibility to infer ecodesign parameter	1st Judgement	Time-related cverage	Geographical coverage	Technological coverage	Completeness	Representativeness	Other Items	2nd Judgement		
Water (Use)	v	○	v	v	X	X	X	v	X	(e) Quantity of consumables needed for use and maintenance	
Detergent (Use)	v	○	v	v	X	X	X	v	X	(c) Water consumption	
Material ~ Production	X	X	-	-	-	-	-	-	-		

Ecodesign parameter: EuP directive, AnnexI(2005), **2nd criteria**: ISO 14044 (2006)

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Step2　LCA・LCC

1. Analize the important stage and process precisely after Step1.

   a) Material ~ Production: Collect Data of the production factory for small units of the products.(Housing, Driver, Controller, Washing Tub・・・)

   Material, Parts:　Collect the material and weight.

   Anscillary Material, Utility, Waste allocate to unit by man/hour of the unit production.

   b) Use：Use washing frequency by the actual survey data

   c) Survey for other stage more precisely if possible.

2. Extract the stage and process having large environmental impact and cost.

3. Infer the ecodesign parameter and generate the improvement option.

4. Check the adequacy by 1st and 2nd criteria and go to the next step (Step3 or Phase2).

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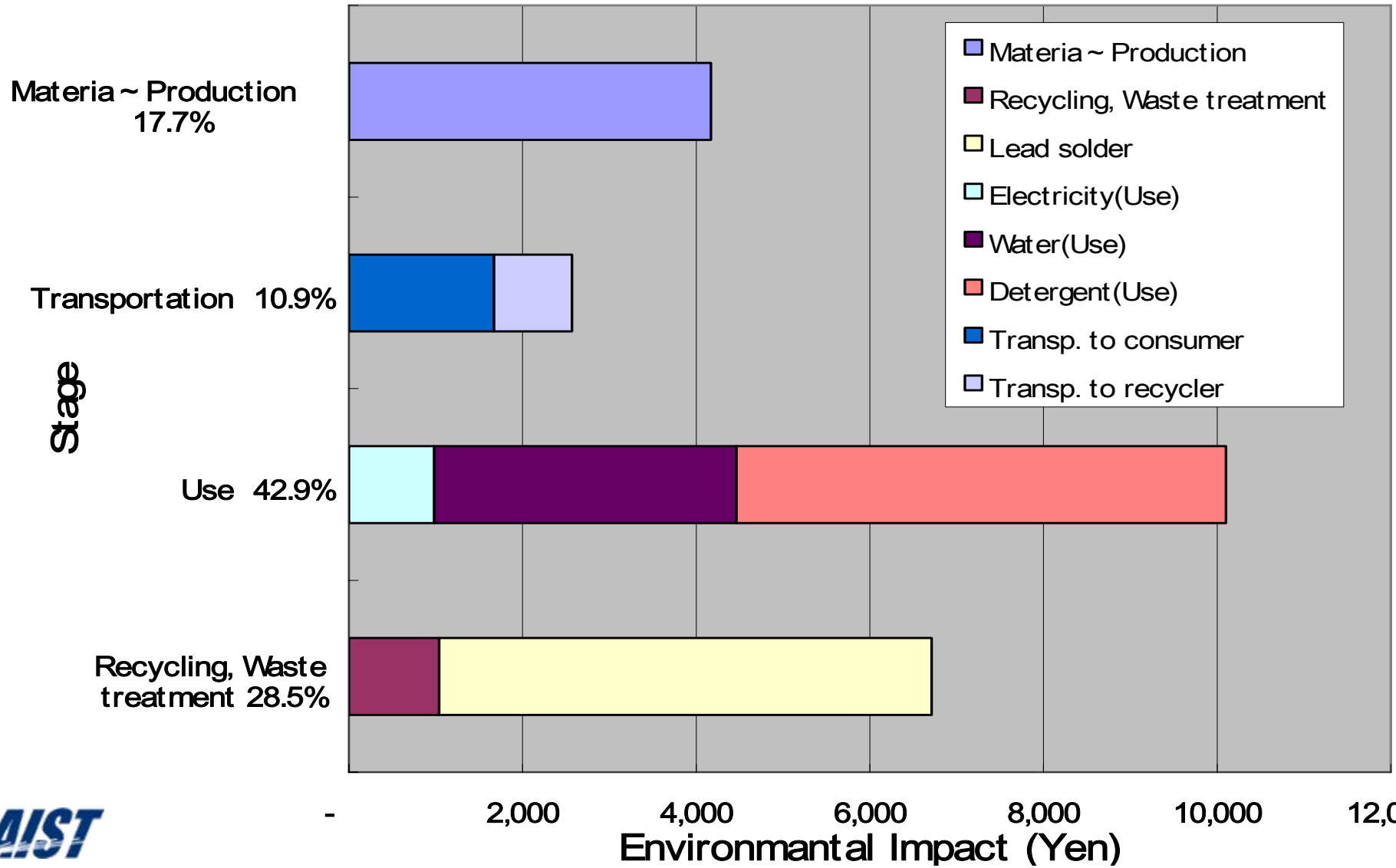
Step2 LCA Results
(Environmental Impact: 23,500 Yen)



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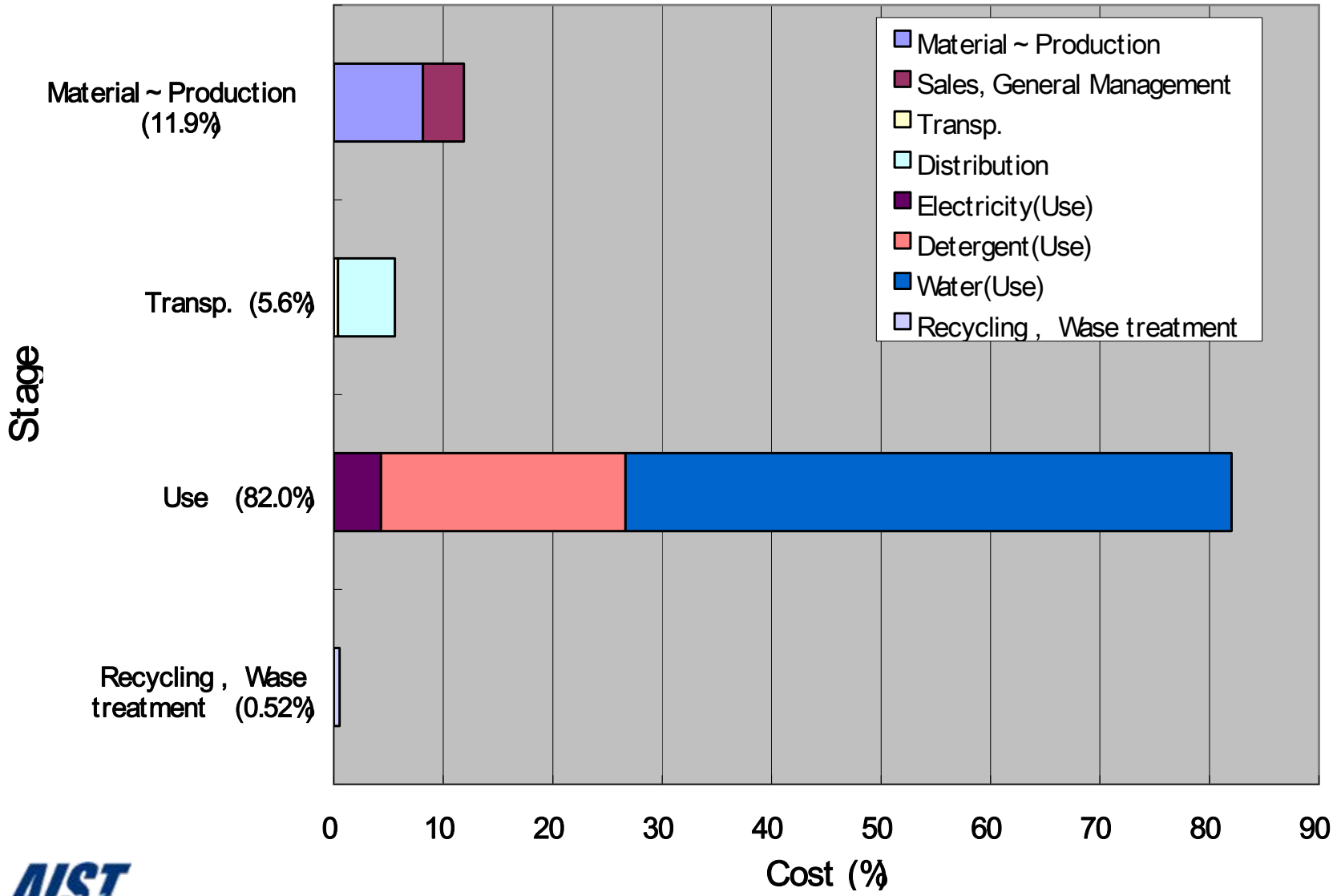
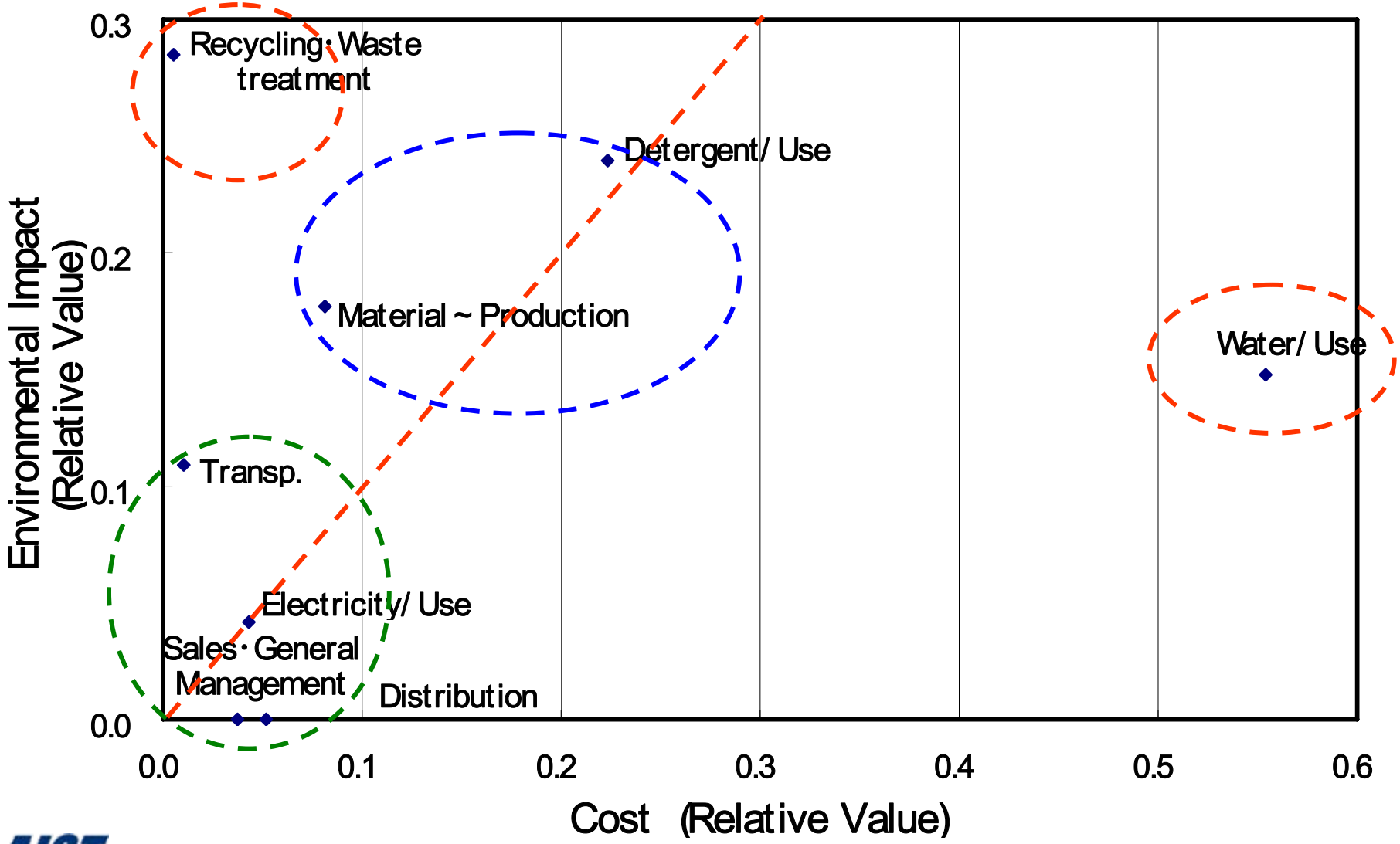
LCA Software:SimaPro7, Database: Ecoinvent, AIST, Impact Evaluation: LIME

Step2 LCC Results



Step2 Cost- Environmental Impact Profile for Stages



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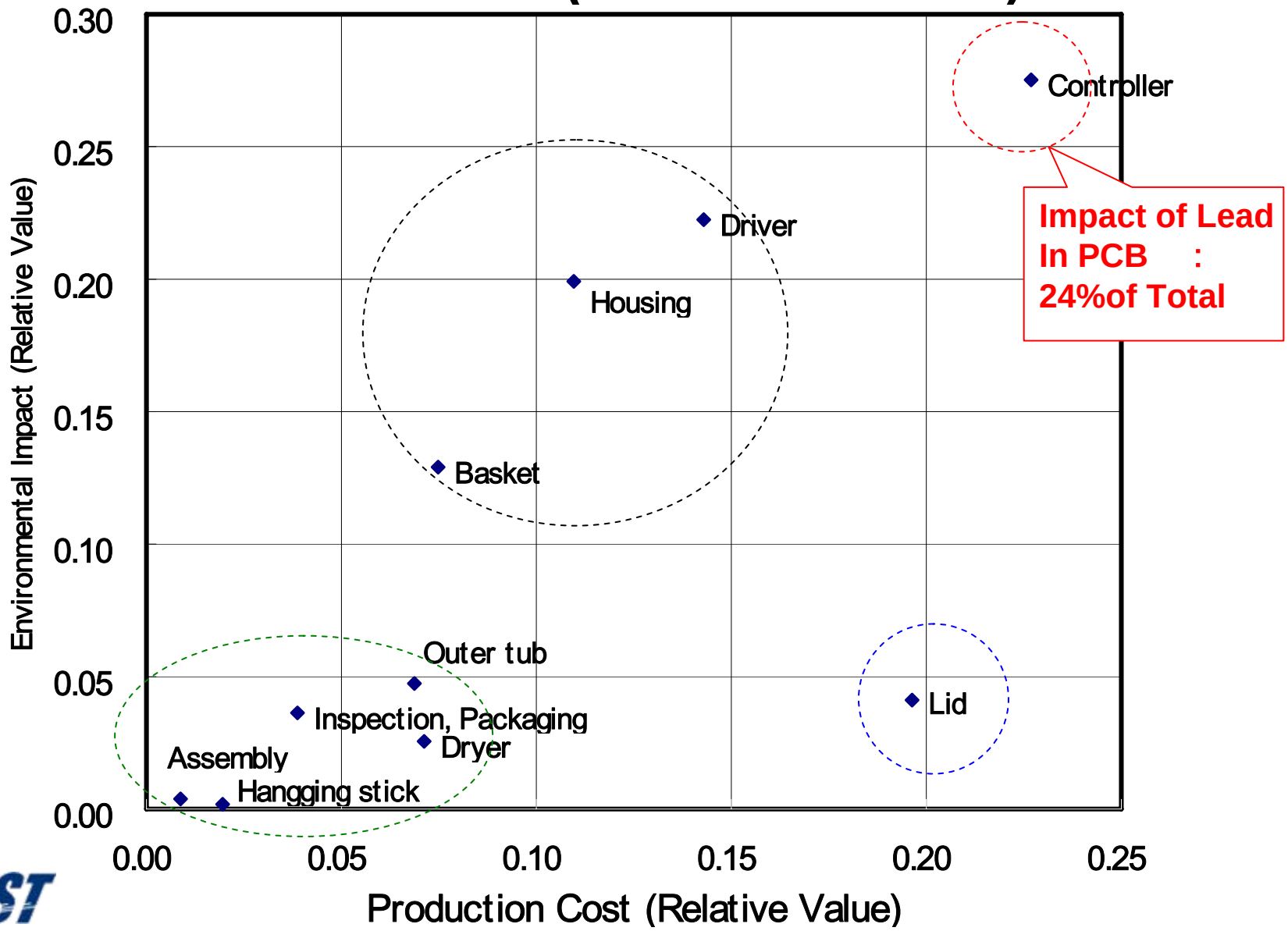
Cost and Environmental Impact for Unit Production (Relative Value)



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Adequacy Check for the Step2 LCA and LCC

Identified Problem	Adequacy checking									Ecodesign Parameter to be improved (EuP Directives)	Improve-ment Option
	1st criteria		2nd criteria (ISO14044)								
	Possibility to infer ecodesign parameter	1st Judgement	Time-related coverage	Geographical coverage	Technological coverage	Completeness	Representativeness	Other Items	2nd Judgement		
Water (Use)	v	○	v	v	v	v	v	v	○	(e) Quantity of consumables needed for use and maintenance	Dewater
Detergent (Use)	v	○	v	v	v	v	v	v	○	(c) Water consumption	Saving of detergent
Material ~ Production	v	○	v	v	v	v	v	v	○	(d) Use of hazardous substances *(Pb, PCB of Controller)*	Lead-free soldering
Recycling, Waste treatment	v	○	v	v	v	v	v	v	○	(d) Emission to soil *(Pb, Potential Environmental Impact)*	Lead-free soldering

Ecodesign parameter: EuP directive, AnnexI(2005), **2nd criteria**: ISO 14044 (2006)

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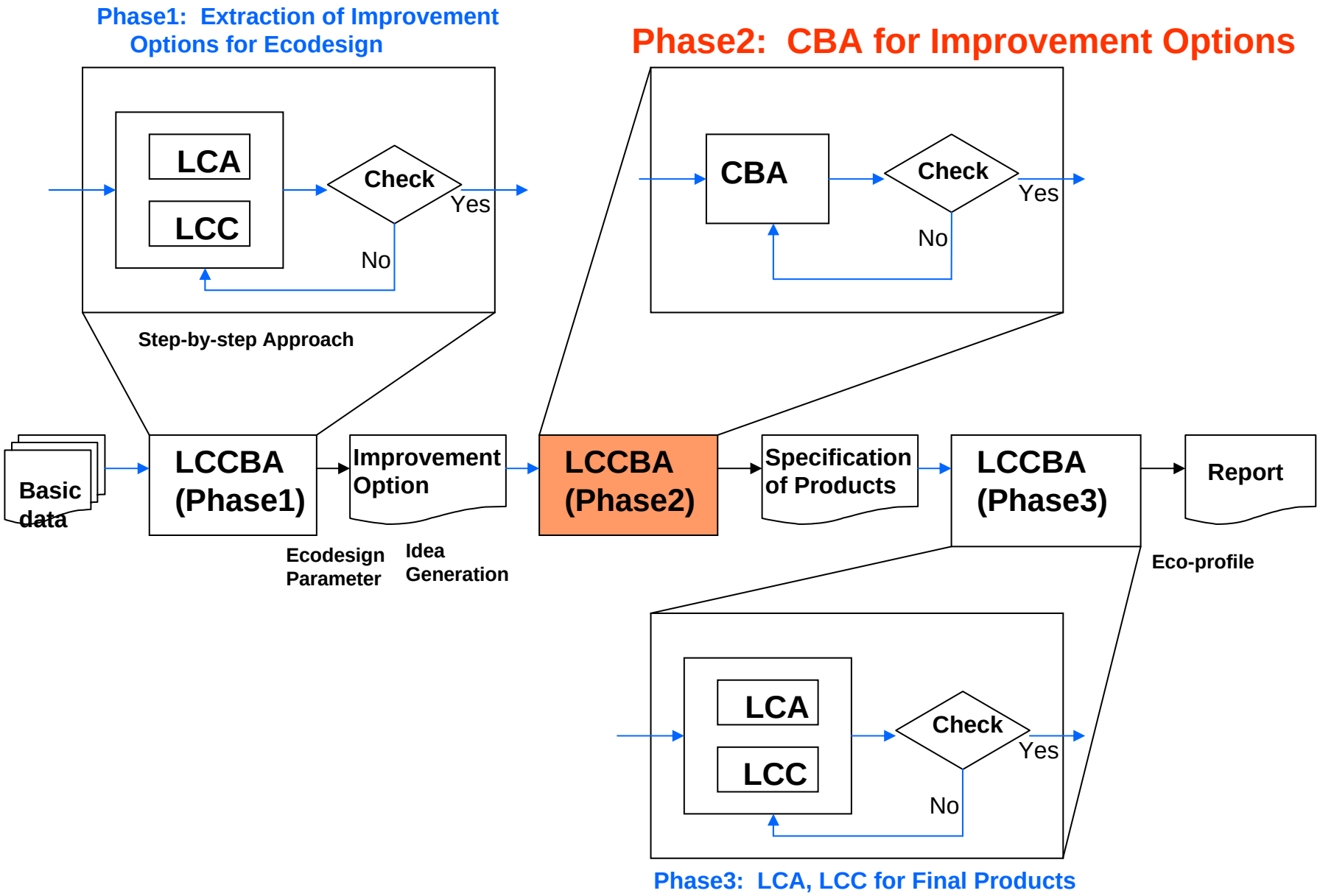


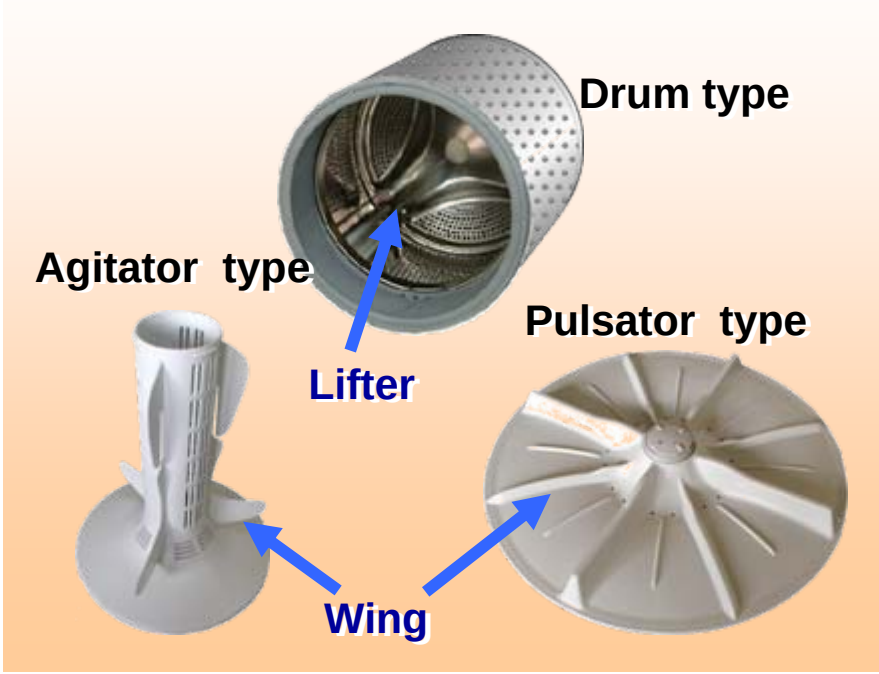
Process Flow of LCCBA

Precise Examination of Environmantal Options

Environmental Options	**Dewater**	Saving of Detergent	**Pb Free Soldering**
Methods under consideration	· Trend of consumer · Quality of Washing	· Effect for Cleaning	· Cost, · Usability, · Characteristics of Solder, · Equipment
Issues considered	· Circulation of High density detergent liquid by new dewater pulsator	(No adoption)	· Sn0.7Cu solder
Method adopted	· Washing by dewater pulsator · Control for high torque motor · Production equipment	-	· Production Engineering · Production Equipment

(1) Dewater Scenario

Conventional Method



Trap clothes to rotate

Move clothes by water flow

New Dewater Method

New dewater pulsator

Slide clothes up and down

Use little water used

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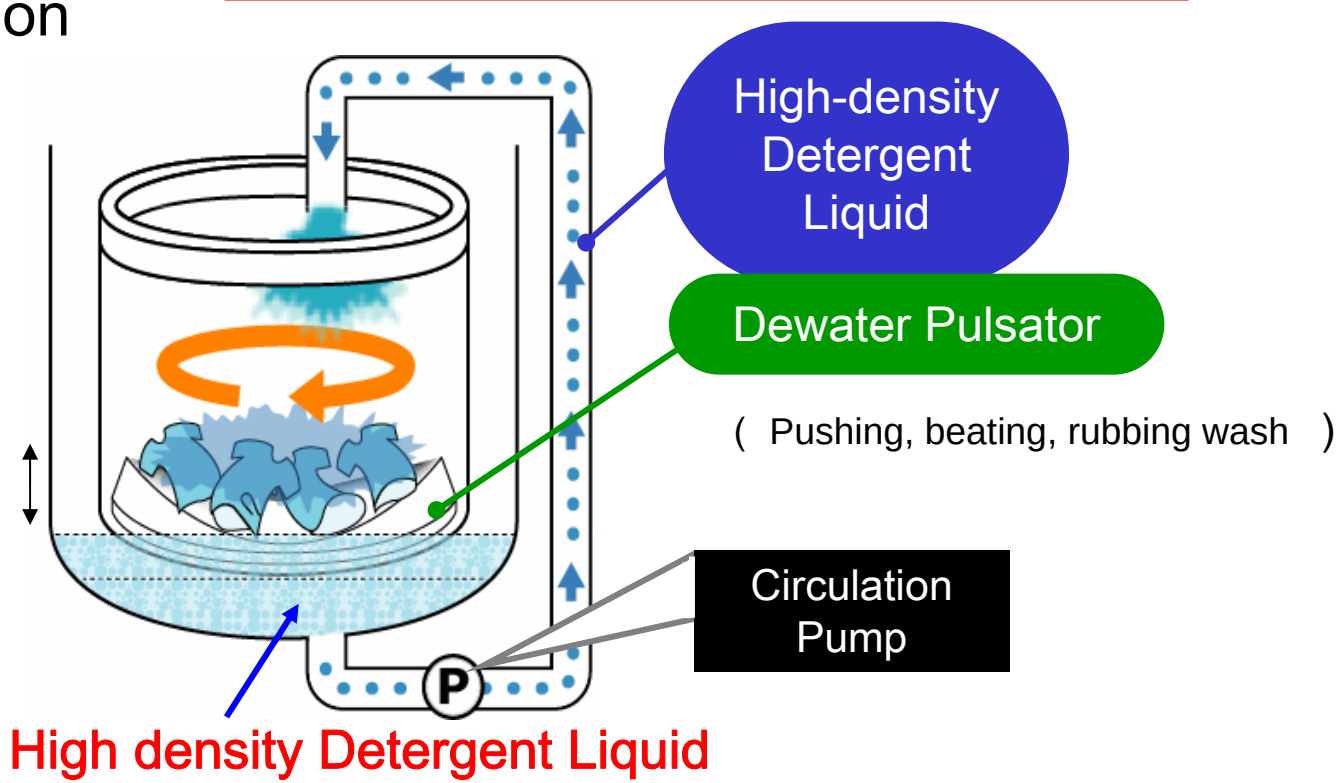
Dewater

Point of Development

Dewater Washing by Circulation

- Pushing, beating, rubbing wash by dewater pulsator
- Reuse of high-density detergent liquid by circulation



Data for Dewater Scenario

		Before	After
Materal - Production		-	Circulation Unit Production Cost above
Use	Electricity	157 Wh	170 Wh
	Water	196 L	88 L
	Detergent	47 g (1.62Wash/day ×365day/year× 11.5year) Cost above	47 g (1.62Wash/day×365day/year× 11.5year) Cost above
Others		-	Cost Increase of Developing Division Production Division Assistance Division *(Estimation of increase ratio)*

Red: LCC Data

Basic Data before and after Dewater by Circulation

Circulatin unit

(Weight of Laundry: 8kg)

Stage	Resource･Energy		Unit	Before	After	Difference	Cost Difference (Yen)	Unit cost
Material ~ Production	Material, Parts			Without Circulaion unit	With Circulaion unit	26 kinds of Materials, 1.28kg	1,784.00	
	Manufacturing Energy		kWh	0.00	0.26	0.26	3,904.00	
Use	Electricity	for washing	Wh/ washing	157.81	170.00	12.18	0.27	22Yen/ kWh
		for a year	kWh/ year	84.50	91.03	6.52	143.56	22Yen/ kWh
		for LC	kWh	971.77	1046.81	75.02	1,650.97	22Yen/ kWh
		LC cost		21,378.95	23,029.92	1,650.97		
	Water	for washing	L/ washing	196.00	88.00	- 108.00	- 13.82	
		for a year	kL/ year	104.95	47.12	- 57.83	- 7,402.13	
		for LC	kL	1,206.92	541.88	- 665.04		
		LC cost (tapwater)	Yen	154,485.19	69,360.70	- 85,124.49	- 85,124.49	128Yen/ kL
		LC cost (sewage system)	Yen	120,691.56	54,188.05	- 66,503.51	- 66,503.51	100Yen/ kL
	Detergent	for washing	g/ washing	47.40	47.40	0.00	0.00	0.38Yen/ g
		for a year	kg/ year	25.38	25.38	0.00	0.00	
		for LC	kg	291.88	291.88	0.00	0.00	
		LC cost*	Yen	407,468.77	257,491.74	- 149,977.03	- 144,289.03	

* This value does not include the indirect cost

Water (Use)
-152,000 yen

Electricity(Use)
+1,650 yen

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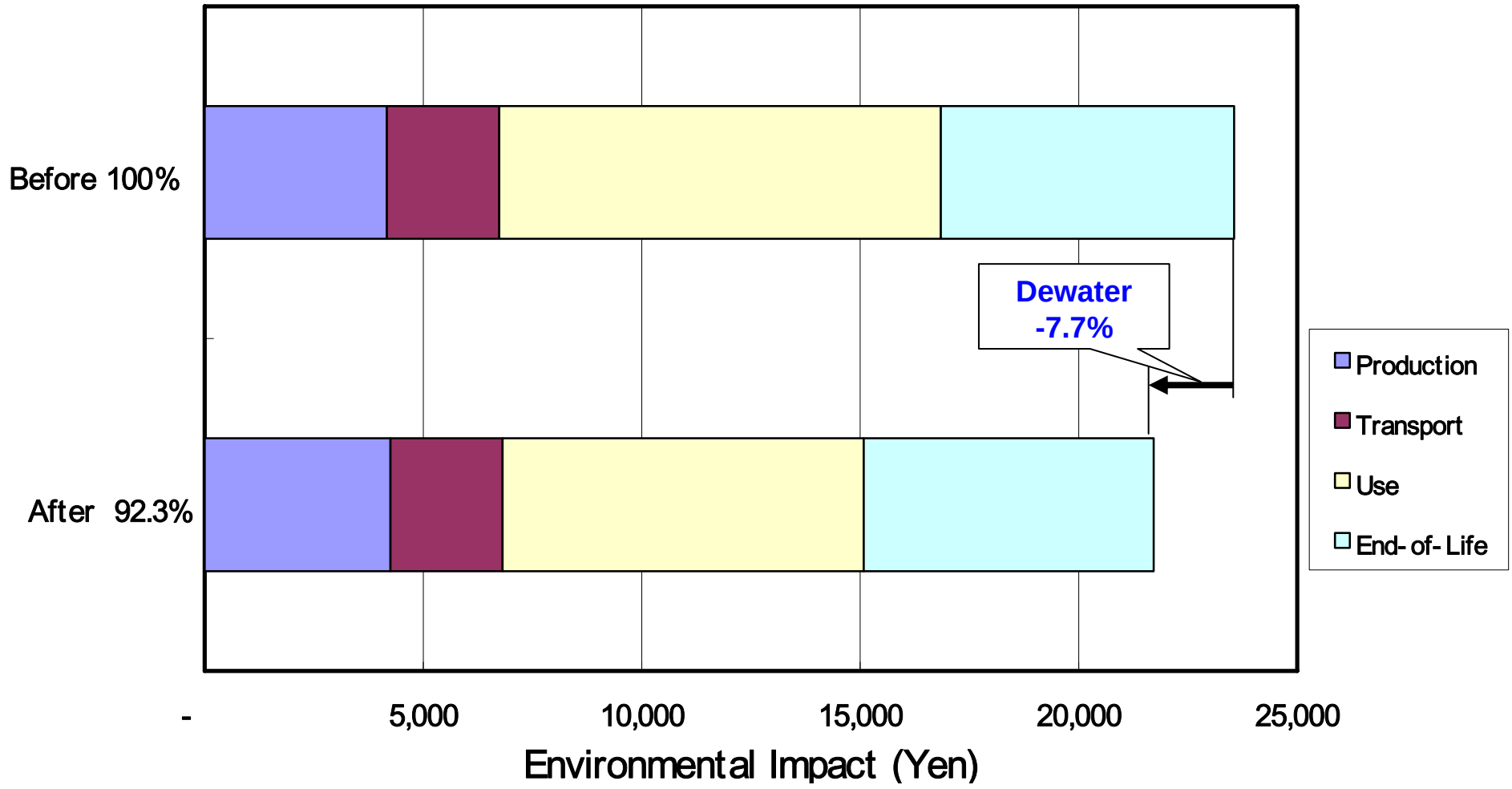
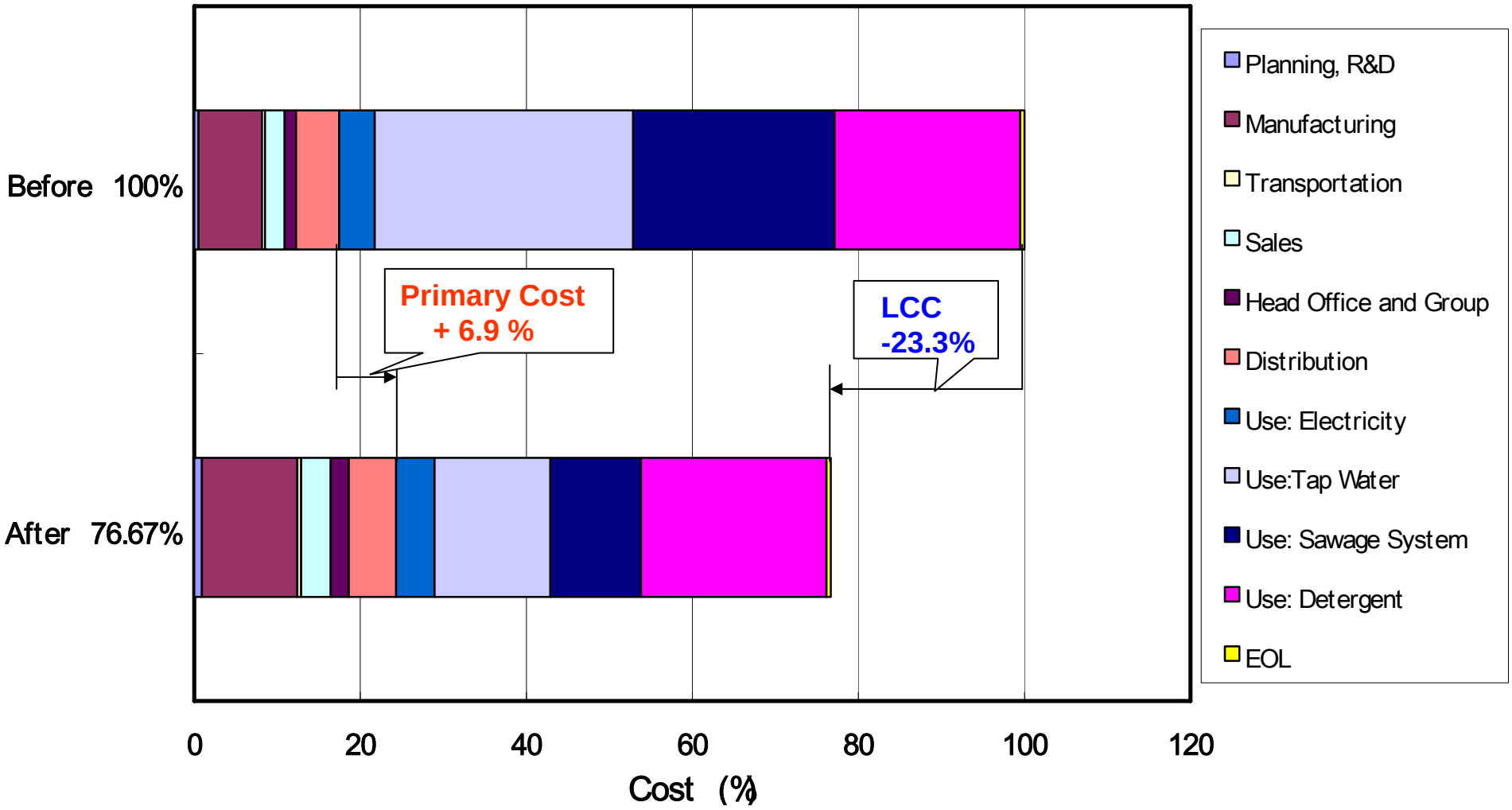
LCA Results (Dewater)



LCC results (Dewater by circulation)



(2) Lead-free Scenario

Stage: Material~Production, Controller Unit

PCB: Lead solder → Lead-free solder

Following Potential Environmental Impacts will be diminished.

- Long term leaching to water by landfill
- Emission to soil by illegal dumping
- Emission to air, water, soil by uncontrolled recycling through exportation of reuse goods etc. to developing countries.

Data for Lead-free Scenario

	Before	After
Solder	Sn37Pb 37g Cost above	Sn0.7Cu 34g Cost above
Electricity (Reflow oven)	1.67 kWh Cost above	1.71 kWh Cost above
Others	-	・ Depreciation of Reflow Oven ・ Cost Increase of Production Engineering *(Estimation of increase ratio)*

Red: LCC Data

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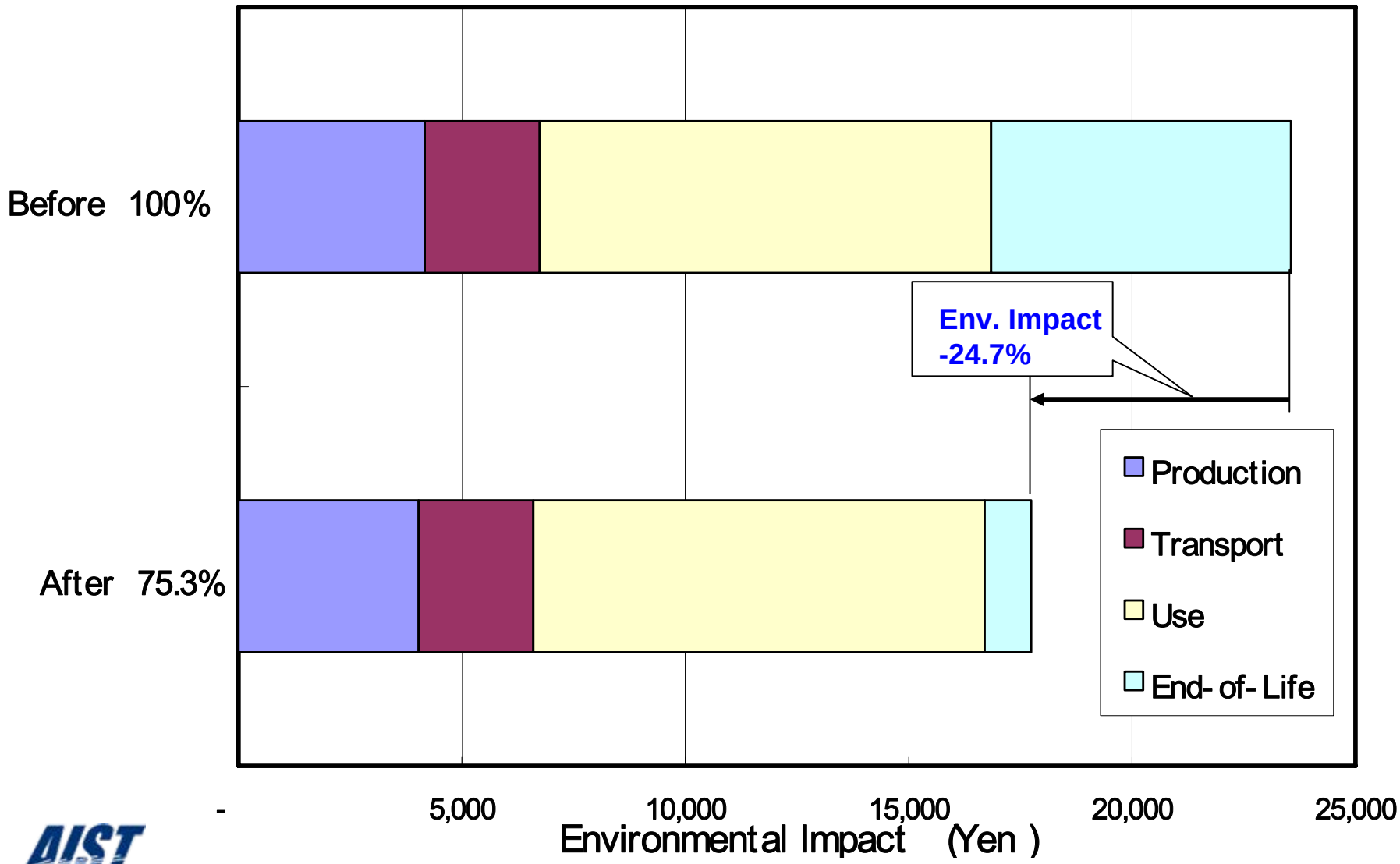
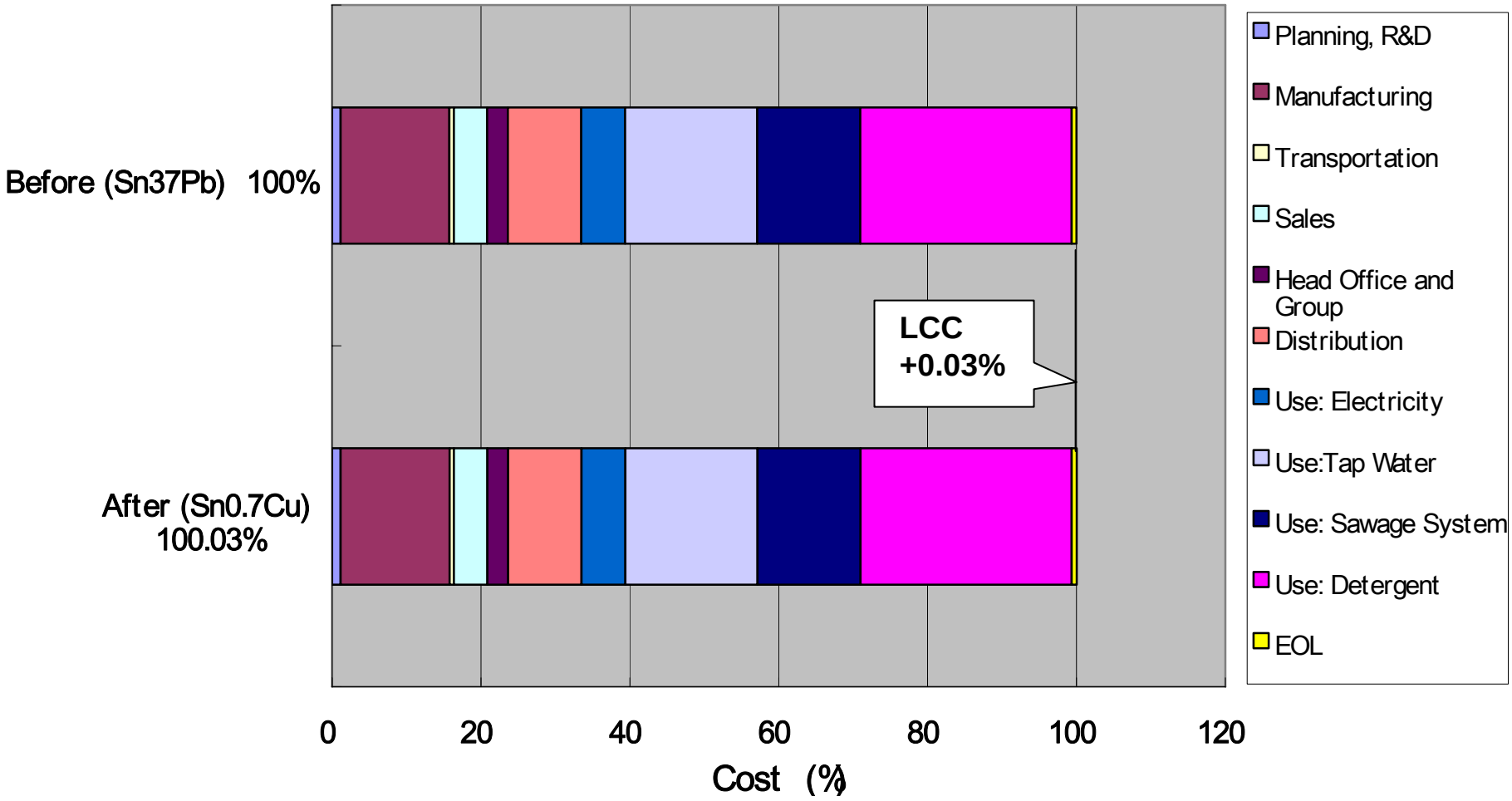
LCA Results (Lead-free Soldering)



LCC (Before and after Lead Free)



LCC・LCA・CBA

B/C :no unit, other values :Yen

	LCC		LCA		CBA	
Scenario	Lifecycle Cost (fictitious value)	Cost for measures C	Envirnmental Impact	Benefit by measures B	B-C	B/C
Washing Machine (baseline)	394,700		23,500			
(1)Dewater by water-circulation	274,100	-120,600	21,700	1,800	122,400	
(2)Lead-free Soldering	394,870	170	17,700	5,800	5,630	34.1

C: LCC after the measure-LCC before the measure

B: Environmental impact before the measure - Environmental impact after the measure

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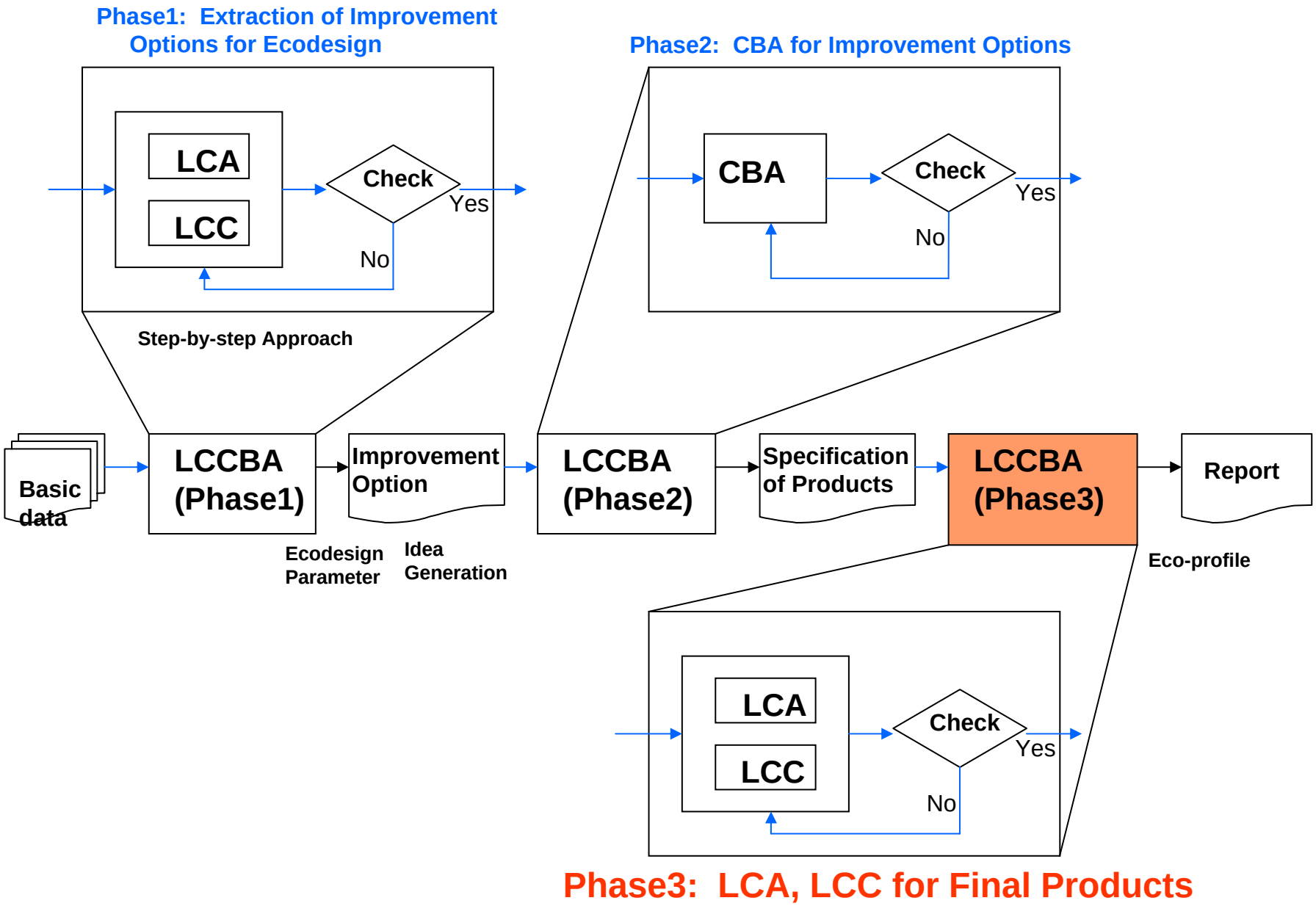

Process Flow of LCCBA

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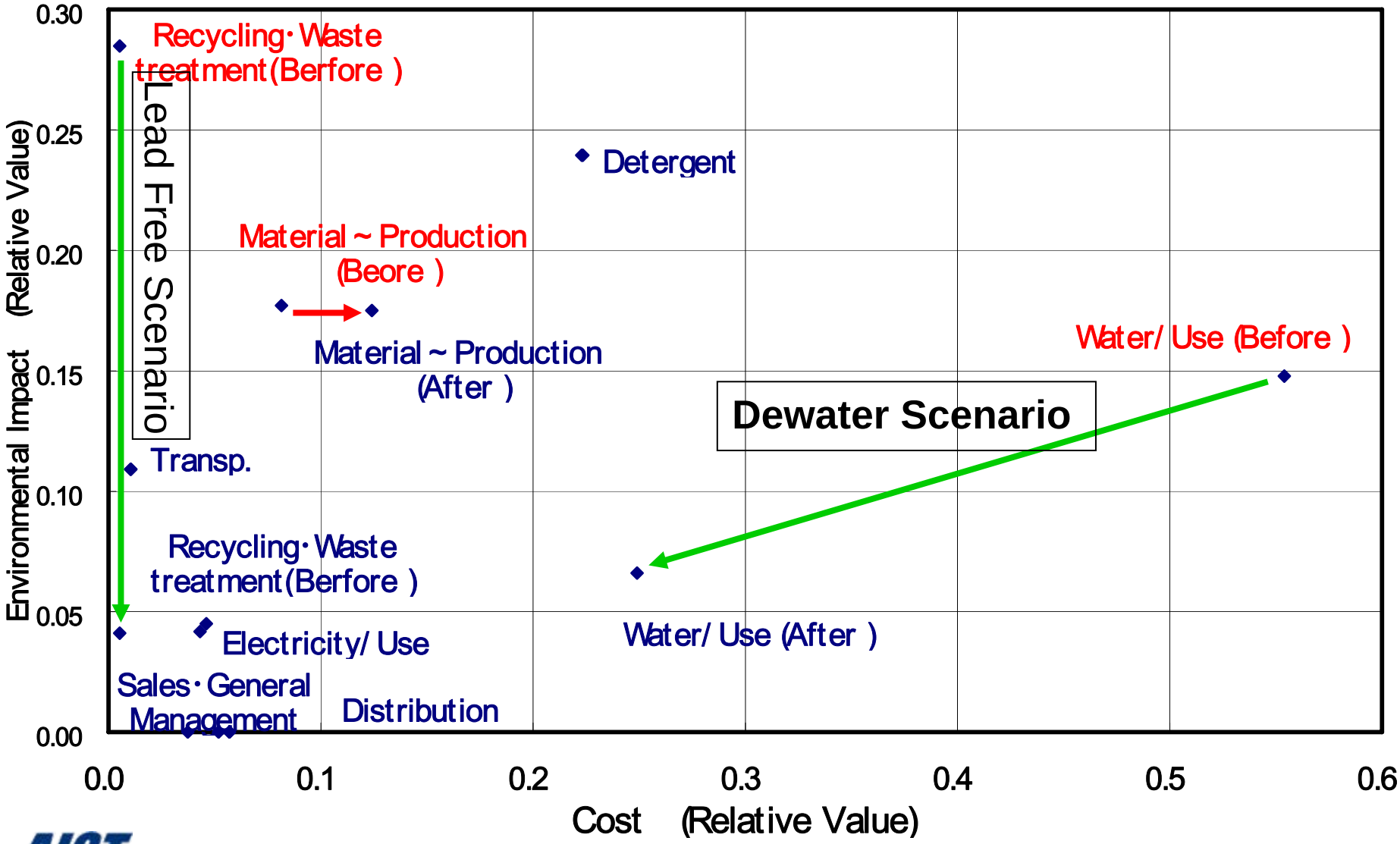
Cost and Environmental Impact for stages Before and After (Relative Value)



Conclusion

1.LCCBA method is developed using LCA, LCC and CBA with LIME monetary value and fit to EuP Ecodesin Management request; including,

- Phase1: Find the stage and process with large environmental impact and cost, ecodesign parameter and improvement options,
- Phase2: Improvement scenario generation (technical, social, economical survey) and CBA,
- Phase3: LCA and LCC for final products to confirm the effect of improvement.

2. An LCCBA example of washing machine is achieved.

Water in use, Pb in PCB are identified as problem and dewater scenario and lead-free soldering scenario are studied with LCA,LCC,CBA and estimated to be effective for environment and cost.

Next Task

- Combining the research for the waste emission scenario, and using uncertainty analysis →upgrade the LCCBA method.
- Apply the method into many other electrical and electronic products (printer, copier, desk top and personal computer, LCD projector, etc.)
- Project Member: Fujitsu, Canon, Ricoh, NEC, Hitachi

- Write a Guide Book and diffuse the LCCBA method to the manufacturers.

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