



SESHA Texas Hill Country Meeting Austin, TX

Accelerating Sustainable Manufacturing

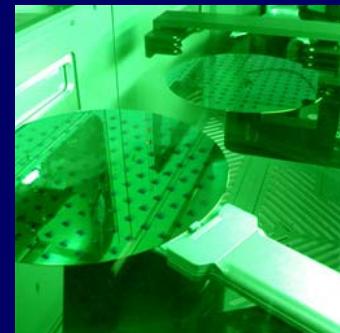
Key Environmental Performance Indicators for the Semiconductor Industry

Laurie Beu

Laurie.Beu@ismi.sematech.org

Steve Trammell

Steve.Trammell@ismi.sematech.org



Agenda

- Key Environmental Performance Indicators (KEPIs), defined
- ISMI KEPI Project
- Drivers for KEPI Development
- Steps for Developing KEPIs
- The KEPI Challenge
- Preliminary Semiconductor KEPIs
- Conclusions

What are KEPIs?

- A set of environmental performance indicators that quantify the KEY environmental impacts associated with the manufacture, use and disposal of a product.
- KEPIs are not manufacturing operational metrics
- KEPIs can be identified via Life Cycle Assessments, but KEPIs are not lifecycle assessments in and of themselves.

What is the ISMI ESH Technology Center?

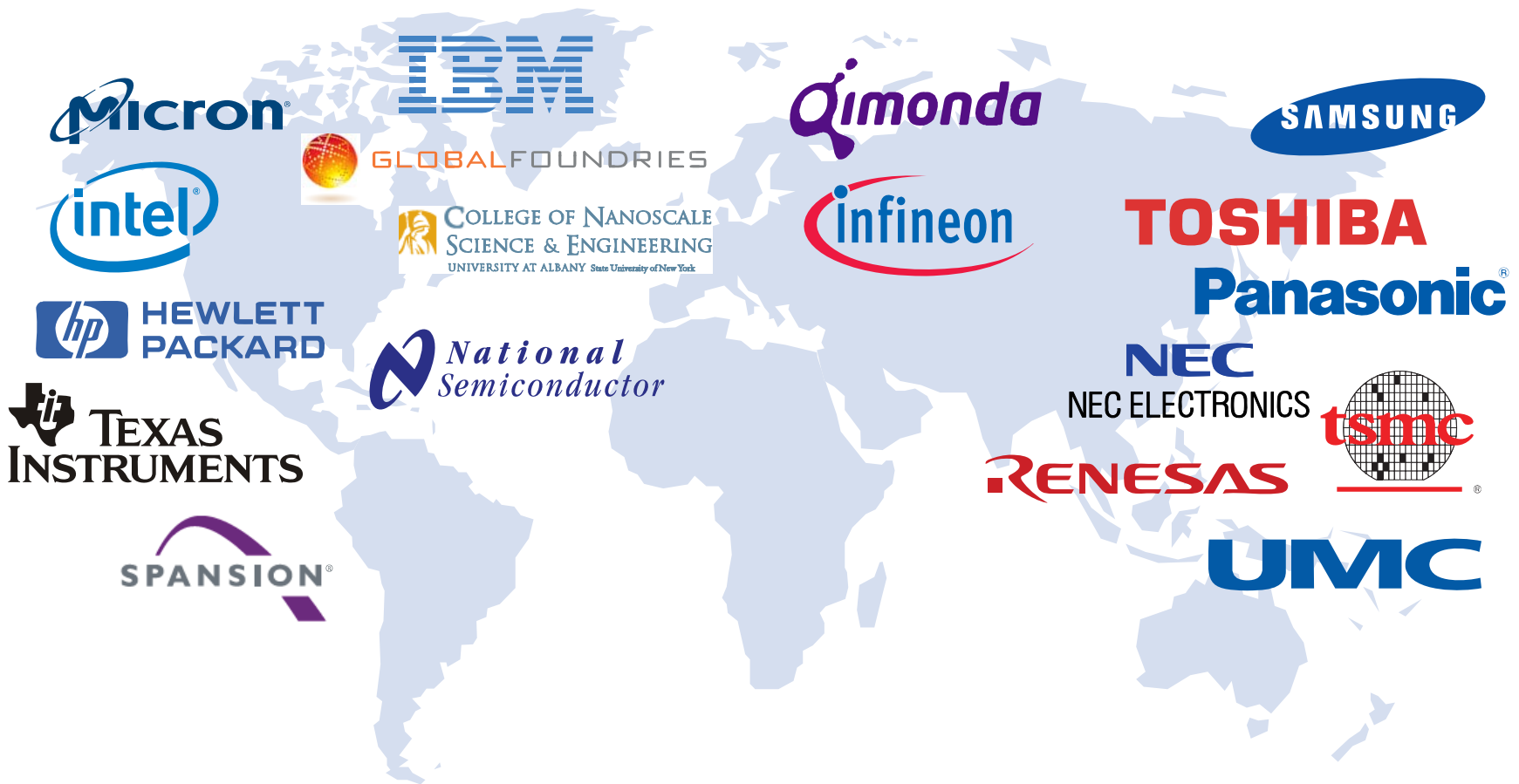


The ISMI ESH Technology Center is the industry's **first and most comprehensive** world-wide collaborative R&D center dedicated to cooperatively finding and implementing the **most cost-effective, environmentally-friendly manufacturing processes and procedures**



ISMI ESH Technology Center

Members and Partners



ISMI Member Interest in KEPIs

- ISMI KEPI project began in 2008 to:
 - Proactively address future regulations and voluntary reporting initiatives
 - Respond to customer requests for product environmental performance
 - Track product environmental performance over time

KEPI Drivers

- Regulatory
- Voluntary Labeling Initiatives
- Customer Requests for Product Environmental Data
- Trade Association Metrics
- Sustainability Metrics and Reporting

Energy-using Products (EuP) Directive Overview



- Published by the European Union, directive seeks to establish a framework for energy-using products (EuP) before placement on market.
- Does not apply to transportation of people or goods.
- Is not a replacement for waste management and chemicals protocol.
- A set of key environmental performance indicators (KEPIs) allows manufacturers to determine energy and environmental impacts of their product.
- Implementation measures proposed for specific EuP Products including:
 - Personal Computers, Standby and off-mode losses in EuPs, Imaging equipment (faxes, copiers, printers, etc.), commercial refrigerators and freezers, domestic dishwashers and washers.

EuP Directive General KEPI Set

Table 89 Environmental impacts overview for a Desktop PC used in an office.

Nr	Life cycle Impact per product:	Date	Author
0	EuP Lot 3 prep study: Office desktop PC	0 MZ	



Life Cycle phases -->		PRODUCTION			DISTRI- BUTION	USE	END-OF-LIFE*			TOTAL	
Resources Use and Emissions		Material	Manuf.	Total			Disposal	Recycl.	Total		
Materials		unit									
1	Bulk Plastics	g		627			564	63	627	0	
2	TecPlastics	g		501			451	50	501	0	
3	Ferro	g		6911			346	6565	6911	0	
4	Non-ferro	g		987			49	937	987	0	
5	Coating	g		2			0	2	2	0	
6	Electronics	g		1439			767	672	1439	0	
7	Misc.	g		2287			114	2172	2287	0	
	Total weight	g		12753			2292	10461	12753	0	
Other Resources & Waste							see note! debit credit				
8	Total Energy (GER)	MJ	1917	341	2259	368	13571	158	191	-33	16165
9	of which, electricity (in primary MJ)	MJ	1090	102	1192	0	13464	0	78	-78	14578
10	Water (process)	ltr	749	17	766	0	904	0	71	-71	1600
11	Water (cooling)	ltr	309	90	399	0	35877	0	17	-17	36260
12	Waste, non-haz./ landfill	g	27328	911	28239	204	15880	782	227	555	44877
13	Waste, hazardous/ incinerated	g	574	6	580	4	316	1687	88	1599	2499
Emissions (Air)											
14	Greenhouse Gases in GWP100	kg CO2 eq.	117	21	138	28	596	12	13	-1	761
15	Ozone Depletion, emissions	mg R-11 eq.	negligible								
16	Acidification, emissions	g SO2 eq.	1072	107	1179	94	3483	23	67	-43	4713
17	Volatile Organic Compounds (VOC)	g	8	4	12	4	7	0	1	-1	22
18	Persistent Organic Pollutants (POP)	ng i-Teq	183	18	201	1	90	5	1	5	297
19	Heavy Metals	mg Ni eq.	221	43	265	10	254	43	10	33	563
	PAHs	mg Ni eq.	139	3	142	7	49	0	8	-8	190
20	Particulate Matter (PM, dust)	g	81	27	108	101	428	203	3	200	837
Emissions (Water)											
21	Heavy Metals	mg Hg/20	407	1	408	0	91	13	45	-32	467
22	Eutrophication	g PO4	7	1	8	0	0	1	1	0	9
23	Persistent Organic Pollutants (POP)	ng i-Teq	negligible								



EuP KEPI: Use Phase Subset

(Electronic Imaging)

Pos nr	USE PHASE Description		unit	Subtotals
211	<u>Product Life</u> in years	6	years	
	<u>Electricity</u>			
212	On-mode: Consumption per hour, cycle, setting, etc.	360	kWh	360
213	On-mode: No. Of hours, cycles, settings, etc. / year	1	#	
214	Standby-mode: Consumption per hour	0	kWh	0
215	Standby-mode: No. Of hours / year	0	#	
216	Off-mode: Consumption per hour	0	kWh	0
217	Off-mode: No. Of hours / year	0	#	
	TOTAL over Product Life	2,16	MWh (=000 kWh)	65
	<u>Heat</u>			
218	Avg. Heat Power Output	0	kW	
219	No. Of hours / year	0	hrs.	
220	Type and efficiency (Click & select)			85-not applicable
	TOTAL over Product Life	0,00	GJ	
	<u>Consumables (excl. spare parts)</u>			<u>material</u>
221	Water	0	m ³ /year	83-Water per m3
222	Auxilliary material 1 (Click & select)	666	kg/ year	57-Office paper
223	Auxilliary material 2 (Click & select)	3,994	kg/ year	79-Toner
224	Auxilliary material 3 (Click & select)	0	kg/ year	85-None

EuP KEPI Disposal Subset

(Electronic Imaging)

Pos nr	DISPOSAL & RECYCLING Description		unit	Subtotals
	<u>Substances released during Product Life and Landfill</u>			
227	Refrigerant in the product (Click & select)	0	g	1-none
228	Percentage of fugitive & dumped refrigerant	0%		
229	Mercury (Hg) in the product	0	g Hg	
230	Percentage of fugitive & dumped mercury	0%		
	<u>Disposal: Environmental Costs perkg final product</u>			
231	Landfill (fraction products not recovered) in g en %	2155	5%	88-fixed
232	Incineration (plastics & PWB not re-used/recycled)	14298	g	91-fixed
233	Plastics: Re-use & Recycling ("cost"-side)	3484	g	92-fixed
	<u>Re-use, Recycling Benefit</u>			
		in g	% of plastics fraction	
234	Plastics: Re-use, Closed Loop Recycling (please edit%)	348	2%	4
235	Plastics: Materials Recycling (please edit% only)	3136	18%	4
236	Plastics: Thermal Recycling (please edit% only)	13938	80%	72
237	Electronics: PWB Easy to Disassemble ? (Click&select)	360	YES	98
238	Metals & TV Glass & Misc. (95% Recycling)	23712		fixed

Other Regulatory Drivers

- Several countries have initiated carbon labeling programs:
 - Japan labeling of 30 consumer products beginning April 2009.
 - UK voluntary Carbon Trust label for consumer products
 - Korea Green “Start Carbon” product labeling for 10 products including a washing machine, LCD glass, and a heater.

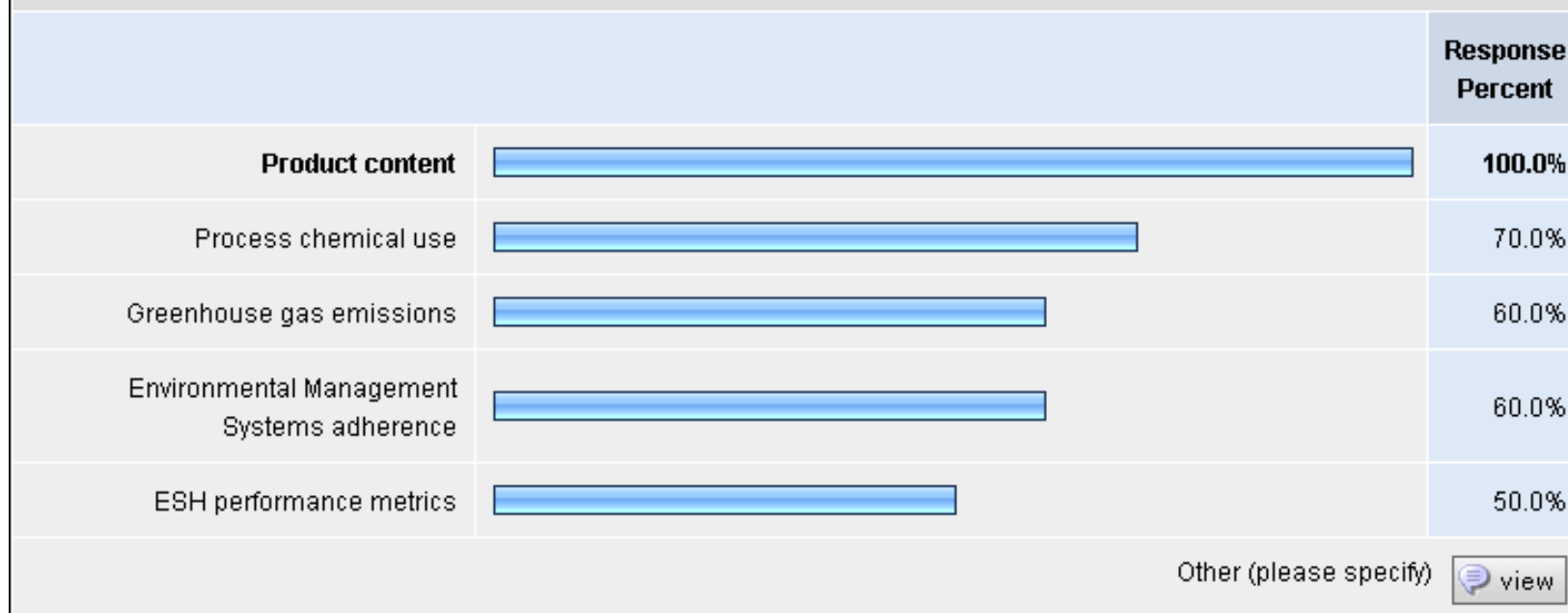


working with
the Carbon Trust



Customer Requests for Product Environmental Information

1. What ESH information are your customers asking for (check all that apply):



Comment Text

1. greenhouse gas emissions from supply chain and use of product
2. Supplier EHS performance metrics

Trade Association Environmental Metrics



- Semiconductor Industry Association Environmental Metrics
- World Semiconductor Council Quantitative Targets
 - Electricity, Water, Wastewater, % recycle water, Total waste, % landfill waste

Sustainability Metrics and Reporting

- Global Reporting Initiative (GRI) has developed sustainability reporting framework for reporting performance
 - Economic
 - Social
 - Environmental

Environment

Performance Indicators

Aspect: Materials

- EN1** Materials used by weight or volume.
- EN2** Percentage of materials used that are recycled input materials.

Aspect: Energy

- EN3** Direct energy consumption by primary energy source.
- EN4** Indirect energy consumption by primary source.
- EN5** Energy saved due to conservation and efficiency improvements.
- EN6** Initiatives to provide energy-efficient or renewable energy-based products and services, and reductions in energy requirements as a result of these initiatives.
- EN7** Initiatives to reduce indirect energy consumption and reductions achieved.

Aspect: Water

- EN8** Total water withdrawal by source.
- EN9** Water sources significantly affected by withdrawal of water.
- EN10** Percentage and total volume of water recycled and reused.

Aspect: Biodiversity

- EN11** Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.
- EN12** Description of significant impacts of activities, products, and services on biodiversity in protected areas and areas of high biodiversity value outside protected areas.
- EN13** Habitats protected or restored.
- EN14** Strategies, current actions, and future plans for managing impacts on biodiversity.
- EN15** Number of IUCN Red List species and national conservation list species with habitats in areas affected by operations, by level of extinction risk.

Aspect: Emissions, Effluents, and Waste

- EN16** Total direct and indirect greenhouse gas emissions by weight.
- EN17** Other relevant indirect greenhouse gas emissions by weight.
- EN18** Initiatives to reduce greenhouse gas emissions and reductions achieved.
- EN19** Emissions of ozone-depleting substances by weight.
- EN20** NO_x , SO_x , and other significant air emissions by type and weight.
- EN21** Total water discharge by quality and destination.



Steps for Developing KEPIs

- Define the product
- Model and analyze the environmental impacts of the product (LCA)
- Identify the main environmental drivers (KEPIs)
- Determine which of these KEPIs can be influenced (eco-design indicators)

Source: EPIC ICT Project: Development of Environmental Performance Indicators for ICT Products on the example of Personal Computers - Deliverable 5;

<http://www.epic-ict.org>

Review of Semiconductor LCAs as basis for KEPIs



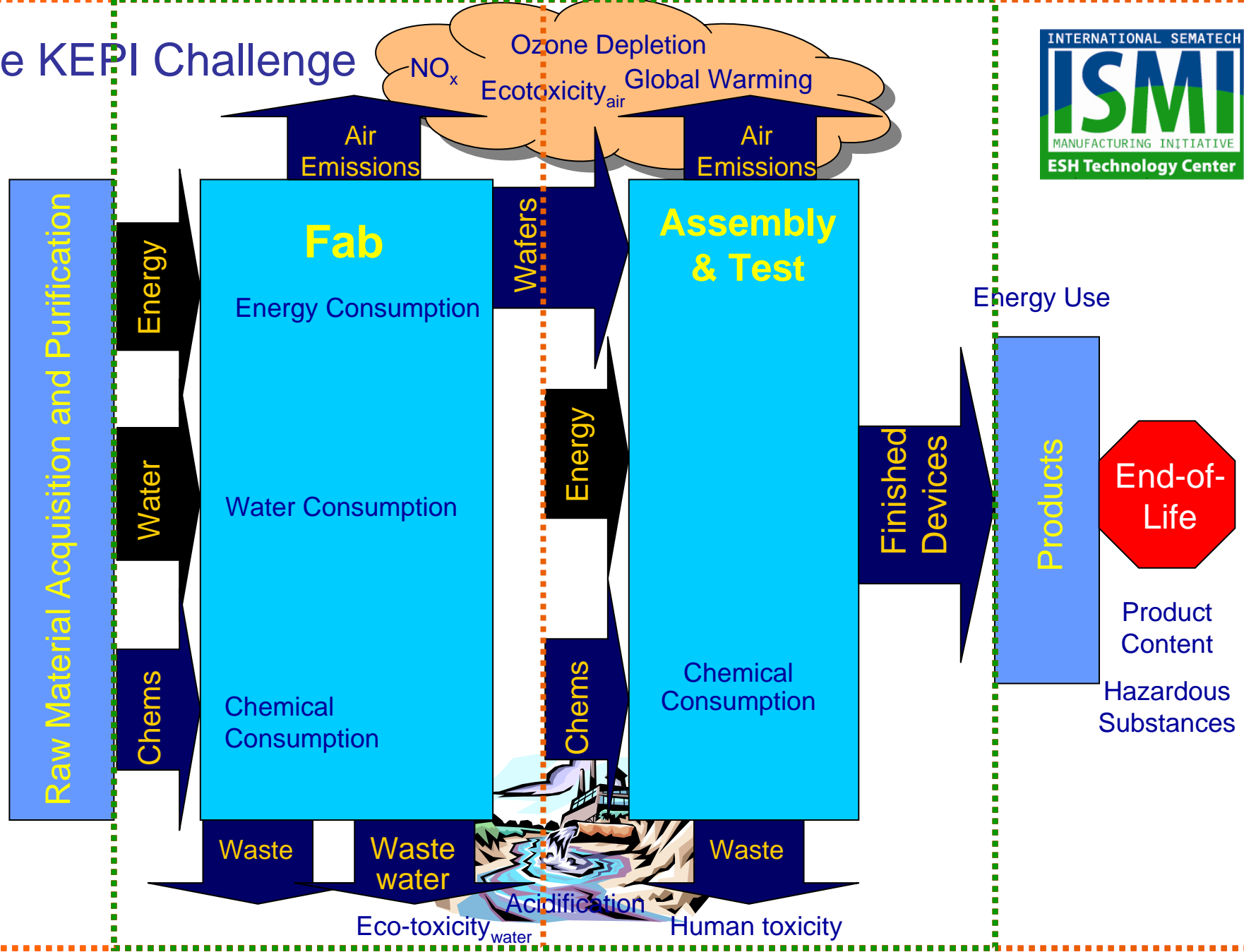
- LCA methodologies not consistent => inconsistent results
 - Different LCAs looked at different aspects of semiconductor life cycle (raw material acquisition, manufacturing, assembly-test, product use, end-of-life).
 - Little data available on impacts of semiconductor raw material acquisition.
 - Significant variability in semiconductor uses results in difficulties characterizing use impacts for all devices.
 - Little data on end of life impacts.
- Common findings in most semiconductor LCAs
 - High impact areas include energy (climate change) and water.

Challenges to Developing Robust Semiconductor KEPIs



- Lack of information on certain life cycle impacts (i.e., raw material acquisition)
- Differences of opinion on the scope of life cycle activities to be considered
- Lack of consistent definitions across countries and regions
 - Hazardous wastes vs. non-hazardous wastes
- Differences in manufacturing facilities
 - Fab only, Fab and Assembly/Test, Assembly/Test only
 - Treatment standards – emissions abatement, waste treatment requirements, etc.
 - Direct discharge vs. discharge to Publicly Owned Treatment Works
 - Differences in electricity sources and their contribution to climate change

The KEPI Challenge



Semiconductor Key Environmental Performance Indicators (KEPIs) Defined



- **Definition:** A set of environmental performance metrics for semiconductor devices, that quantifies the **key environmental impacts** of a semiconductor device or piece part on a per unit of production basis.
- **Accounts for:**
 - **Major direct and indirect environmental impacts** of the manufacture of a product.
 - **Operational efficiency** (yield).

Guiding Principles for KEPI Development



- **Quantifiable**: KEPIs should be **quantitative** so that **performance can be tracked over time**. Whenever possible, standard industry methods of calculation should be used; where no standards exist, new methodology should be developed.
- **Relevant**: KEPIs should track those aspects of semiconductor device manufacturing that have the **greatest environmental impact**.
- **Comparable**: KEPIs should be **consistent and comparable** so that **improvements** in product environmental performance **can be tracked over time**.

Initial Semiconductor KEPIs

KEPI	Subcomponents	Units	Data source and calculation methods
Global Warming Impact	Direct GHG Emissions	Kg Carbon Dioxide Equivalents/Unit of Production	Tracking of GHG emissions including from fuel burned for on-site energy generation and in boilers, process greenhouse gas emissions, and global warming refrigerant emissions; calculated using IPCC and WRI methodologies.
	Indirect Greenhouse gas emissions from purchased electricity	KWH and Kg Carbon Dioxide Equivalents/Unit of Production	Tracking of electricity and other energy purchases; calculated using IPCC and WRI methodologies.
Water Resources	Total Input Water	Liters/Unit of Production	Measured data
	Total Wastewater discharged from manufacturing and support operations	Liters/Unit of Production	Measured or calculated based on measurement of inputs, recycle and re-use.
Chemicals	Total Chemicals	Kg/Unit of Production	Inventory tracking.

Initial Semiconductor KEPIs

KEPI	Subcomponents	Units	Data source and calculation methods
Waste	Total Waste	Kg/Unit of Production	Waste manifests – compilation of other waste categories.
	Total Hazardous Waste Recycled/Re-used/Re-claimed	Kg/Unit of Production	Waste manifests.
	Total Hazardous Waste Disposed/Treated Off-site	Kg/Unit of Production	Waste manifests.
	Total Hazardous Waste Landfilled	Kg/Unit of Production	Waste manifests.
	Total Non-hazardous Waste Recycled/Re-used/Reclaimed	Kg/Unit of Production	Waste manifests.
	Total Non-hazardous Waste Disposed/Treated Off-site	Kg/ Unit of Production	Waste manifests.
	Total Non-hazardous Waste Landfilled	Kg/ Unit of Production	Waste manifests.

Major Differences between KEPIs and Other Metrics

- KEPIs track Global Warming impact via direct GHG emissions and indirect GHG emissions
- SIA tracks total waste generated.



- Other metrics track electricity consumption.



- Other metrics require separate reporting for hazardous vs. non-hazardous and different recycling/disposal categories.

GRI requires reporting of significantly more impacts (air emissions, biodiversity, impact on water sources and receiving bodies, product use phase metrics, transportation, etc.)



Conclusions

- Regulations, customer requests and sustainability goals drive need for KEPIs
- To meet drivers, KEPIs should:
 - Be **product** rather than manufacturing operations **focused**;
 - Initially **focus on** those **aspects of semiconductor product life cycle under control of device manufacturers** (fab manufacturing and Assembly/Test).
- ISMI KEPI project includes efforts to coordinate with other associations ensuring development of metrics