2011 revised edition

Semiconductors Save Energy and Protect The Global Environment

The World Semiconductor Council

May 2011

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INTRODUCTION OF THE WORLD SEMICONDUCTOR COUNCIL

A unique organization for world semiconductor industry's

healthy growth

World Semiconductor Council (WSC)

- Established in 1997.
- WSC now composed of CHINA, CHINESE TAIPEI, EUROPE, JAPAN, KOREA and U.S.
 - Annual report to governments/ authorities.
- Member companies cover more than 95% of worldwide semiconductor production.



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WSC won Climate Protection Award

- World Semiconductor Council received the 1998 Climate Protection Award by U.S. Environmental Protection Agency.
- WSC was prized for PFC reduction activities:
 - Targeting a 10% reduction of the 1995 global PFC emission by 2010.



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SEMICONDUCTOR MARKET

Growing and sustaining most of other industries



Worldwide Semiconductor Market Trend



2010 world semiconductor shipments grew by 32% year on year and reached US\$ 298 billion, in contrast to recent years' slowing down.

Semiconductors are used in various segments, which are computer, communication, consumer, industry and auto, arranging in order of size.

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ENERGY SAVING ACTIVITY & CONTRIBUTION

The semiconductor industry has the large leverage effect over our society overall

Semiconductor industry's role in energy saving

Direct Contribution

- Designing Green semiconductor products that use less energy.
- Purchasing Green inputs to make semiconductors.
- Building Green fabs that use less energy to make chips.

Indirect Contribution

- Designing products that enable energy savings at the electronic systems level.
- Providing products that enable customers and society to save energy (Green IT).

Semiconductor Opportunities From Recent Energy Studies (1)

- Three Recent Studies
 - EPRI (Electric Power Research Institute) study
 - GeSI (Global e-Sustainability Initiative) and The Climate Group study
 - ACEEE (American Council for an Energy Efficient Economy) study for Semiconductor Industry Association in the US



Assessment of Adrievable Patential from Energy

Efficiency and Demand Response Programs in the U.S.

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Semiconductor Opportunities From Recent Energy Studies (2) EPRI Study (2009) Identified Highest Potential Energy Efficiency Opportunities



U.S. (2010-2030)" 2009.

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Semiconductor Opportunities From Recent Energy Studies (3)



GeSI/Climate Group Study (2008)

- In 2007, the carbon footprint of the ICT sector including both production and use of PCs and peripherals, telecoms networks and devices and data centers – was about 2% of the total carbon emissions.
- This figure is expected to grow at 6% annually until 2020.

But in spite of this growth, ...

ICT emissions in 2020 are five times less than the emissions reductions from the ICT efficiency "enabling effect" on the overall economy.

ICT Emissions (from production & use) = 1.4 GtCO_2

ICT enabled emissions savings in economy = $7.8 \, \text{GtCO}_2$

Source: SMART 2020: Enabling the Low Carbon Economy in the Information Age (2008).

Semiconductor Opportunities From Recent Energy Studies (4) ACEEE Study (2009) -- Semiconductor Efficiency Saves 1.2 Trillion kWh



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Semiconductor Opportunities From Recent Energy Studies (5)

ACEEE Study – What does 1.2 Trillion KWhr savings in 2030 mean?

- 22% less electricity consumed than the reference case, and 11% less than today, even though the economy will be about 70 percent larger
- 733 Million Metric Tons less CO₂ emitted in 2030
 - Even more when semiconductor enabled renewable energy (solar, wind) are included.
- 296 plants (600 Megawatt) that are not built by 2030
- \$126 B electric bill savings to consumers and businesses in 2030, and \$1.3 Trillion in savings cumulative from 2010-2030



The semiconductor opportunity

- The semiconductor industry emits relatively small amounts of global warming gases.
 - Nonetheless, the industry is proactively and voluntarily reducing its emissions on a global basis.
- However energy saving offers the greatest opportunity for the semiconductor industry to contribute to the sustainable environment.

World CO₂ Emissions by Sector

- 2008 World CO_2 Emissions: 29 billion ton -



Source: IEA "CO₂ Emissions from Fuel combusition Highlights, 2010 edition"

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WSC will reduce PFCs

- Semiconductor manufacturers have been able to reduce PFC emissions by taking a number of actions including
 - process optimization,
 - use of alternative chemicals,
 - improved abatement systems.
- Semiconductor industry was one of the first global sectors to organize and set emission reduction targets for greenhouse gas reductions.



WSC program to reduce PFC emissions to 10% below 1995 baseline by 2010 is on target

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WSC can save electricity

- WSC also cooperates on energy savings and resource conservation programs.
- WSC has a common global metric for a global data collection on the parameters of electricity normalized on the basis of cm² of silicon.
- WSC has also agreed in 2008, a common definition of expectation levels for the reduction of electricity from the semiconductor production process on a global basis.
 - Expectation level for...
 - WSC normalized electricity reduction 2001 –2010 (30%)

Energy Consumption Per Wafer Area (WSC Electricity Data: 2001-2009) (Normalized: Year 2001=1.0)





Miniaturization for lower power/higher performance

Miniaturization will

- realize the same function with smaller chip and lower power (directed to lower power), and
- realize more functions without increasing power.
 (directed to Integration)
 - (directed to Integration)
- The power consumption to activate one transistor has decreased one tens of thousandth since first transistor was made 50 years ago.



Integration and Power Dissipation

Chip at Production

-unction per

(million transistors)

100,000

(Nu)

500



How can semiconductor products contribute to energy saving in end-products?

- Use semiconductor products that consume lower energy.
- Use energy-saving products in which ICs and software work as system level energysaving function.

- Solid state lighting
- Hard disk drives
- Automobile networking
- Industrial applications
- Cell phone
- PC
- Data centers
- Consumer electronics

Semiconductors drive Solid State Lighting

- Solid State Lighting(SSL) is the new energy saving lighting solution that uses high brightness Light Emitting Diodes(LEDs).
- Application examples:
 - Traffic lights
 - Portable consumer devices
 - Automotive
 - Indoor/outdoor lighting
- The bright colors and high intensity of the integrated SSL solutions result in consuming less overall power compared to other lighting technologies.
- Lighting uses worldwide 19% of the electricity use.
- When taken into account that there is a potential saving of 25 40% possible with new lighting solutions,
 - → This means possible savings of >550 million tons of CO_2 emissions/year.





Semiconductors drive replacement of Hard Disk Drives

- Solid Power Efficiency
- SSDs require less than half the energy of a conventional hard drive. And with almost no heat emissions, the SSD doesn't need a fan to keep its cool.



SSD Benefits over HDD

- High Performance, Fast booting & recovery
- High Reliability, Ruggedness
- Low-power consumption, Light weight



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HDD



Sources : Semiconductor Industry Association in Korea

Semiconductors drive Automobile Networking



Networking

- The electronic content in cars is rapidly increasing. A typical modern car has up to 100 electronic control modules
- Enabling a safer, more comfortable, higher performance, and more efficient driving experience
 Standards: CAN, LIN, MOST, FlexRay



Car Wiring: 50 Kg!

 Multiple systems on the same cable

* Huge reduction of car wiring

 Less weight = less fuel Weight saved = 30 kg per car

15 Megatons of CO₂

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- Globally - annually -



Semiconductors drive energy savings in Industrial Applications

- Industrial activity uses nearly half of all global electrical power and industrial motor systems using the majority of this.
- Motors are inefficient when they operate at full capacity, regardless of need. A "smart" motor can adjust its power usage to a required output through a variable speed drive and intelligent motor controller.
- Variable speed motor systems in key industrial processes can reduce total global warming gas emissions from motor systems by 9% by 2020, and Information Technology driven automation can reduce emissions by an additional 4%.
- Semiconductors can enable a 13% saving by 2020.

Source: "SMART 2020: Enabling the Low Carbon Economy in the Information Age;" 2009.





How can semiconductor products contribute to energy saving in our society?

- Semiconductor enabled technologies help people change behaviors to save energy
- Highly networked systems with sensors can automatically save energy

- Telecommuting
- Smart Metering
- New transport system
- Renewable Energy
- ecommerce
- ebook replace pape
- Smart office building

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Semiconductors enable energy savings through Telecommuting

- **Today many people work with information rather than tangible products. The internet allows these people to work from home rather than the office.**
- An average U.S. telecommuter lives 22 miles from work. One person telecommuting just one day:
 - Saves 1.4 gallons of gasoline, the equivalent of up to 12 hours of an average household's electricity use, and
 - reduces CO₂ emissions by 17 to 23 kilograms per day
- The 3.9 million telecommuters in the U.S. reduced gasoline consumption by about 840 million gallons.
- This reduces curbing CO₂ emissions by nearly 14 million tons, an amount equal to removing 2 million vehicles from the road every year.
- Telecommuting saves the equivalent of 9 to 14 billion kilowatt-hours of electricity per year — the same amount of energy used by roughly 1 million U.S. households every year.

Source: Consumer Electronics Association (CEA) "The Energy and Greenhouse Gas Emissions Impact of Telecommuting and e-Commerce;" September, 2007.

Semiconductors enable Smart Metering

- Energy Efficiency & Management
 - Electric utilities seek to improve demand management capabilities
 - Increasing efficiency at the point of use helps avoid need to build additional power plants
- Smart Meter Functionality
 - Traditional meters only measure total consumption – not when consumption occurs
 - A Smart Meter identifies consumption in more detail – typically time of use



•Time of use information enables basic demand management

Smart Meter communicates with utility for time of use billing, peak load management, etc.
Future use of local network within premise enables monitoring and control over end point devices (HVAC, Water Heater, etc.)

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A new transport system (ITS)

"Intelligent Transport Systems (ITS) is a new transport system which is comprised of an advanced information and telecommunications network for users, roads and vehicles. And ITS contributes much to solving problems such as traffic accidents and congestions." *(Ministry of Land, Infrastructure, Transport and Tourism, JAPAN)*

ITS enables to reduce the CO_2 emission.





ITS : Intelligent Transport Systems

Semiconductors drive Renewable Energy

- Semiconductors are an enabling technology for solar photovoltaic panels and wind turbines.
- Photovoltaic cells are a semiconductor technology.
- Semiconductors convert the DC power generated by solar and wind to the AC power used in most grids.



Semiconductors can improve the efficiency of renewable energy. For example, solar panels are only as efficient as their weakest link, so clouds, dirt, tree shadows, and even bird droppings can greatly degrade panels' efficiency. Semiconductors can overcome this problem by allowing each part of a solar panel array to contribute power independently.



TECHNOLOGY ROADMAP

More research is needed to generate new ideas that can realize Green society.

International Technology Roadmap for Semiconductors (ITRS)

What topics are in 2009 ITRS

- ITRS has included an ESH chapter that covers 4 strategies such as:
 - Understand processes and materials during the development phase;
 - Use materials that are less hazardous or whose by-products are less hazardous;
 - Design products and systems that consume less raw material and resources; and
 - Make the factory safe for employees.
 - **2009 Special Topics:** Energy section notes:
 - Power consumption is now one of the major constraints in chip design, and the ITRS has identified it as one of the top three overall challenges for the last 5 years. Leakage power consumption has been identified as a clear long term threat and a focus topic for design technology in the next 15 years.
 - The major favorable impact on energy usage of advancing semiconductor technology is in the applications, which are often designed to improve the energy efficiency of end-equipments.

International Technology Roadmap for Semiconductors (ITRS)

- At the Emerging Research Devices section, ITRS evaluates two different scenarios. One scenario addresses charge-based devices and technologies for extending CMOS scaling. The other explores "Beyond CMOS" devices.
- For example, carbon-based nanoelectronics is featured as a particular emerging research technology.
- The Architecture section has been re-directed and expanded to include new activities for benchmarking emerging research logic, a new memory architecture, and a new analysis of limits.





SUMMARY

Governments and Authorities can encourage use of energy efficient IT

- Invest in Energy Efficient Research and Development
 - Governments can support for research in energy efficient technologies.
- Build Awareness of Energy Efficient Technologies and Practices
 - Consumer awareness and demand for energy efficient products is the key to developing a scalable and sustainable market for energy efficient products.

 Governments can help expand consumer awareness about the environmental, health, social, and economic benefits that energy efficient technologies deliver.

Governments and Authorities can encourage use of energy efficient IT (Continued)

- Incentives for Energy Efficiency
 - Governments can provide WTO consistent incentives for manufacturers that develop products that meet high standards for energy efficiency and incentives for consumers and businesses to invest in energy efficient products.
 - Examples: tax incentives for manufacturers whose capital investments or products meet high energy efficiency standards, energy utility rebate programs.
- Government-Industry Partnerships
 - Government and industry can create effective standards and share best practices that will increase energy efficiency and reduce energy use.
- Lead by Example
 - Governments can ensure that they only purchase energy efficient products, for example, government data centers can use best available technology to save energy.

Semiconductor industry is contributing to energy savings and environmental protection

- Reducing global warming gas emission
- Focusing on low power technology
- Providing semiconductor products to realize high energy efficient end-products
- Aiming to realize the Green society

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The semiconductor industry is...

- providing products to drive energy saving of end-equipment and the social system
- advancing semiconductor technology to achieve future dramatic energy savings
- achieving healthy growth while being conscious that its products are a key factor to the Green society



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Outreach Activities by Region



Outreach Activities by Region - 2010 Outcome -

< ALL >

Update Green IT presentation material (2010 revised edition)

< JAPAN >

 At WSC in May & GAMS in September, presentation on Semiconductors' Social Contribution Report in Japan by Semiconductor Industry Research Institute Japan (SIRIJ).

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Outreach Activities by Region - 2010 Outcome -

< CHINA >

- **Cooperation with government/organization:**
 - China RoHS:
 - Attending the China RoHS Panels host by the MIIT and CNCA, Through three panel meetings, defining China RoHS Product Item, Certification Rule, Model and Guide..
 - Summary the CSIA ESH member's opinions, providing some proposal about the index of standard in <Discharge standards for electrical industrial pollutants for semiconductor industry> to Ministry of Environment
 - Participated legislative discussion about "Guide for Cleaner production of electronic & electric products Semiconductor components", Ministry of industry and information

Outreach Activities by Region - 2010 Outcome - <chieflese taipel >

- Finished the 1st stage of establishing "Taiwan Green Factory Standard" :
 - by SIA in Chinese Taipei's leading domestic Hi-Tech industries and collaborating with authorities as well as academy.
 - This standards covers clean manufacturing and green building.
 - General guidelines were built in 2010.
 - Finished the 1st stage assessment of "Climate Change Risks on Science Parks" by leading 4 domestic Hi-Tech industries:
 - Concluded the risk level assessment and built countermeasures on flood disaster s



Outreach Activities by Region - 2010 Outcome -

< EUROPE >

- Promotion of SC enabling function through membership of EU Smart Grids and Smart Metering Task Force
- Promotion of the industry with ESIA Sustainability brochure and papers at regular meetings with policy makers
- Individual company presentations on green ICT/products at several industry events attended by policy makers

Outreach Activities by Region - 2010 Outcome - KOREA >

- Cooperation with government and institution
 Evaluation of the amount of carbon in Semiconductor Industry
 - Operation the Climate Change TF
- Korean Carbon Management Club Joining
 - Korean CDP (Carbon Disclosure Project) committee agree that our member company would join the carbon management club.
- Publication of the Carbon Management Report
 - Climate carbon corporate strategy, confrontation instance and result, emission volume of greenhouse gas, carbon management activity

Outreach Activities by Region - 2010 Outcome -

< US >

 SIA in U.S. continued to share the study from the American Council on an Energy Efficient Economy that concluded that semiconductor enabled savings of 1.2 Trillion KWHr are possible by 2030.

See pp. 11-15, "Semiconductor Opportunities From Recent Energy Studies"

< ALL >

Update Green IT presentation material (2011 revised edition)

< JAPAN >

 Facilitate public recognition of SIRIJ's Report on Semiconductor Social Contribution

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< CHINESE TAIPEI >

- Will continue the efforts on establishing "Taiwan Green Factory Standard" :
- to finish it by June/E 2011.
- to help the government to promoting to other industries in 2011/2H.
- Will continue the efforts on the assessment of "Climate Change Risks on Science Parks":
 - to focus on local water shortage
- Will host a GREEN forum in Taiwan in Dec. 2011.

< EUROPE >

- Continuation of SC enabling function through membership of EU Smart Grids and Smart Metering Task Force
- Participation and promotion of SC industry at EU Commission related ICT for energy efficiency/ Green technology events
- Promotion of the industry with ESIA Sustainability brochure and papers at regular meetings with policy makers
- Marketing on the EE enabling benefits of semiconductor devices through advertisements in EU policy maker publications
- Individual company presentations on green ICT/products at several industry events
- Presentation PFC emission reduction / social contribution at the NCGG-6 Conference

< KOREA >

- Cooperation with government and institution
 - Setting the target value of carbon reduction in semiconductor industry for national act
 - Operation the Climate Change TF
- Publication of the GHG reduction technology report
 - Operation the feasible study for future GHG reduction technology for semiconductor industry

< US >

Continue to share results of ACEEE study.

SIA is also a member of DESC, the Digital Energy Solutions
 Campaign. DESC's goal is to advance policies that help drive sustainable economic growth through ICT-enabled energy efficiency and clean energy innovation.
 http://www.digitalenergysolutions.org/