2009 revised edition

Semiconductors Save Energy and Protect The Global Environment

The World Semiconductor Council

November 2009

Contents

2008-2009 Topics

2008 Activities

- **Green IT Symposium (May 28, Tokyo Japan)**

  WSC Chair introduced WSC activities for saving energies and protecting global environment.

< CHINA>

- **1st Sino-US Energy Saving Symposium (Oct.)**
- **IC CHINA (Sep. 18)**

< CHINESE TAIPEI >

- **EPA reviews Semiconductor Industry Association in Chinese Taipei's MOU for PFC Reduction.**

2008 Activities (Continued)

< EUROPE >

- **Involvement to the EU Commission Report - ICT and Energy Efficiency - The Case for Manufacturing**
- **French Nano & Microelectronics Association (Sitelesc)**

< KOREA >

- **Korean Government announcement of eco policy: Green Growth Act**

< JAPAN >

- **CEATEC JAPAN (Sep. - Oct.)**

2009 Activities & Plans

< CHINA>

- **Cooperation with government/organization:**
  - **the Institute of Resources and Environment Standardization Research, CNIS**
  - **China Solid State Lighting Alliance**
  - **Ministry of the Environmental Protection and the National Development and Reform Commission**
- **Translation of the ACEEE report with Semiconductor Industry Association in the US and issue of a white paper about Chinese semiconductor energy savings**
- **2nd Sino-US Energy Saving Symposium (Oct.)**

2009 Activities & Plans (Continued)

< CHINESE TAIPEI >

- **Conference on GHG reduction emission (Jan.)**
- **EPA reviewed Semiconductor Industry Association in Chinese Taipei's current status of PFC reduction (Jul.)**
- **Symposium on the ESH Management (Oct.)**
- **Establish semiconductor Product Category Rule (PCR) for future eco-declaration and eco-labeling through GEDnet**
- **Establish "Green Factory Standard" of Hi-Tech industry involving authorities and companies to build a model among industries**
- **Invited to join Chinese Taipei's "2009 State Energy Conference" to form energy and environment sustainability roadmap in next 4 years**

2009 Activities & Plans (Continued)

< EUROPE >

- **Publication of the Semiconductor Industry Association in Europe Sustainability Brochure (Jan.)**

=> See page 10

- **EU Green Week Conference (Brussels, Jun.)**

EU ENVIRONMENT COMMISSIONER DIMAS & COUNCIL PRESIDENT MIKO VISIT Semiconductor Industry Association in Europe STAND AT GREEN WEEK

2009 Activities & Plans (Continued)

< EUROPE >

- **Non CO_2 Greenhouse Gasses Symposium (Jun.)**

2010 Planned

- **Publications of 2 papers/brochures: "green" contribution of semiconductors for Automotive and Lighting Applications (Q3/4)**
- **"Green IT" like presentation to EU authorities**

Publication of the Semiconductor Industry Association in Europe Sustainability Brochure

2009 Activities & Plans (Continued)

< KOREA >

- **Korean EPA review of the industrial potential GHG reduction date**
- **ESH agreement of "Climate Change Meeting" (until 2010)**

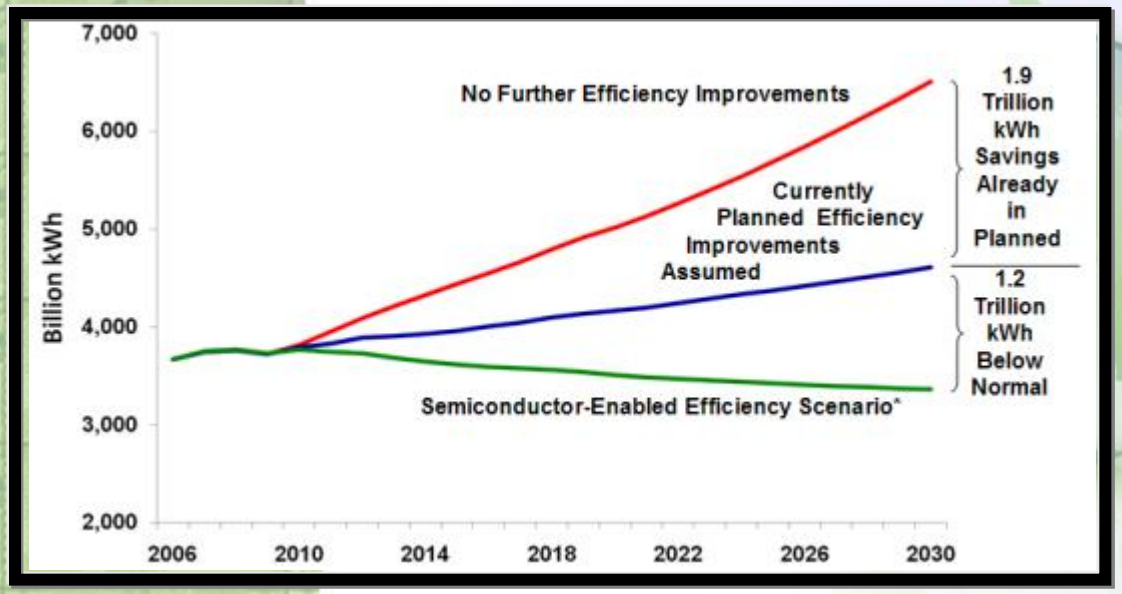
< JAPAN >

- **IC Guidebook (Mar.)**
- **Publication of the Semiconductor Industry Association in Japan Environmental Brochure**

2009 Activities & Plans (Continued)

< US >

- **Study finds semiconductor enabled savings of 1.2 Trillion KWHr possible by 2030 (May)**



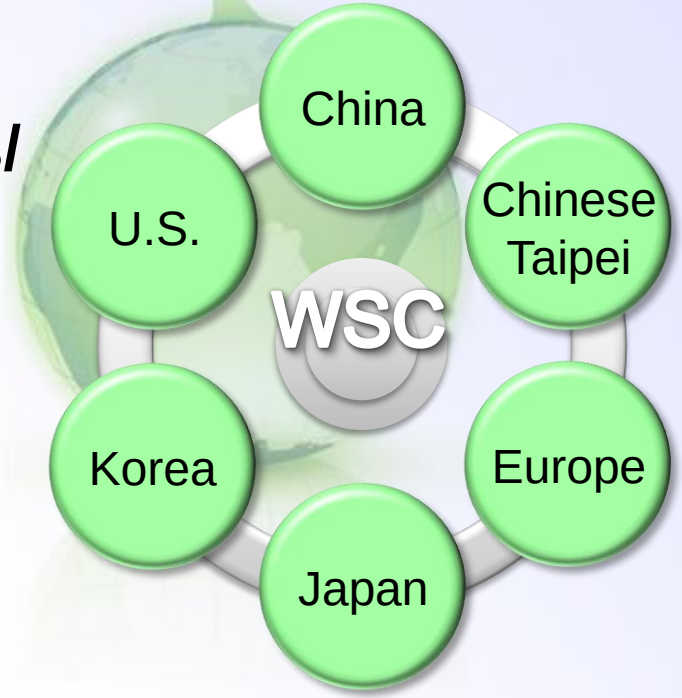
=> See Appendix

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.



Purpose and Basic Principles

- Purpose
  - Promote cooperative semiconductor industry activities
  - Expand international cooperation in the semiconductor sector in order to facilitate the healthy growth of the industry from a long-term, global perspective

- Basic Principles
  - Voluntary participation
  - Fairness
  - Respect for market principles
  - Consistency with WTO rules and domestic laws

WSC promotes…

- Trade rules
- Intellectual Property
- Environmental protection
- Safety & Health
- Technology

13th annual meeting in Beijing

- Date: May 21, 2009
- Attendee: 22 leaders of world semiconductor companies & 6 regional industry associations
- Chair: Zhongyu Yu of Semiconductor Industry Association in China
- Discussed issues:
  - Technology Update
  - Cooperative Approaches in Protecting the Global Environment
  - Effective Protection of Intellectual Property
  - Analysis of Semiconductor Market Data
  - Free and Open Markets
  - Semiconductor Social Contribution Through Outreach

WSC won Climate Protection Award

- World Semiconductor Council received the 1998 Climate Protection Award by U.S. Environmental Protection Agency.

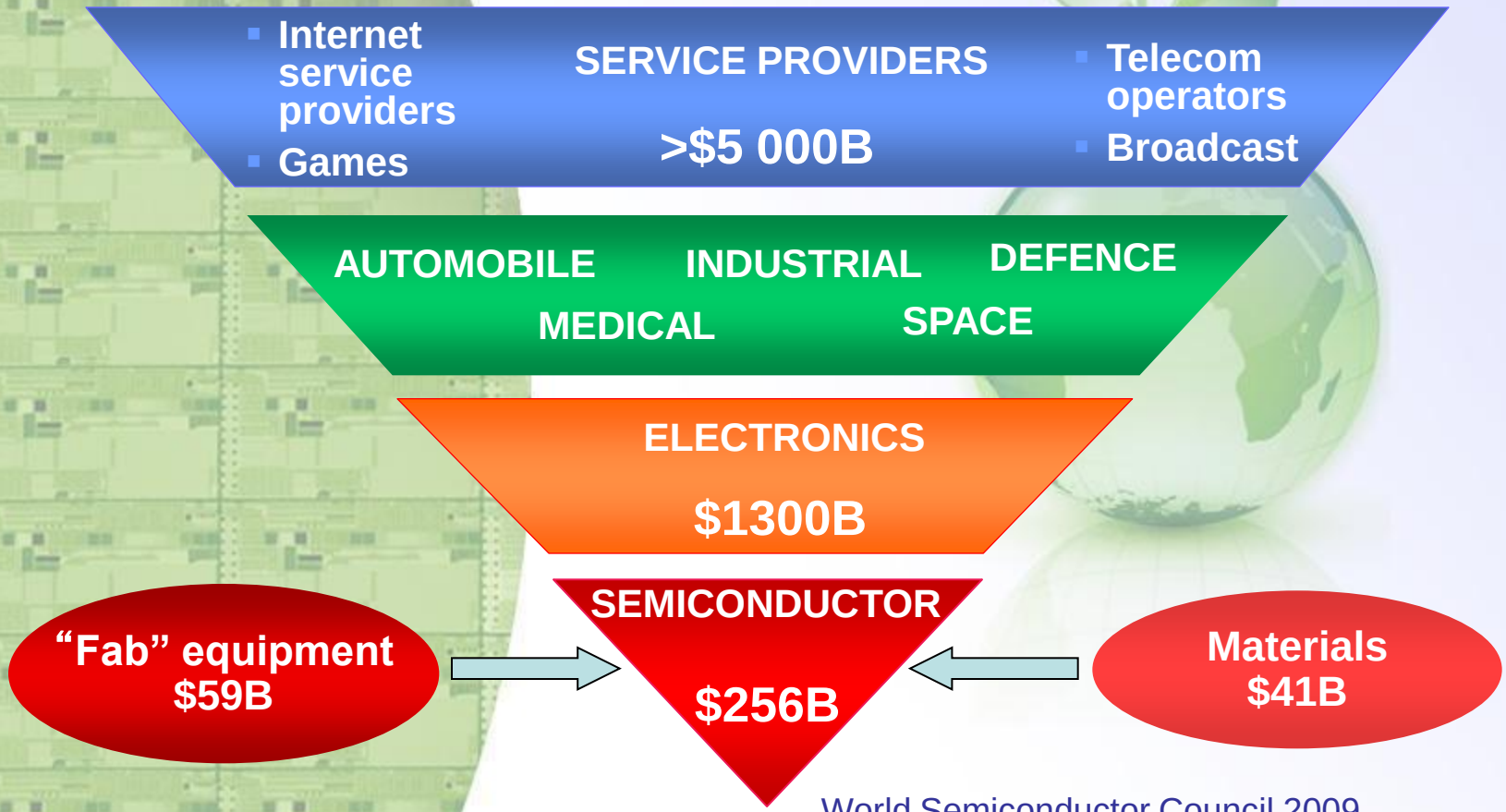
- WSC was prized for PFC reduction activities:
  - Targeting a 10% reduction of the 1995 global PFC emission by 2010.

SEMICONDUCTOR MARKET

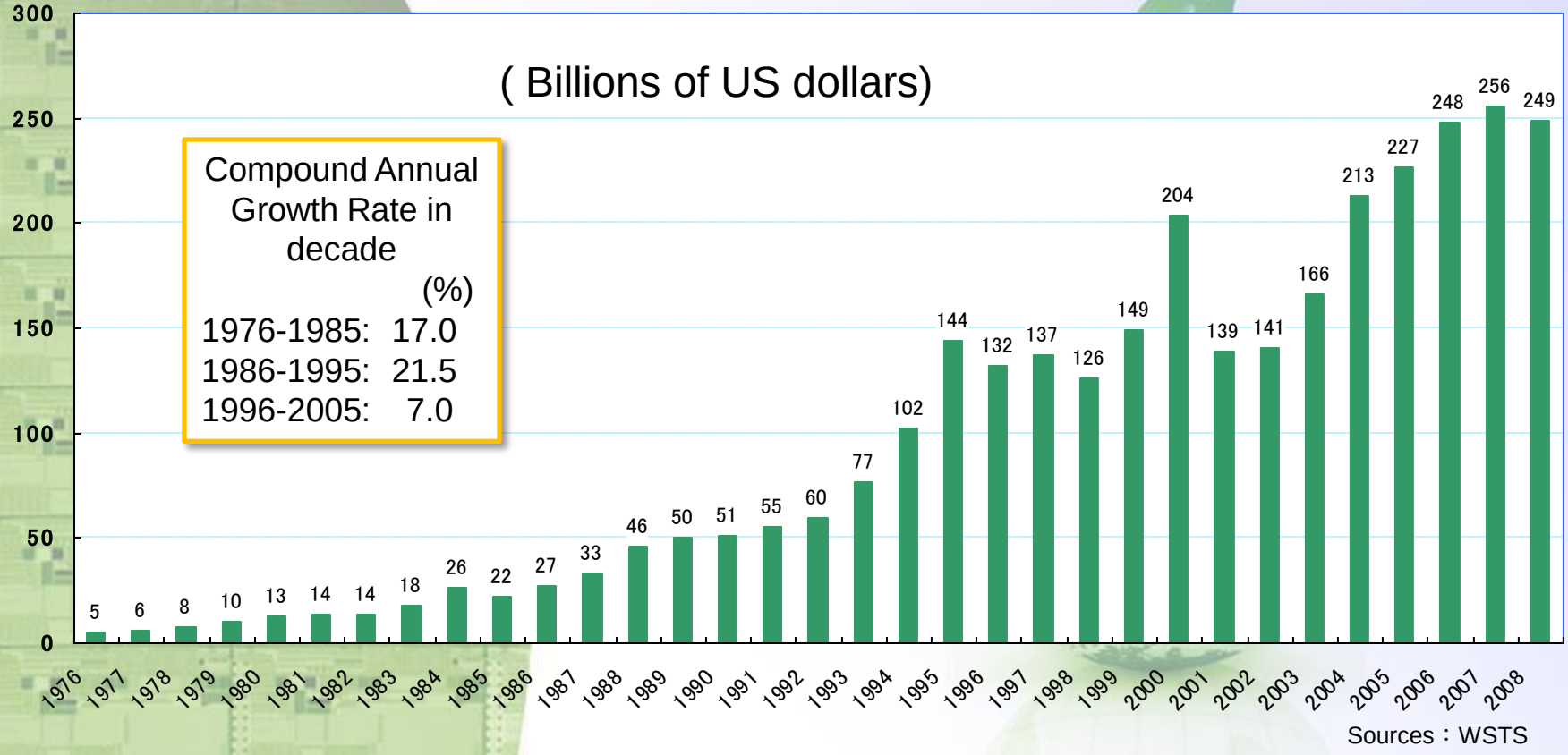
Growing and sustaining most of other industries

Semiconductor as “enabling” industry

Economic impact of the semiconductor industry on key downstream sectors-2007



Worldwide Semiconductor Market Trend



Sources：WSTS

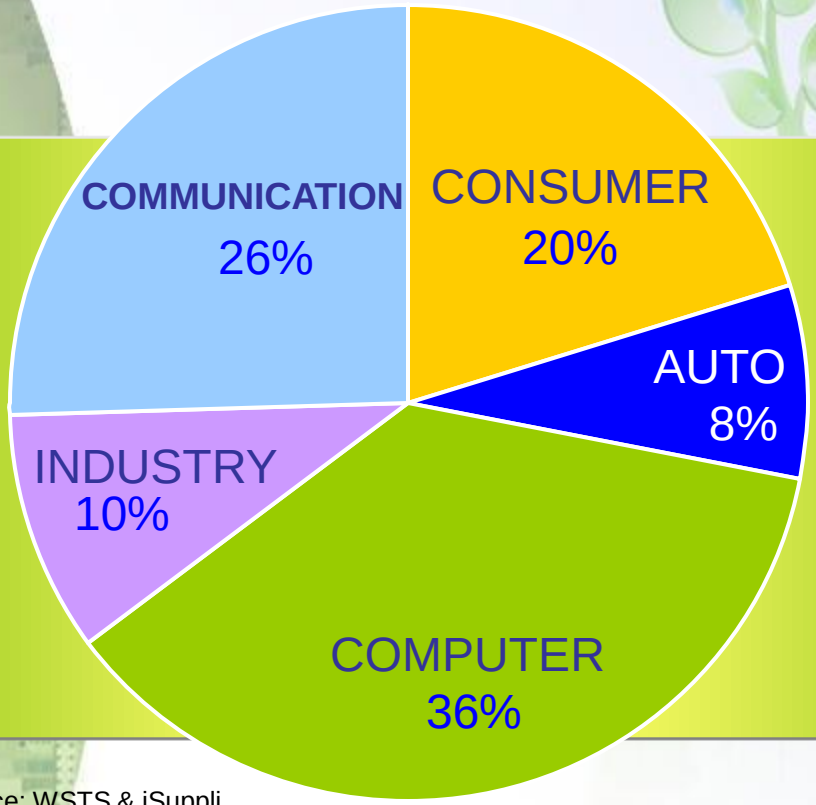
- 2008 world semiconductor shipments reached US$ 249 billion, but declined by 3% from previous year.
- The industry grew by double digit percentage of compound annual growth rate in recent 3 decades, otherwise these several years' gradually-growing market.

Semiconductor enables to save energy as well as to achieve higher performance in various applications






2008 World Semiconductor Market by Application



Source: WSTS & iSuppli,
"World Semiconductor Council 2009; Market Report;
Semiconductor Market Size by Application 1997-2008"



Smart Phone



SSD

NAND flash storage

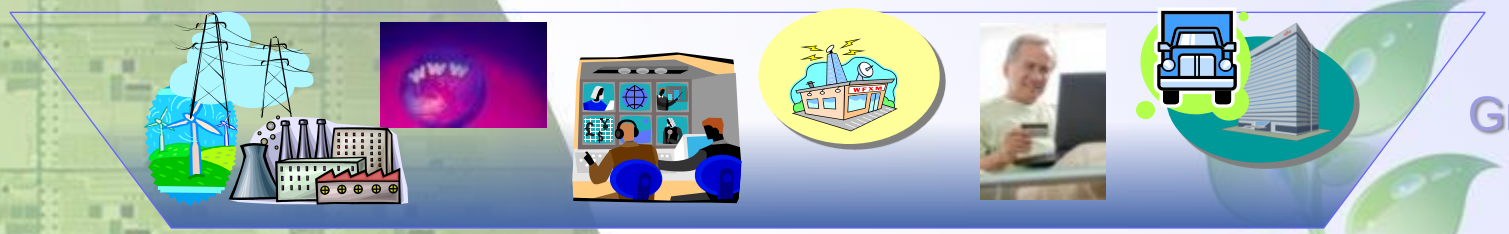
ENERGY SAVING ACTIVITY & CONTRIBUTION

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).



Green Society

Green
End Products

Green Products

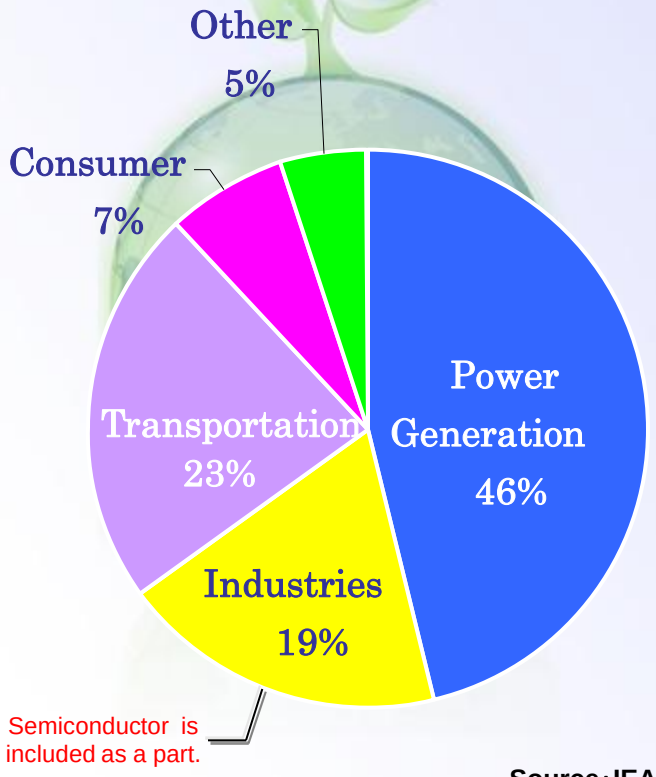
Green Fab

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 CO_2 Emissions by Sector

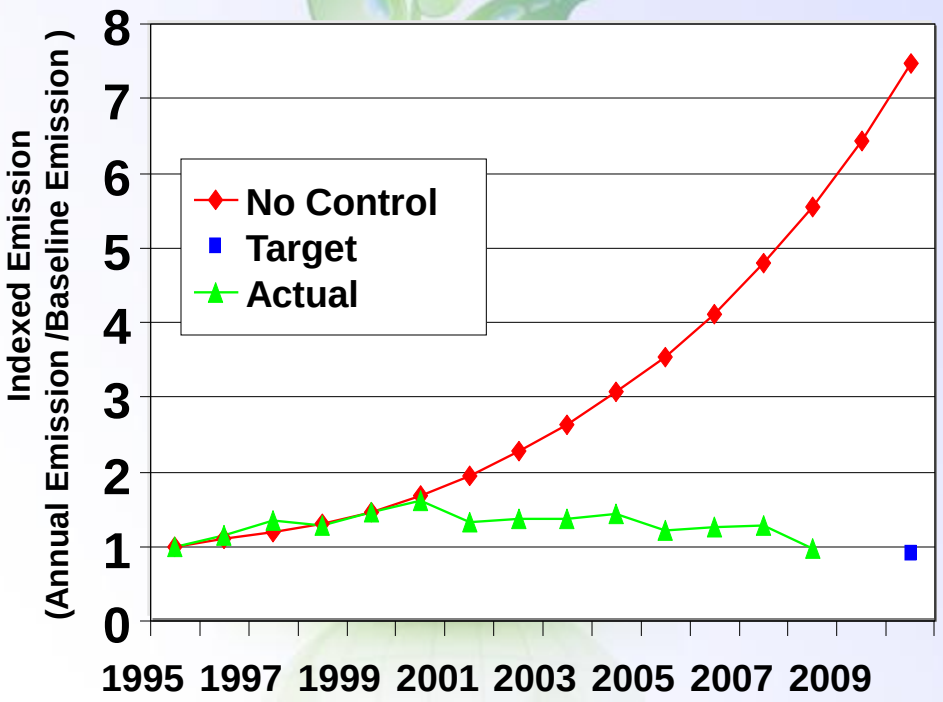
— 2005 World CO_2 Emissions: 27.1 billion ton —



Source: IEA WEO 2007

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.



Source: WSC 2009 Beijing

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

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 cm^2 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: 2001-2007)
(Normalized: Year 2001=1.0)

Source: WSC 2009 Beijing

Green Society

Green
End Products

Green Products

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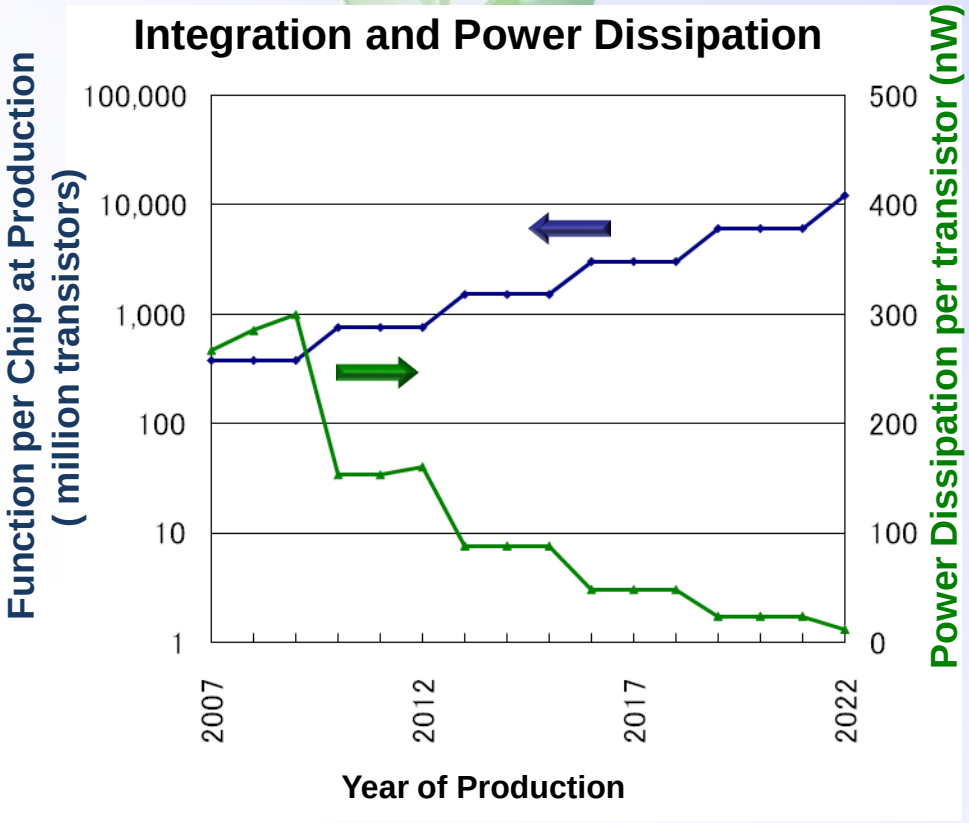
Miniaturization for lower power/higher performance

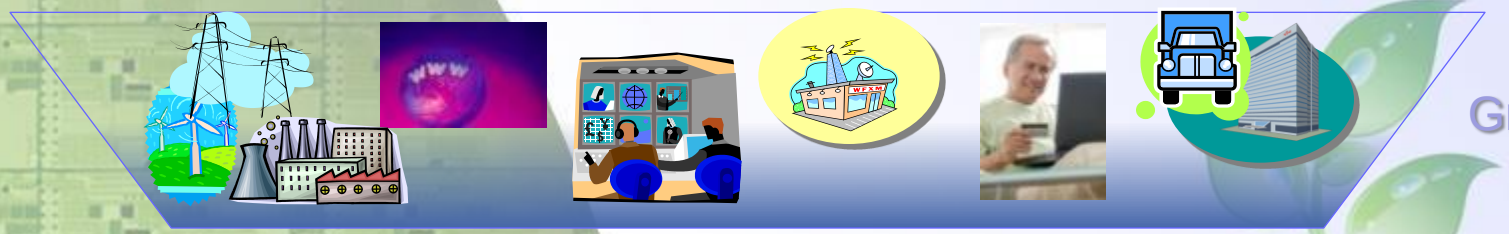
- Miniaturization will
  - realize the same function with smaller chip and lower power. (directed to lower power)
  - Realize more functions without increasing power.

    (directed to Integration)

- The power consumption to activate one transistor has decreased one tens of thousandth since first transistor was made 50 years ago.



Source: JSTC, adapted from ITRS



Green Society

Green End Products

Green Products

Green Fab

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 energy-saving function.**

- **Cell phone towers**
- **Data centers**
- **Engine Control Units**
- **PC, Solid (flash) memory Stand-by power**
- **Tire pressure Monitor**
- **Consumer electronics and appliance**
- **Solid state and fluorescent lighting**

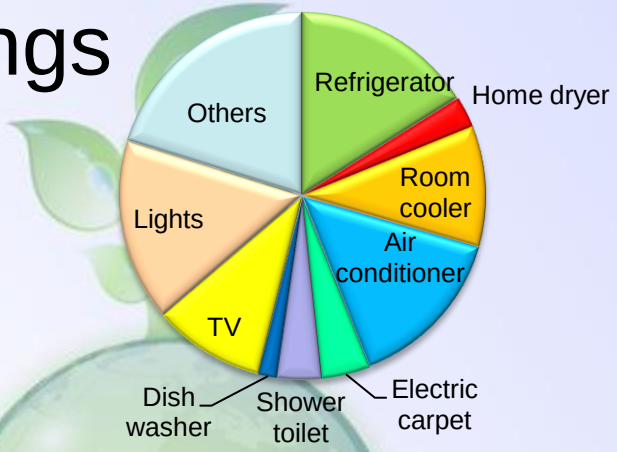
Semiconductors drive Solid State Lighting

- 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 Consumer Electronics and Appliances energy savings

- Household appliances in Japan
  - Air conditioners: 99 million
  - Refrigerator: 58 million
  - Washing machine: 41 million
- Electricity saving by semiconductor devices, i.e. inverter control
  - Air conditioner: 400 (kWh/year/unit)
  - Refrigerator: 100 (kWh/year/unit)
  - Washing machine: 10 (kWh/year/unit)
- Potential total electricity saving by semiconductor devices in Japanese households = 46 billion kWh
  - Equal to reduction of 20 million tons of CO_2 emission



Total: 191 billion kWh

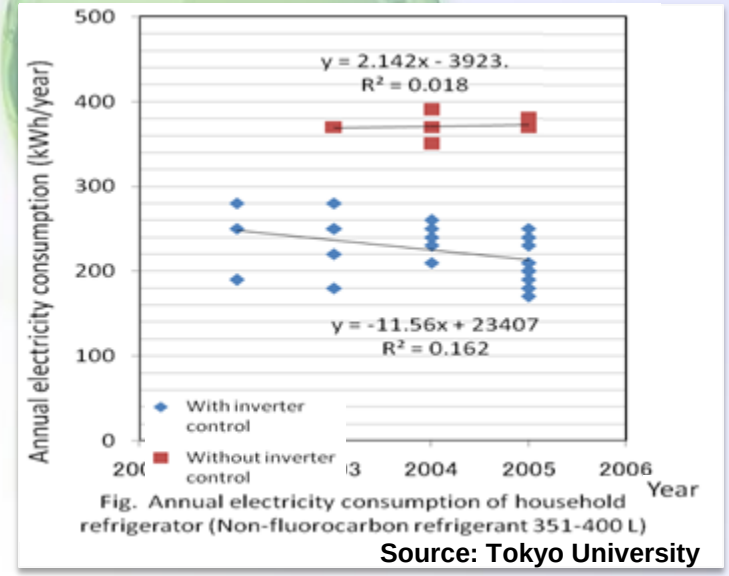


Fig. Annual electricity consumption of household refrigerator (Non-fluorocarbon refrigerant 351-400 L)

Source: Tokyo University

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

2.5” SSD	Power use	2.5” HDD
1 W	active	2.1 W
0.1 W	Idle	1.5 W
0.06 W	Stand by	0.2 W

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

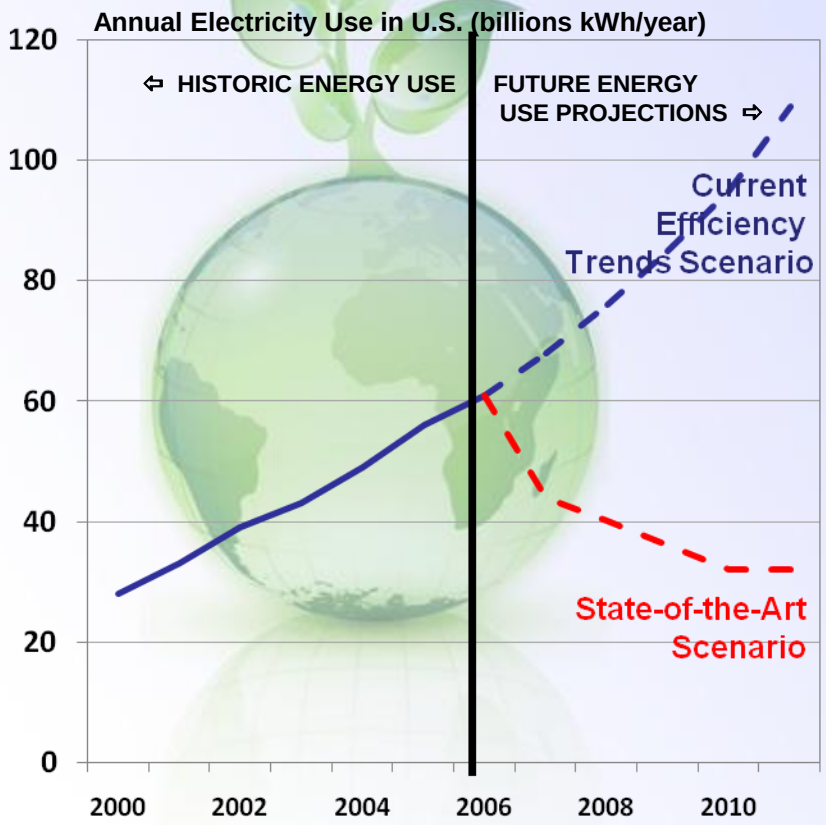
15 Megatons of CO_2

- Globally - annually –

Semiconductors drive Server and Data Center energy savings

- In 2006 servers and data centers in the U.S. consumed 61 B Kilowatt hours, double the amount consumed in 2000.
  - This represents 1.5 percent of total U.S. electricity consumption.
- Under current efficiency trends, U.S. energy consumption by servers and data centers could nearly double again in five years.
- Energy consumption can be reduced by adopting state of the art technologies such as:
  - Aggressively adopt “energy efficient” servers.
  - Up to 80% improvement in efficiency of chillers, fans, pumps, and use of direct liquid cooling.
  - Enable power management at data center level of applications, servers, and equipment for networking and storage.

Aggressive actions on Servers and Data Centers can have dramatic results



US Environmental Protection Agency, “Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431”, August 2, 2007

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.

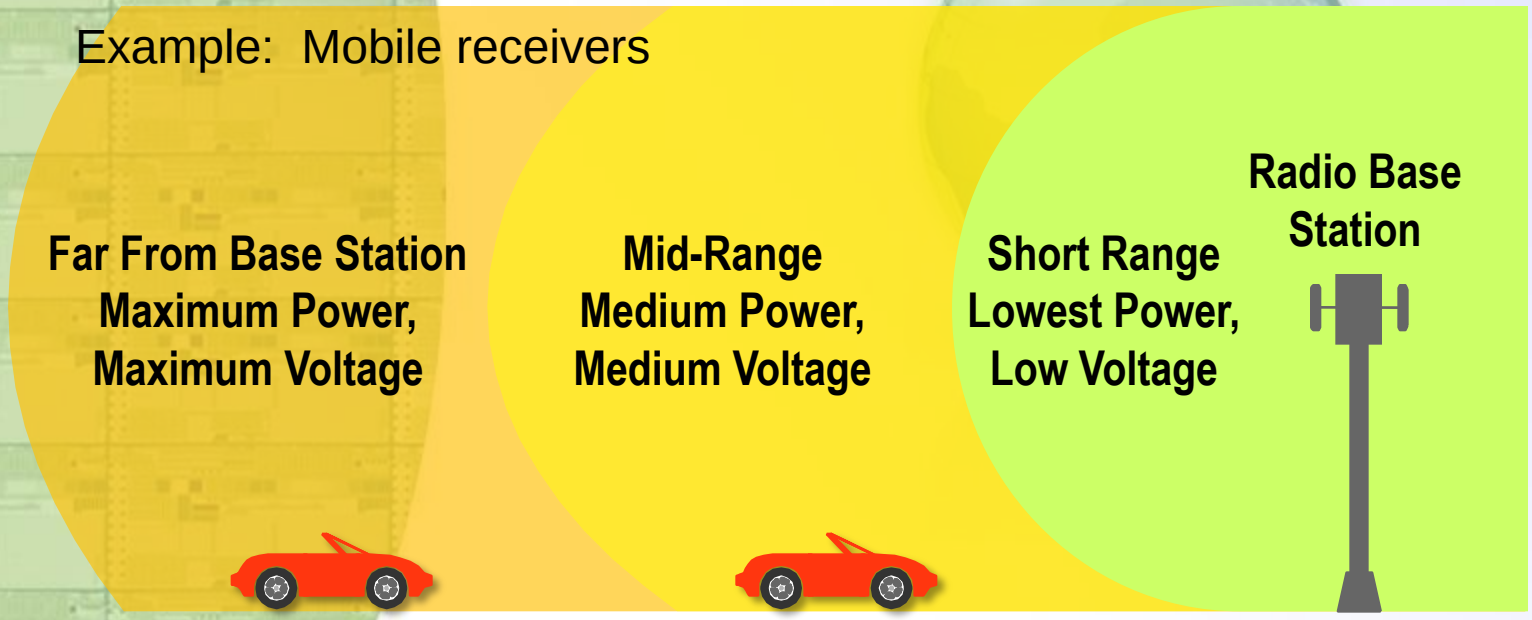
Source: “SMART 2020: Enabling the Low Carbon Economy in the Information Age;” 2009.

Semiconductors drive Power Management solutions

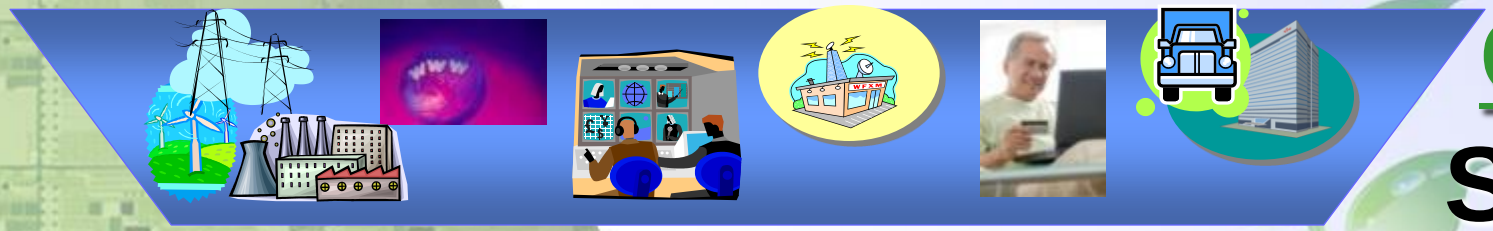
- Chip-Level Power Management
  - Idle, Standby, Halt Modes
  - Adaptive Voltage Scaling

- System Level Power Management
  - Peripheral shutdown
  - Reduced Power Modes

Example: Mobile receivers



Green Society



Green
End Products

Green Products

Green Fab

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**
- **ecommerce**
- **ebook replace paper**
- **Smart Metering**
- **Smart office building**
- **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.

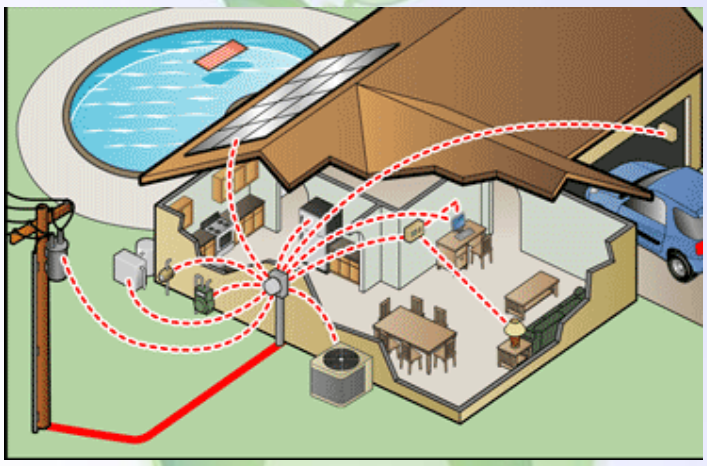
Semiconductors enable energy savings through Telecommuting

- **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 CO_2 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 CO_2 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.)

Electric power management system of Office

Employment of the ECO design for a super skyscraper

～12% reduction of power dissipation in the ECO building

New vibration control system

Adequate core layout

★Energy saving system: e.g. Lights off during personnel absence

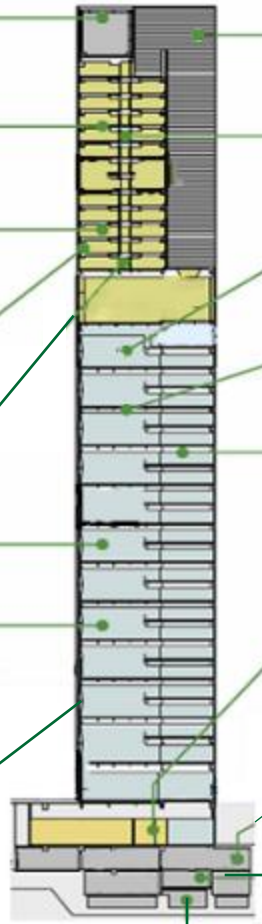
★ ECO rator：Natural air conditioning system

Slab-sleeve unit

Office Garden

★ Intelligent air conditioning system

Windows configuration



Terracotta Tile

Eco shaft

★ Air conditioning with natural ventilation

Metal head lining

★ ECO Lighting System using HF power control

★ BEMS: Building and Energy Management System

★ Chilled-water thermal energy storage system

Reprocessing of kitchen wastewater

Reuse of rainwater

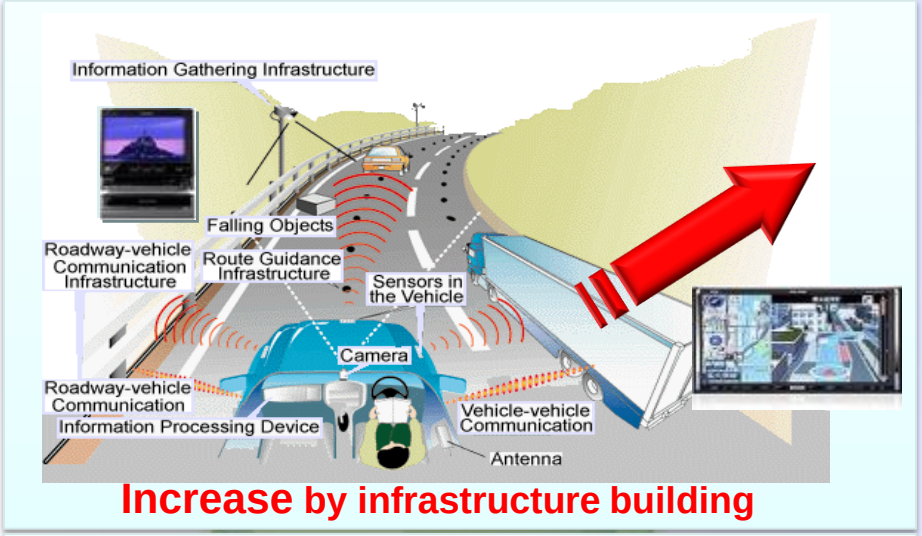
★：*Energy saving areas using Semiconductor/Electronics feature*

Source：Nikkei architecture

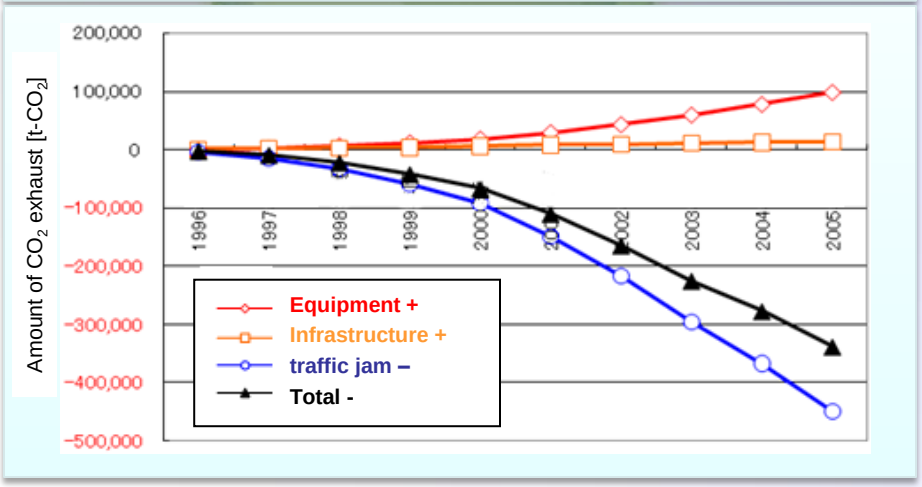
A new transport system (ITS)

- Increase of CO_2 emission associated with spread of ITS:
  - Infrastructure construction
  - Increase of terminals on vehicles
- Reduction of CO_2 emission associated with spread of ITS:
  - Decreasing traffic jam
- Effects of reduction of CO_2 emission by spread of ITS
  - Reduction effects by decrease of traffic jams exceeds greatly increase effects

ITS : Intelligent Transport Systems



Increase by infrastructure building



(reference) Mizuho Information & Research Institute Inc.<In Japan>

TECHNOLOGY ROADMAP

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

International Technology Roadmap for Semiconductors

- ITRS written by over 1200 experts from around the world focused on 16 topics such as design, lithography, test, metrology, interconnect, etc.
- Identifies technical challenges that must be overcome to continue semiconductor technology advances through 2022 and beyond

What topics are in ITRS

- ITRS has included an ESH chapter that covers topics such as chemical assessment, reduction of global warming gas emissions, and ESH as a design element.

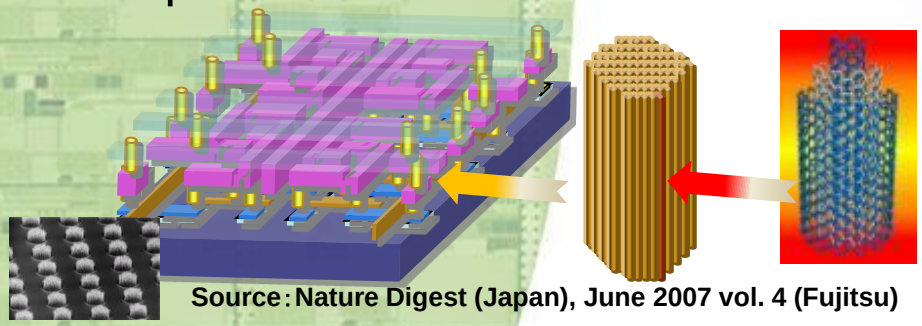
- Recent ITRS have included a System Drivers chapter to align chip roadmaps with the broader electronics industry.
  - *Chapter notes that power is a system driver for portable consumer (battery life), networking/communications, and office equipment*

- 2008 ITRS Update is first to include a special section on energy. Section notes:
  - *Power consumption is one of the major constraints on chip design, and has been one of the top three overall ITRS challenges for the last 5 years.*
  - *The concept of "sleep" mode that originated in circuit design now being applied to semiconductor manufacturing process equipment to reduce factory power consumption.*

Challenges

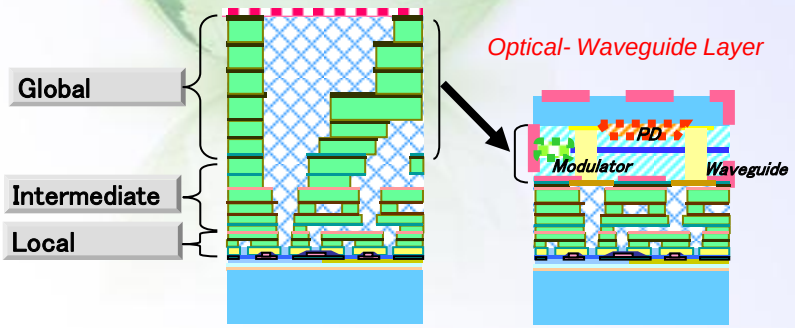
- The ability to continually shrink the circuits on semiconductor is approaching physical and other limits. The ITRS has an Emerging Research Devices chapter that begins to look at replacement technologies.
  - This will be as significant as the transition from vacuum tubes to solid state transistors, or from single transistors to integrated circuits.
- There is currently no replacement technology that would have dramatic energy savings opportunities. More research is needed to generate new ideas that can overcome this problem.

Carbon Nanotube Via



Source：Nature Digest (Japan), June 2007 vol. 4 (Fujitsu)

On-chip optical interconnect



Source: MIRAI-Selete (NEC)

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

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

Appendix

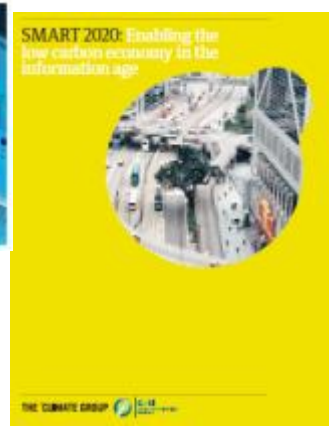
Semiconductor Opportunities From Recent Energy Studies

Susan Moore
AMD

Beijing
May 20, 2009

Semiconductor Opportunities From Recent Energy Studies and Global Report

- Three Recent Studies and A Global Report
  - 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
  - World Economic Forum/World Business Council for Sustainable Development report



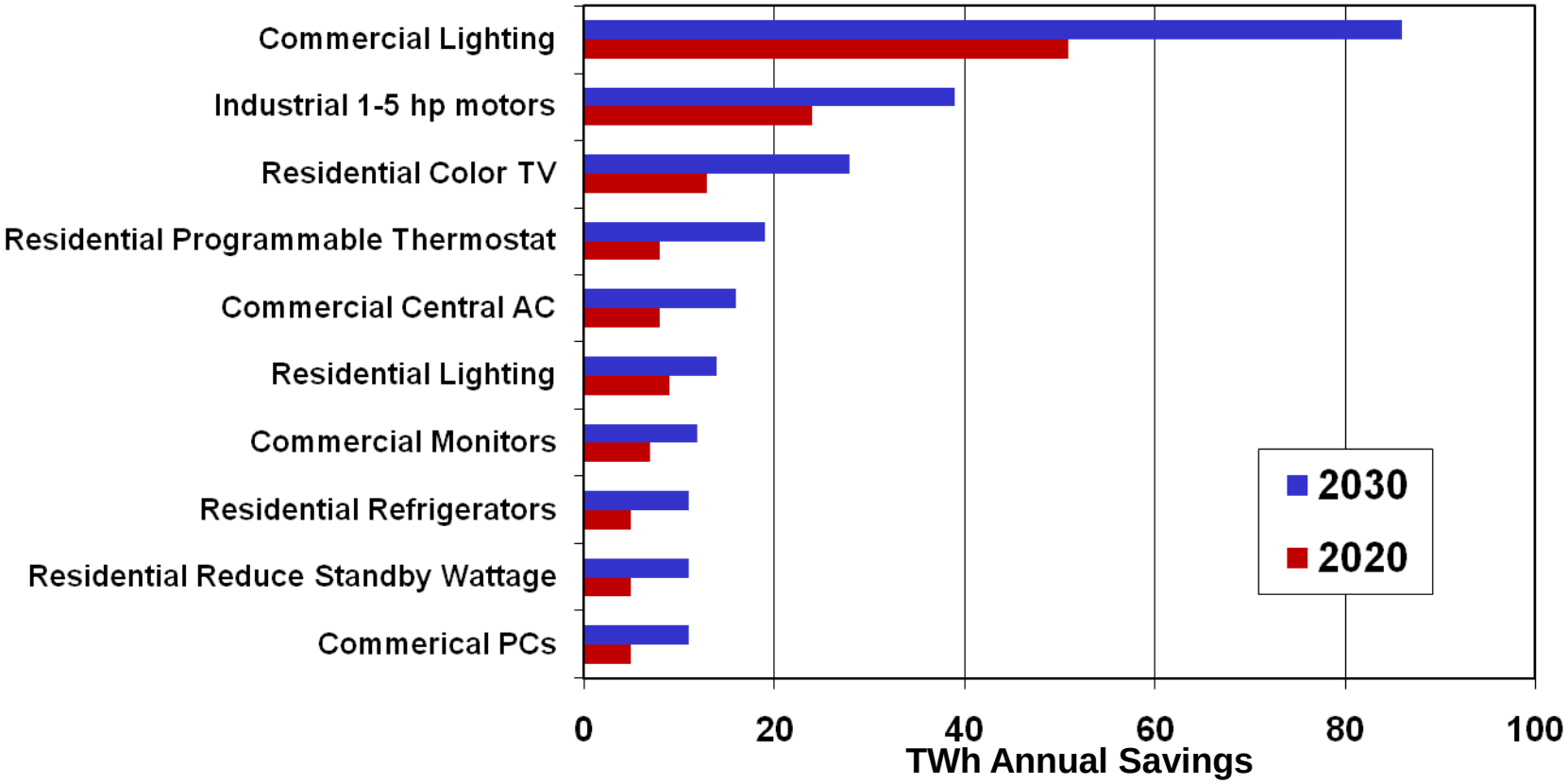
ACEEE
American Council for an Energy-Efficient Economy

WORLD ECONOMIC FORUM
COMMITTED TO IMPROVING THE STATE OF THE WORLD

World Business Council for Sustainable Development

- WSC Conclusion

EPRI Study (2009) Identified Highest Potential Energy Efficiency Opportunities



Source: EPRI "Assessment of Achievable Potential from Energy Efficiency and Demand Response Programs in the U.S. (2010-2030)" 2009.

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, …

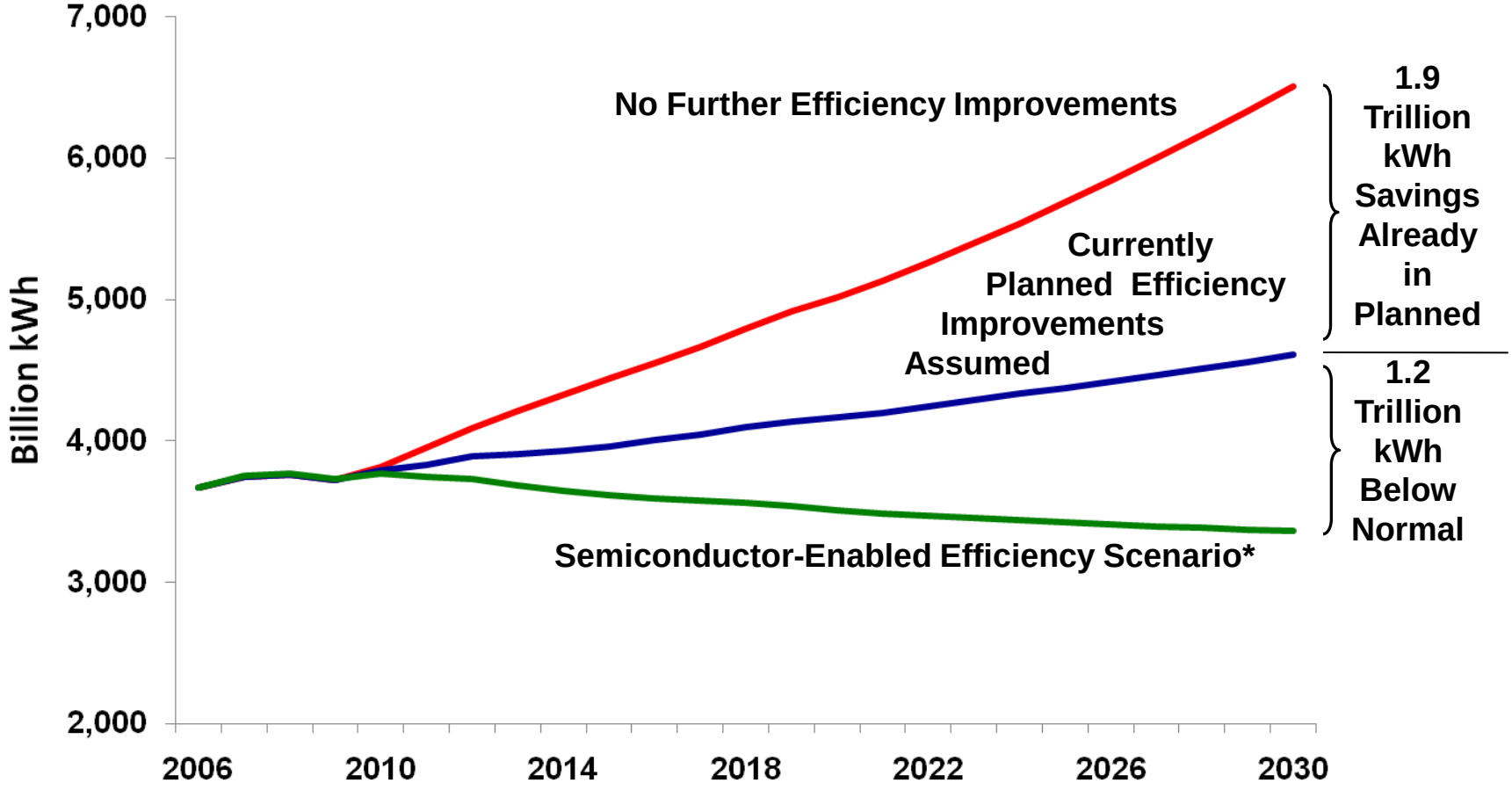
- ICT emissions in 2020 are five times less than the emissions reductions from the ICT efficiency "enabling effect" on the overall economy.

ICT Emissions (from production & use) = 1.4 $GtCO_2$

ICT enabled emissions savings in economy = 7.8 $GtCO_2$

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

ACEEE Study (2009) -- Semiconductor Efficiency Saves 1.2 Trillion kWh



Source: "Accelerated Investments in Semiconductor-Related Technologies Stimulated by Smart Policies" (2009).

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 CO_2 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**

World Economic Forum/World Business Council for Sustainable Development Report and CEO Recommendations (2008)

- Input from > 80 CEO's from a wide range of global sectors.
- Presented to the G8 Leaders as part of the Gleneagles Dialogue on Climate Change, Clean Energy and Sustainable Development

- Recommendations:
  - A rapid, fundamental strategy to reach a low-carbon world economy is needed.
  - All major economies must be party to a new framework – including the U.S., China, and India.
  - The framework should have unambiguous international goals, such as an aspiration to at least halve global greenhouse gas emissions by 2050.
  - Focus on market mechanisms, such as an international carbon market.

Source: CEO Climate Policy Recommendations to G8 Leaders (2008).

Conclusions for WSC

- Given the significant impact that semiconductors have on energy efficiency and renewable energy, all regions' semiconductor industries should "have a seat at the table" in any stakeholders' talks on energy policy.
- Policy makers must recognize that increased energy consumed by ICT lowers consumption in the rest of the economy. Potential savings are 5X total ICT consumption.
- Governments and authorities should review these studies and pursue policies to accelerate adoption of energy efficient solutions enabled by semiconductors.
- As we ask for policies that increase use of semiconductors in energy efficiency applications, there will be an expectation that we also have "green" production and products. We will be expected to lead by example.

The WSC Joint Statement should include a section reflecting these conclusions.