White Paper

Green Opportunities

Sehat Sutardja, PhD

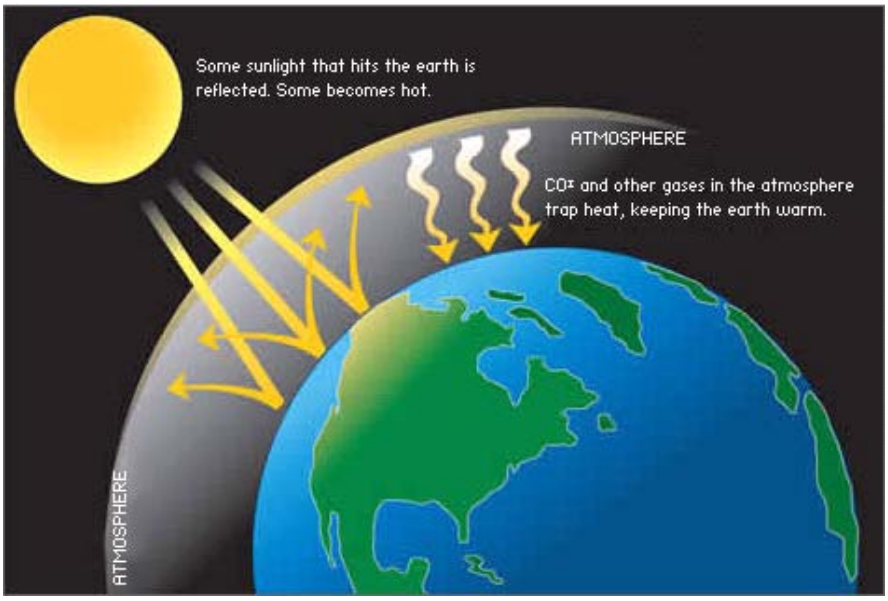
Chairman, President and CEO of Marvell Semiconductor, Inc.

May 2009

Introduction

Global Climate change is a complex, comprehensive and long-term challenge to global society. It is the responsibility of every government, community, agency, company and citizen to take action to reduce Greenhouse Gas (GHG) emissions, and slow down and eventually stop, global warming. Figure 1 shows the process of how GHGs impact the climate and temperature of the earth. The United States, along with many other United Nations Framework Convention on Climate Change (UNFCCC) countries, has identified the ultimate goal of stabilizing GHGs in the atmosphere at a level that avoids dangerous human interference with the climate system. It is broadly recognized internationally that climate change concerns cannot be addressed in isolation from other pressing needs, such as economic development, pollution reduction and energy supply. Successfully addressing these complementary concerns requires the development and commercialization of advanced technologies, particularly those that have the potential to fundamentally alter the way we produce and use energy.

Figure 1: Greenhouse gases (GHGs) in the atmosphere cause global temperatures to rise



Source: U.S. Department of Energy

The sources of GHG emissions are varied and complex. Advances in technologies that can reduce emissions, from energy end use to energy infrastructure, can play a powerful role in affordably reducing GHG emissions. Marvell, a leader in semiconductor innovation, recognized its potential role in climate change and joined the Climate Savers computing initiative in September 2007. Climate Savers is a not-for-profit, green organization of eco-conscious consumers, businesses and conservation organizations. Its technology members include Dell, Google, Hewlett-Packard, Intel, Lenovo and Microsoft, Climate Savers is dedicated to the promotion of developments in green technology and energy-efficient computing. Climate Savers Computing Initiative member companies commit to purchasing energy-efficient PCs and servers for new IT purchases, and to broadly deploying power management. By producing and purchasing power-efficient products, Climate Savers' goal is to reduce computer power consumption by 50 percent by the year 2010. In this paper, several approaches are presented which can significantly reduce GHG emissions and slow down global warming. One of the most notable of these is the addition of Power Factor Correction (PFC) on all power supplies for consumer electronics devices, an area in which Marvell is an industry expert.

Approaches to the "Green Opportunity"

There are different approaches to the green opportunity of reducing GHG emissions. There are also different strategies for both the short term and long term. These approaches include fuel cell hybrid vehicles, intelligent buildings with energy efficient lighting systems, solar panel energy systems, high-efficiency power transmission and distribution systems, high efficiency and power factor correction in consumer electronics devices, or generating more hydro-electric and nuclear power. All of these approaches reduce power consumption, improve efficiency and eventually reduce the carbon footprint worldwide. These approaches will also greatly help and improve the environment and the human living experience.

One effective approach to reducing GHG emissions is to drive a hybrid vehicle versus a traditional gasoline powered car. A typical hybrid car can improve the average gas mileage from 31 miles-per-gallon on a similar-size car to 44 miles per gallon. Assuming the average commuting mileage is about 15,000 miles a year, a savings of about 150 gallons can be derived from driving an eco-friendly vehicle. A typical Co2 emission from a gallon of gasoline is about 19.4 pounds, which means a typical hybrid car effectively reduces about 1.32 tons of carbon dioxide (CO2).[1] Is it cost effective? With paying $5,000 more for a hybrid vehicle, it will take 12 years to cover the cost difference at a gas price of $2.75 per gallon. Plus, the typical battery warranty only lasts for 5 years. Unless the gasoline payback is shorter than 5 years, there is no economic value in buying a hybrid vehicle. To aid in getting the green value sooner, government subsidies are sometimes offered to close the cost gap and make the green choice more affordable for people who want to buy a hybrid vehicle.

Another effective approach to reducing GHG emissions is the utilization of renewable energy on earth, such as solar energy. With the advance of solar technologies, solar panel installations in recent years have begun to expand into residential areas. Considering cost factors such as parts, installation and maintenance on an annual basis, the average payback period for a residential solar installation, sized between 1.3 kilowatts (KW) and 5KW is estimated at about 20-40 years. However, with cost reductions in solar panels and technology improvements, solar energy will dramatically expand in both residential and business, extending into office, manufacturing and commercial facilities.

With the effort to reduce electricity consumption and GHG emissions, various organizations, and some governments, have encouraged the adoption of compact fluorescence light (CFL) bulbs to replace incandescent lights. For a given light output, CFL uses about one-fourth the power of equivalent incandescent lamps. In 2008, the European Union (EU) approved a regulation phasing out incandescent bulbs starting in 2009 and finishing by 2012. The estimated total energy savings is almost 40 terawatts (TW), which leads to the reduction of about 15 million tons of CO2 emission per year. While the purchase price of an integrated CFL is typically three to 10 times higher than the equivalent incandescent light bulb, the extended lifetime and lower energy use will compensate for the higher initial cost. The investment of $3 per CFL is typically paid back in one month.

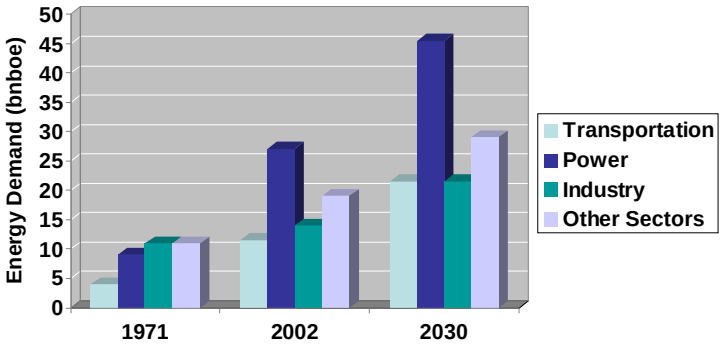
All of these approaches effectively help to reduce GHG emissions and will help to slow down the warming trend in global climate change. However, another approach can go much further to reduce GHGs. The implementation of Power Factor Correction (PFC) in the power supplies of billions of consumer electronics worldwide will prevent the daily waste of a huge amount of energy. Power Factor Correction replaces traditional AC adapters, and “fools” the device into using electrical current more efficiently. By reducing the energy typically lost through copper wires, the power savings from PFC can be up to 50 percent.

The Green Opportunity on Power Supply-Power Factor Correction (PFC)

There are billions of power supplies being used worldwide today. According to the U.S. Environmental Protection Agency (EPA), there are more than 10 billion AC-DC power supplies used in computing, telecommunications and consumer electronics applications worldwide, with an estimated 2.5 billion in the United State alone. There were more than 100 million desktops and 100 million laptops manufactured and sold to customers globally in 2008. At the same time, there were about 1.5 billion cell phone chargers sold, together with the cell phone themselves. All of these electronic devices consume proportionally high amounts of power for normal operation. Figure 2 shows the increasing amount of electrical consumption that is the biggest and fastest growing carbon problem.

However, a big part of the power is wasted during the power transmission, distribution and usage phases of power devices. For example, the power factor of most power supplies used in consumer electronics devices is around 0.5 to 0.6. That means only 60 percent of that power is consumed by the electronics devices and 40 percent of the power is not consumed by the load. That 40 percent of the power delivered to the electronics devices only appears during the power transmission and distribution, which means a huge amount of power is wasted during this process. It is assumed that there are 100 millions PCs running in the U.S. with 120W average power consumption. All of these PCs run under 24 hours a day with 0.6 power factor. If PFC was implemented for more efficient power supplies on all of these PCs in the U.S, it could cut U.S. energy capacity usage by about 40 percent, saving nearly $3 billion annually, at U.S. $0.08 per KWh, and reduce approximately 24 million tons of carbon dioxide emissions per year.[2] In addition to this, the power demands of consumer electronics are growing, as the number of users and devices increases and as applications become more and more power intensive. Therefore, it is extremely important to explore, develop and implement a power efficient strategy in order to reduce the power waste, and thereby reduce GHG emission and improve climate sustainability.

Figure 2: Electricity consumption increasing history and trend



Source: IEA WEO 2004

Below is more detailed information about the benefit for PFC as an important power efficient methodology. Figure 3 shows a typical current input waveform in a traditional non-PFC power supply. The current waveform is a big spike pulse with a sinusoidal input voltage waveform. The non-sinusoidal current pulse produces high third harmonic current and its power factor (PF) is very low, typically around the 0.5 to 0.6 range. The third harmonic current causes a large current to flow through the neutral line in the power distribution system, so extra loss is generated. In addition, low PF also causes extra current to flow through the distribution line, which causes additional power loss. For example, for 1,000W power supply on a 100V Root Mean Square (RMS) value power system, if the power factor is 0.5, the RMS value of the line current will be 1,000W/(100V*0.5)=20A. Figure 4 shows a typical current waveform in a PFC power supply. The current waveform (green) is sinusoidal in this waveform and the PF is close to unity. If the PF is improved to be 1, the line current for this 1,000W power supply will be 1,000W/(100V*1)=10A. This means that the power loss in the distribution line with 0.5 PF will be four times more than that with unity PF. This also means the power distribution system needs to deliver double the capacity to the load with the 0.5 PF than that with the unity PF.

Figure 3: Typical current waveform in non-PFC power supply

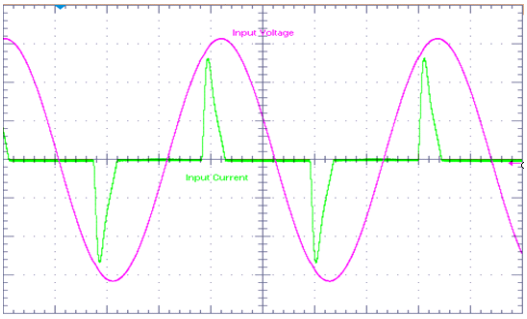
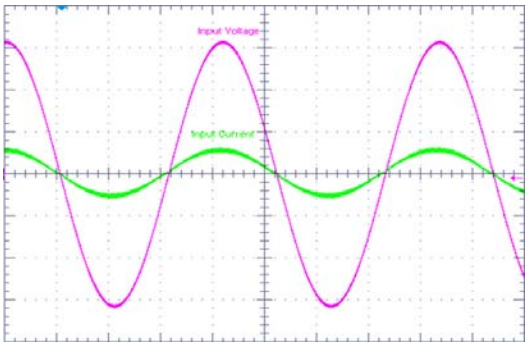


Figure 4: Typical current waveform in PFC power supply



Compared with the hybrid car or solar panel, the implementation of PFC is highly practical. PFC technology has been around for about 20 years, and therefore is considered to be in a mature engineering phase. PFC implementation is also much more time and cost effective. It can be easily designed into power supplies, adding less than $1 per unit in cost and even adding zero cost in many applications. So why are only less than 1 percent of the billions of power supplies implemented with PFC technology? One of the reasons is that there is no strict technical regulation to address and define how efficiently electronics devices should consume power. Only Europe currently mandates PFC implementation in power supplies of devices that operate at higher than 75 watts (W). The U.S. and other countries are going to implement the same regulation, but with a different time frame. However, even if this were completely implemented in the U.S. and all other countries today, it is still far from enough. PFC should go into power supplies that operate below 75W. Fundamentally, it should go into all power supplies to reap the widespread benefits and energy savings of PFC, however, consumer electronics manufacturers have been reluctant to redesign systems based on ignorance or lack of motivation. PFC technology has changed over the year since it was developed 20 years ago, and the implementation can now be pennies. But manufacturers think that adding a dollar of end user cost for a power supply is not worth the effort, and continue with energy wasting legacy designs.

Marvell was the first to market with a digital signal processor (DSP)-based power factor correction (PFC) controller for AC-DC power supplies, and continues to be one of the premier providers of an affordable PFC solution. Marvell designs its power supplies to cut energy usage and reduce the carbon footprint, saving up to 50 percent energy consumption per unit. According to the U.S. Environmental Protection agency there are an estimated 10 billion electronic devices worldwide, more than 2.5 billion in the U.S. alone, which include computers, set-top boxes, video game players, flat screen TVs and household appliances, PFCs. If PFC were widely adopted in the U.S. alone, it would save nearly $3 billion in energy costs annually and reduce 24 million tons of carbon dioxide emissions per year. This means PFC adoption can also help delay or reduce the need to build more power plants. By integrating more functionality onto a single chip consumer electronics manufacturers can increase product reliability while reducing the power supply size and its cost. Figure 5 shows the 90W unity power factor correction adaptor Marvel delivered in 2008. It is the smallest adaptor with this power rating and power factor correction. It saves approximately 40 percent power capacity compared to non-PFC adaptors with the same power rating and is about 30 percent smaller than the common size adaptor in the market.

Figure 5: Size comparison of Apple's iPhone™ and Marvell's 90W/20V PFC adaptor.

Conclusion

The technology is there. It is impactful. So isn't it time to ask ourselves whether we want to live in a sustainable environment in the future, one which we can already imagine? The answer is YES, but only if we take action now to control and start reducing GHG emissions. We already have the technology to help us start using more green power and minimize wasted energy. Marvell is committed to contributing our best technology and product development efforts toward green power. We work daily to design eco-friendly products as well as continually reduce our own carbon footprint to do our part to improve the overall quality of life for every human on the planet. We call on consumer electronic Original Equipment Manufacturers (OEMs) to implement green technologies like PFC now to all devices, and governments to step up the technical regulation requirements to ensure we achieve these benefits in the near term. These steps will help lower GHG emissions, reduce the carbon footprint and help reduce the need to build more power plants. With more consumer education about PFC technology, end users as well can demand power saving devices. PFC is an effective green weapon that eco-conscious companies and consumers can turn to. If all consumer electronics manufacturers began designing power supplies with PFC now, within 24 months we would see a slow down in the trend, rather than an increase in energy consumption as the number of consumer electronic devices continues to grow. PFC can play a vital future role in the billions of ever more power-hungry consumer electronics devices slated to be sold in the next five years.

Footnotes:

1. U.S. Environmental Protection Agency CO2 emission calculator: Co2 emission from a gallon of gasoline ==19.4 pounds/gallon.
2. Calculated on the assumption of 100 million PCs. for Americans who have full-time jobs and regularly use a PC for work without turning it off. At $0.08 per KWh, one PC average power consumption of 0.12KW.

Dr. Sehat Sutardja
Marvell Co-Founder, Chairman, President and Chief Executive Officer

In addition to running the 5,000 person company, Dr. Sutardja participates heavily in Marvell's engineering efforts across analog, video processor and microprocessor design, providing input across all of the company's product lines. He holds 78 patents to date and earned the prestigious IEEE's Fellow Grade status for extraordinary accomplishment. In 2006 Dr. Sutardja was recognized as the Inventor of the Year by the Silicon Valley Intellectual Property Law Association. He holds a Master of Science and Ph.D. degrees in Electrical Engineering and Computer Science from the University of California at Berkeley.

www.marvell.com

Marvell Semiconductor, Inc.
5488 Marvell Lane
Santa Clara, CA 95054, USA

Tel: 1.408.222.2500

PN Green Opportunities-002 8/2010