



The Cold Front

The Electronic Newsletter of The Industrial Refrigeration Consortium

Vol. 7 No. 1, 2007

SUSTAINABILITY

Most of the articles that we feature in the **Cold Front** are technical in nature. This month, we deviate from that norm to present a “softer” piece on the subject that was a focal point for this year’s IRC Research and Technology Forum – *Sustainability*. Although some of the concepts related to sustainability are sensitive and unfortunately political, we hope this article will cut through to provoke your thoughts on both the challenges that lie ahead and the opportunities those challenges provide.

SUSTAINABILITY – A GRAND CHALLENGE

Not since President John F. Kennedy delivered his “Moon Speech” on September 12, 1962 in Rice Stadium has our country aligned to take up a truly “grand challenge.” It was during that speech that President Kennedy put forth a seemingly insurmountable goal:

IRC Staff

Director

Doug Reindl 608/265-3010
 or 608/262-6381
dreindl@wisc.edu

Assistant Director

Todd Jekel 608/265-3008
tbjekel@wisc.edu

Research Staff

Dan Dettmers 608/262-8221
djdetme@wisc.edu

In This Issue

- Sustainability **1-10**
- Upcoming Ammonia Classes **2**
- Noteworthy **2**
- IRC Membership **9**
- Introduction to Food Chilling and Freezing **11**

IRC Contact Information

Toll-free 1-866-635-4721
Phone 608/262-8220
FAX 608/262-6209
e-mail info@irc.wisc.edu

Mailing Address

1415 Engineering Drive
Room 2342
Madison, WI 53706-1607

Web Address www.irc.wisc.edu

"We choose to go to the moon. We choose to go to the moon in this decade and do the other things, not because they are easy, but because they are hard, because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one which we intend to win, and the others, too."

Not quite seven years later, the world watched Apollo 11 astronauts Neil Armstrong (Mission Commander), Buzz Aldrin (Lunar Module Pilot), and Michael Collins (Command Module Pilot) leave the comfort of our terrestrial home to begin their 239,000 mile trip to the moon. On July 20, 1969 after safely settling their lunar module on the moon's surface, Neil Armstrong uttered his famous words: *"Houston, Tranquility Base here, the Eagle has landed."* As a nation, we spent seven years and more than \$25 billion dollars to achieve the single goal Kennedy articulated - put a man on the moon and return him safely to earth by the end of the decade. We made it!

Today and into the future, we face a grand challenge that dwarfs the successful lunar rendezvous by the Apollo 11 astronauts and all those who supported that mission. The grand challenge we face today is achieving global **Sustainability** and the stakes are high.

UPCOMING AMMONIA COURSES

Engineering Safety Relief Systems
May 7-11, 2007 **Anywhere via the web**

Engineering Calculations for PSM & RMP
May 16-18, 2007 Madison, WI

NEW Introduction to Food Chilling and Freezing
June 20-22, 2007 Madison, WI

Design of NH₃ Refrigeration Systems for Peak Performance and Efficiency
September 10-14, 2007 Madison, WI

Introduction to Ammonia Refrigeration
October 16-18, 2007 Madison, WI

Intermediate Ammonia Refrigeration
December 5-7, 2007 Madison, WI

Process Safety Management Audits
January 9-11, 2008 Madison, WI

Ammonia Refrigeration: Uncovering Opportunities for Energy Efficiency Improvements
February 13-15, 2008 Madison, WI

Introduction to Ammonia Refrigeration
March 5-7, 2008 Madison, WI

See www.irc.wisc.edu/education/ for more information.

NOTEWORTHY

- The Industrial Refrigeration Consortium would like to welcome its newest member, **PINNACLE FOODS CORPORATION**.
- Send items of note for next newsletter to **TODD JEKEL**, tjkel@wisc.edu.

What is sustainability? Well Webster's defines it as:

sus·tain·a·bil·i·ty, *noun*

1. To keep in existence; maintain.
2. To supply with necessities or nourishment; provide for.
3. To keep up or keep going, as an action or process: to sustain a conversation.
4. To supply with food, drink, and other necessities of life.



Former Norwegian Prime Minister Gro Harlem Brundtland put it more eloquently – *“Sustainability is the ability to meet the present needs without compromising those of future generations”* ([Wikipedia 2007](#)).

The subject of sustainability is both extremely complex and enormously intimidating. It is one that stirs fear and passion in some while for others it is a vague concept to which they have dedicated little or no thought. Although broad, the basic concepts of sustainability have been around for decades. A more holistic view of sustainability on a global scale is one that is still in its fledgling stages.

Why has there been a resurgence of interest in the topic of sustainability? The answer to this question is somewhat subjective; however, there are two key factors that have reignited the quest for sustainability: energy and climate change. Even though sustainability is broader and encompasses more than these two areas, discussing energy and climate change here will allow us to demonstrate the interconnectedness of what was viewed historically as separate compartmentalized issues. In this article, we highlight some of the challenges in these two areas as well as how they are linked. There is another reason why we think sustainability is a timely and important topic – business. Leading companies are quickly realizing that sustainability will be crucial part of their future. We highlight one large company and their push in sustainability but there are others plotting their course for a sustainable future. Read more and you will understand why.

ENERGY

As the economies of large developing countries expand, energy is a necessary and key ingredient that underpins their continued economic growth. Unfortunately, one of the most flexible and strategic forms of energy we have at-present is petroleum and its availability into the future will increasingly diminish due to its non-renewable nature. As the supply of crude oil decreases, its cost will rise – significantly. It is this rise in crude oil price that will challenge energy intensive economies to adapt or fail.

FIGURE 1 shows the production of crude oil in the continental US from 1900 through 2005. The shape of the production curve fits a “[logistic](#)” distribution that was identified by an American physicist Marion King [Hubbert](#) in the 1950s. The actual behavior in crude oil production shows an early rise in production rate due to the growth in discovery and infrastructure. Eventually, the production rate reaches a peak followed by decreasing production due to resource depletion. This profile in oil production Hubbert theorized has been validated on scales ranging from individual oil wells to whole oil producing countries and the world. In his 1956 paper titled “Nuclear Energy and the Fossil Fuels”, Hubbert predicted that the peaking of oil production in the continental US would occur during a period

between 1965–1970. The actual peak of oil production in the US occurred in 1970 (Wood and Long, 2000).

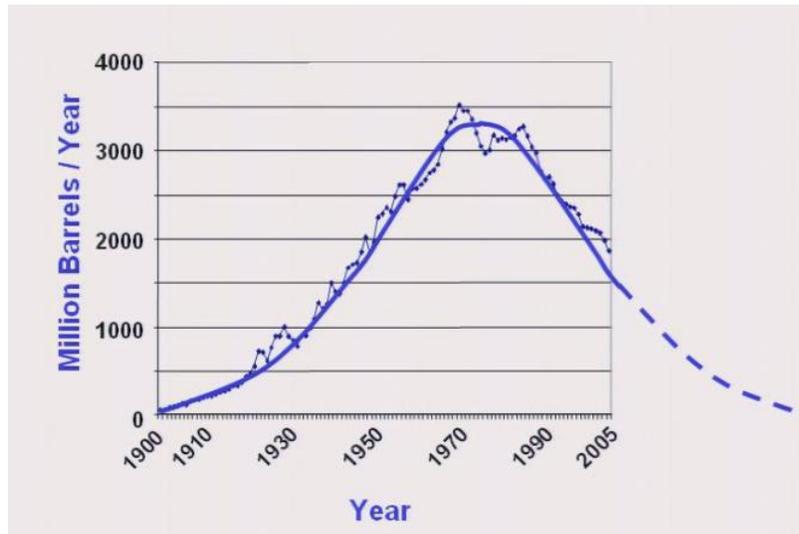


FIGURE 1 Oil production history in the US (points) and a logistic distribution (solid line) with peak production occurring around 1970 (Hirsch 2006).

Beyond the peak production of oil in the US, Hubbert also predicted that **world** oil production would peak around the year 2000. Because good quality data on world oil reserves is not readily available, there is no clear consensus on when world oil production will (or did) actually peak. Hirsch, et al. (2005) summarized a number of forecasts for dates when world oil production will peak as shown in the table below. Quite a variable range to say the least.

Estimates of peaking world oil production (Hirsch, et al. 2005).

Projected Date	Source of Projection	Background & Reference
2006-2007	Bakhitari, A.M.S.	Iranian Oil Executive
2007-2009	Simmons, M.R.	Investment banker
After 2007	Skrebowski, C.	Petroleum journal Editor
Before 2009	Deffeyes, K.S.	Oil company geologist (ret.)
Before 2010	Goodstein, D.	Vice Provost Cal Tech
Around 2010	Campbell, C.J.	Oil company geologist (ret.)
2010-2020	Laherrere, J.	Oil company geologist (ret.)
2016	EIA nominal case	DOE analysis/ information
After 2020	CERA	Energy consultants
2025 or later	Shell	Major Oil Company

Reaching the peak production of oil in the world does not mean a complete run-out is imminent, so what's the problem? Generally speaking, reaching the peak production rate of oil in the world means that we will have consumed approximately half the known total reserves of oil in the world. It is important to keep in mind that as the rate of oil production declines post-peak, the world's demand for crude is expected to escalate into the future. The fundamentals of economics tell us that mismatch between declining production and expanding demand will cause the price of oil to rise until the demand matches the production.

Increased crude prices are expected to exert a particularly harsh impact upon world economies most dependent on low cost crude such as the US. Keep in mind that not long ago, the US experienced brief oil supply interruptions in both 1973 and 1979. The byproduct of those interruptions was high inflation, very high interest rates, growth in unemployment, and recession. The effects of world oil peaking will not be brief but prolonged as the global reserves of crude dwindle (Hirsch 2006).

Our discussion here has focused on crude oil and, clearly, there are other forms of **energy** available such as natural gas, coal, nuclear, wind, solar, hydro, etc. But petroleum is a particularly strategic form of energy due to its high energy density, byproducts, and flexibility for our use – primarily in our transportation infrastructure. In the future, how will we fly a plane on coal, nuclear, wind, solar or hydro? Is crude oil an energy resource we can live without in the future? Should it be conserved for those applications that alternative forms of energy cannot directly serve?

CLIMATE CHANGE

During the last century, some refrigeration technologies and their working fluids have had a particularly profound impact on the environment. Refrigeration systems have the potential of direct environmental impacts due to the release of their working fluids (refrigerants) to the atmosphere. They also have indirect impacts on the environment due to the energy they consume. One of the more significant environmental problems created in the 20th century was attributable to chlorinated fluorocarbons (CFCs) destroying the earth's ozone layer. More information on ozone depletion is provided by the inset shown on **PAGE 10** at the end of this article.

When the subject of global climate change arises, a number of questions come to mind. *Is the source of increasing carbon dioxide concentrations in our environment due to man (combustion of fossil fuels)? Is carbon dioxide really a greenhouse gas? Is our biosphere really experiencing a warming trend on a global scale?* Answers to these questions have been sought by scientists collaborating around the world. In February 2007, the fruits of global scientific community's work were delivered in the form of a fourth assessment report – the Inter-governmental Panel on Climate Change's report on climate change (IPCC 2007). To answer the first question, the IPCC report states:

“Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The global increases in carbon dioxide concentration are due primarily to fossil fuel use and land-use change, while those of methane and nitrous oxide are primarily due to agriculture.”

The IPCC report also documents the science implicating carbon dioxide as one of several “greenhouse gases.” The answer to the last question above is also provided in the report:

“Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level”

In this latest report, the scientists have

underscored their findings of “global warming” by including stronger language e.g. “unequivocal.” What is not clear from the historic and current data is the future trends of potential warming and its collateral impact. Our biosphere is extremely complex, robust, and resilient in a number of ways. Predictions on how our planet will react with increasing levels of atmospheric carbon dioxide vary. Our climate is not static, never has been and never will be; however, as we increasingly consume energy stores created over millions of years in a relatively short period of time, we should be concerned about how the Earth will react to this persistent “force.”

Like other end-use technologies, all refrigeration systems will contribute greenhouse gases indirectly (principally in the form of CO₂ from natural gas and coal fired power generation) as a result of the energy they consume during operation. Reducing the production of greenhouse gases is a daunting challenge with no simple solution. One potential approach to stem the growth in greenhouse gas emissions is to attack the problem using multiple methods called “wedges” (Socolow and Pacala, 2004). These carbon wedges are envisioned to allow continued global growth while maintaining or reducing the atmospheric concentration of carbon dioxide.

FIGURE 2 shows projections of the greenhouse gas burden expressed in terms of the mass of carbon emitted annually. Unabated, the projections of carbon emitted is expected to rise into the future as developing countries evolve and as other forms of energy (e.g. coal) grow in use. The carbon wedges Socolow and Pacala recommend are a means of stabilizing or leveling the emission of carbon into the atmosphere until technologies can be developed

that are capable of reducing the production of greenhouse gases.

Examples of the “wedges” include: energy conservation, renewable energy, reforestation, nuclear, and fuel switching. From the standpoint of industrial refrigeration systems and technologies, focusing on achieving efficiency improvements is one of the easiest and most attainable methods to help in mitigating the production of greenhouse gases. Sustainable refrigeration systems and technologies will, necessarily, have minimal or no environmental impact i.e. have no ozone depletion, be greenhouse gas neutral, and be free of other adverse environmental effects.

INDUSTRY TRENDS IN SUSTAINABILITY

As mentioned previously, sustainability is not new, it has been alive and well in academia and beyond for decades. It is receiving renewed attention as energy and other environmental challenges are becoming more apparent. An announcement related to sustainability made in 2004 by the world’s largest retailer, Wal-Mart, met first with skepticism is now becoming

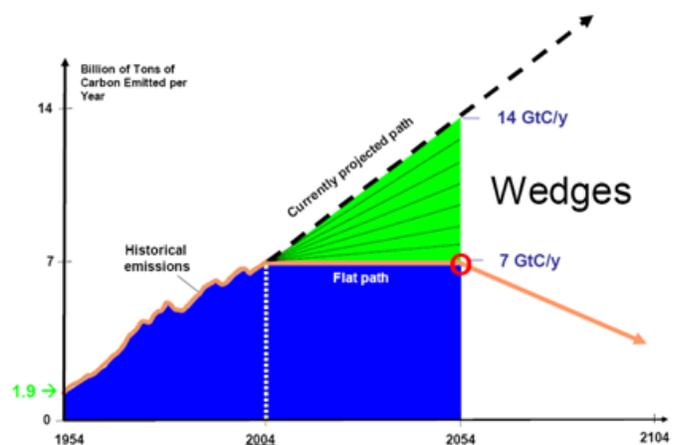


FIGURE 2 Carbon stabilization wedge concept (adapted from Socolow 2005).

reality. In 2004, Wal-Mart outlined a number of very aggressive goals in attempts to make meaningful progress toward a sustainable future. The three goals Wal-Mart established at that time were to (source: Wal-Mart):

- **TO BE SUPPLIED BY 100% RENEWABLE ENERGY**
 - Existing stores 25% more efficient in 7 years
 - New stores 30% more efficient in 4 years
- **TO CREATE ZERO WASTE**
 - Have a 25% reduction in solid waste in 3 years
 - All private brand packaging in 2 years
- **TO SELL PRODUCTS THAT SUSTAIN OUR RESOURCES AND ENVIRONMENT**
 - To have 20% supply base aligned in 3 years
 - Design and support Green Company Program in China

One can debate whether the goals above and their associated metrics are appropriate and realistic; however, the important point is that Wal-Mart is moving in the direction towards achieving sustainability. Surely there will be mid-course corrections but the effort is in motion. Wal-Mart's move into sustainability was reinforced in February 2007 when CEO Lee Scott made public their *Sustainability 360* program. Wal-Mart's *Sustainability 360* is a program that seeks to promote sustainability to everyone Wal-Mart interfaces with including Wal-Mart employees, suppliers, and customers. The six facets or planks that define Wal-Mart's *Sustainability 360* program range from measuring and reducing the environmental footprint on products sold to creating new markets for sustainable products.

What does this have to do with me and my company? The answer to this question is everything. If your company is one of the 60,000 suppliers to Wal-Mart, you will be involved in sustainability! Wal-Mart is currently in the process of establishing baseline data on the state of sustainability across its entire supplier network. Those same suppliers will be expected to establish goals and work toward continuous improvement in achieving sustainability. If you are not a Wal-Mart supplier but a contracting or engineering firm that supports those companies that supply to Wal-Mart, you are a potential strategic partner that will be very much needed to help meet those sustainability goals and objectives.

Even if Wal-Mart has little or no direct impact on your company, a move towards sustainability will increasingly affect your bottom line. Many corporations are discovering that there can be discernable marketplace value in pursuing a "sustainable" business model. General Electric has embarked on a very aggressive "[Ecomagination](#)" campaign that they believe will prove 'technology can be right in step with nature and that 'green is green' (Correa 2006). Other companies are feeling pressure from employees, customers, shareholders, and even investors to move in a direction towards greater environmental sensitivity. As technology improves the cost effectiveness of innovative materials and the efficiency of resources, more and more companies will be pursuing the idea that social responsibility can not only succeed in the current marketplace, but perhaps create

new market opportunities as well. This is shaping up to become a movement that no 21st century business can ignore.

WHAT IS THE IRC DOING?

At the 2007 IRC Research and Technology Forum, we had two excellent presentations relating to sustainability. Professor Tracey Holloway of the University of Wisconsin–Madison presented an overview of the energy and environmental issues facing our planet. Professor Holloway is an atmospheric scientist actively conducting research in global air quality issues and sustainability. Her presentation is available by [clicking here](#). Ron Miller is the Director of Facilities Engineering at General Mills. Mr. Miller delivered the second presentation on sustainability where he provided a business perspective for sustainability as well as a summary of General Mills’ activities in this area. Mr. Miller’s presentation is available by [clicking here](#).

The IRC has worked extensively with end–users to improve the efficiency of their industrial refrigeration systems and plants. Much of the knowledge developed through UW research projects and field experience gained during the efficiency improvement evaluations is documented in our [Industrial Refrigeration Energy Efficiency Guidebook](#).

CONCLUSION

Achieving *sustainability* in the future is going to require a concerted long–term global effort on a scale mankind has never seen. There are no simple and fast solutions. The IRC is committed to supporting its members in paving a path toward future sustainability. Won’t you join us?

If you have any questions or comments on the information in this article, please contact **DOUG REINDL** at the IRC **(866) 635-4721**.

REFERENCES:

- Correa, Sanjay, Manager – Energy and Propulsion Technologies, GE Global Research, “Green is Green”, *Engineering Executives Forum – 2006: Engineering Sustainability in the Global Enterprise*, University of Wisconsin-Madison Department of Engineering Professional Development (2006).
- Pacala, S. & Socolow, R., “Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies”, *Science*, Vol. 305. no. 5686, pp. 968 – 972, August (2004).
- Hirsch, R. L., Bezdek, R., and Wendling, R., “Peaking Of World Oil Production: Impacts, Mitigation, & Risk Management”, Department of Energy Report, February (2000).
- Hirsch, R. L., “Peaking Of World Oil Production: Are you willing to take the risk?”, University of Wisconsin-Madison, Department of Engineering Professional Development, Engineering Executive’s Forum, December (2006).
- Hubbert, M. K., “Nuclear Energy and the Fossil Fuels”, *American Petroleum Institute Spring Meeting*, San Antonio, TX, March, (1956).
- IPCC, “Climate Change 2001: The Scientific Basis”, Intergovernmental Panel on Climate Change, http://www.grida.no/climate/ipcc_tar/wg1/index.htm, (2001).
- Molina, M. J. and Rowland, F. S., “Stratospheric sink for chlorofluoromethanes –chlorine atomic catalyzed destruction of ozone”, *Nature*, 249:810-2, (1974).
- NASA, http://www.nasa.gov/vision/earth/lookingatearth/ozone_record.html, (2006).

Newman, P. A., Nash, E. R., Kawa, S. R., Montzka, S. A. and Schauffler, S. M., "When will the Antarctic ozone hole recover?", *Geophysical Research Letters*, 33: L12814, <http://www.agu.org/pubs/crossref/2006/2005GL025232.shtml>, (2006).

Socolow, R., "Stabilization Wedges: Mitigation Tools for the Next Half-Century", *Avoiding Dangerous Climate Change A Scientific Symposium on Stabilization of Greenhouse Gases*, Exeter, United Kingdom, (2005).

Wood, J. and Long, G., "Long Term World Oil Supply", Energy Information Administration (http://www.eia.doe.gov/pub/oil_gas/petroleum/presentations/2000/long_term_supply/index.htm), 2000.

ADDITIONAL SUSTAINABILITY INFORMATION:

There are a number of places with information on energy, environment, and sustainability. We have selected just a few you may want to browse for additional information.

ASHRAE's Sustainability Efforts: <http://www.engineeringforsustainability.org>

General Electric's Ecomagination Efforts: <http://ge.ecomagination.com>

Hirsch Report on Peak Oil: http://www.netl.doe.gov/publications/others/pdf/Oil_Peaking_NETL.pdf

University of Wisconsin-Madison's Center for Sustainability and the Global Environment: <http://www.sage.wisc.edu>

University of Wisconsin-Madison's Energy Institute: <http://www.energy.wisc.edu>

University of Wisconsin-Madison's Solar Energy Laboratory: <http://sel.me.wisc.edu>

Wal-Mart's Sustainability: http://walmartstores.com/microsite/walmart_sustainability.html

Wikipedia on Sustainability: <http://en.wikipedia.org/wiki/Sustainability>

BECOME AN IRC MEMBER IN 2007

Our mission is **to improve the safety, reliability, efficiency, and productivity of industrial refrigeration systems**. However, do you know that the IRC operates wholly on external funds primarily from ammonia refrigeration end users? In many ways, IRC member companies are just like yours, they have refrigeration needs in the areas of education, technical assistance, and strategic planning. One important characteristic is that IRC member companies see refrigeration as an important component of their business.

Membership in the IRC will allow your organization to engage staff and other IRC member companies to improve your refrigeration capabilities. As an IRC member, you will have access to **telephone hot-line support** on technical, operational and regulatory issues, **internet-based information and technical resources** (including access to IRC webcourses and web-based tools), **technical bulletins, safety updates, specialized publications**, and **refrigeration education** for personnel at all levels.

Hopefully you find this and past issues of the Cold Front helpful and relevant to your operations. By joining the IRC, more awaits you – our best is reserved for members! For more information, contact Doug Reindl at (866) 635-4721.

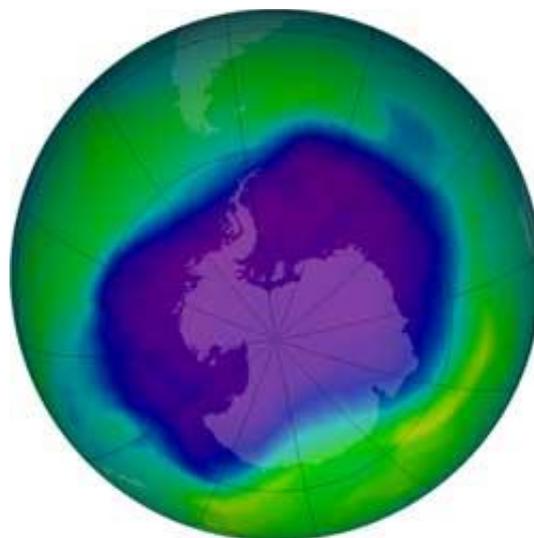
OZONE DEPLETION

The genesis of our current ozone depletion problem began when Thomas Midgley, Jr. (a mechanical engineer working for General Motors) met his assigned task of developing a “safe non-toxic” refrigerant suitable for use in household appliances. In 1928, Mr. Midgley and his colleague Charles Franklin Kettering invented and later patented (#1,886,339) what they believed to be a miracle fluid, dichlorodifluoromethane (CFC-12). The discovery of this single chemical compound spawned a number of other variants that quickly took hold in a range of applications that included: domestic refrigerators (CFC-12), automotive air conditioners (CFC-12), chillers (CFC-11, CFC-12), blowing agents (CFC-11, CFC-12), propellants (CFC-113, CFC 114), and solvents (CFC-113, CFC-114, CFC-115).

In 1974, two UC-Irvine chemists hypothesized that chlorinated fluorocarbons (CFCs) were principally responsible for the thinning of the earth’s ozone layer observed earlier (Molina and Rowland 1974). Their discovery touched off a firestorm of concern in the scientific community with subsequent and swift action in the world’s political community. What resulted was the development and implementation of the *Montreal Protocol* – an international treaty aiming to protect the earth’s ozone layer. Entered into force on January 1, 1989, the Montreal Protocol and its subsequent amendments called for the complete phase-out of a number of substances (principally, CFCs) in attempts to reverse the chemical depletion of the earth’s ozone layer.

The figure immediately to the right shows a satellite image of the largest ever observed ozone hole (blue and purple represent areas with the least ozone) above Antarctica.

Although the complete phase-out of newly manufactured CFCs in developed countries occurred more than a decade ago on January 1, 1996, the inertia of decades of CFC releases is still being felt. Some researchers have forecasted that the rehabilitation and recovery of the earth’s ozone layer will require decades (Newman, et al. 2006). Fortunately, the vast majority of the world’s industrial refrigeration systems utilize anhydrous ammonia as a refrigerant. Ammonia-based refrigeration systems do not contribute to ozone depletion making them a preferred technology from an ozone depletion perspective.



NASA satellite image showing the largest observed ozone hole (11.3 million square miles) above Antarctica on September 24, 2006 (NASA 2006).

With international agreements in place to deal with ozone depleting substances, the next environmental battleground presently being fought relates to greenhouse gases that contribute to global climate. Many of the newly developed synthetic refrigerants that do not contribute to ozone depletion intended to replace CFCs have the unfortunate byproduct of acting as greenhouse gases when they are released to the atmosphere. For example, HFC-134a has a global warming potential of 1,300 relative to carbon dioxide (IPCC 2001). European Union (EU) countries recognize the significance of the new classes of synthetic refrigerants to create future problem; consequently, they are focusing on the development and deployment of refrigeration systems and technologies that exclusively use natural refrigerants: ammonia, carbon dioxide, water, air, and hydrocarbons. From a sustainability viewpoint, ammonia can be viewed as advantageous since it has no direct global warming contribution or ozone depletion potential when released into the environment. It also has the advantage of being successfully and reliably applied in the industrial arena for decades.

Introduction to Food Chilling and Freezing

June 20-22, 2007

The Pyle Center - Madison, WI

The [Industrial Refrigeration Consortium](#) in collaboration with the Department of Engineering Professional Development is pleased to announce a new course titled [Introduction to Food Chilling and Freezing](#) to be held on June 20-22, 2007 at the Pyle Center in Madison, WI. This new course is your opportunity to focus on the principles and practices integral to chilling and freezing of foodstuffs.

The course has been designed to provide practical information on mechanisms involved in the chilling and freezing of foods along with methods that can be used to predict chilling and freezing times. The course features two internationally-recognized faculty in the food processing area: Donald Cleland of Massey University in New Zealand and Richard Hartel from the University of Wisconsin-Madison's Food Science Department.

By attending this course you will increase your knowledge of:

- The importance of product temperature control for quality and safety
- Fundamental processes involved in both chilling and freezing foods
- Equipment commonly used in chilling and freezing foods
- Techniques to enhance the capacity and efficiency of your food chilling and freezing systems.

This course has been specially designed for those needing a better understanding of both the science and technologies for food chilling and freezing. Those who should attend this course includes:

- Food engineers who need an introduction to food chilling and freezing
- Refrigeration engineers and supervisors seeking to enhance their chilling and freezing systems
- Engineering managers with refrigeration responsibilities
- Experienced refrigeration operators desiring a better understanding of chilling and freezing processes
- Newly assigned food science staff
- Other technical staff who want to develop their knowledge of food chilling and freezing

For more details on the course or to register, visit the EPD website at epdwww.engr.wisc.edu. If you have any questions regarding this course, please contact Doug Reindl at 800-442-4214 or dreindl@wisc.edu.