IT@Intel White Paper

Intel Information Technology

Sustainability

September 2009

Establishing Baseline Measurements and a Roadmap for IT Sustainability

Using the data from our model and our roadmap, we have been able to influence Intel IT's CO_2 reduction and avoidance actions in the right direction by reducing energy consumption, developing innovative sustainable solutions, and empowering sustainability.

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Executive Overview

To help Intel consume fewer energy-related resources and produce less waste, Intel IT is executing a sustainability strategy based on our Sustainability Baseline Model, a tool developed in-house that quantitatively measures and predicts the environmental impact of key changes related to IT.

Our goal is to reduce Intel IT's carbon emissions by five percent for 2009 compared to the 2008 baseline. We used our model to calculate our current carbon dioxide (CO_2) footprint and to perform "what-if" analyses to help identify projects with the greatest impact and value related to reducing CO_2 emissions.

We are also implementing a three-phase roadmap that will guide efforts to reduce our carbon dioxide footprint:

- Phase 1. Focuses on baseline sustainability projects with measurable energy reductions in 2009 and beyond.
- Phase 2. Features innovative proofs of concept that can demonstrate further additional energy reductions through 2010.
- Phase 3. Involves proliferation along with research and development, with a focus on using IT to help reduce Intel's carbon footprint in general.

This roadmap helps us maintain our focus and balance our sustainability efforts with business demands.

Using the data from our model and our roadmap, we have been able to influence Intel IT's CO_2 reduction and avoidance actions in the right direction by reducing energy consumption, developing innovative sustainable solutions, and empowering sustainability.

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BUSINESS CHALLENGE

Environmental concerns appear daily in media headlines, and legislation and regulations addressing carbon emissions are growing across the globe. Intel is proactively addressing these concerns by establishing a corporate goal of reducing Intel's absolute global-warming gas footprint by 20 percent by 2012 from 2007 levels.[1]

Intel IT is contributing to this overall goal by developing and executing a strategy to increase our sustainable practices and decrease our carbon footprint. We have committed to reducing our CO_2 emissions by five percent compared to 2008 levels.

To reach these reduction percentages, we had to answer the following questions:

- How could we accurately measure our current CO_2 footprint?
- Once we establish a baseline, how do we measure the effects of changes we make to technology and business processes?
- How can we create a roadmap to reduce Intel IT's energy footprint and support corporate goals, but at the same time balance our sustainability efforts with business demands?
- How can we use the data we collect to motivate and impact change, both inside Intel IT and across the enterprise?

1 See "Intel 2008 Corporate Responsibility Report." Intel Corporation, May 2009.

SOLUTION

To answer these questions, we developed a measurement model that helped determine strategies to reduce CO_2 emissions and determine the effect of these strategies, and built a roadmap for reaching our goals. The model provides reliable data that we can use to guide our decision making processes and create a sustainability culture within IT and across Intel.

Investigating Measurement Options

To determine our current CO_2 emissions, we looked at two options: electrical power metering and modeling.

We have electrical power metering installed at several Intel data centers; this type of metering offers the advantages of real-time data and precision. However, power metering the entire Intel computing and communication infrastructure would be expensive and would take a significant amount of time to implement.

Modeling provided an alternative option. Although not as accurate as power metering, it is far more practical. We already had a detailed equipment inventory, which was originally developed as an asset management and tracking system. This inventory is capable of providing much of the information a model needs. Although modeling depends on other data systems and assumptions, we also have several power-metered environments that provided validation points for our model as it was developed.

After weighing the pros and cons of each measurement option, we decided on a hybrid approach:

- Model now to quickly establish our overall perspective and "what-if" capabilities.
- Complement this with selective power metering, and validate our model as we learn from the power meters.

Justification for installing power meters is not strictly based on sustainability return on investment (ROI), but is usually aligned with other business needs, like improved manageability of environments such as data centers. In the long term, instrumentation-based data center management is still an integral part of our strategy and will be fundamental to managing the many environments within IT as well as across the enterprise. In the future, we envision taking advantage of instrumentation, where the equipment itself provides meter-like data such as power usage and internal temperatures.

Developing the Model

We began our modeling efforts by asking the question: just what is IT's CO_2 impact? Much has been written about energy production, CO_2 emissions, and which human activities affect the total carbon footprint. From industry literature, it has been estimated that two percent of global CO_2 emissions are the result of information and communications technology (ICT) activities. We did not start from scratch, but adopted these estimating approaches and applied them to our IT ecosystem.

Our Sustainability Baseline Model is based on a detailed inventory of equipment, including:

- Data center facilities
- Servers
- Networks
- Storage
- Clients, such as desktop PCs and laptops
- Printers

Our inventory database tracks how many of each type of device we have and where this equipment is located, down to the room level. As shown in Figure 1, the model uses the inventory information, along with variable inputs, to calculate the power consumption and carbon emission of each type of equipment.

COMMERCIAL TRAVEL METRICS

In addition to IT's direct CO_2 footprint, our team also looked at how IT solutions influence the rest of Intel's behaviors. To this end, we considered the impact of IT's collaboration solutions on Intel's travel footprint and how we can help reduce Intel's commercial travel. We decided to augment IT's direct footprint with a calculation for the carbon emissions based on Intel's commercial travel.

For these calculations, we used guidelines from the World Resources Institute (WRI) and the Greenhouse Gas Protocol (GHG Protocol) to calculate CO_2 related to the distance traveled.

MODEL CALCULATION EXAMPLE

At the core of our model is the assumption that all IT CO_2 emissions are the result of power consumption by IT infrastructure. To calculate the CO_2 footprint of a particular energy-consuming device in metric tons, we used the inventory—how many of a particular device we have—plus the kilowatt-hours (kWh) per year the equipment consumes. The latter is calculated by multiplying the power requirements of the equipment by the length of time the equipment is running, as illustrated by the following equation:

$$\text{Energy Usage} = \text{Power Draw} \times \text{Time Powered On per Year}$$

The model uses multiple assumptions that allow us to re-create results (scenarios)

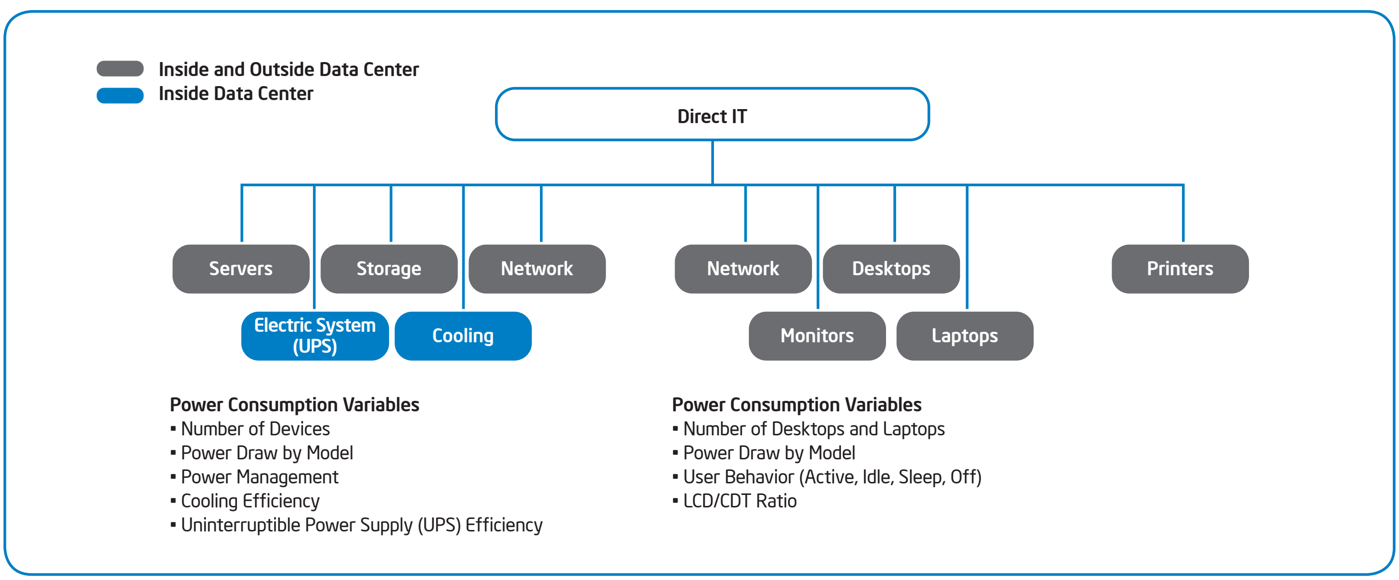

Figure 1. Many types of devices contribute to Intel IT's direct carbon footprint.

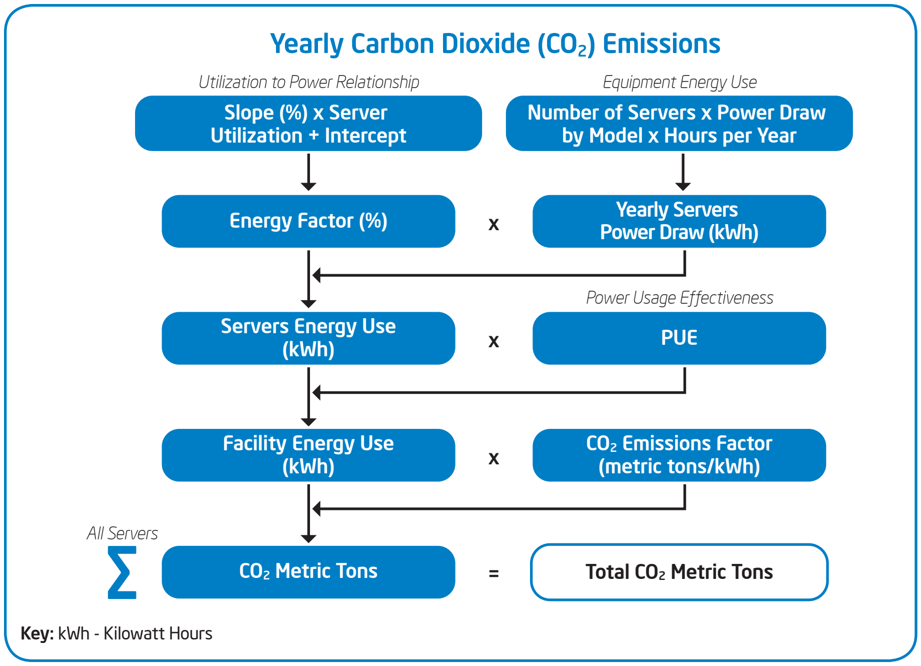

Figure 2. Using inputs and assumptions, our model can accurately calculate the carbon footprint for servers in a facility.

based on critical variables. Here are some examples of assumptions:

- Average number of working days in the year
- Power draw by model
- Average server utilization by type of usage, such as batch or interactive
- Average data center power usage effectiveness (PUE) values
- CO_2 per kWh
- CO_2 emission per passenger mile

The model uses actual data when it exists; otherwise the model uses Intel default values. For example, we have actual PUE values for some data centers. For those data centers for which we do not have a calculated PUE value, the model uses an Intel default value that is based on a calculated average from power-metered data centers.

Figure 2 shows a sample flow that calculates the yearly CO_2 emissions for servers at a facility. By using assumptions and inputs, the model can calculate the total server power draw; then it uses the data center's PUE rating to calculate the total server energy use in kWh. By multiplying the resulting figure by the metric tons of CO_2 produced by one kWh, the equation yields the servers' total yearly CO_2 emissions at that facility.

Similarly, the model can estimate the carbon footprint for storage, network, clients, printers, and commercial transportation components.

Validating the Model

One of the most important steps in modeling is validation. This provides confidence in the model and in the results. We validated our model, comparing its results against several existing data sources. These included:

- Electrical power metering from several data centers
- Uninterruptible power supply (UPS) readings
- Lab benchmarks for desktops, laptops, and server utilization

Data center power metering provided checkpoints on PUE calculations, while periodic UPS readings provided data on power usage. Because Intel's desktops and laptops all follow standard configurations, we could easily test these configurations in a lab by placing an electrical meter on the machine, and then extrapolate across the entire fleet.

Our validation process identified some weaknesses in the model that we were then able to correct. For example, we identified a significant mismatch for a few data centers that led us to realize we were not quantifying storage power footprints correctly.

Using the Model

We have learned that about eight percent of Intel's overall CO_2 footprint is due to ICT equipment. We used the model to analyze our direct IT carbon footprint—considering both where equipment is housed and differing equipment types, as shown in Figure 3. The equipment-type analysis allowed us to categorize our equipment into segments that we can evaluate for potential savings by spawning improvement initiatives.

The resulting information from our model helped set our sustainability direction and leverage points. For example, focusing on our data center power and cooling efficiency and proliferating improvements across Intel data centers can reduce our carbon emissions significantly; and, since the majority of our carbon emissions are generated by servers, regularly refreshing servers, consolidating applications to common platforms, and turning off unused systems could have the greatest benefits.

Through an iterative process, we used the model to help build an IT roadmap as covered in the next section.

Another component of our strategy is to integrate sustainability thinking into our decision making process. Once we had the model, we were able to enhance IT's finance ROI templates by adding relative CO_2 ROI calculations that allow business decision makers to weigh sustainability value as an intangible factor.

Building the Roadmap

We developed a long-term eco-technology roadmap to guide our IT sustainability efforts and help achieve our goal of reducing 2009 carbon emissions by five percent. We first obtained management commitment toward our goal and then established cross-functional teams from across the IT organization, with representatives from key technology domains.

Using the sustainability model to guide our roadmap development, we targeted high-impact business areas. As was shown in Figure 3, IT's carbon footprint breakdown is as follows:

- **70 percent from data centers.** Intel's data centers play a key role in supporting Intel's new technology development. Intel design teams work in parallel around the globe to deliver coordinated technology advances.
- **24 percent from computing and ICT equipment located outside data centers and labs.** Intel is a global company with many sites across the world, and ICT equipment plays a critical role in connecting Intel's workforce.
- **6 percent from client computing.** Intel's client footprint is quite low due to widespread adoption of notebooks across the enterprise; more than 80 percent of Intel's workforce uses low-energy notebooks and monitors.

These three areas provide the highest impact in terms of sustainability benefits and cost considerations.

For each focus area, teams identified energy saving projects aligned to our phased roadmap approach and used what-if analyses to calculate the carbon footprint reduction for each project on a quarterly basis.

Figure 4 illustrates our three-phase sustainability roadmap.

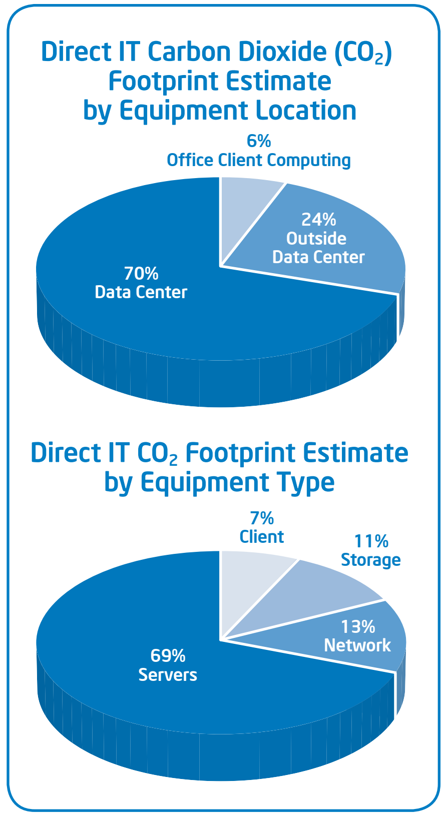

Figure 3. Our model determined that our carbon emissions vary by equipment location and equipment type.

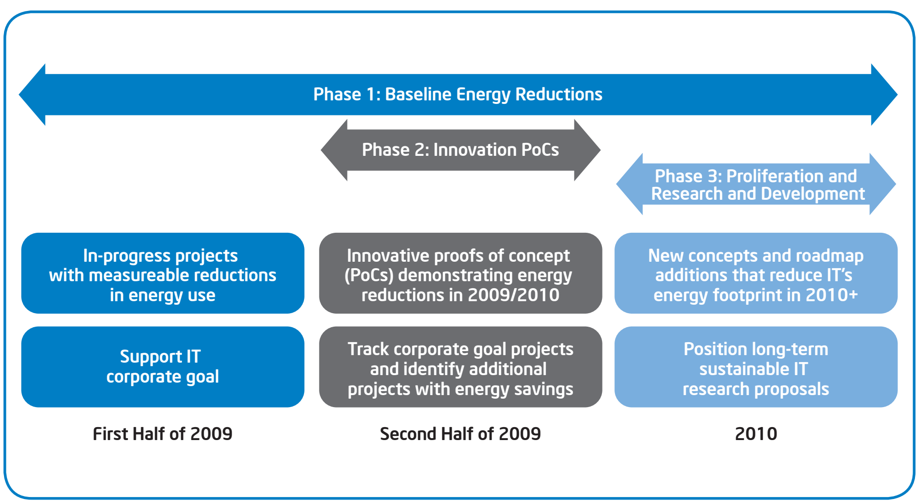

Figure 4. Our three-phase roadmap enables a holistic approach to sustainability, progressing from baseline projects to innovative solutions and strategic research and development.

The roadmap incorporates both footprint reduction and avoidance projects:

- **Footprint reduction.** Projects that reduce kWh consumption and thus reduce the CO_2 footprint. For example, refreshing servers can reduce energy consumption through efficiency and consolidation.
- **Avoidance.** Projects to keep the CO_2 footprint from escalating. For example, virtualization results in more effective utilization of the existing server infrastructure, thereby providing more compute capacity without increasing the number of servers. This can help avoid server purchase and new data center construction, which avoids increasing power consumption.

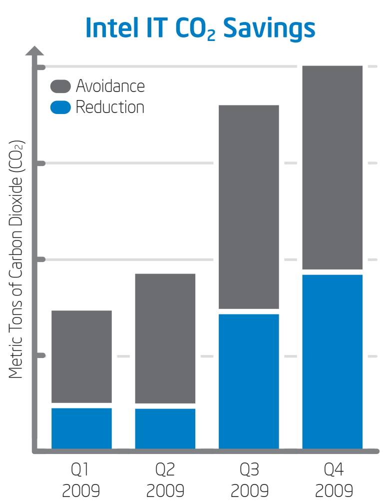

Figure 5. Total carbon footprint reduction and avoidance projects have resulted in a significant CO_2 reduction in 2009. Results for Q1 and Q2 are actuals; Q3 and Q4 are validated forecasts.

PHASE 1: BASELINE ENERGY REDUCTION

Phase 1 of our roadmap focuses on baseline sustainability projects with measurable energy reductions in 2009 and beyond, such as server refresh, data center PUE, and virtualization. Many of these projects were already in progress; in most cases they had been undertaken for cost-reduction purposes.

The main role of the model during Phase 1 is to quantify and help highlight the sustainability impact to the project owners; we are using it as a reward system.

PHASES 2 AND 3: INNOVATION PROOFS OF CONCEPT AND R&D PROLIFERATION

Phase 2 will feature innovative proofs of concept that can demonstrate further energy reductions through 2010; we will track current projects and identify new projects with energy savings. During this phase, we will continue to track our progress toward baseline energy reduction; however, the primary focus will shift to innovative energy-reduction proofs of concept and identifying strategic research programs. The focus will also shift toward identifying opportunities outside of IT where IT solutions can help reduce Intel's overall energy footprint in areas such as office buildings and factories.

Phase 3 will involve proliferation and research and development (R&D), where we'll explore new concepts and roadmap additions beyond 2010. Part of this phase will include developing a long-term sustainability research strategy.

Results

We have generated an active project list for Phase 1. Figure 5 shows these projects' CO_2 impacts for 2009. Numbers for the first and second quarters of the year are actuals, while the third and fourth quarters are projections. The figure includes both carbon footprint reduction and avoidance projects.

FINANCIAL DATA

We added a finance component to the model so we could calculate the net financial impact of potential changes in the IT environment, thereby integrating sustainability into our decision making process. For example, the model helped us calculate the effect of refreshing 1,000 older servers with 300 newer models. In this scenario, the model predicted we could double our compute capacity as well as reduce our CO_2 footprint by about 1,400 metric tons annually. We could also demonstrate a significant savings per year in electricity costs.

MANAGING THE ROADMAP

For each active project, we track the status of its CO_2 emissions. This allows us to view the forecast and actual CO_2 measurements as the year progresses, to help ensure projects are meeting their goals. Some projects may be ahead of their forecast and some may be behind. Analyzing this data helps us identify data discrepancies, potentially remove barriers, and understand end-to-end processes.

Figure 6 shows an example of how we track projects that reduce CO_2.

PROJECT EXAMPLE: SERVER REFRESH

Server refresh projects offer one of the most significant opportunities for CO_2 reduction; currently we have multiple server refresh projects as part of Phase 1.

Intel IT has established a server refresh cadence across our design computing environment. We continue to execute our strategy to refresh aging servers in 2009 with new servers based on Intel® Xeon® processor 5500 series. When replacing older servers, we have found we can achieve consolidation ratios ranging from 7:1 to 13:1 depending on the workload and other factors, while substantially reducing energy consumption.[2]

2 See "Realizing Data Center Savings with an Accelerated Server Refresh Strategy." Intel Corporation, July 2009.

Project Name	Projected Impact (Metric Tons of CO_2)	Actual Impact (Metric Tons of CO_2)	Status
Data Center			
Project 1	xx	xx	On-Track
Project 2	xx	xx	At Risk
Project 3	xx	xx	On-Track
Office			
Project 4	xx	xx	On-Track
Project 5	xx	xx	Behind
Lab			
Project 6	xx	xx	At Risk
Project 7	xx	xx	On-Track
Total	**xx**	**xx**	

Status Key: On-Track; At Risk; Behind

Figure 6. Tracking each project enables us to identify data discrepancies, potentially remove barriers, and understand end-to-end processes.

NEXT STEPS

We plan to execute the phases of our roadmap in parallel. Our focus in 2009 has been on implementing Phase 1; however, we are also beginning to engage in Phase 2 activity and expect to establish Phase 3 strategy by early 2010. Executing the roadmap will be an ongoing process, as we continue to balance our sustainability efforts with business demands and improve our model so we can measure the effects of changes we make to technology and business processes.

As we fine-tune our model and roadmap we will address other important activities:

- Model. We will perform more data analysis to identify specific areas of high energy consumption for various Intel sites by country and by individual data center, campus, and building. This way, we can choose projects that provide the most benefit.
- Roadmap. We will continue to deliver a pipeline of technology solutions to reduce Intel IT's carbon footprint and collaborate with internal business stakeholders to identify opportunities where IT technologies can play a role in reducing Intel's overall carbon footprint. We will also continue to work with internal and external research teams to identify and deliver innovative energy reduction solutions.

Using the Data to Affect Decision Making and Culture

The data our model provides is not useful unless we apply the model as a business tool to accelerate and guide our decision making process. For example, we can use the model to perform additional what-if analyses to determine how certain decisions will affect our carbon footprint.

Although Figure 3 indicated that client computing is responsible for a relatively low carbon emission percentage, that percentage is quite tangible, because almost every Intel employee connects with a PC on a daily basis. We decided to consider this fact in developing our roadmap, and along with attempting to reduce client energy consumption through power management and deployment of solid-state drives (SSDs), we will also use client computing to create awareness, encourage change, and stimulate employee involvement.

Tracking Our Progress

We need to be able to measure the progress and success of the initiatives we pursue to help ensure they can be implemented and tracked at Intel sites around the world. We also need to be able to quantify the results of each project, and we will continue to investigate the challenge of managing the sustainability roadmap across the organization.

Eco-Technology Innovation and Research

In support of our commitment to energy reduction and to developing a pipeline of energy reduction projects, we collaborate internally with the Intel strategic research team (Intel Labs) and product groups to seed next-generation energy reduction projects and early adoption of new Intel® products.

We also collaborate externally with universities and research consortia through a number of research programs such as the European Union's Seventh Framework Programme (FP7). Our research strategy spans direct IT energy reduction plus IT-enabling energy reduction opportunities.

Working with Regulatory Entities and Industry Consortia

The challenges of energy security and climate change have led governments to address these problems. This has resulted in an increasing number of sustainability-related regulations across the globe. Some of these regulations mandate that facilities drawing power above a specific threshold report on energy usage. Our model can support the reporting needs required by specific scenarios.

CONCLUSION

Our Sustainability Baseline Model was an important first step in managing our CO_2 footprint, because it enabled us to define a baseline and the key variables that affect that footprint. The model also allows us to measure our improvements in CO_2 emission reduction and provides a means by which to evaluate future technology and process changes.

Combined with the sustainability model, our three-phase roadmap enables us to:

- Reduce power consumption.
- Develop innovative sustainable solutions.
- Empower sustainability.
- Share our best-known methods within Intel and with the industry.

By setting challenging goals, building cross-functional teams, and developing a focused sustainability roadmap, we are well prepared to meet our sustainability goals.

CONTRIBUTORS

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CO_2	carbon dioxide
FP7	Seventh Framework Programme
GHG	greenhouse gas
ICT	information and communications technology
kWh	kilowatt-hour
PUE	power usage effectiveness
R&D	research and development
ROI	return on investment
SSD	solid-state drive
UPS	uninterruptible power supply
WRI	World Resources Institute

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