Green ICT toward Low Carbon Society
- Green R&D Activities in NTT -

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NTT Energy and Environment Systems Laboratories

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1. ICT & Climate Change

2. NTT Group Vision toward Reducing Environmental Impact
   - The new Green Vision 2020

3. NTT R&D Toward Reducing Environmental Impact
   3.1 Overview
   3.2 Green of ICT
   3.3 Green by ICT
   3.4 Future-Oriented Initiatives

4. Conclusion
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Global Warming Issues and ICT

Improved energy efficiency
- ITS (Intensive control of ETC, VICS, and traffic lights)
- BEMS (Building energy management system)
- HEMS (Household energy management system)

Reduced movement of people and products
- Online shopping, online trading
- Telework, TV conferencing
- Music, video, and software distribution
- e-applications (tax declarations, online receipts)

Improved efficiency of production and consumption
- Supply chain management
- e-publication and distribution
- Paperless office
- Radar for measuring CO2
- Sensing network
- Global simulator

Environmental measurements and predictions
- Online shopping, online trading
- Telework, TV conferencing
- Music, video, and software distribution
- e-applications (tax declarations, online receipts)

Contribute to tackling global warming issues by promoting wider use of ICT

The need (possibility) to decouple GDP and environmental load

"Information and communication technology is mankind's first technology in which increased benefits are not proportional to the consumption of resources and energy."

(Professor Emeritus Yoshio Tsukio)
The IT (ICT) sector accounts for approximately 2% of emissions and contributes to reductions in the other sectors that account for 98% of all emissions.

The IT (ICT) sector is drawing attention from its own energy savings (of ICT) and from its contribution to CO₂ reductions in society (by ICT).
World CO₂ emissions
- Percentage of emissions by country -

- China: 20.6%
- United States: 21.1%
- Germany: 4.6%
- India: 5.7%
- Russia: 3.0%
- Japan: 4.5%
- Canada: 2.7%
- Brazil: 1.9%
- Mexico: 1.6%
- UK: 1.6%
- others: 28.8%

2006
27.3 billion tons
Carbon dioxide (CO₂) equivalent

Non-energy sources
(CH₄, etc.)

Around 45 billion tons

Energy sources
(fossil fuel)

2006
27.3 billion tons

2020

2050

50% Reduction

Amount that must be reduced

7.8 billion tons*
(15% of the global total)

*GeSi: from SMART2020. The effect from telecommuting, teleconferencing, electronic paper, electronic transactions eliminating materials, and movement reduction, a 6% reduction is achieved.

Created from GeSi SMART2020, IPCC materials

From the Japan Center for Climate Change Actions Web site (http://www.jcca.org)

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Estimate of reductions in CO$_2$ Emissions by utilization of ICT in Japan (MIC’s estimation)

- **Green by ICT**
  ICT can potentially reduce CO$_2$ emissions by up to 155 million tons in 2020. This is equivalent to a 12.3% reduction in total emissions relative to 1990 levels in JAPAN.

- **Green of ICT**
  In terms of the amount of CO$_2$ generated by ICT equipment, new strategies are expected to reduce CO$_2$ emissions to around 30 million tons, roughly equivalent to CO$_2$ emissions in 2012.

**Source:** Task Force for ICT Policy in a Global Age, MIC (2016)
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The NTT Group will continue to leverage ICT and the combined talents of its workforce to contribute to the sustainable development of society. We intend to focus our efforts for the environment up to 2020 particularly on the three themes of creating a low carbon society, implementing closed loop recycling, and conserving biodiversity, and will drive those efforts through the three approaches of “Green of ICT”, “Green by ICT”, and “Green with Team NTT”. 
The NTT Group established its NTT Global Environment Charter in 1991, and has long worked to protect the environment. We later set targets to be achieved by fiscal 2011 under our NTT Group Principal Activity Plan Targets and NTT Group Vision for Environmental Contribution. Now that we have achieved all of those targets, we have added the conservation of biodiversity to the basic policies of our NTT Group Global Environmental Charter, and have drawn up a new vision to guide our environmental activities up to fiscal 2021.

**NTT Group Global Environmental Charter**

**Basic principle**
To ensure the harmonious co-existence of people with nature and to achieve sustainable growth, we will do our utmost to protect the global environment in all our corporate activities.

**Basic policies**

1. Compliance with laws and regulations and fulfillment of social responsibilities
2. Reducing environmental loads
3. Establishing and maintaining environmental management systems
4. Developing environmental technologies
5. Social contribution efforts
6. Disclosure of environmental information
7. Conservation of biodiversity (added in fiscal 2011)
Three approaches

**OF**
Green of ICT
Caring for the environment in our business activities

**BY**
Green by ICT
Reducing environmental impacts across society through products and services

**WITH**
Green WITH Team NTT
Protecting the environment together with our employees, their families, and local communities

Conserving biodiversity
Pursuing activities that conserve biodiversity

Creating a low carbon society
Reducing both our own and society’s CO₂ emissions

Implementing closed loop recycling
Efforts to achieve zero emissions

THE GREEN VISION 2020
Creating a low carbon society with green of/ by ICT

- Using the Federation of Electric Power Companies of Japan’s 0.33 kg/kWh as the emission coefficient for setting the fiscal 2021 target
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Power saving through network integration

Network integration by NGN (Next Generation Network)

Source: NTT R&D Initiatives to Reduce Environmental Impact
February 22, 2011
Nippon Telegraph and Telephone Corporation

http://www.ntt.co.jp/prislab/greenrd/index.html

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Low-Power Access Network Equipment

Comparison of earlier ONU (L) and most recent ONU (R)

PHY chip
Physical layer chip for UNI connection

PON chip
Implements basic functionality of G-EPON ONU

Optical module (optical BIDI)
Transceiver module for optical signals

Memory
FPGA and other peripheral chips

AC adapter

GE-PON ONU configuration example

Comparison of earlier ONU (L) and most recent ONU (R)
Power-Efficient Schemes

Hybrid scheme

ONU start-up mode

- 1 G link
- Adaptive link-rate function
- 10 G link

Sleep function

ONU sleep mode

- Unused functions suspended

Start-up mode or sleep mode

Control protocol

1 G link or 10 G link

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Power Savings Through High-Speed Large-Capacity Transport Technology

Increased speed and capacity of optical transport

Point-to-point WDM
Ring NW
Optical 10G ring
Electronic 10G ring

10G multi-ring

Now Mid-term Long-term Time

Exploiting optical characteristics

10G
40G
100G

100T NW

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Technologies for Improving the Energy Efficiency of AWG Multiplexers for Wavelength Division Multiplexing

Array waveguide diffraction grating

AWG demultiplexer without temperature adjustment heater

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Approach to environmentally-aware data center

Solar power systems
- Utilize clean energy to minimize environmental impact of data centers

High-voltage DC power supply
- Develop and deploy high-voltage DC power supply system with low conversion loss

Data center business featuring the latest energy saving technology

Environmentally friendly data centers

High efficiency air cooling technology
- Deploy air cooling technology offering optimal efficiency through analysis

Linked control of ICT devices and air conditioning
- Linked control for standardization of workloads among ICT devices and temperature settings of air conditioners

Virtual technology
- Utilize virtual technology to share IT device resources, reducing number of devices

http://www.ntt.co.jp/ir/events_e/results/2009/090513e.pdf
Power reduction using CBoC (example)

Daytime: 500 W \times 3 \text{ servers} = 1500 \text{ W}

Nighttime: 500 W \times 2 \text{ servers} = 1000 \text{ W}

* Reduction results vary depending on the impact characteristics and the temporal impact fluctuation characteristics of the aggregated system.

Dynamic control

Power turned off at night

Operation using two servers during low-demand nighttime periods.
Technology overview of R&D topics related to reducing CO$_2$ emissions

**Energy-saving**
- HVDC
- Smart grid, smart houses
- Energy-saving systems
- Air-con, etc.

**Clean energy**
- Fuel cell
- Novel battery
- High efficiency solar
- Hydrogen etc.

**CO$_2$ reuse**
- Chemical fixation
- Biofixation, etc.

High-efficiency photovoltaics

Energy savings devices

Air-conditioning systems

Fuel cell

CO$_2$ reuse

Novel battery

Energy offset

Smart grid

Smart house

In-house DC distribution

High-efficiency photovoltaics

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Approach for reducing power consumption based on DC power supply

- HVDC does not require as many power conversion steps with high system effectiveness.
- HVDC lowers drain and reduces facility cost.

**Alternate current (AC)**

1. AC/DC
2. DC/AC
3. DC/AC
4. AC/DC

Battery

- ICT equipment

**Direct current (48-V type)**

1. AC/DC
2. DC/DC

Battery

- ICT equipment

**High-voltage direct current (HVDC)**

1. AC/DC
2. DC/DC

Battery

- ICT equipment

- Decreases the number of steps required for power conversion
- Fuel cells

- Thinner cables
- Improved installation flexibility

- 15% CO2 reduction
- Around 50% Cable-size reduction

Rectifier

Approx. DC400 V

DC48 V

AC100 V to 200 V
Advantages of DC power supply system

Rectifier — Current distribution device

Using high voltage results in thinner cable wires, which improves workability.

Current distribution device — ICT device

Using high voltage enables efficient use of space.

For DC 48-V rectifier

For HVDC rectifier

DC 48-V power supply (Left)

HVDC power supply (Right)

AC 200 V

3-phase transformer

DC 400-V grade

Storage battery

CBOX

ICT device

1 rack

2 racks

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Advantages to on-premise DC power supply system

- CO₂ reduction effect (over 10%) based on household DC power supply
- Backup during power outage

AC power supply system configuration

DC power supply system configuration

Research topics
- Filter technology (Lightning, EMC)
- DC power supply lines and communications technology
- Control protocol
- Standardization of voltage and connectors
LCA (Life Cycle Assessment) is a method of calculating the environmental load across all processes from procurement of raw materials for a product or service to its use and disposal.

Environmental contributions are quantitatively assessed using LCA*. A diagram illustrates the life cycle of a product, including stages such as collection of resources, production of the product, use, and disposal. The diagram also highlights contributions to natural resources, energy, water pollutants, and air pollutants.

* LCA (Life Cycle Assessment) is a method of calculating the environmental load across all processes from procurement of raw materials for a product or service to its use and disposal.
Results of Environmental Impact Evaluation - IP Network -

Disposal/recycling

Use

Production

Recovery by recycling

CO₂ emissions [kg-CO₂/year/subscriber]

-20.0

-10.0

0.0

10.0

20.0

30.0

40.0

50.0

60.0

70.0

80.0

90.0

100.0

110.0

120.0

Lan switch

Router

LAN switch

DSLAM

OLT

Access network equipment

Subscriber station

Transfer facility

Metallic cable

Optical cable

DSLAM: Digital Subscriber Line

DSU: Digital Service Unit

ONU: Optical Network Unit

ADSL: Asymmetric Digital Subscriber Line

OLT: Optical Line Terminal

DSU: Digital Service Unit

ONU: Optical Network Unit

ADSL: Asymmetric Digital Subscriber Line

FLET'S ISDN

FLET'S ADSL

FLET'S ADSL

FLET'S

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Communications Equipment and Facility Resource Savings

Fig. Telecom infrastructure: typical outdoor plant equipment

Table: Representative R&D projects that promise to have resource-saving effect

<table>
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<th>Resource-saving effect</th>
<th>Technology</th>
<th>Overview</th>
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<td>Curb use of resources by extending service life, new repair</td>
<td>Cable conduit repair</td>
<td>Save resources with new maintenance method</td>
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<td>technologies</td>
<td>Bridge conduit repair</td>
<td>Save resources through development of high-performance conduit</td>
</tr>
<tr>
<td>Telephone pole design</td>
<td>Save resources through design optimization</td>
<td></td>
</tr>
<tr>
<td>Low-VOC anti-corrosion paints for radio towers</td>
<td>Save resources by extending service life using high-performance heavy-duty anti-corrosion paints</td>
<td></td>
</tr>
<tr>
<td>Curb use of resources by making equipment denser, more</td>
<td>Compact housing for optical splitter</td>
<td>Save resources through more compact implementation</td>
</tr>
<tr>
<td>compact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curb use of resources by creating new methods</td>
<td>Optical media network maintenance and operations</td>
<td>Save energy by not having to send out maintenance personnel</td>
</tr>
<tr>
<td></td>
<td>support system</td>
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<tr>
<td></td>
<td>Optical cable configuration design</td>
<td>Save resources through better design of optical cable configurations</td>
</tr>
<tr>
<td></td>
<td>Photonic crystal fiber</td>
<td>Save resource through creation of new materials</td>
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Eliminates unnecessary movement of people and materials

There used to be a need to take the trouble to go somewhere, but now you can always be together.

Digitization of materials

You used to be buried under a mountain of CDs, but now you can download any song you want anytime.

More efficient usage of space

You used to struggle with order and return processing, but now product management can be processed from one terminal.

NTT Group Environmental Protection Activity Report 2001
To revolutionize lifestyles and move toward a low-carbon society, quantification and visibility of ICT effects on environmental impact reduction are important issues.

- Determine environmental impact assessment range
- Reduction effect calculation methodology, etc.

### Standardization allowing international comparison and objectivity in ITU-T

**Reduction volume** = energy reduced per person per kilometer (J) x reduced movement distance x reduced number of persons transported x Work efficiency (human workload, etc.)

**Reduction volume** = Energy consumption unit per sq. meter of office space x sq. meters of space used per person x amount of work made efficient (people/year)
### Eight Effects of Reducing Energy Consumption Based on Using ICT

<table>
<thead>
<tr>
<th>Item</th>
<th>Content</th>
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</thead>
<tbody>
<tr>
<td>Consumption of goods</td>
<td>By reducing the consumption of goods (e.g. paper), it is possible to reduce the energy consumption involved with production and disposal and to reduce waste emissions.</td>
</tr>
<tr>
<td>Electric power/energy consumption</td>
<td>By improving the efficiency of electric power and energy use and reducing consumption, it is possible to reduce the energy consumption involved with electricity generation and supply.</td>
</tr>
<tr>
<td>Movement of people</td>
<td>By reducing the movement of people, it is possible to reduce the energy consumption needed for methods of transportation.</td>
</tr>
<tr>
<td>Movement of goods</td>
<td>By reducing the movement of goods, it is possible to reduce the energy consumption needed for transportation methods.</td>
</tr>
<tr>
<td>Office space efficiency</td>
<td>By using office space more efficiently, it is possible to reduce the electricity consumption of lighting and air-conditioning and to reduce energy consumption.</td>
</tr>
<tr>
<td>Storage of goods</td>
<td>By reducing the storage space of goods, it is possible to reduce the electricity consumption involved with lighting and air-conditioning and to reduce energy consumption.</td>
</tr>
<tr>
<td>Business efficiency</td>
<td>By improving business efficiency, it is possible to reduce resource and energy consumption.</td>
</tr>
<tr>
<td>Waste material</td>
<td>By reducing waste emissions, it is possible to conserve the environment and reduce the energy consumption needed to dispose of waste.</td>
</tr>
</tbody>
</table>

#### Example of effective online shopping

- **No movement of people through product return/negotiation**
- **No movement of people through product return/negotiation**
- **No movement of people through comparing/purchasing products**
- **Decrease unnecessary production**
- **Reduce intermediate distribution**
- **Reduce retail sales**
- **Reduce movement of consumers**

**Direct from manufacturer** (e.g., computer, vehicle)
Environmental Impact Assessment System for ICT Services

Assesses environmental load in terms of CO₂ emission

Estimates CO₂ emission for entire lifecycle from production to use and disposal

Can be used to publicize how ICT services can reduce environmental impact.

ICT service (videoconference)

Input network used and conference duration

Assumptions:
12 conferences are held between Tokyo and Osaka a year.
The transport used for face-to-face conference is by "Shinkansen" (bullet train).
Number of persons traveling: 2  Conference duration: 2 hours

Reduction in CO₂ emission: 35%

Conventional means (trip to conference)

Calculate CO₂ emission due to terminals and network

Input travel distance

Calculate CO₂ emission due to transportation systems

Reduction in environmental impact using videoconference
Environmental impact assessment of broadband and ubiquitous services

19 services by B FLET'S (FTTH) and FOMA (3G)
e.g., Web browsing, music download, e-mail

Conventional means, such as purchase of journals and CDs, and posting of letters

Comparison in CO₂ emission

- Production of journals
- Movement to stores

- Production of paper
- Movement to post
- Delivering of letters
- Production of CDs
- Movement to stores

Power consumed by network facilities and in their manufacture

Power consumed by terminals and in their manufacture
Estimated annual CO₂ emission per subscriber line when B FLET’S (FTTH) and FOMA (3G) are used

Conventional means

B FLET’S (FTTH)

46% reduction 93kg-CO₂

79% reduction 120kg-CO₂

Estimated CO₂ emission in kg-CO₂/year
Reduction Potential Effect

Video conference

Energy consumption through the use of ICTs

Conference on a trip

Reduction effect of energy consumption

Reduction Potential Effect

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**NTT’s vision of the Smart Grid**

- **Supply Side Management**
  - Generation
  - Grid Operation
  - Power plant
  - Power distribution
  - Smart community
  - Smart house/building
  - Conventional: One Way Flow of Electricity
  - Smart Grid: Two (N)-way flow of Electricity and Information

- **Demand Side Management**
  - Energy Management/Distributed Energy Resources
  - Smart community
  - Smart house/building

- **Smart grid**
  - Wind power
  - Nuclear power
  - Large-scale solar power
  - Thermal power
  - Power grid
  - Substation
  - Power company
  - Energy network
  - Information network

- **Smart community**
  - IT system
  - Storage batteries
  - Charging station
  - Solar power
  - CGS
  - Fuel cells

- **Smart house/building**
  - Smart building
  - Smart house
  - Charging station

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Safe secure network services

* QoS (CoS) control
  • Priority control: priority transmission of important control signals when disasters occur (gas, power, water outages, etc.)
  • Bandwidth control: priority transmission of important control signals when disasters occur (push delivery of disaster information, weather maps, etc.)
  • Delay, jitter control
* Accommodates various protocols, devices
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Direction of Future Network R&D to Reduce Environmental Impact

Paradigm shift

Network expectations based on new concept

Networks provisioning services that can be customized to the needs of users

/ Scheme for sensing user needs and provisioning custom services
/ Able to support extensive available bandwidth/number of terminals

Available bandwidth: e.g., broadband = video, data center; narrowband = communication between things
Terminal Number: e.g., many = sensor networks, few = high sense of presence

Requirements and challenges of future networks

Nippon Telegraph and Telephone Corporation http://www.ntt.co.jp/islab/greenrd/index.html

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Technologies for More Energy-Efficient Optical Packet Routers

Optical packet router

- Optically clocked transistor array (OCTA)
- Double ring resonator coupled tunable laser diode
- All-optical serial-to-parallel converter
Silicon Photonics

Si-VOA
Ge-PD

8-channel integrated device

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"Ultrasmall Silicon Photonic Devices and Integration Technology Toward Photonic-electronic Convergence"
Highly innovative ultra-low power solutions that will dramatically reduce our energy consumption

Nanomechanical Logic Device

Low-power switching device by controlling spin
("New Journal of Physics, No. 9, 2007, p. 341")
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Direction of R&D in green ICT

**Green of ICT**

- Lower power consumption of ICT equipment (e.g. server, router, terminal device)
  
  Example: Ultra low power device, optical router, sleep mode

- Creation of applicable clean energy in the ICT sector
  
  Example: DC power supply, fuel cell, PV generation, energy network

- Waste recycling in ICT sector
  
  Example: Material recycling, closed recycling

**Green by ICT**

- Contribution by ICT services in reducing society’s energy consumption
  
  Example: E-commerce, video conferencing, paperless office, BEMS, HEMS, smart grid

- Standardization of environment impact assessment methods
Thank you.