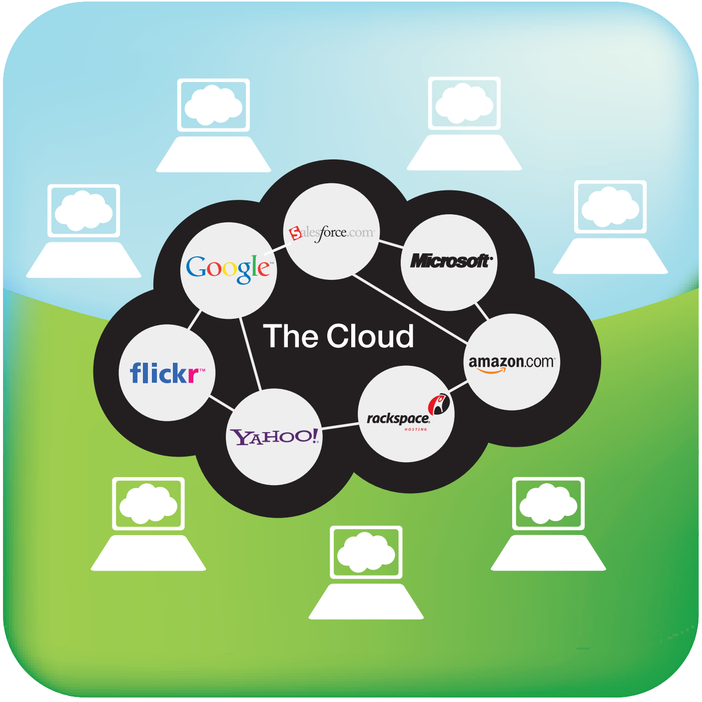
Make IT Green

Cloud Computing and its Contribution to Climate Change

Greenpeace International

GREENPEACE

The announcement of Apple's iPad has been much anticipated by a world with an ever-increasing appetite for mobile computing devices as a way to connect, interact, learn and work. As rumours circulated – first about its existence and then about its capabilities - the iPad received more media attention than any other gadget in recent memory. Apple Chief Executive Officer Steve Jobs finally showcased his company's latest creation before a rapt audience in San Francisco. From their smart phones and netbooks, the crowd feverishly blogged and tweeted real time updates out to a curious world.



Whether you actually want an iPad or not, there is no doubt that it is a harbinger of things to come. The iPad relies upon cloud-based computing to stream video, download music and books, and fetch email. Already, millions access the 'cloud' to make use of online social networks, watch streaming video, check email and create documents, and store thousands of digital photos online on popular web-hosted sites like Flickr and Picasa.

The term cloud, or cloud computing, used as a metaphor for the internet, is based on an infrastructure and business model whereby - rather than being stored on your own device - data, entertainment, news and other products and services are delivered to your device, in real time, from the internet. The creation of the cloud has been a boon both to the companies hosting it and to consumers who now need nothing but a personal computer and internet access to fulfill most of their computing needs.

Google is perhaps the most famous cloud-based company to demonstrate the potential of a cloud platform to drive a hugely successful business model. All of Google's signature products - Gmail, Google Documents and Google Earth - are delivered from the cloud. Its ambitious project to create a digital library will be entirely hosted by servers storing most of the world's published work, all in digitised form.

The cloud is growing at a time when climate change and reducing emissions from energy use is of paramount concern. With the growth of the cloud, however, comes an increasing demand for energy. For all of this content to be delivered to us in real time, virtual mountains of video, pictures and other data must be stored somewhere and be available for almost instantaneous access. That 'somewhere' is data centres - massive storage facilities that consume incredible amounts of energy.

But decisions about how the cloud will be built out are being made by business leaders primarily concerned with quarterly profit statements and earnings for shareholders.

Facebook vs. Yahoo

For example, in January 2010, Facebook commissioned a new data centre in Oregon and committed to a power service provider agreement with PacificCorp, a utility that gets the majority of its energy from coal-fired power stations, the United States' largest source of greenhouse gas emissions. Effectively becoming an industrial-scale consumer of electricity, Facebook now faces the same choices and challenges that other large 'cloud-computing' companies have in building their data centres. With a premium being placed on access to the cheapest electricity available on the grid. In many countries, this means dirty coal.

All the same, other companies have made better decisions for siting some of their data centres. Yahoo!, for instance, chose to build a data centre outside Buffalo, New York, that is powered by energy from a hydroelectric power plant - dramatically decreasing its carbon footprint. Google Energy, a subsidiary of cloud leader Google, applied and was recently approved as a regulated wholesale buyer and seller of electricity in the United States, giving it greater flexibility as to where it buys its electricity to power its data centres.

Brown cloud or green cloud?

Ultimately, if cloud providers want to provide a truly green and renewable cloud, they must use their power and influence to not only drive investments near renewable energy sources, but also become involved in setting the policies that will drive rapid deployment of renewable electricity generation economy-wide, and place greater R&D into storage devices that will deliver electricity from renewable sources 24/7. (See page 11 for prescriptive policy recommendations for IT companies.)

If we hope to phase out dirty sources of energy to address climate change, then - given the massive amounts of electricity needed in order to run computers, provide backup power and coordinate related cooling equipment that even energy-efficient data centres consume - the last thing we need is for more cloud infrastructure to be built in places where it increases demand for dirty coal-fired power. The potential of ICT technologies and cloud computing to drive low-carbon economic growth underscore the importance of building cloud infrastructure in places powered by clean renewable energy. Companies like Facebook, Google, and other large players in the cloud computing market must advocate for policy change at the local, national and international levels to ensure that, as their appetite for energy increases, so does the supply of renewable energy.

"I have always believed that IT is the engine of an efficient economy; it also can drive a greener one"

Michael Dell,
Forbes magazine

How big is the carbon footprint of the Information Technology and Communication sector?

In 2008, The Climate Group and the Global e-Sustainability Initiative (GeSI) issued *SMART 2020: enabling the low carbon economy in the information age*.[i] The study highlighted the significant and rapidly-growing footprint of the ICT industry and predicted that because of the rapid economic expansion in places like India and China, among other causes, demand for ICT services will quadruple by 2020.

SMART 2020 also found that:

- PC ownership will quadruple between 2007 and 2020 to 4 billion devices, and emissions will double over the same period, with laptops overtaking desktops as the main source of global ICT emissions (22%).
- Mobile phone ownership will almost double to nearly 5 billion accounts by 2020, but emissions will only grow by 4%. Broadband uptake will treble to almost 900 million accounts over the same period, with emissions doubling over the entire telecoms infrastructure.

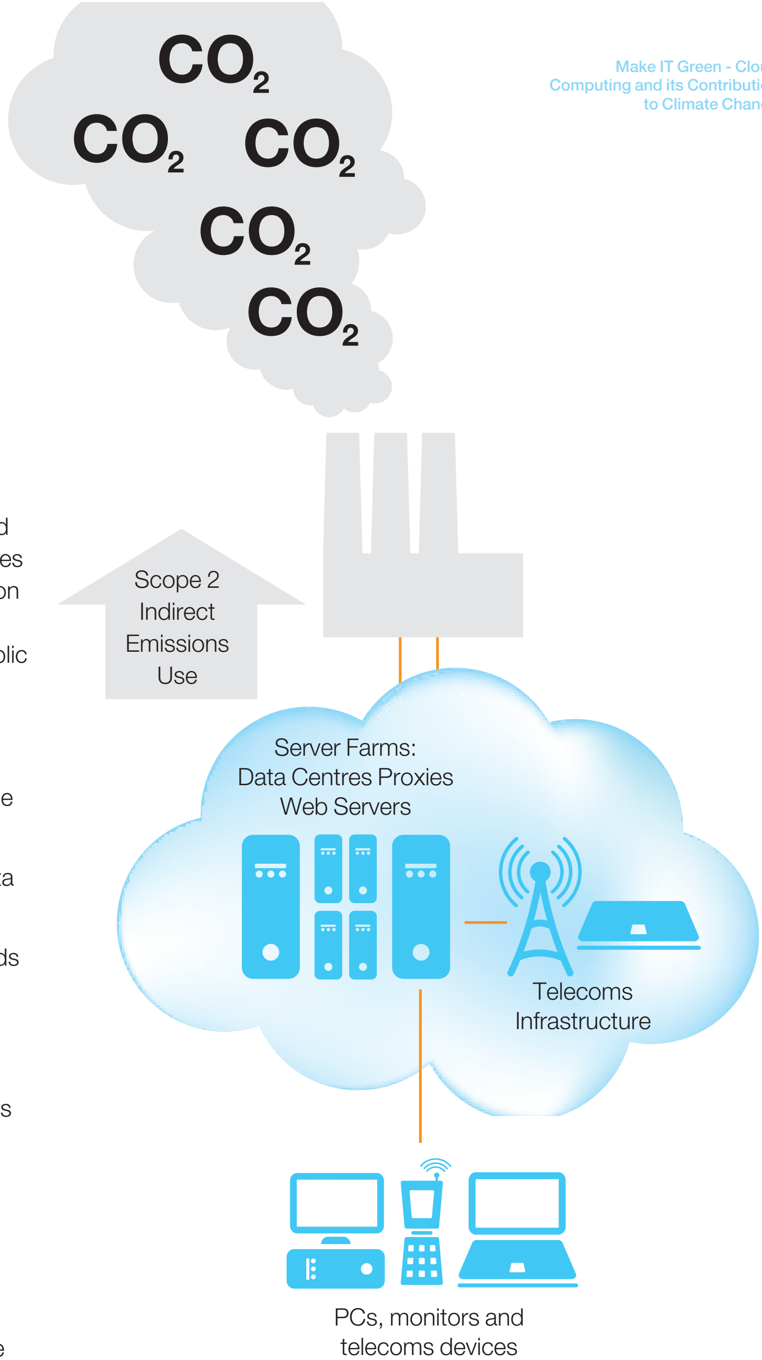
The Smart 2020 study also made a compelling case for ICT's significant potential to deliver climate and energy solutions, estimating that ICT technologies could cut 7.8 $GtCO_2$ of global greenhouse gas emissions by 2020, a 15% reduction over business-as-usual projections. The study posits that innovations from the ICT sector - when combined with increased use of renewable energy - can put the world on a more sustainable path and help keep global temperature increase below the 2°C threshold scientists say is needed to hold off the worst effects of climate change.

	Emissions 2007 ($MtCO_2e$)	Percentage 2007	Emissions 2020 ($MtCO_2e$)	Percentage 2020
World	830	100%	1430	100%
Server farms/Data Centres	116	14%	257	18%
Telecoms Infrastructure and devices	307	37%	358	25%
PCs and peripherals	407	49%	815	57%

$MtCO_2e$ = Metric Tonne Carbon Dioxide Equivalent
$GtCO_2e$ = Gigatonne Carbon Dioxide Equivalent

i Climate Group and the Global e-Sustainability Initiative (GeSI)(2008). SMART 2020: enabling the low carbon economy in the information age. Available at http://www.smart2020.org/_assets/files/03_Smart2020Report_lo_res.pdf

Cloud Computing Growth



2010 has been touted by many in the ICT sector as the 'Year of the Cloud'. While this is likely a prediction that will be repeated in subsequent years, the arrival of the iPad and growth in netbooks and other tablet computers, the launch of Microsoft's Azure cloud services for business, and the launch of the Google phone and the proliferation of mobile cloud applications are compelling signs of a movement towards cloud-based computing within the business sector and public consciousness in a way never seen before.

3 key trends in cloud-based computing

- Continued significant expansion of cloud-based computing despite economic downturn
- Greater attention and growth in deployment of energy-efficient data centres design
- Increased size and scale of data centres being built by major brands

Key questions for cloud-based computing data centre investment

- How big is the cloud in electricity consumption and GHG emissions and how big will it become?
- Where will the cloud be built and what sources of energy will be powering it?
- How may large data centres impact the surrounding load centre's demand for fossil fuels?
- To what extent will efficiency and design improvements reduce the rate of growth?

Powering the cloud - how much will it take?

How much electricity or associated greenhouse gas pollution is currently produced or will be generated to power a much bigger cloud in 10 years? The answer is far from clear, given the rapid growth, and that many major cloud brands refuse to disclose their energy footprint.

The Smart 2020 analysis forecast that the global carbon footprint of the main components of cloud-based computing - data centres and the telecommunications network - would see their emissions grow, on average, 7% and 5% respectively each year between 2002-2020. Underlying this analysis is the number of data centre servers growing on average 9% each year during this period.

Using the global analysis and forecast of the overall ICT emissions footprint in the Smart 2020 Report as a foundation, the following reports seeks to shine a fresh light on the electricity demand of the global cloud, highlighting the scale of the potential demand and importance of where and what sources of electricity are being used to power Facebook, Gmail, and other cloud-based computing platforms. The first of the two adjustments were made to the analysis used in the Smart 2020 Report to disaggregate the projections for growth in the main components of cloud based computing, and place in context of electricity demand and renewable energy supply. The third adjustment incorporates some bottom up analysis of energy demand from data centres in the US, and the scale impact on the size of the overall electricity demand if more accurate estimation of the energy demand and GHG emissions associated with large data centres.To make the data of the report more accessible as an instrument to evaluate the projected impact of the cloud on electricity demand and their relationship to energy policies, the Smart 2020 analysis has been de-aggregated to show overall electricity consumption as outlined below.

2020 ICT Emissions Project

Projections of growth in ICT electricity consumption and GHG emissions by 2020, using 9% annual growth rate estimated in Smart 2020 Report for data centres and recent estimate by Gartner for growth in telecommunications of 9.5% a year.

	Derived electricity consumption	Forecast electricity consumption	Conversion to energy use	Derived electricity emissions
	Billion kWh 2007	Billion kWh 2020	gCO_2e/kWh CAIT e factor	$MtCO_2e$ 2020
Data Centres	330	1,012.02	*526.6*	533
Telecoms	293	951.72	*526.6*	501
Total Cloud	**623**	**1,963.74**		**1034**

Adjustments to Smart 2020 Report

Smart 2020 Adjustment #1:

Scope of Telecoms network reporting

The Smart 2020 Report provides carbon footprint figures in $MtCO_2e$ as a combination of two sources of emissions: indirect emissions from electricity use (scope 2) and indirect emissions from upstream production (scope 3), or embodied carbon. To show electricity or energy use emissions separately, a correction factor [Scope 2/ (Scope 2+3)] will be applied as shown in the table for adjustment #1. This correction factor for Scope 2 is derived from the information provided on global internet footprint in the Smart 2020 Report, which includes PCs in addition to telecoms and data centres.

Adjustment #1--reduction of scope of telecoms network reporting

2007	Total Emissions, $MtCO_2e$	Correction for Scope 2	Derived Electricity Emissions, $MtCO_2e$
Data Centres	116	0.88	102
Telecoms	307	0.88	270
Total Cloud	423		372

Mobile phones accounted for 43% of the carbon footprint of Telecoms. However, to keep the analysis focused on the infrastructure of the cloud and related energy consumption, the energy footprint of mobile phones will be subtracted, as PCs (desktops and laptops) are not counted in this analysis, phones will be also subtracted. The 270 $MtCO_2e$ without mobile phones translates into 154 $MTCO_2$ globally.

Smart 2020 Adjustment #2:

Conversion from emissions to energy

The results available from the Smart 2020 Report are shown as tones of carbon emitted and not in energy units (e.g. electricity consumed kWh). The emission factors used come from McKinsey and Vanttefall Cost Curve, which are not disclosed in the report. Using a publicly-known global factor for the global carbon intensity of electricity production, WRI's CAIT[i], the equivalent electricity consumption is derived as shown in Table 2.

Adjustment #2-Conversion to derived electricity consumption of the global cloud

2007	Derived electricity emissions, $MtCO_2e$	Conversion to energy use, gCO_2e/kWh	Derived Electricity Consumption, Billion kWh
Data Centres	102	526.6	194.2
Telecoms	154	526.6	292.5
Total Cloud	256		486.7

Smart 2020 Adjustment #3:

Top-down vs. bottom-up adjustment for data centre energy consumption

While the Smart 2020 report did a very credible top-down analysis of global data centre consumption, it is important to compare this with a bottom-up approach. Based on the 2007 bottom-up analysis conducted by the US Environmental Protection Agency (US EPA), the estimated electricity consumption of US data centres is 1.7 times larger than the top-down analysis by the Smart 2020 report estimated for the US and Canada combined. If this factor is to be applied to the global electricity consumption in Table 2, the data centres portion would go from the 194.2 to 330 billion kWh and, as consequence, the total cloud energy consumption (data centres plus telecommunications) would be 622.6 billion kWh -; a number that is 1.3 times larger than reported under the Smart 2020 report.

Adjustment #3

2007	Derived electricity consumption, billion kWh	Bottom-up analysis conversion factor	Derived electricity consumption w/bottom conversion
Data Centres	194.2	1.7	330.0
Telecoms	292.5		292.5
Total Cloud	486.7		622.5

Key trends that will impact the environmental footprint of the cloud

Projected regional growth of data centres

Unless cloud data centres are strategically placed to utilise or be co-developed with renewable sources of electricity, the data centre operators are stuck with the same problem everybody has, and having to accept the mix of clean and dirty energy sources that the electric utilities rely upon to feed the grid.

	Emissions 2007 $MtCO_2e$	Percentage 2007	Emissions 2020 $MtCO_2e$	Percentage 2020
World	820	100%	1430	100%
US and Canada	156	19%	215	15%
OECD Europe	115	14%	172	12%
Other developed countries	82	10%	100	7%
Economies in transition	98	12%	143	10%
China	189	23%	415	29%
Rest of the world	180	22%	386	27%

Growth of energy-efficient data centers

More cloud-computing companies are pursuing design and siting strategies that can reduce the energy consumption of their data centres, primarily as a cost containment measure. For most companies, the environmental benefits of green data design are generally of secondary concern.

Facebook's decision to build its own highly-efficient data centre in Oregon that will be substantially powered by coal-fired electricity clearly underscores the relative priority for many cloud companies. Increasing the energy efficiency of its servers and reducing the energy footprint of the infrastructure of data centres are clearly to be commended, but efficiency by itself is not green if you are simply working to maximise output from the cheapest and dirtiest energy source available. The US EPA will soon be expanding its EnergyStar rating system to apply to data centres, but similarly does not factor in the fuel source being used to power the data centre in its rating criteria. Unfortunately, as our collective demand for computing resources increases, even the most efficiently built data centres with the highest utilisation rates serve only to mitigate, rather than eliminate, harmful emissions.

Case Studies of cloud-based expansion

Comparison of significant cloud data centres		Sq Footage	Estimated number of servers	Estimated power usage effectiveness	% of Dirty Energy Generation of local grid	% of Renewable Electricity of local grid
Google	Lenoir, NC	476,000	-	1.21	50.5% Coal 38.7% Nuclear	3.8%
	Dalles, OR	206,000	-	1.2 -	34.4% Coal 3.3% Nuclear	50.9%
	Apple, NC	500,000	-		50.5% Coal 38.7% Nuclear	3.8%
Microsoft	Chicago, IL	700,000	473,000	1.22	72.8% Coal 22.3% Nuclear	1.1%
	San Antonio, TX	470,000	-	1.2	37.1% Coal	11%
Yahoo!	Lockport, NY	190,000	-	1.16	21.0% Coal 27.0% Nuclear	27.7%
	La Vista, NE	350,000	100,000	-	73.5% Coal 14.6% Nuclear	7%

Yahoo! Data Center (Lockport, NY)

Yahoo! is currently building a $150 million US dollar data centre near Buffalo, New York, which will be completed in May 2010. The site was chosen in part due to the low cooling costs expected in the region and the ability to use fresh air cooling, as well as the ready access to low-carbon and low-cost hydro power. The New York Power Authority has approved 10 megawatts of low-cost hydro power for a first phase of construction for a Yahoo! facility. A second phase, expected in the spring of 2012, would receive an additional five megawatts of power.

Apple Computer (North Carolina, US)

Last year, Apple began construction on a $1 billion US dollar data centre in western North Carolina, close to where Google also cited its recent data centre investment. North Carolina's electricity production is high. Coal-fired power plants account for about 60% of the State's electricity generation, while the carbon intensity of the electricity generation in 2005 was 561.4 gCO_2e/kWh.

Cool IT

In the global fight against catastrophic climate change, global greenhouse gas emissions from the energy sector must have peaked by 2015 and returned to current levels by 2020. Greenpeace's Energy [R]evolution Scenario provides a practical blueprint for the world's renewable energy future, and was developed in conjunction with specialists from the Institute of Technical Thermodynamics at the German Aerospace Centre (DLR) and more than 30 scientists and engineers from universities, institutes and the renewable energy industry around the world.[ii]

The report demonstrates how the planet can get from where we are now, to where we need to be. It shows how the world's carbon emissions from the energy and transport sectors alone can peak by 2015 and be cut by over 50% by 2050. The ICT sector holds many of the keys to reaching our climate goals by innovating solutions to mitigate greenhouse gas emissions and increase energy efficiency. Technologies that enable smart grids, zero emissions buildings, and more efficient transport systems are central to efforts to combat climate change.

The ICT sector's abilities to lead and to innovate are the reasons Greenpeace began its Cool IT Campaign in 2009. The campaign uses direct company engagement and public engagement to provide pressure on the ICT industry to put forward solutions to achieve economy-wide greenhouse gas emissions reductions and to be strong advocates for policies that combat climate change and increase the use of renewable energy.

Sub Sectors	Smartgrid	Transportation	Dematerialisation	Buildings	Information Management
Network (IBM Cisco, Fujitsu)	Integration and management of distributed power generation	Congestion pricing and management	Tele-conference	Real-time transfer of information	Facility -level GHG management
	Remote demand management	Smart parking systems	Route planning /Goods management		
		Distributed storage systems			Supply chain management and GHG reporting
Telecom	Wireless grid management		Access to low(er) carbon trans alternatives		Smart meter connectivity
Software (Microsoft, SAP, Google)		Vehicle to grid charging/storage	Meeting Facilitation Software		
	Software for demand response				GHG management dashboards
		Social networking for ride/car sharing	Route planning/ Goods management	Route planning/ Goods management	
Equip Mfgs (HP, Dell, Intel, Ericsson)			Desktop virtualisation	Smart Appliances	
	Demand response integration with IT equipment		E-books, e-music, digital photos, paperless workspace		
	Highly Efficient PCs	3D video conference	Cloud/Virtualisation of servers	Building energy management	

For more information on Cool IT, please visit: www.greenpeace.org/coolit

i World Resource Institute, Climate Analysis Indicators Tool. Carbon intensity of electricity generation for the World is 526.6 and US 543.6 grCO2e/kW. Most recent year available is 2006. http://cait.wri.org/

ii http://www.greenpeace.org/raw/content/international/press/reports/energy-r-evolutionsummary.pdf

Policy recommendations ICT should support

It is clear that as the energy demand of the cloud grows, the supply of renewable energy must also keep pace. Additionally, because of the unique opportunities provided to the ICT sector in a carbon-constrained world, the industry as a whole should be advocating for strong policies that result in economy-wide emissions reductions. Among prime concern is priority grid access for renewable sources of energy. Rules on grid access, transmission and cost sharing are very often inadequate. Legislation must be clear, especially concerning cost distribution and transmission fees. Where necessary, grid extension or reinforcement costs should be borne by the grid operators, and shared between all consumers, because the environmental benefits of renewables are a public good and system operation is a natural monopoly.

Key Principles for climate and energy policy

- Emissions reduction obligations for industrialised countries, as a group, of at least 40% below 1990 levels by 2020, at least three quarters of which need to be met by domestic action.
- Industrialised countries to pay for their emissions permits in order to generate adequate and predictable funding, in the order of at least $140 billion US dollars annually, to support clean energy and other mitigation activities, forest protection and adaptation in developing countries.

A full list of Greenpeace's demands for a fair and legally binding deal are available at http://www.greenpeace.org/raw/content/international/press/reports/copenhagen-greenpeace-demands.pdf

Support real climate action in the United States

The flawed climate bills moving through the US Congress are riddled with giveaways to the coal industry and made hollow by the huge amounts of carbon offsets made available to polluters. Greenpeace is calling on President Obama to support policies to keep global temperatures as far below a 2°C increase as possible, compared to pre-industrial levels, to avert catastrophic climate change by:

- Setting a goal of peaking global emissions by 2015 and be as close to zero as possible by 2050, compared to 1990 levels;
- Cutting emissions in the US by 25% to 40% by 2020, compared to 1990 levels; and
- Joining and encouraging other members of the G8 to establish a funding mechanism that provides $106 billion US dollars a year by 2020 to help developing countries adapt to global warming impacts that are now unavoidable and halt tropical deforestation.

For more information on Greenpeace's demands for President Obama see *Yes He Can -- How President Obama Can Solve the Energy Crisis, Help Reverse Climate Change and Rescue the Economy* at http://www.greenpeace.org/usa/press-center/reports4/yeshecan

GREENPEACE

Greenpeace is an independent global campaigning organisation that acts to change attitudes and behaviour, to protect and conserve the environment and to promote peace.

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