In-Stat

White Paper

Mobile Communications 2008: Green Thinking Beyond TCO Consideration

SKU: IN0804307WHT
Analyst: Kevin Li
Kevin.li@instat.com.cn
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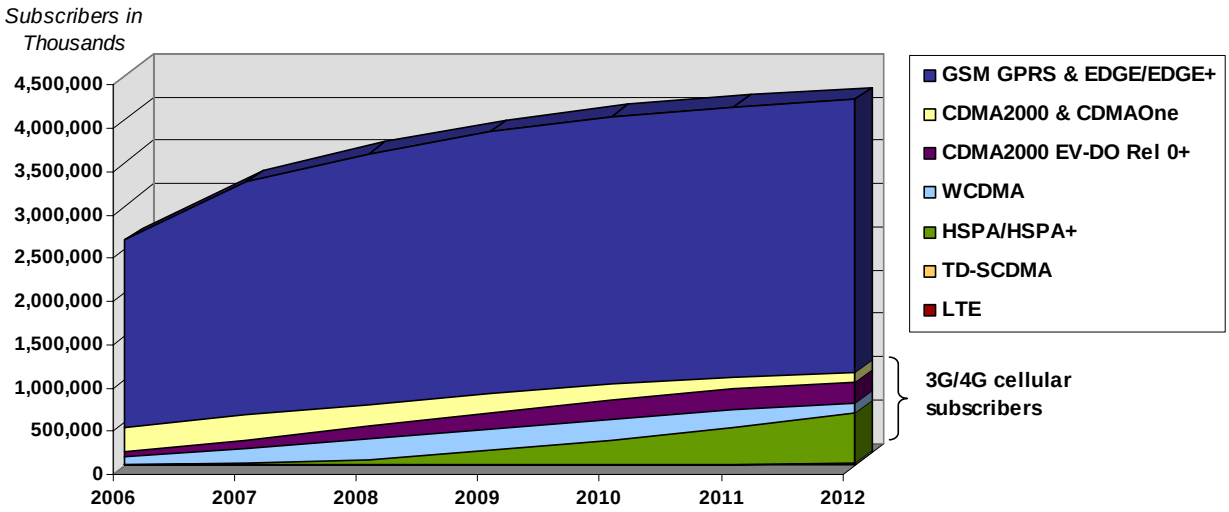
Executive Summary

Mobile communication has experienced impressive growth during the past several years. During 2007, the worldwide mobile subscriber market grew at a rate of 25.9%, from 2.5 to 3.2 billion subscribers. In the next five years, In-Stat predicts that 3G/4G subscribers (i.e., those who subscribe to WCDMA/HSPA, EV-DO, TD-SCDMA, mobile WiMAX, and LTE networks) will grow at a very healthy rate. By the end of 2012, In-Stat expects approximately 965 million 3G/4G subscribers worldwide. However, when assessing the total cellular subscriber market through 2012, 2G technologies are still expected to dominate and will account for over 70% of the worldwide cellular subscriber base as indicated in Figure 1.

Figure 1. Worldwide Mobile Subscriber Forecast 2008–2012



Source: In-Stat, 4/08

In spite of the fact that economy is a primary concern of carriers interested in enlarging their mobile communication networks, green thinking is gaining ground. The need to achieve sustainable development has put increased pressure on governments all over the world, and now governments are looking to telecom operators to decrease power consumption and reduce CO_2 emissions.

Governments and international organizations have taken action to promote green technology:

1) On December 15, 2007, the U.N. (United Nations) Climate Conference agreed on a roadmap for negotiations on a new treaty to combat global warming;

2) On June 4, 2007, China's government launched the National Scheme for Weather Changes, adopting environmental protection as a fundamental goal in its national policy;

3) On March 8, 2007, the European Union promised to decrease its greenhouse gas emissions by 20% by the end of 2010, compared with 1990.

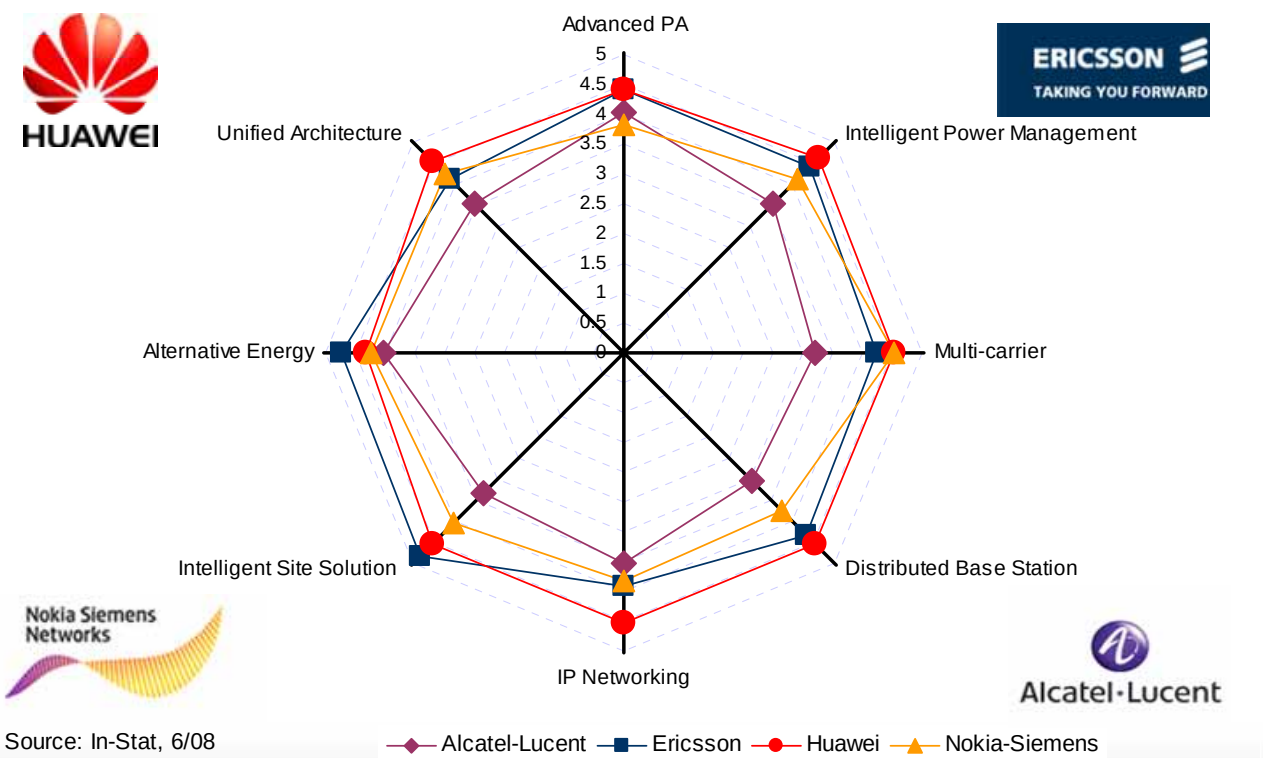
As one important part of the national economy, telecom operators have responded to the governments' requirements on its green policy:

1) T-Mobile has planned detailed approaches to achieve a decrease in power consumption and CO_2 emissions;

2) In 2007, China Mobile has framed a *Green Action Plan* (to be explained in the following chapter), which outlines its efforts during the next three years to save energy and decrease CO_2 emissions.

In-Stat finds that several important technologies like IP connections, distributed systems, advanced PA, and so on, have been employed by equipment vendors to improve the power consumption of base stations. In addition, In-Stat also interviewed some mobile operators to collect their evaluation of four main providers' performance on implementing those green technologies. The average scores are indicated in Figure 2. It's obvious that Huawei holds the advantage on IP networking and distributed base stations. Ericsson has succeeded in adopting intelligent site solutions and alternative energy solutions, while Nokia-Siemens has the advantage on multi-carrier technology.

Figure 2. Capability Comparison Among Different Base Station Vendors



Source: In-Stat, 6/08

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Definition

In this report, the green technology solutions focused on mobile communications include those for GSM, CDMA2000 coupled with WCDMA and TD-SCDMA.

In-Stat used TRX (one TRX will correspond with one carrier frequency) to collect the shipment information of base stations worldwide.

Strong Demand for Mobile Infrastructure

Global Mobile Subscribers Continued High Growth in 2007

Table 1. Global Mobile Subscribers, 2006 and 2007

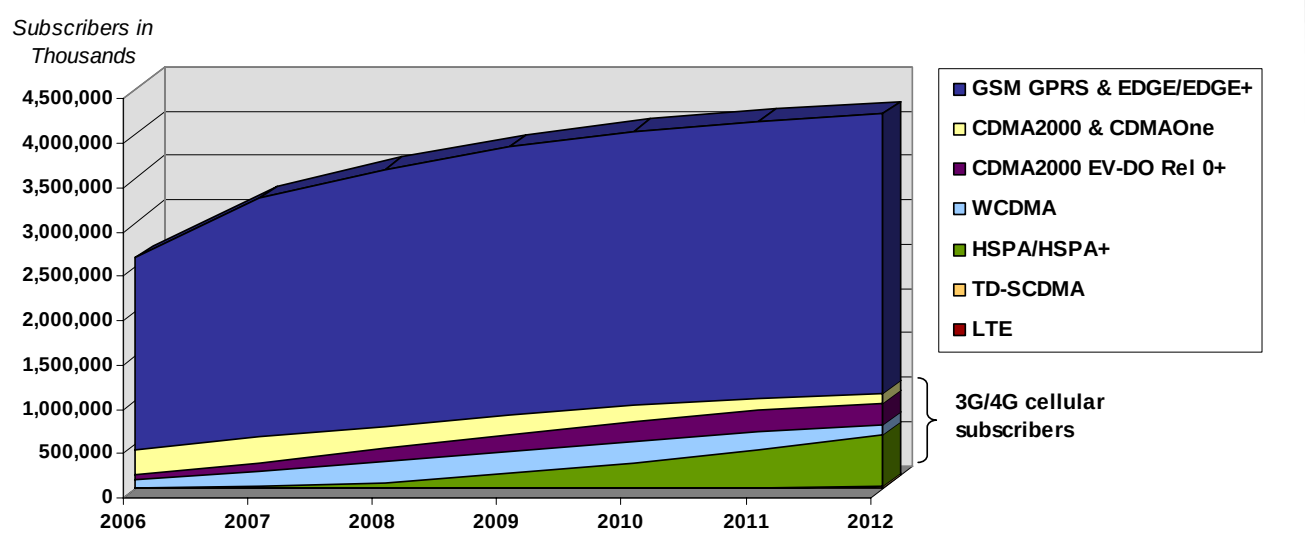
Subscribers by Technology (thousand)	2006	2007	Growth
HSPA/HSPA+	2,817.5	25,376.8	800.7%
WCDMA	94,819.2	170,686.1	80.0%
CDMA2000 EV-DO Rel 0+	49,997.8	89,728.9	79.5%
CDMA2000 & CDMAOne	282,883.0	299,490.2	5.9%
GSM GPRS & EDGE/EDGE+	2,166,452.1	2,685,060.0	23.9%
Total	2,596,969.6	3,270,342.0	25.9%

Source: In-Stat, 4/08

During 2007, the growth rate for worldwide mobile subscribers increased 25.9%, from 2.5 billion in January to over 3.2 billion in December. Among all the air-link technologies, HSPA/HSPA+ has achieved the greatest growth at 800% in 2007 owing to its small base. WCDMA had a growth rate of 80%; while CDMA 2000 and CDMAOne had a moderate increase, about 5.9%. It's worth noting that GSM, which has 83% of the global mobile subscriber market, has grown by 23.9% in the last year.

In the next five years, In-Stat expects that 3G/4G subscribers (i.e., those who subscribe to WCDMA/HSPA, EV-DO, TD-SCDMA, Mobile WiMAX and LTE networks) will grow at a healthy rate. 3G/4G subscribers grew 93% over the course of 2007, and In-Stat expects a 63% growth rate over the course of 2008, with subscriber numbers expected to increase from 285 million in 2007, to 450 million in 2008. By the end of 2012, In-Stat expects approximately 965 million 3G/4G subscribers worldwide, as indicated in Figure 3.

Figure 3. Worldwide Mobile Subscriber Forecast, 2008–2012



Source: In-Stat, 4/08

It's noted that for all mobile subscribers, 2G technologies are still expected to dominate the total cellular subscriber base through 2012, with CDMA2000/CDMAOne and GSM/GPRS/EDGE accounting for over 90% of total cellular subscribers in 2007. Even by the end of 2012, In-Stat expects that 2G technologies will still account for over 70% of the worldwide cellular subscriber base.

2007 Global Cellular Deployment

Cellular infrastructure contract awards are an excellent barometer for the cellular industry as a whole. Cellular operators spend billions of dollars on infrastructure, because it is their belief that this infrastructure will help them generate more revenue. Cellular operators tend to be very thrifty and don't spend money on upgrades until they are required.

In 2007, cellular infrastructure contract awards have exceeded $40 billion, which represents a second peak. It is In-Stat's belief that the peak of $40 billion in infrastructure is not so much from new 3G deployments as it is from strong growth in 2G and 2.5G technology, and close to half of all infrastructure awards came from two countries, China and India. While the deployments of 3G have received much press, it's the rollouts and capacity upgrades of 2G and 2.5G technology that are paying the bills.

2007 Vendors' Share

First, in terms of the number of network contracts, WCDMA-type technologies had a very good year, with a total of 112 new-added contracts in 2007. CDMA 2000 has accumulated 104 new-added contracts worldwide. For the first time ever, TD-SCDMA awards started to appear, with a total of 5 for 2007.

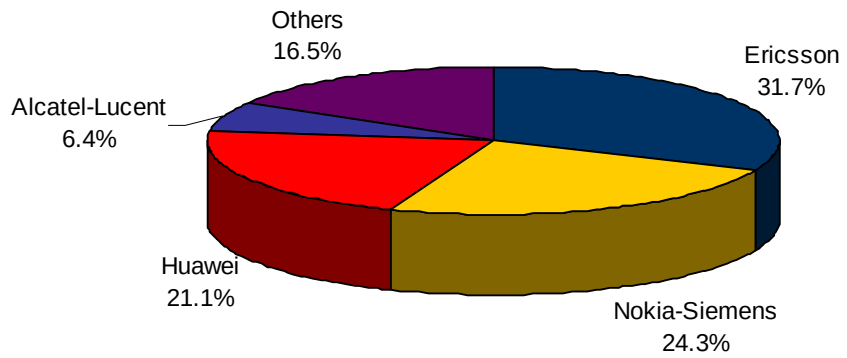
In-Stat collected the worldwide GSM base station shipments for 2007: about 3.4 million TRXs, in which Ericsson, Nokia-Siemens, and Huawei occupy the top three positions, as indicated in Table 2 and Figure 4.

Table 2. Global GSM Shipments and Vendors' Share, 2007

Vendors	Share	Shipment (Thousand TRXs)
Ericsson	31.7%	1074.8
Nokia-Siemens	24.3%	822.3
Huawei	21.1%	713.6
Alcatel-Lucent	6.4%	218.2
Others	16.5%	560.8
Total	100.0%	3389.7

Source: In-Stat, 6/08

Figure 4. Global GSM Shipments and Vendors' Share, 2007



Source: In-Stat, 6/08

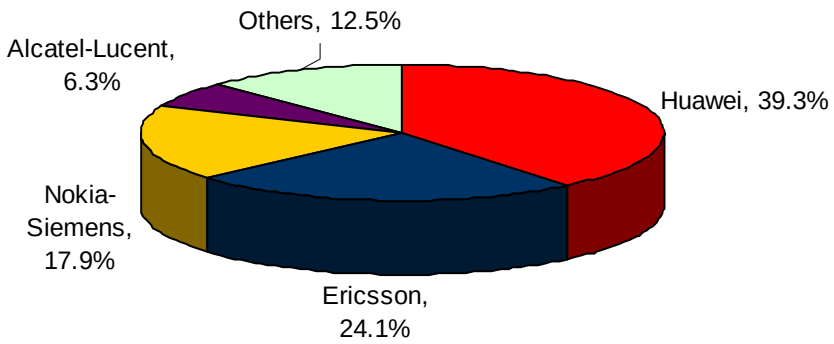
Figures 5 and 6, and Tables 3 and 4 indicate that the market share of the main radio equipment vendors for new-added contracts (excluding network expanding), shows WCDMA contracts include those on HSPA, while CDMA2000 1x EV-DO includes EV-DO R0 and Rev.A.

Table 3. Global New-Added WCDMA Contract Quantities and Vendors' Share, 2007

Vendors	Share	New-added Contract Quantity
Huawei	39.3%	44
Ericsson	24.1%	27
Nokia-Siemens	17.9%	20
Alcatel-Lucent	6.3%	7
Others	12.5%	14
Total	100.0%	112

Source: In-Stat, 6/08

Figure 5. Global New-Added WCDMA Contract Quantities and Vendors' Share, 2007



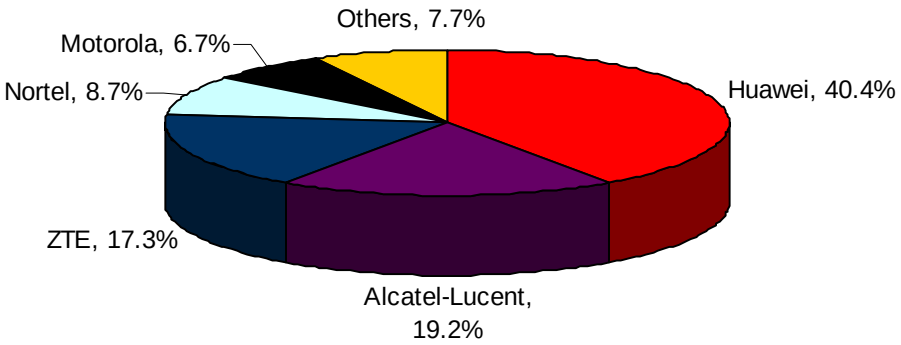
Source: In-Stat, 6/08

Table 4. Global New-Added CDMA2000 1x EV-DO Contract Quantities and Vendors' Share, 2007

Vendors	Share	New-added Contract Quantity
Huawei	40.4%	42
Alcatel-Lucent	19.2%	20
ZTE	17.3%	18
Nortel	8.7%	9
Motorola	6.7%	7
Others	7.7%	8
Total	100.0%	104

Source: In-Stat, 6/08

Figure 6. Global New-Added CDMA2000 1x EV-DO Contract Quantities and Vendors' Share, 2007



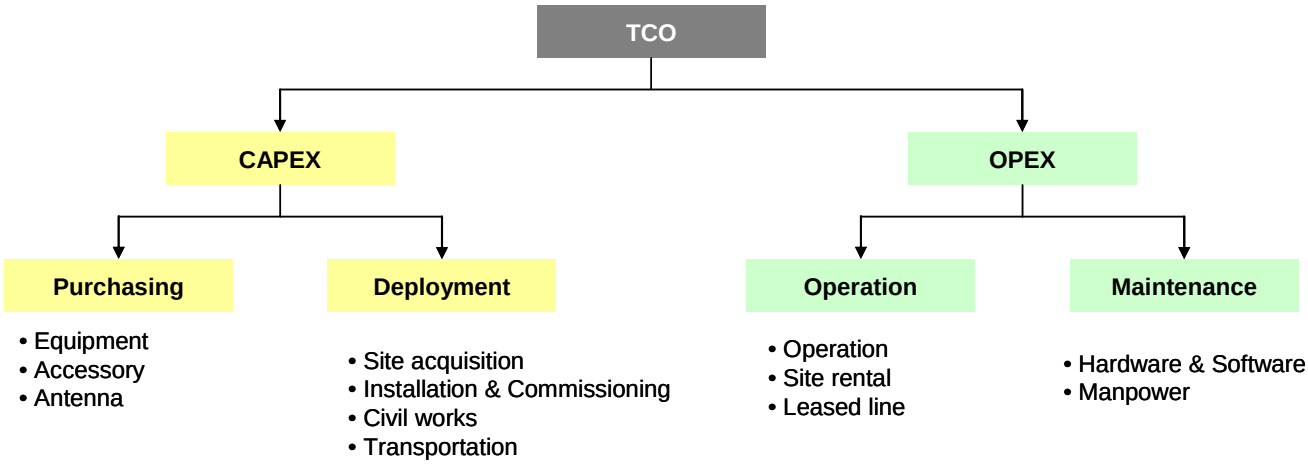
Source: In-Stat, 6/08

TCO Analysis of Mobile Communications

TCO Savings Still the Primary Target

Because of the costly investment of 2G/3G network roll-out, reducing the total cost of ownership (TCO) of networks is still a significant challenge for operators. As indicated in Figure 7, TCO could be divided into two categories: capital expenditure (CAPEX) and operational expenditure (OPEX), which happens in the process of network deployment and operation respectively. Thus, to cut CAPEX and OPEX has been the primary concern of operators in both network deployment and operation phases.

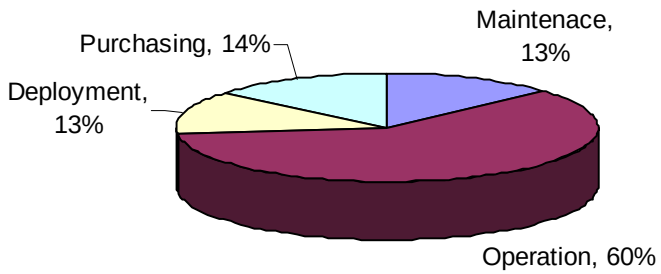
Figure 7. TCO Breakdown



Source: In-Stat, 6/08

As illustrated in Figure 7, CAPEX has two important contributors, purchasing and deployment; while OPEX consists of the cost of operation and maintenance. In an average situation for cellular networks, operation and maintenance costs account for more than 70% of expenses; CAPEX only contributes a small part to the TCO (Figure 8).

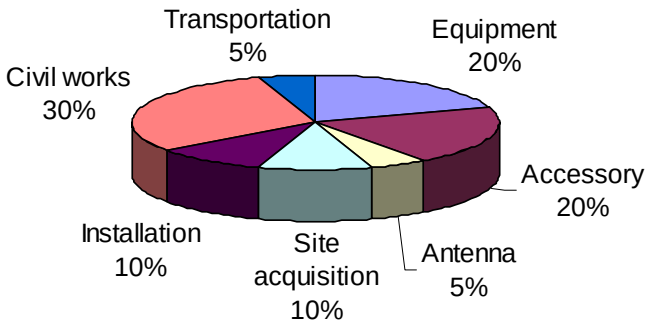
Figure 8. CAPEX and OPEX Breakdown



Source: In-Stat, 6/08

Figure 9 shows the breakdown for CAPEX: Equipment purchasing and network deployment make up the lion's share of CAPEX, which includes equipment, transportation, installation, site acquisition, etc. (Figure 9).

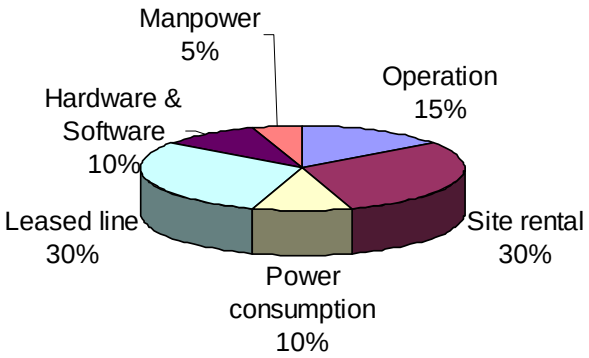
Figure 9. CAPEX Breakdown



Source: In-Stat, 6/08

As the big contributor for TCO, OPEX could be broken down into site rentals, leased lines, power consumption, and so on. Operators have made some efforts to save on these expenditures, like boosting the power amplifier (PA)'s efficiency with advanced technologies; adopting highly-integrated designs that require less site space, thereby reducing the cost of the site rental; installing smaller and lighter equipment; and employing software for network expansion or upgrade.

Figure 10. OPEX Breakdown



Source: In-Stat, 6/08

Please note that the breakdown of CAPEX and OPEX will vary from network to network. In-Stat has provided the breakdown for an average operator.

Green Thinking Beyond TCO Considerations

While TCO savings is still the primary consideration of carriers adopting advanced mobile communication systems, green thinking is becoming a priority, owing to the global awareness that all

industries need to achieve sustainable development. This increased awareness has, in turn, put increased pressure on governments all over the world to act.

Governments and international organizations have taken action to become more green:

1) On December 15, 2007, the U.N. (United Nations) Climate Conference agreed on a roadmap for negotiations on a new treaty to combat global warming;

2) On June 4, 2007, China's government launched the National Scheme for Weather Changes, adopting environmental protection as a fundamental goal in its national policy.

3) On March 8, 2007, the European Union promised to decrease their greenhouse gas emissions by 20% by the end of 2010, compared with 1990;

As an important part of the national economy, telecom operators have responded to the governments' requirements on a greener society:

1) T-Mobile has planned detailed approaches to obtain the decrease of power consumption and CO_2 emissions;

2) China Mobile has framed a Green Action Plan, which outlines their efforts during the next three years to save energy and decrease CO_2 emissions.

Whole-Life-Cycle (WLC) Green Mobile Communications

Why Green?

Protecting the environment and combating climate change are two of the most pressing challenges facing humankind. As energy prices soar, network operators are even more motivated to scrutinize their expenditures and evaluate their environmental and social responsibilities. For example, in the last two years, China's telecom industry (the biggest mobile market globally), has increased by 10%–20% per year. Meanwhile, the energy costs of telecom equipment have increased even more, and are now a higher proportion of carriers' operation costs. According to the 2006 industry energy-usage statistics gathered by China's Information Industry Ministry (MII), the yearly electricity consumption of the telecom industry exceeded 20 billion kilowatt-hours, 10 billion of which was used for the air-conditioning of GSM base stations. Assuming that 300 grams of coal is needed to generate 1 kilowatt-hour, the total energy consumption of base stations in China in 2006 would have used more than 3 million tons of coal.

Operational Energy Usage

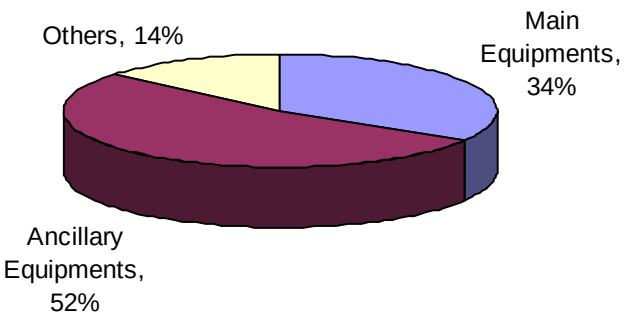
In-Stat has interviewed several telecom equipment vendors and operators, which made clear that base stations account for the biggest part of the power consumption in the total mobile communication system. Furthermore, In-Stat has classified the base stations into three categories: main equipment, ancillary equipment, and other components according to their contribution to energy usage.

1) Energy usage of main equipment: Telecom equipment, like BTS, whose energy consumption depends on the network equipment number and power consumption as well as the traffic load on the network. The statistical data reveals that telecom equipment uses nearly 30 percent of total power used by the site. The power usage of antenna and transmission equipment is relatively small.

2) Energy usage of ancillary equipment: Base station equipment has certain requirements with regard to environmental temperature, humidity, and lustration. In order to guarantee normal operation of telecom equipment, necessary temperature-controlling measures must be taken to balance the machine room's rising temperature, which is caused by the heat generated by the power equipment and outdoor heat exchange. Air-conditioners use the most power in base station equipment rooms, nearly 40%-50% of the total power usage.

3) Energy usage from other components: Other components mainly cover the power distribution system. When electrical energy passes through a power distribution system's transmission process, it will produce line-loss of electricity, which can be further subdivided into technical line-loss and management line-loss. Technical line-loss is electricity that is lost directly in the transmission process.

Figure 11. Contribution to Energy Consumption of the Different Elements of Base Stations



Source: In-Stat, 6/08

One-Time Raw Material Consumption

In practice, the energy usage can be calculated into CO_2 omissions. One kilowatt-hour can be converted into about 0.658 Kg CO_2 omission. Aside from the energy usage closely associated with the operation of base station equipment, the use of other resources and materials can also be calculated by the omission of CO_2.

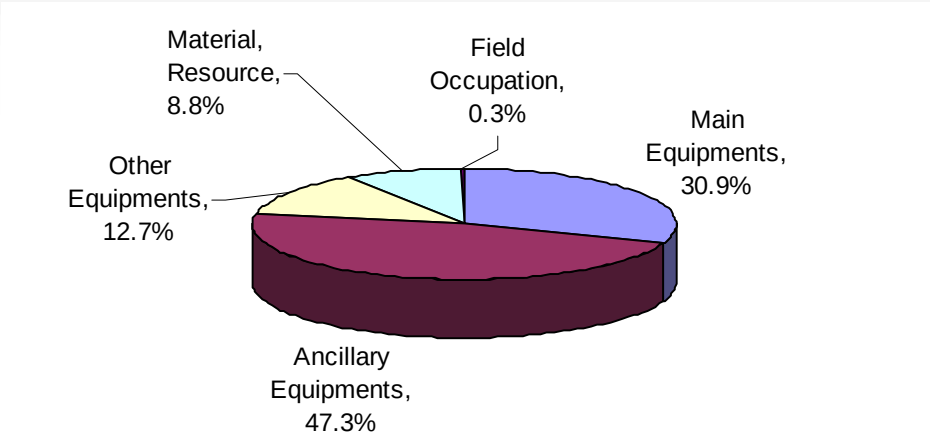
The consumption of raw materials and field-consumption can be converted into CO_2 omission.

1) Material usage refers to the energy used to produce the steel and concrete to build the base stations, which can be converted into CO_2 omissions.

2) The decrease of forest area brought about by the field consumption of base stations can also be converted into CO_2 omissions.

To assume one normal base station can be used for 5 years, the omissions gross is 211 tons CO_2. The one-time consumption of raw material or field occupation can be calculated into CO_2 omissions, and then distributed across the 5-year cycle. As is illustrated in Figure 12, the total CO_2 omissions volume can be broken down by operation energy usage (including main equipment, ancillary equipment, and other equipment) and the one-time consumption (raw material and field occupation).

Figure 12. Contribution Breakdown to CO_2 Omission



Source: In-Stat, 6/08

Key Approaches to Decrease CO_2 Omissions

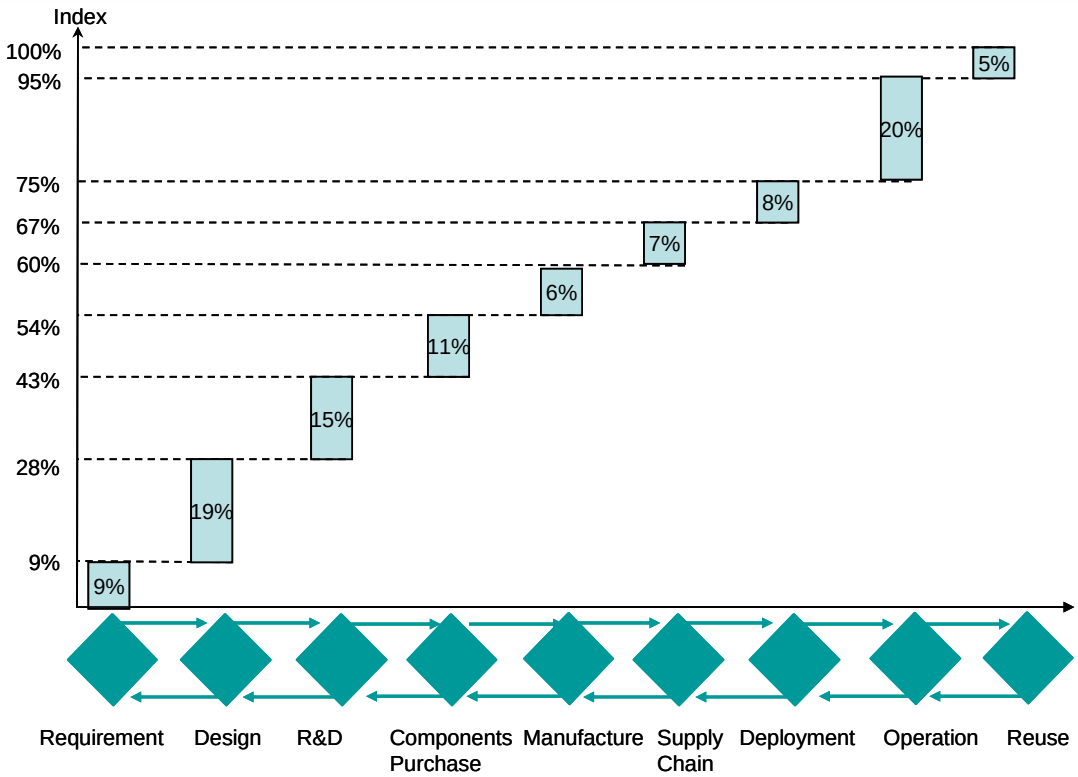
According to the CO_2 omission analysis, key approaches for reducing omissions and energy usage should start with:

- The decrease of the energy used by the equipment in base stations
- The decrease the energy used for cooling, specifically reducing air-conditioner heat generation and power consumption, coupled with increasing telecom equipment heat-resistance capability.
- The decrease of the space required for base stations by employing highly integrated or distributed solutions.

How to Reduce Power Consumption and CO_2 Omission

Whole-Life-Cycle Solutions for Green Mobile Communication

Figure 13. Whole-Life-Cycle-Green Solutions for Mobile Communications



Source: In-Stat, 6/08

Whole-Life-Cycle (WLC) can be used to analyze the potential environmental impact associated with a product or service. WLC describes the whole process of a mobile communication product from requirement, design, R&D, components purchase, supply chain, deployment, operation, and reuse of abandoned equipment. Different solutions can be employed to improve the energy consumption and CO_2 omissions. Furthermore, WLC can also be cited to analyze the contribution to green target of different phases within a life cycle.

- Requirement: operators provide targets on energy usage for specific network equipment.
- Design: power consumption can be considered in the original design phase in the whole life cycle.
- R&D: both R&D and design phases are related to the adoption of new power-saving technology (like efficient PA) or a new hardware platform, etc.

- Components purchase: mainly associated with raw materials and chemicals, which are environmentally friendly, like high-power efficiency and low radiation.
- Manufacture: the energy usage and CO_2 omissions within the office, factory, and other sites related with equipment manufacturing.
- Supply chain: transport from vendors to operators.
- Deployment: network equipment deployment phase.
- Operation: energy consumption of equipment, which accounts for a big part of the total power usage in the whole cycle.
- Reuse: recycling, collection/treatment, and landfill.

In-Stat has interviewed several mobile equipment vendors to obtain some field data for GSM/WCDMA or CDMA2000 networks. These studies have found that the largest individual contribution to most environmental impact comes from operation as indicated in Figure 13, other phases are also evaluated to describe their contribution to energy usage and CO_2 omissions.

Green Organizations and Conferences

Figure 14. Green-Related Organizations and Conference

Source: In-Stat, 6/08

Focusing on the green target, several organizations within the industry have united to take specific actions; which are listed in Figure 14.

INTELEC

INTELEC is an annual conference which examines and analyzes the latest developments in telecommunications energy systems and related power processing devices and circuits. Technical papers present research and new developments in power electronics and telecommunications power systems. There are also tutorials and a technical exhibition of products and equipment.

ATIS

ATIS is a United States-based body that is committed to rapidly developing and promoting technical and operations standards for the communications and related information technologies industry worldwide, using a pragmatic, flexible, and open approach. ATIS NIPP Telecommunication Energy Efficiency will be established in the meeting in 1H08.

NEBS

On November 6, 2007, Chuck Graff of Verizon and Bon Pipkin of AT&T represented the TCG operators organization and made energy-saving summit speeches at the NEBS 2007 annual meeting.

ITU

On April 15, 2008, Malcolm Johnson, director of ITU-T, gave a keynote speech at the Japan Symposium on ICTs and Climate Change, in which he said they planned to achieve 15% energy-saving across the ICT (Information and Communication Technology) industry in the next four years. At present, he is collecting data and analyzing ICT power savings information and will present his report at the Eight-Country Summit in Tokyo in July of 2008.

In December of 2007, TSAG (Telecommunication Standardization Advisory Group) notified each research team about the assessment of ITU-T Recommendations in the light of climate change, and demanded that they evaluate the relationship between the ITU-T standard suggestions and energy-savings and omission-reducing. In addition, the ITU Global Standard Meeting will be held in South Africa on October 20, 2008, during which climate change will be one of the important issues discussed.

Global Carriers' Strategy on Green

As mentioned earlier in the report, the growing awareness of the need for sustainable development has put pressure on the governments all over the world. How to take action is still the big challenge. As an important part of the national economy, telecom operators have responded to governments' requirements on green technology. In-Stat has selected Vodafone and China Mobile to study their strategies and actions on green strategies.

Global Operators' Strategy on Green

Case 1: Vodafone

Table 5. Primary Strategy of Vodafone for Environmental Protection

Items	Purpose
Reuse & Recycling	The main purpose is reducing, reusing and recycling: 1) Network waste. 2) Used handsets. 3) Other waste: The main types of waste produced by offices, call centres and retail outlets are paper, printer toner cartridges, packaging materials and IT equipment.
Energy Use and Climate	Vodafone targets to reduce network carbon dioxide emissions per unit of data transmitted (MB of traffic) by 40% over five years to 2011. The focus is on identifying ways to improve the energy efficiency of network and buildings, and increase use of renewable energy.
Transport	Vodafone calculate its transport use produced around 67,000 tonnes of carbon dioxide in 2006, an increase of 44% from the previous year. Vodafone is working to improve the data on air travel in future.
Water	Vodafone believes water conservation is particularly important in water-stressed regions of the world. The number of such regions is predicted to increase as a result of climate change.
Compliance	To comply with environmental regulations in every country where Vodafone operates
Waste	To reduce, reuse and recycle the waste from network equipments and office.
Ozone Depletion	To replace end-of-life cooling systems in base stations with free cooling (fresh air) systems. To reduce the use of CFCs and HCFCs, hence minimize the damage to the ozone layer of the Earth's atmosphere.

Source: In-Stat, 6/08

Target Set and Energy Audits

Vodafone established the GEMT (Global Energy Management Team), especially being responsible for the implementation of its energy saving strategy. At first, energy efficiency targets will be set in most local operating companies. Targets must be approved by local operating companies' chief executives and are reviewed by GEMT. Vodafone UK was the first operating company to set a target to reduce its energy use—by 12.5% from 2005 to 2009.

In addition, energy audits should be conducted by Vodafone's local operating companies to monitor the energy use and find appropriate approaches to optimize the energy utilization performance. Taking Vodafone Hungary as an example, the energy use at 40 different sites was monitored during 2006–2007 to identify ways to reduce energy use. Around 4,000 unnecessary transceivers were identified, 1,300 of which have already been removed and the remaining 2,700 have been locked.

Specific Approaches for Energy Use Optimization

Vodafone indicates that the energy used to run its networks accounts for more than 80% of its carbon dioxide emissions. There are several ways to reduce network energy use.

Reducing the Need for Air Conditioning

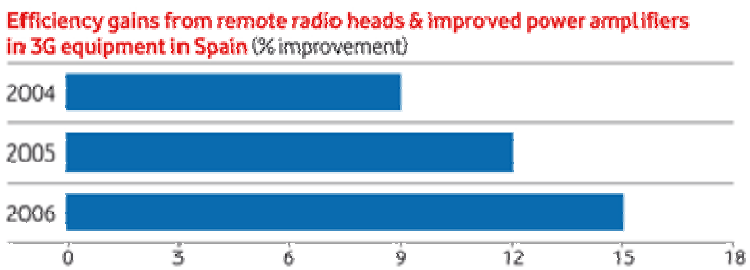
Vodafone's strategy is to install "free cooling"—a system that uses fresh air to cool network equipment—as the default option at new base stations. This reduces the need for energy-intensive air conditioning, saving around 16,000kWh a year per base station. Free cooling has been installed by Vodafone at more than 200 base stations in Germany, Greece, Ireland, and Spain.

Adopting Advanced Technology

Vodafone is actively working with equipment suppliers to improve the energy efficiency of network equipment. The focus is on two key items of network equipment: power amplifiers and remote radio heads. Vodafone thinks the average energy efficiency of power amplifiers from the main suppliers has improved gradually from around 9% in 2004 to 15% in 2006. Remote radio heads relocate the power amplifier closer to the antenna, rather than at the foot of the base station.

Vodafone has cited its local operation in Spain as an example: existing equipment uses around 925W to produce an output at the antenna of around 20W. By upgrading the power amplifier and installing a remote radio head, base stations now use just over half the energy (480W) to generate double the power output (40W).

Figure 15. Efficiency Gains From Remote Radio Heads and Improved PA in 3G Equipment of Vodafone's Operation in Spain



Source: Vodafone, 6/08

Intelligent Energy Management and Alternative Energy

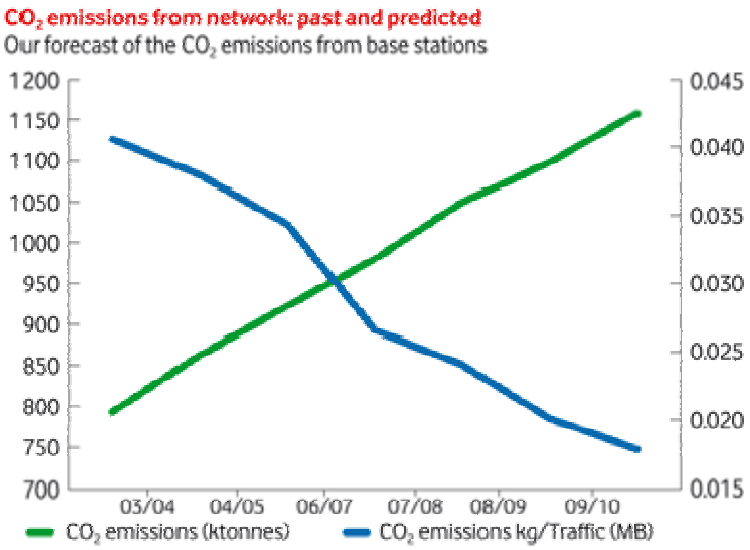
Intelligent energy management mainly involves the remote monitoring and measurement of energy, coupled with the flexible control over the equipment operation, like deactivating unused rectifiers, shutting down some base station sites when traffic demand is lower, and so on.

Alternative energy means that for base stations in remote locations not served by an electricity grid, Vodafone is replacing or supplementing diesel generators with on-site renewable energy systems. These include solar panels, wind turbines, and fuel cells.

Vodafone's Green Target

Figure 16 shows Vodafone's forecast of the carbon dioxide emissions from cellular base stations: The carbon dioxide emissions will increase with the business growth.

Figure 16. Vodafone's Target on CO_2 Emissions From Base Stations



Source: Vodafone, 6/08

Vodafone's target is to improve the overall energy efficiency for transmitting voice and data to reduce network carbon dioxide emissions per unit of data transmitted (MB of traffic) by 40% by 2011, compared with that in 2005.

Case 2: China Mobile

Environmentally sustainable development is an important issue facing the Chinese government. In 2006, China spent over US$ 36.1 billion in environmental protection, which accounted for 1.22% of the GDP in 2006. In the 11th National Five-Year-Plan, the Chinese government adopted *"resource saving and environmental protection"* as an element of its basic national policy. Furthermore, by 2010 the Chinese government plans to have decreased the average energy usage per GDP unit by 20% compared with that in 2005.

Green Action Plan

In 2007, China Mobile began monitoring and collecting environmental data for the development of an index, and established its target for energy savings and the decrease of omissions. In the same year, China Mobile started the *Green Action Plan* which is focused on saving energy and decreasing omissions. The plan consists of seven aspects:

1) Standardization: Promotes architecture standardization, equipment standardization, and design standardization, which will result in reductions in the use of land, materials, and energy in various phases of network building.

2) IP: Using 3G technology to build 2G networks and adopt IP technology on a large scale.

3) Green-packing: Building green packages and developing green transportation standards to promote the substitution and recycling of new material, and decreasing excessive packaging.

4) Main equipment energy-saving: Promotes main equipment energy-saving.

5) Subsidiary equipment energy-savings: Promotes the adoption of new technologies and new products to realize energy-savings of subsidiary equipment.

6) E-business: The B2B application of green action with China Mobile's suppliers in an effort to increase efficiency and decrease resource waste.

7) Environmental protection: Reduces pollutant omissions, enhances the reuse of castoff materials, adopts green energy policies, and promotes social environmental-protection activities.

Green Target

In the Green Action Plan, China Mobile pledges, by 2011, to decrease average energy usage per traffic (MB) by 40% when compared with that in 2005.

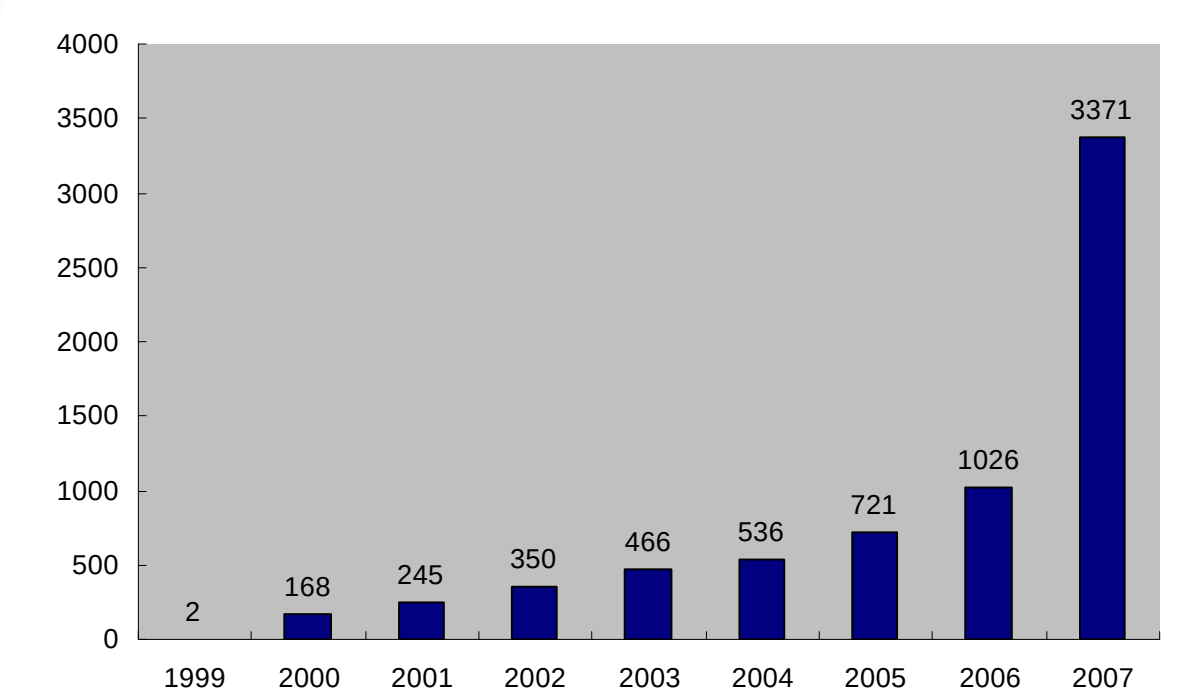
In 2007, China Mobile signed the Green Action Plan with 4 main equipment suppliers and 11 main subsidiary equipment vendors providing mobile telcom equipment, IT equipment, transmission equipment, network-optimized equipment, power-supply equipment, and so on.

Green Energy

Furthermore, China Mobile has chosen green energy in some applications. For instance, in an Inner-Mongolian province, China Mobile adopted a wind-solar-hybrid power solution for its base station. Currently, 202 base stations using green energy power solutions have been put into operation.

In Henan Province, China Mobile established 7 base stations with solar energy systems, which effectively solves the difficulty of supplying energy in and out of the mountain regions. By the end of 2007, 3,371 solar energy systems were put into place by China Mobile. Figure 17 indicates the solar system volume adopted by China Mobile over the past 9 years.

Figure 17. Solar System Initiative Adopted by China Mobile (units)



Source: China Mobile, 6/08

Green Base Station Technologies

Adopted Green Technologies

Advanced PA

New power amplifier technology, which is becoming more and more mature, brings power consumption savings, higher density, larger capacity, and better stability.

The adoption of DPD (Digital Pre-Distortion) coupled with Doherty technology improves the power amplifier efficiency to over 30% from about 9% without DPD and Doherty.

Intelligent Power Management

Our interviews with telecom equipment providers indicate that they have developed software-based power optimization tools. In-Stat calls it *Intelligent Power Management* (IPM). IPM software collects the power consumption data from different components within the base station and identifies the traffic load that is transmitted across the network. When implemented, IPM software identifies idle equipment and may turn it off, or, depending upon a variety of circumstances, it may disable several carrier frequencies or time slots when the traffic load decreases, which then lowers the power usage and increases the power efficiency per transmitted traffic (MB).

Multi-Carrier Technology

Multi-carrier technology enables the base station to support large network coverage and capacity without much change to the base station equipment. With the multi-carrier solution, one TRX/sector could support two or more carriers. Multi-carriers could share some basic hardware and software platform, and, therefore, decrease the power consumption per user.

Distributed Base Stations

In general, a base station system consists of the baseband unit (BBU) and the radio remote unit (RRU); BBU and RRU are used separately to process baseband signals and RF signals respectively. In the distributed base station, BBUs could connect to one or more RRUs by optical fiber. The most important benefit of a distributed base station is that RRUs can be deployed outdoors, while BBUs can be centrally located and shared by different RRUs. Distributed base stations greatly decrease the space required for BBU equipment, minimize the transmission loss, decrease the need for cooling equipment, and, hence, lower power consumption.

IP Networking

First of all, the all-IP core network has been well designed in 3GPP R5 to deliver voice, data, and multimedia services on IP platforms. The all-IP platform transmission takes place on the core network, while on the access network new-generation base stations tend to employ IP transmission between the RNC (Radio Network Controller) and the base station. Compared with TDM, ATM, and MSTP, IP technology can help to reduce network costs for both real-time services and best-effort services, such as data. Furthermore, thanks to the adoption of IP, several resources like the RNC and MSC server can be pooled together and shared to increase efficiency.

As with other telecom systems, base station technology is moving to new designs and manufacturing platform. During our interviews with radio network vendors, they indicated that the base station platform is being transformed from a TDM-centric platform to an IP-centric platform to accommodate the all-IP trend of mobile networking. Furthermore, the IP evolution could also bring about the benefits of power consumption savings, increased volume, and a more unified platform.

Intelligent Site Solutions

As mentioned in the above chapters, cooling systems in base stations will account for more than 30% of the total power consumption. Vendors have two main approaches to optimize the power usage for cooling:

1) By increasing the equipment's tolerance for higher temperatures (from 21°C to 25°C), the average energy use in some base stations can be cut by more than 10%.

2) By adopting free cooling solutions, which use the flow of fresh air to cool network equipment, vendors can reduce the need for energy-intensive air conditioning. In some locations it might be most efficient to use air conditioning during the day while using free cooling at night due to the temperature differences.

Alternative Energy Sources

Telecom vendors are motivated to use alternative energy sources to serve their base stations, like solar panels, wind turbines, and fuel cells.

1) They employ new green energy to help them meet their consumption reduction targets; and

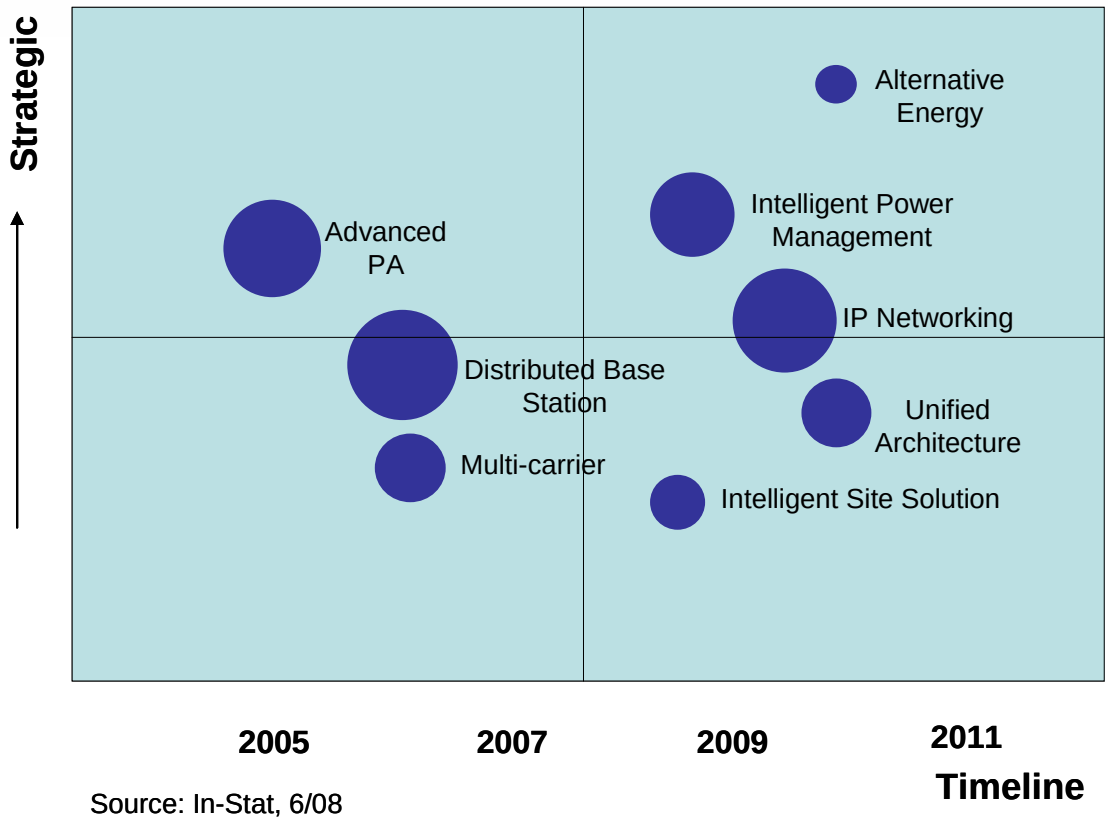
2) They utilize the rich resources found locally, like the abundant solar energy available in desert areas. Generally, hybrid solutions are preferred by operators; for example, a fuel cell might be installed to boost the power when there is not enough sunlight or wind to power those alternative systems.

Unified Architectures

Unified architectures can provide higher stability, reliability, and optimized power consumption, compared with old platforms; furthermore, unified architectures enable the smooth evolution from 2G to 3G via software upgrades based on the same platform.

Operators' Evaluation of and Migration to Green Technologies

Figure 18. Operators' Timeline for Migrating to Green Technologies



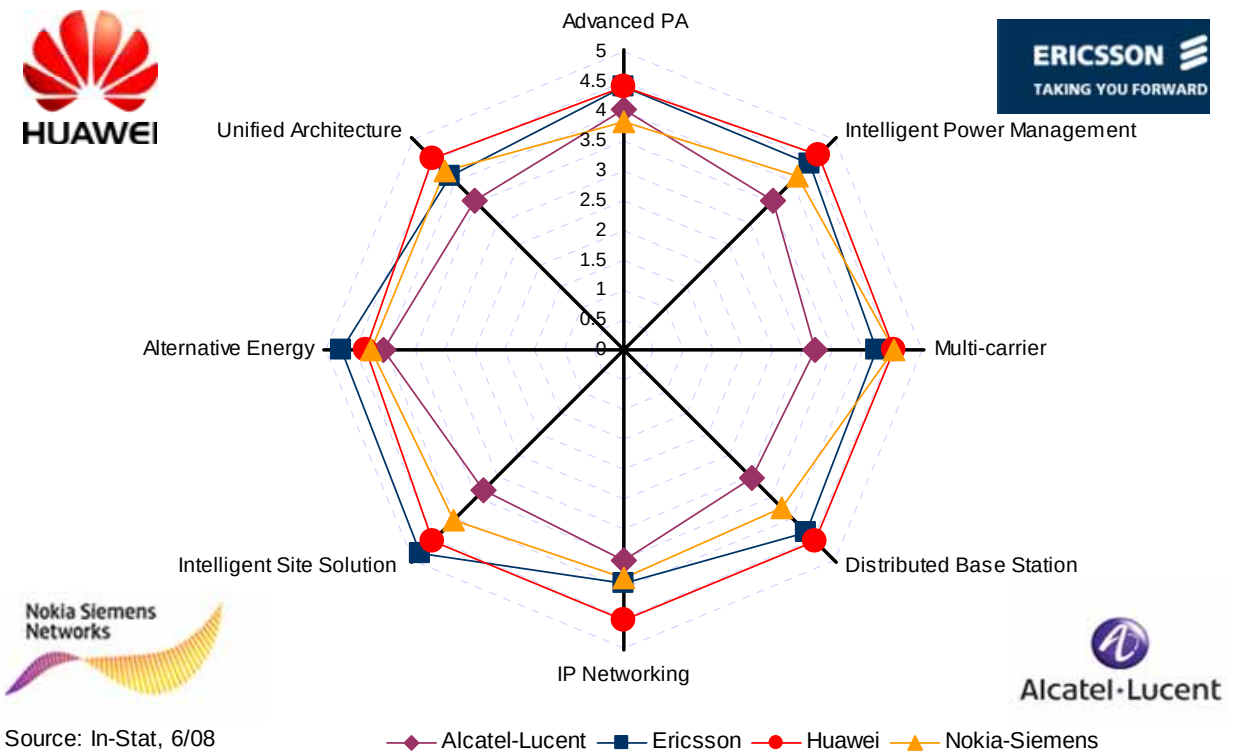
Source: In-Stat, 6/08

In-Stat has represented the above eight green technologies using the elements of time and strategy. Together they represent how much the technology is strategically beneficial for carriers, when weighed with the cost or difficulty of implementing it. For instance, the Alternative Energy, shows the high cost to build new energy systems (like solar) when compared to traditional electrical systems; however, alternative energy represents a very attractive strategic direction when coal and petroleum resources are being depleted. The X axis represents the timeline when adoption is expected by carriers on a large scale. The size of the bubble represents the operators' evaluation of its contribution to the overall green technology target. Each of the eight technologies were evaluated by the carriers we interviewed (Figure 18).

Capability Comparison Among Vendors

The selected radio network providers mentioned below are Alcatel-Lucent, Ericsson, Huawei and Nokia-Siemens. All are big players in the base station field and each have a considerable share in the mobile market.

Figure 19. Capability Comparison Among Different Base Station Vendors



Source: In-Stat, 6/08

In-Stat sent questionnaires to several operators to survey their evaluation on the performance of those base station vendors with respect to the eight green technologies: advanced PA, alternative energy, the intelligent site solution, IP networking, the distributed base station, the multi-carrier solution, and intelligent power management. Scores of 0 to 5 were used to assess each vendors' advantage. The results are presented in Figure 19.

1) Huawei has the advantage on IP networking, distributed base stations, and advance PA.

2) Ericsson is valued by operators on intelligent site solutions, alternative energy, and multi-carrier solutions.

3) Nokia-Siemens has the advantage on multi-carrier technology.

Methodology

Primary and secondary sources of information were used in the development of this report. Primary research consisted of:

- Face-to-face or telephone interviews with the primary mobile base station suppliers: Huawei, Nokia-Siemens, Ericsson, and Alcatel-Lucent, and the mobile service providers Vodafone and China Mobile.
- Face-to-face interviews with specialists in the mobile base station industry.

The majority of secondary data came from information published by equipment vendors, prestigious institutions, local governments, and information compiled by the 3GPP, TISPAN and IEEE (Institute of Electrical and Electronics Engineers). This information was augmented by data from In-Stat's proprietary database and from third-party articles about the global green base station market.

Numbers shown in charts and tables may not add exactly due to rounding—data is calculated at a higher precision than is shown.

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