Controlling the energy footprints
of corporate information services and networks

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Abstract:
Telecommunications is the digital revolution's backbone. Thanks to rapid technological progress, everyone now has permanent, inexpensive access to the Internet everywhere at ever higher connection speeds. This availability is a real opportunity for sustainable development in our societies. A telecommunications operator certified ISO 14001, like Orange, has as one of its priorities to control its environmental impact. This control starts with the design of products and networks in an investment-intensive business with a high turnover rate for material objects. Attention must be paid to the waste management of electronic equipment and the consumption of electricity. Thanks to its ongoing efforts, Orange has obtained promising results, such as a significant reduction in energy consumption per use.

Telecommunications, the digital transition's backbone

A long transition toward digital technology but sustainable advances

To transmit telephone conversations over large distances without distorting the sound, pulse code modulation (PCM) was generalized in the 1980s, a technique we would now describe as a digitization of audio signals. French research (on the cutting edge in this field) then introduced electronic switches, the first marriage between computer science and telecommunications. Advances in digital communications then picked up speed: telematics (Minitel), ISDN (Integrated Services Digital Network) for all customers, and packet-switched networks. Telecommunications figures among the principal users of digital technology.[1]

The two major advances underlying the digital infrastructure date from the mid-1990s. The one is, of course, the Internet, which uses IP, a truly universal language. The other is mobile communications (via GSM, 2G). Faster connection speeds were soon in demand; ADSL and UMTS (3G) both responded to this expectation. This upsurge in the capacity of telecommunications was connected to business and sales.

However this dazzling growth in connection speeds was also possible owing to the ongoing quest for a sober use of resources. For instance, spectral responsivity has been substantially augmented in terms of both the number of bits transmitted per hertz and the network's electricity consumption per hertz. Similarly, the replacement of copper by optical cables allows for gains: a decrease by several orders of magnitude in the energy used to transmit a bit; a sharp reduction in the congestion due to civil engineering works; and a simplified network architecture owing to larger transmission distances.

[1] This article has been translated from French by Noal Mellott (Omaha Beach, France).

Glossary
ADSL: asymmetric digital subscriber line for hardwired broadband access to the Internet.
Backbone network: equipment at the major nodes in the network and on the high-speed routes joining these nodes.
Box: device (residential gateway) installed at the subscriber's place to perform the functions of a modem, which modulates outgoing signals to encode digital information for transmission and demodulates incoming signals to decode the transmitted information for the subscriber.
Consumption by use: ratio of total energy consumption to the number of uses (voice, television, Internet/data) with fixed or mobile connection to a network.
FTTH: Fiber-to-the-Home, optical fiber cables that extend to the subscriber's home.
GSM: Global System for Mobile Communications (originally GSM: Groupe Spécial Mobile), a European standard for second-generation (2G) digital cellular networks.
IP: Internet Protocol.
Local loop: a set of cables connecting terminal points in the network or in the "digital subscribers' loop" to the operator's major switching facilities.
Triple play: fixed access for three uses: vocal transmissions (telephone), television and Internet.
UMTS: Universal Mobile Telecommunications System for third-generation (3G) mobile digital cellular networks.
Virtualization: hardware and software solutions for separating the processing of telecommunication functions from the physical resources used for processing.
WiFi: the commercial name of technology compliant with the IEEE 802.11x standards (defined and updated by the Institute of Electrical and Electronics Engineers, New York) for a wireless local-area Ethernet network.

A permanent, abundant offer everywhere but contrasting environmental effects

Owing to the capacity of the fixed and mobile telecommunications installed by various operators, everyone now has the possibility of permanent, high-speed access to the Internet everywhere (if need be, by satellite). Current connection speeds range up to 1 Gbit/s (gigabit per second) via optical fiber and 150 Mbit/s (megabits per second) via 4G mobile devices. This abundance at increasingly affordable costs has boosted the development of a wider variety of digital services. Besides various sorts of interpersonal communications (including video-conferencing), we might mention: the services for access to the Worldwide Web; the bundled offers of access to television stations, radio stations or on-line games; dematerialized payment services; and, now, direct connections between devices or machines (servers).

There is no denying that telecommunication networks significantly reduce the quantity of paper for writing letters or the number of trips for meetings. We need but observe the drop in the volume of mail delivered by the post office. The time spent on the telephone (at the office or with friends and family) is clear evidence of the gains made in transportation. Nor is there any denying that the demand for communications has exploded, a demand easily satisfied by the permanent, abundant supply of the means of communication available all around us. As a consequence, a major issue for a telecommunications operator is to control the environmental impact throughout its network, including in the terminals installed at the customer's home.

How Orange controls its environmental impact

For a network operator like Orange, two environmental preoccupations stand out and merit discussion: on the one hand, the management of wastes, whether from electric or electronic equipment or from specific materials such as cables; and, on the other hand, control over the consumption of energy, mainly electricity. Other important factors must also be watched: the *"installations classified for the protection of the environment"* (ICPE) on the biggest sites in France, the consumption of paper (which used to be very high due to invoicing), and the reduction of CO_2 emissions from using motor vehicles, for example. The last point, not specific to telecommunications as such, is mentioned in passing.

For several years now, Orange Group, both in its international activities and in Orange France, have undergone the process of certification ISO 14001 on "*environmental management*". Its activities in France received certification in June 2016, following a process stretched out over several years. In the wake of the Orange Group's commitments during the 2015 Paris Climate Conference, an ambitious program has been set up to reduce the Group's energy consumption for certification under ISO 50001 ("*energy management systems — requirements with guidance for use*"). Actions have also been undertaken to boost the circular economy and improve our knowledge about the life cycles of our products and networks. They have brought the proof that the design phase is a key to controlling our environmental impact.

It all starts with design…

Permanent attention must be paid to environmental issues in all our activities, all along the chain. Environmental efficiency improves insofar as it is taken under consideration as early as the phase of designing equipment and systems. I shall present two examples to illustrate this: Internet boxes and a sober 4G.

For broadband access, "Internet boxes", the usual name for "residential gateways" for connection to the Internet, are installed at the customer's home or workplace. The "triple play" box has interfaces for a WiFi router, a land-line telephone, the Internet and decoders for receiving television. These boxes, now in wide used, have aroused serious concern about their environmental impact.

Three points are worth mentioning with respect to designing Internet boxes. The FIRST step is to analyze the box's life cycle to detect all aspects to be taken into account. One important aspect is the box's electricity consumption, which might represent an appreciable cost for the customer. Priority in the design of the box must be given to a sober consumption of energy. Customers should be able to turn the box off when they want. A SECOND point is the packaging: eliminate what is unnecessary — thus reducing the volume of wastes and making life easier for customers. With less packaging, more boxes can be stacked on the same pallet, thus reducing the environmental impact due to transportation. The choice of cardboard for packaging gives a boost to environmentally friendly businesses. The THIRD point is that the phase of design must also take account of how the product will be recycled at the end of its life cycle. When Internet boxes are returned, because they do not work or because subscriptions have terminated, their design makes it easy to test, repair and recondition them.

In the future, operators like Orange will turn toward “virtualizing” certain features now offered by their Internet boxes. These features will no longer be controlled by the box but remotely from the network. They will not be activated — and not consume energy — until used!

Design is also important for more sober 4G products. Several generations of equipment and techniques have been stacked on top of each other to construct a telecommunications network. One of the network operator’s tasks is to make it all work together and to manage updates. The advent of mobile, fourth-generation networks risked amounting to nothing other than adding on more equipment and devices, thus sharply increasing energy consumption. However talks between equipment manufacturers and operators have come up with a more satisfying solution. “Swapping” allows customers to replace 2G or 3G installations with the new equipment, which pools resources and consumes electricity more soberly. This makes it easier to install 4G technology while limiting the energy footprint.

Given the frequency bandwidth used for signal processing, new relay antennas have to be erected for adequate geographical coverage. These antennas have been designed to fit into the landscape and not be eyesores, to the satisfaction of residents.

Managing wastes located everywhere

The customers’ out-of-service terminals are handled like wastes from electric and electronic household appliances. Mobile telephones (cell phones) call for special attention since they are regularly replaced: there are tens of millions of them in France. Besides the legal obligations about recuperation, operators and distributors may undertake actions on their own. Several businesses offer financial incentives for the return of used equipment. Local authorities have set up special containers for used equipment (a positive, environmentally responsible action). Despite such actions, we are forced to admit that the return rate is not so high as expected. It is worth mentioning Orange’s initiative for recycling portable telephones in certain countries, especially in Africa, where these terminals, when they still work, are endowed with a second life on the market for used goods. In turn, a system has been set up in developed lands for returning terminals to keep them from being exported as waste products toward emerging countries.

Computers and network equipment, used in large quantities by telecommunication operators, are also handled like electric and electronic wastes at the end of their life cycle. The appropriate procedure for handling several thousands of tons of such wastes, collected throughout the country, must be well-organized. This equipment might, it should be pointed out, contain sensitive information, such as customers’ personal data. Destroying these data is a prerequisite for discarding the equipment.

More than twenty years ago, a start was made at replacing copper cables with optical fiber for connections between switching stations. As this phase is coming to a close, the copper (or in a few cases lead) cables are now being recuperated. Tens of thousands of tons of cables have been removed from installations and are to be recycled. As optical fiber lines extend to the subscriber’s home (FTTH), copper cables will be stripped out of local loops too.

Managing energy efficiency on location

The equipment turnover rate in telecommunications is close to the rate in computer technology. New equipment tends to consume less energy, thanks to several recent innovations. Since older services rely on old equipment (some of it more than thirty years old), exercising a control over the average energy consumption depends on the management of this older equipment. This entails pooling uses so as to free unused production capacities, cutting off the current to the equipment withdrawn from use, and recuperating the old material, or parts, for maintenance work.

It is worthwhile pointing out that the ratio of electricity consumption per services delivered (*e.g.*, three services in a triple play offer) has been steadily falling for a long time now. This energy performance is evidence of Orange Group's commitment to halve its CO_2 emissions per service by 2020 (in comparison with the baseline of 2006).

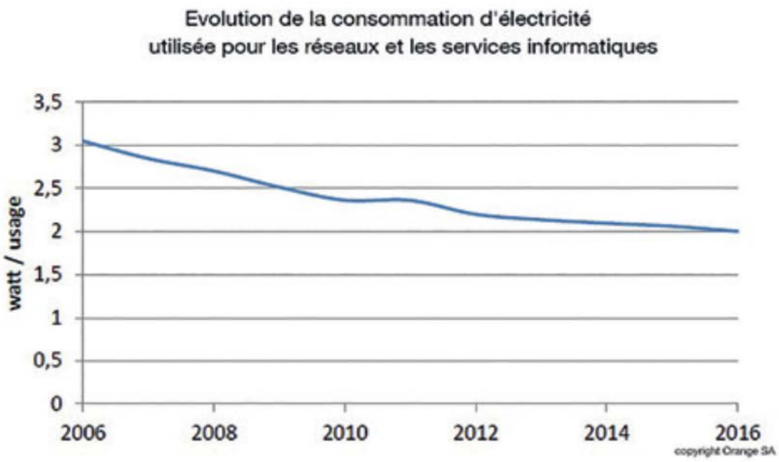

Figure 1: Electricity consumption (watt/use) by information services and networks

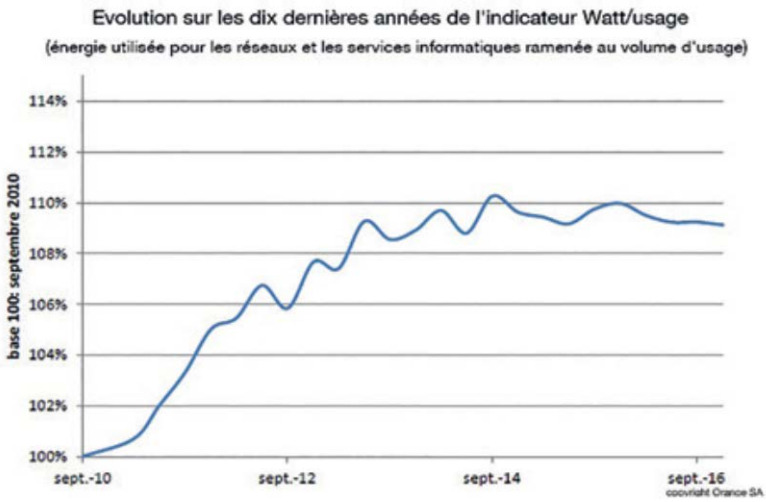

Figure 2: Trend of the watt/use indicator in relation to 2010: The ratio of energy consumed by information systems and networks to the volume of uses

Orange’s energy management system varies according to the size of installations. Let us focus on three categories of installations by size.

In France, there are tens of thousands of small locations, such as relay antennas and small buildings with switching stations for land lines in rural areas. Given the large number of these sites and the low degree of modularity of the equipment there, few levers of action (mainly obtained though engineering procedures and the choice of equipment) are available for managing energy consumption there. Regularly running the equipment on these locations allows for checking whether it still operates correctly.

There are a thousand medium-sized locations in urban areas. They serve these areas or else take traffic from smaller sites. They were often built during the automation of the telephone system. Since electromechanical centers take up room, these sites are now oversized. Key tools for managing them are: pneumatics, adjusting the size and parameters of ventilation systems, and monitoring fill rates. If less space is occupied, more economical techniques, such as forced ventilation, can be installed. Changes are made more frequently at these sites; and this entails operating the equipment more often.

The telecommunication system’s backbone is concentrated at a few very big plants, which contain routers and service platforms. The trend of networks toward virtualization and thus toward porting ever more applications on general-purpose servers is going to make these sites converge toward becoming data centers.

Controlling electricity consumption is a key issue for data centers. Although these big plants control ever more functions, their global electricity consumption has fallen. Much attention has gone into choosing where to locate them and into an ultramodern technique that leans heavily toward ventilation rather than air-conditioning. In effect, optimizing the operation of cooling systems allows for permanent savings on energy. The usual indicator is the rate of power usage effectiveness (PUE), the ratio between a site’s total consumption of electricity and the consumption due to its computer equipment. The PUE can fall by 30% in the new generation of data centers. To chalk up success, the Orange Group has accelerated its long-term program for overhauling and renovating data centers, the aim being to lower even more the PUE in the coming years.

A great potential for change

Telecommunications networks have been evolving for several decades now. In the period we are now entering, several major changes are going to take place all at once.

The migration toward “IP-everywhere” will gradually lead operators to disinvest in old networks. This will go in hand with the installation of new networks with transmission speeds far higher than currently needed (FTTH, 4G, and, soon, 5G). Internet Protocol version 6 (IPv6) and low-consumption technology (such as LoRa) will enable these new networks to connect a large number of devices and appliances.

Many of tomorrow’s services for changing our lifestyles are still in the pipeline or are waiting to be invented. Let us point to a few trends of relevance to the environmental transition:

— trips not made, thanks to “teleconfereincing”, “telemedicine” or enhanced reality for interventions by experts;

— optimized trips thanks to tools for managing transportation infrastructures and to devices that directly signal needs or defects;

— more control over electricity consumption in public areas and at home thanks to connected domotic devices;

— a longer life for equipment thanks to a predictive maintenance based on more information about the state of the equipment;

— … and many other uses still to be discovered.

More than ever, environmental issues will be decisive during the coming decade. Telecommunications will play two roles: make innovations for saving energy in everyday life; and continue the efforts for controlling the consumption of energy thanks to new technology. Orange Group is both aware of this responsibility and proud of its contribution to making tomorrow better.