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Monitoring and optimization of energy consumption of base transceiver stations

Antonio Spagnuolo [a, *], Antonio Petraglia [b], Carmela Vetromile [a], Roberto Formosi [a], Carmine Lubritto [a]

[a] Department of Environmental Science and Technology (DiSTABiF), Second University of Naples, Via Vivaldi, 43, I-81100 Caserta, Italy
[b] Department of Mathematics and Physics (DMF), Second University of Naples, Viale A. Lincoln, 54, I-81100 Caserta, Italy

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ABSTRACT

The growth and development of the mobile phone network has led to an increased demand for energy by the telecommunications sector, with a noticeable impact on the environment.

Monitoring of energy consumption is a great tool for understanding how to better manage this consumption and find the best strategy to adopt in order to maximize reduction of unnecessary usage of electricity. This paper reports on a monitoring campaign performed on six BSs (Base Transceiver Stations) located central Italy, with different technology, typology and technical characteristics.

The study focuses on monitoring energy consumption and environmental parameters (temperature, noise, and global radiation), linking energy consumption with the load of telephone traffic and with the air conditioning functions used to cool the transmission equipment. Moreover, using experimental data collected, it is shown, with a Monte Carlo simulation based on power saving features, how the BS monitored could save energy.

1. Introduction

Telecommunications is one of the sectors where the continuous growth in demand for mobile services and the parallel technological development go hand in hand with regards to energy consumption; it suffice to think that ICT (information and communications technology) is accountable for consumption of about 3% of the world's total electrical energy. By the end of 2030, it is expected that this figure will grow to 1700 TWh [1].

For this reason, the issue of BSs energy management is fundamental for sustainable development of the sector [2].

Previous literature proposes a number of solutions for efficiency and/or energy savings.

The first set of energy-saving suggestions focused on transmission functions. For example, it was proposed to act on the range of action of the plant (cell zooming) [3], on the high-efficiency power amplifiers [4], on the technological improvement of radio frequency units and smart antenna technology [5], by setting the BSs to stand-by mode [5–8], in order to correlate network energy consumption and telephonic traffic load [9,10].

Furthermore, energy consumption can also be reduced by acting on the air-conditioning systems, both via a correct setting of the apparatus system control [11,12] and innovative conditioning systems [13–15].

To better implements the energy saving actions and, consequently, improve the environmental impact of the cellular networks, it is necessary to accurately monitor the energy consumed by a BS.

The aim of this paper is the study and analysis of energy consumption of a BS, and related environmental parameters, through a monitoring campaign aimed at getting a clear and complete picture of the consumption dynamics of a BS, and the variables that exert more influence on its performance.

2. Characteristics of the base transceiver stations studied

The monitoring involved six BSs of the telephone service provider Wind, located in the municipalities of Frosinone, Sora (FR), Cassino (FR), and Pontecorvo (FR) in center Italy. Table 1 reports the

Abbreviations: BS, base transceiver station; TRX, transceiver; GSM, global system for mobile communications; DCS, digital cellular system; UMTS, universal mobile telecommunications system; MRFU, multiple radio filter unit; DRFU, double radio filter unit; BCCH, broadcast control channel; SDCCH, standalone dedicated control channel; FC, free cooling system; CDZ, Air conditioning system; ITU, International telecommunication union; ETSI, European Telecommunications Standards Institute; TA, timing advance; MR, measurement report.

* Corresponding author.
E-mail address: antonio.spagnuolo@unina2.it (A. Spagnuolo).

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technical characteristics of the BS studied: site name, code and size, BS typology (Shelter, Outdoor, and Room), BS technology (GSM/DCS/UMTS), configuration for each technology (number of TRXs per sector), radio unit type (DRFU, MRFU), number of timeslots for voice, data, BCCH, SDCCH.

Regarding the typology, the characteristics of different BSs are indicated below:

Shelter: cabins made of aluminum and polyurethane foam containing the transmission equipment (housed in special boxes), air conditioning system and all that is needed for the correct functioning of the BS.

Room: buildings containing the same equipment as a shelter.

Outdoor: box containing the transmission equipment. Neither any kind of coverage, nor air conditioning systems are present.

The cooling of indoor air is required in the room and shelter because of the high temperatures of the indoor environment; this is due to the large amount of heat dissipated by the transmission systems and to the factor of solar radiations falling on the cabin (the latter is obviously also present in the case of outdoor BSs, though they are not provided with air-conditioning systems).

The methodologies usually used to decrease the temperature inside the shelter can be identified as:

- **FC (Free cooling)**: cooling system that utilizes atmospheric air temperature to lower the temperature inside the structure: the air enters the room from the outside through a vent.
- CDZ (Air conditioner).

In the case study, for both types of BS (shelter, room), the free cooling system and the air conditioner are located on the same machine and are ON/OFF type. When free cooling is turned on, an extractor is activated, which stops the enclosure from overpressuring.

The on/off of the air conditioner and free cooling is controlled by a PLC (Programmable Logic Controller), with preset "ON" thresholds and associated hysteresis values. The latter represents the

Table 1
Technical characteristics of the stations.

SITE CODE			**FR001**				
Site name			FROSINONE CENTRO				
Station type			**SHELTER**				
Size			7 m^2				
Sampling period			24/09/2013–02/10/2013//04/12/2013–11/12/2013				
GSM Config.			2-2-2				
DCS Config.			4-4-6				
UMTS Config.			1-1-1				
Sector	**Radio unit**	**Type**	**TRX**	**Dedicated Voice timeslots**	**Dedicated data timeslot**	**BCCH**	**SDCCH**
FR001D1	1	MRFU	4	28	1	1	2
FR001D2	1	MRFU	4	28	1	1	2
FR001D3	2	MRFU	6	43	1	1	3
FR001G1	2	MRFU	2	12	1	1	2
FR001G2	2	MRFU	2	12	1	1	2
FR001G3	2	MRFU	2	13	1	1	2
SITE CODE			**FR039**				
Site name			SORA CENTRO				
Station type			**ROOM**				
Size			15 m^2				
Sampling period			22/10/2013–29/10/2013				
GSM Config.			2-2-2				
DCS Config.			2-2-2				
UMTS Config.			1-1-1				
Sector	**Radio Unit**	**Type**	**TRX**	**Dedicated Voice timeslots**	**Dedicated data timeslot**	**BCCH**	**SDCCH**
FR039D1	1	DRFU	2	13	1	1	1
FR039D2	1	DRFU	2	13	1	1	1
FR039D3	1	DRFU	2	13	1	1	1
FR039G1	2	MRFU	2	13	1	1	1
FR039G2	2	MRFU	2	13	1	1	1
FR039G3	2	MRFU	2	13	1	1	1
SITE CODE			**FR005**				
Site name			FICUCCIA				
Station type			**OUTDOOR**				
Size			Only cabinet				
Sampling period			02/10/2013–09/10/2013				
GSM Config.			2-2-2				
DCS Config.			3-2-4				
UMTS Config.			1-1-1				
Sector	**Radio Unit**	**Type**	**TRX**	**Dedicated Voice timeslots**	**Dedicated data timeslot**	**BCCH**	**SDCCH**
FR005D1	1	MRFU	3	20	1	1	2
FR005D2	1	DRFU	2	12	1	1	2
FR005D3	1	MRFU	4	28	1	1	2
FR005G1	1	DRFU	2	13	1	1	1
FR005G2	2	MRFU	2	13	1	1	1
FR005G3	2	MRFU	2	12	1	1	2

SITE CODE			**FR009**				
Site name			PAREDA				
Station type			**SHELTER**				
Size			7 m^2				
Sampling period			17/09/2013–24/09/2013				
GSM Config.			2-2-2				
DCS Config.			4-4-4				
UMTS Config.			1-1-1				
Sector	**Radio unit**	**Type**	**TRX**	**Dedicated Voice timeslots**	**Dedicated data timeslot**	**BCCH**	**SDCCH**
FR009D1	1	MRFU	4	28	1	1	2
FR009D2	1	MRFU	4	28	1	1	2
FR009D3	1	MRFU	4	28	1	1	2
FR009G1	1	MRFU	2	12	1	1	2
FR009G2	1	MRFU	2	12	1	1	2
FR009G3	1	MRFU	2	13	1	1	1
SITE CODE			**FR049**				
Site name			PONTECORVO				
Station type			**ROOM**				
Size			10 m^2				
Sampling period			30/10/2013–06/11/2013				
GSM Config.			2-2-2				
DCS Config.			2-2-2				
UMTS Config.			1-1-1				
Sector	**Radio unit**	**Type**	**TRX**	**Dedicated Voice timeslots**	**Dedicated data timeslot**	**BCCH**	**SDCCH**
FR049D1	1	MRFU	3	20	1	1	2
FR049D2	1	DRFU	2	13	1	1	1
FR049D3	1	DRFU	2	12	1	1	2
FR049G1	1	MRFU	3	20	1	1	2
FR049G2	1	MRFU	2	12	1	1	2
FR049G3	1	MRFU	2	13	1	1	1
SITE CODE			**FR011**				
Site name			SAN GIOVANNI				
Station type			**OUTDOOR**				
Size			Only cabinet				
Sampling period			08/11/2013–15/11/2013				
GSM Config.			4-2-0				
DCS Config.			6-4-0				
UMTS Config.			1-1-0				
Sector	**Radio unit**	**Type**	**TRX**	**Dedicated Voice timeslots**	**Dedicated data timeslot**	**BCCH**	**SDCCH**
FR011D1	2	MRFU	6	44	1	1	2
FR011D2	2	MRFU	4	28	1	1	2
FR011G1	1	MRFU	4	28	1	1	2
FR011G2	1	MRFU	2	12	1	1	2