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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Environmental Engineering (EE).

Introduction

The need to reduce emissions and to include energy efficiency as a new paradigm of industrial development is widely acknowledged. In this context the mobile industry is making efforts to deploy energy efficient networks. In the Mobile Green Manifesto 2012 it is stated that mobile industry will reduce its Green House Gas (GHG) emissions per every connection by 40 % by 2020. Even if in this forecast all the variables in the mobile context are taken into account altogether, it is estimated that 80 % of the energy consumption and GHG emissions of the mobile scenario are due to networks. Studies and recommendations in this context are then highly valuable.

Moreover, it is reported from other sources (see [i.1]) that 3 % of current world-wide energy consumption is due to ICT, which causes about 2 % of the overall CO2 emissions. Since mobile broadband data usage has experienced significant growth and a thousand time expansion is expected by 2020, the consequence could be a significant increase of power consumption of mobile networks.

The present document addresses mobile network level Radio Access energy efficiency measurements, and aims to assess the complexity of these measurements both in real networks and in laboratory environments. The focus is on mobile radio access networks, even if the alignment with Network Efficiency measurements in other contexts is deemed as appropriate. Moreover the analysis is based on "partial" networks (as they are defined in the present document), with an hint on how to extend the results to wider ("global") networks.

As for measurements in real networks, the report will study the most appropriate models to describe energy issues in radio access networks and will introduce measurement definitions to validate these models. Data availability for models and measurements will be checked.

As for measurements in laboratory environments, the report will consider the level of complexity that energy efficiency measurements will impose, under the assumption they are an extension of pre-existing single node energy efficiency measurements (like those defined in [i.2]).

The need for network level energy efficiency measurements is widely acknowledged, both as an extension of energy efficiency evaluations on single nodes and as a "building block" for energy efficiency estimations of entire communications networks.

On one hand, there are radio access features whose impact on energy efficiency cannot be fully estimated while considering single node measurements only. As examples, we can cite RRM procedures, interference management, Coordinated MultiPoint (CoMP), relay nodes management, heterogeneous network deployment, DTX methods, and D2D/M2M techniques.

On the other hand, the radio access network is considered to be one of the most significant contributors to the energy consumption of the entire communications network due to its extensive deployment. To form a complete view of network energy efficiency, the radio access portion has to be considered properly and correct estimation of its energy consumption is needed.

The present document, in defining and describing network level energy efficiency, can be beneficial for different reasons:

- get an accurate measurement (rather than a statistical estimate) of radio network energy consumption and efficiency;
- help radio access network operators understand and consequently improve the energy efficiency of their networks, taking into consideration also the quality of service and quality of experience from the served users;
- enable radio access equipment vendors to demonstrate and improve energy efficiency features under real conditions.

Throughout the present document it has to be pointed out that none of the statements made here are intended to specify models, metrics or measurements procedures, but just to report them from a theoretical point of view, aiming to highlight the feasibility of these various issues. Every definition of these issues will be possibly performed when and if a different phase will be started in the Group, aiming at a Technical Specification purpose. Consider that some topics dealt with in the present document could need more detailed analysis in case of an evolution towards a Technical Specification.

The present document is organized as follows. First of all an analysis of the possible metrics to be adopted for network level energy efficiency (clause 5) is presented, including an overview of the data available to build these metrics under real network conditions (power consumed and throughput information). Clause 6 presents the measurement methods in real networks as far as the studies have identified them so far, either from network inspection or relying on the users data. Clause 7 reports the outcome of the evaluations made during the Technical Report lifetime about laboratories network level measurements, with the recommendations on which an agreement has been reached. Next, in clause 8, a method to extend the measurements made in the framework of partial network scenarios, following in particular the ideas developed within the FP7 European Project EARTH and the method called E3F elaborated therein, is presented, with an example about how to have figures of energy efficiency estimation in global networks. Finally a clause about Recommendations for future work is given and the Report is completed by annexes dedicated to the main European projects helpful in the preparation phase of the work (namely, EARTH and OPERA-Net).