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A decision support framework for smart cities energy assessment and optimization

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Abstract

Cities are becoming more and more of a focal point for our economies and societies, particularly because of the on-going urbanization, and the trend towards increasingly knowledge intensive economies as well as their growing share of resource consumption and emissions. Energy is an essential component of life in the cities, as it supports the whole spectrum of their economic activities and secures a certain level of quality of life to residents. To meet public policy objectives under these circumstances, cities need to change and develop in a smart way, without disregarding the issues of energy efficiency and sustainability. In this context, the aim of this paper is to present a Decision Support Framework able to assess and optimize the energy use in Smart Cities. The proposed methodology is addressed to the cities local authorities, so as to optimize the energy use in their premises and achieve significant reduction of CO_2 emissions. The novel Framework includes two pillars: 'Assessment' and 'Optimization'. The 'Assessment' pillar highlights the strengths, the underperforming sectors and the potentials of a city in terms of energy optimization. The 'Optimization' pillar includes a number of targeted action plans that can be used by the building energy managers of a city. The proposed actions in this pillar derive from the DSS for Energy Management component of the Framework that offers short-term scenarios in a weekly basis, and from the DSS for Energy Efficiency component that offers long-term scenarios in a yearly basis. Moreover, these two pillars combine a number of web based components. The 'Assessment' pillar uses The Smart City Energy Assessment Framework tool (e-SCEAF), which can provide fruitful results for assessing the energy behavior and performance of a city. The 'Optimization' pillar uses the Thermal Comfort Validator (TCV) with the relevant action plan and a Toolset for Assessing the Energy use of Buildings. TCV can assist the energy managers in adjusting thermal comfort parameters, in such a way as to optimize energy use and maintain comfort levels in accepted ranges. The Toolset for Assessing the Energy use of Buildings is able to collect real energy consumption data and calculate automatically the energy savings from a list of improvement scenarios. The novelty of the proposed Framework lies on the merging of multidisciplinary data sources from the following domains: weather, building monitoring, users' feedback, energy prices and energy production.

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1. Introduction

Nomenclature

COP21	Paris climate conference
UNFCCC	United Nations Framework Convention on Climate Change
EC	European Commission
EU	European Union
CW	Computing with Words
RES	Renewable Energy Sources
CHP	Cogeneration Heat and Power
ICT	Information and Communication Technology
DSS	Decision Support System
SCEAF	Smart City Energy Assessment Framework
TCV	Thermal Comfort Validator

In December 2015, at COP 21 in Paris, Parties to the UNFCCC reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future [1]. The Paris Agreement builds upon the Convention and – for the first time – brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort. It is a global milestone for enhancing collective action and accelerating the global transformation to a low-carbon and climate-resilient society. It sets out a long-term emissions reduction goal of keeping the global temperature increase well below 2°C while pursuing efforts to limit the rise to 1.5°C.

In February 2015, EC unveiled its Energy Union Strategy, pointing three interconnected key objectives [2]: (a) curb Europe's dependency on imported hydrocarbons; (b) reduce energy consumption and costs; (c) reduce greenhouse gas emissions. The 2030 climate and energy Framework, was adopted by the EU leaders in October 2014 and set three key targets for the year 2030 [3]: (a) at least 40% cuts in greenhouse gas emissions (from 1990 levels); (b) at least 27% share for renewable energy; (c) at least 27% improvement in energy efficiency.

A Smart City is a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses [4]. It is estimated that 80% of the European population will live in urban areas by 2020 while urban areas are responsible for 80% of energy consumption and CO_2 emissions [5]. Energy-efficient cities are the key for an ecological future and that is a crucial part of Europe's 2020 strategy.

This is particularly true for the building sector, which accounts for 40% of total energy consumption in the EU [6]. In order for Europe to achieve its goals, cities need to become "Smarter". This refers to the optimization of energy use in the building and transport sector and the exploitation of sustainable solutions through ICT. In this scope, cities are gradually directed to the use of tools and methodologies to monitor and support their actions towards energy optimization and sustainability. Such tools commonly concern long-term actions and strategies adopted by the city.

Nevertheless, a wide variety of multidisciplinary data available at a city level could be additionally exploited to provide support to city's authorities to enhance sustainability and energy optimization at a level, regarding short-term energy action plans. Such data concern weather forecasting data, social data, energy prices, energy profiles and energy production data.