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Smart Cities and the Environmental Sustainability

ARTICLE INFO

Published in January 2017

Keywords:

ICT
Sustainable Development
Smart Cities
Environment
Environmental Degradation
Wastes Monitoring
Wastes Reduction
Resources Management

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ABSTRACT

The concept “smart city” was introduced already in 1994, and since 2010, after the appearance of smart city projects and support by the EU, the number of publications regarding the topic has considerably increased (Ahvenniemi et al, 2016). With the term smart city, we describe areas who take advantage of the digital technologies, the infrastructure and the exploitation of information in real time, in order to enhance performance and wellbeing, to reduce costs and control resources consumption[1]. Given this, we consider smart cities to be a new efficient philosophy, for the sustainability of the environment and we analyze the structure and the infrastructure of them based on the city needs.

More specifically, this paper focuses on the ICT applications (e.g. resources control, data mining) and implementations in order to understand and study the necessary processes for the production of intelligent contextual information for sustainable smart cities’ development and management. In this direction, we further conduct a research on a Greek sustainable smart project for schools in association with Intelen Group, a pioneering company in smart cloud systems, in order to prove the effectiveness of smart systems in resources reduction. Lastly, we demonstrate the results of the case, highlighting on the positive effect of the Information and Communications Technology in the Environmental sustainability and thus we make safe assumptions and suggestions for related future work or research. Within the context of this paper, we present statistical data and visual representations so as to facilitate the understanding of readers.

1. http://getbusy.gr/Section/GetFile/25/GREEN%20ICT.pdf - Green ICT overview

INTRODUCTION

With the rise of the current century, our world witnessed a remarkable growth of urbanization, a gradual increase in the proportion of people living in urban areas. As Michele Penza et al. suggest it is anticipated that in less than one generation more than two thirds of the planet population will live in urbanized areas and megacities. At the same time, human needs for evolution and development, industries' demand for supplies and productivity, yet our habits, all of them fed and spread the affair of environmental degradation. Given that, a possible key-solution is to protect and maintain our sources as well as monitor our wastes in order to reach a more ecological and sustainable conscience.

For that purpose, smart cities in conjunction with the ICT (information and communications technologies), applied in our urban societies can overthrow the current situation and serve as a powerful vehicle for green and eco-friendly development. Such structures include several applications where sociotechnical interaction between citizens and pervasive devices a.k.a. Internet of Things (IoT) is often needed (Khan et al, 2012). Intelligent cities and sustainable systems aim at improving the quality of life in urban environments, such as addressing scientific and technological innovations, establishing friendly and livable communities and promoting balanced and resilient development. As the International Telecommunication Union underlines in their report[2], cities represent 75% of the total energy consumption and 80% of CO_2 emissions on global basis, highlighting the impact of cities in the environment. In favor of that point, studies have demonstrated that only in building sector, which accounts for 40% of the energy consumption of Europe, ICT use can lead to a reduction of around 10% in total energy consumption.

Even though cities consist of countless physical structures, the assistance of new technologies such as the cloud computing, the Internet of Things, the network of sensors and smart meters enhances the mapping of all the assets and infrastructures of smart sustainable cities. The role played by ICTs in Smart Sustainable Cities is crucial, due to their ability to act as a digital platform from which an information and knowledge network can be created. For instance, environmental sensors can automatically collect data from the environment e.g. water, air quality to name but a few, and transform them into useful information for the system. However such a challenge requires contemporary ICT solutions capable of storing and processing significant amount of data and produce intelligent contextual information (Zaheer Khan et al, 2012). Hence, the effective and efficient design and implementation of waste

2. https://goo.gl/nVpJEH - International Telecommunication Union Report

management system requires understanding, adjustment and optimal correlation of all modern IT standards applications and city needs. Summarizing, Smart government services and smart public infrastructures, which are either completely novel or greatly superior to their traditional predecessor counterparts in terms of ease of use, comprehensiveness, effectiveness, efficiency, and high-speed interconnectedness, are seen as hallmarks of a smart city and its government in the 21st century (Washburn et al, 2010).

In this paper, we are trying to explain the importance of smart cities in addressing sustainability. We highlight the positive aspect of the ICTs in the environmental development and we analyze the main core of the infrastructure in that direction. Over and above, we conduct a theoretical case study, a walkthrough on a sustainable smart project for Greek schools from Intelen Group, a company specializing in Energy Information Systems & Computing and in the development of Smart Grid Services & Smart Metering and other information and management analysis. Eventually, we project the results of the project underlining the positive effects of the ICT in the environment.

LITERATURE REVIEW

Although the term smart city has appeared since 1998 (Van Bastelaer), it is still confusing with regard to its meaning and context, since its definition ranges from mesh metropolitan information and communication technology (ICT) to various ICT attributes in a city (Chourabi, Allwinkle and Cruickshank), to urban living labs (Komninos),or to the "smartness footprint" of a city, which is measured with indexes such as, the education level of its inhabitants, the innovative spirit of its enterprises, etc. (Giffinger). Regarding to Komninos the definition of Intelligent-Smart cities used to describe areas (cities, districts, towns, districts, clusters) in which the local innovation system is supported and upgraded through digital networks and applications. Within this definition are identified and tied together all the key elements of a smart city such as innovation, creativity, knowledge, people who make up the community and of course the technology.

The intelligent infrastructure allows to collect the huge amount of data and intangibles information that a city produces real-time and to connect them with its urban structure and with the actors who work within it, who carry out their activities, use services and make decisions more efficiently. The city gains innovation, which means competitiveness and prosperity.

Two key components of smart cities are:

i. The innovation system (local / regional), which guides the development of knowledge and technology in local organizations (businesses, universities, technology centers, incubators, etc.)
ii. The digital information management applications, facilitating information, communication, decision making, implementation and application technologies, cooperation in innovation, etc.

All these different meanings address the scale and complexity of the smart city domain and describe alternative approaches, schools of thought and researchers who deal with this phenomenon. Furthermore, smart cities have attracted the international attention by international organizations (i.e. the European Union (Anthopoulos and Fitsilis)) and big vendors from the ICT industry (i.e. CISCO, IBM (IBM Institute for Business Value) and Alcatel (Alcatel-Lucent)), the electronics (i.e. Hitachi) and the construction industries (i.e. GALE, POSCO, and HGC Group (Alcatel-Lucent)) are stressed to develop respective products and to utilize this emerging market.

Moreover this aspect may become an opportunity to address climate change while reducing CO_2 emissions. As buildings are responsible for 40% of energy consumption and 36% of EU CO_2 emissions, improving their energy performance is clearly a key to achieving the '20-20-20' European Community Climate & Energy objectives. European policy makers introduced goals for the year 2020 in a number of different sectors. In the energy sector the 2020 goals were based on the three pillars leading European energy policy: Security of supply, competitive markets and sustainability. The 2020 energy goals are to have a 20% (or even 30%) reduction in CO_2 emissions compared to 1990 levels, 20% of the energy, on the basis of consumption, coming from renewable and a 20% increase in energy efficiency. Recent advances on energy metering and energy efficient equipments have been partially adopted in public and residential buildings. Informing the public, and especially the primary and secondary education community, about energy efficient behavior and the new energy-related technologies usually requires significant time, effort and resources, possibly more than the ones a typical organization is willing or able to spare. In addition, the financial benefit that is a determinant factor for the adoption of "green" technologies and best practices is also generally difficult to be accurately estimated and appreciated. Citizens' behavior is an important factor that determines the overall energy consumption of buildings, and may be improved through energy awareness. Results reports indicate that energy-efficiency behaviors account for 51% and 37% of the variance in heat and electricity consumption between buildings, respectively. An energy consumer that is able to know in real time the energy consumption that his/her behavior is causing and compare it to that of other similar users is more likely to initiate changes. The term energy awareness implies the training of a user in terms of understanding how much his actions and his use of appliances contributes to total consumption, and helping him plan specific actions that could lower consumption in a quantifiable way.

The acquired knowledge may be used as follows:

- as the basis for extending the consumers “self-training” to more complicated issues, e.g., understanding correlations between the energy consumption and usage of different sets of appliances, or obtaining a practical meaning of terms and metrics, like reactive power and Watt-hour,
- as the starting point for understanding the connection between personal power consumption and carbon emissions, thus shaping or strengthening the individual "green" consciousness,
- for spurring the user's interest towards inventing strategies for reducing the personal energy needs by cutting off wastes without sacrificing personal comfort.

Almost all sciences can be met in the smart city domain, which approach this phenomenon from different perspectives. Scholars and schools across the world are being or have been investigated this phenomenon and an indicative “picture” is provided.

Given the energy scarcity problem and the consequent need for its optimal use though user awareness, we will conduct a research in a set of smart energy power meters that have already been installed into schools for the real time monitoring of their energy consumption. A Greek sustainable smart project for schools in association with Intelen Group, in order to prove the effectiveness of smart systems in resources reduction.

CASE STUDY

Prior to analyzing the specific aspects of the case study, a short background on the companies involved is crucial. With the help of the Computer Technology Institute and the Greek Research and Technology Network, Intelen was the key company that helped implement the pilot introduced in the present paper.

Specifically, Intelen can be defined as a software analytics start-up company[3], set to create ingenious informatics systems to revolutionize the energy analytics industry. First founded in 2006 by a team of engineers of the National Technical University of Athens (NTUA) and officially established in 2011, the company is considered a pioneer at national level till this day. The group consists of young ambitious scientists and engineers of NTUA and other top schools from around the globe, whose goal is to promote technological research, creative thinking and technological innovation at national and global level, aiming to reflect the Greek applied research and the abilities of the new ambitious Greek scientists. Getting them closer to their goal of national and global recognition are several awards such as TOP-5 ALBA in Green entrepreneurship 2008, best young researchers in Greece (STATUS Magazine 2007) and Innovation Academy member EU i-techpartner.

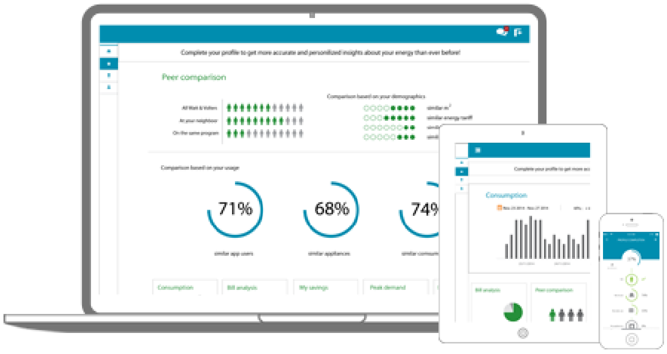
Some of the main factors on which the company specifies are[4]: Energy-Saving Informatics Systems, Energy-Saving Computing, development of Smart Grid Services and Smart Metering. The group has won numerous innovation awards in Greece and abroad in the last 3 years and has three patents in energy informatics, smart metering and services. Especially after taking the big step of a strategic partnership with Google on Energy ICT issues, the group grows rapidly, causing strong interest of major investors from Europe and USA.

Big part of the success mentioned above is due to the launch of their main flagship product called "Intelen DiG SaaS". DiG is a web and mobile app that doubles as an energy module following the Software as a Service (SaaS) solution. Functioning as a monitor of energy consumption, DiG gives the users the ability to learn about alternative practices that cause their daily consumption of energy to be more environmentally efficient. More precisely, Intelen DiG is an application that provides digital energy management both for regulated and de-regulated markets in a way that promotes public-awareness and thus a more environmentally friendly solution[5].

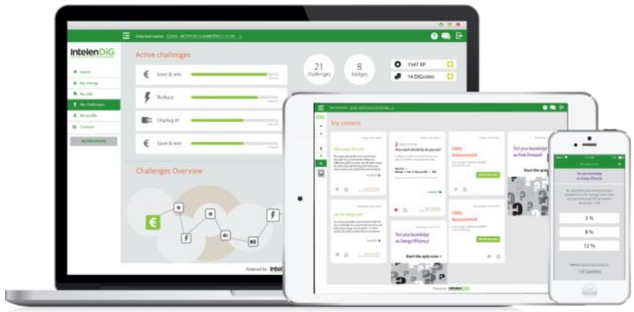
3. http://www.epr.gr/company/13510/
4. https://www.linkedin.com/company/intelen-group
5. http://intelen.com/us/solutions/dig.html

To help customers have an overall view of their energy consumption that will result in a more energy responsible behavior, the product includes a wide range of features such as:

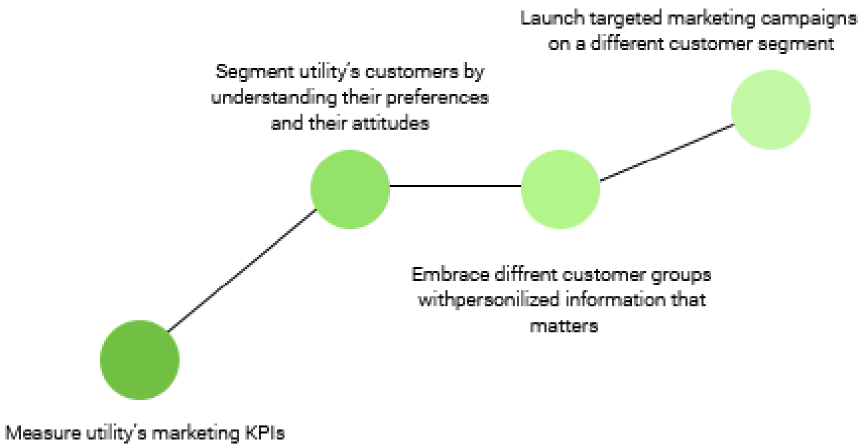
1) Personalized explanatory diagrams for keeping track of the energy waste and cost.



2) Account management.



3) Data driven training materials on energy efficiency and sustainability.



In order to better comprehend the basis of all the projects in which Intelen takes part, we need to take a deeper look into the tools and technologies that are used.

According to the following statement of the company's CEO[6], the importance of the Cloud becomes clear.

«The energy market is transforming. Energy providers are becoming service providers. Our company is supporting this transformation. Our entire philosophy is based on Cloud infrastructure. »

Vassilis Nikolopoulos, Intelen CEO and co-founder.

The ways in which the Cloud contributes in the conservation of the natural resources are plenty. The cost reduction due to less computing systems development, the real-time travelling and analysis of the data that results in faster response and the 24/7 universal access are only a few of the Cloud elements that make it a "green" option.

«The Cloud supports our model (SaaS) for providing services to our end business customer. »

Konstantinos Staikos, Intelen CTO and co-founder.

As a result, Intelen Cloud services partnering with Microsoft Azure platform, creates a complete management environment for the costumers. Using tools as Advanced Analytics and Metering, Machine Learning and Meter Data Management (via Azure Platform), Intelen takes advantage of the global coverage and scalability of the Cloud to create innovative and award-winning applications.

«By leveraging technology we aim to expand the energy supply markets. In addition, our vision is to change the way in which consumers approach energy consumption, through awareness raising, training and by eventually altering consumer behaviour, helping them develop a greener culture. »

Vassilis Nikolopoulos, Intelen CEO and co-founder.

After the brief explanation of the background and tools of Intelen, comes the analysis of the pilot program that took place in several Greek schools counting the energy consumption and waste. As expected, Intelen Cloud is the main tool that helped achieve the metering and management of the data collected.

The innovative and educational pilot implemented by Intelen and Greek governmental organizations aims at encouraging and enabling students to change their behavior so that it becomes more energy and environmentally friendly. The goal is to reduce the schools' energy consumption by at least 10%, even though much larger savings have been reported in our initial installations.

6. Microsoft Azzure, Intelligent Energy management is Cloud based, http://intelen.com/images/company/news/pdfs/case_study_microsoft_ENG.pdf

The pilot provides real-time energy efficiency services over IPv6-enabled networks to the local educational community. Energy data are recorded using IPv6 enabled smart meters. The installed power meters in schools collect energy consumption data that are aggregated through Greek School Network via IPv6 to Intelen's cloud based system. Groups of students will be in charge of monitoring their school's energy performance through the use of the interactive web platform. Via a real-time intuitive interface, the school community will be taught the correlation between the actions they undertake and the energy consumption/CO_2 emissions of their schools, providing in this way significant motivation.

The innovative and educational pilot implemented by the Computer Technology Institute (CTI), Intelen[7] and the Greek Research and Technology Network (GRNET)[8] on the Greek School Network (GSN) aims at encouraging and enabling students to change their behavior so that it becomes more energy and environmentally friendly.

The Greek Research & Technology Network (GRNET) is responsible for providing networking and cloud computing services to the Greek academic and research communities.

The Intelen, a start-up company providing services to the Energy and ICT sector, such as advanced metering (AMI), meter data management(MDM).

The Computer Technology Institute & Press "Diophantus" (CTI)[9], responsible for the administration and the daily operation of the Greek School Network. Specifically the technology that was used is described in the way further on. The proposed system utilizes Intelen's smart metering infrastructure (AMI) consisting of a consumption metering device (CMD) along with its current transformer (CT), a transmitter, and the so-called i-box.

Advanced metering infrastructure (AMI) systems are systems that measure, collect and analyze energy usage, and communicate with metering devices (CMD) such as electricity meters either on request or on a schedule. These systems include hardware, software, communications, consumer energy displays and controllers, and a MDM.

The I-box is a smart network device that acts as a data bridge between the power meter and the local building router. The primary internet connection in education buildings is broadband (xDSL) connection with IPv4 or IPv6 characteristics. The installed power meters collect energy consumption data that are sent over the GSN/GRNET network aggregated to Intelen's Head-End System (HES) and then to Intelen's MDM.

It is really important to understand the use of this small box. I-box is a smart device that acts as a data bridge between the meter and the internet and is capable for a series of services,

7. Intelen: http://www.intelen.com
8. CTI, Computer Technology Institute-"Diophantus", http://www.cti.gr/en/
9. Greek Research and Technology Network—GRNET, https://www.grnet.gr/en

Including the following:

• It performs basic calculations in order to translate the raw data that are collected by the specific CMD to information that can be handled by centralized (cloud) infrastructure,

• It acts as memory storage (buffer) so that in case of a network or other error, data are not lost, but are stored for transmission when network connectivity is re-established,

• It extracts the appropriate key performance indicators (KPIs) from the raw data received by the CMD,

• It receives instructions for extra KPIs from Intelen's Meter Data Management (MDM) System,

• It performs error handling concerning the CMD, the connectivity of the system and the i-box itself.

The MDM is responsible for data acquisition and is capable for a series of services, including energy analysis, financial analysis, and demand response (signal notification, manual and automated response, response analysis, and quantification). Finally, the MDM feeds the processed information to Intelen's intercompany data exchange (IDE) system, which exposes the Web services used by the Web platform ("Web platform and social engagement" section).

PILOT RESULTS FROM 10 SCHOOL BUILDINGS

The selection of the participating schools was an important decision and would influence the success and the impact of the Greek pilot. The selection was based on detailed school characteristics and their location:

-Detailed school characteristics: Greek School Network (GSN) organized a survey to collect information regarding the characteristics of the schools and the school buildings, the teachers' and students' populations, and their kind of interest in environmental issues, including their environmental habits or past activities on related issues.

-Location of the schools: the selected schools was located all over the Greek territory therefore they will present diverse climate and geological conditions. They are located across three adjacent prefectures (Achaia, Korinthia, and Attiki). Variations in energy consumption will be based on percentage basis and they can be monitored without affecting the impact on the achieved energy savings in the pilot.

The final selection of the schools in the pilot has been done based on the compound of the previous factor and the analysis of questionnaire's responses, interviews with interested teachers, and on-site visits that were also performed. Intelen introduce the first results of the smart meters at 10 (out of 50) school buildings. The total energy power savings for the school units over a period of 10 weeks was 12.234 KWh. As a result the calculated monetary benefit is 3.500€, when the electricity school price for energy unit is 0, 12€ per KWh. The probable power saving per school year (40 weeks) is 48,936 KWh.

Table 1 depicts the power energy saving results (in KWH) after a period of ten weeks. It should be noted that first week until tenth week are presented after normalization.

School Name	Power Saving
1st High School Haidariou	21,30%
8th Primary School Vyrona	24,06%
70th Primary School Athens	39,30%
10th Primary school Haidari	33,38%
7th High School Haidari	36,10%
152th Primary School Athens	38,26%
7th High School Peristeri	39,91%
8th Primary School Dafni	33,39%
1/7th Primary School Athens	31,22%
59o High School Peristeri	37,60%

TABLE 1: POWER SAVING IN KWH

Some useful details and school characteristics from the survey (school density, population, cumulative average energy consumption before and after the pilot installation are presented in Table 2.

Also cumulative average energy saving per day is depicted in the same table.

No. of Buildings	10
Av. School Sqm2	~1800 sqm2
Av. Student population	~250 students
Av. Energy / day consumption before smart energy meters	96.1 KWh
Av. Energy / day consumption after smart energy meters	71.7 KWh
Av Energy savings / day	25.39%

TABLE 2: SPECIAL CHARACTERISTICS

Table 3 represents the approximate extrapolated statistics for one school year (consisting of 40 school weeks).

electricity price for schools	0.12€/kWh
Value of savings in 10 weeks	5,872€
Annual consumption at start (280 days)	26,908 KWh
Annual consumption per student	108 KWh/student
Value of annual savings	5,872 €
Value of annual savings per student	2.35€/student

TABLE 3: EXTRAPOLATED STATS

Table 4 depicts some results of the Demand Response (DR) pilot. DR are signals that were sent using mobile SMS and email to the teams responsible, in order to reduce their demand consumptions by specific targets in a specific timeframe (drop by 1,4KW in the next 30mins). The graph shows the engagement efficiency in % to the Demand DR, during 10 weeks. The DR efficiency rose from 65% up to 74% after 4 weeks and then was stable, fluctuating over a median. This means that from the initial DR targets, the schools were able to respond to the DR signals with some delays (~15-20 mins) and to meet their initial DR targets (drop in KW) approx by 75%.

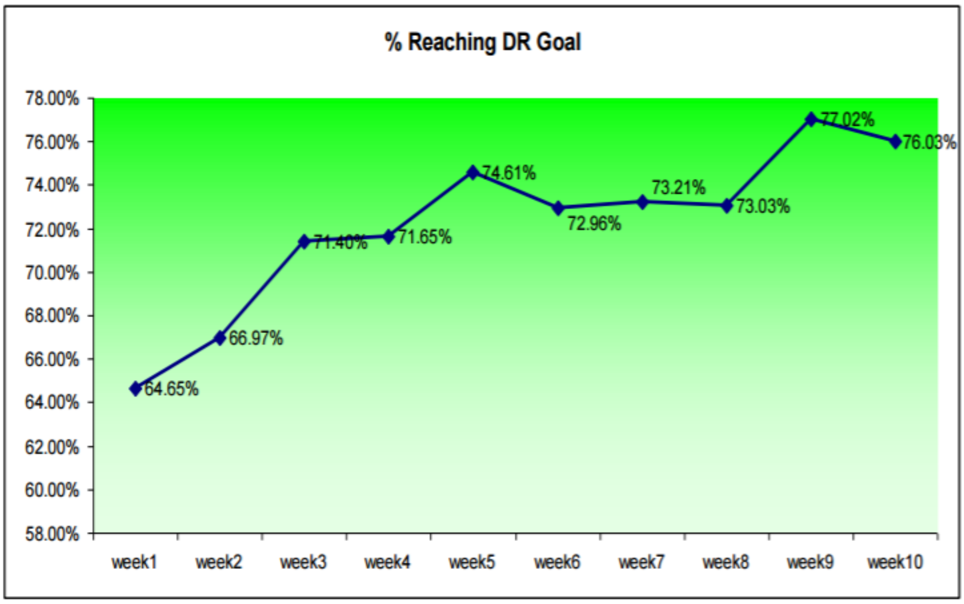


TABLE4 : ENGAGEMENT EFFICIENCY IN % TO THE DEMAND RESPONSE SIGNALS THAT WERE SENT TO THE STUDENT TEAMS

CONCLUSION

Concluding the analysis, we will proceed to state the main overall points made in this paper. Since the number of the world population inhabiting cities or towns by 2020 will be over 10 million people, which is over 50% of the total population, the need of environmentally friendly infrastructures is urgent. In other words, the urban metamorphosis that comes along with the concept of Smart Cities is the key for the future sustainability.

In addition to the technologies that define a Smart City (e.g. renewables integration, energy and water management), ICT is a setting stone for their sustainability. Advanced Environmental meters that are able to process and store a significant amount of knowledge, should be available at all times. The Information and Communication Technologies (ICT), make a base for the storage of information without which the purpose of the smart cities' system would be defeated. Hence, the aspect of their concept and infrastructures is not only positive but highly beneficial for the green urban development.

In favor of the above arguments is a pilot program in Greek schools implemented by Intelen Group and several Greek governmental organizations. Intelen constitutes a reliable start-up company that specifies in revolutionizing the energy analytics industry and provides contemporary cloud services that analyze and store the case study results.

As for the pilot, IPv6 enabled smart meters set up in schools are used to collect energy consumption/ CO_2 emission data that are then transported via IPv6 to Intelen's cloud system. The wise choice of the schools that participated to the study as well as the interaction of the students who were in charge of managing the interface resulted in a reduction of energy waste that was significantly higher than expected. In fact, according to the first results that were introduced by Intelen for the 10 out of 50 schools, every one of them reached over 20% of power saving in the first 10 weeks of the experiment which is translated into 3.500€. Despite the impressive numbers, the procedure also raised awareness to the students through their active interaction, concerning the impact of their actions to the environment. Hopefully, the Greek Pilot in schools will be the starting point of an overall Green logic that will be applied to every aspect of the everyday life, not only as an experiment but as a permanent solution. A first step towards this path could be for the present pilot to be adjusted to every school in the country to enhance the "Green attitude" of young people.

As an extension to this pilot, there could be a cloud based system that measures the wood or tree waste due to the excessive use of paper in Greek Schools. Following the exact same path, there would be a student centered interface to determine accountability of each student to the total waste and a cloud system that would gather all the survey information and transform them into useful knowledge. We firmly believe that the results in saving paper would be equally remarkable.

Not only the notable results of the pilot program but also the danger hiding behind the excessive use of natural resources, make the concept of "Green" ICTs less of an option and more of a vital need. It should be noted that contemporary buildings are not the only part of the human invasion into nature that could be upgraded into less harmful. Some further suggestions for adopting an environmentally friendly scope with the support of the ICTs are smart metering usage for monitoring the water loss and detecting the leaks in buildings, so the water waste can be minimized and solar energy systems to reduce the waste of natural resources.

REFERENCES

1. Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2016). What are the differences between sustainable and smart cities? *Cities*, *60*, 234-245.

2. Allwinkle, S., & Cruickshank, P. (2011). Creating smart-er cities: An overview. *Journal of urban technology*, *18*(2), 1-16.

3. Anthopoulos, L., & Fitsilis, P. (2013). Using classification and roadmapping techniques for smart city viability's realization. *Electronic Journal of e-Government*, *11*(1), 326-336.

4. Dascalaki, E. G., & Sermpetzoglou, V. G. (2011). Energy performance and indoor environmental quality in Hellenic schools. *Energy and Buildings*, *43*(2), 718-727.

5. Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. (2007). Smart cities. Ranking of European medium-sized cities, Final Report, Centre of Regional Science, and Vienna UT.

6. Gill, Tierney, Pegg and Allan, Low-energy dwellings: the contribution of behaviours to actual performance, Building Research & Information,, Volume 38, Issue 5, 2010.

7. HITACHI'S, S. C. T. (2012). Hitachi's vision of the smart city. Hitachi Review, 61(3), 111.

8. IMB Institute---Dirks, S., Keeling, M., & Dencik, J. (2009). IBM How Smart is your city? Helping cities measure progress. *Global Business Services Government Executive Report IBM Institute for Business Value Copyright I*

9. Khan, Z., & Kiani, S. L. (2012, November). A cloud-based architecture for citizen services in smart cities. In *Proceedings of the 2012 IEEE/ACM fifth international conference on utility and cloud computing* (pp. 315-320). IEEE Computer Society.

10. Komninos N (2006) 'Έξυπνες Πόλεις: Συστήματα Καινοτομίας και Τεχνολογίες Πληροφορίας στην Ανάπτυξη των Πόλεων', Περιοδικό Αρχιτέκτονες, Τεύχος 60, σελ. 72-75

11. Koumoutsos, K., Varvarigos, E. A., Nikolopoulos, V., & Liakopoulos, A. (2012, October). Eco-labeling Greek schools for energy efficiency over IPv6. In *Informatics (PCI), 2012 16th Panhellenic Conference on* (pp. 256-260). IEEE.

12. Van Bastelaer, B. (1998, October). Digital Cities and transferability of results. In *4th EDC Conference on digital cities, Salzburg* (pp. 61-70).

13. Penza, M. (2014, November). COST action TD1105: New sensing technologies for environmental sustainability in smart cities. In *IEEE SENSORS 2014 Proceedings* (pp. 1-7). IEEE.

14. Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N., & Nelson, L. E. (2009). Helping CIOs understand "smart city" initiatives. *Growth*, *17*(2).

15. Alcatel-Lucent 2012. http://www.tmcnet.com/tmc/whitepapers/documents/whitepapers/2013/7943-alcatel-lucent-getting-smart-smart-cities-recommendations-smart.pdf

16. GEN6—governments enabled with IPv6, www.gen6-project.eu/.

17. http://ec.europa.eu/energy/efficiency/buildings/buildings_en.htm