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A multi service shared energy storage platform in a smart green neighborhood

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ABSTRACT

Continued growth in electricity demand and global concern for carbon emissions are driving us to develop new ways, strategies and technologies to make our neighborhoods, towns and cities sustainable and smart, to meet our needs and same time ensured a good quality of life. The control of the resources needed by the population, in particular electrical energy and efficiency in terms of energy consumption, are essential today to facilitate the transition to sustainable cities. In this article, we study the integration of efficiency in renewable products per neighborhood in order to minimize its total energy cost with respect to different entities belong to this same neighborhood. We even want to have a positive storage capacity in order to collect excess energy and redirect it to other neighborhoods belonging to the same area which are in need of energy. This will enhance the efficiency of energy produced locally resulting in better quality of life, less gas emission , reducing greenhouse effect and resulting in a wiser management of the resources available in our cities.

Key words: Energy Efficiency, Energy Storage Systems, Renewable Energy, Building Energy Management System, Green and Smart cities…

1. INTRODUCTION

As we know, the growing consumption of energy drives a growth in CO2 emission. In 2005, the five principal countries emitting the maximum of CO2 (US, China, Russia, Japan and India) represent 55 % of the total world emission related to energy (AIE, 2007, p. 200) [32].
According to the intergovernmental study group about the evolution of the climate (2007), the concentration of CO2 in the atmosphere should be stabilized to 450 ppm (AIE, 2007, p.50) (a value that has been probably bypassed) in order to avoid any social damage [32].
This makes the emission of gas a major problem for which we all need to find a solution. One obvious solution is the integration and the use of the green energy as one of the best renewable energies to guarantee a safe future for everyone. As countries grows and develop their needs in energy

Rise to new higher levels. For instance, during the period 2005 up to 2030 the rise in the need of energy in China and India represented 45 % of the world demand in energy (IEA, 2007, p .117) [32]. Actually, cities host more than half of the world population, but they will host more than 75 % of the population today [32]. Renewable energies play a central role in the reduction of the greenhouse effect by transforming of the energy system, more specifically the electrical system. Of course, using only the renewable energies cannot satisfy the need of the growing needs cities and the equivalent consumption of fossil energy to be replaced. In **figure 1 [8]**. We represent the evolution of the primary energy world consumption per resource. We can see the obvious domination of the fossil energy [8].

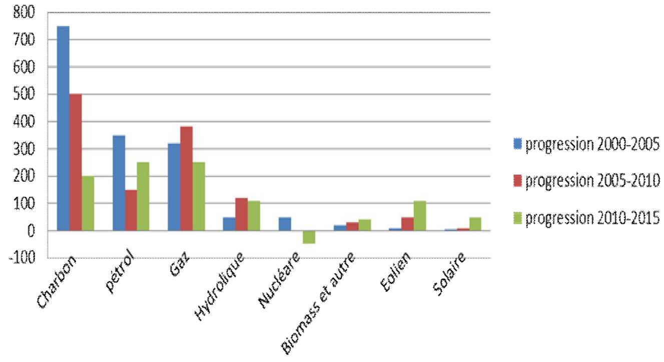

Figure 1: Repartition over 5 year between 2000 and 2015 of the world consumption of primary energy per source (according to the conventions used by BP)

Mastering the demand and the efficiency of the resources usage remains necessary in order to make our cities New methods in cities management is a vital step to ensure this transition and to move from mediocre to a green and better environment.
Today with the rising deployment of the distributed energy resources, retention of electrical vehicles (EV) and the plug-in hybrid electrical vehicles (PHEV) the energy system of houses and buildings becomes more complex. This leads us inevitably to building new models, with new approaches and strategies in energy management with respect to multi-sources and multi charges as a very important step to reach the objectives cited above.

This article studies the integration of renewable energies produced locally in a neighborhood in an intelligent and efficient mean. We propose a management energy model that allows the reduction of the energy consumption all over the neighborhood, enhance the quality of life and make the neighborhood autonomous in term of electrical energy in case the locally produced energy is important. This allows us to have to green eco-friendly neighborhoods.

2. STATE OF THE ART

The energy management in Moroccan cities is the center of attention of many Scientifics, social and economic stakeholders. Many articles and researches have treated this subject in different ways.
Some approaches [1] [4] address the problem of community stock management as solution for storage of renewable energies. They propose a strategy responding to a demand for the management of energy within a community of smart houses. Some buildings possess renewable energy systems (REN) and energy storage systems (ESS). More precisely, an off algorithm plans the integration of renewable resources by marketing energy between produces and buyers while the coordination is ensure by the energy provider.

Using energy storage systems to manage renewable local resources could bring a reduction of the cost and avoid network congestion problems to energy providers [2], [3]. We propose an optimal offline energy-scheduling algorithm for a closed system for which the energy profile is perfectly defined and known à priori. Inspired by the offline solution and based on slides for the management of energy in real time under the practical configuration of the net energy profile with arbitrary errors.

Some research propose energy storage systems for smart homes, in order to allows this houses to have an optimal consumption and also to the energy provider to have a uniform demand by allowing the latest to store energy in periods where unit prices are cheap and deploy when prices are high. This results in very lows bills for households thanks to uniform energy demand pattern [5].

Reasoning over the whole network of consumers belonging to the same neighborhood can only increase the return of energy exploitation and even lead to an autonomous functioning of the whole neighborhood. This technic could ensure a smooth transition to a better quality of life for future generation.

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3. CONTRIBUTIONS

Our contribution is about using innovation for a multi service energy storage unit, this platform of storage is used to collect all the excess of energy in the buildings producing energy locally to redistribute it in a smarter and optimal way to different demanders located in the same area. This energy could be used for other electrical networks, for charging electrical vehicles and participate to the different energy needs of the neighborhood facilities.

We consider a neighborhood, a number B of building (buildings are different type: residential, train station, hospital…). Some buildings have ENR and ESS; we model a system as follows (**Figure 2**):

P: Group of buildings having ESS and ENR.

N: Group of non-producing Buildings

$B = P \cup N$

The management of energy in a neighborhood is treated in a finite time T, this time is divided into equal and indexed intervals t, t=1, 2 …T. All the buildings in this neighborhood have a BEMS (Building Energy Management System), which allows the management of energy, the prediction of the daily demand in energy and the communication with other costumers, among which the storage energy platform.

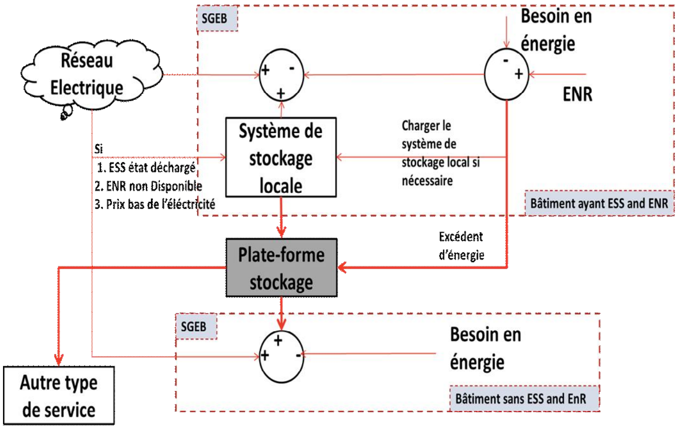

Figure 2: Functioning schema of the proposed platform

The algorithm plans the integration of renewable energy products in this neighborhood. The algorithm will manage every owner of the renewable energy (RE). It determines the quantity of the renewable energy produced by the producing building in and time interval T that must be saved in the ESS of the same building in order for its energy demand to be satisfied in this period. The excess of energy resulting of each interval of time is then sold to different costumers of the community through the storage platform. The schema of **Figure 3** shows a demand scenario of each building.

RE (P): Renewable energy produced by a building P, through a time interval t

ES (P): Stored energy in the local ESS of the building P, in the time interval t

ED (P): Energy demand of a given building P, Producing building, in a time interval t

EB (P): Energy bought from the electrical provider of the neighborhood.

EV (P): Energy sold by a producing building P during a time interval t,

EV (P) = RE (P) + ES (P) + EB (P) – ED (P) (1)

A first objective is to make EB (P) null every t, the off line algorithm which will manage the planning of the integration of the renewable energy, the management of the ESS and the on demand management of the building.

ED (N): Energy demand of a building N, non-producing building.

EF (N): Energy provided by the energy storage platform.

EB (N): Energy bought by a building N, C (N) is the relative cost relative to the energy sold.

ED (N) = EF (N) + EB (N) (2)

A second objective is to make C (N) tend to 0; it is the second role of this algorithm which plans the demand of energy of the building with the energy platform depending on the electricity unit price.

EV: Total energy sold by the group P during all the period T to the storage platform.

EF: Total energy given to the storage platform to a group of N during all the period T.
EB: the energy bought from providers during the whole year.
C: the total cost of energy bought in the whole neighborhood.
The objective is to have during the whole period T, EB tends to 0; otherwise its related cost C should be the minimum possible. This will be ensured by a centralized algorithm which will manage the demands and sells of all the buildings belonging to the service zone, the scheduling of the charging and discharging of the platform.
Our objective function is **F= MIN (C, EA)** for the entire neighborhood and during all the duration T.
ER = EV-EF (3), the remaining energy after satisfying the need of the building during all the period This energy could consumed for other matters.

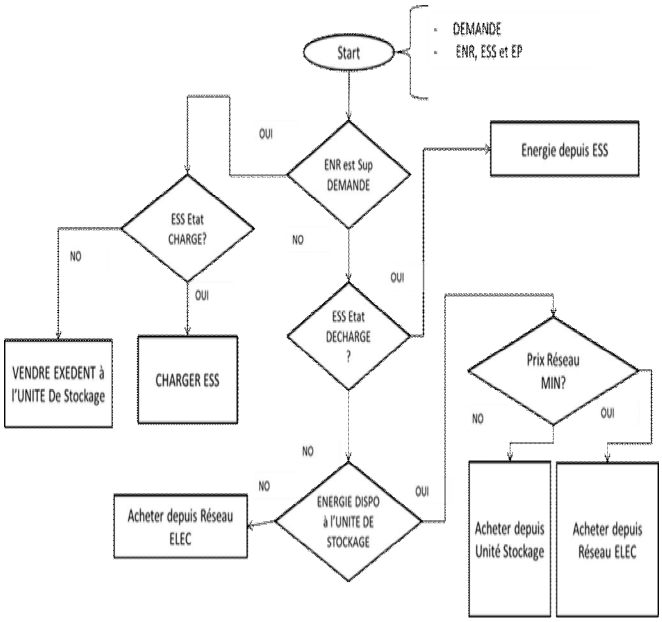

Figure 3: Algorithm of the proposed solution

4. CONCLUSION

This article describes a solution that facilitates the implementation of DR (Demand – Response approach) among buildings belonging to the same neighborhood, and an intelligent use of the resources available. This is done through the usage of a local shared storage platform. Many advantages result from this for the owners of the local products (having local renewable energies) because the platform will allow a big integration of the resources (Efficiency in term of usage) or for adjacent buildings which do not have local energy storage. They can have access to cheaper electricity. The energy provider will benefit from this as equilibrium in its network. In case the local production is important, one can hope to have an autonomous and green.

Nowadays the equipment of renewable energies is experiencing an exponential evolution, and the quantity of energy produced locally is going to grow inevitably. The excess of energy and the good redistribution to other customers via smart algorithms and smart technologies will make a building smart, autonomous with a cheaper cost of energy transportation. This could be extended to cities and therefore enhance the quality of life of future generation.

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