E-Kanban the new generation of traditional Kanban system, and the impact of its implementation in the enterprise

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Abstract

The evolution of information systems and their association with other approaches have created new systems such as: Lean ERP, which results from the link of the Enterprise Resource Planning system "ERP" associated with Lean Manufacturing approach.
Lean ERP, has a variety of new computerized modules, following the Lean approach as: Electronic Kanban production system (E-Kanban), which is the logical continuation of the classic traditional Kanban system with cards. However, E-Kanban has several advantages over traditional Kanban system with cards, such as: better transparency, traceability of all movements in the system, and E-Kanban can work with a greater number of materials.
In this article, we review the literature of traditional Kanban system, its evolution towards electronic Kanban system, in which case apply them? The aim is to distinguish between the two systems and to show the advantages and limitations of their applications to the various stakeholders of a company.

Keywords
Kanban, Electronic Kanban, Lean Manufacturing, ERP, Lean ERP.

1. Introduction

Today enterprises are facing several constraints, mainly global competition, a highly variable customer demand, and the increased variety of products on the market, hence the need to adjust production as much as possible to the needs of the market. In such circumstances, active and accurate control of production must be taken into account.
Several production systems are present to meet customer demands, the traditional classic Kanban system that is part of the Toyota production system (TPS).
Traditional Kanban is a simple and effective tool, which follows a purely Pull approach of Lean Manufacturing; It is a Material Flow Control (MFC) mechanism, that can control: the right amount to produce in a timely manner, inventory levels, supply components, and raw material (Graves et al., 1995), to avoid overproduction (Barkmeyer et Kulvatunyou, 2007). Knowing that the development of the Internet, information and communication technologies (ICT) have enabled enterprises to compete in national and international markets, thus improving their responsiveness (Barkmeyer et Kulvatunyou, 2007). New information and communication systems, such as: RFID: Radio Frequency Identification, EDI: Electronic Data Interchange, ERP: Enterprise Resource Planning (Barkmeyer

et Kulvatunyou, 2007), give new opportunities to develop more automated and sophisticated electronic Kanban systems (Graves et al., 2008) than the traditional systems.
Electronic Kanban also known as E-Kanban includes all the features of the traditional Kanban system, using a mixture of technology to replace traditional elements such as Kanban cards, while signaling actions and changes made in production batches (Graves et al., 2008; Surendra et al., 1999). The computer system can also calculate kanban parameters and update them in the real-time system database (Graves et al., 2008). This usually requires the implementation of a customized system or customization of a Lean ERP system, which holds among these modules electronic Kanban.
Although electronic kanban has many advantages over traditional one, there are few articles that study the E-kanban system, its principles, also its operation within the enterprise.
This article aims to: explain the differences between the two systems: traditional kanban and electronic kanban, why we have improve the classical Kanban system? Who was created to have better manufacturing efficiency. Then analyze the results of the implementation of E-Kanban system within the enterprise, while focusing on the impact of its installation on the suppliers, and finally deduce the gains generated and the limits for the different parts Stakeholders.

2. Kanban systems

The Kanban production system is an old system used for many years, since the creation of Lean Manufacturing by Taïchi Ohno after the Second World War, based mainly on the continuous elimination of waste (Suprasith et al., 2011). This production system is the main key to just-in-time (JIT) (Suprasith et al., 2011), which follows a purely Pull approach (Mayilsamy et Pawan, 2014), its principle is no one can produce a product or service upstream until the client asks downstream and thus the beginning of each process is triggered by the fulfillment of another.

2.1 Traditional Kanban System

Kanban is a signal for the demand for a specific product, in specific quantities of elements or raw materials (Kumar et Panneerselvam, 2007; Muris et Moacir, 2010), to be delivered to a specific process (Mayilsamy et Pawan, 2014). It is a system of managing movements of materials including information system, based on kanban cards that make it possible to trigger the movement from one operation to another (Ramnath et al., 2009).
These Kanban cards have an inventory number attached to part of production, containing all the information and details required for each step, from production to assembly of a product (Kumar et Panneerselvam, 2007; Mayilsamy et Pawan, 2014). They are used to communicate effectively with internal and external operations on issues such as production schedules, delivery time and stock information (Apreutesei et al., 2010). A model of a kanban identification card is presented in Table 1, knowing that there are several types of kanban card, they are editable and flexible according to the need of each enterprise.

Table 1. Example of a traditional Kanban card

Kanban identification card	
product ID	
Description / Specifications of Product	
Provider	
Customer	
Quantity / Weight Received	
Container number	
Destination	

Knowing that each workstation produces or supplies products or components, only when it receives a Kanban card from the upstream workstation (Suprasith et al., 2011), which is considered as a production order. In other words, work is done only when it is necessary (Suprasith et al., 2011).
The kanban system remains simple to implement with low cost, it helps production units to respond rapidly to changes in the supply chain by transferring accurate and automatic information from production (Suprasith et al., 2011), hence there is a continuous flow control of production and stocks (Kumar et Panneerselvam, 2007). To perform it successfully, some basic operating rules must be followed; For example: Production should start only when the client triggers an order (Ramnath et al., 2009); The Kanban boxes must be checked regularly and treated

according to the principle of first in first out (Ramnath et al., 2009); The number of kanban cards needed for each product must be checked (Mayilsamy et Pawan, 2014).
Manufacturing companies that adopt traditional Kanban system generally use a Kanban board to visualize the movement of materials in a manufacturing / production facility Table 2. shows an example of a kanban board proposed for demand to prepare machine in a sewing workshop in order to formalize communication between the various stakeholders, it also gives a visibility on the progress of preparations of Sewing machines by all the persons concerned (Houti et al., 2014).

Table 2. Kanban board for Sewing Machine Park (Houti et al., 2014)

Seam line	Demand of preparation machine	Machine is waiting accessories	Machine being set	Machine Ready to use
MM01				
MM02				
…				
MM16				

Many enterprises use a system like Kanban since the material is controlled using documents, for example at the level of the production department. Control is done via calendar sheets, material list, or product structure; Hence there exist a number of works in which the term kanban is used but without discernment (Muris et Moacir, 2010).
Therefore Kanban system is not suitable for all enterprises, especially those with fluctuating demand, poor quality production processes, or having a relatively wide variety of products. (Suprasith et al., 2011) Decreases or increases in demand for sudden products can also cause problems for a traditional Kanban system. Moreover, this is the case for manufacturing processes that involve several parts or product mergers, which can increase the complexity of a traditional Kanban system, which in turn can lead to a system failure (Suprasith et al., 2011).

2.2 Electronic Kanban System

A traditional kanban system with cards has some limitations, due to the unproductive work caused by the manipulation of cards, but correctable with a computerized system (Drickhamer, 2005). The movement of kanban cards always has some irregularities, since they are not moved at the exact time that the consumption of materials (Drickhamer, 2005), while the pace of manufacturing operations increases and the size of the production batch, the number of card movements also increases; So cards are lost or misplaced sometimes, causing immediate problems in just-in-time production (Kumar et Panneerselvam, 2007). The kanban system remains difficult to adapt to changes in mixed production since the cards have to be collected and replaced by new ones (Mertins et Lewandrowski, 1999). The most optimal solution is the use of a computerized system such as the electronic Kanban system which offers many advantages over the traditional kanban system.
This is why many enterprises have installed ERP systems: enterprise resource planning to improve interactions and communications between their customers and their suppliers (Mabert et al., 2001), thus improving the responsiveness and quality of information, by integrating data and information across the organization, accelerating response time and making decisions faster (Graves et al., 1995).
ERP can be considered as a large software system to link all parts of the business by encouraging best practices of standardized business processes, following a Push approach (Adam et al., 2012). Lean Manufacturing is one of these best practices focused mainly on manufacturing, oriented towards a pull approach (Cruz-Cunha, 2010). This shows a productive way of seeing the synergy that can emerge from a marriage of the two methodologies, offering a Lean ERP system (Cruz-Cunha, 2010).
Lean ERP includes database elements, tool sets, and business process changes via a variety of new modules mainly Lean, implemented in the ERP system such as (Cruz-Cunha, 2010):

- Production smoothing;
- Just in time;
- Value stream mapping "VSM";
- Electronic Kanban.

Many enterprises have chosen to apply the Lean ERP system by installing different Lean ERP modules such as the electronic kanban system which represents several advantages over the traditional kanban system.
A traditional kanban system has some limitations, due to the unproductive work caused by the manipulation of the cards, but correctable with a computerized system (Drickhamer, 2005). The movement of kanban cards always has some irregularities, since they are not moved at the exact time that the consumption of the products (Drickhamer,

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The electronic Kanban system (also referred as E-Kanban) is a signaling system that uses a mixture of technology to trigger the movement of materials within a manufacturing or production facility (Surendra et al.,1999). Kanban is more reliable (Graves et al., 2008), using technology to replace traditional elements such as Kanban cards with barcodes, RFID "Radio Frequency Identification" and electronic messages (Surendra et al.,1999). Has fewer errors in card management and decision making (Graves et al., 2008).
Reason why a description of the electronic kanban system, principles and ideas about its design are necessary and can be presented as follows (Graves et al., 2008):

- First, the electronic kanban should follow the principle of the traditional card based kanban system. These principles include, for example, smoothed and leveled production, mixed model sequencing, stable material flow, operations tight synchronization (takt-time calculations), and pull signals generated by the status of inventory or production system.
- Second, the electronic kanban system should support the continuing improvement that is considered by many authors as one of the most powerful features of the kanban system. The traditional kanban system is used to lower down inventories and minimize production batches until hidden problems are revealed. After the problems are corrected, the inventories and batch sizes are reduced to reveal new problems. This improvement approach should be included in the kanban system to obtain most of the advantages of the pull production system. An electronic kanban system should also support the operations improvement by collecting and reporting data about manufacturing operations and material movement and storage.
- Third, the system must be user-friendly and the system interface must be well designed. Despite all the possibilities that information technology offers, the system should be as simple as possible from the point of view of the operator.
- Fourth, the system can be used to solve card problems. Mixed production, process visibility, system speed and improved reliability are major challenges for investment in the E-kanban system. These functions must be taken into account when planning the control software.
- Fifth, E-kanban will contribute to filling gaps in the manufacturing process such as machine failures, quality problems or material flow problems.

E-Kanban acts as a "command panel", which allows real-time visibility of demand signals and gives an overview of the status of each workstation in the system (Muris et Moacir, 2010). All transaction-related information is automatically collected and analyzed at different stages of the manufacturing process to control and make decisions in relation to the size of production batches, hence the definition of the passage time of the products (Graves et al., 2008; Muris et Moacir, 2010).
The E-Kanban system can also help implement a Pull production system in a manufacturing environment where the traditional kanban system would face difficulties (Graves et al., 2008). It can be used with a mixed production that constantly evolves according to the needs of the customers, as the location and the size of each batch is known and the change of the kanban cards takes place automatically in the computer system (Graves et al., 2008), which reacts as a basis for mutual communication (Muris et Moacir, 2010) with the stakeholders of the enterprise: customers and suppliers and therefore the communication is more clarified. Quality problems or failures of the machine can also be included in the logic of the computer system so that the influence of failures or quality problems is minimized and recovery is done in a controlled manner (Graves et al., 2008).
Therefore, an E-kanban system can bring visibility and improvement of the production and management of materials into an arrangement where operations are dispersed, and therefore if implemented with care, it can eventually work in an environment where a Kanban-based card would not function properly (Graves et al., 2008). That is, the E-Kanban system can be integrated into enterprise resource planning systems that adopt the Lean (Lean ERP) philosophy (Mertins et Lewandrowski, 1999), thanks to their centralized database that gathers all the company's data.

2.3 In which case use kanban or E-kanban?

The E-kanban system is the new generation of the traditional classic kanban system. It has many advantages, such as the history of the operations carried out, which makes possible to check whether the employees use the Kanban

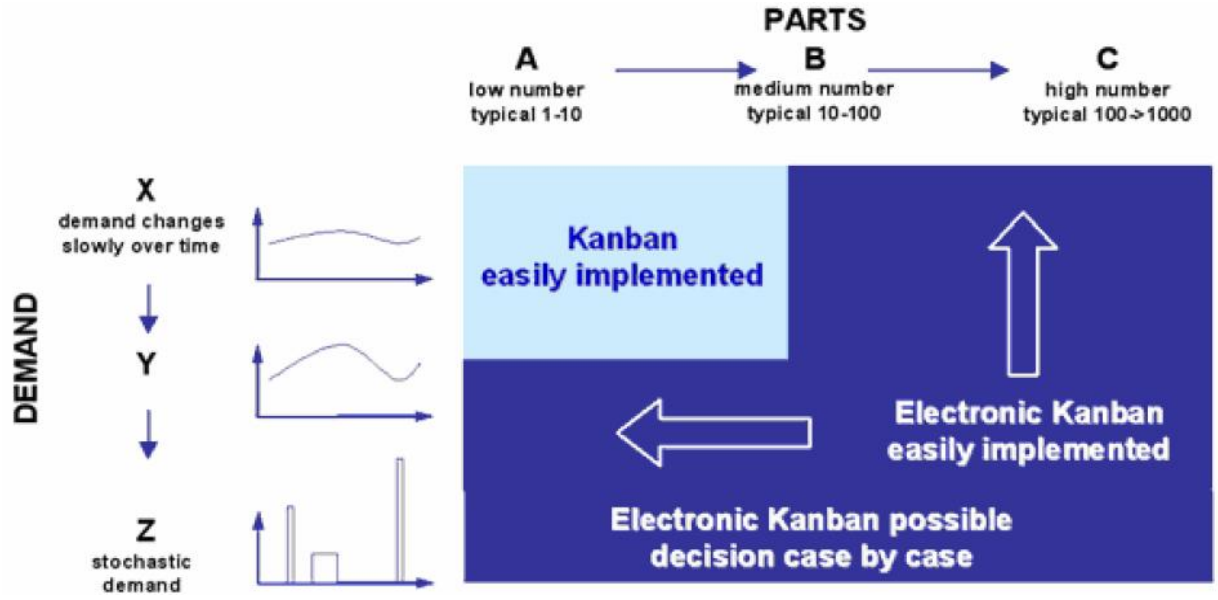
system correctly or not. Which is quite the opposite of the traditional Kanban system which does not gather all the historical data.

There is also a multiplicity of advantages compared to the traditional system mentioned (Graves et al., 2008; Mayilsamy et Pawan, 2014):

- Reduction of manual card handling and order entry activities;
- Eliminating the problem of cards lost;
- The fast and efficient optimization of kanban cards;
- Improved visibility of signals in real time;
- Accurate communication with suppliers;
- The efficiency of suppliers is always analyzed;
- The efficiency of analysis and adjustment of Kanban quantities;
- A delivery of the request at the right time;
- Minimization of material shortages;
- Improving the transparency of the supply chain.

Thus, there are still areas where traditional Kanban may be better than E-Kanban; This occurs when there is no appropriate information in the Lean ERP system in relation to the quantity of products to be produced per day, and depending on the demand whether it is stable or not . What is more detailed in Figure 1 which shows the comfort zones for each kanban system.

Figure 1. Areas of application of Kanban systems and E-Kanban (Suprasith et al., 2011)



As shown in Figure 1, with a growing number of materials circulating in the enterprise, it is very difficult to use the traditional card system, because it is impossible to control the large number of Kanban cards that circulate but with the speed of the changes that can be made at the level of the E-Kanban system there is better applicability. The same thing in the case of a variable or random demand the traditional system becomes unstable, since it cannot operate in a mixed mode variable.

Therefore an electronic Kanban system is more suitable for a variable or even random demand of products, or for a high number of materials that circulates in the workshop; Knowing that it can even work for a stable demand and a small number of materials, except that the cost of its installation remains high compared to this production type, which is why it is recommended to install the traditional Kanban system which fits perfectly with a stable demand that changes slightly over the time, or with a number of materials that is not very large. Hence the necessity of a comparison between the different Kanban systems in order to be able to extract the most from each production system, which is summarized in Table 3 which brings together the points of views of the author of the article and Olga, M.

Table 3. Comparison of card Kanban and E-Kanban

	Card Kanban	E-kanban
Transparent Material flow	✓	✓
Control of ordered material level	✓	✓
Easier and faster ordering of material	✓	✓
Easier work for handlers with material	✓	✓
Regulation and optimization of stock	✓	✓
Simplification of production planning	✓	✓
Works with high amount of materials		✓
Long distances between stations		✓
Quick and precise info		✓
Big financial investment		✓

A comparison between the two Kanban production systems shows that the electronic Kanban system includes some features of the traditional Kanban system with cards, except for the following features that exist in the traditional Kanban system and not in E-Kanban according to Olga, M., namely:

- Visualization of production problems;
- Setting priorities;
- Improving the flexibility of the production line;
- Improved quality (by lot size);

But these functionality is also part of the electronic Kanban system, which is quite logical since it is almost the same basic system, but the difference results in the computerization of the system as examples:

- Visualization of production problems can be done with E-Kanban, the only difference between the two systems is that the problem will be visualized on the informatics tool compared to the traditional system where the problem is detected and reported by the operator.
- The definition of priorities is carried out generally by the person in charge of the Kanban system who defines the priorities for the passage of Kanban cards according to the directions received from the departments concerned, which can also be done by E-Kanban according to the data seizures in the informatics tool.
- Improving the flexibility of the production line is more manageable with an E-Kanban system in the case of mixed or variable production or with a very large number of products circulating in the shop floor, since the traditional system has some limitations in this situation.
- Improved quality, the same batch size can be defined for both systems and therefore the same quality control can be done in both systems.

3. Results of the application of E-Kanban system

3.1 Literature review

In the literature there are several articles that study the traditional Kanban system in all its aspects, and as far as the electronic Kanban system is concerned, there are few articles that deal with it, especially those studying the results of its implementation, gains and limits generated for the enterprise itself and for its various stakeholders: customers and suppliers.

Reason why we thought to review the literature of different articles that deal with the implementation of E-Kanban system in their enterprises, and be interested to its various stakeholders, which has been grouped in the following table:

Table 4. Literature review of case studies of the E-Kanban system

Articles	Stakeholders		
	Enterprises	**Customers**	**Suppliers**
(Drickhamer, D., 2005)	Reduction of waste and NVA at the supply chain level.		
(Kouri, I.A., Salmimaa, T.J., and Vilpola, I.H., 2008)	Acceptance of E-Kanban by employees using an UCD model.		
(Olga, M., 2008)	The various problems encountered during the installation of E-Kanban system.		
(Lee-Mortimer, A., 2008)	Explanation of the functioning of E-Kanban in the enterprise, and the planned stages of evolution of the system.		
(Suprasith, J., Andrew, P.C., Thaloengsak, C., and Chayanun, K.,2011)	Gain generated at the supply chain level.		
(Rong, H., Fei, G., and Cheng, G., 2012)	Optimization of the assembly line space, stock of materials, quality problems solved, and cost saved.		
(Al-Hawari, T., Aqlan, F., 2012)	Reduction of production and work time in process inventory.		
(Raju, N.M., Vijaya, E.K., Upender, G.B., 2013)	Minimization of operational and logistical problems.		Calculation the number of E-Kanban cards for the supplier.
(Mayilsamy, T., Pawan, K.E, 2014)			Use of barcodes on containers.
(Grant, M., Maneesh, K., Vikas, K., and Ann, E., 2014)			Benefits and risks of implementing E-Kanban.

3.2 The implementation of E-Kanban system

3.2.1 In the enterprise

Electronic Kanban has many advantages over the traditional Kanban system, which has been demonstrated in several studies, hence the choice of two case studies already realized to see the impact of its installation at the level of the enterprise.

The first study was carried out for a parts supplier in the automotive industry which produces a cockpit module for a Japanese automaker (Suprasith et al., 2011). The work processes were examined before and after the implementation of E-Kanban system (Suprasith et al., 2011). After the implementation of E-Kanban, the enterprise was able to eliminate steps of the traditional Kanban process and reduce the implementation time, which generated a significant gain in storage costs.

The second study was carried out within Fork Truck at the level of assembly lines, the installation of E-Kanban system made it possible to automatically update the Kanban information, optimization of the space of the assembly line, reduction of stocks of materials in process in the factory, resolution of quality problems, and cost savings (Rong et al., 2012).

The steps of the new electronic Kanban process include:

- Collection and digitization of traditional Kanban in the computer system;
- The transfer of information;
- Transparency and improving efficiency of the supply chain.

Hence the installed E-Kanban system presents the following improvements at the level:

- Real performance and cost savings (Suprasith et al., 2011; Rong et al., 2012; Raju et al., 2013; Al-Hawari et Aqlan, 2012);
- Production delays (Suprasith et al., 2011; Raju et al., 2013; Al-Hawari et Aqlan, 2012);
- Financial costs (Suprasith et al., 2011; Rong et al., 2012; Raju et al., 2013);

- Effective and efficient work processes (Suprasith et al., 2011; Rong et al., 2012; Raju et al., 2013; Al-Hawari et Aqlan, 2012),
- Reducing waste and mistakes (Suprasith et al., 2011; Rong et al., 2012; Raju et al., 2013; Al-Hawari et Aqlan, 2012).

3.2.2 For the different stakeholders:

The installation of a new system within an organization always has positive or negative consequences for the organization itself or its stakeholders.

The application of a well-implemented electronic Kanban system within an organism makes it possible to have positive points for the organism itself, provided that the system is implemented in its comfort zone: with a variable or random demand of products, or for a high number of materials that circulates in the enterprise. Thing that was confirmed in the two practical cases we have cited before, but its application can generate some problems for customers and suppliers of the enterprise.

Knowing that for an electronic Kanban system, whenever the barcode on the Kanban card is digitized or scanned, the states of container changes within the system automatically from «empty» to «in progress» to «in transit» to «full» (Drickhamer, 2005). When a batch size is removed from the Kanban buffer, the barcode on the container is digitized and the Kanban status changes from «full» to «empty»; a new electronic Kanban signal (which is translated in order) is generated in the system and sent automatically to the suppliers (Grant et al., 2014). The supplier can receive Kanban signal in a variety of ways: either through a secure Web site or through an automatically generated e-mail sent to the suppliers (Grant et al., 2014); therefore, from the moment of receipt of the signal, the supplier must prepare the new order of materials within a certain time (Grant et al., 2014). This usually causes problems of delays to the supplier.

As an example, taking the case of an enterprise «A» which manufactures electrical harnesses, its supplier «B» which produces electrical wires and connectors, and its final customer «C» a car manufacturer.

Before the installation of electronic Kanban system, A. was working with a traditional Kanban system, sending two types of orders to its supplier B.:

- Firm orders;
- Forecasts for the following weeks, and at the beginning of each week the customer confirms his order with a firm order.

According to forecasts or firm orders issued by the customer, the supplier makes his own forecasts in turn at the level of its stock of raw material.

After the installation of the electronic Kanban system the situation will automatically change, it will be an automation of purchasing and supply process, so the customer will no longer communicate his forecast needs to his supplier, but it will be transmitted directly every day through the electronic system, in the form of a Kanban signal which will be the subject of a purchase order of the customer's daily requirement.

So in order to apply an E-Kanban system, the enterprise B. must have a flexibility in terms of:

- The capacity of its machines, calculated normally during the first installation of the shop floor, which pushes suppliers to make extensions of their enterprises in order to satisfy the needs of their customers;
- The raw material will generate more stock at the enterprise level and automatically additional costs for supplier B.;
- Work teams will generate high labor costs.

As far as the final customer C. is concerned, he needs the satisfaction of its need, in the present as well as for the future orders in the good conditions. A gain generated in the long term, in order to ensure the durability of the supplier A., the reason why he has an interest to have a profit shared between him and his supplier (in other words it is a giving relation giving for the supplier and his client) in order to be able to perpetuate their relationship for the orders to come, since it is not more than one customer-supplier relationship but a partnership between the two organizations. If supplier A. of customer B. generates losses, it will directly lead to financial problems or even the closure of the enterprise. Consequently customer B. will also have problems within its entity automatically, since he must stop its production in order to look for a new supplier, which he must develop and thus a stoppage of production that will generate enormous losses for customer.

4. Conclusion

Although the electronic Kanban system is an evolution of traditional Kanban system, that has many advantages over the traditional classic Kanban system.

However, in this paper we have tried to identify and explore the two Kanban systems: the traditional Kanban system with cards and the new electronic Kanban system with bar codes, knowing that there is a strong link between the two systems, since traditional Kanban adopts a purely pull approach whereas electronic Kanban adopts pull approach while following push approach based of Lean ERP systems.
The study was based on the practical and theoretical part which showed that all the basic functionalities of Kanban system are kept at the level of electronic Kanban. However, an electronic Kanban system provides opportunities to solve some limitations of the existing traditional Kanban system, such as mixed production, but it automatically generates additional costs for both the supplier and the customer of the entity that is going to install it, which was demonstrated during the theoretical study, that will be concretized by a practical study in the works to come.

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Biography

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