A CYBER-SYSTEMIC APPROACH TO EXPLORE A VIABLE ORGANIZATION FOR AN ELECTRIC VEHICLE SYSTEM

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ABSTRACT

The purpose of this paper is to explore a viable organization for an Electric Vehicles System (EVS) for a big city, to contribute to reduce the pollution impact of the current system based on fossil fuels, to improve the Anthropocene status in general and to improve the environment on a big city on particular

A brief review of systems concepts, theories and methodologies of system dynamics (SD) and the viable system model (VSM) will be given before the proposal application of both streams of Cyber-Systemic Sciences.

The paper will conclude with a theoretical estimation of the benefits generated by the EVS such as: reduction of pollution/, strategies for evolution, sustainability, etc.

We think this is the first time that it is made a viability exploration of the organization of an EVS for a Big City, which support the benefits mentioned before.

Keywords: Antropocene, VSM, EVs, Syntegrity

I. INTRODUCTION

A concern worldwide is the establishment of the *sustainable development*, understood as a multifunctional global system that meet the needs of the current generation and does not compromise the ability of future generations to meet their own needs. Currently alterations to the natural environment are the most important negative characteristic of the process of global development. "The problems can't be solved at the same level of consciousness in which they were created we can't solve problems by using the same kind of thinking we used when we created them", Ackoff (1974).

In large cities, such as the metropolitan area of Mexico City, it was detected as a pressing need, the reduction of pollution caused by the consumption of fossil fuels. In the city of Mexico, according to authorities in the field, are daily consumed 45 million liters of gasoline, of which 19.6 million liters per day, corresponding to 3.7 million private cars in circulation [1].

As an option to help reduce pollution in big cities, it has proposed a system of non-polluting alternative transportation, whose most visible component is the electric vehicle (EV´s).

However, the electric vehicle is only part of the system, other essential components are required in order to be considered as a non-polluting vehicle which contributes to sustainable development and to improve the quality of life.

The implementation of the system of transportation based on electric vehicles can be defined as a interdisciplinary effort directed towards the integration of an organization and technology, appropriate to support sustainable development, within a community.

Based on the theory of change proposed by Kurt Lewin in 1952 (Robbins, p. 695, 1990) and adapted by other researchers (Kuon & Zmud, 1987), (Copper & Zmud, 1990), then it is presented a viable model that incorporates a series of stages recognized in the industrial environment, as stages of the cycle of implementation of a technological system.

This paper only describes briefly some aspects of stages 5 organization and 6 routinization and integration of the system of electric vehicles, following the Viable System Model of S. Beer (1985).

From the concepts of sustainable development and the theories of change and cybernetic governance, arises from the systemic point of view, a model of organization of the transport system based on electric vehicles. This model is composed of at least three major subsystems: (1) the system of production and service of electric vehicles, (2) the system of construction and operation of the support structure, and (3) the system of financial services, all of them strategically coordinated by an Electric Vehicles Commission Authority.

Electric Vehicles offer significant greenhouse (GHGs) gases reduction when compared with conventional internal combustion vehicles. Reductions of over 90% are possible with EV´s running on renewable sources of energy (Lipman T.E. and Delucchi M.A. in Pistoia G, 2010). The percentage is not 100% due to the footprint in greenhouse gases and air pollutants emission “UPSTREAM” in power generation plants.

Table 1.- Main stages in the process of technology change.

STAGE	PROCESS AND OUTPUT OF EACH STAGE
1. STUDY PROBLEM	Process: deployment problems and desirable and feasible solution opportunities. The process begins with a need that stress and a technology pressure or both. Output: identification of technology that best chance of solution offers.
2 APPROVAL	Process: negotiations to support the technology. Output: decision to invest resources.
3 ADAPTATION	Process: development of necessary modifications and installation. Education of users. Output: physical availability of technology.
4 ACCEPTANCE	Process: use of technology. Cultural and organizational changes needed. Output: new organization (VSM) and results actual performance.

5 RUTINIZATION	Process: use of new technology in normal activities. Output: adequacy of legislation, standards, etc.
6 IMPROVEMENT	Process: continuous improvement of technology. Continuous improvement performance. Output: technology is used to its maximum capacity.
7. FURTHER STUDY	Process: just as in stage 1. Output: same as in step 1.

According to several GHGs studies most of the increases are due to internal combustion Vehicles. EV's produce no tailpipe emissions, but their low overall carbon footprint can still be reduced even further with the analyzer instrument to select the period of time when clean sources of electricity are "green", like wind, solar or most efficient conventional power plants.

Table 2.- Atmospheric concentration and increases of Greenhouse gases (GHGs).

Gas	Preindustrial Level	Current Level	Increase since 1750
Carbone dioxide	280 ppm	385 ppm	105 ppm
Methane	700 ppb	1741 ppb	1041 ppb
Nitrous oxide	270 ppb	321 ppb	51 ppb

Source: Adapted from Lipman and Delucchi (2010, pg 117)

II. NOTE ON HYBRID VEHICLES

A hybrid vehicle (HV), is defined as that vehicle whose propulsion energy comes from two or more energy stores, sources or converters. At least storage or converter must be on board the vehicle [2].

Replacement of vehicles with internal combustion engine by electric vehicles, may be carried out in general form by hybrid vehicles, or by a mixture of hybrid and electric; It all depends on the evolution of the technology and the speed of implementation of the basic components such as: energy store; electric motor group; electronic power control and conversion of energy; in his case, "clean" fuel cells and safety devices.

The global automotive industry has developed, cautiously, various prototypes and small fleets of vehicles, both hybrid and electric.

Hybrid vehicles can be designed in many ways possible in series or in parallel, depending on the technology used, but what makes it very attractive the hybrid vehicles is that they can be manufactured today by the automotive industry, with existing technology and require few changes in the infrastructure of fuel supply [3], as well as superior to a conventional car performance : range = 400km, velocity = 162 km/h fuel consumption = 30 km/lt [4], small amount pollution, using methanol, or 90% less polluting if fossil fuel is used.

[1] Metropolitan Commission for the prevention and control of pollution in the Valley of Mexico.

III. THE ELECTRIC VEHICLE

On the other hand, the electric vehicle (EV´s) is defined as a self-propelled vehicle with an electric motor, which supplies electric power from a rechargeable battery. Electric vehicles were sold at the beginning of the XX century, together with internal combustion, but were displaced by these last ones in the years 20´s of the XX century, due to the better performance perceived by male drivers of that era (autonomy, speed, ease of loading fuel, starter motor, etc) [5].

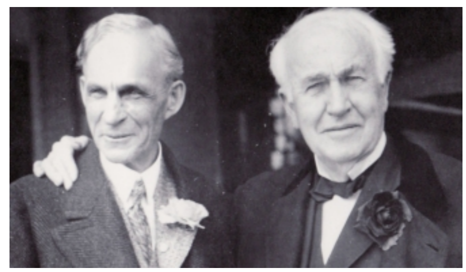

Fig 1.- Electric Vehicle manufactory by H. Ford y T. Edison at the beginning of XX Century

Since its origins, beginning of the 20th century, electric cars have features that favor them: silent, reliable, requiring less maintenance, but also since then they have three features that make them low candidate for adoption:

a. Limited autonomy (132 km, 145 km/h).
b. Longer recharge of energy (3.5 to 8 HR. into slow loading).
c. Price of sale 32,362 USD (Chevrolet Spark 2015).

Given that the environmental, social and technological conditions have changed, the global automotive industry is investing resources in improving those features. The universities have also established lines of research on the three characteristics (a, b, c). For example, UNAM developed in 1997 an electric minibus, IIE evaluated the conversion of a gasoline truck to electricity and ESIME Zacatenco SEPI developed a prototype Sedan or mini pickup electric (TANC-1, project DEPI 970245) in 1998.

These efforts have led to "in the city of Mexico operate the largest fleet in the world of electric vehicles" [6], which is mainly used in the distribution of goods in the city historic center, but the conditions for its implementation to a mass production depend on the design and full implementation of a transportation system based on electric vehicles, as it is described in the following subsection.

[2] Wouk, V. "Hybrids then and now" Spectrum vol. 32, no. 7, pp16-21,1995.
[3] López B. " A look at energing VW technologies" VW Treds s. 97, pp 26-27
[4] Wayne B. Y Fink D. , Stanford Handbook for electrical Engineer. Mc Graw Hill 12 Edition, 1989, pp 89.
[5] Shiffer M. "Taking charge: the electric automovile in América" , Stmithsoniou Institute Press, 1994 en Wouk V. IEEE Spectrum vol. 32,.no. 7,pp 10.

IV. THE VIABLE ORGANIZATION FOR AN ELECTRIC VEHICLES SYSTEM

For the purpose of this paper it is assumed that one of the best way of management the implementation of a new technology is by means of models, therefore it is selected the viable system model (VSM) of Beer (1985). This model is a very descriptive and recursive tool to guide the design of new systems of human activity.

The VSM integrates the principal management functions in five subsystems which could be repeated a different levels of recursions. A recursion is a state of the circular process of reproduction of the same form of components and relationships in a system. The VSM is based on cybernetics and the Ashby (1964) Law of requisite variety: "only variety can absorb variety". If this law is not met the managed system will be out of control.

The VSM take care of variety in both the horizontal relationships of components and the vertical relationships with the larger system which the system of the study is embedded. Both varieties tend to be equal when all the horizontal components move in the same general direction as the vertical recursions. In this case the system is said to improve its viability.

From the systemic point of view it is perceived at least, three large systems, whose dynamic interaction (mutual feedback) will makes possible the initial existence and the subsequent evolution of a transportation system based on electric vehicles; briefly these systems are:

A. The System of construction and operation of infrastructure, B. The system of manufacturing and service of electric vehicles, C. The system of financial services.

To carry out strategic planning and direction which lead to the system towards the goals of sustainable development, it is proposed as governance system, an EV´s authority commission with participation of the State, all the companies that comprise the automotive industry and the community of users of electric vehicles.

A. THE SYSTEM OF CONSTRUCTION AND OPERATION OF INFRASTRUCTURE.

The basic components of this system are described next:

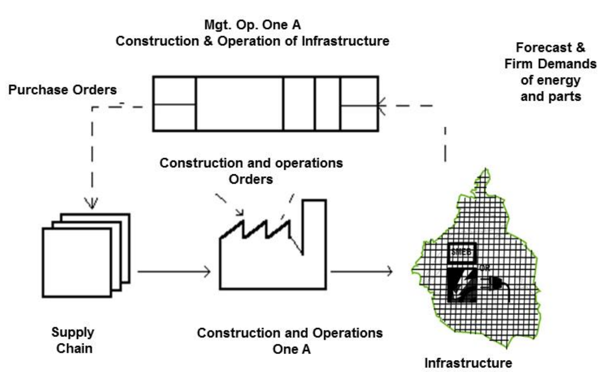

Fig 2.- System One A: Construction and operation of infrastructure

[6] Industria Automotriz, Certeza Económica Jul.Sep 1997, pp. 98.99, Quimera Editores S.A.

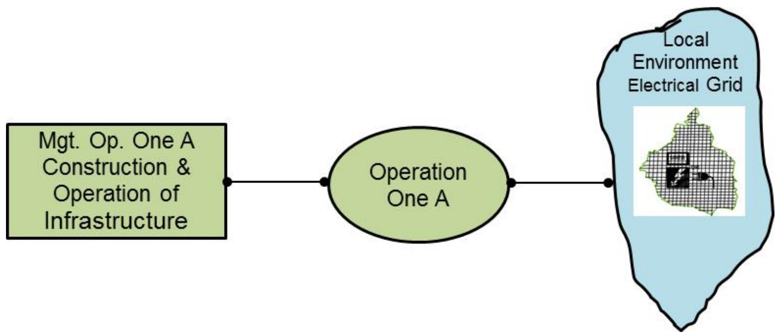

Fig 2b.- System One A: Construction and operation of infrastructure with icons of VSM

A.1 - Resources Supplies System

This type supply chain system consists of, among others, by the following providers coordinated by the management of construction and operation:

1 - Wholesale suppliers of electrical energy:
Private power generation companies, connected in a physical and tariff scheme similar to the internet service provider. They are ecological suppliers of electricity from high efficiency and renewable services, installed outside the Valley, with enough capacity to supply 8kWh per liter of gasoline displaced.

2 - Minority supplier of electric power:
Full stations of load, change, lease and/or replacement of batteries, installed near to the current fossil fuel service stations and every 25 km on roads. Example of a service type franchise:
Believing that a full electric vehicle service station, will provide the service of quick change of batteries to 200 vehicles per day, 200 sets Litio- or better batteries charged by day, requires a $15,000/battery, represents an investment of 3 million, which should be added to investment in equipment of quick change of batteries, safety equipment, substation of conversion (AC/DC) power, land and building, raising the total to approximately 10 million USD investment.

On the other hand, provider's retailers specializing in battery of slow charge can install connection devices type parking meter in the homes of the owners of electric vehicles and in all public and private parking with space dedicated to electric vehicles. These devices operate with credit card and both the car and owner identification numbers. Because of this, some analysts are predicting a lower rate of theft of EV´s, compared to conventional vehicles and a lower insurance premium by that concept.

3 - Suppliers of equipment, parts and components, regulatory, standardized:
They are companies of the industry of electrical manufacturing, currently engaged in the manufacture of equipment, industrial electrical components, which expanded its production range to standardized components for electric vehicles and for the support structure, for example: green plants generators, substations, transmission and distribution lines, telewatthorimeter, cables, connectors, AC/DC converters, devices of charge of battery by induction (without cable) public and private , semiconductor devices, power and control for electric vehicles, safety systems, navigation monitors. Systems of prevention, detection and extinction of fires of electrical or chemical origin, switches, fuses of DC, etc.

A.2 - System Construction and Operation of the Support Structure

This system is comprised of all companies franchises to build, operate, maintain full service stations of fast charging of batteries, lots of slow charging public contacts type parking meter, as well as workshops for maintenance, repair and conversion.

A.3 - System Support Infrastructure

This system has two aspects: tangible aspect , made up of the set of wholesale suppliers and retailers mentioned in subsections A.1 and A.2, and other non-tangible aspects constituted by a set of laws, regulations, decrees, public education campaigns, technical regulations issued by the authorities, Municipal, State and Federal for supporting the operation of electric vehicles, including: Traffic regulation; regulation of accidents of EV's, electromechanical technicians of EV's with competence-based training, Training of firefighters and police for EV´s.

A.4 - Management of Construction and Operation of the Support Structure

This system is integrated in a similar way to the system of management of the production of electric vehicles (B.4).

B. THE SYSTEM OF MANUFACTURING AND SERVICE OF ELECTRIC VEHICLES

System One B represents the total automobile industry available in the country, wich is composed by the most competitive international subsidiaries from the ISA, Europe, and Japan. They produces approximately 1.2 million vehicles per year.

The basic components of this system shown in Fig 3 and listed below.

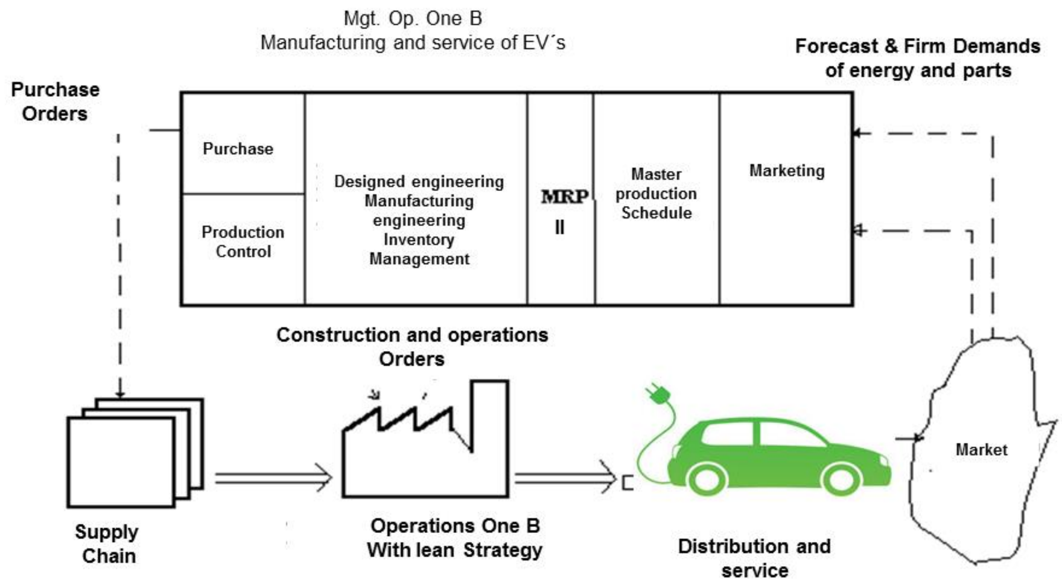

Fig 3.- System One B: The system of manufacturing and service of electric vehicles

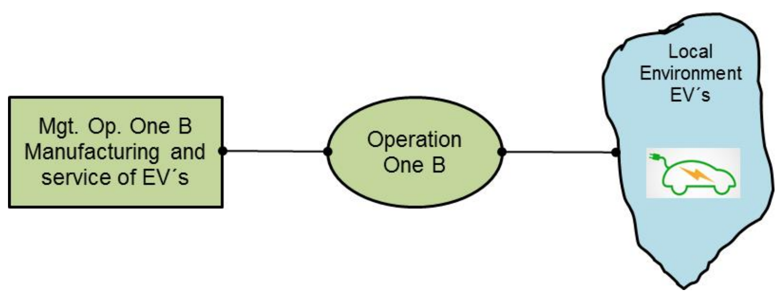

Fig 3b.- System One B: The system of manufacturing and service of electric vehicles with icons of VSM

B.1 - Resource Supply System

System type supply chain: suppliers, raw materials, parts purchasing, human resources and financing.

B.2 - Production System Of Electric Vehicles

System with Lean Production, MRP II and gradualist technology strategy type CIM, in basic production processes: chassis; bodywork; painting; suspension; electromagnetic unit; harnesses for power and control; power and energy control devices; energy battery storage; Assembly and finishing line. System total quality documentation ISO 9000 / 14000 will help to obtain a global manufacturing.

B.3 - System of Distribution and Services

With their respective systems of inventories of scheduled replacement parts and spare parts, designed to provide a level of service greater than or equal to 98%.

B.4 - The Electric Vehicle Production Management System

Equipped with information systems appropriate to support Lean production/MRP II philosophy and technology type CIM gradually. As well as a system of total quality according to ISO 9000/14000 or equivalent standards for the automobile industry.

C. THE SYSTEM OF FINANCIAL SERVICES

The basic components of the financial service system are going to be standard activities of banking facilities of a bank of development. For example granting of credits to industrial enterprises secured with capital assets, raw materials, Access to International Markets of assets, Management of international investments, appropriated resources, according to Basel III, etc.

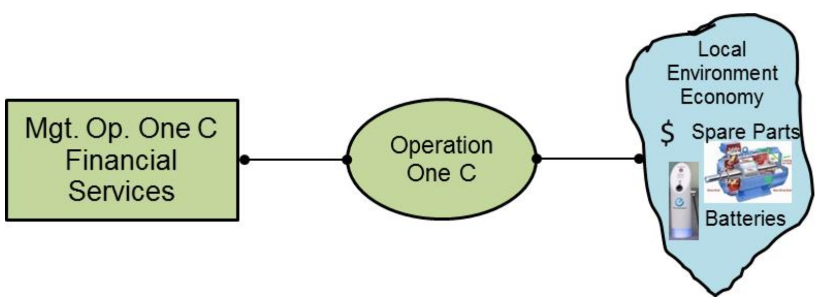

Fig 4.- System One C: The system of financial services with icons of VSM

V. EV´S SYSTEM OF AUTHORITY COMMISSION OF PLANNING AND STRATEGIC DIRECTION

Beside the three system: One A, One B, One C, the VSM include another components called System two for coordination of utilization of resources, System 3 for Senior Management supported by "System three" for monitoring and auditing, System four strategy management and System five for policies identity according to figure 5, 6 and 7.

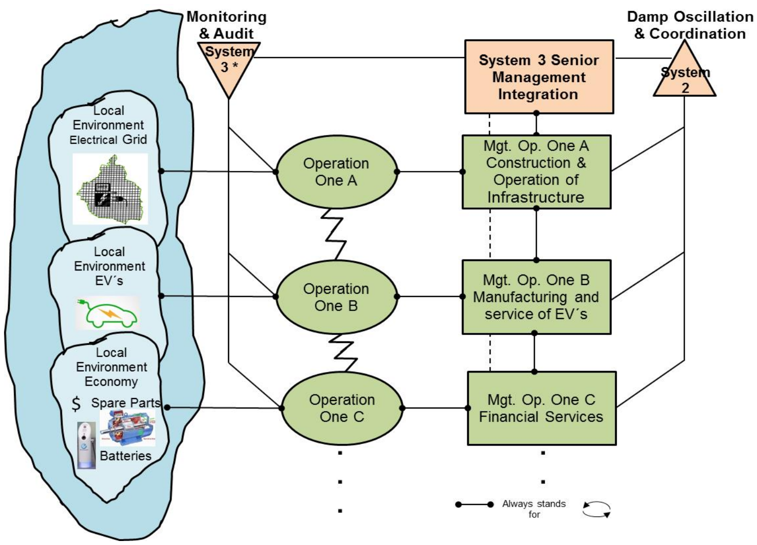

Fig 5.- System one units with systems two, three and three star

An example of research and development to be performance bye system 4 will be the new electrodes in batteries: "Graphene and nanotubes offer promise as a kind ultimate energy storage system. Their charge capacities would exceed those of traditional batteries, and their charge times (on, say, an electric-vehicle battery) would be shorter than the time it takes to pump a tankful of gasoline". Dresselhaus M. (2015)

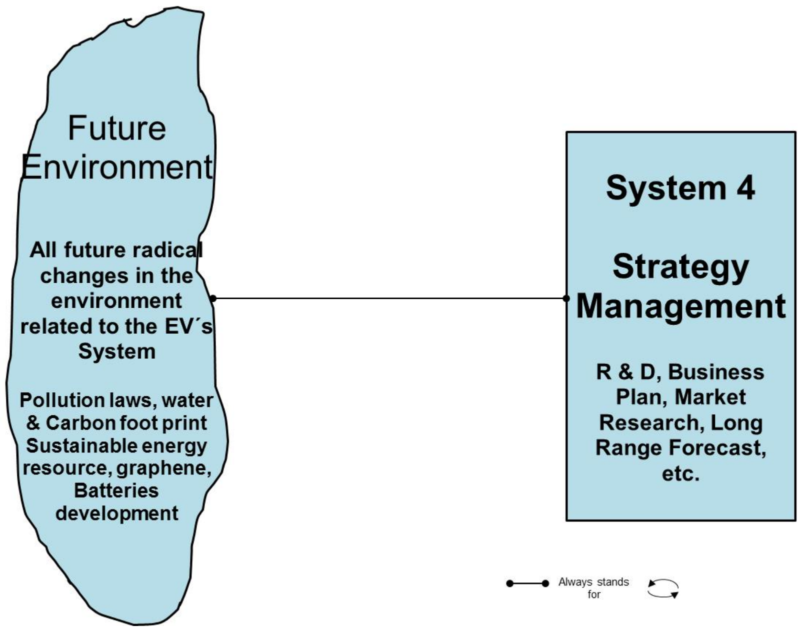

Fig 6.- System four main functions

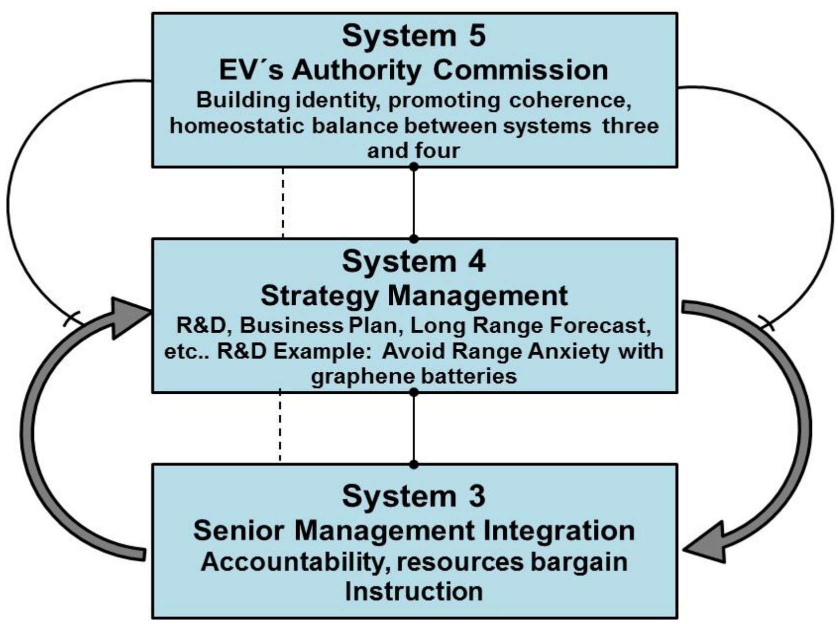

Fig 7.- Systems three, four and five with homeostatic loop between three and four

This component of the system of electric vehicles will synergistically coordinate technological advances that occur both in the production of electric vehicles and in support structure, having as fundamental strategic orientation to achieve genuine sustainable development.

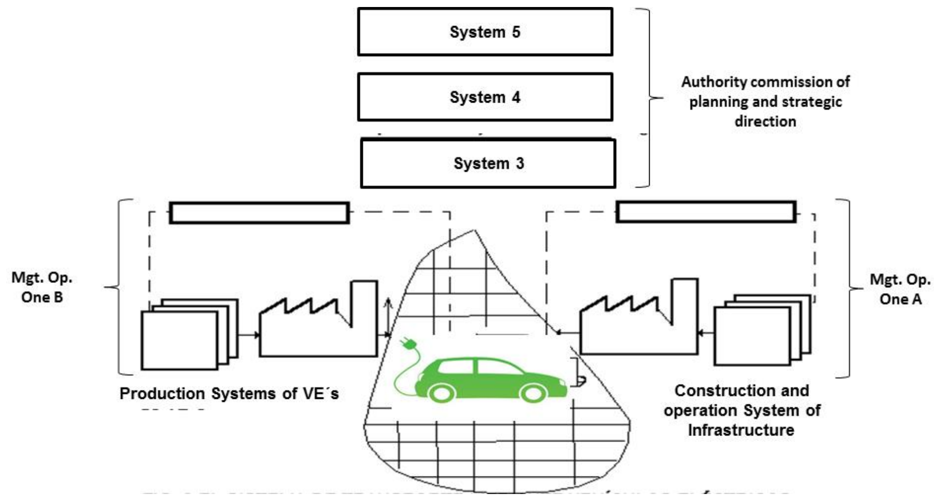

Fig 8.- Whole EV´S system

The commissions have responsibility for:

The laws, decrees, regulations, technical standards are designed so that they are issued by the appropriate authority.

Example of strategies:

- Free competition in the production of supplies for the production of electric vehicles system and support structure.
- Co-ownership public and private patents that are generated during the technological evolution of the two systems, the production system and support structure.
- Rates of consumption of electric power for VE's, daytime, evening and weekend.
- Proportional tax treatment to sustainable development effectively provided by both systems.
- Adequacy of standards ISO 9000/14000 NEMA, ASTM, IEEE, etc.
- Standardization of electric utilities used by electric vehicles;
- Voltage (volts) and current (AMPS);
- Load times;
- Fire equipment;
- Security systems;
- Standard functional characteristics of batteries, control devices, public parking meter type telewatthorimeter of slow loading, etc.

VI. CONCLUSIONS

the vsm help us to reach one of the objects of science: “to coordinate our experiences and to bring them into a logical system”
As a conclusion synthesis: analyzing in more detail and operationalizing the concepts described here, electric vehicle represents a feasible almost immediate solution to the problem of pollution reduction oriented to sustainable development in the Valley of Mexico.

.- EV´S in coordination with renewable energy electrical plants will allow to reduce the pollution by emission close to zero level.

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VIII. ANEX 1

Terminology of Glosary

Consciousness.- The state of a living System who perceive (is aware of) his/her own inside knowledge of inside or outside phenomena and possesses the ability to formulate it for himself/herself and for communication with others.
Inside knowledge includes ethics and morality behaver which a human activity system makes itself responsible of its action.

Governance.- The process of directing a system toward some predefined goal. Due to most of the systems to be governed are complex and Nonlinear, the application of feedback and feed forward do not ensure that the goal is reached such is the human activity system.

Information.- The content of a message apt to trigger some action. A content of a message that produces a change in any of the receiver's probabilities of chose (Ackoff, 1972).