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Feasibility and viability analysis in railway system projects

Análisis de factibilidad y viabilidad de proyectos de sistemas ferroviarios

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Abstract

The logarithmic growth of demography generates needs in an ascending spiral for global mobility and places the rail system as the one with the greatest advantages for the coming decades. The objective of this research was to analyze the feasibility and viability factors of the project in its different stages of railway systems in a sustainable development environment, on the other hand, the feasibility and viability analyzes of railway systems are the scientific basis that must be carried out. carried out before decision-making, to materialize it into a reality, however the railway systems with a lack of these, their future is uncertain, and they will not reach the stage of self-sustainability. The methodology was carried out by a mixed analysis, this derives in quantitative analyzes from international databases of the control of parameters of railway systems, in addition, the estimates and predictions were qualitatively analyzed based on reported hypotheses that served as a basis in decision making. The results obtained from this research were a compilation of international analyzes of companies, governments, and experts in decision-making to understand the factors of sustainable development in railway systems and their economic and technological detonation.

Feasible, Viable. Railway

Resumen

El crecimiento logarítmico de la demografía genera necesidades en espiral ascendente de la movilidad global y coloca el sistema ferroviario como el de mayores ventajas para las próximas décadas. El objetivo de esta investigación fue analizar los factores de factibilidad y viabilidad del proyecto en sus diferentes etapas de sistemas ferroviarios en un entorno de desarrollo sustentable, por otro lado, los análisis de factibilidad y viabilidad de los sistemas ferroviarios son la base científica que debe llevarse a cabo antes de la toma de decisiones, para materializarlo en una realidad, sin embargo los sistemas ferroviarios con carencia de estos su futuro es incierto y no alcanzaran la etapa de auto sustentabilidad. La metodología fue llevada a cabo por un análisis mixto, esto deriva en análisis cuantitativos provenientes de base de datos internacionales del control de parámetros de sistemas ferroviarios, además fueron analizados de forma cualitativa las estimaciones y predicciones con base en hipótesis reportadas que sirvieron como base en la toma de decisiones. Los resultados obtenidos de esta investigación fueron una recopilación de análisis internacionales de empresas, gobiernos y expertos en la toma de decisiones para entender los factores de desarrollo sustentable en sistemas ferroviarios y su detonación económica y tecnológica.

Factible, Viable, Ferrocarril

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Introduction

The global demand for transport will generate in the next century a demand for energy and higher air pollutant emissions, the railway has the potential to reduce this growth in urban environments. Transport annually consumes around 50% of world oil production, generating around 25% of the planet's polluting emissions (Network Rail, 2022). Therefore, the implementation of a railway transport in its different energy modalities in trajectories typical of this transport reduces the time of transfers and pollutants, making it an efficient means of transport. Currently, railway systems move around 10% of passengers and goods globally with an energy demand of around 2% of world oil production (Global Railway Review, 2022). The railway sector is the system that has the greatest affinity for electrification due to its infrastructure conditions and that will hardly be matched by the automotive, aeronautical, and maritime sectors in the coming decades. Passenger rail systems present 90% greater electrification than freight systems. The regions with the greatest activity for high-speed electric trains are Europe, Japan, and Russia, while Latin America depends on hybrid systems or fossil fuels in low-speed rail systems of less than 250 km/h on short, medium, and long distances. Conventional railways represent about 90% of world passenger movements, first India with 39%, China 27%, Japan 11%, and the European Union 9% (Sustainability - UIC - International union of railways, 2023).

Rail systems are classified; high-speed trains and metros (which cover long distances operating at speeds greater than 250 km/h), Metrorail (high-frequency and high-capacity urban services, separated from traffic, underground or elevated), and light rails or trams (lower capacity speed and at street level). High-speed rail, an alternative to aviation, and Metrorail offer a solution to congested and polluted cities. The future of the railway is promising as a means of green transport; however, a disadvantage is the high infrastructure and operating costs required until it becomes a self-sustaining means (Dillman et al., 2023).

The objective of this research was to analyze the feasibility and viability factors of the project in its different stages of railway systems in a sustainable development environment. The difference between feasible and viable is that what is feasible is what can undoubtedly be materialized and viable is what, apparently, can be carried out and could be done. Feasibility and viability studies focused on Railway System projects are the basis for decision-making to understand the factors of sustainable development in their economic and technological detonation (Mladenovič et al., 2022). The results obtained from this research were a compilation of international analyzes of companies, governments, and experts in decision-making to understand the factors of sustainable development in railway systems and their economic and technological detonation.

Methodology

This research used a mixed methodology, this derives in quantitative analysis from international databases of the control of parameters of railway systems, in addition, the estimates and predictions were qualitatively analyzed based on reported hypotheses that served as a basis in the decision. of decisions. The objective of this research was to analyze the feasibility and viability factors of the project in its different stages of railway systems in a sustainable development environment. The mixed analysis of the feasibility and viability factors of the railway project determines the variables involved; technical, financial and decision-making in a sustainable development environment such as; commissioning, mobility improvement, impacts; economic, environmental, reductions of; travel times, emission of polluting gases, traffic accidents, improvement of vehicular traffic levels, commissioning of the railway infrastructure, demand analysis, innovative technologies of the rolling system, strategies of the trace and operation of lines, investment estimation, economic-financial analysis, financing sources, parameter estimation, prediction in decision-making from a compilation of international analyzes of companies, governments and experts in decision-making for sustainable development factors in railway systems and its economic and technological detonation.

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Is the railway system a means of urban mobility for integration or displacement?

Population growth in developing and emerging economies in cities is growing exponentially and will require high demand for more efficient, faster, and cleaner transportation, but the need for speed and flexibility tends to favor car ownership and air travel. However, the railway systems have their field of action together with the other means of transport and none will displace another, they will only present an expansion in the coming years, each one in its field with greater performance according to volumes, masses, and speed of transfer.

The railway industry requires strategic investments and sustainable development plans that trigger the subsidy economy of the system and improve commercial competitiveness and technological innovation. The scenario of a future railway system shows growth of around 42% with 4% energy consumption in the next three decades. The advantages of the railway industry over all means of transport are to have a confined lane (which is only used by this means of transport), which generates a second advantage: reduction of transfer times, which implies two more advantages, reduction of energy consumption and generation of pollutants. On the other hand, its disadvantages are compared to other means of transport, it is the railway infrastructure, involvement of other developing sectors such as the generation of electricity to supply the system, long distances, topographic elevations, lack of flexibility of the railway infrastructure, among others (Sustainability – UIC - International union of railways, 2023).

Feasibility and viability of the energy supply of railway systems with traditional and alternative sources

The railway systems industry in the next three decades will experience a stage of radical changes from oil-based energy systems to hybrid systems and from hybrid systems to electric, until the energy sector in electricity generation can detonate its expansion for the supply of different electric means of transport.

The sources of electricity generation at present obey, to generation plants for energies derived from petroleum such as (generation plants based on diesel motor systems, combined cycle and mineral coal), alternative energy sources in the generation of electricity (hydroelectric, wind, geothermal, solar panels, photovoltaic systems, among others) and the generation of electrical energy through nuclear power plants, which in a controlled manner represent green energy sources that alternately satisfy the energy demand of the railway systems.

The stages of evolution of railway systems in the next three decades will not only be limited to energy systems, but they will also experience radical changes in the implementation of railway systems in technology parameters and high speeds (greater than 250 km/h) for trajectories. long enough to interconnect remote cities. Some countries like India do not have high-speed trains, however their mobility is carried out mostly through low-speed trains, due to this, a next stage of evolution proposed for India and countries with similarities is to celebrate a collaboration agreement. with powers such as Japan for the implementation of high-speed trains with state-of-the-art technologies (Yin et al., 2022).

In 2050, according to the diagnosis made by the Energy Technology Policy Division, the Technology and Perspectives Sustainability Directorate, the International Energy Agency and the Agency and the International Union of Railways, it is expected that the railway activity will transfer worldwide to 15 billion passengers in urban areas with large demographics and this exponential growth in demographic areas ensures the high demand for rail systems, which is a very important factor for system subsidies to be reduced and achieve sustainable operation in a sustainable environment (Xuto et al., 2022).

Standardization of railway parameters

The standardization of track gauge in railway systems (that is, the space between rails) is a proposal with a view to 2030, because, in Europe, Asia and North America, international rail system providers have different gauges. of roads and infrastructure with signaling, electrification and technological parameters that are not compatible with each other that limit the integration of the systems.

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On the other hand, Russia and China are developing a high-speed train with adjustable gauge. The independent operational development of railway systems has given rise to a variety of track systems according to the country of origin of the system manufacturer. Due to the type of train and its technical characteristics of use, its gauge is totally different, which in Europe and Eurasia have generated compatibility problems such as networks of a system, where to solve this problem they have created an entire infrastructure for the transfer of goods and passengers from one train to another, which includes corridors and storage warehouses, merchandise changes, and users from one train with one gauge to another with other railway infrastructure. All these merchandise transfers increase the actual transfer time, cost, and generate delays in the systems. Interoperability in North America was quickly achieved due to the relative simplicity of the rail. Cargo operators own their networks and operate only in three national contexts (Canada, Mexico, and the United States), facilitating greater coordination. This is in stark contrast to Europe and Eurasia, where there are many different countries, operators, and infrastructure managers (Five years into the 2030 Agenda: Time to give a big push to railway transport, n.d.).

Feasibility and feasibility of rail use

The leaders of railway systems International Energy Agency, agree that for a railway system to be competitive in its activity as a means of transport, it must be dedicated to a single activity (transfer of passengers or cargo). In the case of passengers, the subclassification is tourist, business, and daily activities. In the case of freight trains, these will be subclassified in mining industry, manufacturing, finished products for perishables, food products, agricultural industry. The classifications of the type of activity will help to optimize the travel time that includes ascent and descent in a logistics that generates optimal strategies according to the type of activity and competitive with other means of transport of the same type. A bad strategy is to share activities in the railway systems, which generate unjustified delays in travel time according to the interests of our clients, who will pay for the different service packages.

Poor logistics will make potential customers of the railway system incline their preferences to other means of transport, putting the sustainability of the system at risk.

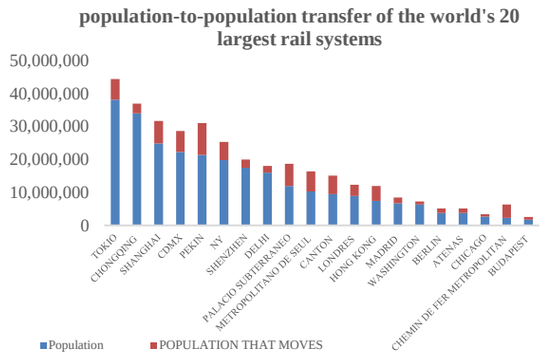
Train systems with activities well directed to a transfer sector allow optimizing not only the transfer time, but also involve other factors such as optimizing the useful life of the entire train infrastructure, maintenance in the train infrastructure systems, the continuity of scheduled trips, reduction of transfer maneuvers in the event of a train breakdown to the maintenance workshops that involve the use of track with itinerary delays in other runs. The railway systems are built under the design of each one of its components and oriented so that together they can operate under a certain amount of load, speed, and number of bogies for each convoy. In the countries with the most experience in the railway industry, the companies dedicated to the railway sector in their different business lines and according to reports from the International Energy Agency agree that the rolling coupling in a metal-metal system depends on parameters such as speed , contact area, types of material, contact pressures, friction coefficients, rolling slip, traction, braking, contaminants, slopes among others, which influence the tribology of mechanical contact and the theory of railway system fracture. The mechanical contact of a railway system when there is a variety of uses for the system is a trigger for couplings with different conditions that lead to premature wear in the rolling material, increasing mechanical vibrations throughout the railway system that in the short term will cause speeds programmed in the railway system development plan have to be reduced to avoid derailment. The plastic deformation in the rolling stock of a railway system is directly linked to the useful life of the system made up of the elements involved in rolling, highlighting the railway rails and railway wheels, so the coupling implies wear on both elements. One of the common errors in railway systems is wanting to use the infrastructure of an existing or new freight train for a passenger train, this implying that the higher freight train generates a coupling with a greater plastic deformation of the system and the passenger train. the rolling stock suffers premature wear to couple to the one with the highest load, causing the convoy to reach a displacement synchronization to avoid derailment.

ISSN: 2410-3993

Railway infrastructure in a technology-demographic-user-sustainable development analysis

The high-speed rail infrastructure has two tracks per line. The high-end variant of high-speed rail systems is Maglev (derived from magnetic levitation), whose operation is based on a system of coils and magnetic fields that move the train along the track and allows speeds around the 500 km/h. At the international level there were six magnetic levitation systems during 2018. The best known is the Shanghai Maglev with a maximum speed of 430 kilometers per hour. Japan intends to use Maglev technology to reach speeds of 500 kilometers per hour on a high-speed line. High speed maglev technologies have high power requirements. it faces even higher infrastructure construction costs, and the costs of operation and subsidies increase with respect to all types of railway technologies, hence the limited existence of these systems in countries that are leaders in the development of technologies. The Hyperloop is a railway system that consists of an electromagnetic passenger propulsion capsule operating through a low-pressure tube (SpaceX, 2013). This system is limited to less than 50% in technical parameters with respect to the Magley model, but it is still in the classification of high-speed trains to move many people.

Metro systems have the highest utilization rate of all rail systems measured in train-kilometers or passenger-kilometers) per kilometer of track length. These are used more intensely in Russia and Japan due to the population density where the frequency of occupation is extremely high. The use of the metro within the railway networks is much greater than that of the high-speed train. Followed by the conventional rail network for passenger and freight services which, according to the International Energy Agency report, has hardly grown in the last twenty years. Currently, the longest conventional rail network is in North America, followed by the European Union, Russia, India, and China (see graph 1).



Graphic 1 Population - transfer population of the 20 largest railway systems in the world (Sustainability - UIC - International union of railways, 2023)

The railway systems are designed to supply the transfer of passengers or goods in densely populated areas, because this complex system to be sustainable requires large capital not only for its initial investment in infrastructure, but also for its operation and a railway system. To be profitable, the project must be in a stage of maturity where the payments for services for its use contribute to the total operating resources of the railway industry. However, to reach this point of equilibrium and profitability, it had to go through several stages where the economic contributions by the system services based on demographic growth and cargo services are increasing according to the population growth of the system's impact area. iron, but the economic resources obtained are not sufficient for the sustainability of the project's operation, so they must be accompanied by government subsidies based on the taxes collected. It is worth mentioning that all railway projects are generally supported by the governments of the Nations, due to the initial investment and its sustainability covers different stages, one of them is the short-term operation with the help of subsidies where these contribute a greater economic amount than payments for user services; however, long-term sustainability encompasses a project where, as it matures, subsidies are gradually reduced and income from services is increased as a result of the region's economic detonation.

ISSN: 2410-3993

The long-term sustainability in its final stage that apart from covering the profitability of the railway company covers the modernization of the system throughout the infrastructure which, to remain within the preference of users, must be competitive with respect to other means of transport offering higher quality of service in a sustainable development program with a vision of reusing useless railway infrastructure for the system that allows obtaining a circular economy program. For this reason, railway system projects must be planned according to the plans and programs of the International Energy Agency for 100 years. If a railway system program is born with defects and does not enjoy the follow-up of the subsidies, it will be destined for bankruptcy in the next administrative change of the government of the nations and will operate with limited budgets until it presents unaffordable major maintenance by the railway company that will return it. inoperative. In the unsuccessful projects of railway systems, the infrastructure is composed of fixed railway lines in the region where it was installed and the trains as parts of the mobile elements. When the railway projects have failed, the sale of the components does not represent even 30% of the recovery of the initial investment in a circular economy with a business model where the largest contribution is made by the sale of the trains (mobile systems).

The creation of railway systems is due to demographic needs accompanied by energy savings, reduced travel time and emission of pollutants, but the opposite case may arise where the railway system is installed in low-demographic areas with limited land use by ecological reserves or protected areas that limit the expansion of urbanization generated by the incorporation of a railway system. In the second case, the railway system will not reach the detonation of the population explosion, nor the economy of large investments of subsidies of different means that allow it to survive.

Business strategies of a railway project

The business strategies of a railway system take as strategies the provision of transfers in densely populated areas with a high frequency of service along the lines, where the average income level creates sufficient demand for trips. Successful rail networks are effective in maximizing capacity utilization with a focus on cost reduction to be less dependent on subsidies.

Subsidy income has as the base of the pyramid the increase in land value with changes in land use for industry, commerce, and high-end housing generation. The revaluation of land close to the railway infrastructure is accompanied by the generation of infrastructure typical of urban areas that will be triggered by private capital that increases the surplus value of the areas surrounding the railway infrastructure.

The environmental impacts of land use are habitat alteration, noise effects, visual disturbance, ecosystem change, displacement of flora and fauna, invasion of ecosystems, water pollution, excessive felling, adaptation, and implementation of ecosystems in areas altered by urbanization, improvement of soil resistance, mineral impacts due to the high demand for concrete and steel, use of pesticides on the train tracks.

The financing of the development of an urban railway system does not only depend on taxes and subsidies: there are additional sources of income that can reach up to 60% of the project under optimal conditions and it depends on innumerable factors within their reach. In a rail system, capturing the benefits of land values in financing plans will offset the high cost of capital investment. “Land value capture” describes actions to benefit from increased commercial property values in the proximity of nodes and stations: Example, network developers must undertake high-return commercial projects within or attached to stations (construction of commercial premises, restaurants and hotels, providing an opportunity for the developer to participate in increasing land values to help finance the high-capacity transport network Tax increase financing is another approach, which involves the use of property taxes to use increased land values in the proximity of high-capacity transportation nodes to finance rail system development.

Other options to finance a railway system are, the taxation of the transport of urban railway systems, registration taxes, fuel taxes (the United States allocates about a quarter of the income from the gasoline tax goes to finance public transport). Pricing policies, road pricing, congestion charging, tolls on specific sections of the road network, parking fees, pricing, vehicle access restrictions in urban areas (peak hours) to promote public transport performance, taxes in private travel operating costs.

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Subsidies can be economically justified, if they do not exceed direct and indirect economic, social, and environmental benefits.

The lack of regulations or the application of regulations on land use is decisive in the way in which private property titles that have been granted for several decades appear. In the best of cases, the land areas before a railway project have private property titles for agricultural land and in the worst case scenarios there are not even owners legally protected by a property title and like the extensions of land in dispute have no rapprochement with an urbanized environment is of little interest to the inhabitants to delimit the properties, because its use is intended for an ecosystem not controlled by man if not by nature. When a project of a railway system is drawn up, it will imply carrying out a whole process of delimitation of properties based on the existing titles and in the case of non-existence, they will be identified by the government authorities and the railway project who, together with the dependencies, are those who issue property titles, taking advantage to become owners of large tracts of land not claimed by the people of small communities. When the railway system project begins to be executed due to its planning, the land surrounding the railway infrastructure already has recently issued owners and title deeds, but which allow the properties to be sold by different real estate consortiums (never known in the region). with different use of land going from reserved-agricultural use to industrial or commercial. This process causes the cost of the square meter of land to increase its value for the sale and resale of properties, which is called the technological explosion and industrialization of the area due to the incorporation of a means of transportation. The areas protected by the identification of species of flora and fauna, so that they can be considered in this exclusive use, must be duly registered in organizations, agencies at the national level and in international organizations, however in most of the global areas they are not counted. with documentation that specifically establishes that it is a protected zone, which is used to make changes in land use and generate a massive destruction of an ecosystem with great negative impacts on the ecological part of the region that generate an imbalance in the factors which constitute sustainable development due to the arrival of a railway system in the region and its technological advances due to private investment from different countries that come to generate an industrialization of the area with great promises of growth and surplus value in an environment that is dragging changes; social, cultural of the region and landscape ecosystem (Sustainability - UIC - International union of railways, 2023).

The train as the main means of transport with trunk auxiliary means of transport

Mobility in large cities that follow models of sustainable development, have as a tendency the mobility models of trunk means of transport, so that different means of transport supply the main system, which is the railway, due to this the sustainability of this does not represent a profitable business model, but it is worth mentioning that sustainable development projects are not exactly profitable in a unique way or in a monopoly way, they achieve their sustainability in a balance that corresponds to the average prices of all means of transport per unit of journey, where sometimes the means that contribute most economically to the business model are those of traditional base energies derived from carbon, but in a commitment of humanity for the balance in sustainable development allows environmental conservation strategies to seek a balance that allows the conservation of the planet with the help of responsible companies and societies.

Discussion of results

Although it is true that developed countries have turned their gaze to the railway, the difference in which the different countries and areas of the world find themselves is very uneven, so the governments of the different countries will have to visualize investment in the industry of your country and areas according to your railway infrastructure and demographic conditions that will make an investment in railway systems feasible-viable-sustainable and sustainable. It is worth mentioning that developed countries have around 23% of the trains in the world and that the predictions of railway system models obey certain specific conditions that involve a railway system with a certain maturity, where the energization of trains is done for the generation of alternative sources, highlighting nuclear, hydrogen, solar, photovoltaic, wind and a combination of the above.

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On the other hand, developing countries must take into account that the acquisition of a railway system from a developed country does not justify that its sustainable-sustainable development model in that potential country will be replicated as it is in underdeveloped countries, in In some cases, third world countries acquire an electric railway system when they do not have electricity generation systems in their infrastructure that can supply the high demands of the train; however, they could acquire a railway infrastructure system, electricity generation plants and all the infrastructure that trains require with a large investment from developing countries, but now within the models of the railway system it is clearly indicated that "it is for highly demographic places and with subsidies in its different stages of the project", but the lack Adequate advice often means that all these specifications that make a railway system sustainable are unknown and the governments of some countries place railway systems in areas of low population and, as underdeveloped countries, subsidies to the railway system may be committed to solve other sectors. of first necessity making the railway systems can be considered not such a good investment alternative that will generate prosperity under certain conditions, but quite the opposite when the development of the countries and the demographic conditions can make the system sustainable in the short, medium and above all in the long term with stages of modernization.

The investments of developing countries in railway systems must be carried out under a very complete analysis of all the factors involved in the different stages of the railway system, with real expectations of the development plans of those countries in an objective manner. In the case of developing countries and their investments in railway systems do not obey their demography in the area of operation of the train, the generation of energy sources, sustainable development models, however the illusion of thinking of having the larger train turns out to be attractive to the governments of the different countries that by acquiring infrastructures that are not suitable for their countries due to the development in which they are, by the sale of railway companies that offer wonders of progress in the purchase of their products as part of your marketing of your products.

It is understood that railway infrastructure companies and subsidiaries live from the sale of their product and are responsible for the quality of their product and operation within the warranty period, but the use and sustainability of the product is the responsibility of the end customer**.**

Conclusions

This investigation, after an analysis of the feasibility and viability of railway system projects, indicates that the incorporation of a railway system can be carried out through an investment project by any of the nations that want and can pay for the system. However, the discipline of compliance with +sustainable development parameters in a responsible manner will make the system sustainable in its different stages of the project with its implications for modernization and technological detonation coupled with changes; social, cultural and landscape ecosystem.

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