Beyond Petroleum: *A look at the impact of electric cars in the three main cities of Ecuador*

Más allá del petróleo: *Una mirada al impacto de los autos eléctricos en las tres principales ciudades del Ecuador*

Abstract

The purpose of this paper is to study the impact of changing private vehicles in Ecuador's three main cities from combustion engines to their electric counterparts, and to assess whether the newly created electricity demand could be met by renewable energies located within the city boundaries. The work studies Ecuador's three main cities: Quito, Guayaquil and Cuenca. It was found that in theory and in the extreme case, if there were a sudden change where all the cars and SUVs of Quito were to be replaced by electric vehicles, an electricity demand would be created that could be satisfied through roof installed solar PV within the city boundaries. It would not be feasible however, to do this through wind power. Overall, it was recognised that in reality the changeover to electric vehicles is not likely to be sudden, plus that a transition to electric cars and SUVs only works towards partially solving the problem of fossil fuel demands from the transport sector, but has little impact on the issue of congestion and space requirements. As such, mass transit, multi-modal, electric transport systems have an important role to play in this context for the next stage of research.

Keywords: electric cars, private vehicles, public transport, renewable energies, Urban Metabolism.

Resumen:

El propósito de este trabajo es estudiar el impacto del cambio de vehículos privados en las tres principales ciudades de Ecuador, y evaluar si la demanda de electricidad creada podría ser satisfecha por energías renovables ubicadas dentro de los límites de la ciudad. El trabajo estudia las tres principales ciudades del Ecuador: Quito, Guayaquil y Cuenca. Se encontró que en teoría y en el caso extremo, si hubiese un cambio repentino donde todos los autos y VUDs de Quito serían reemplazados por vehículos eléctricos, se crearía una demanda de electricidad que podría satisfacerse a través la energía solar fotovoltaica dentro los límites de la ciudad. Esto estaría en línea con la teoría del metabolismo urbano. Sin embargo, no sería factible, hacer esto a través de la energía eólica. En general, se reconoció que en la realidad habría una transición más lenta hacia el uso de vehículos eléctricos, que resolvería parcialmente la demanda de combustibles fósiles del sector de transporte, con poco impacto en la problemática de congestión y la demanda de espacio. Como tal, los sistemas de transporte colectivo y de transporte multimodal tienen un importante papel que desempeñar en este contexto para la siguiente etapa de la investigación.

Palabras clave: carros eléctricos, energías renovables, metabolismo urbano, transporte público, vehículos privados.

Author:
Ing. Michael Maks Davis
MDAVIS930@puce.edu.ec

Facultad de Arquitectura, Diseño y Artes (FADA)
Pontificia Universidad Católica de Ecuador (PUCE)

Ecuador

Recibido: 26 Jun 2016
Aceptado: 23 Nov 2016

ISSN: 1390-7263 e-ISSN: 1390-9274
DOI: 10.18537/est.v006.n010.13

1. Introducción

This paper sets out to answer the research question: "What would be the impact in terms of energy demands if all the cars in Ecuador's three main cities were to change to electric vehicles, and could these demands be met from renewable energies placed within the city boundaries?"

Ecuador, like many countries whose economies rely on petroleum exports, currently faces difficulties due to the sharp decrease in the price of crude oil. Crude oil makes up 55% of Ecuador's exports (Simoes, Hidalgo & Landry, 2014). However, it then needs to spend 3% of its GDP on subsidising refined fossil fuels (World Bank, 2015 and Ministerio de Finanzas, 2015). Additionally, transport is responsible for 49% of the demands for such fossil fuels (MCSE, 2014). On the other hand, Ecuador has invested 4.2 billion USD since 2007, with the aim of having 95.53% of its electricity generated from hydroelectric plants by the end of 2016 (MICSE, 2013). Once installed, hydroelectricity is cheap to generate and does not rely on fossil fuels. It could therefore be said of interest for the country to make a transition from fossil fuel energy demands to electric ones.

The next logical step would be to target the transport sector, changing the demand from fossil fuels to electricity. This was shown in government plans in 2015 to import 15,000 electric cars (Jaramillo, 2015), which would be free of any import taxation (El Universo, 2015). However, if all of the country's vehicles were to change to their electric counterparts, the increase in electric energy demands would represent a 44.4% increase of the hydropower capacity of 2013 (Davis, in press). This would make the national goal of 95.53% of electricity from hydroelectric plants by 2016 unfeasible (given the large demands caused by a national transition to electric vehicles). This study examines electric transport at the scale of Ecuador's three main cities, where at solar and wind power are the renewable energies considered to satisfy the theoretical energy demands created.

It is argued here that for the transport sector to undergo a transition from fossil fuels to electricity, there are two areas that need to be tackled. The first are private vehicles, which make up 7.84% of the total demand, or 18.13% if light load vehicles are included (MCSE, 2014). The second is the freight transport sector, which makes up 19.11 % of the demand (MCSE, 2015). In terms of the former vehicles, the focus is on Ecuador's three main urban centres: Quito, Guayaquil and Cuenca, which between them have 48% of Ecuador's total 795,711 automobiles in circulation (INEC, 2014). Freight transport is beyond the scope of this study. First, it would need to be investigated at a national level, and so would be outside of an assessment of the three cities. Second, this work centres on a transition to electrified transport. At present there are no electric heavy goods vehicles that are commercially available, and so separate research would be required into alternative hydrocarbons, such as biofuels, to meet this demand.

2. Methodology

This research is carried out using secondary resources from other academic studies and ministry reports. First, the theoretical electricity demands created from a mass transition to private electric cars and SUVs in the cities of Quito, Guayaquil and Cuenca are determined. Second, the space requirements to meet these theoretical demands through solar PV and wind power are calculated. In the context of urban metabolism, a consideration is given as to whether the renewable energies could be located within the city boundaries. Third, the ability for Urban Metabolism techniques to be used for urban planning is briefly discussed, where the location of the renewable energies could be harnessed for the socio-economic development of marginal communities. Fourth, given the unlikelihood of an abrupt transition to electric private cars and SUVs, multimodal transit systems briefly looked at.

3. Looking beyond petroleum

3.1 The problem of cars

It is commonly agreed that cities are defined by their transport systems:

"If you plan cities for cars and traffic, you get cars and traffic. If you plan for people and places, you get people and places." (Kent, 2005, http://goo.gl/3wVzfb).

Urry (2007, cited in Brand and Dávila, 2011) goes as far as to argue that mobility infrastructure serves as a paradigm for urban social organisation. Additionally, the United Nations Issue Paper on Transport and Mobility for Habitat III (HIII, 2015b) highlighted the need for "compact cities" (in the EU), or "smart growth" (in the USA) that move away from being dependent on private cars. Indeed, cars are often demonised in the world of urban planning, being seen as carrying few people, needing large spaces and being energy inefficient:

"…the automobile: he's invited for a party, he never wants to leave….and he drinks a lot….and he asks always for more infrastructure, freeways, he's a very demanding person." (Lerner, 2007, https://goo.gl/4oZcKb, mins 2.40 – 3.13).

However, the fact that a preference towards car ownership exists cannot be denied. Whilst ownership of light duty motor vehicles in the more developed countries is said to have stabilised (HIII, 2015b), worldwide it is expected to grow from 1 billion in 2010 to 1.6 billion by 2035 (HIII, 2015b). This leads to two areas in academic research and urban policy planning. First, it is put forward that there must be a rapid transition to electric private vehicles, with a national grid that is able to support the new demands imposed in a low carbon manner (Tran, Banister, Bishop and McCulloch, 2012). Second, it is argued that car use needs to be reduced dramatically, with a strong push towards multimodal transport systems that mitigate the use of cars in urban areas (HIII, 2015b, Rueda, 2011, Hermida Palacios, Calle, and Cabrera, 2015).

3.2 A transition to electric vehicles in Ecuador's three main cities

The three main cities of Ecuador are: Quito and Cuenca (located in the highlands), and Guayaquil (at the coast).

Quito is characterised as long and thin; 80km long and 5km wide on average (Quito, 2013), enclosed within its adjacent mountain ranges. It has three BRT lines that span the North-South of the city (EPMTP, n.d.), and is in the process of constructing an underground metro (Metro, 2011). Additionally, there is a large influx of daily commuters coming from the surrounding valleys into the city, with daily public transport commutes predicted to increase from 47,000 in 2008 to 76,000 by 2025 (Municipio del DMQ, 2009). Guayaquil also has a BRT system called Metrovia, which has three lines: Troncal 1 (Guasmo – Río Daule), Troncal 2 (25 de Julio – Río Daule) y Troncal 3 (Río Daule – Centro) (Fundación Metrovía, 2015). According to Fundación Metrovia (n.d.) Troncal 1 carries 2924.53 passengers per day and Troncal 3 2312.86.

Cuenca is currently in the process of installing a tramline service, making it a pioneer in the andean región. According to the study of the National Institute of Preinvestment (INP, cited in El Tiempo, 2012), the system is set to have 14 units, each with a capacity of 300 passengers. It is added that the Project aims to carry 120,000 passengers daily.

The next step is to assess the potential energy demand from a transition to electric cars in the three cities. In 2013 the overall energy consumption of the transportation sector in Ecuador was 49 million BOE, 16% of which was due to cars and jeeps (MCSE, 2014). The ratio between BOE and kWh is 1:1628.2, giving a total of 12,765,088,000 kWh for cars and jeeps (SUVs) in 2013. This does not take into account the private use of pickup trucks, which are put into the same category as freight vehicles according to the data provided by the Ministry of the Coordination of Strategic Sectors (MCSE, 2014). According to data by the Ecuadorian National Institution of Statistics and Census (INEC, 2014) it can be determined that: a) of the 1,752,712 vehicles registered in 2014, 784,398 are cars and SUVs. Of these 482,294 are located in the provinces of Pichincha (Quito), Guayas (Guayaquil) and Azuay (Cuenca). If a ratio between population and car ownership is then assumed[1], with data from the last Census (INEC, 2010) an estimate can be made for the number of cars and SUVs in Ecuador's three main cities. A ratio can then be calculated between the total national number of vehicles and for each particular city. The respective energy demands for cars and SUVs in each city can then be determined, compared to the overall energy consumption for cars and SUVs in Ecuador in 2013:

- Quito – 242,598 cars/SUVs and 3,947,973,550 kWh per year.
- Guayaquil - 91, 011 cars/SUVs and 1,481,097,031 kWh per year.
- Cuenca – 44,050 cars/SUVs and 716,865,840 kWh per year.

This gives a 6,145.94 GWh demand for the three cities, making up 48% of the total for cars and jeeps in Ecuador. If all of the vehicles were to radically change to their electric counterparts, then gains in efficiency of approximately 2.61 could be made (Davis, in press). This would reduce the demands to:

- Quito – 1,512,633,544 kWh per year (4,144,201 kWh per day).
- Guayaquil - 567470127 kWh per year (1,554,713 kWh per day).
- Cuenca – 274,661,241 kWh per year (752,497 kWh per day).

3.3 The space needed for renewable energies within the city boundaries

The concept of Urban Metabolism is used as a point of departure here, where a city's resilience is increased through having the resources it needs to operate being supplied within the boundaries of the urban environment itself. Urban Metabolism represents a circular economy, where waste is consumed as a resource in continuous cycles (Kennedy et al., 2007, cited in Kennedy, C., et al. 2011). As such, the concept moves away from the transformation of resource flows into waste streams, and has no subsequent harmful impacts on the environment and society that lead to a scarcity of

---

[1] The assumption is that the ratio between the number of cars and SUVs is in direct correlation to the number of people in the province of each respective city. This is likely to be an underestimation, given that vehicle ownership per capita tends to be higher in cities than in rural areas. The exact number of vehicles in each city therefore needs to be substantiated for future research, by carrying out further studies of local statistics from the three cities' respective transit agencies.

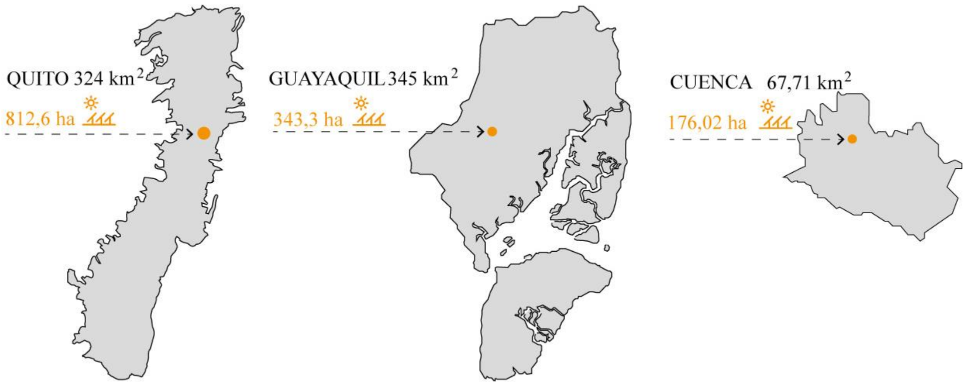

Figure 1: Space requirements for solar PV
Source: Author

the very resources needed (Greyson, 2006). Furthermore, the United Nations Issue Paper on Urban Ecosystems and Resource Management for Habitat III (HIII, 2015a) argues that for a city to be resource efficient it needs to be decoupled from the necessity to exploit external resources. In this context and in terms of renewable energies, an assessment can be carried out about the space required for solar PV and wind power to satisfy the theoretical demand from a massive change to electric vehicles. Following this a consideration can be made as to the possibility of locating the solar PV or wind power within the city limits of Quito, Guayaquil and Cuenca, and as such having them able to meet their own electricity demands of private transport.

In terms of solar PV, according to the Solar Atlas of Ecuador (CONELEC, 2008) the average daily global solar irradiation that falls on the three cities is:

- Quito – 5,100 Wh per m^2 per day.
- Guayaquil - 4,500 Wh per m^2 per day.
- Cuenca – 4,275 Wh per m^2 per day.

If we then take 10% as a reasonable efficiency for a solar PV system in converting solar irradiation to electricity (MacKay, 2008), the following results can be deduced for the areas required in each city to meet the theoretical demands from a mass conversion to private electric cars and SUVs (Table 1 and Figure 1).

City	Theoretical daily electric car/SUV demand (kWh/day)	Electricity potential generated from solar PV (kWh/m^2/day)	Space required for solar PV (ha)
Quito	4,144,201	5,1	812,6
Guayaquil	1,554,713	4,5	343,3
Cuenca	752,497	4,275	176.02

Table 1: Space requirements for solar PV
Source: Author

Let Quito be a case study to assess the feasibility of locating the solar PV needed within the city boundaries. According to the latest Census held in Ecuador (INEC, 2010), Quito has a total of 763,719 households divided into the following typologies:

- House: 57% (435,320).
- Apartment: 29% (221,478).
- Room: 8% (6,097).
- Temporary housing: 6% (45,824).

The Quito Municipality (DMQ, 2011) then classifies the surface area the household occupies as:

- Small household ≤ 65 m^2.
- Large household = between 65 and 120 m^2.
- Extra-large household > 120 m^2.

Let it be assumed that the percentage of houses lie on average on the verge between small and large households, with a surface area of 65 m^2. This would then give the result of a surface area of:

- Housing: 28,295,800 m^2 surface area.

Overall, 28,7% of the household roofs would need to be covered with solar PV (Figure 2) in order to satisfy the potential demand from a mass conversion to electric vehicles, and as such it seems ambitious, yet feasible to locate the renewable energy within the city limits.

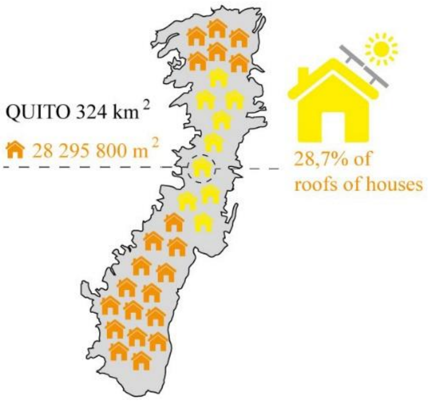

Figure 2: Percentage of roofs of houses needed for solar PV
Source: Author

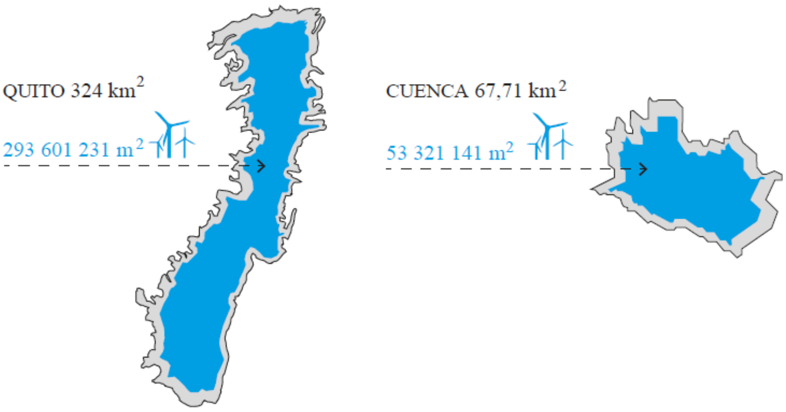

Figure 3: Space requirements for wind power
Source: Author

In terms of wind power, according to Ecuador's National Electricity Advisory Board (CONELEC, 2013) over the short term Ecuador has the potential to produce the following wind power in the provinces of Pichincha (where Quito is located) and Azuay (where Cuenca is located):

- Pichincha (Province where Quito is located) – 109.48 GWh/year in an area of 21.25 km².
- Azuay (Province where Cuenca is located) – 110.13 GWh/year in an area of 21.38 km².

The province of Guayas (where Guayaquil is located) was not included as a potential area for the expansion of wind power (CONELEC, 2013), and so is not taken into consideration here. If a direct ratio is assumed between space required and wind power generated, the following results can be deduced for the areas required in Quito and Cuenca to meet the theoretical demands from a mass conversion to private electric cars and SUVs (Table 2 and Figure 3)..

City	Theoretical daily electric car/SUV demand (kWh/day)	Wind power potential (kWh/m²/day)	Space required for wind power (m²)
Quito	4,144,201	5,2	293,601,231
Cuenca	752,497	5,2	53,321,141

Table 2: Space requirements for wind power
Source: Author

Overall, it is clear to see that solar PV has the potential to meet the theoretical electricity demand within the city boundaries, whereas wind power does not.

3.4 Urban Metabolism as a tool for urban planning and socio-economic development

Urban metabolism is rarely used as a tool for urban planning, save for but a few cases (Kennedy et al., 2007, cited in Kennedy, C., et al. 2011). It is gaining popularity in China however, due to it being seen as a manner through which resource scarcity and economic growth can be coupled (Yuan, Bi, and Moriguichi, 2008). Davis, Jácome and Lamour (2016) take the concept of urban metabolism a step further for its use in developing cities in emerging economies. In the said research it was argued that urban metabolism should be harnessed in such a manner that urban energy demands are met via micro renewable plants, which are located in poverty vulnerable areas leading to their socio-economic development. The said research first carried out a population density and vulnerability index study. This was then used in order to locate the optimal location for a renewable energy plant, where the economic resources that could be generated in the area were evaluated. The same methodology could be used for the solar PV needed to be installed to meet the theoretical demand from a mass conversion to private electric cars and SUVs in Quito, Guayaquil and Cuenca. In this case, a future study should be carried out to assess the manner in which the solar PV could be installed (for example on the roofs of buildings) so as to not only meet requirements for urban metabolism, but where the potential for the socio-economic development of vulnerable urban communities could be examined in greater depth.

3.5 In the short term: the need for multimodal transport systems in Latin America

It is unlikely that full Battery Electric Vehicles (BEVs) will dominate the market over their internal combustion engine counterpart in the medium-term (Tran, Banister, Bishop and McCulloch, 2012). Additionally, as was mentioned previously in section 3.1, cars are seen to carry few people, need large spaces and are energy inefficient[2]. It is therefore ever more important to ensure that multi-modal transport systems mitigate the need for mass car use. A number of interesting case studies for innovative multimodal transport systems can be found in Latin America. For example, Curitiba in Brazil pioneered the Bus Rapid Transit (BRT) system in 1974 (Lerner, 2007). This has been praised as a low-cost mass transit technology, in addition to being implemented with a land-use policy that encouraged increased density in proximity to the BRT stations (HIII, 2015b). The technology has since spread worldwide, seen by the example of Guangzhou in China, which has a BRT system used by 800,000 people daily with an integrated bicycle infrastructure (HIII, 2015b). In Colombia meanwhile, Medellin's use of cable cars as part of its public mass transport system is regarded as being successful. It was able to connect hillside urban communities that were isolated from the metro system, and as such was pivotal in the urban development of these areas (Brand and Dávila, 2011). The three metrocable lines of Medellin have a combined capacity of 7,200 passengers per hour (Serna Gallego, 2011). This is less than the capacity of BRT systems, but provides a solution where relatively isolated hillside urban areas have access to the city for a comparable cost-per-km as BRT (Brand and Dávila, 2011).

4. Conclusions

Overall, it is put forward that Ecuador has a vested interest in a transition to electric transport. The main national energy consumption is refined gasoline, which has to be imported and is then heavily subsidized. Additionally, the country is investing heavily in hydropower, which gives a cheap source of electricity once installed. Should there be a sudden, massive change to private electric cars and SUVs in the three main cities of Ecuador (Quito, Guayaquil and Cuenca), solar PV could potentially be a renewable energy source that would be able to satisfy the extra electricity demands that would be generated within the boundaries of the cities themselves. This is important in terms of urban metabolism, where cities strive to provide their own resources in the future within their urban boundaries. Wind power would not be able to do so within such a paradigm of urban metabolism. In the short term however, such a mass change is not likely, nor would solve the space requirements for cars circulating in the city. As such, multi-modal transport systems that have had success in Latin America should be considered in greater depth whilst there is a transitionary period to electric vehicles.

5. Recommendations for further research

There are a number of fields of study that could be explored further that were highlighted in this research. First, studies need to be carried out of local statistics from the three cities' respective transit agencies, in order to better quantify the exact number of cars and SUVs in circulation in Quito, Guayaquil and Cuenca. Second, legislation and economic parameters need to be studied further in order to assess the potential of the installation of solar panels on urban rooftops, preferably in vulnerable urban areas that could most benefit from socio-economic development. Third, an in-depth study should be carried out of the transition to electric vehicles, and the role multi-modal transport systems have. This is related to the fact that a transition to electric vehicles only works towards partially solving the problem of fossil fuel demands from the transport sector, but has little impact on the issue of congestion and space requirements. The latter issue could be effectively addressed by having mass multi-modal transport systems that run on electricity as the next step.

6. Acknowledgements

The graphics developed for this paper were gratefully provided by Lizeth Marcela Lozano-Huera, an undergraduate student of the Faculty of Architecture, Design and the Arts of the Pontificia Universidad Católica of Ecuador.

Como citar este artículo/*How to cite this article*: Maks, M. (2017). Beyond Petroleum: A look at the impact of electric cars in the three main cities of Ecuador. *Estoa, Revista de la Facultad de Arquitectura y Urbanismo de la Universidad de Cuenca*, 6(10), 151-158. doi:10.18537/est.v006.n010.13

---

[2] It is in order to note however, that even if cars were to become more energy efficient by changing to electric vehicles, they would still carry few people and need large spaces.

Bibliografía

- Alduán, A. S., & Lafuente, M. N. (2012). Metabolismo urbano, energía y movilidad: los retos del urbanismo en el declive de la era del petróleo. Ciudad y territorio: Estudios territoriales, (171), 87-96.
- Brand, P., & Dávila, J. D. (2011). Mobility innovation at the urban margins: Medellín's Metrocables. City, 15(6), 647-661.
- CONELEC. (2008). Atlas Solar del Ecuador con fines de generación eléctrica.
- CONELEC y la Corporación para la Investigación Energética. Quito, Ecuador.
- CONELEC. (2013). Atlas Eólico del Ecuador con fines de generación eléctrica. Ministerio Coordinador de Sectores Estratégicos y Ministerio de Electricidad y Energías Renovables. Quito, Ecuador.
- Davis, M. J. M., Polit, D. J., & Lamour, M. (2016). Social Urban Metabolism Strategies (SUMS) for Cities. *Procedia Environmental Sciences*, *34*, 309-327.
- Davis, M. J. M. (in press). An electrifying change: the need to introduce electric vehicles in Ecuador, and its potential impact on the energy sector. Proceedings of the First International Conference on Urban Physics (FICUP). Quito. Ecuador.
- DMQ, Distrito Metropolitano de Quito. (2011). Ordenanza Municipal No 3746. Retrieved from: http://www.departamentos.com.ec/blog/39-municipio-regulaciones/80-ordenanza-municipal-3746.html
- El Tiempo. (2012). Estudios para tranvía se entregaron ayer. El Tiempo (30 de Agosto de 2012). Retrieved from: http://www.eltiempo.com.ec/noticias/cuenca/2/295389/estudios-para-tranvia-se-entregaron-ayer.
- El Universo. (2015). Autos eléctricos sin aranceles anuncia el Gobierno ecuatoriano. El Universo (12 January 2015). Retrieved from: http://www.eluniverso.com/noticias/2015/02/12/nota/4549911/autos-electricos-aranceles-anuncia-gobierno-ecuatoriano.
- EPMTP. (s.f.). Nuestros corredores. Retrieved from: http://www.trolebus.gob.ec/index.php?option=com_wrapper&view=wrapper&Itemid=674

- Fischer-Kowalski, M., & Hüttler, W. (1998). Society's metabolism. Journal of industrial ecology, 2(4), 107-136.
- Fundación Metrovía. (2015). Mapa de rutas. Retrieved from: http://www.metrovia-gye.com.ec/mapaderutas.
- Fundación Metrovía. (s.f). Producción. Retrieved from: http://www.metrovia-gye.com.ec/PDF/produccion.html.
- Gallego, R. A. S. (2011). Metrocable en Medellín, Colombia. El cable integrado, una nueva dimensíon del transporte por cable aéro. Zugriff am,26, 2013.
- Greyson, J. (2006). An Economic Instrument for Zero Waste, Economic Growth and Sustainability. Journal of Cleaner Production, 15(13-14), 1382-1390. DOI:10.1016/j.jclepro.2006.07.019
- Golubiewski, N. (2012). Is there a metabolism of an urban ecosystem? An ecological critique. Ambio, 41(7), 751-764.
- Habitat III (HIII), 2015a. Issue Paper 16 – Urban Ecosystems and Resource Management. United Nations Conference on Housing and Sustainable Development. New York, USA. Retrieved from: http://unhabitat.org/wp-content/uploads/2015/04/Habitat-III-Issue-Paper-16_Urban-Ecosystem-and-Resource-Management-2.0.pdf.
- Habitat III (HIII), 2015b. Issue Paper 19 – Transport and Mobility. United Nations Conference on Housing and Sustainable Development. New York, USA. Retrieved from: http://unhabitat.org/wp-content/uploads/2015/04/Habitat-III-Issue-Paper-19_Transport-and-Mobility-2.0.pdf.
- Hermida Palacios, M. A., Calle, C., & Cabrera, N. (2015). La ciudad empieza aquí: metodología para la construcción de barrios compactos sustentables.
- INEC. (2010). Censo de Poblacion y Vivienda Quito. Retrieved from: http://www.ecuadorencifras.gob.ec/wp-content/descargas/Manu-lateral/Resultados-provinciales/pichincha.pdf
- INEC. (2014) Anuario de Estadísticas de Transportes 2014. Cuadros Estadísticos de Resultados. Retrieved from: http://www.ecuadorencifras.gob.ec/documentos/web-inec/Estadisticas_Economicas/Estadistica%20de%20Transporte/Publicaciones/Anuario_de_Estad_de_Transporte_2014.pdf.
- Kennedy et al., 2007, cited in Kennedy, C., et al. (2011). The study of urban metabolism and its applications to urban planning and design. Environmental pollution, p.1. 159 (8), 1965-1973.
- Kent, F. (2005, June 1). Streets are People Places. Project for Public Places. Retrieved from: htp:/www.pps.org/blog/transportationasplace/.
- Jaramillo, A. (2015). USD 35 000 costará un auto eléctrico. El Comercio (23 February 2015). Retrieved from: http://www.elcomercio.com/tendencias/autoelectrico-ecuador-costos-tecnologia-electrolineras.html, 2015.
- Lerner, J. (2007, March). Jaime Lerner: A song of the city [Video file]. Retrieved from: https://www.ted.com/talks/jaime_lerner_sings_of_the_city?language=en.
- MacKay, D. (2008). Sustainable Energy-without the hot air. UIT Cambridge.
- Metro. (2011). Metro de Quito. Retrieved from: http://www.metrodequito.gob.ec/metrohome.php?c=43.
- Ministerio Coordinador De Sectores Estratégicos (MICSE). (2013). Sectores Estratégicos para el Buen Vivir. Avanzamos en el cambio de la Matriz Energética [online]. September 2013, no 01. [Date of access: 20 September 2015]. Retrieved from: <http://www.sectoresestrategicos.gob.ec/wp-content/uploads/downloads/2014/03/Web-Sectores-Estrate%CC%81gicos-para-el-Buen-Vivir- 01.pdf>.
- Ministerio Coordinador de Sectores Estratégicos (MCSE). (2014). Resumen Balance Energético 2014. Quito, Ecuador.
- Ministerio de Finanzas. (2015). Programación Presupuestaria Cuatrianual 2015-2018 (p. 73). Quito: Ministerio de Finanzas. Retrieved from: http://www.observatoriofiscal.org/docs/analisisopinion/Presupuesto2015ProgramaCuatrianual.pdf.
- Municipio del DMQ. (2009). Plan Maestro de Movilidad para el Distrito Metropolitano de Quito 2009-2025. Municipio del Distrito Metropolitano de Quito, Empresa Municipal de Movilidad y Obras Públicas, Gerencia de Planificación de Movilidad. Quito.
- Rueda, S. (2011). Las supermanzanas: reinventando el espacio público, reinventando la ciudad. In Ciudades (im) propias: la tensión entre lo global y lo local (pp. 123-134). Centro de Investigación Arte y Entorno.
- Simoes, A., Hidalgo, C., Landry, D. (2014). A proportional representation of Ecuador's exports. Atlas of Economic Complexity, MIT Media, Lab, Boston, USA.
- Tran, M., Banister, D., Bishop, J. D., & McCulloch, M. D. (2012). Realizing the electric-vehicle revolution. Nature climate change, 2(5), 328-333.
- World Bank. (2014). Ecuador, Country at a Glance. Retrieved from: http://www.worldbank.org/en/country/ecuador.
- Yuan, Z., Bi, J., Moriguichi, Y. (2008). The Circular Economy. A New Development Strategy in China. Industrial Ecology in Asia, 10(1-2), 4-8. DOI: 10.1162/108819806775545321