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Evaluación de bicicletas eléctricas como alternativa de movilidad

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Fecha: 17 de marzo del 2021
Hora: 11:00 am hora Colombia
Enlace ZoomID: 8293063080



UNIVERSIDAD
DEL AZUAY



Evaluación de bicicletas eléctricas como alternativa de movilidad

Cuenca – Ecuador



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Seminario

RELIVE – Red Latinoamericana de Investigación en Energía y Vehículos

17-Marzo-2021

Agenda

- Evaluation of the electric bicycle as an alternative mobility in the city of Cuenca, Ecuador
- Automatic Estimation of Demand Matrices for Universities through Mobile Devices

Introduction

In recent years, cities have been designed for **vehicles** and large infrastructures have been constructed for their circulation. As a result, **vehicular congestion** has significantly **increased air pollution**. Consequently, intermediate cities are looking for more sustainable mobility options before they face road collapse.

Introduction

Habitat III



The New Urban Agenda represents a shared vision for a better and more sustainable future – one in which all people have equal rights and access to the benefits and opportunities that cities can offer, and in which the international community reconsiders the urban systems and physical form of our urban spaces to achieve this.

Since 1950's, cities have been designed around vehicles, which is currently generating a negative impact.



Introduction



Fuente: http://www.joc.com/regulation-policy/transportation-policy/us-transportation-policy/long-term-highway-spending-bill-seems-within-reach_20150714.html



Fuente: <http://cdn.sydneycycleways.net/wp-content/uploads/2015/04/suit-ride-feature-image.jpg>



Fuente: http://www.bicycling.com/sites/bicycling.com/files/articles/2016/09/rally_post-work.jpg

Introduction

¿Is the weather a problem?



The weather is just a pretext for not using the bicycle, the polls proved it!

Fuente: http://farm3.staticflickr.com/2791/4368913694_09b1d454a2_z.jpg

Introduction

Space Evaluation

Fuente: <http://www.cyclingpromotion.org>



60 people



1 bus



60 bicycles



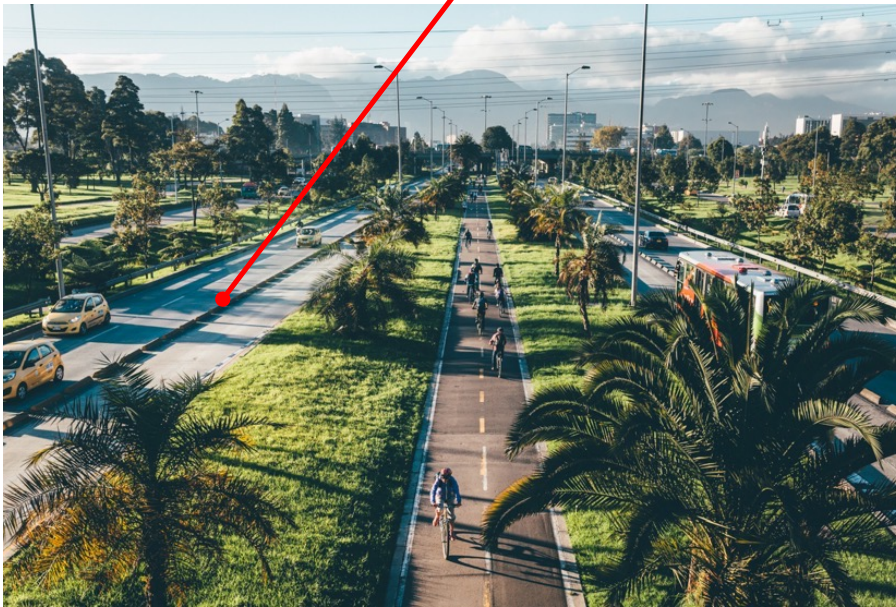
60 cars

Introduction

Examples

Limit the cars by minimum
number of passengers

More space for
alternative mobility



Fuente: <http://www.worldwidecyclingatlas.com/journal/earth-day-bogota/>





29 millions
EF for e-bikes

Cherry, Weinert, & Xinmiao, 2009



Shared Bicycles
Programs

Ji, Cherry, Han, & Jordan, 2014



≈30% of the mobility
is by bicycle

Junta de Andalucía, 2014; Paul & Bogenberger,
2014



Regulations for urban
transit

Baumann, Claire; Bojacá, Mariana; Rambeau, 2013

466'000.000
e-bikes

Fuente: (Du et al., 2013)



Bici Quito

- Shared Bicycles Programs
- 300 e-bikes

Baumann, Claire; Bojacá, Mariana; Rambeau, 2013

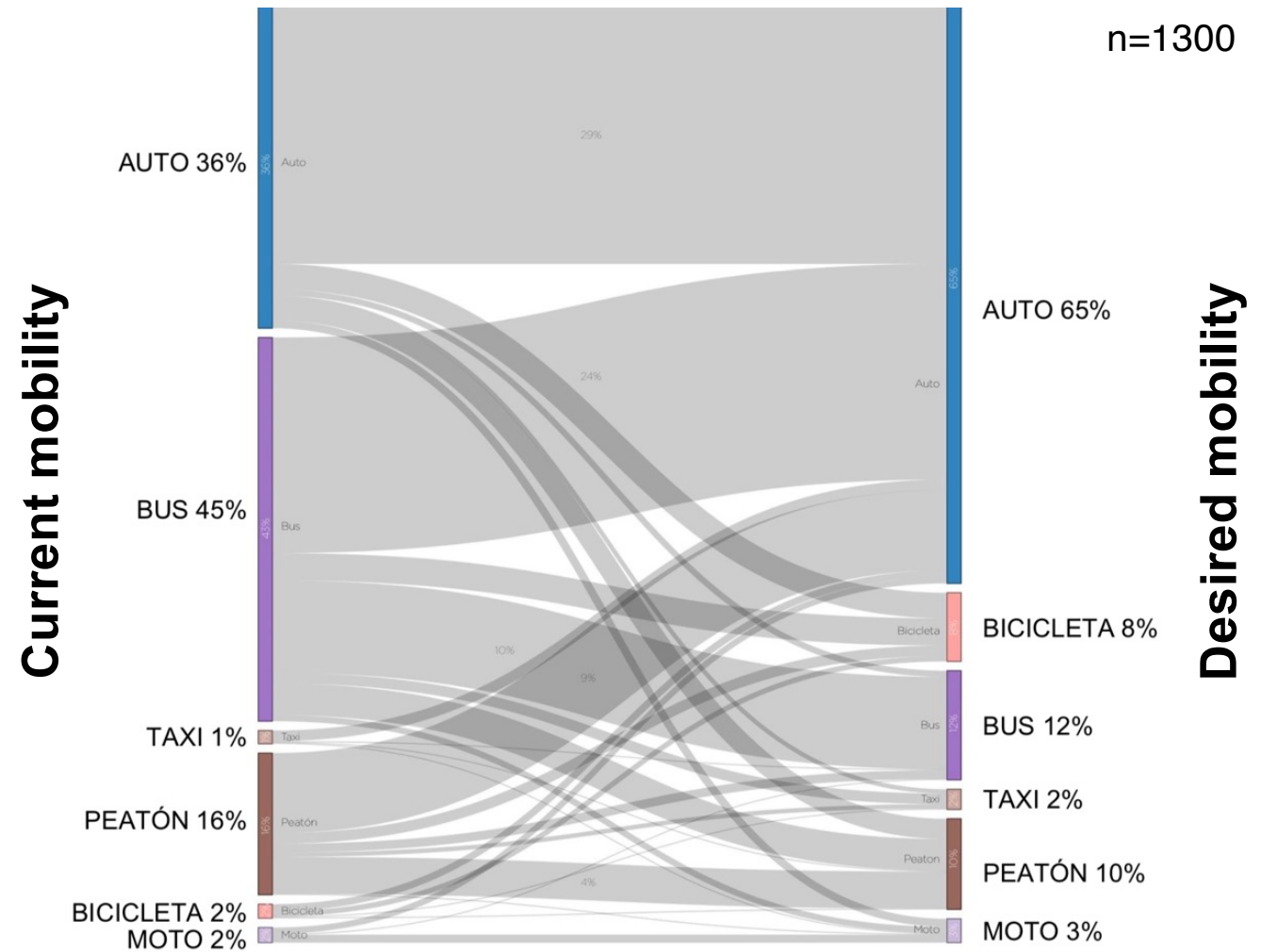
Bici Pública Cuenca

- Shared Bicycles Programs
- 200 bicycles

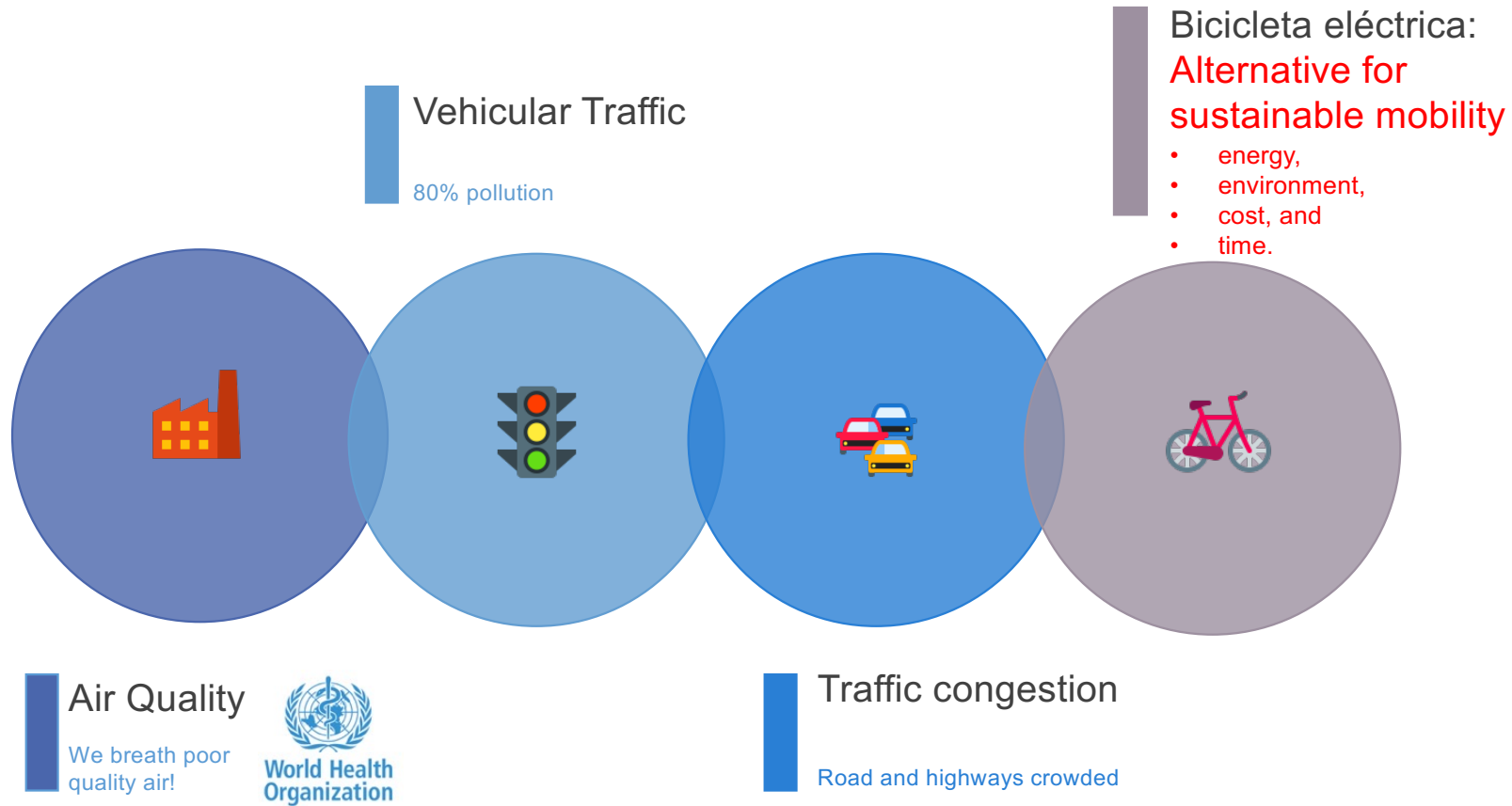
Bici Pública Cuenca, 2021

Introduction

Cuenca's current and desired mobility



D. Orellana (2017), Pies y Pedales, Evidencias científicas para una movilidad active, Seminario Internacional de Movilidad Sostenible



Materials and Methods

Bicycle, GPS, Energy Analyzer, Test Vehicles, Useful Documents

Materials



E-bike



GPS

20 Hz



Energy analyzer

Energy: kWh



Cars

N= 11

Engines:

1 600 – 2 400 cm³

Year:

>2007



PerformanceBox



Excel



Minitab 17



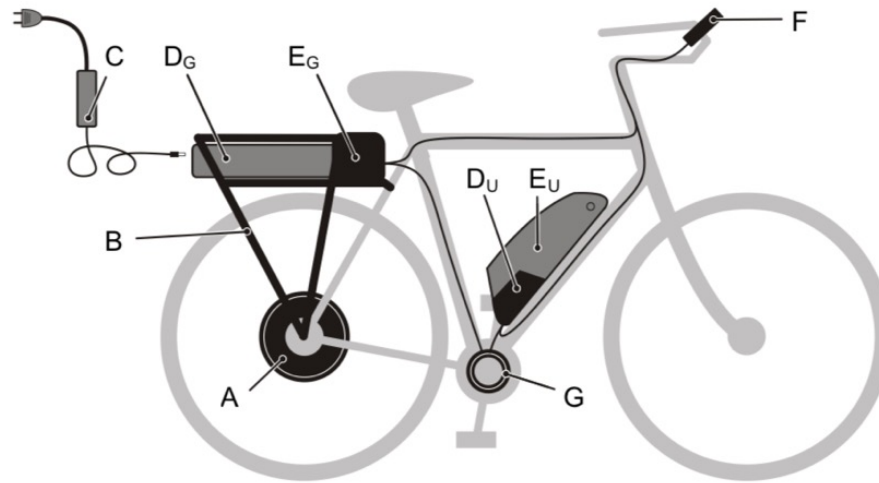
Matlab 2015



Google Earth Pro

Software

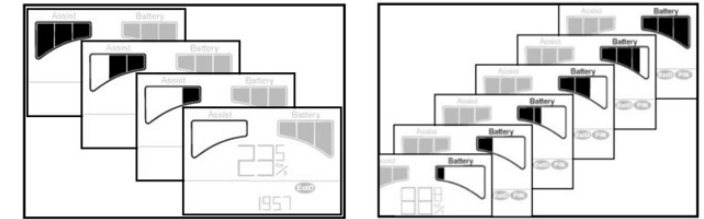
Materials



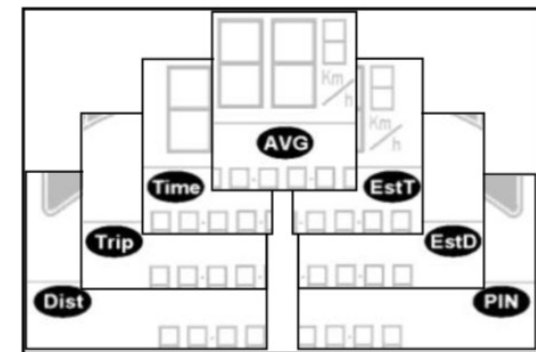
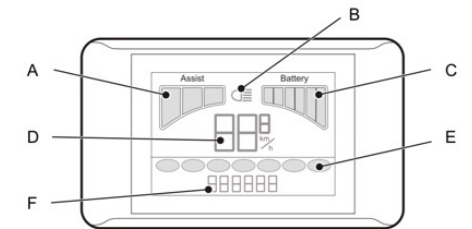
E-bike's components

Fuente: Heilmann, (2014) *E—Bike Drive System DirectPower*, Operation Instructions

- A Motor
- B Luggage carrier
- C Charger
- D_G Luggage carrier battery
- D_U Downtube battery
- E_G Control housing with control, luggage carrier type
- E_U Control housing with control, downtube type
- F Display and control unit
- G Pedalling sensor



A	Assistance level
B	Bicycle lighting
C	Battery charge status
D	Current travel speed
E	Function display
F	Display line



E-bike



Useful Documents



City's plans



Bycycles' plan



4 Ríos Tramway Project
In Progress

Methodology



Random days



Slopes



Traffic



People



Around the city



Table 1: Routes details

Route	Distance	Elevation Gain / Loss	Max slope	Avg slope
1	6.34 km	190.0 m, -101.0 m	14.0%, -16.6 %	4.4%, -4.5%
2	6.77 km	146.0 m, -48.5 m	11.2%, -10.1%	2.8%, -2.8%
3	5.28 km	84.5 m, -23.0 m	8.5%, -5.1%	2.2%, -1.5%
4	5.95 km	135.0 m, -38.6m	11.2%, -7.3%	3.1%, -2.1%
5	6.92 km	64.6 m, -85.3 m	0.0%, -12.1%	2.1%, -2.1%
6	6.71 km	52.0 m, -121.0 m	8.6%, -8.0%	2.3%, -2.5%



Random hours



Wheather



Male and Femele



Body shape



50 cyslists



≈ 1.500 km

City's topography

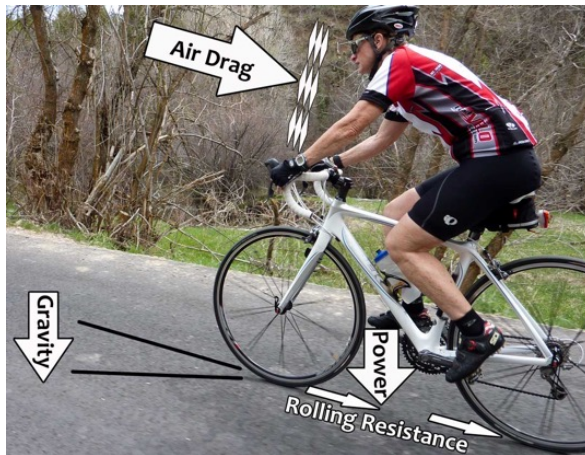


Edición: Plan de Movilidad y Espacios Públicos Cuenca, agosto 2015.

Fuente: Plan de Ordenamiento Territorial Cuenca.

Vehicle Dynamics

$$F_x = F_d + R_x + R_i + R_g$$



Fuente: <http://www.blog.ultracycle.net/wp-content/uploads/2010/05/CyclingForces.jpg>

$$F_d = \frac{1}{2} \cdot C_d \cdot \rho_a \cdot A_f \cdot v^2$$

$$R_x = f_r \cdot m \cdot g \cdot \cos \theta$$

$$P_w = F_x \cdot v$$

$$R_i = m \cdot a$$

$$E = P_w \cdot \Delta t$$

$$R_g = m \cdot g \cdot \sin \theta$$

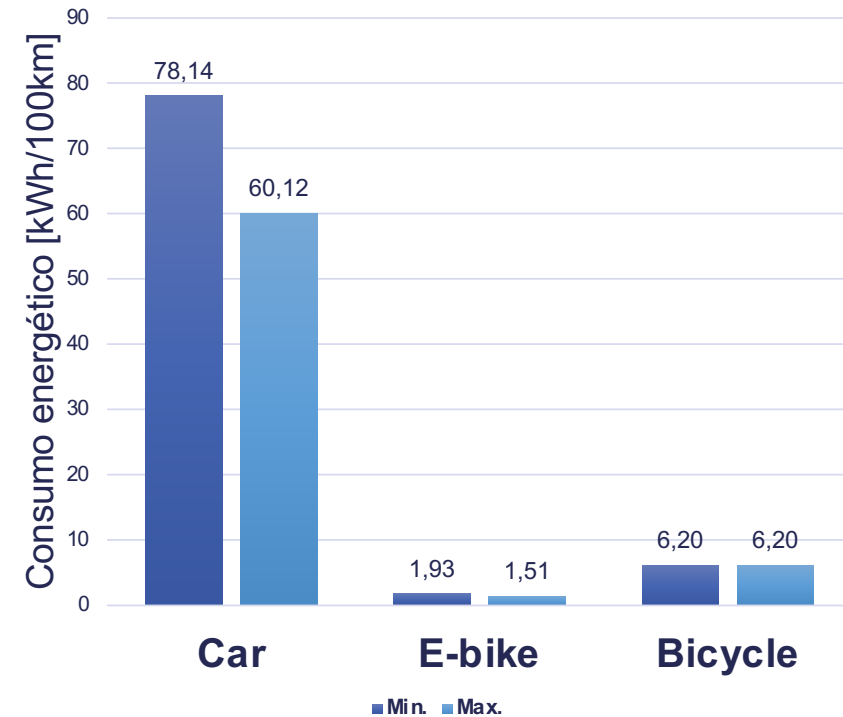
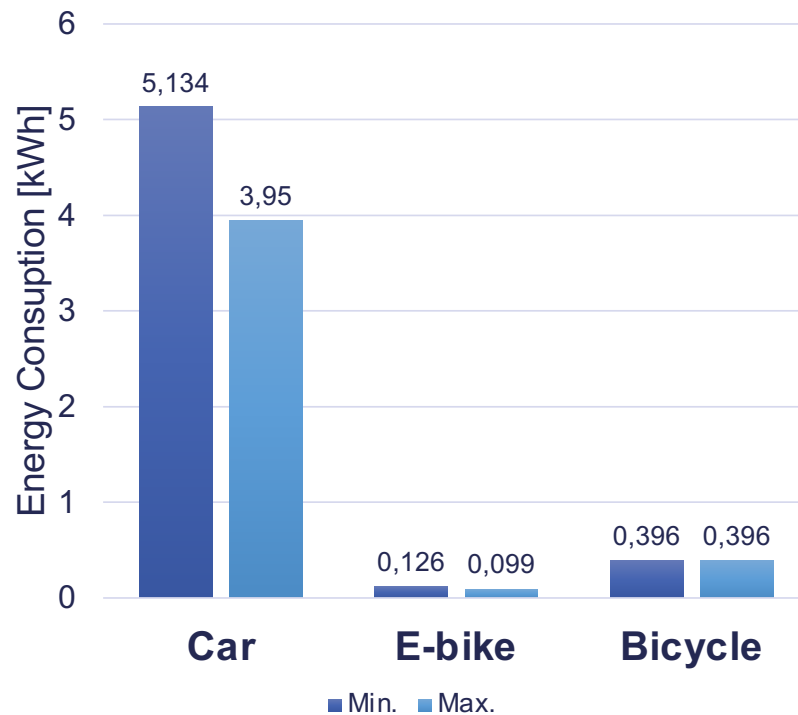
Results

Bicycle, GPS, Test Cars, City's Plans

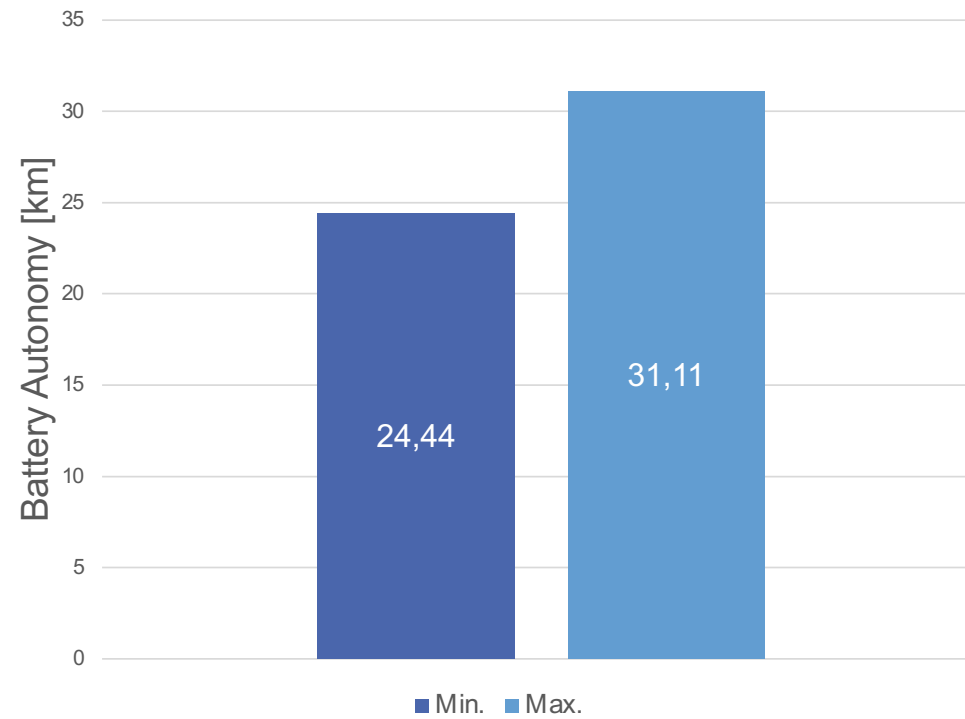
Energy Consumption Results



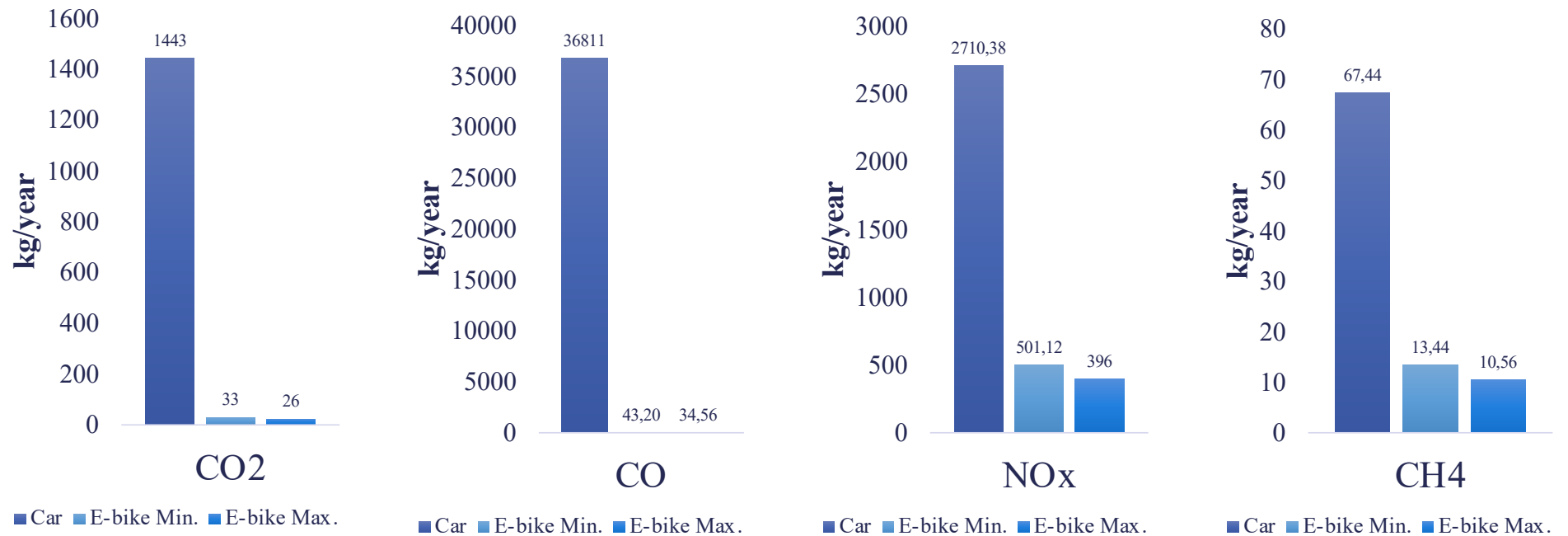
Cuenca
151 kWh/month



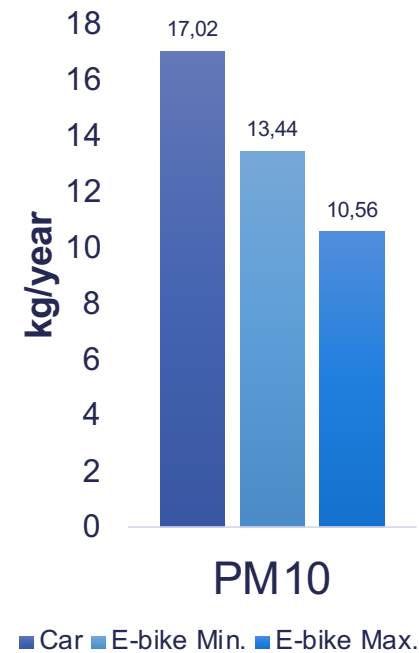
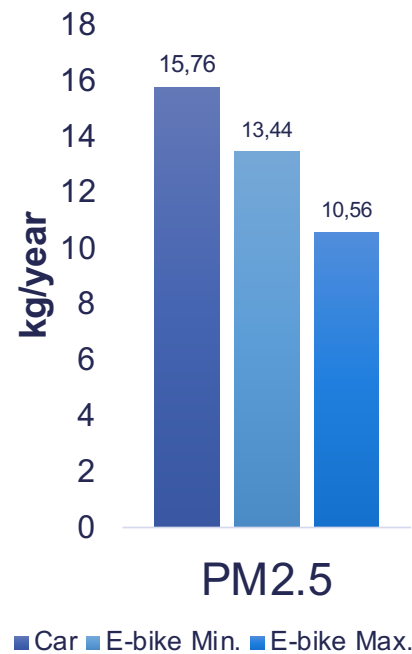
Battery Autonomy



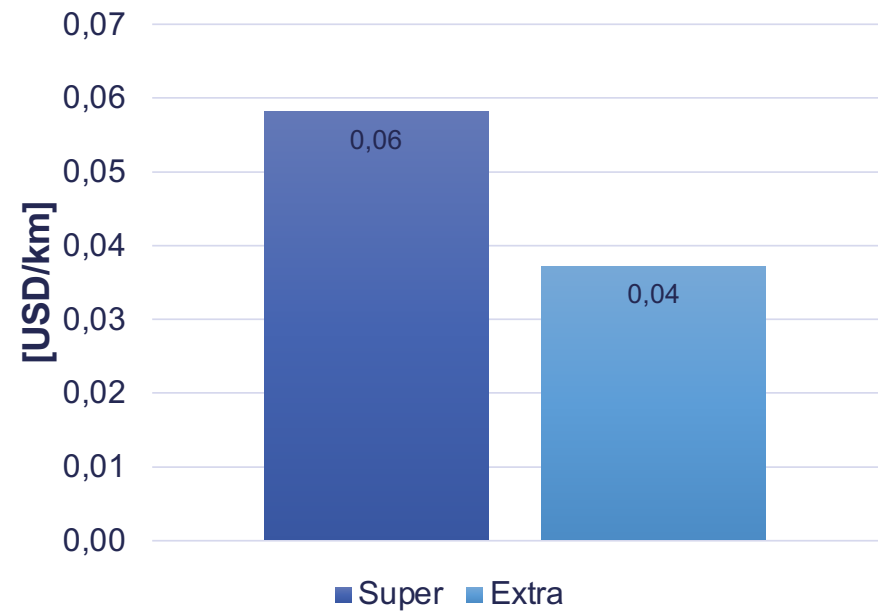
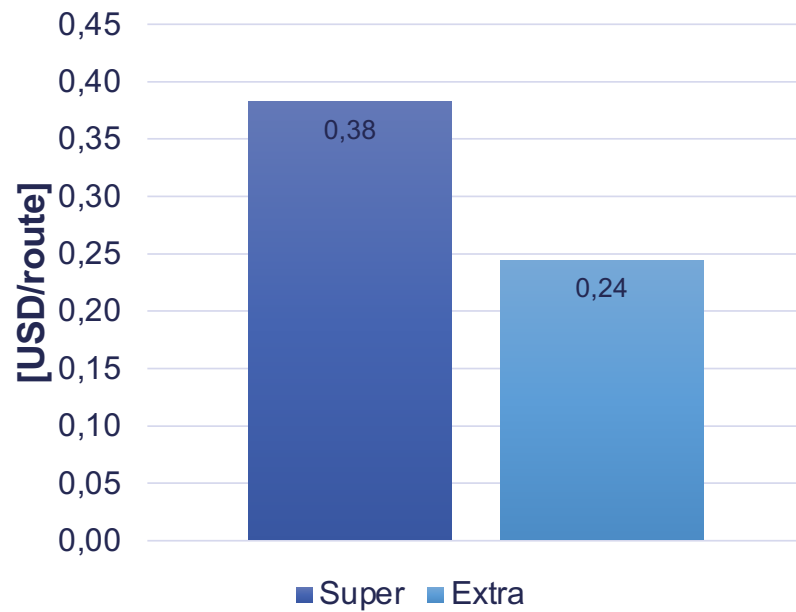
Emissions: Greenhouse Gases



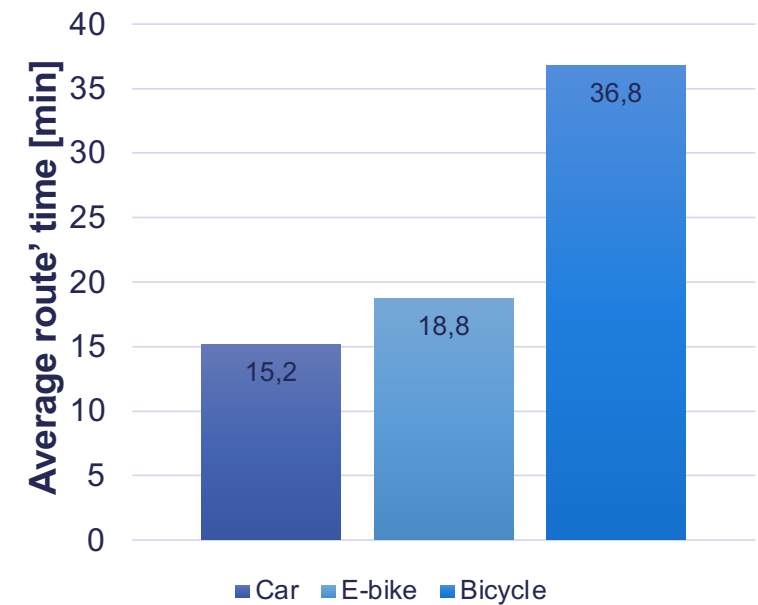
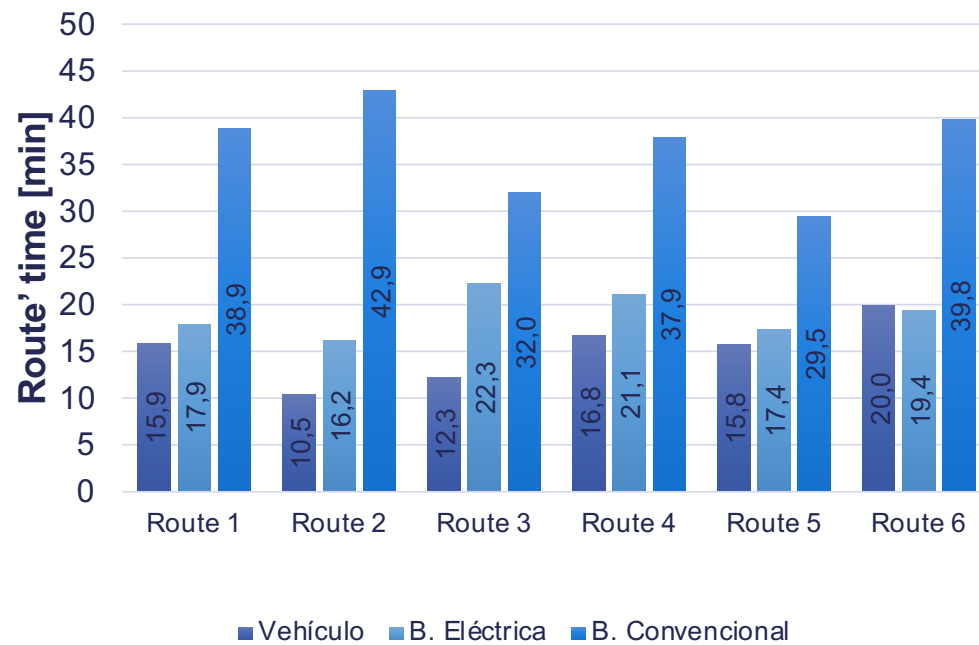
Emissions: Particulate Matter



Cost by route and distance



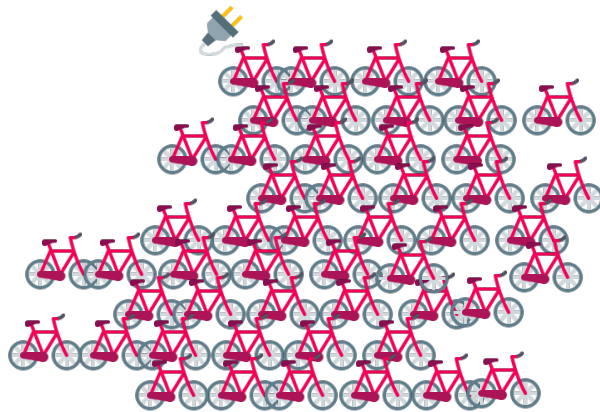
Time



Conclusions

Energy, Emissions, Cost and Time

Energy



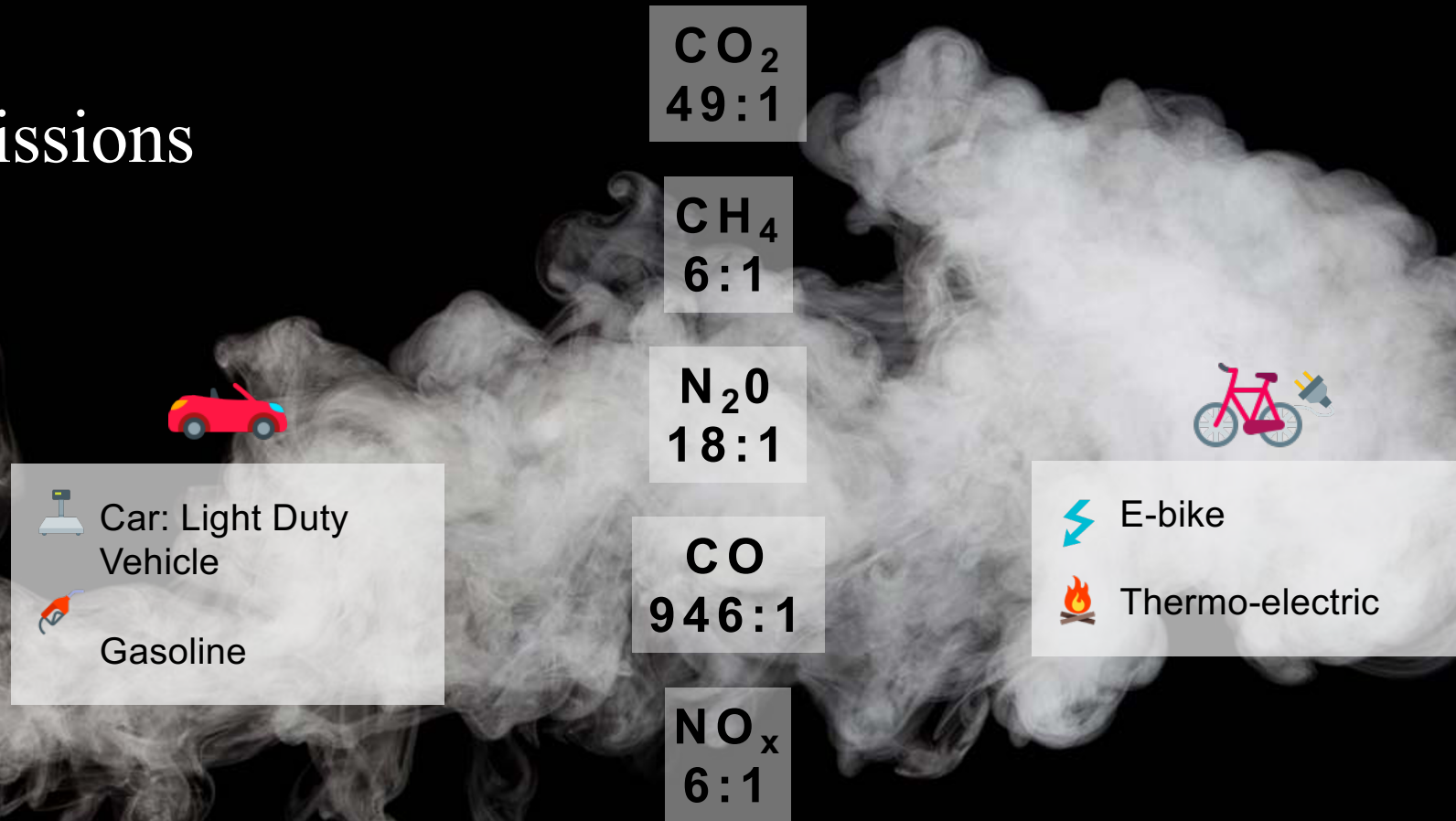
52 e-bikes
0,099 kWh
99 Wh

vs.



1 Car
5,13 kWh
5130 Wh

Emissions



Emissions



Ciclist



E-bikes



Renewable energy

¡Zero emmisions!

Costs



4 routes/day
20 days/month



Subsidized
\$750/año

Save 98%

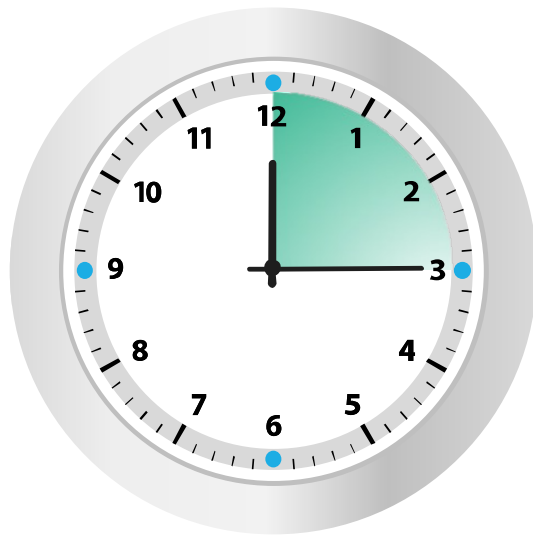
Residential
620 USD/año

Save 75%

Comercial
\$750/año

Save 96%

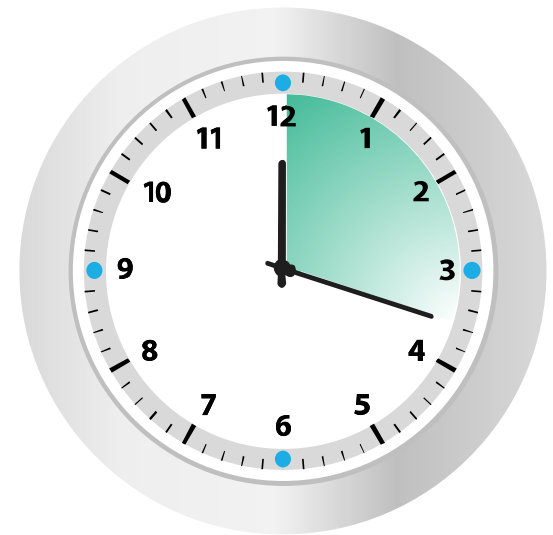
Time



15 min / 6.5 km aprox.



3.5 min more than the car



18 min more than the e-bike

Automatic Estimation of Demand Matrices for Universities through Mobile Devices

Iván Mendoza*, Gustavo Álvarez, Mateo Coello, Joaquín López, Pablo Carvallo

Universidad del Azuay

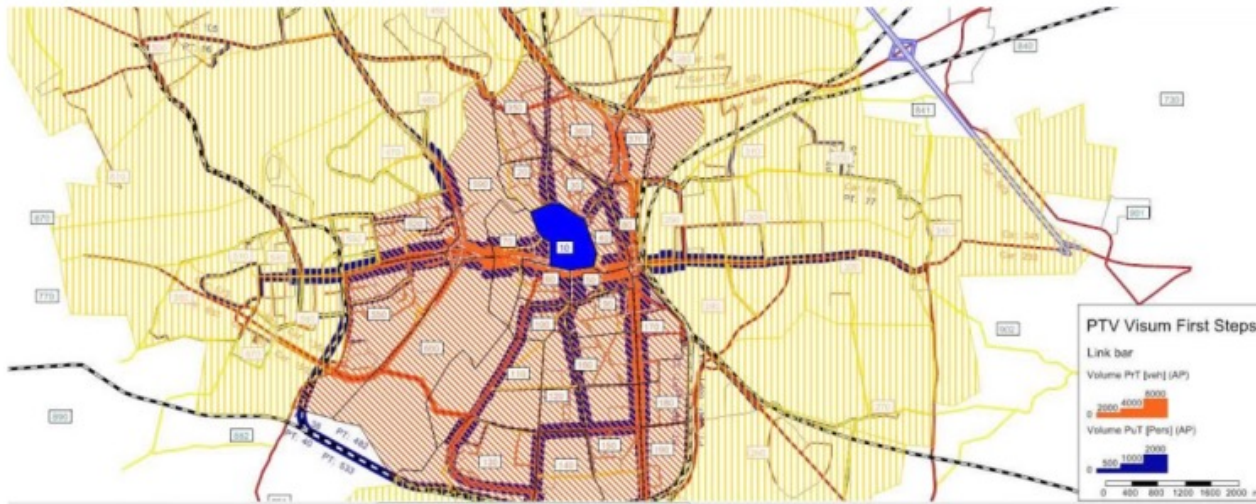
*imendoza@uazuay.edu.ec





Transport-related Simulations

- Predict traffic under different scenarios
- Test changes in infrastructure



What is required?

- > Transportation Network of Interest
- > Loaded with expected demand (trips)
- > Specific capacities, speed limits, etc
- > Scenarios to assess



OD Matrices

→ Zone to zone trips



Zone label



Zone production



Zone attraction

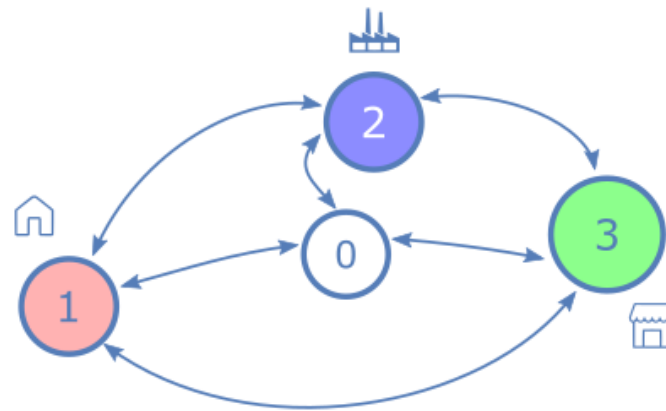
		Destinations					
Origins		A	B	C	D	E	total
	A	0	20	20	0	10	50
	B	10	0	10	0	0	20
	C	20	30	0	30	20	100
	D	10	0	10	0	10	30
	E	0	10	20	15	0	45
	total	40	60	60	45	40	245

Matrix characteristics

- > Endpoints denoted by Row and Column ID's
- > Cells contain Trips from Zone A to B
- > Dynamics captured by Multiple Matrices
- > Production can be Time Consuming

Automatic Estimation through Big Data

→ Trips can be registered via specialized app

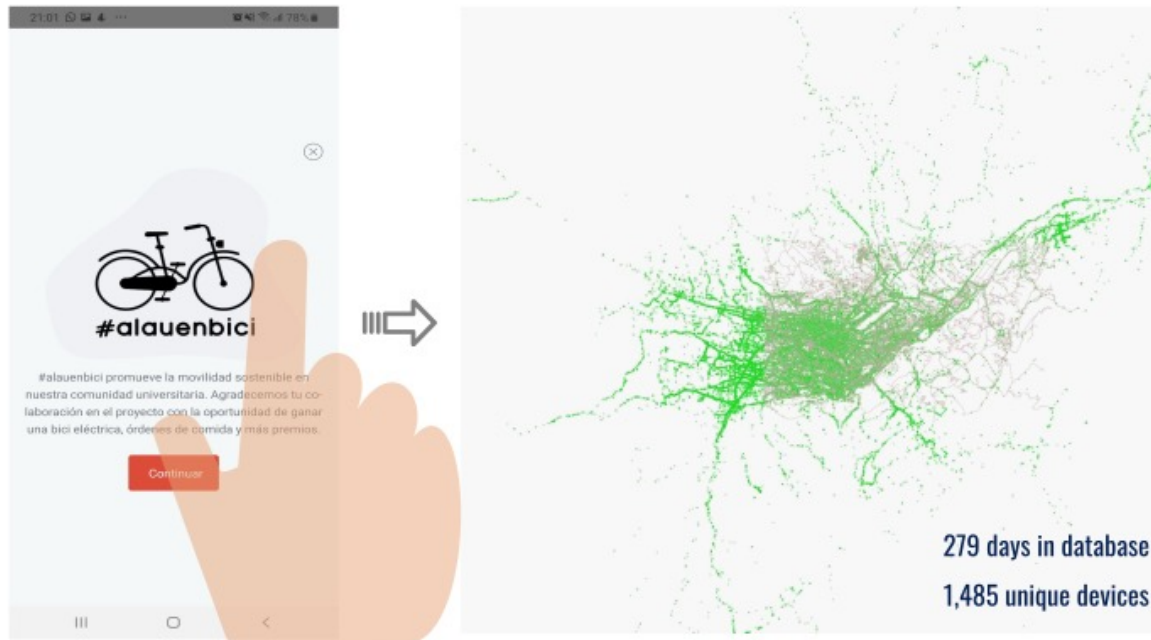


Trip detection

- > Entered by user when planning
- > Automatically detected when moving
- > User identity not required
- > Data aggregated into trip chains

Automatic Estimation through Big Data

→ Users are tracked the whole day

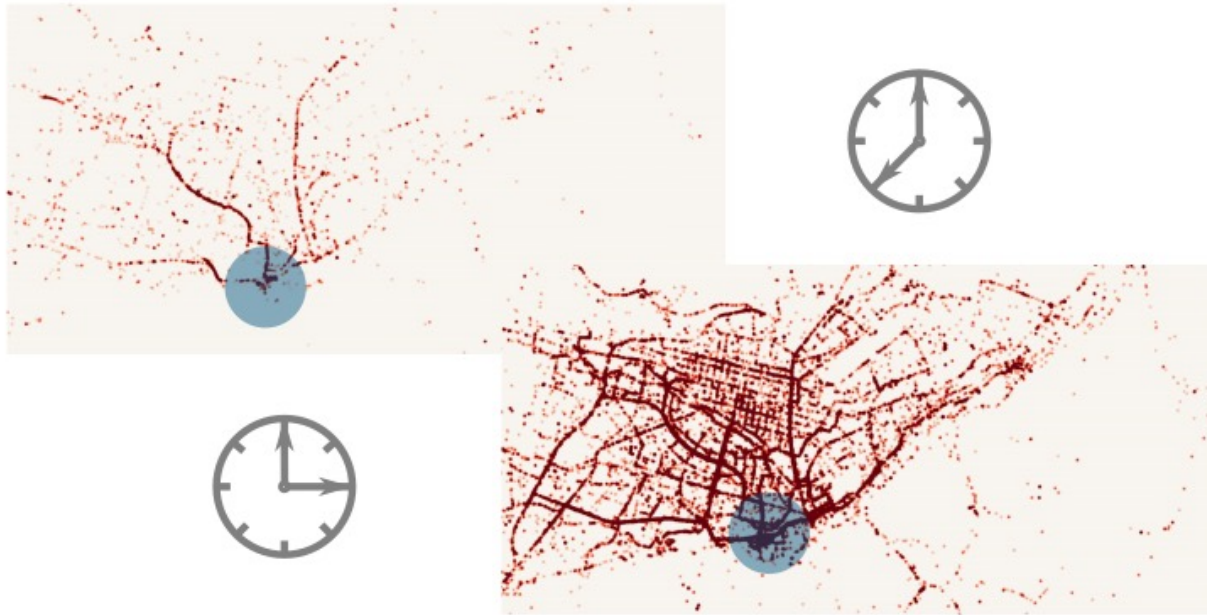


Demand for Universities

- > Students tracked by existing app
- > GPS traces stored in servers
- > Trip endpoints and departures are inferred
- > Demand at different time periods

Automatic Estimation through Big Data

→ Heatmaps at different time periods



Mobility Patterns in Universities

- > Dynamics in demand are captured
- > Accessibility maps around University
- > Routines detected after several days
- > Home locations are inferred



Proof of Concept

→ Aggregating trips into OD matrices



	A	B	C	D	E	total
A	0	20	20	0	10	50
B	10	0	10	0	0	20
C	20	30	0	30	20	100
D	10	0	10	0	10	30
E	0	10	20	15	0	45
total	40	60	60	45	40	245

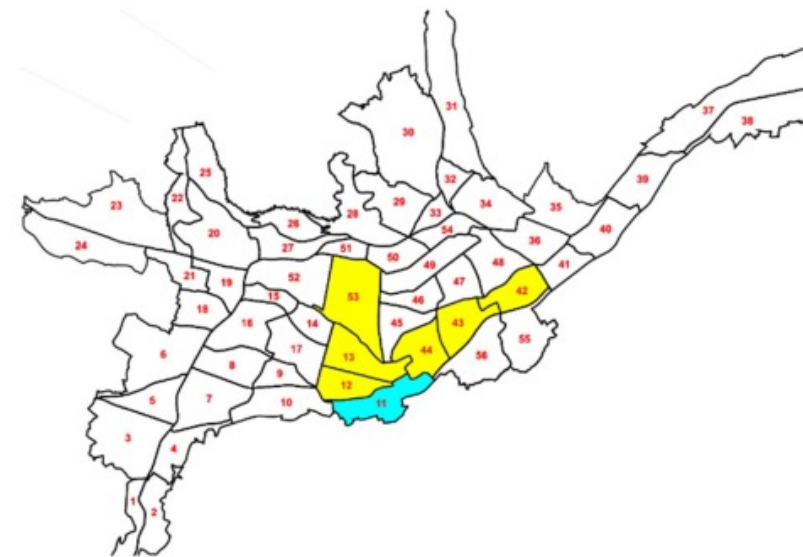
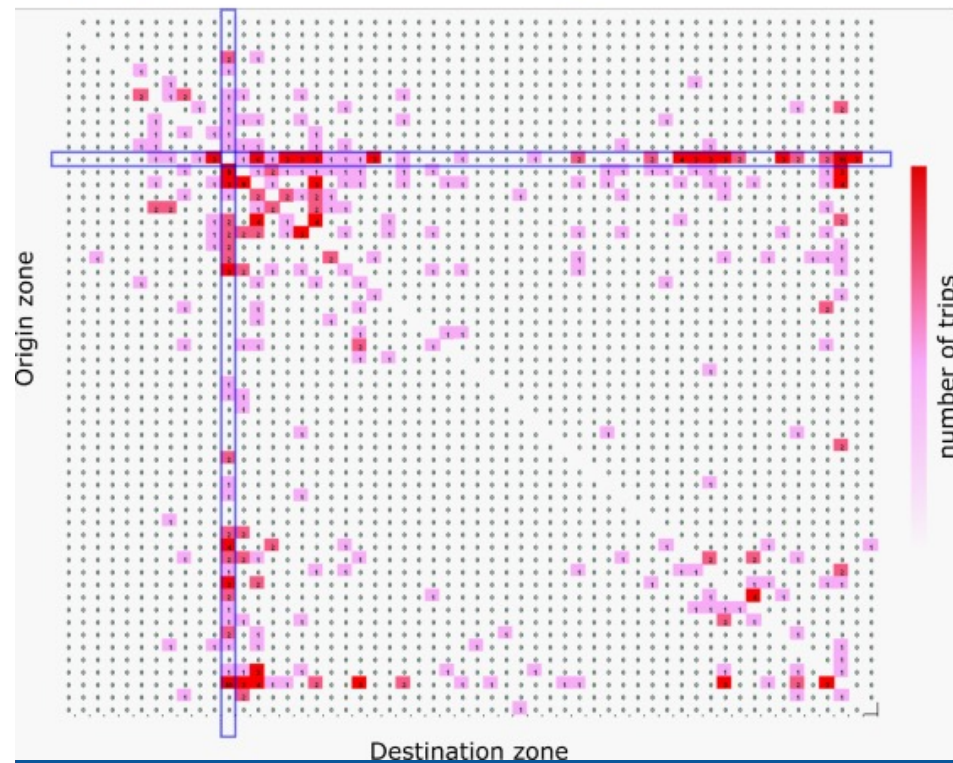


	A	B	C	D	E	total
A	0	10	20	0	10	40
B	10	0	10	0	0	20
C	10	30	0	20	20	80
D	10	0	10	0	10	30
E	0	10	20	15	0	45
total	30	50	60	35	40	215

What is required?

- > Finding routines per user (OD frequency)
- > Snap to zones
- > Counting trips between zones
- > Including dynamics

Proof of Concept





Conclusions

Discussion

- > Continuous tracking allows retrieving correct trip chains
- > Routines help detecting outliers (uncommon trips)
- > Improving detection of travel mode will help classify demand
- > Automatic generation of ODM will help assess implemented strategies

Otros estudios

- **Presentación en congresos:**

- Evaluation of the electric bicycle as an alternative mobility in the city of Cuenca, Ecuador
- <http://www.ieomsociety.org/paris2018/papers/99.pdf>
- Automatic Estimation of Demand Matrices for Universities through Mobile Devices
- <https://ieeexplore.ieee.org/document/9272071>

- **Tesis de pregrado:**

- Evaluación de una bicicleta eléctrica como alternativa de movilidad en la ciudad de Cuenca

- <http://dspace.uazuay.edu.ec/bitstream/datos/6339/1/12509.pdf>
- Determinación del ciclo típico de conducción de una bicicleta en las ciclovías de la ciudad de Cuenca
- <http://dspace.uazuay.edu.ec/bitstream/datos/6350/1/12518.pdf>
- Evaluación de la bicicleta eléctrica para entrega de documentos y paquetería liviana en la ciudad de Cuenca
- <http://dspace.uazuay.edu.ec/handle/datos/729>
- Programa de Incentivos para uso de la bicicleta como medio de transporte activo caso de estudio: Universidad del Azuay
- <http://dspace.uazuay.edu.ec/handle/datos/9426>

Q & A

Thank you!