NACIONES UNIDAS

CEPAL

Pontificia Universidad JAVERIANA Bogotá

# Urban Personal Transport goes Electric

## Bicycles, Scooters, Motorcycles and Cars.

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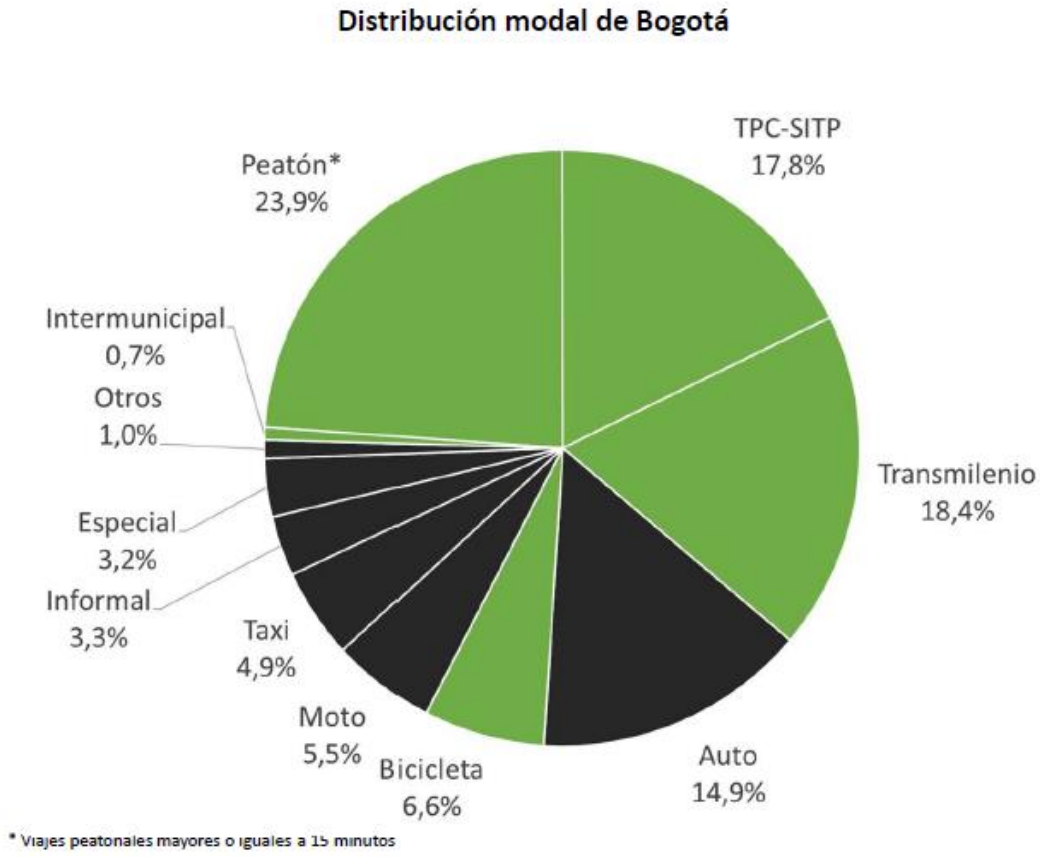
# Bogota before the pandemic

~ 10 M trips/day

~ 10 km/trip

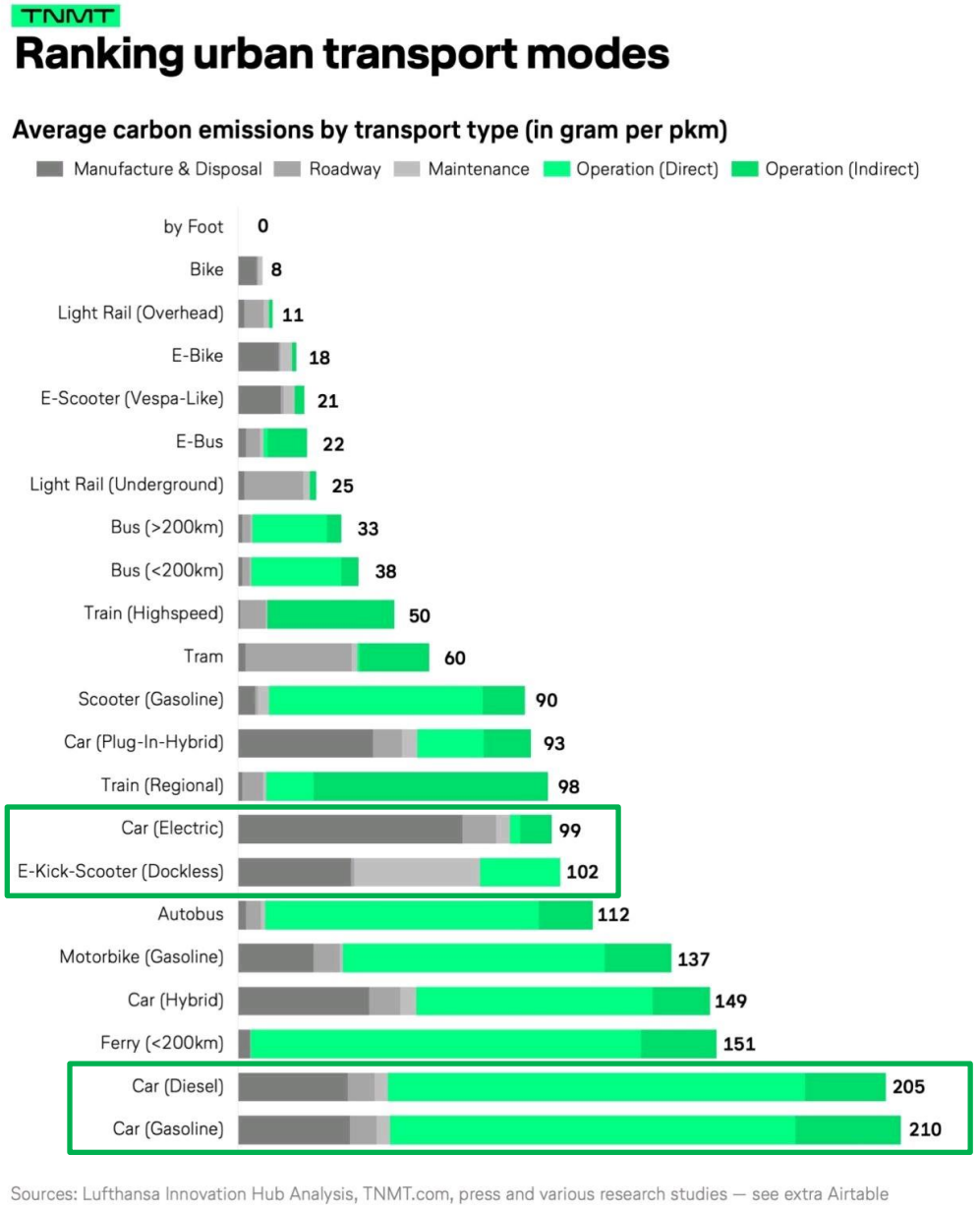
~ 100 M km/day




**~ 25 M km/day individual motorized transport**

# Don’t worry the future is electric, the future is “green”

But how green is “green”?



# Options in Bogotá

**$4 M** 30 km
370 Wh

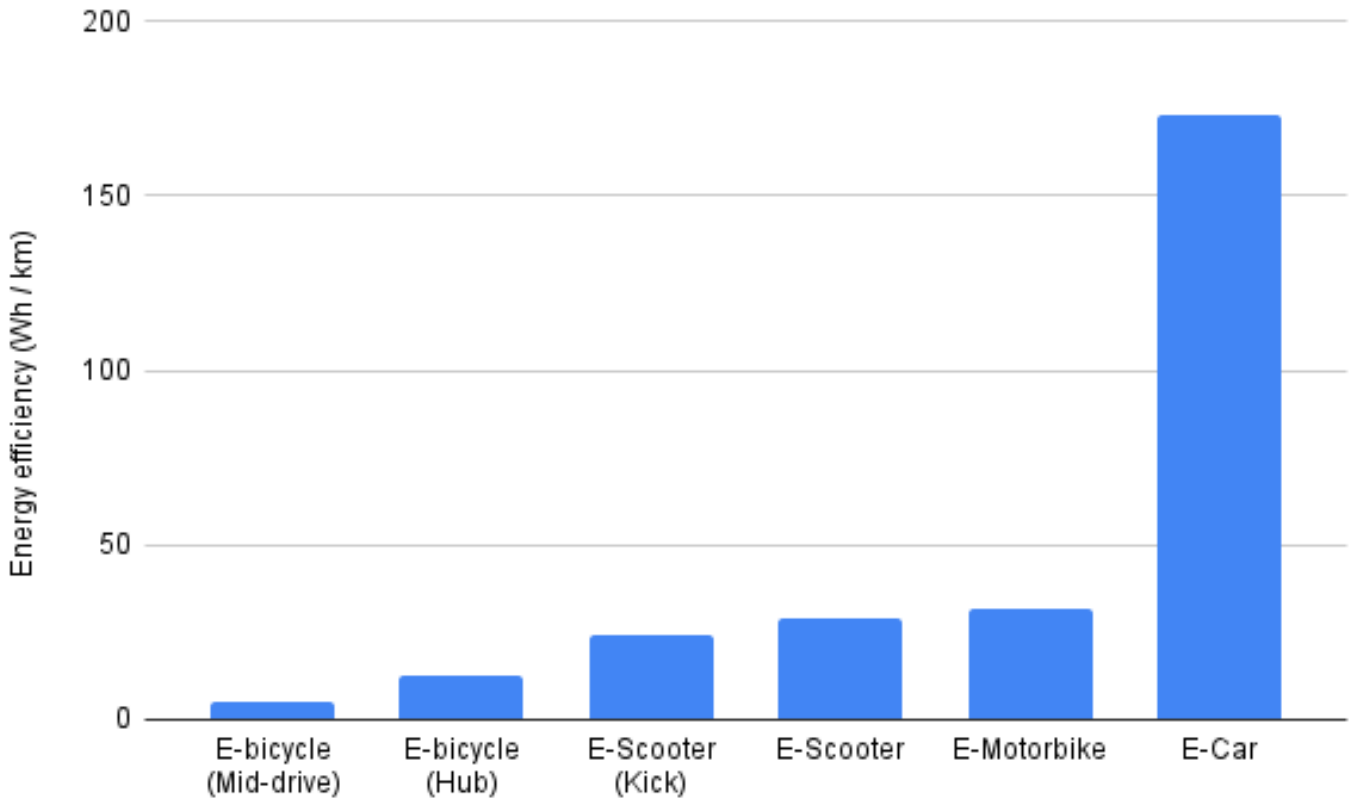
**$4 M** 40 km
960 Wh

**$5.5 M** 80 km
2300 Wh
(Lead)

**$10 M** 60 km
1900 Wh

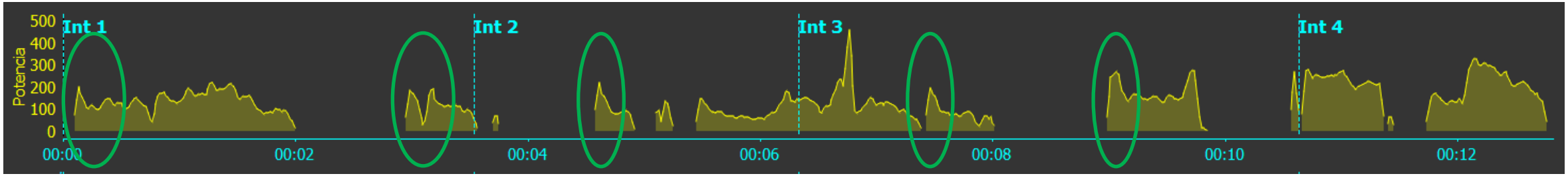
**$140 M** 300 km
52000 Wh

# Energy per km performance



# Where is energy required

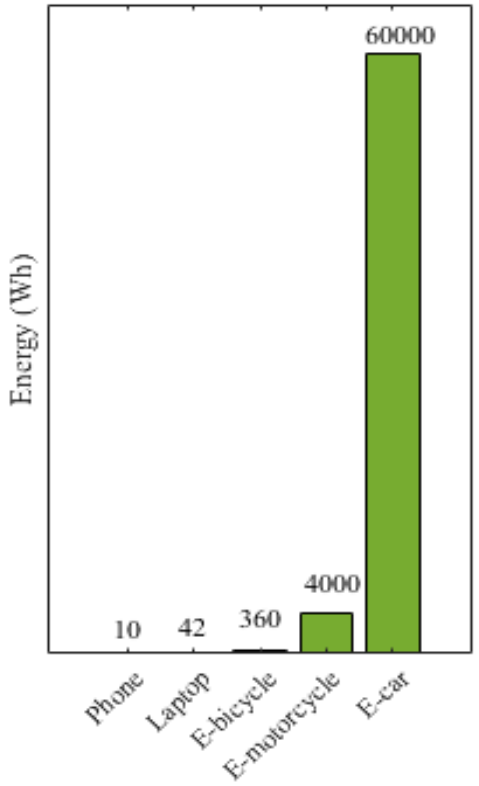
A normal (short) cycling commute in Bogota, let's look at its **power profile**

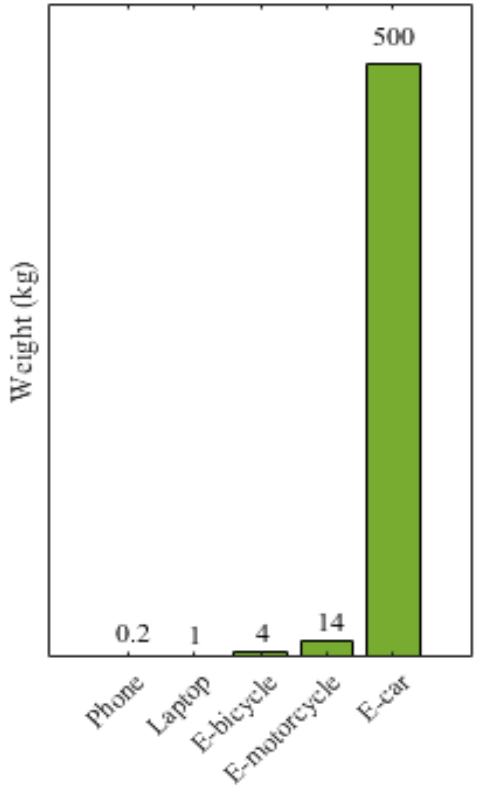


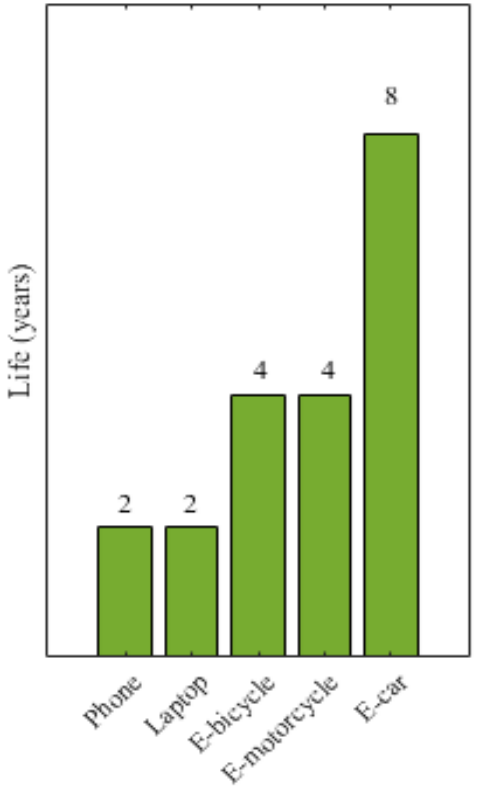

- Stopping/Starting requires significantly more power.

- At low rpm, low energy efficiency.
- E-bikes can combine pedaling and motor power for very efficient battery use.

# Lithium batteries



# How green is “green”

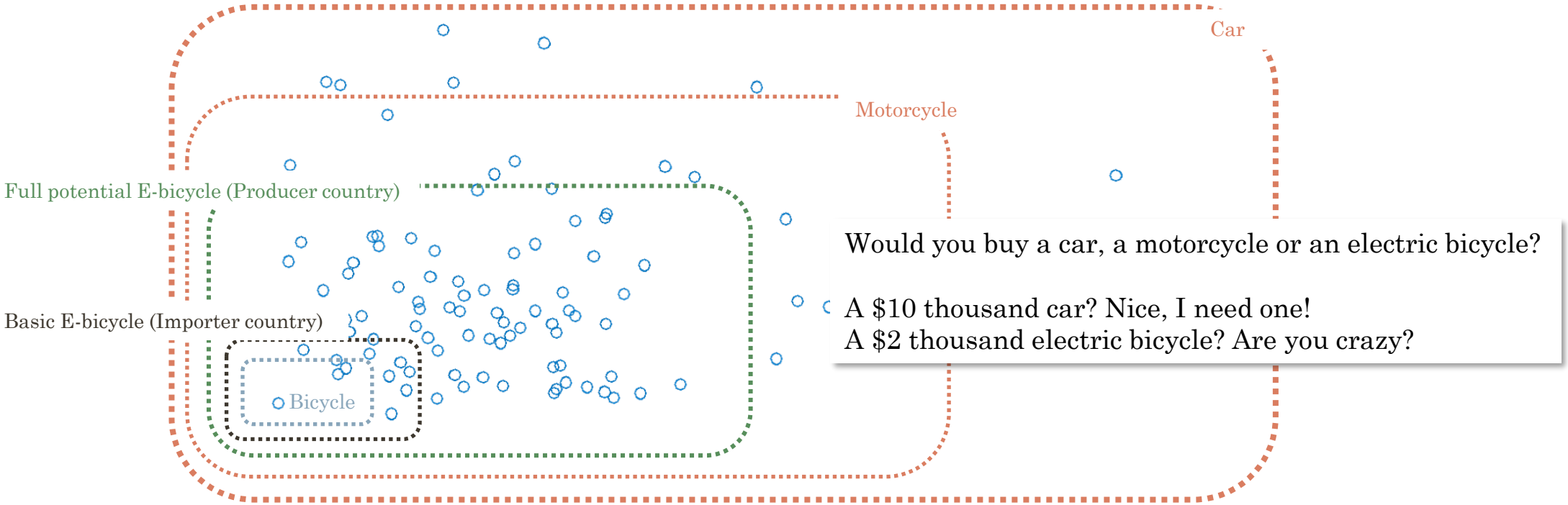
- 25 million km/day **in a year, with e-cars:**
  - 1.600.000.000.000 Wh (1.6 trillion)
  - 3.300 tons of lithium

- 25 million km/day **in a year, with e-bicycles:**
  - 0.047.000.000.000 Wh (0.05 trillion or 50 billion)
  - 114 tons of lithium

# E-bicycles vs motorbikes and cars…

Wait… are you trying to compare e-bicycles with motorcycles or cars? **YES!**

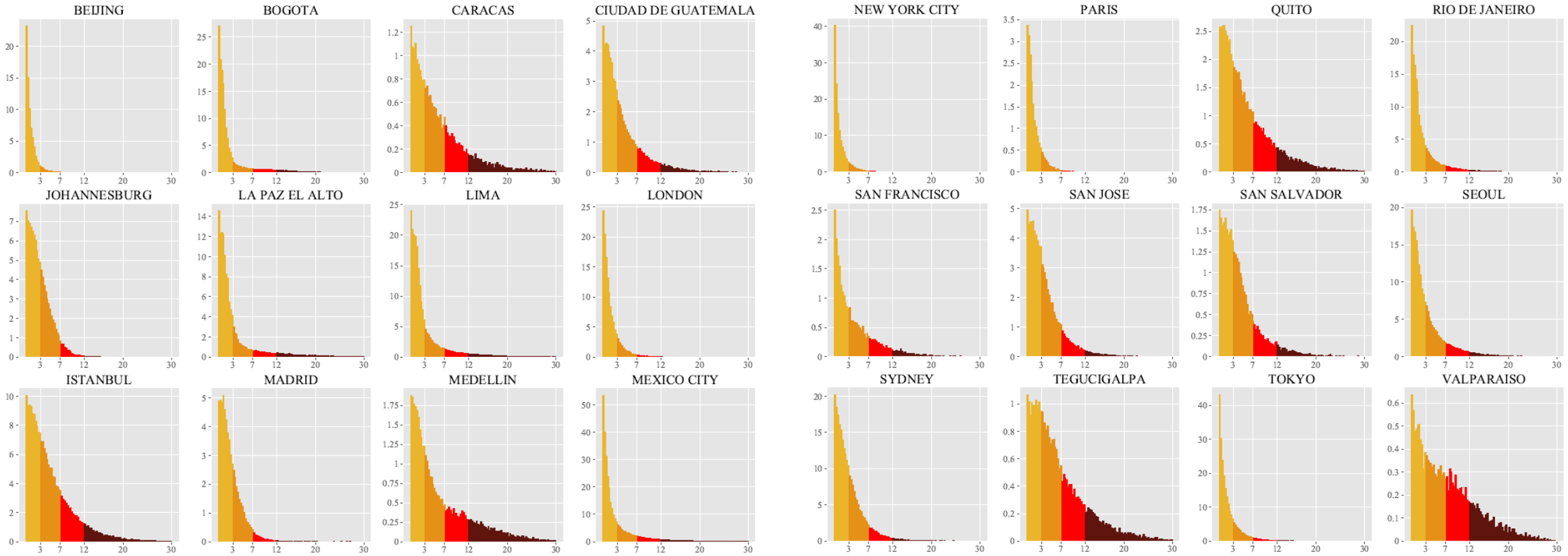
City trips (schematic)
Any two dimensions: distance, weight capacity, power, passengers...
and **the vehicle where you can complete the trip**.




Would you buy a car, a motorcycle or an electric bicycle?

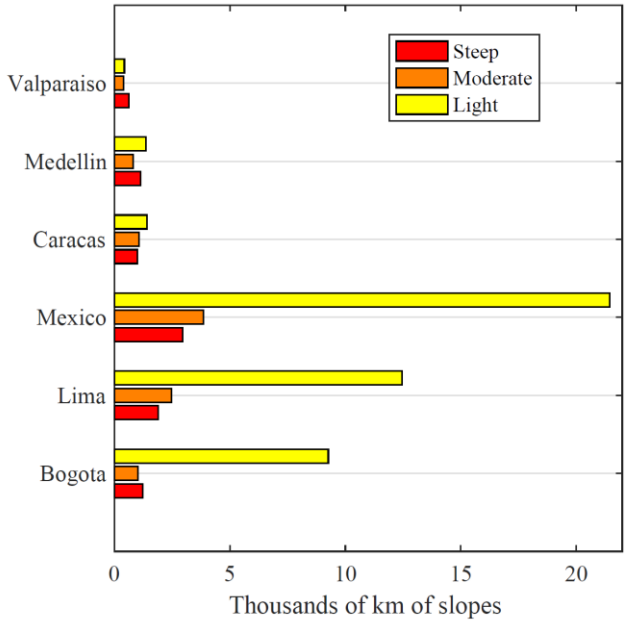
A $10 thousand car? Nice, I need one!
A $2 thousand electric bicycle? Are you crazy?

# Cities and Slopes




Slopes: light (< 3%), moderate (3% to 7%), steep (7% to 12%) and very steep (> 12%)

# Cities and Slopes




Cities are not so flat as we think

| | | Slope coordinate | | | Slope | | | Slope |
|---|---|---|---|---|---|---|---|---|
| | | Light | Mod. | Steep | Index | | | Vol. (km) |
| 1 | Valparaiso | 29 | 25.8 | 45.1 | 0.880 | 1 | Sydney | 10210 |
| 2 | Tegucigalpa | 32.2 | 31.8 | 35.9 | 0.831 | 2 | Istambul | 7883 |
| 3 | Quito | 38.5 | 30.6 | 30.8 | 0.753 | 3 | Mexico C. | 6792 |
| 4 | Caracas | 38.9 | 29.7 | 31.3 | 0.748 | 4 | Johannesburg | 4928 |
| 5 | Medellin | 41.1 | 25.1 | 33.7 | 0.723 | 5 | Seoul | 4864 |
| 6 | Istanbul | 41.5 | 32.6 | 25.7 | 0.717 | 6 | S. Jose (CR) | 4475 |
| 7 | S. Salvador | 47.6 | 34.6 | 17.6 | 0.652 | 7 | Lima | 4346 |
| 8 | S. Jose (CR) | 53.7 | 32.9 | 13.3 | 0.583 | 8 | Rio de J. | 3738 |
| 9 | S. Francisco | 52.5 | 26.7 | 20.6 | 0.582 | 9 | Quito | 3367 |
| 10 | Guatemala C. | 53.1 | 28.4 | 18.3 | 0.578 | 10 | La Paz-El A. | 3176 |
| 11 | Johannesburg | 61.5 | 33.1 | 5.2 | 0.510 | 11 | Guatemala C. | 2657 |
| 12 | Sydney | 61.7 | 28.9 | 9.3 | 0.489 | 12 | Bogota | 2232 |
| 13 | Seoul | 62.8 | 24.1 | 13 | 0.462 | 13 | Caracas | 2049 |
| 14 | Madrid | 68.3 | 27.5 | 4.1 | 0.421 | 14 | Medellin | 1937 |
| 15 | La Paz-El A. | 70.9 | 14.3 | 14.7 | 0.356 | 15 | Tegucigalpa | 1857 |
| 16 | Mexico C. | 71.1 | 15.6 | 13.2 | 0.354 | 16 | Tokyo | 1841 |
| 17 | Lima | 71.6 | 15.9 | 12.4 | 0.348 | 17 | S. Salvador | 1684 |
| 18 | Rio de J. | 74.3 | 16.7 | 9 | 0.320 | 18 | New York C. | 1550 |
| 19 | Bogota | 78.9 | 9.4 | 11.7 | 0.259 | 19 | Madrid | 1499 |
| 20 | Tokyo | 79.9 | 15.7 | 4.3 | 0.259 | 20 | London | 1495 |
| 21 | London | 84.6 | 13 | 2.3 | 0.203 | 21 | S. Francisco | 1392 |
| 22 | Paris | 86.5 | 12 | 1.5 | 0.181 | 22 | Valparaiso | 1008 |
| 23 | New York C. | 88.6 | 9.7 | 1.6 | 0.150 | 23 | Beijing | 354 |
| 24 | Beijing | 94.1 | 5.2 | 0.7 | 0.079 | 24 | Paris | 218 |

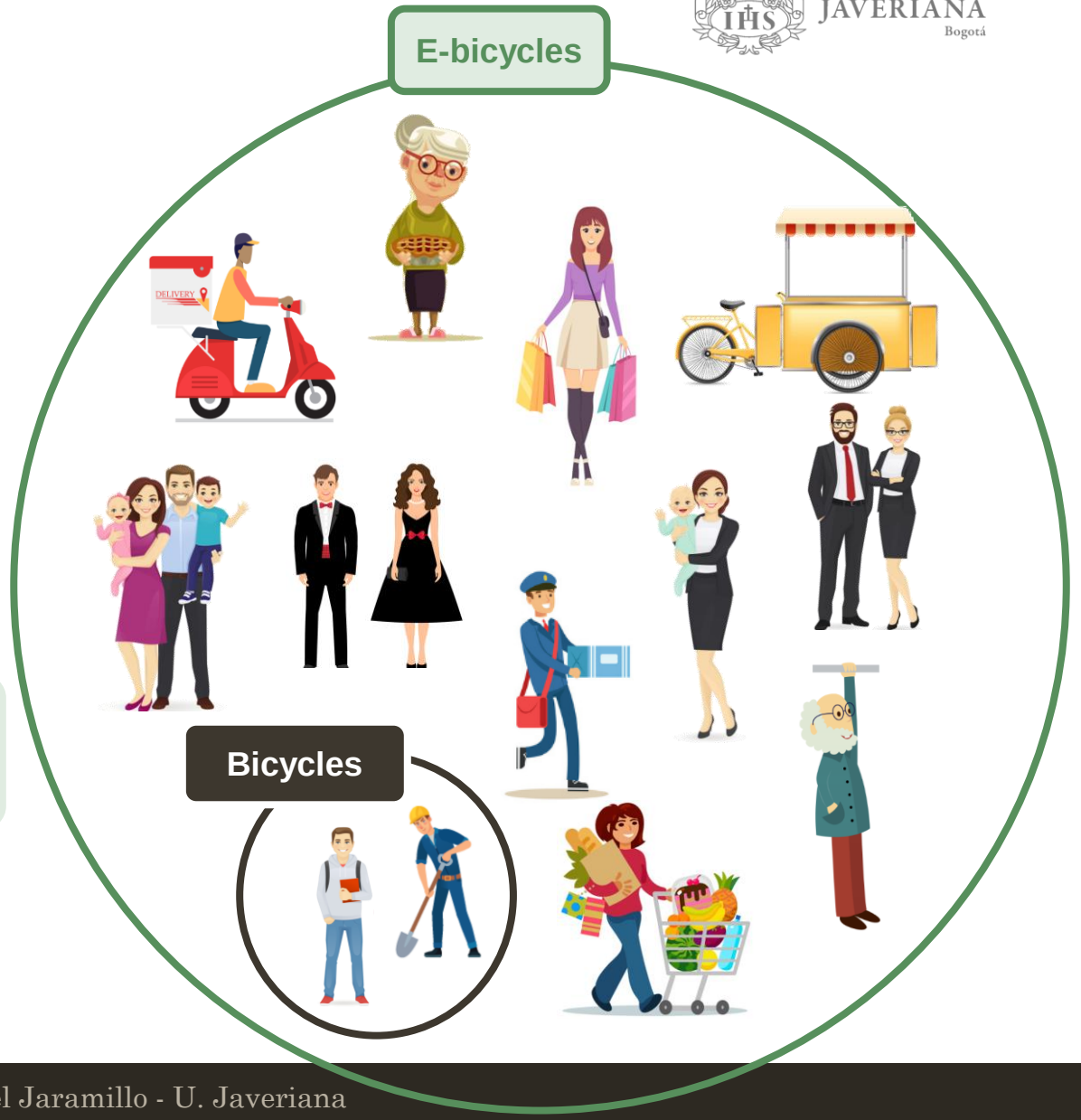
% calles

# E-bicycle for public health

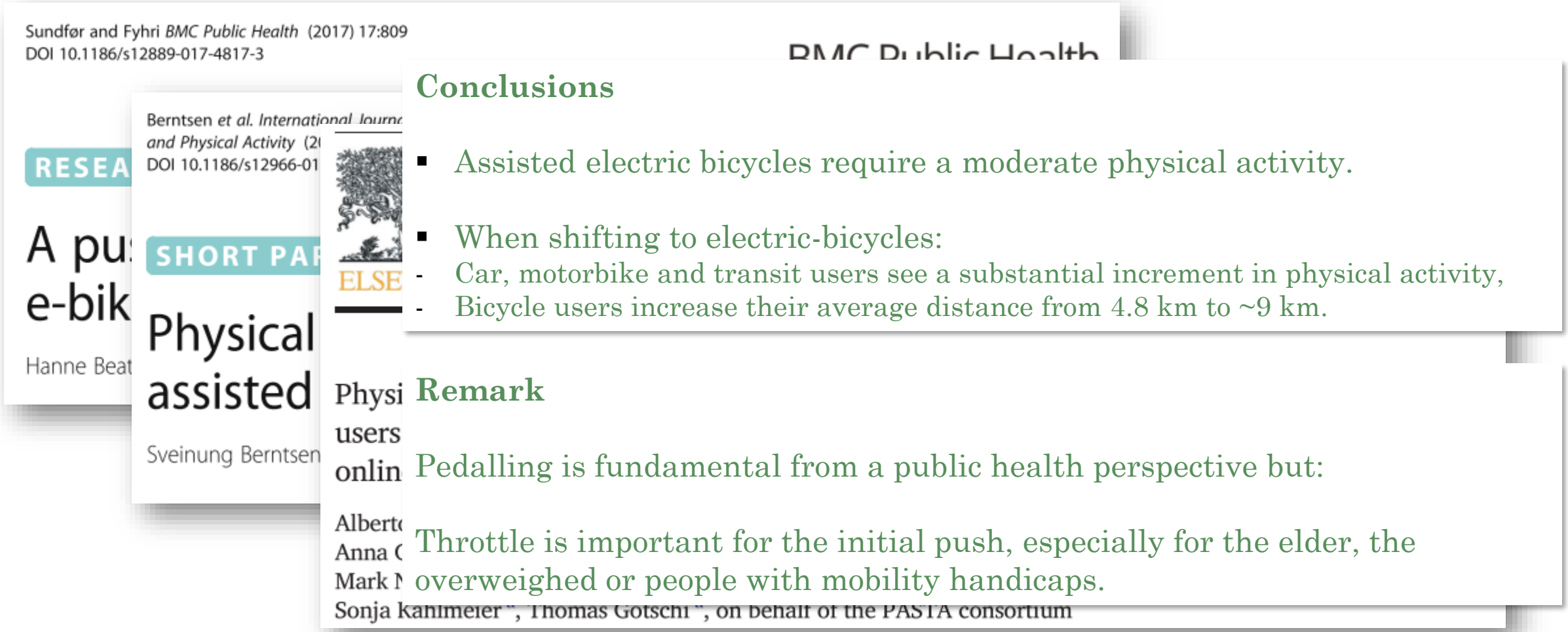
| | Regular bicycle | E-bicycle |
|---|---|---|
| **Distance** | 5 km | > 10 km |
| **User type** | Risky | Any |
| **Physical condition** | Good | Any |
| **Genre** | Masculine | Any |
| **Age** | Young | Any |
| **Trip type** | Work, study | Any |

**Average user**

Support regular bicycles



# What about pedalling?




## Conclusions

- Assisted electric bicycles require a moderate physical activity.

- When shifting to electric-bicycles:
  - Car, motorbike and transit users see a substantial increment in physical activity,
  - Bicycle users increase their average distance from 4.8 km to ~9 km.

## Remark

Pedalling is fundamental from a public health perspective but:

Throttle is important for the initial push, especially for the elder, the overweighed or people with mobility handicaps.

# You don’t understand…

I’m too fancy of a guy…

I live in the suburbs…

I have two kids!

I always carry heavy stuff

No man, really heavy stuff!

I am a motorcycle lover…

Riese und Muller


Stevens

Yuba

Urban arrow

Gazelle

Harley Davidson

Innovations in electric bicycles are expanding their potential.
If you want to live in a better city in the future, your city should have lots of electric bicycles.

In 2020, Germans bought approximately 200.000 e-cars… and 2 million e-bicycles! (Think of subsidizing!)

E-bicycles are the best way get closer to the bicycle for any type of citizen (non-cyclists!).

- Congestion? Less cars, more e-bicycles.
- Fatal crashes? less motorbikes, more e-bicycles.
- Cheaper transport? more e-bicycles.
- Too expensive transport infrastructure? Invest more in e-bicycles.
- Pollution? Less trucks, more cargo e-bicycles.
- Transit overcrowded? more e-bicycles.
- Sedentary population and chronic health issues? More and more e-bicycles.

Well I can't have that many electric bicycles!

Rad power bikes

## Thank you for you attention!

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# Bicis eléctricas vs carros y motos

| | Carro | Moto | Bici-e |
|---|---|---|---|
| **Costo promedio** | **$ 49.5 M** | **$ 5.4 M** | **$ 3.3 M** |
| **Gastos 1era vez** | | | |
| Matrícula | $ 450.000 | $ 217.000 | $ 0 |
| Curso | $ 650.000 | $ 600.000 | $ 0 |
| Licencia/examen | $ 400.000 | 138.000 | $ 0 |
| **Subtotal** | $ 1.500.000 | $ 955.000 | $ 0 |
| **Gastos anuales** | | | |
| Soat/Impuesto/Seguro | $ 2.300.000 | $ 480.000 | $ 0 |
| Gasolina/Energía | $ 2.500.000 | $ 492.000 | $ 53.000 |
| Parqueadero | $ 720.000 | $ 360.000 | $ 300.000 |
| Mantenimiento | $ 500.000 | $ 60.000 | $ 50.000 |
| Accesorios* | $ 400.000 | $ 350.000 | $ 420.000 |
| **Subtotal** | **$ 6.420.000** | **$ 1.442.000** | **$ 823.000** |
| **TOTAL** | **$ 7.920.000** | **$ 2.697.880** | **$ 823.000** |
| Estratos de compra | 3,4,5,6 | 1, 2, 3 | 4, 5, 6 |

Accesorios*: para la bici-e incluye el reemplazo de una batería en 5 años, para carros y motos, incluye llantas en 5 años.

**En 5 años**

Suponiendo depreciación del 30% para todos los vehículos, sin choques ni robos.

Bici-e vs 2do carro (11.8 M/año)
**Ahorro de gastos = 32.5 M**
**Ahorro de compra: = 26.6 M**

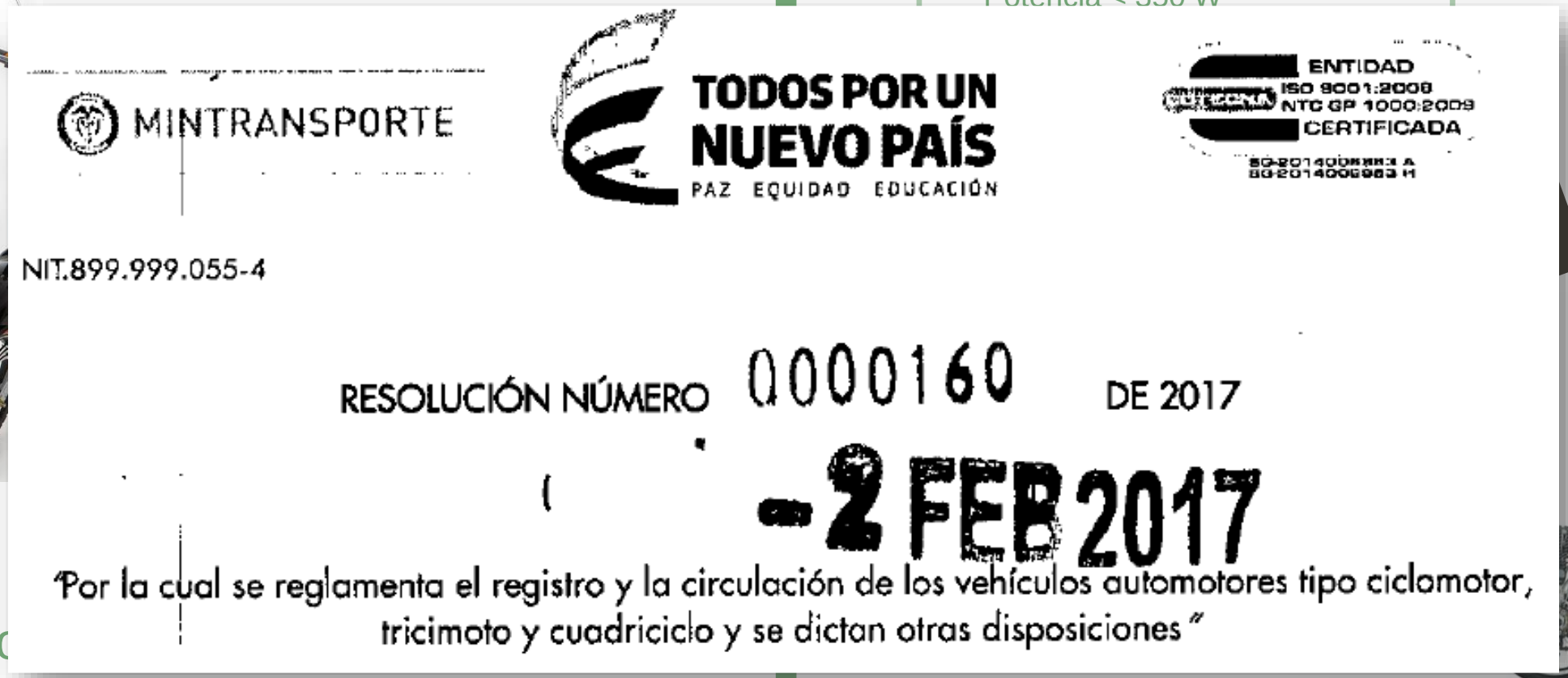
Bici-e vs 2da Moto (1 M/año)
**Ahorro de gastos = 3.6 M**
**Ahorro de compra = 1.2 M**

Habría más ahorro si se incluyeran gastos de la primera vez.

Ahorros proyectados con 5% ef. anual.

# Qué es y qué no es una bici eléctrica

## Ciclomotores y MOPED



MINTRANSPORTE

NIT.899.999.055-4

TODOS POR UN NUEVO PAÍS
PAZ EQUIDAD EDUCACIÓN

ENTIDAD ISO 9001:2008 NTC GP 1000:2009 CERTIFICADA

RESOLUCIÓN NÚMERO 0000160 DE 2017

( -2 FEB 2017

"Por la cual se reglamenta el registro y la circulación de los vehículos automotores tipo ciclomotor, tricimoto y cuadriciclo y se dictan otras disposiciones"

Po

SOAT, matrícula, etc.

## Bicis de pedaleo asistido

- Peso < 35 kg
- Potencia < 350 W

Por la ciclorruta, libres.

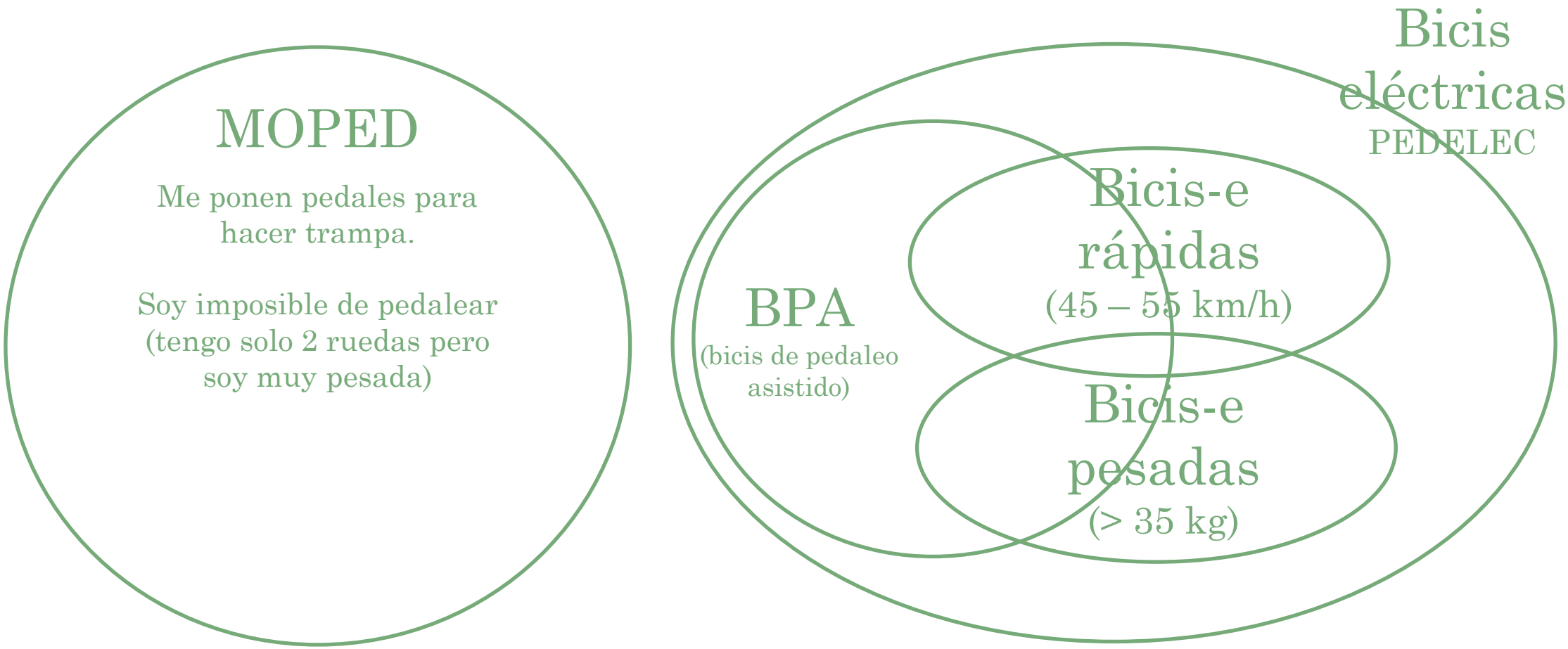
# Qué es y qué no es una bici eléctrica


**Gazelle Ultimate Speed 380 2020**

## Ciclomotores

**Electric Bromptom**

# Qué es y qué no es una bici eléctrica



- Peso > 35 kg
- Potencia = 300 W
- Motor ON hasta 30 km/h
- Sin acelerador

# What is an electric bicycle

I have pedals to avoid regulations…
but nobody pedals me.


Some authorities ask:

- Are they dangerous?
- Do you MUST pedal?


Licence, register, taxes, insurance, no right to use cycling infrastructure…

Free!
Just like normal bicycles

# How dangerous are electric bicycles?

## Or… where does danger come from?

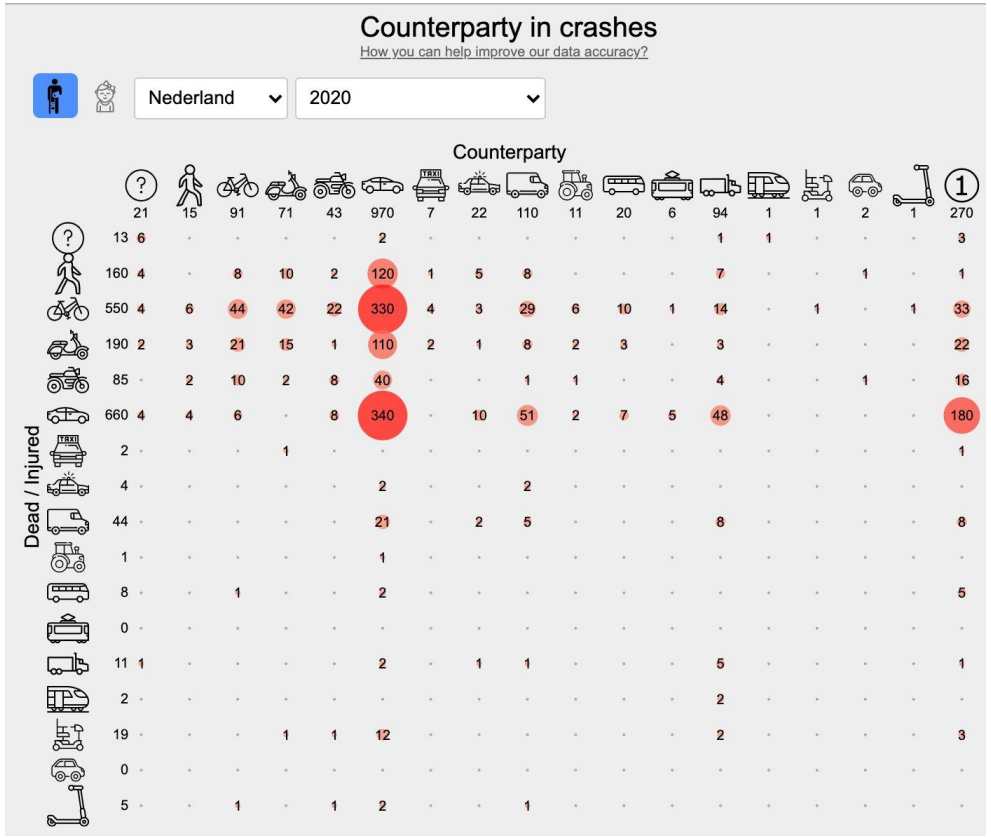
### Fatal crashes, Bogota 2019

| Víctimas | Peatones | Bicicletas | Motocicletas | Vehículos livianos | Buses de transporte de pasajeros | Taxis | Transporte de carga | Autolesión, volcamiento o caída de ocupante | Vehículo sin identificar |
|---|---|---|---|---|---|---|---|---|---|
| Peatones | 0 | 4 | 85 | 50 | 52 | 13 | 18 | 0 | 14 |
| Ciclistas | 0 | 0 | 7 | 8 | 17 | 8 | 23 | 8 | 0 |
| Motociclistas | 3 | 4 | 6 | 24 | 31 | 5 | 27 | 38 | 0 |
| Acompañantes de motocicleta | 0 | 0 | 2 | 3 | 8 | 4 | 8 | 6 | 0 |
| Conductores de transporte público | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Pasajeros de transporte público | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 6 | 0 |
| Conductores de taxi | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Pasajeros de taxi | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 1 | 0 |
| Ocupantes de vehículos livianos | 0 | 0 | 1 | 4 | 2 | 0 | 2 | 1 | 0 |
| Ocupantes de transporte de carga | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |

0 | 1-20 | 21-40 | 41-60 | 61-80 | 81-100

Source

### The Crashes | Nederland




Source

# How dangerous are electric bicycles?

Well, danger is a combination of speed and weight

Amount of danger = $mass\ x\ speed^2$

An electric bicycle could be faster and heavier…
… but never as dangerous as the real dangers of urban transport.
Ironically, electric-bicycles are the only vehicles with speed limiters!

## Speed pedelecs
(45 – 55 km/h)


Gazelle Ultimate Speed 380

## Family or Cargo e-bikes
(> 35 kg)

Hikobike, UTE

# Components of an electric bicycle

**Battery (~1/3 Bike's cost)**

Voltage: 24 – 48 V
Charge: 10 Ah – 15 Ah
Energy: 240 – 720 Wh

**Engine / Motor (Battery + motor adds extra ~ 10 kg)**

Power (nominal): 250 – 750 W
Torque: 20 – 100 Nm

**Controller (Controls the power)**

Power: 250 – 1000 W

**Sensor (activates the motor when pedalling)**

12 – 1000 samples per pedal cycle

# Components of an electric bicycle

## Types of motors

**Hub-motor**
Wheel (front/rear)

Hilly terrain? You need > 500 W
Imagine going up a hill in a car with no gears…

Cheaper.

**Mid-drive**
Pedal axle

Hilly terrain? 250 W are OK
Imagine going up a hill in a car with gears!

More torque with less power.
More autonomy.

## Types of sensors

**Cadence Sensor**

Only detects pedalling.

Cheaper.

+ small and short-life battery

→ Cheap e-bicycle.
Ok, prefer your car.

**Torque Sensor**

Detects pedalling and how strong you pedal.

Better power control.
More autonomy.

+ big reliable battery

→ High performance e-bicycle.
Tired of traffic jams?

Some backup slides…

# What is an electric bicycle

MOPEDS

I have pedals to avoid regulations… but nobody pedals me.

PEDELECS, E-bicycles

EAPC
(Electrycally-assisted pedal cycles)

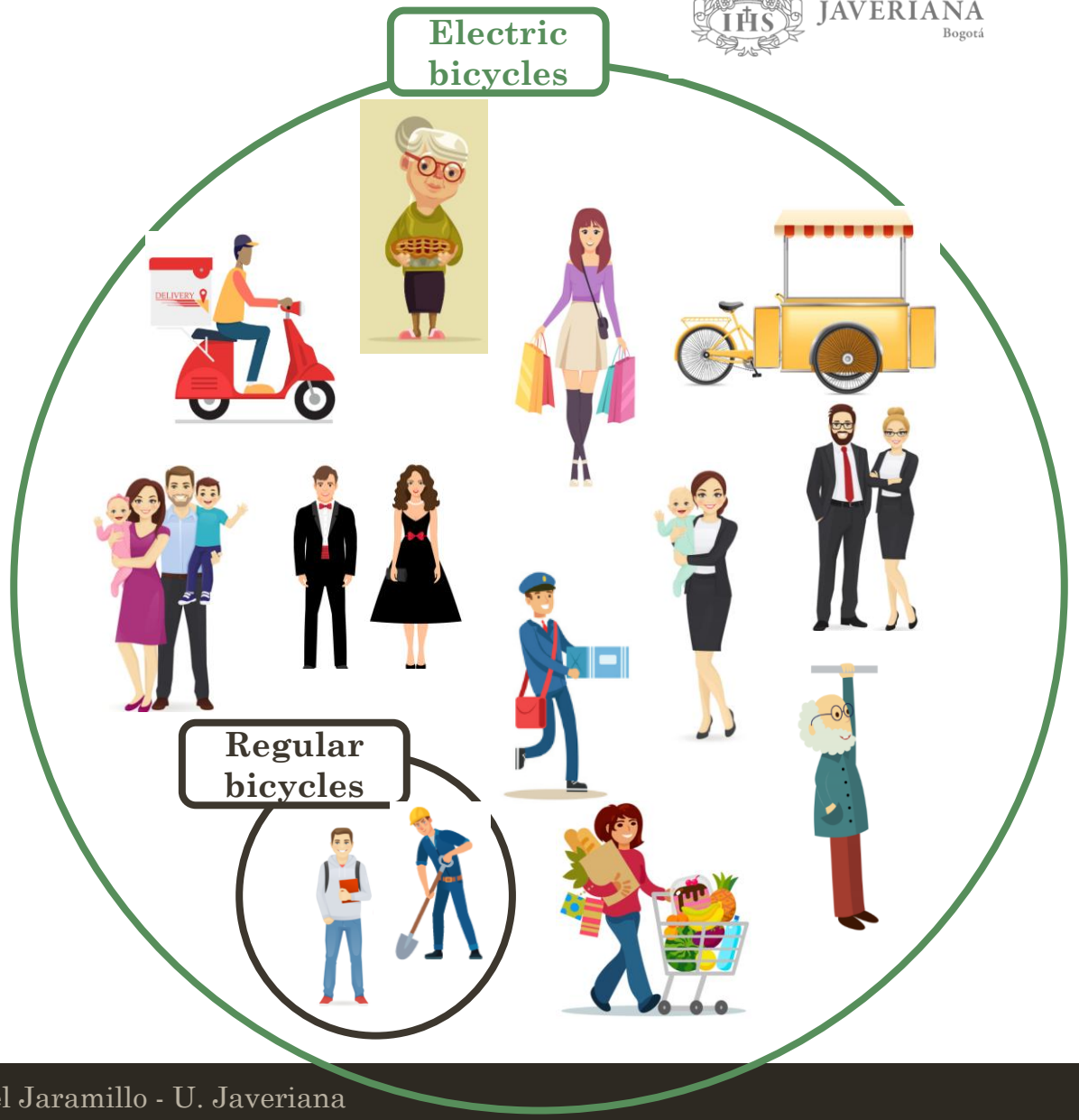
Speed pedelecs
(45 – 55 km/h)

Cargo e-bikes
(> 35 kg)

# Public health strategy

| | Regular Bicycle | E-Bicycle |
|---|---|---|
| **Distance** | 5 km | > 10 km |
| **User type** | Risky | Any |
| **Physical condition** | Good | Any |
| **Genre** | Masculine | Any |
| **Age** | Young | Any |
| **Trip type** | Work, study | Any |

**Average user profile**



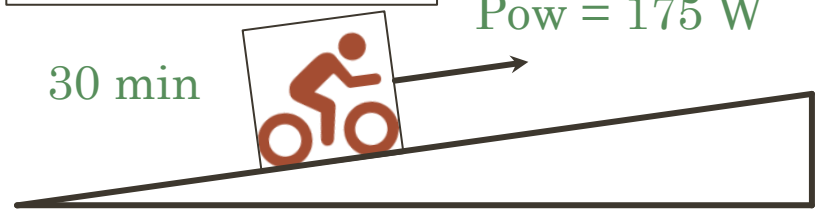
# Flattening your city

| Patios summit | 6 km (6.9%) |
|---|---|

Avg. cyclist

Vel = 11.5 km/h
Pow = 175 W

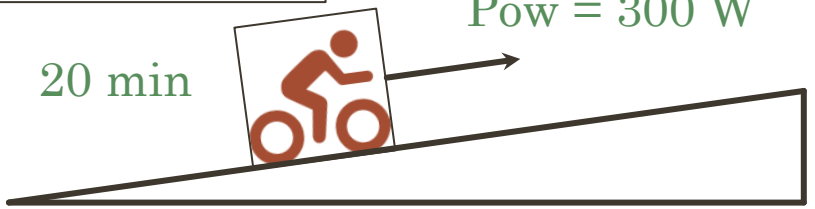
30 min



PRO Cyclist

Vel = 17 km/h
Pow = 300 W

20 min



**Like a regular bicycle 20 min trip in a flat terrain at 20 km/h!**

Anyone + e-bicycle

Vel = 17 km/h
Pow = 50 W

20 min