“It takes CO_2 to save CO_2 and ...
... it takes money to make money”

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SNCF Voyages
Paris

Introduction:

Three received wisdoms about trains running faster:

- they are more energy consuming,
- they are more harmful for the environment
- they are more expensive.

So ...
What's the point with increasing the commercial speed?

Demonstration

1 – Carbon balance of a rail high speed line

How to assess it?

2 – Impact of a speed increase on the carbon balance

" It takes CO_2 to save CO_2 and ..."

3 – The cost of speed

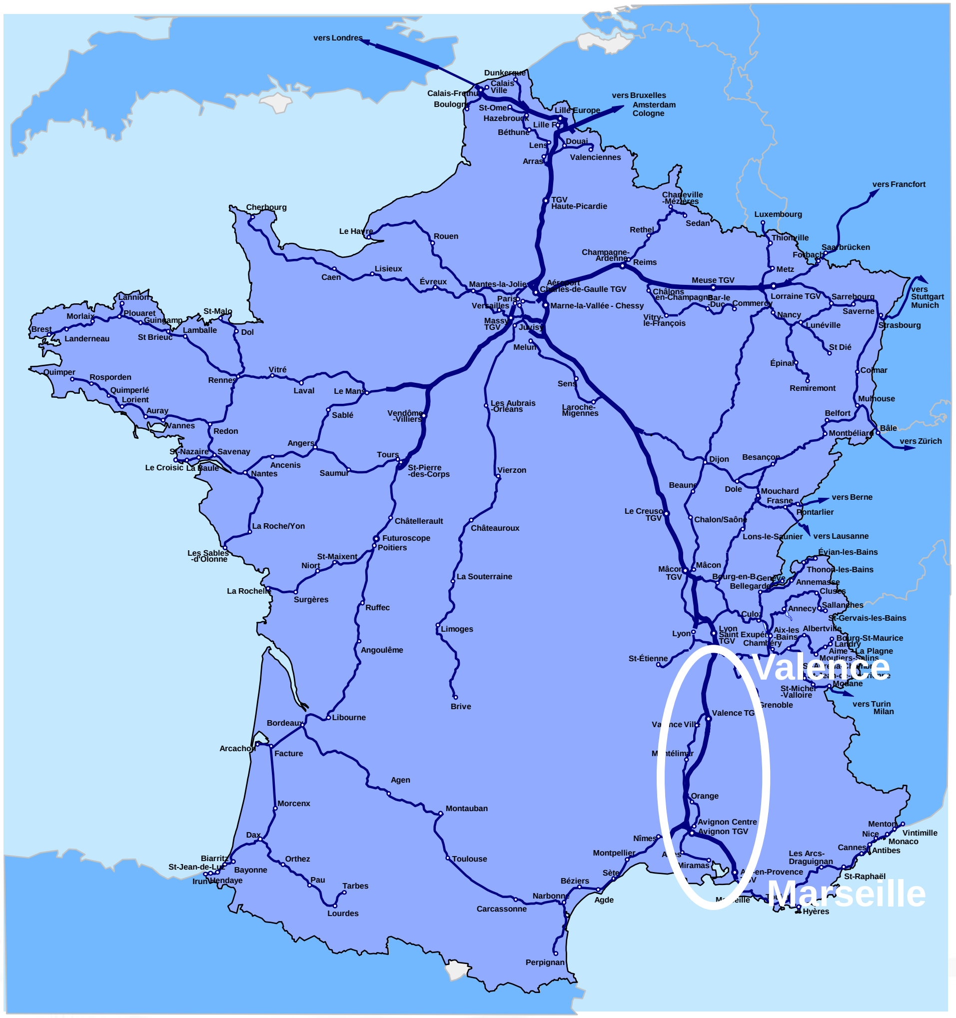
"... it takes money to make money."

1. Carbon balance of a High Speed Line

HSL commisioned in June 2001

250 km from Valence to Marseille

22 million passengers



1. Carbon balance of a High Speed Line

Calculation boundaries

1. Conception

Energy in offices
Paper
Informatic and Electronic materials

2. Construction

Earthwork
Transport of construction materials
Structures (Bridges, Tunnels, etc.)
Tracks with Ballast, Rail & Sleeper
Equipments for Signaling & Electricty transport
Railway Stations & Maintenance Centers
Rolling Stock Construction

3. Operation

Energy Consumptions for Rolling Stock
(traction, air conditioning, recovery braking energy)
Maintenance of Rolling Stock

4. Disposal

Disposal of Rolling Stock

"Rolling Stock + line equipments"

"Stations"

"Structures"

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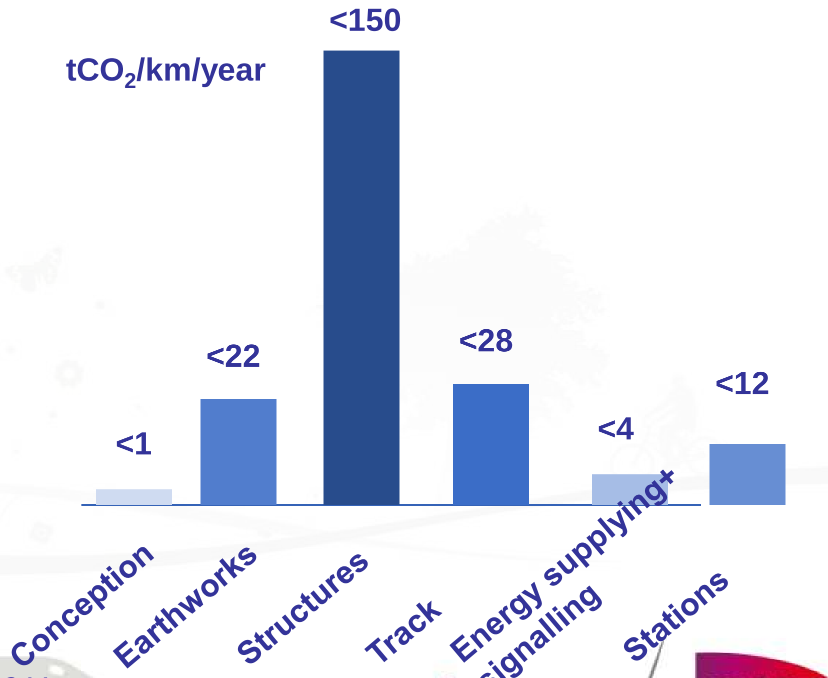
1. Carbon balance of a High Speed Line

Mediterranean HSL infrastructure carbon footprint

Conception	250 km	100 years
Railway equipments	250 km	50 years
Rail	250 km	30 years
Tunnels	12.8 km	100 years
Viaducts	11.km	100 years
Earthworks	191.4 km	100 years
Main Stations	2 stations	100 years
Secondary stations	2 stations	100 years

Total 2,200,000 tons of CO2
over the whole infrastructure life period



1. Carbon balance of a High Speed Line

Rolling Stock carbon footprint

- 155 t of Fiber reinforced plastic
- 34 t of copper
- 50 of glass

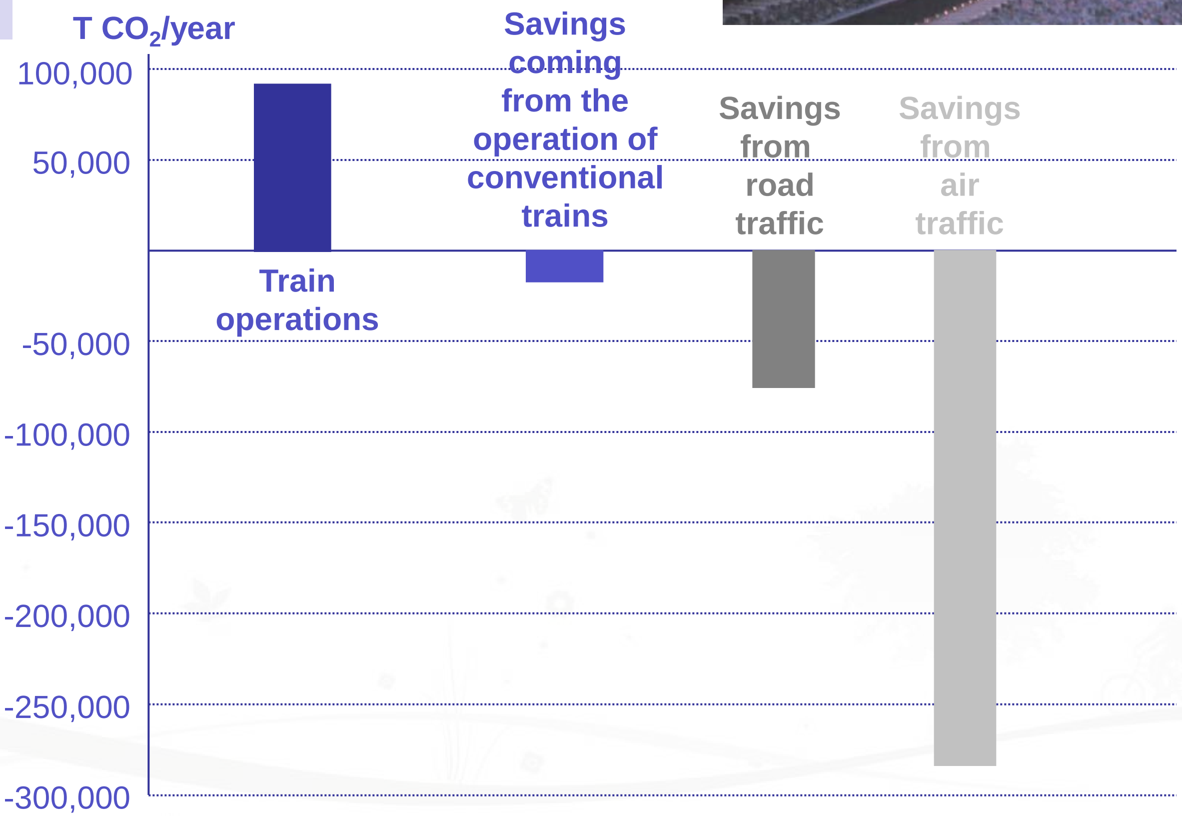
- average lifespan: 30 years
- 670 seats per train (average)

- revision: every 4 years : 45 t of iron and 0.25 t of copper
- maintenance and cleaning every second day: 7.7 t of water, 0.125 t of waste, +1,555 kWh

- asumption for disposal: all metals may be recycled into other products

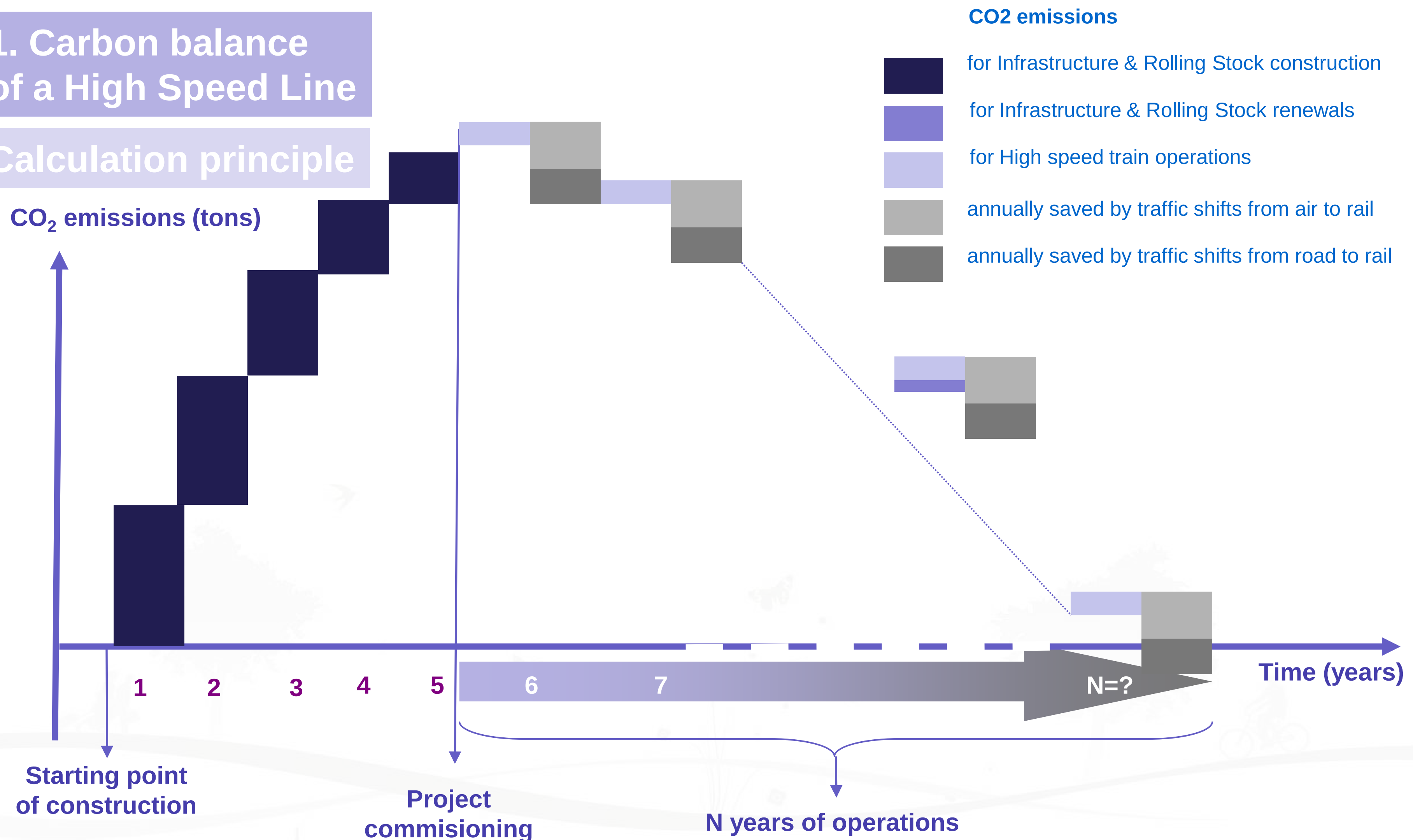
1. Carbon balance of a High Speed Line

Operations carbon footprint



1. Carbon balance of a High Speed Line

Calculation principle

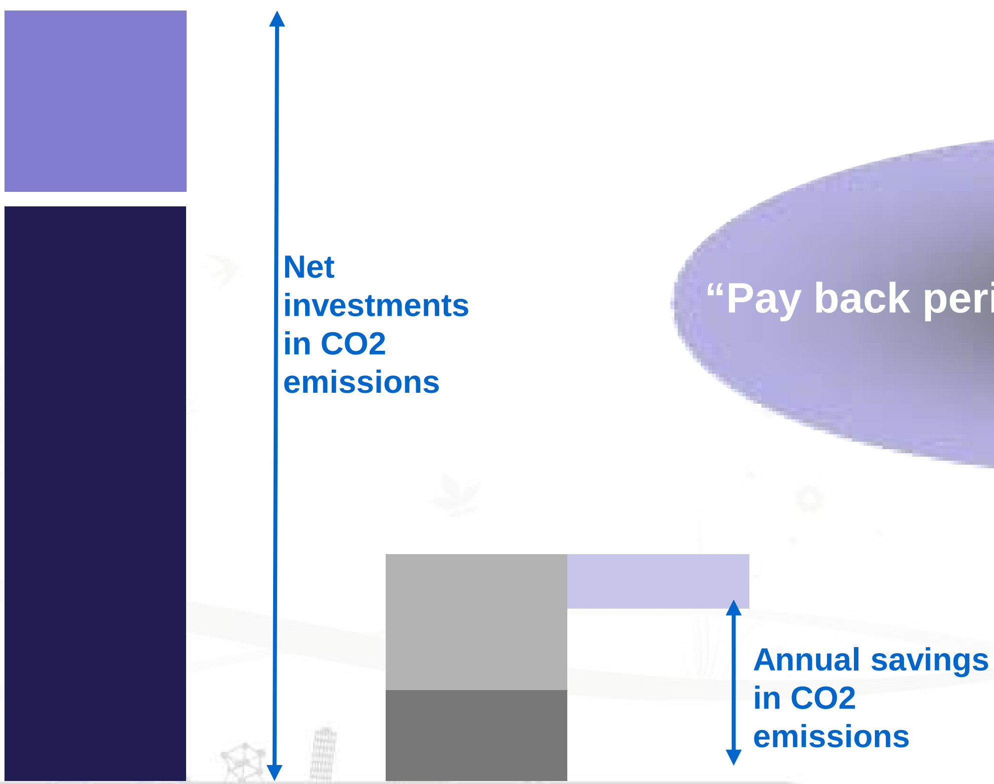


1. Carbon balance of a High Speed Line

Calculation principle

CO2 emissions

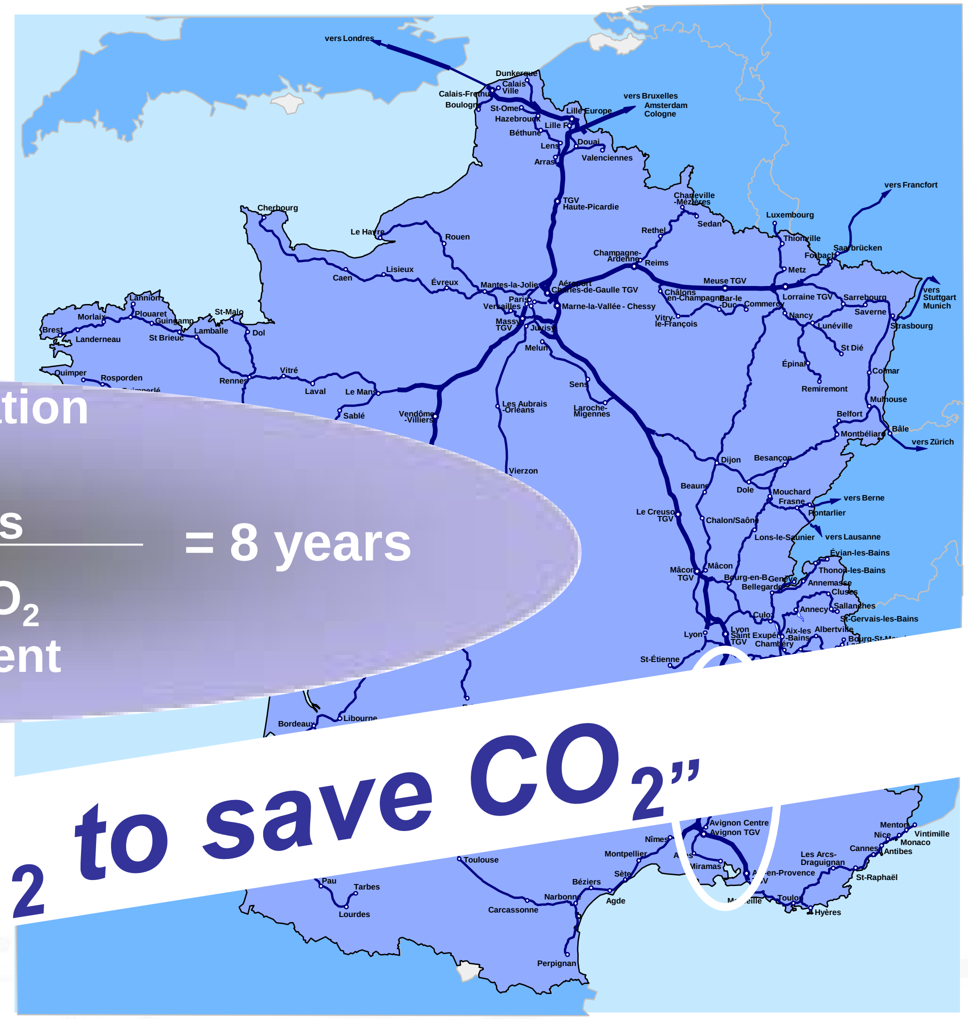
- for Infrastructure & Rolling Stock construction
- for Infrastructure & Rolling Stock renewals
- for High speed train operations
- annually saved by traffic shifts from air to rail
- annually saved by traffic shifts from road to rail



$$\text{"Pay back period"} = \frac{\text{Annual savings in } CO_2 \text{ emissions}}{\text{Net investments in } CO_2 \text{ emissions}}$$

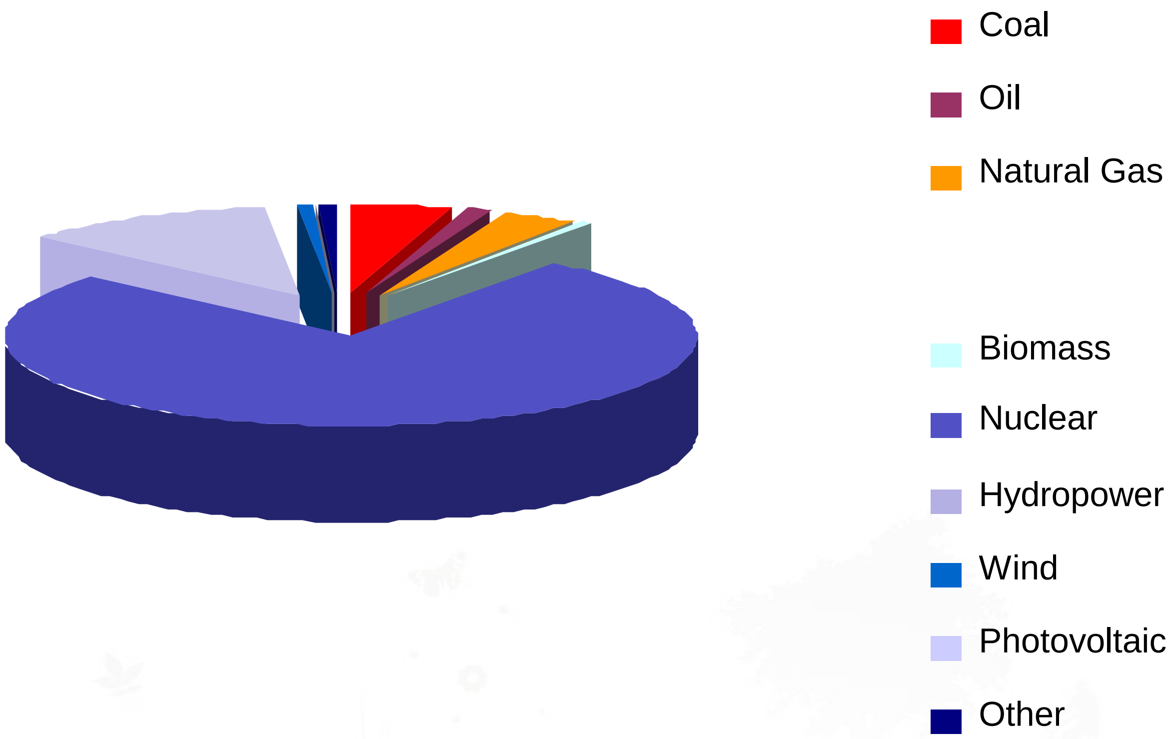
1. Carbon balance of a High Speed Line

$$\text{"Pay back period"} = \frac{\text{Net operation t } CO_2 \text{ savings}}{\text{Net t } CO_2 \text{ investment}} = 8 \text{ years}$$



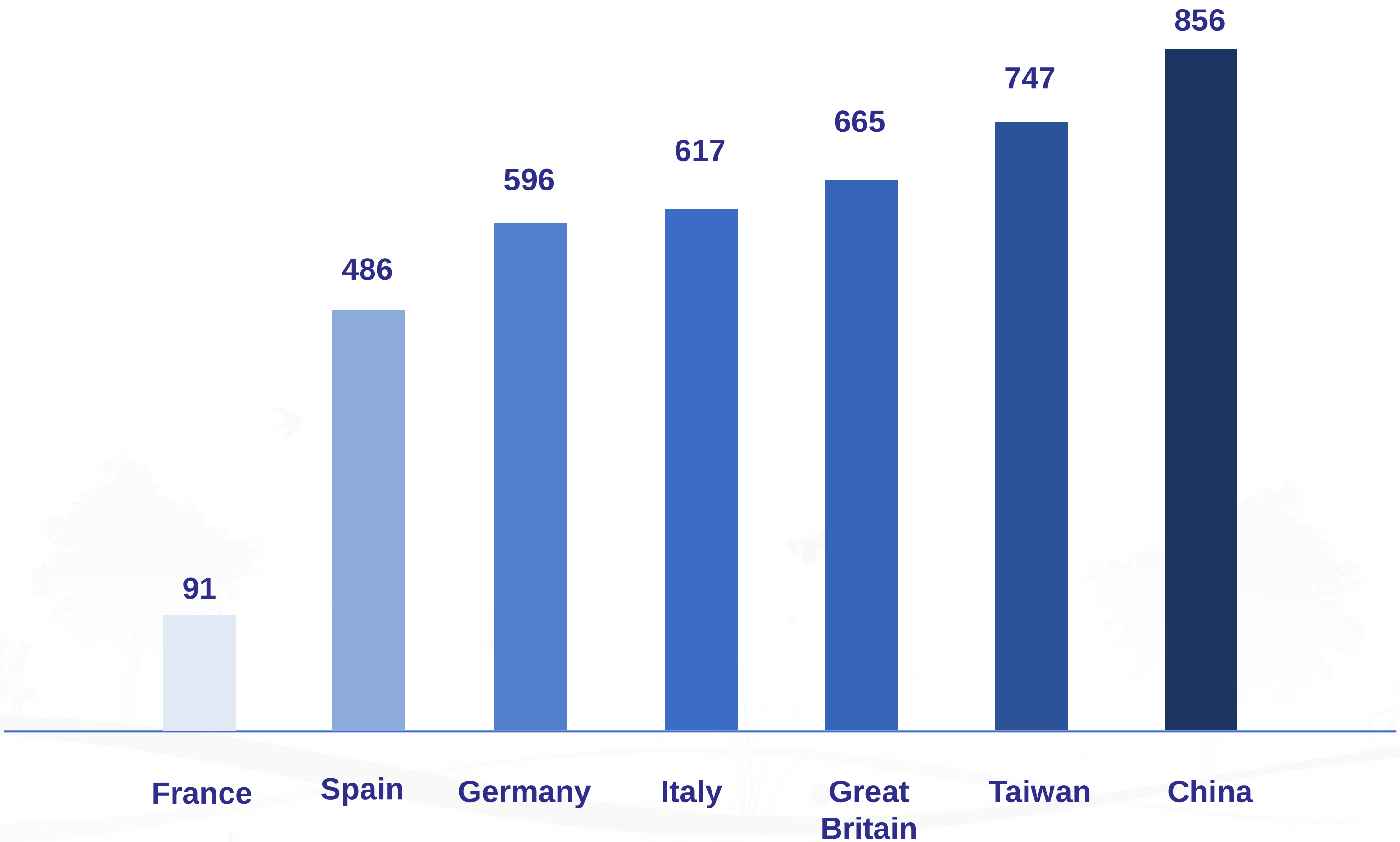
"It takes CO_2 to save CO_2"

Carbon Footprint of Electricity Generation



91 g CO_2 per kWh in France

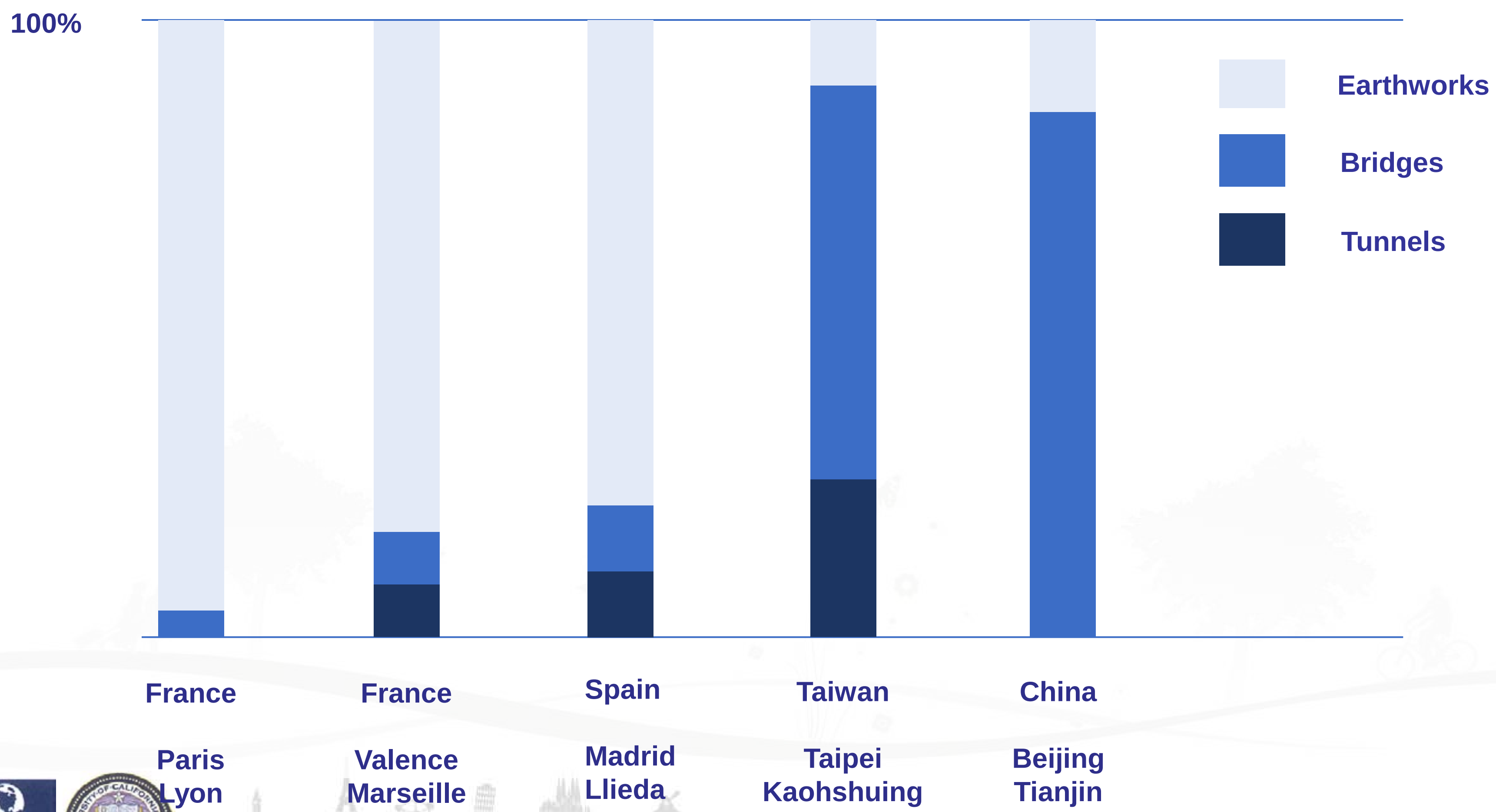
Carbon Footprint of Electricity Generation (2007)*



* EIA 2008 sources

1. Carbon balance of a High Speed Line

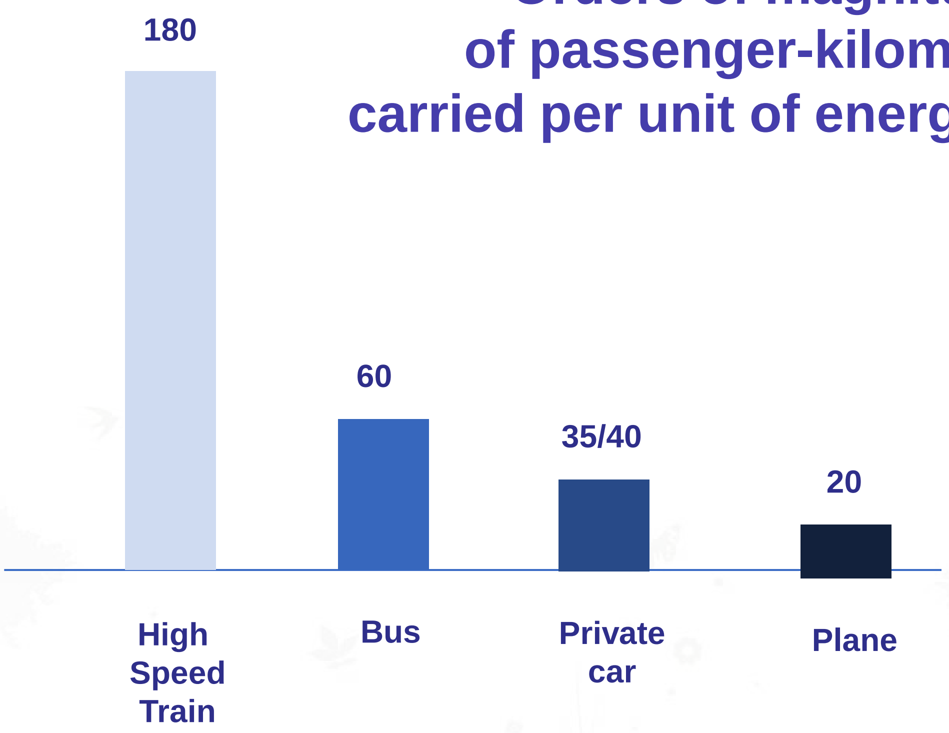
Infrastructure Mix



1. Carbon balance of a High Speed Line

Energy efficiency:

Orders of magnitude of passenger-kilometers carried per unit of energy (1 Kwh)



Demonstration

1 – Carbon balance of a rail high speed line

How to assess it?

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2 – Impact of a speed increase on the carbon balance

The higher the speed

The more powerful and adhering the trainset

The shorter the line

The fewer and smaller the structures (tunnels/bridges)

Less energy consumption and CO_2 emissions for the line construction

The shorter the travel times

The better the rolling stock productivity

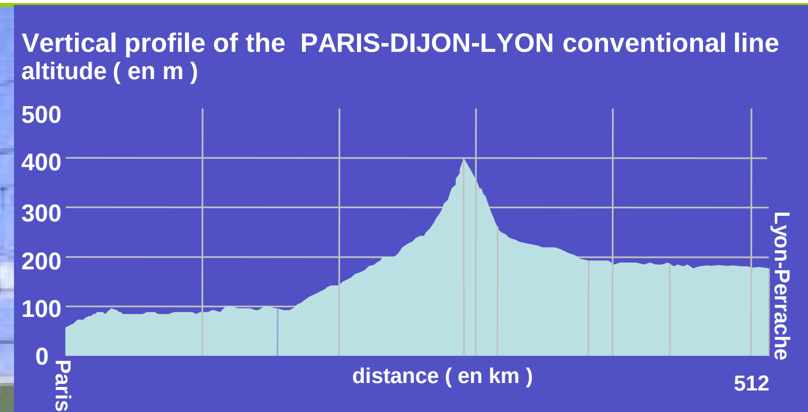
More energy and CO_2 for running the trains ?

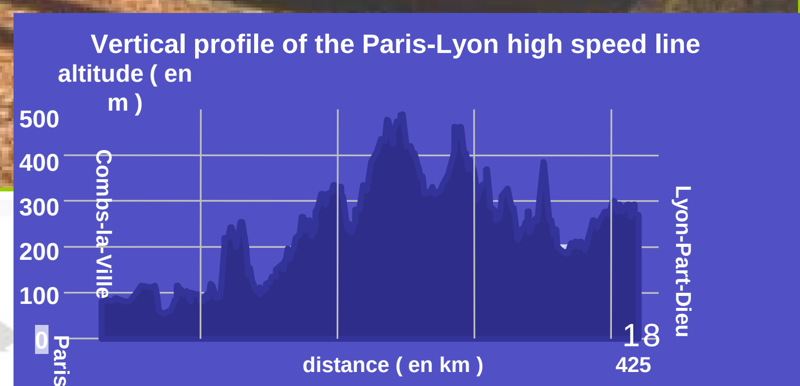
Less energy consumption and CO_2 emissions for the RS construction

The more attractive the train

The more energy and CO_2 saved from modal shifts

2 – Impact of a speed increase on the carbon balance





2 – Impact of a speed increase on the carbon balance

But what about the train energy consumption?

<u>Power rule:</u>
Does the train power increase with the cube of its speed?

<u>Energy rule:</u>
Is energy consumption in proportion with the square of the speed?

2 – Impact of a speed increase on the carbon balance

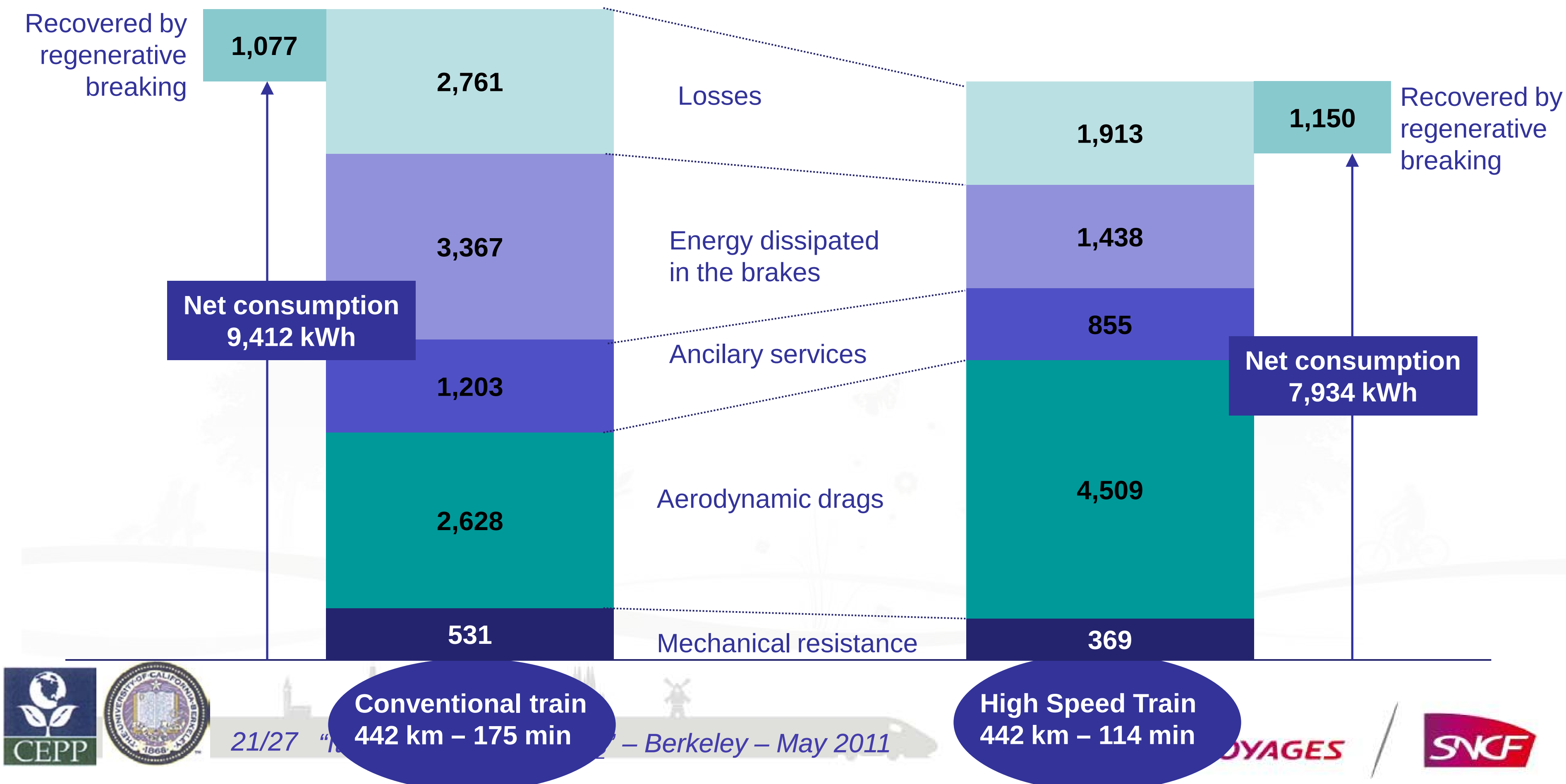
Mechanical resistance	Air Intake resistance	Aerodynamic resistance	Decelerat breaking losses	Downhill breaking losses	Ancilary services	Train & infrastructure losses
$(K_1+C)*(M/s)*\mathbf{V^0}$	$K_2*\mathbf{V^1}$	$K_3(C:s)*\mathbf{V^2}$	$K_4*(M/s)*(1/SD)*\mathbf{V^2}*(1-RgC)$	$K_5*(M/s)*\mathbf{V^{-1}}*(1-RgC)$	$K_6\mathbf{V^{-1}}$	$\rho T * \rho i$

Shorter Route

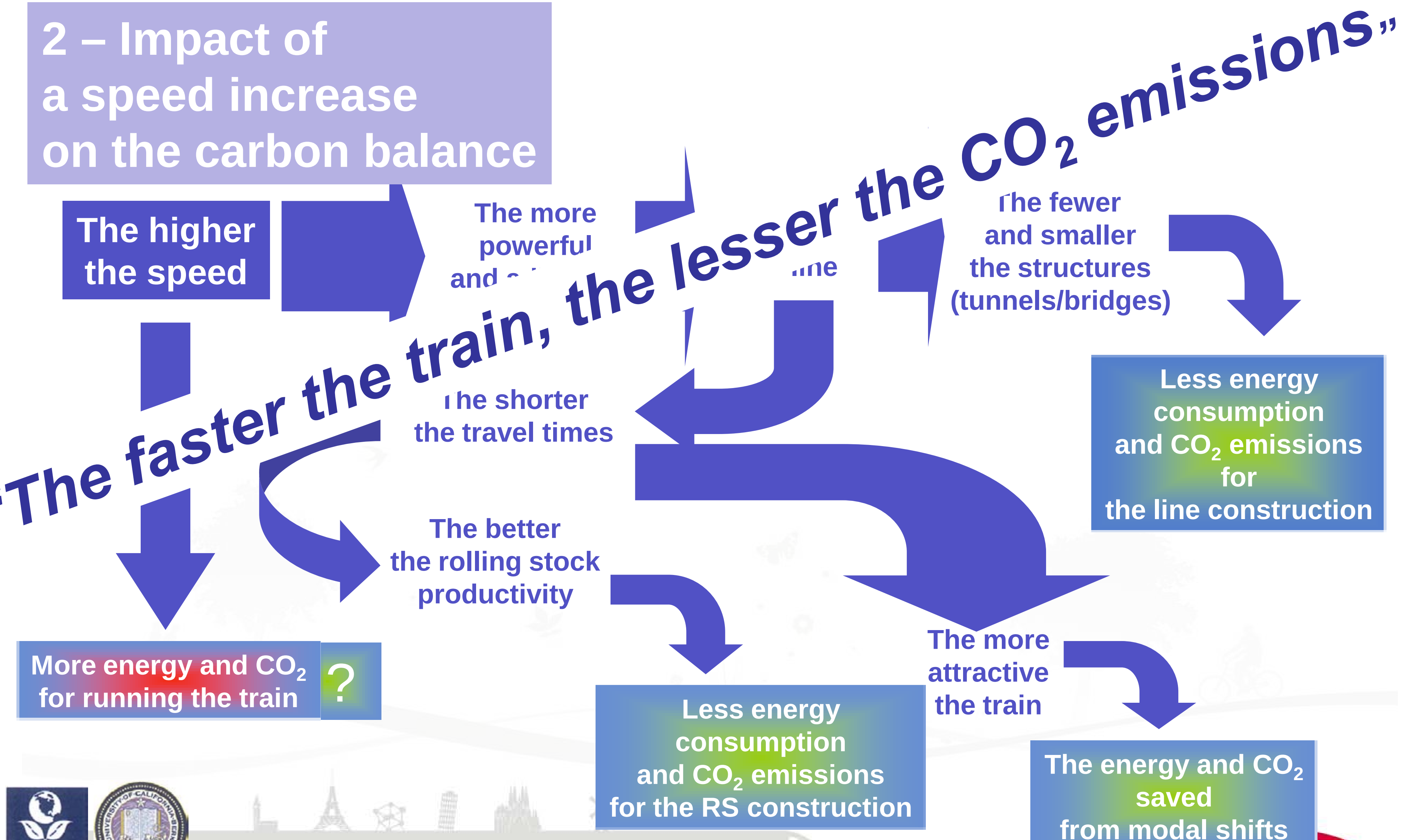
Load factor

Less intermediate stops

2 – Impact of a speed increase on the carbon balance



2 – Impact of a speed increase on the carbon balance

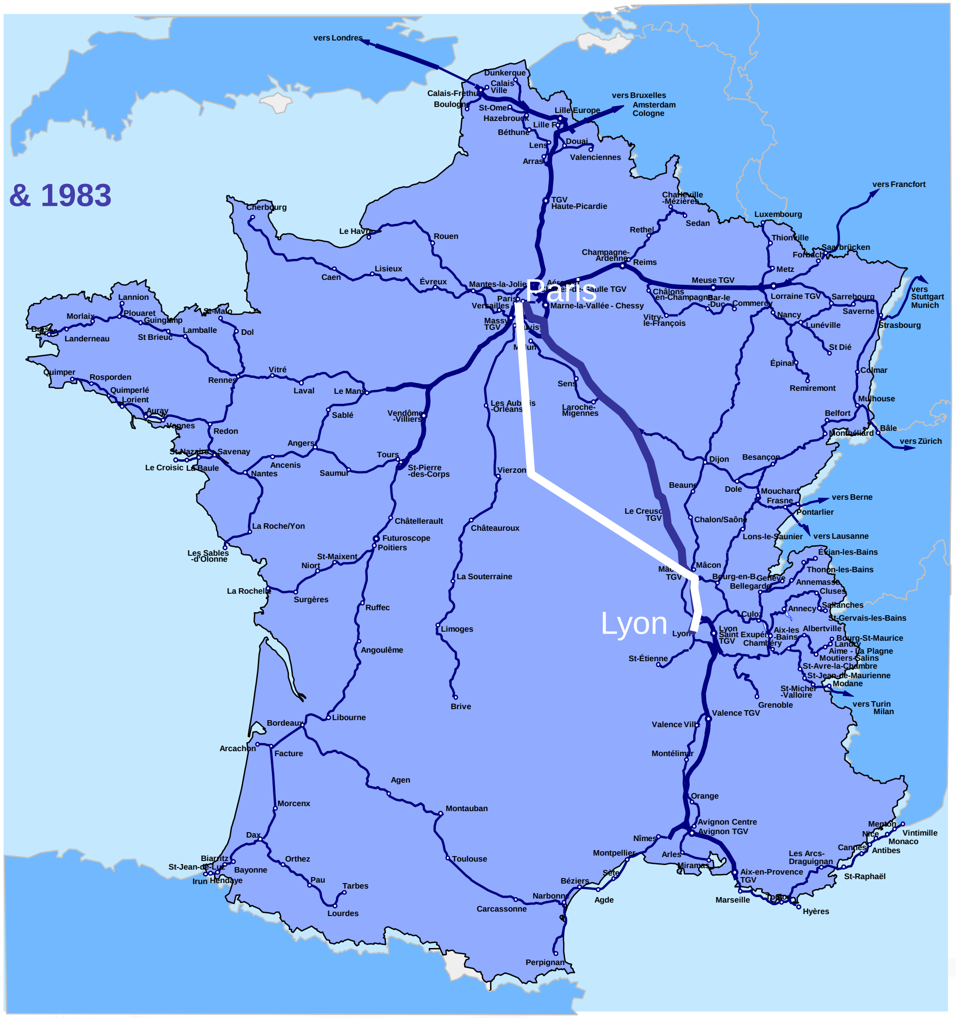


3. The cost of speed

First Paris-Lyon High Speed Line Commisioned in 1981 & 1983

Speed:

260 km/h in 1981
270 km/h in 1985
300 km/h in 2000



Second Paris-Lyon High Speed Line planned for 2025

What Speed?

300 km/h
320 km/h
or 360 km/h

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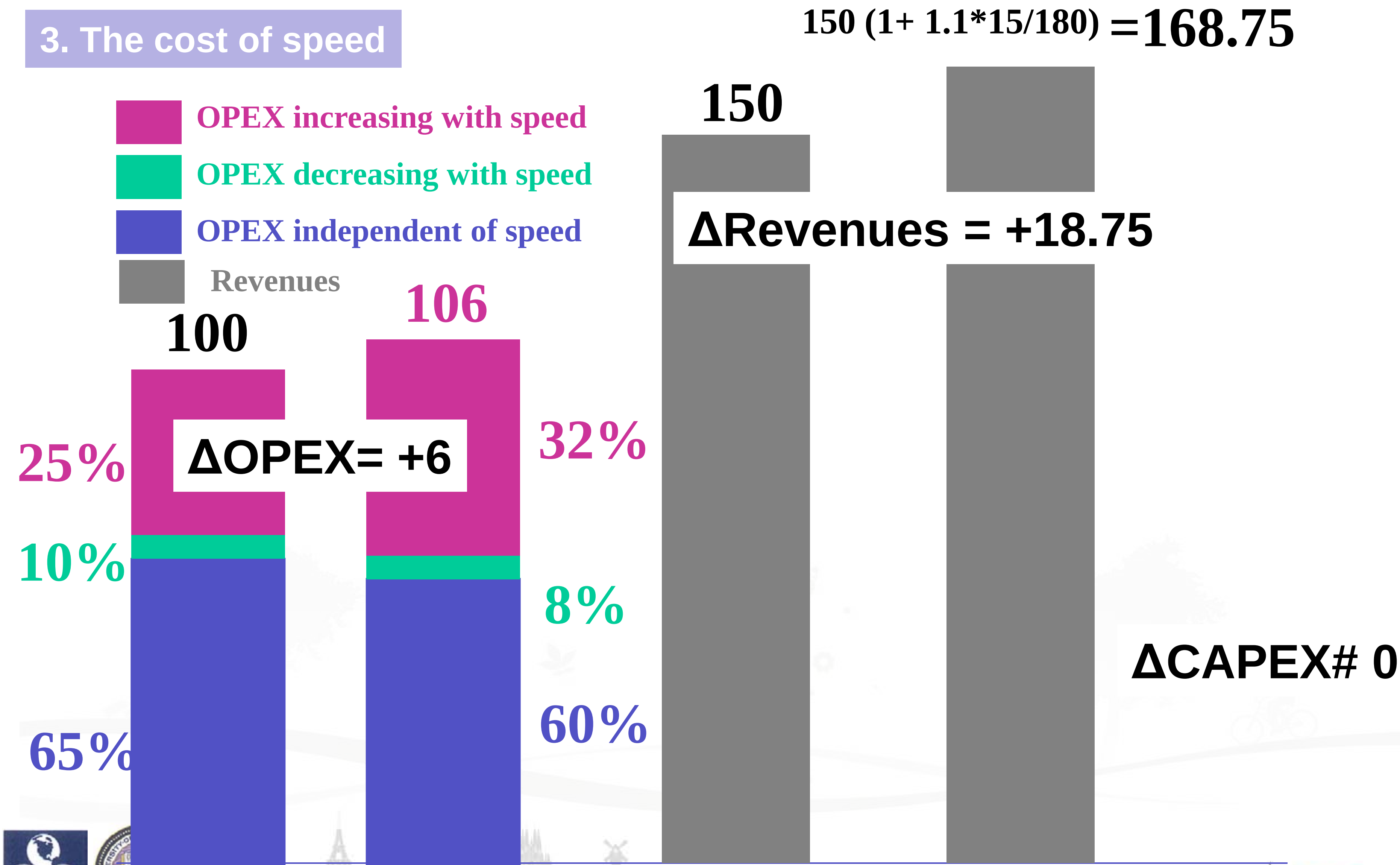
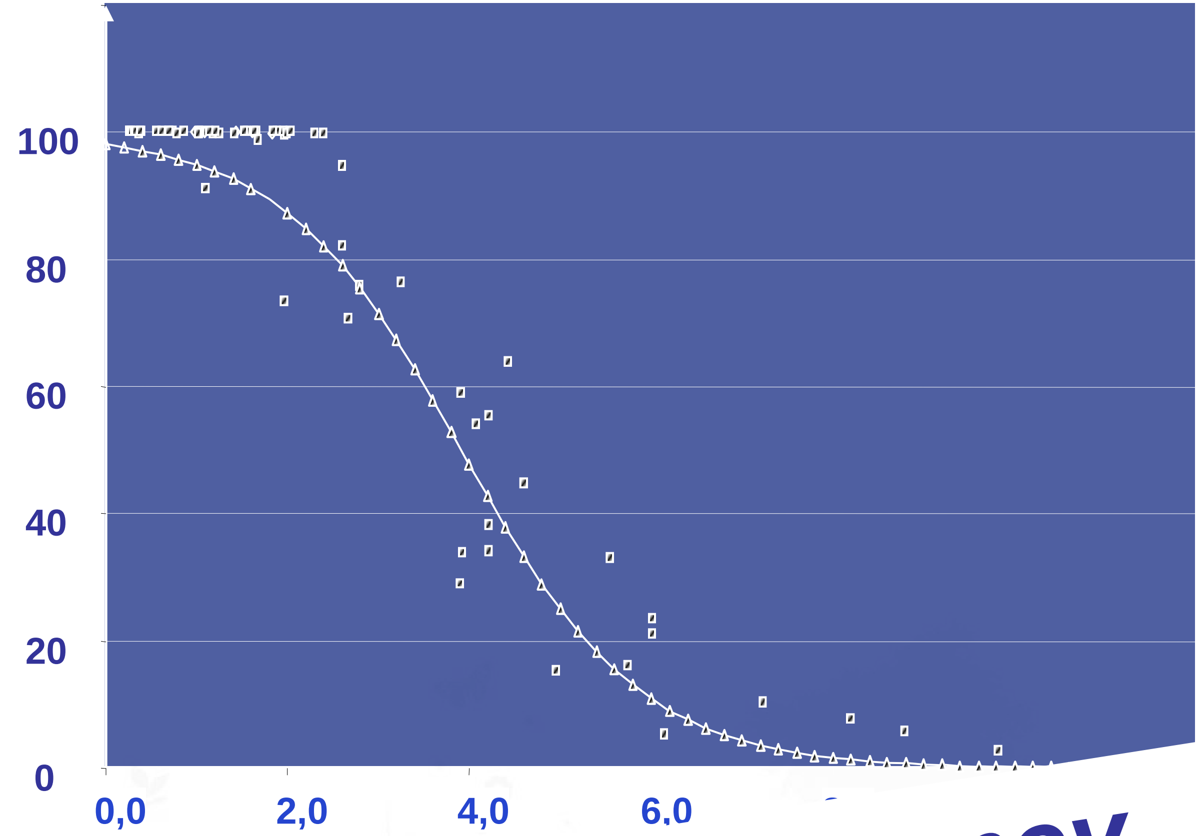


3. The cost of speed

% Rail / Rail+Air



Two key factors:

-a large air market

-rail travel times in the 2 to 4h range

"It takes money to make money"

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Thank you for your kind attention.