Some costs and advantages of the transition to an electric mobility

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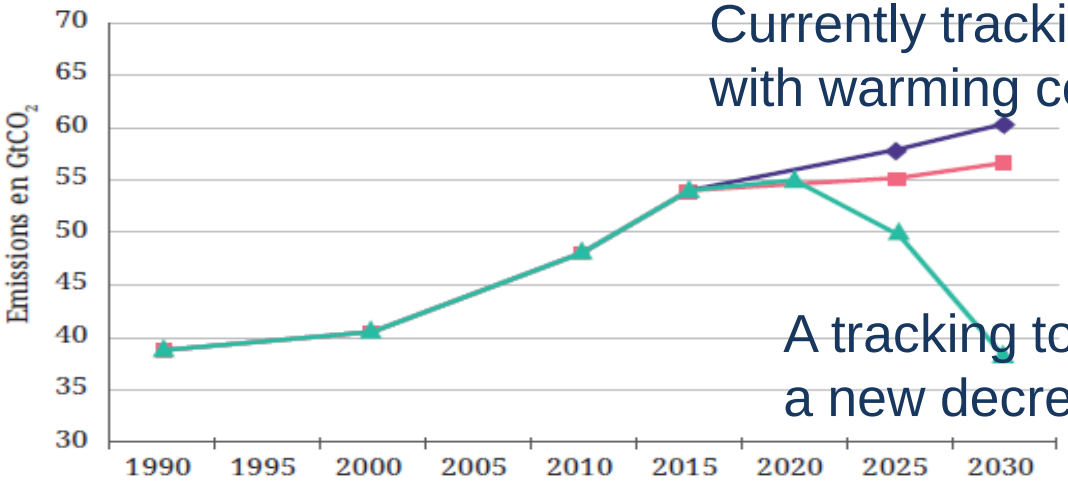
The Cost of European Energy Transitions

THE ELECTROMOBILITY FROM DIFFERENT PERSPECTIVES

1	A GHG story
2	A technological story
3	A microeconomic story
4	An environmental story
5	An electric system story
6	A macroeconomic story
7	An industrial story
8	A conclusion

1- A GHG story : A necessary transition but what transition ?



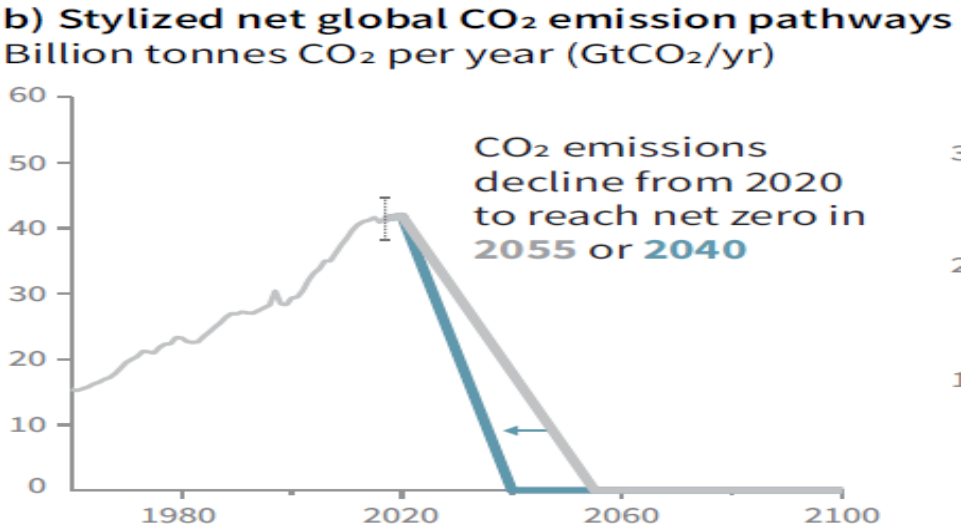
Currently tracking towards 3°C by 2100, with warming continuing afterwards(=NDCs)

A tracking towards 2°C by 2100 needs a new decrease of 30 %

2030 :

- 52 – 58 GtCO2/yr current track
- 26 to 28 GtC02/yr 1,5 °C

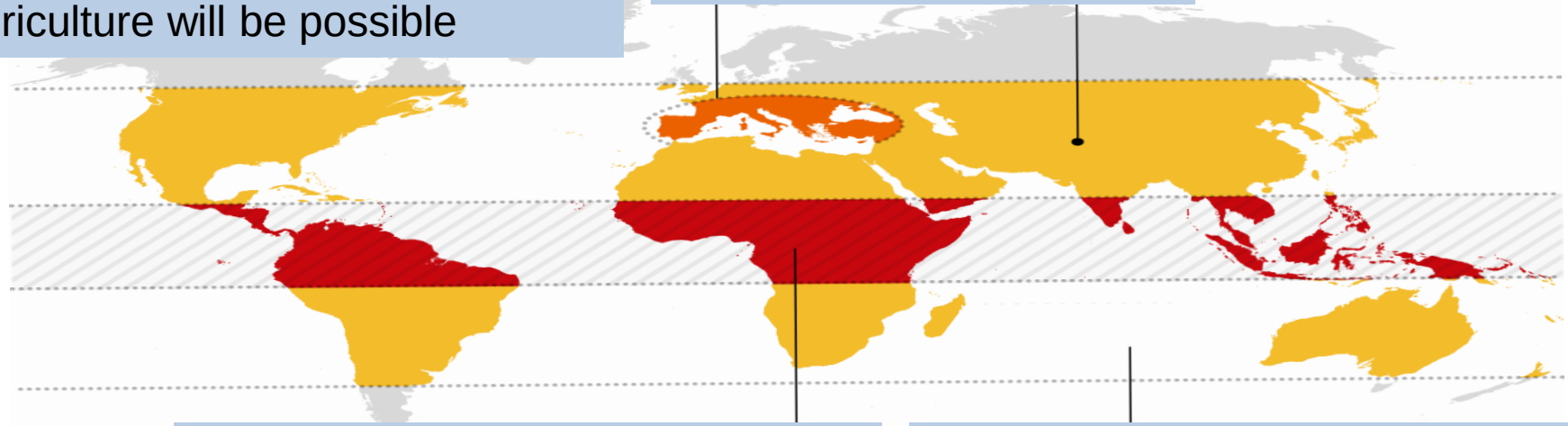
Avoiding overshoot and reliance on future large-scale deployment of carbon dioxyd removal (CDR) can only be achieved if global CO2 emissions start to decline well before 2030



1- A GHG story : A world with 4°C more would be another one which can't be reached without considerable migrations

Canada, Siberia, Scandinavia, and Alaska
The vast majority of humanity will live in high-latitude areas, where agriculture will be possible

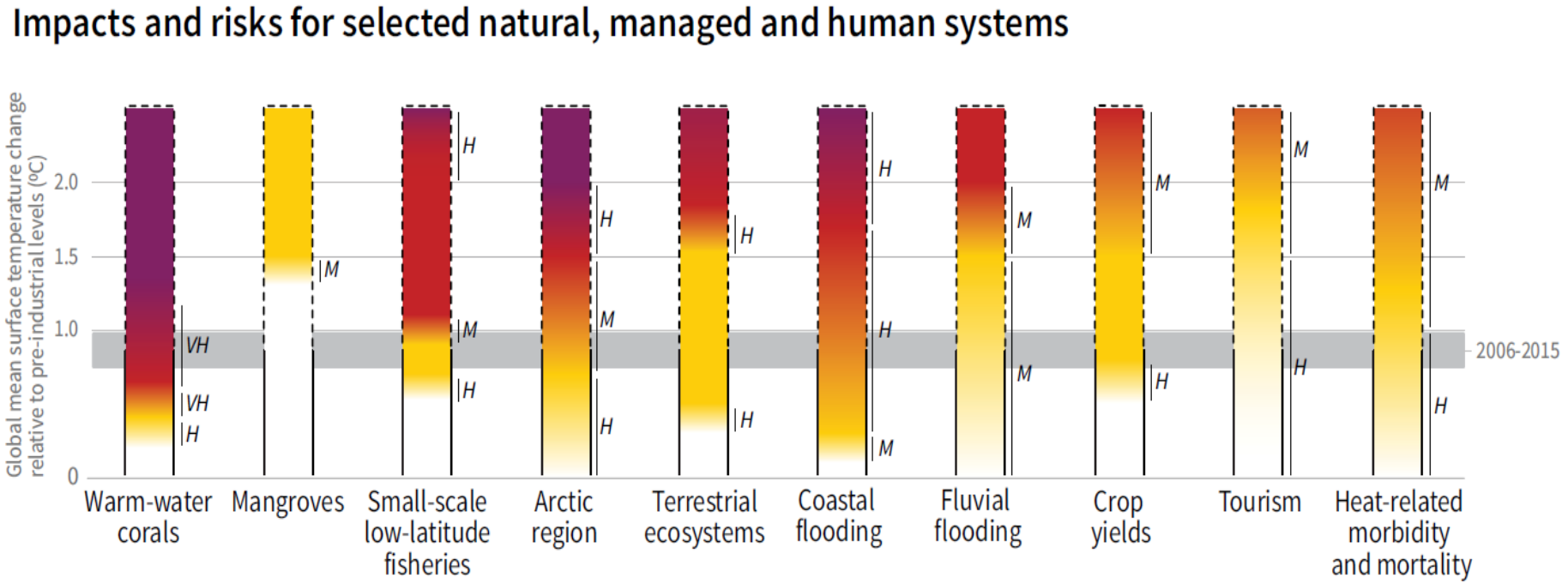
Southern Europe
Saharan deserts will expand into southern and central Europe



Equatorial belt
High humidity causing heat stress across tropical regions will render them uninhabitable for much of the year. To the north and south will lie belts of inhospitable desert

Oceanic dead zones
Coral reefs, shellfish and plankton will be wiped out by rising acidity and algae starving the oceans of oxygen. Without prey, larger sea life will decline rapidly

1- A GHG story : A transition towards 1,5 °C is better than 2° C



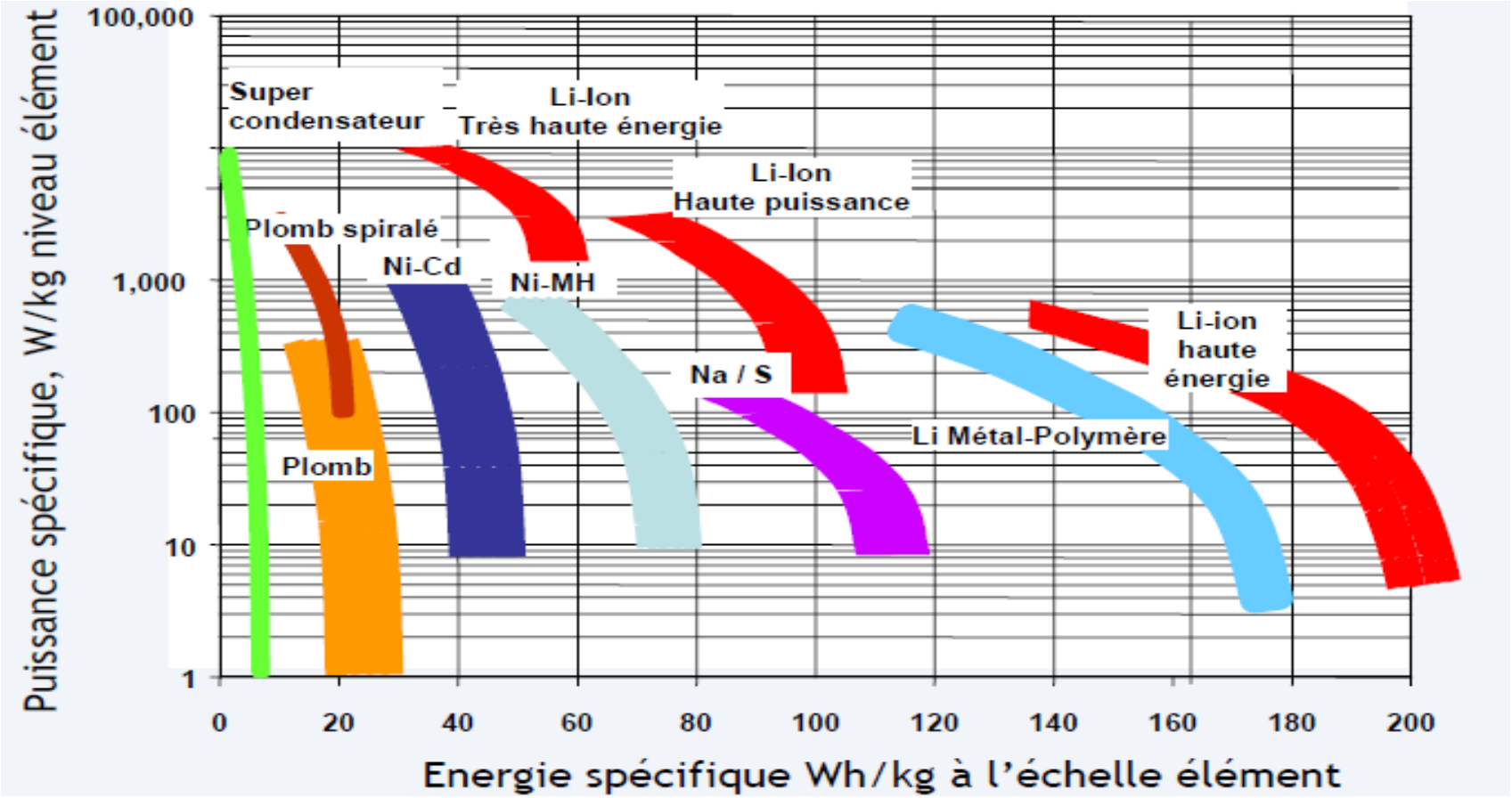
Main consequences :

- Coral reefs, for example, are projected to decline by a further 70–90% at 1.5°C (high confidence) with larger losses (>99%) at 2°C (very high confidence).
- Ocean acidity and sea life

Transports = 20 % of the world GHG emissions

A sharp decline in GHG emissions is necessary
Electromobility is a good candidate

2- A technological story: the massic energetic density



Source : Saft, Panorama Ifp **2010**

Thomas Edison : : 1910 : Ni-Fe

Mi 1990 : Pb : 20Wh/kg

Début 2010 : Li-Ion : 170 Wh/kg

2- A technological story: the massic energetic density : from 20 Wh/kg to 280 today, and 350 in 2025

	First serial application in vehicles	Volumetric energy density[1] [Wh/L]	Gravimetric energy density[1] [Wh/kg]
Adv. chem.			
Potential Li air technology	2030	-	>500
Li-Metal/Solid state technologies			
Cathode: Ni-rich Anode: Li-Metal Electrolyte: Ceramic based structure	2025	>1,000	>400
Cathode: Ni-rich Anode: Li-Metal Electrolyte: Polymer based structure	2022	>1,000	>400
Cathode: Mn-rich Anode: Li-Metal Electrolyte: Stabilised "liquid"	2025	>1,000	>350
Adv. LiT formulations			
Cathode: Mn-rich Anode: Graphite (<85%)/Silicon (>15%)	2024	900-1,000	250-300
Cathode: Ni-rich/HV-Spinels Anode: Graphite (<90%)/Silicon (>10%)	2021	~900	250-300
Next gen LiT formulations			
Cathode: NCM721 Anode: Graphite (<90%)/Silicon (>10%)	2020	800-900	>240
Cathode: Advanced NCA Anode: Graphite (90%)/Silicon (10%)	2019	780-800	290-300
Cathode: NCM622-NCM811 Anode: Graphite (95%)/Silicon (5%)	2018	350-600	180-280
Current LiT formulations			
Cathode: NCA Anode: Graphite (95%)/Silicon (5%)	2014	650-690	230-260
Cathode: NCM523-NCM622 Anode: Graphite (100%)	2016	220-400	150-180
Cathode: NCM111-NCM523 Anode: Graphite (100%)	2014	220-250	150-160

2018 -2019
5 à 10 % Si Anode
NCA : 290 – 300 Wh/kg
NCM 811: 180 – 280 Wh/kg

Electromobility becomes possible for :
VP on long distances
Truck driving

Target 2025
> 350 Wh/kg

Electromobility becomes possible for :
????

Source : Roland Berger, Aircraft electrical propulsion, Onwards and Upwards

2- A technological story: We need to double the gravimetric energy density of batteries (≥ 600 Wh/kg)

~100

electrically propelled aircraft are in development around the world today.

~10% OR UP TO ~25%

Will be aviation's share of global CO_2 emissions by 2050 unless significant technological change occurs.

2032

The year when Roland Berger's panel of industry experts expects the first >50 seat hybrid-electric aircraft to make a fare-paying flight between London and Paris.

Source : Roland Berger, Aircraft electrical propulsion, Onwards and Upwards

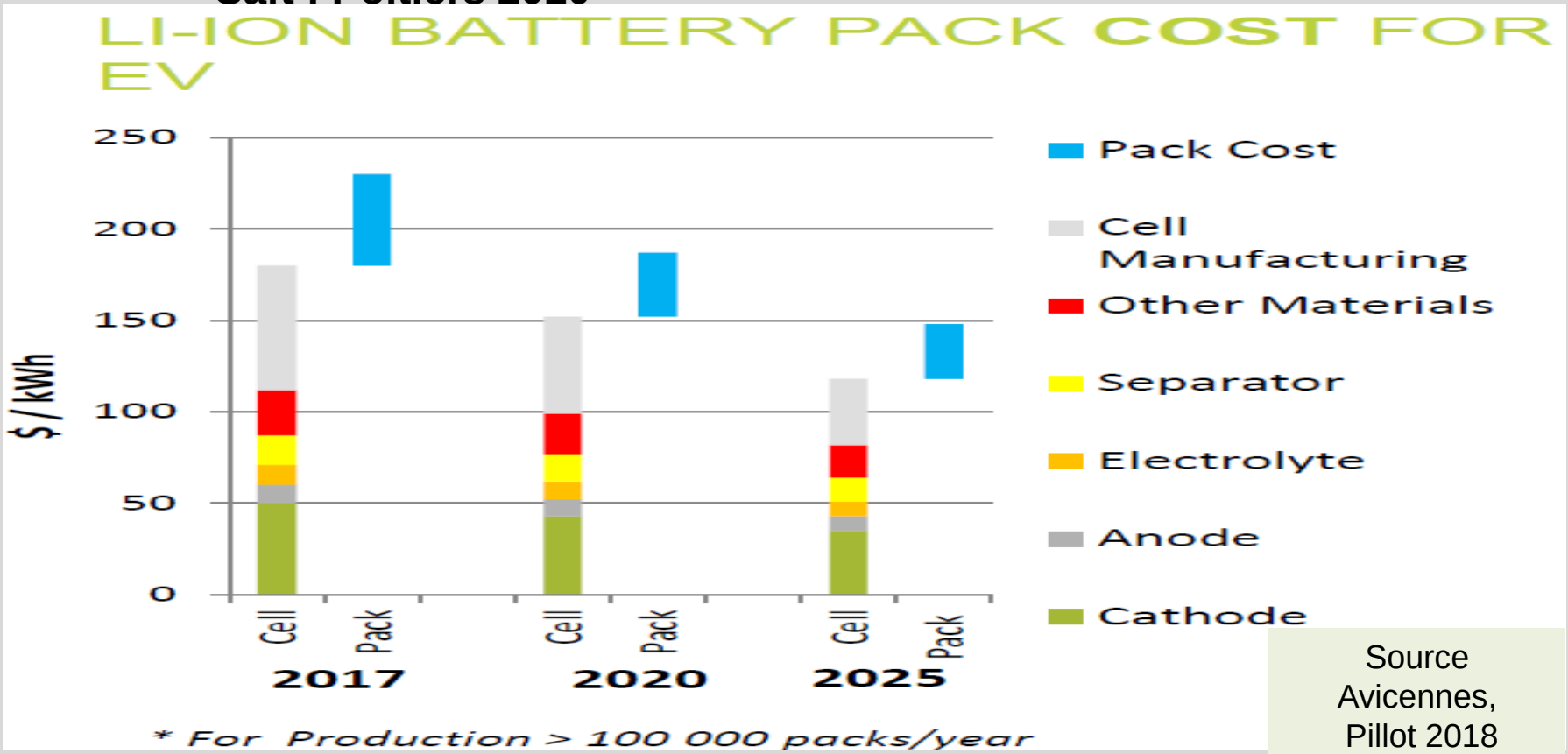
3- A microeconomic story : costs divided by ten

From 2010 to 2025, the kWh cost of a Li-Battery cell should have been reduced by ten :

1 000 € en 2010, ≤150€ today, less than 100 € in 2025

Saft : Poitiers 2010

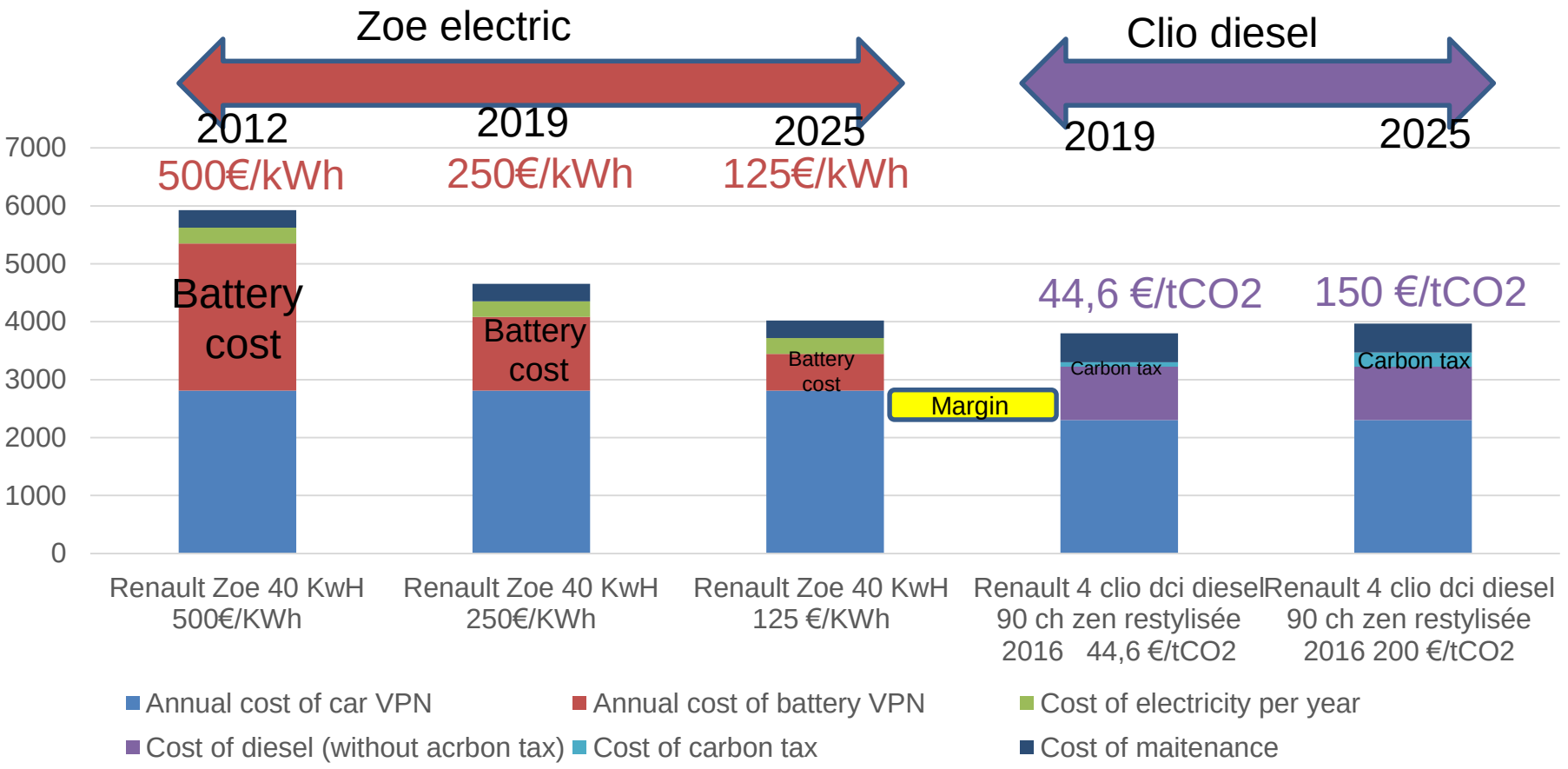
BNEF 2025 : 75 €/kWh



Source Avicennes, Pillot 2018

3- A microeconomic story : total cost of ownership per year. Four factors : i) battery cost, ii) production cost iii) carbon tax; iv) diesel price

The total cost of ownership per year will be roughly the same (for a thermal and an electric vehicle without subsidies) in 2025 with a CO2 tax of 150 €/tCO2 and a battery cell about 125€/kWh … with more margins in the price of the electric vehicle (without its battery) for bigger batteries



Hypotheses : ownership : 8 years, 13 000 km/year, diesel : 1,6 €/l; battery capacity : 40 KWh; GHG emissions <60gCO2:Km

3- A microeconomic story : trucks with a range until 500 km could become profitable in Europe by 2025

IEA and ETC foresee a possible development of electric trucks during the course of the 2020s

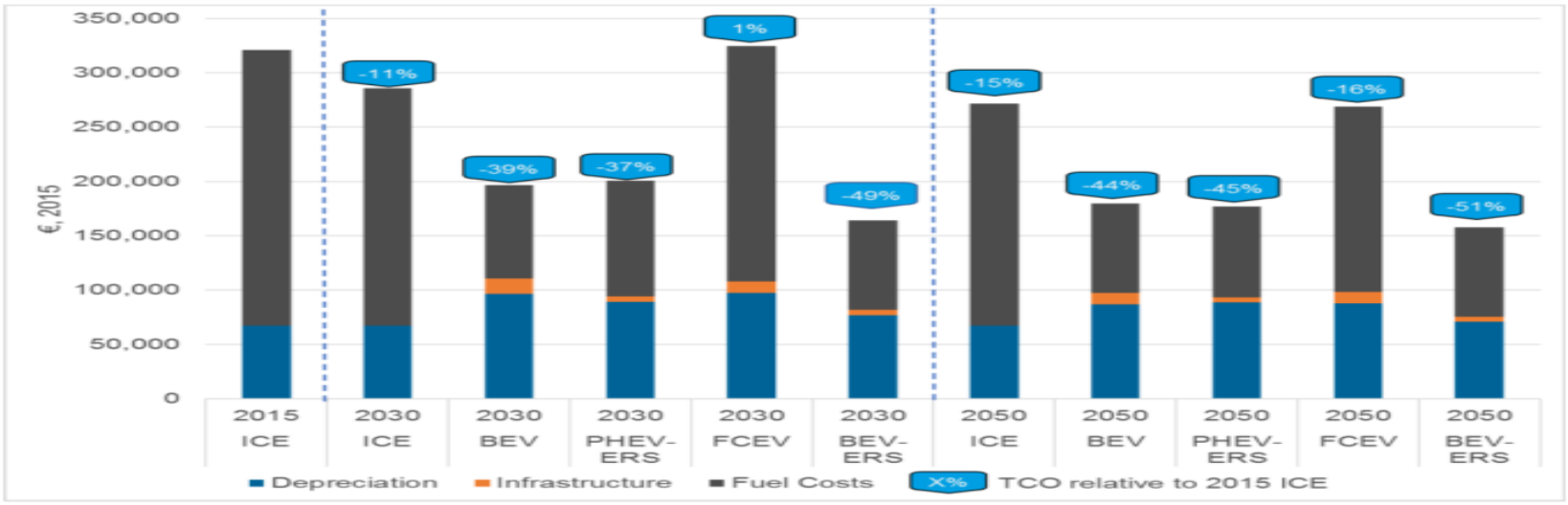
- In its *Global Ev Outlook 2018*, the IEA estimates that at USD 260/kWh battery prices, heavy freight trucks become competitive over ten years of ownership in Europe if they operate with a very limited all-electric range (close to 300 km). (500 km for a battery cost of USD 120/kWh).

- **ETC** (Energy transitions commission) estimates, supported by other studies, that the total cost of operation of electric drivetrain vehicles will fall below those of ICE vehicles during the course of the 2020s, even if there were no carbon price applied to road transport fuels, thanks to cost reductions in the price of batteries and availability of low-cost electricity. The cost advantage would arise first for city buses and lighter, shorter-distance trucks, extending eventually to very long-distance trucks by the end of the decade. This would leave no need for the long-term use of biofuels while CNG is unlikely to play a major transitional role, given the pace at which electric vehicles could become cost-competitive and the need to develop dedicated infrastructure that could rapidly be stranded

3- A microeconomic story : trucks with a range until 700 km could become profitable in Europe by 2025

The main finding of the TCO analysis is that due to the high mileage of HHGVs and increased efficiency of the electric motor, the lower running costs of BEV and PHEV based powertrains more than outweigh the higher capital costs. For FCEVs, the vehicles achieve cost-competitiveness with ICEs by 2050, although remain more expensive than other advanced powertrains. This largely reflects the fact that hydrogen fuel costs are substantially higher than obtaining the equivalent energy content directly from electricity.

Figure 5.3 Total cost of owning and running a heavy HGV over 5 years with various powertrains in the TECH scenarios in 2030 and 2050 (€)



Source : Cambridge econometrics and the European climate foundation, Decarbonising road freight in Europe:A socio-economic assessment

4- An environmental story : the cost of urban atmospheric pollution

Population density of areas crossed by the infrastructure

inhabitants/km²	Intercity	Diffuse urban	Urban	Dense urban	Very dense urban
Range	< 37	37-450	450-1,500	1,500-4,500	> 4,500
Average density	25	250	750	2,250	6,750

Official reference value proposed for road transport (emissions from combustion and wear)

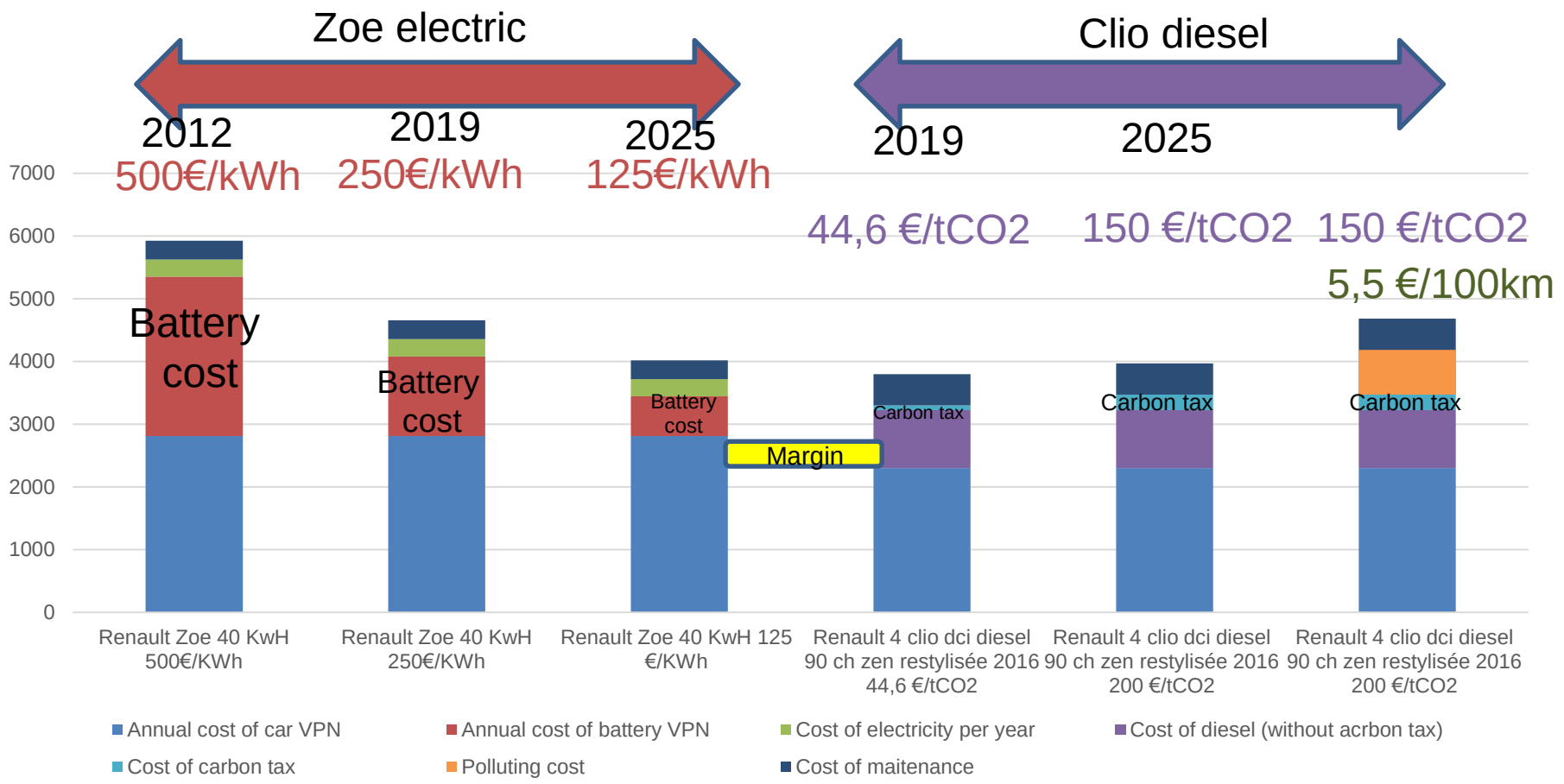
€2010/100 vehicle.km	Very dense urban	Dense urban	Urban	Diffuse urban	Intercity
PC	15.8	4.3	1.7	1.3	0.9
Diesel PC	20.4	5.5	2.2	1.6	1.1
Petrol PC	4.5	1.3	0.6	0.5	0.5
LPG PC	3.6	1.0	0.4	0.3	0.2
LCV	32.3	8.7	3.4	2.4	1.6
Diesel CV	33.7	9.1	3.5	2.5	1.6
Petrol CV	6.3	1.9	0.9	0.8	0.8
Diesel HGV	186.6	37.0	17.7	9.4	6.4
Motorcycle	8.7	2.5	1.0	0.8	0.5
Bus	125.4	24.8	11.9	6.3	4.2

NOx, SO_2, COVNM and PM2,5 emissions costs by EURO standard category due to combustion by PC and LCV.

PC: passenger car; LCV: light commercial vehicle; CV: commercial vehicle; HGV: heavy goods vehicle.

4- An environmental story : the cost of urban atmospheric pollution

When we take into account the polluting cost, a mean diesel (Euro 2 or Euro 3) is more expensive than the today's electric vehicle …

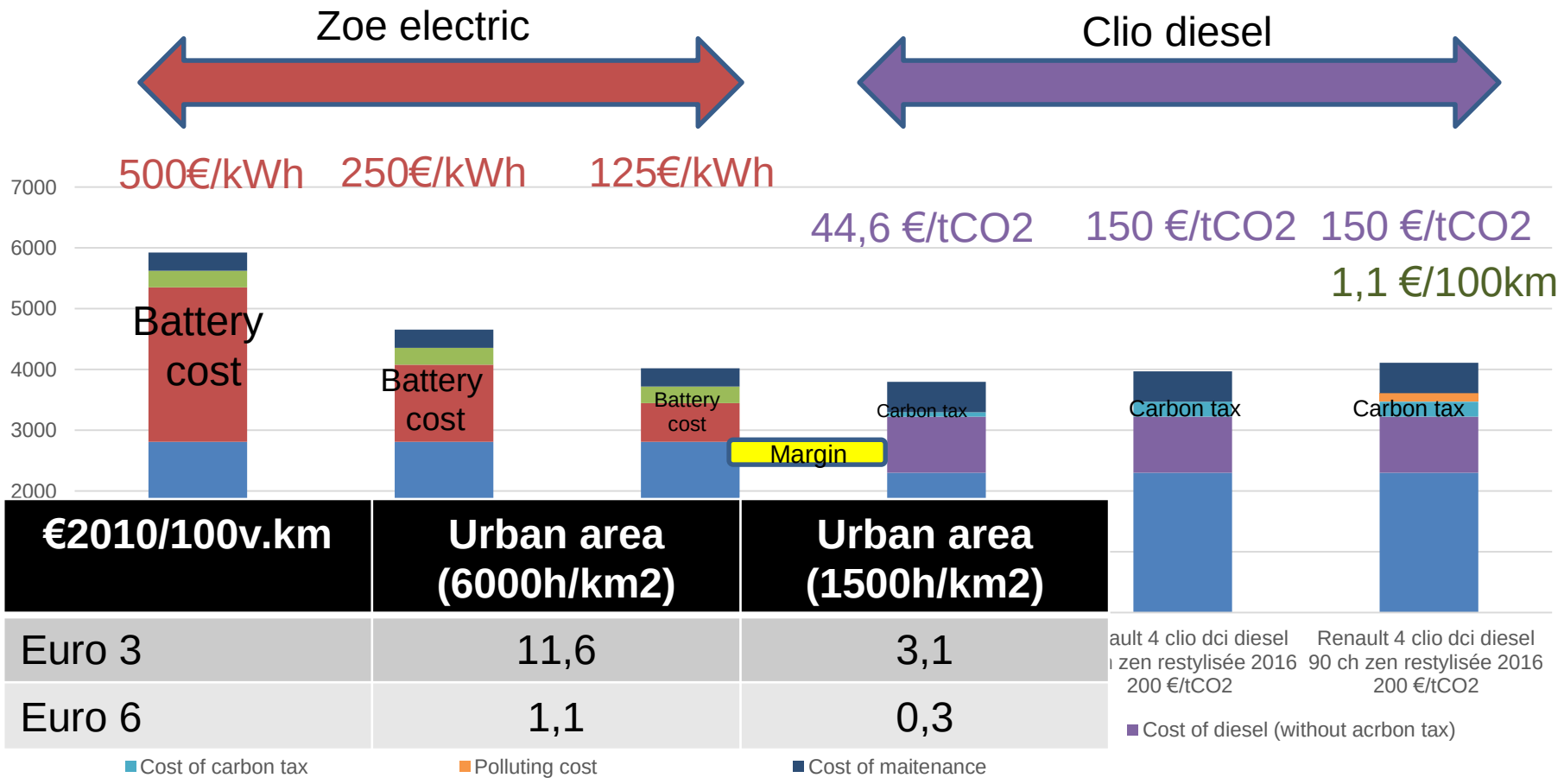


Hypotheses : ownership : 8 years, 13 000 km/year, diesel : 1,6 €/l; battery capacity : 40 KWh

4- An environmental story : the cost of urban atmospheric pollution

When we take into account the polluting cost of a diesel Euro 6, the addition is smaller !

= Ban on diesel Euro 2 and 3 ??? (11 M France)
Don't forget : there are diesels and diesels !



€2010/100v.km	Urban area (6000h/km2)	Urban area (1500h/km2)
Euro 3	11,6	3,1
Euro 6	1,1	0,3

Hypotheses : ownership : 8 years, 13 000 km/year, diesel : 1,6 €/l; battery capacity : 40 KWh

5- An electric system story : rethinking the electricity system

A revolution of this kind requires rethinking how automobiles and the systems for supplying the energy they require are interconnected. The production, transmission and distribution of electricity, and electric vehicles themselves must all form part of a single system.

Batteries will not be passive objects like fuel tanks, rather they will help the grid function efficiently by adjusting the amount of power they use for echarging to meet supply and participating in regulating the grid's frequency. Looking to the long term, they may even supply energy to the grid or homes at peak times.

Annual cost of electricity could be divided by two for the consumer

- Charges according to the prices
- Vehicle to home
- Vehicle to grid.

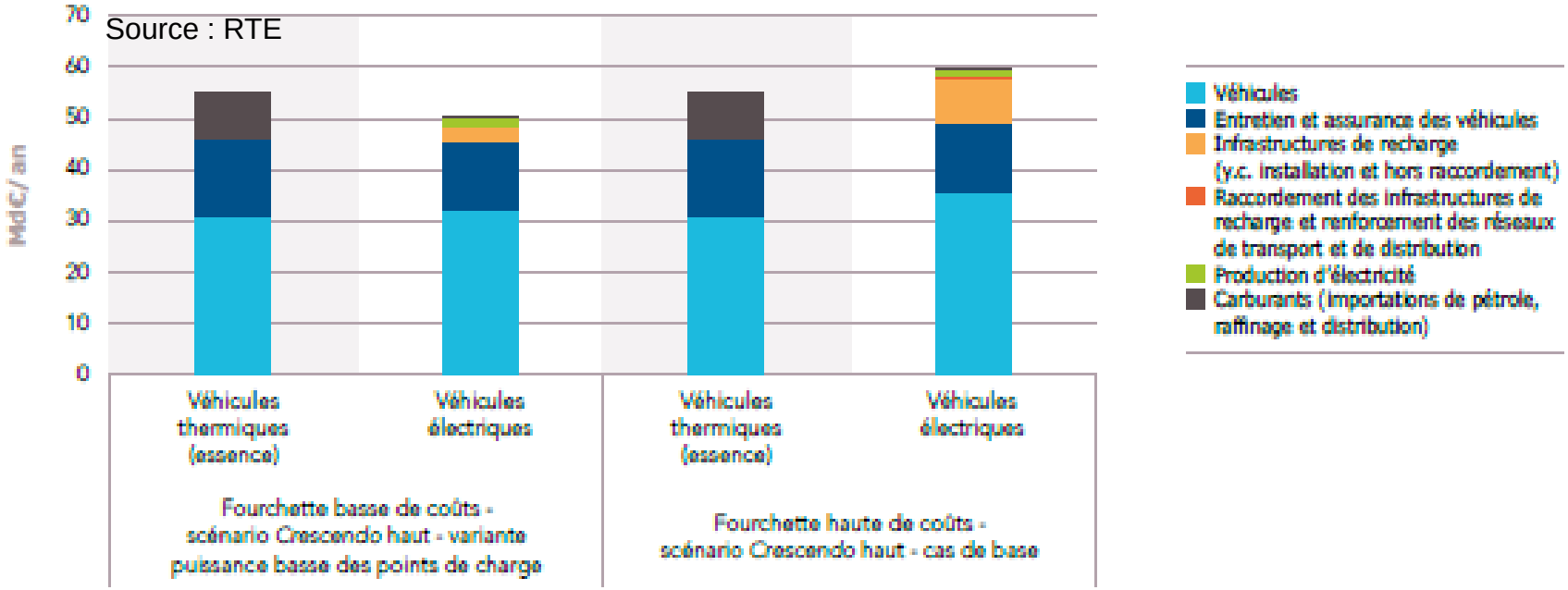
(= profit for the consumer)
Source RTE

Benefits for the electrical system
- consumption of less than 48 Twh in 2035 : 15 MVP - 1/10th of the electric global consumption in France
- The global cost of electricity production can be divided by a factor 2

Source RTE

5- An electric system story : rethinking the electricity system

Annual total cost for 15,6 million vehicles in 2035 for thermal or electric cars



6- A macroeconomic story : some uncertainties : a great variety of results on employment

Zone	Auteur (année)	Titre	Impact
Allemagne	Bundestag (2013)	*The Future of the Automotive Industry*	**Mixed** Depending on the growth of productivity versus the growth of value creation (assumed at 2,7% p.a. in Germany) ECVs impact on employment ranges from – 68,000 to 138,000 in 2030
EU	CE Delft (2012)	*Literature Review on Employment Impacts of GHG reduction policies for transport*	**Positive** This literature review reports that most studies find a positive impact of EVs on employment based on a simplified theory
EU	CE Delft (2013)	*Impact of Electric Vehicles*	**Positive** (but benefits to Hybrid/Fuel efficient market not necessarily pure EV) 110 000 new jobs created in the EU by 2030 in production and R&D
EU	Cambridge Econometrics Ricardo-AEA (2013)	*Economic Assessment of Low Carbon Economy*	**Positive** Tech 1 Scenario (5): European employment increase of 443,000 jobs; CPI Scenario (6): increase of 356,000 jobs BY 2050 jobs increase to 2.3m in all low-carbon scenarios examined
EU **Global**	EC (2011) McKinsey & Company (2011)	*Roadmap for moving to a Competitive Low Carbon Economy* *Boost*	**Positive** Net job creation to be an increase of 0,7% (~1,5 million jobs) by 2020 jobs compared to BAU **Positive** 420,000 additional FTEs in global powertrain. Employment shifts from industrialised to emerging countries
EU Source FTI	Cambridge Econometrics *et al.* (2013)	*Fuelling Europe's Future*	**Positive** Between 660,000 and 1.1m net jobs could be generated by 2030. This increases to between 1.9m and 2.3m by 2050

Most studies foresse a small increase of GDP . Three main factors of uncertainty :

- Oil prices
- Future of the european automotive industry
- Location of the batteries production

7- An industrial story : « the car industry is under siege » (NYT June 6, 2019)

European automotive industry = about 12 million employees

Electric challenge	Mobility challenge	Autonomous car challenge
The internal combustion engine is under attack from electric challengers	Car ownership is becoming optional in the age of Uber	New technologies will automate much of the task of driving

« It's going to be the biggest challenge we've seen in the last 100 years and it's going to be really expensive for the biggest companies » Erik Gordon

The automotive industry is facing unprecedented challenges

7- An industrial story : grabbing the opportunity

The number of EVs worldwide is expected to be in the millions of vehicles by 2030, with an annual market revenue in the tens of billions of dollars

- No consensus between the studies : but **the European automobile industry**, which has mastered the internal combustion engine technology, **could lose a significant number of jobs due to the car electrification,**

- What matters is not so much whether new jobs associated to electric vehicle production will compensate for the job lost for ICE vehicles production.
What matters is whether the French and European automobile industry will be able to leverage the EVs new opportunity.

- **Jobs will actually depend mainly on market shares and value added by the French and European industries, especially with competition from China** which masters battery technology and currently produces more than half of electric cars in the world

7- An industrial story : grabbing the opportunity

- As the strategy adopted by China and demonstrates, the development of the automobile sector and its associated jobs in France and Europe require the implementation of i**ndustrial policy measures in favour of EVs**.

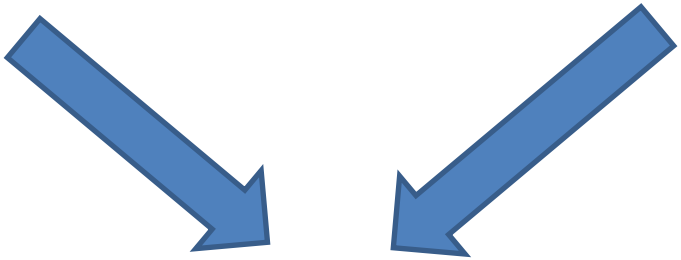
- ***A significant R&D effort is needed***, primarily on batteries but also on new materials, digital technology as well as recycling.
- **If, in the medium term, the European Union does not manage to produce its own batteries, it will have to pay significant imports costs on every car** (which would be reduced if the final assembly of batteries takes place in Europe and if battery cells are produced in oversea manufacturers plants located in Europe) and will depend on the countries controlling the supply chain of critical materials. **It must therefore provide strong support for R&D regarding next-generation batteries**, as part of the Horizon 2020 programme or its successor, mobilizing resources allocated to societal issues or critical technology, or as part of a European disruptive innovation agency..
- ***A policy supporting EV demand in the ramp-up period*** (purchase grants, subsidies to install charging points) must be introduced in order for manufacturers to have access to a sucient market to be able to continue to innovate.

8- Conclusion :The electric revolution ? A new era of mobility

Until recently, the autonomy of electric vehicles was limited to 150 km, and **daily commuting**.

Technological progress

Reduction of the cost of batteries



New era of mobility
Autonomy of more than 300 km
Recharges in less than half an hour
Tomorrow, we'll see electric trucks and perhaps electric planes

8- Conclusion

EVs constitute an industrial opportunity for France and the European Union that we should not miss out on.

Three measures to go forward :

- **a significant carbon tax in Europe**, associated to a carbon border would enable France and Europe to retain a larger share of the value added from the production of tomorrow's vehicles and would also provide an incentive for manufacturers to produce their ultra-low emission cars and batteries in ultra-low emission countries;

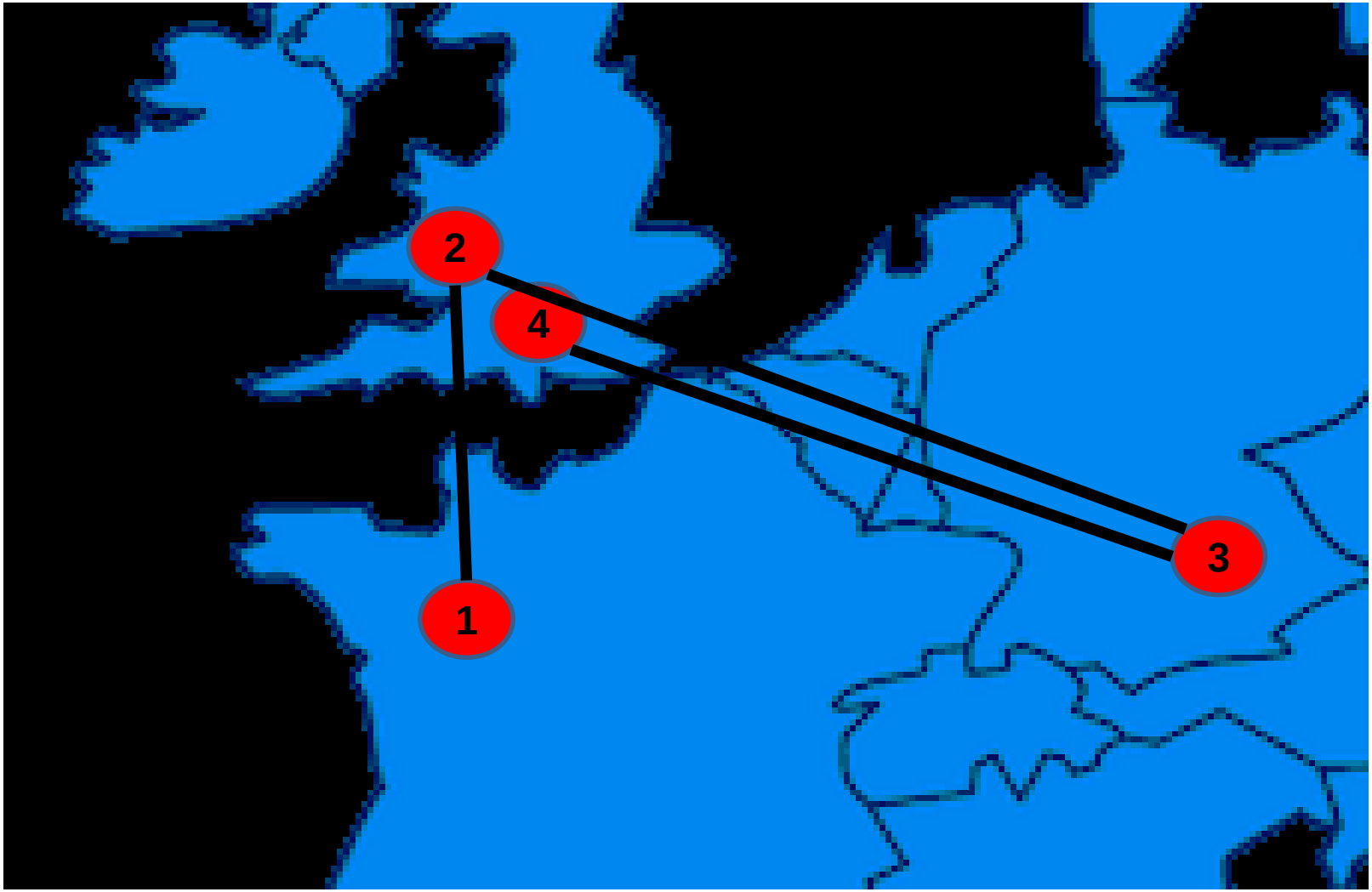
- "**the implementation of a European industrial programme** supporting clean vehicles **with the setting up of a European battery production**

- **A deployment of common infrastructures to make it possible to travel through Europe**.

***(See** the speech on the European Union given by the France's President at the Sorbonne in September 2017)*

APPENDIX

9 - A human story : the incredible journey of a Mini BWW crankshaft



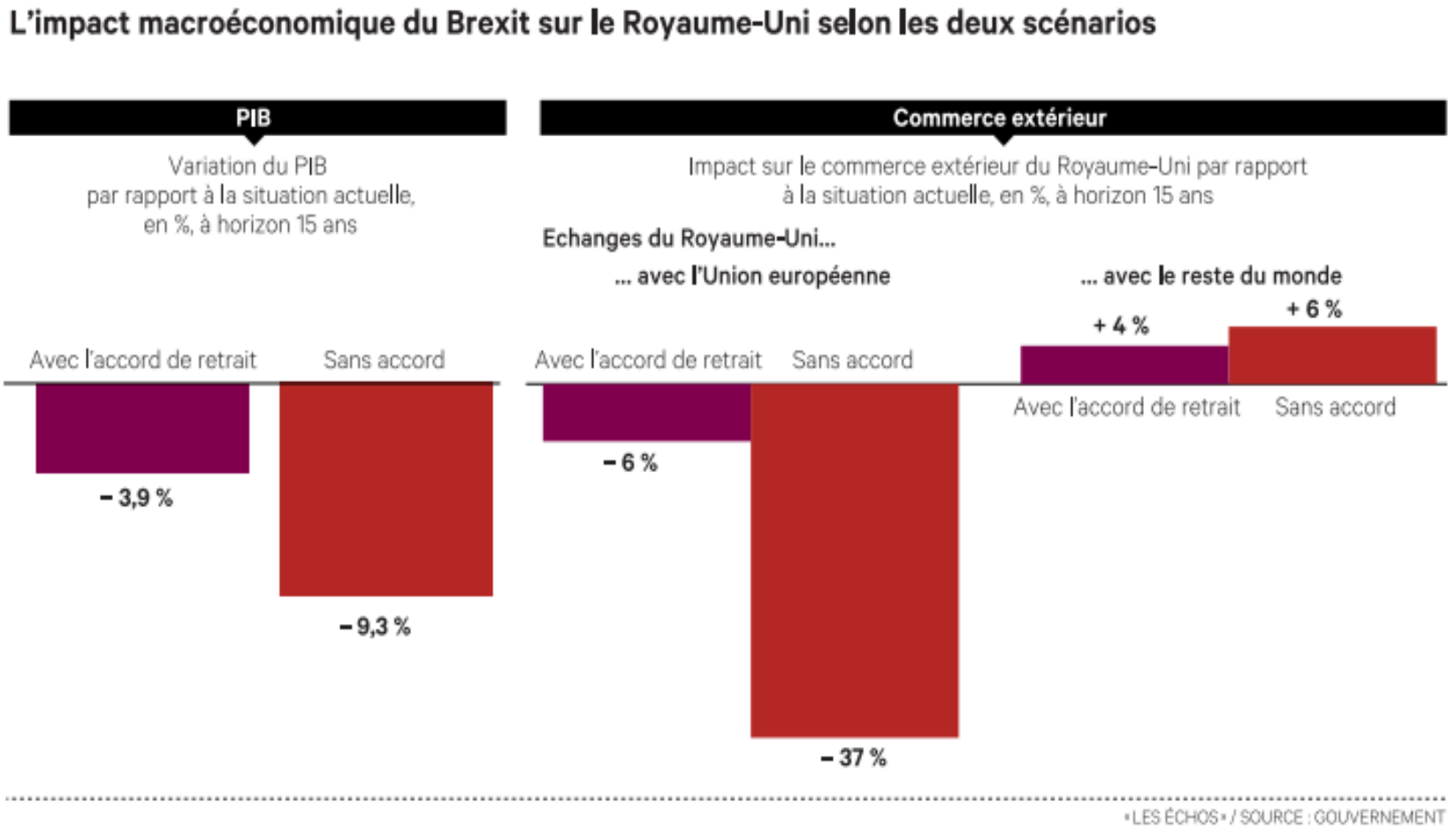
9 A human story : The desastrous impact of a Brexit without any deal

First step : France	Cast of the raw crankshaft
Second step : UK : in Warwickshire	Drilled and milled into shape
Third step : Munich	Inserted into the engine
Fourth step : UK : Oxford	Engine « married » with the car
Fifth step : sold in France or Germany	Sold, at last, to the consumer

- A journey of more than 2.000 miles and no less than three crossing of the Channel before the finished car rolls off the production line
- Just impossible in case of a hard Brexit
- On average, just 41% of the parts used in a car assembled in the UK are actually produced in the country
- -Brexit must let parts move across the Channel quickly and affordably.

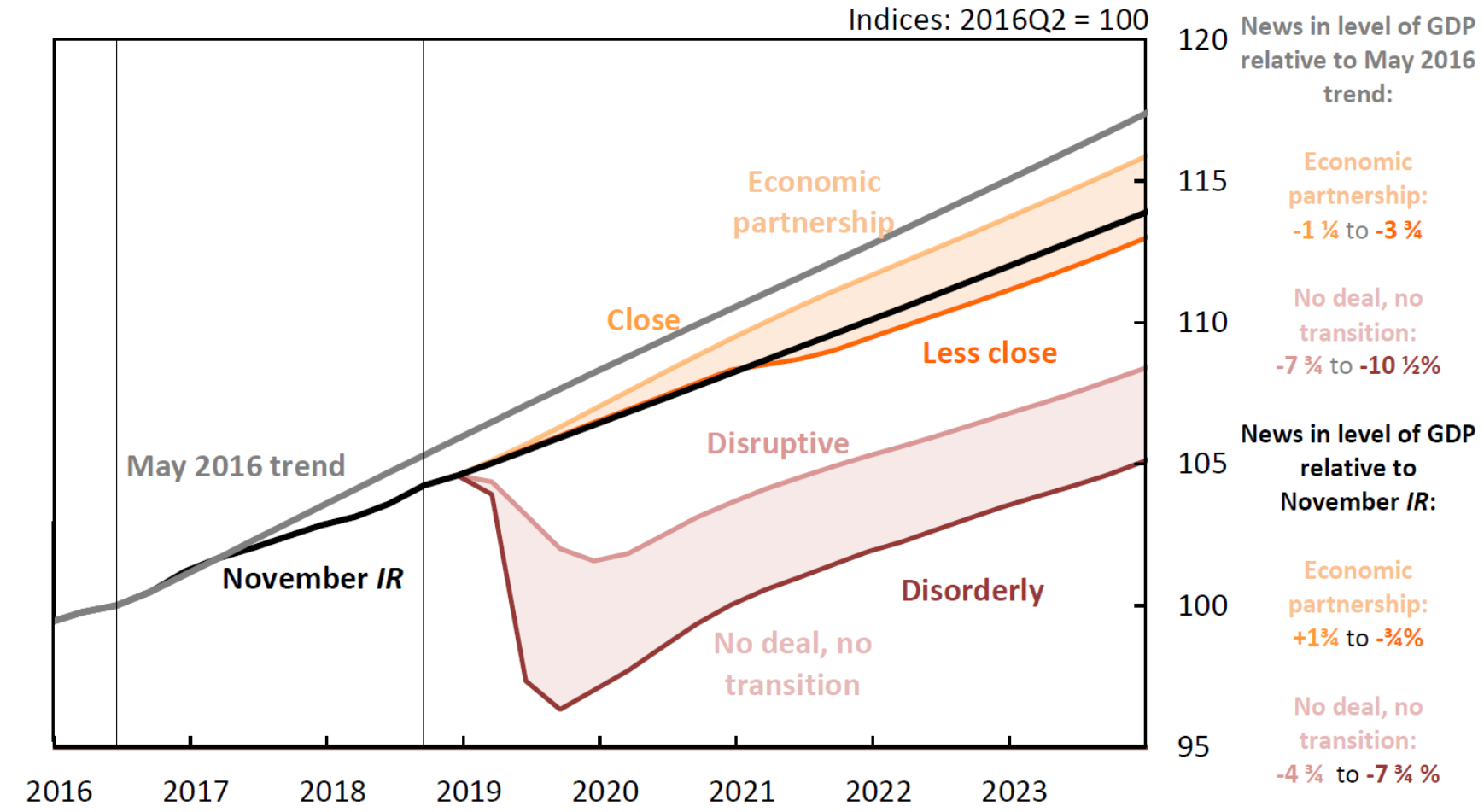
Source : Guardian, A Mini part's incredible journey shows how Brexit will hit the UK car industry, Fri 3 Mar 2017

9 A human story The desastrous impact of a Brexit without any deal



The threat of a Brexit

Chart A: GDP in EU withdrawal scenarios



Sources: ONS and Bank calculations.