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A tale of two car systems

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The meeting held in Bonn two weeks ago has likely been the last round of formal negotiations before the 21st Conference of Parties (COP21) in Paris. Up to now, more than 140 countries, accounting for about 90% of global emissions, have already submitted IPPC commitments to reduce emissions. Kyoto only covered 35 countries and about 15% of global emissions.

The very different carbon intensity among countries and areas of the world could be an issue to be targeted in the Conference, e.g. in transport system for the US and other world economies, some of which are facing the echoes of the diesel-gate scandal.

An historical overview is useful to understand where the difference among the US and the EU is coming from.

The Ford F-150, the most popular variant of the F-Series, has been the best-selling vehicle in the United States for over 30 years and the best-selling pickup for over 4 decades.

In Europe, this role has been covered for several years by the Volkswagen Golf, with a total sale figure of over 30 million cars since 1974.

These two vehicles, as iconic as different, are emblematic of a very different car history between the United States and the European Union. The Ford F-150 (EPA Size Class: Standard Pickup Trucks 2WD), 6 cylinders, 3.7 liters, automatic 6-speed, gasoline, model year 2013, with a curb weight of around 4,870 lbs., runs 17 miles per gallon in the city, 23 in the highway, 19 in the combined cycle. The Volkswagen Golf (EPA Size Class: Compact Cars),4 cylinders, 2.0 liters, automatic or manual 6-speed, diesel, model year 2013, with a curb weight of around 2,980 lbs., runs 30 miles per gallon in the city, 42 in the highway, 34 in the combined cycle (Source: fueleconomy.gov).

The first mass motorization in US occurred during 1920s, with the Ford T. Then, the baby boomers helped fortify the notion of the suburban single-family houses, reachable by means of affordable cars, as the American dream. In 1956 President Dwight Eisenhower signed the Federal-Aid Highway Act, by which over 41,000 miles of highways were built. The US have the most widespread road network worldwide (6,586,610 km) with one of the highest figure of km per capita (around 22 km) and the highest number of passenger cars per capita (around 800 per 1,000 inhabitants). Already in the ‘70s the US had over 400 cars per 1,000 inhabitants compared to less than 200 in Europe. The development of widespread road networks and the relatively low price of gasoline led to the diffusion in the US of bigger cars, with larger engines and using more fuel than in Europe. Only after the ‘70s, due to the oil crises, the dimensions of engines were reduced for cars and also for pickups and VANs. Nonetheless the figure for pickups has been steadily increasing from the ‘90s (see Figure 1).

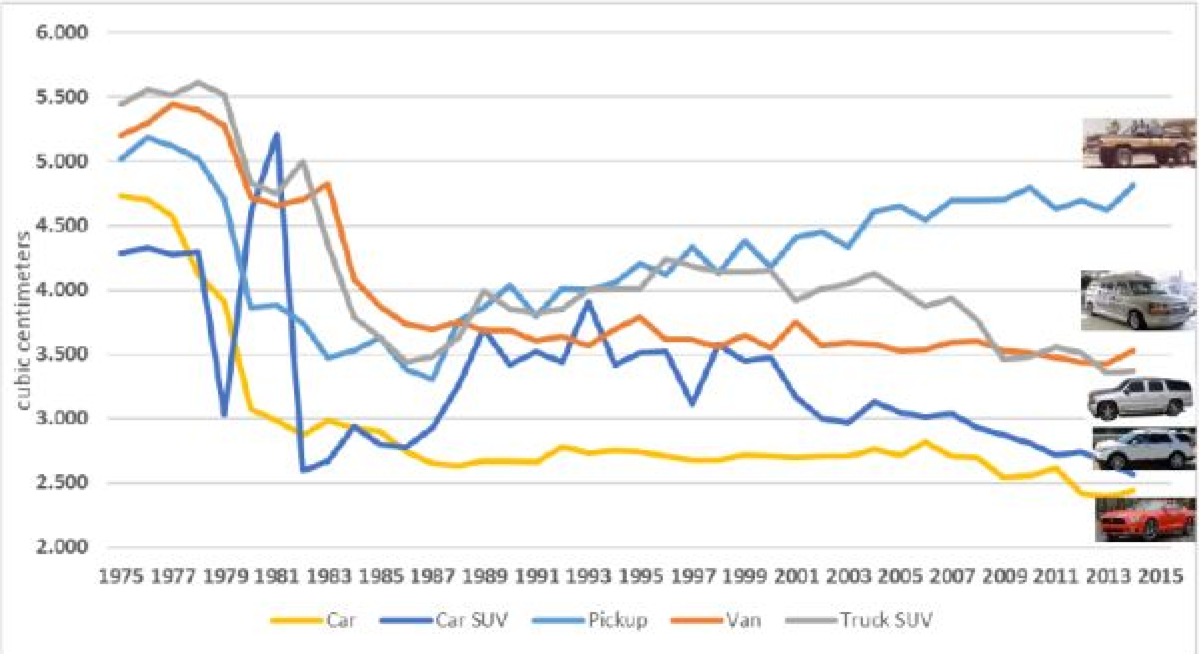

Figure 1: Production-Weighted Engine Size of New Domestic and Imported Cars and Light Trucks. Model Years 1975-2014 (cubic centimeters). Note: Includes light trucks of 8,500 lbs. or less. Source: U.S. Environmental Protection Agency.

Besides that, light trucks have been gaining market share from the early 1980s until 2004, mainly due to increases in the market share of sport utility vehicles (SUVs), both as Car SUV and as Truck SUV. Accordingly, light vehicle production shares have changed from 1975 to 2014 (see Figure 2).

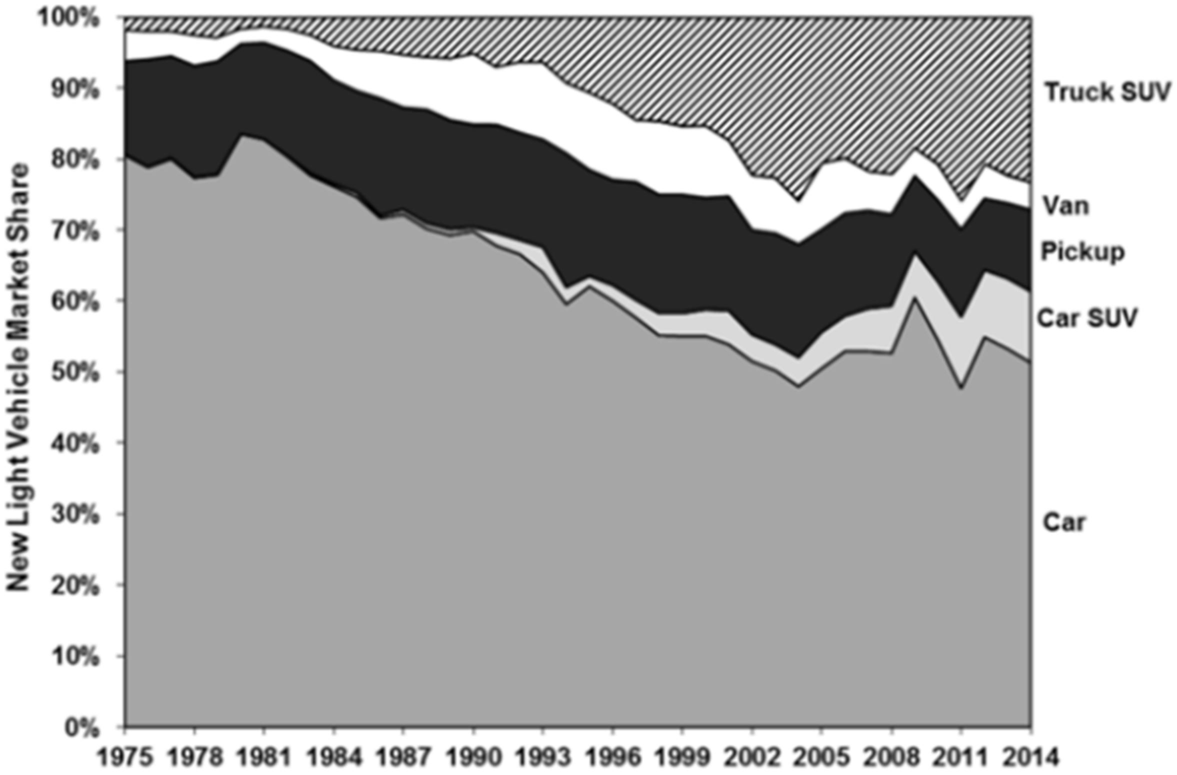

Figure 2: Light Vehicle Production Shares, Model Years 1975–2014
Source: [U.S. Environmental Protection Agency](#).

Thus, from the ’80 to nowadays US have had:
- cars with smaller engines and a diminishing market share;
- pickups with larger engines and a roughly unchanged market share;
- car SUVs and truck SUVs with a highly increasing market share and roughly unchanged engines, which are however larger than those of cars.

The global effect being a stock of vehicles which are bigger and with larger engines and then liable to be less fuel efficient than in EU.

The mass motorization in Europe occurred after World War II, with the diffusion of Volkswagen Beetle, Citroen 2C, Fiat 600 and so on. These cars, certainly not large and forerunners of even smaller city cars (Fiat 500, Mini Minor) had great success in Europe. These small cars were also more appropriate for historical cities across Europe, characterized by narrow streets unsuitable for car traffic.

Later, the oil crises of ‘70s in Europe, where oil production was significantly lower than in US, caused a major focus on energy saving and so produced the first and most important boost for the more fuel-efficient diesel engines throughout Europe. European States started favoring diesel by applying an overall rate of tax lower than on petrol [1] (see also Figure 3). Therefore, despite being more expensive than petrol before tax, diesel is cheaper at the pump than petrol in almost all EU Member States, except the UK, Bulgaria, Cyprus, Hungary and Romania[2].

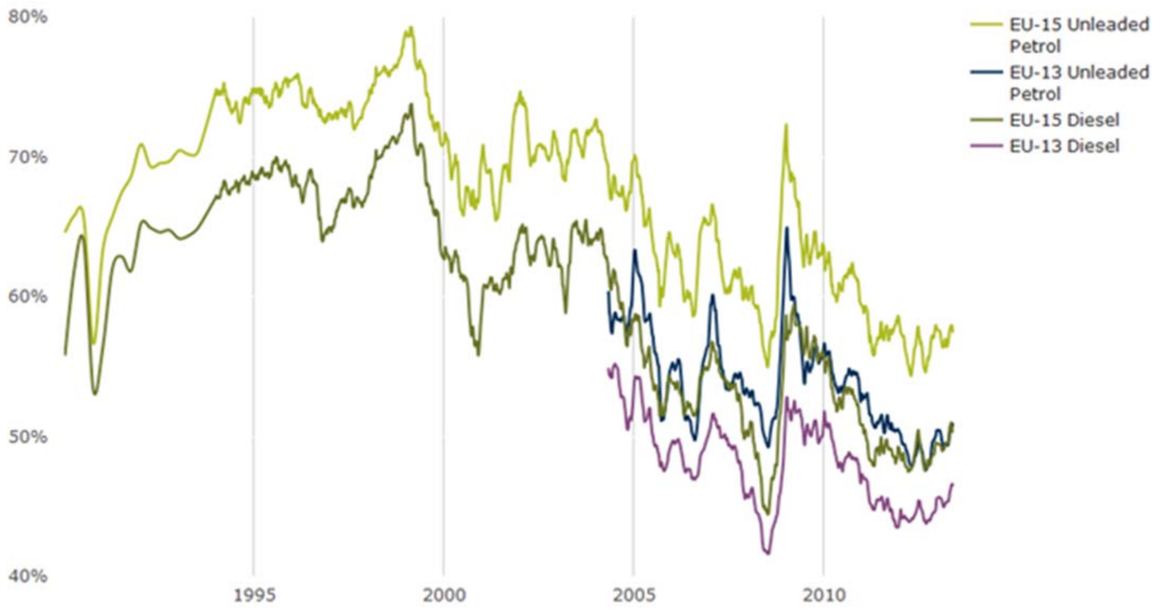

Figure 3- EU tax share in transport fuel prices.

Note: EU-15 (old Member States that acceded to the EU before 2000): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom. EU-13 (Member States that acceded to the EU in 2004-2013): Cyprus, Czech Republic, Estonia, Hungary, Lithuania, Latvia, Malta, Poland, Slovenia, Slovakia - 2004; Bulgaria, Romania – 2007; Croatia – 2013.

Source: European Environment Agency.

European policies thus contributed to the diffusion of diesel, which has since then allowed significant money saving to European drivers, considering that gasoline prices at the pump have been and are significantly higher in European States than in US (see Table 1).

Table 1: Pump price for gasoline (US$ per liter)

Country Name	1995	1998	2000	2002	2004	2006	2008	2010	2012	2014
Belgium	1,18	1,12	0,96	1,04	1,5	1,63	1,5	1,87	2,09	1,9
Switzerland	1,02	0,86	0,78	0,89	1,29	1,27	1,3	1,66	1,88	1,74
Germany	1,12	0,96	0,91	1,03	1,46	1,55	1,56	1,9	1,96	1,8
Denmark	1,08	1,05	1,01	1,09	1,51	1,58	1,54	2	2,02	2,01
Euro area	0,925	0,84	0,75	0,84	1,21	1,34	1,5	1,7	1,92	1,79
Spain	0,89	0,84	0,73	0,83	1,21	1,15	1,23	1,56	1,75	1,63
European Union	0,88	0,78	0,765	0,855	1,225	1,33	1,39	1,685	1,915	1,775
Finland	1,2	1,17	1,06	1,12	1,54	1,55	1,57	1,94	2,08	1,89
France	1,17	1,11	0,99	1,05	1,42	1,48	1,52	1,98	1,91	1,79
United Kingdom	0,92	1,11	1,17	1,18	1,56	1,63	1,44	1,92	2,17	1,92
Italy	1,18	1,19	0,97	1,05	1,53	1,56	1,57	1,87	2,28	2,14
Sweden	1,17	1,09	0,94	1,06	1,51	1,46	1,38	1,87	2,1	1,82
United States	0,34	0,32	0,47	0,4	0,54	0,63	0,56	0,76	0,97	0,76

Source: World Bank.

These different situations and policies explain why diesel cars account for about 55% of cars sale in Europe and less than 3 % in the US (in 2013).

Thus, when environmental policies were first developed ('70s in the US; mid '70s in the EU with a growing effectiveness in later decades thanks to an increasing "centralization" of environmental competences) the car industries and markets were already well-established and running in the US and Europe.

In the US, the 1970 Clean Air Act, among other requirements, also enacted deadlines and penalties for automobile emission standards in new cars, resulting in the development and adoption of catalytic converters and so reducing automobile pollution. EPA was also established in 1970 and given a broad responsibility for regulating motor vehicle pollution.

The strict emission limits set by the Clean Air Act (90 percent reduction in emissions from new automobiles by 1975) were then delayed due to exogenous changes in the economic environment, uncertainty about the environmental friendliness of targeted technologies, and inherent problems associated with forcing the development of new technologies (see Table 2).

Table 2: Federal Emissions Standards in US, 1968-1981 (grams / mile)

Model Year	HC	CO	NOx
Uncontrolled Vehicle	8.7	87	4.4
1968	6.2	51	--
1970	4.1	34	--
1972	3.0	28	--
1973			3.1
1975	1.5 (0.41)	15 (3.4)	
1976			(0.41)
1977			2
1980	0.41	7	
1981		3.4	1

Note: Numbers in parentheses are the 1970 Clean Air Act standards. Numbers in bold indicate that the standards in place satisfied the 90 percent requirement. HC = hydrocarbons; CO = carbon monoxide; NOx = nitrogen oxides.

Source: Gerard and Lester (2005).

Federal legislation in 1981 established then new emission standards, retroactively known as "Tier 0," beginning in 1987. The Clean Air Act Amendments (CAAA) of 1990 subsequently defined two new tiers of standards for light-duty vehicles:

Tier 1 standards, which were published as a final rule on June 5, 1991, were phased-in progressively between 1994 and 1997;

Tier 2 standards, which were adopted on December 21, 1999, were phased-in from 2004 to 2009, and currently apply to vehicles up to 8,500 lbs. (gross vehicle weight rating - GVWR) and "medium-duty passenger vehicles" (MDPV) - larger SUVs and passenger vans 8,500-10,000 lbs. (GVWR).

The emission limits for, e.g., NOx are reported in Table 3.

Table 3: Emissions for NOx

Year	1975	1977	1981	1994	1999	2004-2009
NOx - Standard (gpm)	3.1	2.0	1.0	0.6	0.3	0.07
NOx - Reduced (from previous standard)		35%	50%	40%	50%	77%

Source: EPA, Emission facts.

US policies have always given much emphasis to reduction of "local" pollutants (especially NOx and non-methane organic gases) deriving from heavy traffic congestion, particularly in big cities, which have been associated with negative health impacts. The first cases of photochemical smog (or Los Angeles smog) were reported around 1940 in Los Angeles, where peculiarities of its geography and weather patterns make it especially predisposed to the accumulation of smog.

Less attention has been given to "global" emissions (namely CO2), associated with climate change and also providing a good proxy for the fuel economy of vehicles.

In the European Union the legal framework for road emissions consists in a series of directives, each amendment to the 1970 Directive 70/220/EEC, which regards the approximation of the laws of Member States on measures to be taken against air pollution by emissions from motor vehicles. For Light Duty Vehicle standards the stages are typically referred to as Euro 1 (adopted in 1993), Euro 2 (adopted in 1997), Euro 3 (adopted in 2001), Euro 4 (adopted in 2005), Euro 5 (adopted in September 2009) and Euro 6 (adopted in September 2014). Beginning with Euro 5, standards have been issued by direct Regulations, which are directly enforceable in all Member States, as opposed to Directives, which must be transposed into each individual Member State.

EURO 1 and 2 had CO, HC+NOx and PM limits. Euro 3 added NOx-specific limits in addition to HC+NOx limits. Positive ignition vehicles were exempted from PM standards through the Euro 4 stage. Diesel oxidation catalysts (DOCs) were widely used to comply with Euro 3 and Euro 4 standards. For diesel engines, Euro 5 had two sets of limits scheduled for implementation: Euro 5a and Euro 5b. For gasoline engines, there was only one set of standards, referred to as Euro 5. Implementation of Euro 5 and Euro 5a began in September 2009. Euro 5b went into effect in 2011.

Euro 5b legislation included, for the first time, a PN (Particle Number) emission limit of 6.0×1011/km to the mass-based limits for compression ignition engines established in Euro 5a. Euro 5 improves on Euro 4 by focusing on particulate matter from diesel cars. Euro 5 requires particle filters for diesel cars and mandates PM emissions be reduced to 5 mg/km.

As for EURO 6, some studies [3] demonstrated that NOx emission levels are reduced by 66% from Euro 5, requiring the use of NOx after-treatment devices in addition to in-cylinder measures such as cooled EGR (exhaust gases recirculation). LNTs [4] showed good NOx reduction performance and durability. On the other hand, SCR [5], while offering also good NOx reduction performance, offers more flexibility for fuel economy and reduction of CO2 emissions.[6]

A comparison between regulations for emissions and fuel economy in US and Europe is given in Table 4. It must be noted that TIER 2 limits in the US were applied already when in Europe EURO 4 was still in force (1/2005-9/2009), with significantly higher limits for NOx and PM.

Table 4: Emissions and fuel economy standards in US and Europe

	US	EU	
Emission standards (grams/mile):			
	Full useful life (TIER 2)	EURO 5	EURO 6
Nitrogen oxides (NOx)	0,07	0,10 gasoline; 0,29 diesel	0,10 gasoline; 0,13 diesel
Non-methane organic gases (NMOG)	0,09	0,11 gasoline [7], diesel [8]	0,11 gasoline, diesel2
Particulate matter (PM)	0,01 (0,003) [9]	0,008	0,007
Carbon monoxide (CO)	4,2	0,8 (diesel) 1,6 (gasoline)	0,8 (diesel) 1,6 (gasoline)
GHG, 2016	250	208	
GHG, 2020	213	152	
Fuel economy standards (miles/gallon):			
2015 for UE (CO2 grams per km and km/liter)		41,6 gasoline; 47,6 diesel (130 and 17,7 gasoline, 20,2 diesel)	
2016 for US (CO2 grams per km and km/liter)	34,8 gasoline; 39,8 diesel (155,3 and 14,8 gasoline, 16,9 diesel)		

In more general terms, it can be noted that US have a more consuming transport system than EU (and also with the highest production of CO2 per capita among industrialized countries worldwide; see Table 5).

This very different carbon intensity in the transport systems of two of the main economies of the world (the European Union[10] and the United States accounted for almost 50% of nominal world GDP in 2014) could be an issue to be targeted in the upcoming COP21 in Paris, when the echoes of the diesel-gate scandal very likely will not have faded away yet.

Table 5: CO2 emissions of transport per capita (tCO2 / cap)

	2000		2005	2010	2011	2012	2013	2000 - 2013 (%/year)
World	0,78		0,83	0,84	0,84	0,85	0,85	0,7
Europe	1,64		1,72	1,63	1,60	1,57	1,55	-0,5
European Union	1,81		1,90	1,79	1,76	1,71	1,68	-0,6
Russia	0,85		0,98	1,16	1,21	1,20	1,23	2,9
Ukraine	0,41		0,49	0,55	0,54	0,56	0,54	2,2
North America	5,79		5,88	5,24	5,14	5,14	5,19	-0,8
Canada	4,47		4,70	4,79	4,75	4,76	4,85	0,6
United States	5,93		6,01	5,29	5,18	5,19	5,23	-1,0
Latin America	0,76		0,81	0,90	0,93	0,98	0,98	2,0
Asia	0,29		0,33	0,39	0,41	0,43	0,43	3,3
China	0,21		0,31	0,46	0,49	0,51	0,53	7,3
India	0,09		0,10	0,16	0,17	0,18	0,18	5,3
Japan	2,02		1,93	1,77	1,72	1,69	1,68	-1,4
South Korea	1,68		1,81	1,77	1,72	1,76	1,80	0,5
Pacific	2,91		2,88	2,81	2,82	2,87	2,83	-0,2
Australia	3,85		3,82	3,79	3,81	3,91	3,85	0,0
New Zealand	3,11		3,25	3,09	3,07	3,03	3,02	-0,2
Africa	0,20		0,21	0,25	0,24	0,25	0,25	1,9
Middle-East	1,30		1,52	1,63	1,65	1,71	1,71	2,1

Source: ENERDATA.

[1] Minimum taxe rate is 359 € for 1000 liters on (unleaded) petrol and 330 € on diesel (gas oil).

[2] UK having chosen an identical taxation for petrol and diesel; the other Countries having a low difference in taxation that does not compensate for cost difference before tax.

[3] E.g. http://theicct.org/sites/default/files/publications/ICCT_LDVcostsreport_2012.pdf.

[4] Lean NOx traps.

[5] Selective catalytic reduction (SCR) with ammonia.

[6] The study concludes that "Manufacturers will likely choose the NOx after-treatment technology based on a combination of cost, reliability, fuel economy, and consumer acceptance."

[7] *NMHC-non-methanehydrocarbon*.

[8] HC+NOx = 0,37 in EURO V; 0,27 in EURO VI.

[9] In TIER 3, FTP; phase-in (% of sales): 20 % in 2018, 40% in 2019, 70% in 2020, 100 % in 2021).

[10] EU-28 plus Norway, Switzerland, Iceland (source: http://databank.worldbank.org/data/download/GDP.pdf)