



SWEDEN

ROAD TRANSPORTATION

*Transport in Sweden, the
automotive sector's
transformation is
taking shape*

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Transport in Sweden, the automotive sector's transformation is taking shape

In a European context marked by an almost universal increase in CO₂ emissions from motor transport, Scandinavia, and especially Sweden, is demonstrating that this evolution is not inevitable by showing a significant and regular decrease in emissions. In this chapter we have tried to analyse the factors related to this evolution, and in particular the links between the Swedish government's long-standing and very proactive policy on carbon taxation, and the strategy of the economic players. This case study ultimately attempts to answer this important question: to what extent are the elements of success of the Swedish stakeholders' strategy sustainable and reproducible?

Head editor • Climate Chance Observatory

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1 • ACCELERATED DECLINE IN DOMESTIC TRANSPORT EMISSIONS

Since 2007, Sweden has seen its carbon emissions decline continuously. Statistics from the Swedish Environmental Protection Agency, as part of its 2017 annual inventory of greenhouse gas emissions, in accordance with the UNFCCC guidelines, show that this trend continued in 2016 with a 1.99% decrease in emissions compared to 2015 (see Figure 1).

Carbon Dioxide (CO ₂) (kt)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
NATIONAL TOTAL (excluding LULUCF, excluding international transports)	52,816.5	50,723.1	47,153.2	52,927.3	48,970.0	46,403.6	44,769.0	43,225.7	43,385.6	42,568.0
Domestic transport, total	20,970.1	20,350.7	20,037.2	20,090.1	19,643.6	18,418.9	17,910.6	17,703.8	17,661.7	16,686.1

FIGURE 1. EVOLUTION OF OVERALL CO₂ EMISSIONS AND THOSE FROM TRANSPORT BETWEEN 2007 AND 2016 IN SWEDEN

Source : Statistical database sweden, SMED on behalf of the swedish environmental protection agency, 2017

This decrease was as a result of the domestic transport sector in particular, which recorded a significant decrease of 5.6% in CO₂ emissions between 2015 and 2016. This drop in overall emissions from motor transport comes after a decrease of 11.76% between 2010 and 2016 (see Figure 2). This sustainable trend and its remarkable acceleration over the last year is nevertheless occurring against a background of stable, or even increasing, transport emissions in Europe, reaching 1029 MtCO₂eq in 2014 and 1048 MtCO₂ in 2015.

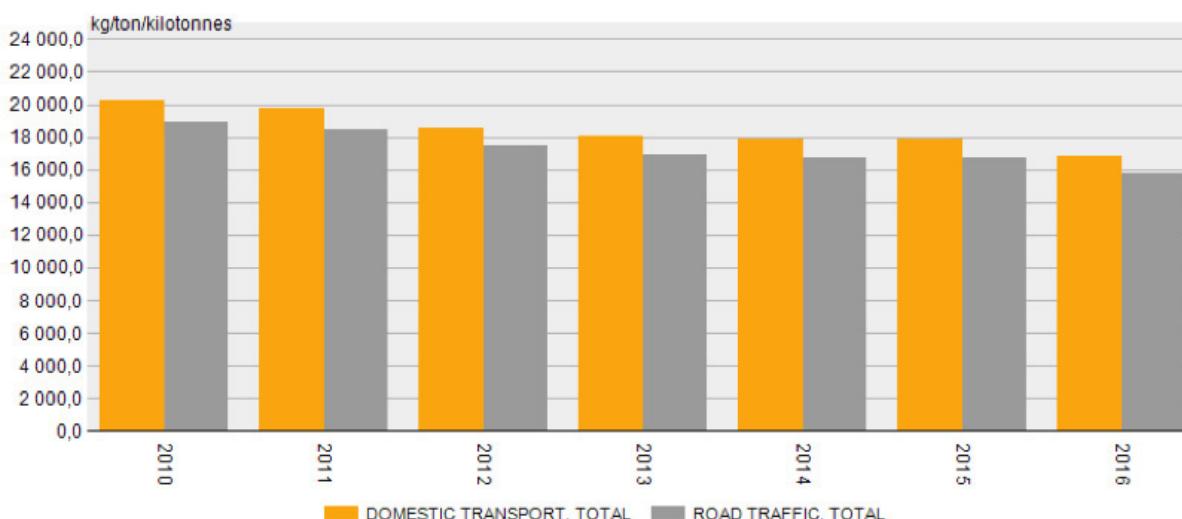


FIGURE 2. GREENHOUSE GAS EMISSIONS FROM TRANSPORT IN SWEDEN, 2010-2016

Source : Swedish Environmental protection agency, 2017

Sweden's distinctiveness comes first and foremost from the State's proactive policy to abandon fossil fuel energy, from ecological taxation and from the overall transformation of the transport sector, a coherent action which was analysed in particular in 2017 in the report "CO₂ emissions and economic incentives" for the Nordic Council of Ministers (Jordal-Jorgenssen et al., 2017). It would not make much sense to analyse the actions developed by non-state stakeholders, if we did not first focus on the policies being pursued by the Swedish state.

2 • THE SWEDISH STATE'S PROACTIVE POLICY IN THE FIELD OF TRANSPORT

Le gouvernement suédois est l'un des premiers pays au monde à utiliser la fiscalité écologique comme The Swedish government is one of the first countries in the world to use ecological taxation as a cornerstone of its environmental policy (Millock, 2010). **Thus, Sweden was the first country to introduce a carbon tax in 1991 at EUR 27 per tonne of CO₂ (Akerfeld & Hammar, 2015). This tax is now 96€/tCO₂, making Sweden the country with the highest carbon tax (I4CE, 2017).**

This significant taxation is combined with ambitious objectives to reduce its greenhouse gas emissions. The Swedish government announced the "Fossil Free" initiative within the framework of COP21 in 2015, in order to highlight the drive of national companies, institutions and organisations to contribute to the climate effort. The ambition is to make Sweden the first country without fossil energy. **The Free Fossil Declaration states that the stakeholders signing up to it must carry out concrete and coordinated actions with a view to reducing their national greenhouse gas emissions:**

"The ambition is to make Sweden one of the first fossil free welfare countries in the world. Not only because it is our responsibility to future generations, but because it makes economic sense. To achieve this, all actors in society must work actively to reduce emissions. Fossil Free Sweden is open to all actors who support the declaration drawn up for the initiative."

Source : Free fossil declaration, government offices of sweden, 2015

In its third biennial report to the UNFCCC, the Swedish government sets a goal of a 70% reduction in GHG emissions in 2030 compared to 2010, excluding domestic air traffic (Ministry of the Environment & Energy, 2017).

In the transport sector, **in 2016, the Swedish government set out an infrastructure investment plan for the 2018-2029 period** totaling SEK 622.5 billion (EUR 60.9 billion) for the entire plan (Swedish Transport Agency, 2017). While the investments are mainly aimed at maintaining existing rail and road infrastructure, the Swedish government has six main objectives: accessibility, environmentally-friendly mobility, development of regional networks, security, entry of the Swedish transport network into the EU market and, the sixth objective that must be highlighted, reducing the environmental and climatic impact of the transport sector:

"Consequently the Government proposes several policies and measures aimed at the transport sector in the budget proposal for 2018. Lately the local climate investment program has granted support for infrastructure for the introduction of electrical vehicles [...] a bonus/malus-system for new light vehicles and an emission reduction obligation for petrol and diesel to further spur emission reductions in the transport sector. Moreover, the Government proposes that a tax on air travel will be introduced with the aim to reduce the climate impact of aviation."

Source : Sweden's third biennial report under the UNFCCC, Government offices of sweden, 2015

In addition to this infrastructure investment plan, Sweden is pursuing its policy of developing mobility backed by biofuels, including air transport with the first test flight of an ATR plane using biodiesel in 2017. According to EurObserv'ER's analysis, "Sweden is not exactly aiming to totally eliminate fossil fuels in transport. The definition given by the commission of experts in charge of implementing this plan is "establishing a fleet of vehicles independent of petroleum fuel mainly fueled by biofuels and electricity" (EurObserv'ER, 2017).



3 • A REDUCTION OF EMISSIONS BACKED BY THE DEVELOPMENT OF THE BIOFUELS SECTOR

• THE RISE OF THE SWEDISH BIOFUELS SECTOR •

Definition and categorisation of biofuels

The first generation of biofuels refers to those derived from food products (more precisely the storage organs of crops: seeds, beet roots, oil palm fruits). They are therefore in competition with agricultural products dedicated to human and animal nutrition. There is a difference between the petrol (bioethanol) sector based on the industrial fermentation of sugar contained in sugary and starch plants (wheat, maize), and the diesel (biodiesel) sector obtained from vegetable oils or animal fats converted into fatty acid esters (fatty acid methyl esters - FAME). Within the "oil" sector, it is important to note the increasing share of biodiesel obtained by hydrotreating oils

(HVO), which, despite its superior properties and increasing use of waste oils and residues and agro-industrial waste, remains a first generation biofuel.

Second generation fuels are derived from the transformation of lignocellulose from agricultural residues (straw), forest residues (woods, leaves, and so on) or from dedicated energy crops with high biomass productivity (short-rotation coppice). This transformation is thermochemical to obtain a synthetic biodiesel (the Biomass to Liquid or BtL industry), or biochemical to produce ethanol. These biofuels are still in the development phase and their commercialisation should be confirmed by 2020.

Source: Ministère Français de la transition écologique et solidaire

TEXT BOX 1

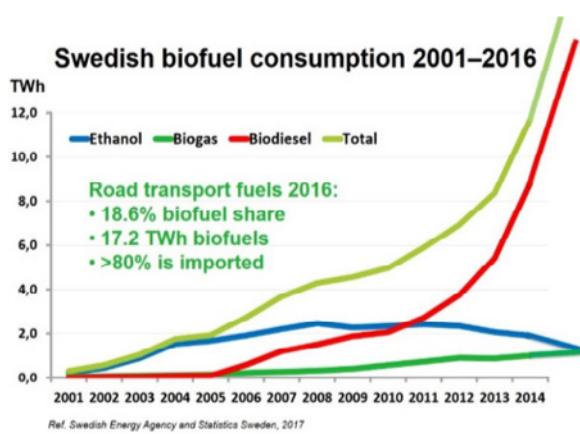


FIGURE 3. BIOFUEL CONSUMPTION IN SWEDEN, 2001-2016

Sources figures 3 et 4 : SVEBIO, 2017

The consumption of biofuels in Sweden has increased significantly in recent years (see Figure 3). While ethanol and biogas consumption has been slowly developing, biodiesel consumption has increased exponentially. Comparison of the fuels used (see Figure 4) confirms the growing trends of Swedish consumption of biofuels in 2016 (1.32Mtoe, +23.77% compared to 2015), with, notably, an increase in biodiesel consumption (1.096 Mtoe, +34.36%), far ahead of the declining consumption of ethanol (0.11Mtoe, -21.68%) and biogas fuels (0.11Mtoe, -1.83%) (EurObserv'ER, 2017).

In 2016, this impressive increase in the consumption of biofuels, especially biodiesels, largely accounts for the observed reduction in CO₂ emissions from motor transport, as the evolution of the car fleet and changes in behaviour do not appear to have had a significant impact on emissions at this stage.

According to the Swedish Energy Agency, the representation of biofuels in the sector reached 19% in 2016 compared to 15% in 2015 and should continue to increase in the coming years to reach a volume of nearly 2 million tonnes in 2020, 80% of which being biodiesel. The biofuels sector benefits from the strong responsiveness of Swedish economic players, with massive investments in advanced biofuel production units, including biodiesel (see Figure 6). Their organisation within a very active professional association, the Swedish Association of Bioenergies (Svebio), bears witness to this.

In 2017, Svebio noted a certain stagnation in the development of traditional biofuel production units, with only three new ethanol production centres by St1, Agroetanol and SEKAB, two new FAME biodiesel units by Perstorp, and a few additional Biogas centres by E.ON, Swedish Biogas, Strängnäs, and so on. Conversely, the organisation recorded a significant wave of new pilot and commercial projects for HVO biodiesel (hydrotreated vegetable oils) for which, the Swedish oil company Preem, for example, has planned a 600% increase in its production capacity to reach 1.3 million m³ in 2023. This increase in projects shows the extension of the HVO market, and the erosion of the quasi-monopoly of the Finnish company Neste which currently represents more than 50% of world capacity with 2.5 million tonnes (Greenea, 2017).

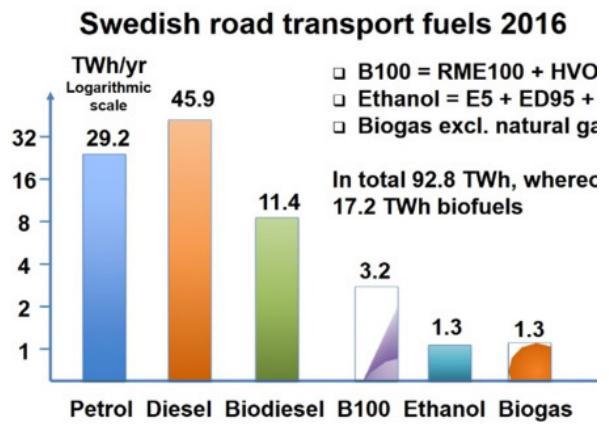


FIGURE 4. COMPARISON OF THE FUELS USED IN SWEDISH ROAD TRANSPORT IN 2016.

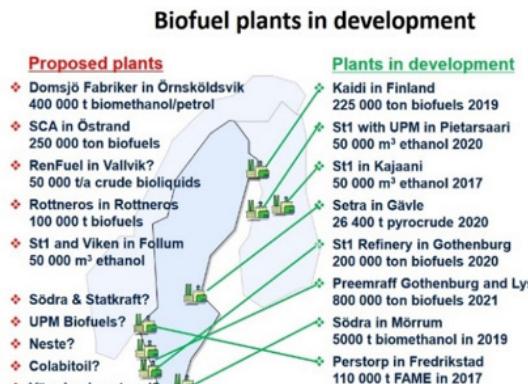
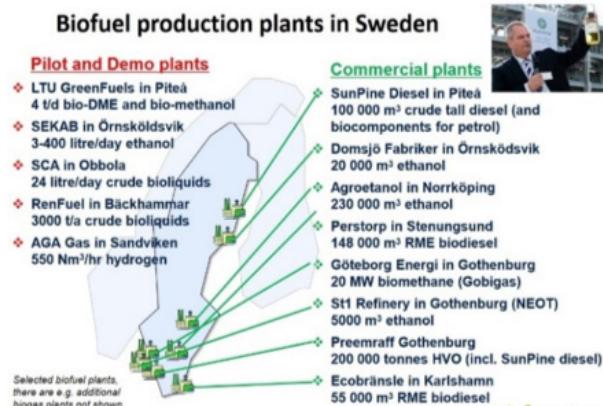


FIGURE 5. DEVELOPMENT OF BIOMASS PRODUCTION PROJECTS IN SWEDEN.

Source : SVEBIO, 2017

HVO biodiesel from Neste

The Finnish company Neste has developed and patented a process for the hydrogenation of vegetable oils for the production of biodiesel. As in the traditional process, it is a catalytic reaction. The difference is that, this time, the oil is brought into the presence of hydrogen, instead of methanol which is used for other types of biodiesel and in particular for FAME biodiesel. The product obtained is a synthetic diesel fuel that, technically, can be used at almost 100% in a conventional engine. This technology also makes the final product more stable with a higher combustion index. It also avoids the co-production of glycerin, for which there are not always local outlets.

Source : Eurobserv'er, 2017

TEXT BOX 2



• **HVO BIODIESEL ENABLING EUROPEAN TARGETS TO BE EXCEEDED** • The rapidly expanding sector enabled the country to achieve the 30% renewable energy threshold for final transport energy consumption in 2016, an increase of 6 points compared to 2015 (Eurostat), and more than three times the European target of 10% renewable energy in the transport sector by 2020.

This performance by Sweden is linked to the specific accounting procedure that HVO partly benefits from as an advanced fuel. The raw materials used are still mainly of an agricultural nature and similar to those used for first generation FAME-type biodiesel. However, it allows for the more attractive use of agricultural residues and waste, especially those mentioned in Directive 2009/28/EC (Annex IX). HVO biodiesel operators using these raw materials are considered to be using advanced biofuels by the European Union, so they can claim double accounting of their real energy value and contribute doubly to the achievement of European objectives.

The consumption of biofuels in Sweden complies with EU directives

The development of the European Union's market for biofuels for transport is currently, and will be until 2020, governed by Directive 2015/1513 of 9 September 2015, the so-called CASI Directive, which amends Directive 98/70/EC on the quality of petrol and diesel fuels; and Directive 2009/28/EC on the promotion of the use of energy from renewable sources. These two guidelines have been revised to recognise and mitigate the detrimental impact that first generation biofuel production can have on the environment, due to greenhouse gas emissions associated with cases of indirect land-use change (ILUC), that is, the conversion of farmland to crops for biofuel production. Thus, the share of agrofuels from these dedicated crops (cereals, starch-rich plants, sugary plants and oilseeds) has been capped at 7% of total energy consumption in transport. The EU, however, is aiming for a 10% renewable energy target in the transport sector by 2020. The remaining 3% can therefore be obtained through electric transport, or through the use of so-called "advanced" biofuels produced from

specific raw materials that can claim double accounting (Annex IX).

Respect of European criteria is a requirement to be able to count biofuels in the share of renewables in total energy consumption and to be able to benefit from public support schemes. It results in the issuing of "certificates". They stipulate, on the one hand, a reduction of at least 50% of GHG emissions from biofuels compared to fossil fuels, and 60% for installations after 5 October 2015. On the other hand, they render ineligible biofuels derived from raw materials coming from land of high value in terms of biodiversity or with a large carbon stock (primary forests, wetlands, peatlands, and so on). Finally, Member Countries have an obligation to carry forward GHG emissions related to indirect changes in land use according to the type of plants used. On the other hand, it considers those from "advanced" biofuels, derived from the raw materials mentioned in Annex IX, as nil due to the current lack of data for their estimation.

Source : 2017 Biofuel barometer, european directives

TEXT BOX 3

This high-quality biodiesel has the other advantage of being able to be used in a high concentration in diesel engines, or even in pure form since the marketing of HVO100 in 2015. To promote their consumption, Sweden applies different tax exemption rates according to the type of biofuel (ethanol, FAME or HVO), and according to the content of the mixture in biofuels. HVO 100 is thus 100% exempt from both the carbon tax and the energy tax, and its price remains competitive with that of fossil diesel. The total consumption of HVO doubled between 2015 and 2017 to reach 73% of liquid biofuel shipments (see Figure 5), making it the third most consumed fuel in Sweden, behind petrol and diesel.

Year	FAME (m ³)	HVO (m ³)	Ethanol (m ³)
2011	250,563	44,943	619,161
2012	294,009	131,085	607,208
2013	292,895	289,095	354,569
2014	431,015	438,813	326,560
2015	422,590	704,687	263,446
2016	341,203	1,203,680	213,446
2017	330,847	1,441,780	205,367

FIGURE 6.
DELIVERED VOLUME
OF RENEWABLE
FUELS IN SWEDEN
(M³), 2011-2017

Source : Swedish Institute of petroleum and biofuels, 2017

Conversely, FAME biodiesel and bioethanol production are gradually decreasing and only accounted for 17% and 10% respectively in 2017. This industrial strategy is consistent with the reduction of biofuels from dedicated agricultural production encouraged by the European Union.

4 • AN ENVIRONMENTAL ASSESSMENT OF SWEDISH BIOFUELS: STILL TO BE CLARIFIED

The Swedish strategy, however, raises questions in relation to the foreseeable evolution of the world market for biofuels intended in particular for transport in the European Union. A study commissioned by the European Commission in 2015 shows that biodiesels from vegetable oils (rapeseed, palm, soybean, sunflower) may ultimately be more emitting than conventional diesel, by including the "ILUC emission" factors due to land use changes caused by their production - up to three times more in the case of palm oil. 70% of these emissions are attributed to peatland degradation in Malaysia and Indonesia caused by palm plantations.

Faced with the environmental problems caused by the massive production of biofuels, the European Union wants to support "advanced" and second generation biofuels, by gradually reducing the authorised ceiling for the inclusion of biofuels from agricultural products (see Text box 3), which is currently under discussion in the context of the revision of the 2030 energy package.

To reduce the impact of its production, **the Swedish biofuel industry is relying on the definition given to a number of materials considered by Swedish national authorities to be residues that theoretically do not compete with food production.** It falls within the scope of "advanced" biofuels and is therefore not subject to the same traceability requirements. This is the case, for example, with Palm Fatty Acid Distillate (PFAD), a processing residue derived from the refining of crude palm oil. The bulk of biofuel production destined for the Swedish market remains linked to European production. However, there was a significant increase in imports of raw materials for HVO biodiesel from Indonesia and Malaysia between 2015 and 2016 (see Figure 8), which corresponds to the imports of PFAD.



	Sweden	Europe excluding Sweden	Indonesia	Malaysia	USA	Other	Total
2011	32,452	2,489					34,941
2012	59,021	55,946	8,502	6,734	9,399		139,602
2013	101,836	189,354	49,239	24,892	25,876		391,196
2014	93,405	286,729	56,110	17,874	28,994		483,111
2015	99,664	429,792	86,107	20,310	96,031		731,904
2016	46,269	573,770	182,596	73,104	142,134	344,999	1,220,738

FIGURE 7. HVO USED IN SWEDEN, BY COUNTRY OF ORIGIN, SINCE 2011, VOLUME (M³)

Source : Swedish energy agency, 2017

In 2016, for the first time since 2011, no palm oil as such was used for the production of HVO biodiesel. PFAD, in contrast, represented 22% of the raw materials in 2016, whereas it was absent in 2015.

	Tall oil	Vegetable or animal oils	Slaughter-house waste	Palm oil	Animal fat	Rapeseed	PFAD	Corn	Other	Total
2011	32,452	2,489	0	0	0	0				34,941
2012	64,589	30,034	29,743	15,236	0	0				139,602
2013	100,113	5	201,409	74,131	15,540	0				391,196
2014	106,419	108,447	168,708	73,984	25,554	0				483,111
2015	112,114	227,009	220,713	106,418	0	65,651				731,904
2016	84,283	459,473	234,807	0	0	101,416	276,593	43,240	20,926	1,220,738

FIGURE 8. RAW MATERIALS FOR THE MANUFACTURE OF HVO USED IN SWEDEN, SINCE 2011, BY VOLUME (M³)

Source : Swedish energy agency, 2017

Substituting PFAD for palm oil allows Sweden to reduce the emissions ascribed to indirect changes in land use, since suppliers are not subject to the obligation to carry forward the emissions due to the production of agricultural residues and waste, nor are they subject to the same traceability requirements.

Le Palm Fatty Acid Distillate (PFAD)

Considered a residue, Directive 2015/1513 considers it to have "estimated indirect land-use change emissions of zero". This is in line with Neste, which believes that the demand for PFAD will not put additional pressure on arable land in favour of palm oil, but rather will incentivise improvements in processes to reduce its quantity. This position relies on its low concentration in crude palm oil of around 4 to 5%, and on its market price, which is 15% lower than that of a tonne of refined palm oil (Zero and Rainforest Foundation Norway, 2016). Neste has nevertheless announced that it will implement the same level of traceability for PFAD as for palm oil by 2020.

TEXT BOX 4

However, the evolution of the PFAD market shows that the increasing exploitation of agricultural residues gradually gives them a similar impact on land use. **Added to the opportunities that PFAD also finds in the food and cosmetics industry, its use in the transport sector could increase economic pressure on land, making its use a temporary solution.** With 57 million tonnes of palm oil produced by Malaysia and Indonesia in 2017 (USDA), their potential for producing PFAD can be estimated at nearly 2 million tonnes. This is just 8 times the current Swedish demand for PFAD in 2016, which could develop very quickly. **It is therefore very clear that use of this resource is not reproducible on a large scale.**

The Norwegian government, reconsidering its emissions related to palm oil production, has moreover re-designated PFAD as a "co-product" in 2017, and Sweden should do the same from 2019. It will thus fall within the scope of the sustainability criteria of the directive, which impose stricter reporting of emissions and traceability on operators, and it will lose the benefit of double accounting. The debate over redefining the status of PFAD could lead to the reclassification of other derived products such as technical corn oil (TCO), which is considered to be a residue from the production of ethanol used for the production of biodiesel, or Tall Oil Fatty Acid (TOFA), a residue from paper production.

The special attention given by Sweden to biodiesel, especially HVO, therefore allows it to comply, for the time being, with European requirements and to have a leading role in reducing emissions and in energy transition in the transport sector. **The environmental impact of the Swedish strategy nevertheless remains to be clarified and will depend heavily on future developments in the local production share of second-generation biofuels.** In the long term, the evolution of the Swedish car fleet could play a bigger role in Sweden meeting its emission reduction targets.

Relocating the production of raw materials in the long term

Sweden currently occupies 0.39 hectare per capita of the available arable land in the world, which should be compared to the available arable land per capita on a world scale, which was estimated at only 0.194 ha in 2016 by the Food and Agriculture Organization. Of these 0.39 ha, approximately 0.05 ha represent land dedicated to Swedish biofuel production, of which almost 80% (or about 0.04 ha) of this land is located abroad (see Figure 7). To meet these challenges in part, the Swedish Knowledge Center for Renewable Transportation Fuel, a research institute funded by the Västra Götaland region and by industrialists and universities active in the biofuels sector, believes that the country is in a position to relocate, by 2030, the production chain of around 20 TWh, that is the total current biofuel consumption in Sweden. They believe that this can be done without

indirect land-use changes, but rather through the increased use of residues from agriculture, forestry, industry and so on, and also (a point on which the report is very proactive) by reconverting land currently used for alcohol and meat production, which represent the majority of land use in Sweden. Sweden could thus triple its timber harvest and continue to sustainably manage its resources (De Jong-Akselsson et al, 2017).

In order for Sweden to be a pioneer country in the transition to a fossil fuel free transport sector, we need to include a high realisation of domestic biofuel production. We should not shift a dependency on imported fossil fuels, for a dependency on imported biofuels.

Source : Biofuels from agricultural biomass - Land use change in swedish perspective, the swedish knowledge centre for renewable transportation fuels, sweden, 2017

TEXT BOX 5

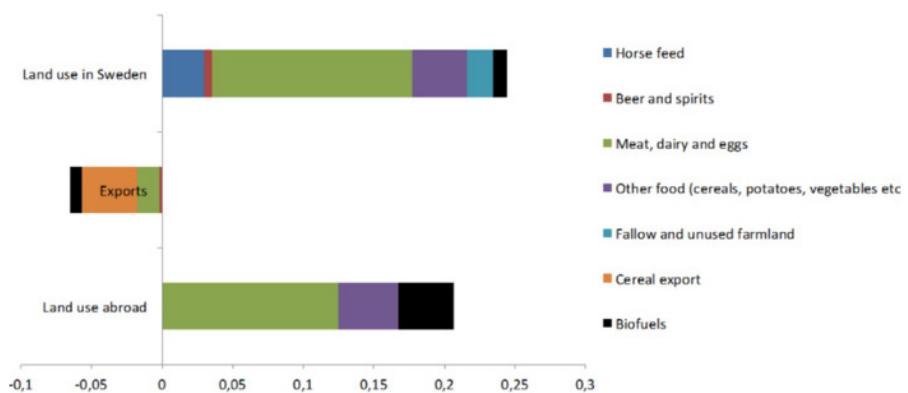


FIGURE 9. ARABLE LAND USED BY THE AVERAGE SWEDE, IN SWEDEN AND ABROAD (IN HECTARE PER PERSON)

Source :Swedish knowledge centre for renewable transportation fuels, 2017

5 • THE EVOLUTION OF THE SWEDISH CAR FLEET

• AN INCREASE IN THE FLEET DOES NOT LEAD TO AN INCREASE IN EMISSIONS •

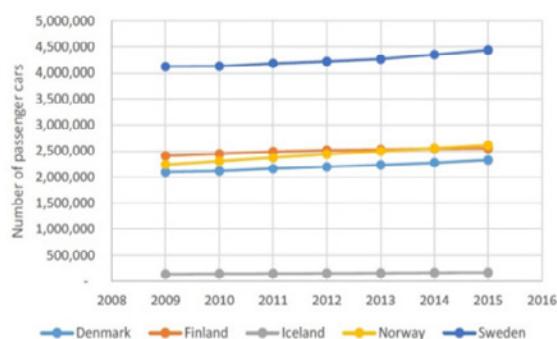


FIGURE 10. EVOLUTION OF THE CAR FLEET IN THE NORDIC COUNTRIES FROM 2009 TO 2015

The trajectory of carbon emissions by Sweden's transport sector shows a steady decline since 2007. However, as stated in the report "CO₂ emissions and economic incentives" for the Nordic Council Minister (Jordal-Jorgensen et al., 2017) on motor transport, the Swedish car fleet has increased since 2009 from 4.30 million cars in 2009 to 4.67 million in 2015, an increase of 9.11% (see Figure 10). This increase, which is greater than in the rest of Scandinavia, can be partly explained by the lack of registration taxes linked to the size and power of vehicles, unlike its Nordic neighbours (Swedish Transport Agency, 2017).

Added to this is the significant increase in car travel in Sweden (see Figure 11), from 63.28 million km in 2008 to 65.82 million km in 2015 (TRAFA, 2017). This occurred despite the initiatives of several Swedish communities, such as Stockholm and Gothenburg, to introduce a "congestion" tax to reduce urban traffic.

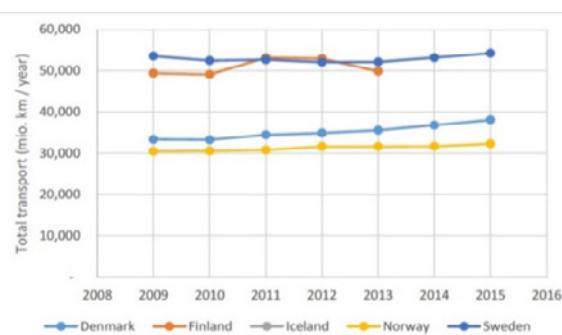


FIGURE 11. EVOLUTION OF DISTANCES TRAVELED BY CAR IN THE NORDIC COUNTRIES BETWEEN 2009 AND 2015

The reduction of CO₂ emissions in Sweden can therefore be explained primarily by the improvement of vehicles, new types of engine and the use of biofuels, rather than by changes in behaviour. This improvement in vehicle quality is particularly striking in Sweden, according to

the European Environment Agency and the European Commission services (see Figure 12), which shows the considerable progress made since 2000 in reducing CO₂ emissions per kilometre.

The figures provided by Bil Sweden, the Swedish trade association for manufacturers and importers of cars, trucks and buses, show a significant evolution of the car fleet between 2016 and 2017 with 379,393 new cars in 2017, an increase of 1.9% compared to 2016, the highest figure ever recorded (Bil Sweden, 2018).

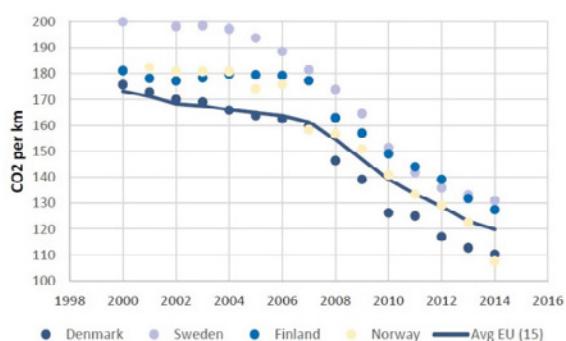


FIGURE 12. CO₂ EMISSIONS PER KILOMETRE OF NEW CARS IN THE NORDIC COUNTRIES BETWEEN 2000 AND 2014

Sources Figures 10 à 12 : Nordic Council of ministers, 2007, P39 et 43

As in the rest of Europe, there has been a significant decrease in the share of newly registered diesel cars with a decrease of 4.3% in 2017. This type of car thus represents only 49.1% of the new car fleet compared to 52.3% in 2016 (Bil Sweden, 2018). However, the decline in the diesel fleet did not lead to an increase in CO₂ emissions in 2016 (diesel vehicles are less CO₂ emitting than petrol vehicles), as was announced on the European scale by the Jato Dynamics Institute. This institute attributed the increase in average CO₂ emissions of new cars from 117.8 g/km in 2016 to 118.1g/km in 2017 to the drop in diesel car numbers (and the increase in SUV vehicles) (study presented at the Geneva Motor Show in March 2018).

• **SUPER "GREEN CARS" AND THE PROACTIVE INDUSTRIAL POLICY OF THE MANUFACTURERS •**
The distinctive position of Sweden regarding diesel biofuels, as well as the use of a significant proportion of ethanol in petrol vehicles, help explain this result, but the rapid development of the sale of "super green cars", a label given to vehicles that emit less than 50gCO₂/km, should also be taken into consideration.

In 2017, a record year of new vehicle sales, super green cars accounted for 5.1% (19,000 cars) of new cars registered, an increase of 1.6 percentage points over 2016 (3.5%). Bil Sweden's 2018 forecast, confirmed so far by the first quarter sales results, provides for 34,000 "super-clean" cars to be newly registered in 2018, representing 9.4% of the total expected market of 360,000 new cars. **This change in the Swedish car fleet through the rapid deployment of "super-green cars" is a major hope factor for the reduction of CO₂ emissions, which shows the importance of a synergy between government financial incentives and the dynamism of manufacturers.**

Super-Green Cars and the Ecological Taxation of Vehicles in Sweden

The 2011-2018 Super-Green Car Premium Ordinance, which came into force in January 2012, aimed to promote the sale of energy-efficient and low-emission cars, which refers to cars that emit less than 50g of CO₂ per kilometre (2016 threshold). The "super-green car premium" consisted of a purchase bonus of SEK 20,000 (EUR 1,960) for a hybrid vehicle and SEK 40,000 (EUR 3,920) for electric vehicles. The Swedish government has decided to replace this premium from 1 July 2018 by a bonus/malus system for passenger cars, which extends to low-emission buses and trucks.

The malus applies to both diesel and petrol vehicles and continues for the first three years on the road. It is 82 SEK/gCO₂/km (8 €/gCO₂/km) between 95 gCO₂/km and 140gCO₂/km, then rises to 107 SEK/gCO₂/km (10.50 €/gCO₂/km). The bonus for zero emission vehicles is progressive up to 60 gCO₂/km to reach SEK 10,000 (EUR 977), within a limit of 25% of the purchase price of



the vehicle. The aim is to reach an average of 95 gCO₂/km for all vehicles on the road by 2022, which corresponds to the threshold to be reached by 2021 set by the European Union.

TEXT BOX 6

At this stage, super green cars do not yet represent a significant share in the Swedish car fleet, and the weak development of the electric car (only 0.8% of the Swedish car fleet in 2015) raises questions about the adequate development of the electrical charging infrastructure throughout Sweden. Gas-powered vehicles are falling (1.4% in 2015), while hybrid power still accounted for only 2% in 2015. According to the report "CO₂ emissions and economic incentives", if the average age of the car fleet in Sweden was 10.2 years in 2014, lower sales prices for electric vehicles (EUR 30k on average), simple hybrids (EUR 25k on average) and hybrid plug-in vehicles (EUR 38k on average) would actually make it possible to envisage the rapid renewal of the fleet with less emissive vehicles, even though the average prices of petrol cars (EUR 12k) and diesel cars (EUR 23k) would remain stable (Jordal-Jorgensen et al., 2017, p.47-50).

Volvo's commitment to the end of internal combustion engines

Swedish vehicle manufacturer Volvo announced in early July 2017 that all new models it would release from 2019 would be fully electric or hybrid. Models launched before this date will still have combustion engines. It will gradually introduce models ranging from all-electric

to hybrids with rechargeable batteries into its range. Volvo's strategy must be related to that of its owner, the Chinese manufacturer Geely, which aims to develop an offer of electric vehicles in China, and to open an innovation centre for their development in Gothenburg, Sweden.

TEXT BOX 7

Other research initiatives to be closely monitored have also been launched, such as "electric light trucks" by the truck manufacturer Scania, in partnership with Siemens, Volvo and Alstom (ICCT, 2017) to move towards zero-emission freight transport. The November 2017 Global Electric Trucks Market Research Report states that while the global electric truck industry suffered a slowdown in 2016, the overall trend over the past four years is positive (+55% between 2013 and 2016,+ USD 41 million) and it should maintain its momentum in the coming years to reach USD 159 million in 2021. A technologically complementary infrastructure is important for these plans to convert to electric power. For example, Scania, in partnership with Siemens, is developing "e-highway" highway electrification projects (Siemens, 2015) based on the omnibus model. The University of Lund has initiated the "Elonroad" project (ICCT, 2017) on the basis of a conductor rail that allows electric cars and trucks to recharge while driving.

• SUV'S CONTRASTING WITH THE POSITIVE TRAJECTORY OF THE SWEDISH CAR FLEET • The massive development of the market for sport utility vehicles (SUVs), which mainly have diesel engines, is a worrying signal that increases the risks of increased CO₂ emissions and microparticles cancelling out the positive effects of "super-green cars". The Volvo XC60 SUV was the best-selling car in Sweden in 2017, with 21,419 models sold (Statistica, 2018). Foreign manufacturers have also established themselves on the Swedish market with, for example, the Volkswagen Tiguan SUV, which is the 7th best-selling car in the country.

The growing SUV market in Europe

Between 2006 and 2016, sales of SUVs in Europe grew by 300% (from 1.12 million vehicles in 2006 to 3.88 million in 2016). This trend seems to be confirmed in the coming years as Jato Dynamics' forecasts predict 6 million SUVs will be registered in 2020 (Jato Dynamics, 2017, p. 4). With only 3.9% of SUVs benefitting from electric engines in 2017, the increase in SUV sales contributed to the recorded increase in European CO₂ emissions of at least 0.1% over the 2016-2017 period.

TEXT BOX 8

CONCLUSION

In conclusion, Swedish national policy has given stakeholders in the various road transport sectors a strong incentive base for their investments in technological innovation in both vehicle and biofuel performance. However, the Swedish situation presents contradictory trends, as evidenced by the development of the diesel SUV market and the increase in car journeys, despite traffic limitations in urban areas. The issue of accounting for CO₂ emissions related to biofuel consumption in Sweden will be central in the coming years. Changes to supply (especially for palm oil) and relocation of production will be essential choices if Sweden is to demonstrate the sustainability of its biofuel-based strategy for reduction of emissions, which for now appears to be a temporary solution and one which is not reproducible on a global scale. How these contradictory trends develop will determine whether Sweden will be tomorrow's showcase for climate-compatible road transport.

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