Biofuels
Ethanol in focus

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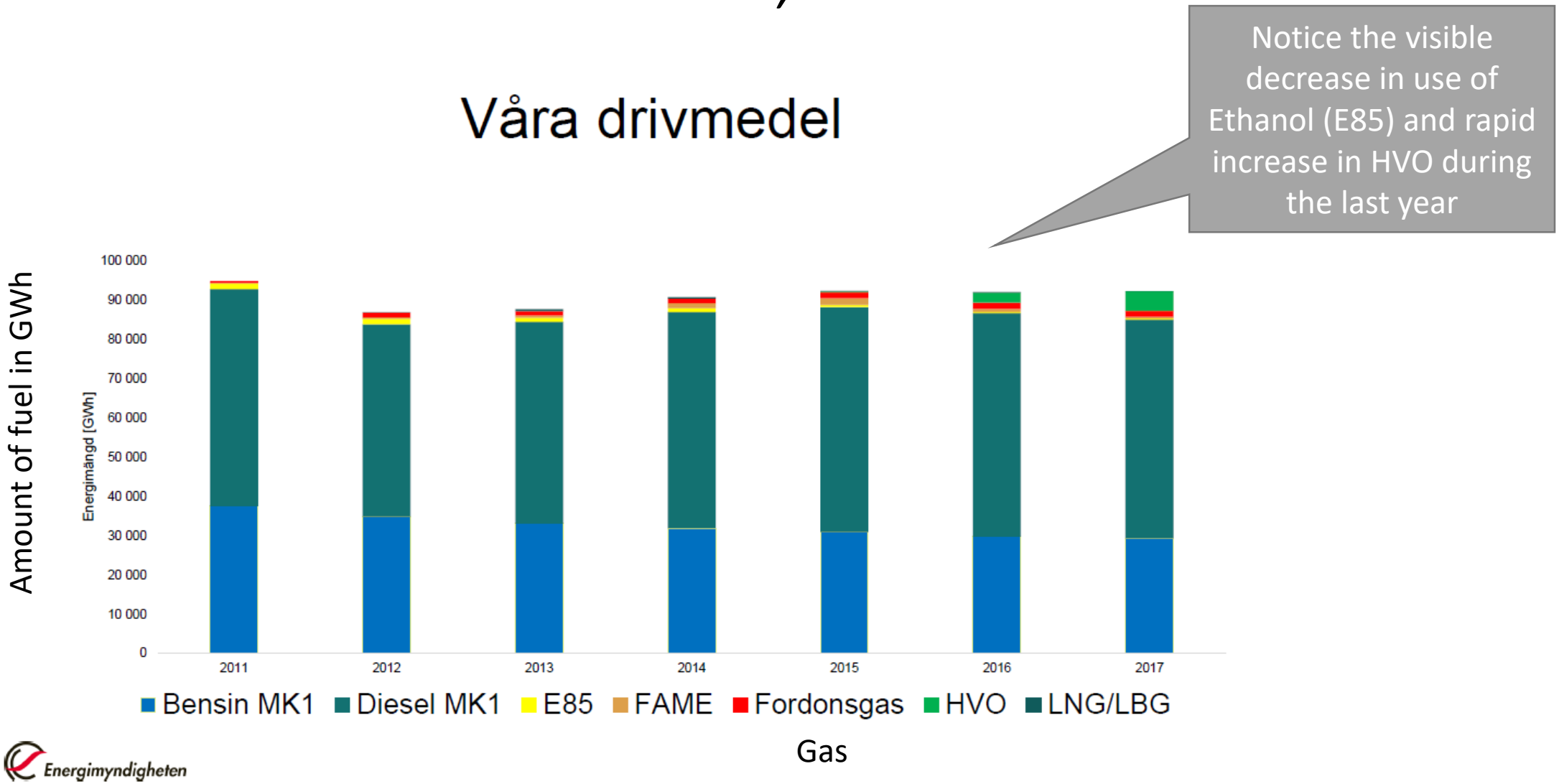
National law requires use of biofuels in Sweden

- According to the national law in Sweden biofuels are added to all conventional fuels available in gas stations as a part of national goal to reduce climate impact and increase the use of biofuels.
- For example “normal” diesel in Sweden contains actually 20 % of biofuels HVO or FAME as a law. However a diesel vehicle can also run on 100 % HVO.
- Similar rule applies for gasoline. “Normal” gasoline contains minimum 2,6 % biofuel, however the national average in 2017 was 5,6%. Otherwise it isn’t allowed to sell the fuel for road vehicles in Sweden
- However all gas stations/fuel suppliers have a variety of fuel products that contain up to 100 % biofuels.

Vehicle fuels in Sweden, 2017



Energimyndigheten

HVO - Hydrogenated vegetable oil

- It is a type of biodiesel that is chemically identical or very similar to fossil diesel and can therefore replace fossil diesel to 100%
- HVO is made from the same raw materials as so-called FAME fuels (fatty acid methyl esters). What distinguishes is the manufacturing process.

Ethanol – the history

- The introduction of ethanol into the gasoline began in Sweden in the 1920s when so-called bentyl was present (75 % ethanol and 25 % gasoline).
- During the 1950s, the ethanol disappeared and then returned in the 1980s when a factory in Lidköping turned Swedish grain into ethanol, which was then mixed into the gasoline. A four percent share became the E4 fuel (4 % ethanol and 96 % gasoline).
- Only in the 1990s did the ethanol mixture increase, which became the E85 fuel (85 % ethanol and 15% gasoline).

Ethanol – the history

- In 2005 the E85 fuel seriously spread in Sweden, this thanks to the so-called pumping law, which expressed an obligation to provide renewable fuels at stations that sold gasoline and diesel over a certain volume. It immediately appeared in the sales statistics, especially as the number of so-called flexi fuel cars, i.e. cars that can run on either gasoline or E85.
- E85 sales went from virtually zero in 2004 to just under 20,000 m^3 in 2005. In 2008 sales were up at just over 207,000 m^3. The peak year was 2011 with just over 220,000 m^3.
- But since then, E85 sales have collapsed as the fuel became more expensive, much thanks to tax increases. In 2017 just under 32,000 m^3 of E85 were sold.
- The reason for getting ethanol car owners running with E85 in the tank is thus economical. Since E85 (and E75 as it really is during the winter months because the petrol share then increases to 25 %) has lower energy content than gasoline, more E85 fuel per mile is required than if the same car is run on gasoline. Previously, 30-35 % higher consumption of ethanol in the tank was used. The environmental cost was thus higher than with gasoline in the tank.

Ethanol E85 today

- Since the beginning of 2018 E85 became tax free in Sweden, the government removed the tax on E85 and biodiesel at the end of 2017. As a result, the price of E85 fell in January 1, 2018. This means that it is now cheaper to drive on E85 than before, while it has become more expensive to run on gasoline as the tax on gasoline was raised at the said date.
- One might wonder if it has become cheaper to drive on E85 than on gasoline in Sweden? Not really. It actually costs more or less the same. However the Swedish ethanol* accounts for a considerably lower carbon dioxide load than gasoline.

How much does it cost to drive on E85 and gasoline?

- It is just as expensive (or cheap, depending on how you look at it) to drive on E85 like driving on gasoline, or just slightly more expensive.
- In this example we have taken two older ethanol cars that were common before and which are still rolling on the roads to a considerable extent, as well as a brand new ethanol model that is one of the few still sold. Noteworthy is that today's gasoline engines have become significantly more efficient than those that existed about ten years ago, even petrol engines that have been optimized to handle the E85 fuel.
- Calculations are based on each car's official consumption figures for mixed driving, for both fuel types, according to the European driving cycle
- And following prices for E85 (SEK 10.95 per L) and 95-octane gasoline (SEK 14.86 per L)

Volvo V70 2.0F 2008

- Mileage when driving on petrol (0.86 L / 10km)
- SEK 12.78 per 10km.

- Mileage for driving at E85 (1.20 L / 10km)
- SEK 13.14 per 10km.

- Advantage
- Petrol of SEK 0.36 per km.

How much does it cost to drive on E85 and gasoline today?

Ford Focus 1.8 FlexiFuel 2006

- Mileage when driving on petrol (0.70 L / 10km)
- SEK 10.40 per 10km

- Mileage cost when driving at E85 (1.05 L / 10km)
- SEK 11.50 per 10km

- Advantage
- Petrol with SEK 1.10 per 10km

Volkswagen Golf Sports Combi 1.4 TSI Multifuel 2018

- Mileage when driving on petrol (0.53 L / 10km)
- 7.88 SEK per 10km.

- Mileage cost when driving at E85 (0.72 L / 10km)
- 7.88 SEK per km.

- Advantage
- No winner with a difference of SEK 0.00.

Ethanol ED95

- ED95 is a renewable fuel that is produced / imported mainly by the Swedish company SEKAB, which is used for internal combustion engines in heavy vehicles such as trucks and buses. http://www.sekab.com/biofuel/ed95/
- ED95 consists of over 90% of 95% ethanol, ignition improvers, lubricants and other additives. The fuel is not compatible with E85, that is, you cannot use the ED95 in a Flexifuel car.
- ED95 reduces fossil carbon dioxide emissions and the proportion of soot and other particles and is not affected in the same way by global oil prices and crises compared to ordinary diesel.
- ED95 releases more of other harmful substances, such as various nitrogen oxides.
- Because of the lower energy content of the fuel, ethanol vehicles have a higher fuel consumption than a corresponding diesel vehicle.
- The smell from an ethanol vehicle can also be perceived as unpleasant, especially from older ones.
- ED95 engines are available from autumn 2015 in environmental classes up to Euro 6.

Ethanol ED95

- In 2015, it was mainly the Swedish truck and bus manufacturer Scania that opted for the fuel in newly manufactured vehicles in Sweden and Europe where they had a large selection of mainly city buses from the late 1980s onwards.
- However, Volvo made smaller series of ethanol buses intended for SL (Stockholm public transport) during the 1990s.
- In Sweden, the largest part has been invested in ethanol-powered buses by SL during the early 1990s.
- Since 2004, SL has instead investing in biogas and also biodiesel / RME / HVO and biodiesel hybrids
- Since 2014 the number of ethanol buses have decreased. SL and Sweden in general is investing more in biodiesel / RME / HVO, hybrid buses and biogas. Many ethanol buses have been converted to be able to run on biodiesel.
- The main reason that SL has withdrawn from investing in ethanol buses is the environmental goal for improved energy efficiency, the total cost (vehicle, fuel and maintenance) and the discussion/criticism that ethanol production is stealing land from food production (however this is also a concern for some types of HVO, depending how it is produced).
- Since all SL busses ca 2100 are now running on renewable fuels the focus has shifted to improve the total energy efficiency of the fleet (it is also an EU directive/law). Thus the less energy efficient alternatives (ethanol and even biogas) have become less attractive.
- Ethanol ED95 costs today 11,79 SEK per L for a business customer on a

Stockholm public transport bus fleet fuels

	Basline year : 2011	2017	2018
Person kilometres	1 792 000 000	1 899 000 000	1 880 000 000
Fuel and electricity consumtion in bus traffic (ca 2100 busses)			
Diesel [l] (5 % RME)	35 899 257	1 960	59 734
RME [l] (100 %)	3 338 647	21 786 130	36 651 588
HVO [l] (100%)	0	26 570 313	15 206 773
Etanol [l] (ED95 and E85)*	35 511 540	14 057 937	11 444 269
Biogas [Nm^3]	6 335 942	14 133 339	13 396 098
Electicity [MWh]	0	0	111
Share of renewable content based on energy content	44 %	97 %	97 %

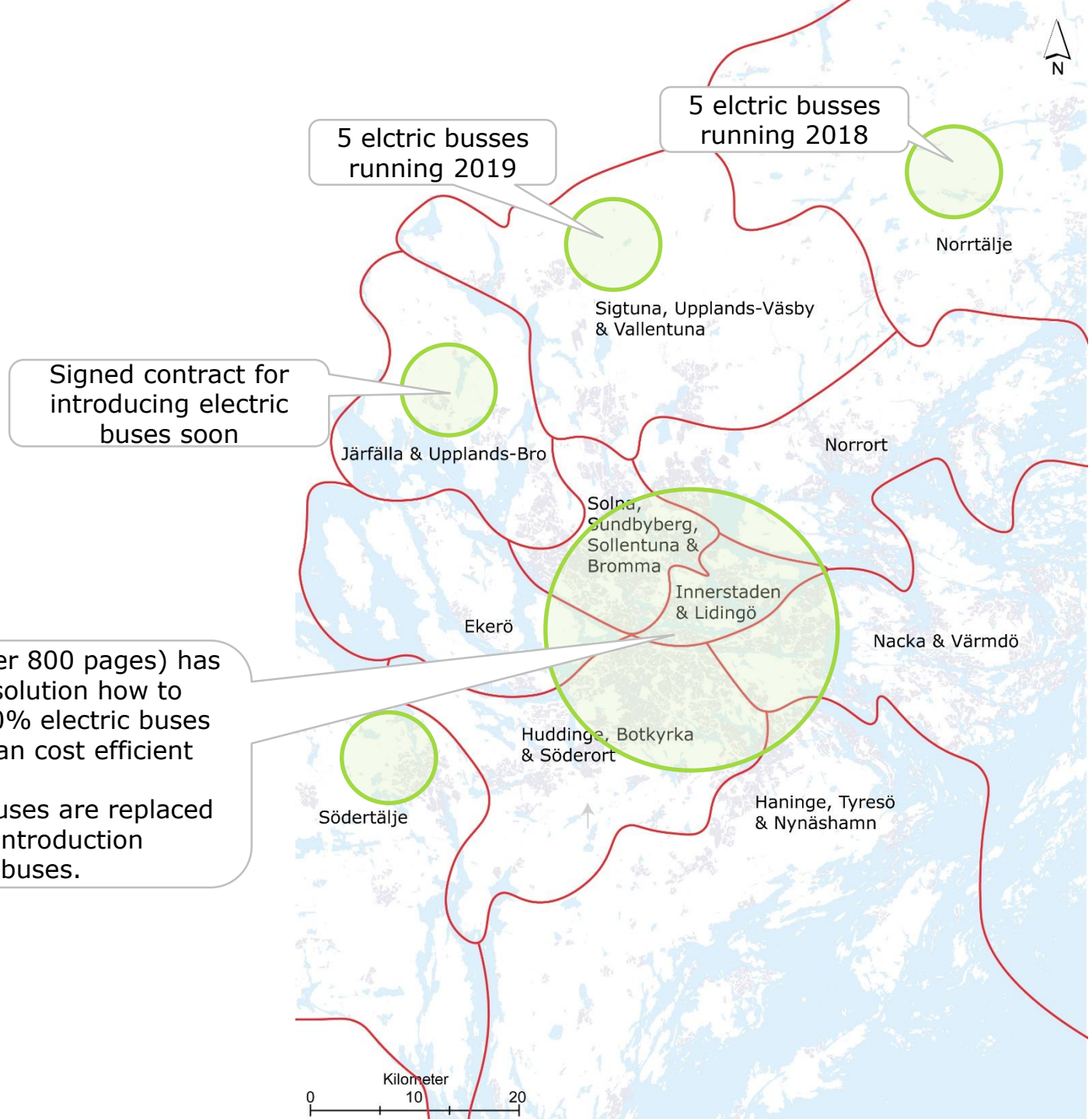
*ED95 is approximately 100 % of total ethanol consumption

ED95 bus

ED95 bus

Electric busses

- The potential in Stockholm County



The largest investigation study (over 800 pages) has just been finished to suggest a solution how to replace 119 biofuel buses with 100% electric buses in the inner city of Stockholm in an cost efficient manner.
During coming 10-15 yrs biofuel buses are replaced by electric buses by gradual introduction 40%-> 60%->100% of buses.

Electric self-driving bus

- Video: https://www.stockholmdirekt.se/nyheter/har-kor-sls-nya-forarlosa-bussar/reprjh!7Y0BINykPBbwSV8fFSIqQ/

Capacity: 11 passengers
Speed: 15-20 km/h