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THE COSTS-BENEFITS ANALYSIS OF ELECTRIC AND HYBRID VEHICLES IN THE SERBIAN TRANSPORT SECTOR

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INTRODUCTION

Considering the important role of electric vehicles (EVs) in transport and for the environment in most industrialised countries, it is somewhat surprising that few cost-benefit analyses (CBA) have been undertaken. CBA is a tool for comparing effects, positive and negative, of different activities or projects. To be able to make a comparison between different effects it is convenient to calculate all the effects in monetary units. Doing this requires simplifications, simplifications that can be more or less strong. It is important to be aware of the simplifications and to discuss these so that we can more easily see what the effects of them are on the result. So, rather than giving any precise measure of consequences of costs and benefits, this paper can hopefully contribute to our understanding of the order of magnitudes for different measures taken.

There are two types of EVs: battery electric vehicles (BEVs) and hybrid vehicles (HVs). Tehere are in practice many types of HVs which can be broadly categorised into two main types of HVs: hybrid gasoline vehicles (HGVs), which use gasoline as the “primary” energy, and hence is independent of central electricity production, and hybrid battery vehicles (HBVs), which are used as a BEV most of the time, and which also largely uses centrally produced electricity as primary energy, but which has a combustion engine largely as an auxiliary engine in order to increase performance and driving distance. In this paper we will focus on HGVs since it is more likely that they will become socially beneficial. However, for comparison we report some results for HBVs as well. Further, from the perspective of car manufacturers, there seems to be much more activity on HGVs compared to HBVs. Cars such as Toyota Prius and Honda Insight that already are at the market are indications of this.

We also undertake a partial and full CBA. In the partial CBA we simply calculate the net benefit of a switch of one driven vehicle kilometre (vkm) from conventional vehicles to an EV. In the full CBA we then include the costs infrastructures.

1 BASIC ASSUMPTIONS

1.1 Production costs for different vehicles

For BEVs, characteristics and incremental price are presented in Table 1; the baseline is a small gasoline car (Renault Clio size). The comparison is undertaken for two different battery capacities, where both are of Nickel-Metal Hydride (NiMH) type. We see directly that both the car weight and price increase drastically with battery capacity, and hence with driving range and performance.

Table 1: *Characteristics and incremental price for a small BEV, compared to a comparable gasoline car*

Characteristics BEV	Low range	High range
Weight	830	1720
Drag coefficient	0,28	0,28
Tire	0,008	0.008
Motor power, *kW*	41,5	81
Battery weight, *kg*	225	775
Battery size, *kWh*	16,9	58
Incremental price (over small car), EUR	6406	22686

For HGVs, characteristics and incremental price are presented in Table 2; the for the comparisons is instead a Volvo V70.

Table 2: *Characteristics and incremental price for a small HGVs relative to a comparable gasoline car*

Characteristics cars	Conventional car	Mild hybrid	Advanced hybrid
Weight	1290	1320	1340
Test weight	1418	1475	1475
Drag coefficient	0,28	0,28	0,28
Tire	0,008	0,008	0,008
Engine type	2,5L I-4	1,8L I-4	1,6L I-4
Motor power, *kW*	112	90	70
Elec. motor, *kW*	None	12	30
Valves	4 s VVT	4 s VVT	4 s VVT
Transmission	5-spd man.	5-spd man.	Elect. CVT
Axle ratio	3,73	3,27	3,27
City FC, *l/100km*	8	6,5	5,34
Highway FC, *l/100km*	5,3	5,2	4,8
Composite FC, *l/100km*	6,8	5,95	5,1
Battery	-	1 *kWh*, 12 *kW*	2,5 *kWh*, 30 *kW*
Incremental price, EUR	base	2197	4225

Tabele 3 presents the characteristics and prices for hybrid diesel trucks (HDTs), compared to conventional diesel trucks.

Table 3: *Characteristics and incremental price for conventional and hybrid diesel trucks*

Characteristics trucks	Conventional trucks	HDTs mild hybrid	HDTs advanced hybrid
Gross weight, *tons*	12	12	12
Payload, *tons*	6,5	6,5	6,2
Engine power, *kW*	165	125	125
Engine type	6L I-6 diesel	4L I-4 diesel	4L I-4 diesel
Elec. motor, *kW*	None	40	125
Generator, *kW*	None	None	90
Battery	None	6 *kWh*, 40 *kW*	12 *kWh*, 80 *kW*
Pure BEV range	None	None	12 to 15 *km*
Fuel cons., *l/100 km*	28	22,5	20,2
Incremental price, EUR	base	7575	28270

Tabele 4 presents the characteristics and prices for hybrid diesel bus (HDBs), compared to conventional diesel bus.

Table 4: *Characteristics and incremental price for conventional and hybrid diesel bus*

Characteristics bus	Conventional bus	HDBs mild hybrid	HDBs advanced hybrid
Gross weight, *tons*	17	17	17
Payload, *tons*	12,2	12,2	12,2
Engine power, *kW*	170	130	130
Engine type	6L I-6 diesel	4L I-4 diesel	4L I-4 diesel
Elec. motor, *kW*	None	40	130
Generator, *kW*	None	None	90
Battery	None	7 *kWh*, 40 *kW*	14 *kWh*, 80 *kW*
Pure BEV range	None	None	15 to 20 *km*
Fuel cons., *l/100 km*	29	23,5	21
Incremental price, EUR	Base	7665	28890

1.2 The costs of infrastructure

The cost of infrastructure could be important, especially when the costs have to be covered by a small amount of cars. Since the uncertainties are large, however, we will also consider the extreme case with no costs for the infrastructure. The use of BEVs will require investments in infrastructure. Introduction of BEVs will probably not imply that there is a need for invetments in thegeneral electricity net. Instead, investments for charging the vehicles are needed. There are two types of charging analysed: conventional (slow) charging (at home), and rapid charging (one station per 40 cars, distributed in the city-centre). The latter possibility turns out to be very expensive, even though the service level obviously increases since the risk of a sudden electricity shortage decreases. It should be noted, however, that also rapid charging is fairly slow compared to fuelling of gasoline, and may require almost some half an hour. If, say, there are two cars before you in the line this can obviously be very time consuming. It is therefore not at all obvious that such public investments are motivated, and we will present results with and without rapid charging. Based on Brannstrom (2000), the average annual infrastructure costs for slow charging is estimated to 82,5 EUR per vehicle. The additional annual cost for rapid charging is estimated to 855 EUR per vehicle.

1.3 Emission factors

The envronmental costs associated with different types of vehicles constitute an important part of our analysis. There are two important components: the emissions associated with different vehicles, and the valuation of these emissions. For the emissions factors for gasoline and diesel vehicles we use the estimates by Ahlvik et al. (1996). These are estimated average emission factors, during the lifetime of a car of a certain vintage, based on many sources including decided and planned future emission standards within the EU. Factors such as increasing emission with age of the vehicle and cold-start effects are accounted for. We assume that emission factors for HGVs are 50% of the emission factors for gasoline cars (except for CO_2 where emissions are proportional tothe fuel use, implying about 75% of the emission factors for gasoline cars); for HBVs we assume the emissions factors (except for CO_2 and indirect emissions from electricity production) are 20% of the emission factors for gasoline cars. Furthermore we assume that BEVs do not produce any local or regional emissions.

Table 5: *Estimated emission factors for vehicles of different vintages*

Vintage	VOC, *g/km*	NO_x, *g/km*	Particles-Pm, *mg/km*
Passenger cars, gasoline (city)			
1995	1,87	0,34	7
2005	0,81	0,09	3
Passenger cars, diesel (city)			
1995	0,27	0,82	63
2005	0,12	0,28	27
Passenger cars, hybrid gasoline (mild)			
1995	0,45	0,13	6,5
2005	0,19	0,04	2,6
Passenger cars, hybrid gasoline (advanced)			
1995	0,22	0,07	3,25
2005	0,1	0,02	1,3
Passenger cars, hybrid electric			
1995	0,18	0,05	2,6
2005	0,08	0,02	1,2
Trucks/bus, diesel			
1995	0,72	9,7	200
2005	0,3	4,9	100

1.4 Emissions from electricity production

The important question here is what consequences in terms of emissions that an additional kWh electricity produced will cause, and not the average consequences from all the electricity currently produced.

For the purpose of CBA, we will look at three different cases:

1. Clean non-fossil alternative. There are no external costs from electricity production.
2. Clean fossil alternative. The electricity is produced by fossil fuel (natural gas).
3. Fossil alternative. The electricity is produced by fossil fuel (coal).

We argue that the third alternative is in principle the most reasonable one, and that the first alternative should be viewed as an extreme case.

1.5 Noise costs

Unfortunately, there is very little done on estimating the external noise cost per km for different vehicles, under varying circumstances. Still, we know that EVs, and hybrid vehicles, are less noisy than gasoline and diesel vehicles, and ignoring these differences would obviously bias the CBA estimates.

Table 6: *Assumed external noise costs from different vehicles, EUR/100 km*

Different vehicles	External cost, EUR/100km
Gasoline or diesel passenger cars	0,6
BEV	0,1
HBV	0,2
HGV (mild)	0,4
HGV (advanced)	0,4
Diesel truck	6
HDT (mild)	3
HDT (advanced)	3
Diesel bus	5,8
HDB (mild)	2,9
HDB (advanced)	2,9

It is sometimes argued that there are negative side effects of these more quite vehicles, since it would be more difficult to discover them, and hence that safety could be worsened. On the other hand, one could also argue that noise makes it more difficult to concentrate, and to communicate with other people, such as children, and hence that safety could improve by lowering the noise levels. In the lack of clear evidence on this point we assume that the net effect is zero, i.e., we do not include any possible indirect effects on safety.

1.6 Willingness to pay for non-conventional vehicles

One important part of the possibility and effects of an introduction of non-conventional powered vehicles is the consumers maximum willingness to pay (WTP) for these vehicles, and the corresponding effects on consumer welfare. There are several differences between standard vehicles and alternative fuel vehicles, and these differences will of course affect the WTP. It is difficult to predict what the price of an EV would be for it to compete with conventional cars, since there are very few studies on the willingness to pay for EVs. We can use the parameter estimates in Ewing and Sarigollu (1998) to simulate the price of BEVs that would result in a specific market share.

Table 7: *Levels of attributes for gasoline and electric cars*

	Gasoline car	BEV
Repair and maintenance cost, EUR	1000	1000
Range, *km*	300	300
Refuel rate, *min*	5	300
Emission rate (compared with EV)	65%	-
Travel time, *h*	4	4
Trip to work cost, EUR/sedmici	21	0

We assume that a conventional car that is comparable with the BEV in other respects costs 10500 EUR. We assume thatthe travel time (one-way) is the same for both cars. The assumption about an equal repair and maintenance cost is also crucial for the results. These values together imply that the electric car must not cost more than approximately 11000 EUR, i.e. roughly the same price as the gasoline vehicle.The today market price BEV is 17400 EUR.

For HGVs, HDTs and HDBs we assume that the only difference from a standard gasoline vehicle is the gasoline consumption, and that a car buyer is indifferent between the two types of vehicles when the price difference between them is equal to the difference in expected cost of gasoline use. We assume an expected life-length of 17 years for all vehicles.

For HGVs (mild) the difference in gasoline consumption is (6,8-5,95)·150=144 litres per year and for the HGVs (advanced) the difference is (6,8-5,1)·150=255 litres per year (assuming an average driving distance of 15000 kilometres per year). With a fixed real gasoline price of 1 EUR, this implies that the present value of the cost savings is 17·144·1=2448 EUR and 17·255·1=4335 EUR respectively.

For HDTs (mild) the difference in diesel consumption is (28-22,5)·300=1650 litres per year and for the HDTs (advanced) the difference is (28-20,2)·300=2340 litres per year (assuming an average driving distance of 30000 kilometres per year). With a fixed real diesel price of 0,8 EUR, this implies that the present value of the cost savings is 17·1650·0,8=22440 EUR and 17·2340·0,8=31824 EUR respectively.

For HDBs (mild) the difference in diesel consumption is (29-23,5)·300=1650 litres per year and for the HDBs (advanced) the difference is (29-21)·300=2400 litres per year (assuming an average driving distance of 30000 kilometres per year). With a fixed real diesel price of 0,8 EUR, this implies that the present value of the cost savings is 17·1650·0,8=22440 EUR and 17·2400·0,8=32640 EUR respectively. These cost savings have to be compared with the estimated incremental prices for each vehicle (see table 2, 3 and 4).

Table 8: *Consumer surplus (CS) used in the CBA, EUR*

Different vehicles	CS (cost saving-incremental price)
BEV	11000-17400= -6400
HGV (mild)	2448-2197=251
HGV (advanced)	4335-4225=110
HDT (mild)	22440-7575=14865
HDT (advanced)	31824-28270=3554
HDB (mild)	22440-7665=14775
HDB (advanced)	32640-28890=3840

2 COST-BENEFIT ANALYSIS

2.1 External costs per distance unit

Given the discussion above we can calculate the environmental cost per 100 km for the different types of vehicles. The results are reported in tabeles 9, 10, and 11.

Table 9: *Estimated external environmental costs for passenger cars, EUR/100 km*

Local env. costs	Regional env. costs	Base CO_2	High CO_2	Noise	Env. costs base CO_2	Env. costs high CO_2
Gasoline passenger cars						
0,18	0,08	0,59	2,35	0,6	1,45	3,2
Diesel passenger cars						
1,15	0,04	0,51	2,01	0,6	2,3	3,8
Battery electric passenger cars, clean non-fossil electricity production						
0	0	0	0	0,1	0	0
Battery electric passenger cars, clean fossil electricity production						
0	0	0,17	0,67	0,1	0,27	0,77
Battery electric passenger cars, fossil electricity production						
+	0,05	0,17	0,67	0,1	0,32	0,82
HBV, clean non-fossil electricity production						
0,03	0,01	0,12	0,46	0,2	0,35	0,7
HBV, clean fossil electricity production						
0,03	0,01	0,25	1	0,2	0,49	1,24
HBV, fossil electricity production						
0,03	0,03	0,25	1	0,2	0,51	1,26
HGV (mild)						
0,07	0,02	0,52	2,05	0,4	1,01	2,54
HGV (advanced)						
0,03	0,01	0,45	1,76	0,4	0,89	2,21

We can see that the environmental costs generally increase drastically when the larger CO_2 valuation is used.

For passenger cars we see that diesel cars have higher associated environmental costs compared to gasoline cars. The difference is largely due to higher emissions of particles, which in turn are considered the most important emissions from a human health perspective. Diesel cars have typically lower CO_2 costs, but this difference is perhaps smaller than one might think when simply comparing fuel consumption in litre/km. First, diesel has a higher energy content per litre and, second, diesel causes higher CO_2 emissions per energy unit as well.

BEVs have in general lower environmental costs, as expected. However, we also see that BEVs actually have higher CO_2 costs than gasoline and diesel cars when we assume fossil (coal) electricity production. The reason for this is a combination of relatively inefficient BEVs today and the fact that the fossil electricity production is relatively energy inefficient. We also see that the regional enviromental costs from electricity production are non-negligible but smaller than the corresponding regional environmental costs from gasoline and diesel cars.

For trucks and bus the local environmental costs, particularly in larger cities, are assumed to be substantial, largely due to pariculate emissions but also noise. We see that noise costs contribute largely to the environmental costs and that the CO_2 valuation case.

Table 10: *Estimated external environmental costs for city trucks, EUR/100 km*

Local env. costs	Regional env. costs	Base CO_2	High CO_2	Noise	Env. costs base CO_2	Env. costs high CO_2
Diesel trucks						
5,28	1,37	2,82	11,15	6	15,47	23,79
HDT (mild)						
2,23	0,58	1,87	7,37	3	7,67	13,17
HDT, clean non-fossil electricity production						
2,23	0,58	1,73	6,84	3	7,54	12,64
HDT, clean fossil electricity production						
2,23	0,58	1,85	7,29	3	7,65	13,09
HDT, fossil electricity production						
2,23	0,59	1,85	7,29	3	7,67	13,11

Table 11: *Estimated external environmental costs for city bus, EUR/100 km*

Local env. costs	Regional env. costs	Base CO_2	High CO_2	Noise	Env. costs base CO_2	Env. costs high CO_2
Diesel bus						
5,28	1,37	2,82	11,15	6	15,47	23,79
HDB (mild)						
2,23	0,58	1,87	7,37	3	7,67	13,17
HDB, clean non-fossil electricity production						
2,23	0,58	1,73	6,84	3	7,54	12,64
HDB, clean fossil electricity production						
2,23	0,58	1,85	7,29	3	7,65	13,09
HDB, fossil electricity production						
2,23	0,59	1,85	7,29	3	7,67	13,11

2.2 Partial cost-benefit analysis

Partial costs-benefit analysis includes only the effects on the environment. The results are reported in tabele 12-17.

Table 12: *Net benefit in EUR/100 km of replacing a gasoline passenger car by a BEV*

Environmental benefit low CO_2	Environmental benefit high CO_2
Clean non-fossil electricity production	
1,45-0,10=1,35	3,2-0,10=3,1
Clean fossil electricity production	
1,45-0,27=1,18	3,2-0,77=2,43
Fossil electricity production	
1,45-0,32=1,13	3,2-0,82=2,38

Table 13: *Net benefit in EUR/100 km of replacing a gasoline passenger car by a HV*

Environmental benefit low CO_2	Environmental benefit high CO_2
HGV (mild)	
1,45-1,01=0,44	3,2-2,54=0,66
HGV (advanced)	
1,45-0,89=0,56	3,2-2,21=0,99
HBV, clean non-fossil electricity production	
1,45-0,35=1,1	3,2-0,70=2,5
HBV, clean fossil electricity production	
1,45-0,49=0,96	3,2-1,24=1,96
HBV, fossil electricity production	
1,45-0,51=0,94	3,2-1,26=1,94

Table 14: *Net benefit in EUR/100 km of replacing a diesel passenger car by a BEV*

Environmental benefit low CO_2	Environmental benefit high CO_2
Clean non-fossil electricity production	
2,3-0,10=2,2	3,8-0,10=3,7
Clean fossil electricity production	
2,3-0,27=2,03	3,8-0,77=3,03
Fossil electricity production	
2,3-0,32=1,98	3,8-0,82=2,98

Table 15: *Net benefit in EUR/100 km of replacing a diesel passenger car by a HV*

Environmental benefit low CO_2	Environmental benefit high CO_2
HGV (mild)	
2,3-1,01=1,29	3,8-2,54=1,26
HGV (advanced)	
2,3-0,89=1,41	3,8-2,21=1,59
HBV, clean non-fossil electricity production	
2,3-0,35=1,95	3,8-0,70=3,1
HBV, clean fossil electricity production	
2,3-0,49=1,81	3,8-1,24=2,56
HBV, fossil electricity production	
2,3-0,51=1,79	3,8-1,26=2,54

Table 16: *Net benefit in EUR/100 km of replacing a diesel truck by a HDT*

Environmental benefit low CO_2	Environmental benefit high CO_2
HDT (mild)	
15,47-7,67=7,8	23,79-13,17=10,62
HDT (advanced)	
15,47-7,54=7,93	23,79-12,64=11,15

Table 17: *Net benefit in EUR/100 km of replacing a diesel truck by a HDB*

Environmental benefit low CO_2	Environmental benefit high CO_2
HDB (mild)	
15,48-7,69=7,79	23,8-13,19=10,61
HDB (advanced)	
15,48-7,56=7,92	23,8-12,66=11,14

2.3 Full cost-benefit analysis

In addition to the cost and benefit components included in the last sub-section, we include here the consumer surplus (CS) and infrastructure investments needed. In CBA we assume that the average driving distance is 15000 kilometres per year for each vehicle, and that all replaced vehicles are gasoline cars or diesel trucks and bus. For trucks and bus we assume that the average driving distance is 30000 kilometres. The results are reported in tabeles 18-24.

In table 18 we see that BEVs are socially very unprofitable in all cases except from the case with the extreme assumptions of a high valuation of CO_2 emissions, completely clean electricity production and no rapid charge of the electric vehicles. We can also see that rapid charging appears to be very expensive and constitute a large part of the social deficit.

Table 18: *Annual social net benefit of replacing a gasoline passenger car by a BEV, EUR*

Clean non-fossil electricity production			
		Low CO_2	High CO_2
Environmental benefit		1,35·150·17=3442,5	3,1·150·17=7905
CS		-7400	-7400
Infrastructure	No rapid charge	-82,5	-82,5
	Rapid charge	-855	-855
Total	No rapid charge	-4040	422,5
	Rapid charge	-4812,5	-350
Clean fossil electricity production			
		Low CO_2	High CO_2
Environmental benefit		1,18·150·17=3009	2,43·150·17=6196,5
CS		-7400	-7400
Infrastructure	No rapid charge	-82,5	-82,5
	Rapid charge	-855	-855
Total	No rapid charge	-4473,5	-1286
	Rapid charge	-5246	-2058,5
Fossil electricity production			
		Low CO_2	High CO_2
Environmental benefit		1,13·150·17=2881,5	2,38·150·17=6069
CS		-7400	-7400
Infrastructure	No rapid charge	-82,5	-82,5
	Rapid charge	-855	-855
Total	No rapid charge	-4601	-1413,5
	Rapid charge	-5373,5	-2186

Hybrid vehicles, on the other hand, are much more promising. We focus on hybrids that are not grid-charged, since grid-charged, since grid-charged vehicles are expected to be very expensive, and they require some additional infrastructure investment. Further, their performance compared to various kinds of HGVs is expected to be inferior. We see that the most basic kind, denoted mild HGVs (table 19), which will never be driven as a pure BEV, are generally more profitable from a social perspective than advanced HGVs (tabele 20), which will be powered as a pure BEV below a certain speed (e.g. 15 km/h). The mild and advanced HGV are profitable.

Table 19: *Annual social net benefit of replacing a gasoline passenger car by a HGVs (mild), EUR*

	Low CO_2	High CO_2
Environmental benefit	0,44·150·17=1122	0,66·150·17=1683
CS	251	251
Total	1373	1934

Table 20 *Annual social net benefit of replacing a gasoline passenger car by a HGVs (advanced), EUR*

	Low CO_2	High CO_2
Environmental benefit	0,56·150·17=1351	0,99·150·17=2524,5
CS	110	110
Total	1461	2634,5

Tabele 21 and 22 provides the results for hybrid trucks, of which the advanced type is possible to grid-charge, and hence is possible to use as a pure BEV truck for shorter distances. Nevertheless, despite better environmental performances with respect to local and regional pollutants, the mild HDT is profitable.

Table 21 *Annual social net benefit of replacing a diesel truck by a HDT (mild), EUR*

	Low CO_2	High CO_2
Environmental benefit	7,8·300·17=39780	10,62·300·17=54162
CS	14865	14865
Total	54645	69027

Table 22 *Annual social net benefit of replacing a diesel truck by a HDT (advanced), EUR*

	Low CO_2	High CO_2
Environmental benefit	7,93·300·17=40443	11,15·300·17=56865
CS	3554	3554
Total	43997	60419

Table 23 *Annual social net benefit of replacing a diesel bus by a HDB (mild), EUR*

	Low CO_2	High CO_2
Environmental benefit	7,79·300·17=39729	10,61·300·17=54111
CS	14775	14775
Total	54504	68886

Tabele 23 and 24 provides the results for hybrid bus.

Table 24 *Annual social net benefit of replacing a diesel bus by a HDB (advanced), EUR*

	Low CO_2	High CO_2
Environmental benefit	7,92·300·17=40392	11,14·300·17=56814
CS	3840	3840
Total	44232	60654

CONCLUSIONS

There are a number of conclusions or insights that appear to be fairly robust. First, compared to conventional gasoline passenger cars, BEVs seem simply not to be profitable, unless an unanticipated major breakthrough in battery technology takes place. Second, there are a number of other EVs that appear to be much more promising from a social point of view, including various kinds of HGVs, HDTs and HDBs. Obviously, if there would be a surprising technological breakthrough in battery technology, which would largely improve performance at a much lower cost then we can certainly not rule out BEVs. Similarly, if the development of disel trucks and bus will be better with respect to noise, fuel economy, and fine particle emissions, then the profitability of HDTs and HDBs will correspondingly decrease, or even possibly disappear.

There are also issues worth reflecting on which that are normally not part of a conventional CBA, but which may nevertheless be important from a social welfare point of view. For example, technological path dependency is obviously a crucial phenomenon in the history of development of cars, and of engines in particular. Indeed, if starting from scratch with each possible technology today, it seems very unlikely that such an odd and complicated technology such as Otto-engine would even be considered to be a reasonable option. Still, we do not start from scratch, and billions of dollars have been put into the development of this peculiar technology. Hence, trying to affect the path to an overall more beneficial one by “creating the market” for EVs seems very difficult, and it is possible that some policy makers (and others) have been overly optimistic in this respect. Still, there is of course a social value of knowledge with respect to different technologies etc, e.g. since we do not know which technologies that will survive and develop in a few decade perspectives.

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