Society's costs and benefits of electric vehicle incentives

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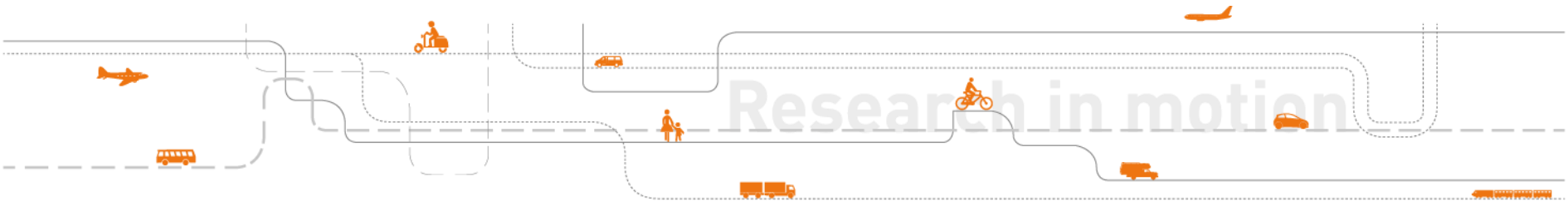

What do we mean by costs?

- Not taxes or subsidies. These are just redistributive transfers.
- The economic cost of public expenditure (or foregone revenue) is determined by the marginal cost of public funds (MCF), due to resource misallocation (tax distortion)
- By convention, in Norway MCF = 0.2. Hence, it costs € 0.20, in terms of reduced value added, to raise an extra € in tax.

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Deadweight loss

- Recent research (Bjertnæs 2015), suggests that MCF = 0.05 for income tax and VAT.
- The welfare loss caused by distortionary taxation is referred to by economists as the deadweight loss, given by the change in consumer surplus.
- …. but change compared to what benchmark?

Scope of analysis presented here

The welfare cost has a tangible and an intangible component.

- Tangible costs show up in the GDP, in the value added, and in the bank accounts, books and wallets of businesses, public agencies and private households – as objective cash flows.
- Intangible costs are subjective (dis)advantages affecting utility: time losses/savings, consumer (dis)satisfaction, range anxiety/certainty. Their value is measured in terms of willlingness-to-pay – the fundamental principle of cost-benefit analysis (CBA). The deadweight loss in intangible, like leisure time and travel time savings.

Only tangible costs and benefits are considered in this presentation. We do not present a full CBA.

Rather than asking what the situation would have been with some other, hypothetical tax system, we compare two alternative scenarios for the future.

Incentives for zero emission vehicles in Norway

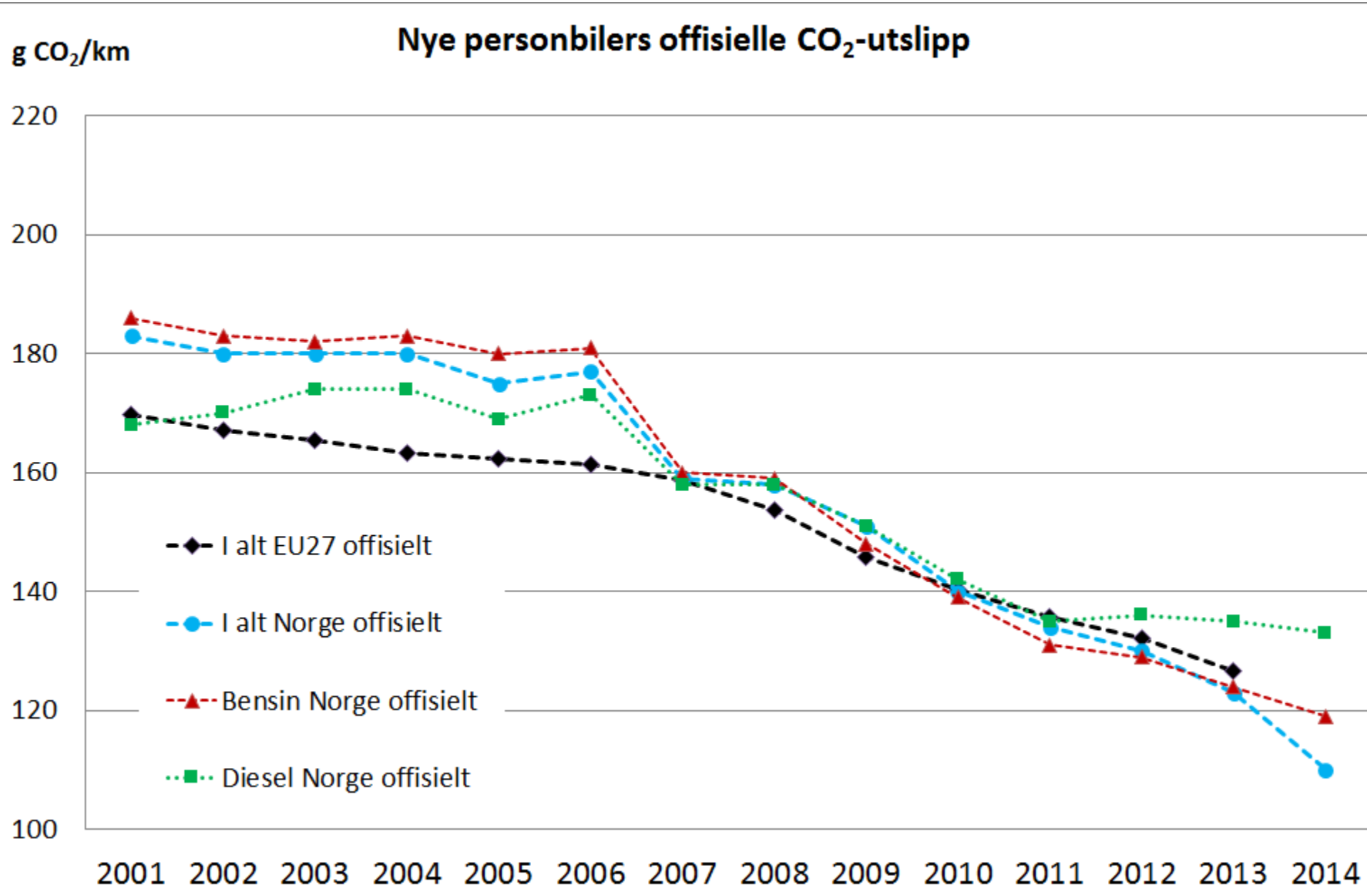
Battery electric vehicles (BEVs) and fuel cell electric vehicles (FCEV) are exempt of

- value added tax,
- vehicle purchase tax,
- road tolls and public parking charges.

They benefit from

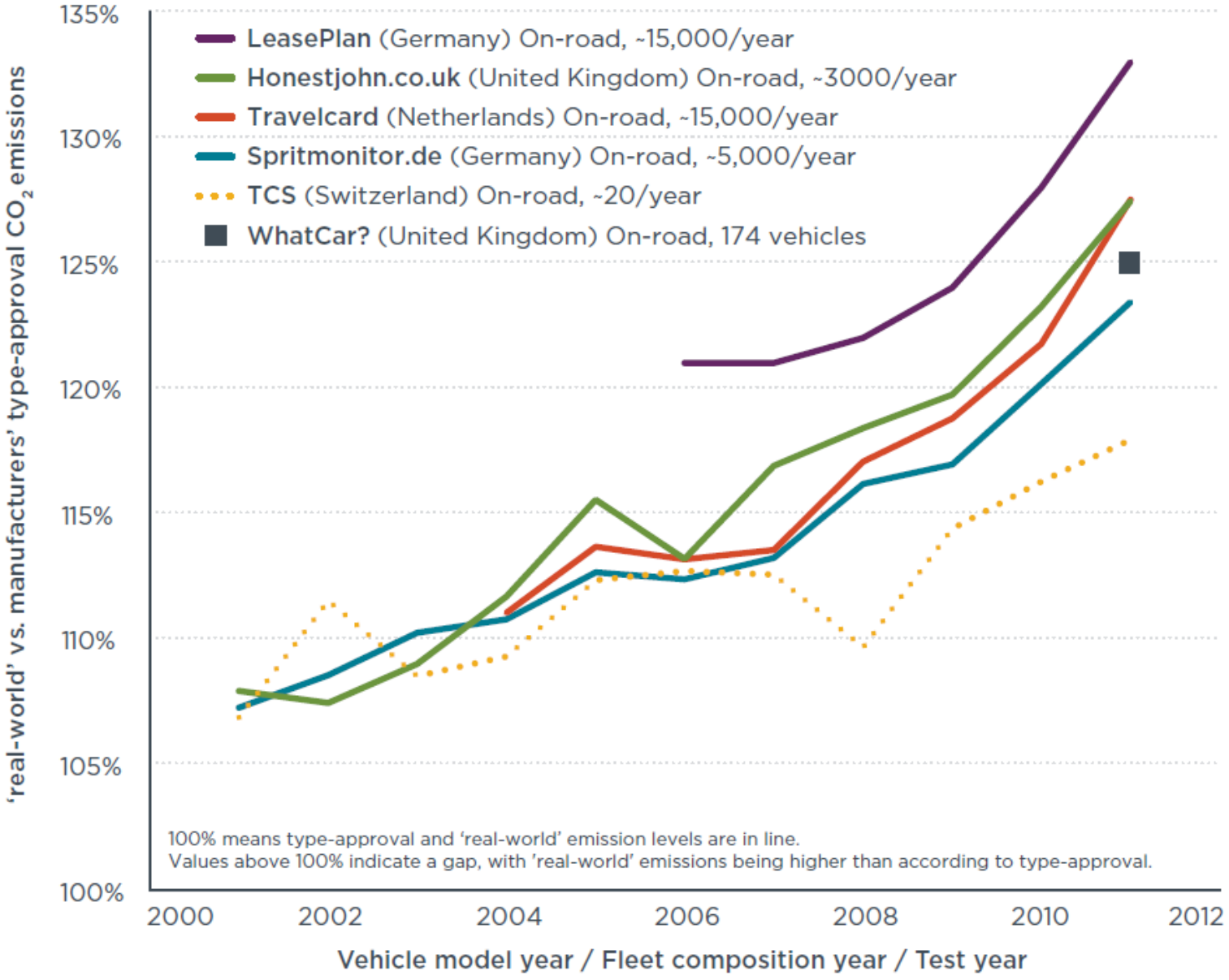
- strongly reduced annual registration tax
- reduced income tax on company cars
- reduced ferry fares (at most equal to those payable for MCs)
- access to the bus lane
- free public parking, often with
- free recharging.

Type approval (NEDC) CO_2 emission rates



Increasing gap between laboratory measurements and real world emissions on the road

Source:
Mock et al. (2013)



Divergence, real-world vs. manufacturers' type-approval CO_2 emissions for various on-road data sources.[1]

Real-world emissions exceed type approval rates. Source: Mock et al. 2014

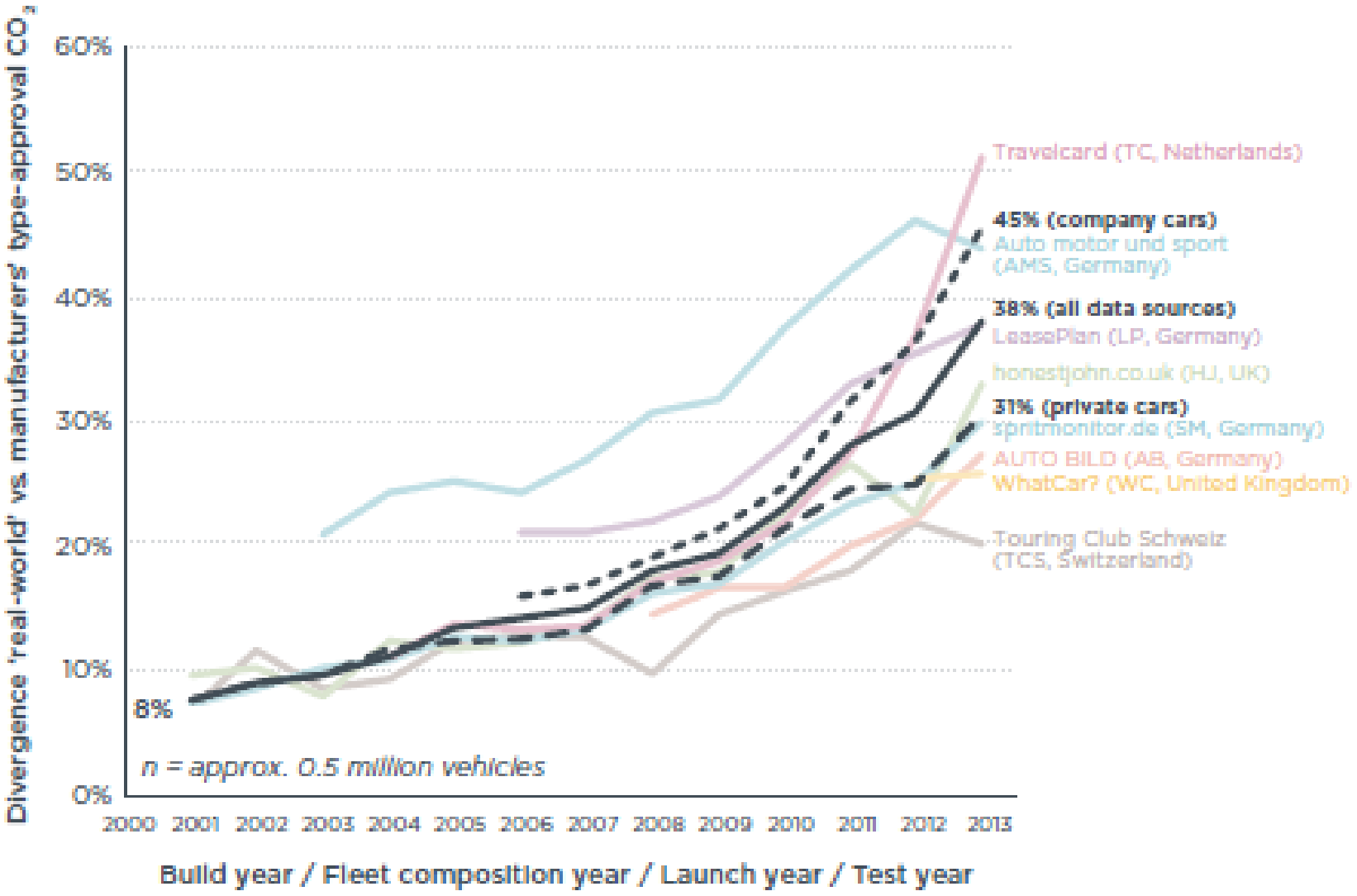
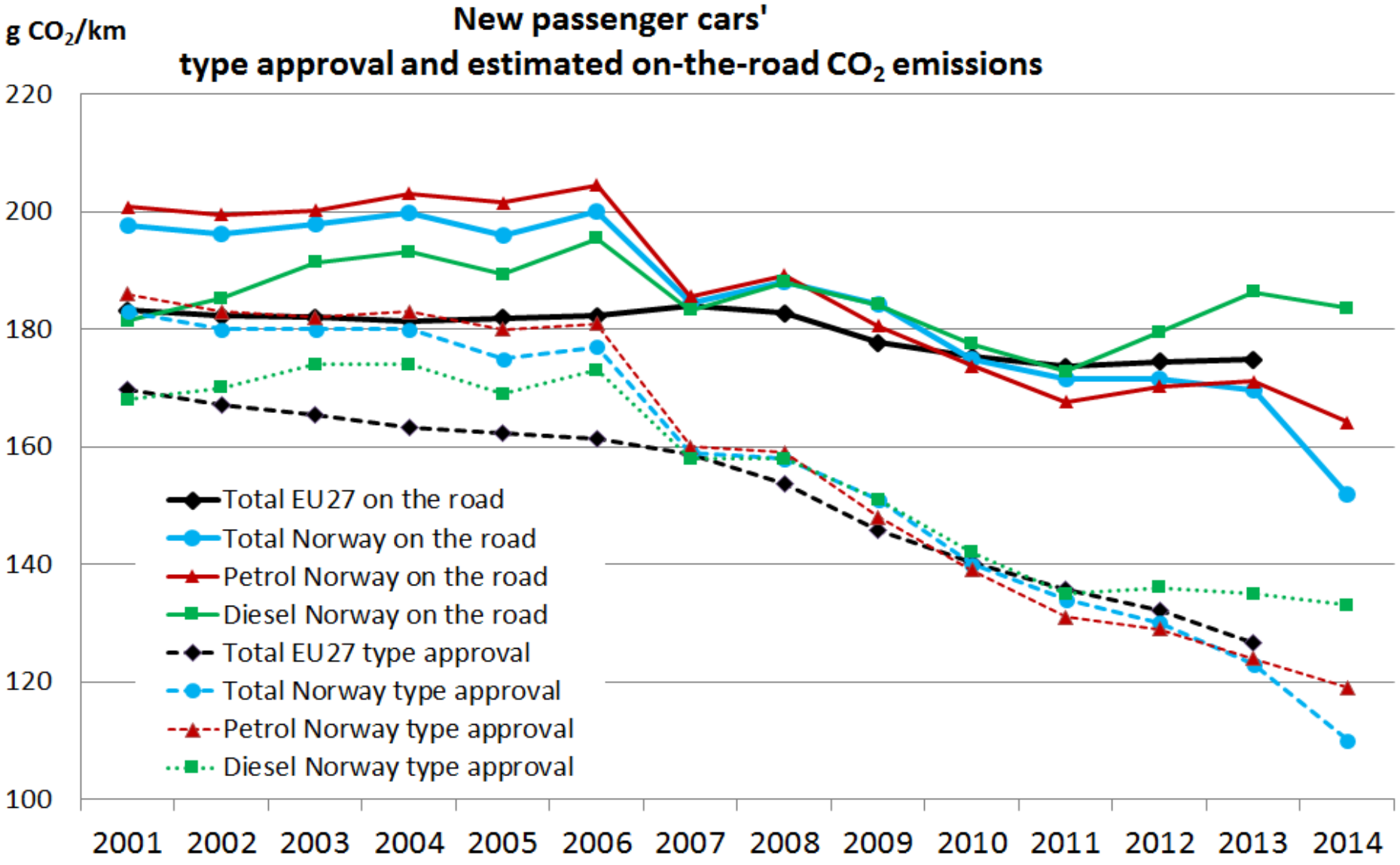
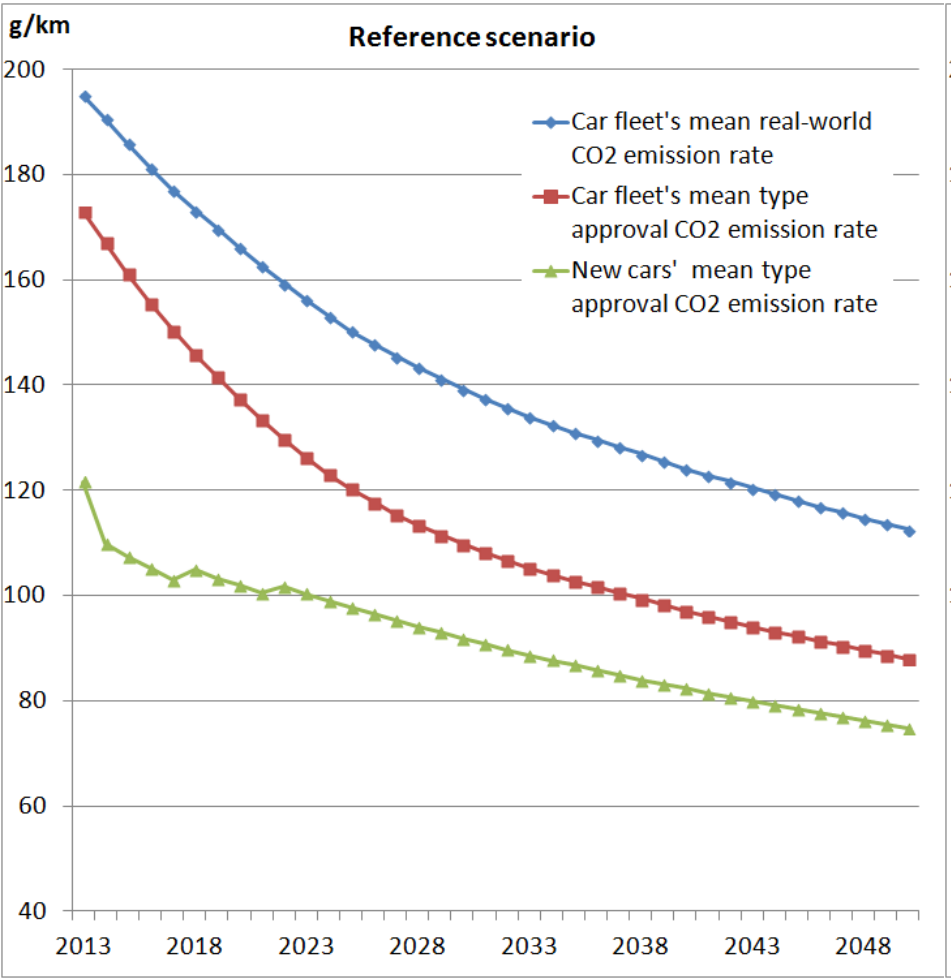


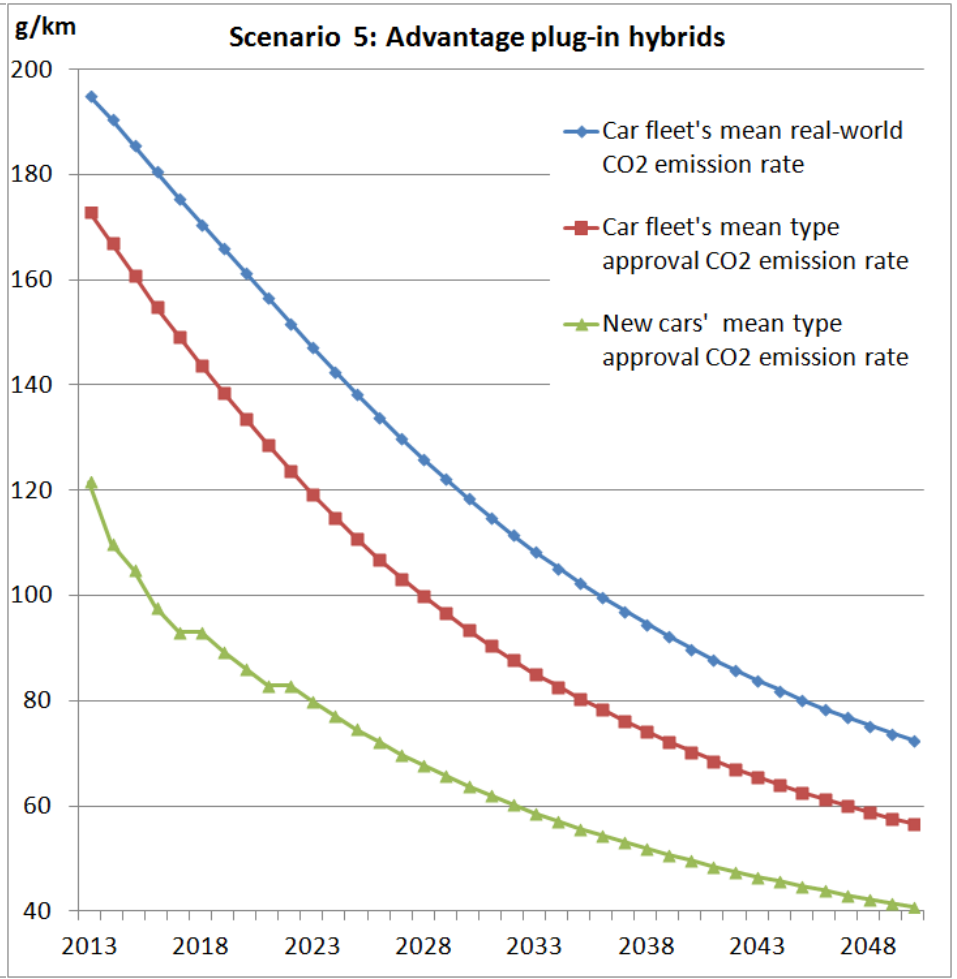
Figure 1. Divergence of real-world CO_2 emissions from manufacturers' type-approval CO_2 emissions for various on-road data sources, including an average estimate for private and company cars as well as all data sources.

The NEDC test lies

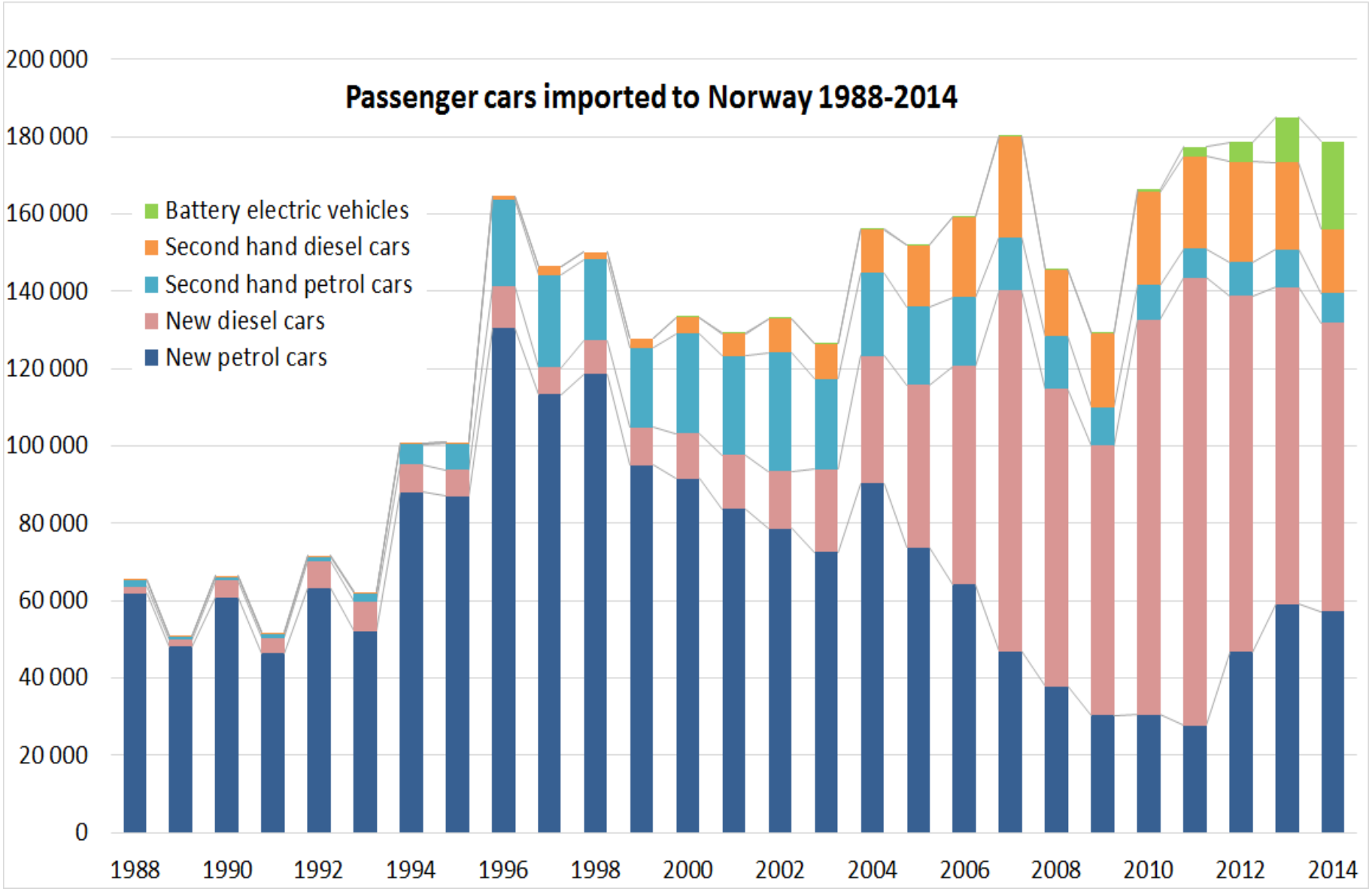


Three metrics, two scenarios





Market shares in Norway



Reference and intervention scenarios

Intervention: steeper CO_2 purchase tax component

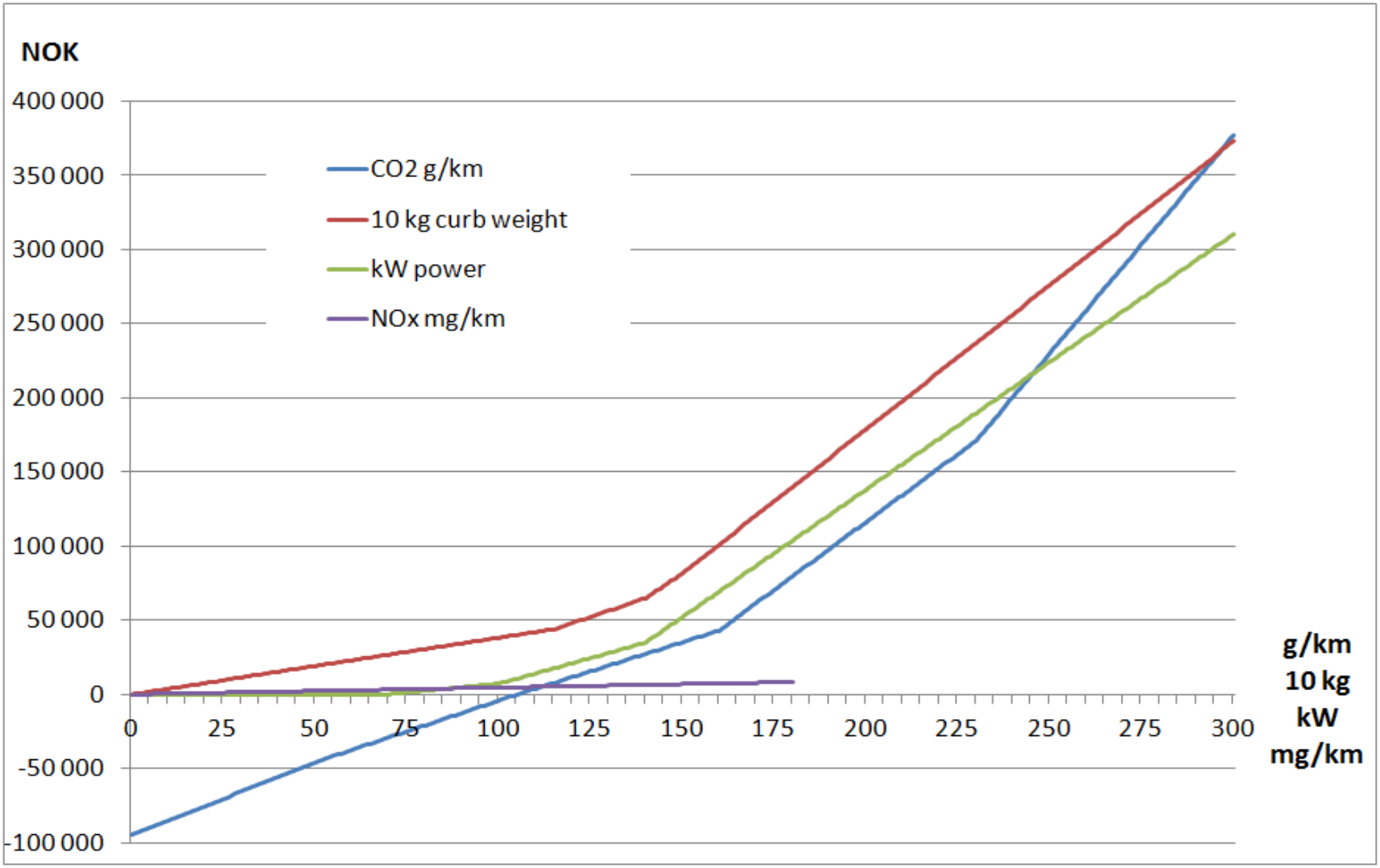
Scenario 8: Reference path with quick price convergence between rechargeable vehicles and conventional cars (ICE vehicles).

Scenario 9: Intervention path with quick price convergence between rechargeable vehicles and conventional cars (ICE vehicles). Compare to Scenario 8.

Scenario 10: Reference path with slow price convergence between rechargeable vehicles and conventional cars (ICE vehicles).

Scenario 11: Intervention path with slow price convergence between rechargeable vehicles and conventional cars (ICE vehicles). Compare to Scenario 10.

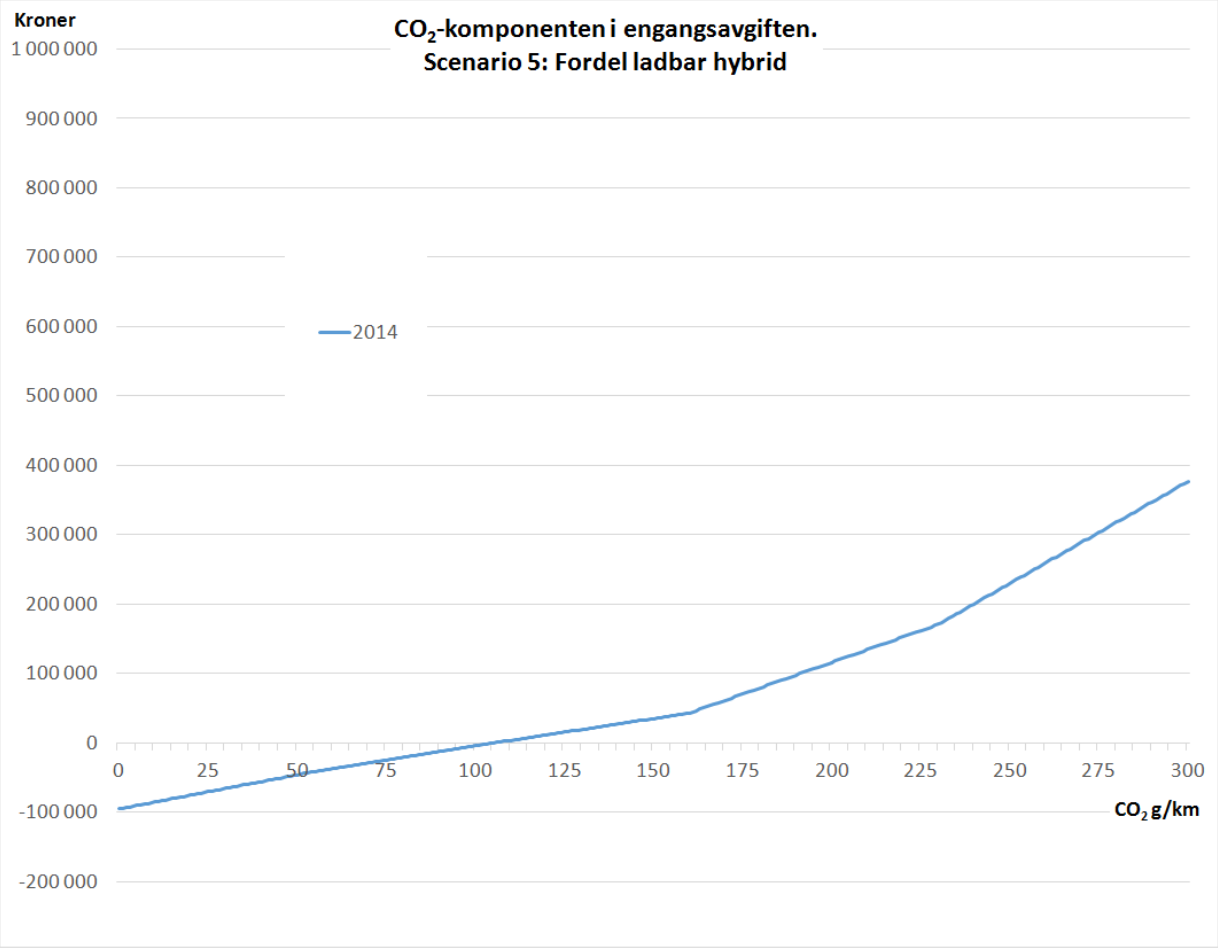
The purchase tax on new passenger cars in Norway 2014



As of 11 June 2014, € 1 = NOK 8.10.

2014:

The CO_2 component of the vehicle purchase tax



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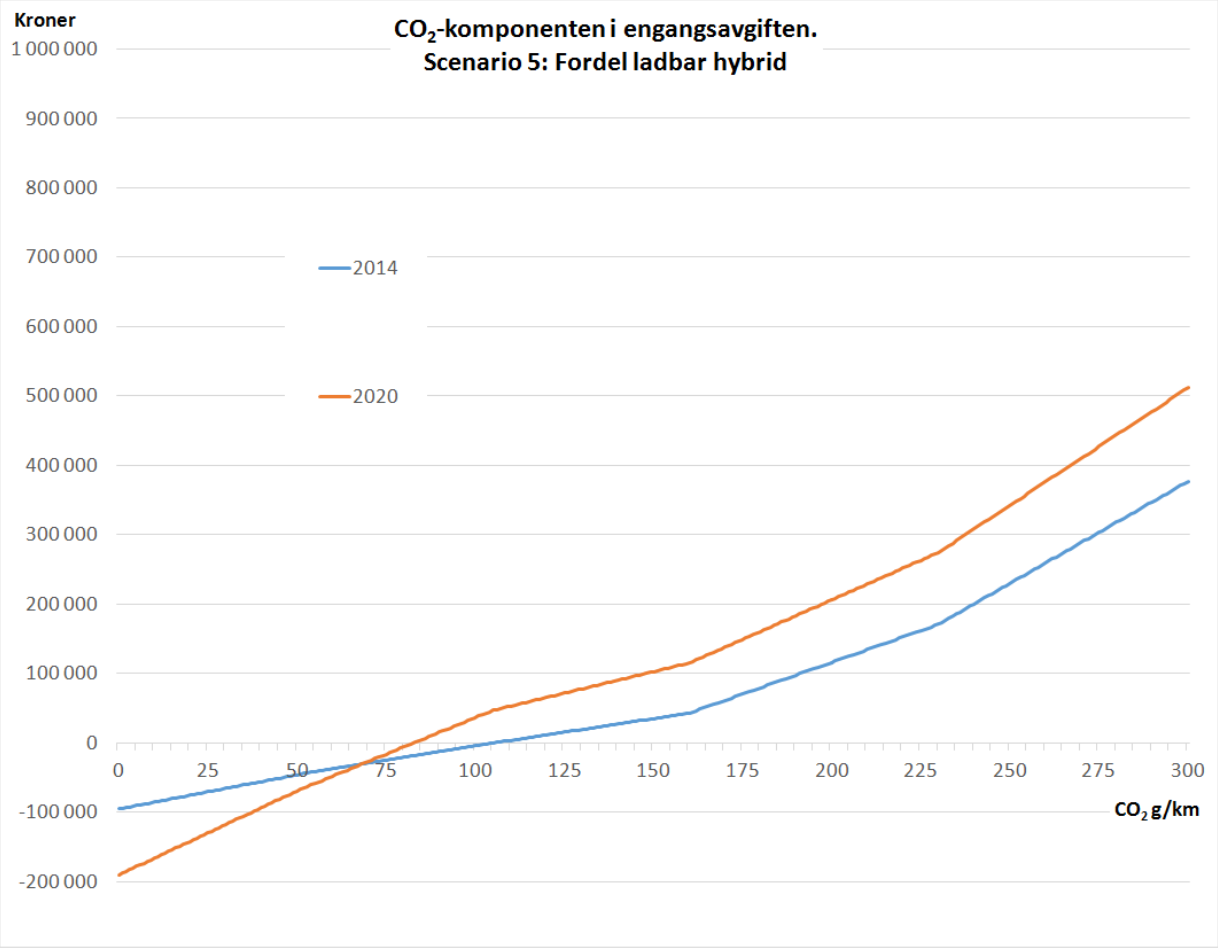
Intervention scenario 2020:
The CO_2 component of the vehicle purchase tax



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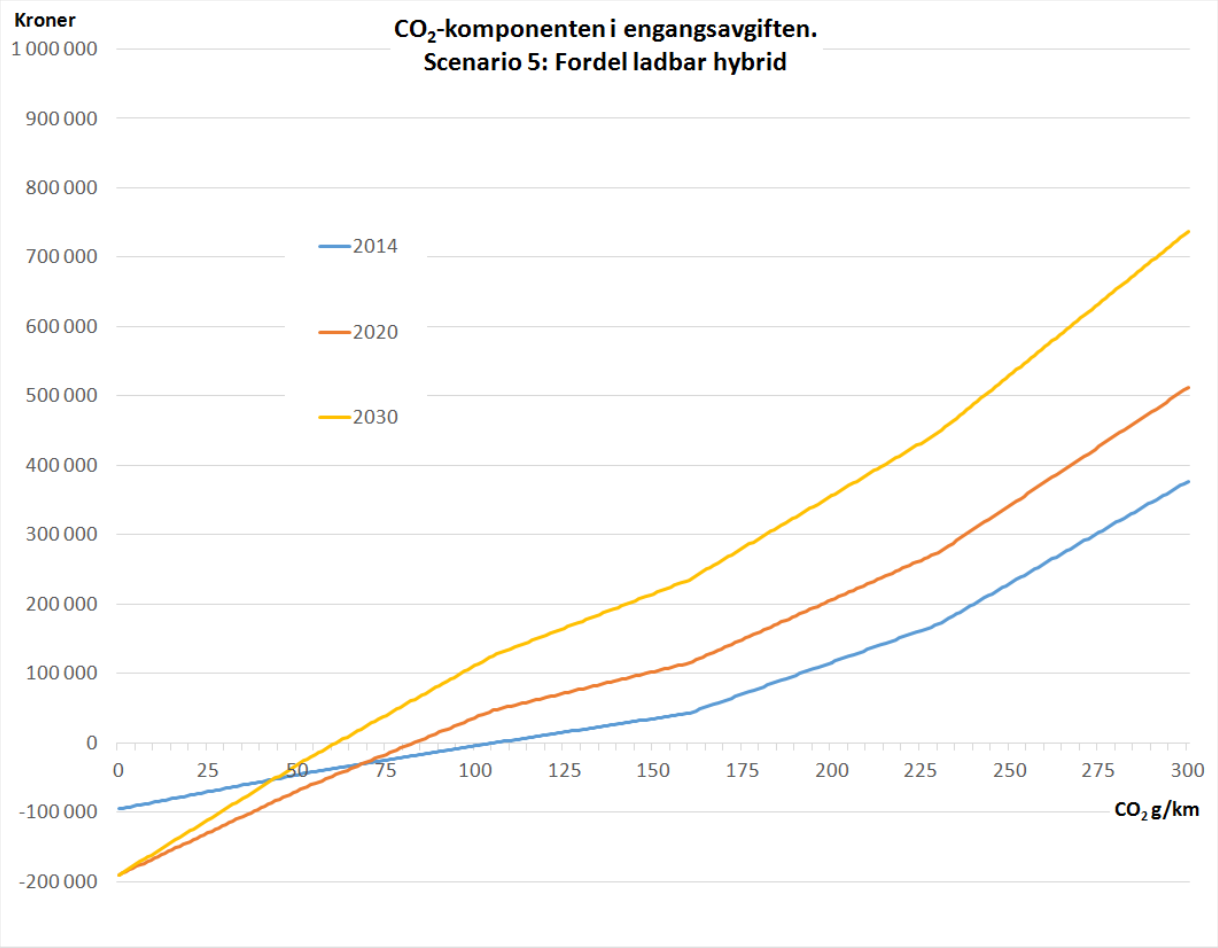
Intervention scenario 2030:

The CO_2 component of the vehicle purchase tax



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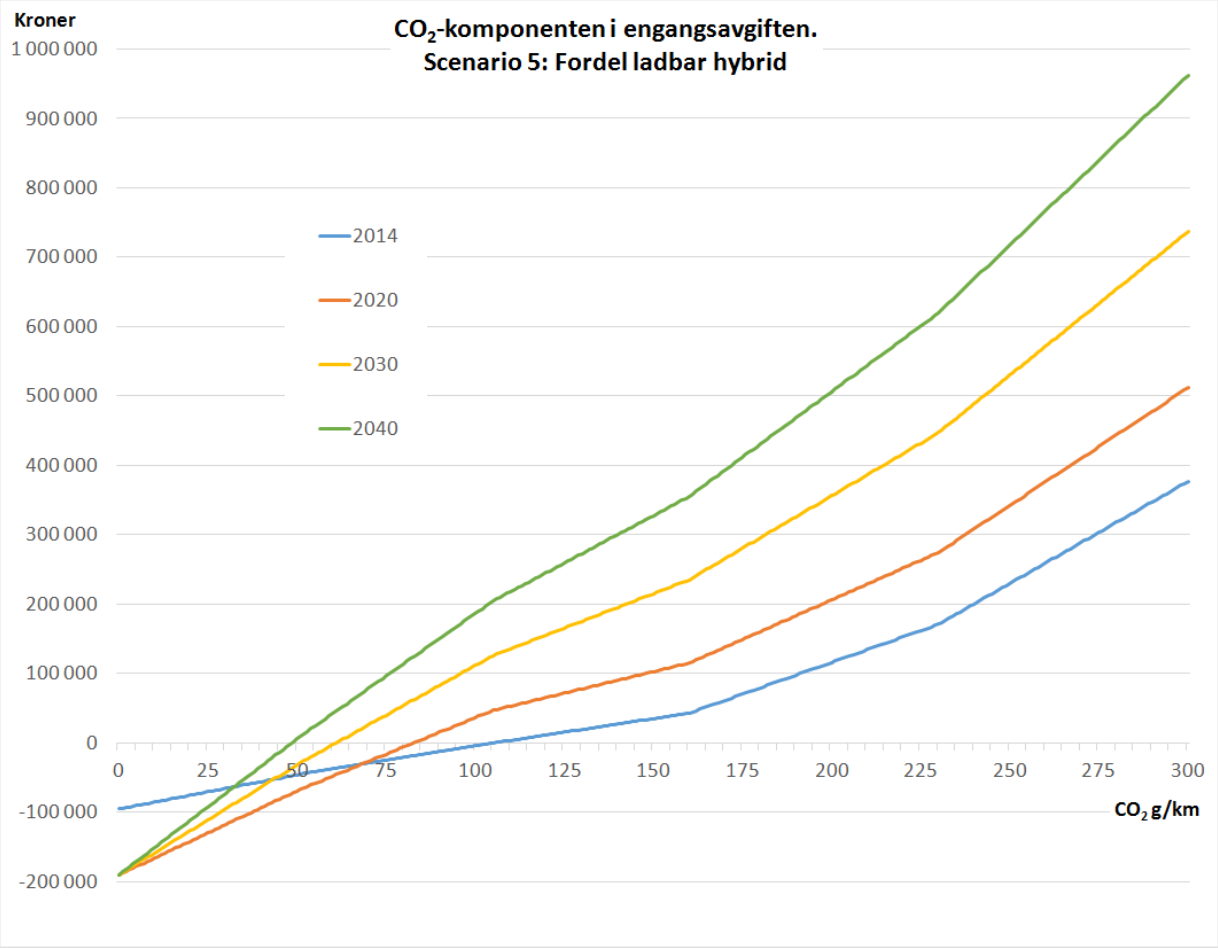
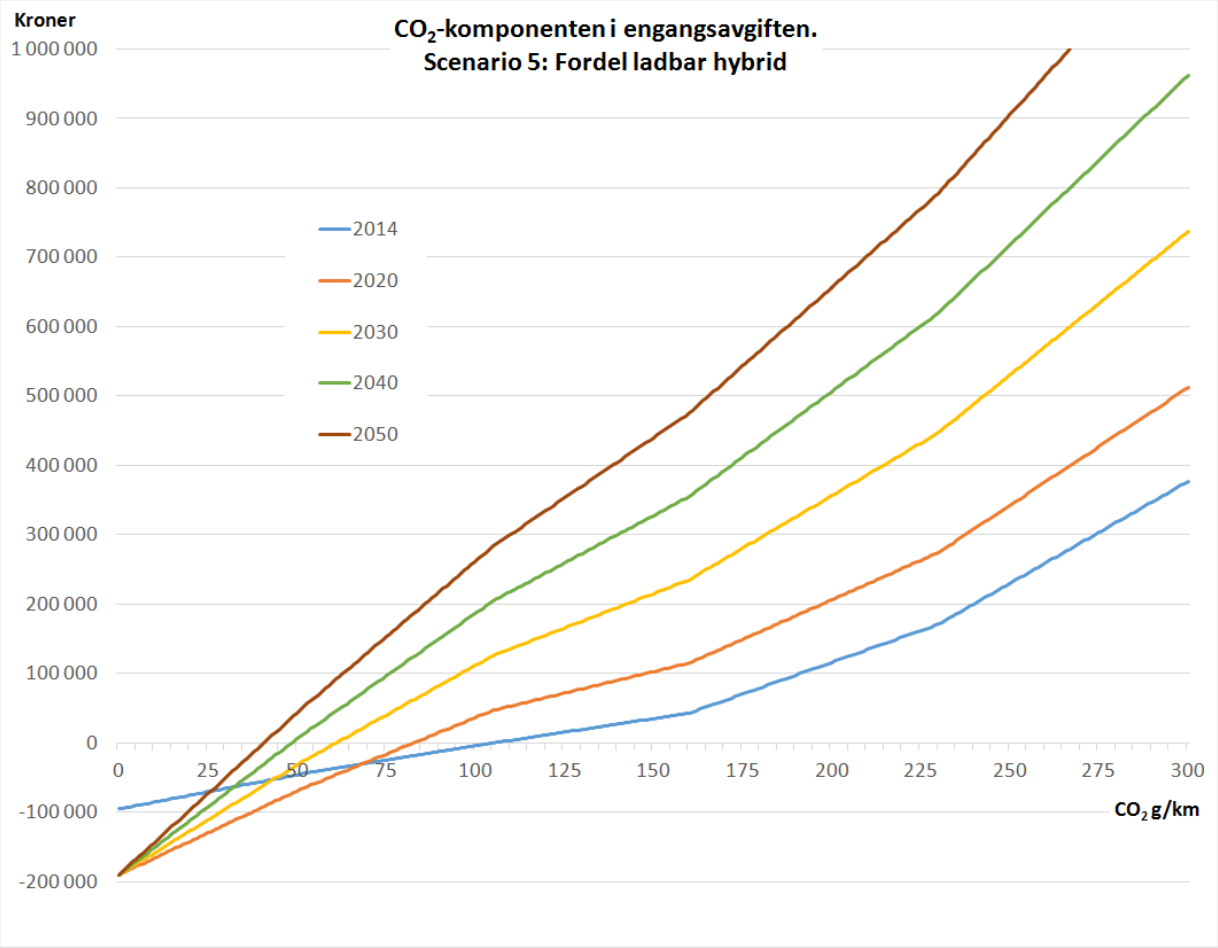
Intervention scenario 2040:

The CO_2 component of the vehicle purchase tax

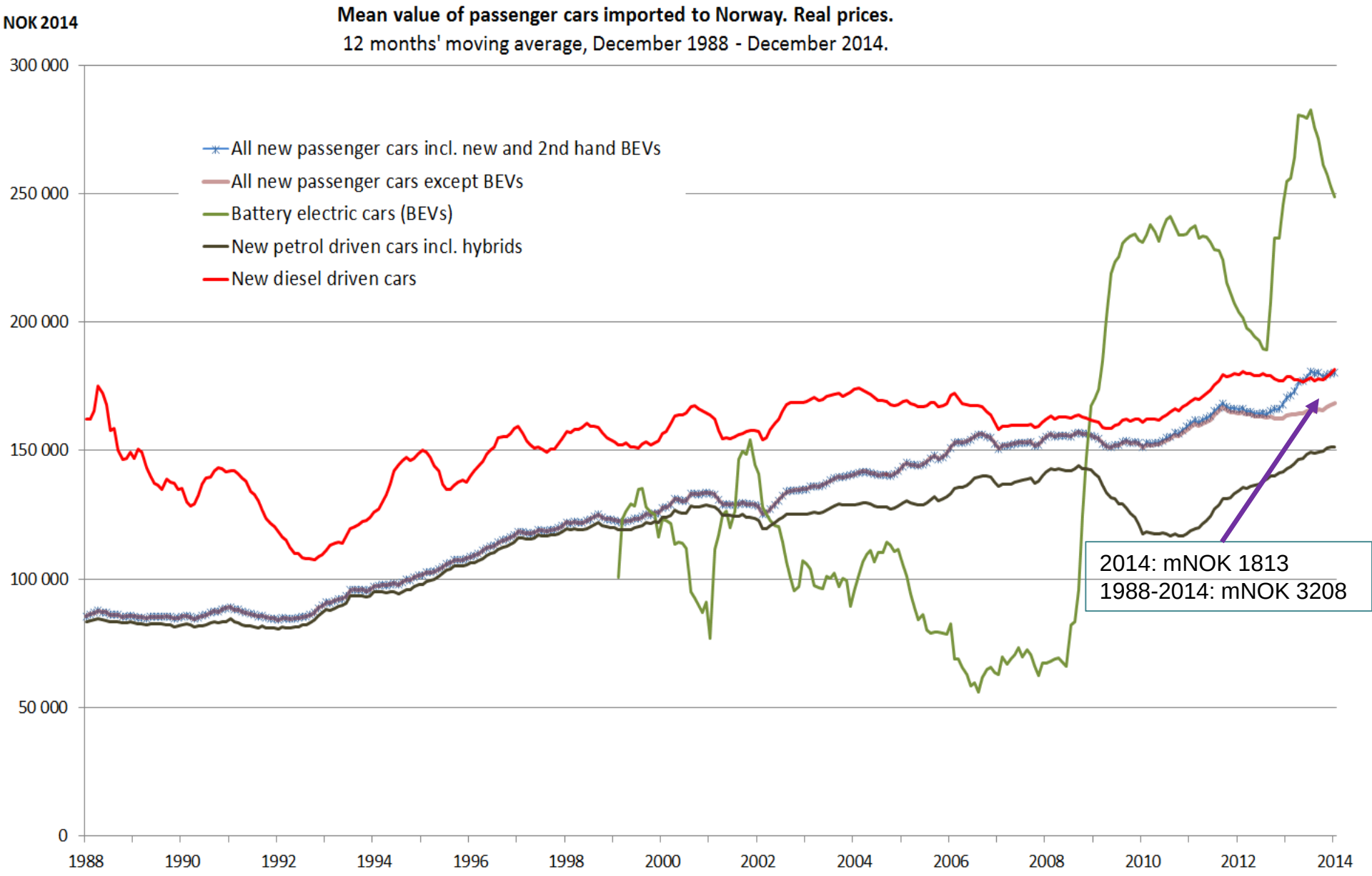


Intervention scenario 2050:

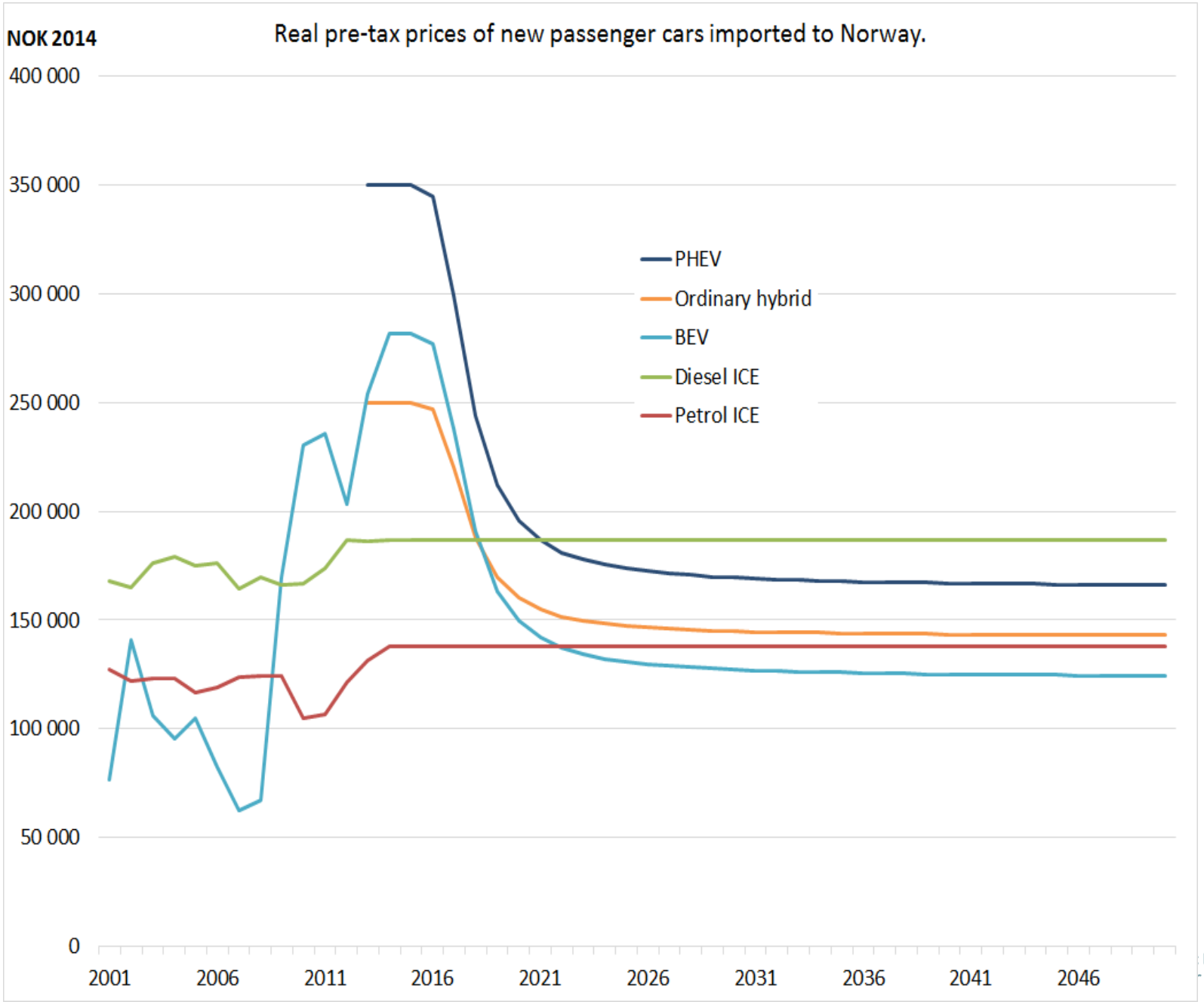
The CO_2 component of the vehicle purchase tax



BEVs are more expensive – 1.8 bNOK extra cost in 2014: up 7 %



Import prices of new cars, assuming quick price convergence



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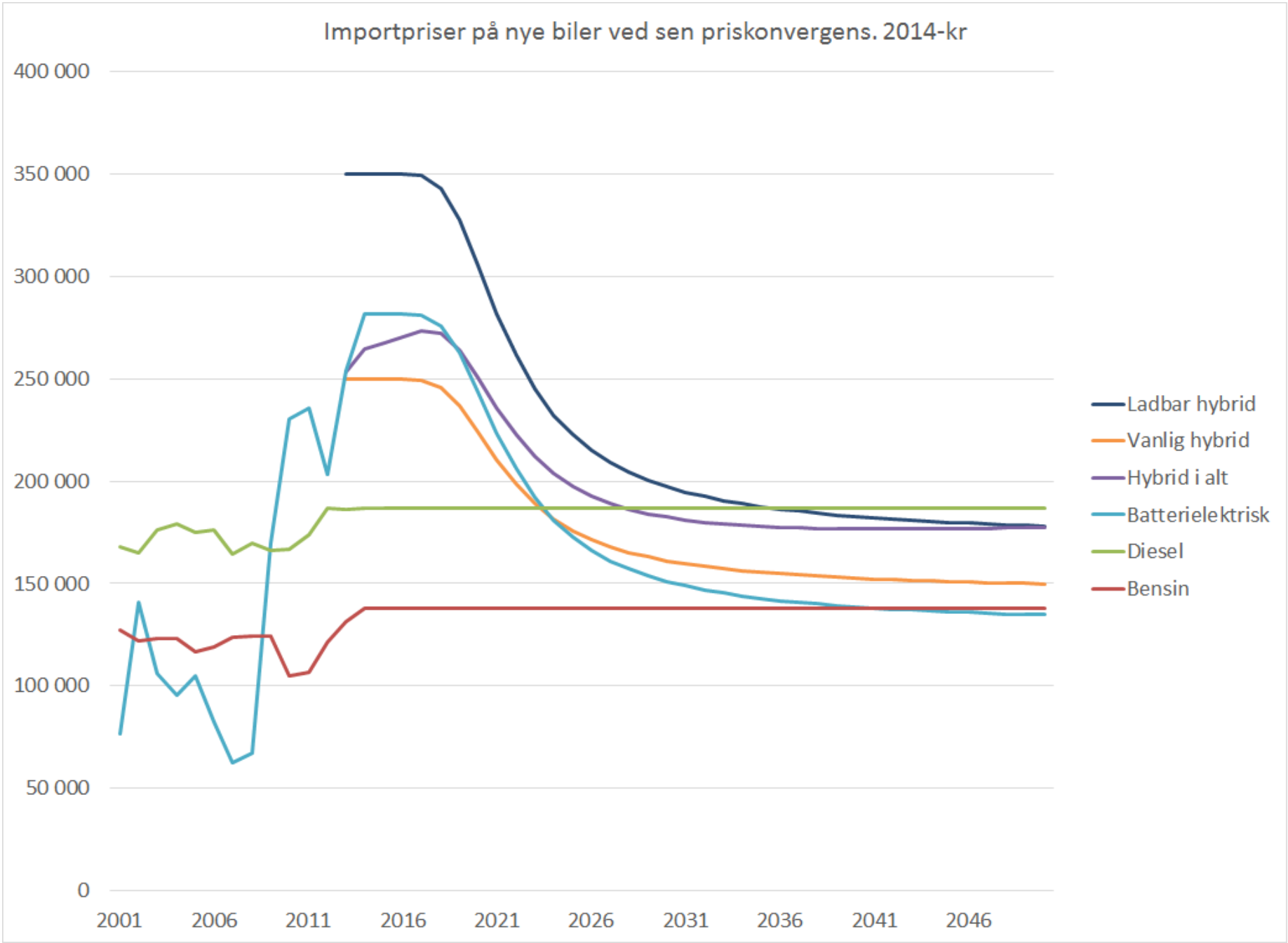
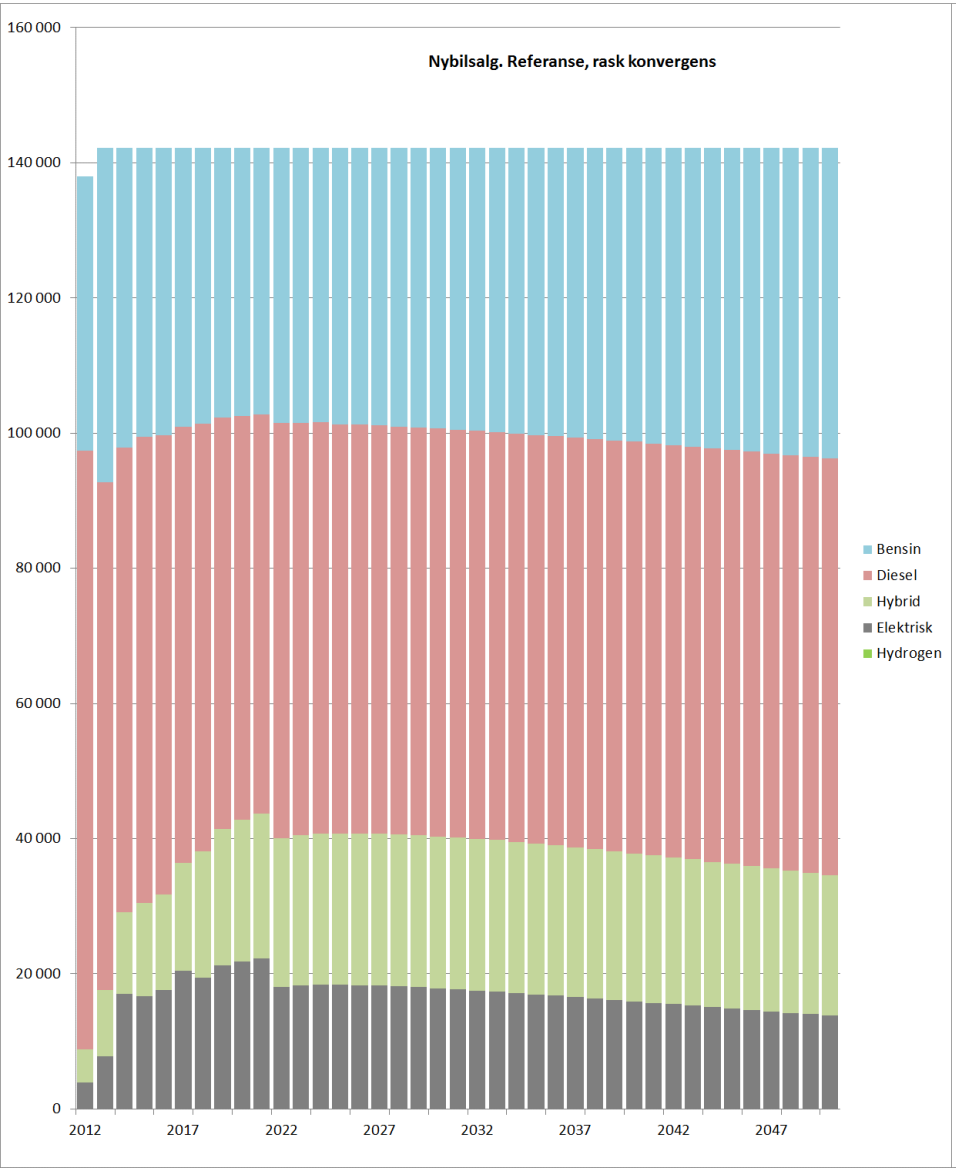
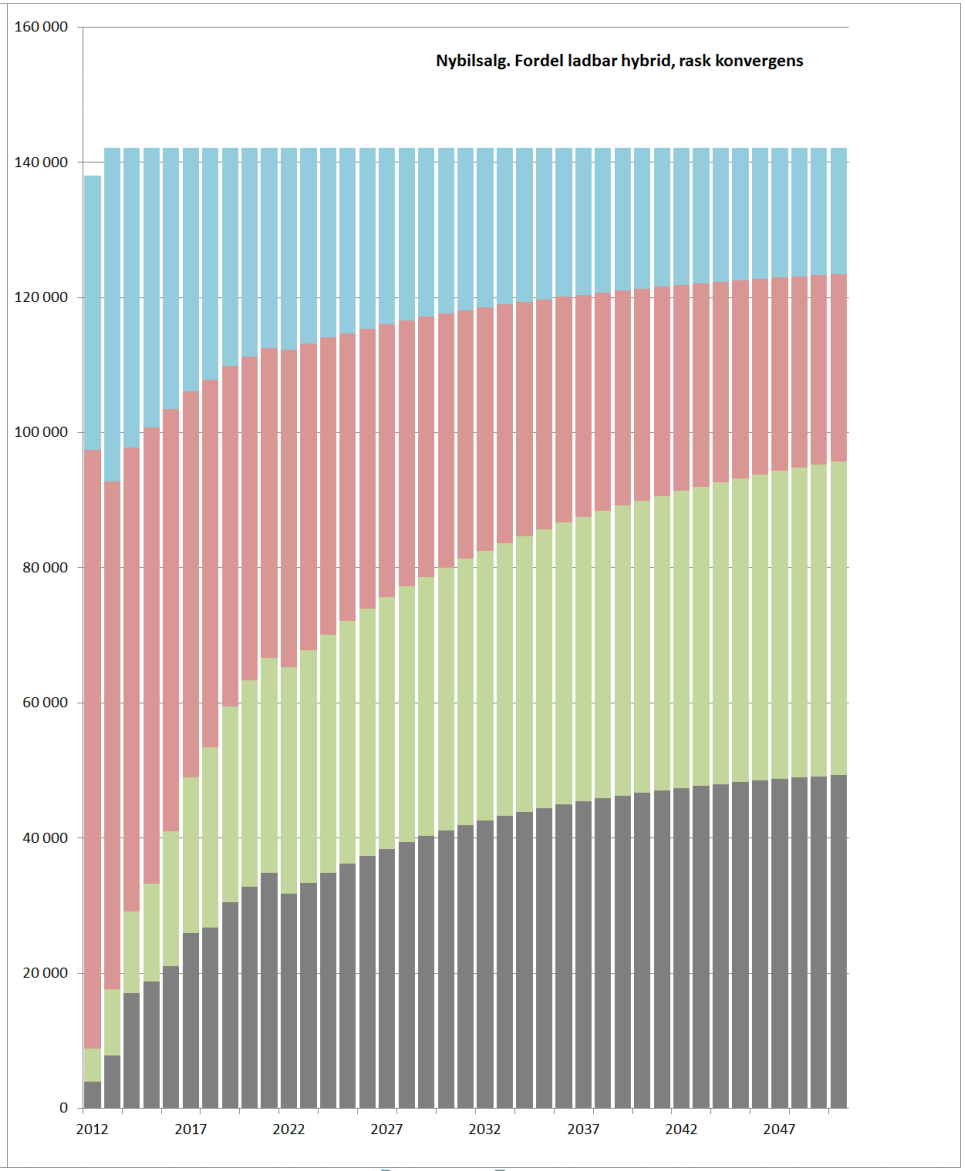
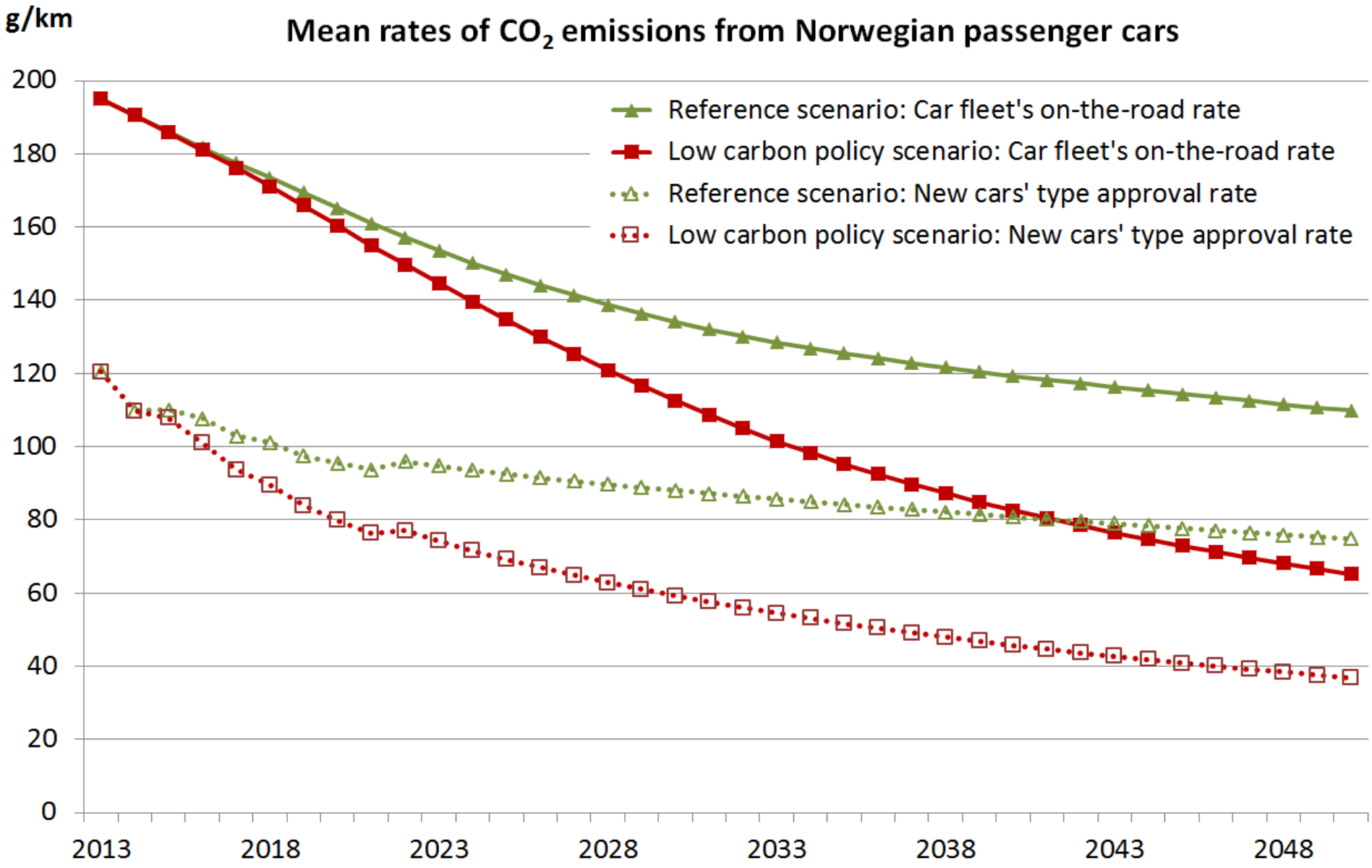
Import prices of new cars, assuming slow price convergence

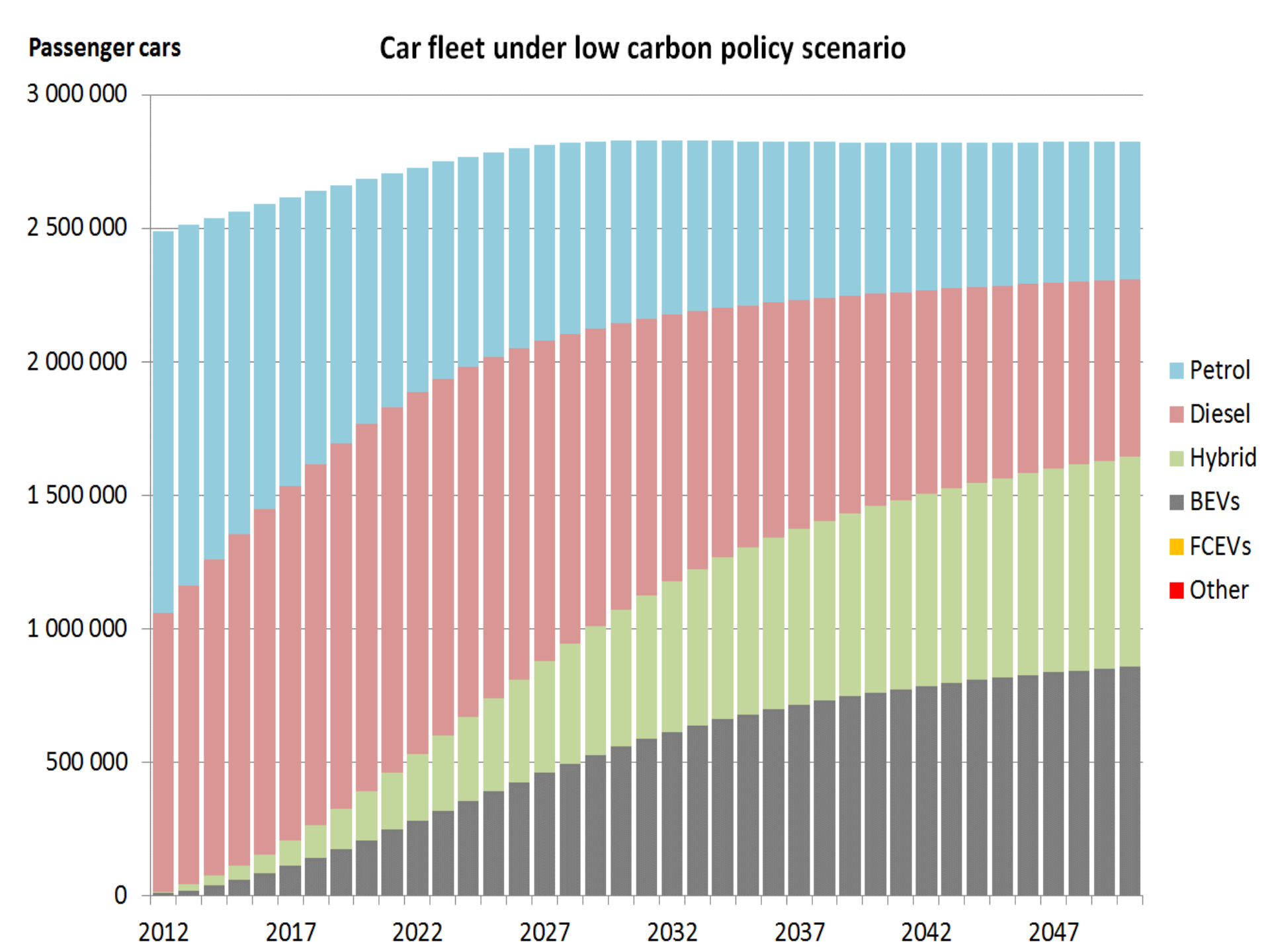


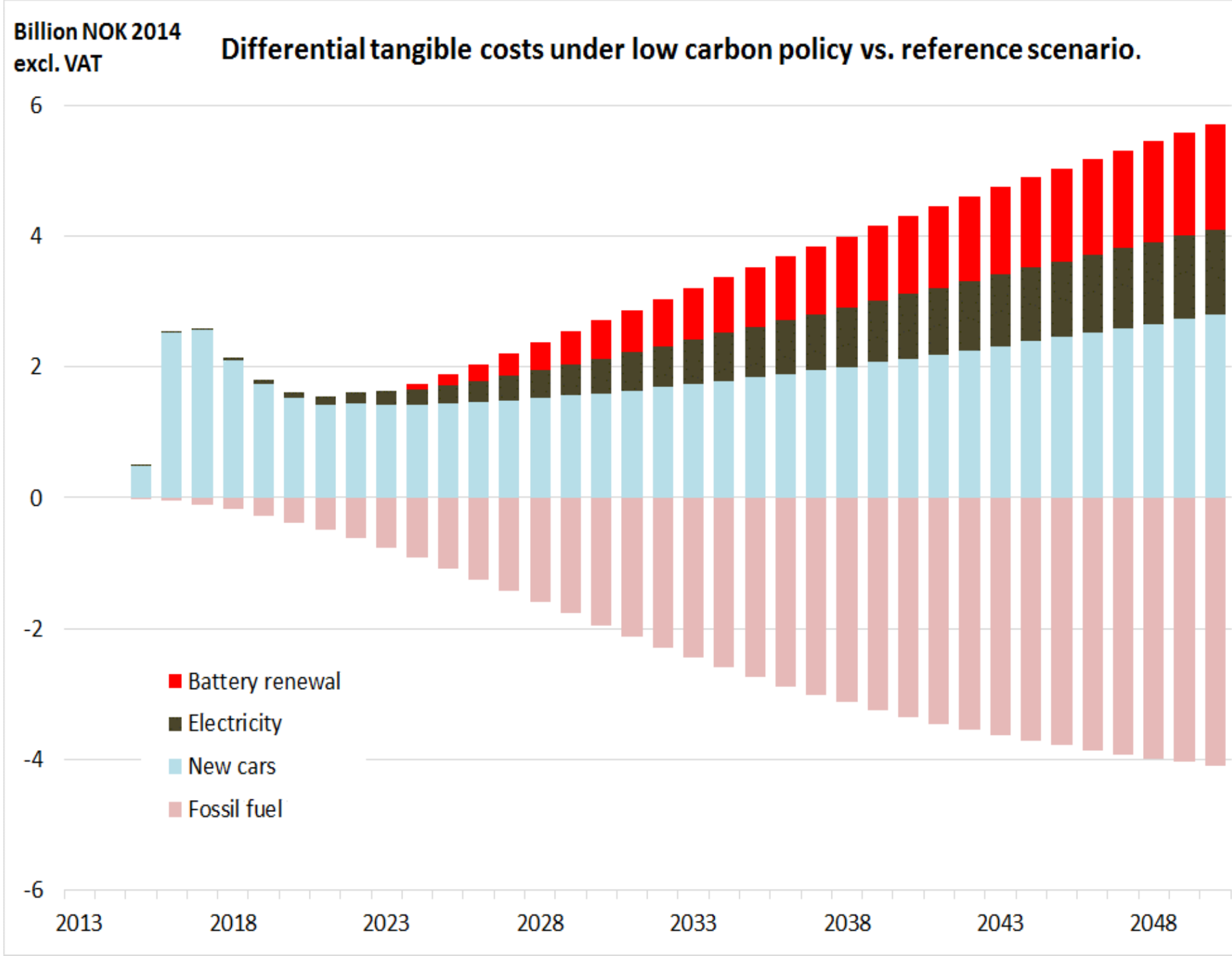
New car sales in reference and intervention paths. Quick price convergence.



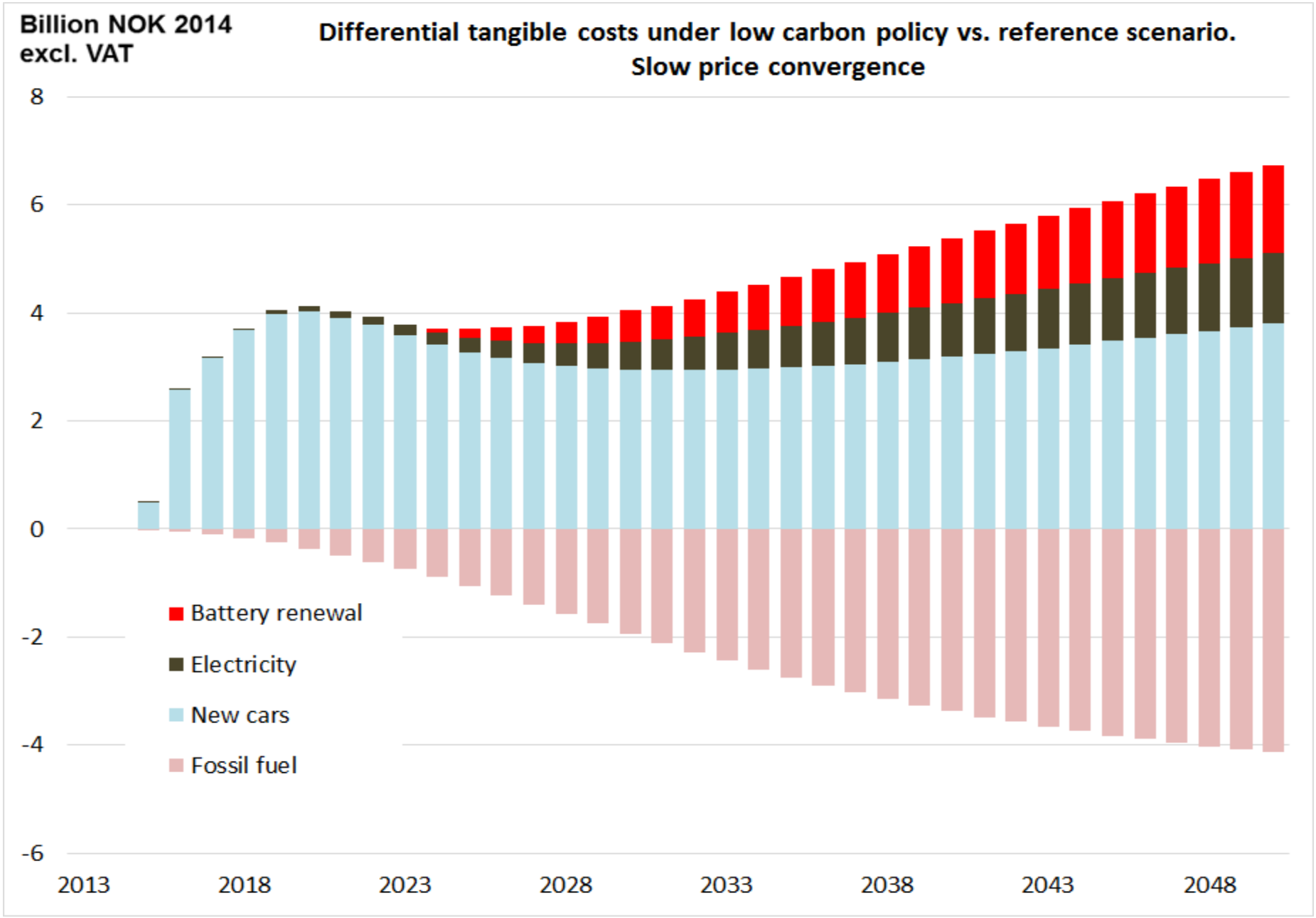


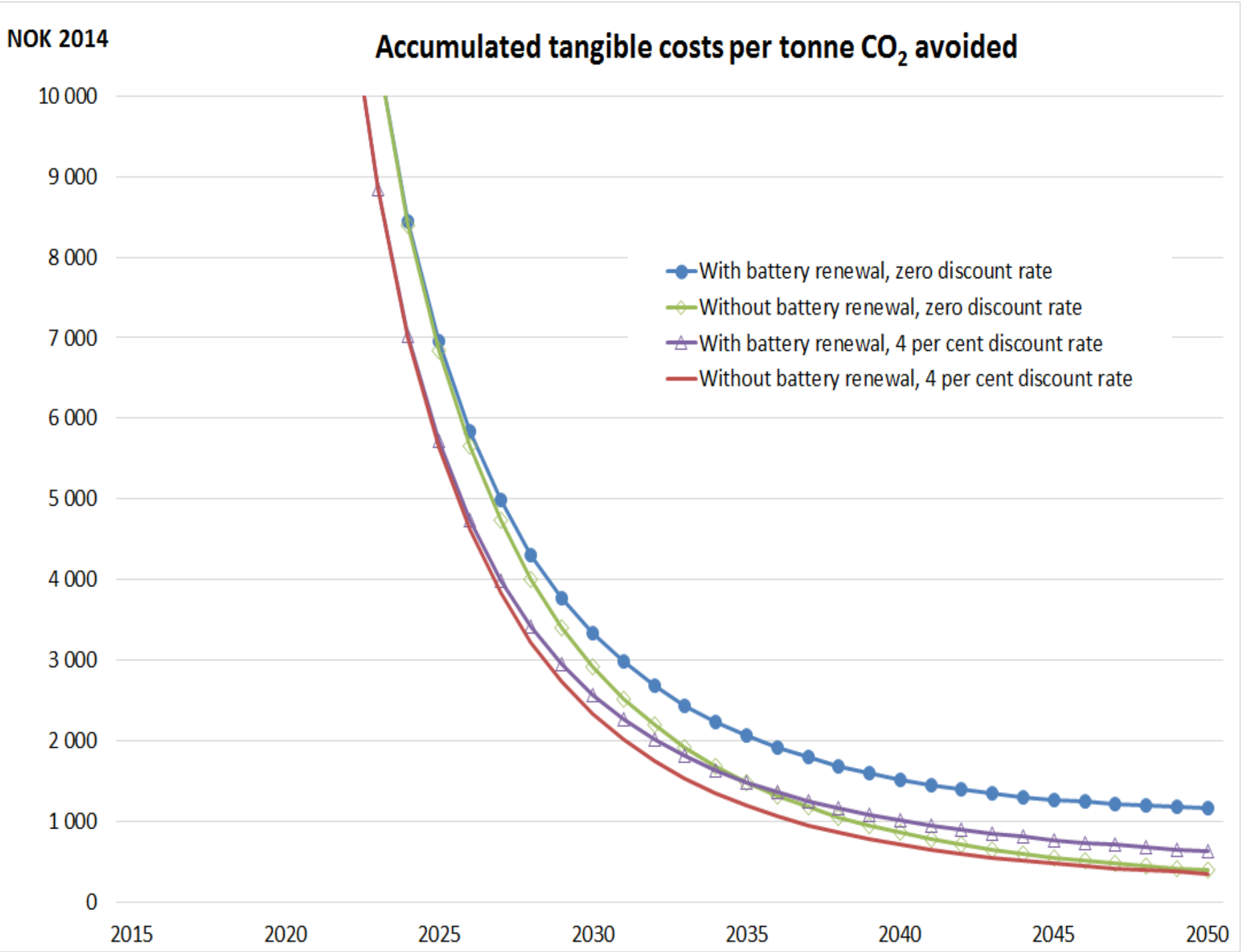

g/km
Mean rates of CO_2 emissions from Norwegian passenger cars
200
180
160
140
120
100
80
60
40
20
0
2013
2018
2023
2028
2033
2038
2043
2048
Reference scenario: Car fleet's on-the-road rate
Low carbon policy scenario: Car fleet's on-the-road rate
Reference scenario: New cars' type approval rate
Low carbon policy scenario: New cars' type approval rate

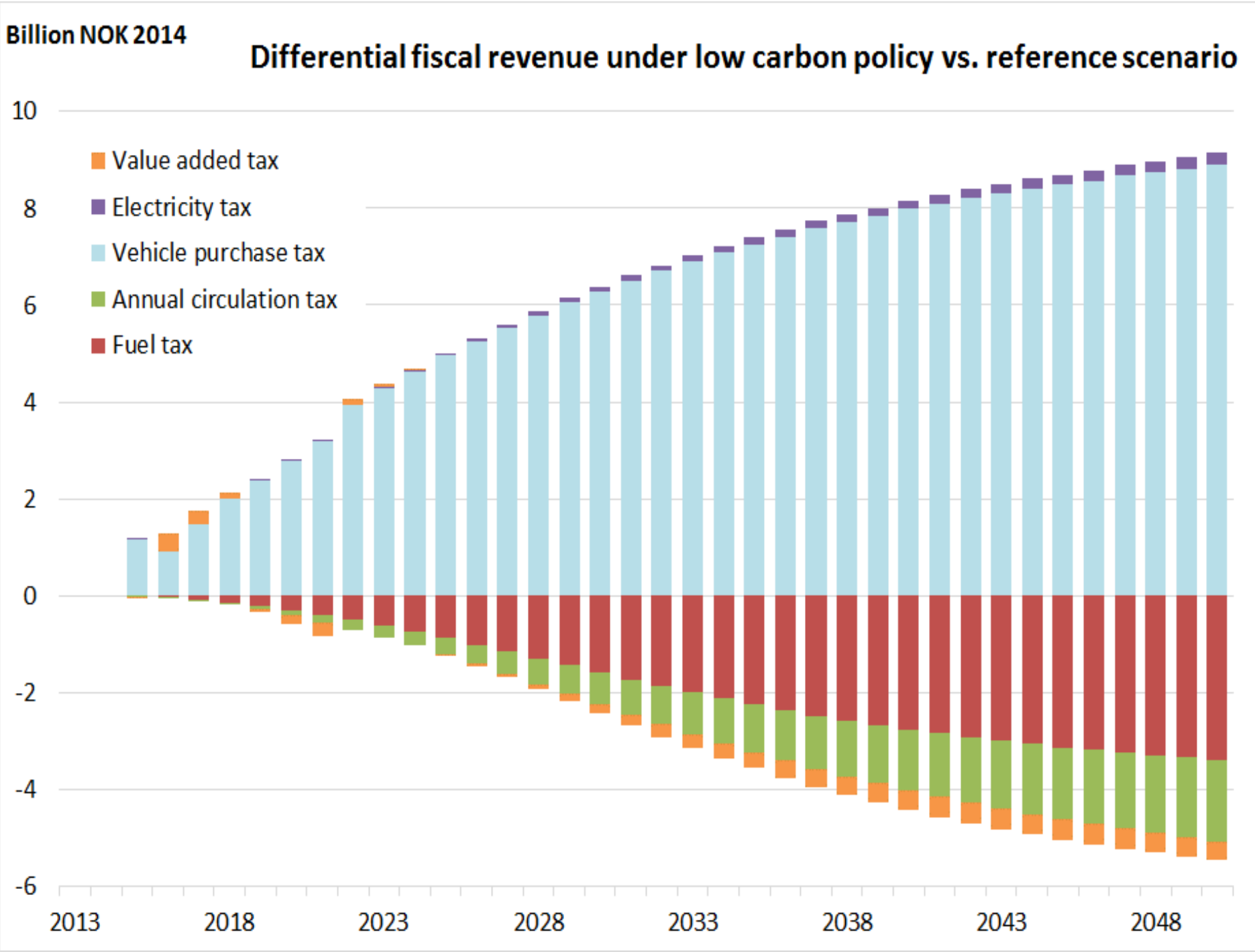

Passenger cars
Car fleet under low carbon policy scenario
3 000 000
2 500 000
2 000 000
1 500 000
1 000 000
500 000
0
2012
2017
2022
2027
2032
2037
2042
2047
Petrol
Diesel
Hybrid
BEVs
FCEVs
Other


Billion NOK 2014
excl. VAT
Differential tangible costs under low carbon policy vs. reference scenario.
6
4
2
0
-2
-4
-6
2013
2018
2023
2028
2033
2038
2043
2048
Battery renewal
Electricity
New cars
Fossil fuel

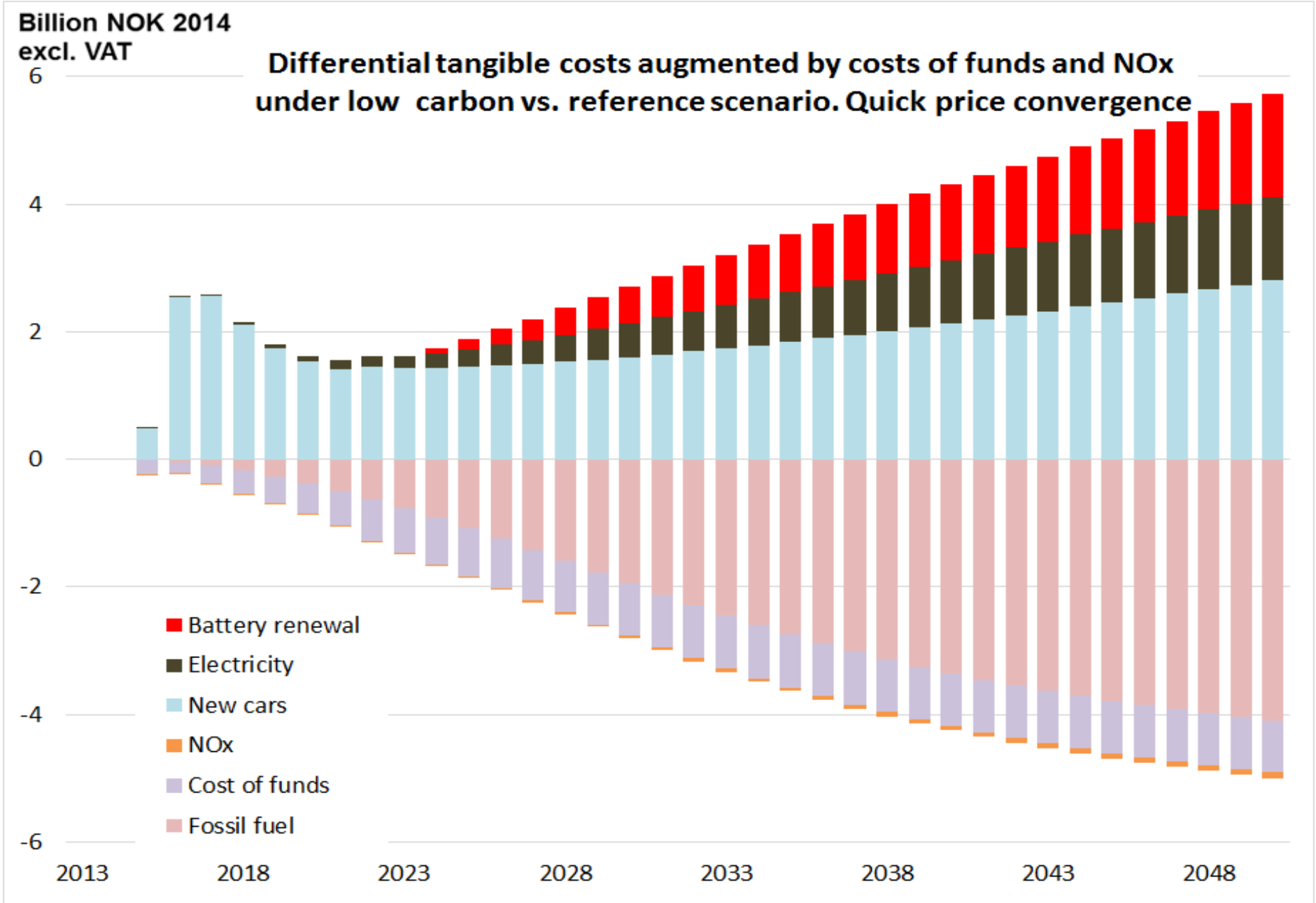
Differential tangible economic costs under intervention path vs. reference path, assuming slow price convergence




NOK 2014
Accumulated tangible costs per tonne CO_2 avoided
10 000
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
0
2015
2020
2025
2030
2035
2040
2045
2050
With battery renewal, zero discount rate
Without battery renewal, zero discount rate
With battery renewal, 4 per cent discount rate
Without battery renewal, 4 per cent discount rate


Billion NOK 2014
Differential fiscal revenue under low carbon policy vs. reference scenario
10
8
6
4
2
0
-2
-4
-6
Value added tax
Electricity tax
Vehicle purchase tax
Annual circulation tax
Fuel tax
2013
2018
2023
2028
2033
2038
2043
2048

Differential tangible costs augmented by costs of funds and NO_X, under intervention path vs. reference path, assuming quick price convergence (bNOK per annum)



Challenge: internalising externalities

Electrification removes the external costs of GHG, NO_X and exhaust PM emissions. At low speed, the noise is also reduced.

Remaining externalities are due to

- congestion,
- road wear,
- accidents,
- PM from pavement, tires and brake pads, as well as
- tire noise at high speed.

Present fuel taxes internalise part of these external costs. When cars are converted to electric energy, the main market correction mechanism is removed and vehicle kms travelled (VKT) may increase.

How to counteract this? Generalised GPS based road pricing?

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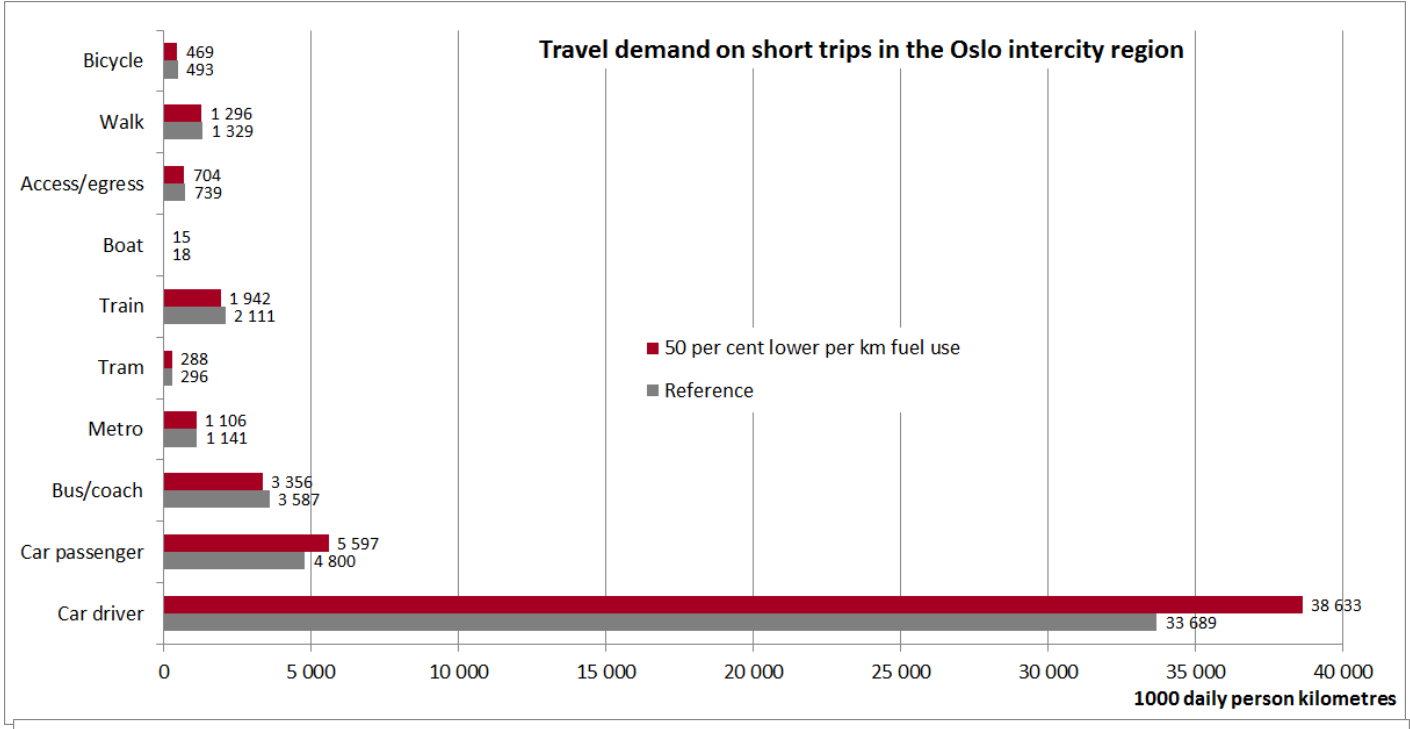
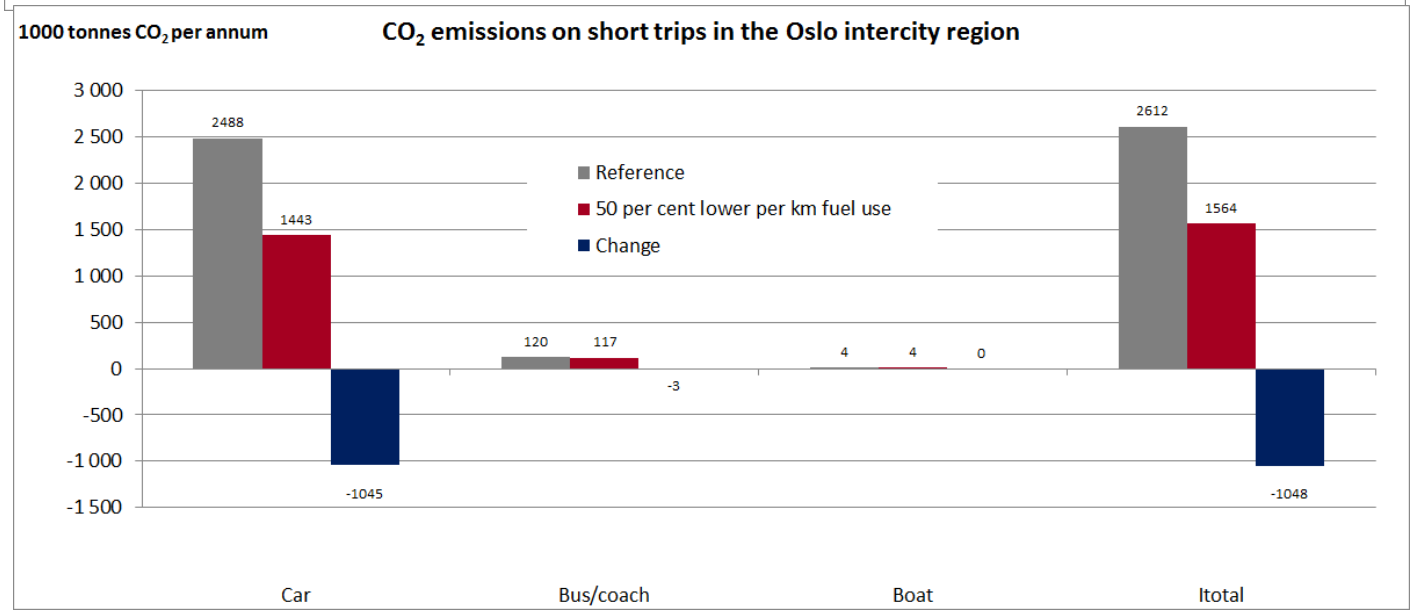
50 % lower per km fuel consumption





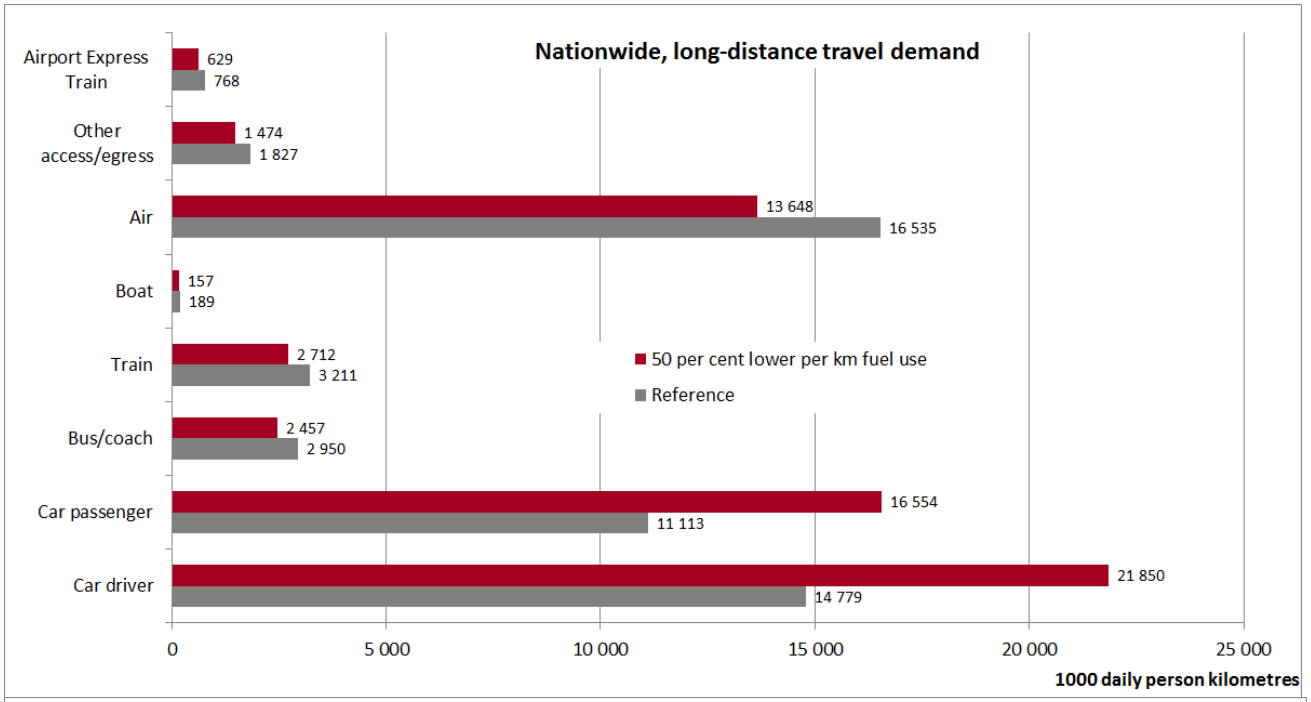
Short trips:

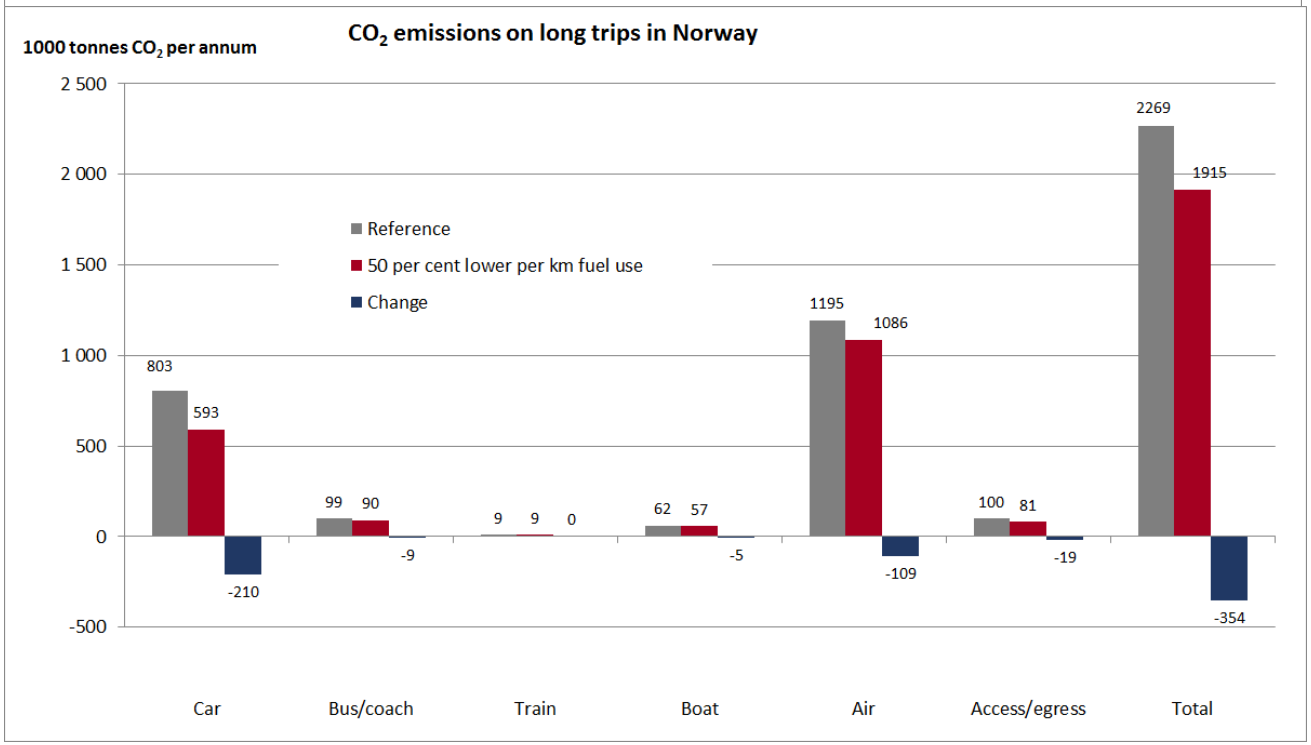
+ 15 % car VKT

- 42 % car CO_2

- 40 % total CO_2

50 % lower per km fuel consumption





Long trips:

+ 48 % car VKT

- 26 % car CO_2

- 9 % air CO_2

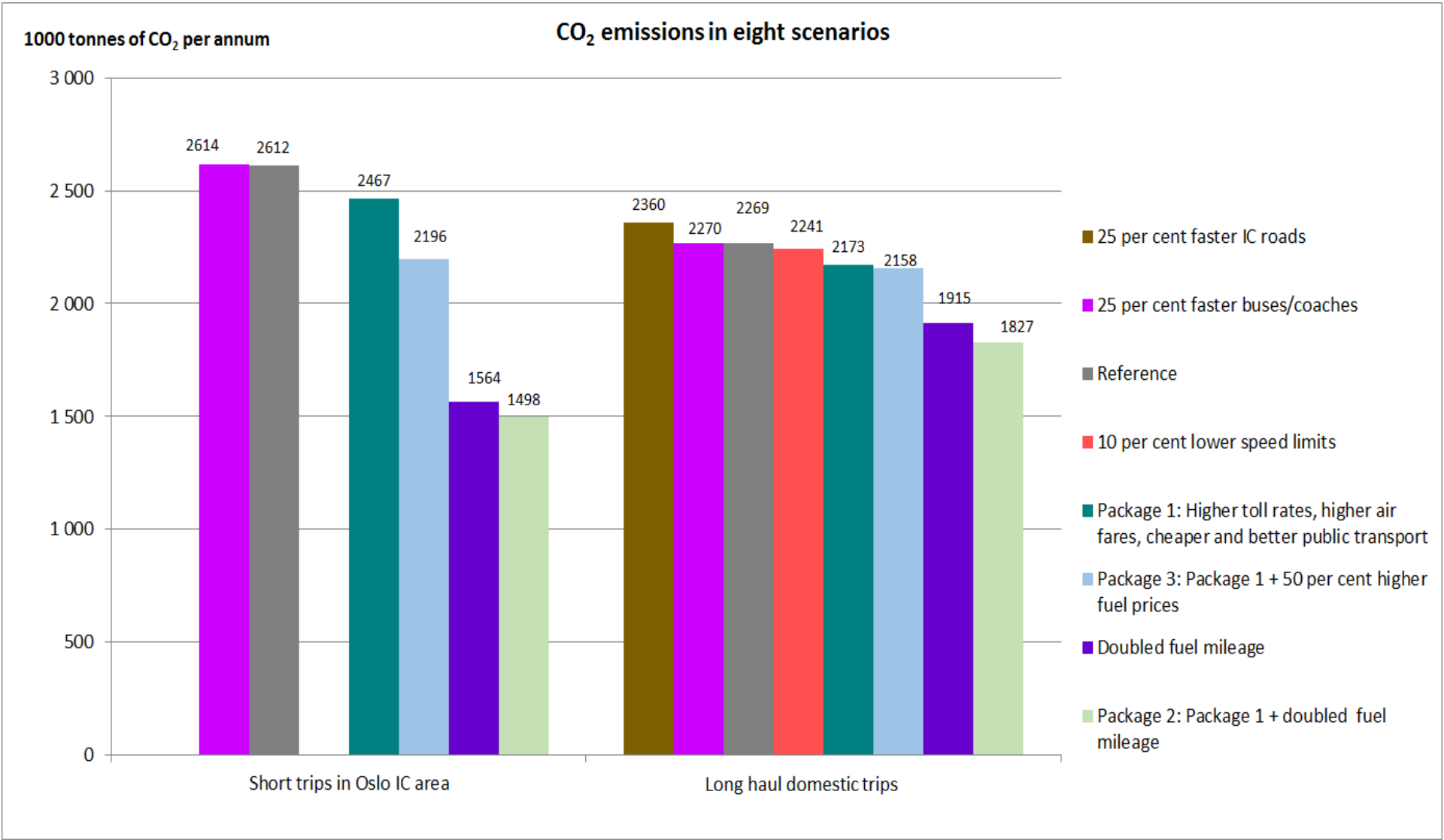
- 16 % total CO_2

Rebound effect

- The rebound effect of a 50 per cent reduction in per km fossil fuel consumption has been estimated at 15 per cent more VKT on short trips, and 48 per cent more on long trips (>100 km one way).
- In terms of CO_2 emissions, the overall abatement effects have been estimated at 40 and 16 per cent, respectively, on short and long trips. The latter figure reflects a considerable transfer of trips from the air mode to private cars.
- Looking at the car driver mode alone, CO_2 emissions go down by 42 and 26 per cent on short, resp. long trips.

Other instruments work less well

- 50 % higher fuel prices: 6-8 % less CO_2 (11 and 0.5 % on short/long trips
- Drastically cheaper and better public transport: 5-6 % less CO_2



Conclusions (1)

- In 2014, the extra cost, due to electrification policies, of vehicle import to Norway is roughly bNOK 1.8.
- During 1988 through 2014, the accumulated cost is bNOK 3.2
- Benefits will take the form of reduced (and possibly cheaper) energy use. A long term perspective is called for.
- An aggressive fiscal policy, benefiting vehicles emitting less than 50-100 g/km, may reduce annual emissions from the passenger car fleet by 60-70 per cent in 2050, compared to 2013 (before rebound effect).
- As compared to the reference path, the emissions reduction under the intervention path as of 2050 is about 42 per cent (before rebound effect).

Conclusions (2)

- As of 2050, the accumulated tangible costs of the intervention policy has been estimated at NOK 400 to 2 500 per tonne of CO_2.
- A crucial factor is how fast the manufacturing costs of BEVs and PHEVs will converge to those of conventional cars.
- The intervention scenario implies increased government revenue from purchase tax.
- When costs of funds and NO_X are included, long term tangible costs may, in the best of cases, drop below zero (after 2038).
- Recall that intangible costs are not included in the calculations. These include the subjective costs of range anxiety, of maintenance and second hand value risk, and of other consumer surplus elements.

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Conclusions (3)

- Electrifying the passenger car fleet is the single most effective GHG abatement measure in Norwegian transport.
- But it works slowly – only as fast as car fleet renewal.
- Only battery electric vehicles (BEVs) pull down the average CO_2 emission rate. The emission reduction 'recorded' for petrol and diesel driven cars is for the most part fictitious.
- Electrification is essential to large-scale GHG abatement in transport – a *sine qua non*.

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Thank you for listening!

BIG scenarios

Scenario	0				1				2			
Label	**No change**				**Same tax system**				**Reference path**			
	Diesel	Petrol	Hybrid	BEV	Diesel	Petrol	Hybrid	BEV	Diesel	Petrol	Hybrid	BEV
Per cent annual reduction in per km fuel consumptior	0	0	0	0	1	1	3	0	1	1	3	0
NOx emission	Euro 6 from 2015				Euro 6 from 2015				Euro 6 from 2015			
Tax incidence	1	1	1	1	1	1	1	1	1	1	1	1
Equipment package	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %
Per cent annual reduction in real vehicle price before	0	0	0	0	1	1	3	3	1	1	3	3
VAT on BEVs from year				2051				2051				2022
Purchase tax on BEVs from year				2051				2051				2020
Normal road toll and ferry fares for BEVs from year				2051				2051				2018
Tightened purchase tax from 2015 until year	none	none	none	none	none	none	none	none	none	none	none	none
Increased deduction for very low emission rates	none	none	none	none	none	none	none	none	none	none	none	none

Scenario	3				4				5			
Label	**Transitory tax increase**				**Continuous tax increas**				**Advantage PHEVs**			
	Diesel	Petrol	Hybrid	BEV	Diesel	Petrol	Hybrid	BEV	Diesel	Petrol	Hybrid	BEV
Per cent annual reduction in per km fuel consumptior	1	1	3	0	1	1	3	0	1	1	3	0
NOx emission	Euro 6 from 2015				Euro 6 from 2015				Euro 6 from 2015			
Tax incidence	1	1	1	1	1	1	1	1	1	1	1	1
Equipment package	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %	50 %
Per cent annual reduction in real vehicle price before	1	1	3	3	1	1	3	3	1	1	3	3
VAT on BEVs from year				2022				2022				2022
Purchase tax on BEVs from year				2020				2020				2020
Normal road toll and ferry fares for BEVs from year				2018				2018				2018
Tightened purchase tax from 2015 until year	2020	2020	2020	2020	2050	2050	2050	2050	2050	2050	2050	2050
Increased deduction for very low emission rates	none	none	none	none	none	none	none	none	2016	2016	2016	2016

All scenarios assume a gradual improvement in BEV quality, worth NOK 100 000 by 2022 and 160 000 by 2050. Hybrids improve half as much.

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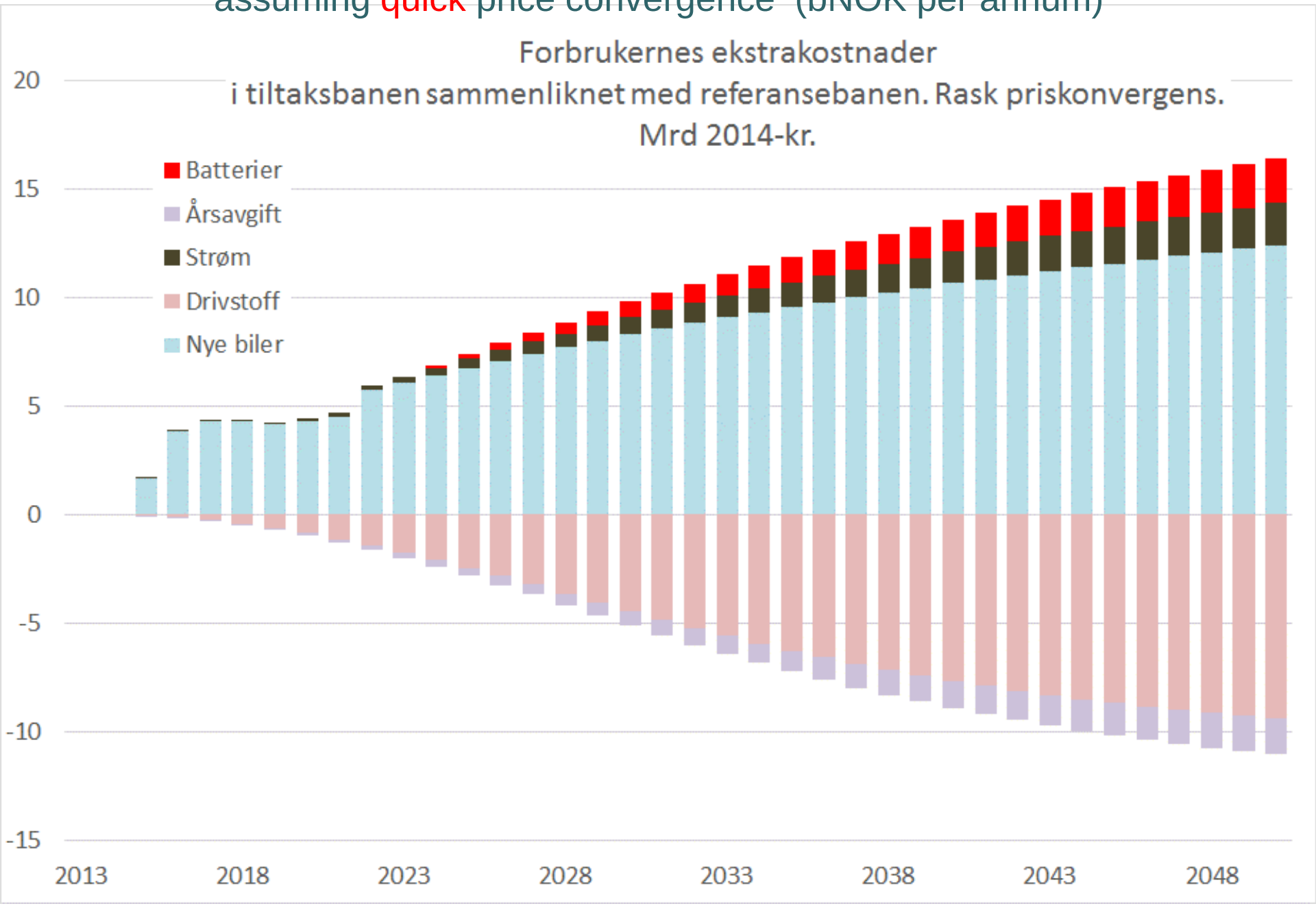
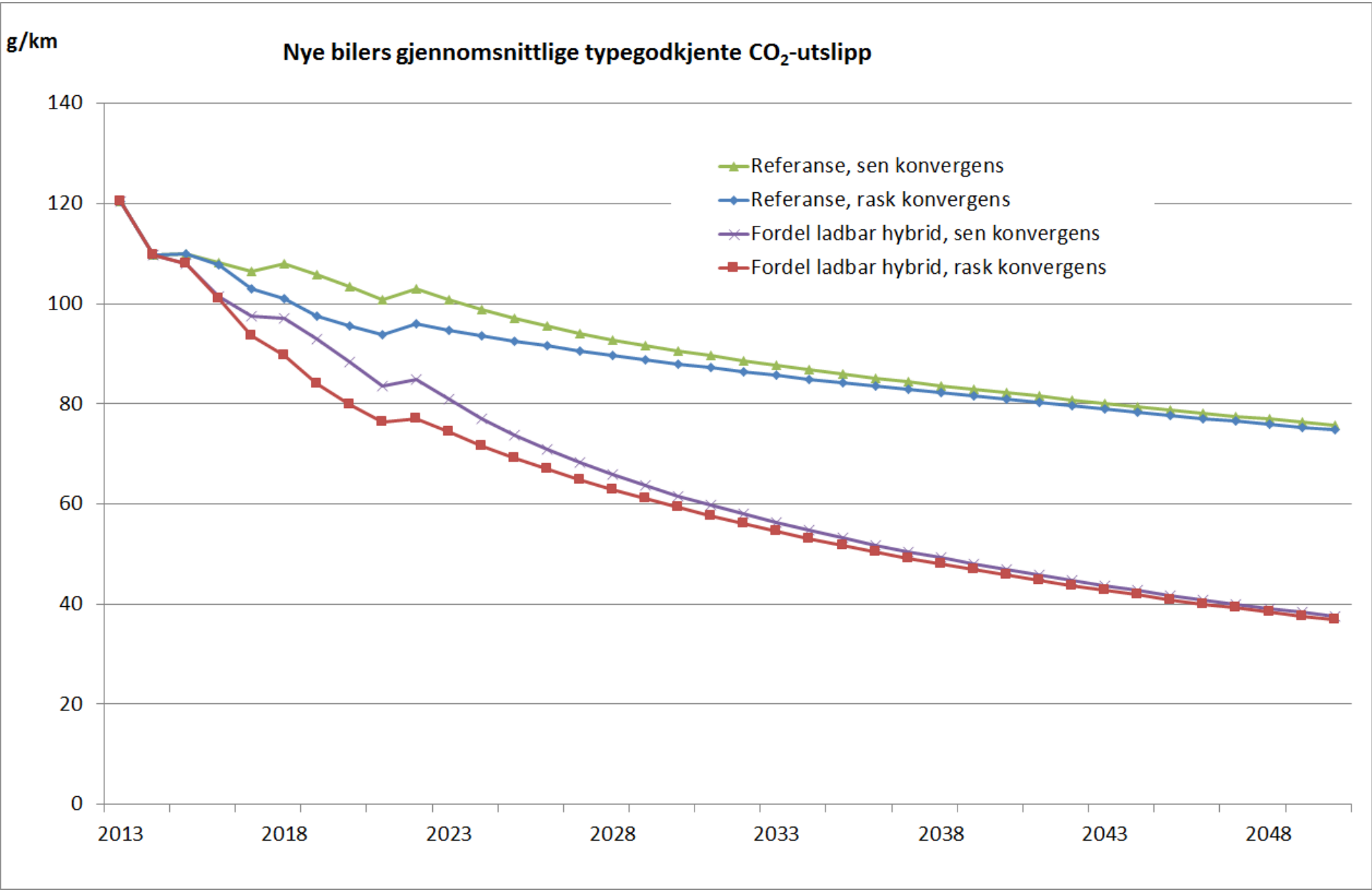
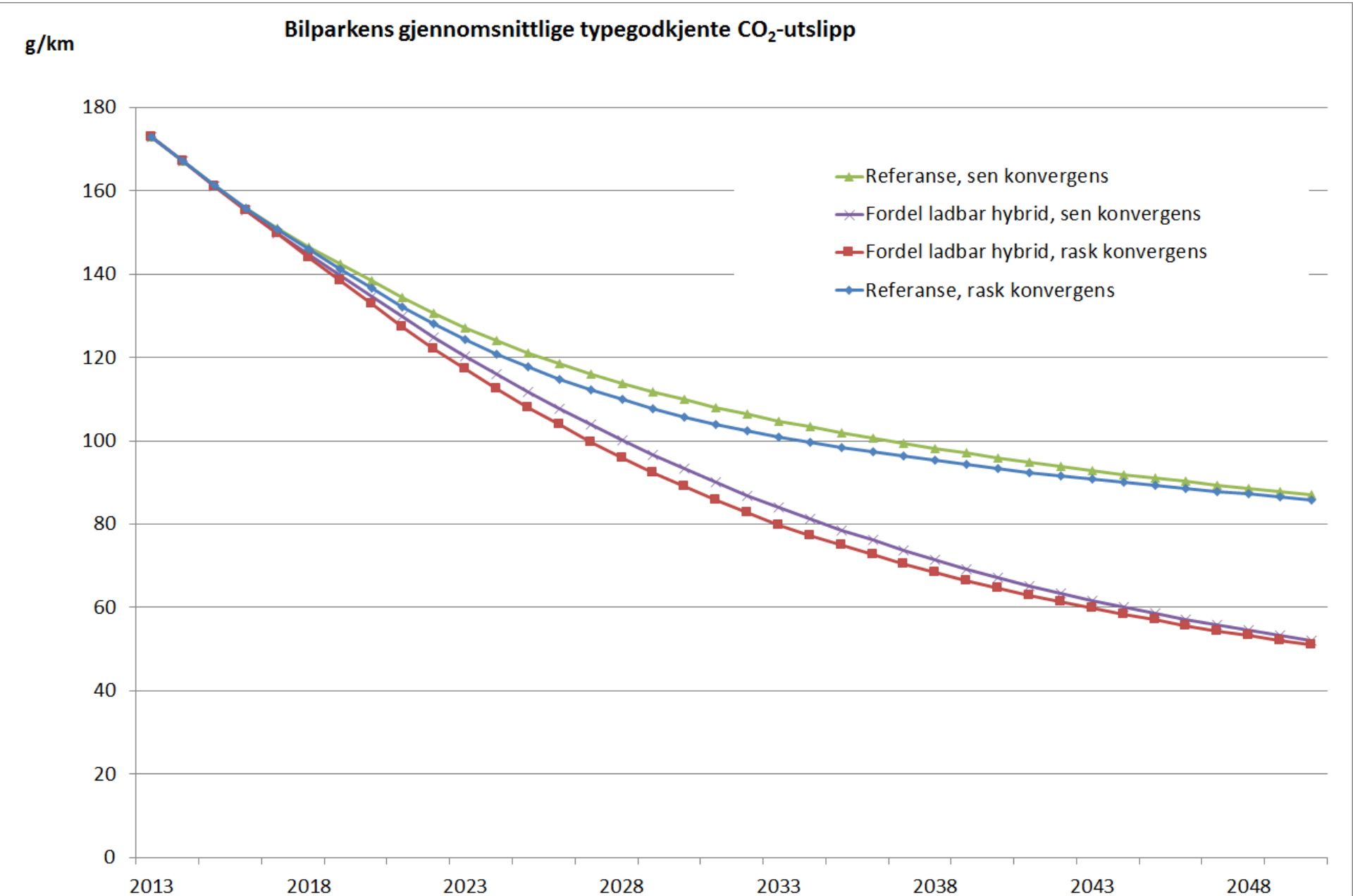
Differential consumers' expenditure under intervention path vs. reference path, assuming quick price convergence (bNOK per annum)



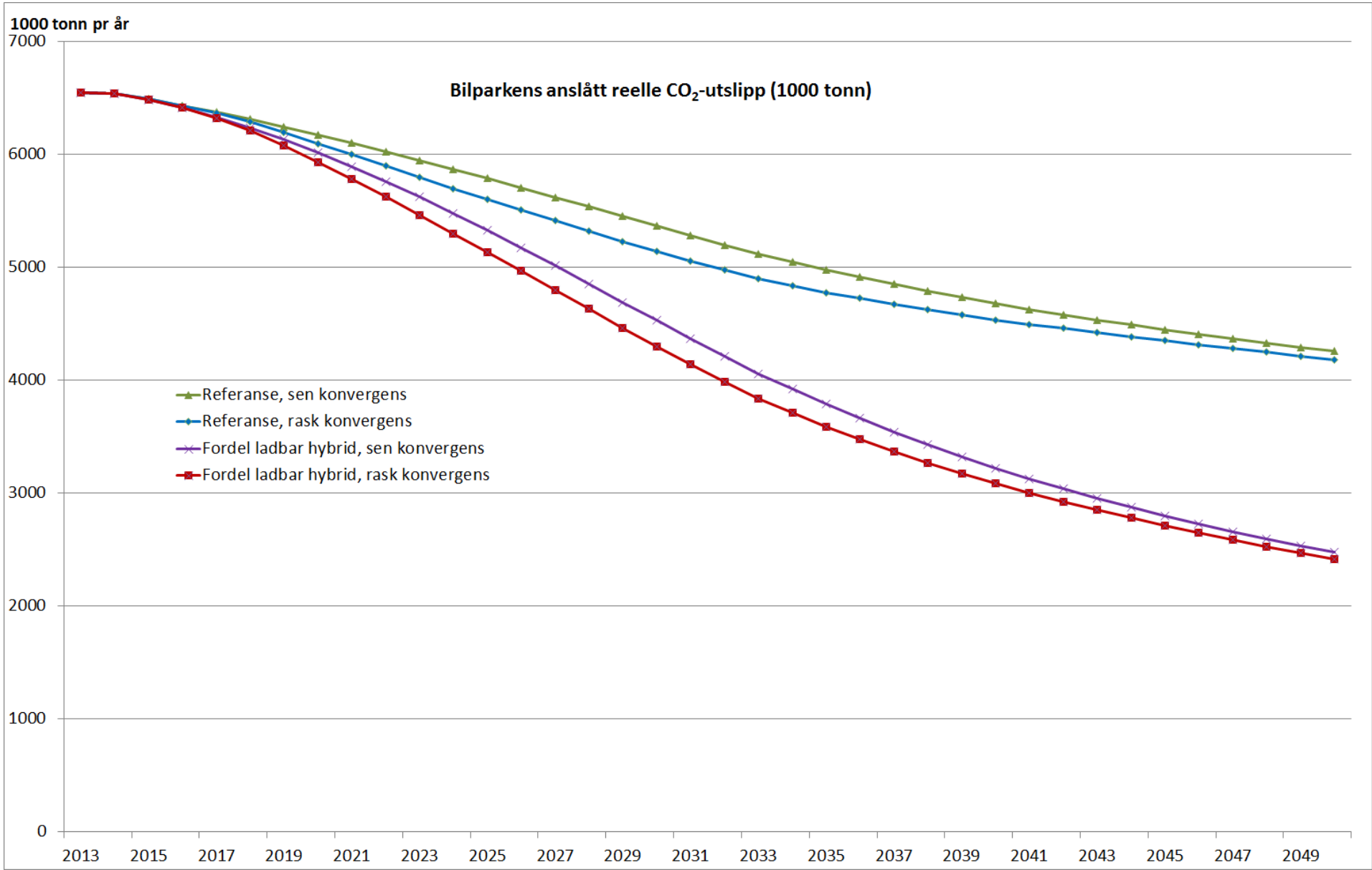
New cars' mean type approval CO_2 emission rate



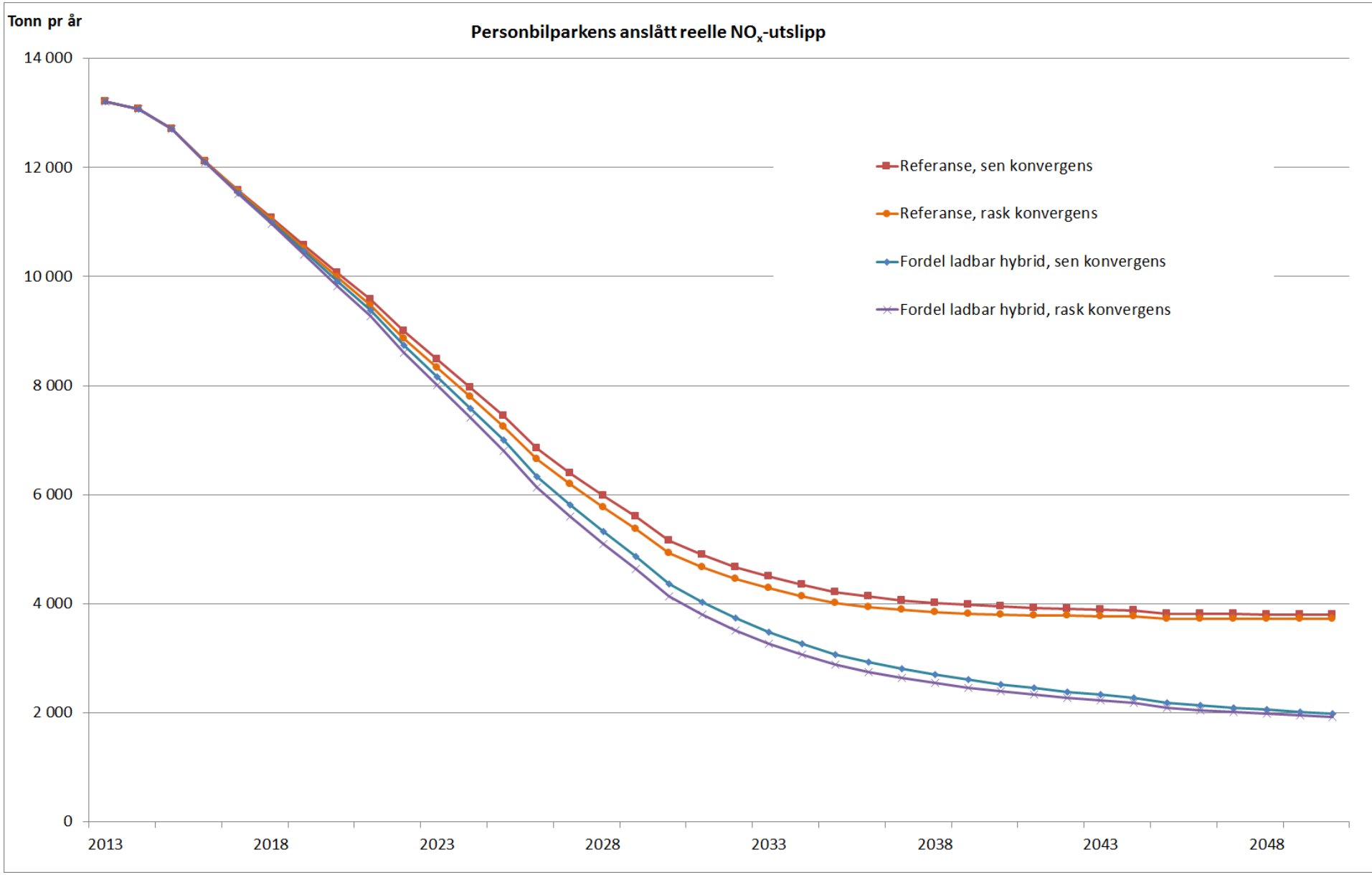
Car fleet's mean type approval CO_2 emission rate



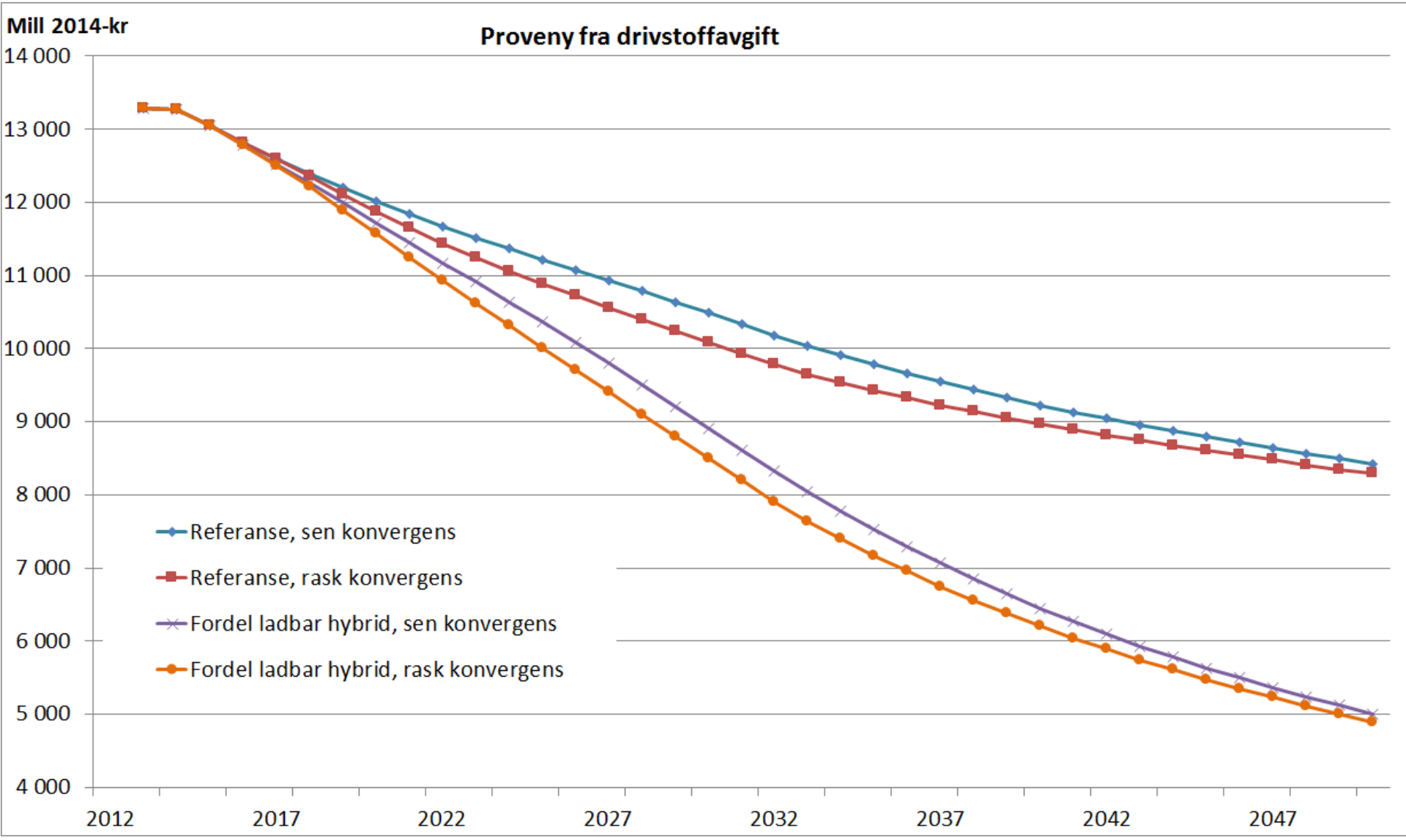
Car fleet's estimated real CO_2 emissions (1000 tonnes per annum)



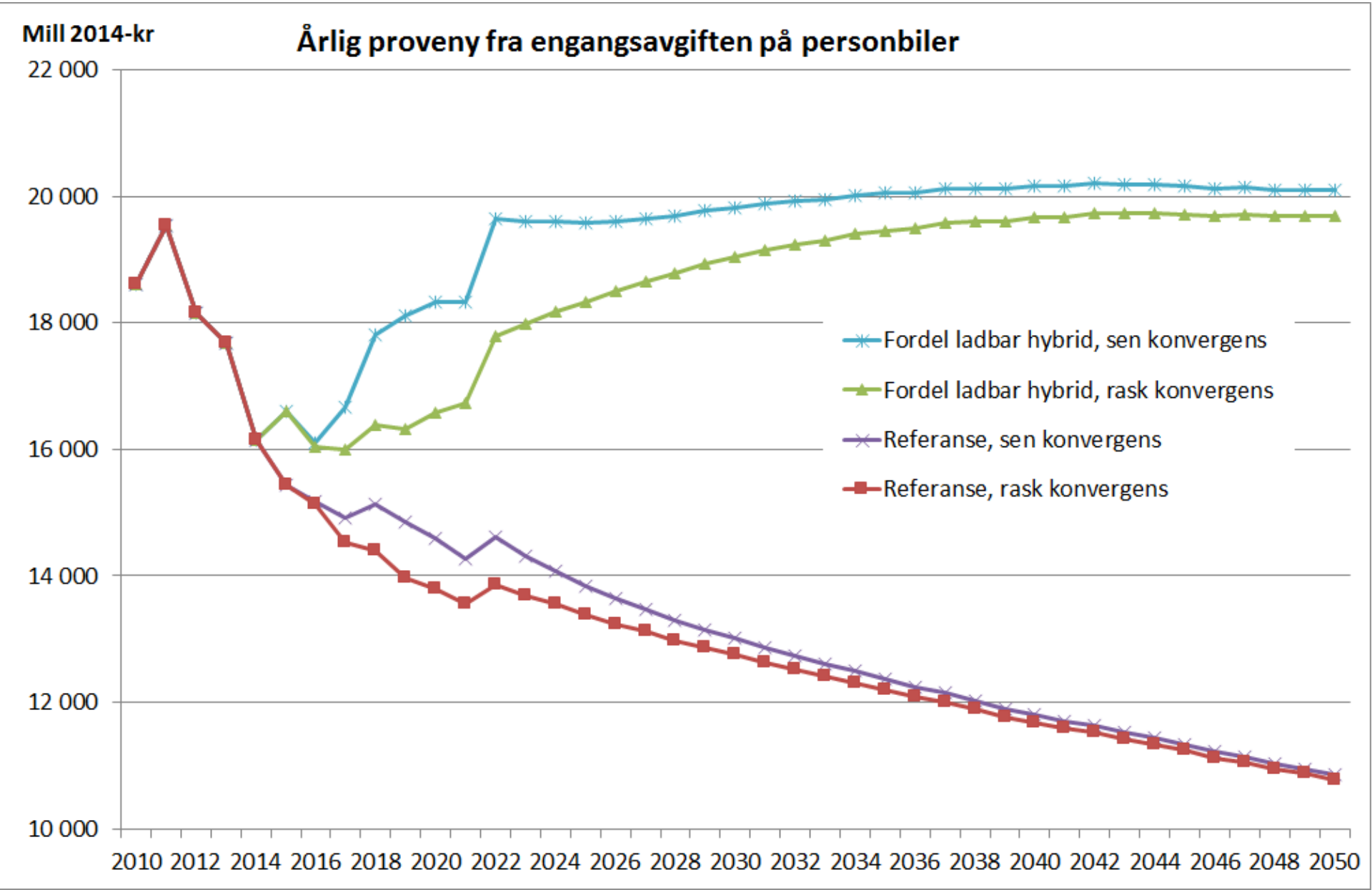
Car fleet's estimated real NO_X emissions (tonnes per annum)



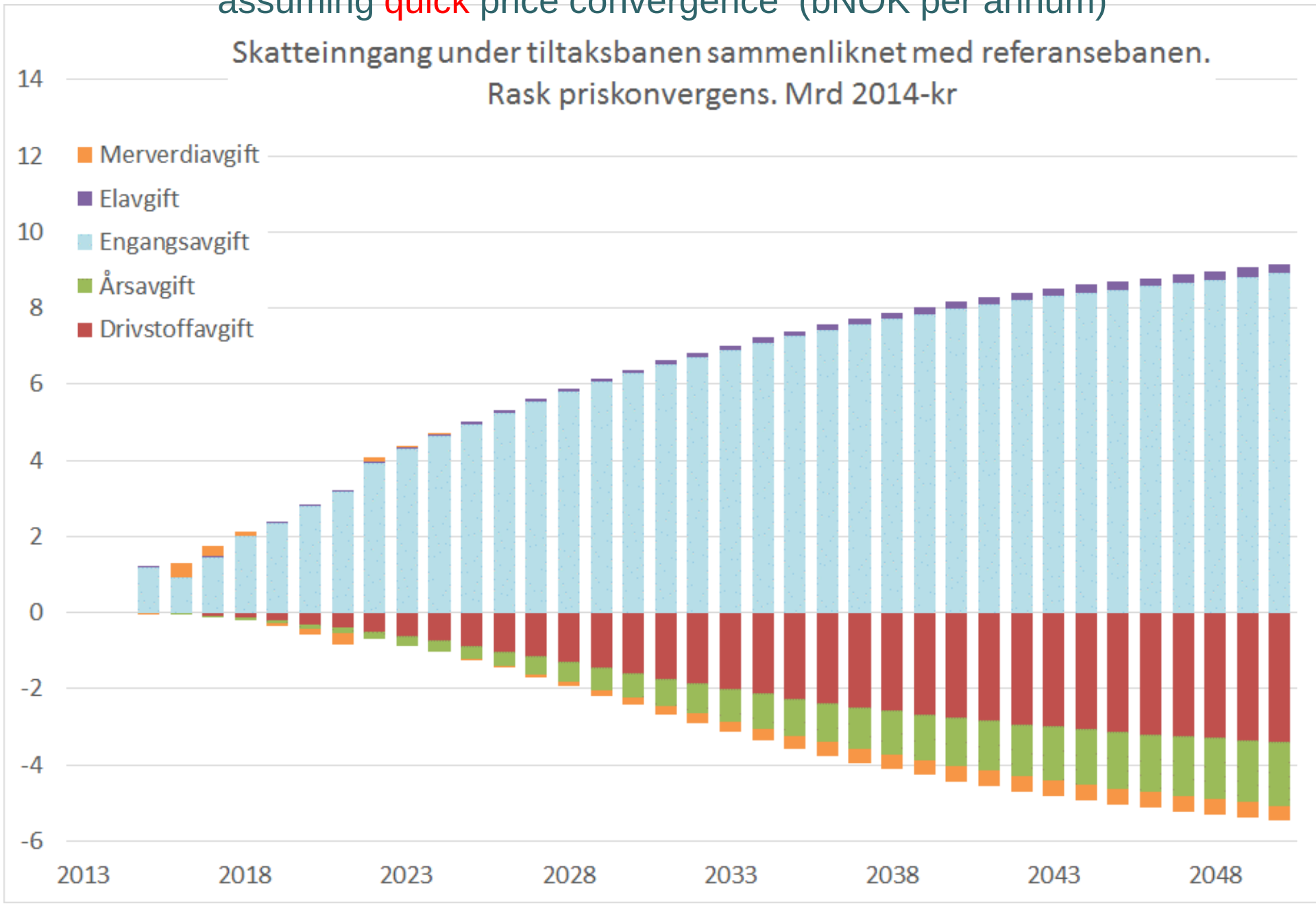
Projected government revenue from fuel tax (mNOK per annum)



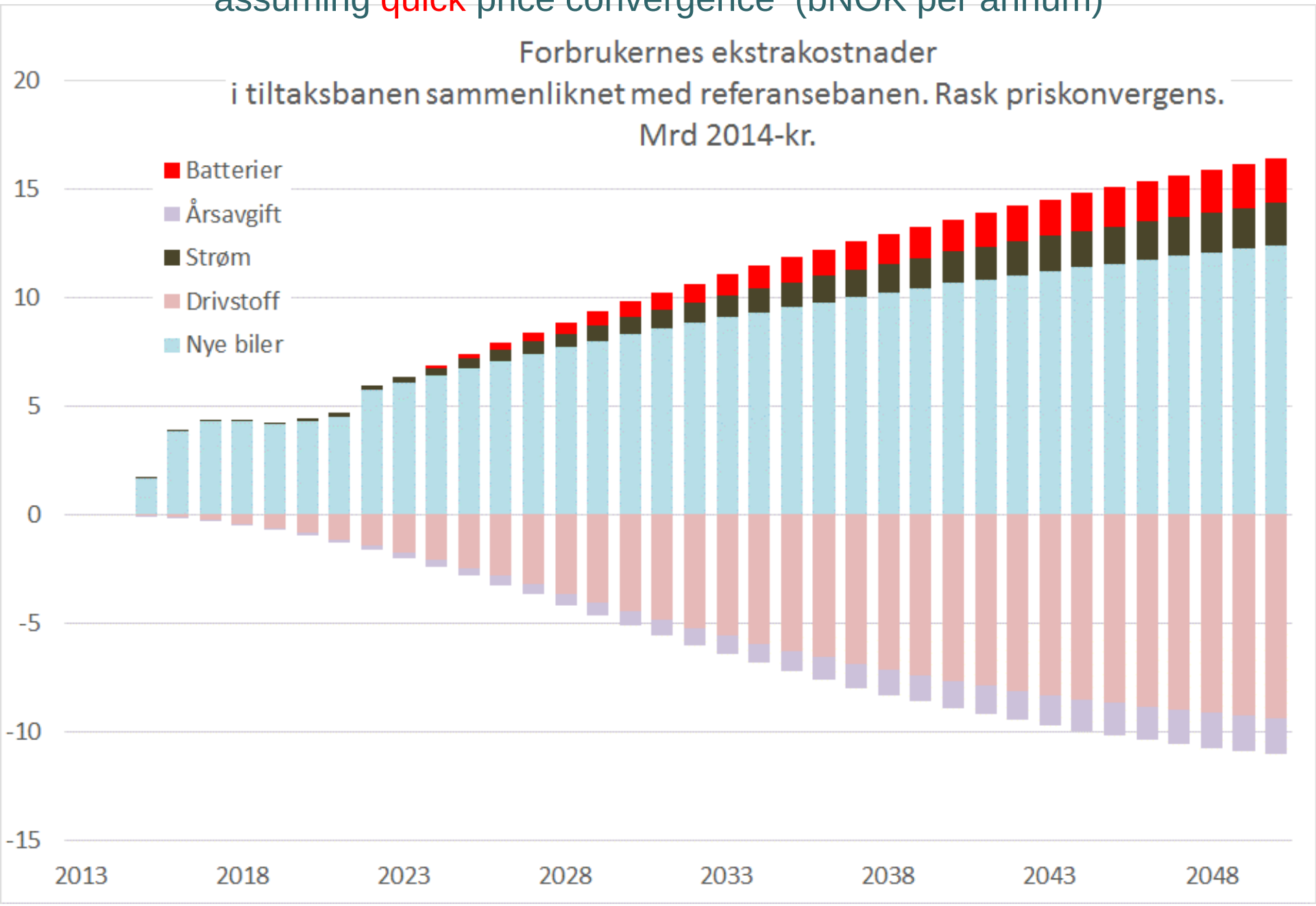
Projected government revenue from vehicle purchase tax (mNOK per annum)



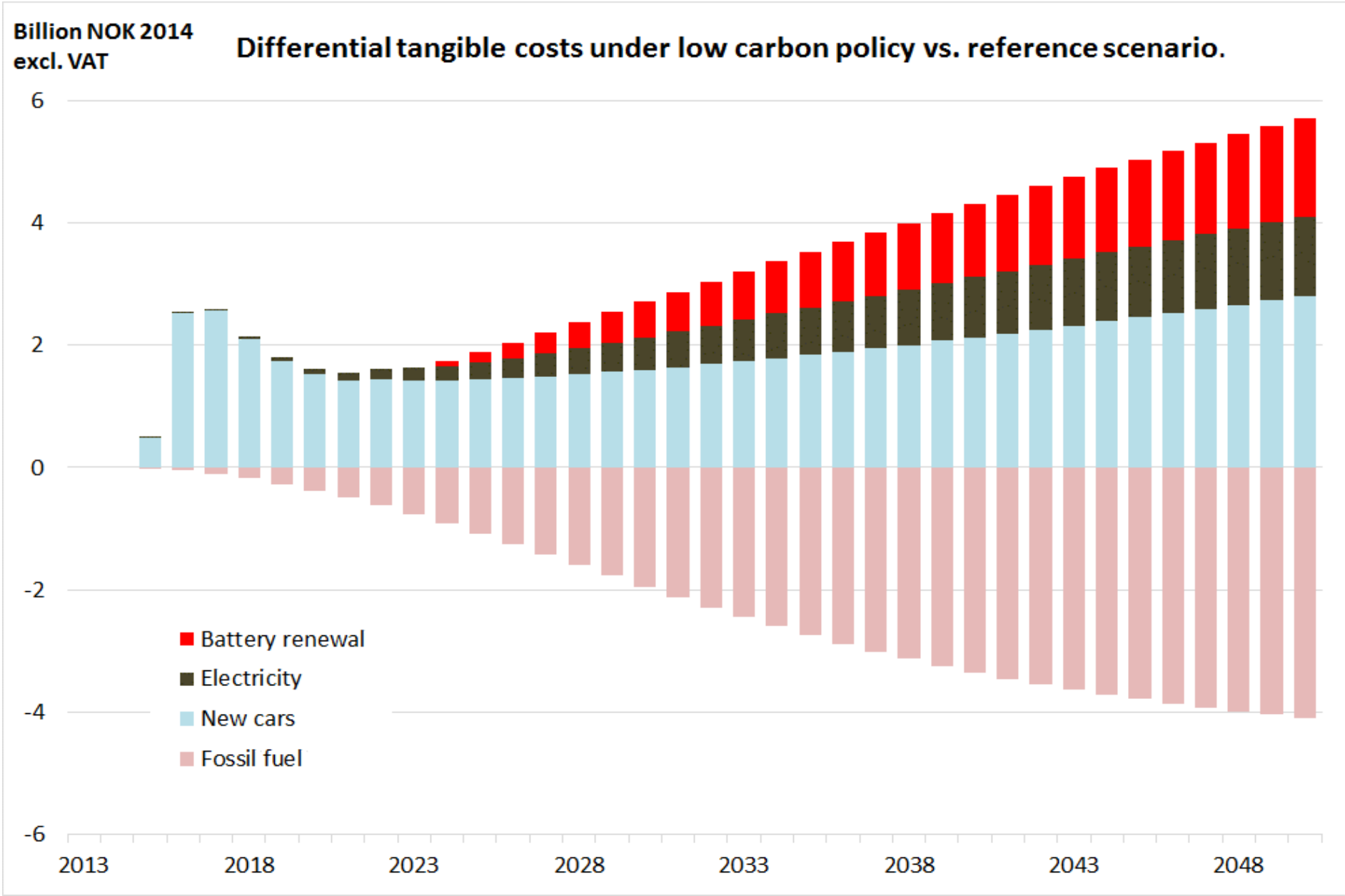
Differential tax revenue under intervention path vs. reference path, assuming quick price convergence (bNOK per annum)



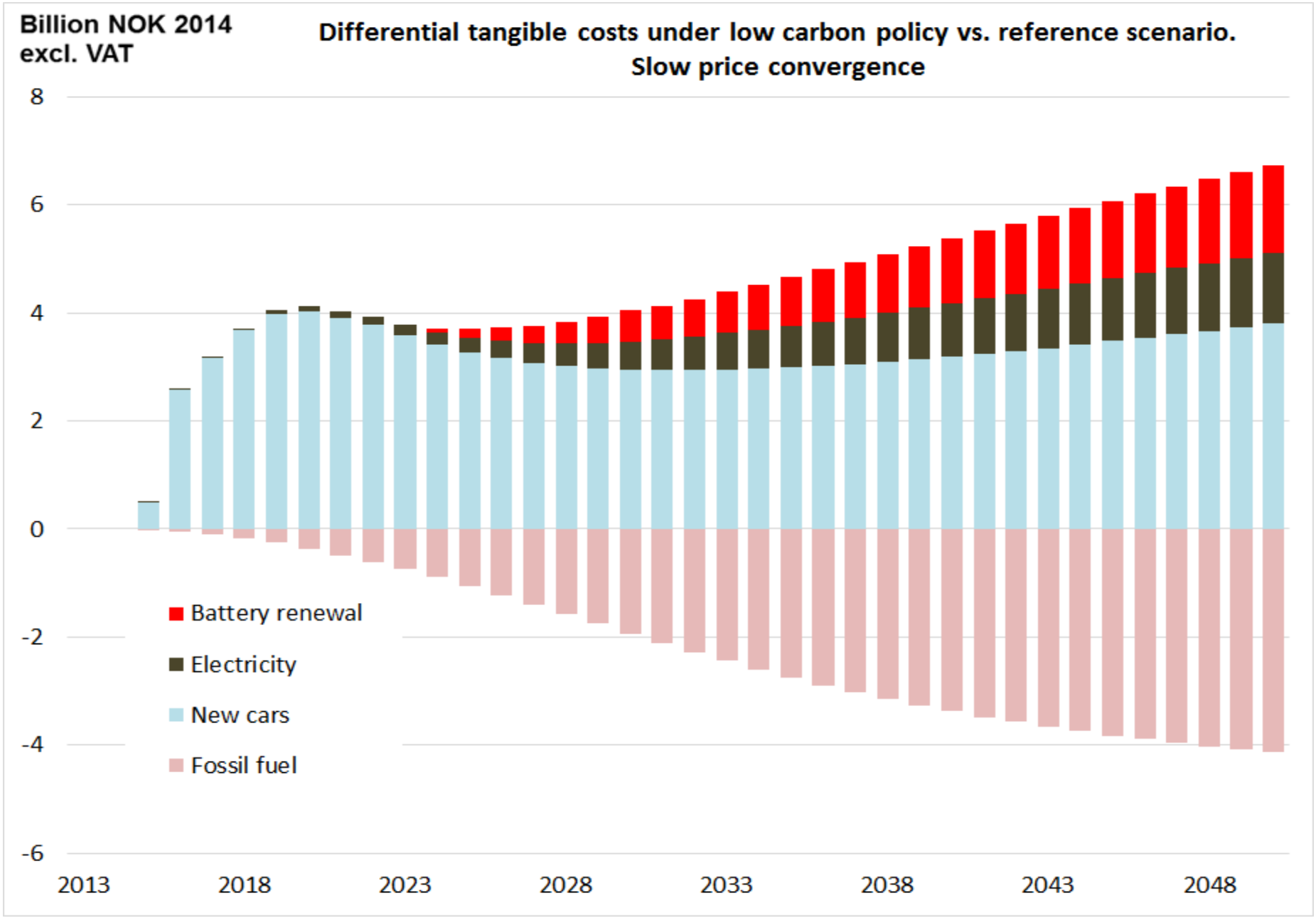
Differential consumers' expenditure under intervention path vs. reference path, assuming quick price convergence (bNOK per annum)



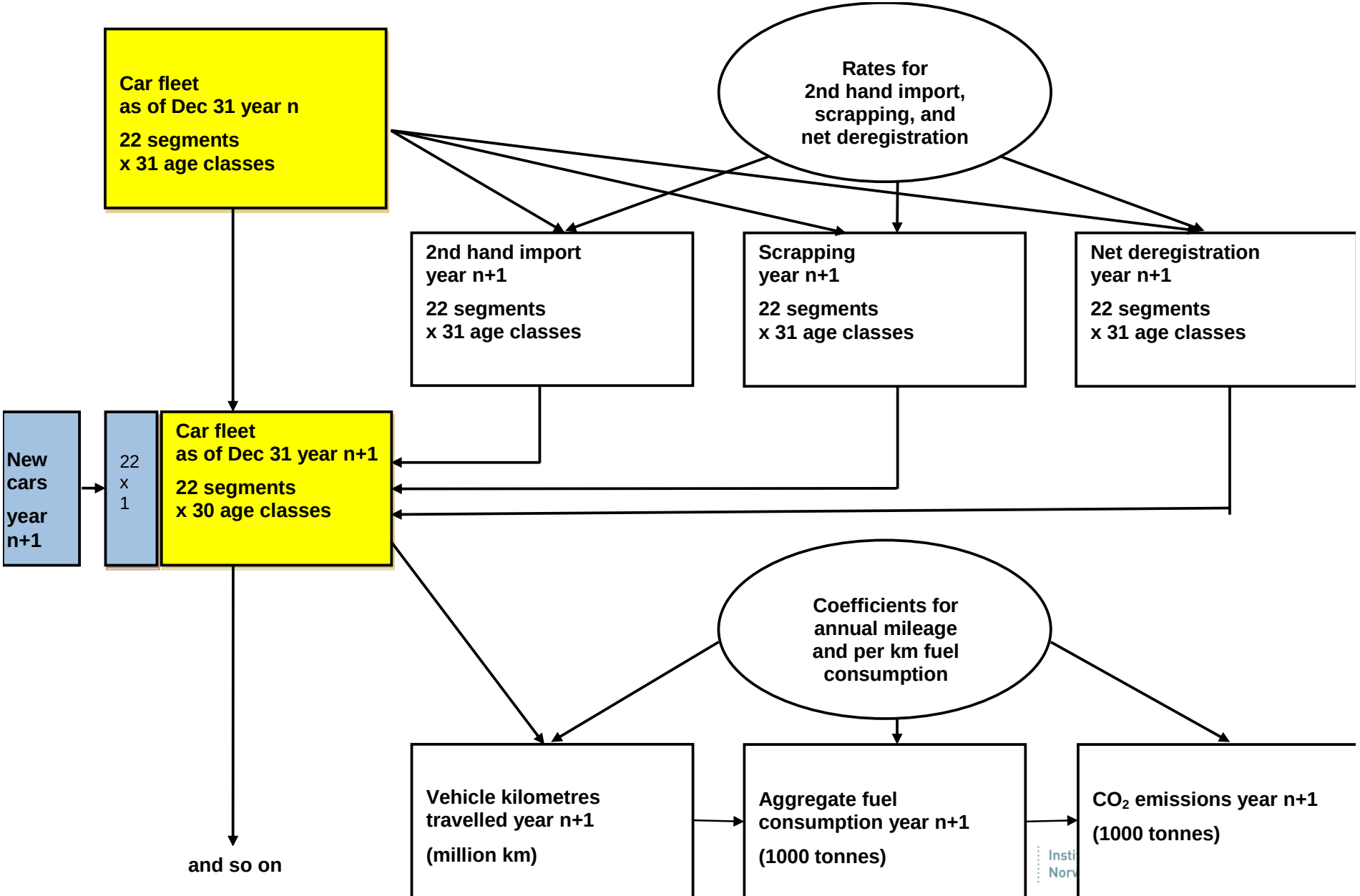
Differential tangible economic costs under intervention path vs. reference path, assuming quick price convergence



Differential tangible economic costs under intervention path vs. reference path, assuming slow price convergence



The BIG model of the passenger car fleet



Segment no.	Energy	Curb weight (kg)
1	Hybrid	
2	Battery electric (BEV)	
3	Hydrogen	
4	Other	
5	Petrol	0-999
6	Petrol	1000-1199
7	Petrol	1200-1299
8	Petrol	1300-1399
9	Petrol	1400-1499
10	Petrol	1500-1599
11	Petrol	1600-1799
12	Petrol	1800-1999
13	Petrol	2000+
14	Diesel	0-999
15	Diesel	1000-1199
16	Diesel	1200-1299
17	Diesel	1300-1399
18	Diesel	1400-1499
19	Diesel	1500-1599
20	Diesel	1600-1799
21	Diesel	1800-1999
22	Diesel	2000+

BIG segments

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A discrete choice model for new car sales (1)

A nested logit model was estimated based on complete sales data between January 1996 and mid-2011.

A total of 38 491 different vehicle models have been identified and their annual sales recorded.

The model is entirely generic, so as to predict the demand for new models with given attributes.

The upper nests consist of 20 different brands plus a residual nest assembling ‘all other brands’.

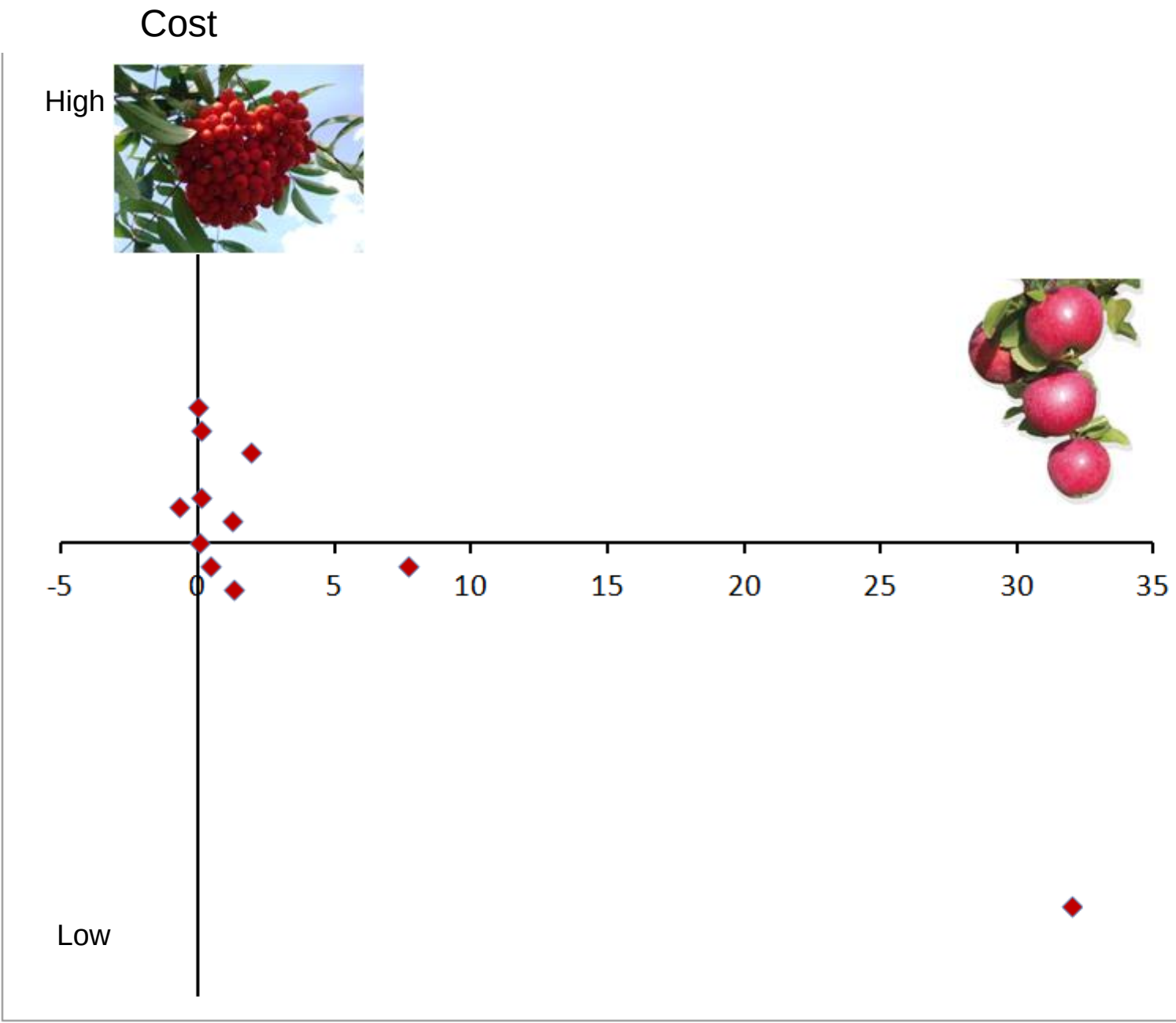
Choice model predicts the market shares of new car models under varying tax regimes.

A discrete choice model for new car sales (2)

Independent variables include

- vehicle's make (dummy)
- list price (deflated)
- purchase tax amount (deflated)
- type of energy (petrol, diesel, hybrid, battery)
- calculated kilometre cost of fuel (deflated)
- curb weight
- engine power
- number of seats and doors
- dummies for front, rear or 4-wheel drive

Marginal abatement costs



CO_2 abatement
Per cent of all emissions from domestic travel

Decoupling:
change certain factor(s)

$$emissions = GDP \cdot \frac{tonne / person\ kms}{BNP} \cdot \frac{vehicle\ kms}{tonne / person\ kms} \cdot \frac{energy\ consumption}{vehicle\ kms} \cdot \frac{emissions}{energy\ consumption}$$

The further to the left,
the higher the political and economic cost.

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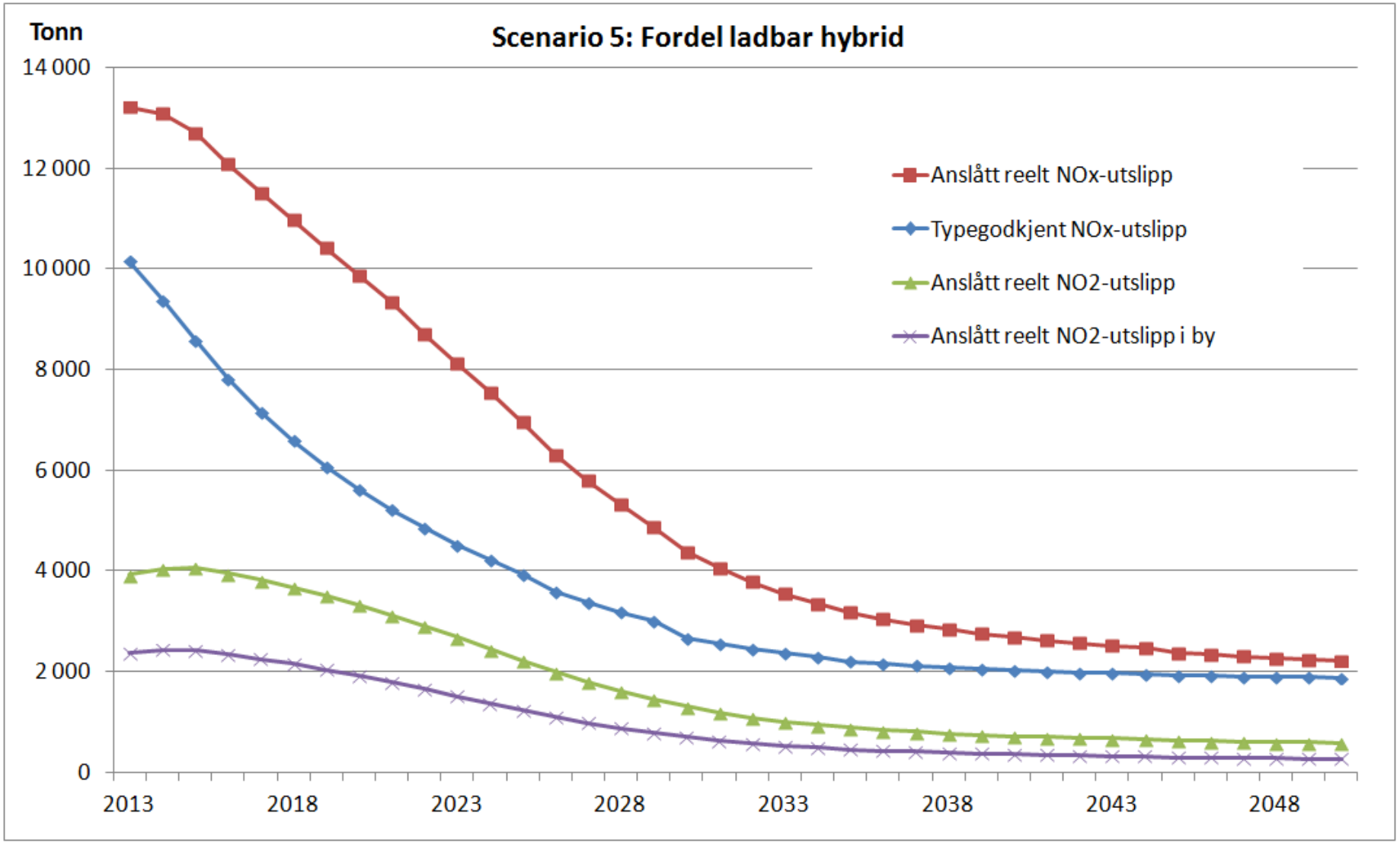
NO_x og NO_2


Tonn
Scenario 5: Fordel ladbar hybrid
14 000
12 000
10 000
8 000
6 000
4 000
2 000
0
2013
2018
2023
2028
2033
2038
2043
2048
Anslått reelt NOx-utslipp
Typegodkjent NOx-utslipp
Anslått reelt NO2-utslipp
Anslått reelt NO2-utslipp i by

NO_x i seks scenarier