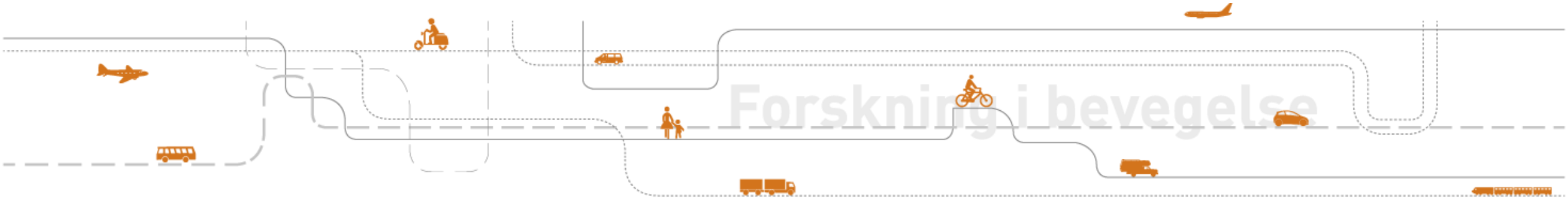
From market penetration to vehicle scrappage

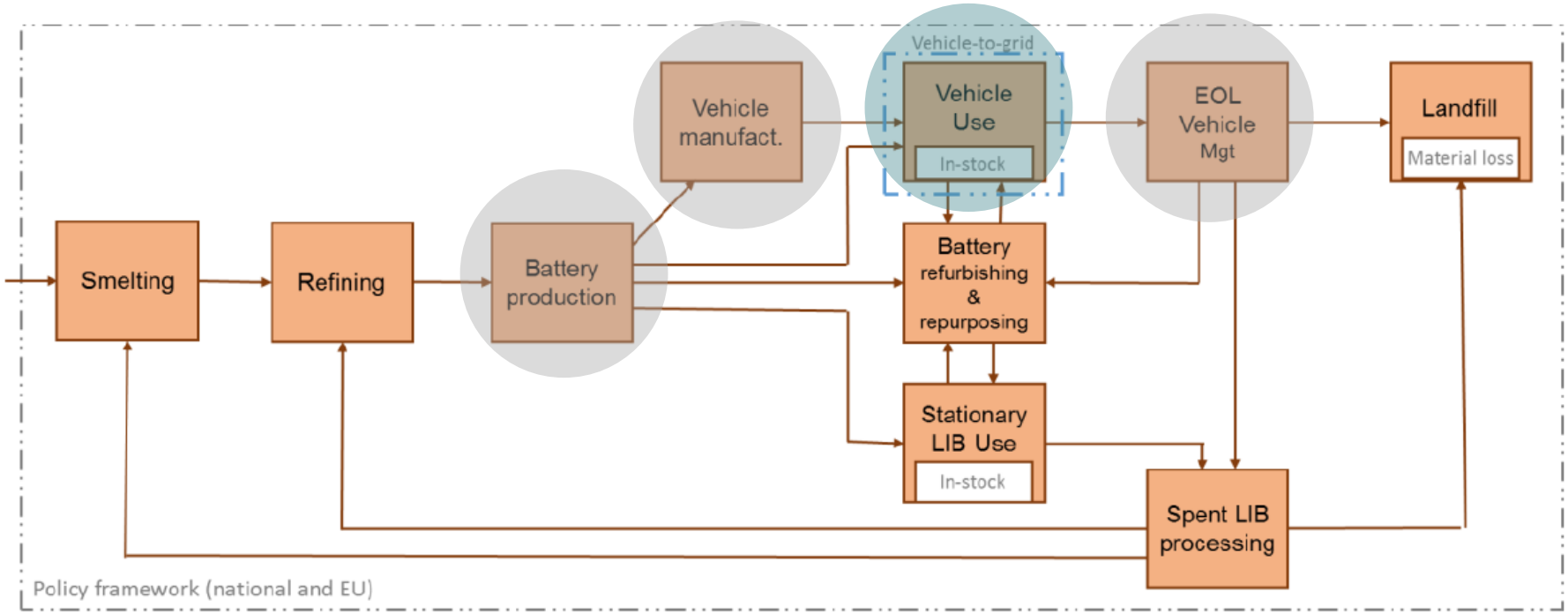
– The movement of Li-Ion batteries through the Norwegian transport sector

TØI: Erik Figenbaum, Rebecca Thorne, Lasse Fridstrøm

Conference: Norwegian opportunities with Lithium-Ion batteries
11th December, Oslo



- **Estimates of electric passenger vehicle sales and scrappages**
- **Estimates of corresponding battery amounts and types**

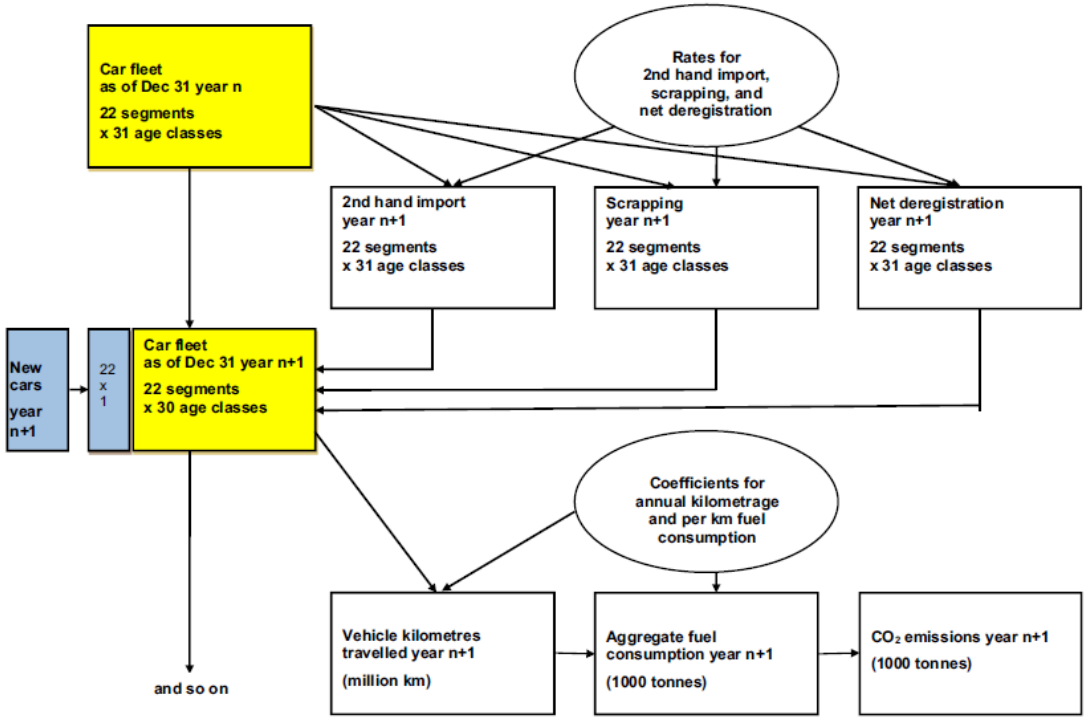


LIB system (project proposal)

See method note: TØI (2019): Estimating stocks and flows of electric passenger vehicle batteries in the Norwegian fleet

Methodology to estimate vehicle flows

- Electric vehicles are split into nine weight segments for different production years.
- Each has a corresponding ‘survival rate’ to the next year, allowing **fleet losses** to be calculated
- New **vehicle sales** are predicted according to a conservative sales estimate (‘Perspektivmeldingen’).



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ORIGINAL PAPER

A stock-flow cohort model of the national car fleet

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Abstract
Purpose Various regulatory and fiscal policy instruments are in force to reduce the amount of greenhouse gases and local pollutants emitted by private cars. The incentives operate primarily—or exclusively—on the newest generation of cars. But how fast will technological developments affecting new vehicle models penetrate into the car fleet? The speed at which the adverse effects of private car use will be mitigated through the normal vehicle renewal process, or through an accelerated one, carries considerable interest. Suitable modelling tools are needed. This paper aims to demonstrate the usefulness and flexibility of a bottom-up stock-flow modelling approach to private car fleet forecasting and policy analysis.
Methods In the BIG model of the Norwegian automobile fleet, the annual stocks and flows characterising the car fleet are specified as matrices of 682 mutually exclusive and exhaustive cells, formed by cross-tabulations between 22 vehicle segments and 31 age classes. New car registrations follow from a disaggregate generic discrete choice model based on two decades of complete sales data for individual passenger car models.
Results Example projections are presented onto the 2050 horizon under a low carbon fiscal policy scenario as well as a business-as-usual scenario. The fiscal policy is seen to make a large difference in terms of long term fuel consumption and CO_2 emissions.
Conclusions Stock-flow cohort modelling of the automobile fleet is a powerful and handy tool for policy analysis. Even quite simple and straightforward accounting relations may provide important insights into the dynamics of fleet development. It is possible to incorporate, into the stock-flow modelling framework, interesting and useful behavioural relations, explaining aggregate automobile ownership and travel demand, scrapping and survival rates, or consumer choice in the market for new cars.

Keywords Passenger cars · Fleet forecasting · Fuel economy · Greenhouse gases · Recursive model · Bottom-up

1 Introduction and rationale

The prospect of having two billion private cars roaming the planet’s streets and roads, while emitting greenhouse gases as well as local pollutants, is discomforting [1]. Responsible governments worldwide are contemplating how to prevent the motor vehicle stock from reaching unsustainable levels and/or to decouple income and travel demand growth from environmental degradation and climate change [2]. In most OECD countries, passenger cars constitute the primary source of greenhouse gas (GHG) emissions from transport.

The European Commission has mandated maximum CO_2 emission targets for new passenger cars sold in 2015 and 2021, respectively. The targets are 130 g of CO_2 per km in 2015 and 95 g/km in 2021, as measured by the NEDC laboratory test cycle. To meet the targets, automobile manufacturers are working to reduce the type approval fuel consumption of conventional vehicles equipped with internal combustion engines (ICE), while also introducing a widening range of zero and low emission vehicles, such as battery electric (BEV) and plug-in hybrid electric vehicles (PHEV).

Similarly, the Euro 1–6 standard for light duty vehicles and the Euro I–VI standard for heavy duty engines oblige

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Fridstrøm et al. (2016). A stock-flow cohort model of the national car fleet. Eur. Transp. Res. Rev. 8: 22

Methodology to estimate vehicle flows

New car sales for all weight segments, for that year, n

Change in vehicle fleet for one year, n

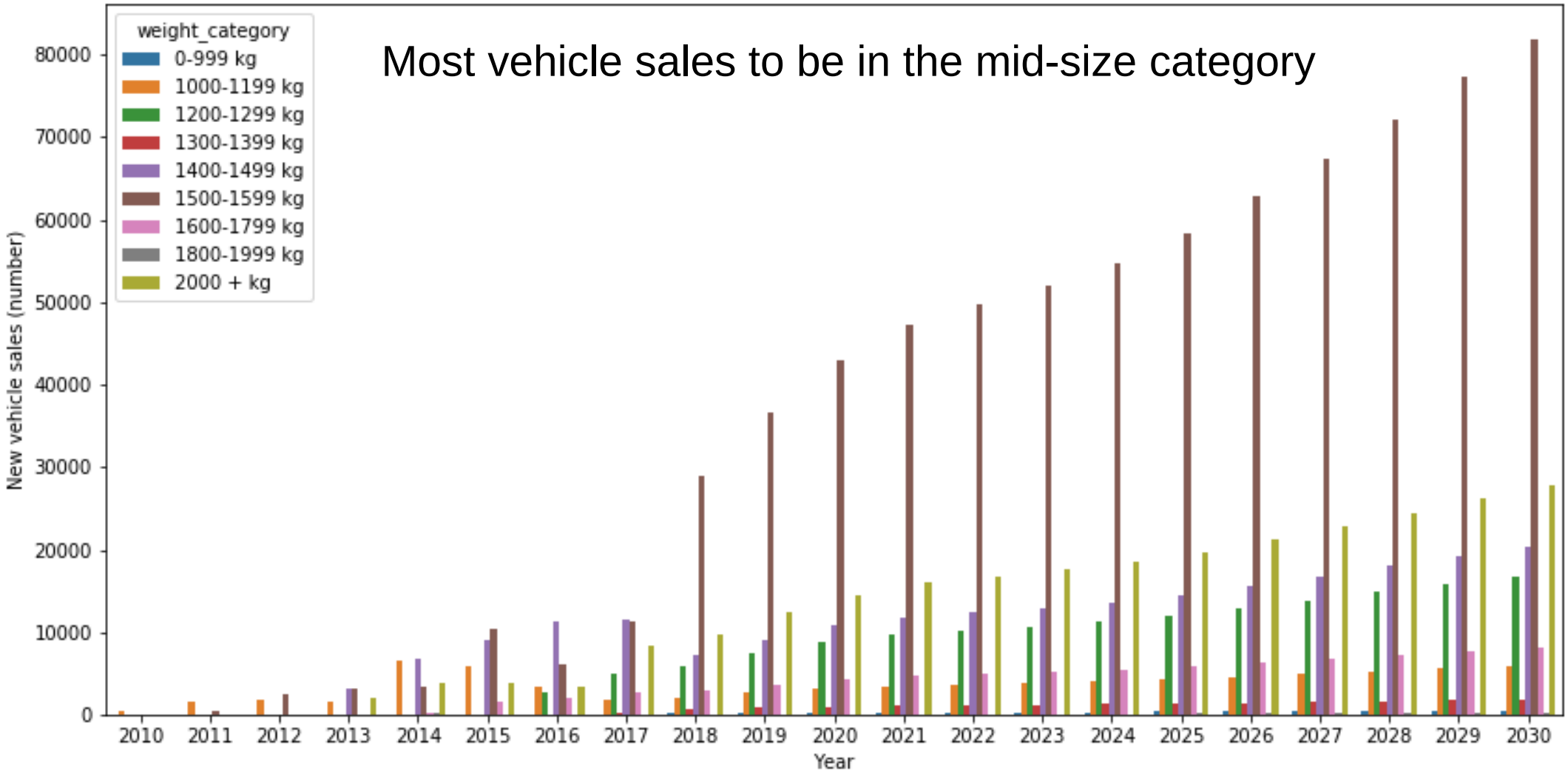
$$\Delta f_n = \sum s_n + \sum \Delta C_{(n-1)}$$

Net stock change for all vehicles older than 1 year, and for all weight segments

Estimated per year, and per weight segment

Fridstrøm et al. (2016). A stock-flow cohort model of the national car fleet. Eur. Transp. Res. Rev. 8: 22

New electric vehicle sales (passenger vehicles)

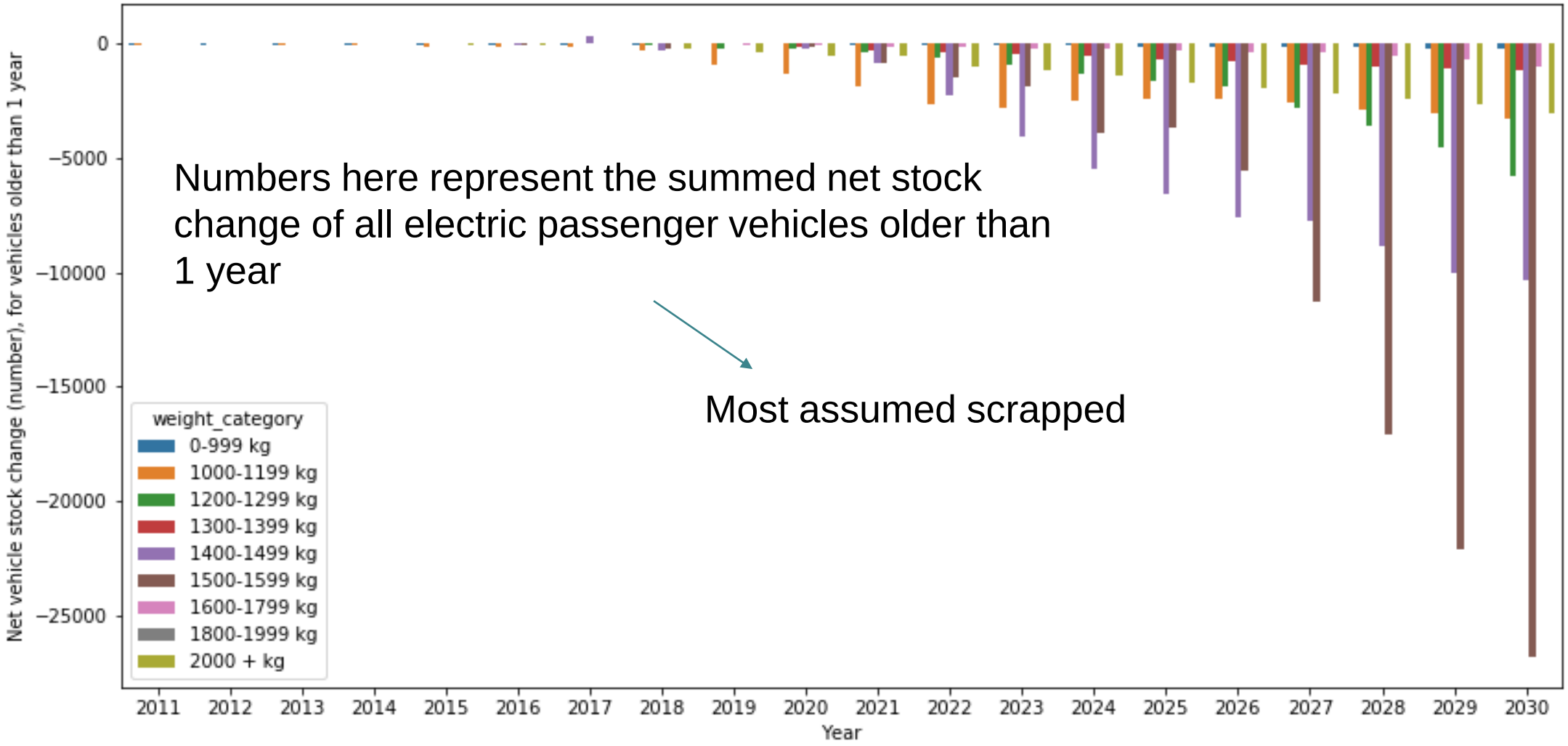


How does this compare to ‘real’ data?

Year	Actual new vehicle sales (OFV)	New vehicle sales (modelled)	Change (%) Modelled to OFV
2011	2000	1988	1
2012	3951	4231	-7
2013	7882	9884	-25
2014	18081	21055	-16
2015	25777	30758	-19
2016	24217	28936	-19
2017	33025	41423	-25
2018	46069	57555	-25

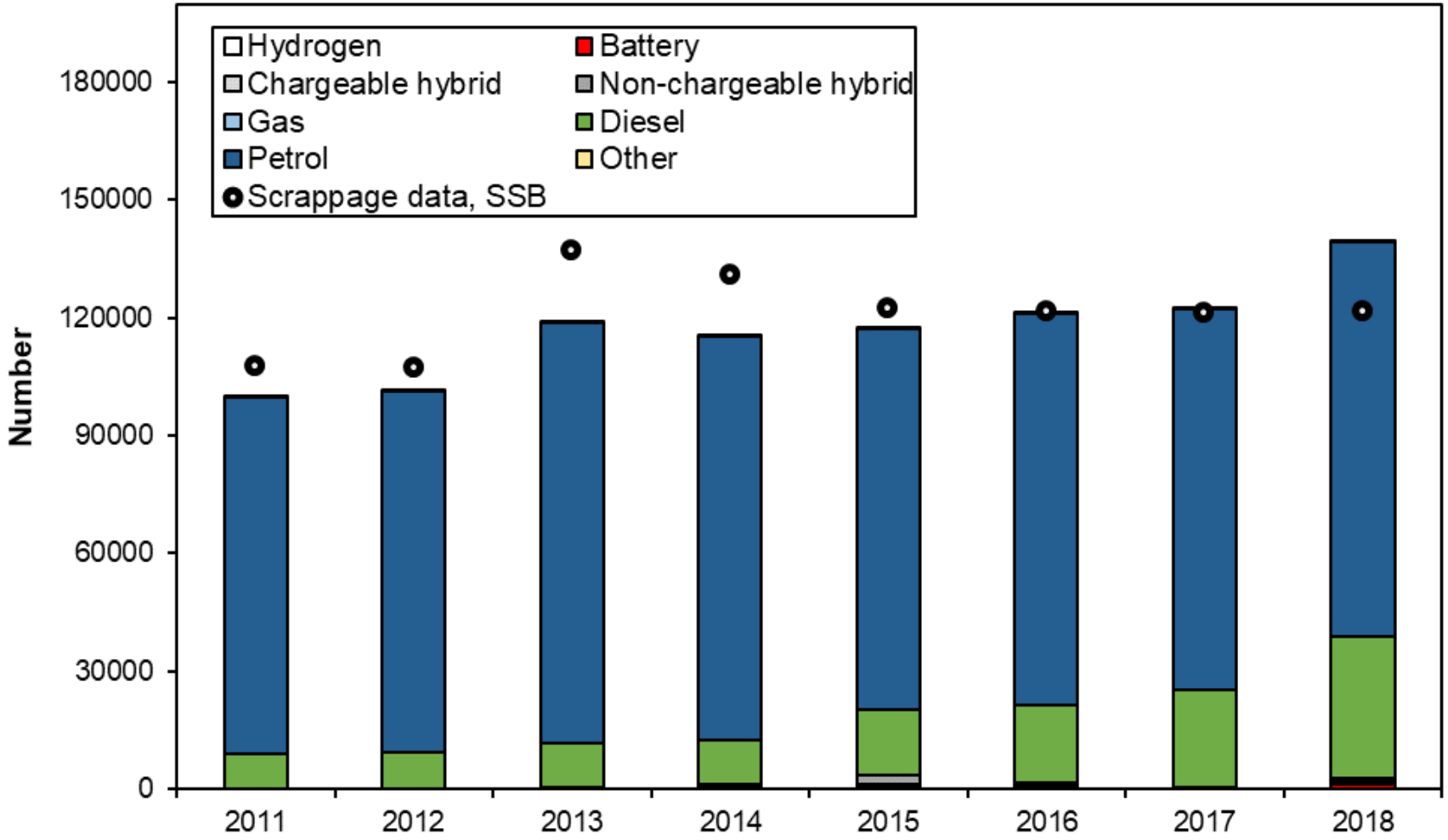
Stocks and flows model also includes second hand import of (almost) new vehicles, that have already been registered abroad once before during the same year

Fleet electric passenger vehicle losses



How does this compare to ‘real’ data?

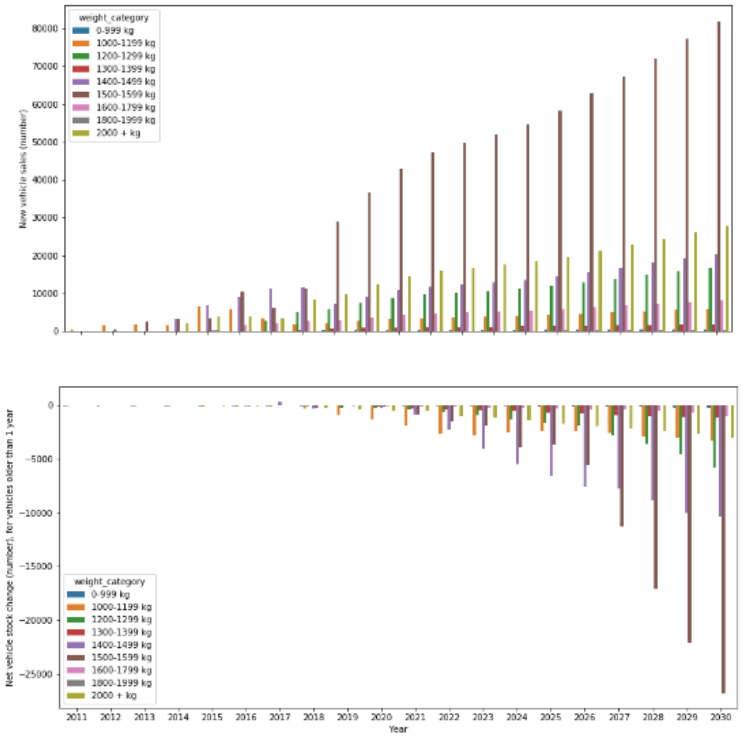
Scrappage data from SSB vs. Number vehicles exiting the fleet from model



- Estimates of electric passenger vehicle sales and scrappages
- **Estimates of corresponding battery amounts and types**

Methodology to estimate battery flows to 2030

Stocks and flows cohort model results



\+ Background (historical) data on:

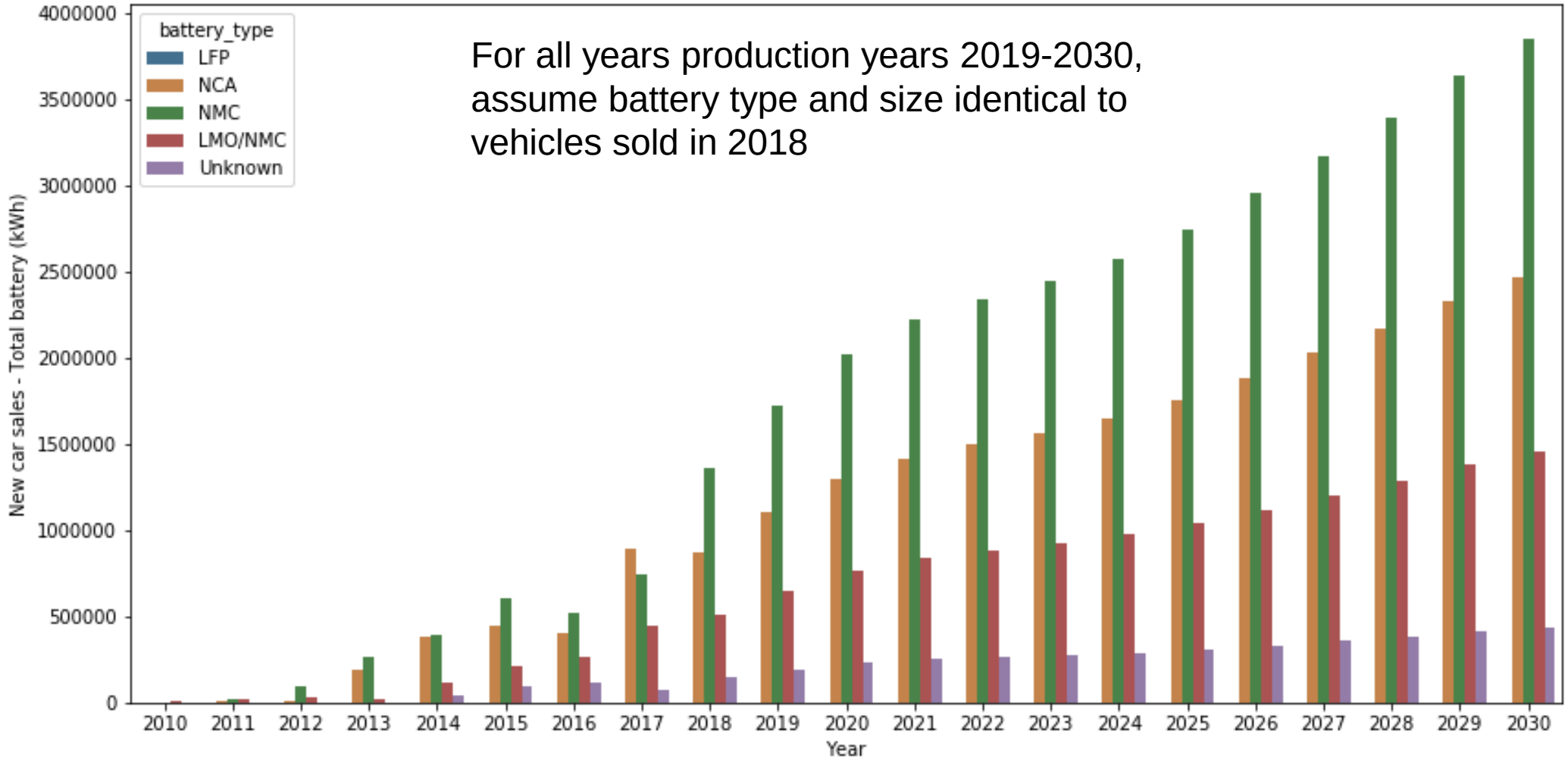
1. Electric car sales — Opplysningsrådet for veitrafikken
2. Battery types/characteristics — Electric Vehicle Database

Full make/model	Nominal battery size (kWh)	Battery type
Audi e-tron 55 Quattro	95.0	NMC
BMW i3 120 Ah	42.2	LMO/NMC
Chevrolet Bolt	60.0	NMC
Citroen Berlingo Multispace	22.5	Unknown
Citroen C-Zero	16.0	LMO/NMC
FIORINO 40 KW	18.0	Unknown
Fiat 500	24.0	Unknown
Ford Focus	33.5	LMO/NMC
Hyundai IONIQ	38.3	NMC

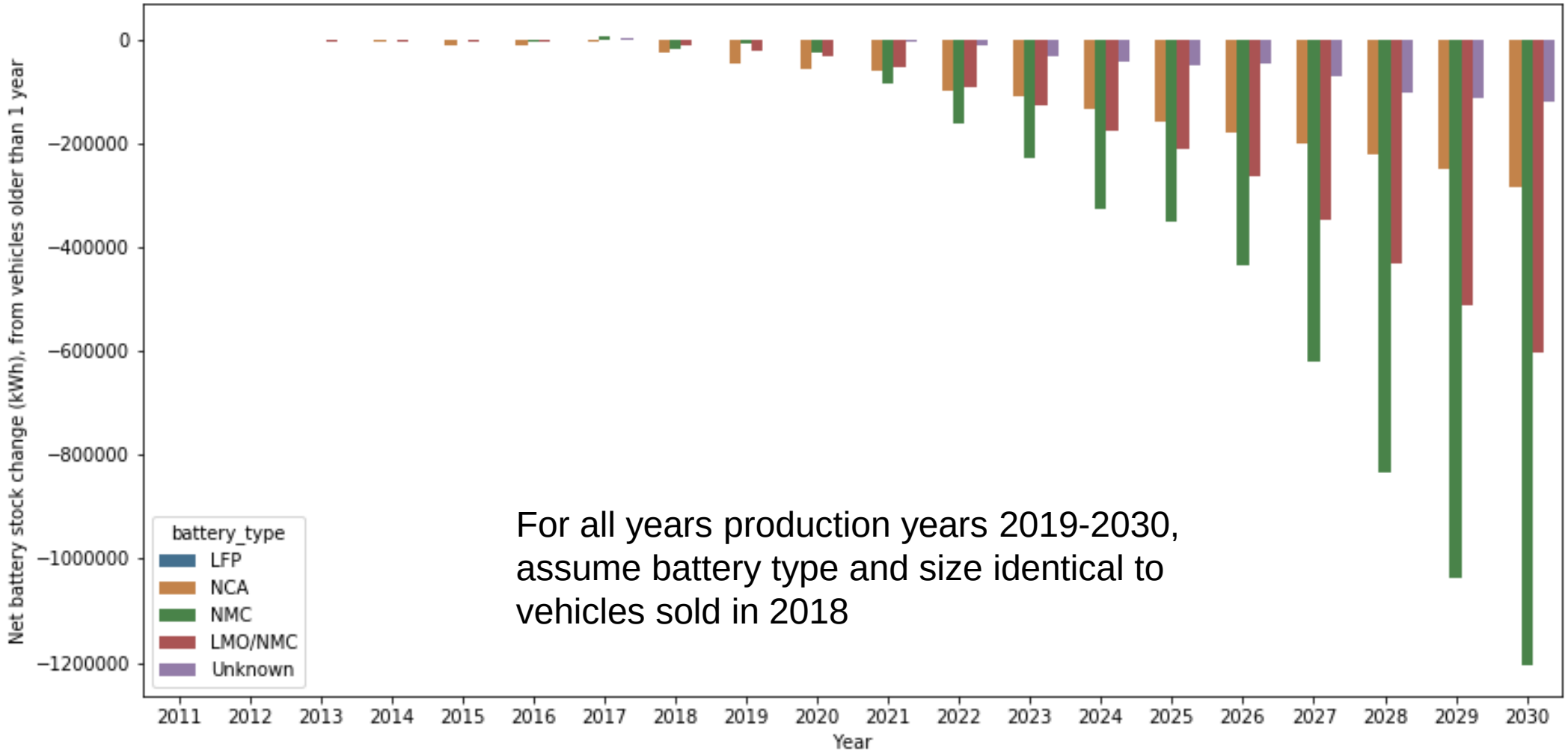
Estimates of:

1. The amount of batteries entering the passenger vehicle fleet to 2030
2. The net change of batteries in fleet electric passenger vehicles to 2030

Estimates of quantities of batteries in new electric passenger vehicle sales



Estimates of battery scrappage from electric passenger vehicle fleet



For all years production years 2019-2030, assume battery type and size identical to vehicles sold in 2018

More information?

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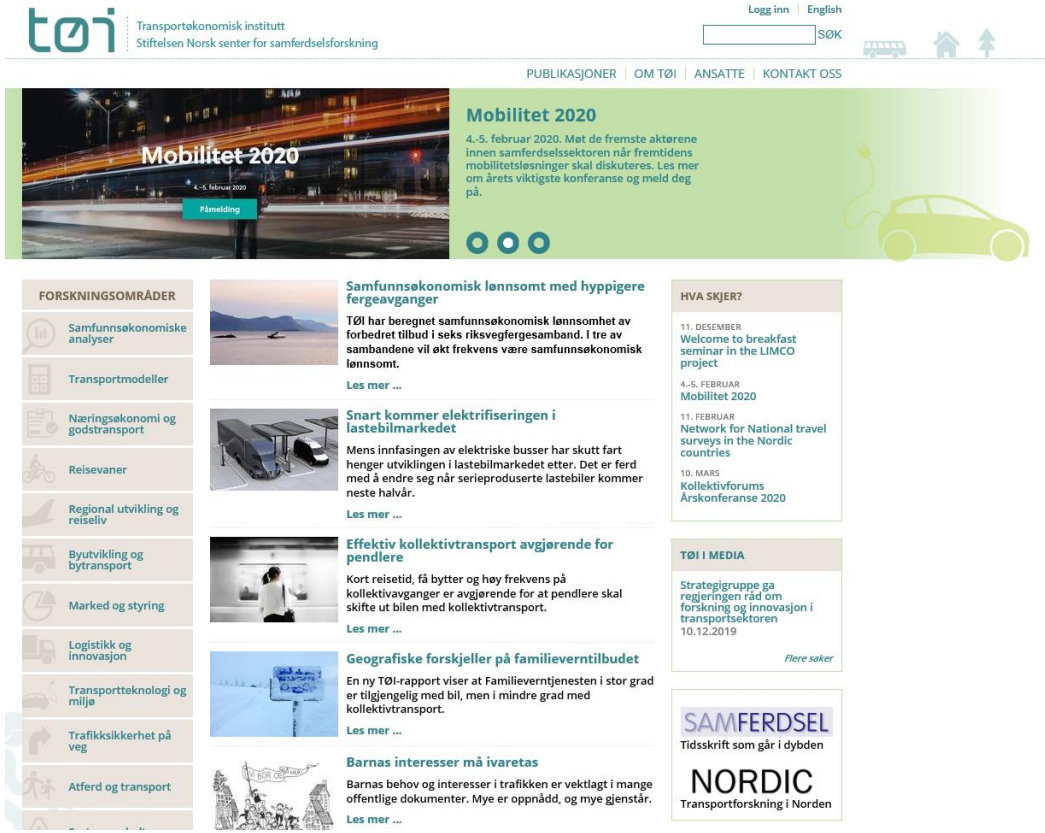

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