Institute of Transport Economics
Norwegian Centre for Transport Research

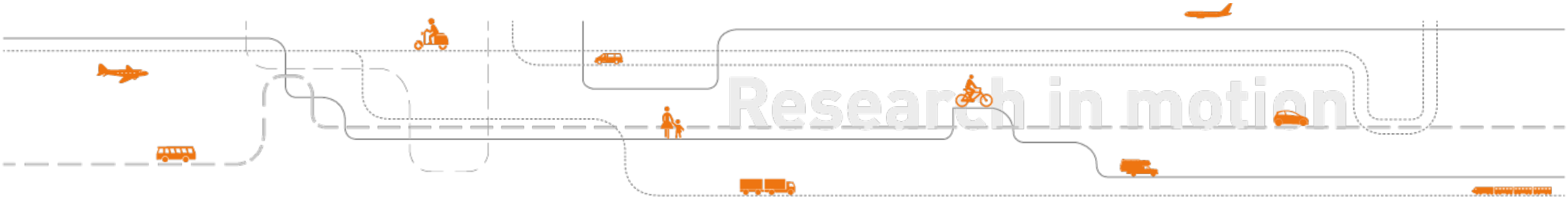
MOZEES
Mobility Zero Emission Energy Systems

www.toi.no

Norwegian EV Charging Infrastructure and User Experiences

The future of Electric Vehicle Infrastructure in the U.S. Webinar. 2 may 2019
The National Academies of Sciences – Engineering - Medicine

Chief Research Engineer Erik Figenbaum
Institute of Transport Economics
Oslo, Norway



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- Multi-disciplinary Independent, non-profit research foundation.
- To develop and disseminate transportation knowledge with scientific quality and practical application

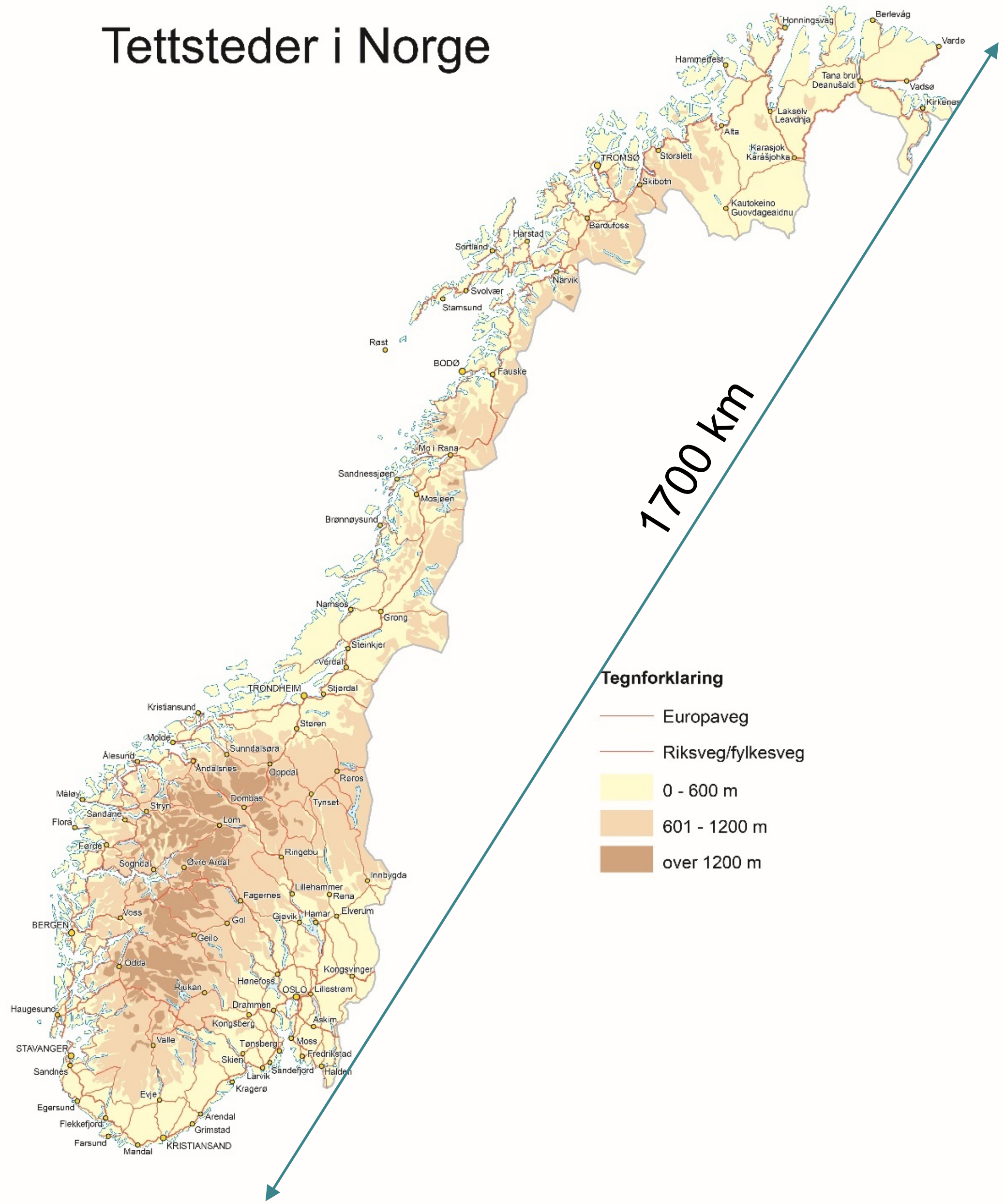
Norway quick facts

- 5.3 million inhabitants

- 2.75 million passenger vehicles, of which:
  - *194 000 Battery Electric Vehicles (7.1%)*
  - *96 000 Plug in Hybrid vehicles (3.5%)*

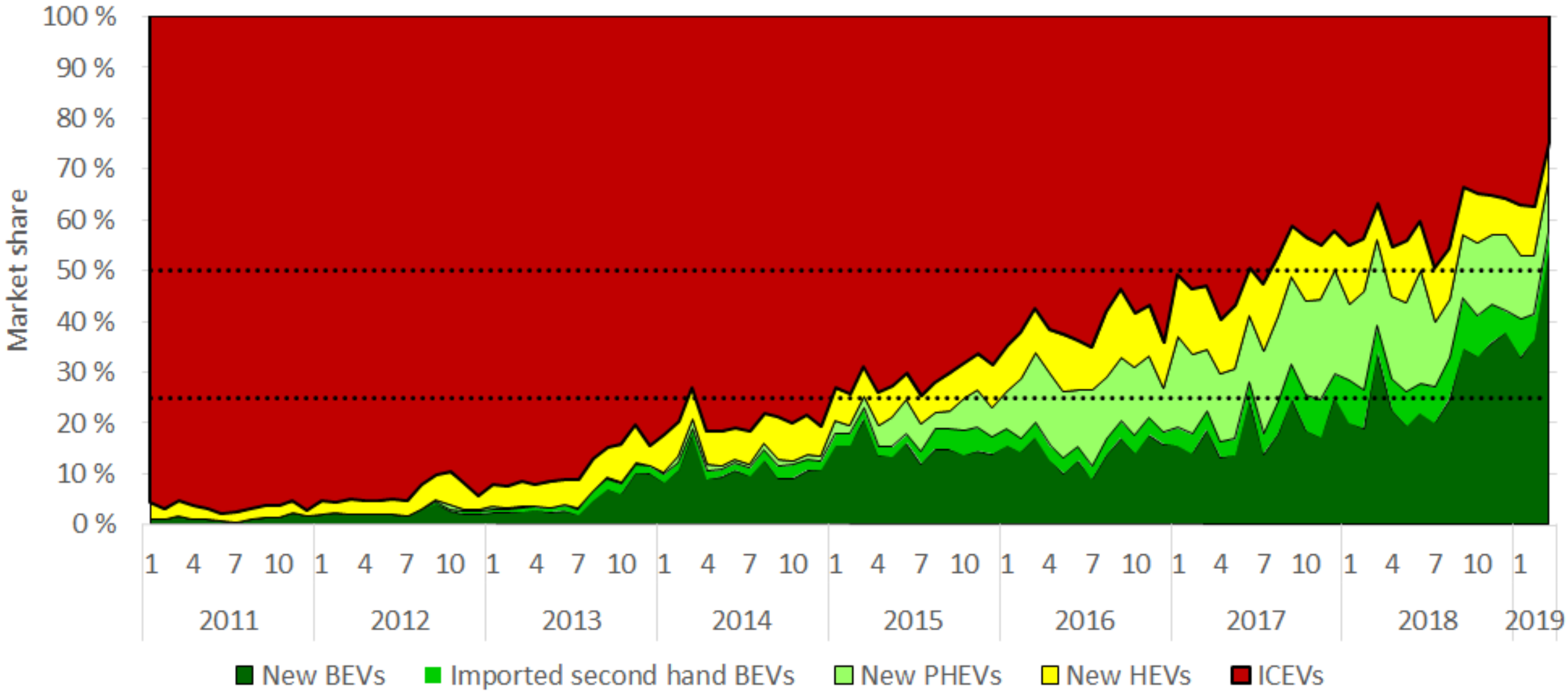
- 0.48 million Light commercial vehicles, of which:
  - *5 300 Battery Electric Vans (1.1%)*

- Charging infrastructure (status 01.01.2019)
  - *~1 100 50 kW CCS/Chademo fast chargers in ~500 locations*
  - *~7 500 public normal chargers + domestic type sockets*
  - *~90 000 Type 2 EVSE wallbox home chargers*
  - *Tesla Supercharger infrastructure*



Sources:
Vehicle register (status 01.01.2019) and Statistics Norway
E. Figenbaum 2018. Electromobility Status in Norway. TOI report 1627/2018.
New un-published estimates from 2018 TOI BEV user survey

Monthly market shares

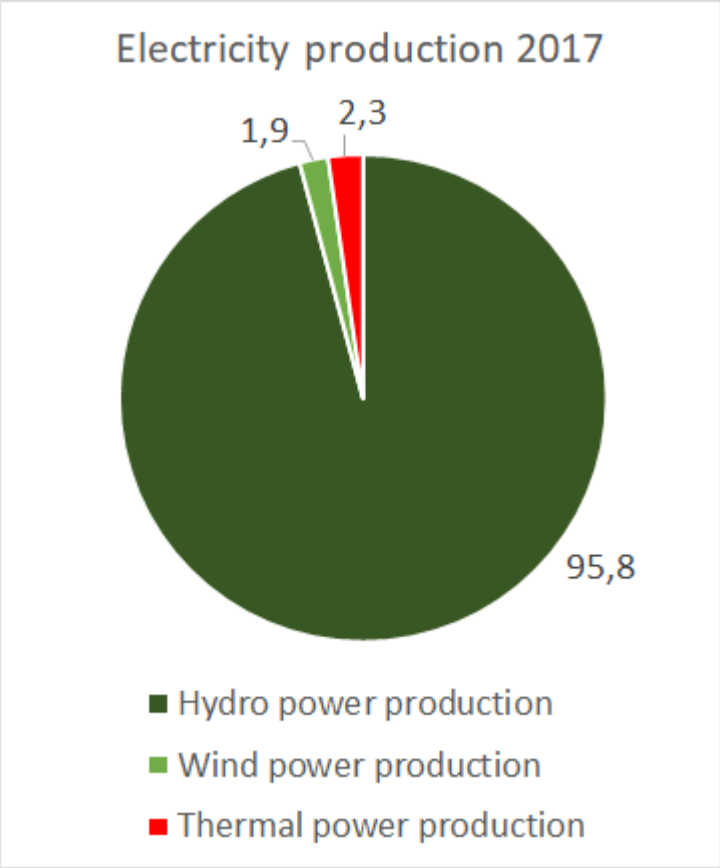


Source: www.OFVAS.no and the Norwegian Vehicle register (data from the Norwegian Public Roads Administration)

The first main reason for the high adoption of BEVs

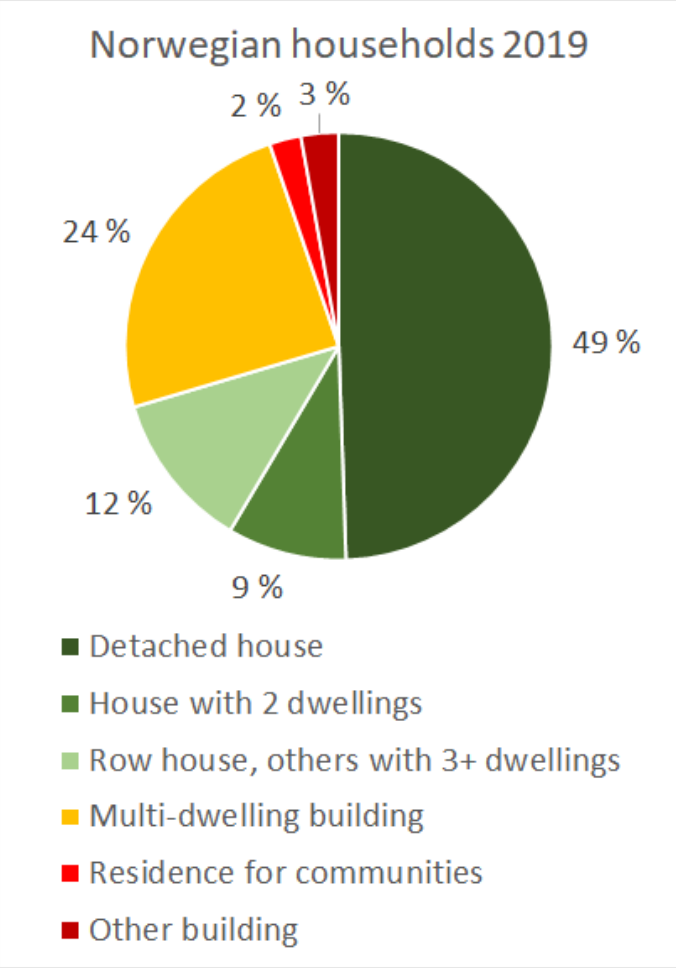
Norway is especially suited for BEVs

Clean Electricity, strong grid



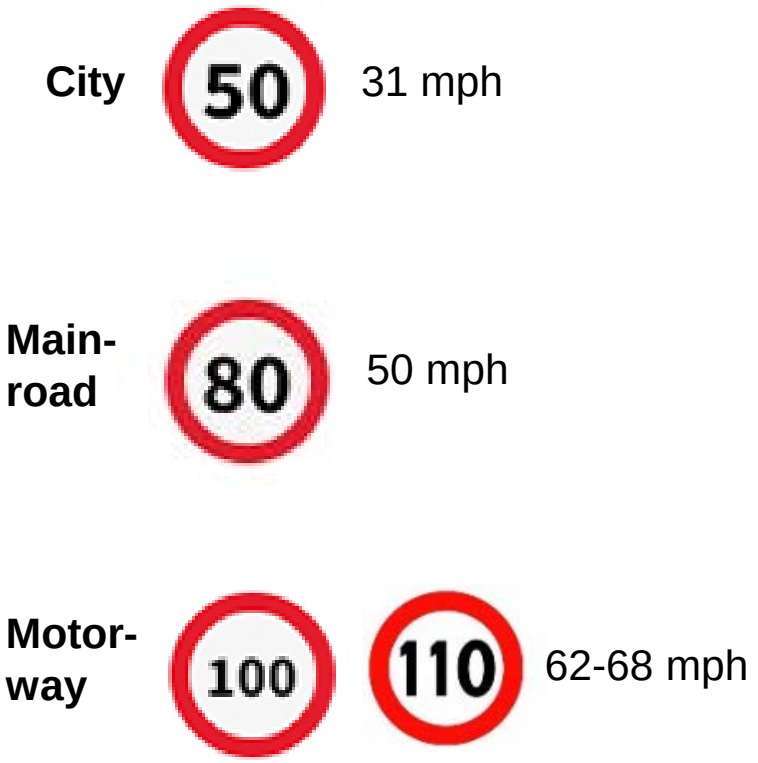
Source: Statistics Norway

Private parking access



Source: Statistics Norway

Moderate road speeds



Long distance trip average speed: 70-80 km/h

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The second main reason for the high adoption of BEVs

Norway have introduced BIG incentives and kept them in place

- National
  - *Exemption from VAT (25% on other vehicles)*
  - *Exemption from registration tax*
  - *Reduced annual (circulation) tax*
  - *Reduced benefit taxation on company cars*
  - *Exemption from tax on change of ownership (introduced 2018)*

- Local
  - *Free toll roads*
  - *Free parking*
  - *Reduced ferry rates*

  } New policy: Max 50% of ICEV rate, local decision

  - *Access to bus lanes*

  New policy: Need to have a passenger in rush hours some places

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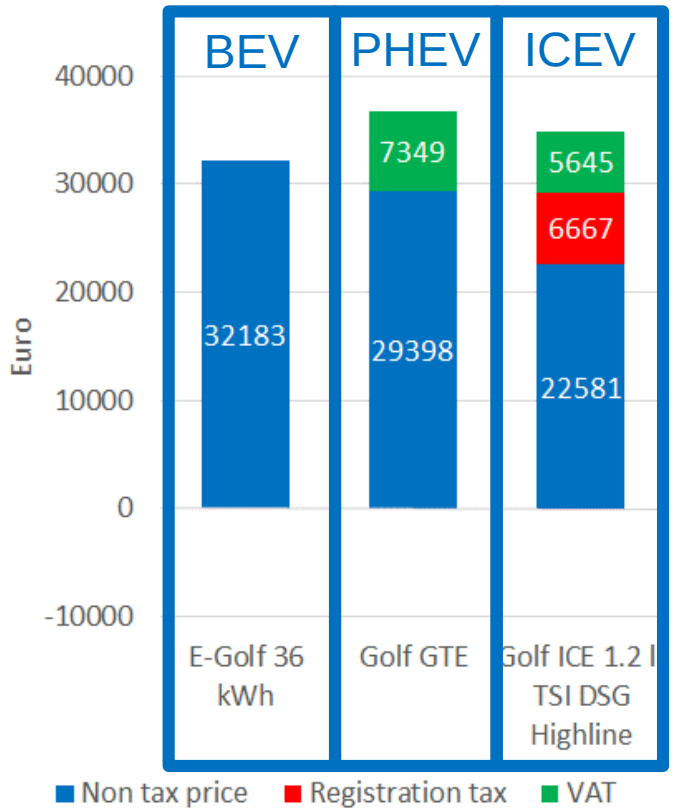
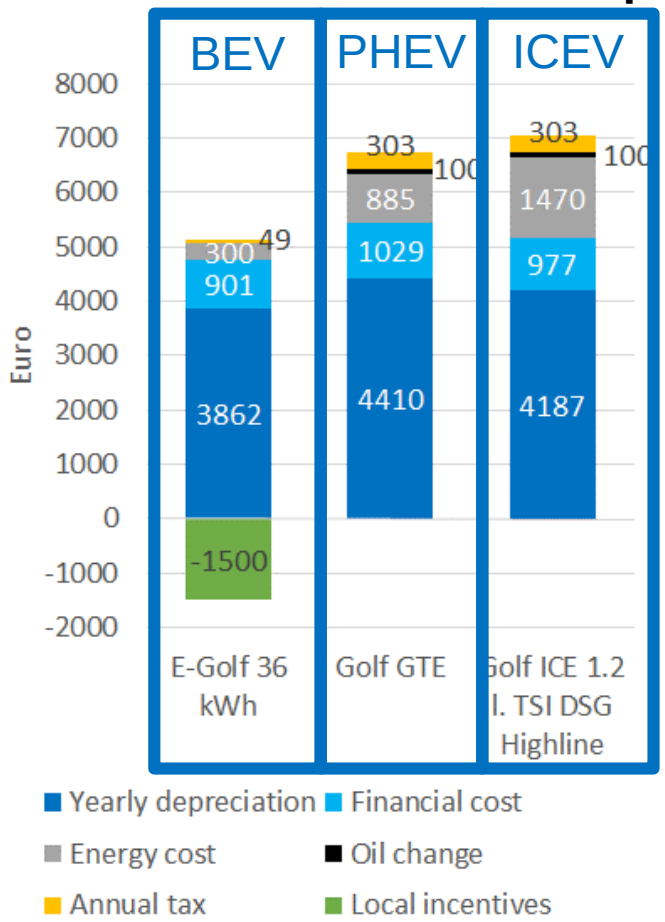
VW Golf in 3 versions:

1. BEV – E-Golf
2. PHEV - GTE
3. ICEV – Gasoline

Purchase prices



Annual cost of ownership



Sources:
E. Figenbaum, M. Kolbenstvedt 2016. Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle users. TOI report 1492/2016
E. Figenbaum 2018. Electromobility Status in Norway. TOI report 1627/2018.

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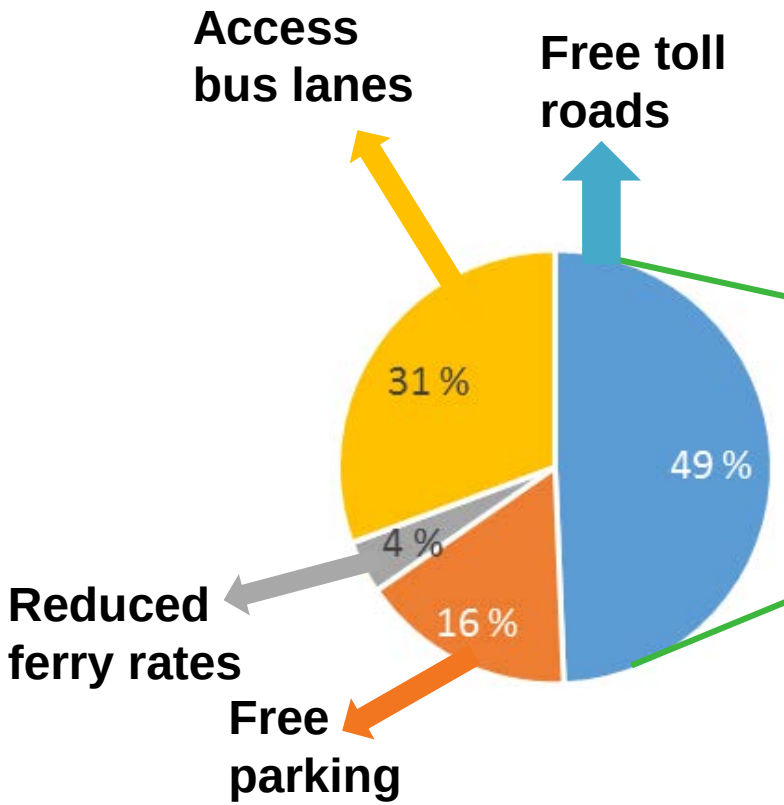
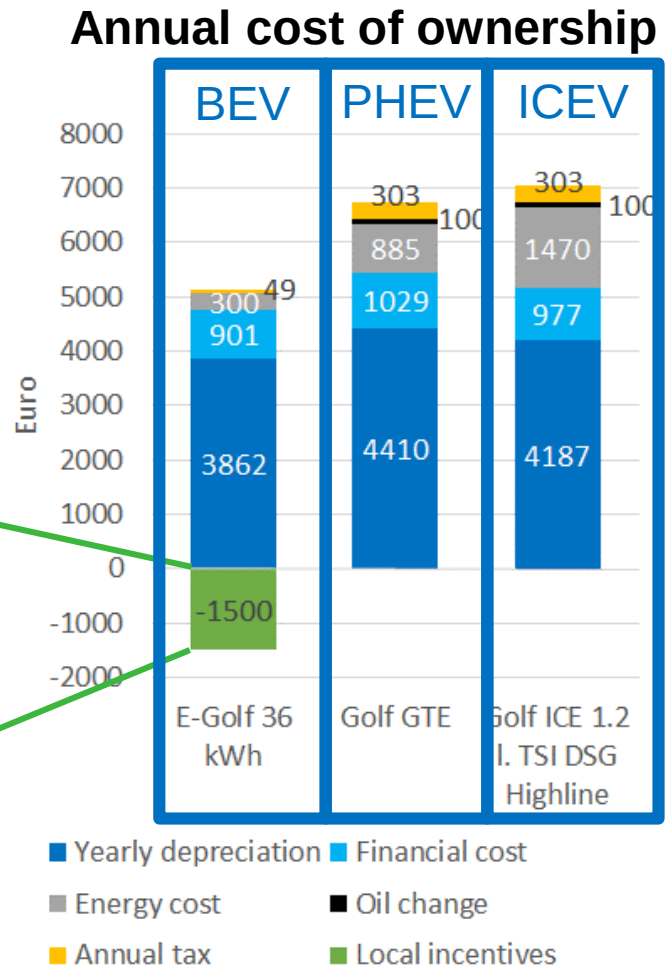
BEV total cost of ownership advantage:
3 200 Euro/year





Sources:
E. Figenbaum, M. Kolbenstvedt 2016. Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle users. TOI report 1492/2016
E. Figenbaum 2018. Electromobility Status in Norway. TOI report 1627/2018.

Who owns BEVs in Norway?

85% are consumers

- Younger than average
- 79% are multi-vehicle owners
- Families, children <18y
- Large transportation need
- Live in cities or outskirts
- 94% can charge at home

Buying motivation

- Reduced user cost
- Vehicle matching needs
- Incentives
- Environment

Experience

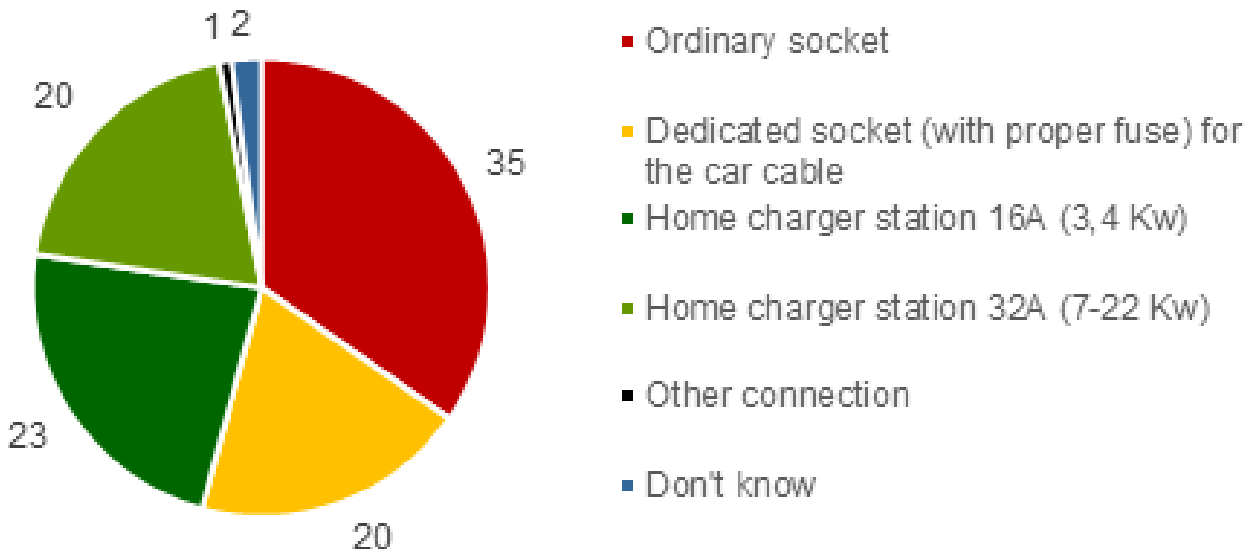
- Few challenges
- Have alternatives when range short

Sources:
E. Figenbaum, M. Kolbenstvedt 2016. Learning from Norwegian Battery Electric and Plug-in Hybrid Vehicle users. TOI report 1492/2016
E. Figenbaum 2018. Electromobility Status in Norway. TOI report 1627/2018.

Home charging

Detached/small houses

- No public support available
- EVSE wallbox cost about 1200-1800 US$ to install



Flats with common parking

- Parking facility jointly owned
- Annual meeting decides
- High cost
- Insufficient grid power

Typical solution:

- Basic infrastructure jointly owned
- Load shedding equipment
- Common cost: 1000 US$/flat
- Wallbox chargers are bought by flat owners which is billed for the electricity
- Charger cost: 1500 US$/flat

- Public support for basic installation

Source: Unpublished results from a TOI BEV user survey in 2018

Public charging infrastructure (1)

Up to 2010

- *A few hundred public chargers*
- *People also used available outdoor domestic plugs*

2010-2011

- *Public support program – Normal chargers, first come first serve*
- *Money left was used to install a few fast chargers in late 2011*

2012-2014

- *National support fast chargers – first come first serve, 40%*
- *Municipalities installed free to use public «normal chargers»*

Photo: Elbilforeningen.no

Public charging infrastructure (2)

2015-2017

- *Supply a fast charger network along major roads*
  - 2 fast + 2 semi-fast/50 km, 8000 km road network
  - Tenders for service – up to 100% support
  - Lowest bidder
  - Teamed up with McDonalds, fuel stations etc.

- *Free to use public normal chargers in cities*

2018

- *Full fast charger coverage along all major roads*
- *Normal public charging infrastructure lags fleet*
- *Municipalities subcontract operation to operators*

Public charging infrastructure - 2019 and beyond

Cities – Fast charging

- Fully commercial market, no support
- Challenge: Land to put chargers on

Cities – Normal charging

- Main challenge: On-street parkers
- From free to use to paid service

- **Fast charging between cities**
  - Economic viability, with variability workday, weekend, vacation?
  - Expanding to super fast (150 - 350 kW)

- **Destinations**
  - Resorts
  - Private cabins and holiday homes

Not that fast….

Average fast charge session:

- 30 kW power from 50 kW chargers
- 20 minutes duration
- 10 kWh energy charged
- ~13-19 fast charge events per user per year

Main reasons for low power:

- Primitive battery thermal management systems
- Cold winters

Result:

- Costs transfer from vehicle manufacturer to fast charge operator

Advice:

- Type approval test of charge speed versus ambient temperature

Photo: Norsk Elbilforening

Source: Figenbaum E. 2019. Charging into the future – Analysis of fast charger usage. TOI Report 1682/2019

2017 fast charger usage by users that charged in 2016

	Average	10-perc	20-perc	Median	80-perc	90-perc	95-perc	98-perc
# of Charge events per year	**13.1**	1	1	**5**	18	**32**	48	**80**
# of Locations used	**4.2**	1	1	**3**	6	**9**	13	**17**
# of Counties charged in	**2.1**	1	1	**2**	3	**4**	5	**7**
# of Municipalities charged in	**3.5**	1	1	**2**	5	**8**	10	**14**
# of Months users charged in	**4.3**	1	1	**3**	7	**10**	11	**12**

Source: Figenbaum E. 2019. Charging into the future – Analysis of fast charger usage. TOI Report 1682/2019

Four fast charger user types, separated markets

Users

- Occasional user (30%): likely use fast charger when they have a rare range problem
- Frequent user (10%): likely people without home charging or professional users
- Long distance trip user (rare): fast charges to get to far-away destinations
- Local user (common): fast charges regularly to solve their everyday needs

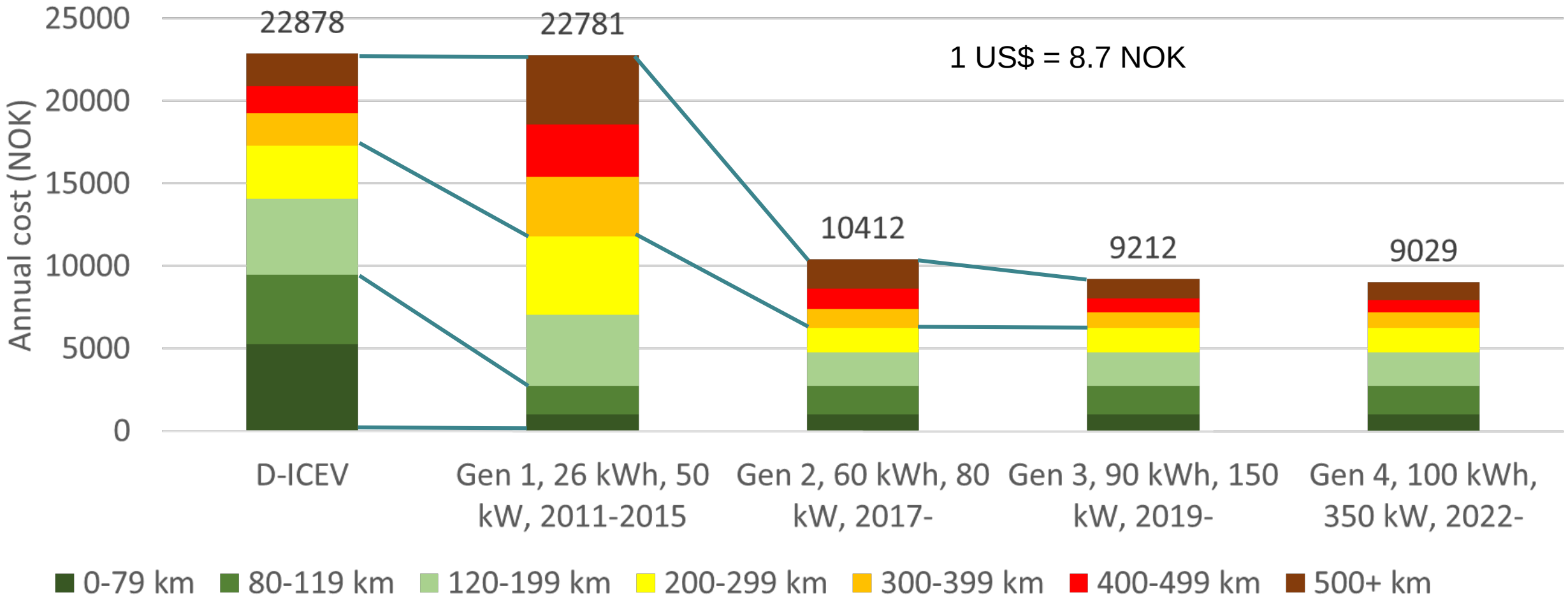
Markets

- South-East and Innlandet: Users often charge in other provinces
- Other provinces: Most charge within province

Source: Figenbaum E. 2019. Charging into the future – Analysis of fast charger usage. TOI Report 1682/2019

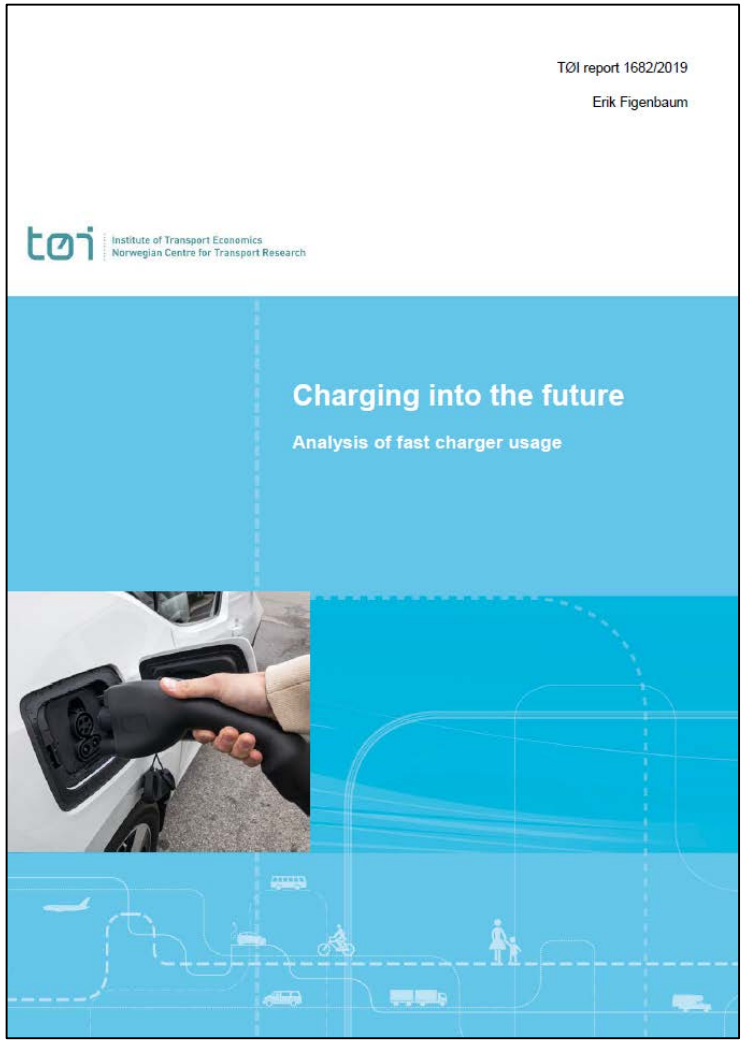
Everyday money saver…long distance time waster…

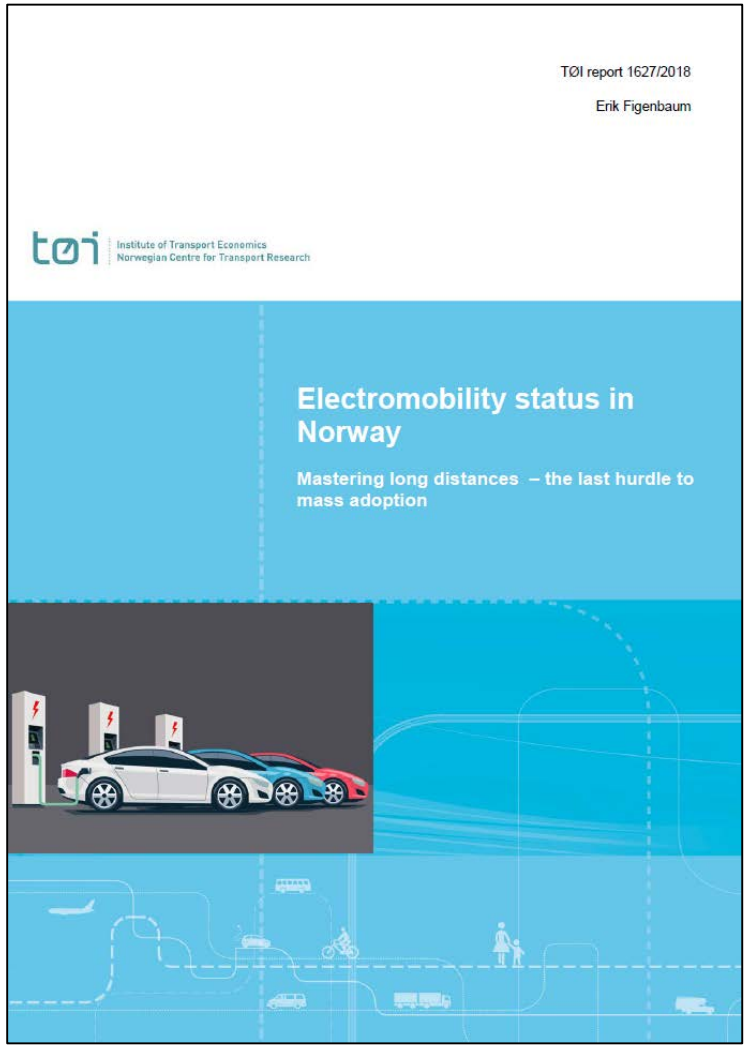
Total cost of energy and charge/pause time over a year, average long distance driving pattern



Source: E. Figenbaum 2018. Electromobility Status in Norway. TOI report 1627/2018.

More information:





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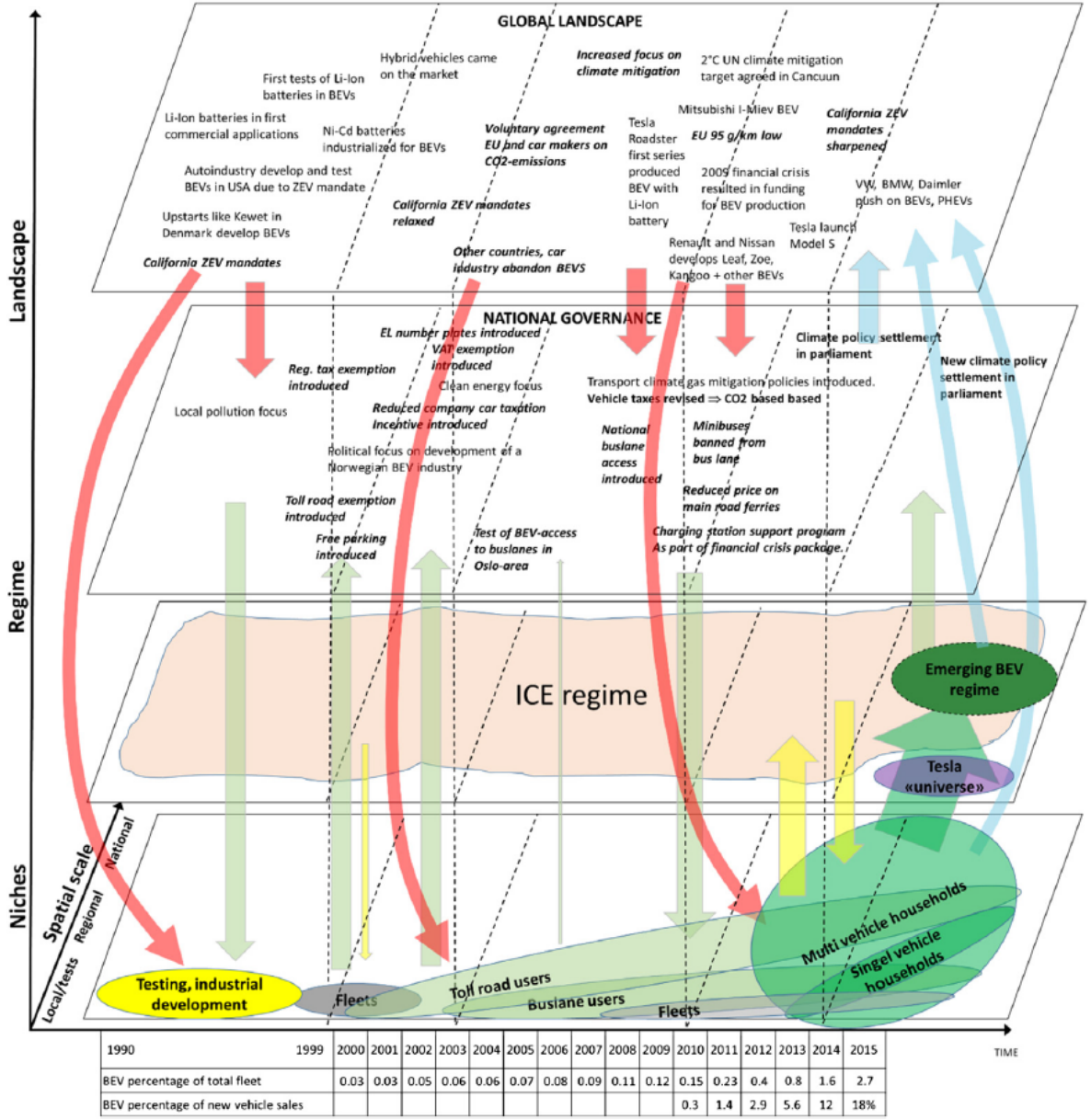
https://www.toi.no/ansatte/figenbaum-erik-article31074-202.html

Back-up slides

The third main reason for the high adoption of BEVs

Three decades of complex interactions between niche markets, regimes (automobility as we know it) and landscape (long term trends)

1. Niche market experimentation
2. Weak ICEV regime
3. BEV industrialization efforts
4. Strong governance with large incentives
5. Enabling landscape (Li-Ion tech, vehicles)
6. ICEV regime grabbed BEV opportunity
7. Interested, wealthy and able consumers



	1990	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
BEV percentage of total fleet			0.03	0.03	0.05	0.06	0.06	0.07	0.08	0.09	0.11	0.12	0.15	0.23	0.4	0.8	1.6	2.7
BEV percentage of new vehicle sales													0.3	1.4	2.9	5.6	12	18%

Fig. 11. Multi-level perspective framework for analysing Electromobility in Norway. Red arrows: International influence on Norway, Blue: Norwegian BEV market influence on global landscape, Yellow: Influence between regime and niches, Green: Influences between governance and niches. Sources of sales volumes of BEVs: OFVAS (2015), SSB (2015a). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Source: E. Figenbaum / Environmental Innovation and Societal Transitions 25 (2017) 14-34
https://www.sciencedirect.com/science/article/pii/S2210422416301162?via%3Dihub

Public normal charging

- On street:
  - *Very challenging due to cost, permit, practicality, time*
  - *Makes road use less flexible*
  - *Installation in parking houses much easier*

- Have been a free service:
  - *Some use it to get free parking*
  - *Use data unreliable*
  - *Has blocked private initiatives*

- More important as adoption increases among users without parking

The second main reason for the high adoption of BEVs

Norway have introduced BIG incentives and kept them in place

…..to be able to get people out of these….

…..and into these…….

The second main reason for the high adoption of BEVs

Norway have introduced BIG incentives and kept them in place

...but now, getting people out of these…

...and into these equal substitutes is much easier!