

**AT A
GLANCE**

*A case study on
how to succeed in
electric*

NORWAY VEHICLE ELECTRIFICATION STUDY



***What all countries should learn from
the global leader***

The first inside-out report to catch up with the world leader in car electrification, Norway



The future exists already: it is in Norway, which is 10 years ahead of any other country in car electrification!

And no, it is not only about money!

Understanding the Norwegian paradigm will allow all stakeholders to save billions!

- **A 120-page analysis of Norway's car electrification success** based on:
 - 25 years of direct experience in the field
 - PTOLEMUS EV consulting experience
 - Six months of research & analysis incl. interviews with key stakeholders
- **An examination of the global challenges of electrification**
 - Market drivers and inhibitors
 - Understanding supply chain and battery metal challenges
 - The medium to long-term EV outlook
- **An in-depth assessment of the take-off of the Norwegian EV market** incl.:
 - Key traits of the Norwegian transport market
 - The direct and implicit costs of Norway's support for EVs
 - The role of fuel price and efficiency in the EV TCO analysis
 - The impact on CO₂ emissions
 - How Norway compares with other markets
- **A study of the EV charging market at home and in public venues**
 - Market size and key players
 - The economics of public charging
 - Consumer challenges with EV public charging and driving range
 - The effect of Tesla's charging network
- **A detailed assessment of Norway's EV success stories and their cost:**
 - Purchasing (tax) incentives
 - Usage incentives, from tolling to parking
 - The charging infrastructure and payment strategy that worked
 - And the ecosystem that made it happen
 - **8 policies / best practices to emulate**
- **The 6 major errors to avoid**
 - What did not work even in Norway
 - The negative side effects of EVs
- **15 recommendations for governments worldwide to set their policy**
- **10 recommendations to OEMs**
- **10 recommendations to EV charging point operators (CPOs)**

By responding to these questions, the report will help you avoid reinvent the wheel in electrification!

Will Norway succeed with its 100% EV target for new passenger cars in 2025?

What can other countries learn from Norway's approach to electrification? Successes and failures/gaps?

What are the biggest drivers and inhibitors of EV adoption, in Norway and elsewhere?

For how long should government maintain the policy of offering EV purchase benefits?

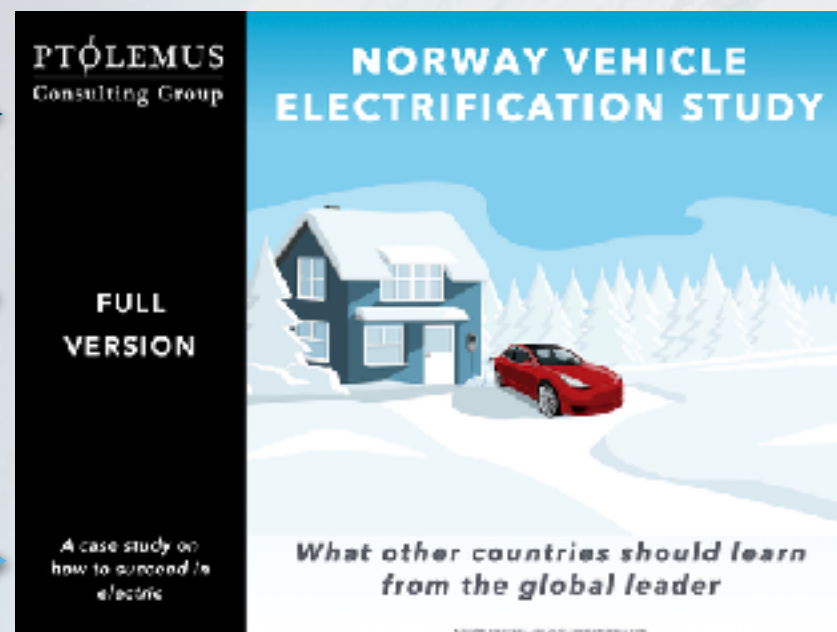
Who will win in the public charging market, Tesla or Ionity?

What should governments, OEMs, and public charging operators do to improve customers' public charging experience?

What should OEMs do to give EV buyers a realistic idea of the range of their EVs?

What should government's role be in making sure there will be enough public chargers?

What is the best way for governments to stimulate the adoption of EVs?



What is the TCO of EVs vs ICEVs, in Norway and Europe?

What will be the impact of EVs on fuel tax revenues, road funding and public transport?

What are the factors holding back a rapid move to full electrification of the car fleet?

The report combines the expertise of several experts



Frederic Bruneteau

Managing Director, Brussels

The founder of PTOLEMUS, Frederic has accumulated **25 years of experience of the mobility and transport domains** and 15 years of strategic and financial advisory.

He has become **one of the world's foremost experts of connected mobility** and is interviewed on the subject by publications such as the *Financial Times*, *Forbes*, the *Wall Street Journal* and *The Economist*. He has also spoken at over 40 conferences on the subject.

He has led over 180 consulting projects and helped many world leaders define their strategy and implement it.

Clients he has served include AAA Data, Abertis, AGC Automotive, Allianz, AXA, Baloise, BP, Bridgestone, BRP, Cihon, CNH Industrial, Danlaw, DMP, Europ Assistance, the European Commission, HERE, Hitachi, Kapsch, the Netherlands' Ministry of Transport, Mobile Devices, Octo Telematics, Michelin, OMV, Pioneer, Qualcomm, Scania, Société Générale, Telit, TomTom, Toyota and WEX.

Frederic has led many assignments related to electrification.

Frederic fully reviewed this report.



Lars Godell

Director, Strategic Foresight, Oslo

A Norwegian citizen, Lars has **more than 25 years of experience from strategic and operational work** as a senior analyst, adviser, and executive **in the global telecom industry**. Last year he analysed the Norwegian mobility market for an investor.

He has specialised in techno-economic analyses of infrastructure and services for the purposes of product and business development, strategy, regulatory and public affairs.

Lars has been advising CxO-level clients and colleagues for 25 years, 17 of which with **Telenor**, one of the world's largest mobile operators.

He spent 8 years as a principal European telecom analyst with **Forrester Research**. His hype-busting research on the business case for new technologies as well as advice on industry restructuring resulted in a CEO-level network and almost daily interviews with journalists.

Lars has an MSc degree in political science from the University of Oslo and an **MBA degree from the University of Chicago Booth School of Business**.

Lars led the research, analysis and writing of this report.



Paul Maupin

Marketing Director, Brussels

An American citizen, Paul has 15 years of experience in digital marketing in a range of responsibilities such as website development, copywriting, CRM, analytics, project management, product development, social media management and content strategy.

Paul has worked with a broad range of international clients and brands, large and small, to develop relevant, consistent, and results-oriented digital communication and marketing strategies across channels.

Responsibilities he endorsed over his career include:

- Developed, implemented and supervised the

global content marketing strategy for **Radisson Hotel Group**, including data-driven marketing, communication with key internal and external stakeholders;

- Managed digital channels, social presence and marketing strategy for the Europe region at **UPS**, including implementation of paid campaigns alongside ad agencies and content creation for the pan-European central channels.

Paul reviewed the report and leads our marketing of the report.

The report dissects the Norwegian electrification model and brings lessons to all stakeholders

1. Introduction..... 3

2. The global challenges of electrification..... 18

- A. What is electrification?
- B. Market drivers and inhibitors
- C. Understanding supply chain and battery metal challenges
- D. The outlook for EV batteries
- E. The medium to long-term EV outlook
- F. Understanding the different EV charging options

3. The state of the Norwegian EV market..... 28

- A. Putting Norway on the map
- B. Norway's position as a major energy supplier
- C. Key traits of the Norwegian transport market, including taxation and road tolling
- D. Electrification of transport as a tool to reduce climate emissions
- E. Norway's transport electrification targets and results, and in comparison with other countries
- F. To support decarbonisation, Norway has also stimulated the adoption of hybrid cars
- G. Norway's EV purchase and usage benefits

H. The direct and implicit cost of Norway's support for EVs

I. Norway's superior EV charging infrastructure

J. Understanding consumers' car purchasing preferences

K. The role of fuel price and fuel efficiency in the EV TCO analysis

L. Forecast until 2030 for the electrification of different vehicle categories

M. Forecast for road traffic until 2030

N. Overview of the EV public charging market

- ✓ Market size and key players
- ✓ Understanding consumers' experience with EV public charging and driving range
- ✓ National government's limited subsidies for EV public charging infrastructure
- ✓ The economics of public charging
- ✓ The effect of Tesla opening its charging network
- ✓ Comparison of Tesla and IONITY, including assessing the future of IONITY

O. The EV success has helped stimulate many industrialisation initiatives and start-ups

4. Norway's electrification success stories..... 77

- A. Ensure stable and broad political support
- B. Fix home charging first
- C. Carefully support public charging network

D. Keep purchase benefits until 2027

E. Change the purchase benefits away from subsidies to taxation

F. Include usage benefits

G. Introduce special EV license plates

5. Pitfalls to avoid..... 95

- A. Ensure sufficient cheap renewable electricity
- B. Stop supporting hybrids now
- C. Balance electrification with other public policy goals
- D. Ensure careful fine-tuning of incentives
- E. Force the automotive OEMs and dealers to provide realistic EV range and battery charging information
- F. Ensure sufficient regulation of the public charging market

6. Conclusions & recommendations 110

- A. Governments and regulators
- B. Automotive OEMs
- C. EV charging operators

The report includes over 100 figures (1 of 3)

Page 22

- % of global reduction in road transport CO₂
- % of new car sales to be EV
- % of emissions cut through renewable energy
- % of power-related emissions to be cut
- Battery demand

Page 23

- EV battery costs
- Control over the supply chain of EVs

Page 24

- % of EVs use of lithium-ion batteries
- Lithium supply
- Lithium prices
- Density of minerals mining
- Density of Lithium mining
- Market shares of batteries production

Page 25

- Prospects on lithium prices
- Median EV cost disadvantage in Norway
- Current rest of world median cost EV disadvantage

Page 26

- Fossil fuel prices
- Global EV sales

Page 29

- Norwegian Sovereign Wealth Fund
- Norwegian revenues from oil and gas
- Norwegian exports of natural gas
- Norwegian GDP per capita
- Norwegian car ownership
- Norwegian population density
- Norwegian export of hydropower

Page 30

- % of Norwegian green energy production
- Norwegian energy prices

Page 31

- Planned investments in 2022-2023 transport plans
- Money collected from tolls

Page 32

- Inland transport infrastructure investment per capita

Page 33

- Road infrastructure maintenance expenditure per capita

Page 34

- CO₂ produced by sector

Page 35

- Transport climate emissions by sector

Page 36

- Average CO₂ emissions for newly registered passenger cars

Page 37

- New sales of different vehicle classes

Page 38

- EV share in new car registrations
- VAT exemptions from EV purchases
- Annual TCO savings
- % of home charging of EVs

Page 39

- Norway's main EV benefits

Page 42

- EV penetration of new cars sold
- EV penetration of all cars in use

Page 44

- Public charging infrastructure comparison

Page 45

- EV purchase benefits

Page 46

- Amount of tax revenue by category

Page 47

- Plug-in hybrid sale as % of all new car sale

Page 48

- EV share of all registered cars
- % of used cars purchased
- Share of EVs in new cars sold
- Average life length of cars

Page 49

- Survey of populations preference in car choice

Page 50

- Incentive preferences of Norwegians when purchasing a car

Page 51

- Annual total cost of cars
- Purchase tax exemption worth
- Annual fuel saving compared to ICEV
- Annual toll road discounts
- Annual TCO savings for EVs

The report includes over 100 figures (2 of 3)

Page 52

- EVs overall efficiency
- EVs cost efficiency

Page 53

- Norway's top-selling new passenger cars

Page 54

- Forecast breakdown of new vehicle registrations by engine type & vehicle category

Page 55

- Forecast road traffic volume by vehicle category and emission type

Page 56

- Charging locations for Norwegian population

Page 57

- Density of public charging

Page 59

- Number of battery swap stations in China
- Growth of battery swap stations
- Average time to swap a battery

- Average time to fully charge an electric vehicle
- Target of battery swap stations in 2025

Page 60

- Electrification targets per vehicle category
- Expected required number of fast charges

Page 61

- Public charging stations by type of charger

Page 62

- Financial support to build fast charging networks
- Norwegian government spending
- EV purchase incentives

Page 64

- Public charging operators who dominate the Norwegian market

Page 65

- EV charging market in Norway

Page 66

- Annual revenue and transactions of EV charging market
- Average price of transaction
- Annual number of customers and spending per year
- Yearly distance for an EV in Norway
- % of customers who use public charging stations
- % of customers needs satisfied through public charging
- Number of CPs across Europe RFID device gives access to

Page 67

- % of EV drivers who experienced queues in 2021
- Waiting times of queues experienced by EV drivers
- % of drivers experiencing out-of-service situations for fast charges
- Time taken to charge an EV until 80%
- Ionity prices
- % of EV owners who find pricing models charging models easy to understand

- % of EV owners who want an interoperable payment solution

Page 68

- Ideal number of charging points per station
- EV winter range

Page 69

- Set up cost of electricity supply for a high-capacity station
- Hardware setup costs

Page 71

- EU charging sessions per charging point per day
- Number of charging points and station in Norway and Europe differentiated by charging company

Page 73

- % of charging station made by repeat customers
- Number of pilot charges made in Nuremberg
- Average of charges made per day in Nuremberg
- Maximum kW hubs will offer

The report includes over 100 figures (3 of 3)

Page 74

- Amount of funding secured by Morrow Batteries
- Amount of funding secured by FREYR Battery
- Amount of investments made by FREYR Battery
- Hydrovolt's targets in battery recycling

Page 75

- Number of subscriptions, employees and funding of imove

Page 76

- Growth of easese
- Employees of Zaptec

Page 79

- Electrification target for new cars

Page 81

- % of private charging points in 2030
- % of EU electricity spent on EVs in 2030
- % of EU total EVs charging capacity demand held by public charging in 2030

- % of installed charging capacity held by private charging

Page 82

- Comparisons of implications for national public charging infrastructure policies

Page 83

- Growth of the public charging method
- National government spending to finance charging stations

Page 84

- EU target of CO₂ reduction
- Page 85
- European Commission's "Fleet-based target"

Page 86

- ACEA's target proposal
- Number of EU-27 public charging points needed in 2030
- Average utilisation level of public chargers

Page 88

- % growth in EV sales thanks to financial incentives

Page 89

- Tax benefits after 100% electrification in Norway

- Phase out of EV subsidies in Germany

Page 90

- Number of EVs imported in Norway, and subsidised abroad
- % of exported LDVs, of all new cars

Page 91

- Number of electric cars sold in Germany in the last 10 years
- Number of electric cars in use in 2022 in Germany
- Amount of spending on subsidies to EV buyers in Germany
- % change in installation base of electric cars in Germany
- Loss to German tax payers

Page 92

- Breakdown of Norwegian EV incentives

Page 94

- Nations 100% EV sales targets

Page 97

- Norway's power balance in 3 electrification scenarios

Page 98

- Licensed offshore wind capacity in Norway
- Ambition levels of offshore wind by country

Page 99

- Life cycle CO₂ emissions by powertrain and type of electricity production

Page 100

- Incidence of Norway's climate policy

Page 101

- Evolution of traffic in amount of trips

Page 102

- Survey on change in Norwegians ways of transport
- Norwegians access to EVs

Page 104

- Revenues from car-related purchase and usage taxes

Page 107

- Expected evolution of the main EV purchase and usage benefits

Norway Vehicle Electrification Study - Glossary

AC	Alternating current (for slow-speed EV chargers)
ACEA	European Automobile Manufacturers' Association
ACER	EU Association for Cooperation of Energy Regulators
AFIR	Alternative Fuels Infrastructure Regulation
BEV	Battery-electric vehicle*
Carbon net zero	UN climate agreement target for cutting greenhouse gas emissions to as close to zero as possible by 2050
CCS	Combined Charging System - a standard for fast charging of EVs up to 350 kilowatts
CHAdeMO	"CHArge de MOve" is a standard for fast EV charging supported by 5 major Japanese automakers
CO₂	Carbon dioxide
COP - 26	Conference of the Parties - UN's annual climate change conference. COP-26 was in 2021
CP	Charging point - a reserved parking space at a charging station (location) with charging availability for one car
DC	Direct current (DC), one-directional flow of electric charge (used in fast EV chargers)
DNV	Det Norske Veritas
EC	European Commission
ESS	Energy storage system (e.g. large batteries used by utilities to store intermittent renewable energy)
EU	European Union
EV	Electric vehicle*
Grid	Electricity network
GW	Gigawatt
GWh	Gigawatt hour

HDV	Heavy delivery vehicle (>3.5 tons).
ICCT	International Council on Clean Transportation
ICEV	Internal combustion engine vehicle
IEA	International Energy Agency
ITF	International Transport Forum, intergovernmental organisation at the OECD
kW	kilowatt
kWh	kilowatt hour. 1 kWh is the energy volume that equals an effect consumption of 1 kW over a period of one hour
LCE	Lithium carbonate equivalent
LDV	Light delivery vehicle, (<3.5 tons)
MW	Megawatt
NOK	Norwegian kroner (currency)*
OECD	Organisation for Economic Cooperation and Development
OEM	Original Equipment Manufacturer
PHEV	Plug-in-hybrid-electric vehicle
R&D	Research and development
RHS	Rectangular Hollow Section (standard for metals)
SLA	Service-level agreement
TCO	Total Cost of Ownership
tW	Terrawatt
tWh	Terrawatt hour
TØI	Institute of Transport Economics ("Transportøkonomisk Institutt")
VAT	Value-added tax
WLTP	Worldwide Harmonized Light Vehicles Test Procedure, for EV range

The report mentions 70 companies and organisations (1/2)

Company	Country	Type	Company	Country	Type	Company	Country	Type
ABB	Switzerland	Industrial	easee	Norway	Smart EV charging hardware	IEA	France	Energy advisory
ACEA	Belgium	Industry association	Elbil	Norway	News site	imove	Norway	Car subscription
Aftenposten	Norway	Newspaper	Elbil24	Norway	News site	IONITY	Germany	EV charging operator
Agora Verkehrswende	Germany	Think-tank	Energi Norge	Norway	Industry association	ITF	France	Think-tank
Audi	Germany	Automotive	Enova	Norway	Energy innovation advisory	Kinect Energy	US	Energy company
Autobransjens Leverandørforening	Norway	Industry association	Euractiv	Belgium	News site	Kople	Norway	Energy company
Automotive News Europe	US	Magazine	European Commission	Belgium	International organisation	Kruser	Norway	Electric boat sharing
Bloomberg	US	Media company	Eviny	Norway	Energy company	Mer	Norway	EV charging operator
Business Insider	US	News company	Financial Times	UK	Newspaper	Mercedes-Benz	Germany	Automotive
ChargeUp Europe	Belgium	Industry association	Fortune	US	Magazine	Morrow	Norway	EV battery production
CircleK	Canada	Fuel retail	FREYR Battery	Norway	EV battery production	Motor	Norway	Magazine
DNV	Norway	Assurance & risk management	Goldman Sachs	US	Financial services	NAF	Norway	Car owner association
e-on	Germany	Energy company	Hydro	Norway	Aluminum production	NIO	China	Automotive
EAFO	Belgium	Energy information	Hydrovolt	Norway	EV battery recycling	NOBIL	Norway	EV charging database
			ICCT	US	Think-tank			

The report mentions 70 companies and organisations (2/2)

Company	Country	Type
Northvolt	Sweden	EV battery production
Norwegian EV Association	Norway	Car owner association
NRK	Norway	Public broadcaster
NVE	Norway	Electricity regulator
OECD	France	International organisation
OFV	Norway	Automotive information
Plug	Norway	Electric maritime charging
recharge	Norway	EV charging operator
Ruter	Norway	Public transport provider
Siemens	Germany	Industrial
Statens Vegvesen	Norway	National road authority
Statistics Norway	Norway	National statistics agency
Statkraft	Norway	Energy company

Company	Country	Type
Statnett	Norway	National grid operator
Stellantis	France	Automotive
Tesla	US	Automotive
Tibber	Norway	Smart electricity retail provider
TØI	Norway	Think-tank
Transport & Environment	Belgium	NGO
US Geological Survey	US	Government entity
VDA	Germany	Industry association
Volkswagen	Germany	Automotive
Wells Fargo	US	Financial services
Wikipedia	US	Encyclopedia
World Population Database	US	Demographics data provider
Zaptec	Norway	Smart EV charging hardware

An illustration of a red Tesla Model S parked in a snowy landscape, connected to a charging station mounted on the side of a blue house. The house has a white door and several windows. In the background, there are snow-covered evergreen trees and a clear blue sky. The scene is depicted in a clean, stylized manner with soft shadows.

To download the full report
abstract, go to
[https://www.ptolemus.com/
research/norway-vehicle-
electrification-study/](https://www.ptolemus.com/research/norway-vehicle-electrification-study/)

An illustration of a red Tesla Model S parked in a snowy landscape, connected to a charging station mounted on the side of a two-story blue house with a white roof. The background features snow-covered evergreen trees under a clear blue sky.

**For any assistance in your
electrification strategy, please
contact:**

**Frederic Bruneteau
Managing Director
fbruneteau@ptolemus.com**

**For information or comments on
this publication or to purchase a
license to this report, please
contact:**

EV@ptolemus.com

Thank you!

The first strategy consulting & research firm entirely focused on geo-connected mobility & automation

Strategy consulting services

Strategy
definition

Investment
assistance

Procurement
strategy

Innovation
management

Business
development

Project
management

Market research services

Off-the-shelf
reports

Subscription
services

Custom
market
research

Fields of expertise

Mobility services

Car pooling
Car sharing
MAAS

Micro-mobility
Ride hailing
Shared mobility

Smart parking
Tax refund

Vehicle services

bCall
eCall
Fleet telematics
SVT / SVR

Tracking
VRM
In-car Wi-Fi
Parking

Navigation
Speed cameras
Traffic information

Energies

BEV
EV charging
EVaaS

Fuel cards
Hydrogen

PHEV
Vehicle-to-grid

Usage-based charging

Car As A Service
Electronic Toll
Collection

Mobility-as-a-
Service
Road charging

UBI / PAYD
Vehicle rental
Vehicle leasing

Vehicle data & analytics

AI
CAN-bus
Crowd-sourcing
Data protection

Driving behaviour
OBD
Predictive
analytics

Remote
diagnostics
xFCD

Vehicle automation

ADAS
Autonomous cars

Autonomous
trucks

Robo-taxis
Shuttles

Enabling technologies

Positioning (GNSS
/ WiFi / cellular)
M2M /
connectivity

Smartphones
Sensors

Telematics
devices
V2X

PTOLEMUS has performed nearly 200 consulting assignments in mobility and electrification



Perform a market sizing of the global EV market opportunity

Power grid & power generation systems group



Perform a high level analysis of EV OEMs in North America

Large IT supplier



Help our client make acquisitions in the fleet electrification supply market

Large Asian engineering group



Help the company in defining its 10-year future strategic plan

Global ITS leader



Identify the best practices of EV apps to help it design the app of its new EV

Major outdoor vehicle OEM



Assisted the board of its technology unit in its strategy definition

Global motorway operator



Valuation of a global EV bus & coach fleet telematics solution provider

Charging solution provider



Definition of their future mobility services value proposition, strategy and roadmap

Roadside assistance group



Conduct the due diligence of 2 fleet / EV software companies

Large engineering group



Conducted the strategic review of a major road operator's mobility services business

Major road operator

PTOLEMUS can help your organisation define and achieve its electrification strategy

- **Strategy definition**

- Evolution of strategy towards EVs
- Fleet electrification strategy
- Charging network strategy
- Sustainability strategy
- Emission measurement & reduction plan

- **Investment assistance**

- Strategic review
- Commercial due diligence
- Market forecasting

- **Innovation management**

- Integration with fleet telematics
- Vehicle electrification strategy
- Value proposition to EVs
- Value added services (VAS) strategy

- **Procurement**

- Identification of relevant suppliers
- Selection of telematics technology & suppliers

- **Business development**

- Partnership strategy definition
- Partnership strategy implementation

- **Deployment**

- Data privacy strategy
- Analytics, scoring and pricing strategy
- Specifications of telematics-enabled products
- Design & deployment of telematics platform

Feel free to inquire about our other reference reports and markets forecasts as well as our subscriptions

Recent publications

AUTONOMOUS DRIVING



CONNECTED VEHICLE



ELECTRIFICATION



ELECTRONIC TOLLING



INSURANCE



FLEET MANAGEMENT



MOBILITY



PTOLEMUS Consulting Group

Strategies for Mobile Companies

contact@ptolemus.com

www.ptolemus.com

@PTOLEMUS

