**EV/PHEV roadmap milestones**

### Policy framework

- Adequate incentives for EV/PHEV purchase and production in line with targets; co-ordination of recharging infrastructure development in key areas.
- EVs should become commercially viable without significant subsidies; support should continue for widespread expansion of recharging infrastructure.
- Fast recharging options have achieved lower cost, with batteries well suited; support for widespread implementation of fast recharging as needed to ensure widespread availability.
- Availability of higher power/energy-dense batteries should position policy makers to encourage remaining segments of light-duty vehicle markets to “go electric”, including greater use in large, longer-distance vehicles.

### Vehicles/batteries

- Lower and medium-volume production, with design optimisations to 2015; then rapidly increase numbers of models offered; provide recharging infrastructure where appropriate.
- Vehicles become fully commercial; batteries reach all target specifications for cost and durability, including additional cycling tolerance in line with advanced batteries; full recycling systems in place.
- Vehicles/battery systems are reliable and safe; achieve near-term technical and cost targets, such as USD 300/kWh battery cost; and safe; achieve near-term technical and cost targets.
- Batteries continue to improve; introduce a new generation of batteries that significantly outperform lithium-ion at a similar cost.
- EVs achieve superiority to internal combustion engines in most respects, close the gap in driving range.

### Codes/standards

- Ensure plug and charging systems are compatible across major regions, including home “smart metering” systems for home and public recharging stations; develop protocols for fast recharging.
- Common systems for vehicle-to-grid electricity; fast recharge and/or battery swapping well established.
- Refine codes and standards as needed; modify to accommodate innovations in batteries, smart grid systems, etc., but minimise the need for reinvestments in existing systems.

### Recharging/electricity infrastructure

- Establish home recharging and begin major investments in street/office daytime commercial recharging, including rapid charging where appropriate.
- Expansion of recharging infrastructure to more areas, greater use of fast recharging; fully established vehicle-to-grid electricity systems.
- Completion of most recharging infrastructure in OECD and other major economies; expand globally as countries establish reliable, low-carbon electricity generation systems.
- Ongoing recharging infrastructure and generation system expansion and refinement as needed; with ongoing increase in systems and capacity to handle fast charging.

### RD&D

- Ensure vehicle/battery systems are reliable and safe; achieve near-term technical and cost targets; such as USD 300/kWh battery cost; develop advanced battery concepts and prototypes.
- Continue RD&D on advanced battery designs moving towards demonstration and deployment as concepts mature; incorporate lessons learned from earlier experiences.
- Achieve widespread introduction of next generation of batteries, full deployment of smart-grid systems and related technologies.
- Ongoing RD&D as needed; focus on improving battery performance to maximise vehicle driving range.

---

**Key findings**

- Roadmap vision: industry and governments should attain a combined EV/PHEV sales share of at least 50% of LDV sales worldwide by 2050.
- In addition to contributing significant greenhouse-gas emissions reductions, the roadmap’s level of EV/PHEV sales will deliver substantial benefits in terms of improved oil security, reduced urban area pollution and noise.
- Policy support is critical, especially in two areas: ensuring vehicles become cost-competitive and providing adequate recharging infrastructure.
- The consumer comes first: wider use of EVs/PHEVs will require an improved understanding of consumer needs and desires, as well as consumer willingness to change vehicle purchase and travel behaviour.

- Performance measurement will be needed: the IEA roadmap contains a set of proposed metrics and targets for key attributes like driving range and battery requirements to ensure that EVs/PHEVs achieve their potential.
- RD&D priorities: research, development and demonstration must continue to reduce battery costs and ensure adequate materials supply. More research is also needed on smart grids and the vehicle-grid interface.
- International collaboration can accelerate deployment: industry and governments need to work together on research programmes, codes and standards, and alignment of vehicle and infrastructure roll-out.
Urgent action needed in the next 10 years to achieve 2050 targets

Battery costs through 2020

Battery costs for PHEVs and EVs must drop rapidly toward USD 300/kWh in order to bring vehicle costs to competitive levels.

Number of models offered through 2020

Vehicle sales must grow rapidly

CO₂ emission reduction, BLUE Map scenario, 2010-2050

The GHG reductions and EV/PHEV penetrations displayed here are based on the IEA ETF BLUE Map scenario, which targets an aggressive 50% reduction in CO₂ worldwide by 2050 relative to 2005 levels. For transport, a 30% GHG reduction is targeted, which will require rapid market penetration of electric vehicles and plug-in hybrid vehicles.

For light-duty vehicles, electric and plug-in hybrid vehicles account for 2.6 Gt of CO₂ equivalent emissions reductions by 2050, about half of total reductions for light-duty vehicles.

Global map of regional EV/PHEV sales

Electric and plug-in hybrid vehicle indicative sales targets in BLUE Map scenario

CO₂ emission reduction, BLUE Map scenario, 2010-2050

Global emissions (Gt CO₂)

The GHG reductions and EV/PHEV penetrations displayed here are based on the IEA ETF BLUE Map scenario, which targets an aggressive 50% reduction in CO₂ worldwide by 2050 relative to 2005 levels. For transport, a 30% GHG reduction is targeted, which will require rapid market penetration of electric vehicles and plug-in hybrid vehicles.

For light-duty vehicles, electric and plug-in hybrid vehicles account for 2.6 Gt of CO₂ equivalent emissions reductions by 2050, about half of total reductions for light-duty vehicles.

Final energy consumption in the transportation sector, by fuel type

Less carbon-intensive electricity is needed to realise EV/PHEV emissions reductions

www.iea.org/roadmaps
Battery costs through 2020

Battery costs for PHEVs and EVs must drop rapidly toward USD 300/kWh in order to bring vehicle costs to competitive levels.

Number of models offered through 2020

Global map of regional EV/PHEV sales

Global emission reduction, BLUE Map scenario, 2010-2050

The GHG reductions and EV/PHEV penetrations displayed here are based on the IEA’s Global Energy Technology Splendid Lineage (GEMS) scenario, which targets an aggressive 50% reduction in CO₂ worldwide by 2050 relative to 2005 levels. For transport, a 30% GHG reduction is targeted, which will require rapid market penetration of electric vehicles and plug-in hybrid vehicles.

For light-duty vehicles, electric and plug-in hybrid vehicles account for 2.6 Gt of CO₂-equivalent emissions reductions by 2050, about half of total reductions for light-duty vehicles.

Electric and plug-in hybrid vehicle indicative sales targets in the BLUE Map scenario

Number of models

Global EV/PHEV sales

CO₂ emission reduction, BLUE Map scenario, 2010-2050

Final energy consumption in the transportation sector, by fuel type

Less carbon-intensive electricity is needed to realise EV/PHEV emissions reductions

Urgent action needed in the next 10 years to achieve 2050 targets
**ELECTRIC AND PLUG-IN HYBRID VEHICLE ROADMAP**

### INTERNATIONAL ENERGY AGENCY

**www.iea.org/roadmaps**

---

**EV/PHEV roadmap milestones**

**Policy framework**

- Adequate incentives for EV/PHEV purchase and production in line with targets; co-ordination of recharging infrastructure development in key areas

**2010**

- Vehicle sales 7 million
- Global market share 9%

**2020**

- Vehicle sales 20 million
- Global market share 30%

**2030**

- Vehicle sales 70 million
- Global market share 48%

**2040**

- Vehicle sales 100 million
- Global market share 60%

**Vehicles/batteries**

- Vehicles become fully commercial, batteries reach all target specifications for cost and durability, including additional cycling tolerance in line with advanced batteries; full recycling systems in place

**Codes/standards**

- Common systems for vehicle-to-grid electricity sales; fast recharge and/or battery swapping well established

**Recharging/electricity infrastructure**

- Expansion of recharging infrastructure to more areas; greater use of fast recharging; fully established vehicle-to-grid electricity systems

**RD&D**

- Ongoing RD&D on advanced battery designs moving towards demonstration and deployment as concepts mature; incorporate lessons learned from earlier experiences

---

**Key findings**

- Roadmap vision: industry and governments should attain a combined EV/PHEV sales share of at least 50% of LDV sales worldwide by 2050.

- In addition to contributing significantly to greenhouse-gas emissions reductions, the roadmap's level of EV/PHEV sales will deliver substantial benefits in terms of improved oil security, reduced urban area pollution and noise.

- Policy support is critical, especially in two areas: ensuring vehicles become cost-competitive and providing adequate recharging infrastructure.

- The consumer comes first: wider use of EVs/PHEVs will require an improved understanding of consumer needs and desires, as well as consumer willingness to change vehicle purchase and travel behaviour.

- Performance measurement will be needed: the IEA roadmap contains a set of proposed metrics and targets for key attributes like driving range and battery requirements to ensure that EVs/PHEVs achieve their potential.

- RD&D priorities: research, development and demonstration must continue to reduce battery costs and ensure adequate materials supply. More research is also needed on smart grids and the vehicle-grid interface.

- International collaboration can accelerate deployment: industry and governments need to work together on research programmes, codes and standards, and alignment of vehicle and infrastructure roll-out.