Driving renewable energy for transport

Next generation policy instruments for renewable transport (RES-T-NEXT)

Name

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CE Delft

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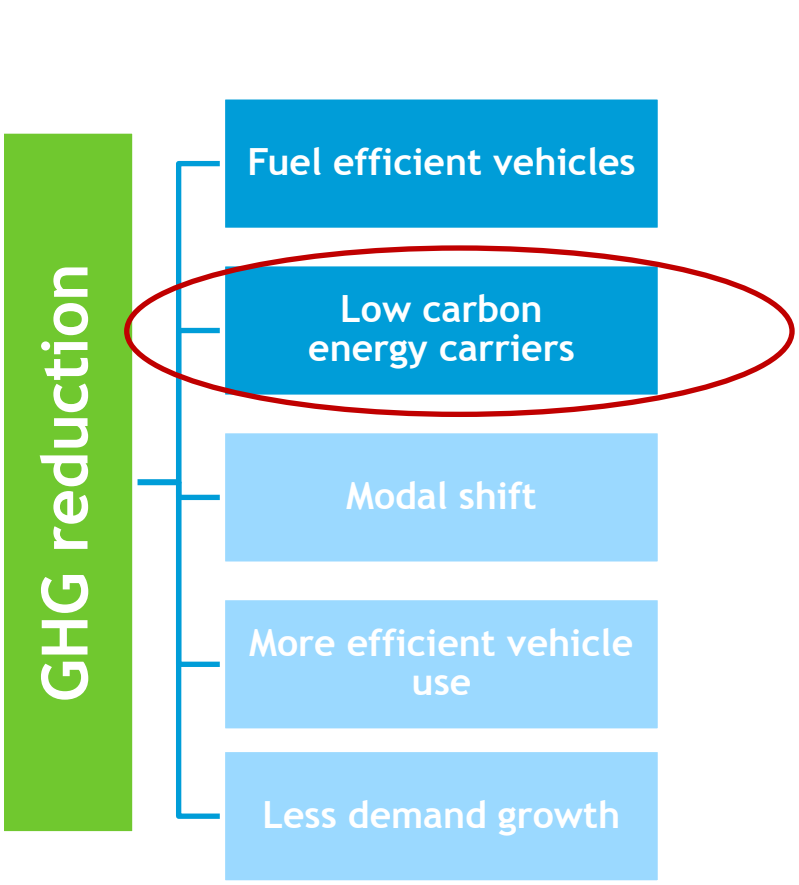
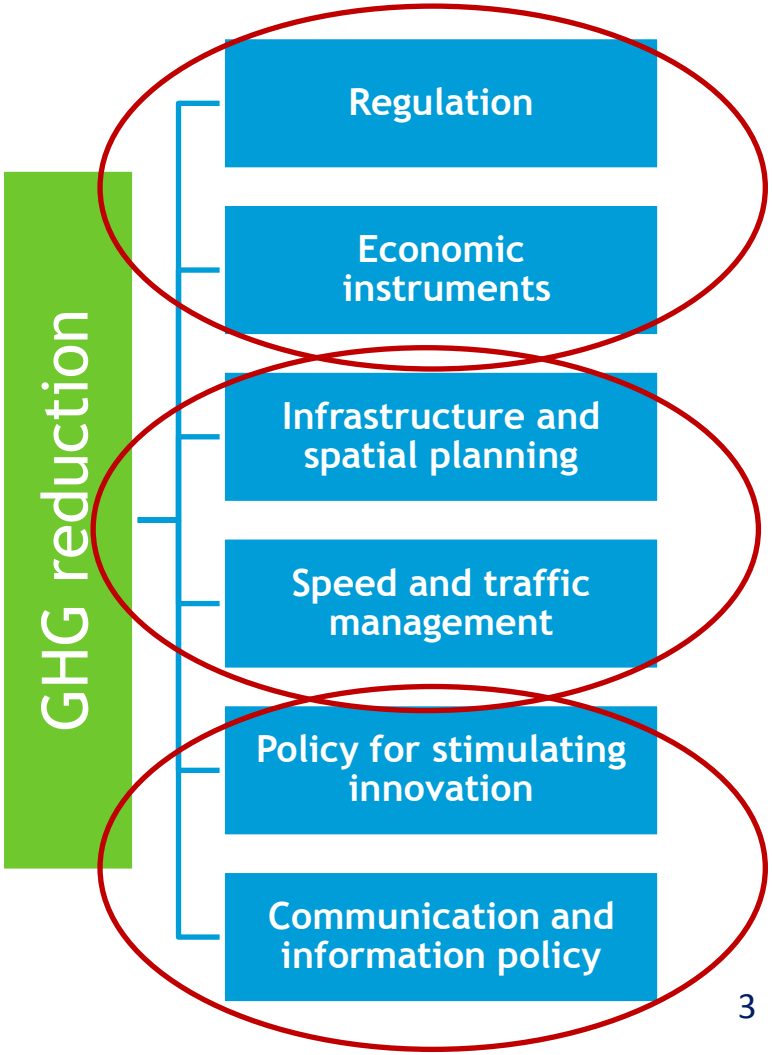
Broader context of the study: GHG reduction options (technical/behavioural) and main types of policy instruments





The mission of IEA-RETD is to accelerate the large-scale deployment of renewable energies

RETD stands for “Renewable Energy Technology Deployment”.

IEA-RETD is a **policy-focused, technology cross-cutting platform** (“Implementing Agreement”) under the legal framework of the International Energy Agency

- Created in 2005, currently **8 member countries**: Canada, Denmark, France, Germany, Ireland, Japan, Norway, UK.
- IEA-RETD commissions annually **5-7 studies** bringing together the experience of some of the world’s leading countries in RE with the expertise of renowned consulting firms and academia.
- Reports and handbooks are freely available at www.iea-retd.org.
- IEA-RETD organizes **workshops** and presents at international events.

Agenda

Background, objectives

Study overview: pathways considered and their advantages/disadvantages

Key policies currently used to promote RES-T

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Conclusion and major findings

Next generation policy instruments for renewable transport (RES-T-NEXT)

- The transition from conventional fuels to renewable energy sources in transport (RES-T) is crucial for meeting long-term climate targets and energy security goals
- Large-scale uptake of alternative energy carriers requires changes in three main dimensions: vehicles, infrastructure and availability of energy carriers
- Barriers impede transition to alternative energy and policy interventions are needed, but differ per technology pathway and can change over time
- Various regions have developed policies to increase RES-T; some were more successful than others
- To ensure a transition to RES-T in all regions, lessons learned must be considered from the approaches taken so far and need innovative policies

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Primary aim is to provide recommendations for next generation policy instruments and strategies to increase RES-T

Aspect	Included
Renewable energy sources for transport (RES-T)	• Renewable electricity • Biofuels (both liquid and gaseous) • Hydrogen
Sector	Transport sector including the dependencies between the transport sector, the energy sector, and industry
Transport modes	• Passenger transport (cars, two wheelers and buses) • Urban freight transport (light commercial vehicles and light trucks)
Policy measures	• Financial incentives • Regulations • Awareness/information related policies • Public procurement and PPPs • Transport and Spatial policies
Geographical scope	IEA-RETD member countries (Canada, Denmark, France, Germany, Ireland, Japan, Norway, and United Kingdom) and other relevant countries (e.g. USA, Japan)
Time horizon	• Short term: up to the next 5 years • Mid-term: 10-15 years • Long term: 30-40 years

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Battery-electric and hydrogen more radical pathways than biofuels (unless high blends are used)

RES-T Pathway	Characteristics
Battery-electric	• Relatively radical pathway because the performance and usage of vehicles and energy infrastructure are inherently different from ICVs: vehicles need to be charged not fuelled and the driving range is significantly smaller (for now) compared to ICVs. • Distinction made between Full Electric Vehicles (FEVs) and semi-electric vehicles: Plug-in Hybrid Electric Vehicles (PHEVs) and Electric Range Extended Vehicles (EREVs). • The semi-electric technologies are less radical compared to FEVs, as the driving range is comparable to ICVs.
Hydrogen	• Also radical because the vehicle technology (Fuel Cell Electric Vehicles (FCEVs)) and energy infrastructure are inherently different from ICEVs • Could be combined with battery-electric with fuel cells as range extender • Only the application of hydrogen by means of FCEVs is explored in this study
Biofuel	• More moderate pathway, especially for low blends, which can be used by conventional vehicles and distributed by existing infrastructure • High blends and biogas require some adjustments in vehicles (dedicated biofuel vehicles) and infrastructure and therefore more technical adaptations. • Compared to hydrogen and electric vehicles, less radical as the vehicle performance and usage is similar to those of ICVs

Battery-electric and hydrogen more advantageous for GHG, air pollution emissions reduction and energy security

Advantage	Energy carrier		
	Battery-electric	Hydrogen	Biofuel
Preventing climate change – decarbonisation	High**	High**	Medium-high *
Reducing local air pollution and noise	High	High	Low
Reducing the dependency on imports – security of energy supply	High**	High**	Medium
Exploiting market opportunities – employment, trading balance and GDP benefits	High	High	Medium-high
Buffering – electricity storage	Low/Medium***	High***	n/a

* applies to advanced biofuel and biofuels without significant ILUC or other adverse GHG impacts

** If consumed electricity/hydrogen has been produced with renewable sources

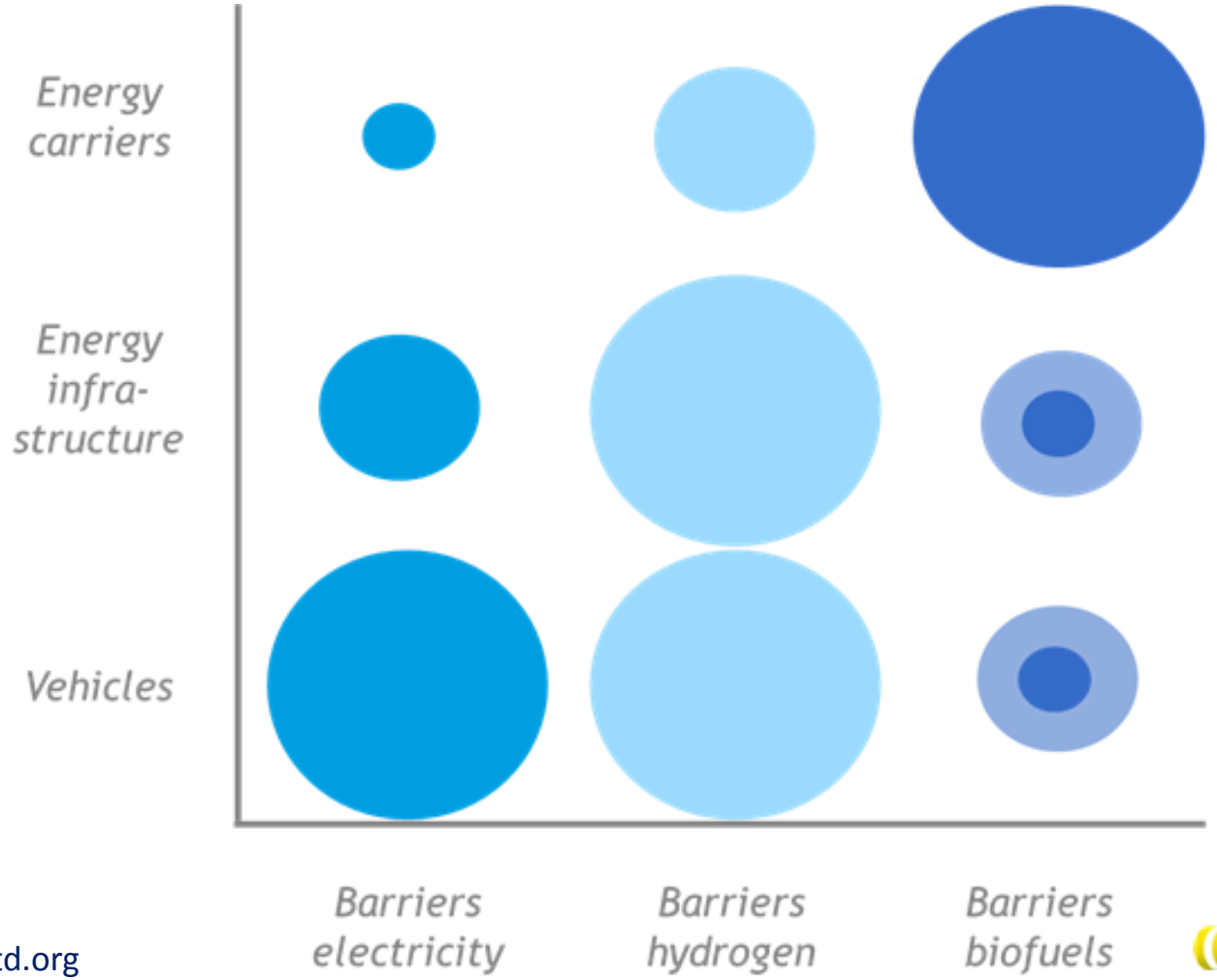
*** The magnitude of these advantages and their (economic) value is still uncertain

Financial and infrastructure barriers high for battery-electric and hydrogen, low-medium for biofuels

Barrier	Dimension	Energy carrier		
		Battery-electric	Hydrogen	Biofuel
Financial barriers*	Energy Carrier	Low	Low	High
	Energy infrastructure	Medium	High	Low-medium**
	Vehicle	High	High	Low
Technical barriers vehicle technology & compatibility	Vehicle	Medium-High	High	Low-medium**
	Energy carrier	Low	Low	Low-medium**
Low acceptance by transport users	All	Medium-High	High	Low-medium**
Lack of sufficient energy infrastructure	Energy infrastructure	Medium	High	Low-medium**
Vested interests	All	High	High	Medium
Competition for the use of available renewable energy sources	Energy carrier	Low	Low	Medium
Investment risks*	All	High	High	High

*Financial barriers are from a demand/consumer perspective; investment risks rather from the supply/industry perspective.
**Medium mainly applies to high blends. These barriers are low for low blends, as these can be used with existing infrastructure and vehicles.

Battery-electric and hydrogen require transition where vehicles and energy infrastructure need to be completely replaced by a new framework; transition incremental for biofuels



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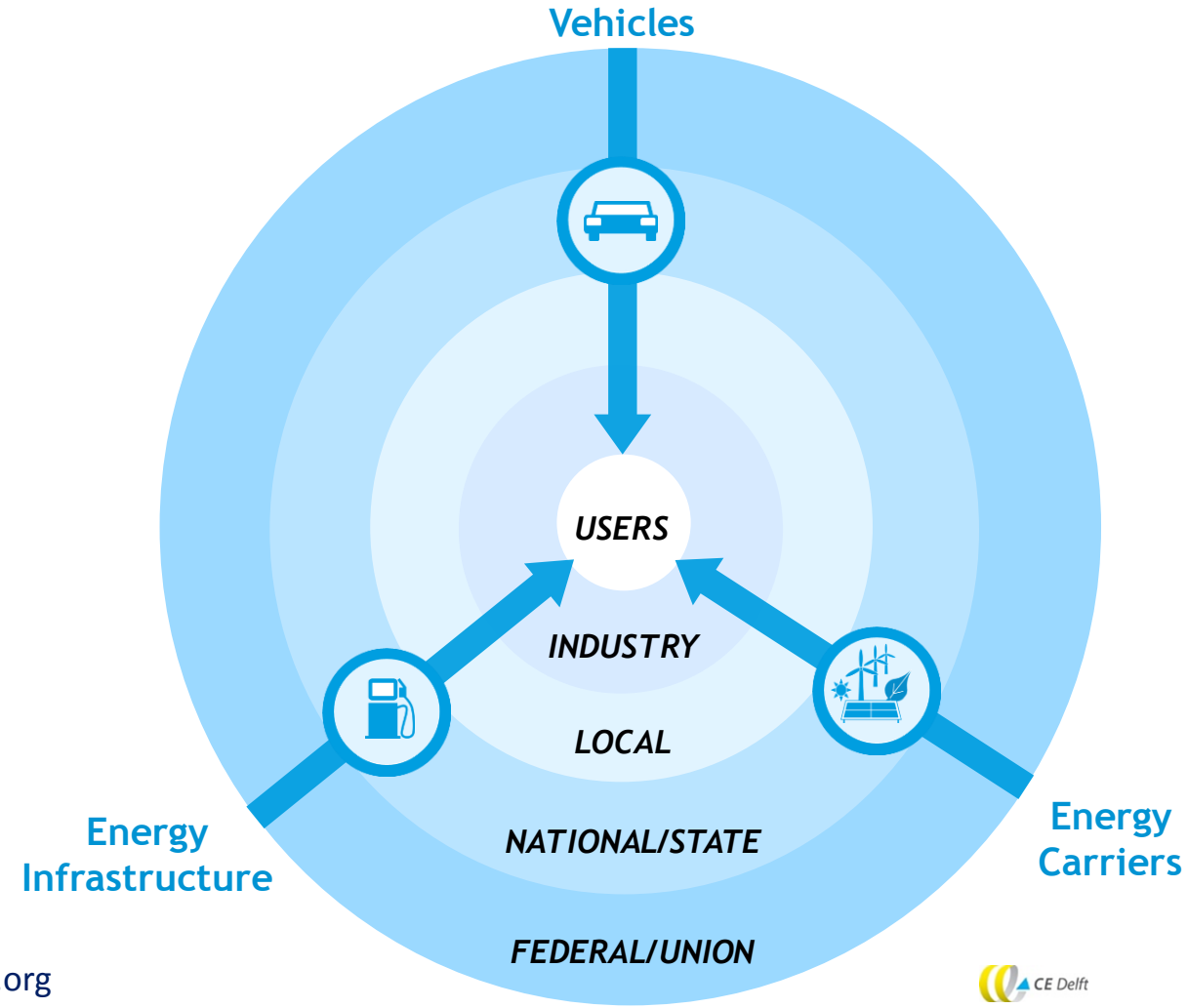
Without policy intervention at different administrative levels and three dimensions, transition to RES-T unlikely to take place



Mix of policies used to promote RES-T; some more effective than others

	US/Canada	EU	China	Japan
Energy carrier	• Mandate on the volume of renewables in fuel	• Mandate for RES-T • Mandate for renewables in fuels	• Targets for renewables in fuel	• Mandate for volumes of ethanol
Energy Infrastructure	• No federal policies on alternative infrastructure , but States have grants/ loans	• Directive requiring MS to implement policy for alternative energy infrastructure	• Large scale roll-out of EV charging points in 20 pilot cities	• Subsidies for H2 filling stations and charging points
Vehicle	• LDV/HDV standards • Some US states have ZEV Mandates	• LDV standards with specific incentive for EVs • Many fiscal incentives for AFVs by MS	• LDV/HDV standards • Min. shares of AFVs in public fleets • AFV subsidy scheme	• LDV/HDV standards • National targets for AFV sales

Most barriers can be overcome with multiple types of policy instruments directed at each pillar

Barrier	Pillar	Main type of policy instrument				
		Financial instruments	Regulation	Information provision	Public procurement & PPPs	Transport & Spatial policies
Financial barriers	Vehicle	X	X		X	X
	Energy carrier	X	X		X	
	Energy infrastructure	X			X	
Technical barriers	Vehicle	X	X		X	
	Energy carrier	X				
Low acceptance by transport users	All	X		X	X	X
Lack of sufficient energy infrastructure	Energy infrastructure	X	X		X	
Vested interests	All	X	X		X	X
Competition for the use of renewable energy	Energy carrier	X	X			
Investment risks	All	X	X		X	X

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Policy options assessed and scored on six criteria

Criteria	Definition
Increase in alternative energy carriers	Strength of the incentives to stimulate alternative energy carriers, and where possible the results (i.e. share of alternative energy carriers).
Increase in renewable energy	Impact of the policy instrument on the use of energy carriers in transport are made from renewable energy sources
GHG emissions reduction	GHG emission reduction (TTW and WTW) realised by the instrument in relative (e.g. % reduction in the region) and absolute terms (e.g. in g/km)
Coverage	Coverage of the instrument; instruments which influence a large share of the supplied energy, infrastructure, or vehicle fleet of a particular region can have a potentially larger effect on RES-T/GHG emission reduction
Cost effectiveness	Net costs to society in terms of euro per tonne of CO_2-eq, which is very case-specific
Ease of implementation	Difficulty of implementing the policy instrument (government perspective)

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Scoring reflects the current situation with respect to the state-of-the-art and cost of technology; could change over time

	Increase alternative powertrains	Increase renewable energy	GHG reduction	Coverage	Cost-effectiveness	Ease of Implementation
--	Strong decrease in alternative powertrains	Strong decrease in renewable energy consumption	Strong increase in relative GHG emissions	Very small coverage (very small share of the market)	Very high net costs to society	Very difficult
-	Decrease in alternative powertrains	Decrease in renewable energy consumption	Increase in relative GHG emissions	Small coverage (small share of the market)	Modest to high net costs to society	Difficult
o	Neutral impact on alternative powertrains (i.e. no change)	Neutral impact on renewable energy consumption	Neutral impact on relative GHG emissions	Medium coverage (significant share of the market)	(close to) neutral costs to society	Modest
+	Increase in alternative powertrains	Increase in renewable energy consumption	Decrease in relative GHG emissions	Large coverage (large share of the market)	Modest to high net benefit to society	Easy
++	Strong Increase in alternative powertrains	Strong increase in renewable energy consumption	Strong decrease in relative GHG emissions	Very large coverage (entire market)	Very large net benefit to society	Very easy
#	Unclear or dependent on design	Unclear or dependent on design	Unclear or dependent on design	Unclear or dependent on design	Unclear or dependent on design	Unclear or dependent on design

Most effective instruments to increase alternative powertrains are ZEV mandates, incentives in vehicle registration taxes, and incentives in company car taxation schemes

		Effectiveness			Other criteria		
Type of policy instrument		Increase Alt. Power-trains	Increase renewable energy	Reduce GHGs	Coverage	Cost-effectiveness	Ease of Implementation
Financial instruments							
1	Incentives in energy taxation	o/+	+	++	++	+	+
2	Incentives in vehicle registration taxes	++	o	++	++	#	+
3	Incentives in company car taxation	++	o	++	+	#	+
4	PPP and subsidies for energy infrastructure	o/+	o/+	o/+	+	o	o
5	Incentives in (urban) road pricing and tolls	+	o	o/+	o	-	o
Regulation							
6	Fuel regulation	o	+/++	+	++	-	o
7	Renewable energy mandates	o	++	+	++	-	+
8	Regulation of charging/fuelling infrastructure	+	+	+	++	o	+
9	CO_2 regulation for road vehicles	+	o	++	++	++	o/+
10	ZEV mandates	++	o	+/++	+	--	-

Traffic and land-use policies and in particular green public procurement usually have much lower coverage as the share of the fleet that is affected is relatively small – financial instruments have the largest coverage

		Effectiveness			Other criteria		
Type of policy instrument		Increase alt. power-trains	Increase renewable energy	Reduce GHGs	Coverage	Cost-effectiveness	Ease of implementation
Traffic management and land-use policies							
11	Incentives in parking policies	+	o	o/+	o	-	o/+
12	High Occupancy Vehicle (HOV) lane incentives	+	o	o/+	o/-	+	o/+
13	Urban access restrictions	o/+	o	o/+	o	#	o
Other policies							
14	Information provision	o/+	o/+	o/+	+	#	+
15	Green public procurement	+	o	+	-	#	+
16	Pilot/demonstration project	n/a	n/a	n/a	n/a	n/a	n/a
17	Policies to increase RE consumption	n/a	n/a	n/a	n/a	n/a	n/a

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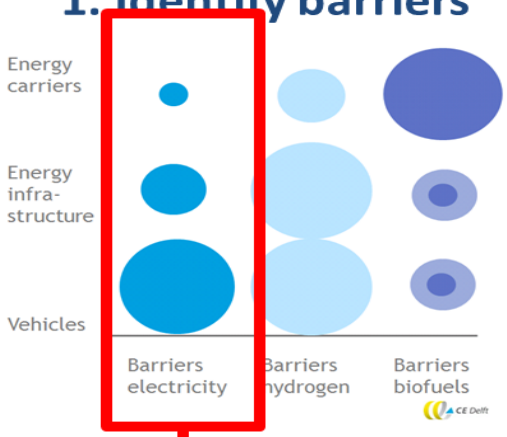
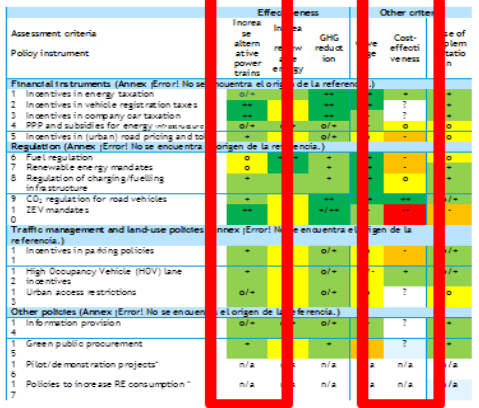
Short list of policy instruments was created for each pathway considering barriers and scores of different policy options

Deriving the strategic policy mix for the electric pathway

1. Identify barriers

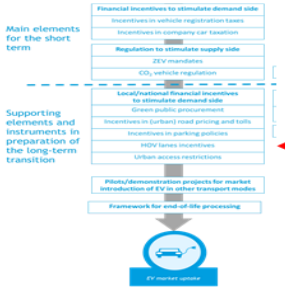


2. Evaluate policies

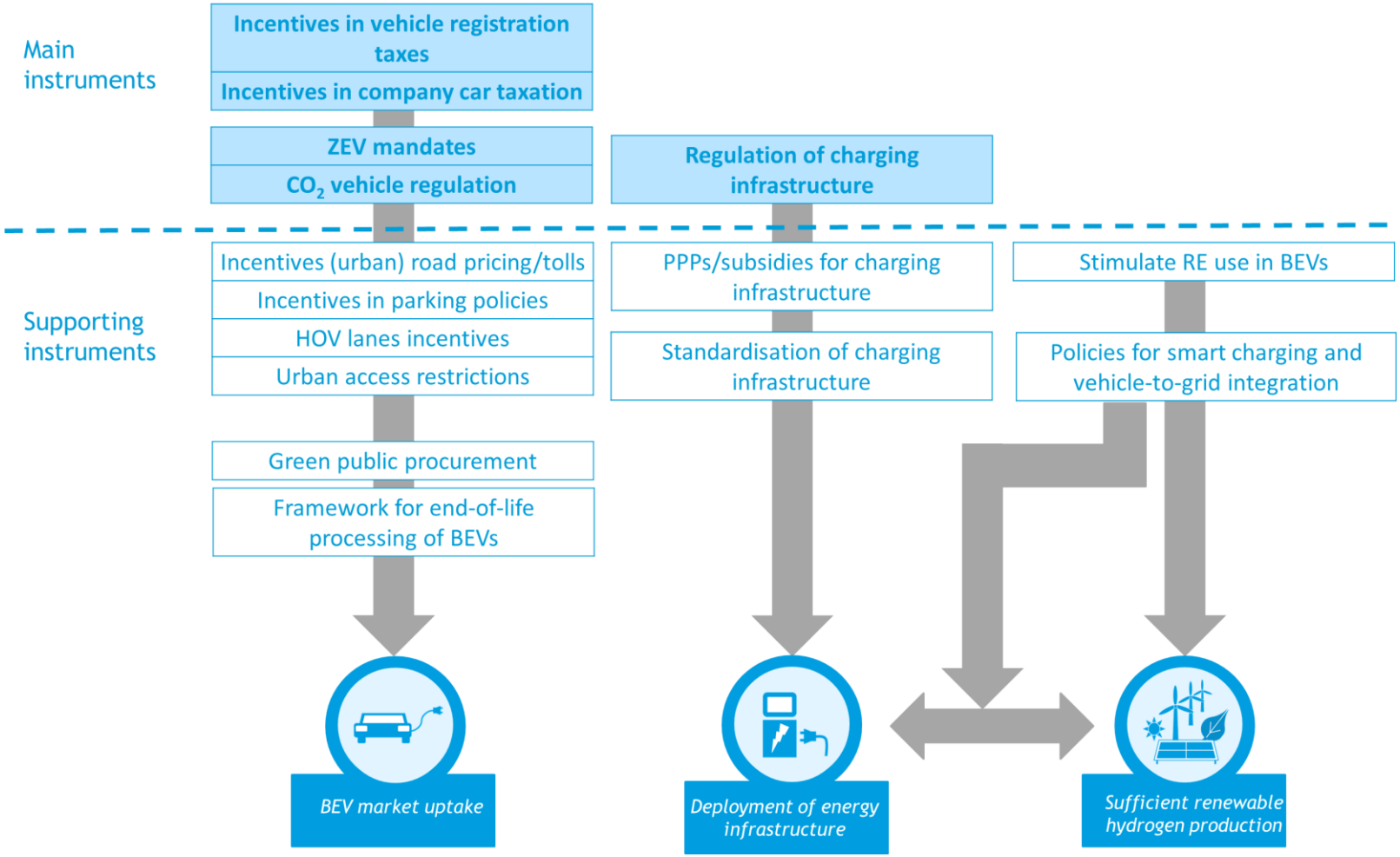


Assessment criteria / Policy instrument	Effectiveness: Increase alternative power-trains	Effectiveness: Increase renew. energy in ESY	Effectiveness: GHG reduction	Other criteria: Cost-effectiveness	Other criteria: Ease of implementation
Financial instruments (Annex ¡Error! No se encuentra el origen de la referencia.)					
1 Incentives in energy taxation	o/+		++	+	+
2 Incentives in vehicle registration taxes	++		++	?	+
3 Incentives in company car taxation	++		++	?	+
4 PPP and subsidies for energy infrastructure	o/+	+	o/+	o	o
5 Incentives in (urban) road pricing and tol	+		o/+	-	o
Regulation (Annex ¡Error! No se encuentra el origen de la referencia.)					
6 Fuel regulation	o	+	+	-	o
7 Renewable energy mandates	o	+	+	-	+
8 Regulation of charging/fuelling infrastructure	+		+	o	+
9 CO_2 regulation for road vehicles	+		++	++	o/+
10 ZEV mandates	++		+/++	--	-
Traffic management and land-use policies (Annex ¡Error! No se encuentra el origen de la referencia.)					
11 Incentives in parking policies	+		o/+	-	o/+
12 High Occupancy Vehicle (HOV) lane incentives	+		o/+	-	o/+
13 Urban access restrictions	o/+		o/+	?	o
Other policies (Annex ¡Error! No se encuentra el origen de la referencia.)					
14 Information provision	o/+	+	o/+	?	+
15 Green public procurement	+		+	?	+
16 Pilot/demonstration projects*	n/a	n/a	n/a	n/a	n/a
17 Policies to increase RE consumption *	n/a	n/a	n/a	n/a	n/a

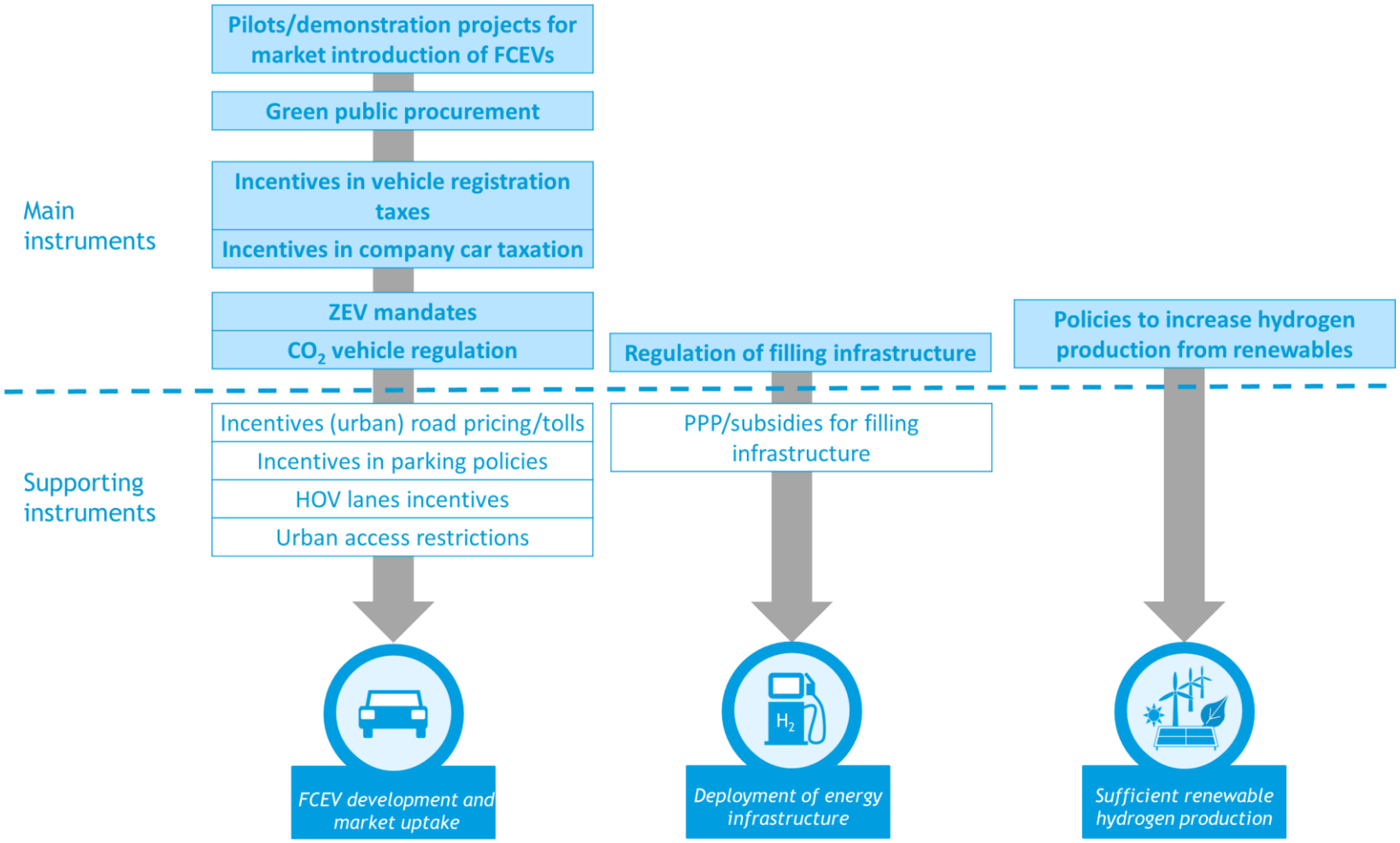
3. Define policy strategy pathway



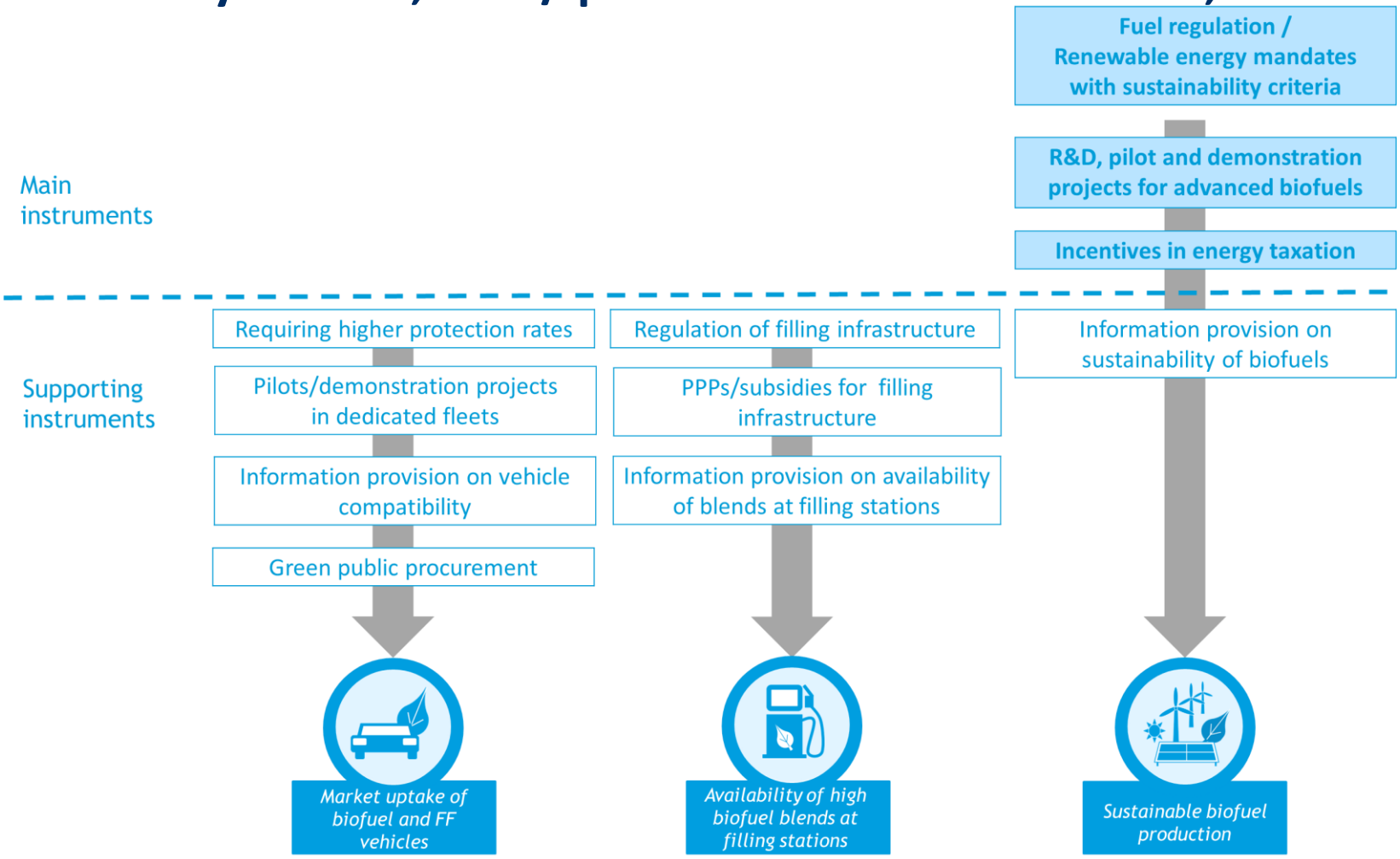
Main policy instruments: Incentives, ZEV mandates, CO_2 vehicle regulation and regulation of charging



Same types of main instruments as for battery–electric along with pilot projects, green public procurement and policies to increase RES-hydrogen

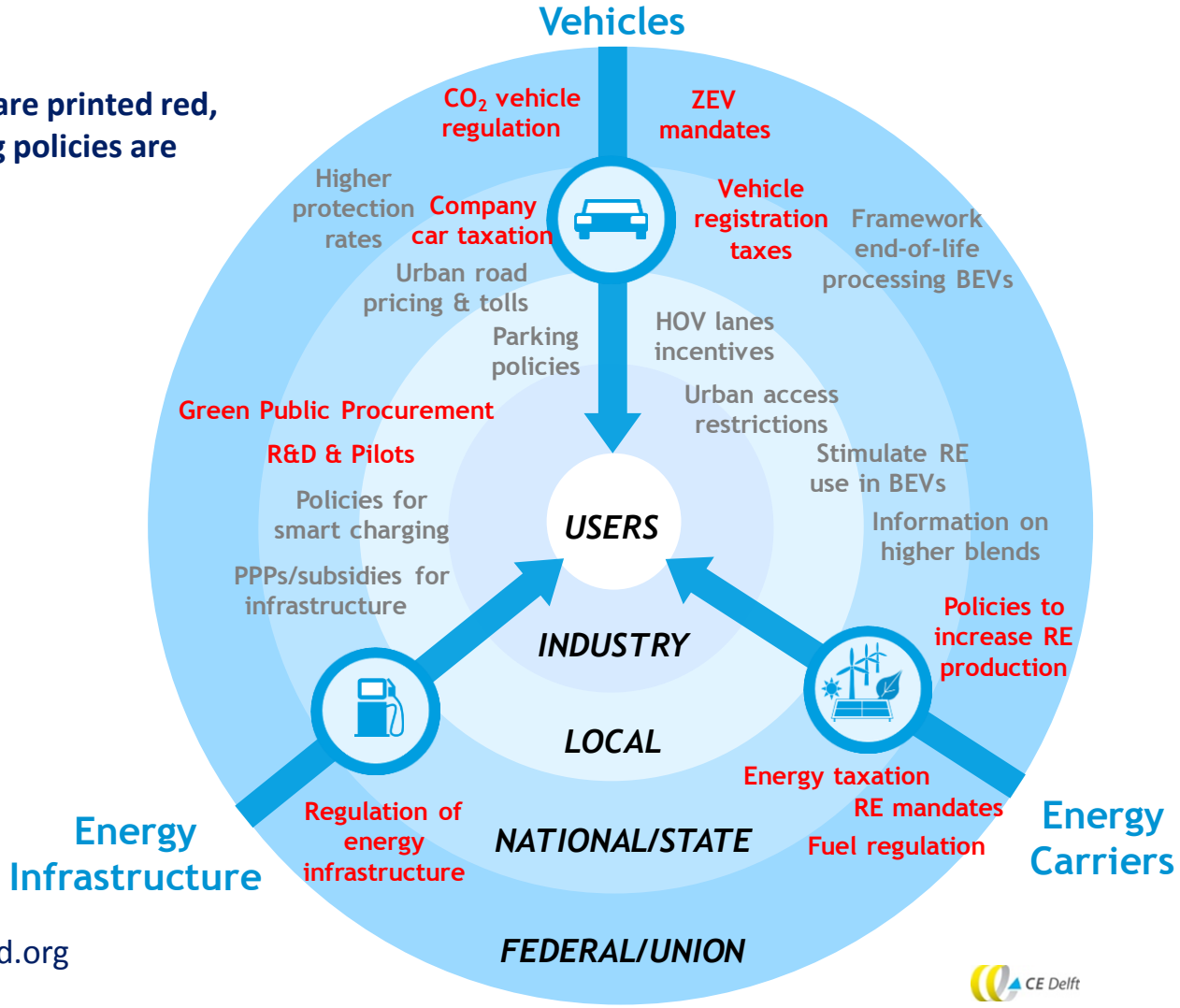


Main policy instruments: Fuel regulation/RE mandates with sustainability criteria, R&D/ pilots for advanced biofuels, incentives



Most policies are primarily targeting the commercialisation and uptake of technology that is sufficiently mature

Main policies are printed red, the supporting policies are printed grey.



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Relevant for all technology pathways and must be taken into consideration

- Generic policies or targeting specific user groups?
- Technology neutrality
- Costs-effectiveness vs preparing for long-term transition
- Dealing with uncertainty
- Consistency and alignment of policy instruments
- Differences between regions

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Battery-electric, hydrogen and biofuels can help achieve RES-T and therefore, climate goals

- RES-T is essential to achieve climate goals
- Battery-electric is most promising pathway, though hydrogen is a feasible and complementing pathway too
- Biofuels is easier to implement but concerns remain on GHG emission reductions and sustainability
- Each pathway requires policies at different administrative levels
- Policies need to be coordinated, harmonized and continuous, providing regulatory and investment certainty

Renewable energy sources in transport (RES-T) are crucial for avoiding climate change

- There is a wide variety of policy instruments that can be implemented at different administrative levels to remove the barriers to RES-T change.
- Most policy instruments increase the share of alternative powertrains, but few (also) directly target the share of renewable energy consumption.
- All policies investigated reduce GHG emissions, but highest GHG emission reductions can be expected from instruments targeting both RES-T and fuel efficiency improvements of conventional vehicles.
- There are cross-cutting issues for all three pathways that must be taken into account when designing a policy package:
  - Policies should be designed from a social cost-effectiveness principle, but there could be a trade-off with long-term climate goals
  - Policies should be defined early on and be as continuous as possible
  - The design of policy instruments should be harmonised where possible
  - In choosing the mix of policy instruments, specific local or national circumstances should be taken into account

Battery electric is most promising pathway, though hydrogen may complement or provide an alternative; biofuels depends on the availability of sustainable feedstock

Battery-electric

- Though there are significant barriers, potential benefits in GHG emissions reduction and improved are quality are high.
- The technology has already been commercialised; it now requires policy instruments which generate volume.
- In the short to medium-term, strict CO_2 regulations for road vehicles and ZEV mandates are very important. The demand side can best be stimulated by financial incentives in VRTs and company car taxation, supported by various local incentives.

Hydrogen

- The hydrogen technology is not yet fully commercialised and requires policies which primarily promote pilots, first market uptake and further product development.
- Policies for standardising the technology and for stimulating information sharing to achieve a more positive public perception for this pathway are necessary.

Biofuels

- The biofuel pathway represents the least radical pathway, with fewest barriers, but also results in smaller and more uncertain reductions of GHG emissions and air pollutants.
- There is a clear need for a long-term policy framework that includes mandates, subtargets for advanced biofuels and financial incentives to guarantee investment security to biofuel producers, OEMs and the fuel industry.
- With guaranteed volumes of available sustainable feedstock, higher blending limits can be established.

THANK YOU!

For additional information on RETD or RES-T-NEXT

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Abbreviations

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Abbreviation		Abbreviation	
AFV	Alternative Fuel Vehicle (includes biofuel vehicles and ZEVs)	LCV	Light Commercial Vehicle
BEV	Battery Electric Vehicle (includes FEVs/EREVs/PHEVs)	LDV	Light Duty Vehicle (LCV/car)
CNG	Compressed Natural Gas	LEV	Low Emission Vehicle (defined in Californian Standards)
CO_2	Carbon dioxide	LNG	Liquefied Natural Gas
CPT	Clean Power for Transport	LTZ	Limited Travel Zones
EREV	Extended Range Electric Vehicle	MJ	Mega-Joule
ETS	Emission Trading System	MS	Member State
EV	Electric vehicle (includes BEVs/FCEVs)	Mt	Mega ton
FAME	Fatty acid methyl esters (form of biodiesel)	NGO	Non-Governmental Organisation
FCEV	Fuel Cell Electric Vehicle (running on hydrogen)	NO_x	Nitrogen Oxides
FEV	Full Electric Vehicle	OECD	Organisation for Economic Co-operation and Development
FFV	Flex-Fuel Vehicles	OEM	Original equipment manufacturer
FQD	Fuel Quality Directive	PHEV	Plug-in Hybrid Electric Vehicle
GHG	GreenHouse Gas	PPP	Public-Private Partnership
GPP	Green Public Procurement	PZEV	Partial Zero Emission Vehicle (defined for ZEV Mandates)
GVD	Greener Vehicle Discount	RE	Renewable Energy
GVW	Gross Vehicle Weight	RED	Renewable Energy Directive
H_2	Hydrogen	RES-E	Renewable Energy Sources for Electricity
HDV	Heavy Duty Vehicle (HGV/bus)	RES-T	Renewable Energy Sources for Transport
HGV	Heavy Goods Vehicle	TCO	Total Cost of Ownership
HOV lane	High Occupancy Vehicle Lane	TTW	Tank-to-wheel
ICE	Internal Combustion Engine	ULEV	Ultra Low Emission Vehicles (ZEVs and relatively fuel efficient ICVs)
ICV	Internal Combustion Engine Vehicle	VRT	Vehicle Registration Taxes
ILUC	Indirect Land Use Change	WTT	Well-to-tank
kWh	kilo-Watt-Hour	WTW	Well-to-wheel