



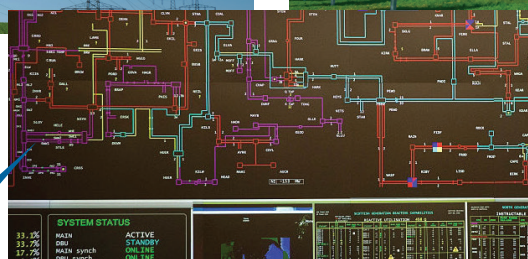
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Electric Cars, the Smart Grid, and the Energy Union:

**Coordinating Vehicle CO₂ Reduction Policy
with Power Sector Modernisation**

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Acronyms

CO₂	Carbon Dioxide	LDV	Light-Duty Vehicle
DSO	Distribution System Operator	R&D	Research and Development
EU	European Union	RES	Renewable Energy Sources
EV	Electric Vehicle	TCO	Cost of Ownership
G2V	Grid to Vehicle	TSO	Transmission System Operator
ICE	Internal Combustion Engine	ULEV	Ultra-Low-Emission Vehicle
ICT	Information and Communication Technologies	V2G	Vehicle to Grid
IEC	International Electrotechnical Commission		

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Executive Summary¹

The European Commission is due to issue a proposal revising the light-duty vehicle (LDV) CO₂ regulation² by the end of 2016.

This policy brief explains why the revision should take into account the needs of market actors beyond the auto manufacturers and their supply chains, specifically including electricity infrastructure developers and delivery bodies. This paper examines the case of electric vehicles (EVs) and pays particular attention to the interdependence between the LDV regulation and the changing policy landscape relating to power markets and electricity networks. Greater policy coordination and coherence has the potential to accelerate achievement of multiple policy goals at lower cost and significantly enhance the European Union's global competitiveness and quality of life for EU citizens. The optimal regulatory mechanism will be a consistent set of near- and long-term binding LDV CO₂ reduction standards, complemented with an ultra-low-emission vehicle (ULEV) quota, that could be tradable. This mechanism should be coordinated with delivery of the Energy Union vision; time frames to achieve EU climate, energy, and environmental quality goals; power market design reforms; and completion of the European Union's single digital and energy markets.

Today, Member States developing infrastructure strategies and distribution system operators (DSOs) setting out investment plans can only guess what might happen to LDV CO₂ standards and the associated EV rollout beyond 2021. Yet Directive 2014/94/EU requires Member States to estimate EV numbers for 2025 and 2030, develop infrastructure strategies based on this demand, and report this information to the Commission. Indeed, it is necessary to develop infrastructure plans based on assumptions about the long-term future as network asset lifetimes can be up to 45 years³ and scenarios for infrastructure investment planning look decades ahead.⁴ In developing their business plans for the grid, system operators need to make a large number of assumptions about growth in energy demand, including the rollout of EVs, the extent to which energy demand

can be managed, and the sequencing of investment in grid reinforcement according to identified needs and priorities. Greater certainty about these assumptions can reduce margins or allowances for error and so reduce the risk for underutilised assets or stranded assets. Greater certainty regarding infrastructure needs will also give governments and investors greater confidence to make significant investments.

In addition to the need for better infrastructure planning, there is an even more fundamental reason that forward-looking LDV standards are needed. The lack of availability of public charging infrastructure is often cited as a major barrier to EV rollout, but charging points are just the “tip of the iceberg” with regard to the power system's readiness for EVs. The full iceberg is actually the capability of the power system to integrate EVs at least cost while maximising their benefits, particularly with respect to cost-effective integration of variable renewable energy generation.

EU policymakers are now well aware of the need to increase the power system's flexibility in order to cost-effectively integrate variable renewable energy. It is also well known that demand response combined with storage, along with application of smart grid technologies made possible through recent huge innovation in digital information and communication technologies (ICT), offers a highly cost-effective source of flexibility. EVs,

1 With thanks to reviewers Phil Baker, Senior Advisor, The Regulatory Assistance Project; Richard Cowart, Director, The Regulatory Assistance Project.

2 Regulation 333/2104/EC.

3 The UK regulator, Ofgem, recently reviewed the economic asset life for depreciation of distribution assets and decided on 45 years. Retrieved from <http://www.ofgem.gov.uk/Networks/Policy/Documents1/assetlivedecision.pdf>

4 See Gunther, E.W. (2016, February 25). Distribution system planning for pervasive DER. IEEE Smart Grid webinar. Retrieved from <http://smartgrid.ieee.org/resources/webinars/past-webinars>

conveniently, can provide very cost-effective flexibility through controlled charging. In any case, mass rollout of EVs would require controlled charging in order to avoid expensive reinforcement of electricity distribution networks and expansion of generation capacity. Smart power policies enabling controlled charging and the capture of this value, along with smart infrastructure investment, can therefore facilitate or even accelerate EV rollout.

As transaction costs can easily erode the value of small flexible loads, the value proposition for demand response in the residential sector could be much more interesting with uptake of larger discrete loads in the home, such as EVs, around which smaller loads could be clustered. Rollout of EVs could potentially help kick-start demand response in the residential sector, with significant societal benefits.

The growth of the EV market will not be linear; in fact, there's a good chance it will be exponential. Planning is key to ensuring networks are adequately prepared for the pace of this growth. Not only is knowledge of likely demand important, but the coordination and timing of regulatory change in different sectors will be important too. Much needs to come together at the right time; the more successful the European Union is at achieving this, the greater will be the rewards for the region's competitiveness.

Many experts expect the impact of digital technologies on the power sector to enable empowerment of the demand side of the power system, potentially resulting in rapid change. Digitalisation of electricity networks and application of smart grid technologies are already opening up many new business opportunities, and this trend is expected to continue. Coordinating and accelerating development and implementation of policies relating to data, telecommunications, the Internet of Things, cybersecurity, equipment interoperability, and minimum standards will be of fundamental importance.

Europe has the advantage of a strong automotive industrial base on which to build; the region has the second largest vehicle market, the highest absolute automotive R&D spending, and high net exports.⁵ The continent's historical position as an innovation leader, however, is being challenged by Asia, so efforts need to intensify if Europe is to stay ahead. Innovation is also required in developing and applying smart grid technologies, and regulation of DSOs will need to be designed to support innovation and minimise risk where possible.

Perhaps the greatest challenge will be regulating to maximise the benefits of this technologic revolution. Power market reforms will be needed to reveal the value

of flexibility in relation to integrating variable renewable energy and to ensure consumers can easily access this value. Regulatory reforms will also be necessary to ensure that electricity network operators are adequately incentivised to make best use of smart grid technologies for cost-effective management and operation of their networks, integrating distributed energy resources that include generation, demand, and storage. Regulatory change and implementation typically takes many years, and DSOs will need to undergo considerable organisational and cultural change in order to transform their business operations. There is a risk that the pace of change could vary considerably across Europe with negative consequences for the competitiveness of the European Union as a whole. Some Member States may be resistant to reforms, whereas others may be highly motivated and able to modernise their systems. Resource-constrained regulators and low-income Member States may need assistance. Indeed, the European Union can play an important role in ensuring that progress is sufficiently ambitious and consistent across the EU28. The clearer the need and timing for grid modernisation and investment, the greater the motivation to adapt and implement needed regulatory reforms.

Officials who have as clear an understanding as possible of the scope and pace of the change that is required are more likely to take a long-term view, approving the large financial commitments necessary to modernise the grid while reforming regulation to ensure investments are efficient. Greater regulatory certainty will naturally reduce risk and encourage greater private investment.

Experience informs that binding standards for CO₂ from LDVs accelerate improvement relative to a voluntary approach—for example, mandatory performance standards introduced in 2009⁶ accelerated annual improvement in LDV fuel efficiency from one percent to four percent.⁷ With a number of EV models now available

5 Gunther, 2015.

6 Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO₂ emissions from new passenger cars. Retrieved from: <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0333&from=EN>

7 ICCT. (2014, January). EU CO₂ Emission standards for cars and light commercial vehicles.

in car showrooms, targets no longer need to be set based on possible incremental improvement that can be achieved through the best available techniques applicable to the dominant technology. It is now possible to focus on outcomes and coordinate the time frames of multiple strategies that combine to deliver these outcomes (see Figure 2 in full text).

Setting a trajectory of binding CO₂ reduction targets, as illustrated in Figure 3 in the main text, would both drive innovation in the near term and give foresight on the pace of change to long-term goals. This is important for long-term planning in the automobile sector, as well as the power sector and other affected sectors. With a longer-term planning perspective, car manufacturers would be better able to reveal more information about their long-term strategies and infrastructure needs.

There could be various options to consider with respect to how far apart these targets would be, the curvature of the trajectory, and how many of these targets would be binding or non-binding. Such decisions would need to be underpinned by an analysis of costs and benefits, with the objective of optimising these over the duration of the transition. In addition to the benefit of CO₂ reduction, it would be important to incorporate co-benefits such as E.U.-wide macroeconomic gains, improved competitiveness, and better air quality.

It would be possible to accelerate the share of EVs by specifying a quota or target number for their sales. However, regulatory experience cautions against picking technology winners. Indeed, alternative ULEV technologies, such as hydrogen-powered fuel cells, are already available. CO₂ reduction targets for LDVs, however, could be combined with a tradable ULEV sales quota for car makers, as the definition of ULEVs could encompass a variety of very-low-emission technologies. This would help drive change in larger steps, rather than incremental improvement, and trading could provide car manufacturers with flexibility if their sales goals hit above or below the quota.

Today, as the cost of EVs is falling rapidly, the share of them on the road is already significant and much greater than that of the more expensive hydrogen fuel cell alternative, with costs rapidly falling. Current market data suggest that the EV share will grow significantly, at least in the near- to medium-term future. The final share of EVs in Europe's LDV fleet is of course uncertain, as much can change regarding innovation and consumer preferences, among other factors. Nevertheless, it is clear that system operators will need to prepare to integrate both renewable energy sources (RES) and EVs into the

grid. If EV penetration remains relatively low, system operators would need to plan for use of alternative and potentially more expensive options to integrate RES.

Analysts will be able to use market data and car manufacturer forecasts to estimate the extent to which a CO₂ reduction target is likely to affect the share of EVs in new car sales (see Figure 4 in main text). This will be critical information for all market actors involved in the electrification of transport, and such analysis will be more accurate in the presence of a quota system such as that suggested here.

Experience to date informs us that binding LDV CO₂ reduction targets effectively drive innovation. The extent to which they do so is dependent on the design of the regulation. In the case of EVs, as this paper illustrates, regulation must evolve to cater to new market actors and other sectors that are involved in delivering decarbonisation of the transport sector. With this in mind, the design of LDV CO₂ reduction targets should be guided by the following principles and considerations.

- Although LDV CO₂ reduction targets must be part of a holistic and integrated transport strategy, the targets must be applied to those who can deliver—that is, auto manufacturers. Such targets need to be part of an e-mobility strategy and should be complemented with an industrial strategy, stimulus packages, and technologic integration policies.
- Coordinated targets are critical to align market actors in different sectors toward achieving common goals, as well as to ensure that those actors achieve multiple policy objectives cost effectively. The design of the LDV CO₂ reduction trajectory should be aligned with commitments set out in key EU policies and strategies that are relevant, including but not limited to: the Transport White Paper, the Energy Union strategy, the EU 2050 Low Carbon Economy Roadmap, the E.U.'s Thematic Strategy on Air Pollution, and the European Commission's 2030 Energy & Climate strategy.
- Roadmaps are essential to defining a vision and possible pathways to delivering that vision, but binding targets are the proven way to give investors the confidence they need. A defined binding long-term end goal can influence decisions and investments that are made in the medium term and perhaps even the short term, as market actors will be highly motivated to maximise the benefits of investment and minimise the risk for underutilisation or stranding of assets. This is particularly important for vehicle manufacturers and DSOs.

- The timeframes for any binding targets must give policymakers and all affected market actors, including those providing fuel infrastructure (e.g., electricity distribution system operators), as much foresight as possible with respect to the minimum pace of change needed. At the same time, targets should not be too far apart. Thus, it is necessary to have a set of binding targets or mileposts stretched out in time, coordinated with the ambition and timing of targets applied in other policy areas or sectors of relevance.
- Binding near-term targets (e.g., 2025, 2030) are needed to ensure capture of the benefits of innovation and to ensure that decarbonisation of the LDV fleet stays on track to meet longer-term goals. If rapid growth in the share of EVs is foreseen and planned for, motivations to properly implement the power market reforms enabling demand response will be strengthened. This policy synergy is an opportunity to unleash the benefits of the smart grid and single energy and digital markets.
- Setting a target for 2030 provides an important opportunity to coordinate EU energy, climate, and transport policies and achievement of the Energy Union goals. By 2030, the power sector should be well on its way to full decarbonisation with a much greater share of variable RES in the power mix. By this time it should be expected that market design reforms are implemented such that flexibility is fairly compensated, aggregated energy demand and storage fully participate in power markets, power networks are well on the road to being modernised and actively managed, and consumers have access to a wide range of attractive energy product and service offerings.
- Mid-term targets (e.g., 2035, 2040, 2045) could be used to indicate the minimum pace of change, with these targets becoming automatically binding once a certain point in time is reached, providing sufficient foresight for policymakers and affected market actors (e.g., 15 years in advance). As the objective is to provide regulatory certainty, revision of these targets should be possible only under well-defined and restricted conditions.
- Ideally mechanisms should be technology-neutral to avoid picking technology winners. CO₂ reduction targets for LDVs, however, could be combined with a tradable ULEV sales quota for car makers, and the definition of ULEVs could encompass a variety of very low-emission technologies, including EVs. This would help accelerate change to the pace needed, and car manufacturers could benefit from the flexibility of a tradeable quota.
- As LDV CO₂ reduction targets apply to tailpipe emissions, such targets may need to be applied to the whole lifecycle of the vehicle, including its fuel. If power sector decarbonisation goals are coordinated with transport decarbonisation goals, policymakers can be confident that electrification of transport will result in decarbonisation of transport.⁸

8 For simulations on EU power sector decarbonisation and impact on EV CO₂, see Eurelectric (2015, March). Smart Charging: steering the charge, driving the change. At 50.

Electric Cars, the Smart Grid, and the Energy Union:

Coordinating Vehicle CO₂ Reduction Policy with Power Sector Modernisation

Introduction

The European Commission is due to issue a proposal revising the light-duty vehicle (LDV) CO₂ regulation⁹ by the end of 2016. This policy brief explains why the design of this should be adapted to take into account the needs of market actors beyond the auto manufacturers and their supply chains, with focus also on infrastructure developers and delivery bodies. This paper examines the case of electric vehicles (EVs), paying particular attention to the interdependence between the LDV regulation and the changing policy landscape around power markets and electricity networks. Greater policy coordination and coherence has the potential to accelerate achievement of multiple policy goals at least-cost and significantly enhance the European Union's global competitiveness and quality of life for EU citizens.

The benefits of EVs for Europe

EVs promise substantial potential for improving urban well-being. Air quality standards are currently not met in many parts of Europe, particularly for PM2.5 and ozone,¹⁰ but EVs have no tailpipe emissions and also create far less noise than conventional vehicles. If aligned with decarbonisation of the power sector, EVs also have the potential to decarbonise the passenger car fleet in the longer term and could also help cost-effectively integrate variable renewable energy generation.

Policies have been successful in driving growth of renewable energy generation, much of it variable wind and solar power. In 2014, the projected share of renewable energy in the European Union's gross final energy consumption reached 15.3 percent.¹¹ E.U. policymakers are now well aware of the need to increase the power system's flexibility in order to cost-effectively integrate variable renewable energy. It is also well known that demand response combined with storage, along with application of smart grid technologies made possible through recent huge innovation in digital information and communication technologies (ICT), offers a highly cost-

effective source of flexibility. It just happens that EVs can provide very cost-effective flexibility through controlled charging. In any case, mass rollout of EVs would require their controlled charging in order to avoid expensive reinforcement of electricity distribution networks. Smart power policies to enable controlled charging and smart infrastructure investment can therefore facilitate or even accelerate EV rollout, while more rapid rollout can facilitate more rapid deployment of renewable power generation.

The switch from internal combustion engines to EVs would reduce the European Union's dependency on oil, spur innovation, and potentially create additional jobs, thereby providing economic stimulus and improving Europe's relative competitiveness. For example, a study conducted by Ricardo-AEA and Cambridge Econometrics¹² illustrated that ambitious ULEV roll-out could improve Europe's growth prospects and create 500,000 to 1.1 million net additional jobs and reduced dependency on oil imports worth between €58 billion and €83 billion per year by 2030.

The impact of digital technologies on the power sector is expected by many to enable empowerment of the system's demand side and could potentially bring about rapid change. Digitalisation of electricity networks and application of smart grid technologies are already opening up many new business opportunities, and this trend is expected to continue. Using metrics and shift indices to track global trends,¹³ Deloitte has observed

9 Regulation 333/2104/EC

10 For state of EU air quality data, see <http://www.eea.europa.eu/soer-2015/europe/air>

11 European Commission (2015). Renewable energy progress report. COM(2015) 293 final.

12 European Climate Foundation. (2013). Fuelling Europe's future: How auto innovation leads to EU jobs. Conducted by Ricardo-AEA and Cambridge Econometrics.

13 Hagel, J., Brown, J.S., Samoylova, T., Lui, M. (2013). From exponential technologies to exponential innovation: Report 2 of the 2013 Shift Index series. Deloitte Center for the Edge.

how exponential innovation is happening on the back of exponential improvement in core digital technologies. The impact of these technologies is amplified when they interact and combine in innovative ways, leading to new products, services, businesses, and technologies. New entrant Tesla provides a good example of a company that has managed to exploit this opportunity, causing considerable disruption to dominant incumbents in the market.

The market share of EVs is presently tiny, but sales are growing rapidly, and Europe is emerging as a market leader. In the first half of 2015, the European Union led the EV market for the first time, with all-electric vehicle sales in the region rising 55 percent over the first six months of 2014.¹⁴ At present, analysts¹⁵ estimate that EVs are likely to achieve total cost of ownership (TCO) parity with internal combustion engine (ICE) cars much earlier in Europe compared with China and the United States. At such an early stage of market development, Europe cannot afford to be complacent if it wants to seize the opportunity to reduce its dependency on foreign innovation and import of automobile parts, such as batteries.

Europe has the advantage of a strong industrial base on which to build; the region has the second largest vehicle market, the highest absolute automotive R&D spending, and high net exports.¹⁶ However, the continent's historical position as an innovation leader is being challenged in the alternative vehicle transition. Analyses by EY and the Organization for Economic Co-operation and Development (OECD) reveal signs of investment leakage and indicate that the European Union is falling behind Asia,¹⁷ which is ahead of the European Union in terms of innovation as measured by patent applications and R&D spending. China's recent dramatic scale-up of public expenditure on EV R&D places it among key players for the future. To ensure that Europe remains the global

Smart charging and aggregation will be essential for the cost-effective integration of EVs into the electricity distribution networks while maintaining system reliability.

leader, EY recommends a supportive political framework, including long-term targets and targeted policy to drive innovation along the value chains of European businesses. These recommendations concur with those of many other analysts arguing in favour of strong policy signals to drive innovation and deliver societal

benefits.¹⁸

EVs need the smart grid if costs are to be managed ...

Smart charging and aggregation will be essential for the cost-effective integration of EVs into the electricity distribution networks while maintaining system reliability. Compared with the traditional approach of expanding the electric grid simply to service expected growth in load, in coming decades DSOs will increasingly manage power flow in both directions using aggregated energy resources (generation, demand, storage), likely managed by aggregators (see Box 1) and enabled through application of advanced operating technologies and digital ICT.

Without policy forethought, EVs could increase the peak demand of the energy system, leading to a need for additional generation and transmission capacity and resulting in increased power prices for all energy consumers. Smart charging can allow phasing the recharging processes to enable consumption of electricity when variable renewable energy sources (RES) are available, while controlling recharging to ensure net energy demand stays within system capacity limits. This approach makes best use of existing network and energy generation capacity, even at very high EV penetration levels. This strategy is not only cost-effective, but also allows for sound risk management.

The highest risk to the overload of the grid owing to simultaneous charging of EVs will be at the distribution

14 According to Renault, Z.E., quoted in, Pyper, J. (2015, August 18). As European Electric Vehicle Sales Spike, Demand Slows in the US. Greentechmedia.

15 TCO parity between EVs and ICEs is expected to be achieved by 2021 in Europe and 2025 in China, whereas ICE cars remain the cheapest option in the United States owing to lower fuel prices. See UBS. (2016, March). Q series – 9. Global autos: What is the power train of the future?

16 UBS, 2016.

17 EY. (2014, October). Europe's low carbon industries: A health check. See also T&E. (2015, May). 2025 CO₂ Regulation. The next step to tackling transport emissions, p. 4.

18 E4Tech; Lockwood, et al. (2007), and Watkiss, et al. (2004), quoted in Bird, J. (2008). Driving down CO₂ emissions: Using mandatory targets to improve vehicle efficiency. IPPR.

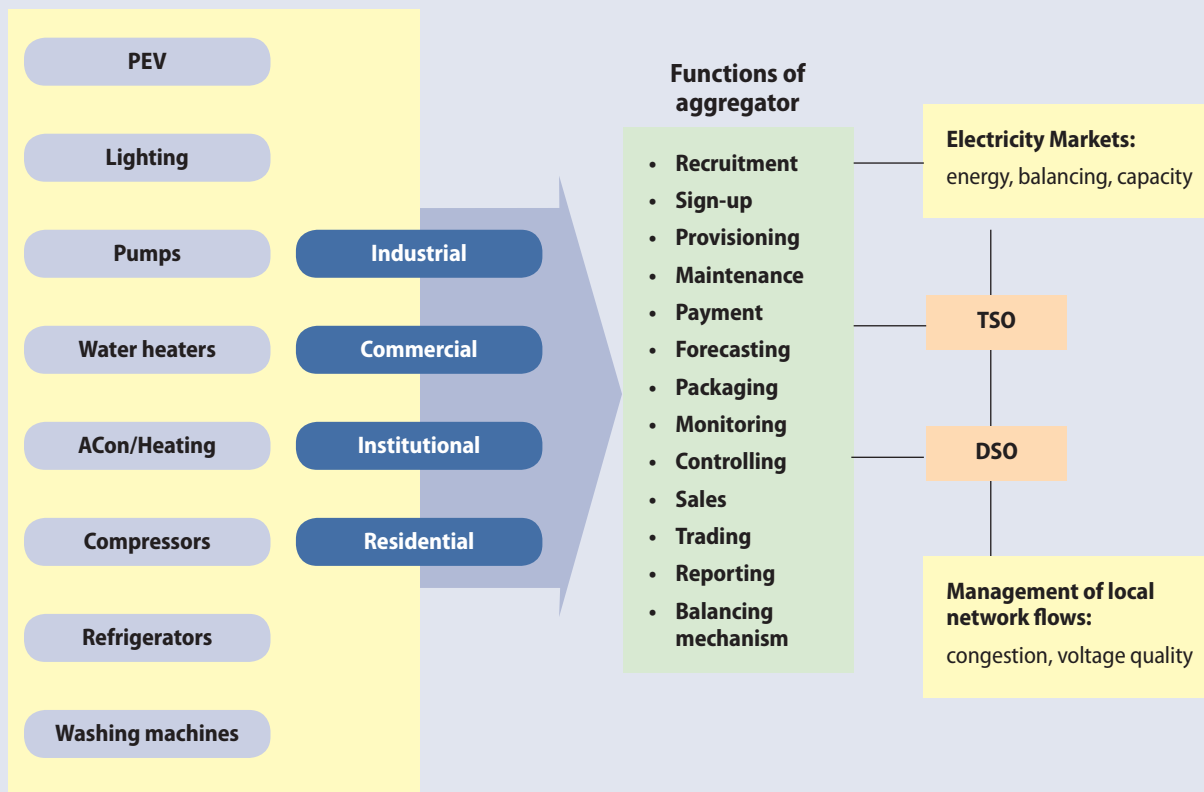
19 Net energy demand is total energy demand minus available variable renewable generation.

Box 1

Aggregators Will Be Critical for Successful Smart Control of Large-Scale EV Charging

If small consumers who are willing and able to manage their load in response to market and grid conditions are to extract value from the wholesale electricity markets, their loads will need to be aggregated or pooled to reduce transaction costs, meet market or programme requirements, and reduce compliance risk. An aggregator combines different energy resources from different sources and providers in order to act as one entity toward the demand response purchasers—power market exchanges, DSOs, transmission system operators, balancing responsible

parties. Aggregators also manage different price signals from different market players and act in the best interest of the customer, maximising the value of the customer's demand response potential. To do this, the aggregator undertakes a number of functions, such as trading, administration, and load control, which removes the hassle factor for consumers (a well-known barrier to demand response). In cases in which the aggregator is not a supplier, the consumer would maintain a contract with the supplier.



level, and particularly on distribution transformers. Local transformers could be overloaded even at times when total system energy demand is off-peak. For example, analysis by Pudjianto et al²⁰ suggests that uncontrolled electrification of heating and transport could increase peak demand on the United Kingdom's distribution networks by up to two to three times, potentially giving rise to a massive need for distribution network reinforcement costing up to £36 billion in the period 2010 to 2050. This risk varies substantially with local network conditions, but can be managed with implementation of well-designed policies.

... and the smart grid needs EVs as the power mix changes

Growth in the share of variable renewable energy generation will increase the need for flexibility in the power system. EVs offer this flexibility, and if owners could tap into its value, it would give them a powerful

20 Pudjianto, D., Djapic, P., Aunedi, M., Gan, C.K., Strbac, G., Huang, S., and Infield, D. (2013). Smart control for minimizing distribution network reinforcement cost due to electrification. *Energy Policy* 52; 76–84.

incentive. This could improve the business case for EV ownership and help accelerate EV rollout, while at the same time supporting the rapid rise of renewables.

EV owners are unlikely to want to provide flexibility unless they believe the material benefits are worth having and that they can be sure their car will be recharged to the level required when needed. EV owners must therefore receive fair compensation for the value of their flexibility when charging their car (and perhaps in time, discharging to the grid as well—see Box 2).

The European Commission and national energy regulators recognise that demand response can provide a very cost-effective form of flexibility, one that could help reduce the costs of integrating variable renewable energy generation into the power system. Market barriers to aggregated energy demand, however, are widespread across the European Union,²¹ and the scale of demand response participation in European power markets is quite inferior compared to what has been achieved in other regions of the world.²² Regulators are therefore exploring and debating how to reveal the value of flexibility in power markets and electricity network regulation, as well as how to improve demand-side participation.²³ The Commission is expected to make legislative proposals in 2016 as part of the market design package, an initiative under the umbrella of the Energy Union strategy.²⁴ It should be possible to implement these reforms before 2020.

One of the things on which most market design experts agree is the importance of ensuring market prices that reflect as closely as possible the full real-time value of energy and balancing services. Prices that reflect temporal scarcity and surplus create the demand for flexibility and therefore reveal its value. Thus, power market prices should encourage EV owners to recharge their batteries when prices are low (generally when renewable generation is plentiful and underlying demand is relatively low) and to stop charging when prices are high (as net energy supply is scarce and total system capacity is reaching its limit).

EV owners should also be fairly compensated for any services they supply to TSOs or DSOs, such as balancing reserves or ancillary services, local congestion relief, and voltage quality. Grid operators can reduce investment

Growth in the share of variable renewable energy generation will increase the need for flexibility in the power system. EVs offer this flexibility, and if owners could tap into its value, it would give them a powerful incentive. This could improve the business case for EV ownership and help accelerate EV rollout, while at the same time supporting the rapid rise of renewables.

costs or delay investment, and indeed minimise the potentially negative impacts of EVs on the grid, by sending price signals to electricity consumers in order to influence how and when they use energy. Grid operators could vary grid tariffs over time and across geography to influence when EV owners charge their vehicles; in its simplest form, tariffs could vary between a low rate at night and a high rate in the day or at times of peak demand. DSOs could also procure demand response in certain congested locations using contracts if it is more cost-effective to do so compared with reinforcing the

network. DSOs' price signals will need to become more sophisticated, however, with growth in EVs and variable renewable energy generation, because net energy demand will become increasingly unpredictable. Prices will need to better reflect the real-time state of the power system to enable cost-efficient system balancing and grid congestion management.

Aggregators, essential to extracting the flexibility value of EV smart charging (see Box 1), will be able to manage different price signals from different market players and thus maximise the value of the customer's demand response potential. The aggregator might convert the value obtained from different sources into simpler fee-for-service arrangements for customers providing flexible EV charging.

Customer engagement in the residential sector is an important goal of the Energy Union vision, but transac-

21 Smart Energy Demand Coalition. (2015). Mapping demand response in Europe today.

22 Hurley, D., Peterson, P., and Whited, M. (2013). Demand Response as a Power System Resource. Montpelier, VT: The Regulatory Assistance Project.

23 For example, see Smart Grid Task Force and EG3 report. (2015). Regulatory Recommendations for the Deployment of Flexibility. . Regulatory recommendations for the deployment of flexibility. See also European Commission (2015). Delivering a new deal for energy consumers. COM(2015) 339; and European Commission. (2015). Launching the public consultation process on a new energy market design. COM(2015)340.

24 See European Commission. (2015). A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy. COM(2015) 80.

Box 2

Electric Vehicles as a Highly Flexible Energy Resource

The way that batteries are recharged can offer significant flexibility to the power system. The recharging of an EV can be controlled such that the level and rate of charge can be adjusted up or down, accelerated or decelerated, interrupted, or restarted on a second-to-second or minute-to-minute basis without significant harm to battery life. Recharging can therefore be flexibly managed around the availability of variable RES; charging can also be controlled to avoid overload of local transformers and to avoid increasing total system peak demand.

Unidirectional charging, when power flows from the grid to the vehicle, is also known as grid-to-vehicle (G2V) charging. Unidirectional EV charging can offer grid services right away, even without smart interval meters in households. The necessary ICT will be installed in the car and activated via the Internet, and even if vehicle-to-grid (V2G) discharge is not viable yet.

V2G, or bidirectional, charging involves two-way power flow in which vehicles are able to discharge electricity to the grid. In theory, EVs operating in a V2G framework could provide storage and support for renewable resources, as well as contingency reserves and ancillary services to distribution systems. Current research findings conclude that bidirectional charging is not yet commercially feasible, largely

because of charging losses and degradation of the battery. An additional cost is the inverters needed to enable transfer of electricity from vehicle to grid. Yet technologic advances and higher market value for the grid services that could be offered by V2G might change the economics in the future.

Compared with fast, high-capacity charging (i.e., International Electrotechnical Commission [IEC] Modes 3 and 4), low-capacity charging (i.e., IEC Modes 1 and 2) does not require expensive charging equipment. It presents a much lower risk for stress to the distribution system along with greater opportunity to provide grid services to the system operator. Although there are times when a fast charge is needed to continue a journey, most EV users require a known amount of charge during the day or overnight in order to conduct their journeys when they need to, with some battery capacity always in reserve. That said, they are likely to be indifferent as to how the charging is managed so long as the vehicle is ready to go when required. The average car is only driven two hours a day, meaning an EV would be available most of the time for recharging.

In summary, controlled unidirectional low-capacity charging can successfully deliver the vast majority of benefits and can be promoted immediately for the benefit of system operators, vehicle owners, and all electricity users generally.*

* G4V WP7. (2011). *System analysis and definition of the roadmap*. Available at: <http://www.g4v.eu/>

tion costs can be high relative to the value of flexibility available. Hence, demand-response aggregators in Europe are currently only active in the industrial and commercial sectors. The value proposition for demand response in the residential sector, however, will become much more interesting with uptake of larger discrete loads in the home, such as EVs or heat pumps. EV rollout could therefore potentially kick-start demand response in the residential sector. Other smart household appliances (small loads) could be clustered to the EV load as part of an attractive business proposition. It is easy to envision that early “active” electricity consumers will be EV owners signing up for demand response contracts at the time they purchase or lease their vehicle. Aggregators might establish partnerships with auto manufacturers and battery manufacturers to market “e-mobility bundles” to consumers.

Charging points are just the “tip of the iceberg”

For electrification of transport, the availability of public charging points and the readiness of the electricity networks presents a significant challenge. There is a chicken and egg situation to be resolved in rolling out EVs and recharging infrastructure, including the need to “smart” the grid. Consumers may not have access to a charging point for their car, or may be uncertain about the availability of recharging services when travelling long distances, while recharging station providers are uncertain as to how quickly the numbers of EVs will grow and the usage rates of charging stations.

Currently, private sector ownership of EV recharging infrastructure is the dominant model in Europe. Where

the market is not ready or is unable to deliver, public sector investment can play an important facilitative role to kick-start the market, as is happening in Italy, Ireland, and Spain. Thus, in Europe, DSOs are largely not responsible for investing in EV charging points, but they are expected to accommodate them. Depending on how DSOs are regulated, they can influence the cost allocation for connecting charging points to the network (e.g., locational connection charges) to ensure that fast charging stations are not built within already congested local networks. Fast charging stations should also receive price signals from the wholesale power market that reflect the state of the energy system. Thus, the cost of the services should be highly variable, and sometimes very expensive. When there is demand, however, the private sector will naturally respond and build such charging stations. A higher priority for public policy should be the rollout of normal speed (yet smart) public charging infrastructure for EV owners who cannot charge on their own property (e.g., residential on-street charging).

If charging station development is the tip of the iceberg, then the full iceberg is the capability of the power system to integrate EVs at least cost while maximising the benefits, particularly with respect to cost-effective integration of variable RES. This will be enabled through a whole suite of regulatory reforms relating to a number of areas, including power markets, retail electricity markets, infrastructure regulation, decarbonisation, data protection, cybersecurity, digitalisation, the Internet of Things, and telecommunications. Effective policy coordination will be key to cost-effective EV integration. The potential of policy synergies can be tapped for the benefit of EU competitiveness and improved quality of life for EU citizens.

Many electricity distribution networks are not ready for large numbers of EVs

Europe's electricity distribution networks are to a large extent "dumb," aging, and of widely variable quality and resilience. Typically, distribution networks in northern

and western regions of Europe are more robust than those in the southern and eastern regions.²⁵ If the rollout of EVs is rapid or even exponential and network planning and investment is inadequate, there is a high chance that some networks won't be able to cope.

Massive investment in the distribution system is required to replace aging infrastructure, integrate distributed energy resources, and smarten the grid while maintaining acceptable power quality and reliability. It is estimated that European electricity networks will require €600 billion in investment by 2020, two-thirds of that in distribution grids. By 2035, the distribution share of the overall transmission and distribution network investment is estimated to grow to almost 75 percent, and to 80 percent by 2050.²⁶ At present, however, many Member States are not investing in their grids at the level and rate needed.²⁷ There has been an overemphasis in recent years on short-term cost minimisation, which in some countries has had a detrimental impact on investment, credit quality, and DSO performance.²⁸

In developing their business plans for the grid, DSOs need to make a large number of assumptions about location and growth in variable renewable energy generation and energy demand, the extent to which demand can be managed, and the sequencing of investment in grid reinforcement according to identified needs and priorities. Greater certainty about these assumptions in the long term, including the rate of EV rollout, can help reduce margins or allowances for error and so minimise the risk for underutilised or stranded assets. Missed opportunities for cost-effective investment or avoidance of underinvestment are also important where an asset is being replaced or upgraded and where the marginal cost of incremental added capacity would be small, but going back later to upgrade again could be very expensive. Long-term foresight is particularly important for infrastructure investment planning as distribution network assets have long lifetimes of up to 45 years²⁹ and planning scenarios look decades ahead.³⁰

25 CEER. (2015, February 12). CEER benchmarking report 5.2 on the continuity of electricity supply data update. Ref: C14-EQS-62-03.

26 European Commission 2011, IEA World Energy Outlook 2012, and European Energy Roadmap 2050, as quoted in Eurelectric's report, Electricity distribution investments: what regulatory framework do we need. May 2014.

27 Ibid.

28 Ibid.

29 The UK regulator Ofgem recently reviewed the economic asset life for depreciation of distribution assets and decided on 45 years. See <http://www.ofgem.gov.uk/Networks/Policy/Documents1/assetlivedecision.pdf>

30 See Gunther, E.W. (2016, February 25). Distribution system planning for pervasive DER, IEEE Smart Grid webinar.

In addition, the clearer the need for the investments and their necessary timing, the more likely it will be that governments and authorities approve the large financial commitments necessary to modernise the grid and the more likely that private investors will be willing to invest.

The regulatory models traditionally used for calculating DSOs' revenues tend to favour capital investment (capex), with a rate of return applied to the regulated asset base. Application of smart grid technologies, however, can deliver significant savings, delaying or removing the need to reinforce networks and therefore avoiding or reducing capex. Smart grid development and operation is also likely to require higher operating expenditure (opex) than in the past. The capex bias needs to be reduced or removed—by, for example, applying cost efficiency factors to total revenues (totex) and linking revenues to performance in achieving goals³¹ as opposed to investment in assets—if DSOs are to be incentivised to develop and manage a smart grid that optimises capex and opex. At the same time, revenue setting will need to take into account that grid modernisation will require some upfront capex, such as ICT-related hardware. This regulatory change may take many years to deliver the desired outcomes, but the clearer the pathway and thus the clearer the need, the greater the motivation to adapt and implement needed regulatory changes.

The DSO price control time frame—typically three to five years—may or may not coincide with the timeframe for the setting of LDV CO₂ standards. Some regulators will likely follow the United Kingdom's lead by increasing the duration of price control periods to

facilitate innovation and assist longer-term planning and delivery.³² Long-term strategy and assumptions, however, should inform short- and medium-term investment decisions. Today, for example, DSOs setting out investment plans can only guess what might happen to LDV CO₂ standards and associated EV rollout beyond 2021. It is also extremely difficult for Member States to develop long-term policy frameworks for the deployment of alternative fuels infrastructure, particularly estimation of alternatively fuelled vehicles in 2025 and 2030, as well as estimates of the demand for new charging points as required by Directive 2014/94/EU.

The rollout of EVs will not be linear ... in fact, there's a good chance it will be exponential

The pace of EV rollout will not be linear and orderly. Some experts expect growth to be exponential as tipping points could be reached. Electric industry views collected by a recent Eurelectric³³ survey were split 6:4:1 that EV market growth would be respectively S-curve, exponential, or linear. Several factors could influence the comparative economics of EVs versus ICEs or other powertrains, and changes could be rapid. Such factors could include fluctuations in wholesale oil prices, steep cost reductions in batteries,³⁴ cheaper power prices and payments for demand response; a switch in relative depreciation rates of ICEs and EVs,³⁵ or changes to EU fuel taxes. For example, UBS analysts³⁶ conclude that EVs are likely to achieve cost of ownership (TCO) parity with ICE cars in just five years in Europe, largely because

31 Lazar, J. (2014, May). Performance-based regulation for EU distribution system operators. Montpelier, VT; The Regulatory Assistance Project.

32 Ofgem has increased the price control period for DSOs from five to eight years. Ofgem. (2013). Strategy decision for the RIIO-ED1 electricity distribution price control.

33 Respondents from 11 countries participated, including distribution system operators, retailers, and industry associations. See Eurelectric. (2015, March). Steering the change, driving the charge, p. 46.

34 In a recent Bloomberg webinar, November 18, 2015, "Major trends in electrified transport," it was reported that the cost of batteries dramatically reduced over 2014 and 2015 to around \$350/kwh. These cost reductions exceed or look set to exceed many projections according to Clean Technica; for example, in 2013 the IEA predicted \$300/kwh for 2020.

35 The "Major trends in electrified transport" webinar also reported that electric cars are depreciating considerably more rapidly relative to ICEs. This has a significant impact on sales of new electric cars, as many new car owners will want to be able to sell their car later on. At some point, this phenomenon could be reversed, with ICEs depreciating more rapidly than low-carbon vehicles, should it become clear that high carbon vehicles will be hard to sell in the future given policy commitments and new car sales trends. Scrappage policies might then become an attractive policy instrument for local authorities wanting to accelerate the phase-out of ICEs.

36 UBS. (2016, March 9). Global autos: What is the power train of the future? Q series.

of expected steep cost reductions in batteries. Another factor affecting the rate of rollout is that ownership of new technologies can geographically cluster, as people are considerably influenced by neighbours and peers.³⁷

Having a greater degree of knowledge about the likely minimum proportion of low-carbon vehicles in new car sales will give cities and local politicians more confidence to set local environmental quality targets and introduce complementary policies to facilitate and accelerate ULEV uptake or ICE phase-out. Local policy will be an important factor that DSOs will need to take into account and is an important reason the rate of EV rollout will vary across Europe. Such variation, however, may not be desirable from the point of view of the automobile industry in consideration of their global competitiveness. EU policies are therefore very important in ensuring a relatively coordinated pace of change across Europe, minimising Member States' ability to put off the needed policy implementation while also supporting low-income Member States as necessary.

To accelerate the decarbonisation of LDVs, the European Union will need to design policies to provide as much foresight as possible for all affected market actors—particularly DSOs that need long lead times for planning infrastructure development—to minimise the risk for unacceptable consequences that could result from rapid or disruptive change. The speeding up of the pace of change has implications not just for investment but also for management of the capacity and capability of a DSO's workforce. Therefore, any policy measure that can reduce uncertainty and therefore assist investment planning will be welcome from a DSO's point of view.

The power system “iceberg” is only at the start of its transformation

Member States will need to reform the way they regulate DSOs to ensure they are incentivised to make the best use of existing assets, to innovate, and to make optimal and cost-efficient investment choices aligned with achievement of policy goals. The link between revenues and volume of energy sales needs to be truly broken, as energy efficiency and self-generation/consumption reduces energy sales. DSOs must be incentivised to invest the appropriate mix of capital and operating expenditure to encourage development of smart grid infrastructure and the application of smart grid technologies to achieve regulated goals. The UK regulator Ofgem has attempted to address these challenges by adopting an output/performance-based approach to regulating DSO revenues,

which involves linking a substantial proportion of those revenues to achievement of defined outcomes or performance indicators.

The EU Energy Union market design legislative proposals, due in 2016, could drive the needed reforms forward in a timely and coordinated manner across the European Union. Key performance indicators or targets could be defined to inform about progress in, for example, modernising European distribution networks and effectively integrating distributed energy resources. Such indicators can be used as revenue drivers for DSOs and can also enable comparison and benchmarking of Member States.

The capability, capacity, and financial resources of national energy regulators varies significantly across Europe.³⁸ Member States whose regulators are less capable and have fewer resources than others may be challenged to deliver timely reforms. Out of necessity, resource-constrained regulators will tend to opt for simpler models of DSO regulation,³⁹ which could increase the risk for not achieving desired outcomes as effectively as would otherwise be the case. Such countries, however, might also follow the lead of more experienced and better resourced regulators. To increase the possibility of that, E.U.-level regulatory principles and facilitated exchange of best practice and learning could therefore be particularly helpful.

For the DSO, effective regulation will lead to cultural change, a typically challenging and slow process that could be accelerated with greater certainty about goals to be delivered in the short, medium, and long term. The regulated power network business has not experienced much change in many decades. The process of liberalisation and unbundling of generation and supply from the networks, initiated in the 1990s and implemented through a series of legislative packages, has been a major change for the industry. Yet it has not fundamentally affected how these companies invest in and operate their networks. Perhaps

37 Kahn, M.E., & Vaughn, R.K. (2009). Green market geography: the spatial clustering of hybrid vehicles and LEED registered buildings. *B.E. J Econ Anal Pol*, 9, 2, Article 2.

38 PWC, FSR/EUI. (2014, September 16). An EU-wide survey of energy regulators' performance.

39 EUI. (2012, June). Working Paper RSCAS 2012/31: Implementing incentive regulation and regulatory alignment with resource bounded regulators.

the most radical change to network operation came about a century ago, starting in the United States when Samuel Insull of Commonwealth Edison transformed the electricity sector from one that was based on distributed, small generators, which were not connected together through networks, to a centralised model based on large generators connected through electricity networks to demand spread across many users. Between 1907 and 1930, the utilities' share of total U.S. electricity production, relative to privately owned generators, jumped from 40 percent to 80 percent.⁴⁰ Since this change, the traditional approach for network companies has been to “fit and forget,” building out the grid to connect and provide the one-way flow of electricity from large centralised generation to customers.

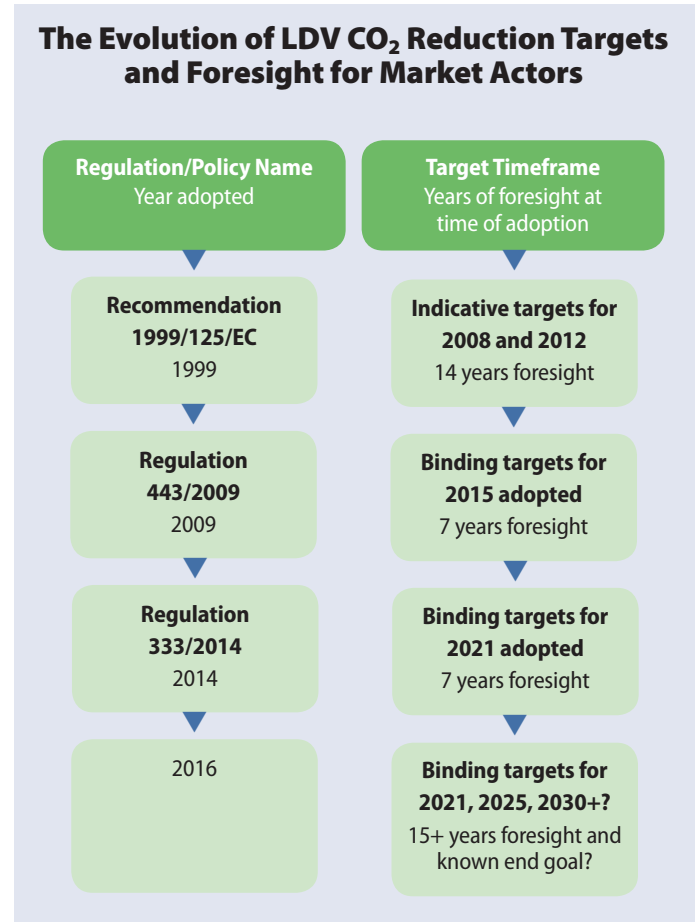
As DSOs become required to actively develop and manage smart grids, cost-efficiently integrating distributed energy resources and managing load to reflect varying wholesale market conditions, DSOs will experience fundamental changes to their existing business model. These companies need strong leadership and considerable time to put in place the sweeping changes that will be necessary to longstanding practices, work flows, and organisational structures. They will need to effectively deal with not only the legacy physical systems, but also the legacy human habits and attitudes that can impede progress. Although some DSOs are taking initiative to innovate and transform their business operations, the majority will depend on regulatory reforms that will realign their business model with achieving public policy objectives.

Auto manufacturers need greater certainty and foresight, too

Until now, the timeframe for LDV CO₂ standards has largely been determined by the time needed for car manufacturers and their supply chains to design, produce, and sell a new car model—around seven years.⁴¹ In addition, the level of ambition has traditionally been based on best available techniques relating to ICE technology, although more recently the design has evolved to kickstart sales of ULEVs by incorporating mechanisms such as

Auto manufacturers have always called for longer timeframes; they need them more than ever now with the switch from ICEs to alternative power trains underway.

Figure 1



supercredits⁴² (Figure 1).

With the switch from ICEs to ULEVs, auto manufacturers will need to do considerable planning.⁴³ They will need to innovate to further develop and refine new technologies, construct new facilities, reorganise production processes and supply chains, and develop strategic partnerships with non-traditional market actors. They will also need to ensure their workforce is retrained

40 DuBoff. (1979). p. 40; quoted in Carr, N. (undated). The end of corporate computing. Blog post.

41 Car manufacturers state that the lead time can be up to 12 years, but some 7 years of this is the production phase during which no major changes are made to the model available for sale. To get a new design on the road can take around 5 years. See <http://www.internationaltransportforum.org/Topics/pdf/ACEA.pdf>

42 Regulation 443/2009 allows sales of ultralow carbon vehicles to count 3.5 times toward the manufacturers' fleet average emissions through a supercredit mechanism.

43 See European Climate Foundation. (2013, June). Fuelling Europe's future: How auto innovation leads to EU jobs.

and recruit expertise as necessary. In coming years, manufacturers also need to make choices with respect to the share of investment in incremental improvement to ICEs versus the share of investment in alternative ULEVs. The timeframe of binding commitments would strongly influence the latter.

Longer-term binding CO₂ reduction targets could give auto manufacturers greater certainty and predictability, crucial for long-term planning and helpful in reducing investment risk. At the same time, near-term targets are still needed to capture the benefits of innovation and to ensure that progress toward achievement of long-term targets stays on track.

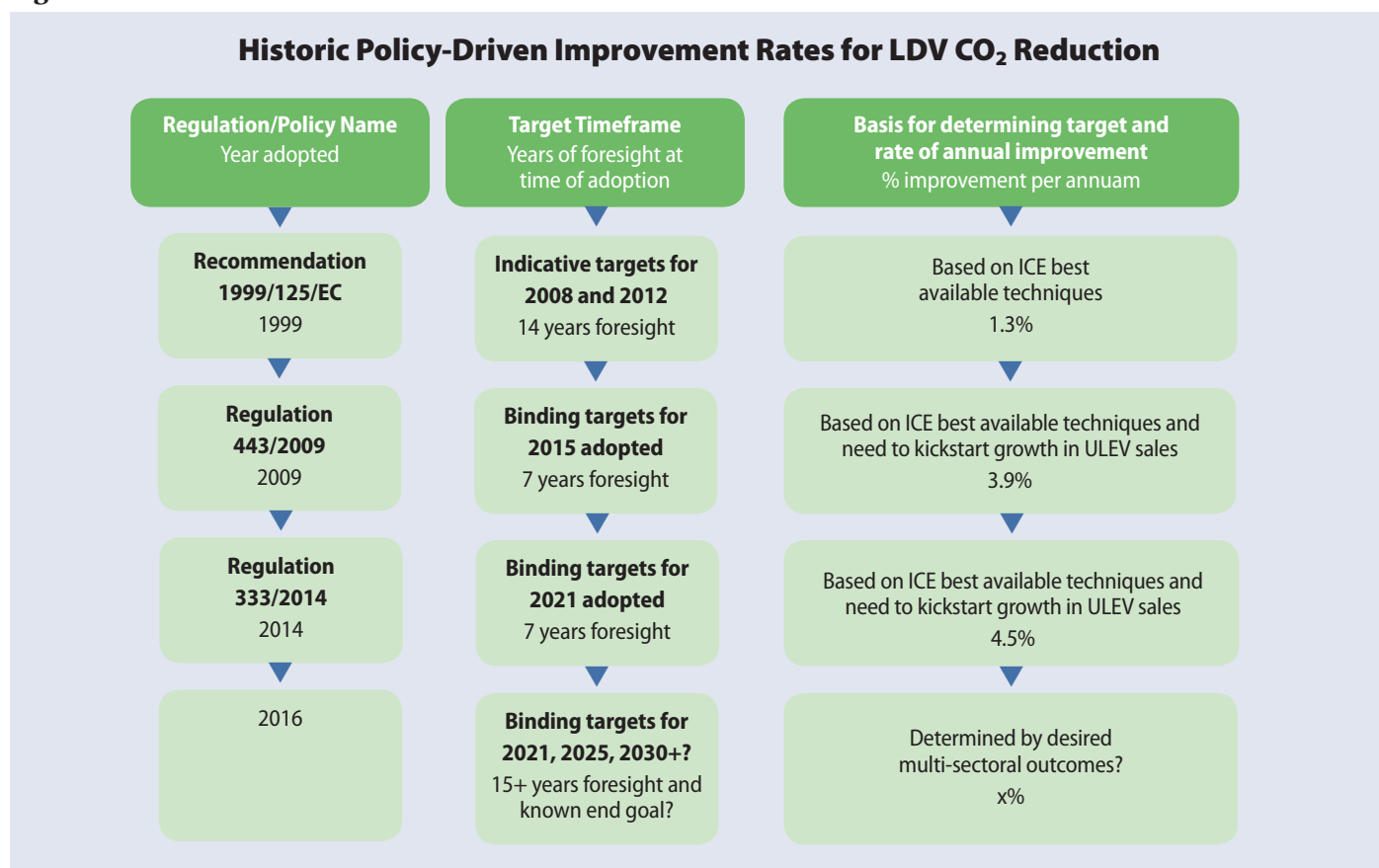
Policy recommendations

Experience shows that binding standards for CO₂ from LDVs accelerate improvement relative to a voluntary approach—for example, mandatory performance

standards introduced in 2009⁴⁴ accelerated annual improvement in LDV fuel efficiency from one percent to four percent.⁴⁵ With a number of EV models now available in car showrooms, targets no longer need to be set based on possible incremental improvement that can be achieved through the best available techniques applicable to the dominant technology. It is now possible to focus on outcomes and coordinate the timeframes of multiple strategies that combine to deliver these outcomes (Figure 2).

Setting a trajectory of binding CO₂ reduction targets, as illustrated in Figure 3, would both drive innovation in the near term and give clarity on the pace of change to long-term goals, which is important for planning in the automobile sector, as well as the power sector and other affected sectors. If able to take a longer-term perspective, car manufacturers would be better able to reveal more information about their strategies and infrastructure needs in that timeframe.

Figure 2

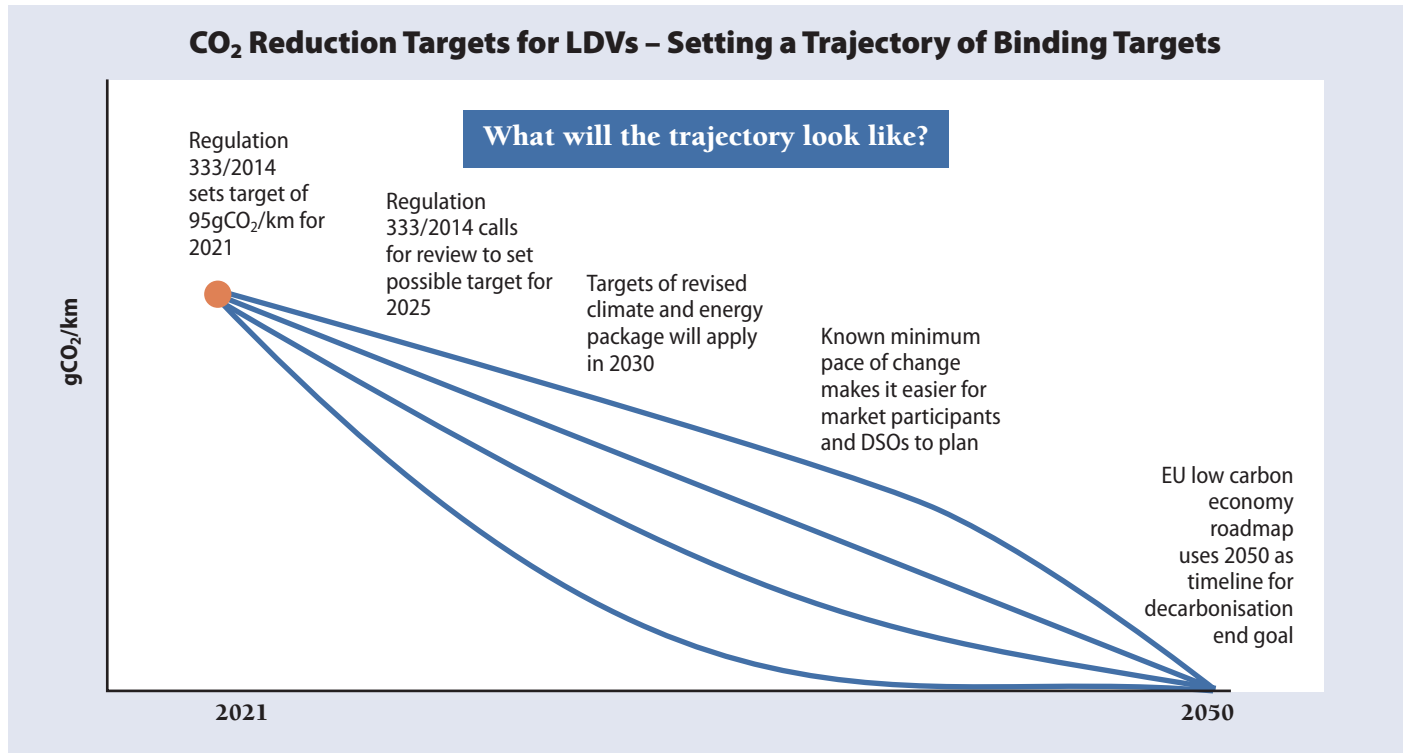


44 Regulation (EU) No 333/2014 of the European Parliament and of the Council of 11 March 2014 amending Regulation (EC) No 443/2009 to define the modalities for reaching the 2020 target to reduce CO₂ emissions from new passenger cars. See [http://eur-lex.europa.eu/legal-](http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R0333&from=EN)

content/EN/TXT/PDF/?uri=CELEX:32014R0333&from=EN

45 ICCT. (2014, January). EU CO₂ emission standards for cars and light commercial vehicles.

Figure 3



There could be various options to consider with respect to how far apart these targets would be, the curvature of the trajectory, and how many of these targets would be binding or nonbinding. Such decisions would need to be underpinned by an analysis of costs and benefits, with the objective of optimising these over the duration of the transition. It would be important to incorporate co-benefits in addition to the benefits resulting directly from CO₂ reduction, such as E.U.-wide macroeconomic benefits and improvements in competitiveness and air quality.

Growth in the market share of EVs could be accelerated by specifying a target number for EV sales or a quota. However, regulatory experience cautions against picking technology winners. Indeed, alternative ULEV technologies, such as hydrogen-powered fuel cells, are already available. CO₂ reduction targets for LDVs, however, could be combined with a tradable ULEV sales quota for car makers, as the definition of ULEVs could encompass a variety of very low-emission technologies. This would help drive change beyond incremental improvement to the level that is needed, and if the quotas were made tradable, they could provide car manufacturers with flexibility for over- and underachievement.

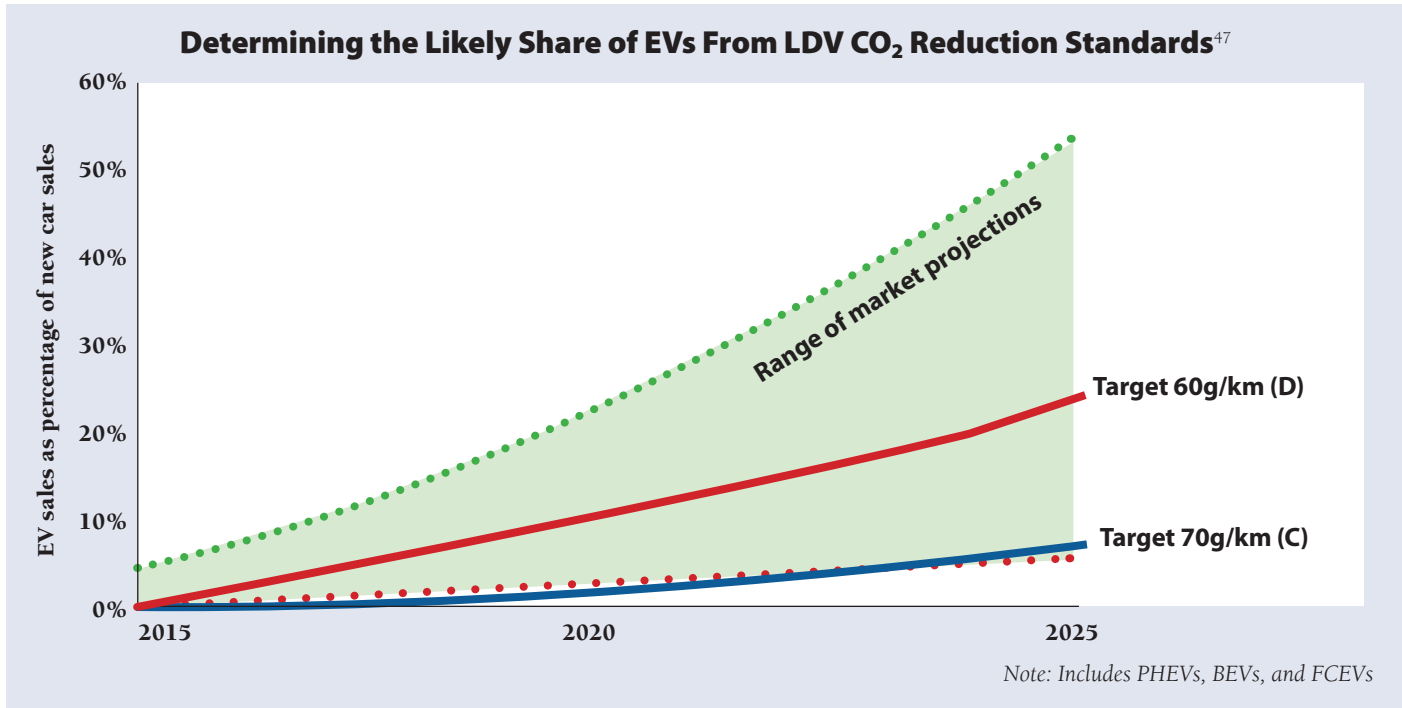
Today, the share of EVs on the road is already significant and much greater relative to the more

expensive hydrogen fuel cell alternative, with costs rapidly falling. Current market data suggest that the EV share will grow significantly at least in the near- to medium-term future. The final share of EVs in Europe's LDV fleet is of course uncertain, as much can change with innovation and consumer preferences, among other factors.⁴⁶ Nevertheless, it is clear that system operators will need to prepare for EV and RES integration. With low EV penetration, system operators would need to plan for use of alternative and potentially more expensive options to integrate RES.

Analysts will be able to use market data and car manufacturer forecasts to estimate the extent to which a CO₂ reduction target is likely to affect the share of EVs in new car sales (Figure 4). This will be critical information for all market actors involved in the electrification of transport. Such analysis will be more accurate with

⁴⁶ A recent report by UBS, however, puts battery electric vehicles in "pole position" for the powertrain of the future, ahead of fuel cell vehicles, because they provide a better low-carbon ecosystem fit owing to their energy storage capability and because infrastructure costs to accommodate fuel cell vehicles are expected to be four to five times greater compared with EVs in a zero-carbon world. See UBS. (2016, March 9). Q series. Global autos: What is the power train of the future?

Figure 4



quotas.

Experience to date informs us that binding LDV CO₂ reduction targets effectively drives innovation, but the extent of that depends on regulation design. As illustrated by this paper for the case of EVs, the design of regulation must be evolved to cater for new market actors and other sectors that are involved in delivering decarbonisation of the transport sector. With this in mind, the following principles and considerations should guide the design of LDV CO₂ reduction targets:

- Although LDV CO₂ reduction targets must be part of a holistic and integrated transport strategy, the targets must be applied to those who can deliver—that is, auto manufacturers. Such targets need to be part of an e-mobility strategy and should be complemented with an industrial strategy, stimulus packages, and technologic integration policies.
- Coordinated targets are critical to align market actors in different sectors toward achieving common goals, as well as to ensure that those actors achieve multiple policy objectives cost effectively. The

design of the LDV CO₂ reduction trajectory should be aligned with commitments set out in key EU policies and strategies that are relevant, including but not limited to: the Transport White Paper,⁴⁸ the Energy Union strategy, the EU 2050 Low Carbon Economy Roadmap,⁴⁹ the E.U.'s Thematic Strategy on Air Pollution, and the European Commission's 2030 Energy & Climate strategy.

- Roadmaps are essential to defining a vision and possible pathways to delivering that vision, but binding targets are the proven way to give investors the confidence they need. A defined binding long-term end goal can influence decisions and investments that are made in the medium term and perhaps even the short term, as market actors will be highly motivated to maximise the benefits of investment and minimise the risk for underutilisation or stranding of assets. This is particularly important for vehicle manufacturers and DSOs.
- The timeframes for any binding targets must

⁴⁷ Ricardo, A.E.A. (2012, 10 December). Exploring possible car and van CO₂ emission targets for 2025 in Europe, p. 4.

⁴⁸ European Commission. (2011). Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. White paper. COM(2011) 144 final, which requires 60-percent CO₂

reduction for transport by 2050 relative to 1990.

⁴⁹ European Commission (2011). A Roadmap for moving to a competitive low carbon economy in 2050. COM(2011) 112 which sets out CO₂ reduction targets for different sectors to 2050.

give policymakers and all affected market actors, including those providing fuel infrastructure (e.g., electricity distribution system operators), as much foresight as possible with respect to the minimum pace of change needed. At the same time, targets should not be too far apart. Thus, it is necessary to have a set of binding targets or mileposts stretched out in time, coordinated with the ambition and timing of targets applied in other policy areas or sectors of relevance.

- Binding near-term targets (e.g., 2025, 2030) are needed to ensure capture of the benefits of innovation and to ensure that decarbonisation of the LDV fleet stays on track to meet longer-term goals. If rapid growth in the share of EVs is foreseen and planned for, motivations to properly implement the power market reforms enabling demand response will be strengthened. This policy synergy is an opportunity to unleash the benefits of the smart grid and single energy and digital markets.
- Setting a target for 2030 provides an important opportunity to coordinate EU energy, climate, and transport policies and achievement of the Energy Union goals. By 2030, the power sector should be well on its way to full decarbonisation with a much greater share of variable RES in the power mix. By this time it should be expected that market design reforms are implemented such that flexibility is fairly compensated, aggregated energy demand and storage fully participate in power markets, power networks are well on the road to being modernised and actively managed, and consumers have access to a wide range of attractive energy product and service offerings.
- Mid-term targets (e.g., 2035, 2040, 2045) could be used to indicate the minimum pace of change, with these targets becoming automatically binding once a certain point in time is reached, providing sufficient foresight for policymakers and affected market actors (e.g., 15 years in advance). As the objective is to provide regulatory certainty, revision of these targets should be possible only under well-defined and restricted conditions.
- Ideally mechanisms should be technology-neutral to avoid picking technology winners. CO₂ reduction targets for LDVs, however, could be combined with a tradable ULEV sales quota for car makers, and the definition of ULEVs could encompass a variety of very low-emission technologies, including EVs. This would help accelerate change to the pace needed, and car manufacturers could benefit from the flexibility of a tradeable quota.
- As LDV CO₂ reduction targets apply to tailpipe emissions, such targets may need to be applied to the whole lifecycle of the vehicle, including its fuel. If power sector decarbonisation goals are coordinated with transport decarbonisation goals, policymakers can be confident that electrification of transport will result in decarbonisation of transport.⁵⁰

50 For simulations on EU power sector decarbonisation and impact on EV CO₂, see Eurelectric (2015, March). Smart Charging: Steering the charge, driving the change, p. 50.

Related RAP Publications

The Market Design Initiative: Enabling Demand Side Markets

Demand Response as a Power System Resource

<http://www.raponline.org/document/download/id/6597>

Demand response refers to the intentional modification of electricity usage by end-use customers during system imbalances or in response to market prices. While initially developed to help support electric system reliability during peak load hours, demand response resources currently provide an array of additional services that help support electric system reliability in many regions of the United States. These same resources also promote overall economic efficiency, particularly in regions that have wholesale electricity markets. Recent technical innovations have made it possible to expand the services offered by demand response and offer the potential for further improvements in the efficient, reliable delivery of electricity to end-use customers. This report reviews the performance of demand response resources in the United States, the program and market designs that support these resources, and the challenges that must be addressed in order to improve the ability of demand response to supply valuable grid services in the future.

EU Power Sector Market Rules and Policies to Accelerate Electric Vehicle Take-up While Ensuring Power System Reliability

<http://www.raponline.org/document/download/id/7441>

How and when plug-in electric vehicles (EVs) are recharged can dramatically affect the electric grid. As a result, regulation of the power sector could have a significant influence on the rate of EV rollout. This paper explores how regulation can be developed to minimise negative grid impacts, maximise grid benefits, and shrink the total ownership gap between EVs and internal combustion engine vehicles. The author discusses EU

power sector policies and market rules that can facilitate or promote EV rollout with a focus on the role and design of time-varying electricity pricing, adaptation of EU electricity market rules to enable demand response and properly value flexibility, and the character of regulation that will likely be needed to encourage distribution system operators (DSOs) to be effective contributing partners in advancing progress with the roll-out of EVs.

Power Market Operations and System Reliability in the Transition to a Low-Carbon Power System

<http://www.raponline.org/document/download/id/7600>

As the power sector moves quickly toward decarbonization, authoritative research is demonstrating that a reliable transition that achieves economic, security, and climate goals is not only possible, but can be done at no more than – and possibly less than – the cost of “business as usual.” To achieve this, however, the discussion about market design needs to shift from traditional notions to a focus on what kind of investment will most efficiently complement production from a growing share of variable resources. This paper, which follows from an earlier collaboration between RAP and Agora Energiewende for the European Pentilateral Energy Forum, is the latest in a series of RAP papers on how market design can efficiently facilitate the transition to a clean power sector. It points out that the debate over energy-only versus energy-plus-capacity markets, while important, misses the point to some extent. What is needed is a more comprehensive discourse about how to optimize the mix of market instruments, governance, and regulation to best capture the need for an increasingly flexible system – ensuring that low-carbon reliability solutions can be implemented at reasonable cost.

Smart Rate Design for a Smart Future

<http://www.raponline.org/document/download/id/7680>

The electric utility industry is facing a number of radical changes, including customer-sited generation and advanced metering infrastructure, which will both demand and allow a more sophisticated method of designing the rates charged to customers. In this environment, traditional rate design may not serve consumers or society best. A more progressive approach can help jurisdictions meet environmental goals and minimize adverse social impacts, while allowing utilities to recover their authorized revenue requirements. In this paper, RAP reviews the technological developments that enable changes in how electricity is delivered and used, and sets out principles for modern rate design in this environment. Best practices based on these principles include time-of-use rates, critical peak pricing, and the value of solar tariff.

Performance-Based Regulation for EU Distribution System Operators

<http://www.raponline.org/document/download/id/7332>

This paper encapsulates work derived from workshops in Europe in 2012 on setting future tariffs for distribution system operators (DSOs), particularly when it comes to incentivizing smart grid, distributed generation, and demand response. It also serves as a foundation document for future action to implement regulatory reforms that may follow from those workshops.

The report begins with an overview of performance-based regulation (PBR), including historical experience. It then addresses the type of mechanisms that may be appropriate for consideration in Europe. It concludes with caution about how electricity distributors may take advantage of any system that is promulgated, and suggests checks and balances as a mechanism is rolled out to ensure that societal goals are met and gaming of the mechanism is minimized.



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