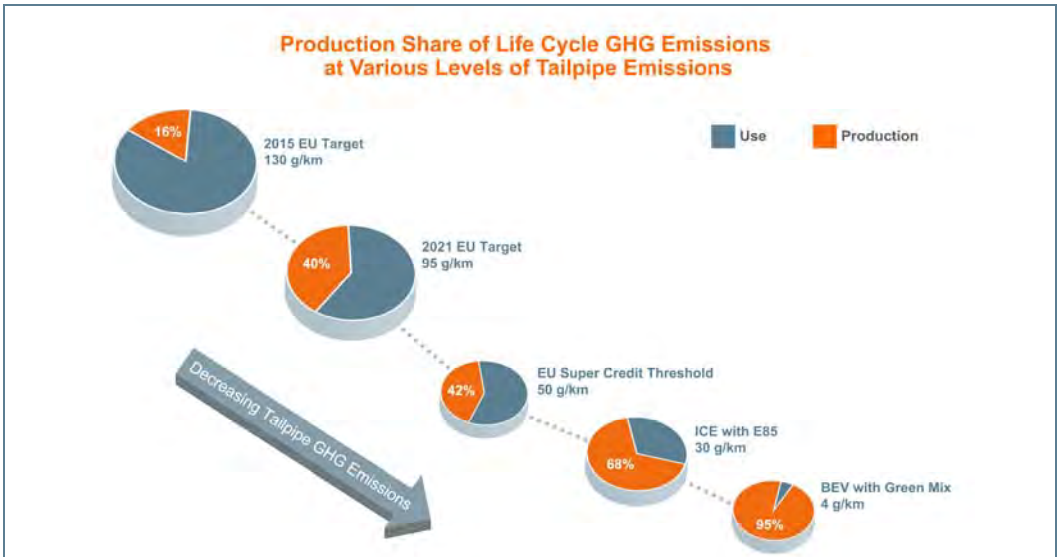
Taking a *Life Cycle* Approach to Automotive Environmental Policy

SUMMARY

Policies with the goal of reducing climate change impacts from cars focus on reducing tailpipe emissions. While automakers can respond by improving fuel economy with lightweight materials, this can lead to an increase in carbon emissions over the life of a vehicle. Taking a *life cycle* approach to automotive environmental policy—from production to disposal—helps avoid such unintended consequences.

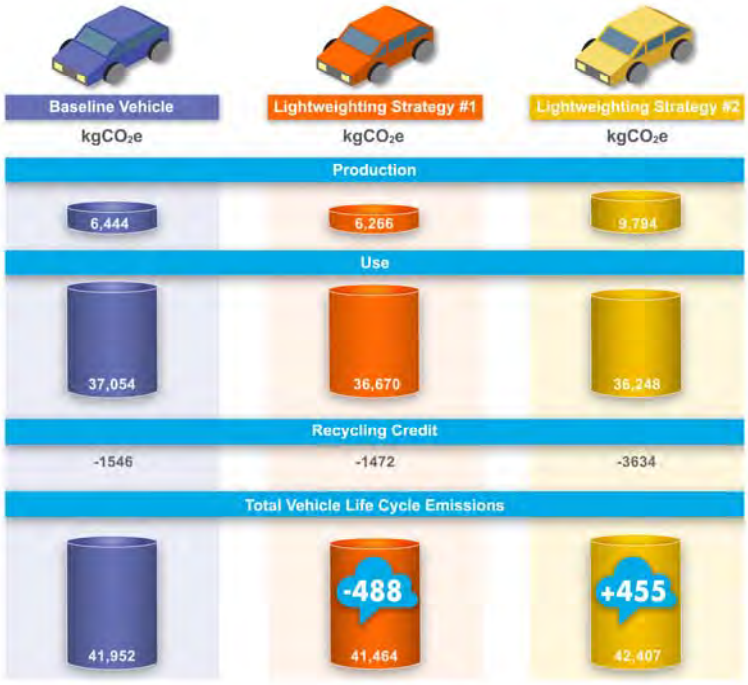
Tailpipe Mitigation is Not Enough

Most climate impacts from internal combustion vehicles come from tailpipe carbon dioxide (CO_2) emissions. The other life cycle stages, which include vehicle production, fuel production, and vehicle disposal, have much lower greenhouse gas (GHG) emissions. Understandably, therefore legislators focus on curbing tailpipe CO_2 emissions and increasing fuel economy. However, automotive climate policy with an exclusive focus on tailpipe emissions opens the door to unintended consequences. This is equally true for vehicles that use biofuels, electric power trains, or light-weight materials to increase fuel economy.



As use phase emissions are minimized, Production phase share of emissions in the total life cycle increases significantly.

Critics of biofuels contend that they can cause, directly or indirectly, more GHG emissions than they avoid. Sceptics of electromobility argue that the GHG emissions of producing electric vehicles—and the electricity to drive them—can outweigh their lack of tailpipe emissions. The production of light-weight materials is typically GHG-intensive, so their widespread use would significantly increase the climate change impact of vehicle production. Good environmental policy aimed at reducing climate impact from vehicles therefore needs to consider these “upstream emissions,” which could severely compromise or even negate their climate change mitigation goals.



Without LCA, some lightweighting strategies can lead to a net increase in total life cycle emissions—an unintended consequence.

The Unintended Consequences of Vehicle Lightweighting

Vehicle lightweighting, in particular, poses a threat to effective automotive climate policy. Light-weighting can increase total climate impact and defeat the purpose of the policy since the increase in emissions from vehicle production can be larger than the emissions saved due to improved fuel economy. The trend of increasing drive-train efficiency and decreasing carbon-intensity of fuels and electricity will further reduce any benefits gained from decreasing the weight of the vehicle. The importance of addressing the unintended consequences of tailpipe-only regulation therefore will only grow in the future.

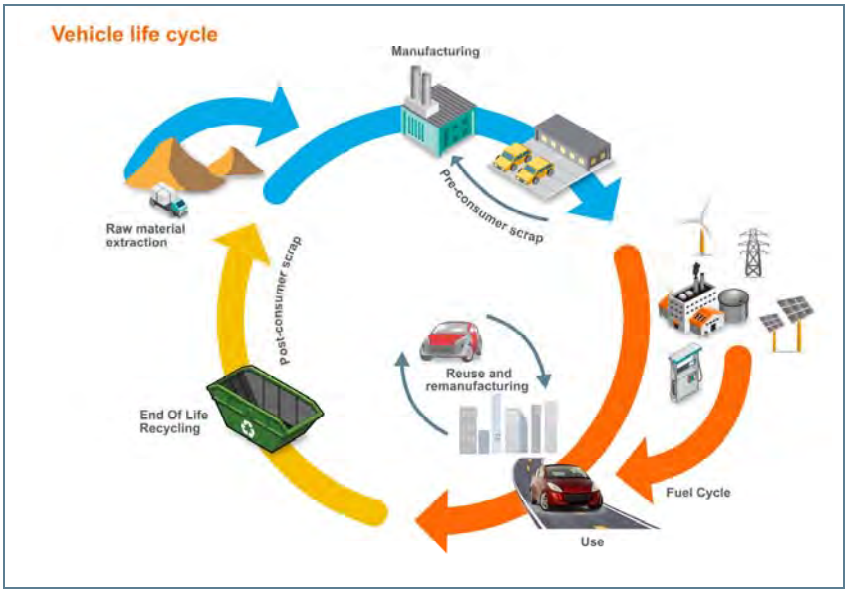
Therefore the 2014 revision to the EU's regulation on CO_2 emissions from new passenger cars states that ***"policy action should […] ensure that those upstream emissions do not erode the benefits related to the improved operational energy use of vehicles."***

Life Cycle Assessment Helps Avoid Unintended Consequences

The only way to avoid unintended consequences is to use life cycle thinking and life cycle assessment (LCA). LCA is a mature environmental assessment tool with global standards and close to 50 years of development and practice. It provides a rigorous methodology to account for all emissions generated during the life of a product, making it the ideal tool to identify and quantify environmental trade-offs.

Today LCA is widely used by academia, industry, government, and non-governmental organizations. Together with academia, companies and industry associations are leading the way in the deployment of LCA. Most car manufacturers are already using life cycle thinking and LCA, which is equally accepted by material producers.

In fact, together with many of their member companies, the trade associations of the steel, aluminium, and plastic industries are among the most active members of the global LCA community.



Environmental agencies around the world support LCA, including those of the European Commission, which call it the "the best framework for assessing the potential environmental impacts of products currently available." Life-cycle-based environmental regulation is in its infancy and not without challenges. Nevertheless, environmental regulators and policy makers have begun to draft legislation with a life cycle perspective, such as California's Low Carbon Fuel Standard. The regulation of automotive GHG emissions provides a unique opportunity to align regulatory practice with the state of the art in environmental product policy and launch a new area of successful environmental legislation free of major unintended consequences.

How to Use LCA in Environmental Policy

There are many ways to use life cycle thinking and LCA in environmental policy. The best way to integrate them into the policy making process or the policies themselves will depend on the specifics of each regulatory issue. As a minimum, life cycle thinking and LCA should always be used during the policy process, so that unintended consequences can be identified and their potential size can be gauged. Once it has been established that the risk of unintended consequences is substantial and their potential size is significant, as is the case with automotive GHG emissions, life cycle thinking or LCA should be used to mitigate the trade-offs that generate the unintended consequences.

Trade-offs cannot be avoided by regulating production and use phase emissions separately. This can only be achieved by life-cycle-based policies that generate incentives to reduce life cycle emissions. The regulation of the European producers of various automotive materials under the EU's Emission Trading Scheme, for example, has no impact on the material choice of the world's or even Europe's car manufacturers, who source materials and components globally.

Professor Finkbeiner and colleagues at Technical University Berlin recently completed a detailed and careful examination of how to integrate life cycle thinking and LCA into automotive GHG regulation. They find that such integration is highly desirable, and that there are various feasible ways to do so. A summary of the research report can be found at LCA Compendium - Policy Options for Life Cycle Assessment Deployment in Regulation

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How is LCA Already Applied in Legislation?

SUMMARY

Taking a life cycle approach in policy helps to avoid unintended consequences and to make policy more effective. Life cycle thinking (LCT) and life cycle assessment (LCA) are already known and acknowledged by many policy makers and directly or indirectly considered in some legislation. Moreover, LCA is widely accepted in the private sector which applies and develops LCA approaches for many years.

Legislators already recognized the need for life cycle thinking and life cycle assessment

Life cycle thinking (LCT) supports decisions towards more sustainable development. One method which makes LCT operational is life cycle assessment (LCA). The European Commission (EC) even calls it "the best framework for assessing the potential environmental impacts of products, process and systems."(EC 2003) (EC 2008).

LCT and LCA allow the identification of trade-offs and unintended consequences of existing policies and can help to formulate and implement policies, for instance by using LCA indicators such as life cycle greenhouse gas (GHG) emissions. A recent study published by the EC`s Joint Research Centre (JRC) states that by applying life cycle-based methods "policies can be targeted more effectively so that the maximum benefit is achieved relative to the effort expended" (Sala et al 2016).

Environmental policy is already widely based on LCT

The need for life cycle-based information for supporting decisions is acknowledged in many EU policies such as the following:

- Communication "Integrated Product Policy - Building on Environmental Life Cycle Thinking (COM(2003)302)"
- Strategy "Taking sustainable use of resources forward (COM(2005)666)"
- Sustainable Consumption and Production (SCP) and Sustainable industrial policy Action Plan (COM(2008)397/3)"
- "End of Life Vehicle Directive (2000/53/EC)" or the "Resource Efficient – flagship initiative under the Europe 2020 (COM (2011)571)"

LCT IN LEGISLATION

Policy, schemes and labels based on LCT:

- Integrated Product Policy - Building on Environmental Life Cycle Thinking (COM(2003)302)
- Taking sustainable use of resources forward (COM(2005)666)"
- Sustainable Consumption and Production (SCP) and Sustainable industrial policy Action Plan (COM(2008)397/3)
- End of Life Vehicle Directive (2000/53/EC)" or the "Resource Efficient – flagship initiative under the Europe 2020 (COM (2011)571)"
- Eco-Management and Audit Scheme (EMAS)
- EU Ecolabel (Regulation No 66/2010)
- EC´s Product Environmental Footprint (PEF) (Recommendation 2013/179/EU)

Moreover, schemes and labels such as EMAS and Ecolabel aiming at promoting Sustainable consumption and production (SCP) refer to LCT. The EU Ecolabel (Regulation No 66/2010) for instance requires that ecolabel performance criteria shall be determined considering the whole product life cycle. In addition, a pilot phase is currently testing the EC´s Product Environmental Footprint (PEF) (Recommendation 2013/179/EU) – a method which aims at measuring and communicating the life cycle environmental performance of products and organizations.

LCA IN LEGISLATION

Policy acknowledging LCA as a decision support tool:

- Better Regulation for better results – An EU Agenda (COM(2015)215)
- Resource efficiency opportunities in the building sector (COM(2014)445)
- Innovation for sustainable growth (COM(2012)60)
- Circular Economy Package (COM(2015)614)
- EU Ecodesign Directive
- Renewable Energy Directive (RED)
- EU Fuel Quality Directive

LCA is acknowledged as a decision support tool and already directly or indirectly used in legislation

Many environmental policies explicitly mention LCA. For example, the EC communications "Better Regulation for better results – An EU Agenda (COM(2015)215)" and "Resource efficiency opportunities in the building sector (COM(2014)445)" include LCA in their toolboxes and/or refers to it as a method to produce reliable, transparent and comparable data enabling decision support for policy makers. Other policies such as the strategy "Innovation for sustainable growth (COM(2012)60)" or the "Circular Economy Package (COM(2015)614)" support LCA as a tool to be explored for the measurement and communication of environmental information.

An example for a legislation which is based on LCT and indirectly on multi-criteria LCA is the EU Ecodesign Directive. Conducting an LCA is not required from companies when applying the Directive, but LCA studies are mandatory during the development of the policy implementation measures, i.e. for defining ecodesign requirements for energy-related products.

An example of an existing legislation in the EU which is directly based on LCA (specifically a single issue LCA, i.e. a carbon footprint) is the Renewable Energy Directive (RED) which includes the calculation of life cycle GHG emissions of biofuels. This policy is based on full life cycle-based limit values. Similarly, an LCA of GHG emissions is required in the U.S. under the current Renewable Fuel Standard.

Moreover, the revised Fuel Quality Directive (COM(2009)30) introduced a target for fuel suppliers to reduce life-cycle GHG emissions from transport fuels , meaning that environmental impacts of fossil fuels must refer to the LCA or to Well-to-wheel (WTW).

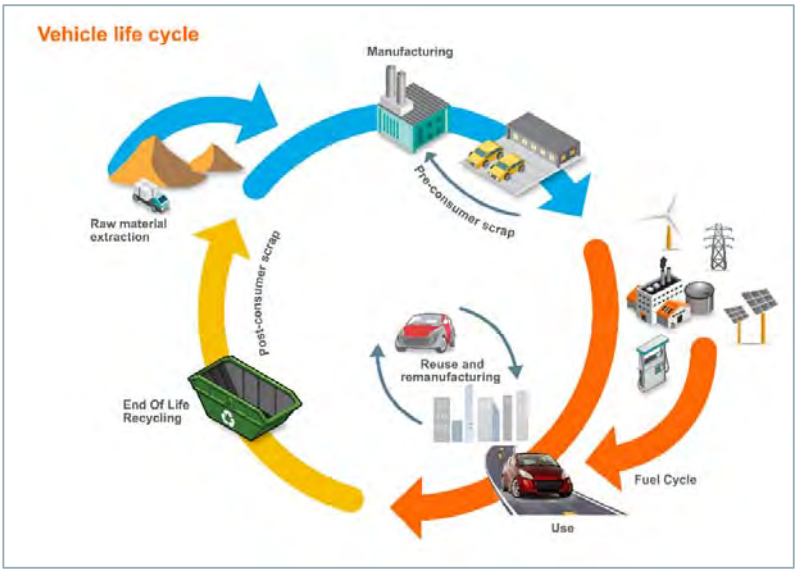
The private sector recognizes the importance of LCA

In industry LCA has been acknowledged and widely applied for many years by companies and industry associations in different sectors. Together with academia they are leading the way by actively using and developing LCA approaches. This includes for instance automotive companies such as BMW Group, Daimler AG, Renault, Volkswagen AG, Nissan or Toyota (BMW; Finkbeiner et al 2006; Chanaron 2007; Morel et al 2011; Warsen and Krinke 2012; Daimler 2015; Nissan 2015; Toyota Motor Corporation 2016) and material associations such as the World Steel Association, the European Copper Institute, Plastics Europe or the European Aluminum Association (PlasticsEurope 2011; e.g. World Steel Association 2011; EAA 2013; European Copper Institute 2017).

The relevance of LCA for the private sector is also reflected in several initiatives, such as the MEASURE project (2015-2016), one of the European SPIRE coordination and supporting actions. This project brought together leading European process industries in chemistry, consumer goods, steel, automotive and waste to work on a roadmap for a harmonized life cycle-based sustainability assessment in the EU process industry. A survey conducted amongst the industry partners revealed that the LCA method is regularly used by more than 60% of the respondents, occasionally by about 25%, and single issue LCAs, such as carbon or water footprint, are gaining importance.

Integrating LCA in automotive legislation is promising and feasible

Life cycle-based environ-mental regulation is already exists, but is still in its infancy and not without challenges. However, examples from policy and industry practice show that integrating LCT and even LCA in decision making is feasible. The LCA community has been working for years in this direction by promoting knowledge on LCA and developing and providing solutions for technical requirements of LCAs such as databases, data collection formats, customized LCA software, communication formats etc.



An effective automotive climate policy aiming at CO_2 reduction in road transport must consider the whole life cycle rather than focusing only on tailpipe emissions as is current practice. The Technical University of Berlin developed a comprehensive framework of policy options for life cycle-based CO_2 emissions regulation in the automotive industry by considering existing legislation and industry practice, demonstrating that implementation of LCT and LCA in automotive CO_2 regulation is feasible (Lehmann et al 2015).

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References

BMW Sustainable value report 2015. Acting sustainably. Achieving objectives. https://www.bmwgroup.com/content/dam/bmw-group-websites/bmwgroup_com/responsibility/downloads/en/2015/BMW_SVR_2015_RZ_EN.pdf. Accessed 4 January 2017

Chanaron J-J (2007) Life Cycle Assessment Practices: Benchmarking Selected European Automobile Manufacturers. Int J Prod Lifecycle Manag 2:290–311.

Daimler (2015) Daimler Sustainability Report 2015. https://www.daimler.com/documents/sustainability/other/daimler-sustainability-report-2015.pdf. Accessed 4 January 2017

EAA (2013) Environmental Profile Report for the European Aluminium Industry. Data for the year 2010. Life Cycle Inventory data for aluminium production and transformation processes in Europe. http://european-aluminium.eu/media/1329/environmental-profile-report-for-the-european-aluminium-industry.pdf

EC (2003) Communication from the Commission to the Council and the European Parliament - Integrated Product Policy - Building on Environmental Life-Cycle Thinking /COM/2003/0302 final. http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52003DC0302&from=EN

EC (2008) European Platform on Life Cycle Assessment (LCA), European Commission (EC), DG Climate. http://ec.europa.eu/environment/ipp/lca.htm. Accessed 19 April 2017

European Copper Institute (2017) Copper Life Cycle Analysis for Products. http://copperalliance.eu/about-copper/life-cycle-centre/life-cycle-assessment. Accessed 4 January 2017

Finkbeiner M, Hoffmann R, Ruhland K, Liebhart D, Stark B (2006) Application of Life Cycle Assessment for the Environmental Certificate of the Mercedes-Benz S-Class. Int J Life Cycle Assess 11:240–246.

Lehmann A, Finkbeiner M, Broadbent C, Balzer RT (2015) Policy Options for Life Cycle Assessment Deployment in

Legislation. In: Sonnemann G, Margni M (eds) LCA Compend. - Complet. World Life Cycle Assess. Springer Dordrecht Heidelberg New York London, pp 213–224

Morel S, Reyes T, Darmon A (2011) A consistency analysis of LCA based communication and stakeholders needs to improve the dialogue on new electric vehicle. In: Finkbeiner M (ed) Towar. Life Cycle Sustain. Manag. Springer Dordrecht Heidelberg New York London, pp 547–557

Nissan (2015) Nissan Motor Corporation Sustainability Report. http://www.nissan-global.com/EN/DOCUMENT/PDF/SR/2015/SR15_E_P112.pdf#page=21. Accessed 4 January 2017

PlasticsEurope (2011) Eco-profiles and Environmental Declarations. Version 2.0. Brussels, http://www.plasticseurope.org/documents/document/20110421141821-plasticseurope_eco-profile_methodology_version2-0_2011-04.pdf

Sala S, Reale F, J. C-G, Marelli L, R. P (2016) JRC technical report: Life cycle assessment for the impact assessment of policies. Life thinking and assessment in the European policies and for evaluating policy options. doi: doi:10.2788/318544

Toyota Motor Corporation (2016) Environmental Report 2016. Toward the Toyota Environmental Challenge 2050. http://www.toyota-global.com/sustainability/report/er/pdf/environmental_report16_fj_en.pdf

Warsen J, Krinke S (2012) The life cycle approach at Volkswagen. ATZ Worldw 114:4–9.

World Steel Association (2011) Life Cycle Assessment Methodology Report. Director General World Steel Association (worldsteel), Brussels, http://www.worldsteel.org/publications/bookshop/product-details.~Life-cycle-assessment--LCA--methodology-report~PRODUCT~LCA1~.html, December 10, 2016

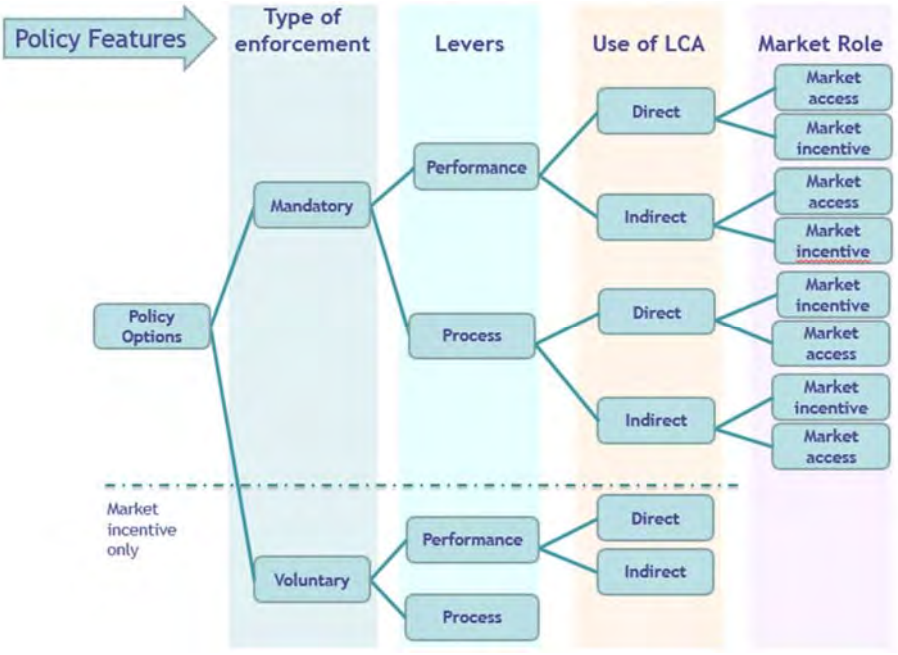
Implementing Life Cycle Thinking in Vehicle Regulations – Policy Options

SUMMARY

Including a life cycle perspective in automotive CO_2 regulation is needed. It would help to avoid unintended consequences of existing tailpipe only focus and support the overall target of CO_2 reduction in road transport. Several policy options that include a life cycle perspective exist, and some of them have already been implemented in current legislation – though not yet for automotive CO_2 regulation.

A broad range of life cycle based policy options exist

A detailed study of how to integrate life cycle thinking (LCT) and life cycle assessment (LCA) into automotive CO_2 regulation is provided by Prof Finkbeiner and colleagues at the Technical University Berlin (Lehmann et al. 2015). A broad range of policy options was proposed considering different policy features such as type of enforcement, levers, use of LCA and market role (see Figure).



Portfolio of policy options developed by combining different policy features

The policy options include mandatory and voluntary options, as well as options which may require a product re-design and options which define requirements on a company level, not leading to a product re-design. Moreover, the options differentiated between those with the direct requirement for full LCA studies, indirect solutions not requiring the provision of LCA data, as well as options addressing different legislative targets (e.g. restrict market access or provide market incentives).

The most stringent solution for using LCA in automotive legislation would be the so-called *mandatory-performance-direct option*, e.g. mandatory life cycle-based CO_2 limit values. The softest policy option would

be a *voluntary-process-based option*, which, as an example, may simply require to report life cycle-based CO_2 emissions as part of environmental programs.

Some of the policy options are already implemented in real world legislation

There are several examples of current legislation, beyond automotive CO_2 regulation, that are already based on LCT/LCA. Some of them can be allocated to the theoretical policy options. An example for an existing *mandatory-performance-direct* policy option is the Renewable Energy Directive 2009/28/EC (RED), which requires the calculation of full life cycle GHG emissions of biofuels and considers their "performance" by defining limit values. An example for a *mandatory-performance-indirect legislation* is the EU-Ecodesign Directive 2009/125/EC, which is indirectly based on LCA: conducting an LCA is not required when applying the Directive, but LCA studies are mandatory during the development of the policy implementation measures, i.e. for defining ecodesign requirements for energy-related products.

There is no clear scientific overall preference for one single policy option.

All policy options were analysed in detail. It was shown that there is no clear scientific overall preference for one single option. Also, it was found that robustness and credibility can principally be guaranteed by all policy options and that solutions for most technical requirements are already available – what is still missing is a consensus on the setting of these requirements.

Voluntary policy options are realistic and can offer short-/mid- term solutions for integrating a life cycle perspective in automotive CO_2 regulation.

According to the feedback obtained from stakeholders in key automotive markets (EU, U.S., Japan, China) including original equipment manufacturers (OEMs), policy making bodies, scientists and material associations, voluntary policy options as a complement to the existing tailpipe regulations were identified as the most realistic from a short-/mid-term perspective – particularly when combined with a credit system.

The developed portfolio of policy options and the knowledge gained from their detailed analysis provide the basis for developing a concept on how to integrate a life cycle perspective into automotive CO_2 regulation. The options, as well as potential implementation pathways, will be further developed, while continuing to consider the feedback from ongoing stakeholder dialogues.

Though the focus in this work is on automotive CO_2 regulation, the policy options developed can principally be used for other industries and other environmental impacts as well.

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References

Lehmann, A. et al., 2015. Policy Options for Life Cycle Assessment Deployment in Legislation. In G. Sonnemann & M. Margni, eds. *LCA Compendium - The Complete World of Life Cycle Assessment*. Springer Dordrecht Heidelberg New York London, pp. 213–224.

Communication for Policy Makers

Implementing Life Cycle Thinking in Vehicle Regulations - Implementing LCA Credit Options Part I

SUMMARY

Including a life cycle perspective in automotive CO_2 legislation is needed. One promising short-/mid-term solution are voluntary life cycle based CO_2 emission credits as a complement to existing tailpipe legislation. They would help to buffer unintended consequences of the existing tailpipe only focus and be effective to support the overall target of CO_2 reduction in road transport.

Several policy options to integrate Life Cycle perspective in legislation exist

A detailed study on how to integrate life cycle thinking (LCT) and life cycle assessment (LCA) into automotive CO_2 regulation is provided by Prof Finkbeiner and colleagues at Technical University Berlin. Several mandatory and voluntary policy options were proposed, described and discussed with various stakeholders in the automotive key markets (EU, U.S., Japan, China) including original equipment manufacturers (OEMs), policy making bodies, scientists and material associations.

Voluntary policy options are realistic and promising from a short-/mid-term perspective

According to the feedback obtained by the stakeholders the voluntary policy options were identified as the most realistic and preferred options from a short-/mid-term perspective – particularly when combined with credit systems.

Life Cycle-based CO_2 emission credits can complement and improve current tailpipe regulation

Voluntary credit options would support the existing regulations without requiring the development of a separate set of legislation. In addition, credits, even though not yet life cycle-based, are already an existing policy element. For example, in the EU, credits are provided on a voluntary basis as incentives for “Eco-innovations”, i.e. technologies which provide a confirmed contribution in terms of reducing CO_2 emissions (e.g. an LED low beam module). The credits obtained (e.g. 1g CO_2/km) can be used to meet the OEM´s specific CO_2 emissions fleet targets (UPI 2011; Magneti Marelli 2014).

Life cycle-based CO_2 emission credit options pick up this idea by rewarding OEMs who implement and use LCT/LCA for reducing LC CO_2 emissions.

A broad range of LC based emission credit options exist

Several technology neutral credit options exist ranging from rather simple options which are based on LCT and more advanced options based on LCA. The LCT options expand the viewpoint beyond current tailpipe CO_2 regulations by rewarding improvements in the production phase or additional measures in the use phase (e.g. addressing user behavior). The LCA options are based on quantitative global warming potential (GWP) reductions along the life cycle or consider additional environmental impacts beyond climate change.

Credits could be provided, for instance, based on the existence of an *ISO 14040/44 conform LCA study showing a continuous improvement*. That means, that a CO_2 emission credit can be granted, if the life cycle based GWP of a new car model is lower compared to a predecessor model (e.g. 120 g $C0_2$/km instead of 130 g $C0_2$/km). The achieved savings could be rewarded with a credit considering a robust ‘threshold or exchange

rate' between demonstrated reduction and credit granted – e.g. the 10g LC CO_2/km savings would be rewarded with a credit for use phase CO_2 emissions in full, but with e.g. 1g or 2 g CO_2/km only. This credit option promotes LCT and continuous improvement while directly avoiding problem shifting.

Another option could be to provide a credit to vehicles with a *small leakage rate to the rest of the life cycle* of e.g. < 20%. That would mean that a new car with a use phase reduction compared to a predecessor of e.g. 10 g/km could be rewarded with a credit (e.g. 1g CO_2/km) in addition to this reduction, if the rest of the life cycle does not increase more than e.g. 2 g/km (i.e. 20% of 10 g/km). This credit directly addresses the issue of problem shifting from the use to the other life cycle phases.

The credit options presented here will be further evaluated in terms of their effectiveness, viability and support from various stakeholders and finetuned based on the outcomes of the ongoing stakeholder dialogues, e.g. regarding potential feasible and robust implementation pathways.

The policy options present a low entry barrier approach for a specific field of legislation, i.e. CO_2 legislation in the automotive sector. However, they generally may be transferred to other environmental impacts and sectors as well.

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References

Lehmann, A. et al., 2015. Policy Options for Life Cycle Assessment Deployment in Legislation. In G. Sonnemann & M. Margni, eds. *LCA Compendium - The Complete World of Life Cycle Assessment*. Springer Dordrecht Heidelberg New York London, pp. 213–224.

Magneti Marelli, 2014. CO2 2020 Regulations: the EU has officially included Magneti Marelli Automotive Lighting's "E-Light" LED technology among the Eco-innovations for automobiles. Available at: http://www.magnetimarelli.com/press_room/news/co2-2020-regulations-eu-has-officially-included-magneti-marelli-automotive-lighting [Accessed November 16, 2014].

UPI, 2011. EU adopts automaker eco-innovation credit. Available at: http://www.upi.com/Business_News/Energy-Industry/2011/07/27/EU-adopts-automaker-eco-innovation-credit/UPI-32021311763140/ [Accessed November 16, 2013].

Communication for Policy Makers

Implementing Life Cycle Thinking in Vehicle Regulations - Implementing LCA Credit Options Part II

SUMMARY

Including a life cycle perspective in automotive CO_2 legislation for instance by voluntary life cycle based emission credits would help to buffer unintended consequences of the existing tailpipe only focus and support the overall target of CO_2 reduction in road transport. Several credit options and proposals addressing how to implement them in a robust and feasible way are already proposed.

Several voluntary life cycle-based CO_2 emission credit options exist, which can complement and improve the current automotive tailpipe CO_2 regulation

A comprehensive study by Prof. Dr. Matthias Finkbeiner and colleagues at Technical University Berlin (TUB) developed technology neutral policy options illustrating how life cycle thinking (LCT) and life cycle assessment (LCA) could be integrated into automotive CO_2 regulation using a credit system.

The *life cycle-based CO_2 emission credit options* include rather simple options based on LCT and more advanced options based on LCA. The LCT options expand the view beyond current tailpipe CO_2 regulations by rewarding improvements (e.g. innovative technologies) in the production phase or additional measures in the use phase (e.g. addressing user behavior). The LCA options are based on quantitative GWP (global warming potential) reductions along the life cycle or consider additional environmental impacts beyond climate change.

Technical solutions for implementing the credit options are already available

Implementing life cycle-based CO_2 emission credit options into legislation requires the definition and specification of methodological requirements (e.g. rules for conducting LCA or for measuring CO_2 reductions) and technical requirements (e.g. lifetime driving distance) as well as rules for calculating the credits.

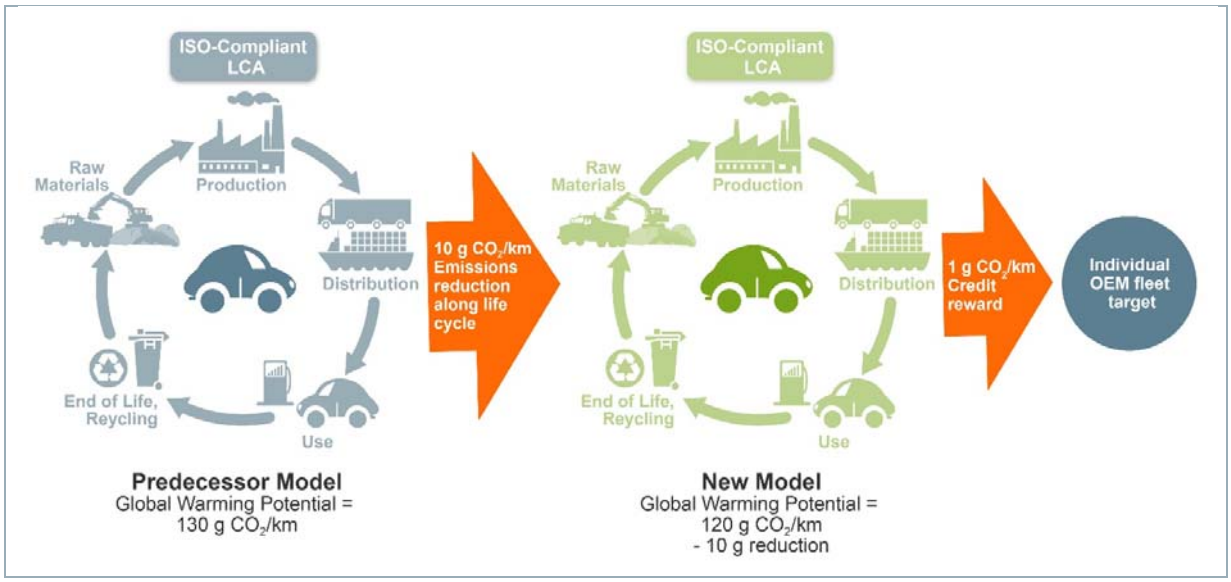
Solutions for these requirements are already available and presented in several so-called illustrative examples developed by the TUB considering existing approaches from practice (e.g. LCA modelling approaches from original equipment manufacturers (OEMs), material associations, policy, academia). For example, LCA could be conducted based on different approaches such as the existing ISO 14040/44 standard but with an additional specification for cars, either as additional ISO or CEN standard or a product category rule (PCR). All these requirements need to be defined by the policy makers (following scientific advice, stakeholder consultations and proper impact assessment).

Implementing the credit options, calculating and rewarding credits is possible in a robust and feasible way

For policy implementation, the robustness of the LCA implementation is more important than the precision or level of detail. This will entail the use of simplified calculations (similar to those under the existing EU End of Life Vehicles-Directive) and a robust “threshold or exchange rate” for the credit to ensure that credits are only obtained for actual life cycle CO_2 reductions.

Credits could be provided for instance based on the existence of an *ISO 14040/44 conform LCA study showing a continuous improvement*. That means, that a CO_2 emission credit can be granted, if the GWP of a new car model is lower compared to the one of the predecessor model (e.g. 120 g $C0_2$/km instead of 130 g

$C0_2$/km). The achieved savings could be rewarded with a credit considering a robust 'threshold or exchange rate' between demonstrated reduction and credit granted – e.g. the 10g life cycle CO_2/km savings would be rewarded with a credit for use phase CO_2 emissions in full, but with e.g. 1g or 2 g CO_2/km only (See figure).



There are several opportunities to operationalize the credit options

One option to operationalize the life cycle-based CO_2 emission credits could be to integrate them into the type approval process. OEMs would conduct an LCA study in a standardized way and the LCA model and data would then be verified and validated by external and independent reviewers to ensure, that the reductions in life cycle emissions are real. Transparency of reporting will help ensure credibility is maintained.

Another option in the EU could be to integrate the credit options into the existing voluntary Eco-innovation scheme under Regulation 443/2009/EC, which provides credits as incentives for "Eco-innovations", i.e. technologies leading to reduced tailpipe CO_2 emissions that are not considered under the existing type-approval tests. Life cycle-based CO_2 emission credits would pick up this idea and reward innovative OEMs which use LCT/LCA to reduce life cycle CO_2 emissions.

Voluntary life cycle-based CO_2 emission credits present a low entry barrier approach to integrate the life cycle perspective into current automotive legislation. These policy options as well as potential implementation pathways will be further evaluated in terms of their effectiveness, viability and acceptance and finetuned based on the outcomes of the ongoing stakeholder dialogues.

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