*32nd Electric Vehicle Symposium (EVS32)*
*Lyon, France, May 19 - 22, 2019*

# Increasing the Effectiveness of Electric Vehicle Purchase Incentives

Aivars Rubenis[1,2], Laila Kelmere[2], Andra Zvirbule[2]

[1]*Ivory Group, Skolas 15-7, Ikskile, Latvia, aivars.rubenis@ivorygroup.eu*

[2] *Latvia University of Life Sciences and Technologies, Jelgava, Latvia, Liela iela 2*

**Executive Summary**

Many governments are offering financial incentives for EV purchases to in crease their sales – grant, income tax deductions and rebates. The article analyses if the efficiency of these incentives depends on the method of payment by comparing their total costs of ownership (TCO) by means of traditional financial discounting and psychological utility discounting using q-exponential method. The results based on data from Latvia, show that suggested method of supporting downpayment for EVs demonstrate the highest psychological value for EV grants, while income tax deductions show the lowest results. Authors suggest creating a pilot project to test the hypothesis in real life by offering a choice of both models for the consumers.

## 1 Introduction

The importance of the decrease of $CO_2$ emissions has been once again emphasized in IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial level[8], and with transport being one of the sectors lagging behind the most, there are hardly any doubts anymore in the world about the necessity to stimulate the introduction of electric vehicles (EV) to the market as the means of decreasing $CO_2$ emissions in transport sector. Most of the governments in OECD countries are actively supporting electric mobility with various incentives, which in research usually are broadly categorized in three groups: monetary, infrastructure and traffic regulations[15]. This article will look at the first group – monetary incentives, which include purchase incentives and monetary lifetime incentives, focusing on a particular part of it – the financial purchase incentives.

There have been many researches proving the efficiency of financial incentives, noting that they are among the most important factors for faster EV adoption[19]. With amounts varying greatly, from few thousands up to 20000 in Norway[11]. Also Latvia had a short-lived support program for EV purchases in 2014 and a result 174 EVs were purchased within a couple of month, while the money lasted [22]. Afterwards, without subsidies the number of EV sales dropped to 25 vehicles in 2017, which is 0.1% of all new vehicles sold in Latvia[16]. The consumer survey in Latvia in 2016 60% of the respondents named EV price as the main obstacle for EV purchase[17]. Therefore, a research was commissioned by the government of Latvia to assess necessity for subsidies for electric vehicle purchases. The total cost of ownership (TCO) analysis showed, that in Latvia the cost difference between EV and internal combustion engine (ICE) vehicles ranges from negative (for luxury vehicle class) to 10 thousand EUR and a minimum necessary subsidy was suggested 3500 EUR[18].

The aim of this article is to analyse the most effective way how these EV purchase incentives can be delivered, assuming all other incentives staying constant.

# 2 Methods

## 2.1 Purchase incentives

Hardman et al[6] categorize monetary incentives in four groups: Point of Sale Grant Incentives, VAT and Purchase Tax Exemptions, Post purchase rebates and Income tax credits. These groups can be analysed from two points of view - governmental and customer - with common aim, how to maximize the effect with minimum investment from public[1] budget.

The previous research has confirmed the direct relationship between the financial incentives ($S_{EV}$) and the number of EVs sold ($N_{EV}$)[15][19]:

$$N_{EV} = f(S_{EV}) \tag{1}$$

Therefore, it can be presumed, that if Latvia would set it's EV purchase subsidy to 3500 EUR, it should covert to a certain number of vehicles purchased, which would form a certain share of total number of vehicles sold, which, in turn would require a specific investment from a budget.

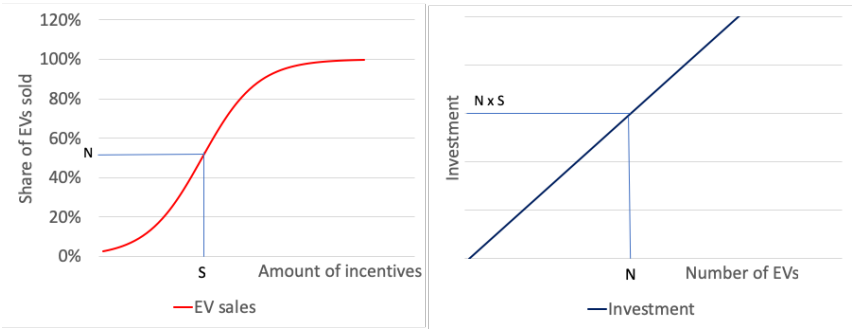



Figure 1: Relationship between incentives and market share of EVs and investment

In order to increase the amount of EVs sold, while staying in the limits of the budget, one needs to assess if there is a difference of customer preferences between the four purchase incentive groups.

## 2.2 Consumers

Several points have to be considered, to maximise the subjective value of the incentive in the eye of the consumer, and hence incentive's efficiency.

Firstly, the incentives have to be simple and easy to perceive to work.

Research in behavioural economics has shown, that purchase incentives do not attract consumers because they have calculated the financial savings they may achieve - consumers prove to be unable to make economically sound forecasts and often make biased decisions[20]. In general customers evaluate if 1) the price of the new car is fitting its performance; 2) the price of the car meets the expectations; and 3) the car is good value for money comparing to other cars[7] and purchase incentives raise the perceived value[15].

Secondly, the people value "right now" inconsistently and unreasonably higher than "later" - this is known as "hyperbolic discounting" [9] and it leads people to discount the future very heavily when sacrifices (or in case of EV purchases – investments) are needed now [12]. With this in mind we'll be looking at how purchase incentive groups affect the cash flows of the consumer.

[1] Within scope of this article we're not differencing between local, state, or federal budgets, assuming that all investments are either private or public (i.e. paid by taxpayers for the public good).

From this point of view, point of sale grants and VAT and purchase tax exemptions can be considered purchase incentive; however, post purchase rebates and income tax credits for individual customers, like done in USA[4] particularly does not reflect the value for the consumer.

Table 1: Cash flow time frame of the purchase incentives

| Purchase incentive | At point of sale | Month(s) after the sale | Up to a year after the sale |
|---|---|---|---|
| Point of sale grant incentives | X | | |
| VAT and purchase tax exemptions | X | X | |
| Post purchase rebates | | X | |
| Income tax credits | | | X |

Thirdly, while there are many subjective reasons why one might prefer one car alternative to the other, there are still financial constraints with which each customer have to comply.

If the budget available for a car purchase is limited, the customer will not buy the car he or she desires, but the one that he or she can afford – the income has been noted a sensitive factor even in so prosperous countries as Norway[11]. Additionally, the subsidies are more important for the "budget" class of vehicles and not for the luxury vehicles, as the research on Tesla purchases support[6]. Unfortunately, small class EVs are comparatively much more expensive than their ICE counterparts compared to large, luxury vehicles. So, on average, small class EV TCO is about 10000 EUR more than respective class ICE vehicles in Latvia, while luxury cars are on par [18].

Taking that into account, the approach should be oriented towards making EV purchases as appealing as possible by implementing the assumptions described above.

## 2.3 Approach

The analysis will be carried out on looking at cash flows from the point of view of the purchaser based on the Latvian TCO calculations for Kia Soul and VW Golf EV and ICE models, laid out in detail in [18].

The analysis will involve 5 cash flow scenarios:

a) cash flows without grant;
b) cash flows with the grant of 3500 EUR – traditional approach, decreasing total EV price;
c) cash flows with the income tax credit of 3500 EUR;
d) cash flows with the grant of 3500 EUR – author's suggested approach, decreasing price and using it to decrease the down payment for the car lease.

The authors' suggested approach is based on three previous assumptions (simple, now, within budget) as well as famous sales technique, that people don't mind spending money that they don't see - as widely demonstrated by credit cards[13]. For years car industry has used various techniques to lure purchasers into buying cars, and one of them includes lowering the down payment, thus making the purchase of the vehicle comparably easier, at the same time making future payments larger. This will even out the cash flows between EV and ICE vehicles, because, while it has always been a selling point for EVs that usage costs are much lower than for ICE vehicles, it has so far almost never utilised in practice to offset bank leasing payments.

## 2.4 Discounting

For the purposes of this research we have used three discounting calculations, discounting on monthly basis.

For both the TCO discounting and governmental cost discounting standard exponential discounting is used:

$$V_{(0)} = V_{(t)}(1 + {}^{r}/_{12})^{-t} \quad (2)$$

where $V_{(0)}$ – present (discounted) value, $V_{(t)}$ – value at time $t$ (in months), $r$ – yearly discount rate, which in case of Latvia is 5.03% for individuals, based on average lease rates in Latvia[1] and 0.25% for government, based on 5 year fixed rated domestic treasury bond rate[21].

For psychological discounting we have used q-exponential utility discount function[2] which has a relatively high discount rate over short time periods and a relatively low discount rate over long periods.

$$V_{(0)} = V_{(t)}\left[1 + (1-q)\mathrm{k}_q t\right]^{\frac{-1}{1-q}} \quad (3)$$

Where parameters $q$ – demonstrates the time inconstancy (distance from exponential function) and $k_q$ - a degree for outcome discount[5].

Psychological discounting in fact involves two discounts to include the gain-loss asymmetry, which states that losses are discounted at lower rate than gains are[10]. In this article the empirical data from research done by Han and Takahashi[5] was used to demonstrate the principle of the assumption. Recalculated for month time periods the $q$ and $k_q$ coefficients for positive gains were -6.54 and 0.2475, and for negative losses were -5.33 and 0.111 respectively.

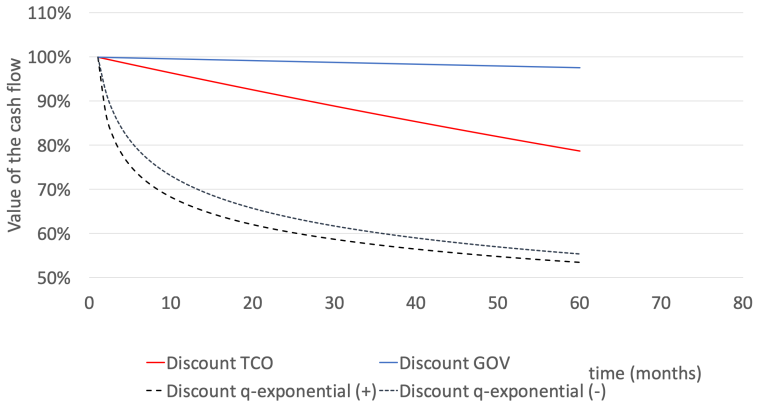



Figure 2: Present value discount rates $V_{(0)}/V_{(t)}$ used for cash flow discounts.

# 3 Results and discussion

## 3.1 The Cash Flows

The detailed undiscounted cash flows from owning and using WV Golf and KIA Soul EV and ICE vehicles are presented in the Appendix 1 and the discounted cash flows in the Appendix 2.

The summary of those are presented in table 2, which shows that the differences between the efficiency of the same amount of subsidy is much larger from consumer's psychological point of view than it is from financially objective TCO calculation, which should normally be used by companies to evaluate the costs of their vehicle fleet.

The financially objective differences between TCOs in Latvia for Kia Soul diesel and electric versions are 3459 EUR. With 3500 EUR grant the TCO differences fluctuate between 161 and -5 EUR, which is insignificant (within 1% of the vehicle value).

However, looking from individual user psychological discounting point of view, the differences fluctuate significantly. If the psychological TCO difference without grant is 3414 EUR, then depending on the payment method 3500 EUR grant still gives the TCO differences between 1100 and -86 EUR, or 7% of the vehicle value.

Table 2: The vehicle TCOs using financial and psychological discounting

| Vehicle | | Financial TCO | | | Psychological TCO | | |
|---|---|---|---|---|---|---|---|
| | | Total TCO, EUR | Difference EUR | Difference % | Total TCO, EUR | Difference EUR | Difference % |
| KIA Soul 1.6 GDi | | 18967 | | | 15135 | | |
| Kia Soul EV | | | | | | | |
| Without grant | A | 22462 | 3495 | 18% | 18550 | 3414 | 23% |
| Grant 3500 | B | 19024 | 57 | 0% | 15858 | 722 | 5% |
| Income Tax Relief 3500 | C | 19128 | 161 | 1% | 16246 | 1110 | 7% |
| Rebate 3500 | D | 18990 | 23 | 0% | 15702 | 567 | 4% |
| Grant for down payment 3500 | E | 18962 | -5 | 0% | 15050 | -86 | -1% |
| Volkswagen Golf 1.4 TSI | | 21888 | | | 17373 | | |
| Volkswagen e-Golf | | | | | | | |
| Without grant | A | 31473 | 9586 | 44% | 25826 | 8453 | 49% |
| Grant 3500 | B | 28036 | 6148 | 28% | 23134 | 5761 | 33% |
| Income Tax Relief 3500 | C | 28140 | 6252 | 29% | 23522 | 6149 | 35% |
| Rebate 3500 | D | 28002 | 6114 | 28% | 22978 | 5605 | 32% |
| Grant for down payment 3500 | E | 27973 | 6086 | 28% | 22326 | 4953 | 29% |

The results for Volkswagen e-Golf show similar trend, considering that without grant the electric version is almost 50% more expensive to own than diesel version and is included in this analysis as an extreme example of TCO differences.

The different efficiencies of the same amount of incentive is shown in the table 3.

Table 3: Efficiencies of incentives under various scenarious

| Scenario | | Cash spent | Effect from the grant | | | Difference, EUR | | | Difference % | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Gov-t costs | Financial TCO | Psychological | Gov-t costs | Financial TCO | Psychological | Gov-t costs | Financial TCO | Psychological |
| Without grant | A | | | | | | | | | | |
| Grant 3500 | B | 3500 | 3500 | 3437 | 2692 | 0 | -63 | -808 | 0.0% | -1.8% | -23.1% |
| Income Tax Relief 3500 | C | 3500 | 3483 | 3333 | 2304 | 17 | -167 | -1196 | 0.5% | -4.8% | -34.2% |
| Rebate 3500 | D | 3500 | 3497 | 3472 | 2848 | 3 | -28 | -652 | 0.1% | -0.8% | -18.6% |
| Grant for down payment 3500 | E | 3500 | 3500 | 3500 | 3500 | 0 | 0 | 0 | 0.0% | 0.0% | 0.0% |

## 3.2 Comparative advantages – state value

When choosing the most beneficial scheme a state should be considering two aspects of the incentive, to achieve maximum efficiency from the customers – the costs and the ease of use.

From the costs point of view, there are two aspects that could be examined - the difference in money costs and the differences in program administration costs. The latter is beyond the scope of this article as it depends too much of peculiarities of legal and administrative systems of each country. The analysis of the former however display that the differences are minuscule.

The full discount calculations are presented in Annex 3, but table 3 shows financial costs for government in each method. In case of income tax relief, the costs are the lowest as the government delays actual spending for at least a year. In this case (using the Latvia government 5 year bond rates[21]) the government wins 17 EUR, while loses 1196 EUR of grant efficiency. In addition, income tax relief is discriminative against people of lower income, because one can only qualify if one's income tax is sufficiently large. Thus, in case Latvia

would want to implement such a method according to Latvia tax laws, less than 1% of the people would qualify. Thus, income tax reliefs are the worst of the four methods evaluated.

The second worst is the EV cost rebates. They psychologically lose less than straight grants, however their implementation encompasses much confusion and involment from the customer[3] thus discouraging consumers instead of making EVs more enticing.

The suggested approach for using grant as a lease down payment shows the lowest psychological TCO, as it is all received straight away and involves the least outgoing payments when purchasing the car.

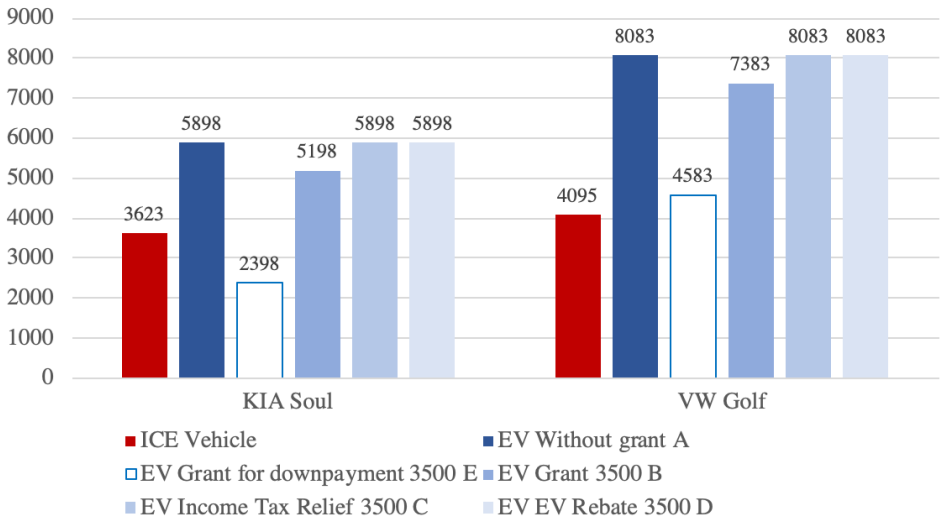



Figure 3: Immediate cash outflow from vehicle purchases.

## 3.3 The accounting differences for the companies

According to the International Accounting Standard (IAS) 16, an item of property that qualifies for recognition as an asset shall be measured at its cost. The cost of an item of property is the cash price equivalent at the recognition date. If payment is deferred beyond normal credit terms, the difference between the cash price equivalent and the total payment is recognised as interest over the period of credit[23] . In our example, the credit terms are normal.

For measurement after recognition, the entity shall choose either the cost model or the revaluation model[23] . For vehicle, it is more appropriate to use the cost model, because in the normal situation the value of the vehicle only declining rather than increasing. In the cost model after recognition an asset, an asset shall be carried at its cost less any accumulated depreciation and any accumulated impairment losses.

Depreciation of an asset begins when it is available for use, i.e. when it is in the location and condition necessary for it to be capable of operating in the manner intended by management. The depreciable amount of an asset shall be allocated on a systematic basis over its useful life and the depreciation charge for each period shall be recognised in profit or loss unless it is included in the carrying amount of another asset.

A variety of depreciation methods can be used to allocate the depreciable amount of an asset on a systematic basis over its useful life. These methods include:

1) the straight-line method – a constant charge over the useful life if the asset's residual value does not change;
2) the diminishing balance method – results in a decreasing charge over the useful life;
3) the units of production method – based on the expected use or output[23].

It has been observed that the linear method is most commonly used when calculating depreciation for vehicles.

Government grants are assistance by government in the form of transfers of resources to an entity in return for past or future compliance with certain conditions relating to the operating activities of the entity. Grants

related to assets are government grants whose primary condition is that an entity qualifying for them should purchase, construct or otherwise acquire long-term assets. Subsidiary conditions may also be attached restricting the type or location of the assets or the periods during which they are to be acquired or held. Government grants shall be recognised as income over the periods necessary to match them with the related costs which they are intended to compensate, on a systematic basis.[24]

The calculation of costs and revenues in accounting, as well as the impact of the net result in the profit or loss account, are presented in the Appendix 4. While it's obvious, that government grant would have a positive impact on the company's financial results, however, if the government wants to facilitate EV introduction, the whole taxation policy must provide a positive impact on the company's financial flow from the purchase of EV and during their use. E.g. in Latvia companies may deduct only 50% of the prepaid VAT from vehicle purchase and use[14], which greatly discourage purchases of electric vehicles, as they, being more expensive, are more disadvantaged by this tax than ICE vehicles. The flaws in tax policies like these must be fixed before even considering incentives for EV purchases.

# 4 Conclusions

Based on the research it can be concluded, that the method of payment really does make a tangible difference, and it can be quantified using psychological discounting. The research advises that indeed the suggested approach of has the lowest TCO from the four methods analysed.

The authors therefore suggest following policy changes:

a) make sure that existing tax policies do not disadvantage electric vehicles;
b) prefer direct grants instead of tax reliefs;
c) prefer simple automatic and immediate incentives instead of delayed rebates

Because authors are not aware of any governmental incentive thus far focusing grants to EV lease downpayment to minimise initial costs, authors suggest creative initial pilot project to test the hypoothesis in real life. The pilot project should involve the option for people to choose between traditional grant and the suggested method, to test the assumptions when consumers are spending real money, not just answering questionnaires.

# Acknowledgments

This paper has been published as a part of the research contract with Road Traffic Safety Directorate of Latvia (contract No. 11-EVKD/933).

# References

[1] Bank of Latvia, *Main Interest Rates in Latvia (Galvenās procentu likmes)*. https://www.bank.lv/statistika/dati-statistika/procentu-likmju-statistikas-raditaji/galvenas-procentu-likmes, accessed on 10/28/2018.

[2] D.O. Cajueiro, *A note on the relevance of the q-exponential function in the context of intertemporal choices*. Physica A: Statistical Mechanics and its Applications, ISSN 03784371, 364(2006), 385–388.

[3] California Air Resources Board, *Implementation Manual for the Clean Vehicle Rebate Project* (CVRP). 2018.

[4] *Federal Tax Credits for All-Electric and Plug-in Hybrid Vehicles*, https://www.fueleconomy.gov/feg/taxevb.shtml, accessed on 03/14/2019.

[5] R. Han et Al., *Psychophysics of time perception and valuation in temporal discounting of gain and loss*. Physica A: Statistical Mechanics and its Applications, ISSN 03784371, *391*, 24 (2012), 6568–6576.

[6] S. Hardman et Al, *The effectiveness of financial purchase incentives for battery electric vehicles – A review of the evidence*. Renewable and Sustainable Energy Reviews, ISSN 18790690, 80(2017), 1100–1111.

[7] A. Herrmann, et Al, *The influence of price fairness on customer satisfaction: An empirical test in the context of automobile purchases*. Journal of Product and Brand Management, ISSN 10610421, *16*, 1 (2007), 49–58.

[8] Intergovernmental Panel on Climate Change, *IPCC special report on the impacts of global warming of 1.5 °C - Summary for policy makers*, 2018

[9] D. Laibson, *Golden Eggs and Hyperbolic Discounting*. The Quarterly Journal of Economics, ISSN 0033-5533, (1997).

[10] G. Loewenstein et Al., *Anomalies in Intertemporal Choice: Evidence and an Interpretation*. The Quarterly Journal of Economics, ISSN 0033-5533, (1992).

[11] A.C. Mersky, et Al., *Effectiveness of incentives on electric vehicle adoption in Norway*. Transportation Research Part D: Transport and Environment, ISSN 13619209, 46(2016), 56–68.

[12] R. Metcalfe et Al., *Behavioural economics and its implications for transport*. Journal of Transport Geography, ISSN 09666923, 24(2012), 503–511.

[13] D. Prelec et Al., *Always Leave Home Without It: A Further Investigation of the Credit-Card Effect on Willingness to Pay*. Marketing Letters, ISSN 09230645, (2001)

[14] Republic of Latvia, *Value Added Tax Law, 2018*

[15] N. Rietmann et Al., *How policy measures succeeded to promote electric mobility – Worldwide review and outlook*. Journal of Cleaner Production, ISSN 09596526, 206(2019), 66–75

[16] Road Traffic Safety Directorate of Latvia, *Vehicle Statistics in Latvia*. *Vehicle Statistics in Latvia*, https://www.csdd.lv/transportlidzekli/transportlidzekli-vizualizacija, accessed on 07/02/2018

[17] A. Rubenis et Al., *Analysis of the development of the Latvian national electric vehicle charging network (in Latvian)*. Riga*,* 2016

[18] A. Rubenis, et Al., *Evaluation of a Necessity for Subsidies for Electric Vehicle Purchases in Latvia: 2013–2017*. In Reliability and Statistics in Transportation and Communication. RelStat 2018. ISBN 978-3-030-12450-2, Springer, 2019, pp. 637–646.

[19] W. Sierzchula et Al., *The influence of financial incentives and other socio-economic factors on electric vehicle adoption*. Energy Policy, ISSN 03014215, *68*, (2014), 183–194.

[20] R.H. Thaler et Al., *Choice Architecture*. ISBN 9780300122237, *2014*

[21] Treasury of the Republic of Latvia, *Latvia Treasury Bond Rate Report*. *Report on Latvia Treasury Bond rates*, https://www.kase.gov.lv/sites/default/files/public/frd/iekšējais_tirgus/review_2018-10-17.pdf, accessed on 10/29/2018

[22] Latvia Ministry of Envrionment, *Klimata pārmaiņu finanšu instrumenta finansēto projektu atklāta konkursa Siltumnīcefekta gāzu emisijas samazināšana transporta sektorā – atbalsts elektromobiļu un to uzlādes infrastruktūras ieviešanai" nolikums*. *(in Latvian)* http://www.varam.gov.lv/lat/darbibas_veidi/kpfi/projekti/?doc=17817, accessed on 05/20/2016

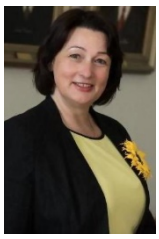
[23] *Commission Regulation (EC) No 1126/2008 of 3 November 2008 adopting certain international accounting standards in accordance with Regulation (EC) No 1606/2002 of the European Parliament and of the Council. International Accounting Standart 16 "Property",* https://eur-lex.europa.eu/legal-content/en/txt/?uri=celex:32008r1126, accessed on 10/29/2018

[24] *Commission Regulation (EC) No 1126/2008 of 3 November 2008 adopting certain international accounting standards in accordance with Regulation (EC) No 1606/2002 of the European Parliament and of the Council. International Accounting Standart 20 "Accounting*", https://eur-lex.europa.eu/legal-content/en/txt/?uri=celex:32008r1126, accessed on 10/29/2018

## Authors

Aivars Rubenis is a PhD candidate from Latvia University of Life Sciences and Technologies. He's also a researcher in Lesla Ltd, a company developing wireless energy transfer solutions. Aivars Rubenis is doing his research on economics, specialising on electric vehicles and wireless energy transfer. Aivars Rubenis is also a consultant for government of Latvia on electric vehicle policies.

Laila Kelmere is a PhD candidate from Latvia University of Life Sciences and Technologies. She currently works at the Faculty of Economics and Social development, Latvia University of Life Sciences and Technologies as a lecturer. Laila does research in Law and Economics, Private and Public Finance and Accounting Scholarship.



Andra Zvirbule is a professor at the Faculty of Economics and Social development, Latvia University of Life Sciences and Technologies and chief researcher in Entrepreneurship and Management Institute