

## FEEBATE SYSTEM AS AN ALTERNATIVE TO TAXES IN ENVIRONMENTAL REGULATION OF LIGHT VEHICLE TRANSPORTATION

*The article examines the problem of increasing air pollution from moving vehicles in Ukraine relying on the European experience of dealing with the problem. The System Dynamic method is used to build a feebate model to decrease the air pollution in Ukraine on the basis of P'HAPI framework. To lessen CO<sub>2</sub> emissions, the authors introduce a feebate program that is the alternative to environmental taxes and fiscal ways to stimulate purchases of electric cars in Ukraine. The model suggests that fees for diesel, gasoline, or hybrid car are paid annually, whereas the rebate is paid once at the purchase time of a new pure electric vehicle. The feebate fund uses initial investment from government to launch its work; fees and interest earned are used to pay the rebates.*

*The conducted analysis and the realization of System Dynamics model allowed to develop an effective programme that lasts 6 years from 2018 till 2024, increases the market share of electric cars, reduces the share of diesel and gasoline cars and results in significant decrease of the level of CO<sub>2</sub> emissions and air pollution. Several important obstacles on the way to implement the policy are mentioned in the article, namely legislative, administrative, social, informational, and infrastructural. The results of this research can be used when making management decisions by state regulators. The feebate policy turned out to be promising as it offers an alternative to taxation and a perspective way to promote better environmental regulation in transportation.*

**Keywords:** system dynamics, taxation, feebate system, financial instruments, environmental regulation, transport, CO<sub>2</sub> emissions, electric cars, sustainable development.

**JEL classification:** H23, L91, Q28, Q38, R48

### **Introduction and research problem.**

Environmental problems such as air or water pollution, waste disposal, biodiversity loss and climate change are worldwide and human caused and affect social communities and their wellbeing all around the world. International agreements such as the Stockholm Declaration, Convention on Biological Diversity, Kyoto Protocol, Paris Climate Act raise the responsibility for environment at the world and national level and make countries-participants actively manage environmental issues. Ukraine has taken responsibility to contribute to the worldwide problem at the national level signing Paris Climate Act.

In the world environmental regulation is dealt with the help of financial tools and the reasons for it are founded on sustainable development, “polluter pays”, prevention and other principles of environmental law. Financial instruments used for environment maintenance are taxation and fees, tax exemptions and subsidies. There are also financial

market tools such as air and water emissions cap-and-trade, feebate programmes, green and revolving funds, mitigation banking and land trusts, deposit-refund schemes.

Therefore financial instruments aim at dealing with negative externalities that affect the third party – environment to lessen the human impact and to encourage social responsibility and sustainable development in environmental sphere, expand precautionary and preventive means of environmental protection.

**Recent publications analysis.** The approach of eliminating the negative externality and optimize the level of taxation has been developed by Arthur Pigou (Pigouvian tax). The scientist introduced levying taxes on emissions that producers discharge basing on the theory of negative externalities, that represents market failure because as consumption or production of goods and services does harm to the third party.

The problems of implementing traditional fiscal instruments of environmental regulation are

reflected in the books of Garrett Hardin, Mark A. White, Robertson C. Williams, Herman E. Daly, Geoff Riley, Samuel A. Bleicher, James L. Huffman.

Recent scientific research of international environmental organizations, such as Environmental Justice Organizations, Liabilities and Trade, The International Council on Clean Transportation (ICCT), The Environmental Defence Fund, Environmental Science, World Land Trust, Zero Waste Europe and others are devoted to the alternative financial tools such as feebate programmes and cap-and-trade schemes.

For instance, the research of ICCT concludes that if VAT could be converted into feebate programme based on CO<sub>2</sub>, this would spur the major incentives towards reduction in CO<sub>2</sub> emissions [1].

**Unsolved parts of the problem.** Ukraine deals with environmental challenges, namely air pollution, water contamination, waste disposal, nuclear waste accumulation and biodiversity loss. However, according to Environmental Performance index (overall score 52.87) the lowest scores in Ukraine are on forest, energy, climate and air pollution, and the biodiversity policy performance. Nowadays Ukraine has to be more effective in environmental regulation because of Association Agreement and the need to apply Directives of the EU on environmental issues.

Ukraine has such financial instruments of environmental regulation as environmental tax, rent payments, tax exemptions, and green tariffs. However, the share of ecological tax revenues in Ukraine is 0.17 % from GDP, whereas OECD-countries have on average 1.56 % [7]. The lack of financing for environmental protection is compounded by the large scale of tax evasion in Ukraine [2]. Such market financial tools as cap-and-trade market, environmental crediting are not spread and well-developed. Although environmental protection is funded from state and local budgets as expenditure, enterprises and organizations finance environmental issues mostly on their own (68 % of total share). Only several banks offer credits for energy-efficiency for households, some of them are in collaboration with international banks that offer additional grants, cap-and-trade programme has survived several attempts of establishment but is not functioning now, there are only a couple of charity funds that deal with solving ecological issues. A few international creditors support environmental protection issues in Ukraine through loans and grants.

**Research goal and questions.** The article aims to find an alternative market way of regulating the environment in Ukraine, namely to develop a model of feebate system in light vehicle transport sector.

**Main findings.** To achieve the tasks set on the environmental regulation in light vehicle transportation we would like to address European experience and researched proposals for the Ukrainian case in the modelling with System Dynamics. We built a feebate model for light vehicle transportation means to decrease the air pollution in Ukraine on the basis of P'HAPI approach within System Dynamics framework. In the System Dynamics model we offered to establish the level of permissible CO<sub>2</sub> emissions at the level of 95 g/km for diesel and gasoline cars and 60 g/km for hybrid cars. The fees were dependent on CO<sub>2</sub> emissions for diesel, gasoline or hybrid car and paid annually, whereas the rebates were paid once at the time of the purchase of a new pure electric vehicle.

We aim at creating a sustainable system which would lessen the need in financing from budget or address governmental budgeting only in case of certain risky conditions for the fund which would not allow it to work as it should. The focus here is to decrease the expenditure burden at the governmental budget because the goal of the system is not to be dependent on governmental expenditure allocation. However, the government should be a strong adept and organizing body at first to incentivize and give the start to the fund and the feebate programme.

According to the International Council on Clean Transportation (ICCT) feebate programmes are regarded as the most promising incentives towards better environmental performance [1]. A feebate programme means that more efficient vehicles receive rebates and less are punished with fees. So, a feebate programme is considered as a fund transfer, not a tax, since the money from fees of those who decide to purchase a higher CO<sub>2</sub> emitting vehicles are redistributed to those who choose to buy lower emitting vehicles as a reward for their decision. Feebate programmes are advanced technology implementation incentives that address oil dependence and CO<sub>2</sub> emissions.

Feebate programmes are beneficial because they influence the consumer decision making and reward a consumer with a tangible and immediate rebate, but also it rewards the society because of reduced potential emissions and fuel consumption.

The most well-tailored feebate-like system exists in France, it turned out to be effective since first established on market of vehicles in 2008, as there was a strong increase in sales of cars with emissions 101–120 g/km of CO<sub>2</sub>, in contrast a drop in sales of cars with CO<sub>2</sub> emissions between 120 and 250 g/km. However, no decrease experienced sales of luxury category gasoline vehicles with emissions

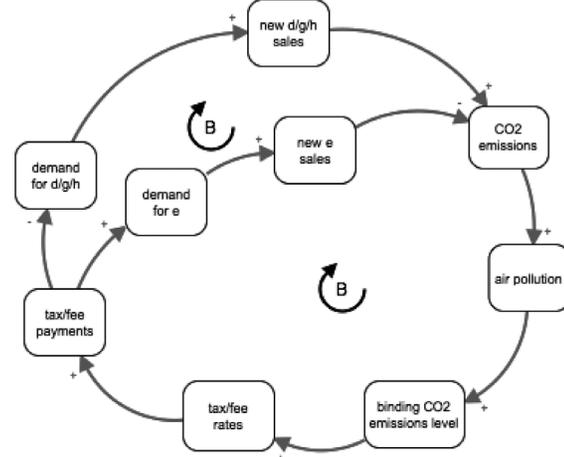
higher than 250 g/km of CO<sub>2</sub>, which suggests their price insensitivity.

As our modelling is built with System Dynamics mechanisms we need to deeply understand the framework of this modelling tool. There is a step-by-step method of dealing with System Dynamics models called P'HAPI created by Erling Moxnes, P stands for problem, H – hypothesis, A – analysis, P – policy and I – implementation [4].

The Problem here is the undesired behavior that we observe: the air pollution, or the level of CO<sub>2</sub> in atmosphere, from moving means of transportation, or light cars, has been constantly increasing throughout the years in Ukraine. The long average lifetime of exploitation of a car in Ukraine is about 19.6 years, which is two times higher than in Europe (about 8) [7]. The level of ecological taxation is low, thus the problem is not addressed properly, which poses hazards for life and well-being of the Ukrainian citizens and the neighboring countries as the environmental problems spread without obstacles. Furthermore, the absence of a reasonable solution for the problem increases the price and inventory dependence from traditional kinds of energy resources, namely crude oil, gas and coal and prevents new alternative green technologies in transportation from being implemented nationwide.

The Hypothesis explains the possible cause of the problem: the air pollution from moving light vehicles increases because of the high levels of CO<sub>2</sub> emissions due to high average amount of CO<sub>2</sub> discharge that is relevant to prevailing car fleet in Ukraine, or gasoline and diesel cars. As the number of hybrid with lower emission rates and pure electric cars which don't emit CO<sub>2</sub> is low since the market share for these two kinds of cars is 0.07 % each for 2017 and there is no certain regulatory amount of CO<sub>2</sub> emissions to be followed the level of air pollution is growing. As it was mentioned the taxes on diesel, gasoline and hybrid cars depending on environmental harm imposed on car owners don't exist, though there are some indirect taxes. As referred before there is no direct impact on the level of CO<sub>2</sub> emissions to reach a permissible one, likewise on the number of diesel and gasoline cars regarded as high polluters and hybrid cars. Apparently there should be a feedback loop on the presented issue. The more diesel, gasoline and hybrid car sales there are, the more CO<sub>2</sub> emissions occur, consequently air pollution, the more binding level of CO<sub>2</sub> emissions is set, the more tax/fee payment rates there are the more tax/fee payments are collected and the less demand for such kinds of cars is, but the demand for electric cars rises otherwise. The more electric car sales

there are in the fleet, the fewer emissions they produce and the less air pollution is accumulated. Thus, there are the two balancing or negative loops on the Causal Loop Diagram (Fig. 1) that means there is feedback when we enlarge something but the object we influence shrinks, declines and vice versa and a present goal-seeking behavior, so we need to reach a certain CO<sub>2</sub> emission level that is limited by the binding level.



**Fig. 1.** Causal Loop Diagram

Source: built by the authors using Stella Architect Software

Since there are no direct taxes that affect the emissions the loop for Ukraine case has hardly been applied by now. Thus the model should be built with the policy in it to deal with the problem.

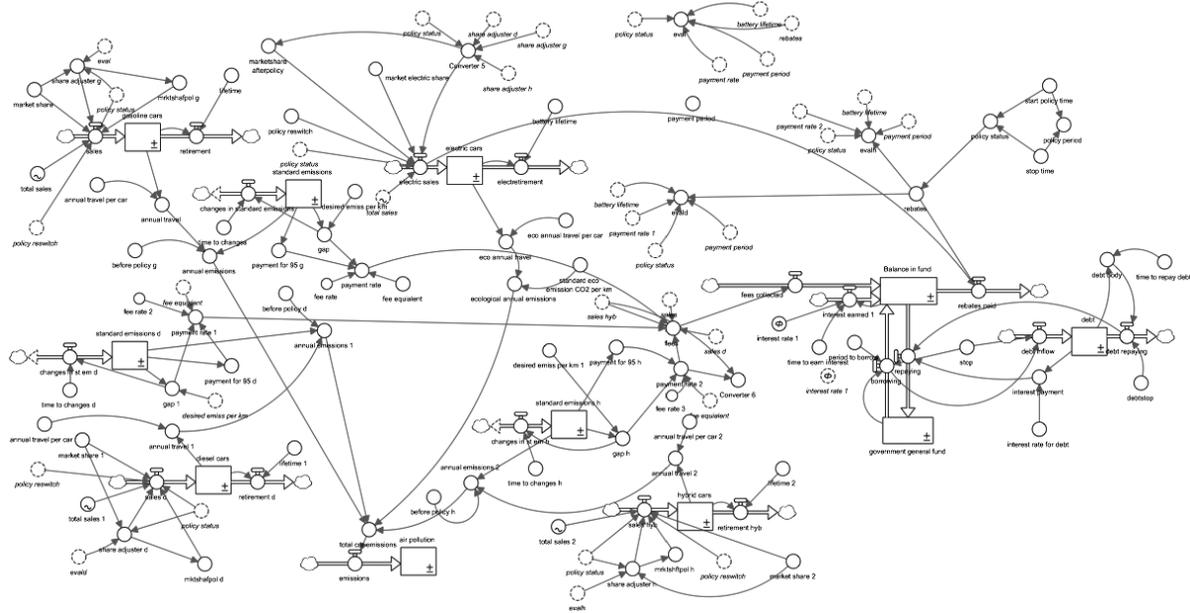
Analysis develops the structure and behavior of the model. Here for modelling purposes we combine analysis and policy that presents hypothesis and methods to reduce the problem and strategy to achieve desired development. Firstly, it is important that in Fig. 2 one can observe the basic structure and the policy structure. There are 5 stocks in basic structure and 6 more added with the policy.

Here in the model we see accumulating cause and effect relationships when dealing with stocks, which need time for them to respond, as well as instantaneous cause and effect relationships that require usually external causes to get the effect revealed. We should mention in analysis that time step or DT is 1/4, which alters accumulation and shows how frequent the stock is calculated next time. So, in general the formula for each stock is

$$Stock_t = Stock_{t-1} + (Inflow_{t-1,t} - Outflow_{t-1,t}), \quad (1)$$

where each stock at time  $t$  consists of the stock at time  $t-1$  and the difference between inflow and outflow.

The basic stocks are gasoline cars, diesel cars, hybrid cars, electric cars and air pollution. The



**Fig. 2.** Basic and policy structure  
 Source: developed by the authors using Stella Architect Software

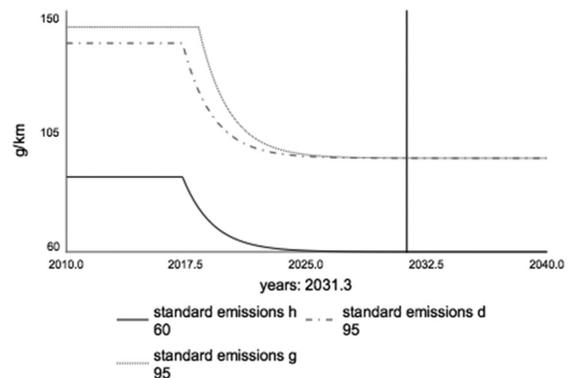
gasoline cars, diesel, electric and hybrid cars have sales as an inflow and retirement as an outflow.

Let us explain some stocks and relationships with variables such as converters in the policy part of the model.

The policy of our model is based on the feebate programme; it is the way how Andrew Ford offered to manage the level of air pollution [3]. Thus there are three aspects of the model: a goal-seeking emission standard part, the part that evaluates the feebate choice and influences the market shares and a financial part of a feebate fund and possible additional sources of filling. In policy part of the model there is a hypothesis and behavior features as well. The hypothesis is that gasoline/diesel/ hybrid cars emit such high levels of CO<sub>2</sub> emissions because there is no regulation on these levels and unless the regulation appears the behavior of air pollution won't change in time. Therefore given the regulation exists the tougher the desired level of emissions is the lower the standard emissions by each kind of car will be. Furthermore, we introduce a financial disincentive for a car owner to exploit the described kinds of cars. And the further his car is from the desired level of emissions the more the owner pays. This is the fee part of the feebate programme, it is not the lump sum of the penalty, but it partially resembles the German system of a circulate tax. Meanwhile, there are rebates that are offered per electric car and the more financially attractive the rebate comparing to the fee, the more new electric cars will be sold and the less CO<sub>2</sub> emissions will be discharged, because the market share of the electric cars will rise, but the rest of the

cars will be sold not so actively. Eventually, we should reduce the level of air emissions.

We introduced the desired level of CO<sub>2</sub> emissions per car at the same level as it is the European goal to reach by 2020 – 95 g/km of CO<sub>2</sub> for diesel and gasoline cars, for hybrid cars the goal is 60 g/km as it is one of the benchmarks of hybrid CO<sub>2</sub> emissions level that previously was paid a rebate, but since 2018 isn't in France, it is still appears to be suitable for Ukraine though. Thus, the more the difference between the desired and actual level of emissions (a gap) the more the owner should pay annually. There is a penalty for each g/km of CO<sub>2</sub> that is higher than the binding level, both of them vary according to the kind of the car. The amount of payment is diminishing as the gap decreases, however, there is a fixed payment when the car reaches the desired level of emissions because we assume that after the



**Fig. 3.** Goal-seeking behaviour of standard emissions stock  
 Source: built by the authors using Stella Architect Software

level is accomplished it will be changed with a new further policy introduced. There is a goal-seeking behavior that illustrated by exponential decay, the stock decreases, we see that for three of the kinds of vehicles the goal is reached in the 2030 year (Fig. 3).

The fee we would like to introduce is paid annually. For each gasoline and hybrid kinds of cars fee rates are proposed to be similar, and the most severe fee rate is imposed on the diesel car with regard to the European practice. We set the fee rates close to German case, namely for diesel cars the fee rate is 9.5 EURO or 289 UAH per car [5]. For hybrid car and gasoline car the fee rate is 4 EURO or 122 UAH per car. The payment rate with fee equivalent of 1 g/km is calculated as

$$\begin{aligned}
 \text{Payment rate} = & \text{IF } \text{TIME} > 2014 \text{ THEN} \\
 & (-\text{gap}_1 / \text{fee\_equivalent}) * \text{fee\_rate}_d + \\
 & + \text{payment\_for\_95}_d \text{ ELSE } 0.000001,
 \end{aligned} \tag{2}$$

where payment rate has units UAH per year.

Given we know the information about sales and receive payment from each type of car we can estimate the fees that we collect from all these sources. The fees is an inflow named “fees collected” (UAH/year) of the Balance in fund (UAH) – the stock for the feebate programme (Fig. 4).

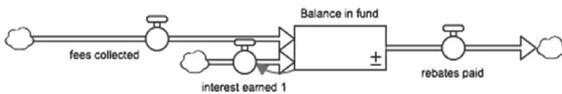


Fig. 4. Balance in feebate fund

Source: built by the authors using Stella Architect Software

The initial amount of money in stock is zero. The outflow is rebates paid (UAH/year). Rebates paid is determined by rebates multiplied by electric sales, because we pay rewards only for buying a pure electric car. With regard to the rebates we established a sum of payment that decreases as policy is close to its ending. First, the policy has policy status, the start and stop time and policy period (Fig. 5).

The start policy time is 2018 (year) and stop time is 2024 (year), the equation for policy period is

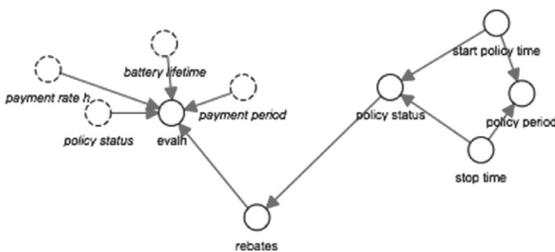


Fig. 5. Policy status

Source: built by the authors using Stella Architect Software

$\text{stop\_time} - \text{start\_policy\_time}$  or 6 years. The policy status has set to cover exactly time period between start and stop as

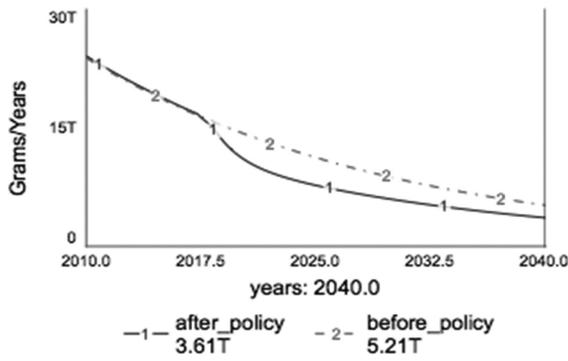
$$\begin{aligned}
 \text{Policy status} = & \text{IF} \\
 & (\text{TIME} > \text{start\_policy\_time}) \\
 & \text{AND } (\text{TIME} \leq \text{stop\_time}) \text{ THEN } 1 \text{ ELSE } 0.
 \end{aligned} \tag{3}$$

The logic says if the rebate is of a particular sum and the lifetime of the electric car (assumed as the battery life) is 10 years (in our case), then each year of the car exploitation the owner receives a reward for car usage rebates/battery\_lifetime. Each year of diesel/gasoline/hybrid car usage costs the owner  $\text{payment\_rate}_g / \text{payment\_period}$ . Thus, if the difference between the reward each year and the fee, so we would call it pure reward is more than 0 then it makes up a fraction of the fee, and the higher the fraction of the pure reward than a fee, the more the owner has interest to purchase a new electric car. Therefore the market share of gasoline/diesel/hybrid cars will be changed due to the demand adjustment that will take place.

We assume that the feebate fund should work automatically because it is planned as sustainable. We suppose that we started to collect fees several years before the policy because the initial value of the fund is 0. Likewise, we need the strong initial investment into the fund that is where government should be initiative. Let us assume that we can borrow money from the general governmental fund on ecological needs but only once, but the repayment will be after the policy ends, so only from 2025. In addition, since 2014 the fund earns 10 % of interest. The fees begin to flow into the fund in 2014 but the targeting of CO<sub>2</sub> emissions starts from 2018, which means that the payment rate is made up from the same fee rate but the fix starting amount of CO<sub>2</sub> emissions without policy. We borrow the 0.25 % of the general governmental fund on ecological needs, which is 7118,3 mln UAH [6]. The percentage was discovered in the process of simulating. The amount of borrowing becomes the amount of debt inflow to debt stock. The debt repaying is organized by the standard scheme where there is a debt body payment and interest payment of the remaining debt amount.

We suppose that we repay debt in 8 years at the rate of 17 % per year [5]. Thus, the repaying as inflow to governmental general fund on ecological needs from the balance in fund is a sum of debt body payments and interest payments. The fund shouldn't go bankrupt repaying the debt. The behavior of the model with the policy is the next step to discover.

As a result, we take a look at the level of CO<sub>2</sub> emissions comparing the behavior without policy and with the policy (Fig. 6).



**Fig. 6.** CO<sub>2</sub> emissions with and without policy  
 Source: built by the authors using Stella Architect Software

The level of total car emissions without policy is (5,206 bln g/year – 5,2 mln ton/year) and with policy (3,609 bln g/year – 3,6 mln ton/year), it means that the decrease the policy brings with achieving desired CO<sub>2</sub> level and feebate programme is 30.6 % or 1,589 bln g/year or about 1,6 mln ton/year. Consequently the air pollution drops too. The level of air pollution without policy is 658,449 bln g (or 658,4 mln ton) and with policy on – 601,208 bln g (or 601,1 mln ton of CO<sub>2</sub>), which illustrates 8.7 % of decline.

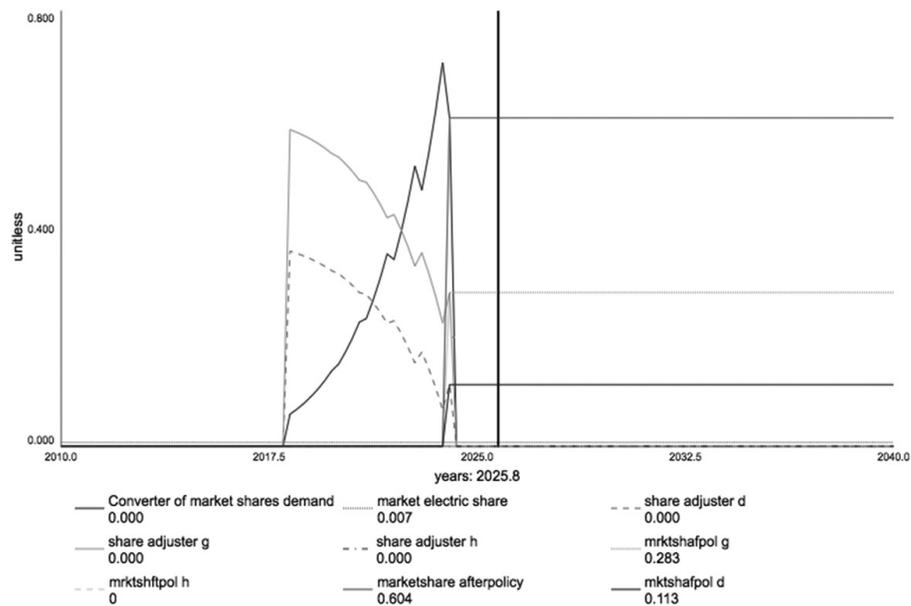
It is important to see what the market shares for each kind of cars are, because we planned to decrease the number of high-polluters and raise the electric car fleet. We can observe what happened since 2018 when the policy began (Fig. 7), in the policy period the market share of gasoline/diesel/hybrid cars turns from 0.608/0.378/0.007 to 0.283/0.113/0.000, whereas the market share of electric cars rises from 0.007 to 0.604.

**Conclusions and further research proposals.**  
 The results of the policy simulation turned out to be

quite satisfactory as they are consistent with the solution of the problem described. System Dynamics methods helped to recreate the cause and effect relationship and feedback loops that can occur within the final system with policy in reality. In the System Dynamics model we propose to set the level of permissible CO<sub>2</sub> emissions at the level of 95 g/km for diesel and gasoline cars and 60 g/km for hybrid cars. Based on the goal-seeking behavior if the policy starts in 2018 and the level of current CO<sub>2</sub> emissions declines once for two years the target will be achieved in about 2030.

To lessen emissions we introduce feebate programme that is the alternative to environmental taxes and fiscal ways to stimulate purchases of electric cars in Ukraine. The fees for diesel, gasoline or hybrid car are paid annually, whereas the rebate is paid once at the purchase time a new electric vehicle. The feebate fund uses initial investment from government, fees and interest earned to pay the rebates.

The last issue to consider is Implementation of the policy, which literally means the obstacles that policy can encounter on its way: legislative (the very policy, fund for feebates and binding levels of emissions should be set officially and executed), administrative (the fees collection and rebates involve administrative processes, monitoring and supervisory procedures), labour issue (employees are needed to work in the fund that requires extra expenses), informational (the citizens should be informed properly on the fact of policy, which means additional costs), public denial and lack of understanding (political protest against the policy), time issue (delays may cause the policy to stumble at any stage of the policy implementation).



**Fig. 7.** Market shares within and after policy  
 Source: built by the author using Stella Architect Software

Furthermore, we should consider an infrastructural aspect of the policy. Nowadays in Ukraine the key implementation obstacle towards tougher electric cars coverage is the lack of electric charging stations. The current number of stations covers only 20 % of the Ukrainian territory, thus most owners of electric cars (90 % of the total) charge their cars at home compared to 60 % of total home-chargers in the world. The other problem for electric cars market in Ukraine is high price on the vehicle and the price of resources for its maintenance, technical service. The last mentioned hindrances can be a negative influence on the electric purchase choice as of the customer's side, but they are not included in the policy polemics, so even if it does not cover the technical and service issues of the electric car usage, but they are involved

in the implementation development. These are the problems that one should deal with before and on the way of policy implementation and are the potential areas where the model can be deepened and expanded in future.

The policy states a solution to decrease CO<sub>2</sub> emissions and air pollution and change the role of electric cars on the market, thus pays car owners' attention to the environmental problems and makes them aware of the financial responsibility for the level of disastrous air emissions from car exploitation. Furthermore, there is not only an ecological advantage in using electric cars, but economic as well, since the fuel prices, supplementary materials for maintenance of gasoline and diesel cars are anticipated to grow in the future.

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### СИСТЕМА «ШТРАФІВ І ПІЛЬГ» ЯК АЛЬТЕРНАТИВА ОПОДАТКУВАННЮ ПРИ РЕГУЛЮВАННІ ВПЛИВУ АВТОМОБІЛЬНОГО ТРАНСПОРТУ НА НАВКОЛИШНЄ СЕРЕДОВИЩЕ

У статті розглянуто проблему застосування фінансових важелів регулювання навколишнього середовища, зокрема забруднення повітря транспортними засобами в Україні. Застосовуючи методи системної динаміки, зокрема метод РНАР<sup>2</sup>I, та спираючись на європейський досвід розв'язання проблеми, автори побудували модель системи «штрафів і пільг», метою якої є проведення ефективної державної політики зменшення забруднення повітря в Україні. Для зменшення рівня викидів CO<sub>2</sub> автори пропонують запровадити програму, яка є альтернативою іншим фінансовим важелям регулювання, насамперед екологічним податкам, кредитуванню та іншим фіскальним способам стимулювання закупівель електрокарів в Україні. Система «штрафів і пільг» передбачає, що плата за використання дизельних, бензинових або гібридних автомобілів сплачуватиметься щорічно залежно від рівня викидів, тоді як пільга (знижка) виплачуватиметься одноразово під час придбання нового електричного транспортного засобу. Запровадження програми потребує фонду фінансових ресурсів, який на початковому етапі буде сформований за рахунок інвестицій уряду, а згодом використовуватиме отримані відсотки та доходи для оплати пільг (знижок).

Проведений аналіз і реалізація моделі системної динаміки дають змогу розробити ефективну державну програму, що триватиме шість років, призведе до збільшення частки ринку електрокарів, зменшення частки ринку дизельних і бензинових автомобілів та значного зниження рівня шкідливих викидів і забруднення повітря. У статті також ідеться про важливі перешкоди на шляху реалізації державної програми, зокрема законодавчі, адміністративні, соціальні, інформаційні та інфраструктурні.

Результати дослідження можуть бути використані під час ухвалення управлінських рішень державними регуляторами. Запропонована модель може стати основою державної політики управління навколишнім середовищем, оскільки вона створює альтернативу оподаткуванню та сприяє збільшенню ефективності екологічного регулювання транспорту.

**Ключові слова:** системна динаміка, оподаткування, система «штрафів і пільг», фінансові важелі, регулювання навколишнього середовища, транспорт, викиди CO<sub>2</sub>, електрокари, сталий розвиток.

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