Problems of decision making in subject domain "Electric Vehicle"

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The worldwide market of electric vehicles (EV´s) is gaining momentum. Given that in the early 2000s the EV business was not considered as promising, today we can state with confidence that the future lies within electric vehicles domain. Due to the large amount of smog, the relevance of EV´s is growing faster every day. It is already clear at the governmental level how much the introduction of electric cars can help solving the environmental situation, so countries are actively creating governmental initiatives. There is currently a legislative initiative on the introduction of electric vehicles (EVI): a common policy of different countries to accelerate the production and adaptation of electric vehicles around the world. Currently, EVI includes such regions as Africa, Asia, Europe and North America, namely 14 countries: Canada, India, Germany, France, Finland, China and others.

Unfortunately, Ukraine does not have its own production of electric vehicles, and the infrastructure of charging stations was not developed at all few years ago, but at the end of 2020 the number of electric vehicles registered in Ukraine was about 25,853 units, compared to 5757 units in 2017, which shows an increase in the number by 450% in three years and outpaces the world growth rate, where for the corresponding period growth was less than 270%.

In fact, the demand among Ukrainians for "green" transport, significant steps in the development of renewable energy over the past 5 years, as well as the government's loyalty to import electric cars from abroad contributed to the spread of the use of electric cars among the population.

From December 2017 to the end of 2022 the Verkhovna Rada abolished the 20% tax on added value in the import of electric cars to Ukraine.

Most of the electric cars in Ukraine are not new, they are bought either abroad and imported by the owners or sold in the country by dealers. According to data for June 2018, the following electric cars are the most popular in Ukraine: Nissan Leaf - 1621 units, BMW i3 - 182, Tesla Model S - 123, Mercedes-Benz B-Class Electric Drive - 78, Smart Fortwo Electric Drive - 69, Tesla Model X - 57, KIA Soul EV - 53, Volkswagen e-Golf - 52, Toyota RAV4 EV - 46, Fiat 500e - 37.

Therefore, today Ukraine faces a huge number of tasks, the solution of which is necessary for the further development of the electric transport sector. And to solve these problems, the key is to analyze the current state of development of electric vehicles.

Let's move on to the task of analysis and selection of types of charging stations for Ukraine. The difficulty of solving it is that each machine has its own characteristics and can be charged with a certain type of charging, depending on its connector and the type of charging station. The solution of the problem is based on the need to build an ontology of the subject area "electric car".

As a rule, the computer ontology of the subject area means a triplet:

$O = < X, R, F >$, *where*

$X = \{x_1, x_2, \ldots, x_i, \ldots, x_n\}, i = 1, \ldots n$, *– a finite set of concepts of a given subject area;*

$R = \{r_1, \ldots, r_k, \ldots, r_n\}, R: x_1 \times x_2 \ldots \times x_n$ *– a finite number of semantically significant relationships between the concepts of the subject area;*

$F = X \times R$ *– a finite set of interpretation functions defined on a set of concepts and / or relations. A partial case of the task of a set of interpretation functions is a glossary, which is compiled for a set of concepts* X *.*

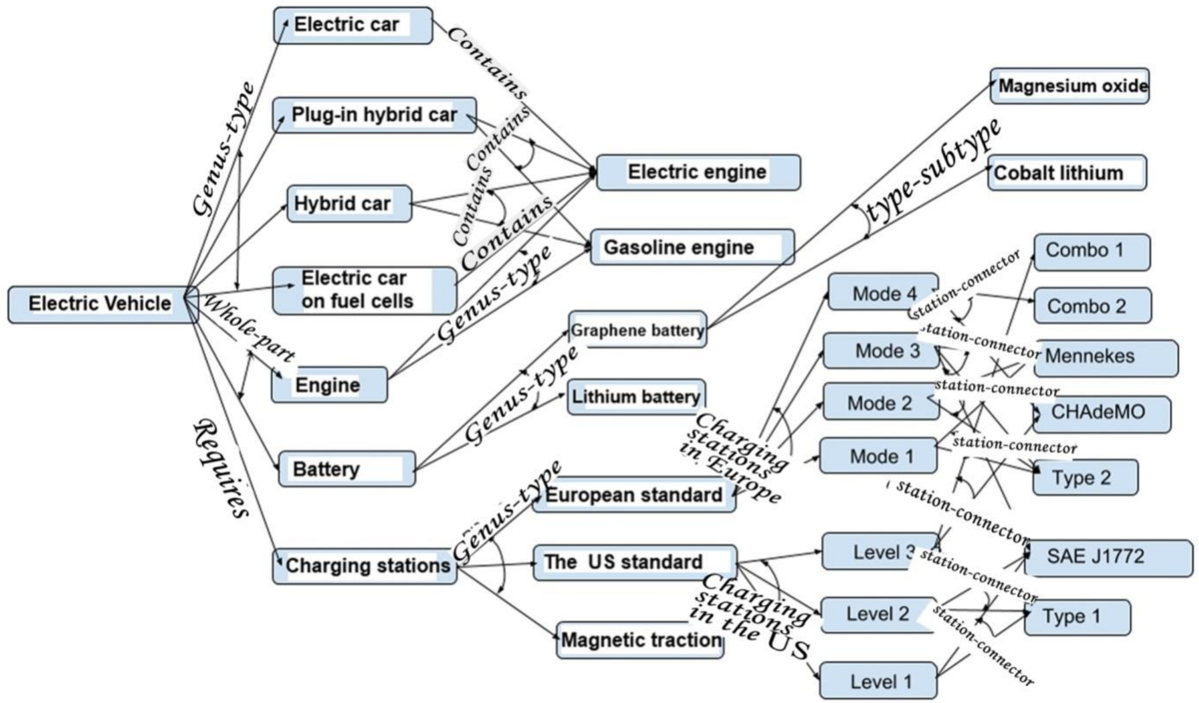
In this manner, an ontology is a system that describes the structure of a particular problem area and consists of many classes of concepts related to relationships and their definitions.

Let's build such a system for the specified subject area.

In this task we used OWL (Web Ontology Language − a language that allows you to describe classes and relationships between objects in them). Implementation was carried out in Protégé 5.2. This is a special environment created by the Stanford Center for Biomedical Informatics Research to build a knowledge base.

Let´s consider our subject area in detail to create its ontology. We formulate the set X *. It will represent classes and subclasses in the ontology. Concepts such as «Electric car», «Hybrid cars», «Plug-in hybrid cars», «Electric cars on fuel cells», «Internal combustion engine», «Electric motor», «Battery», «Graphene battery», «Lithium battery», «Lithium Cobalt», «Magnesium Oxide», «Charging Stations», «Magnetic Thrust», «Nino», «US Standard», «Level 1», «Level 2», «CCS Type 1», «Level 3», «CCS Combo 1», «CHAdeMO», «Standard of Europe», «Mode 1», «Mode 2», «Mode 3», «SAE J1772», «Mennekes», «CCS Type 2», «Mode 4», «CCS Combo 2».*

Let's build an ontograph of a fragment of the subject area "Electric car"



In this example, let's take a closer look at the components and connections of the "Electric Vehicle" subject area. Since there are different types of electric cars: electric car, hybrid car, plug-in hybrid car and car on fuel cells, each of them corresponds to a certain branch of the ontograph.

The main elements of an electric car, as in any other car, are the battery and the engine.

Charging stations in the world are divided according to standards. There are two main standards: European and American. Therefore, in the branch "Charging Stations", there is a division into subclasses "European Standards" and "US Standards". Despite the fact that the characteristics are almost similar, their names are different, "European Standards" branch on their characteristics to "Mode 1", "Mode 2", "Mode 3" and "Mode 4", and "US Standards" on their characteristics - on "Level 1", "Level 2" and "Level 3". The problem with charging stations is that not every electric car can be charged by every station. It all depends on the type of connectors that are installed during production. Moreover, American manufacturers prefer one type of connector, European - another. This is how the "Mennekes" and "Type 2" connectors are branched for European "Mode 1" and "Mode 2" standards; "Mode 3" connectors "Mennekes", "Type 2" and "SAE J1772"; for "Mode 4" connectors "CHAdeMo" and "Combo 2"; and for US standards: "Level 1" - "Type

1" and "SAE J1772"; "Level 2" - "Type 1" and "SAE J1772"; and "Level 3" - "CHAdeMo" and "Combo 1".

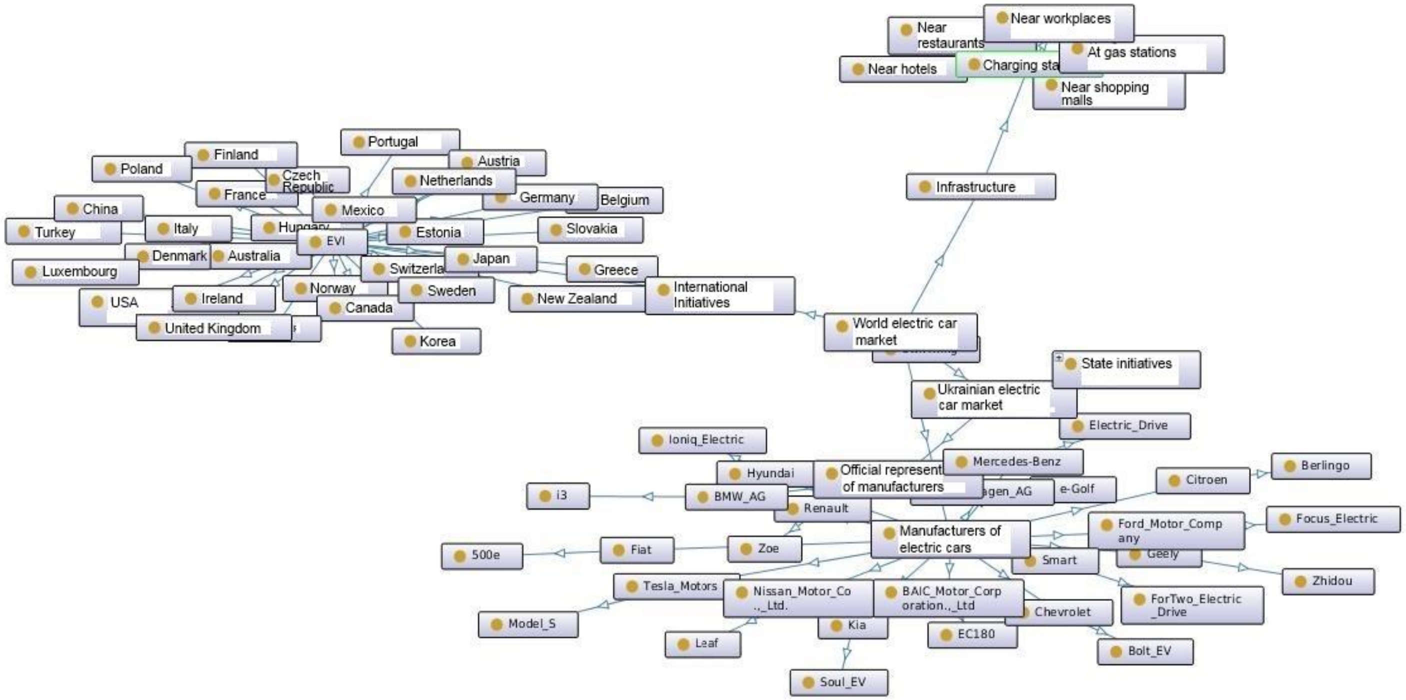
Also today there are achievements in the development of new wireless charging stations. They are also called magnetic traction charging. Japan has even launched a test bus, which is charged in this way. Therefore, in the branch "Charging Stations" there is a type of "Magnetic Thrust" as a type of charging.

Later in the report, the decision-making area will be considered as a multi-level structure, which has four levels and includes a problem area, a model area, a method area and an implementation area.

We will present a set of ontologies $\{O_{DM}\}$ *for presenting the decision-making process as a multilevel system of ontologies. Such a system of ontologies will include the presentation of problems of the subject area (formulation of the problem and, accordingly, its model, definition of the scheme / scenario / method of solution), ontology of subject-formal and formal representation (transformation of models into a formal record, definition of scenario, method and algorithm). knitting) and implementation of this process.*

To represent the level of the problem area, we construct a new ontology.

Onthology of the problem area



Analyzing it, one can understand what problems the "Ukrainian electric car market" has and how it differs from the "World car market". On the branch "World Electric Vehicle Market" you can see that there are many manufacturers of electric vehicles. Moreover, international initiatives involving a large number of leading countries are used for their development. Infrastructure for electric vehicles is developed. Charging stations are mostly installed in public places and at the homeowner's.

Considering the branch "Ukrainian market of electric cars" we can conclude that there are very few representatives or manufacturers of electric cars in Ukraine, relative to the total number of manufacturers. However, Ukraine has already created a state initiative and stimulates demand for electric cars by lowering taxes on their purchase. When placing gas stations for public use, you should pay attention to where exactly to install them. It is most rational to do as they do on the world market, ie to place where people will spend a certain amount of their time, because the car needs to be recharged.

Based on the results of the study, the following CONCLUSIONS can be drawn.

1. The ontology for the subject area "electric car" is constructed.

Protégé 5.2 development environment was used to build ontologies. This presentation makes it possible to assess the system-analytical problem area and to understand how best to use it.

2. An adapted mathematical model and method for assessing the effectiveness of quantitative and qualitative development of the organizational system of infrastructure of electric vehicles and hybrids in Ukraine and Kiev.

Specific conclusions were made:

3. The level of development of electric vehicle infrastructure of each region according to some separate criteria, from those selected for analysis. For example, the Nikolaev area has an average level of development on number of registrations of electric transport, however the level of development of system of charging stations - low. And vice versa:

with the average development of the qualitative and quantitative indicator of charging stations in Cherkasy region, the indicator of the level of registered electric transport is low. Such results are important for building local development plans.

4. The level of development of each region of Ukraine in all three areas selected for research. Such results are necessary for a global analysis of the industry, for example, to identify prosperous and underdeveloped regions, followed by an analysis of significant factors (which may include: resource level, income level, public awareness and awareness, etc.), as well as building prospects and industry development plans and related factors. For example, Chernihiv and Kropyvnytskyi oblasts have a very low level of industry development, in contrast to the very highly developed Odesa, Kharkiv oblasts and the city of Kyiv.

5. In general, the conducted work opens an opportunity for a large amount of further research, search and implementation of ways to solve the problems facing Ukraine in the development of electric transport and its infrastructure. Improving the energy network of charging stations (quantitative and qualitative; joining the state program "Large Construction" (to build "green" infrastructure and development of backward regions), *creating prospects for business and individuals, their incentives for development in the industry (eg , continuation of the program "warm loans" for the installation of charging stations), investment in the development and production of domestic electric vehicles and, importantly, the opportunity to pioneer in the production of agricultural machinery (in particular, as of today, the greatest potential is electric public transport: electric buses, trams - All these are goals that must be achieved to some extent in order to keep up with global trends in both technological (energy saving, renewable resources), environmental (environmental conservation) and conscious-intellectual (awareness of the need).*

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THANKS FOR YOUR ATTENTION!