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Julia Galchynska
D.Sc. (Economics), Associate Professor of the Department of Marketing and International Trade,
National University of Life and Environmental Sciences of Ukraine
11 Heroyiv Oborony Str., Kyiv, 03041, Ukraine
galchynskaya@gmail.com
ORCID ID:
https://orcid.org/0000-0003-4260-3072

Yaroslava Larina
D.Sc. (Economics), Professor of the Department of Marketing named after A. F. Pavlenko,
Kyiv National Economic University named after Vadym Hetman
54/1 Peremohy Ave., Kyiv, 03057, Ukraine
larin.sla@gmail.com
ORCID ID:
https://orcid.org/0000-0002-2712-7824

Olga Varchenko
D.Sc. (Economics),
Professor of the Department of Finance, Banking and Insurance,
Bila Tserkva National Agrarian University
8/1 Soborna Sq., Bila Tserkva, 09117, Kyiv region, Ukraine
omvarchenko@ukr.net
ORCID ID:
https://orcid.org/0000-0002-9090-0605

Nataliya Struk
D.Sc. (Economics),
Associate Professor of the Department of Accounting and Audit,
Ivan Franko National University of Lviv
18 Svobody Ave., Lviv, 79007, Ukraine
nstruk@econom.lnu.edu.ua
ORCID ID: https://orcid.org/0000-0002-1933-265X

Olena Gryshchenko
PhD (Economics),
Senior Researcher, National Science Center
«Institute of Agrarian Economics»
10 Heroyiv Oborony Str., Kyiv, 03041, Ukraine
lena@iae.kiev.ua
ORCID ID: https://orcid.org/0000-0003-2271-3629

Perspectives of Ukrainian bioenergy development: estimation by means of cluster analysis and marketing approach

Abstract
Development of the world economy requires energy supply, which under stable growth must be based on alternative energy resources. Bioenergy is an integral part of energy security supply in volatile countries. It can satisfy a considerable part of energy demand of agribusinesses and other companies as well as facilitate problem-shooting in energy, ecological and social sectors in some regions. Enhancing bioenergy in Ukraine is one of the strategic ways in the development of the alternative energy sector, taking into account high volatility of the country and significant potential of biomass available for energy production.
This research intends to determine conditions and mechanisms of development and functioning of bioenergy clusters based on preliminary specification of the bioenergy potential of the territories, taking into account modern marketing approaches.
This article contains evaluation of the bioenergy production growth in countries such as China, Germany, France, the USA, Canada, Brazil and Ukraine. The feasibility of the cluster approach for Ukrainian bioenergy development has been proved. In order to combine Ukrainian regions according to all types of energy resources the authors applied the method of clustering analysis. The key point of the method implies that, based on the given set of indicators which are defined as the main characteristics of the object, every object

of the population belongs to a similar class. Therefore, in order to study the efficiency of usage of bioenergy resources in a particular region, it is necessary to classify a set of indicators to identify standard forms. To systemize Ukrainian regions, the Isodata algorithm Isodata, based on the types of the economic and energy potential of biomass, is taken into account. To implement the analysis, the following indicators are considered: the biomass energy potential of primary cell waste, the biomass energy potential of trimming, the biomass energy potential of refining, the energy potential of wooden biomass, the mold biomass potential, the energy potential of bioenergy crops, the corn energy potential (biogas).
Market players organize groups with regard to their industries, territories and other factors, namely clusters which are likely to become effective tools in while carrying out scale projects under tough competition. In the minor energy sector cooperation between research and manufacturing enterprises, which satisfies energy needs both of cities and individual customers, is growing. This approach perfectly meets all requirements of the regional development of Ukrainian bioenergy.
The main goal of bioenergy clusters is to develop competitive advantages of regions by increasing all types of biomass and biofuel production. This implies the following priorities: creation of a database of agribusiness enterprises, which potentially are members of the cluster and corresponding infrastructure, establishment of marketing communications in order to inform members and potential investors about bioenergy advantages, introduction of regional databases by means of webpages, newsletters, public discussions etc., enhanced vocational training of bioenergy industry employees and investment attraction to finance bioenergy projects.
As a result, the authors of the paper propose a classification of Ukrainian regions based on the indicators of the economic energy potential of wastes and energy crops in agribusinesses, which is the basis for cluster formation. Vinnytsia, Kyiv, Poltava, Sumy, Khmelnitsky and Chernihiv regions refer to the first type with the biggest bioenergy potential, which makes it possible to create 2 energy clusters by combining central-west and north-east regions. Such a methodology gives an opportunity to satisfy the needs of the regions and districts which need additional energy resources taken from own biomass.
Priority tasks of the bioenergy cluster include: development of the database of agribusiness entities which potentially are the cluster members and corresponding infrastructure, informing members and investors about bioenergy benefits, creation of the regional information database identifying the resources, capacity and the transport system, vocational training, investment attraction in order to implement bioenergy projects. Based on clusters, economic relations build up a competitive and sound investment climate to support the economy, which, in turn, provides high living standards. The authors have defined the procedure for exercising the cluster initiative and determined the structure of marketing support for cluster projects.
Keywords: Bioenergy; Biomass Capacity; Cluster Analysis; Classification of Regions; Bioenergy Cluster; Cluster Initiative
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Гальчинська Ю. М.
доктор економічних наук, доцент кафедри маркетингу та міжнародної торгівлі,
Національний університет біоресурсів і природокористування України, Київ, Україна
Ларіна Я. С.
доктор економічних наук, професор кафедри маркетингу ім. А. Ф. Павленка,
Київський національний економічний університет імені Вадима Гетьмана, Київ, Україна
Варченко О. М.
доктор економічних наук, професор кафедри фінансів, банківської справи та страхування,
Білоцерківський національний аграрний університет, Біла Церква, Україна
Струк Н. С.
доктор економічних наук, доцент кафедри обліку й аудиту,
Львівський національний університет імені Івана Франка, Львів, Україна
Грищенко О. Ю.
кандидат економічних наук, провідний науковий співробітник,
ННЦ «Інститут аграрної економіки», Київ, Україна

Визначення перспектив розвитку біоенергетики в Україні з використанням кластерного аналізу та маркетингових підходів

Анотація. У статті визначено світові тенденції розвитку біоенергетики. Здійснено оцінювання динаміки обсягів виробництва біоенергії в Китаї, Німеччині, Франції, США, Канаді, Бразилії та Україні. Наголошено на необхідності активного розвитку біоенергетики як одного з стратегічних напрямів розвитку сектору альтернативних джерел енергії в Україні, враховуючи високу залежність країни від імпортних енергоносіїв, і великий потенціал біомаси, доступної для виробництва енергії. Доведено, що дієвим інструментом реалізації масштабних біоенергетичних проектів підприємств в умовах інтенсивної конкуренції можуть стати учасники ринку, об'єднані в групи за галузевим, територіальним

чи іншим принципом – кластери, досвід створення яких переконує в перспективності такого підходу розвитку економіки. У малій енергетиці розвиток отримують мережеві форми взаємодії науково-виробничих фірм, які забезпечують потреби муніципальної енергетики, окремих споживачів. Такий підхід найбільшою мірою відповідає потребам регіонального розвитку біоенергетики в Україні. У статті визначено мету та пріоритетні задачі діяльності біоенергетичних кластерів, до яких зокрема віднесено створення бази суб'єктів агробізнесу, що є потенційними учасниками кластера та відповідної інфраструктури; інформування учасників та інвесторів про переваги біоенергетики; створення інформаційної бази регіону з визначенням локалізації джерел сировинної бази, переробних потужностей, транспортної системи; підвищення рівня кваліфікації працівників у сфері біоенергетики; залучення інвесторів для фінансування розвитку біоенергетичних проектів.
Для об'єднання областей України за усіма видами енергетичних ресурсів автори скористалися методом кластерного аналізу. Для проведення такого аналізу за допомогою алгоритму «Isodata» вибрано показники: енергетичний потенціал біомаси первинних відходів рослинництва, енергетичний потенціал біомаси обрізки плодових дерев, енергетичний потенціал біомаси відходів переробної промисловості, енергетичний потенціал деревної біомаси, біогаз з гною, енергетичний потенціал енергетичних культур, енергетичний потенціал кукурудзи (на біогаз).
У результаті запропоновано класифікацію областей України за показниками економічного енергетичного потенціалу відходів та енергетичних культур у сільськогосподарських підприємствах у ринковому обігу, що дозволило виділити три типи областей, що є підставою для утворення енергетичних кластерів. До першого типу з найбільшими біоенергетичними потенціалами увійшли Вінницька, Київська, Полтавська, Сумська, Хмельницька, Чернігівська області, що дозволило створити два енергетичних кластери, об'єднавши центрально-західні, а також північно-східні області. Такий методологічний підхід дає змогу задовольнити потребу областей і районів у додаткових енергоресурсах енергією на основі власної біомаси.
Доведено, що економічні відносини на основі кластерів формують модель конкурентоздатної та інвестиційно привабливої економіки, що забезпечує високі рівень та якість життя населення. У статті визначено також порядок запуску кластерної ініціативи та структуру маркетингового забезпечення кластерного проекту.
Ключові слова: біоенергетика; потенціал біомаси; кластерний аналіз; класифікація областей; біоенергетичний кластер; кластерна ініціатива.

Гальчинская Ю. Н.
доктор экономических наук, доцент кафедры маркетинга и международной торговли,
Национальный университет биоресурсов и природопользования Украины, Киев, Украина
Ларина Я. С.
доктор экономических наук, профессор кафедры маркетинга имени А. Ф. Павленко,
Киевский национальный экономический университет имени Вадима Гетьмана, Киев, Украина
Варченко О. М.
доктор экономических наук, профессор кафедры финансов, банковского дела и страхования,
Белоцерковский национальный аграрный университет, Белая Церковь, Украина
Струк Н. С.
доктор экономических наук, доцент кафедры учета и аудита,
Львовский национальный университет имени Ивана Франко, Львов, Украина
Грищенко Е. Ю.
кандидат экономических наук, ведущий научный сотрудник,
ННЦ «Институт аграрной экономики», Киев, Украина

**Определение перспектив развития биоэнергетики в Украине
с использованием кластерного анализа и маркетинговых подходов**

Аннотация. В статье определены мировые тенденции развития биоэнергетики. Проведена оценка динамики объемов производства биоэнергии в Китае, Германии, Франции, США, Канаде, Бразилии и Украине. Отмечена необходимость активного развития биоэнергетики как одного из стратегических направлений развития сектора альтернативных источников энергии в Украине, учитывая высокую зависимость страны от импортных энергоносителей и значительный потенциал биомассы, доступной для производства энергии. Доказано, что действенным инструментом реализации масштабных биоэнергетических проектов предприятий в условиях интенсивной конкуренции могут стать участники рынка, объединенные в группы по отраслевому, территориальному или другому принципу – кластеры, опыт создания которых убеждает в перспективности такого подхода развития экономики. В малой энергетике развитие получают сетевые формы взаимодействия научно-производственных фирм, которые обеспечивают потребности муниципальной энергетики, отдельных потребителей. Такой подход в наибольшей степени отвечает потребностям регионального развития биоэнергетики в Украине. В статье определены цели и приоритетные задачи деятельности биоэнергетических кластеров, к которым в частности относится создание базы субъектов агробизнеса, которые являются потенциальными участниками кластера и соответствующей инфраструктуры; информирование участников и инвесторов о преимуществах

биоэнергетики; создание информационной базы региона с определением локализации источников сырьевой базы, перерабатывающих мощностей, транспортной системы; повышение уровня квалификации работников в сфере биоэнергетики; привлечение инвесторов для финансирования развития биоэнергетических проектов.
Для объединения областей Украины по всем видам энергетических ресурсов авторы воспользовались методом кластерного анализа. Для проведения такого анализа с помощью алгоритма «Isodata» были выбраны показатели: энергетический потенциал биомассы первичных отходов растениеводства; энергетический потенциал биомассы обрезки плодовых деревьев энергетический потенциал биомассы отходов перерабатывающей промышленности; энергетический потенциал древесной биомассы; биогаз из навоза; энергетический потенциал энергетических культур; энергетический потенциал кукурузы (на биогаз).
В результате предложена классификация областей Украины согласно показателям экономического энергетического потенциала отходов и энергетических культур в сельскохозяйственных предприятиях в рыночном обороте, что позволило выделить три типа областей, что является основанием для образования энергетических кластеров. К первому типу с наибольшими биоэнергетическими потенциалами отнесены Винницкая, Киевская, Полтавская, Сумская, Хмельницкая, Черниговская области. Это позволило создать два энергетических кластера, объединив центрально-западные, а также северо-восточные области. Такой методологический подход позволяет удовлетворить потребность областей и районов в дополнительных энергоресурсах энергией на основе собственной биомассы.
Доказано, что экономические отношения на основе кластеров формируют модель конкурентоспособной и инвестиционно привлекательной экономики, обеспечивая высокий уровень и качество жизни населения. В статье определены также порядок запуска кластерной инициативы и структура маркетингового обеспечения кластерного проекта.
Ключевые слова: биоэнергетика; потенциал биомассы; кластерный анализ; классификация областей; биоэнергетический кластер; кластерная инициатива.

1. Introduction

Development of the world economy both in general and in some countries and regions in particular requires significant energy resource provision which should be based on the usage of alternative energy resources under the sustainable growth concept. Bioenergy plays an important role in achieving an appropriate level of energy-based country security and can satisfy most of the demand in agricultural and other businesses as well as facilitate much of energy, ecological and social issues in some regions. In particular, at this stage, bioenergy is a leading energy source in the EU member states. «The conception of bioenergy input to the future energy mix of EU is a vitally important for mid-term and long term climate aims» (Mandley et al., 2020). Bioenergy value is gathering pace in Asia and Lain America. Non-renewal exploitation reduced by bioenergy technology implementation will result in energetic and economic self-sufficiency of the Ukrainian state and its regions.

2. Brief Literature Review

Ukrainian scientists Heletukha & Zhelezna (2013), Denysenko (2020), Kaletnik & Pyndyk (2013; 2016), Romanyshyn & Sadovnyk (2017), Roik & Kurylo (2013), Syvolapov, Huz, Novytskyi and Marchenko (2016) and others are studying modern ways of bioenergy implementation and its perspective evaluation. The potential of renewable sources of energy in Ukraine has been assessed by Syvolapov, Huz, Novytskyi and Marchenko (2016). The share of bioenergy with regard to the Ukrainian power saving policy has been analyzed by Royiik, Kurylo, Ganzhenko, Gumentyk, Kaletnyk, Pyndyk, Kogut, Romanyshyn and Sadovnyk. The abovementioned researchers claim numerous obstacles in the development process of the Ukrainian bioenergy. At the same time, regional growth of bioenergy often remains beyond studies. Among foreign scientists bioenergy issues are viewed by Durus, Tahir, Foster, Dinin, Klensi, Kalitzkiy, Goldwin, Eastwood, Reid, Ali, Field, Eastwood, Durusut, Zheng Zhao, Yu Long Chen, Pui-Donhg Changh, Mandli, and Yunginger who highlight bioenergy growth peculiarities in the USA, Ireland, Germany, Austria and China. In the latter works, the authors view regional aspects of bioenergy in terms of efficient land use. For instance, they point to the fact that «intensive bioenergy frequently results in intensive carbon emissions due to the changes in land use as well as manufacturing, harvesting and transporting» (Reid, Ali, & Field, 2019). Focus on the development and maintenance of bioenergy clusters is made in studies by Plieninger, Thiel, Bens & Hüttl (2008), and Rasmussen et al. (2020), who describe both conditions and the process of creation of bioenergy clusters in some European countries.

3. Purpose

The purpose of this paper is to define the conditions and mechanisms of creation of bioenergy clusters and their functioning based on a pre-analysis of the territory bioenergy potential by taking into account different cultures and local marketing approaches.

4. Research Data and Methodology

In order to integrate Ukrainian regions in terms of all kinds of energy resources, the authors used the method of a rating theory and a cluster analysis. The principle of the method lies in the fact that based on predefined features which are identified as the main object characteristics, each object refers to the class from which it varies the least. Under the algorithm of classification according to the given principal, there is a removal feature.

In Euclidean space, the distance between vectors X and Y with coordinate $X(x_1, x_2, ..., x_n)$ and coordinate $Y(y_1, y_2, ..., y_n)$ is defined as:

$$D=\sqrt{\sum_{1}^{n}(x_i - y_i)^2} = ||X - Y|| . \quad (1)$$

The proximity of the object which is classified according to the prototypes of the class is used as a classification criterion, and such an approach is called the object classification for the minimum proximity criteria.

There are several methods of cluster identification: the basic method of cluster analysis, the maximum distance algorithm (the furthest clusters are identified first); the algorithm of intra-group average and the Isodata algorithm (Iterative Self-Organizing Data Analysis Techniques).

The result of the layered grouping in the cluster analysis is the total allocation of measurements into homogeneous groups. The cluster analysis is based on the similarity of objects. The identification of the most similar entities assists in the total allocation of measurements into groups (clusters). Apart from combinatorial groups, the cluster analysis requires a group division taking into account corresponding features. Sharply defined notions of each group and their quantity are defined by the program.

The uniformity of the total is defined by the rule of a certain metric calculation which identifies the unit of the similarity of units in the aggregate. Its choice is a key to cluster analysis which influences on the final total allocation into groups. The most well-known is Euclidean metric, according to which the distance between objects is calculated as:

$$C_{jk} = [\sum_{i=1}^{m} (z_{ij} - z_{ik})^2]^{\frac{1}{2}} , \quad (2)$$

where:

z_{ij} and z_{ik} - the standardized average i-th in j-th and k-th unit of the population.

If elements x_i are equal, the weighted Euclidean distance is calculated with value ω_i:

$$C_{jk} = [\sum_{i=1}^{m} \omega_i (z_{ij} - z_{ik})^2]^{\frac{1}{2}} . \quad (3)$$

As the proximity of the classifying object to certain analogues will be used as the criterion for its implementation, such an approach is called the classification of the objects based on the minimum bias criterion. Therefore, in order to explore the efficiency of regional bioenergy resources utilization, it is necessary to classify based on the abovementioned criteria to identify standard enterprises. To classify Ukrainian regions in terms of their biomass economic power potential, the Isodata algorithm has been selected (Lukashin, 2003; Mandel, 1988). It has a wide range of extra heuristic procedures included into integration solution.

5. Results

In the past two decades, bioenergy has become one of the most effective and perspective trends of alternative energy. The production process and further use of bioenergy resources comply with the Paris Agreement (COP21). The boost of bioenergy development is determined by the following factors: implementation of «green» state programs, shortage of non-renewable resources storage, rising energy prices and enhancement of bioenergy competitiveness.

The situation regarding bioenergy production significantly differs around the globe (Table 1). Accordingly, China, Germany and Brazil are the countries with the quickest growth. At more controlled pace bioenergy is explored by Canada and France. Despite her substantial potential, Ukraine is insufficiently developing this economic sector.

It can be observed that the growth rate of bioenergy production in Canada and the USA is slowing down. In Ukraine, this trend has been gaining pace since 2015. Bioenergy industry development depends on bioenergy materials, croplands, the volume of imports, government incentives and other factors.

In terms of the current severe competition bioenergy clusters, grouped by industry, area and other factors, are expected to both facilitate the implementation of large-scale bioenergy projects and boost economy development. In particular, bioenergy clusters have been created in Poland (Rasmussen, Giełczewski, Wójtowicz, & Rosemarin, 2020), as well as in Austria and Germany (Plieninger, Thiel, Bens, & Hüttl, 2008). Clusters, which are defined as spatial proximity between companies and branches, take into account the following advantages of agglomeration: low transport costs and a possibility of intangible relations, for example information and experience exchange (Dannenberg & Kulke, 2005).

Power economy includes different types of clusters. In high capacity energy, «traditional» types of clusters are formed around core business presented by the largest and the most competitive companies which export energy and services beyond the region. Low capacity energy is dominated by research and manufacturing companies which satisfy the needs of local public power systems (municipal electric utility) and consumers. The latter approach meets the needs of the regional development of bioenergy in Ukraine.

The main target of bioenergy clusters is to develop competitive advantages of regions by means of output ramp-up of all types of biomass and biofuel which intends to solve the following tasks:

- developing a base of agribusiness entities which are potential participants of the clusters and the corresponding infrastructure;
- arranging the marketing communication system to inform the participants and potential investors about the advantages of bioenergy;
- setting the regional database by means of creating webpages, publications, public discussions, identifying the raw materials basis and introducing a transport system;
- vocational training of the staff engaged in bioenergy;
- attraction of domestic and international investors to financing bioenergy projects.

The triple helix - business, government and science - is necessary to develop clusters (Gerashchenko, Nezhuga, & Okseniuk, 2018). Given this condition, constant development of clusters is sustained with the establishment of relationships between end product companies or service companies, suppliers of specialized products (biomass in particular), financial institutions and related companies.

Additionally, to sustain cluster development, it is necessary to join firms which work with distribution channels or consumers, infrastructure providers, trade associations and other entities that support cluster members, organizations which set standards, public and other organizations which provide vocational training, education, data provision and marketing research, as well as with public authorities who impact clusters.

Table 1:
Bioenergy production track record in both the world and particular countries (GWh)

	2000	2005	2015	2018	2018 to 2000, %	2018 to 2015, %
World	142,261	206,379	466,697	522,552	3.7 times	+12%
China	2,421	5,200	40,738	67,301	27.8 times	1.7 times
France	2,479	3,391	6,522	8,335	3.4 times	1.3 times
Germany	4,331	14,708	50,326	50,880	11.7 times	+1%
Ukraine	0	0	199	301	-	1.5 times
Canada	8,172	8,965	12,683	10,661	1.3 times	-16%
USA	56,180	57,981	70,067	67,885	1.2 times	- 3%
Brazil	7,855	13,643	49,892	54,498	6.9 times	+9%

Source: IRENA (2020), Renewable Capacity Statistics 2020; IRENA (2020), Renewable Energy Statistics 2020, The International Renewable Energy Agency, Abu Dhabi

The methodology of cluster generation by Fox Williams suggests the following stages:
1. To identify the core: companies which produce the core product of the cluster;
2. To disclose support: equipment and service suppliers for core companies;
3. To identify soft infrastructure: education, marketing, legislation and finances;
4. To set apart physical infrastructure (Gerashchenko, Nezhuga, & Okseniuk, 2018).

In order to classify Ukrainian regions by the types of biomass energy potential, the Isodata algorithm was applied. The base value of the latter is set by the way of the matrix which has n columns and m lines:

	X_1	X_2	...	X_n
Y_1	x_{11}	x_{12}	...	x_{1n}
Y_2	x_{21}	x_{22}	...	x_{2n}
...		...	...	...
Y_m	x_{m1}	x_{m2}	...	x_{mn}

where:
X_i - the vector-column (i = 1, 2, ..., n);
Y_j - the vector-line (j = 1, 2, ..., m).

In this case, the columns are the indicator names, and lines are the range value.

Research index numbers:
X_1 - biomass power potential of primary waste of crops;
X_2 - biomass power potential of trimming waste;
X_3 - biomass power potential of refinery waste;
X_4 - energy potential of wood biomass;
X_5 - biogas from mold;
X_6 - potential of energy crops;
X_7 - corn energy biogas potential.

The Isodata algorithm is similar to the one which evaluates ave (average) in intergroups. Similar to that algorithm, the cluster cores are random ave which are evaluated interactively. Unlike the previous algorithm, Isodata contains a range of additional heuristic procedures integrated into the scheme.

At the first stage, it is necessary to define a range of the initial cluster core N_c Z_1, Z_2, ..., Z_{Nc}. While working with the range {x_1, x_2, x_N}, the Isodata algorithm requires three main steps:
1) classification parameters are identified;
2) modes are allocated according to clusters which correspond to primary cores;
3) an image set which includes fewer θ_N elements is excluded;
4) each core cluster is adjusted to the sample mean;
5) an average distance between objects, which are part of subset S_i, is calculated and is supposed to be the cluster core;
6) the general average distance between objects which belong to separate clusters and corresponding core clusters is calculated;
7) depending on mathematical terms implementation the transition to step 8 or 11 is done or iteration is repeated;
8) for each subset of random images, the standard deviation vector σ_j; is calculated;
9) each standard deviation vector σ_j , has the maximum of element $\sigma_{j\,max}$;
10) the core cluster is determined;
11) the distance D_{ij} between all pairs of the core clusters is measured;
12) the distance D_{ij} is compared to θ_c. Distances which appeared to be less than θ_c, are ranked by increase, the next step should include clustering;
13) each distance $D_{iL\,jL}$ is calculated to match a particular cluster pair with cores z_{il} and z_{jl} ;
14) if the current iteration circle is final, the algorithm implementation comes to its end. Otherwise, it is required to return to Step 1, if the parameters of the cluster have to be changed, or to the Step 2 where the parameters do not change.

The classification results, carried out according to the mentioned algorithm, are displayed in Table 2, where X_1 - primary crop waste, X_2 - trimming waste, X_3 - refining waste, X_4 - wood biomass, X_5 - mode biomass, X_6 - energy crops, X_7 - corn for biogas.

Based on the results of the given classification, Table 3, where Ukrainian regions are located within the clusters, is formed.

To consolidate all the regions by types of energy resources, we applied cluster analysis, Euclidean metric in particular. It allowed us to use a range of indices which are taken as the basic object characteristics. Each object from the general totality is referred to the class from which it differs the least. Consequently, three types of regions have been formed as a basis for energy clusters. The first type was made up of regions with the highest bioenergy potential, in particular Vinnytsia, Kyiv, Poltava, Sumy, Khmelnytsky and Chernihiv. It allowed us to establish two energy clusters with regard to the central west and the north-east of the country (Figure 1).

This method enables regions and districts to satisfy their extra energy resources produced by means of own biomass (Figure 2).

Based on estimations and researches two clusters are formed - North-East and Central-West which will supply and produce heating and electric energy from biomass. The latter shows significant possibilities and perspectives of the bioenergy market in Ukraine (Table 4).

Arranging bioenergy clusters, based on evaluation of bioenergy potential in particular regions, provides for the utilization of up-to-date methodology of cluster arrangement (Galchynska, 2019). Clusters are one of the most efficient means of implementation of both innovative

Table 2:
The results of the classification (Euclidean metric)

	X1	X2	X3	X4	X5	X6	X7	Average distance	Object number
					Average				
Cluster 1	704.2	2	17	215	23	129.8	101.2	167.9	6
Cluster 2	124.6	0.8	0	311.9	10.8	118.4	97.1	191	7
Cluster 3	255.7	3.5	51	47.2	13.2	108	49.8	119.9	11
					Dispersion				
Cluster 1	124	2.8	24.6	107.5	29.3	65.5	53	40.8	0
Cluster 2	84	0.8	0	192.5	10.3	80.2	75.7	117.7	0
Cluster 3	91.6	5	37.6	46.6	10.2	74.3	31.5	53.1	0
					Deviation				
Cluster 1	17.6	142.9	144.2	50	127.6	50.4	52.4	24.3	0
Cluster 2	67.4	101.5	0	61.7	95.4	67.8	78	61.7	0
Cluster 3	35.8	142	73.7	98.8	76.7	68.8	63.1	44.3	0

Source: Compiled by the authors

Table 3:
Classification of Ukrainian regions based on the potential rates of waste and energy crops in agribusinesses in 2019 market turnover, thousands of tons of oil equivalent

Region	Primary crops waste	Trimming waste	Refining waste	Wood biomass	Biogass from mode	Energy crops	Corn for biogas	distance km	Cluster number
Vinnytsia region	569.73	7.64	57.84	157.77	31.51	48.70	37.41	183.79	1
Kyiv region	761.02	0.67	7.52	371.66	78.36	76.74	52.82	189.96	1
Poltava region	827.43	0.68	36.85	72.23	14.36	180.40	108.34	196.61	1
Sumy region	578.97	0.45	0.00	216.00	2.22	185.50	158.21	150.84	1
Khmelnytsky region	640.17	1.93	0.00	170.45	10.59	89.13	85.21	91.88	1
Chernihiv region	847.82	0.50	0.00	302.05	0.75	198.50	165.20	194.43	1
Volyn region	84.24	0.20	0.00	228.34	10.49	181.68	187.21	144.01	2
Zhytomyr region	221.83	0.13	0.00	728.65	2.60	231.56	168.31	448.44	2
Zakarpattia region	0.00	0.74	0.00	269.27	0.44	118.64	50.15	140.19	2
Ivano-Frankivsk region	149.29	0.54	0.00	215.27	16.73	39.44	36.38	141.05	2
Lviv region	199.92	1.02	0.00	271.84	29.29	36.27	30.32	137.18	2
Rivne region	175.38	0.37	0.00	327.42	13.71	176.61	176.97	112.25	2
Chernivtsi region	41.63	2.41	0.00	142.35	2.18	44.63	30.12	213.61	2
Dnipro region	222.02	2.42	31.84	22.83	24.80	109.89	50.71	47.25	3
Donetsk region	188.85	0.62	21.33	19.81	23.62	223.64	101.32	149.14	3
Zaporizhzhia region	200.35	2.47	78.99	6.97	11.52	100.55	44.71	74.48	3
Kirovohrad region	309.31	0.66	99.17	29.25	4.43	35.64	15.64	109.55	3
Luhansk region	113.43	0.35	12.91	56.78	1.36	47.22	14.55	163.92	3
Mykolaiv region	194.69	6.66	85.76	9.66	3.65	103.44	32.27	82.26	3
Odesa region	321.98	17.45	114.63	24.39	7.16	258.08	95.63	183.90	3
Ternopil region	353.02	1.15	0.00	75.94	16.45	37.89	36.98	134.14	3
Kharkiv region	230.44	1.08	41.51	112.02	18.63	54.53	20.57	93.18	3
Kherson region	239.36	5.21	33.43	12.98	3.40	144.01	86.88	67.19	3
Cherkasy region	439.22	0.96	41.51	148.11	30.65	72.74	49.06	213.34	3

Source: Compiled by the authors

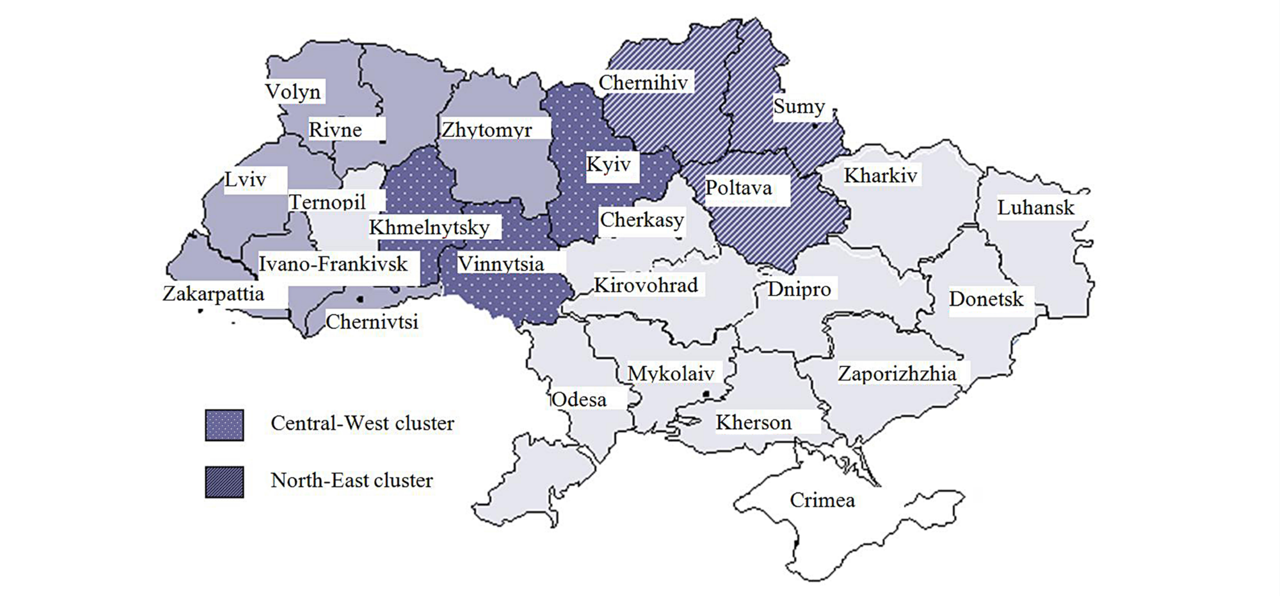

Figure 1:
Classification of Ukrainian regions based on energy and economic biomass indices (Euclid method) in 2019
Source: Created by the authors based on own calculations

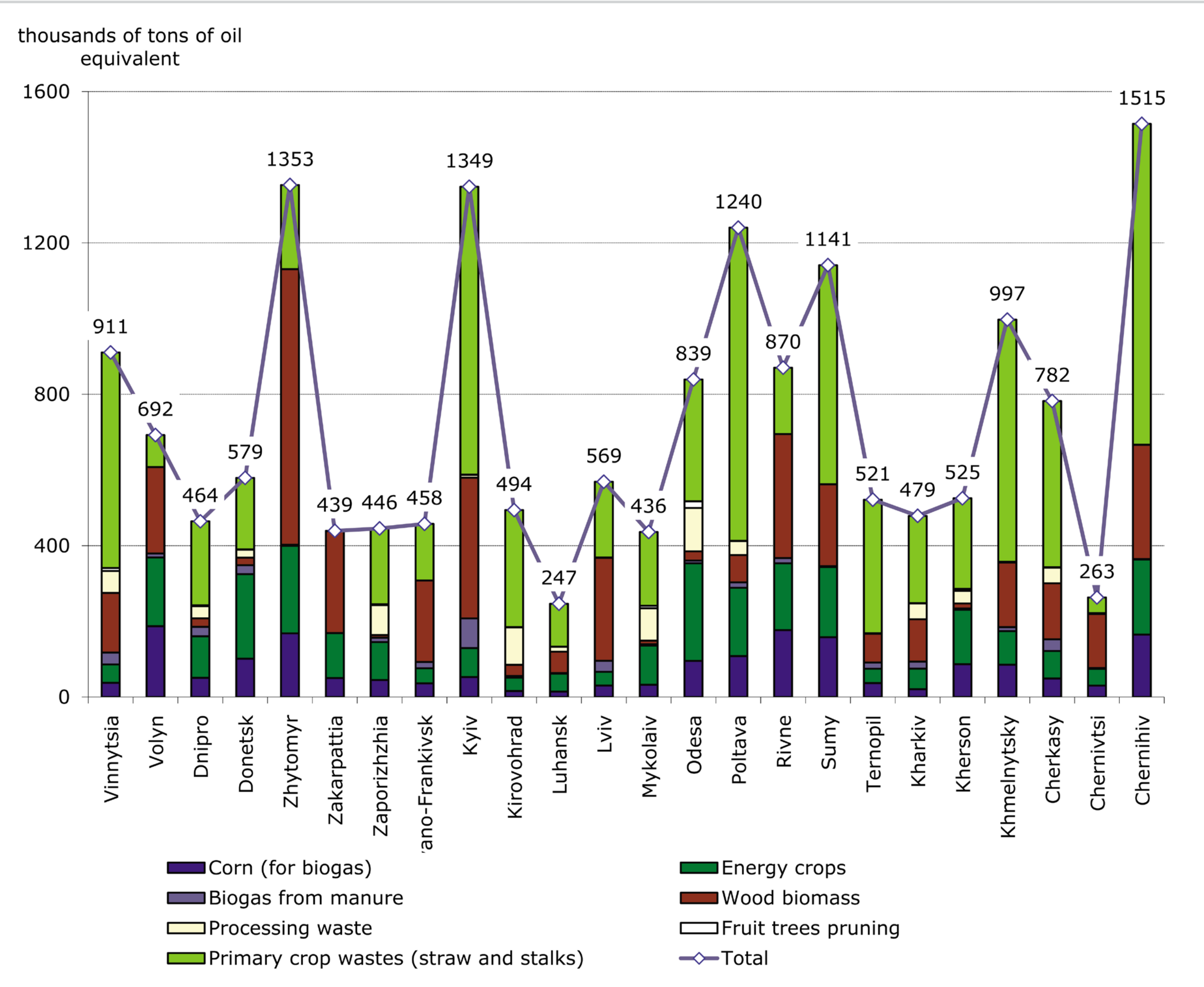

Figure 2:
Economic energy potential of biomass of agricultural enterprises, 2019
Source: Compiled by the authors

processes and forms of regional development, where conglomerates with reduced costs due to mutual technological cooperation have become more competitive than separate enterprises. Cluster mergers give rise to different economic areas aiming to expand the free trade zone, free flows of capital and human resources, Also they function as structural components of the global system.

Economic relations based on clusters create competitive and sound economy which provides high living standards. Clusters are necessary because the implementation of innovation requires resources and expertise which are often beyond a separate company; clusters are a combination of competition and cooperation.

Clusters and regional production systems are sources and factors of economic development of territories. The main target of the cluster is to increase domestic and international competition of its members due to scientific research and innovations, education and training, and political support.

The launch of cluster incentive in terms of arrangement and development includes the following business activities: information and communication, cluster member training, building cooperation between the members, marketing and PR; internationalization, search for sources of financing and launching investment projects. More details can be found in Table 5.

Table 4:
Analysis of the Central-West and North-East clusters by means of economic energy potential of wastes and energy crops, 2019

Region	Fuel in total, thousand tons of conditional fuel	Fuel utilization, thousand tons of oil equivalent	Economic and energy biomass potential of agro businesses, thousand tons of oil equivalent	Funding ratio %	Heating energy, thousand tons of oil equivalent	Electric energy, thousand tons of oil equivalent	Funding ratio 2017 year,%
Central-West cluster							
Vinnytsia	3,706	2,594	865	33.3	4.7	0.40	×
Kyiv	3,298	2,309	1,284	55.6	80.4	6.02	×
Khmelnytsky	1,638	1,147	1,024	89.3	20.8	1.25	×
Total:	8,643	6,050	3,172	52.4	105.9	7.67	1.88
North-East cluster							
Poltava	3,848	2,693	1,214	45.1	25.4	-	×
Sumy	1,572	1,100	1,149	104.4	7.1	-	×
Chernihiv	1,662	1,164	1,452	124.8	7.3	1.13	×
Total:	7,082	4,957	3,815	77.0	39.8	1.13	0.83

Source: Compiled by the authors

Table 5:
Business profile within cluster incentives

Profile	Basic elements
Information and communication	• Database of enterprises and cluster stakeholders • Enterprise and cluster stakeholder visits • Website setting with search engine. Contact with mass media • Business newsletters publication • Arranging meetings, events, trainings
Studying	• Learning needs analysis • Vocational and management training • Special events such as (trainings, seminars, study tours) on regular basis • Development of internal study platforms in the company • Making contacts between bioenergy manufacturers and universities, scientific establishments
Cooperation	• Contacts establishments between cluster members, for instance, between export syndicates or joined ventures • Cooperation between enterprises, R&D structures, knowledge centers and special services suppliers • Support and monitoring of scientific and research projects
Marketing and PR	• Enhancement of existing cluster participants, involvement of new companies and organizations, attraction • of new clients and investments • Cluster brand: development, management and enhancement; • PR and promotional activities at the national and international levels; coordination and consultations with governmental agencies
Internationalization	• Access to foreign events and conferences • Promotion of clusters abroad
Financing	• Financing of the primary phase of cluster initiatives • Financing of events

Source: Compiled by the authors

A cluster initiative has its own growth cycle. Although clusters are partly affected by the market, clustering must be a planned process. The marketing support of the cluster project must be provided with marketing research. Such research includes trends in the bioenergy market and a marketing study of biofuel manufacturers. Marketing analysis finalizes market data about biomass suppliers, bioenergy and biofuel manufacturers within clusters. Cluster feasibility and the output concept are based on marketing analysis. The next stage includes elaborating a marketing complex with an effective system of merchandising and demand boosting. Finally, it is recommended to carry out auditing and control of quality and quantity indicators and make adjustments if necessary.

6. Conclusions

The dynamics of the volume of bioenergy production significantly differs around the world: China, Germany and Brasil are the fastest growing. They are followed by Canada and France. Although Ukraine possesses a great potential, the bioenergy industry is still underdeveloped.

Clusters, combined by industry type or area, might become an effective tool for the implementation of large bioenergy projects under the current conditions of intensive competition. In order to combine Ukrainian regions by types of energy resources, cluster analysis was. With the help of Euclidean metric, we have determined a set of indicators, where each object of the general totality is applied to the class from which it differs the least. As the result, based on the given data, three groups of regions have been singled out. The first group with the largest bioenergy potential includes Vinnytsia, Odesa, Khmelnytsk, Poltava, Sumy and Chernihiv regions. This made it possible to create 2 energy clusters. These clusters enable to supply regions and districts, which need extra energy resources, with bioenergy.

Launching bioenergy clusters includes the following activities: information and communication, training of cluster members, cooperation between members, marketing and PR, internationalization. financing and investment projects. Cluster project marketing involves market research, market analysis, marketing mix formation and regulation, as well as operation control.

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