HADMÉRNÖK

XIII. Évfolyam 1. szám – 2018. március

THE SPLITTING OF AN ENERGY SYSTEM

ENERGETIKAI RENDSZER FELOSZTÁSA

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Absztrakt

Az energetikai rendszer összekapcsolása messzemenőkig az emberiség egyik legnagyobb vívmánya. A folyamatos fejlesztéseknek hála 1880-ban vette kezdetét a villamos hálózat kiépítése a világon. Az európai hálózat növekedését elsősorban a két nagy világégés gátolta. Azonban annak végével és a vasfüggöny megszűnésével a rendszer elérte jelenlegi állapotát. A következő nagy lépés az Európát Észak-Afrikával valamint az Arab-félszigettel összekötő interkontinentális hálózat elkészítése jelentené. Jelen koncepció alapján ez a megvalósulás 2020-ra valósulhat meg. Az így megépülő architektúra jóval rugalmasabb, stabilabb több tartalékot tartalmazna, mint a korábbi hálózaté. Az Észak-Afrikai területek jóval magasabb lefedettséggel rendelkeznének, mint jelenleg ami részben növelné az ellátás biztonságát és olcsóbbá tenné a villamos energiát is. Azonban a nagyobb kiterjedés potenciálisan nagyobb támadási felületet is jelentene az Európán kívüli területek felől. Ezért egy olyan szigetekre bontás szükséges mely megvalósulása esetén a hálózat nem áll le teljesen, hanem adott területekre válik szét. Az így kialakult kisebb mikrogridek önműködően tartják fenn magukat egészen az újbóli szinkronizációig.

Kulcsszavak: *Energetika, felosztás, energia szigetek, kritikus infrastruktúra, védelmi stratégiák*

Abstract

Connecting the energy system to far is one of the greatest achievements of mankind. Thanks to continuous developments in 1880, the construction of the electric network in the world began. The growth of the European network was primarily hampered by the two major world fires. However, with its end and the end of the Iron Curtain, the system has reached its present state. The next big step would be to create an intercontinental system linking Europe with North Africa and the Arabian Peninsula. Based on this concept, this realization can take place by 2020. The system thus built would be much more flexible and stable than more reserves than the previous network. North African areas would have a much higher coverage than at present, which would partially increase security of supply and make electricity more expensive. However, the larger extent would potentially be a greater attack area than non-European areas. Therefore, an exploration of islands is necessary, in which case the network will not be completely disrupted but will break up into specific areas. The micro grids thus formed are self-sustaining until they are re-synchronized.

Keywords: *Energetics, splitting, energy islands, critical infrastructure, defence strategies*

A kézirat benyújtásának dátuma (Date of the submission): 2018.01.10.
A kézirat elfogadásának dátuma (Date of the acceptance): 2018.03.18.

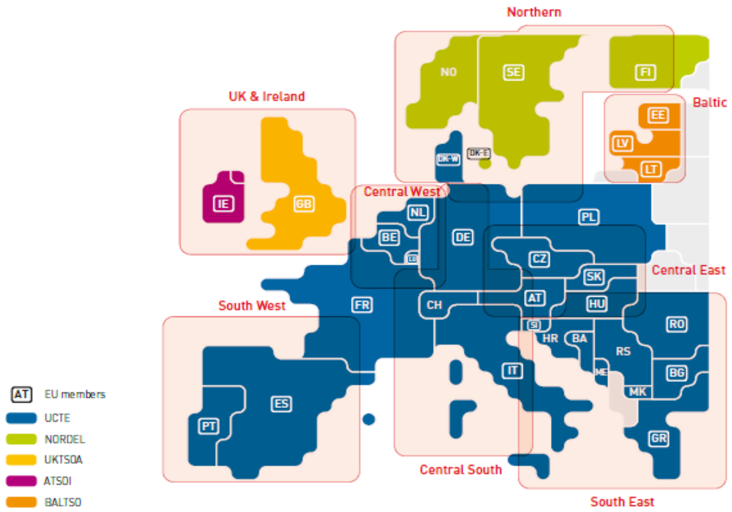
INTRODUCTION

The European energy system has undergone a major change in recent years. These events include the 1995 CENTREL[1] network linked to the predecessor UCPTE[2] system. Its members are Poland, Hungary, Slovakia and the Czech Republic. The so-formed network is called the UCTE[3] system, which is the world's leading edge, providing electricity for about 743 million people. Its complexity is characterized by its inclusion in 24 countries. Due to the different economic situation in the countries, energy distribution systems in the respective states vary considerably. Monitoring of such a size and area system was a very difficult task and therefore a common system operator had to be established. The system includes the following countries: Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, France, Germany, Greece, Hungary, Italy, Luxembourg, Macedonia, Montenegro, Netherlands, Poland, Portugal, Romania, Serbia, Slovakia , Slovenia, Spain, Switzerland. It appears from the list that not all countries in the European region are covered by this organization, islands and northern areas are missing. Due to territorial fragmentation and historical events, energy networks and discoveries have evolved to varying degrees, so several system management organizations could develop. Here We would mention the other organizations which, although independent, form a unit under the umbrella of ENTSO-E[4]. This association is organized by the European System Operators' Organization to oversee the following systems:

- UCTE
- NORDEL[5]
- UKTSOA[6]
- ATSOI[7]
- BALTSO[8]

However, the aforementioned organizations are considered independent in terms of synchronization, but they are unified in terms of energy transmission and trade.

[1]CENTREL – was an association of transmission system operators from the Czech Republic, Poland, Hungary and Slovakia, founded on 11 October 1992, in the field of electric power engineering.
[2] UCPTE - Union for the Coordination of Production and Transmission of Electricity
[3] UCTE - Union for the Coordination of the Transmission of Electricity
[4] ENTSO-E - European Network of Transmission System Operators for Electricity
[5] NORDEL – was an association of transmission system operators in the Nordic region (Denmark, Finland, Iceland, Norway and Sweden)
[6] UKTSOA - UK Transmission System Operators Association
[7] ATSOI - Association of the Transmission System Operators of Ireland
[8] BALTSO - Baltic Transmission System Operators



1. figure Territorial coverage of the ENTSO-E[9]

Now let's go back to UCTE's system. In order to be able to operate the network, the organization carries out the tasks of the electricity system operator and the operator. These include synchronization, regulation, development and enforcement of secure security policies, meeting needs, and defining the built-in reserves of countries. One of these is the most important regulation and the definition of reserves.

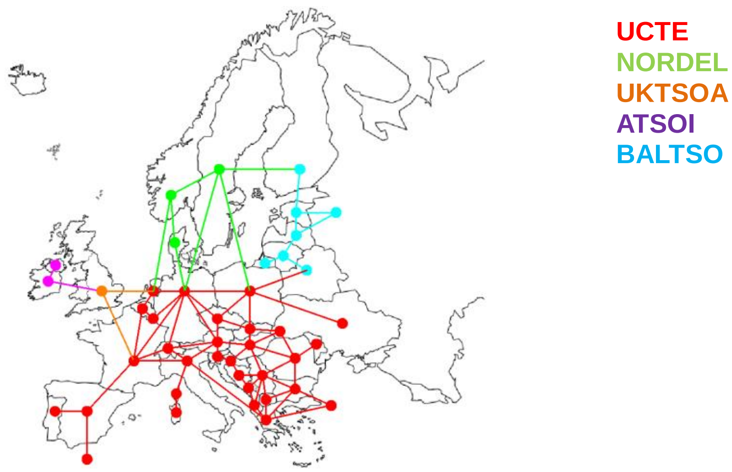
The purpose of this article is to familiarize the reader with the complexity of energy systems and thereby introduce the concept of an island plant within electrical systems. Such sorting requires many background data. In my opinion, one can say a superficial splitting can be done. However, the task is still extremely complex. I mainly build on the country's population data, consumption patterns and the energy, export / import, and built-in reserves produced in that country. Of course, you should be aware of the characteristics of the transmission network and the performance flows. At the moment, however, I have only intended to divide the VER since We currently have enough current data for this system. In the course of the solution, a number of mathematical formulas are produced through the combinatorium to the statistics. Firstly, We have created the grid of the whole European system. This network grid is based on the existence of interconnections between countries and the energy export / import route. Obviously, a real-time load and delivery statistics give a more accurate picture. The data We have provided mainly covers an annual interval, and this could be done by adding a winter / summer period. My results are mainly based on statistical bases, and clearly give the best approximation if these data are as close to reality as possible. Unfortunately, the entire system map requested by ENTSO-E has not been obtained so far, so it is more difficult to obtain the necessary data.

CONNECTION OF THE ENERGY SYSTEM

Related systems

Understanding the energy system is directly related to the structure of a connection system. We wanted to llustrate this relationship system by drawing a simple graph. In the figure, We have listed all five European system operators as they are in great contact with each other. The basis for the figure was determined by energy flow strategies.

[9] [http://www.energiestrategie.at/images/stories/pdf/33_ucte_08_transmdevelplan.pdf, 9. page]



2.figure Graf of the ENTSO-E

The simplicity of the picture lies in the fact that We have only indicated the relationship between countries. In fact, it would be necessary to mark the full a d the most important line sections, but due to the depth and size of the work, it is time to elaborate or mark it as a simple task.

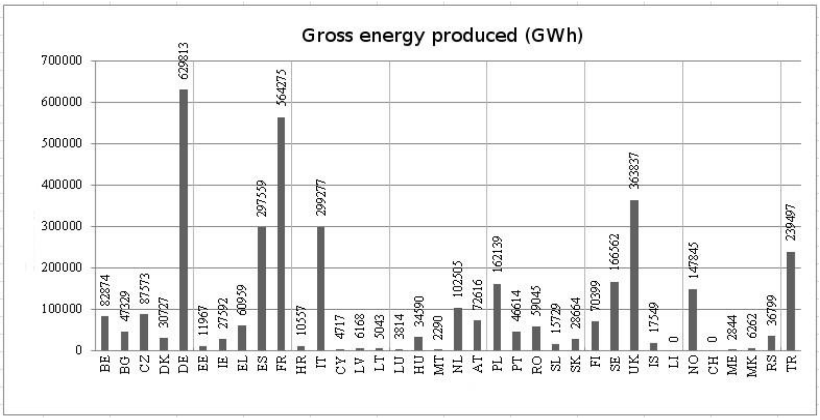
ENTSO-E and the connected countries

From an economic point of view, European countries are very different, as are geographic conditions. Determining the financial conditions when constructing the intercontinental network is important for how the power plant can meet its construction needs. This is required if the system is in the state of having to reserve, for any reason, whether due to maintenance or human omission, and thus prevent the system from collapsing. The determination of the reserves is always the responsibility of the European system operator, in which case UCTE does this. For generating reserves, the power plant block with the largest built-in power is always specified. Consequently, power plants need to be built to cover such a block, which are quick to react. This is a significant additional cost for the countries that have signed up, or if additional facilities are built up, additional reserves should be provided to the system. By defining the territorial conditions, we can strive for the most efficient energy of the states. So in the mountains there are no solar power systems, but reservoir hydroelectric power plants. Fortunately, Europe is well diversified in the Balkans and North Africa. The third and most important feature of the system is the analysis of current consumption patterns. As countries tighten their relationships with one another, trade in energy sharing also has greater opportunities. However, the import or export of sufficient quantities of energy can only be achieved by means of adequately constructed transmission lines. For this, the load factors, that is, the consumption needs to be looked at. We will give the answer to these questions but We can best pass it in tabular form because it is easier to understand the differences.

Countries	Built in power(GW)	Population	Countries	Built in power(GW)	Population
Marocco	2	32.725.847	Saudi Arabia	55	29.200.000
Egypt	18	74.033.000	Iraq	27	28.945.000
Algeria	11,2	37.900.000	Lebanon	2,038	4.822.000
Tunisia	4,024	10.074.951	Syria	7,8	22.530.746
Libya	6,8	6.202.000	Turkey	61,151	78.785.548
Israel	11,664	8.134.100	Jordan	18,73	6.534.300

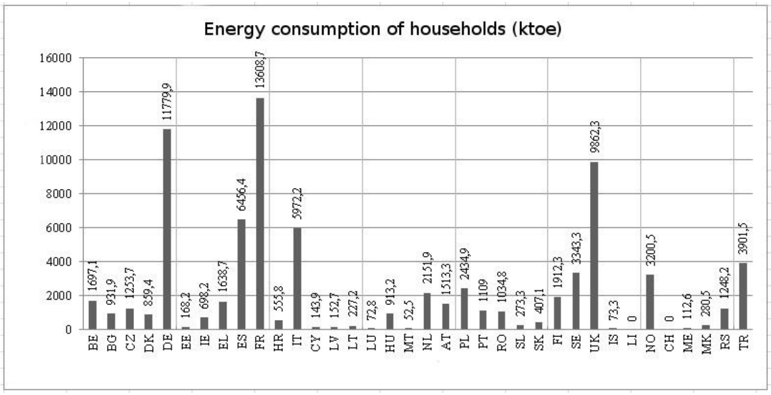
1. table The parameters of the external connected countries

First, consider the level of gross electricity production in the EU-27. Gross in this case means that it includes all the quantities produced by a plant based on a different raw material. This amount is calculated from the values transmitted through transformers and distributors after the power plants. Because they measure the facility then no resources are needed for power plant operation. [1], [2]



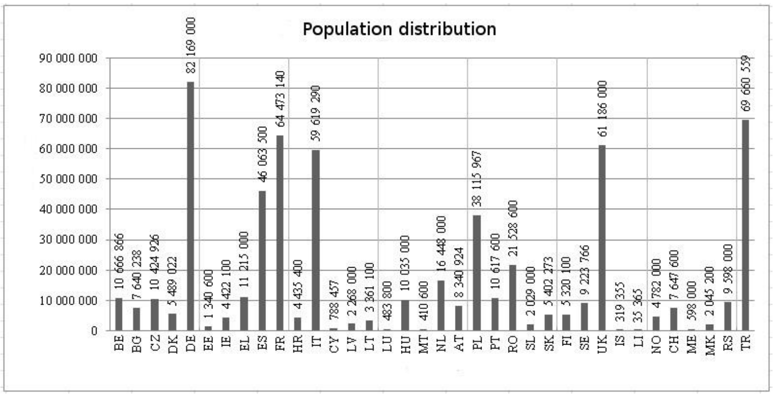
3. figure produced gross energy

The following results aim to review the use of energy by households. The data reflect the use of electricity and hot water. Industrial consumers in this respect are less interesting because they keep up to one unit of energy in predetermined times, so they follow the trend. Significant fluctuations occur only in households. In the table below, the energy is expressed in 1000 tons of oil unit (1 ktoe). Conversion is 1toe = 11.63MWh. [3]



4. figure Energy consumption of households

As the next figure, We identify the distribution of the population of the countries, as basically this data is the most helpful in designing the big network. [4]



5. figure Population distribution

The natural conditions have the greatest influence on the location of the power plants that make up the system.

THE CHARACTERIZATION OF THE HUNGARIAN ENERGY SYSTEM

The division of the Hungarian energy system in this article is much easier to accomplish than the European and North African systems, which is the subject of the final research plan. The present Hungarian system forms a multiple loop system. As the basic topologies are depicted jointly, this greatly facilitates energy transfer. Serving can reach users on multiple routes.

It can be seen from the table that the basic supply of the country is provided by the base stations. These facilities rely on a technology that provides clean, energy-efficient power. Scheduling power plants can also be used to offset the ups and downs of consumption, but their faster start-up is more costly than under finning. The third group with the fastest starting coefficient is peak power plants. They serve to meet hectic energy demands. Absolute zero can be set up within 15 minutes. The fourth group that has not been shown because of its capabilities is a peak power plant, but its function is special gas turbine power plants at Black Start facilities. There are three such power plants in the country. These facilities are able to resurrect the entire Hungarian electrical system from the Black Out state.

Energy flowing

At present, the power plants of the Hungarian electric power system cannot maintain itself. It needs imports that our neighbours provide us. This amount is 16631GWh, however, the market requires that we also provide energy for sale at 4756GWh. It is clear from Hungary's territorial potential that it plays a central role, these conditions are particularly well realized in energy trade. So we can say that we can get very high profits by launching or modernizing our many power plants. However, this is prevented by political or Hungarian green organizations. Paks II. the country would have a huge advantage over other states. The network would gain 2 x 1200MW power. Such a performance increase would mean a higher primary energy reserve, which would benefit both the international and the Hungarian network. Thus, the backup system would change as follows: the primary reserve would increase to 180MW to the secondary 300MW, while the tertiary reserve would increase to 1050MW. Currently, however, only investment at the negotiation level is ongoing. According to an ENTSO-E report for 2017, the country has taken or has taken the energy as follows:

GWh	SK	UA	RO	RS	HR	AT
HU imp.	8299	4835	759	952	417	1369
HU exp.	9	20	524	278	2911	1014

2. table Rate of the hungarian export-import

MAVIR[10] applies Load-Flow calculations to achieve the correct flow of energy. Instruments gather information about the loads you need (effective, reactive, and consumption data) from specific points of the network (nodes, substations). The required software and hardware support is provided by the SCADA[11] system itself. The dispatcher can easily navigate and is able to issue the appropriate instructions on the surface of the electric power system status and load. In order for the system to be able to do so, you need to perform an active status estimation to return the correct data. This method also takes into account the error factor with an appropriate interval. This can be solved using the method of weighted least squares. [5 p. 32]

$$Q=\int_M (y-y)^2 dU=\int_M (F(U)-f(U))^2 dU \tag{1}$$

so

$$[H^T R^{-1} H] * [\Delta x] = [H^T R^{-1}] * [z-h(x)] \tag{2}$$

where

H- the masurement function
$[z-h(x)]$ - error vector
R - the matrix of measurement errors
x - the vector of the state variables
h - measurement function derived from state variables

[10] MAVIR - Hungarian Independent Transmission Operator

[11] SCADA - Supervisory control and data acquisition

z - measurement vector

The actual measured value and its change are equal to the difference between the ideal value and the error factor. The resulting system of equations can be solved by the Lagrange or Gauss method.

$$a_{11}x_1+a_{12}x_2+\ldots+a_{1n}x_n=b_1 \quad (3)$$

$$a_{21}x_1+a_{22}x_2+\ldots+a_{2n}x_n=b_2 \quad (4)$$

$$a_{m1}x_1+a_{m2}x_2+\ldots+a_{mn}x_n=b_m \quad (5)$$

The Gaussian method gives a much more inaccurate value than Lagrange because it does not allow the equation systems to be solved along boundary conditions.

$$D_1 f(a)+\lambda_1 D_1 g_1(a)+\lambda_2 D_1 g_2(a)+\ldots+\lambda_q D_1 g_q(a)=0 \quad (6)$$

$$D_2 f(a)+\lambda_1 D_2 g_1(a)+\lambda_2 D_2 g_2(a)+\ldots+\lambda_q D_2 g_q(a)=0 \quad (7)$$

.

$$D_p f(a)+\lambda_1 D_p g_1(a)+\lambda_2 D_p g_2(a)+\ldots+\lambda_q D_p g_q(a)=0 \quad (8)$$

Optimizing of the system components

The structure of the whole system is given, it can be infinitely divided, but this method is cumbersome and complicates the measurement. The system and, through this, the operators have a short time available until the need is served. Therefore, simplifying the system optimization is a necessary process. For example, a power plant electrical connection may be associated with some topological elements. The constituents required to build the topology are:

- Node: Interfaces that do not contain other switches, branches, or rays
- branch: it has a set of independent impedance elements and two nodes
- I swear: the totality of elements that do not participate in the transmission of electricity and connect a node to a potential-free battery
- consumer point: the totality of nodes where electric consumer switches are opened
- input point: points for which a power generating unit is connected, and any nodes giving an external interface
- switch: a device that can connect and disconnect between two points
- flowmeter: the current transformer location between two nodes- Voltage meter: The voltage changer is located between two nodes

Calculation of the network mapped in this way makes it much simpler and quicker results are called topological calculations. Simplify in this way electrical machines, power plants, complete topology and pipeline sections. The Load Flow has assigned different security elements and criteria for load allocation. These operators are immediately able to detect and quickly fix the problem. Such a system element is a switch simulation that can simulate the current state of the network as it is used, as if the coupling was to be performed in the true sense. By collecting overloaded branches, the system warns the intervener of the branches approaching the specified constant criterion, which may cause damage to the network. Energy systems typically use the topic of analysis, for example, the contingency analysis module. A program package under the Load Flow test for electrical reliability testing, which is designed to perform the loss of network elements. The last module is designed to optimize load balancing. Do this in such a way as to minimize the loss of the given loads. Your tool kit includes shunt elements, control elements, reactive elements and other loads.

SPLITTING OF THE SYSTEM

The distribution of the Hungarian electric power system can not be considered only at national level. The reason for this is that after the redistribution of wars and territories affecting Europe, the current successor states were not able to modernize the system to such an extent that everyone could say it to their own. Thus, the territorial division of Hungary goes beyond current borders, but this can not be an obstacle in the European Union. The current system operators also cooperate with each other in managing the system. The discussions so far have all contributed to the establishment of the appropriate system and their control. But above all, I would rely on the tables in point two where the individual population groups and their average electricity consumption were determined. Accordingly, We share the number of population and the type of power plants in the given district and the energy produced by them, of course taking into account the energy flow on high-voltage cables as well. Our most important base power plants do not appear, as they are the basis for system production and are not currently being exported. So the energy produced by our power plants in TWh is a total of 30,13TWh: [6]

Paks.	Mátra	Kiser.	Duna.	Csepel	Oroszl.
15,36	5,15	4,5	0,93	0,9	0,88
Bp.	Gönyű	DKCE	Pannon		
0,96	0,21	0,09	0,12		

3. table The productive capacity of major Hungarian power plants

Consumption at regional or county level can be calculated as a country by country. Looking at the fourth chapter, the population of Hungary consumes 913.2 ktoe of electricity. Converting to MWh, the result will be 10.62TWh. The population of Hungary is currently 9,897 million people, as consumption is given to households with 2.6 persons live in one household. Thus 3806538 households are located in the country. Based on these values, household consumption per year is 2.78MWh. Peripheral use is thus:

County	Population	Household	Consumption(MWh)
Bács-Kiskun	530379	203991,92	567097,55
Békés	371322	142816,15	397028,91
Borsod-Abaúj-Zemplén	701160	269676,92	749701,85
Csongrád	423826	163010,00	453167,8
Fejér	428295	164728,85	457946,19
Győr-Moson-Sopron	447033	171935,77	477981,44
Hajdú-Bihar	542192	208535,38	579728,37
Heves	314441	120938,85	336209,99
Jász-Nagykun-Szolnok	394891	151881,15	422229,61
Komárom-Esztergom	314450	120942,31	336219,62
Nógrád	207637	79860,38	222011,87
Pest	1213290	466650,00	1297287
Somogy	322197	123921,92	344502,95
Szabolcs-Szatmár-Bereg	565326	217433,08	604463,95
Tolna	235874	90720,77	252203,74
Vas	260950	100365,38	279015,77
Veszprém	360387	138610,38	385336,87
Zala	290204	111616,92	310295,05
Szum	9897765	3806538	10582994,88

4. table County-level consumption and population data

Considering the flows and consumption requirements in Hungary and abroad and a previous map, We designate the next distribution based on the planned pipeline construction plans. In most cases, data for 2016-2017 served, and calculations rely on these resources.

6. figure Possible division of the energy system

SUMMARY

In Our article only one Hungarian networking deals. However, the long-term goals include the construction of the already mentioned intercontinental network. This is a common interest in implementing this system, so much investment is much cheaper than the current concept. The operational reliability of the system is much more outstanding. However, this is not the biggest problem, but the population of North Africa and the Arabian Peninsula, politically and ideologically different. Attacking such a degree of network from any point is a failure or disintegration of the entire system. For this reason, a network should be split into islands of a given size so that such an intervention cannot occur. This article discusses consumer habits and needs in detail. From these, the number of power plants needed to supply has been calculated. It is an unusual problem for industrial consumers, which are not listed in detail and some of them state secrets. Their analysis requires more work and approximation. However, it is apparent from the division that the division of islands cannot be influenced by the boundaries of the borders. It cannot interfere with political and ideological views either. When designing the system, only the larger facilities were marked. With the involvement of the smaller ones, the boundaries clearly appear, but the division is not indefinable as it would greatly increase the amount of time spent. However, in my opinion, one important point would be that under no circumstances should the energy supply of a country's country be influenced by any external factors. This is a simple security issue, so the network must be configured to be independent of external factors, so a micro island must be created. It is not necessary to create a separate island, but it is necessary to create an inner circle for the city. This is a strategic issue. My assumption is that the simplified distribution of the network can be realized by including network parameters, electrical consumption requirements and population data.

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