

DEVELOPMENT OF AN INFORMATION AND LOGICAL DATABASE MODEL FOR ACCOUNTING AND MOVEMENT OF WIND TURBINE EQUIPMENT

K.Akischev^{1*}, A.Tulegulov¹, Z.Nurtai¹, E.Ospanov², K.Aryngazin³, U.Kurmanbek⁴

¹Kazakh University of Technology and Business named after K. Kulazhanov, Astana, Kazakhstan,

²NJSC "Shakarim University", Semey, Kazakhstan,

³NJSC Toraighyrov University, Pavlodar, Kazakhstan,

⁴Kyrgyz State University named after I. Arabaev, Bishkek, Kyrgyzstan,

e-mail: Akmail04cx@mail.ru

The article describes the information and logical model (ILM) of the database of accounting and movement of equipment of wind turbines of the Ermentau wind farm in the Akmola region. IFM is implemented in accordance with the IDEF1X methodology. The relationships of entities are shown and analyzed, the types of connections, the use of primary and foreign keys are determined. The application of the IDEF1X methodology used in the development of relational databases is shown, the conditional syntax is specially designed to build a conceptual scheme. The advantages of the IDEF1X methodology are described.

Keywords. Essence, attributes, methodology, information and logical model, database, wind turbine, equipment

ЖЕЛ ҚОНДЫРҒЫСЫ ЖАБДЫҚТАРЫНЫҢ ҚОЗҒАЛЫСЫ МЕН ЕСЕБІНІҢ АҚПАРАТТЫҚ-ЛОГИКАЛЫҚ ДЕРЕКТЕР БАЗАСЫН ӘЗІРЛЕУ

К.Акишев¹, А.Түлегүлов¹, Ж.Нұртай¹, Е.Оспанов², К.Арынғазин³, У.Курманбек⁴

¹ Қ. Құлажанов атындағы Қазақ технология және бизнес университеті АҚ, Астана, Қазақстан,

² Шакарим атындағы университет КЕАҚ, Семей, Қазақстан,

³ Торайғыров атындағы университет КЕАҚ, Павлодар, Қазақстан,

⁴ И. Арабаев атындағы Қырғыз мемлекеттік университеті, Бишкек, Қырғызстан,

e-mail: Akmail04cx@mail.ru

Мақалада Ақмола облысындағы Ерментау жел электр станциясының жел генераторларының жабдықтарын есепке алу және жылжыту дерекқорының ақпараттық-логикалық моделі (ILM) сипатталған. IFM idex әдіснамасына сәйкес жүзеге асырылады. Нысан қатынастары көрсетілген және талданған, қосылым түрлері, бастапқы және сыртқы Түйінтерді қолдану анықталған. Реляциялық мәліметтер базасын жасауда қолданылатын idex әдіснамасын қолдану көрсетілген тұжырымдамалық схеманы құру үшін шартты синтаксис арнайы жасалған. Idex әдістемесінің артықшылықтары сипатталған.

Түйін сөздер: мәні, атрибуттары, әдістемесі, Ақпараттық-логикалық моделі, мәліметтер базасы, жел генераторы, жабдық.

РАЗРАБОТКА ИНФОРМАЦИОННО-ЛОГИЧЕСКОЙ МОДЕЛИ БАЗЫ ДАННЫХ УЧЕТА И ДВИЖЕНИЯ ОБОРУДОВАНИЯ ВЕТРОВОЙ УСТАНОВКИ

К.Акишев¹, А.Түлегүлов¹, Ж.Нұртай¹, Е.Оспанов², К.Арынғазин², У.Курманбек⁴

¹ Казахский университет технологии и бизнеса им.К.Кулажанова, Астана, Казахстан,

² НАО Университет Шакарима. Семей, Казахстан,

³ НАО Торайғыров Университет, Павлодар, Казахстан,

⁴ Кыргызский государственный университет имени И. Арабаева. Бишкек, Кыргызстан,

e-mail: Akmail04cx@mail.ru

В статье описана информационно-логическая модель (ИЛМ) базы данных учета и перемещения оборудования ветрогенераторов Эрментауской ветроэлектростанции в Акмолинской области. ИЛМ реализована в соответствии с методологией IDEF1X. Показаны и проанализированы взаимосвязи сущностей, определены типы соединений, использование первичного и внешнего ключей. Показано применение методологии IDEF1X, используемой при разработке реляционных баз данных, специально разработан условный синтаксис для построения концептуальной схемы. Описаны преимущества методологии IDEF1X.

Ключевые слова: сущность, атрибуты, методология, информационно-логическая модель, база данных, ветрогенератор, оборудование

Introduction. Wind turbines include expensive and technically complex equipment that ensures the conversion of wind energy into electrical energy. The service life of wind turbines is up to 30 years, so much attention is paid to issues related to reliability, quality of installation and components of turbines.

Due to the need to withstand various types of loads, both static, dynamic, structural and environmental, high requirements are imposed related to ensuring the safety, functionality and manufacturability of the VU.

At the same time, it should be understood that the greatest impact on the VU is exerted by external factors, which include climatic conditions, installation sites, and the presence of man-made impacts.

The current standards, IEC 61400-3-1 [1], IEC TS 61400-3-2 [2], DNVGL-ST-0437 [3], are designed to normalize various requirements for design loads (DLC), normal, emergency and other situations during transportation or installation, to assess the maximum fatigue loads on the system, which The VU can withstand all prevailing environmental conditions during its design life.

Taking into account various normal and extreme conditions for various design situations leads to the need for constant monitoring and monitoring of a larger number of components of the control unit, ensuring the normal operation of all technological equipment.

Meeting the requirements related to carbon neutrality forces the world powers to increasingly use wind energy to generate electricity [4-8].

VUS using aerodynamic lift are divided into horizontal and vertical depending on the orientation of the axis of rotation.

The latest trends of WU are the approach with a horizontal axis or propeller type, which include [9]:

- blades;
- braking systems;
- gondola;
- rotary mechanism;
- electric generator;

- automation and control;
- the tower;
- lightning protection;
- wind force sensor;
- transmission;
- control cables;
- other mechanisms.

The gondola houses an electric generator, a gearbox and a rotor and almost all the equipment that ensures the operation of the VU Fig.1.

To date, according to [10], about 38% of the operating costs of the VU are for maintenance. Equipment failure: On average, there are 8.3 failures per turbine per year, including 6.2 minor repairs, 1.1 major repairs and 0.3 major replacements. Workforce: On average, it takes 116 days and 9 specialists to carry out a major replacement and 7 days and 3 specialists for minor repairs. Frequent delays due to 'days of no access' caused by bad weather. Aging equipment: Some analysts predict that operating costs will increase from 184,000 pounds per Megawatt per year when the turbine is new to 426,000 pounds per MW per year when the turbine is 15 years old [10].

In this regard, in order to optimize the process of timely repair, maintenance and replacement of equipment, measures are needed related to the development of a database of accounting and movement of components of the VU, for timely replacement and repair, and elimination of equipment downtime.

The relevance of the research lies in the need to develop an information and logical model of the database of accounting and movement of the components of the VU, which is the basis of a relational database.

The object of the study is the VU of the Yerementau wind farm, the subject of the study is the management of the process of accounting and movement of VU equipment.

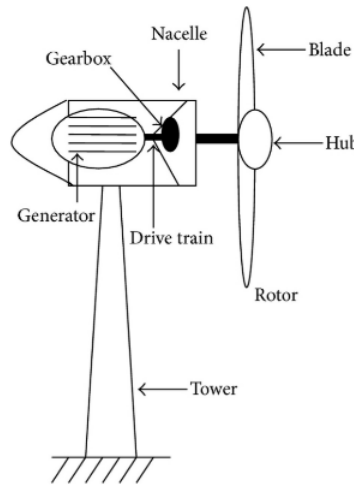


Figure 1- The main elements of the wind turbine

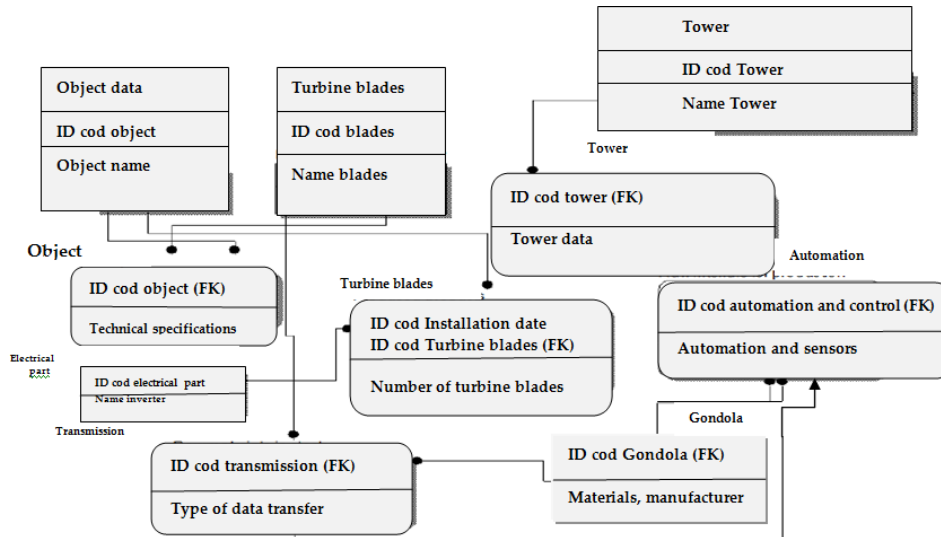


Figure 2 -Information and logical model of the database of accounting and movement of the equipment of the wind farm

The purpose of the study. Development of an information and logical model of the database of accounting and movement of WU equipment.

Methods and materials. The information logic model was developed in the ERwin case environment, which allowed us to get our idea of the data structure, expressed in terms of the entity-connection model in IDEF1X notation, for subsequent generation of the database schema. Building an information model in the ERwin case environment requires the implementation of certain sequences:

1. Creating a logical ER model.
2. Definition of the physical data model.
3. Generation of the database schema in the target DBMS environment (at the author's choice) [11-12].

Discussion of the results. In our case, ERwin is used only as a means of implementing the principles of building an information and logical model and is a popular CASE tool to support the IDEF1X methodology.

In Fig. 2.the information-logical model (ILM) of created in the ERwin case is shown.

- The main entities of the developed ILM include:
- DATA ON THE OBJECT ID;
 - DATA ON THE ELEMENTS OF THE WIND TURBINE (TOWER) ID;
 - ROTOR ID;
 - BLADES ID;
 - WIND GENERATOR ID;
 - GONDOLA ID;
 - AUTOMATION AND ID MANAGEMENT;
 - ID ROTARY MECHANISM;
 - BRAKE SYSTEM ID;
 - THE MAIN LOAD-BEARING COMPONENTS OF THE ID;
 - TRANSMISSION ID;
 - ID SCREW ADJUSTMENT SYSTEM.

As shown in Fig.2 IFM, the entities, attributes, primary keys and relationships of each entity are reflected. The main elements of the WU equipment are, object data, which include:

- installation location;
- coordinates;
- type of soil;
- wind roses;
- average wind speed;
- the direction of the mass flight of birds;

The bearing part of the wind farm consists of a foundation. The wind farm foundation is the element on which all the equipment is mounted, therefore it is made of monolithic reinforced heavy concrete of high strength class, the mass of which is tens or hundreds of tons.

The wind turbine tower is mounted directly on the foundation using anchor bolts. The wind farm tower is made of either metal or reinforced fiberglass. Ladders, a growth cable for power cables and controls are attached to the inside of the tower. Power cabinets with control equipment are located on the concrete floor of the tower.

The blades of the wind farm turbine are attached directly to the rotor of the wind turbine and can reach a length of more than a hundred meters and weigh up to several tens of tons, are made of fiberglass or carbon fiber.

The wind farm gondola is mounted using anchors to the tower, it houses a wind generator, control sensors, a braking system, adjustment systems and various auxiliary equipment. The gondola has upper and lower hatches for access and maintenance of equipment.

Unlike many of them, the parent entity here can be attributed to each, since the failure of one part of the node can lead to the shutdown of the entire system.

Let's take a closer look at each entity.

The entity "OBJECT DATA" contains the following attributes Fig.3:

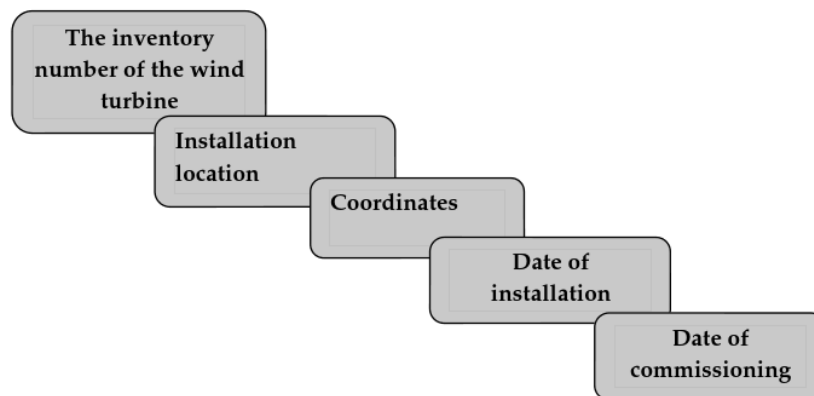


Figure 3 - Attributes of the entity "OBJECT DATA"

The essence of the "Blade" contains the following attributes Fig.4:

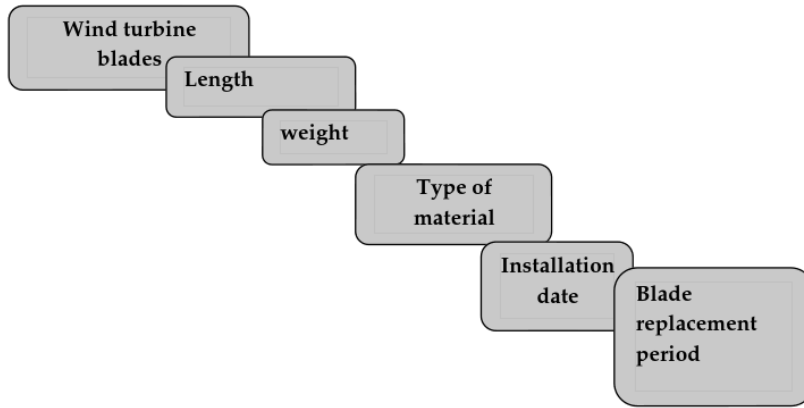


Figure 4 - Attributes of the "Blades" entity

The "GONDOLA" entity contains the following attributes Fig.5:

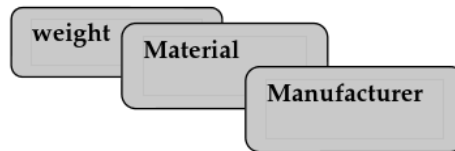


Figure 5 - Attributes of the "BLADES" entity

We will analyze the paired connections of the information-logical model (see Fig.6) between entities.

1."Object classifier" and "Technical Specification" object (see Fig. 3). For two related objects: one image of the first object "Object Classifier" corresponds

to one image of the second object "Technical Specification", and one image of the second object "Technical Specification" corresponds to one image of the first object "Object Classifier". The one-to-one relationship.

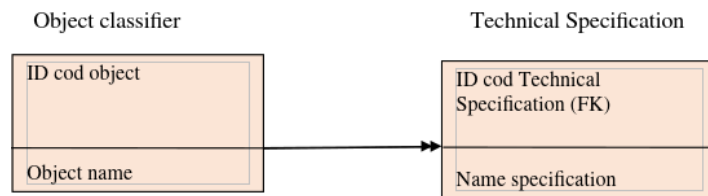


Figure 6 - Connection between the entities «Object classifier» and «Technical Specification»

The entity is described in the IDEF1X diagram by a graphical object in the form of a rectangle. The upper part is called the key attributes, and the lower part is called the attribute area. The key attributes of the object "Object Data" contain the fields "ID cod object".

The key attributes contain the primary key for the object. A primary key is a set of attributes selected to identify unique instances of an object. The primary key attributes are located above the row in the key area. Non-key attributes are located under the row in the

attribute area.

In the example, the attributes "ID _code object", "ID_code_specification" are a potential key, since they are unique for all instances of the "technical specification" entity. When choosing a primary key for an entity model, an additional (surrogate) key is often used, that is, an arbitrary number that uniquely identifies an entry in the entity.

A surrogate key is best suited for the role of a

primary key because it is short and identifies instances in an object the fastest. In addition, surrogate keys can be automatically generated by the system so that the numbering is continuous. Potential keys that are not selected as primary keys can be used as secondary or alternative keys[13].

One recipe classifier can contain multiple recipe compositions, and a recipe composition can correspond to only one recipe classifier.

2. Connection of the "Tower" object and the "Gondola" object. A one-to-one connection. (see fig.7)



Figure 7 - Connection of the entity «Tower» and «Gondola»

As we can see from the model, the essence of "Tower" depends on the essence of "Gandola" and on the essence of "Object data".

Connection of the entity «Object data» and the entity «ID cod _ Object data » (see fig.8).

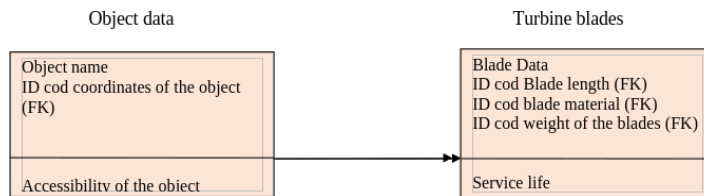


Figure 8 - Connection of the entity «Object data» and entity «Turbine blades»

A one-to-many connection. Blades from different manufacturers, with different service life, can be supplied by different suppliers at the same facility.

When identifying entities that do not depend on other objects in the model, they are called independent entities [13].

Often, in the final implementation of a relational database, different data access indexes are mapped using alternative keys. If the objects in the IDEF1X diagram are connected, the connection passes a key (or a set of key attributes) to the child object. These attributes are called foreign keys (FK). Foreign keys are defined as attributes of the primary keys of the parent object, which are passed to the child object through their connection. The transmitted attributes are called migrating [13].

In IDEF1X, the concept of dependent and independent entities is expanded by the type of relationship between two entities. Identifying relationships are indicated by a solid line between entities.

In the IDEF1X notation, dependent entities are represented as rounded rectangles (see Fig.2). Dependent entities are further classified into entities that cannot exist without a parent entity, and entities that cannot be identified without using a parent key (entities that depend on identification). For our case, all entities depend on the entity "Object Data", since they cannot exist without it.

Non-identifying connections unique to IDEF1X also connect the parent entity to the child. Non-identifying connections are used to display another type of transfer of foreign key attributes - transfer to the data area of a child entity (below the line). Non-identifying connections are displayed as a dotted line between objects. Since the transmitted keys in a non-identifying connection are not part of the primary key of the child object, this type of connection is not displayed in any identifying dependency [13].

The information logic model (ILM) is based on the analysis of all entity relationships, where PK (primary key) is the primary key that was defined during the

design of entities, and FK (foreign key) is a foreign key that includes attributes that form relationships between entities.

The logical structure of the relational database is built on the basis of the developed information and logical model. Currently, there are a large number of software products for the development and administration of databases that can be used to create a database of accounting and movement of wind turbine equipment.

Conclusions. Summarizing the above, we note that the advantage of IDEF1X compared to many other

relational database development methodologies is:

- strict hierarchy and standardization of modeling;
- the established standards allow to avoid various interpretations and violations in the constructed model;
- avoid critical and unforeseen situations;
- there is no need to eliminate their consequences, which has a positive effect on the quality and timing of the project.

The presented IFM is the basis for creating a database, which will be discussed in another article.

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Information about the authors

Akishev K. M. - Candidate of Technical Sciences, Ass. Professor, Kazakh University of Technology and Business named after K. Kulazhanov, Astana, Kazakhstan, e-mail: akmail04cx@mail.ru;

Tulegulov A. D., Ph.D., Ass. Professor, Kazakh University of Technology and Business named after. K. Kulazhanov, Astana, Kazakhstan e-mail:tud62@yandex.ru;

Nurtai Z.T. - Ph.D., Ass. Professor, Kazakh University of Technology and Business named after. K. Kulazhanov, Astana, Kazakhstan e-mail: zhadira_nurtai@mail.ru

Aryngazin K. Sh.- Ph.D.,Professor, , Pavlodar, Republic of Kazakhstan, , e -mail: kapar47@mail.ru;

Ospanov E. A.- PhD, Associate Professor,NAO Shakarim University, Semey, Kazakhstan, e -mail:78oea@mail.ru;

Kurmanbek U.- Doctor of Technical Sciences, Associate Professor, Bishkek,, Kyrgyzstan, , e -mail: ilim_2003@mail.ru

Информация об авторах

Акишев К. М. -к.т.н., асс. профессор, Казахский университет технологии и бизнеса им. К. Кулажанова, Астана, Казахстан: e-mail:akmail04cx@mail.ru;

Тулугулов А. Д.- к.ф.м.н., асс. профессор, Казахский университет технологии и бизнеса им. К. Кулажанова, Астана, Казахстан: e-mail:tud62@yandex.ru;

Нуртай Ж. Т. - доктор PhD, асс. профессор, Казахский университет технологии и бизнеса им. К. Кулажанова, Астана, Казахстан: e-mail: zhadira_nurtai@mail.ru

Арынгазин К. Ш.-к.т.н., профессор,. Павлодар, Казахстан, e-mail: kapar47@mail.ru;

Оспанов Е. А.- доктор PhD, асс. профессор, НАО «Университет имени Шакарима, Семей, Казахстан, e-mail: 78oea@mail.ru

Курманбек У.- доктор технических наук, доцент, Бишкек, Кыргызстан, e-mail:ilim_2003@mail.ru