



STUDY TOUR TO PEOPLE'S  
REPUBLIC OF CHINA:



# WORKING TOGETHER TOWARDS MORE ENERGY EFFICIENT DISTRIBUTION POWER TRANSFORMERS

## IN KAZAKHSTAN

## I. FOREWORD

In Kazakhstan electricity consumption has been steadily rising since the late 1990s. The country predominantly relies on coal-based energy generation which directly leads to high emissions of CO<sub>2</sub>, the main greenhouse gas: in 2014 the annual total of CO<sub>2</sub> emissions approached 70 million tonnes. A significant technical potential to reduce emissions lies in increasing the efficiency of common electricity-intensive appliances and equipment. Heavy equipment such as Power Transformers lose nearly 5 per cent of global electricity each year and it is expected that the global installed stock of transformers will more than double by 2040, making them one of the larger areas for energy efficiency development. A distribution power transformer is an essential part of the modern energy transmission chain as they are used in the electricity transmission and distribution grid system to adjust voltage and current. Generally, electricity passes through up to five transformers as it travels from the power plant to the customer.

The shift to more Energy Efficient Distribution Power Transformers can provide a range of significant economic, social and climate benefits, especially as these are long life products. According to the United for Efficiency (U4E) Country Savings Assessment for Kazakhstan, a market transformation to higher energy-efficient distribution transformers can save of over 6 TWh of electricity consumption cumulatively by 2040 from the implementation of Best International minimum energy performance standard (MEPS) regulations. The switch to more energy efficient distribution transformers could avoid the emission of more than 6 million tonnes of greenhouse gas emissions and provide energy bill savings of more than \$ 400 million USD by 2040 for all electricity consumers in Kazakhstan, which could in turn avoid the need to construct and finance more than 100 MW of new Conventional Power Plant capacity or equivalent.

The U4E organised study tour to China took place between December 2nd and 7th of 2019, under the framework of the UNDP GEF Project “Energy efficient standards, certification and labelling for appliances and equipment in Kazakhstan” with the objective of transforming the Kazakhstan market towards energy-efficient appliances and equipment, thereby reducing electricity consumption and greenhouse gas emissions. The project aims to integrate climate change measures in national policies, strategies and planning, while improving education through awareness-raising campaigns and human/institutional capacity building on climate change mitigation.

The United for Efficiency initiative, a long-term partner of UNDP, provides international technical assistance to Kazakhstan in their goal to promote, demonstrate, deploy, and transfer innovative energy efficient technologies, particularly energy efficiency in appliances and equipment, to achieve real, sustainable market transformation and global environmental benefits. The core focus is the implementation of best international Minimum Energy Performance Standards (MEPS), which have a growing track record of achieving large-scale savings throughout the world. The project also supports the introduction of voluntary High-Efficiency Performance Standards (HEPS) in conjunction with product labelling and government procurement rules. Enforcement of both MEPS and HEPS is carried out by accredited certification laboratories, which the project supports with methodological guidance and needed equipment recommendations. The project also conducts supporting market research, informational outreach and technical support to residential and industrial consumers. In this sense, the project includes support to Kazakhstan’s national transformers manufacturers by advancing their knowledge on best global practices in energy efficient Power Distribution Transformers technologies. Through supports provided by United for Efficiency’s international team of technical transformer and energy policy experts, a one-week Study Tour to China was organized utilizing U4E’s direct linkages with the relevant main Chinese power transformer manufacturers, one of the most modern and energy-efficient global industries in the sector.

## About United for Efficiency

United for Efficiency ([united4efficiency.org/](http://united4efficiency.org/)) is a global initiative led by the United Nations Environment Programme, supported by leading companies and organizations with a shared interest in transforming markets for lighting, appliances and equipment, by encouraging countries to implement an integrated policy approach to energy-efficient products so as to bring about a lasting, sustainable and cost-effective market transformation. The approach focuses on the end-user market and targets the five main components of the value chain for an energy efficient market: 1. Standards and Regulations, 2. Supporting Policies including Education/Information/Training, 3. Market Monitoring, Verification and Enforcement, 4. Finance and Financial Delivery Mechanisms including Incentives and Public Procurement, and 5. Environmentally Sound Management and Health.

United for Efficiency provides countries with tailored technical support through their in-house international experts and specialised partners, to get the most out of countries' electricity by accelerating the widespread adoption of energy-efficient products, allowing monetary savings on consumer electricity bills, helping businesses to thrive through greater productivity, enabling power utilities to meet growing demands for electricity and assisting governments in reaching their economic and environmental ambitions. Currently the initiative is present in more than 30 countries worldwide. Based on each country's circumstances, United for Efficiency works with any of the following products: Lighting,

Refrigerators, Room Air Conditioners, Electric Motors and Distribution Power Transformers – the 5 products that together consume over half of the world's electricity. Such support is available at three levels: Global, Regional and National; providing tools and resources and supporting multiple stakeholders on international best practices, regional policy roadmaps and harmonization process recommendations through guidelines and publications, such as energy efficiency Policy Guides, Global Model Regulations Guidelines, Model Public Procurement Specifications and Financing Guidelines. In addition, the initiative provides capacity building and education, policy tools and technical resources which include Country Savings Assessments completed for more than 150 countries showing the significant available financial, environmental, energy, and societal benefits that are possible with a full transition to more energy-efficient electrical products. This growing suite of tools and resources equip policymakers to understand the opportunities and steps needed to start transforming their markets to efficient appliances and equipment.

## About the United Nations Development Programme:

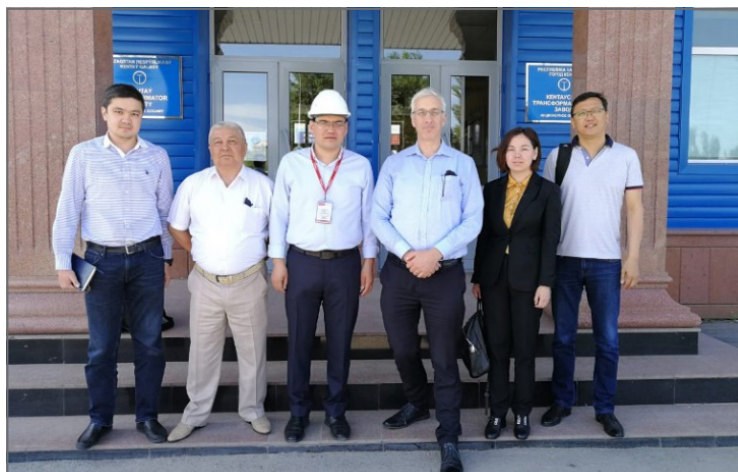
UNDP partners with people at all levels of society to help build nations that can withstand crisis and drive and sustain the kind of growth that improves the quality of life for everyone. On the ground in 177 countries and territories, UNDP offers a global perspective and local insight to help empower lives and build resilient nations.

## II. THE PREPARATION STAGE FOR THE STUDY TOUR TO CHINA

Before the Study Tour kicked off, the technical assistance was initiated by establishing good contacts with the main transformer factories in Kazakhstan: the Kentau Transformer Plant and the Ural Transformer Plant of the Alageum Electric Group. The first Technical mission in June 2019 by the United for Efficiency (U4E) Programme Manager, Mr. Paul Kellett, the UNDP project team and specialists at the Kentau transformers plant assessed the local conditions, the energy efficiency technologies used at the plants and the local market requirements.

A second mission to the country later in August 2019 by U4E technical partner, the International Copper Association (ICA) specialist Mr. Mayur Karmarkar, defined the development path and the facilities from leading enterprises in China to attend during the Study Tour to exchange on the various uses of energy efficient technologies in transformers production and management expertise.





**Picture 1: The representatives of Kentau factory, Ministry of industry and infrastructural development of Kazakhstan, UNDP project and U4E at the entrance to Kentau transformers factory.**



**Picture 2: Mr. Mayur Karmarkar, expert of International Copper Association (ICA) and Mr. Nurbol Tlemisov, Technical Director of Kentau Transformer Plant.**

The study tour to China took place between December 2nd and 7th of 2019 and covered the following route: Nur-Sultan-Shanghai-Guangdong-Guangzhou-Nur-Sultan in accordance with the developed tour programme. It consisted of several stages: preparation stage and later the visits and meetings, in which the participants gained valuable experience and developed recommendations for Kazakhstan.

The delegation included:

- Director of the Technical Department of the Alageum Electric Group – Mr. Bauyrzhan Khudaibergenov,
- Technical Director of the Kentau Transformer Plant JSC – Mr. Nurbol Tlemisov,
- Technical Director of the Ural Transformer Plant LLP – Mr. Maksat Ussenbayev,
- Leading Design Engineer for Electromagnetic Calculations 6-10-20kV JSC from the Kentau Transformer Plant - Mr. Otabek Nalibayev
- Leading Process Engineer from the Kentau Transformer Plant JSC - Mr. Kassymkhan Alimbetov
- UNDP project Manager - Mr. Sergey Inyutin
- The Director of the Almaty Kerneu Electric company, who assisted in translating the Chinese language - Mr. Kumarbek Amanbek.



**Picture 3: Kazakhstani delegation (6 members) at Shanghai airport.**

### III. STUDY TOUR: SCHEDULE, VISITS, MEETINGS AND OBJECTIVES

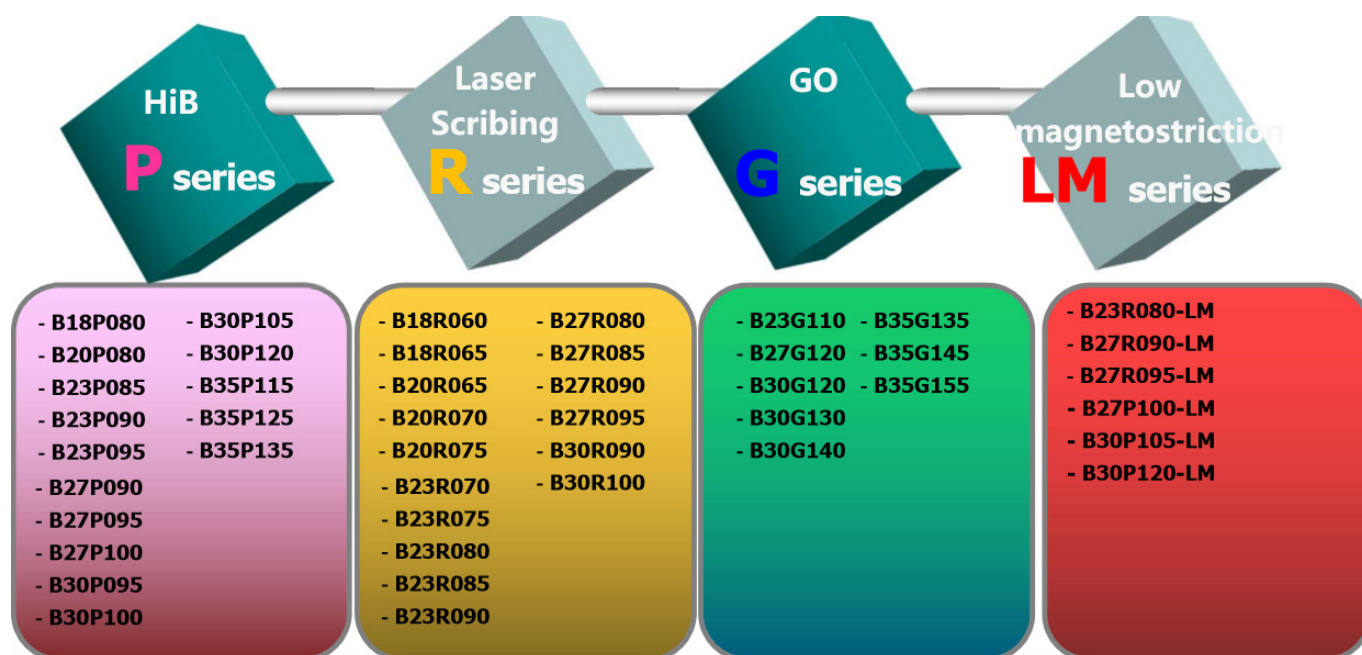
DAY 1 (Shanghai)	
<b>Arrival date:</b>	December 2 – Monday
<b>Flight:</b>	Arrival in Shanghai
<b>Arrival in:</b>	Shanghai, China (Hongqiao International Airport), Terminal 2; 2.20 pm
<b>Hotel:</b>	Intercontinental Shanghai Jing'an
<b>Bus:</b>	From airport to hotel
<b>Events:</b>	No
DAY 2 (Shanghai)	
<b>Date:</b>	December 3 – Tuesday
<b>Company name:</b>	Bao Steel and China National Institute of Standardization
<b>Address:</b>	上海宝钢研究院 (Shanghai)
<b>Bus:</b>	From hotel to Bao Steel
<b>Visit time:</b>	2.30-5.30 pm
DAY 3 (Guangdong)	
<b>Date:</b>	December 4 – Wednesday
<b>Flight:</b>	CZ3596: 8: 50-11: 25 am; from Shanghai airport to Guangzhou airport
<b>Hotel:</b>	Hotel in Guangdong Kaiping city
<b>Bus:</b>	from Guangzhou airport to Guangdong city
<b>Company name:</b>	Haihong & Dupont, transformer manufacturer in Guangdong
<b>Address:</b>	广东开平市
<b>Visit time:</b>	2.30-5.00 pm
DAY 4 (Guangdong)	
<b>Date:</b>	December 5 –Thursday
<b>Bus:</b>	Guangdong Kaiping city to Guangzhou Panyu-by local plant
<b>Hotel:</b>	Hotel in Guangdong Panyu city
<b>Company name:</b>	Pearl Electric Equipment & Cargill and Guangdong Testing Institute of Product Quality Supervision
<b>Address:</b>	广州番禺市
<b>Visit time:</b>	2.30-5.00 pm
DAY 5 (Guangzhou)	
<b>Departure date:</b>	December 6 – Friday
<b>Flight:</b>	Guangzhou, China (Baiyun International Airport), Terminal 2; 4.35 pm
<b>Departure:</b>	from Guangzhou International Airport to Kazakhstan
<b>Arrival:</b>	Nur-Sultan (Nursultan Nazarbayev International Airport), Terminal 1, December 7, 00.35 am

The aim of the Study Tour was to explore the replication and adoption in Kazakhstan of energy efficiency standards and best practices from Chinese Distribution Transformers production. During the study tour, the engineers from the Kazakhstan Transformer manufacturing factories had the opportunity to:

- learn from the experience gained by the Chinese manufacturers over a decade producing energy-efficient transformers;
- get acquainted with various modern technical solutions for insulating materials, electrical steel and new design solutions in the production of energy-efficient transformers;
- have access to technical documentation, instructions and methods for the production of energy-efficient transformers;
- gain knowledge on modern test modules for assessing the energy efficiency parameters of transformers.

## First Technical Visit: Bao Steel and China National Institute of Standardization

Upon the arrival to Shanghai the participants met with Bao Steel Company specialists and the representatives of the Chinese National Institute of Standardization, where the new Chinese energy efficiency standards for transformers were discussed. At the Bao Steel company, the participants learned about the characteristics of grain oriented electrical steel (Figure 1) and about the trends in which the Chinese manufacturers are moving towards to improve the performance of electrical steel. Below are the characteristics of various steel grades to be used for new types of energy-efficient transformers, diagrams D2 and D3 are presented in Table 1, Table 2 beside.



**Figure 1: D.I. 2 manufacturing Bases (Baoshan & Qingshan) for Grain-Oriented electrical steel (GOES) with a capacity of 900 kt/y No.1 in the world**

Source: Baosteel



Grade		Time to market	P17/50 , W/Kg	B8 , T	AWV, dBA	Recent progress
1	B20R070	2014年12月	0.67	1.92	60	Application in high-efficiency 110kV, 220kV, 500kV PT successfully
2★	B18R065	2015年01月	0.63	1.92	60	Application in S15 high-efficiency DT successfully
3★	B30R090	2015年12月	0.88	1.93	60	Application in 500kV PT successfully
4★	B27R080	2015年08月	0.78	1.92	60	Application in PT successfully
5	B23R075	2013年10月	0.73	1.93	60	Application in ±1100kV HVDC successfully
6	B30P120-LM	2015年03月	1.06	1.92	56	Produces 10000t in 2019, Noise decrease 2~4dB in PT and DT.
7	B30P105-LM	2015年03月	1.00	1.92	56	
8★	B27R095-LM	2016年11月	0.90	1.92	56	
9	B27R090-LM	2016年11月	0.86	1.92	56	

Table 1: D2. Global Initial Products ★ : Global Initial Products

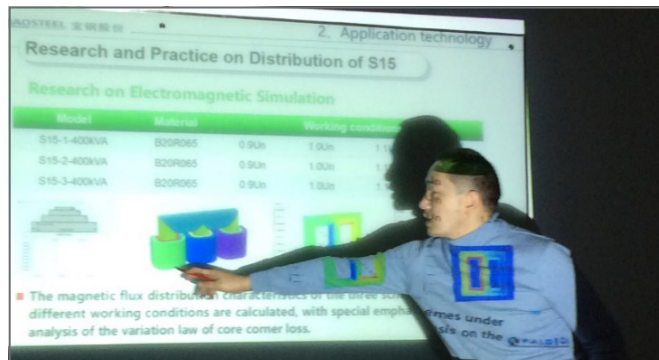
Source: Baosteel

Grade		Time to market	P17/50 , W/Kg	B8 , T	AWV, dBA	Recent progress
1★	B20R065	2017、08	0.63	1.92	60	Application in S15 high-efficiency DT successfully
2★	B18R060	2018、07	0.58	1.92	60	Application in S15 high-efficiency DT successfully
3★	B18P080	2017、07	0.76	1.92	60	Application in S15 high-efficiency DT successfully
4★	B20P080	2018、03	0.76	1.92	60	Application in S15 high-efficiency DT successfully
5	B23R070	2018、07	0.68	1.92	60	Application in high-efficiency DT and DC converter successfully
6	B23R080-LM	2018、05	0.75	1.92	56	Application in S13 high-efficiency DT successfully

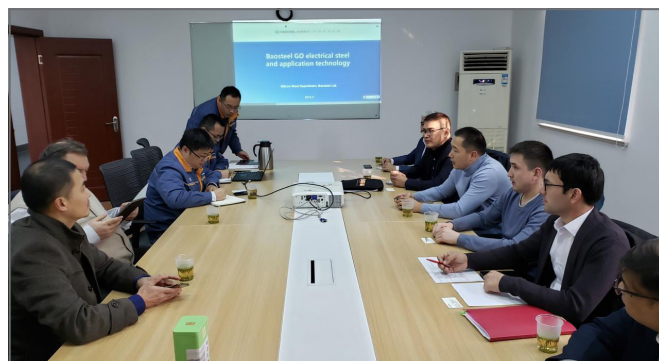
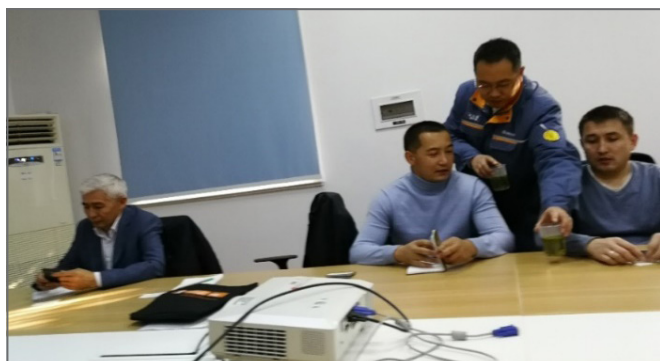
Table 2: D3. Global Initial Products ★ : Global Initial Products

Source: Baosteel

As regards the quality management system – the comparative analyses of the transformers manufactured from the improved electrotechnical steel was demonstrated. In China there are programmes which incentivise transformers plants to produce energy efficient models, so it was proposed to study such programmes in more detail in order to test them in Kazakhstan.



**Picture 4 & 5: Meeting in Bao Steel design department and presentation on steel grades.**



**Picture 6 & 7: Bao Steel and the China National Institute of Standardization, the production of various steel grades, a comparative analysis was conducted by a group of experts.**

During the meetings, it was found that the new Chinese standard for energy efficiency is higher than that of the EU, which allows the sale of products and technologies widely, even in the USA.



**Picture 8: Group photo upon meeting completion in the hall of Baosteel design department.**



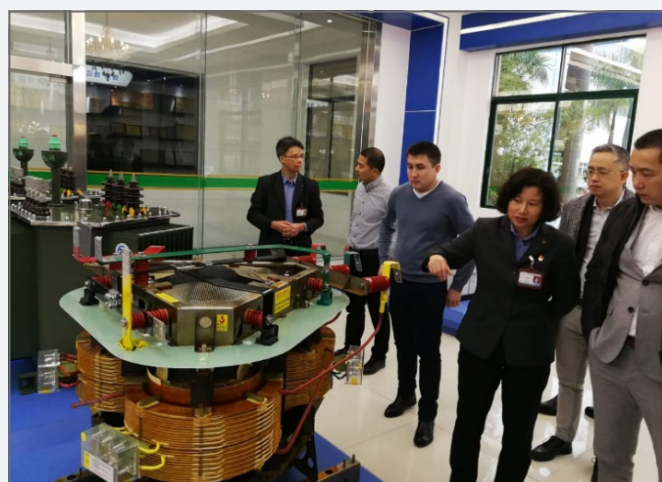
## Second Technical Visit: Haihong Electric CO in Guangdong city

At the Haihong Electric CO the delegation visited the exhibition room with more than 200 patents, 3D transformers, and magnets made of high energy efficiency steel made by the 3D method. Also, models of dry transformers with toroidal magnetic circuits made of amorphous steel and anisotropic electrotechnical steel were shown. The participants discussed the current technical characteristics of transformers with toroidal magnetic circuits and checked out the comparative table with the traditional magnetic circuit.

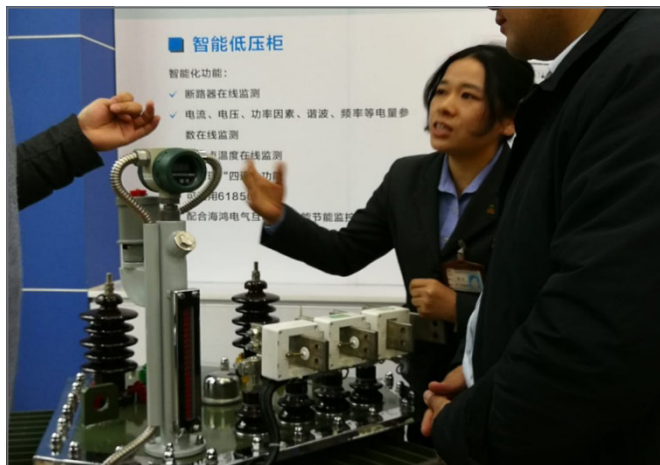


**Picture 9: Kazakhstan delegation and ICA experts' team at Haihong Electric CO in Kaiping**

Ms. Song Danju, Manager of the Technology Department and a specialist on new technologies, presented digitalization processes in transformer manufacturing and a sample of a “smart” transformer. Mr. Zha Lischen, Director of Haitong Electric CO, also discussed the design of an energy efficient transformer developed by the company which utilizes special resins & high temperature withstanding paper insulation to manufacture dry windings. Another “smart” transformer was presented by one of the leading developers, Ms. Liang Sijing, Manager of the International Business Department.



**Picture 10 & 11: Ms. Song is presenting the design of an EE dry-type transformer with air-barrier insulation developed by this company and a high-energy-efficient amorphous steel magnet in 3D.**



**Picture 12: Leading specialist, Mrs. Liang Sijing, the Manager of International Business Department, showing the “Smart” Transformer with remote access sensors in the city of Kaiping**

Figure 2 below shows an example of the best available technologies (BAT) for transformer manufacturing, in improved design - (3D) and the material of the magnetic core: the most promising is the use of magnetic cores made of amorphous (nanocrystalline) alloys. When using them, no-load losses can be reduced more than 5 times in comparison with magnetic cores made of cold-rolled electrical steel, being also safe and environmentally friendly devices:

- “Green” transformer with a low noise level (-45 dB);
- Natural insulating oil used as a medium.
- Eco-friendly: oil is non-toxic and not hazardous to water and soil; good biodegradability and environmental compatibility.
- Safety: the ignition temperature of vegetable oil is usually above 350 degrees.
- Compared with Energy efficiency level 1 standard, no-load loss is average 15~20% lower and no-load current is average 65% lower.



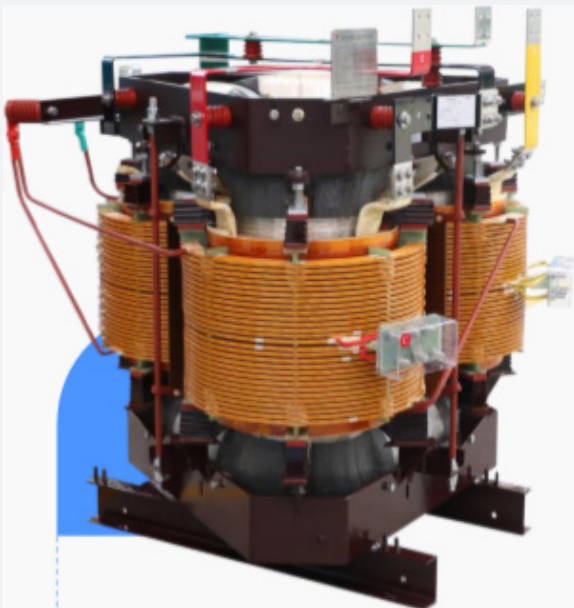
**Figure 2: Amorphous Alloy Closed 3D Wound Core Technology**



Figure 3 below shows a 3D Wound Core Dry Type Transformer.

Given that the consumption of material is reduced, the no-load loss, load loss and no-load current of the open ventilated 3D wound core dry-type transformers are 30% and 70% respectively, lower than those of the open ventilated stacked core dry-type transformers. Product features:

- Environmental protection: Low Noise Level, Product noise is lower than 45 dB and material recycled
- Safe and Reliable: Anti-fire & Anti-explosion
- Strong overload capacity: Insulation class R (class C), maximum allowable temperature 220°C. Overload capacity is strong.
- Anti-moisture & Dust-proof and strong climate resistance
- Safe and reliable
- Compared with Energy efficiency level 1 standard, no-load loss is average 25~30% lower and no-load current is average 65% lower.



**Figure 3: Alloy 3D Wound Core Dry Type Transformer**

Source: presentation given by HAIHONG ELECTRIC Co.,LTD

In Kaiping city, interesting discussions were held on the automated troubleshooting system for customer's transformers, which also includes the remote diagnosis of parameters – remote monitoring. The actual transformers monitoring system in Kaiping is carried out in a real-time environment. The well-developed system of remote monitoring really impressed the Kazakhstan team who offered to enhance cooperation in this field.



**Picture 13: Mr. Kasymkhan Alimbetov against the background of a real-time transformer monitoring system in the city of Kaiping.**

### Third Technical Visit: Pearl Electric Equipment & Cargill and Guangdong Testing Institute of Product Quality Supervision

In Guangdong City the delegation met with representatives of the Pearl Electric Equipment Company & Cargill and the Testing Institute of Quality Control.

The Pearl Electric Equipment company produces diverse types of transformers: dry transformers with cast insulation of 35kV and lower, distribution transformers with mineral oil of 35kV and lower and oil power transformers of 230kV and lower. Even green technologies are used – like using a biodegradable, natural ester liquid as oil for transformers.

Also, the Pearl Electric factory showed the complete production cycle of transformers 6-10-35-110 kV, oil and dry transformers, shared experiences on the production of dry transformers of casting design and some aspects on production of cast-in winding.

The study tour participants learned about the Cargill Company production – the natural ester for transformers that also addresses the climatic solutions category. The company provided all the necessary information about the mineral oil they use. Since there are requests on using this type of oil, it seems necessary to learn more about this and to analyze the possibility of its widespread use in Kazakhstan.





Picture 14 & 15:  
 The Kazakhstani delegation  
 and ICA expert discussing  
 the presentation in a  
 conference room at the Pearl  
 Electric plant.



At the meetings, equipment for testing transformers was presented, such as the Process Quality Control (QC).



Picture 16 & 17

## IV. CONCLUSIONS

- The remarkable progress made in the Chinese production of energy efficient transformers, digitalization and automation processes, and the wide usage of sensors within distant access technology should be highlighted.
- China's factories utilised transformer manufacturing technologies from leading companies like "ABB" and "DuPont", with a successful integration of national scientific staff and local developers.
- The approach to the development of the energy efficiency system, compliance to the high efficiency quality standards (new standards in China are even higher than in the EU) allows the worldwide sale of the production and technologies, including to the USA.
- The adoption of a new three-level standard on energy efficiency and the nationwide introduction of the relevant requirements makes for good headway in the manufacturing of energy efficient transformers.
- The factories in China produce magnets from various steels, including amorphous iron, and their own facilities using local plants considerably decreases the final production costs.
- The Kazakhstan delegation noted the great experience of China regarding the promotion of energy efficient transformers through legal subsidies for high efficiency transformers manufacturers, thus, expenses for new technologies get compensated.

## V. GRATITUDE

- The participants of the study tour would like to express their thanks to UNDP Kazakhstan and UNEP's United for Efficiency initiative for all the support provided for the study tour trip arrangement and getting in contact with the Chinese manufacturers and international experts.
- Also, the participants would like to express their gratitude to the specialists of the International Copper Association: Mr. Mayur Karmarkar, Director Asia Sustainable Energy: Mr. James Li and Marketing Director: Mr. Philip Zhang. They were very considerate to the Kazakhstan team during the study tour to all the factories visited.
- Special thanks to Mr. Kumarbek Amanbek, the Director of Almaty Kerneu Electric company, for his translation services and overall coordination during the trip.



