Energy Efficiency Promotion of Distribution Transformer in China

Submitted by: China Transformer Association
Reducing Losses in Power Distribution through Improved Efficiency of Distribution Transformers (EWG 05 2015A)

Energy Efficiency Promotion of Distribution Transformer in China

28 March 2017 | Jeju Island, Korea
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Part One

Policy Guidance
Part One  政策导向  Policy Guidance

01  三部委制定《配电变压器能效提升计划（2015-2017）》
   
   Distribution Transformer energy-saving promotion program (2015-2017) by three ministries

02  工信部公布变压器“能效之星”产品目录（2016）
   
   2016 Transformer “Energy star” catalog by MIIT( Ministry of Industry and Information Technology)

03  发改委公布《战略性新兴产业重点产品服务指导目录》2016版
   
   2016 Strategic Emerging Industry Key Product and Service Guidance Catalog by NDRC (National Development and Reform Commission)
Part One  政策导向  Policy Guidance

《配电变压器能效提升计划》

为全面提升配电变压器能效水平，三部委制定了《配电变压器能效提升计划（2015-2017年）》。

In order to boost transformer energy efficiency level, three ministries (MIIT, AQSIQ, and NDRC) have launched Distribution Transformer energy-saving promotion program (2015-2017).
《配电变压器能效提升计划》

预计到2017年底，初步完成高耗能配电变压器的升级改造，高效配电变压器在网运行比例提高14%，累计推广高效配电变压器6亿千瓦安。

At the end of 2017, China is planning to initially complete the upgrade project of distribution transformer, and increases the rate of on-grid high efficient transformer by 14%. Totally there will be cumulative 600 million kVA.
To promote application of energy efficient transformers, MIIT has announced transformers “Energy Star” catalog (2016).
《“能效之星”产品目录》
Transformer “Energy Star” Catalog

《目录》涵盖了变压器14个型号产品，能效指标（评估值）均优于能效一级，包括：
Catalog covers 14 models of transformers, energy efficiency (evaluation value) of which is better than energy efficiency level, including:

A. 油浸式非晶合金铁心配电变压器
Amorphous alloy oil immersed transformers

B. 油浸式电工钢带铁心配电变压器
Silicon steel oil immersed transformers

C. 干式非晶合金铁心配电变压器
Amorphous alloy dry type transformers

D. 干式电工钢带铁心配电变压器
Silicon steel dry type transformers

E. 电力变压器
Power transformer
以国内某企业生产的油浸式非晶合金铁心配电变压器SH-M·RL-30~630/10-NX1为例，空载损耗和负载损耗的实测值均低于标准值：

Take SH-M·RL-30~630/10-NX1 Amorphous alloy oil immersed transformers from A company as an example, hereby the actual values of no-load loss and load loss is lower than standard specified.
2016 Strategic Emerging Industry Key Product and Service Guidance Catalog have been launched by NDRC.
Policy Guidance

Add Plant oil transformers, amorphous alloy transformers, and 3D wound core dry type transformers as high efficient industries in the catalog which means energy-saving transformer promotion is boosting.
国家通过制定相关能效政策支持能效变压器应用推广，推动节能环保事业发展。此外，随着市场上能效变压器涌现，国家制定相关能效标准规范并指引变压器节能技术前进，促使国内精英变压器企业在国家标准基础上制定企业标准，共同推进能效变压器稳健发展。

China supports energy efficient transformer application and promotes energy conservation and environmental protection development technology of transformer through energy conservation policy. In addition, with the boosting market of energy efficiency transformers, China develops relevant energy efficiency standards in order to guide the transformer energy-saving technology forward, and encourages the domestic elite enterprises to make their enterprise standards based on national standards, to promote the steady development of energy efficient transformers.
Part Two

标准规范

Standard Regulation
Part Two  标准规范  Standard Regulation

能效标准  
Energy Efficiency Standard

为推动能效变压器的发展，国家标准GB 20052-2013《三相配电变压器能效限定值及能效等级》于2013年10月1日正式实施，规定了三相配电变压器的能效等级、能效限定值、节能评价值和试验方法。此外，电力变压器能效标准正筹备修订中，或将合并配电与电力变压器为一个能效标准。

The implementation of Standard GB 20052-2013 Minimum allowable values of energy efficiency and energy efficiency grades for three-phase distribution transformers on Oct 1st, 2013 is specified energy efficiency grade, limit value, evaluation value and test method. In addition, the Energy efficiency standard of Power transformer is going to revised which may combine with DT as a new standard.
Part Two  标准规范  Standard Regulation

能效标准  Energy Efficiency Standard

欧盟能效标准与中国能效标准对比  EU Standard VS Chinese standard

我国硅钢1级、2级空载损耗与欧盟A0水平基本一致，而我国非晶1级、2级空载损耗比欧盟A0水平低；我国硅钢1级负载损耗与欧盟AK水平基本相当。可看出我国能效标准劣于欧盟能效标准。

The no load loss of efficiency level 1, and 2 of Chinese silicon steel transformer and the European Union A0 level is basically the same. However, the no load loss of efficiency level 1, and 2 of Chinese amorphous alloy transformer is lower than the EU A0; The load loss of efficiency level 1, and 2 of Chinese silicon steel transformer and the EU AK level is basically the same. We can see that Chinese energy efficiency standard is slightly better than the EU energy efficiency standard.
能效标准
Energy Efficiency Standard

美国能效标准与中国能效标准对比 US Standard VS Chinese Standard

- 由下表可知，我国硅钢能效1级、非晶能效1级效率略低于美国标准。
- Total loss for US standard is slightly better than Chinese silicon steel and amorphous alloy energy efficiency level 1 specified.

<table>
<thead>
<tr>
<th>额定容量 Capacity</th>
<th>美国Equipment Class 1 US Equipment Class 1</th>
<th>中国硅钢1级 Chinese silicon steel energy efficiency level 1</th>
<th>中国非晶1级 Chinese amorphous alloy energy efficiency level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVA</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>50</td>
<td>99.11</td>
<td>98.88</td>
<td>99.02</td>
</tr>
<tr>
<td>100</td>
<td>99.25</td>
<td>99.08</td>
<td>99.15</td>
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<tr>
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<td>99.39</td>
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</tr>
<tr>
<td>500</td>
<td>99.49</td>
<td>99.38</td>
<td>99.42</td>
</tr>
</tbody>
</table>

注：负荷率为50%时的效率参数。美国相关数据来自《Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule》。
Note: The above data is calculated at 50% loaded. The US data is coming from Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule.
能效标准
Energy Efficiency Standard

日本能效标准与中国能效标准对比（Japanese Standard VS Chinese Standard）

由图表分析可知，我国硅钢能效1级、非晶能效1级产品的总损耗略优于日本能效配电变压器。

It is concluded that the total loss of Chinese energy efficiency level 1 of silicon steel and amorphous alloy transformer is superior to that of Japanese standard.

<table>
<thead>
<tr>
<th>额定容量 Capacity</th>
<th>日本变压器 Japanese standard</th>
<th>中国硅钢1级 Chinese energy efficiency level 1 of silicon steel</th>
<th>中国非晶1级 Chinese energy efficiency level 1 of amorphous alloy</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVA</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>50</td>
<td>253</td>
<td>217</td>
<td>174</td>
</tr>
<tr>
<td>100</td>
<td>409</td>
<td>352</td>
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<td>125</td>
<td>478</td>
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<td>357</td>
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<td>160</td>
<td>568</td>
<td>496</td>
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<td>663</td>
<td>590</td>
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<td>250</td>
<td>775</td>
<td>700</td>
<td>601</td>
</tr>
<tr>
<td>315</td>
<td>910</td>
<td>830</td>
<td>721</td>
</tr>
<tr>
<td>400</td>
<td>1074</td>
<td>988</td>
<td>851</td>
</tr>
<tr>
<td>500</td>
<td>1255</td>
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<tr>
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<td>1715</td>
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<td>2200</td>
<td>2068</td>
</tr>
<tr>
<td>1000</td>
<td>2967</td>
<td>2890</td>
<td>2768</td>
</tr>
<tr>
<td>1250</td>
<td>3554</td>
<td>3370</td>
<td>3230</td>
</tr>
<tr>
<td>1600</td>
<td>4340</td>
<td>4070</td>
<td>3893</td>
</tr>
</tbody>
</table>

注：容量在500kVA以下的总损耗负荷率为40%，500kVA以上的总损耗负荷率为50%。
Note: Above table is the total loss at 40% load rate for 500kVA and below, and at 50% load rate for 500kVA above.
## 能效标准
### Energy Efficiency Standard

### 印度能效标准与中国能效标准对比 (Indian Standard VS Chinese Standard)

- 印度五星能效配电变压器的总损耗比我国硅钢能效1级、非晶1级产品低。
- Total loss of Indian five star distribution transformer is higher than Chinese energy efficiency level 1 silicon steel and amorphous alloy product.

### 总损耗参数表 Total loss

<table>
<thead>
<tr>
<th>额定容量 Capacity</th>
<th>印度五星 Indian standard</th>
<th>非晶1级 Chinese energy efficiency level 1 of amorphous alloy</th>
<th>硅钢1级 Chinese energy efficiency level 1 silicon steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>kVA</td>
<td>W</td>
<td>W</td>
<td>W</td>
</tr>
<tr>
<td>63</td>
<td>1050</td>
<td>1030</td>
<td>980</td>
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<tr>
<td>100</td>
<td>1500</td>
<td>1495</td>
<td>1415</td>
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<td>160</td>
<td>1700</td>
<td>2180</td>
<td>2050</td>
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<td>2100</td>
<td>2575</td>
<td>2425</td>
</tr>
<tr>
<td>250</td>
<td>2700</td>
<td>3020</td>
<td>2850</td>
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<td>315</td>
<td>2750</td>
<td>3615</td>
<td>3405</td>
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<td>400</td>
<td>3330</td>
<td>4270</td>
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<td>500</td>
<td>4100</td>
<td>5110</td>
<td>4810</td>
</tr>
<tr>
<td>630</td>
<td>4850</td>
<td>5900</td>
<td>5530</td>
</tr>
<tr>
<td>1000</td>
<td>7000</td>
<td>9720</td>
<td>9070</td>
</tr>
</tbody>
</table>

### 总损耗对比 TOTAL LOSS COMPARISON

- 印度配电 Indian standard
- 非晶1级 Chinese energy efficiency level 1 of amorphous alloy
- 硅钢1级 Chinese energy efficiency level 1 silicon steel product
能效标准
Energy Efficiency Standard

土耳其能效标准与中国能效标准对比（Turkish Standard VS Chinese Standard）

- 土耳其能效配电变压器的总损耗略优于我国硅钢能效1级产品。
- Total loss of Turkish standard is slightly better than Chinese silicon steel energy efficiency level 1 specified.
综上所述，我国能效标准略优于欧盟、日本、印度等国家的能效标准，但与美国、土耳其等部分国家的能效标准对比依然有需要提升的地方，我国变压器行业不断进行技术研发，提升产品性能，加快在配电变压器领域的节能减排步伐。

In summary, Chinese energy efficiency standard is slightly better than that of EU, Japan and India. However, comparing with United States, and Turkey, China still needs to be improved. Chinese transformer industry is continuously doing technology research to develop product performance, and speed up the pace of energy-saving and emission reduction in the field of distribution transformers.
电网能效提升计划
Power Grid Energy Boosting Program

近年来，电网公司在大型投标上积极采购能效变压器产品，推劢能效变压器发展。此外，早在2011年，国家电网公司发布了《第一批重点推广新技术目录》，文中“5.2 节能配电变压器”强调2011年，新增配电变压器应采用节能型变压器；2012年起，新增配电变压器全部使用节能型配电变压器。

In recent years, the grid companies have increased procurement of energy-efficient transformers in the large-scale bidding to promote the development of energy efficient transformers. In addition, as early as 2011, the State Grid Corporation released the Focusing on the promotion of new technology first catalog, item 5.2 in which ‘energy-saving distribution transformer’ specifies that in 2011, the new distribution transformers should be energy-saving transformers; and new distribution transformers must be energy-efficient products from 2012.
Part Two  标准规范  Standard Regulation

电网能效提升计划
Power Grid Energy Boosting Program

《国家电网公司重点推广新技术目录（2014版）》中阐述了国家电网2014-2019年重点推广9项配用电新技术，其中对节能型配电变压器有如下展望:

节能型配电变压器主要包括S13型立体卷铁心变压器、非晶合金变压器、自动调容调压变压器等。按照推广应用计划，2014-2016年，新增配电变压器中，S13型及非晶变压器节能型变压器不低于60%，自动调容调压变压器不低于15%；2017-2019年，新增配电变压器全部采用节能型变压器。

*Focusing on promoting new technology catalog by State Grid Corporation (2014)* specifies that:

Energy efficient transformers include S13 3D wound core transformer, amorphous alloy transformer, auto capacity and voltage adjusting transformer and so on. According to the program, for new distribution transformer procurement in 2014 to 2016, the percentage of S13 3D wound core transformer and amorphous alloy transformer is higher than 60%, while auto capacity and voltage adjustment transformer is higher than 15%. 2017-2019, All the new distribution transformer should be energy efficient products.
随着电网改造的投入加大，我国的变压器市场增长迅速，目前已成为国际第二大市场。国内较大的精英变压器企业有海鸿电气有限公司、上海置信电气股份有限公司，其在变压器行业起着“领头羊”的作用，在基于国家标准的前提下，制定了一系列优于国家或行业标准的企业标准，推动变压器行业进一步发展。

Chinese transformer market is going rapidly and has become the second largest market in the world. Some national elite enterprises as the leaders of transformer industries such as HAIHONG ELECTRIC CO., LTD. and SHANG HAI ZHIXIN ELECTRIC CO., LTD. have compiled enterprise’s standards which are superior to national standards to push transformer technology moving forward.
HAIHONG enterprise standard Q / HDF 003-2016 specifies the no-load current is 70% less than S11 type in the national standard GB / T 6451-2015.
HAIHONG enterprise standard Q/HDF 004-2016 specifies the no-load current is 70% less than SCB10/SGB10 type in the national standard GB/T 10228-2015.
小结 Summary

通过标准制定规范变压器行业发展。国内变压器企业在标准的指引下进行技术改进，促进技术发展。立体卷铁心结构由于节能减排优势明显，是变压器能效提升的重要手段，将会成为变压器节能技术的发展方向，是国内变压器行业发展的风向标。此外，我国也在积极开发节能友好型变压器产品，如植物油变压器、自动调容调压变压器等。

Regulate the transformer industry through standards. Under the guidance of the standards, domestic transformer enterprises have improved technology. 3D wound core structure technology will become the development direction of transformer energy-saving technology, which is an important means of upgrading the energy efficiency of the transformer due to its obvious advantage on energy-saving and emission reduction. In addition, China is also developing energy-saving friendly transformer products, such as Plant oil transformers, automatic capacity and voltage adjustment transformers and so on.
Part Three

技术发展情况

Technology Promotion
Part Three  技术发展情况  Technology Promotion

突破传统平面结构，是一种结构更合理，制造成本更低、性能优良、质量可靠的高效节能变压器。

Break through the traditional plane structure. With a more reasonable structure, transformer has advantages - lower manufacturing costs, excellent performance, reliable quality and high efficiency.

- **节能降耗  Energy saving and loss reduce**
  - 空载损耗低 Lower NLL
  - 空载电流低 Lower NL current

- **安全可靠  Safe and reliability**
  - 三相平衡 Symmetrical 3 Phase
  - 抗短路能力强 Strong ability to withstand short circuit
  - 温升均匀 Even Temperature Rise

- **绿色环保  Green and environment - friendly**
  - 噪音低 Lower noise
  - 漏磁小 Small magnetic flux leakage
随着变压器能效水平在标准的规范下不断提升，以及节能产品的消费趋势导向，闭口立体卷铁心变压器凭借其节能环保的优势将逐步成为未来变压器市场的主流。

With continuous improvement of the transformer energy efficiency level standard, as well as consumer energy-saving products trends, closed type 3D wound core transformer will gradually become the mainstream of the future transformer market with its advantages of energy saving and environmental friendly.
Part Three 技术发展情况 Technology Promotion

折叠式双接缝立体开口铁心变压器
Folded Double-seam Open Triangular Core Transformer

采用原有绕线设备生产，各项性能参数略逊于闭口立体卷铁心产品。
Transformer can use the original winding equipment for production, but its performance parameters are slightly not as good as those of closed 3D wound core products.

- 铁心采用多级阶梯错列直接缝形式，装配简便，但接驳口存在接缝、气隙。
  Core is with multi-level staggered column of direct seam structure, assembly of which is simple. But there are joints and air gaps on the junction.

- 铁心、线圈可单独制造，缩短生产周期。
  Core and coil can be manufactured separately, so that shortens the production time.
折叠式双接缝立体开口铁心变压器因其特殊的加工工艺尚未确定型号标准，且相关技术、生产工艺及工装设备方面还需继续完善和发展。

The open triangular core transformer does not have standard to identify its type due to its special production process. Related technology, production technology and equipment need to continue improving and developing.
立体卷铁心非晶变压器
Amorphous Alloy 3D Wound Core Transformer

铁心强度高，三相受力均匀，抗短路能力强。
High core strength, uniform three-phase force, strong ability to withstand short-circuit

线圀戔面为囿形，热点温升均匀。
Circular winding section, hot-spot temperature rise even

铁心无接缝，气隙损耗小，空载电流显著降低。
Seamless core, low air gap loss, reduced no-load current

节能节材、噪声低。
Energy and material saving & lower noise
Amorphous alloy 3D wound core transformer can significantly reduce power consumption and power generation capacity, so that it can reduce emissions of CO$_2$ and SO$_2$. It has significant social benefit, and is in line with today's initiative social concept "green, environmental protection, low carbon".
**Plane Open Amorphous Alloy Transformer**

平面开口式非晶变压器是传统非晶结构变压器，市场基础较广泛。

Plane open amorphous alloy transformer is traditional structure product with large market share.

生产工艺简单，铁心为平面结构，三相磁路不平衡，且铁心重量和体积增加，导致空载损耗高。

Simple production; plane core structure with unbalanced three-phase magnetic circuit; increased core weight and volume cause high NLL

开口式结构，装配简便，但铁心磁路不连贯，接驳口存在接缝、气隙。

Open structure, easy assembly, but non-coherent magnetic circuit, seams, air gap

绕组是矩形结构，受力不及圆形绕组均匀，抗短路能力及热稳定性较差，运行时噪声大。

Rectangular winding, uneven force subjected to winding, poor short circuit resistance and thermal stability, large noise during operation
平面开口式非晶变压器
Plane Open Amorphous Alloy Transformer

现状 Current situation

平面开口式结构为传统非晶变压器结构，其运行噪声大、空载损耗高和抗短路能力差等难题难以克服，未来市场占有率将逐步下降。

The market share of Plane open amorphous alloy transformer of traditional core structure will be reduced in the future because it is difficult to overcome the disadvantages of high running noise and no load loss, and poor ability to withstand short-circuit.
敞开式立体卷铁心干式变压器
Open Ventilated 3D Wound Core Dry Type Transformer

采用饼式线圈结构，温升均匀，且高压线圈为连续式结构，维护简便。
Disc winding structure and even temperature rise. Continuous HV winding structure. Easy maintenance.

铁心为立体三角形结构，三相磁路平衡，空负载损耗低，抗短路能力强。
3D wound core. Symmetrical 3 Phase, lower LL and NLL, strong ability to withstand short-circuit

绝缘等级高，为R级，最高允许温度为220℃。
High insulation class - R class; the maximum Insulation system temperature is 220℃.

产品整体浸漆，具有强耐气候性、防潮、防尘、防火的特点。
Unified varnish immersed, with strong weather-proof ability, damp-proof, dust-proof and fire retarded features.
随着国际对环保要求的提高，对社会可持续发展的重视，以及未来环保政策、措施的走向等，敞开式立体卷铁心干式变压器将以其在环保方面的优势，在未来的市场竞争中形成较强的竞争能力。

With high demand for environmental protection, importance of sustainable development of society, as well as future environmental protection policies, open ventilated 3D wound core dry type transformer will have strong competitiveness which is environmental friendly advantage in future market competition.
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自动调容调压变压器  Auto Capacity and Voltage Adjustment Transformer

自动调容调压变压器具有大、小两个容量，可根据用电负荷利用调容开关及时改变容量，达到提高供电可靠性和降低空载损耗的作用。

Auto capacity and voltage adjustment transformer has one big and one small capacity, which changes capacity according to loading situation by capacity changer, in order to increase the reliability of power supply and reduce no-load loss.

- 耐冲击能力强  Strong ability to withstand impulse force
  - 三相平衡  Symmetrical 3 Phase
  - 抗短路能力强  Strong ability to withstand short circuit
- 绿色环保  Green and environmental friendly
  - 噪音低  Lower noise
  - 漏磁小  Small magnetic flux leakage
- 节能节材  Energy and material saving
  - 节省材料  Material saving
  - 空载损耗，空载电流低  Lower no load loss and no load current
  - 容量调节，降低负荷差异造成的能耗  Adjust capacity to reduce energy loss caused by load difference
- 三相平衡  Symmetrical 3 Phase
- 抗短路能力强  Strong ability to withstand short circuit
- 温升均匀  Even Temperature Rise
中国独有的自动调容调压变压器，满足电网分散、季节性强、平均负荷率低的环境运行要求，改变以往大马拉小车的不合理现象，提高电网的功率因数，降低网损，经济效益明显，市场潜力巨大。

Chinese unique auto capacity and voltage adjustment transformer fits with the decentralized, strong seasonal, and low average load rate of power grid, to change the unreasonable phenomenon of “big house with small cart”, reduce network loss, and increase power factor with significant economic benefits. It has great market potential.
植物绝缘油是由天然的油料作物经压榨，精炼和改性工艺制备而成。

Plant insulating oil is made from natural oil crops by pressing, refining and modification process.

植物绝缘油生物降解率高，符合新型环保要求。

Plant insulation oil meets new environmental requirements with high biodegradation rate.

油纸配合更优，电场分布更均匀，有利于延长变压器的使用寿命。

Oil and paper matching better, more uniform electric field distribution, has advantage of extending the life of transformer.

燃点高，阻燃性好，适合防火要求高的地区。

High ignition point, flame retardant, suitable for high fire protection areas.

材料来源广，有效降低生产成本。

Wide material source, effectively reduce production costs.
我国对植物绝缘油的研究起步较晚，但随着绝缘油技术及生产水平的进一步发展，植物油变压器凭借环保可再生、安全可靠、过载能力强等优势将有更广阔的发展空间。

China has late start of research on plant insulating oil. However, with the further development of insulating oil technology and production level, plant oil transformer will have a broader development with its advantages of environmental friendly, recyclable, safe and reliable, ability to withstand overload and so on.
高过载配电变压器，是为解决用电负荷短时急剧增长而研发的一种配电变压器。

High overload withstanding distribution transformer, is to solve the short-term rapid growth in electricity consumption.

在保证基本用电容量的前提下，既满足小负荷长期用电需求，又兼顾过负荷短期用电需求。

In the premise of ensuring the basic capacity of electricity, it can not only meet the small-load long-term demand for electricity, but also the short-term overload demand for electricity.

具有节能、高效、环保、空载电流小、无功损耗低、抗突发短路能力强等特点。

With advantages of energy saving, high efficiency, environmental friendly, low no-load current, low reactive loss, strong ability to withstand short-circuit and etc.
高过载配电变压器有效缓解农忙时期及春节期间农村地区配电变压器短时段严重过载运行的状况，减轻电网压力，确保用电安全，具有广阔的市场前景和巨大的发展潜力。

This type of transformer effectively relieves the serious short-duration overload during the Spring Festival and busy working rural period. It reduces the pressure of the grid and ensures the safety of electricity. It has broad market prospects and great potential for development.
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结论 Conclusion

中国将持续深化变压器节能技术发展，进行变压器节能改造，加快淘汰高耗能变压器，推进全社会节能减排事业，促进社会可持续发展。

China will continue progressing the technology of energy-saving transformer, upgrading the energy saving transformers, accelerating the elimination of high energy-consuming transformers, advancing the movement of energy conservation and emission reduction, and promoting sustainable development of the whole society.
谢谢聆听

THANK YOU FOR YOUR ATTENTION