Analysis of Chinese Policies and Mechanisms for Energy Efficient Motor Systems

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Abstract

In the last two decades, China, as the "world factory", has consumed more than 70% of their electricity on industries, in which around 75% was used by Electric Motor Driven Systems. In 2014, China ranked No. 1 by consuming 28.3% of the global electricity use on motor systems. According to the Energy Conservation Law (approved in 1997, revised in 2007, 2016), China launched a series of national policies and programs improving energy efficiency of electric motors and motor systems. From 2010 to 2014, China has developed six batches of catalogues for energy-efficient motors and subsidized them through a national financial incentive program called "Jienenghuimin"[1] [1]. In 2013, China launched a three-year National Motor Energy Efficiency Improvement Plan (2013-2015), aiming to deploy high efficient motors, eliminate inefficient motors and improve motor system efficiency, in which Minimum Energy Performance Standards (MEPS) and labelling schemes were improved, catalogues of Eliminated High Energy Consumption and Backward Mechanical and Electrical Equipment (incl. motors, compressors, fans, pumps and transformers) were updating, national training and regional system audit programs such as Topmotors China Zhenjiang Pilot [2] [7] were conducted. But due to multiple barriers, the motor system energy saving potentials in China were still not well tapped.

With support of the Energy Foundation, Renergy Technology Consulting Beijing LLC has implemented a 1-year project "Mechanism Research & Policy Analysis on China Motor System Energy Efficiency Improvement", in which the existing policies and programs were reviewed and analyzed, barriers hindering motor system efficiency improvement in China were identified, and recommendations to improve the policies were made accordingly. In this paper, the key findings and results of this project are presented, including the development and harmonization of exiting MEPS, new development of China Energy Label (CEL) with QR code, related compliance and enforcement programs, analysis of the "Jienenghuimin" financial incentive program, as well as the barrier analysis for implementing Energy Efficiency Retrofit Projects both in Motor Users' and ESCOs' perspectives. In addition, lessons learned from the local level and financial sectors were summarized. This paper concludes with suggested options for improving motor system energy efficiency policies and mechanisms in China.

Key words: Analysis of Policies and Mechanisms, Electric Motor Driven Systems, China National Motor Energy Efficiency Improvement Plan, the "Jienenghuimin" Financial Incentive Program, Minimum Energy Performance Standards (MEPS), China Energy Label (CEL), Barrier Analysis, Policy Recommendations

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[1] Jienenghuimin means Promoting Energy-Efficient Products for the Benefit of the People, see the official website of this program: www.jienenghuimin.net.

Background

With the fast economic growth in the past decade, China's electricity consumption increased from 3643.2 Terawatt hours in 2009 to 5919.8 Terawatt hours in 2016. The Figure 1 shows that more than 73% of China's electricity were used on second industry from 2009 to 2016, and in which electric motor systems consumed more electricity than any other end use in China. According to the statistics, by 2013, the estimated installed capacity of the electric motor stock in China was about 2.1 TW, and their total electricity consumption was about 3,400 TWh/a, which accounted for 64% of China's total electricity consumption. In the industrial sector, electric motors consumed 2,900 TWh electricity which accounted for around 75% of industrial electricity consumption.

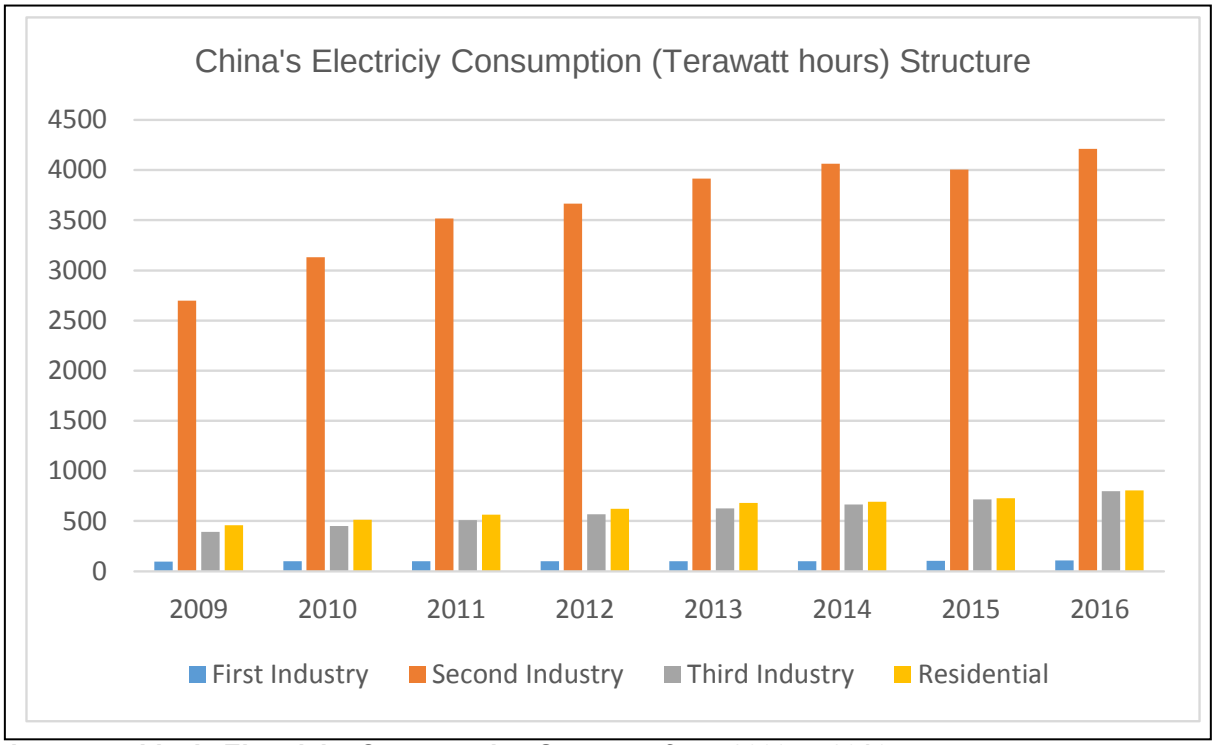

Figure 1. China's Electricity Consumption Structure from 2009 to 2016.

Data Source: National Energy Administration (NEA), China.

According to the statistics of the Ministry of Industry and Information Technology (MIIT), the average energy efficiency (EE) of Chinese motor systems is 10% to 20% lower than the level of developed economies. Problems exists with backward motor manufacturing technology with low innovation, lack of speed control, inefficient transmission systems, no automatic and intelligent system control, inadequate standardization services and enforcement, weak market-driven mechanisms etc.

In China, more than 60% of the electricity is generated by coal, so that the average emission factor of 1 kWh electricity in China is about 1 kilogram of CO_2. The significant electricity savings will help China contribute to tackling climate change by peak its carbon emissions by 2030.

Legal Framework

China's Energy Conservation Law [3] forms the legal basis of Motor EE & Motor System EE regulation. By 2016, it was revised twice since 1997 as shown below, and there is a specific article in each version to emphasize EE of the end-use equipment of motor driven systems.

- Version 1, Nov. 1997: article 39, II, *encouraging application and innovation on technologies such as efficient motors, fans, pumps as well as speed-adjusting technologies etc.*

- Version 2, Oct. 2007: article 31, *the state encourages industrial enterprises to adopt efficient energy-saving motors, boilers, kilns, fans, pumps and other equipment, the CHP cogeneration, waste heat and pressure utilization, clean coal and advanced energy monitoring and control technologies.*

- Version 3, Jul. 2016: article 31 did not change.

National Goals and Action Plan

In June 2013, the Ministry of Industry and Information Technology of China (MIIT) and the General Administration of Quality Supervision, Inspection and Quarantine of China (AQSIQ) co-launched a national program named "Electric motor energy efficiency improvement plan (2013-2015)" aiming to deploy 170 GW of high efficient motors (i.e. IE3 and IE4) and to eliminate 160 GW of older inefficient motors, to improve motor systems by motor replacement of 100 GW, and to refurbish 20 GW in replaced motors.

Since electric motors work with their respective application (pump, fan, compressor, etc.) as a system, it is obvious that only replacing motors cannot improve system efficiency effectively. Barriers hindering the implementation of this national plan were identified such as lacking analysis of cost-effectiveness of motors system efficiency, enforcement measures are not strong enough to supervise and monitor the market, the design, innovation of relevant technologies as well as energy service business models cannot adapt to the fast market change etc. Hence "system optimization" becomes more and more critical both in engineering, management as well as policy design.

To remove these barriers, with the funding of the Energy Foundation China, Renergy Technology Consulting Beijing LLC (Renergy), in cooperation with China Machinery Industry Energy and Resources Conservation Center (MERC), launched and implemented a project called "Mechanism Research & Policy Analysis on China Motor System Energy Efficiency Improvement" to support the goal of motor system efficiency improvement by 3% to 5% by 2020, which will result in 78 to 130 TWh per year of electricity savings.

This will be achieved by 2020 via providing recommendations for the policy effectiveness and implementation mechanism, developing guidelines and case studies on motor system efficiency, designing and conducting pilot training programs for the managers in factories by applying the guidelines and conducting technical know-how exchange between China and advanced regions.

Chinese Policies on Motor System Energy Efficiency

In early this century, China started developing policy framework and technical regulations such as Minimum Energy Performance Standards, Energy Labeling schemes, and financial incentive programs for electric motors and other equipment in the motor driven systems.

Minimum Energy Performance Standards (MEPS)

In the past two decades, China has developed a series of national MEPS for electric motors, including small power motors (6W – 3.7kW), small and medium three-phase asynchronous motors (0.75kW – 375kW), permanent magnet synchronous motors (0.55kW – 375kW) and high voltage induction motors (160kW – 25,000kW). The detailed information could be seen in Figure 2. In China, the MEPS are in place at IE2 level (see Figure 3.), but the planned increase towards the IE3 level in September 2016 was postponed.

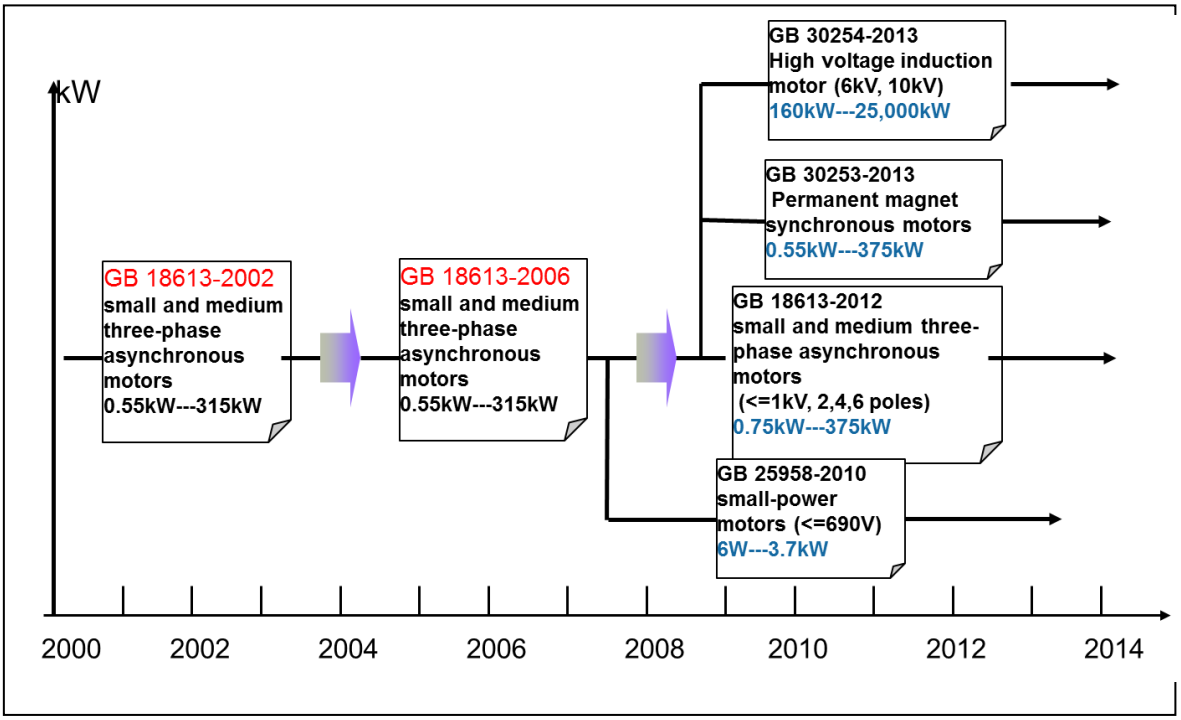

Figure 2 Development Roadmap of Chinese MEPS for Electric Motors.

Figure source: China National Institute of Standardization (CNIS), 2016.

GB18613-2006 old MPES	GB18613-2012 new MEPS	IEC60034-30-1	Average EE (%)	EE difference between tiers (%)	Chinese motor models
/	**Tier 1**	**IE4**	**93.1**	**1.6**	/
Tier 1	**Tier 2**	**IE3**	**91.5**	**1.5**	**YE3** series
Tier 2	**Tier 3**	**IE2**	**90.0**	**3.0**	**YE2,YX3** series
Tier 3	not allowed any more	IE1	87.0	/	**Y,Y2,Y3** series

Figure 3 Energy Efficiency Tiers Mapping between Chinese and IEC MEPS for Electric Motors.

Figure source: Shanghai Electrical Apparatus Research Institute (SEARI), 2016.

On 20th April 2016, preparatory meeting for revising Motor MEPS GB18613-2012 was held in Beijing, The key points from standardization experts were as follows:

- Coordination of the existing MEPS;
- Alignment with IEC standards (extension to 0.12kW～1000kW, 50V～1000V, 8-pole motors added);
- Top-runner EE requirement, which is not same as Japan's Top Runner Programme, and only the models fulfil this requirement could get subsidies or be given priority by government procurement;
- Implementation of the target minimum allowable values of energy efficiency for motors (addressed in the article 4.4 of GB18613-2012: 7.5kW-375kW due Sept. 2016; <7.5kW due Sept. 2017)

MEPS for other equipment in the motor driven systems such as pumps for fresh water, AC contactors, air compressors and fans were also developed. These standards together with MEPS of electric motors, made current assessment of the whole motor driven system possible. The names of these standards are as below, and some of them are facing revision in 2017. For example, the first MEPS for air compressors GB 19153 entered into force in November 2003, and then was revised in 2009, now it is under the second revision. Since the United States of America (USA), the European Union (EU) are developing their own air compressor MEPS, the USA is also developing MEPS for fans, so it is the right moment to align their testing methods and energy efficiency indicators.

- GB 19762 - 2007 Minimum allowable values of energy efficiency and evaluating values of energy conservation of Centrifugal Pump for Fresh Water
- GB 21518 - 2008 Minimum allowable values of energy efficiency and energy efficiency grades for AC contactors
- GB 19153 - 2009 Minimum allowable values of energy efficiency and energy efficiency grades for displacement air compressors
- GB 19761 - 2009 Minimum allowable values of energy efficiency and energy efficiency grades for fan

China Energy Label (CEL)

Renergy is implementing an international energy efficiency program called "Topten" in China, aiming promoting best available technologies (BAT) on EE through third party testing, market research, EE product selection and benchmarking, consumer education, and policy advocacy. In past years, recommendations to improve the current China Energy Label scheme were well received by the key policy maker at CNIS. The key messages included: the label shall be easy to understand for consumers, add information on both efficiency and sufficiency to avoid the rebound effect called "Jevons Paradox"[2], add a QR code (Quick Response Code) to be used from smart devices etc. CNIS acknowledged Renergy's advice and integrated it into the revised Administration Regulation on Energy-Efficiency Labelling, which was officially enforced on 1st June 2016. A QR code was added to offer more information both for market monitoring and consumer guidance, and 150 product models were included in the 2016 Top-Runner product list. Besides benefit for consumers, the QR code also helps the local energy conservation supervision officers to monitor the market in a more convenient and efficient way. This achievement was significant for China and it was summarized by Topten International team so as to provide advice and references to relevant policy makers of the European Commission.

[2] https://en.wikipedia.org/wiki/Jevons_paradox

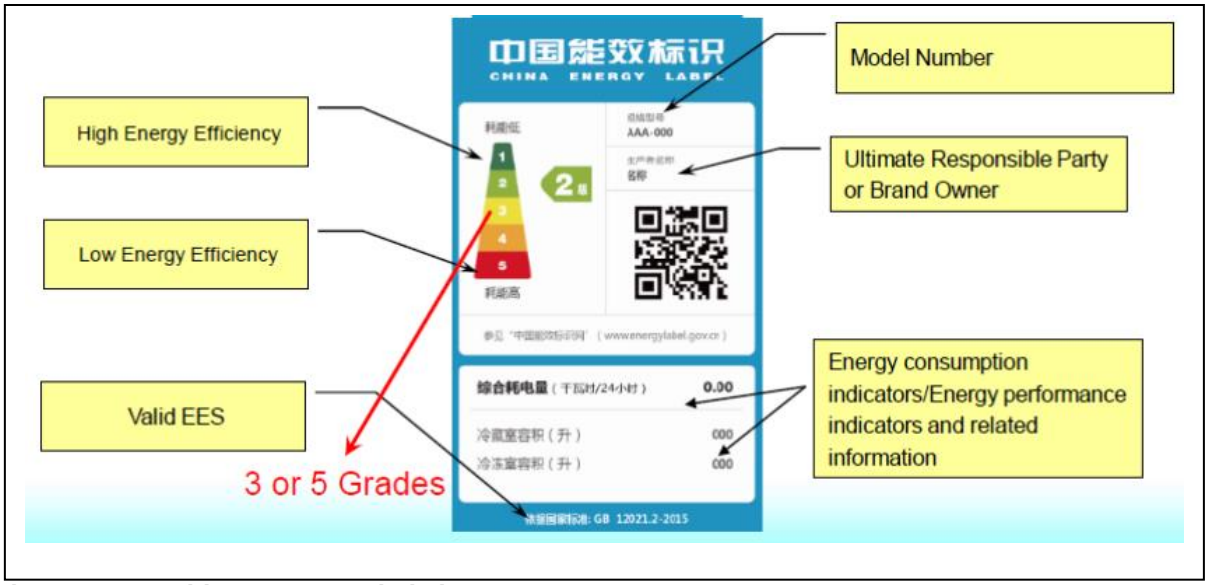

Figure 4 New China Energy Label since June 2016.

Figure source: China National Institute of Standardization, 2016

On 20th September 2016, Refurbished Motors were included into the new China Energy Label schemes to encourage motor refurbishment industry's innovation and development and this new regulation took into forces on 1st October 2016. Before that, the replaced old inefficient motors could only be recycled as wasted metal or illegally be sold to black market so that the inefficient repaired/refurbished motors again went to Chinese rural market or remote areas. The new CEL regulation regarding refurbished motors consists of the following key points:

- Quality of the refurbished motors shall be guaranteed;
- Energy efficiency of the refurbished motors needs complying to existing MEPS: GB18613;
- 380V, 50Hz, 0.75kW-375kW, 2,4,6 poles

Compliance and Enforcement (CEL)

Compliance and Enforcement are key to success of any policy implementations. But the situation of enforcement of MEPS and CEL are not optimistic as we expected. According to statistics from International Cooper Association (ICA) in 2014, 38.37% of small and medium three-phase asynchronous motors manufactured in China were IE2, and even 52.22% of them were below IE2, i.e. more than half of them were produced, sold and used illegally.

During implementation of the project, project team noticed this situation in factories, and most of motors we have seen were labeled as tier 3 (See Figure 5), but without checking if it was really complying with tier 3 EE requirements.

Figure 5 CEL of motors in factories, Jiangsu province, China

Figure source: photos taken by ZHENG Tan.

From December 2013 to April 2014, China conducted nationalwide Motor Manufacturers On-site Checking to monitor the market. Activities consisted of integrity and quality of their self-checking report, registration and implementation of China Energy Labeling, Conformity testing etc.

Consequences of non-compliance include public announcement of the non-complied companies and product models; ineligible products could not be sold and used; ineligible companies could not apply subsidy any longer; blacklist and notice to authorities, banks etc. to cease their loan or no longer provide any financial support, stop in charge person of ineligible companies to buy flight and train ticket etc.

Financial Incentives (Jienenghuimin Program + Tax Reduction)

From June 2010 to 2014, six batches of subsidized model lists (see Tabel below) for electric motors were developed and used, three types of motors were covered by the subsidy program, and the subsidy rate varies from 3.5 EUR to 13.3 EUR per kW. More than 33 million kW energy efficient motors got subsidized with 1.4 billion RMB (circa 186 million EUR) in total. 1.7 billion RMB (circa 226 million EUR) subsidies went to pumps, fans, compressors, transformers. It was estimated that by the end of 2016, around 100 million kW high energy efficient motors were promoted and 3 billion RMB (circa 400 million EUR) subsidies were given to energy efficient motors.

Due to lacking motivation to change, the motor users in China have been reluctant to alter their existing motor systems even they could get subsidized new energy efficient motors. Besides the subsidy from central government, Chinese local governments including provincial and municipal governments provide supplementary subsidies to attract more factories and ESCOs joining this program. For instance, Guangdong provinces gave 126 million EUR to motor users and ESCOs who implemented motor system EE retrofits projects from 2013 to 2016.

According to the statistics from ESCO Committee of China Energy Conservation Association (EMCA), by 2014, more than 3,200 ESCOs were active in China, their services generated in total 30 million tons of coal equivalent (TCE) of energy savings, which was equivalent to 75 million tons of CO_2 emission reduction, where 33% of total energy savings were caused by electric motor system retrofits. The central government also provided its support for ESCOs through tax reduction policies. In

December 2010, the Ministry of Finance (MoF) and State Administration of Taxation jointly issued the Notice on Policy Issues of Value Added Tax, Business Tax and Corporate Income Tax in Promoting the Development of the Energy Service Industry, which gave energy service companies a temporary exemption from value added tax and business tax, an exemption from corporate income tax for the first three years of implementation, a 50% tax levy for the next three years.

Six batches of Chinese national subsidized model list for EE motors:

No. of batches	Date of official announcement	Number of listed motor manufactures	Number of listed models: low-voltage three-phase asynchronous motor	Number of listed models: high-voltage motors	Number of listed models: permanent magnet motors
1	August 1st 2010	13	996	0	65
2	March 8th 2011	48	1440	6653	343
3	July 26th 2011	34	677	8760	459
4	March 21st 2012	29	737	10669	388
5	December 2nd 2012	90	4752	14485	935
6	August 28th 2014	85	2041	10842	1150
Total			**10643**	**51409**	**3340**

China national subsidy program criteria for EE motors:

Type	Rated power (kW)	Subsidy (RMB/kW)	Subsidy (EUR/kW)
Low-voltage three-phase asynchronous motor	0.55 ⩽ rated power ⩽ 22	58	7.72
	22 ⩽ rated power ⩽ 315	31	4.13
High-voltage motors	355 ⩽ rated power ⩽ 25000	26	3.46
Permanent magnet motors	0.55 ⩽ rated power ⩽ 315	100	13.32

Historical exchange rates between the Chinese Yuan Renminbi (CNY) and the Euro (EUR) between 1/1/2014 and 2/24/2017 was used, i.e. 1 Euro = 7.5090 Yuan RMB.

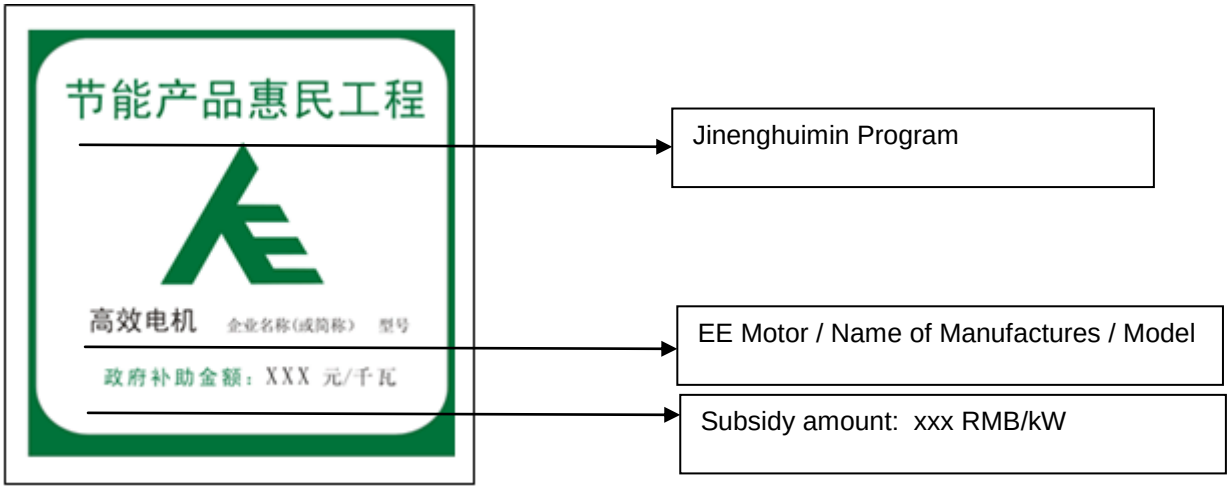

Figure 6 Label of China Subsidy Program for EE Products ("Jienenghuimin").

Figure source: www.jienenghuimin.net

The central government gradually realized that only subsidizing energy efficient electric motors could not significantly improve the energy efficiency of motor systems. On 23rd January 2017, the Ministry of Finance has officially announced that the national subsidy program "Jienenghuimin" for energy efficient motors stops since March 1st 2017.

Mechanisms for Improving Motor Systems Energy Efficiency in China

In order to improve the energy efficiency of electric motor systems in China, a bunch of implementing measures were taken. In this paper, we address the development trend of multiple mechanisms for improving EE of motor systems in China from the following **"Four Plus"** perspectives.

Single Equipment + Systems

According to global research [4] [5] [6], energy efficiency of a motor driven unit is dependent on multiplication of energy efficiency of individual component of the whole system (see Figure 7). Therefore, high energy efficiency of single equipment such as motors, pumps, fans and compressors is crucial and necessary making a high EE motor system possible. But a simple combination of super high efficient components might not reach optimal efficiency as a motor driven system. Adaptation to the real needs, to working conditions, as well as to cost-effectiveness of the investment are important for convincing energy managers and their bosses to think, evaluate, and implement EE retrofit projects in a very holistic and systematic way.

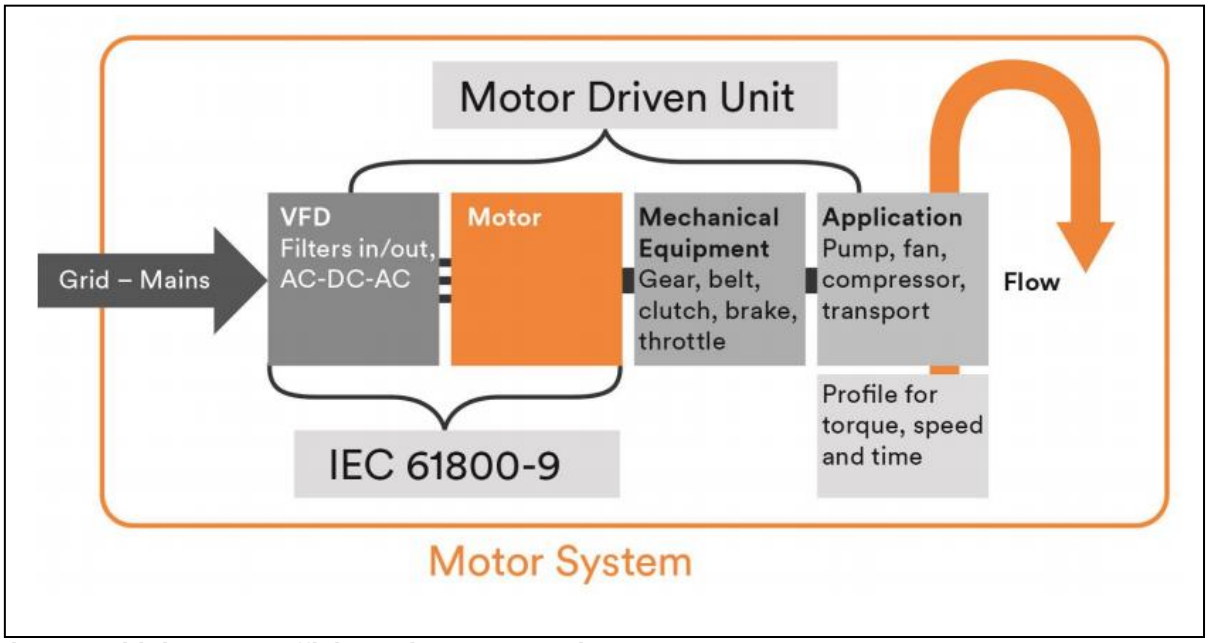

Figure 7 Think energy efficiency in a systematic way!

Source: Impact Energy Inc. 2016

Existing Stock + Incremental Market

China started making Catalogue of Eliminated High Energy Consumption and Backward Mechanical and Electrical Equipment since 2009. The Catalogues cover products such as electric motors, compressors, fans, pumps and transformers. By February 2016, four batches of catalogues were released, in which 386 motor models, 33 compressor models, 52 fan models, 125 pump models and

57 transformer models were listed, that all of them could not be manufactured, sold and used in China.

In addition, the Catalog of Energy-saving Mechanical and Electrical Equipment (Motor) (2016) and the Catalog of Energy Efficiency Star (Motor) (2016) were also developed to ensure high penetration rate of EE equipment for incremental market in China.

The Catalogue of Eliminated High Energy Consumption and Backward Mechanical and Electrical Equipment (Motor) (2016)

From December 2015 to March 2016, according to the China national energy performance standards such as:

- "Minimum allowable values of energy efficiency and energy efficiency grades for small and medium three-phase asynchronous motors"(GB 18613-2012),

- "Minimum allowable values of energy efficiency and the energy efficiency grades for cage three-phase high voltage induction motor"(GB 30254-2013),

in accordance with the principle of eliminating the products which are in backward technical level and have alternative products, MERC has developed a Catalogue of Elimination of High Energy Consumption and Backward Mechanical and Electrical Equipment (Motor) (2016) aiming to eliminate the following two Chinese motor series:

- JK and JS of small and medium three-phase asynchronous motors,

- JK and JS series of cage three-phase high voltage induction motors.

JK and JS, these two series models were widely used in the 90s last century in China, so they are old and inefficient according to the new MEPS. There will be a total of 58 product specifications to be eliminated by the end of 2017. This catalogue was officially announced by MIIT in April 2016, and it formed technical basis of phasing-out existing inefficient motors in China.

The Catalog of Energy-saving Mechanical and Electrical Equipment (Motor) (2016) and the Catalog of Energy Efficiency Star (Motor) (2016)

To encourage all industries to manufacture and use advanced, high-efficient energy-saving equipment, MERC has developed the Catalog of Energy-saving Mechanical and Electrical Equipment (Motor) (2016) and the Catalog of Energy Efficiency Star (Motor) (2016), the former one includes models with the energy efficiency level of tier 1 and tier 2 and the latter one only includes top energy efficient models with the energy efficiency level of tier 1.

a) Processing applications: by 18th August 2016, MERC has received 89 applications for "Energy-saving Mechanical and Electrical Equipment" from 41 motor manufacturers from 16 provinces and cities in China, 72 applications for "Energy Efficiency Star" from 33 motor manufacturers from 16 provinces and cities in China. Both catalogs included 3 kinds of motors, i.e. small and medium three-phase asynchronous motors, three-phase high voltage induction motor and permanent magnet synchronous motors.

b) Product selection and evaluation: an expert consortium was established to evaluate the products based on a comprehensive selection criteria, consisting of aspects of energy efficiency, environmental protection, quality, safety, technological innovation, producing capacity, sales data and the users' comments etc. On 7th September 2016, the product evaluation meeting for these two catalogs were successfully held in Beijing. The draft version of these two catalogs[3] were approved in this meeting and published by MIIT to call for comments during 28th September to 14th October 2016.

[3] The official announcement (at least accessible by the end of 2016):
http://www.miit.gov.cn/n1146295/n1652858/n1653100/n3767755/c5268960/content.html

c) Results: after revision according to the feedback from industries and the public, the final catalogs[4] were published by MIIT on 15th November 2016, and will be effective during the next three years. The Catalog of Energy-saving Mechanical and Electrical Equipment (Motor) (2016) has in total 54 motor models in which 22 low-voltage models from 20 companies, 18 high-voltage models from 6 companies and 14 permanent magnet models from 11 companies. The Catalog of Energy Efficiency Star (Motor) (2016) has in total only 4 motor models in which 2 high–voltage models from 1 company and 2 permanent magnet models from 2 companies.

Energy Efficiency + Comprehensive Environmental Perspectives

Renergy has been promoting the Life Cycle Assessment (LCA) method to key policy makers, combining product energy efficiency evaluation in the use phase together with other parameters in the phases of design, manufacturing, recycling or refurbishment phases, etc. as well as economic parameters. On 21st September 2015, the Communist Party of China (CPC) Central Committee and the State Council, published a reform plan for promoting ecological progress in China, the plan is so-called the "Integrated Reform Plan for Promoting Ecological Progress". In article 46 of this plan, the establishment of a unified system for green products is required: *"Products that are licensed as environmentally friendly, energy-efficient, water-saving, circular, low-carbon, recyclable, or organic will be uniformly classified as green products, and standardized green product standards, certifications, and logos will be established for them. Improvements will be made to policies on fiscal and tax support and government procurement for the research and development, production, transport, delivery, purchase, and use of green products."* It soon was listed in the 2016 work points of "The Central Leading Group for Comprehensively Deepening Reforms". A working group was set up in which Renergy actively took part, together with its partner organizations, contributing with technical support and international policy perspectives. On 7th December 2016, the State Council officially announced guidelines and requirements for establishing the Green Products framework, in which main objectives and tasks, key measures and principles were clarified for the further implementation.

This reform is revolutionary for China's EE standards, labeling and certification systems, and will definitely influence Green Products' Evaluation of individual equipment of motor driven systems. Now a new question was raised that how a Green System will be determined based on this new concept of Green Products in China.

Training + Green Finance Instruments

Principles and Guidelines for Exploiting Electricity Saving Potentials of the Electric Motor Systems

To facilitate motor system users to exploit the electricity savings potentials of their motor systems and implement the energy-saving projects in a more cost-effective way, the project team developed the principles and guidelines for the target audience including technical experts in local governments, energy managers and technical engineers in the factories. The content consists of principles of screening motor system energy saving potential, energy saving potential assessment methods, motor system applications and transmission efficiency assessment guidelines. The drafty versions were discussed with factory staff and engineers and raised their interest to develop and to use this guideline. The final version was also recognized by external experts. Through discussions, the project team improved understanding about the factories' demand for the training courses and got recommendations (on easy readability, direct operability etc.) for further training programs.

Guidelines for Energy-saving Technological Upgrading of Motor Systems in the Cement Industry

From December 2015 to February 2016, the project partner MERC conducted field visits to Chinese cement manufactures and investigations for the cement industry regarding their energy-saving technological upgrading of electric motor systems, in cooperation with the China Building Material Federation. The cement industry consumes 57% of the energy in the building materials sector in

[4] http://www.miit.gov.cn/n1146295/n1652858/n1652930/n4509607/c5361110/content.html

China, which makes it the most energy-intensive industry where the electricity cost accounts for 30% to 35% of the total production cost. More than 60% of the Chinese cement production lines have so far implemented energy-saving technology upgrading programs of their motor systems. The electricity saving potential of reducing the energy demand of the rest cement production lines by around 20% still has not yet been tapped. The project team made the Guidelines for Energy-saving Technological Upgrading of Motor Systems in the Cement Industry and the content consists of motor system energy audits, implementation of technological upgrading, evaluation of energy savings, instructions on different kinds of motor systems in the cement industry and typical case studies.

Training Workshops

a) The project team developed training courses and materials for improving China motor system energy efficiency based on needs from the energy mangers and technical engineers from industrial enterprises, as well as from the local Energy Conservation Supervision Centers (ECSC)[5]. The training materials integrated the up-to-date domestic and international know-how and experiences, covering policies, technologies and applications, principles and guidelines for motor system check, applications of energy-saving technologies such as Variable Frequency Drives (VFDs) etc.

b) On 21st September 2016, in cooperation with Suzhou Institute of Energy Management, the project team conducted trainings for enterprises' senior managers and local energy conservation supervision centers in Jiangsu provinces. Around 200 participants from Jiangsu province, Suzhou city and Yancheng city etc. attended the training, and the training materials were well disseminated to them. In addition, an on-site training for 20 senior technicians was organized in a factory in Suzhou, electrical power testing, pump system energy efficiency evaluation as well as energy saving potentials and pay-back period calculation were introduced and demonstrated. The on-site training was interactive and intuitive for the trainees, so that it gained very positive feedback.

Green Finance

a) Stakeholders from financial sectors were invited as experts participating in the project. Green financing policies and tools like carbon trade, or energy savings trade were trained for target companies.

b) Local government such as Zhenjiang Economic and Information Technology Commission (ZEITC), who is mainly responsible for improving industrial EE, provided 10 million RMB into a money pool, as guarantee to leverage more fund from Banks. E.g. Bank of Jiangsu allocated 100 million RMB as green loan with very competitive loan rate either to factories who will implement EE retrofit projects of their motor systems, or to energy service companies who invest relevant EE retrofit projects and will be paid back with healthy future money flow.

Recommendations & Conclusion

During the project period, the project team communicated with key stakeholders in the policy making and implementing filed, via policy workshop, face-to-face presentations by visiting, and composed the policy recommendations based on our surveys and research. The **"Four Plus"** perspectives were specified and elaborated in a final policy report, in which our main recommendations are as follows,

- a) firstly, in the national level, making middle and long-term goals for improving motor system energy efficiency in China is needed; secondly, to improve the effectiveness of policy implementation, the coordination of existing policies in different phases and aspects are necessary, e.g. policies in production, integration, selling, using, refurbishment and recycling etc.
- b) one key to success is to optimize the existing systems, including
    - to nationally raise the awareness of motor system efficiency, to strengthen capacity of large electricity users (whose annual electricity consumption is higher than 10GWh) by

[5] According to statistics, by 2013, China had more than 2,100 Energy Conservation Supervision Centers and more than 16,000 staff in total.

professional trainings, and to improve the management level of energy saving by adopting ICT technologies;

- (governments at all levels) to introduce (financial or non-financial) incentive policies to guide users phasing-out inefficient equipment and to carry out greener production process and system optimization in parallel;
- to foster independent third-party audit, assessment and verification institutions to support best available technology penetration and standardization processes.

- c) another key to success is to regulate the incremental market.
  - From the production aspect, to strengthen supervision and enforcement is important to avoid manufactures keeping producing inefficient equipment;
  - from the using perspective, green design of a production line is important and awareness raising for designers is needed to solve the over-capacity problem from the early stage;
  - high efficient models shall be strictly required during the whole process of approving a new project, equipment procurement, operational verification and so forth;
  - regular check and benchmarking of energy efficiency level within same industries are helpful to set new goals as a Top-runner of Motor System Energy Efficiency;
- d) market-driven forces, such as the use of taxation, green loan, electricity pricing, Energy Performance Contracting (EPC) and other economic means, are helpful, e.g., green finance instruments could help SMEs implement their retrofits projects on motor system efficiency optimization with lower acceptable financing cost.

It is worthwhile to conclude this paper with a significant improvement of China's EE policy on motor systems. The core concept of the project, "systematic efficiency", was highly recognized by policy makers in China. On 30th June 2016, MIIT published the 13th five-year plan (2016-2020) of industrial green development in China, in which it was firstly stated that **"the industrial energy saving shall focus from component to the whole system, from one part to the whole processes"**, and a national goal was set that **"the average energy efficiency of China's motor systems shall be improved by 5% by 2020"**. In addition, a road map establishing China's national standard for evaluating electric motor system energy efficiency was announced by CNIS on a meeting hosted by China Energy Conservation Association (CECA) on 4th December in Changsha, Hunan province. More research and analysis on the upcoming polices and mechanisms will be conducted by the project team in future.

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List of Abbreviations

CECA China Energy Conservation Association

CEL China Energy Label

CNIS China National Institute of Standardization

EE Energy Efficiency / Energy Efficient

ESCOs Energy Service Companies

EPC Energy Performance Contracting

IEC International Electrotechnical Commission

LCA Life Cycle Assessment

MEPS Minimum Energy Performance Standards

MERC Machinery Industry Energy and Resources Conservation Center of China

MIIT Ministry of Industry and Information Technology of China

MoF Ministry of Finance of China

VFDs Variable Frequency Drives

ZEITC Zhenjiang Economic and Information Technology Commission