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Energy Cooperation Platform
中国 - 欧盟能源合作平台

Comparative study on policies for products' energy efficiency in EU and China

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EU-China Energy Cooperation Platform was launched on 15 May 2019, to support the implementation of activities announced in the "Joint Statement on the Implementation of EU-China Energy Cooperation". The overall objective of ECECP is to enhance EU-China cooperation on energy. In line with the EU's Green Deal, Energy Union, the Clean Energy for All European initiative, the Paris Agreement on Climate Change and the EU's Global Strategy, this enhanced cooperation will help increase mutual trust and understanding between EU and China and contribute to a global transition towards clean energy on the basis of a common vision of a sustainable, reliable and secure energy system. Phase II of ECECP is implemented by a consortium led by ICF, and with National Development and Reform Commission-Energy Research Institute. Policy steering is by the EU (DG ENER) and the China National Energy Administration.

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ICF

CNIS 中国标准化研究院 CHINA NATIONAL INSTITUTE OF STANDARDIZATION

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Glossary

Term	Description
AHU	Air handling unit
AV	Audio-visual
BVU	Bidirectional ventilation unit
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CENELEC	Comité Européen de Normalisation Electrotechnique (European Committee for Electrotechnical Standardisation)
EEI	Energy Efficiency Index
EU	European Union
European standard	A standard adopted by a European standardisation organisation
GB	China standard
HRS	Heat recovery system
IEC	International Electrotechnical Commission
ISO	International Organisation for Standardisation
MEPS	Minimum energy performance standard
NRVU	Non-residential ventilation unit
RVU	Residential ventilation unit
Standard	A technical specification, adopted by a recognised standardisation body, for repeated or continuous application; compliance is not normally compulsory, unless the standard is referred to in legislation
UVU	Unidirectional ventilation unit
VU	Ventilation unit

EXECUTIVE SUMMARY

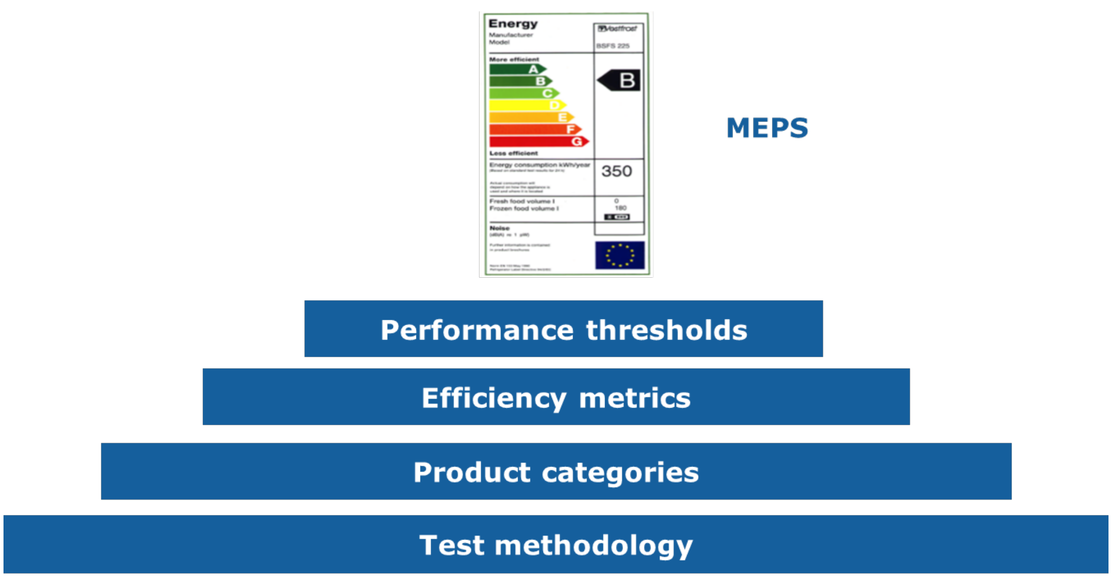
This study presents a provisional analysis of the degree of harmonisation that exists in energy performance regulatory requirements in China and the EU for a select group of products. The report addresses: split room air conditioners, domestic refrigeration appliances, televisions, electric motors, distribution transformers, chillers, commercial refrigerated display cabinets, air handling units, and air compressors. For each product group a systematic, but necessarily somewhat superficial, appraisal has been conducted that considers the degree of harmonisation that exists with regards to:

- Scope and nature of requirements.
- Energy performance test procedure.
- Product categorisation.
- Energy efficiency metrics.
- Efficiency levels.
- China-EU alignment potential.

For most of these product types, both China and the EU set minimum energy performance standards (MEPS) with the exception of air handling units in China and air compressors in the EU (although draft regulations exist). For consumer-facing products, the EU and China specify energy labelling, while China also has such labels, or at least energy efficiency grades, for industrial/commercial products, with the exception of air handling units.

It is clear that at a technical level, especially at the level of energy performance measurement, there is already a high degree of harmonisation for these products, but this tends to lessen the higher-up the harmonisation pyramid the product groups are assessed (Figure ES1.1).

Figure ES1.1: Hierarchy of factors that affect the technical potential to align MEPS and labelling requirements.



Perhaps surprisingly, the least harmonisation among the consumer products currently seems to occur for televisions, despite both economies drawing upon ostensibly the same test procedure. There is no market reason or fundamental policy logic for this divergence – it simply seems to have occurred due to disconnected policy development processes. The product types and their usage conditions are very similar in the two economies.

Domestic refrigerators are the next product with the least level of harmonisation, which is also counterintuitive because until quite recently there was a considerable degree of harmonisation between the approaches and requirements applied in both China and the EU. In part, this is explicable by the EU moving toward the adoption of test methods that align with the new IEC standard, in a rather radical departure from the previous standard. China appears to be undergoing a similar transition but has retained much of its original approach to product categories and efficiency metrics, while the EU has made significant changes in these areas. From a product characteristic perspective there is considerable similarity in the nature of products sold in both markets, but with some differences in certain product types.

Split room air conditioners also have considerable similarities in approach, especially at the testing level, but there are some differences which might mean that a product tested and rated under one system would need to be re-rated to be declared under the other. While there is a logic in applying different weightings to part-load performance rating points in both economies due to climatic and usage differences, there is no inherent reason why the same test conditions could not be tested and rated for performance declaration purposes, where there a desire to do so.

For distribution transformers the test method, rating approach and means of setting MEPS levels (in terms of load and no-load loss levels) is the same in both economies, the only significant differences being in the product categories applied (which partly reflect local product types) and the actual performance levels required. It would be reasonably straightforward to compare the latter in subsequent work and equally to probe the reasons for the current product categorisation distinctions. On first inspection there appears to be no market barrier in the manner in which products are tested and rated, but this could be probed in more detail in future work.

For electric motors, both economies are using the same system to test and classify the energy performance of the main types of AC induction motors. There are some differences in efficiency level requirements and also in product scope which could be examined and potentially addressed in future work, were there to be a desire to align requirements.

The energy performance of comfort chillers is regulated in both economies. A priori, it is likely that the level of harmonisation concerning the test method is very high, if not identical, but there are differences in the part-load test conditions, the weighting applied to the part-load test points and the treatment of auxiliary loads. In addition, the scope of the EU's regulations is broader in that it includes process chillers, whereas China's is understood to be focused exclusively on comfort chillers. Further investigation could clarify the differences and determine pathways to greater alignment.

MEPS and mandatory energy labels apply to commercial refrigerated display cabinets in both China and the EU. Both economies apply a similar product scope in their respective regulations. There is strong alignment in the test method applied and although there are some differences in the versions of the standards and some technical specificities, the level of alignment between both economies seems high. Significant differences are evident for the energy efficiency metrics. Accordingly, the level of the MEPS and energy efficiency classes of the energy labels cannot be easily compared, although there is no intrinsic reason why this should be the case.

Of the two economies, only the EU currently regulates the efficiency of air handling units (AHUs), although China has a voluntary energy performance standard. The EU regulation applies to both bi- and uni-directional AHUs, while only the former are addressed in China's voluntary standard. It is likely that test procedures will deviate, but both economies have similar thermal efficiency metrics. There appears to be a need for both economies to further improve their standards, giving scope for technical cooperation on these aspects that could lead to further alignment.

For air compressors, both economies appear to be using the same method to test the energy performance of rotary compressors. The EU regulations are in the draft stage, but China's are already in place and cover more compressor types than those in the EU. Although the energy efficiency metrics for rotary compressors are different in both economies a direct conversion of the results is possible. Nonetheless, being able to compare the regulatory efficiency levels would require additional investigation. Considering that the EU regulation on rotary standard air compressor packages is still a draft and that other types are not yet considered in the EU, air compressors could be a good candidate for further investigation to examine if further alignment is sensible.

In order of harmonisation (from greatest to least) the products very roughly rank as follows:

- Electric motors.
- Distribution transformers.
- Split room air conditioners.
- Domestic refrigeration appliances.
- Televisions.
- Commercial refrigerated display cabinets/Air Compressors.
- Chillers/Air handling units.

However, in actuality there is a strong degree of technical harmonisation for all of these product groups, with most deviations occurring due to:

- minor differences in test methods or their application.
- differences in product categorisation and efficiency metrics.

Unfortunately, these differences mean that it is usually impossible to make a direct comparison of the stringency of regulatory efficiency levels, even though the test methods usually align. Making such comparisons would require the development of normalisation methods which, while perfectly achievable, is beyond the scope of the current exercise.

As a general observation, it can be remarked that there is no inherent logic behind these deviations in product categorisation and efficiency metrics other than disconnected and divergent regulatory processes. It can also be noted that the extent of alignment in both economies is largely based on both making use of international

(IEC/ISO) test standards and to some extent on direct emulation in the early days of equipment MEPS and labelling programmes. However, recent trends appear to be toward greater divergence, as both economies have begun to adapt international standards (or make their own) and no work is ongoing aside from this project to support regulatory discourse and alignment.

The value proposition of alignment

China and the EU are two of the world's three major economies and collectively exert enormous influence over product standards at the global level. When the two economies have aligned approaches, the evidence suggests that the approach adopted is rapidly emulated by other economies around the world, with the partial exception of North America. This helps facilitate trade and technology transfer on a global scale. In the case of equipment energy efficiency, such alignment has the potential to speed up the dissemination of good commercial, industrial and regulatory practice around the world and thereby accelerate the adoption of highly energy efficient technologies. Even if the two economies choose to set different efficiency thresholds in their respective MEPS and labelling programmes, alignment of test methods, product categorisation and efficiency metrics will create a common accounting framework, reduce compliance costs, aid transparency and facilitate more rapid adoption of high impact efficiency requirements internationally. Thus, efforts to stimulate greater alignment are important for the climate change mitigation and green growth agenda. In recent times the opposite trend can be observed: there has been more divergence between the approaches adopted. This risks the creation of standardisation and regulatory poles, which could have the reverse effect.

Recommended actions

Arguments could be made, in terms of similarity of product types, international trade volumes and international regulatory coherence, for greater harmonisation for each of these product groups – especially with regard to the perspective used to determine and classify energy performance. In principle, there are no fundamental reasons why there should be differences in approach between China and the EU. The current work has identified the extent of similarity and differences at a provisional level, but in each case there would be value in conducting deeper, more authoritative and comprehensive investigations, were there to be willingness among the policymaking communities to explore options for greater harmonisation. It should be noted that such harmonisation does not need to entail harmonising policy thresholds, but rather all the factors that define product energy performance. In particular, this relates to factors which do not reflect fundamental differences, such as climatic and usage differences, and consumer preferences for different types of products.

At a technical level, for a subsequent round of work for each of these products, the recommendation would be to:

- Conduct a thorough assessment of the current levels of alignment and non-alignment with regard to all the energy performance factors discussed in this report.

- Conduct a thorough investigation of conformity assessment requirements and procedures to determine to what extent differences exist, whether there is any underlying rationale for differences identified, or whether this is simply due to disconnected regulatory development processes.

Beyond the technical aspects it would also be relevant to explore the rationale for greater alignment (the value proposition of harmonisation), and the opportunities and willingness within the policymaking processes within both economies to explore greater alignment.

With regard to trade, work could be done to clarify the trade volumes of these products (in value and units) between the two economies and globally. Such work should not ignore trade in parts and components, which can often be larger than trade in the finished good itself. The research could be complemented by a related energy impact analysis to determine the scale of energy use that could be affected by these product groups and hence help to determine the groups where there would be the most value from more detailed cooperation. In parallel, an appraisal of the standardisation and regulatory processes would allow information to be gathered on the potential for alignment, and factored into subsequent decisions about exploratory alignment exercises.

1. INTRODUCTION

The aim of this project is to develop a comparative report on energy-saving policies for products in the EU and China identified in the 2019 Joint Statement on the Implementation EU China Energy Cooperation on Energy, and to explore ways of aligning these for at least one globally traded group.

The products addressed are:
- Split room air conditioners.
- Chillers.
- Domestic refrigerators.
- Commercial refrigerators.
- Televisions.
- Electric motors.
- Transformers.
- Air handling units.
- Air compressors.

The intended results are:

R1. Improved exchanges between the EU and China on their respective positions and approaches to global energy challenges.

R2. Greater understanding of each other's energy policies and development methods for policy makers.

R3. New contacts established with Chinese policy makers and influential experts in Chinese think tanks and academic institutions.

R4. Greater awareness of EU-China energy cooperation activities among experts, administrators and in the general public.

R5. Improved confidence and trust between European and Chinese policy makers and stakeholders on energy matters.

R6. Improved awareness within China of the benefits of EU-China collaboration.

To conduct this work, European experts (Paul Waide of Waide Strategic Efficiency and Antoine Durand of Fraunhofer ISI) formed a project team with Chinese experts (Li Pengcheng, Liu Meng, Yujuan Xia & Ren Liu) from the China National Institute of Standardisation (CNIS).

Work began in mid-April 2021 and the deliverables have been produced according to the following schedule:

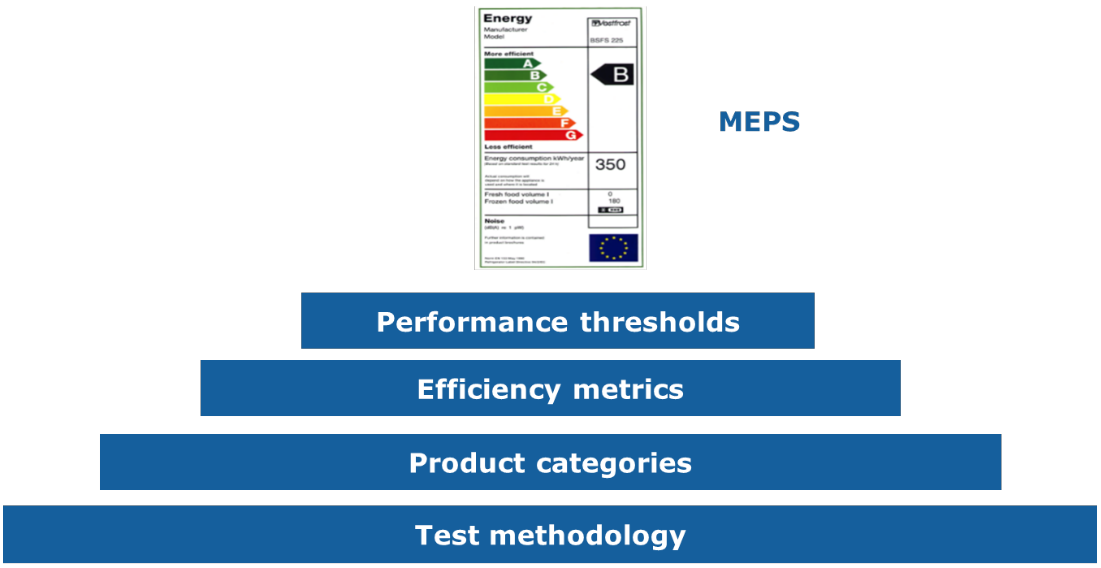
Deliverable No. and nature	Delivery date
D1. Draft Report Framework: ‘A comparative report on the energy-saving policies for products in the EU and China’	15 May 2021
D2.1 First Draft Report: First draft focused on five products	1 July 2021
D2.2 Second draft for all nine products	30 September 2021
D3 Final Report: ‘A comparative report on the energy-saving policies for products in the EU and China’	7 November 2021

This current report is deliverable D3 and covers all nine product groups.

2. METHODOLOGY

When considering the elements that underpin the establishment of energy performance regulatory requirements such as MEPS and energy labelling of products there is a hierarchy which is expressed in the following figure (Figure 2.1).

Figure 2.1: Hierarchy of factors that affect the technical potential to align MEPS and labelling requirements[1]



Harmonisation can occur at any or all of these levels but each builds upon the level(s) below, such that it is only possible to have harmonised energy performance thresholds if the energy efficiency metrics used are the same. Equally, it is only possible to have harmonised efficiency metrics if the product categorisation applied in the metrics is the same and the way in which energy performance is measured (the energy performance testing methodology) is the same. Similarly, product categorisation applied within energy efficiency metrics is often the same as or builds upon that used in test standards. Thus, before considering the extent of harmonisation of efficiency thresholds used in policy settings it is first necessary to consider the extent of harmonisation in all the preceding factors.

With reference to the above, for each product type investigated this report presents a provisional, i.e. non-comprehensive, comparison of the approach and degree of alignment which exists for each of the following aspects:

- Scope and nature of requirements.
- Energy performance test procedure.
- Product categorisation.
- Energy efficiency metrics.

1 Note, product categories can sometimes come before test methods.

- Efficiency levels.
- China-EU alignment potential.

The methodology applied follows this hierarchy in comparing first the scope, then the test methodology, then the product categorisation, then the efficiency metrics and finally the energy performance thresholds applied in each economy. It is important to appreciate that the energy performance thresholds can only be unambiguously compared if the preceding factors are also aligned. If they are not, a comparison may either be meaningless or require application of technically-derived energy performance conversion methods, which is beyond the scope of the current study. Also, the current investigation is inherently provisional in nature due to limited budgeted resources and broad scope, which means that the analysts are attempting to do an appraisal based on what they already understand and what can be quickly determined from a scan of the relevant technical and regulatory documentation. However, it does not encompass a fully detailed point-by-point comparison of all technical aspects (such as all applicable aspects in testing, etc.), so it will not produce a definitive and comprehensive assessment. Nonetheless, it aims to characterise correctly the main technical and regulatory factors and hence provide a reasonable basis for prioritisation for subsequent potential alignment work. In addition, it is important to understand that the focus is on characterising the technical characteristics of product energy efficiency requirements in both economies, and drawing upon this to determine which product types are most promising from a technical perspective for further alignment activity.

The focus is not on issues such as savings potentials, trade or process pathways to align regulatory policy settings. These topics would have to be investigated in subsequent work, should there be a desire to continue to explore this topic. Lastly, the focus is on in-use energy performance requirements and hence does not address other environmental impact requirements associated with other parts of the product lifecycle or non-energy-in-use factors.

3. FINDINGS ON THE NINE PRODUCTS

This section presents the study teams' findings with respect to the existing level of harmonisation and prospects for further harmonisation in the energy performance requirements set in China and the EU respectively for the nine product groups investigated in this project. Each product has been appraised in accordance with the same structure, comprising sub-sections on: summary of existing regulations, scope, energy performance test procedure, product categorisation, efficiency metrics, efficiency levels and China-EU alignment potential.

3.1 Split room air conditioners

Summary of existing regulations

China has both MEPS and energy labelling for split room air conditioners. The most current requirements are set out in GB 21455-2019: Minimum allowable values of the energy efficiency and energy efficiency grades for room air conditioners.

The EU sets ecodesign requirements for room air conditioners in COMMISSION REGULATION (EU) No 206/2012 of 6 March 2012 Implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans.

The EU's energy labelling requirements are set out in COMMISSION DELEGATED REGULATION (EU) No 626/2011 of 4 May 2011 Supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of air conditioners.

Scope

The EU's regulations include several types of products and not only split room air conditioners (the focus of this section), but China's are focused exclusively on split room air conditioners. The EU regulations cover split units up to 12kW of cooling capacity, while China's include units with capacities up to 14 kW. Both sets of regulations address cooling-only or reversible units i.e. those that can both cool and heat a space.

GB 21455-2019 is applicable to:

- room air conditioners using air-cooled condensers and hermetic motor compressors with a rated cooling capacity no greater than 14 000 W and under working condition T1.
- low ambient temperature air source heat pump air heaters with nominal heating

capacity no greater than 14 000 W.

The regulation is not applicable to mobile air conditioners (which are addressed in the EU regulations, but are not split room AC units), multi-connected air conditioning (heat pump) units or ducted air conditioners.

The EU's regulations do not apply to:
- appliances that use non-electric energy sources.
- air conditioners of which the condenser-side or evaporator-side, or both, do not use air for heat transfer.

An important difference is that the EU regulations do apply to multi-split air conditioners (i.e. units which have one outdoor condenser unit connected to multiple indoor evaporator units), whereas China's do not.

Energy performance test procedure

The method of testing air conditioners used in China and the EU appears to be identical (at least on initial inspection) and is aligned with the ISO methodology.

ISO 5151:2017 *Non-ducted air conditioners and heat pumps — Testing and rating for performance*

The full load rating points used in both the cooling and heating modes are the same in both economies and align with the ISO method. Differences occur in the test points used at part-load. China requires testing at 25% of full load conditions or at a lower load level specified by the manufacturer. They also require testing at another intermediate point between the lowest load point (25% of full capacity or lower) and full load conditions. A formula is then applied to determine the performance at intermediate test points. By contrast, the EU specifies four precise test conditions for the cooling load which correspond to full load (100%), 74%, 47% and 21% of full load. In the heating mode, three precise test conditions are specified.

Aside from these differences there may be variations in how inverter AC units are set-up for testing under part-load operating conditions, but this would need to be checked were a fuller investigation to be conducted. Note, the manner in which inverter units are set-up for part-load testing is a topic that is currently under consideration in the on-going review of the EU's regulatory requirements.

The test measurement standard used in the EU regulations for split room air conditioners is EN14511:2013, which defines the rated performance and measurement methods to be used for all air conditioners in cooling and in heating mode. The standard EN14825:2016 defines the calculation and testing points to calculate the seasonal energy efficiency (SEER) and seasonal coefficient of performance (SCOP) and completes, where required, measurement methods defined in standard EN14511.

Product categorisation

The EU links its MEPS energy efficiency requirements to the global warming potential

(GWP) of the refrigerant used, such that products using lower GWP refrigerants have to meet less stringent MEPS requirements.

China sets slightly more rigorous energy efficiency requirements and grades for units with lower cooling/heating capacity, whereas the EU requirements are not differentiated by cooling capacity.

Efficiency metrics

China specifies MEPS and labelling requirements in terms of a seasonal energy efficiency ratio (SEER) for cooling-only air conditioners and in terms of an annual performance factor (APF) for reversible units (i.e. those capable of both heating and cooling). The APF is an aggregate indicator of the performance in the cooling mode (expressed in terms of an SEER) and of the performance in the heating mode (expressed in terms of a heating seasonal performance factor (HSPF)). Both the SEER and HSPF metrics (and hence also the APF) express the performance of the air conditioner at full load and at part-load operating conditions.

Regardless of whether a SEER, HSPF or APF metric is used, they are all expressed in terms of the ratio of the delivered useful thermal energy (cooling, heating or both) per unit of electricity consumed i.e. in units of Watts (thermal) per Watt (electric).

China's method to produce the SEER, HSPF and APF aligns with that used in the ISO standards:

- ISO 16358-1:2013 *Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors — Part 1: Cooling seasonal performance factor.*

- ISO 16358-2:2013 *Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors — Part 2: Heating seasonal performance factor.*

- ISO 16358-3:2013 *Air-cooled air conditioners and air-to-air heat pumps — Testing and calculating methods for seasonal performance factors — Part 3: Annual performance factor.*

The EU also uses a SEER metric to express air conditioner performance in the cooling mode, and uses a Seasonal Coefficient of Performance (SCOP) to express the performance in the heating mode. As noted earlier, there are differences in the part-load rating conditions used in China and the EU, such that despite application of methods to interpolate part-load performance at intermediate design temperatures, there could be differences in the derived part-load values for the same product. Even were this not the case, the final SEER values will still differ because the weightings given to estimated part-load performance at each outdoor temperature vary due to systematic differences in the average climate. Nonetheless, the fact that the full-load input rating values are directly comparable, and that the principles applied in order to derive part-load performance are essentially comparable, still indicates there is a relatively high degree of alignment[2]. The situation is similar for the heating mode where the full and part-load test point rating conditions and test method for the full-load input rating values are the same, but the part-load test conditions and weighting applied to these to derive the HSPF (in China) or SCOP (in the EU) are different due to climatic differences. Note, while China reports one nationally averaged HSPF the EU reports three, which depend on the climate (average, warmer, colder).

Efficiency levels

China specifies MEPS and then five energy efficiency grades (levels) that are indicated on the energy label wherein grade 1 is the highest efficiency level and grade 5 the lowest (and is the same level as the MEPS requirements).

Table 3.1.1 indicates the energy efficiency thresholds that delineate the energy efficiency grades applied to heat-pump (reversible) type room air conditioners in China expressed in terms of the APF. The thresholds are slightly more stringent for units with smaller cooling capacities than those with larger cooling capacities which reflects the current state of the market.

Table 3.1.1: China's Indicators of energy efficiency grades for heat-pump type room air conditioners

Rated cooling capacity (CC) W	Annual performance factor (APF)				
	Energy efficiency grades				
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
CC≤500	5.00	4.50	4.00	3.50	3.30
4 500<CC≤7 100	4.50	4.00	3.50	3.30	3.20
7 100<CC≤14 000	4.20	3.70	3.30	3.20	3.10

Table 3.1.2 shows the requirements, expressed in terms of SEER, for cooling only air conditioners.

Table 3.1.2: China's indicators of energy efficiency grades for cooling-only type room air conditioners

Rated cooling capacity (CC) W	Seasonal energy efficiency ratio (SEER)				
	Energy efficiency grades				
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
CC≤4 500	5.80	5.40	5.00	3.90	3.70
4 500<CC≤7 100	5.50	5.10	4.40	3.80	3.60
7 100<CC≤14 000	5.20	4.70	4.00	3.70	3.50

2 In actuality, in order to reduce the number of test points, the ISO standard (based on Chinese, South Korean and Japanese standards) models some of the part load points. This is one of the reasons why CEN did not consider the adoption of the ISO standard. For differences in climate, the ISO standard contains an annex that allows users to apply regional variations in heating and cooling load curves.

Table 3.1.3 shows the SEER (for the cooling mode) and SCOP (heating mode) thresholds applied in the EU energy label.

Table 3.1.3: The EU's energy efficiency classes for air conditioners

Energy efficiency class	SEER	SCOP
A+++	SEER ≥ 8.50	SCOP ≥ 5.10
A++	6.10 ≤ SEER < 8.50	4.60 ≤ SCOP < 5.10
A+	5.60 ≤ SEER < 6.10	4.00 ≤ SCOP < 4.60
A	5.10 ≤ SEER < 5.60	3.40 ≤ SCOP < 4.00
B	4.60 ≤ SEER < 5.10	3.10 ≤ SCOP < 3.40
C	4.10 ≤ SEER < 4.60	2.80 ≤ SCOP < 3.10
D	3.60 ≤ SEER < 4.10	2.50 ≤ SCOP < 2.80
E	3.10 ≤ SEER < 3.60	2.20 ≤ SCOP < 2.50
F	2.60 ≤ SEER < 3.10	1.90 ≤ SCOP < 2.20
G	SEER < 2.60	SCOP < 1.90

Table 3.1.4 shows the MEPS thresholds, for cooling mode (SEER) and heating mode (SCOP) applied in the EU.

Table 3.1.4: The EU's requirements for minimum energy efficiency for air conditioners

	SEER	SCOP (Average heating season)
If GWP of refrigerant >150	3.60	3.40
If GWP of refrigerant ≤ 150	3.24	3.06

Due to the differences in how the SEER is determined in China compared to in the EU, it is not strictly possible to compare these values. A simplified comparison could potentially be derived through application of a theoretical normalisation method, but the derivation and application of such a method is beyond the scope of this study. However, it is likely that the highest EU requirements (A+++ level) are more ambitious than China's grade 5 level for the SEER. The MEPS levels shown in Tables 3.1.1 (grade 5 boundary) and 3.1.4 are probably more comparable. It should be noted that not all the EU label classes shown in Table 3.1.3 are permitted, as some are below the MEPS thresholds shown in Table 3.1.4.

China-EU alignment potential

The types of room air conditioner products sold in China and the EU are comparable and the same types of technologies predominate in both markets, with a significant proportion of EU product being manufactured in China. Both economies use test procedures that have strong alignment with the ISO test methods, including the same rating point test conditions being applied in both cooling and heating mode at full-load. There is a difference in the choice of energy efficiency metrics, however, with China using an APF for heat pumps (reversible AC) and the EU setting separate requirements for the cooling mode (SEER) and the heating mode (SCOP), but the underlying inputs used to derive the metrics used in each economy are similar and the basic principles applied are essentially the same. The SEER values derived in both economies are not directly comparable because of the difference in weightings applied to the input test rating points due to climatic differences. Similarly, the SCOP (EU) and HSPF (China) values are not directly comparable for the same reason, even though the underlying input part and full load test point values appear to be directly comparable. There may also be differences in how low power modes are treated.

Overall, there appears to be a lot of commonality in the approaches used at the technical level prior to derivation of the final efficiency metrics and the setting of efficiency thresholds, but not complete harmonisation. A more in-depth investigation would determine the precise degree of alignment and whether there is any opportunity to remove minor differences at this level that would avoid the need to re-test the same product for performance declaration and conformity assessment purposes in order for it to be eligible to be sold on either market. But a priori, room air conditioners would appear to be good candidates for further China-EU alignment investigation.

It should be noted that the EU is in the process of revising its energy labelling and MEPS requirements for air conditioners, including a review of its test procedures, efficiency metrics, MEPS and labelling thresholds. While more stringent MEPS and labelling requirements may emerge from this, it is also possible there could be changes in how products are set-up for testing at part loads and the rationale underpinning these considerations could be of interest to both economies' regulatory processes.

3.2 Domestic refrigerating appliances

Summary of existing regulations

In China, GB 12021.2-2015 *Maximum allowable values of the energy consumption and energy efficiency grades for household refrigerators* sets out the MEPS and energy grades (to be used in labels) for domestic refrigerating appliances.

The EU applies MEPS for domestic refrigerating appliances under COMMISSION REGULATION (EU) 2019/2019 of 1 October 2019 *laying down ecodesign requirements for refrigerating appliances pursuant to Directive 2009/125/EC of the European Parliament and of the Council and repealing Commission Regulation (EC) No*

643/2009.[3] Energy labelling requirements are specified in COMMISSION DELEGATED REGULATION (EU) 2019/2016 of 11 March 2019 *supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to energy labelling of refrigerating appliances and repealing Commission Delegated Regulation (EU) No 1060/2010*.[4]

In addition, COMMISSION REGULATION (EU) 2021/341 of 23 February 2021 *amending Regulations (EU) 2019/424, (EU) 2019/1781, (EU) 2019/2019, (EU) 2019/2020, (EU) 2019/2021, (EU) 2019/2022, (EU) 2019/2023 and (EU) 2019/2024 with regard to ecodesign requirements for servers and data storage products, electric motors and variable speed drives, refrigerating appliances, light sources and separate control gears, electronic displays, household dishwashers, household washing machines and household washer-dryers and refrigerating appliances with a direct sales function*[5] contains provisions which amend the Ecodesign requirements for 2019/2019. Furthermore, COMMISSION DELEGATED REGULATION (EU) 2021/340 of 17 December 2020 *amending Delegated Regulations (EU) 2019/2013, (EU) 2019/2014, (EU) 2019/2015, (EU) 2019/2016, (EU) 2019/2017 and (EU) 2019/2018 with regard to energy labelling requirements for electronic displays, household washing machines and household washer-dryers, light sources, refrigerating appliances, household dishwashers, and refrigerating appliances with a direct sales function*[6] contains provisions which amend the Energy Labelling requirements for (EU) 2019/2016.

The set of EU regulations came into effect in March 2021.

Scope

The scope of the EU's regulations applies to electric mains-operated refrigerating appliances with a total volume of more than 10 litres and less than or equal to 1 500 litres. It excludes:

- professional refrigerated storage cabinets and blast cabinets, with the exception of professional chest freezers.
- refrigerating appliances with a direct sales function.
- mobile refrigerating appliances.
- appliances where the primary function is not the storage of foodstuffs through refrigeration.

The Chinese standard is applicable to household refrigerators with motor-driven compressor, wine storage cabinets, and built-in refrigerating appliances. It is not applicable to:

- those refrigerators with a transparent door dedicated to display.
- those designed for other special purposes.

The Chinese standard has no scope restriction in terms of volume, even if it stresses that it includes refrigerators of 500 litres and above.

3 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R2019&from=DE
4 https://eur-lex.europa.eu/legal-content/en/TXT/PDF/?uri=CELEX:32019R2016&from=EN
5 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0341&from=EN
6 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0340&from=EN

Both the EU and the Chinese regulations cover household fridges, freezers and combination refrigerator-freezers as well as wine storage cabinets. The main difference is that GB 12021.2-2015 does not apply to absorption refrigerators[7] and excludes refrigerators with a transparent door.

Energy performance test procedure

The IEC 62552 standard *Household refrigerating appliances - Characteristics and test methods* was updated in 2015 and amended in 2020, the current version is the IEC 62552:2015+AMD1:2020. It is a major update compared to the 2007 version of the standard. In particular, the energy consumption test now has two specified ambient temperatures (16°C and 32°C) and is carried out without test packages. IEC 62552-3:2015/AMD1:2020 *Household refrigerating appliances - Characteristics and test methods - Part 3: Energy consumption and volume*.[8]

GB 12021.2-2015 mentions that the latest edition of the IEC 62552 applies, consequently it is currently based on IEC 62552-3:2015/AMD1:2020.

For the EU market, ANNEX III of the Ecodesign regulation specifies the measurement methods. The EU regulation is mostly based on IEC 62552-3:2015/AMD1:2020 but clarifies some specific points. The European standardisation body (CENELEC) published the standard EN 62552:2020 to provide dedicated methods for measuring the energy performance according to the Ecodesign and labelling regulations. The differences which impact testing the most are as follows:

- the EN standard has an additional requirement/test for chill compartments.[9] If the refrigerating appliance does not fulfil this requirement, the chill compartment cannot be defined.
- the EN standard has an additional requirement for wine storage cabinets. According to the EN IEC 62552-2:2020, during the storage test at 25°C, the relative humidity in the compartments must be measured and has to lie between 50% and 80%.
- during the freezing capacity test, the space to place light load is better defined in the EN than in the IEC standard and stacks that may be removed to make place for the light load are minimised.
- the positions of the thermocouple sensor during the energy consumption test may differ slightly.

Whilst according to the IEC and EN standards, the variable temperature compartment must be set to the most energy consuming condition, the EU regulation states that it must be set to the coldest position, except in the case of a variable temperature compartment rated as a fresh food and/or chill compartment.[10]

7 Corresponding to low noise refrigerating appliances in the EU regulation.
8 https://webstore.iec.ch/publication/21803
9 This is defined in EN IEC 62552-3: 2020 Annex ZA Chill compartment temperature control test.
10 See Annex III 1(a) and Annex III 1(f)(1) of the Ecodesign regulation.

In general, the test procedures used in the EU and in the Chinese regulations show a high level of harmonisation. The few deviations are likely to have a very limited impact on the measured energy consumption in most cases. For wine storage cabinets and refrigerating appliances with chill compartments, the deviation of the test procedures has a larger impact.

Product categorisation

China differentiates 10 categories of domestic refrigerating appliances, while the EU differentiates only six. Table 3.2.1 provides an overview of the product categorisation. Most of the common domestic refrigerating appliances from the Chinese categories are defined in one single category in the EU regulation.

Table 3.2.1: Product categorisation for domestic refrigerating appliances

In China	In the EU
Excluded	Dedicated low noise refrigerating appliances with fresh food compartment(s)[11]
Excluded	Low noise refrigerating appliances with transparent doors
Excluded	Other low noise refrigerating appliances, with the exception of low noise combi appliances with a frozen compartment
Excluded	Wine storage appliances with transparent doors
10.Wine storage cabinet	Other wine storage appliances
1. Refrigerator without star compartment 2. Refrigerator with 1-star compartment 3. Refrigerator with 2-star compartment 4. Refrigerator with 3-star compartment 5. Refrigerator-freezer 6. Frozen food storage cabinet 7. Chest refrigerator-freezer 8. Chest freezer 9. Upright freezer	All other refrigerating appliances, with the exception of low noise combi appliances with a frozen compartment[12]

Efficiency metrics

In China, the standard energy efficiency index of refrigerators is defined in the GB 12021.2:2015 as:

$$\eta_s = E_s / E_{base} \times 100\,\%$$

With:

- E_{base}: Reference energy consumption (in kWh/24h) is a baseline for product energy consumption comparison, defined as:

$$E_{base} = \left(M \times V_{adj} + N + CH + D_c\right) \times S_r / 365$$

11 This means a refrigerating appliance without vapour compression and with airborne acoustical noise emission lower than 27 A-weighted decibel referred to 1 pico watt (dB(A) re 1 pW).

12 T is the most common product category.

M and N reflect the performance of the reference appliance, the values are product category specific.
V_{adj} is the adjusted volume of a refrigerator, reflecting the energy service provided by the appliance. It is based on the volume and temperature of each compartment and also takes into account whether the appliance is a built-in or not and the climate class.
CH is variable temperature compartment correction factor.
S_r is a function correction factor.

- E_s is the standard value of energy consumption, in kWh/24h, calculated as:

  $$E_s = [(E_{daily,16℃} \times \text{Day16℃} + E_{daily,32℃} \times \text{Day32℃}) + E_{aux}]/365$$

  Where $E_{daily,16°C}$ and $E_{daily,32°C}$ are the daily energy consumption measured according to the IEC 62552:3-2015 standard for stable operation at an ambient temperature of 16°C and 32°C.
  Day16°C = 192 days and Day32°C = 173 days

Both the energy label grades and the MEPS level are set in terms of η_s.

In the EU, the Energy Efficiency Index (EEI) is defined as:

EEI = AE/SAE

With:

- *AE*: annual energy consumption in kWh/a, calculated as:
  $AE = 365 \times E_{daily}/L + E_{aux}$
  With:
  $E_{daily} = 0,5 \times (E_{16} + E_{32})$
  E_{aux}: auxiliary energy
  L: lead factor

- SAE: standard annual energy consumption in kWh/a, calculated as:

  $$SAE = C \times D \times \sum_{c=1}^{n} A_c \times B_c \times [V_c/V] \times (N_c + V \times r_c \times M_c)$$

  With:
  c: index number for a compartment (n: total number of compartment)
  V_c: compartment volume
  V: total volume
  r_c, N_c, M_c *and C*: modelling parameters specific to each compartment
  A_c, B_c *and D*: compensation factors for defrost, built-in/freestanding and the freezer star rating.

Both the energy label classes and the MEPS level are set in terms of EEI.

The metrics in China (η_s) and in the EU (EEI) are based on different approaches and are therefore calculated differently. In China, the modelling parameters for calculating the energy consumption of the reference appliance are based on product categories. In the EU, they are compartment specific. In both cases, the measured energy consumption is calculated based on the consumption at 16°C and at 32°C ambient temperature. However, the weighting applied to each is not the same in both economies.

Efficiency levels

For the reasons previously mentioned it is not possible to make a direct comparison of efficiency levels.

China's energy efficiency grades used in the energy label and by default the MEPS level (which is set at the grade 5 level) are shown in Table 3.2.2.

Table 3.2.2: Energy efficiency grade thresholds applicable to domestic refrigerating appliances in China (where grade 5 is the MEPS requirement)

Energy efficiency grade	Refrigerator-freezer		Wind storage cabinet	Chest refrigerator-freezer	Other types (Type 1, 2, 3, 4, 6, 8 and 9)
	Standard energy efficiency index η_s	Total energy efficiency index η_s	Standard energy efficiency index η_s	Standard energy efficiency index η_s	Standard energy efficiency index η_s
1	η_s<25%	η_s<50%	η_s<55%	η_s<35%	η_s<45%
2	25%<η_s≤35%	50%<η_s≤60%	55%<η_s≤70%	35%<η_s≤45%	45%<η_s≤55%
3	35%<η_s≤50%	60%<η_s≤70%	70%<η_s≤80%	45%<η_s≤55%	55%<η_s≤65%
4	50%<η_s≤60%	70%<η_s≤80%	80%<η_s≤90%	55%<η_s≤65%	65%<η_s≤75%
5	60%<η_s≤70%	80%<η_s≤90%	90%<η_s≤100%	65%<η_s≤75%	75%<η_s≤85%

As indicated in Table 3.2.2, depending on the availability of the corresponding test methods, the metrics of the standard energy efficiency index and the total energy efficiency index are both used to evaluate the energy efficiency of refrigerator-freezers, but only the standard energy efficiency index is used for the other product categories defined in the current version of this standard.

The EU's Energy Efficiency Index MEPS limits are shown in Table 3.2.3 and in the label thresholds in Table 3.2.4. The MEPS requirements will be tightened in March 2024 for all product categories.

Table 3.2.3: Maximum EEI for refrigerating appliances, expressed in %

	EEI (from 1.3.2021)	EEI (from 1.3.2024)
Dedicated low noise refrigerating appliances with fresh food compartment(s)	375	312
Low noise refrigerating appliances with transparent doors	380	300
Other low noise refrigerating appliances, with the exception of low noise combi appliances with a frozen compartment	300	250
Wine storage appliances with transparent doors	190	172
Other wine storage appliances	155	140
All other refrigerating appliances, with the exception of low noise combi appliances with a frozen compartment	125	100

Table 3.2.4: Energy efficiency classes of refrigerating appliances in the EU

Energy efficiency class	Energy efficiency index (EEI)
A	EEI ≤ 41
B	41 < EEI ≤ 51
C	51 < EEI ≤ 64
D	64 < EEI ≤ 80
E	80 < EEI ≤ 100
F	100 < EEI ≤ 125
G	EEI > 125’

China-EU alignment potential

China and the EU do not apply exactly the same regulatory scope for domestic refrigerating appliances. Nevertheless, compressor-driven refrigerators, freezers and combination refrigerator-freezers, which account for the largest market share, are covered by both economies, as well as the wine storage cabinet (without transparent doors). While the IEC 62552:2015+AMD1:2020 fully applies for the Chinese regulation, the test procedure required in the EU shows some deviations. For refrigerators, freezers and combination fridge-freezers, the measurement of energy consumption is expected to be similar in both economies. Wine storage cabinets and appliances with a chilled compartment show larger deviation with regard to the test procedures.

The efficiency metrics are different, but since the alignment of the test procedures is high, it would be possible to calculate the efficiency in one economy and to estimate it in the other economy.

In general, the potential for alignment is high, but the EU regulations do not completely abide by the IEC standard and the regulation was only implemented in 2021.

3.3 Televisions

Summary of existing regulations

In China, GB 24850-2020 *Minimum allowable values of energy efficiency and energy efficiency grades for flat panel televisions and set-top boxes* sets out the MEPS and energy grades (to be used in labels) for televisions.

In the EU the Ecodesign requirements, which include MEPS, are specified in COMMISSION REGULATION (EU) 2019/2021 of 1 October 2019 *laying down ecodesign requirements for electronic displays pursuant to Directive 2009/125/EC of the European Parliament and of the Council, amending Commission Regulation (EC) No 1275/2008 and repealing Commission Regulation (EC) No 642/2009*. Energy labelling requirements are specified in COMMISSION DELEGATED REGULATION (EU) 2019/2013 of 11 March 2019 *supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to energy labelling of electronic displays and repealing Commission Delegated Regulation (EU) No 1062/2010*.

In addition, Commission Regulation (EU) 2021/341 of 23 February 2021 *amending Regulations (EU) 2019/424, (EU) 2019/1781, (EU) 2019/2019, (EU) 2019/2020, (EU) 2019/2021, (EU) 2019/2022, (EU) 2019/2023 and (EU) 2019/2024 with regard to ecodesign requirements for servers and data storage products, electric motors and variable speed drives, refrigerating appliances, light sources and separate control gears, electronic displays, household dishwashers, household washing machines and household washer-dryers and refrigerating appliances with a direct sales function* contains provisions which amend the Ecodesign requirements for 2019/2021.

Both the Chinese and EU regulations are recent, having been adopted between 2019 and 2021.

Scope

The regulations in both China and the EU address other products alongside televisions, but as the focus of this analysis is televisions, these other products are not discussed further. With regard to televisions, China's regulations are applicable to LCD and OLED televisions (hereinafter collectively referred to as flat panel televisions), which work normally under AC 220 V and 50 Hz power supply, and receive, demodulate and display terrestrial, cable, satellite or other analogue and digital signals. They are also applicable to LCD and OLED display devices, which are mainly used as televisions and circulated as television products without tuners.

The EU regulations stipulate that they apply to televisions[13] but not to:

a) any electronic display with a screen area smaller than or equal to 100 square centimetres.
b) Projectors.
c) all-in-one video conference systems.

13 Where 'television' means an electronic display designed primarily for the display and reception of audiovisual signals and which consists of an electronic display and one or more tuners/receivers; and 'electronic display' means a display screen and associated electronics that, as its primary function, displays visual information from wired or wireless sources.

d) medical displays.
e) virtual reality headsets.
f) displays integrated or to be integrated into products listed in points 3(a) and 4 of Article 2 of Directive 2012/19/EU of the European Parliament and of the Council.
g) electronic displays that are components or sub-assemblies as defined in point 2 of Article 2 of Directive 2009/125/EC.
h) industrial displays.
i) broadcast displays.
j) security displays.
k) digital interactive whiteboards.
l) digital photo frames.
m) digital signage displays which meet any of the following characteristics:

   i. designed and constructed as a display module to be integrated as a partial image area of a larger display screen area and not intended for use as a standalone display device;
   ii. distributed self-contained in an enclosure for permanent outdoor use;
   iii. distributed self-contained in an enclosure with a screen area less than 30 dm^2 or greater than 130 dm^2;
   iv. the display has a pixel density less than 230 pixels/cm^2 or more than 3 025 pixels/cm^2;
   v. a peak white luminance in standard dynamic range (SDR) operating mode of greater than or equal to 1 000 cd/m^2;
   vi. no video signal input interface and display drive allowing the correct display of a standardised dynamic video test sequence for power measurement purposes;

n) status displays.
o) control panels.

Energy performance test procedure

At their core the test methods used in both China and the EU have a strong degree of alignment with the international method, IEC 62087-1: 2015 *Audio, video, and related equipment - Determination of power consumption - Part 1:General*. This standard specifies the general requirements for the determination of power consumption of audio, video, and related equipment. Requirements for specific types of equipment are specified in additional parts of this series of standards and may supersede the requirements specified in this standard. Moreover, this part of IEC 62087 defines the different modes of operation which are relevant for determining power consumption. This first edition of IEC 62087-1 together with IEC 62087-2 to IEC 62087-6 cancels and replaces the older IEC 62087:2011. Most economies around the world use this standard but there can be important local differences in how it is applied and also related testing aspects that affect the measured TV energy performance and in particular, the on-mode screen power consumption.

One aspect of note is that EU 2021/341, published on 23 Feb 2021 (see above), includes amendments to EU 2019/2021 mainly concerning the test method, including the Dynamic Broadcast video sequence which is different from IEC 62087. The new video sequences are provided for SDR (including those for SD and HD respectively) and HDR (5-minute sequences for HLG and HDR10 respectively) and can be downloaded from the given EU website. In addition, a new variant of the 'box and outline' dynamic test pattern, providing a dynamic format with colour, shall be used for all peak white display luminance measurements and not the 3-bar black and white pattern previously used. As a result, the EU testing method is now understood to be quite different from IEC 62087, but so are some aspects of China's test method.

There are a number of differences in how TVs are tested in China and the EU which are liable to affect the comparability of their energy performance test results, and especially for the primary on-mode power consumption values as follows:

- In the EU, TVs are required to be placed on the market in 'Home mode' settings and may be placed on the market with a forced menu on initial activation that proposes alternative settings. Where a forced menu is provided, the normal configuration shall be set as the default choice during testing, otherwise the normal configuration shall be the out-of-the-box setting. In China, the normal configuration shall be set as the default mode when they leave the factory (equal to out-of-the-box setting), otherwise another similar mode shall be used if no default setting is provided or the brightness and contrast cannot be adjusted in the default setting. Although the approaches seem similar, in order to get the best value for either brightness or energy consumption, the manufacturers may adjust the forced menu or default menu[14]. This may cause differences but it is hard to say how significant this is without a deeper investigation.

- When setting TVs up for testing, China applies a test pattern comprising eight greyscales and nine windows to help adjust the contrast and brightness settings and then tests the brightness of the nine windows, whereas the EU does not. This has some impact on the test result of brightness, but may not appreciably affect the energy consumption test results in the on mode.

- The EU sets minimum peak white luminance thresholds when a TV is being tested in the normal mode, whereas China does not impose any luminance requirements but instead simply records the luminance measured during testing.

- The EU tests TVs in the standard dynamic range (SDR) and high dynamic range (HDR) modes respectively and provides corresponding Dynamic Broadcast video sequences for each. China's test method uses the IEC 62087 video sequences, which are only for the SDR mode and hence do not activate the TV to operate in HDR mode and do not quantify the effect of the HDR mode on energy consumption.

- With regards to automatic brightness control (ABC) the EU test method stipulates that if ABC is available, measurements shall be made with it switched off. If it cannot be switched off, then the measurements shall be performed in an ambient light condition of 100 lux measured at the ABC sensor. In China, the test method stipulates that where ABC is available, measurements shall be made with it switched off. If ABC cannot be switched off, then the

14 This arises because China and the EU have different metrics for rating energy efficiency (see next sub-section).

measurements shall be performed in an ambient light condition of less than or equal to 300 lux measured at the ABC sensor. These requirements are similar but not identical. However, the purposes (blocking the start-up of ABC function) and the effect on testing results are the same.

- There may be some differences in how low power modes are tested, but this would need to be checked in a deeper investigation.

As a consequence of these differences, it is not possible to make a direct comparison of the on-mode power consumption values reported under the test procedures used in China and the EU.

Product categorisation

Despite the apparent differences in wording, the main product categorisation for TVs is the same in both economies for all practical purposes (e.g. the EU's requirements theoretically include non-flat screens and China's does not specify, but in practice includes all current TVs using flat screen technology).

Apart from this, the main distinction in product categorisation for energy labelling is that if a TV is a High Dynamic Range product the EU allows its energy performance to be tested and rated both under the normal Standard Dynamic Range approach and the High Dynamic Range approach. China's regulations treat all TVs as if they are Standard Dynamic Range products (most of the up-market TVs in China have HDR functionality, but the test sequence is lacking in IEC 62087, and HDR film sources are very rare and cannot make the best use of the HDR function).

In the case of MEPS, the EU's Ecodesign regulation sets MEPS in on-mode limits distinguished by three technologies:

- displays with resolution up to 2 073 600 pixels (HD).
- displays with resolution above 2 073 600 pixels (HD) and up to 8 294 400 pixels (UHD-4k).
- displays with resolution above 8 294 400 pixels (UHD-4k) and for MicroLED display.

China's MEPS and labelling regulation also sets MEPS in energy efficiency (lumen per watt) distinguished by three technologies:

- displays with resolution up to 1920×1080 (equal to 2 073 600 pixels) (HD).
- displays with resolution above 1920×1080 (equal to 2 073 600 pixels) (HD) and up to 3840×2160 (8 294 400 pixels) (UHD-4k).
- displays with resolution above 3840×2160 (8 294 400 pixels) (UHD-4k).

Efficiency metrics

The EU sets TV energy efficiency criteria via an energy efficiency metric that combines the power consumed in the on-mode and the screen area. The index applied for energy labelling purposes is:

$$EEI_{label} = \frac{(P_{measured} + 1)}{(3 \times [90 \times tanh(0{,}025 + 0{,}0035 \times (A - 11) + 4)] + 3) + corr_l}$$

where:

A: viewing surface area in dm^2.

$P_{measured}$: measured power in the on mode in Watts in the normal configuration.

$corr_l$: correction factor that distinguishes between screens used for TVs, monitors or digital signage and is only applied for labelling purposes and not for MEPS under Ecodesign regulations.

The energy label thresholds are set in terms of this index, but in the case of MEPS levels a slightly different one is applied. The effect is to require larger screen areas to achieve lower unit screen area power consumption to attain a given efficiency level. This reflects the findings of both technical and statistical analyses that reveal that larger screens tend to attain lower per unit area power levels (all other aspects being equal) when compared to smaller screens. It is thus designed to avoid giving larger screens an advantage that could inadvertently encourage higher power consumption.

The energy performance indicator used in China's regulations is simply the screen luminance per watt as measured under the standard test procedure, where a higher value indicates a more energy efficient screen. This is different from the EU's approach because it allows the screen luminance to be a variable as much as the screen power and also it does not take account of the tendency for larger screens to use less power for any given luminance levels compared to smaller screens.

Efficiency levels

For the reasons previously mentioned, it is not possible to make a direct comparison of the efficiency levels and to do so would require research work to be conducted to allow normalisation between the different test approaches. If successful, such a normalisation method might be able to determine the relative stringency of the two economies' MEPS and labelling requirements but almost certainly would not be sufficiently reliable to permit the conversion of any given product's test results between the two systems for conformity assessment rating purposes.

The EU's Energy Efficiency Index MEPS limits are shown in Table 3.3.1 and the label thresholds in Table 3.3.2.

Table 3.3.1: Energy efficiency index limits (MEPS) applicable to TVs in the EU

	EEI_{max} for electronic displays with resolution up to HD	EEI_{max} for electronic displays with resolution above HD and up to UHD	EEI_{max} for electronic displays with resolution above UHD and for MicroLED displays
1 March 2021	0.90	1.10	n.a.
1 March 2023	0.75	0.90	0.90'

Table 3.3.2: Energy efficiency class thresholds applicable to TVs in the EU

Energy efficiency class	Energy efficiency index (EEI_{label})
A	$EEI_{label} < 0.30$
B	$0.30 \le EEI_{label} < 0.40$
C	$0.40 \le EEI_{label} < 0.50$
D	$0.50 \le EEI_{label} < 0.60$
E	$0.60 \le EEI_{label} < 0.75$
F	$0.75 \le EEI_{label} < 0.90$
G	$0.90 \le EEI_{label}$

In addition, the amended Ecodesign regulations specify that:

> 'The energy consumption of the product and any of the other declared parameters shall not deteriorate after a software or firmware update when measured with the same test standard originally used for the declaration of conformity, except with explicit consent of the end-user prior to the update. No performance change shall occur as a result of rejecting the update. A software update shall never have the effect of changing the product's performance in a way that makes it non-compliant with the ecodesign requirements applicable for the declaration of conformity.'

China's energy efficiency grades used in the energy label and by default the MEPS level are shown in Table 3.3.3.

Table 3.3.3: Energy efficiency grade thresholds applicable to TVs in China (where grade 5 is the MEPS requirement)

Energy efficiency grades	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
Energy efficiency/ (cd/W)	4.0	3.0	2.0	1.5	1.0

The MEPS applicable to flat panel televisions with resolution up to 1920×1080 is Grade 3, the MEPS for flat panel televisions with resolution above 1920×1080 and up to 3840×2160 is Grade 4, and the MEPS for flat panel televisions with resolution above 3840×2160 is Grade 5.

China-EU alignment potential

Despite the fact that televisions sold in China and the EU have the same technologies (for the most part) and are sold in significant trade volumes, the lack in commonality in the test methods and efficiency metrics means that it is not possible to compare the MEPS and labelling policy settings. A priori, there is no inherent reason why such differences in approach should exist between the two economies and both appear to have introduced local deviations to the application of the IEC's test method, which is widely used elsewhere. The differences in approach seem to have arisen due to the disconnected processes to define performance and policy measures in the two economies. In practice, were TVs to be considered for further investigation of their alignment potential, there would need to be higher-level agreement that it was desirable to move towards such alignment.

3.4 Electric motors

Summary of existing regulations

China has MEPS and energy labelling requirements for motors as specified in GB18613-2020: *Minimum allowable values of energy efficiency and values of efficiency grades for motors*.

The EU has MEPS and energy efficiency grade disclosure (information & rating plate) requirements as set out in COMMISSION REGULATION (EU) 2019/1781 of 1 October 2019 *laying down ecodesign requirements for electric motors and variable speed drives pursuant to Directive 2009/125/EC of the European Parliament and of the Council, amending Regulation (EC) No 641/2009 with regard to ecodesign requirements for glandless standalone circulators and glandless circulators integrated in products and repealing Commission Regulation (EC) No 640/2009*.

In both economies the currently appliable regulations were recently revised (2020 in China and 2021 in the EU).

Scope

For the most important class of motors in terms of market adoption levels and energy use (3-phase induction motors) the scope of China's and the EU's requirements is almost identical. The EU also has requirements for some types of single-phase AC induction motor and for motors with an integrated variable speed drive, whereas neither of these products is regulated in China. Conversely, China sets requirements for a specific type of DC motor (which the EU does not) and also distinguishes requirements for capacitor-start asynchronous motors, capacitor-run asynchronous motors, two-value capacitor asynchronous motors and capacitor-run motors for air conditioner fans.

A summary of the scope of application of these requirements is shown in Table 3.4.1 below.

Table 3.4.1: Application scope of requirements for electric motors

Applicable to	In China	In the EU
AC induction motors		
No. of poles	2, 4, 6, 8	2, 4, 6, 8
Power range (kW)	0.12 – 1000	0.12 -1000
Voltage range	< 1000V	50V up to 1000V
Motor speed	Single speed	Single speed
No. of phases	3	3 or 1
Frequency	50Hz	50 or 50/60Hz
Direct on-line	Within scope	Exclusively
DC motors	Brushless DC motors (10W~1100W) for air conditioner fans	No
Variable speed drives	No	Yes
Other types	• capacitor-start asynchronous motors • capacitor-run asynchronous motor • two-value capacitor asynchronous motors • capacitor-run motors for air conditioner fans	Ex eb increased safety motors

Energy performance test procedure

A priori, it appears that both the Chinese and EU energy performance test standards are fully aligned. Both appear to be aligned with IEC motor energy performance test standards of which the most important are:

- IEC 60034-1:2017 Rotating electrical machines - Part 1: Rating and performance.
- IEC 60034-2-1:2014 Rotating electrical machines - Part 2-1: Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles).

IEC 60034-1:2017 is applicable to all rotating electrical machines except those covered by other IEC standards.

A more detailed investigation would be needed to confirm which version of this standard is used in China and the EU and whether there are any modifications in how it is applied within the Chinese/EU standards respectively; however, there has been much work over the last 15 years to align national/regional standards with international ones for motors and it seems likely that there is complete alignment.

IEC 60034-2-1:2014(B) is intended to establish methods of determining efficiencies from tests, and also to specify methods of obtaining specific losses. This standard applies to DC machines and AC synchronous and induction machines of all sizes within the scope of IEC 60034-1. The latest edition includes the following significant technical changes with respect to the previous edition: grouping of the test methods into preferred methods and methods for field or routine testing; addition of the details of the requirements regarding instrumentation; addition of the description of tests required for a specific method in the same sequence as requested for the performance of the test.

A more detailed investigation would be needed to confirm which version of this standard is used in China and the EU and whether there are any modifications in how it is applied within the Chinese/EU standards respectively.

Product categorisation

As shown in Table 3.4.1, AC induction motors can be distinguished by the number of poles, voltage range, frequency range, phases and speeds, but for the principal AC induction motor types China and the EU are fully aligned.

A distinction is that China's efficiency requirements for AC induction motors also apply to explosion-proof types whereas the EU's treat this sub-type as a separate category.

Aside from this, there are differences in the other types of motors covered (or not covered), as illustrated in Table 3.4.1.

Efficiency metrics

Both China and the EU use AC induction motor energy efficiency metrics and classifications (i.e. classification into grades) that are fully aligned with the IEC method set out in:

- IEC 60034-30-1:2014 *Rotating electrical machines - Part 30-1: Efficiency classes of line operated AC motors (IE code)*.

IEC 60034-30-1:2014 specifies efficiency classes for single-speed electric motors that are rated according to IEC 60034-1 or IEC 60079-0, for operation on a sinusoidal voltage supply. This standard establishes a set of limit efficiency values based on frequency, number of poles and motor power. No distinction is made between motor technologies, supply voltage or motors with increased insulation designed specifically for converter operation, even though these motor technologies may not all be capable of reaching the higher efficiency classes.

The EU's requirements for motors with integrated VSDs are believed to use an efficiency classification aligned to that reported in IEC 60034-2-3:2020: *Rotating electrical machines - Part 2-3: Specific test methods for determining losses and efficiency of converter-fed AC motors*.

Efficiency levels

The MEPS and efficiency grades for AC induction motors defined in both the Chinese and European regulations are aligned with the IEC's IE classification. China's MEPS are set at the IE3 level for all AC induction motors from 0.12kW to 1000kW, including Ex eb increased safety motors. The EU's are the same in 2021 for motors in the power range of 0.75kW to 1000kW, excluding Ex eb increased safety motors (which have no MEPS requirements), but are IE2 (less efficient than IE3) for motors in the range from 0.12kW to 0.75kW. However, from 2023 the EU will require a minimum IE4 class for AC induction motors in the capacity range of 75kW to 200kW and a minimum IE2 class for Ex eb increased safety motors in the power range of 0.12kW to 1000kW. From 2023 the EU will also require single phase motors > 0.12kW to attain the IE2 class (these are not subject to MEPS in China).

China also sets MEPS for:

- capacitor-start asynchronous motors.
- capacitor-run asynchronous motors.
- two-value capacitor asynchronous motors.
- capacitor-run motors for air conditioner fans.

These are for smaller capacity motors than the majority of those covered in the main 3-phase AC induction power group.

The EU requires motors within scope to report their IE class (from IE1 to IE4) as per the latest published version of IEC 600034-30-1. China transposes these IE classes into efficiency grades wherein for the main 3-phase AC induction motor category Grade 3 (the lowest permitted grade) is equivalent to IE3, Grade 2 is equivalent to IE4, but Grade 1 appears to be consistent with an IE5 class. The IE5 class, which is also sometimes referred to as the ultra-premium efficiency class, is a higher level that is under discussion for formal inclusion in the IEC standard.

In the case of motors with integrated variable speed drives, the EU MEPS are set at the IE2 level within the power range of 0.12kW to 1000kW. China has no requirements for such motors.

China-EU alignment potential

A priori alignment already appears to be very high for the most important categories of motors (the main AC induction types). The test methods and efficiency rating systems would appear to be fully aligned, although this would need to be verified by means of a more in-depth investigation, at least for the most important motor types. There is potential for further alignment, however, as:

- China has already adopted the de facto IE5 efficiency class and the EU has

not (presumably because this is still not officially recognised within the IEC standard).
- China has MEPS and grading requirements for some DC motor types and some other AC motor types for which the EU does not.
- the EU has MEPS requirements for single phase motors and motors with an integrated variable speed drive while China does not.
- China's MEPS are more ambitious for motors in the range 0.12-0.75kW (until 2023) and Ex eb increased safety motors.

This would suggest that despite the recent adoption of regulations in both China and the EU, there is good potential from a technical perspective to explore further alignment in the future.

3.5 Distribution transformers

Summary of existing regulations

China has set MEPS and efficiency grades for transformers under GB 20052-2020: *Minimum allowable values of energy efficiency and energy efficiency grades for power transformers*.

The EU applies MEPS for transformers under COMMISSION REGULATION (EU) 2019/1783 of 1 October 2019 *amending Regulation (EU) No 548/2014 on implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers*.

Many of the current requirements are specified in: COMMISSION REGULATION (EU) No 548/2014 of 21 May 2014 *on implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers.*

As the latest Chinese and European regulations were set in 2020 and 2019 respectively, they are both fairly recent.

Scope

China's GB 20052-2020 standard specifies the minimum allowable values of energy efficiency, energy efficiency grades, and test methods for three-phase power transformers. It is applicable to oil-immersed three-phase non-excitation voltage-regulating distribution transformers with a voltage level of 10 kV and a rated capacity of 30 kVA – 2 500 kVA, dry-type distribution transformers with a rated capacity of 30 kVA – 2 500 kVA, and oil-immersed three-phase transformers with a rated frequency of 50 Hz, a voltage class of 35 kV – 500 kV, and a rated capacity of 3 150 kVA and above. It is not applicable to high impedance transformers.

The EU's 2019/1783 regulation sets out ecodesign requirements for placing on the market or putting into service power transformers with a minimum power rating of 1 kVA used in 50 Hz electricity transmission and distribution networks or for industrial applications. This includes:

- medium power transformers i.e. a power transformer with all windings having rated power lower than or equal to 3 150 kVA, and highest voltage for equipment greater than 1.1 kV and lower than or equal to 36 kV.

- large power transformers i.e. a power transformer with at least one winding having either rated power greater than 3 150 kVA or highest voltage for equipment greater than 36 kV.

The regulation does not apply to transformers specifically designed for the following applications:

(a) instrument transformers, specifically designed to transmit an information signal to measuring instruments, meters and protective or control devices or similar apparatus.

(b) transformers specifically designed and intended to provide a DC power supply to electronic or rectifier loads. This exemption does not include transformers that are intended to provide an AC supply from DC sources such as transformers for wind turbine and photovoltaic applications or transformers designed for DC transmission and distribution applications.

(c) transformers specifically designed to be directly connected to a furnace.

(d) transformers specifically designed to be installed on fixed or floating offshore platforms, offshore wind turbines or on board ships and all kinds of vessels.

(e) transformers specifically designed to provide for a situation limited in time when the normal power supply is interrupted due either to an unplanned occurrence (such as a power failure) or a station refurbishment, but not to permanently upgrade an existing substation.

(f) transformers (with separate or auto-connected windings) connected to an AC or DC contact line, directly or through a converter, used in fixed installations for railway applications.

(g) earthing or grounding transformers specifically designed to be connected in a power system to provide a neutral connection for earthing either directly or via an impedance.

(h) traction transformers specifically designed to be mounted on rolling stock, connected to an AC or DC contact line, directly or through a converter, for specific use in fixed installations for railway applications.

(i) starting transformers, specifically designed for starting three-phase induction motors so as to eliminate supply voltage dips and that remain de-energised during normal operation.

(j) testing transformers, specifically designed to be used in a circuit to produce a specific voltage or current for the purpose of testing electrical equipment.

(k) welding transformers, specifically designed for use in arc-welding equipment or resistance-welding equipment.

(l) transformers specifically designed for explosion-proof applications in accordance with Directive 94/9/EC of the European Parliament and of the Council and underground mining applications.

(m) transformers specifically designed for deep water (submerged) applications.

(n) medium Voltage (MV) to Medium Voltage (MV) interface transformers up to 5 MVA used as interface transformers in a network voltage conversion programme and placed at the junction between two voltage levels of two medium voltage networks; these need to be able to cope with emergency overloads.

(o) medium and large power transformers specifically designed to contribute to the safety of nuclear installations.

(p) three-phase medium power transformers with a power rating below 5 kV.

Note, the analysis presented in this report is confined to distribution transformers which essentially align with the medium power transformer definition applied in the EU regulations and thus the large power transformers will not be considered further.

Energy performance test procedure

Both China and the EU are thought to measure transformer power losses using test procedures based on the IEC60076 series (JB/T 10317-02 & GB 20052-2020 in China and EN50464-1:2007 in the EU). Specifically, the methods are understood to be broadly aligned with the following IEC standards:

- IEC 60076-1:2011 *Power transformers - Part 1: General* applies to three-phase and single-phase power transformers (including auto-transformers) with the exception of certain categories of small and special transformers.

- IEC 60076-11:2018 *Power transformers - Part 11: Dry-type transformers* applies to dry-type power transformers (including auto-transformers) having values of highest voltage for equipment up to and including 72.5 kV and at least one winding operating at greater than 1.1 kV.

- IEC TS 60076-19:2013 *Power transformers - Part 19: Rules for the determination of uncertainties in the measurement of the losses on power transformers and reactors* illustrates the procedures that should be applied to evaluate the uncertainty affecting the measurements of no-load and load losses during the routine tests on power transformers.

- IEC 60076-24:2020 *Power transformers - Part 24: Specification of voltage regulating distribution transformers (VRDT)* applies to medium power transformers from 25 kVA up to 3 150 kVA with highest voltage for equipment up to 36 kV, or in low voltage (LV) networks with highest voltage for equipment of up to 1.1 kV equipped with voltage regulating devices. Voltage regulating distribution transformers are transformers equipped with components to control primary or secondary voltage for on-load voltage regulation purposes.

The procedures also conform with other relevant IEC standards in the 60076 series.

Product categorisation

China regulations distinguish between the following categories of transformer (distribution types):

- 10 kV oil-immersed three-phase double-winding non-excitation voltage-regulating distribution transformers.
- 10 kV dry-type three-phase double-winding non-excitation voltage-regulating distribution transformers.
- 35 kV oil-immersed three-phase double-winding non-excitation voltage-regulating power transformers.
- 35 kV oil-immersed three-phase double-winding on-load voltage-regulating power transformers.
- plus, another 24 types in higher voltage ranges (beyond the distribution transformer range).

Within these categories for the requirements that pertain to the most important distribution transformer product categories, there is a distinction in the Chinese MEPS levels depending on whether a product is using electrical steel strips or amorphous alloy (no such distinction is made in the EU's requirements).

The EU distinguishes between medium power transformers (the subject of this analysis) and larger power transformers (not considered here). Within the medium power transformer category (i.e. the distribution transformer) further sub-categories are added to address the following:

- three-phase liquid-immersed medium power transformers with one winding with Um[15] ≤ 24 kV and the other one with Um ≤ 1.1 kV.
- three –phase dry-type medium power transformers with one winding with Um ≤ 24 kV and the other one with Um ≤ 1.1 kV.
- full load and no load losses correction factors are applied in the case of other combinations of winding voltages or dual voltage in one or both windings (rated power ≤ 3 150 kVA) for:
    - One winding with Um ≤ 24 kV and the other with Um > 1.1 kV.
    - One winding with Um = 36 kV and the other with Um ≤ 1.1 kV.
    - One winding with Um = 36 kV and the other with Um > 1.1 kV.
    - Case of dual voltage on one winding.
    - Case of dual voltage on both winding.
- medium power transformers with rated power ≤ 3 150 kVA equipped with tapping connections suitable for operation while being energised or on-load for

15 'Highest voltage for equipment' (Um) applicable to a transformer winding is the highest r.m.s. phase-to-phase voltage in a three-phase system for which a transformer winding is designed in respect of its insulation.

voltage adaptation purposes (Voltage Regulation Distribution Transformers[16] are included in this category).
- pole-mounted transformers[17].

In summary, both China and the EU distinguish transformer energy performance by whether a product is liquid (oil) cooled or dry-type, but only the EU distinguishes between pole-mounted transformers or otherwise (practically, ground mounted on pads).

Efficiency metrics

Both China and the EU set their distribution transformer MEPS in terms of maximum permitted no load (i.e. zero power loading) and full load (i.e. maximum power loading) power loss limits expressed in Watts. Some other economies set their MEPS in terms of maximum permitted losses at 50% loading. When the approach used in China and the EU is applied, it is possible to determine what the maximum permitted losses would be at any given loading level by applying a well-established formula. This means that it appears that it is possible to directly compare the ambition of the efficiency levels applied in both economies for any given load level.

Efficiency levels

The maximum full load and no load losses permitted in the Chinese and EU regulations are apparently directly comparable, as the test method and rating conditions appear to be equivalent. Table 3.5.1 shows the EU's requirements for liquid transformers and Table 3.5.2. shows China's requirements for the same (oil filled transformers). Comparing these, it seems that the EU's MEPS are more stringent than China's and are somewhere between China's Grade 1 and Grade 2 requirements. The EU does not set higher efficiency grades or classes for transformers, so only the MEPS levels can be directly compared.

16 'Voltage Regulation Distribution Transformer' means a medium power transformer equipped with additional components, inside or outside of the transformer tank, that automatically control the input or output voltage of the transformer for on-load voltage regulation purposes.

17 'Medium power pole mounted transformer' means a power transformer with a rated power of up to 315 kVA suitable for outdoor service and designed to be mounted on the support structures of overhead power lines.

Table 3.5.1: Maximum load and no-load losses (in W) for three-phase liquid-immersed medium power transformers with one winding with Um ≤ 24 kV and the other one with Um ≤ 1.1 kV

	Tier 1 (from 1 July 2015)		Tier 2 (from 1 July 2021)	
Rated Power (kVA)	Maximum load losses P_k (W)(*)	Maximum no-load losses P_o (W)(*)	Maximum load losses P_k (W)(*)	Maximum no-load losses P_o (W)(*)
≤25	C_k (900)	A_o (70)	A_k (600)	A_o - 10% (63)
50	C_k (1 100)	A_o (90)	A_k (750)	A_o - 10% (81)
100	C_k (1 750)	A_o (145)	A_k (1 250)	A_o - 10% (130)
160	C_k (2 350)	A_o (210)	A_k (1 750)	A_o - 10% (189)
250	C_k (3 250)	A_o (300)	A_k (2 350)	A_o - 10% (270)
315	C_k (3 900)	A_o (360)	A_k (2 800)	A_o - 10% (324)
400	C_k (4 600)	A_o (430)	A_k (3 250)	A_o - 10% (387)
500	C_k (5 500)	A_o (510)	A_k (3 900)	A_o - 10% (459)
630	C_k (6 500)	A_o (600)	A_k (4 600)	A_o - 10% (540)
800	C_k (8 400)	A_o (650)	A_k (6 000)	A_o - 10% (585)
1000	C_k (10 500)	A_o (770)	A_k (7 600)	A_o - 10% (693)
1250	B_k (11 000)	A_o (950)	A_k (9 500)	A_o - 10% (855)
1600	B_k (14 000)	A_o (1 200)	A_k (12 000)	A_o - 10% (1 080)
2000	B_k (18 000)	A_o (1 450)	A_k (15 000)	A_o - 10% (1 305)
2500	B_k (22 000)	A_o (1 750)	A_k (18 500)	A_o - 10% (1 575)
3150	B_k (27 500)	A_o (2 200)	A_k (23 000)	A_o - 10% (1 980)

(*) Maximum losses for kVA ratings that fall in between the ratings given in Table 1.1 shall be obtained by linear interpolation.

Table 3.5.2: China energy efficiency grades of 10 kV oil-immersed three-phase double-winding non-excitation voltage-regulating distribution transformers

Rated capacity kVA	Grade 1						Grade 2						Grade 3						Short-circuit impedance %
	Electrical steel strip			Amorphous alloy			Electrical steel strip			Amorphous alloy			Electrical steel strip			Amorphous alloy			
	No-load loss W	Load loss W		No-load loss W	Load loss W		No-load loss W	Load loss W		No-load loss W	Load loss W		No-load loss W	Load loss W		No-load loss W	Load loss W		
		Dyn11/ Yzn11	Yyn0		Dyn11/ Yzn11	Yyn0		Dyn11/ Yzn11	Yyn0		Dyn11/ Yzn11	Yyn0		Dyn11/ Yzn11	Yyn0		Dyn11/ Yzn11	Yyn0	
30	65	455	430	25	510	480	70	505	480	33	535	510	80	630	600	33	630	600	4.0
50	80	655	625	35	735	700	90	730	695	43	780	745	100	910	870	43	910	870	
63	90	785	745	40	880	840	100	870	830	50	930	890	110	1 090	1 040	50	1 090	1 040	
80	105	945	900	50	1 060	1 010	115	1 050	1 000	60	1 120	1 070	130	1 310	1 250	60	1 310	1 250	
100	120	1 140	1 080	60	1 270	1 215	135	1 265	1 200	75	1 350	1 285	150	1 580	1 500	75	1 580	1 500	
125	135	1 360	1 295	70	1 530	1 450	150	1 510	1 440	85	1 615	1 540	170	1 890	1 800	85	1 890	1 800	
160	160	1 665	1 585	80	1 870	1 780	180	1 850	1 760	100	1 975	1 880	200	2 310	2 200	100	2 310	2 200	
200	190	1 970	1 870	95	2 210	2 100	215	2 185	2 080	120	2 330	2 225	240	2 730	2 600	120	2 730	2 600	
250	230	2 300	2 195	110	2 590	2 470	260	2 560	2 440	140	2 735	2 610	290	3 200	3 050	140	3 200	3 050	
315	270	2 760	2 630	135	3 100	2 950	305	3 065	2 920	170	3 275	3 120	340	3 830	3 650	170	3 830	3 650	
400	330	3 250	3 095	160	3 660	3 480	370	3 615	3 440	200	3 865	3 675	410	4 520	4 300	200	4 520	4 300	
500	385	3 900	3 710	190	4 380	4 170	430	4 330	4 120	240	4 625	4 400	480	5 410	5 150	240	5 410	5 150	
630	460	4 460		250	5 020		510	4 960		320	5 300		570	6 200		320	6 200		4.5
800	560	5 400		300	6 075		630	6 000		380	6 415		700	7 500		380	7 500		
1 000	665	7 415		360	8 340		745	8 240		450	8 800		830	10 300		450	10 300		
1 250	780	8 640		425	9 720		870	9 600		530	10 260		970	12 000		530	12 000		
1 600	940	10 440		500	11 745		1 050	11 600		630	12 400		1 170	14 500		630	14 500		
2 000	1 085	13 180		550	14 000		1 225	14 640		710	14 800		1 360	18 300		720	18 300		5.0
2 500	1 280	13 360		670	15 450		1 440	14 840		860	16 300		1 600	21 200		865	21 200		

China-EU alignment potential

There is already a high degree of alignment in how the energy performance of distribution transformers is tested and how the energy performance is determined (i.e. the energy efficiency metrics) in China and the EU. Some differences exist with regard to the sub-categorisation which may reflect some systemic differences in the products used in each market but could also be due to differences in how performance factors have been addressed in the respective regulatory process. In higher power capacities (beyond the distribution transformer range) there is a difference in approach regarding the choice of energy performance metrics, which could be worthy of further examination.

Aside from this, there are differences in the relative stringency of the requirements which may be due in part to different average load factors but also to the relative value placed on conserved energy. Overall, from a technical perspective distribution transformers seem to have a high degree of alignment between the two economies and could be good candidates for further investigation to examine if further alignment is sensible.

3.6 Chillers

Summary of existing regulations

In China, GB 19577-2015 *Minimum allowable values of energy efficiency and energy efficiency grades for water chillers* sets out the MEPS and energy grades (to be used in labels) for liquid chillers.

In Europe, COMMISSION REGULATION (EU) 2016/2281 of 30 November 2016 implementing Directive 2009/125/EC of the European Parliament and of the Council establishing a framework for the setting of ecodesign requirements for energy-related products, with regard to ecodesign requirements for air heating products, cooling products, high temperature process chillers and fan coil units, sets Ecodesign requirements, including MEPS for chillers.

Scope

The scope of the EU's regulation covers a variety of product types beyond just chillers, but in the case of chillers it addresses both comfort chillers and high temperature process chillers which are defined as follows:

'comfort chiller' means a cooling product:

a. whose indoor side heat exchanger (evaporator) extracts heat from a water-based cooling system (heat source), designed to operate at leaving chilled water temperatures greater than or equal to + 2°C.

b. that is equipped with a cold generator.

c. whose outdoor side heat exchanger (condenser) releases this heat to ambient air, water or ground heat sink(s).

'high temperature process chiller' means a product:

a. integrating at least one compressor, driven or intended to be driven by an electric motor, and at least one evaporator;

b. capable of cooling down and continuously maintaining the temperature of a liquid, in order to provide cooling to a refrigerated appliance or system, the purpose of which is not to provide cooling of a space for the thermal comfort of human beings;

c. that is capable of delivering its rated refrigeration capacity, at an indoor side heat exchanger outlet temperature of 7°C, at standard rating conditions;

d. that may or may not integrate the condenser, the coolant circuit hardware or other ancillary equipment.

Although it is not explicitly stated in the regulation itself, China's standard GB 19577-

2015 is understood to address what the EU define as comfort chillers. Process chillers are not believed to be in its scope. The standard is applicable to water chilling (heat pump) packages using the vapour compression cycle with compressors driven by motors. It does specify that 'Water chillers shall meet the requirements of GB/T 18430.1 or GB/T 18430.2 and GB 25131.' These standards would need to be analysed in detail to determine what specific types of chillers would be within scope.

Aside from the comfort or process chiller scope difference, the EU regulations are applicable to chillers using:

- vapour-compression cycle.
- sorption cooling.
- evaporative cooling.

China's regulations only apply to those using the vapour-compression cycle but include evaporative cooling types too.

One other difference is that the EU's requirements are not limited to products powered by electricity and include those driven by internal combustion engines. China's are understood to be limited to electrically powered equipment.

Energy performance test procedure

In China the following standards are used to test and rate chiller energy performance:

> GB/T 10870: 2014 *The methods of performance test of water chilling (heat pump) packages using the vapour compression cycle*.
>
> GB/T 18430.1: 2007 *Water chilling (heat pump) packages using the vapour compression cycle – Part 1: Water chilling (heat pump) packages for industrial and commercial and similar applications*.
>
> GB/T 18430.2: 2016 *Water chilling (heat pump) packages using the vapour compression cycle – Part 2: Water chilling (heat pump) packages for household and similar applications*.

The EU standards used to test chillers and rate their energy performance are not explicitly stated in the Ecodesign regulations, which makes it problematic to know which test method is applicable; however, from reading the preparatory study and checking standardisation websites it appears that the relevant standards are those set out below.

The cooling and heating mode energy performance of mainstream vapour compression chillers is tested via:

> EN 14511-1:2018 *Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 1: Terms and definitions*.
>
> This standard specifies the terms and definitions for the rating and performance

of air conditioners, liquid chilling packages and heat pumps using either air, water or brine as heat transfer media, with electrically driven compressors when used for space heating and/or cooling. It also specifies the terms and definitions for the rating and performance of process chillers. It applies to: factory-made units that can be ducted, factory-made liquid chilling packages with integral condensers or for use with remote condensers, factory-made units of either fixed capacity or variable capacity by any means, and air-to-air air conditioners which can also evaporate the condensate on the condenser side. In the case of units consisting of several parts, it applies only to those designed and supplied as a complete package, except for liquid chilling packages with remote condenser. It is primarily intended for water and brine chilling packages but can be used for other liquid, subject to agreement. The units having their condenser cooled by air and by the evaporation of external additional water should have their performance in the cooling mode determined in accordance to EN 15218. For those which can also operate in the heating mode, the EN 14511 series applies for the determination of their performance in the heating mode.[18]

EN 14511-2:2018 *Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 2: Test conditions*.

This has the same scope as EN 14511-1 and specifies the test conditions for the rating of air conditioners, liquid chilling packages and heat pumps, using air, water or brine as heat transfer media, with electrically driven compressors when used for space heating and/or cooling.

EN 14511-3:2018 *Air conditioners, liquid chilling packages and heat pumps for space heating and cooling and process chillers, with electrically driven compressors - Part 3: Test methods*.

Gas-fired sorption chillers are tested via:

EN 12309-3:2014 *Gas-fired sorption appliances for heating and/or cooling with a net heat input not exceeding 70kW - Test conditions*.

Evaporatively cooled chillers are tested via:

EN15218:2013 *Air conditioners and liquid chilling packages with evaporatively cooled condenser and with electrically driven compressors for space cooling - Terms, definitions, test conditions, test methods and requirements*.

Product categorisation

China's regulations set distinct requirements depending on:

- the nature of cooling medium/method: either air cooled and evaporatively cooled, or water cooled.
- the cooling capacity (CC): either <50kW or above for air cooled and

18 NOTE 1 Part load testing of units is dealt with in EN 14825

evaporatively cooled types, or CC ≤538kW, 528kW<CC ≤1163kW, and CC >1163kW for water cooled types.

The EU distinguishes its requirements by the following comfort chiller types:

- Air-to-water chillers with rated cooling capacity < 400 kW, when driven by an electric motor.
- Air-to-water chillers with rated cooling capacity ≥ 400 kW when driven by an electric motor.
- Water/brine to-water chillers with rated cooling capacity < 400 kW when driven by an electric motor.
- Water/brine to-water chillers with ≥ 400 kW rated cooling capacity < 1 500 kW when driven by an electric motor.
- Water/brine to-water chillers with rated cooling capacity ≥ 1 500 kW when driven by an electric motor.
- Air-to-water comfort chillers, when driven by an internal combustion engine.

Efficiency metrics

China applies an integrated part load value (IPLV) efficiency metric as defined in the previously mentioned standards. The approach is to take the Coefficient of Performance values tested under rating conditions, designed to represent 100%, 75%, 50% and 25% of the full-load operating conditions, and to apply a weighted average to these four test values to determine the IPLV score.

In the EU the energy efficiency performance determination and rating of chillers appears to be determined via the EU standard:

prEN14825: 2020 *Air conditioners, liquid chilling packages and heat pumps, with electrically compressors, for space heating and cooling- Testing and rating at part load conditions and calculation of seasonal performance*.

This standard takes the results from the previously mentioned test standards as inputs and applies calculation methodologies to determine the rated energy performance. Specifically, the prEN14825: 2020 standard gives the temperatures and part load conditions and the calculation methods for the determination of seasonal energy efficiency ratio (SEER) and $SEER_{on}$ (for the cooling mode), seasonal space cooling energy efficiency $\eta_{s,c}$, seasonal coefficient of performance (SCOP), $SCOP_{on}$ and $SCOP_{net}$, and seasonal space heating energy efficiency $\eta_{s,h}$ and seasonal energy performance ratio SEPR. These calculation methods can be based on calculated or measured values. In the case of measured values, it covers the test methods for determination of capacities, EER and COP values during active mode at part load conditions. It also covers test methods for power input during thermostat-off mode, standby mode, off mode and crankcase heater mode.

The basic approach used in EN14825 mirrors the IPLV (integrated part load value) method that was originally developed in the USA for chillers and was subsequently adopted in China. However, the following observations can be made:

- both the EU's $SEER_{on}$ and China's IPLV use four rating conditions, one of which is full-load and the other three are part-load.

- the basic method and test conditions to determine full-load cooling (or heating) efficiency appear to be equivalent (although this would have to be verified in a more in-depth analysis).
- the part-load test conditions are not the same.
- the weighting applied to the part-load conditions are not the same (reflecting climatic and usage differences).

While both the $SEER_{on}$ and the IPLV use a set of part-load test conditions, China and the EU apply different weightings to these part-load performance values to reflect the climatic differences and some systematic differences in how the products are used which affects the prevalent indoor usage conditions. This means that even were the test rating points to be the same and the test methods applied to be equivalent, the weightings applied are not and hence the $SEER_{on}$ and IPLV values are not directly comparable.

Specifically, the Chinese standard GB/T 18430.1 requires a chiller's performance to be tested at 100%, 75%, 50% and 25% cooling load, with ambient temperatures of 35°C, 31.5°C, 28°C, and 24.5°C respectively. Where this is not possible, the test should be carried out at the closest available capacity point.

The European regulation requires a chiller's seasonal cooling performance to be tested at part-loads with ambient temperatures of 35°C, 30°C, 25°C, and 20°C respectively. Thus, while a priori the method of test is likely to align with that used in China the actual ambient test conditions are slightly or somewhat different at the lower part loads.

In addition, the EU includes the following additional loads in its SEER rating that China does not appear to include in its IPLV:

- thermostat-off mode.
- standby mode.
- off mode.
- crankcase heater mode.

These loads will be secondary to the primary thermal performance aspects but will lead to some differences and constitute a slightly more holistic approach to energy performance rating.

Lastly, the design of the methodology applied in the EU regulations has gone to some lengths to enable the cooling (or heating) performance to be compared across different technologies (e.g., different chiller or other cooling types and similar for heating) and across the fuels used (to reflect the primary energy required and hence better facilitate comparison that accounts for the carbon and cost impacts of the energy service). For this reason the SEER values are converted into a $\eta_{s,c}$ percentage index that aims to factor in the primary energy. The formula used to determine the $\eta_{s,c}$ value is not specified in the regulation (presumably only in the standards) but regression of published data where both the $\eta_{s,c}$ and SEER values are reported shows that it is a simple linear function of the SEER as follows:

SEER = 0.025&* $\eta_{s,c}$ + 0.0712

In summary, it is likely that the level of harmonisation concerning the test method is very high if not identical but there are differences in the part-load test conditions, the weighting applied to the part-load test points and the treatment of auxiliary loads used to derive the SEER or IPLV values, and then the EU applies an additional conversion factor to derive the $\eta_{s,c}$ value to reflect the primary energy impact on an equivalent basis across other technologies used to provide comfort cooling (or heating).

Efficiency levels

China's efficiency requirements for chillers expressed both in terms of IPLV (cooling mode) values and COP (heating mode) values are set out in Table 3.6.1 and 3.6.2.

Table 3.6.1: China's energy efficiency grades for chillers (Index I)

Type	Cooling capacity (CC) kW	Energy efficiency grades			
		1	2	3	
		(IPLV) W/W	(IPLV) W/W	(COP) W/W	(IPLV) W/W
Air cooling or evaporative cooling	CC≤50	3.80	3.60	2.50	2.80
	CC>50	4.00	3.70	2.70	2.90
Water cooling	CC≤528	7.20	6.30	4.20	5.00
	528<CC≤1 163	7.50	7.00	4.70	5.50
	CC>1 163	8.10	7.60	5.20	5.90

Table 3.6.2: China's energy efficiency grades for chillers (Index II)

Type	Cooling capacity (CC) kW	Energy efficiency grades			
		1	2	3	
		(COP) W/W	(COP) W/W	(COP) W/W	(IPLV) W/W
Air cooling or evaporative cooling	CC≤50	3.20	3.00	2.50	2.80
	CC>50	3.40	3.20	2.70	2.90
Water cooling	CC≤528	5.60	5.30	4.20	5.00
	528<CC≤1 163	6.00	5.60	4.70	5.50
	CC>1 163	6.30	5.80	5.20	5.90

The EU's minimum energy performance requirements are set out in Table 3.6.3.

Table 3.6.3: Europe's Ecodesign MEPS for chillers (minimum seasonal energy efficiency, expressed in %)

	$\eta_{s,c}$(*)
Air-to-water chillers with rated cooling capacity < 400 kW, when driven by an electric motor	161
Air-to-water chillers with rated cooling capacity ≥ 400 kW, when driven by an electric motor	179
Water/brine to-water chillers with rated cooling capacity < 400 kW when driven by an electric motor	200
Water/brine to-water chillers with ≥ 400 kW rated cooling capacity < 1 500 kW when driven by an electric motor	252
Water/brine to-water chillers with rated cooling capacity ≥ 1 500 kW when driven by an electric motor	272
Air-to-water chillers with rated cooling capacity ≥ 400 kW, when driven by an internal combustion engine	154

From this it can be observed that China applies both a minimum IPLV value and a minimum COP (full load) value whereas the EU only sets limits on the $\eta_{s,c}$ value (directly related to the SEER and hence similar to the IPLV). If the EU MEPS were expressed in terms of SEER they would range between 3.92 W/W ($\eta_{s,c}$ = 154) and 6.88 W/W ($\eta_{s,c}$ = 272).

China-EU alignment potential

The energy performance of comfort chillers is regulated in both economies. A priori, it is likely that the level of harmonisation concerning the test method is very high, if not identical, but there are differences in the part-load test conditions, the weighting applied to the part-load test points and the treatment of auxiliary loads. These are then compounded in differences (that are not very visible because they are not elucidated in the efficiency regulations) in how the aggregate overall energy performance in cooling and heating modes is determined. In addition, the scope of the EU's regulations is broader in that it includes process chillers whereas China's is understood to be focused exclusively on comfort chillers.

The level of trade in chillers has not yet been examined but they reside in the domain where there could be significant trade volumes for the mainstream smaller capacities but probably much less (unless at the component level) for larger finished products. Most likely though, there is at least significant trade at the upstream value chain level and perhaps some at the smaller finished product level. In addition, greater alignment of EU-China approaches would undoubtedly greatly facilitate international alignment throughout not just Eurasia but also other major geographic regions such as Africa, Latin America and Australasia.

It should be noted that the only aspect that technically merits deviation in the approaches applied is the level of weighting given to part-load test conditions. The part-load test conditions themselves could be aligned, as could the treatment of auxiliary loads, the product categorisation and aggregate metric for combined heating and cooling performance. Thus, there is considerable technical potential to align approaches in a manner that would in no way limit the needs to adapt requirements to the specific circumstances applicable to each market.

Further investigation could clarify the residual uncertainties about the testing, efficiency metrics, trade and upstream value chain.

3.7 Commercial refrigerated display cabinets

Summary of existing regulations

In China, GB 26920.1-2011 *Maximum allowable values of the energy consumption and energy efficiency grades of commercial refrigerating appliances – Part 1: Refrigerated display cabinets with remote condensing unit* sets out the MEPS and energy grades (to be used in labels) for commercial refrigerated display cabinets. In addition, GB 26920.2-2015 *Maximum allowable values of the energy consumption and energy efficiency grades of commercial refrigerating appliances – Part 2: Commercial refrigerated cabinets with self-contained condensing unit*, sets out the MEPS and energy grades for commercial refrigerated cabinets with self-contained condensing unit.

The EU applies MEPS for commercial refrigerated display cabinets under COMMISSION REGULATION (EU) 2019/2024 of 1 October 2019 *laying down ecodesign requirements for refrigerating appliances with a direct sales function pursuant to Directive 2009/125/EC of the European Parliament and of the Council*[19] while energy labelling requirements are specified in COMMISSION DELEGATED REGULATION (EU) 2019/2018 of 11 March 2019 *supplementing Regulation (EU) 2017/1369 of the European Parliament and of the Council with regard to energy labelling of refrigerating appliances with a direct sales function*.[20]

In addition, COMMISSION REGULATION (EU) 2021/341 of 23 February 2021 *amending Regulations (EU) 2019/424, (EU) 2019/1781, (EU) 2019/2019, (EU) 2019/2020, (EU) 2019/2021, (EU) 2019/2022, (EU) 2019/2023 and (EU) 2019/2024 with regard to ecodesign requirements for servers and data storage products, electric motors and variable speed drives, refrigerating appliances, light sources and separate control gears, electronic displays, household dishwashers, household washing machines and household washer-dryers and refrigerating appliances with a direct sales function*[21] contains provisions which amend the Ecodesign requirements for 2019/2024. Furthermore, COMMISSION DELEGATED REGULATION (EU) 2021/340 of 17 December 2020 *amending Delegated Regulations (EU) 2019/2013, (EU) 2019/2014, (EU) 2019/2015, (EU) 2019/2016, (EU) 2019/2017 and (EU) 2019/2018 with regard to energy labelling requirements for electronic displays, household washing machines and household washer-dryers, light sources, refrigerating appliances, household dishwashers, and refrigerating appliances with a direct sales function*[22] contains provisions which amend the Energy Labelling requirements for 2019/2018.

The set of EU regulations apply from March 2021.

Scope

The scope of the EU regulations applies to electric mains-operated refrigerating appliances with a direct sales function, including appliances sold for refrigeration of items other than foodstuffs. The Ecodesign regulations exclude:

- refrigerating appliances with a direct sales function that are only powered by energy sources other than electricity.
- remote components, such as the condensing unit, compressors or water condensed unit, to which a remote cabinet needs to be connected in order to function.

19 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R2024&from=EN
20 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R2018&from=DE
21 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0341&from=EN
22 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0340&from=EN

- food processing refrigerating appliances with a direct sales function.
- refrigerating appliances with a direct sales function specifically tested and approved for the storage of medicines or scientific samples.
- refrigerating appliances with a direct sales function that have no integrated system for producing cooling, and function by ducting chilled air that is produced by an external air chiller unit; this does not include remote cabinets nor does it include category 6 refrigerated vending machines, as defined in Table 5 of Annex III of Regulation (EU) 2019/2024.
- professional refrigerated storage cabinets, blast cabinets, condensing units and process chillers as defined in Regulation (EU) 2015/1095.
- wine storage appliances and minibars.
- vertical static-air cabinets with non-transparent doors: these are professional refrigerating appliances and are defined in Commission Regulation (EU) 2015/1095.

In addition, MEPS requirements do not apply to all products covered by the Ecodesign regulation; they exclude:

- refrigerating appliances with a direct sales function that do not use a vapour compression refrigeration cycle.
- refrigerating appliances with a direct sales function for the sale and display of live foodstuffs, such as refrigerating appliances for the sale and display of living fish and shellfish, refrigerated aquaria and water tanks.
- Saladettes.
- horizontal serve-over counters with integrated storage designed to work at chilled operating temperatures.
- corner/curved and carousel cabinets[23].
- vending machines designed to work at freezing operating temperatures.
- serve-over fish counters with flaked ice.

The scope of the EU energy label regulation is the same as that of the MEPS requirements. However, both EU regulations have a broader scope than solely commercial refrigerated display cabinets.[24] While refrigeration appliances without integrated system for producing cooling are excluded from the EU regulations, remote cabinets are not and they are therefore regulated.

The Part 1 (GB 26920.1-2011) of the Chinese standard is:

23 See amendment in Regulation (EU) 2021/341.

24 Further product categories covered by the EU regulations but out of the scope of this study are: beverage coolers, ice-cream freezers, refrigerated vending machines, gelato-scooping cabinets and roll-in cabinets.

- applicable to remote refrigerated display cabinets for sales and display of foodstuffs.

- is not applicable to refrigerated automatic vending machine and non-retail refrigerated display cabinets.

Regarding Part 2 (GB 26920.2-2015), it is applicable to:

- self-contained refrigerated cabinets for sales and display of foodstuffs.

- closed self-contained beverage refrigerated display cabinets for stores, hotels and restaurants.

- refrigerated cabinets with solid door (such as kitchen fridges, refrigerated storage cabinets and work top refrigerators) and the non-retail self-contained refrigerated cabinets).

For remote and self-contained refrigerated display cabinets, the scope of the MEPS and labelling regulations in both economies is very similar.

Energy performance test procedure

GB 26920.1-2011 mentions that tests shall be carried out in accordance with relevant requirements of GB/T 21001.1-2007, GB/T 21001.2-2007, and Chapter 4 of GB 26920.1-2011. Since GB/T 21001.1-2007 and GB/T 21001.2-2007 are identical to ISO 23953-1:2005 and ISO 23953-2:2005 respectively. The ISO standards basically apply to the test procedure of GB 26920.1-2011.

GB 26920.2-2015 mentions that tests for the commercial refrigerated cabinets with self-contained condensing unit for the use of retail and display shall be carried out in accordance with relevant requirements of GB/T 21001.2-2015 (identical to ISO 23953-2:2005); the refrigerated cabinets with solid door and the non-retail self-contained refrigerated cabinets shall be in accordance with the SB/T 10794.2-2012 (which is basically identical to ISO 23953-2:2005); and the self-contained beverage refrigerated display cabinet shall be in accordance with the SB/T 10794.3-2012 (which is developed as the China commercial standard but basically follows the technical principles within ISO 23953-2).

The ISO standards are effectively applied for the test procedure of GB 26920.1-2011. Therefore, it can be considered that the test procedure of GB 26920.2-2015 aligns with the ISO method.

In the EU, there are no harmonised standards for the product group covered in this section. However, the regulation (EU) 2017/1369 mentions clearly which standards apply for refrigerating appliances with a direct sales function:[25] EN ISO 23953-1:2015 *Refrigerated display cabinets Part 1: Vocabulary* and EN ISO 23953-2:2015 *Refrigerated display cabinets Part 2: Classification, requirements and test conditions*.

25 'The terminology and testing methods of use in Regulation (EU) 2019/2018 are consistent with the terminology and testing methods adopted in EN 16901, EN 16902, EN 50597 and EN ISO 23953-2 and EN 16838'.

Both standards are identical to the corresponding ISO standards. CEN TC 44 WG1 is leading an update of these standards. The ISO standards will be revised under ISO/TC 86/SC 7 with an ISO lead.

The test procedure in China is based on ISO 23953-2:2005, while the EU regulation refers to ISO 23953-2:2015. It was not possible to assess in detail the difference in test conditions between the two different versions of the ISO 23953 standard.

Product categorisation

The EU regulation differentiates between the following four categories of commercial refrigerated display cabinets:

- vertical and combined supermarket refrigerator cabinets.
- horizontal supermarket refrigerator cabinets.
- vertical and combined supermarket freezer cabinets.
- horizontal supermarket freezer cabinets.

There are roughly four categories of similar products corresponding to the Chinese counterpart.

Efficiency metrics

In China, the standard energy efficiency index of commercial refrigerators (refrigerated display cabinets with remote condensing unit) is defined in GB 26920.1-2011 as:

$$\eta = ECC/ECC_{max} \times 100\%$$

With:

- η: Energy efficiency index.
- ECC: Energy consumption coefficient of remote refrigerated display cabinets, in kWh/(24 h•m^2).
- ECC_{max}: Minimum allowable values of energy efficiency of remote refrigerated display cabinets, in kWh/(24 h•m^2).

Both the energy label grades and the MEPS level are set in terms of η.

For refrigerated cabinets with self-contained condensing units, the standard energy efficiency index is defined in GB 26920.2-2015 as:

$$\eta = TEC/TEC_{max} \times 100\%$$

With:

- η: Energy efficiency index.
- TEC: The measured Total Energy Consumption of self-contained commercial refrigerated cabinets, in kWh/(24 h).
- TEC_{max}: Maximum allowable values of energy consumption of self-contained commercial refrigerated cabinets, in kWh/(24 h).

In the EU, the Energy Efficiency Index (EEI) used for the energy label classes and the

MEPS level is defined as follows:

EEI = AE/SAE

With:

- AE: annual energy consumption in kWh/a, calculated as:
  $AE = 365 \times E_{daily}$

  With:
  E_{daily}: energy consumption of the refrigerating appliance with a direct sales function over 24 hours, expressed in kWh/24h.

- SAE: Standard Annual Energy consumption in kWh/a, calculated as:

  $$SAE = 365 \times P \times \sum_{c=1}^{n} (M + N \times Y_c) \times C_c;$$

  With:

  c: index number for a compartment (n: total number of compartment). For refrigerating appliances with a direct sales function with all compartments having the same temperature class and for refrigerated vending machines, there is no distinction of compartments. n = 1.

  P: correction factor that accounts for the differences between integral and remote cabinets.

  N, M: modelling parameters specific to each category of appliances.

  C_c: temperature coefficient means a correction factor that accounts for the difference in operating temperature. Depending on the product category and characteristics of the appliance, C is a value or is calculated.

  Y_c:

  - For beverage coolers: Y_c is the equivalent volume of the compartments of the beverage cooler with target temperature T_c. It is based on the gross volume and the target temperature T_c of each compartment and also takes into account the climate class.

  - for all other refrigerating appliances with direct sales function: Y_c is the sum of the TDA (Total Display Area) of all compartments of the same temperature class of the refrigerating appliance with a direct sales function, expressed in square meters (m^2).

The aforementioned information shows that the efficiency metrics in both economies are different.

Efficiency levels

China's energy efficiency grades used in the energy label and by default the MEPS level (which is set at the grade 5 level) are shown in Table 3.7.1. It is the same for remote refrigerated display cabinets as for refrigerated cabinets with self-contained condensing units.

Table 3.7.1: Energy efficiency grades of remote refrigerated display cabinets and for refrigerated cabinets with self-contained condensing units (where grade 5 is the MEPS requirement)

Energy efficiency index	Energy efficiency grade
$\eta \leq 55\%$	1
$55\% < \eta \leq 65\%$	2
$65\% < \eta \leq 80\%$	3
$80\% < \eta \leq 90\%$	4
$90\% < \eta \leq 100\%$	5

Since 1 February 2021, the EU's Energy Efficiency Index limit (MEPS) has been 100 and will be tightened to 80 from 1 September 2023. The label thresholds are presented in Table 3.7.2.

Table 3.7.2: Energy efficiency classes in the EU

Energy efficiency class	EEI
A	EEI < 10
B	10 ≤ EEI < 20
C	20 ≤ EEI < 35
D	35 ≤ EEI < 50
E	50 ≤ EEI < 65
F	65 ≤ EEI < 80
G	EEI ≥ 80

China-EU alignment potential

MEPS and mandatory energy labels apply to commercial refrigerated display cabinets in both economies. Basically, China and the EU have a similar scope of products for commercial refrigerated display cabinets. In terms of test procedures, the ISO 23953-1 and -2 standards apply to both China and the EU. However, there are some differences in the versions of the standards and some technical specificities (for example, some product categories are required to be tested with the door-closed in the EU but with the door-open in China), but the level of alignment between both economies seems high. Large gaps can be observed for the energy efficiency metrics. Accordingly, the level of MEPS and energy efficiency classes of the energy labels cannot be easily compared between the two economies.

3.8 Air handling units

Summary of existing regulations

In China there is no mandatory standard setting out the MEPS for air handling units (AHUs). National *voluntary* standard GB/T 21087-2020 *Energy Recovery Ventilators for Outdoor Air Handing* developed under SAC/TC 143 *HVAC and Purification Equipment* mainly focuses on energy exchange performance and gives the general performance requirements (including thermal exchange efficiency, ratio of energy recovery, energy efficiency index) and corresponding methods for energy recovery ventilators for outdoor air handing. There is no comprehensive national standard for AHUs focusing on all aspects of performance, and especially for energy efficiency. In practice, this standard should be applied together with other related voluntary industry standards[26]. For air handling units, there are no energy labelling requirements.

The EU applies MEPS for air handling units under COMMISSION REGULATION (EU) No 1253/2014 of 7 July 2014 *implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for ventilation units*.[27] There are no energy labelling requirements for air handling units[28]. This EU regulation is currently under review, with the *Supporting study for the review of the Ecodesign and Energy Labelling Regulations on ventilation units* having been completed in July 2020.[29] A document presenting the revised Regulation was discussed during the 2nd Stakeholder Meeting on 7 May 2020.[30] It is still unclear which amendments of the Ecodesign regulation will be made, or even if they will be made at all. So far, the proposal does not include any energy labelling for AHUs.

Scope

The scope of the EU regulation (EU) 1253/2014 applies to ventilation units and establishes ecodesign requirements for putting them on the market or putting them into service. Ventilation unit (VU) means an electricity driven appliance equipped with at least one impeller, one motor and a casing, intended to replace utilised air with outdoor air in a building or a part of a building. The regulation differentiates 'residential ventilation unit' (RVU) and 'non-residential ventilation unit' (NRVU), which are defined according to the maximum flow rate.

The latter category (NRVU) corresponds to air handling units and means a ventilation unit where the maximum flow rate of the ventilation unit exceeds 250 m^3/h, and where the maximum flow rate is between 250 and 1 000 m^3/h, and the manufacturer has not declared its intended use as being exclusively for a residential ventilation

26 Like GB/T 34012-2017 ***Air cleaners for Ventilation Systems*** which mainly focuses on purification performances and gives the general performance requirements (including cleaning energy efficiency) and corresponding testing methods for air cleaners for ventilation systems.

27 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1253&from=EN

28 Only ventilation units with a maximum flow rate that does not exceed 250 m^3/h (also covered by Regulation (EU) 1253/2014) are subject to energy labelling requirements through ***COMMISSION DELEGATED REGULATION (EU) No 1254/2014 of 11 July 2014 supplementing Directive 2010/30/EU of the European Parliament and of the Council with regard to energy labelling of residential ventilation units***. See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32014R1254&from=EN

29 https://op.europa.eu/en/publication-detail/-/publication/362dece9-0f58-11eb-bc07-01aa75ed71a1

30 https://www.ecoventilation-review.eu/downloads/20200416%20-%20Discussions%20Document%202nd%20Stakeholder%20Meeting%20Review%20Study%20VUs.pdf

application.[31]

The Regulation excludes NRVU which:

- are axial or centrifugal fans that are only equipped with a housing in terms of Regulation (EU) No 327/2011.

- are exclusively specified as operating in a potentially explosive atmosphere as defined in Directive 94/9/EC of the European Parliament and of the Council[32].

- are exclusively specified as operating for emergency use, for short periods of time, and which comply with the basic requirements for construction works with regard to safety in case of fire as set out in Regulation (EU) No 305/2011 of the European Parliament and of the Council[33].

- are exclusively specified as operating:
    - where operating temperatures of the air being moved exceed 100°C.
    - where the operating ambient temperature for the motor driving the fan, if located outside the air stream, exceeds 65°C.
    - where the temperature of the air being moved or the operating ambient temperature for the motor, if located outside the air stream, are lower than 40°C.
    - where the supply voltage exceeds 1 000 V AC or 1 500 V DC.
    - in toxic, highly corrosive or flammable environments or in environments with abrasive substances.

- include a heat exchanger and a heat pump for heat recovery or allowing heat transfer or extraction, being additional to that of the heat recovery system, except heat transfer for frost protection or defrosting.

In China, the GB/T 21087-2020 standard is applicable to bidirectional AHUs with filters and energy recovery components which recover energy from exhaust air and pre-process the supply air by cooling, heating, humidifying/dehumidifying and filtering. The standard does not specify the range of the airflow for the ventilation system which means that both RVUs and NRVUs are covered.

For AHUs, the scope of application is different: the Chinese standard only applies to bidirectional AHUs, whilst the European regulation also includes unidirectional AHUs but specifies the maximum flow rate of the ventilation.

Energy performance test procedure

In the EU, there is currently no harmonised standard for AHU, as no reference has been published in the Official Journal of the European Union for this product group.

31 Ventilation units with a maximum flow rate over 1 000 m^3/h is always considered as an NRVU.
32 Directive 94/9/EC of the European Parliament and the Council of 23 March 1994 on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres (OJ L 100, 19.4.1994, p. 1).
33 Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC (OJ L 88, 4.4.2011, p. 5).

However, the EU has published titles and references of transitional methods of measurement and calculation for the implementation of Commission Regulation (EU) No 1253/2014 of 7 July 2014 *implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for ventilation units.*[34]

In addition, the Commission has issued a 'request for standardisation': *M/537 COMMISSION IMPLEMENTING DECISION C(2015) 8325 final of 27.11.2015 on a standardisation request to the European Committee for Standardisation as regards ventilation units in support of Regulation (EU) No 1253/2014 and Delegated Regulation (EU)*.[35] The following relevant standards have been elaborated or are in the process of elaboration. They are not based on ISO or IEC standards:

- EN 13053:2019 *Ventilation for buildings. Air handling units. Rating and performance for units, components and sections*. This European Standard applies to tests in a laboratory and in situ. It is applicable both to mass produced air handling units and tailor-made Air Handling Units. This European Standard applies to AHU and individual sections of AHU with the designed air flow > 250 m^3/h. It applies to UVUs with additional air treatment components in addition to filtration. It does not include:
    - residential unidirectional and bidirectional ventilation units.
    - non-residential unidirectional ventilation units which consist of only a casing, a fan with or without filter.

- prEN 17291: 2018.[36] *Fans - Procedures and methods to determine and evaluate the energy efficiency of non-residential unidirectional ventilation units*. This standard provides procedures and methods for measuring and calculating the energy efficiency and associated characteristics of non-residential unidirectional ventilation units when driven by electric motors. Unidirectional ventilation units include roof fans and box fans. This document includes unidirectional ventilation units with and without filters. Additional air treatment items are considered in this document but are excluded in the determination of the efficiency of the product. This document does not include:
    - residential unidirectional and bidirectional ventilation units.
    - non-residential bidirectional ventilation units.

GB/T 21087-2020 *Energy Recovery Ventilators for Outdoor Air Handing* defines the testing method for energy performance related parameters including thermal exchange efficiency (including sensible exchange efficiency and total exchange efficiency), ratio of energy recovery, energy efficiency index, air volume, rated power, etc. Within this standard, Table 3 specifies the standard testing conditions, covering the setting of dry bulb temperatures and wet bulb temperatures at both supply air inlets and exhaust air inlets, rated voltage and rated air volume. Annex A of this standard defines the test procedure for air volume, static pressure drops, available pressure, and rated power of energy recovery AHUs and energy recovery components including three different types of testing equipment with different connecting methods depending on whether air ducts are used. Annex F defines the test procedures and methods for measuring and calculating for thermal exchange efficiency, ratio of energy recovery and energy

34 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52016XC1111(09)&from=EN
35 http://ec.europa.eu/growth/tools-databases/mandates/index.cfm?fuseaction=search.detail&id=558
36 Draft European standard (prEN).

efficiency index of energy recovery AHUs and energy recovery components. Annex B defines specific requirements regarding testing equipment, testing conditions, and testing procedure regarding in situ testing. This standard applies to residential and non-residential bidirectional AHUs with filters and energy recovery components. It does not mention any editions of IEC standard series.

In addition, fan efficiency is defined in the mandatory energy efficiency standard GB 17961-2020 *Minimum allowable values of energy efficiency and energy efficiency grades*, which defines the energy efficiency metric, the energy efficiency testing method and the energy efficiency grades (including MEPS) for fans. It is applicable to all kinds of separate fans especially for factory use, including but not limited to the axial flow type fans most commonly used in AHUs.

Product categorisation

GB/T 21087-2020 *Energy recovery ventilators for outdoor air handing* only applies to bidirectional units with heat recovery systems (HRS) and filters. There is no need to further divide the AHUs into sub-categories.

The EU regulation differentiates only two categories of AHU:

- ‘unidirectional ventilation unit’ (UVU) means a ventilation unit producing an air flow in one direction only, either from indoors to outdoors (exhaust) or from outdoors to indoors (supply), where the mechanically produced air flow is balanced by natural air supply or exhaust.

- ‘bidirectional ventilation unit’ (BVU) means a ventilation unit which produces an air flow between indoors and outdoors and is equipped with both exhaust and supply fans.

It also distinguishes AHU:

- with/without run-around heat recovery system (HRS).
- with/without filter.

Efficiency metrics

In the EU, no Energy Efficiency Index (EEI) is defined for NRVU.[37] However, there are specific ecodesign requirements, which are based on the following three metrics:

- thermal efficiency of a non-residential HRS (η_{t_nrvu}), which is the ratio between supply air temperature gain and exhaust air temperature loss, both relative to outdoor temperature, measured under dry reference conditions, with balanced mass flow, an indoor-outdoor air temperature difference of 20 K, but excluding thermal heat gain from fan motors and from internal leakages.

37 For RVU, a specific energy consumption (SEC) is defined.

The thermal efficiency of a non-residential heat recovery system is defined as:

$$\eta_{t\_nrvu} = (t_{2''} - t_{2'}) / (t_{1'} - t_{2'})$$

where:
η_t: thermal efficiency of the HRS.
$t_{2''}$: temperature of the supply air leaving the HRS and entering the room, in °C.
$t_{2'}$: temperature of the outside air, in °C.
$t_{1'}$: temperature of the exhaust air, leaving the room and entering the HRS, in °C.

- minimum fan efficiency (η_{vu}), which is the specific minimum efficiency requirement for VUs within the scope of this Regulation. It depends on the nominal electric power input (P) of the fan drives, including any motor control equipment, at the nominal external pressure and the nominal airflow[38].

- internal specific fan power of ventilation components (SFP_{int}) (expressed in W/(m^3/s)), which is the ratio between the internal pressure drop of ventilation components and the fan efficiency, determined for the reference configuration.

In China, the following metrics are adopted in GB/T 21087-2020:

- thermal exchange efficiency including sensible thermal exchange efficiency and total thermal exchange efficiency:

  - Sensible thermal exchange efficiency is the ratio of temperature difference between supply air inlet and supply air outlet to that between supply air inlet and exhaust air inlet. This metric is similar to thermal efficiency mentioned in EU regulations and leads to the same calculation results. It is calculated as:

    $$\eta_{wd} = \frac{t_{OA} - t_{SA}}{t_{OA} - t_{RA}} \times 100\%$$

    Where:
    η_{wd}: Sensible thermal exchange efficiency, in %.
    t_{OA}: Dry-bulb temperature of supply air inlet, in °C.
    t_{SA}: Dry-bulb temperature of supply air outlet, in °C.
    t_{RA}: Dry-bulb temperature of exhaust air inlet, in °C.

  - Total thermal exchange efficiency is the ratio of enthalpy difference between supply air inlet and supply air outlet to that between supply air inlet and exhaust air inlet. It is calculated as:

    $$\eta_h = \frac{h_{OA} - h_{SA}}{h_{OA} - h_{RA}} \times 100\%$$

    Where:
    η_h: Total thermal exchange efficiency, in %.
    h_{OA}: Enthalpy value of supply air inlet, in kJ/kg.
    h_{SA}: Enthalpy value of supply air outlet, in kJ/kg.
    h_{RA}: Enthalpy value of exhaust air inlet, in kJ/kg.

38 See prEN 17291:2018 for UVU

- ratio of energy recovery, which is the ratio of energy recovered to the electricity consumed during the recovery process, calculated as:

$$RER = \frac{m_{SANet}\,|h_{SA} - h_{OA}| \times 1000}{\left(\frac{\Delta P_s \times Q_{SA}}{\eta_{fs}} + \frac{\Delta P_e \times Q_{EA}}{\eta_{fe}} + P_{fz}\right)}$$

Where:

RER: Ratio of energy recovery.
m_{SANet}: Mass flow of clean supply air, in kg/s.
h_{SA}: Enthalpy value of supply air outlet, in kJ/kg.
h_{OA}: Enthalpy value of supply air inlet, in kJ/kg.
Δp_s: Resistance at supply air side, in Pa.
Q_{SA}: Air supply volume, in m^3/s.
η_{fs}: Total efficiency of fan for supplying air, which is taken as 0.55.
Δp_e: Resistance at exhaust air side, in Pa.
Q_{EA}: Exhaust air volume, in m^3/s.
η_{fe}: Total efficiency of fan for exhausting air, which is taken as 0.55.
P_{fz}: Input power of auxiliary equipment (impeller motor, controller, etc.), in W.

- energy efficiency index, which is the ratio of the sum of the total energy exchanged between the supply and exhaust airflow and the energy possessed by the airflow to the input power, calculated as:

$$COE_{ducted} = \frac{[\,|m_{SANet}\,(h_{SA} - h_{OA})| \times 1000] + P_{vma}}{P_{in}}$$

$$COE_{unducted} = \frac{|m_{SANet}\,(h_{SA} - h_{OA})| \times 1000}{P_{in}}$$

With:

$$m_{SANet} = m_{SA}\,(1 - UEATR)$$

$$P_{vma} = \left(\sum_{1}^{4} |P_{SN} + P_{VN}|\right) m_{SANet} \times v_s$$

$$P_{in} = P_{em} + P_{aux}$$

Where:
COE_{ducted}: Energy efficiency index of ducted AHUs.
m_{SANet}: Mass flow of clean supply air, in kg/s.
h_{SA}: Enthalpy value of supply air outlet, in kJ/kg.
h_{OA}: Enthalpy value of supply air inlet, in kJ/kg.
P_{vma}: Energy of supply air, in W.
P_{in}: Input power of AHUs, in W.
$COE_{unducted}$: Energy efficiency index of unducted AHUs.
M_{SA}: Mass flow of supply air, in kg/s.

UEATR: Unit exhaust air transmission ratio, in %.
P_{sn}: External static pressure at the supply air inlet and outlet, in Pa.
P_{vn}: Dynamic pressure at the supply air inlet and outlet, in Pa.
V_s: Specific volume of supply air, in m^3/kg.
P_{em}: Input power of motor, in W.
P_{aux}: Input power of other components and elements, in W.

- Fan efficiency, which is defined in the mandatory energy efficiency standard GB 17961-2020 *Minimum allowable values of energy efficiency and energy efficiency grades.* It can be calculated from measured data of stagnation flow volume, fan input power and fan pressure.

China and the EU calculate the thermal efficiency of AHUs in the same way, even if the terms used are different: η_{t_nrvu} in the (EU) No 1253/2014 and η_h (sensible thermal exchange efficiency) in GB/T 21087-2020. Both economies are also addressing fan efficiency but the equivalency of the metrics could not be compared in this provisional assessment[39]. To do so would require additional research.

It should be noted that the Chinese standard covers additional requirements, which are based on total thermal exchange efficiency and ratio of energy recovery. Those requirements and metrics are not part of the EU standard.

Efficiency levels

In the EU, as there are no overall efficiency metrics (see last sub-section), the requirements are set on different criteria, which were tightened in January 2018:[40]

- The minimum thermal efficiency η_{t_nrvu}
    - of all HRS except run-around HRS[41] in BVUs shall be 73%.
    - of run-around HRS in BVUs shall be 68 %.

- The minimum fan efficiency for UVUs (η_{vu}) is
    - 6.2 % * ln(P) + 42.0 % if P ≤ 30 kW and
    - 63.1 % if P > 30 kW.

- The maximum internal specific fan power of ventilation components (SFP_{int_limit}) in W/(m^3/s) is
    - for a BVU with run-around HRS
      1 600 + E – 300 * q_{nom} /2 – F if q_{nom} < 2 m^3/s and
      1 300 + E – F if q_{nom} ≥ 2 m^3/s.
    - for a BVU with other HRS
      1 100 + E – 300 * q_{nom}/2 – F if q_{nom} < 2 m^3/s and
      800 + E – F if q_{nom} ≥ 2 m^3/s.

39 In China, it is part of the GB 17961-2020 standard.
40 See also implementation guideline: https://ec.europa.eu/energy/sites/default/files/documents/implementation_guide_-_ventilation_units_with_cover.pdf
41 'Run-around HRS' is a heat recovery system where the heat recovery device on the exhaust side and the device supplying the recovered heat to the air stream on the supply side of a ventilated space are connected through a heat transfer system where the two sides of the HRS can be freely positioned in different parts of a building.

- 230 for an UVU intended to be used with a filter.

where:

- q_{nom} is the nominal flow rate of an NRVU (m^3/s) at standard air conditions 20°C and 101 325 Pa.
- E is the efficiency bonus, which is a correction factor taking account of the fact that more efficient heat recovery causes more pressure drops requiring more specific fan power.
- F is the filter correction (Pa), which is a correction value to be applied if a unit deviates from the reference configuration of a BVU.

with:

- for all HRS except run-around HRS: the efficiency bonus E = (η_{t_nrvu} – 0.73) * 3 000 if the thermal efficiency η_{t_nrvu} is at least 73 %, otherwise E = 0.
- For run-around HRS in BVUs: the efficiency bonus E = (η_{t_nrvu} – 0.68) * 3 000 if the thermal efficiency η_{t_nrvu} is at least 68 %, otherwise E = 0.
- F = 150 if the medium filter is missing; F = 190 if the fine filter is missing; F = 340 if both the medium and the fine filters are missing.

In addition, the Ecodesign regulation sets some functional requirements:

- if a filter unit is part of the configuration, the product shall be equipped with a visual signal or an alarm in the control system which shall be activated if the filter pressure drop exceeds the maximum allowable final pressure drop.
- all ventilation units, except dual use units, shall be equipped with a multi-speed drive or a variable speed drive.
- all BVUs shall have a HRS.
- the HRS shall have a thermal by-pass facility.

In China, the requirements are set on different criteria as follows:

- thermal exchange efficiency where Table 3.8.1 shows the requirements in terms of thermal exchange efficiency.

Table 3.8.1: Thermal exchange efficiency requirements

Type		Cold recovery	Heat recovery
Total exchange type of ERV and ERC	total thermal exchange efficiency	≥55%	≥60%
Sensible exchange type of ERV and ERC	sensible thermal exchange efficiency	≥65%	≥70%
ERV: energy recovery ventilators for outdoor air handling; ERC: energy recovery components.			

- ratio of energy recovery is the ratio of energy recovered to the electricity consumed during the recovery process.

- the measured ratio of energy recovery should be no less than 95% of rated value.

- energy efficiency index is the ratio of the sum of the total energy exchanged between the supply and exhaust airflow and the energy possessed by the airflow to the input power.

- the measured energy efficiency index should not be less than 95% of rated value.

- fan efficiency:

  GB 17961-2020 *Minimum allowable values of energy efficiency and energy efficiency grades* gives specific requirements for MEPS and energy efficiency grades for each subcategory of fans including centrifugal type, axial flow type, and forward curved centrifugal type directly connected to external rotor motor. GB 17961-2020 defines corresponding MEPS and energy efficiency grades for each subcategory of fans with different pressure coefficient ψ and specific speed n_s. Considering the most commonly used axial flow fans in AHUs, for example, the energy efficiency requirements are shown in Table 3.8.2.

Table 3.8.2: Fan efficiency

Hub ratio γ	Efficiency η_r（%）								
	№2.5≤device number<№5			№5≤device number<№10			device number≥№10		
	Grade 3	Grade 2	Grade 1	Grade 3	Grade 2	Grade 1	Grade 3	Grade 2	Grade 1
γ<0.3	55	66	69	58	69	72	60	73	77
0.3≤γ<0.4	59	68	71	61	71	74	63	75	79
0.4≤γ<0.55	61	70	73	64	73	76	66	77	81
0.55≤γ<0.75	63	72	75	67	75	78	69	79	83

China-EU alignment potential

While AHUs are regulated with mandatory requirements in the EU through the regulation EU 1253/2014, China covers this product group with a voluntary standard (GB/T 21087-2020). Both standards show gaps in terms of harmonisation.

Regarding the scope, the Chinese standard only covers bidirectional AHUs, while the European one also includes unidirectional AHUs, therefore only bidirectional AHUs are covered by both economies. China may consider expanding the scope to cover unidirectional AHUs. The test procedures could not be compared within this work, but as they are not based on common ISO or IEC standards, it is assumed that the testing conditions may be different.

Both the EU and China have a similar metric for thermal efficiency of AHUs. However, China differentiates the requirements for both cooling and heating conditions and includes additional energy efficiency metrics for thermal exchange performances. Both the EU and China may need to further improve their standards to attain a comprehensive standard for AHUs.

The EU regulation is currently under revision but the focus seems to be on residential VUs and not on the non-residential VUs which correspond to AHUs. In China, there is still no plan to develop a mandatory energy efficiency standard for AHUs. In consequence, no major steps towards a reduction of the alignment gap can be expected from the EU regulation currently. However, in the event that the AHU industry were to ask for a comprehensive and mandatory energy efficiency standard, China could refer to EU standards and attain some extent of harmonisation at least for thermal exchange efficiency.

3.9 Air compressors

Summary of existing regulations

In China, GB 19153-2019 *Minimum allowable values of energy efficiency and energy efficiency grades for displacement air compressors* sets out the MEPS and energy grades (to be used in labels) for air compressors.

The EU has no regulation dealing with the energy efficiency of air compressors; however, two Ecodesign preparatory studies on compressors have been carried out and two working documents (draft ecodesign regulations) were elaborated in 2019:

- the most recent study covered low pressure and oil-free compressor packages.[42] A working document on Possible ecodesign requirements for low pressure compressor packages and oil-free compressor packages - DRAFT ECODESIGN REGULATION[43] is available; product information requirements are defined but energy efficiency requirements are not.

- lubricated/oil-injected compressor packages are referred to as 'standard air' and were addressed in a preceding study[44]. A working document on Possible ecodesign requirements for standard air compressor packages - DRAFT ECODESIGN REGULATION[45] is available and includes energy efficiency requirements. Only this draft regulation is presented here.

Both EU draft regulations were made available in July 2019, however it is not clear if and when the draft will be finalised and adopted.

Scope

The scope in EU's draft regulation for standard air compressor packages is rotary standard air compressor packages with a maximum volume flow rate of between 5 to 1280 l/s when supplying air at discharge pressure(s) equal to or higher than 7 bar(a)

42 This study started in April 2015 and was completed in June 2017. https://www.eco-compressors.eu/downloads/FINAL_REPORT_LOT31_LP-OF_20170607.pdf

43 https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/compressors/2019-07-19-wd-low-pressure-and-oil-free-compressors-2.pdf

44 This study started in March 2012 and was completed in June 2014. See https://www.eco-compressors.eu/downloads/FINAL_REPORT_Lot31_Task1-5_20140603.pdf and https://www.eco-compressors.eu/downloads/FINAL_REPORT_Lot31_Task6-7-8%2020140603.pdf

45 https://www.eceee.org/static/media/uploads/site-2/ecodesign/products/compressors/2019-07-19-wd-standard-air-compressors-2.pdf

and not exceeding 15 bar(a).

'Standard air compressor package' means an air compressor specified for and capable of supplying air drawn in from the ambient, at discharge pressures between 7 bar(a) and 15 bar(a), and in which the air that is compressed comes into contact with one or more intentionally added substances for sealing, cooling and/or lubrication (of moving members and/or the enclosure they move within) except water.

The regulation shall not apply to rotary standard air compressor packages:

- the stage(s) of which is/are driven by single-phase electric motors.
- designed and specified to function in potentially explosive atmospheres as defined in Directive 94/9/EC of the European Parliament and of the Council[46].
- designed and specified to function at inlet air temperatures, the daily average value of which is below 15°C or above 50°C.
- designed and specified to function at ambient pressures prevailing at altitudes exceeding 1000 metres above sea-level.

China's GB 20052-2020 standard specifies the minimum allowable values of energy efficiency, energy efficiency grades, and test methods for air compressors. It is applicable to：

- oil injected rotary air compressors for general use with the drive motor power of 1.5 kW – 630 kW and the discharge pressure of 0.25 MPa - 1.4 MPa[47] (including oil injected screw air compressors for general use, oil injected single-screw air compressors for general use, oil injected sliding vane air compressors for general use, and oil injected vortex air compressors for general use).
- variable speed oil injected rotary air compressors for general use with the drive motor power of 2.2 kW - 315 kW and the discharge pressure of 0.25 MPa - 1.4 MPa (including variable frequency oil injected screw air compressors for general use and integral permanent magnet variable frequency screw air compressors).
- reciprocating piston air compressors for general use with the drive motor power of 0.75 kW – 75 kW and the discharge pressure of 0.25 MPa - 1.4 MPa (including reciprocating piston micro air compressors and stationary reciprocating piston air compressors for general use).
- oil-free reciprocating piston air compressors with the drive motor power of 0.55 kW - 22 kW and the discharge pressure of 0.4 MPa - 1.4 MPa.
- direct drive portable reciprocating piston air compressors.

The EU and China apply different scopes in their respective (draft) regulations. Regarding rotary air compressors, MEPS in the EU would only cover products between 7 and 15 bar. In China, the regulation starts at 2.5 bar but stops at 14 bar. It

46 OJ L 100, 19.4.1994, p. 1.
47 10 bar = 1 MPa.

considers the drive motor power and differentiates the technologies. In addition, China also defines MEPS for different types of reciprocating piston air compressors.

Oil injected rotary air compressors for general use with the drive motor power of 1.5 kW - 630 kW and the discharge pressure of 7 bar - 14 bar as well as variable speed oil injected rotary air compressors for general use with the drive motor power of 2.2 kW - 315 kW and the discharge pressure of 7 bar - 14 bar would be covered by MEPS in both economies, as long as the flow rate ranges between 5 to 1280l/s.

Energy performance test procedure

The method of testing air compressors in China and the EU appears to be very similar.

GB 19153-2019 refers to GB/T 3853 *Displacement compressor - Acceptance tests* modified from ISO 1217. The main changes from ISO 1217 are:

- the normative reference was updated from ISO standard to GB standard, such that the GB standard is identical to the ISO standard; editorial modifications were introduced.
- the part regarding noise measurement from ISO 1217 was deleted as GBT3853 does not consider noise or include a noise test.
- the unit of pressure was changed from bar to MPa to conform with Chinese practice.

In the EU, according to the standard inlet conditions required to calculate the isentropic efficiency, the draft regulation is based on the ISO 1217:2009 and ISO 1217:2009/AMD 1:2016.

Consequently, the level of harmonisation regarding the test procedure is very high.

Product categorisation

China differentiates between five categories of air compressors, while the EU defines only one product category in the draft regulation for standard air compressor packages (see Table 3.9.1).

Table 3.9.1: Product categorisation for air compressors

<table>
<tr><th>In China</th><th>In the EU</th></tr>
<tr><td>Oil injected rotary air compressors for general use with the drive motor power of 1.5 kW - 630 kW and the discharge pressure of 0.25 MPa - 1.4 MPa (2.5 - 14 bar)</td><td rowspan="2">Rotary standard air compressor packages with a maximum volume flow rate between 5 to 1280 l/s when supplying air at discharge pressure(s) equal to or higher than 7 bar(a) and not exceeding 15 bar(a).</td></tr>
<tr><td>Variable speed oil injected rotary air compressors for general use with the drive motor power of 2.2 kW - 315 kW and the discharge pressure of 0.25 MPa - 1.4 MPa (2.5 - 14 bar)</td></tr>
<tr><td>Reciprocating piston air compressors for general use with the drive motor power of 0.75 kW - 75 kW and the discharge pressure of 0.25 MPa - 1.4 MPa (2.5 - 14 bar)</td><td>Excluded</td></tr>
<tr><td>Oil-free reciprocating piston air compressors with the drive motor power of 0.55 kW - 22 kW and the discharge pressure of 0.4 MPa - 1.4 MPa (4 - 14 bar)</td><td>Excluded</td></tr>
<tr><td>Direct drive portable reciprocating piston air compressors</td><td>Excluded</td></tr>
</table>

Efficiency metrics

In China, the efficiency metrics of air compressors are defined in GB 19153:2019 in terms of specific input power.

For air compressors, except variable speed oil injected rotary air compressors and air compressor packages, the specific input power formula is:

$$e_{vc} = K_{14} \times \frac{P_{corr}}{q_{V.corr}}$$

With:

e_{vc}: Specific input power of air compressor, in kW/(m^3/min).

P_{corr}: Specific input power measured, calculated and corrected as per GB/T 3853, in kW.

$q_{V.corr}$: Volume flow rate of packaged compressor measured, calculated and corrected as per GB/T 3853, in m^3/min.

K_{14}: Correction factor of suction temperature for specific input power, non-dimensional, calculated as:

$$K_{14} = \sqrt{\frac{T_x}{293.2}}$$

With: T_x: Measured suction temperature of air compressor, in K.

For variable speed oil injected rotary air compressors, the specific input power shall be calculated by weighting the specific input power at 100%, 70% and 40% of the volume flow rates of the packaged compressor at full load:

$$e_{vc} = \sum_{i=1}^{n} (e_{vc,i} \times f_i)$$

Where:

e_{vc}: Specific input power of variable speed oil injected rotary air compressor, in kW/(m^3/min).

$e_{vc.i}$: Corresponding specific input power of air compressor when the volume flow rate of variable speed oil injected rotary air compressor in full load under the specified conditions is i, in kW/(m^3/min), calculated as per the earlier formula.

f_i: Weighting factor, selected as per Table 3.9.2.

i: Conditions corresponding to 100%, 70% and 40% volume flow rates of variable speed oil injected rotary air compressor in full load.

Table 3.9.2: Weighting factors for calculation of specific input power of variable speed oil injected rotary air compressor

Percentage to volume flow rate of packaged compressor in full load	Weighting factor
100%	25%
70%	50%
40%	25%

In the EU, the draft Ecodesign regulation for standard air compressor packages is based on isentropic efficiency. This energy efficiency metric is defined as:

$$\eta_{isen,fixed} = \frac{V_{1max} \times p_1 \times \frac{\kappa}{(\kappa - 1)} \times \left[\left({p_2}/{p_1} \right)^{\frac{\kappa - 1}{\kappa}} - 1 \right]}{(P_{real} \times 10)}$$

Where:

$\eta_{isen,fixed}$: isentropic efficiency of the compressor package when supplying the inlet volume flow rate for the applicable discharge pressure, multiplied by 100 gives percentages (%).

V_{1max}: maximum volume flow rate for the applicable discharge pressure p_2, at standard inlet conditions, in l/s.

p_1: inlet pressure, in bar(a), by default 1 bar(a).

p_2: discharge pressure at standard inlet conditions, in bar(a).

P_{real}: electric input power of the basic package for the applicable working point, in kW.

κ: isentropic exponent of air is 1.4 by convention.

Where only one rated discharge pressure higher than 7 bar(a) but less than 15 bar(a) is specified, the calculation of fixed speed isentropic efficiency shall be determined for just this rated discharge pressure.

For variable speed oil injected rotary air compressors, the variable speed isentropic efficiency is calculated using the equation below.

$$\eta_{isen,var} = \sum_{i=1}^{n} (\eta_{isen,i} * f_i)$$

Where:

i is the designation for an inlet volume flow rate of either 100%, 70% or 40% of the maximum volume flow rate.

$\eta_{isen,var}$: variable speed isentropic efficiency of the compressor package, based on the isentropic efficiency when supplying either 100%, 70% or 40% of the maximum volume flow rate (l/s) for the applicable discharge pressure, weighted by factor f_i, multiplied by 100 gives percentages (%).

$\eta_{isen,I}$: the isentropic efficiency when supplying either 100%, 70% or 40% of the maximum volume flow rate (l/s) for the applicable discharge pressure, multiplied by 100 gives percentages (%).

f_i: weighting factor, the values are the same as in China (see Table 3.9.2).

The metrics in both economies are different: China’s regulation is based on specific input power while in the draft EU regulation, the metrics are based on isentropic efficiency. However, the level of harmonisation is high, as it is possible to convert the specific input power into isentropic efficiency (a formula is provided in GB 19153-2019 Annex A).

Efficiency levels

China’s requirements on specific input power are provided in several tables, where the figures depend on characteristics of the product and on the energy efficiency grades used in the energy label, and by default the MEPS level (which is set at the grade 3 level). An overview of the main figures is provided in Table 3.9.3.

Table 3.9.3: Energy efficiency grades of air compressors

Grade 3	Min MPa	Efficiency kW/(m³/min)	Max MPa	Efficiency kW/(m³/min)
Energy efficiency grade 3 of oil injected rotary air compressors for general use				
1.5kW	0.3	7.4	1.25	15.8
630kW		4.4(4.1 for liquid)		8.9 (8.5 for liquid)
Energy efficiency grade 3 of variable speed oil injected rotary air compressors for general use				
2.2kW	0.3	7.8MPa	1.25	16.6
315kW		4.6(4.4 for liquid)		9.5(9.1 for liquid)
Energy efficiency grade 3 of reciprocating piston air compressors for general use (air cooling)				
0.75kW	0.25	8.5	1.4	16.3
75kW		/		/
Energy efficiency grade 3 of oil-free reciprocating piston air compressors				
0.5kW	0.4	11.9	1.4	/
22kW		/		11.4 (9.9 for liquid)
Energy efficiency grade 3 of oil-lubricated direct drive portable reciprocating piston air compressors				
0.25kW	0.2	6.1	1.0	18.5
3kW		5.1		15.5
Energy efficiency grade 3 of oil-free direct drive portable reciprocating piston air compressors				
0.25kW	0.2	6.8	1.0	19.4
3kW		5.4		16.0

According to the EU's draft regulations, the target efficiency for rotary air compressor packages shall be calculated as follows:

$$\eta_{target} = a \times ln^2(V_{1max}) + b \times ln(V_{1max}) + c + \{100 - (a \times ln^2(V_{1max}) + b \times ln(V_{1max}) + c)\} \times \frac{d}{100}$$

Where:

η_{target}: isentropic efficiency that the product shall achieve.

a, b and c are coefficients given in Table 3.9.4 for fixed speed rotary air compressor packages and variable speed rotary air compressor packages.

V_{1max}: maximum volume flow rate per discharge pressure (minimum discharge pressure, maximum discharge pressure and rated discharge pressures higher than 7 bar(a) and less than 15 bar(a).

d: proportional loss factor.

Table 3.9.4: Coefficients

Standard air compressor type	Coefficients of the formula to calculate the minimum isentropic efficiency, depending on flow rate ($V_{1,max}$)		
	a	b	c
Fixed speed rotary standard air compressor	-0.928	13.911	27.110
Variable speed rotary standard air compressor	-1.549	21.573	0.905

The fixed speed isentropic efficiency of a fixed speed rotary compressor package and the variable speed isentropic efficiency of a variable speed rotary compressor package at:

- the minimum discharge pressure.
- the maximum discharge pressure.
- any other rated discharge pressure less than 15 bar(a) but exceeding 7 bar(a).

shall be equal to or exceed the corresponding target efficiency calculated on the basis of the same maximum volume flow rate specified for that same discharge pressure and for a proportional loss factor value of d = -15 (from 1 June 2022) and d = -10 (from 1 June 2024).

China-EU alignment potential

Air compressors are regulated in China through the regulation GB 19153-2019. In the EU, this product group is not yet regulated; however, two Ecodesign regulations have been drafted recently. Only the proposal on rotary standard air compressors includes MEPS. Regarding the scope, the Chinese regulation covers more types of rotary standard air compressor packages than the EU draft regulation. Furthermore, the two regulations do not have exactly the same range of discharge pressures.

However, for rotary air compressors, the test procedures used in China and in the EU seem to be almost aligned with the latest ISO 1217 standard. Although the energy efficiency metrics are different in both economies, it is possible to convert the results, contributing to a high level of harmonisation. The MEPS requirements are also different in both economies and comparing the levels would require additional investigation.

Finally, considering the fact that the EU regulation on rotary standard air compressor packages is still a draft, air compressors might be a good candidate for further investigation in order to examine if further alignment is sensible.[48]

48 Furthermore, since the EU draft regulation on low pressure and oil-free compressor packages does not include MEPS, there is also an opportunity for alignment with China's regulation for this product group.

4. PROVISIONAL RECOMMENDATIONS

This study has assessed the China-EU energy performance harmonisation potential for:

- split room air conditioners.
- domestic refrigeration appliances.
- televisions.
- electric motors.
- distribution transformers.
- chillers.
- commercial refrigerated display cabinets.
- air handling units.
- air compressors.

It has found that at a technical level, especially at the level of energy performance measurement, there is already a high degree of harmonisation, but this tends to lessen the higher-up the harmonisation pyramid (see Figure 2.1) product groups are assessed from.

Perhaps surprisingly, the least harmonisation among the consumer products currently seems to occur for televisions, despite both economies drawing upon ostensibly the same test procedure. There is no real market reason or fundamental policy logic for this divergence – it simply seems to have occurred due to disconnected policy development processes: the product types and their usage conditions are very similar in the two economies.

Domestic refrigerators are the next product with the least level of harmonisation, which is also counterintuitive because until quite recently there was a considerable degree of harmonisation between the approaches and requirements applied in both China and the EU. In part this is explicable by the EU moving toward the adoption of test methods that align with the new IEC standard, which is a rather radical departure from the previous one. China appears to be undergoing a similar transition but has retained much of its original approach for product categories and efficiency metrics while the EU has made significant changes. From a product characteristic perspective, there is considerable similarity in the nature of products sold in both markets but with some differences in certain product types.

Split room air conditioners also have considerable similarities in approach, especially at the testing level, but also some differences which might mean that a product tested and rated under one system would need to be re-rated to be declared under the other. While there is a logic in applying different weightings to part-load performance rating points in both economies due to climatic and usage differences, there is no inherent reason why the same test conditions could not be tested and rated for performance declaration purposes, were there to be a desire to do so.

For distribution transformers the test method, rating approach and means of setting

MEPS levels (in terms of load and no-load loss levels) is the same in both economies. The only significant differences appear to be in the product categories applied (which partly reflect local product types) and the actual performance levels required. It would be reasonably straightforward to compare the latter in subsequent work and equally to probe the reasons for the current product categorisation distinctions. On first inspection, there appears to be no market barrier in the manner in which products are tested and rated but this could be probed in more detail in future work.

For electric motors, both economies are using the same system to test and classify the energy performance of the main types of AC induction motors. There are some differences in efficiency level requirements and also in product scope which could be examined and potentially addressed through future work were there to be a desire to align requirements.

The energy performance of comfort chillers is regulated in both economies. A priori, it is likely that the level of harmonisation concerning the test method is very high, if not identical, but there are differences in the part-load test conditions, the weighting applied to the part-load test points and the treatment of auxiliary loads. In addition, the scope of the EU's regulations is broader in that it includes process chillers, whereas China's is understood to be focused exclusively on comfort chillers. Further investigation could clarify the differences and determine pathways to greater alignment.

MEPS and mandatory energy labels apply to commercial refrigerated display cabinets in both economies, and both economies apply a similar scope of products. There is strong alignment in the test method applied, and although there are some differences in the versions of the standards and some technical specificities, the level of alignment between both economies seems high. Significant differences are observed for the energy efficiency metrics. Accordingly, the level of MEPS and energy efficiency classes of the energy labels cannot be easily compared although intrinsically there is no reason why this should be the case.

Only the EU currently regulates the efficiency of air handling units although China has a voluntary energy performance standard. The EU regulation applies to both bi- and uni-directional AHUs while only the former are addressed in China's voluntary standard. It is likely that test procedures will deviate but both economies have similar thermal efficiency metrics. There appears to be a need for both economies to further improve their standards, so there is scope for technical cooperation on these aspects that could lead to further alignment.

For air compressors both economies appear to be using the same method to test the energy performance of rotary compressors. The EU regulations are in the draft stage, but China's are in place and cover more compressor types than the EU's. Although the energy efficiency metrics for rotary compressors are different in both economies, it is possible to directly convert the results, although being able to compare the levels would require additional investigation. Considering that the EU regulation on rotary standard air compressor packages is still a draft and that other types are not yet considered in the EU, air compressors might be a good candidate for further investigation to examine if further alignment is sensible.

In order of harmonisation (from greatest to least) the products very roughly rank:

- Electric motors.
- Distribution transformers.
- Split room air conditioners.
- Domestic refrigeration appliances.
- Televisions.
- Commercial refrigerated display cabinets/Air compressors.
- Chillers/Air handling units.

But in actuality there is a strong degree of technical harmonisation for all of these product groups with most deviations occurring due to:

- minor differences in test methods or their application.
- product categorisation and efficiency metrics.

Unfortunately, these differences mean that it is usually not possible to directly compare the stringency of efficiency levels even though the test methods usually align. Making such comparisons would require the development of normalisation methods which, while perfectly possible to develop, is beyond the scope of the current exercise.

As a general observation, it can be remarked that there is no inherent logic behind these deviations in product categorisation and efficiency metrics other than disconnected and divergent regulatory processes. It can also be noted that the extent of alignment in both economies is largely based on both making use of international (IEC/ISO) test standards and to some extent on direct emulation in the early days of equipment MEPS and labelling programmes. However, recent trends appear to be toward greater divergence as both economies have begun to adapt international standards (or make their own) and no work is ongoing (aside from this project) to support regulatory discourse and alignment.

The value proposition of alignment

China and the EU are two of the world's three major economies and collectively exert enormous influence over product standards at the global level. When the two economies have aligned approaches, the evidence suggests that the approach adopted is rapidly emulated by other economies around the world with the partial exception of North America. This helps facilitate trade and technology transfer on a global scale. In the case of equipment energy efficiency, such alignment has the potential to speed up the dissemination of good commercial, industrial and regulatory practice around the world and thereby accelerate the adoption of highly energy efficient technologies. Even if the two economies choose to set different efficiency thresholds in their respective MEPS and labelling programmes, alignment of test methods, product categorisation and efficiency metrics will create a common accounting framework, reduce compliance costs, aid transparency and facilitate faster adoption of impactful efficiency requirements internationally. Thus, efforts to stimulate greater alignment are important for the climate change mitigation and green growth agenda. In recent times the opposite trend can be observed where there has been more divergence between the approaches adopted and this risks the creation of standardisation and regulatory poles which could have the reverse effect.

Recommended actions

Arguments could be made in terms of similarity of product types, international trade volumes and international regulatory coherence for greater harmonisation, at least from the perspective used to determine and classify energy performance, for each of these product groups. In principle there are no fundamental reasons why there should be differences in approach between China and the EU. The current work has identified the extent of similarity and differences at a provisional level but in each case there would be value from conducting deeper, more authoritative and comprehensive investigations, were there to be willingness among the policymaking communities to explore options for greater harmonisation. It should be noted that such harmonisation does not need to entail harmonising policy thresholds, but rather all the factors that define product energy performance which are not necessarily different due to more fundamental differences, such as climatic differences, usage differences and preferences for different types of products.

At the technical level for a next round of work for each of these products it would be recommended to:

- conduct a thorough assessment of the current levels of alignment and non-alignment with regard to all the energy performance factors discussed in this report.

- conduct a thorough investigation of conformity assessment requirements and procedures to determine to what extent differences exist and whether there is any underlying rationale for any differences identified or whether this is simply due to disconnected development processes.

Beyond the technical aspects it would also be relevant to conduct actions to explore the rationale for greater alignment (the value proposition of harmonisation), and the opportunities and willingness within the policymaking processes within both economies to explore greater alignment.

With regard to trade, work could be done to clarify the trade volumes (in value and units) between the economies and more globally of these products – this could examine trade in finished goods but should not ignore trade in parts and components which can often be larger than for the finished good itself. This could be complemented by a related energy impact analysis to determine the scale of energy use that could be affected these product groups and hence help to determine the groups where there would be the most value from more detailed cooperation. In parallel, an appraisal of the standardisation and regulatory processes would allow information on the potential to align these to be gathered and factored into potential decisions about exploratory alignment exercises.

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