Mr. Kestutis Sadauskas (Director)
Avenue de Beaulieu 9 / Beaulieulaan 9
1160
Bruxelles / Brussels
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Dear Mr Kestutis,

Nanoco Technologies Ltd ('Nanoco') is a manufacturer of nanomaterials including non-Cd quantum dots ('QD') used in lighting and display technology. Nanoco is writing to you with respect to the ongoing stakeholder consultation covering 'Cd Quantum-Dot Joint Evaluation' including three RoHS exemption requests from Lighting Europe, OSRAM GmbH and Najing Technology Co. Ltd. ('Applicants', 'Exemption Requests').

Nanoco is of the view that (i) the Exemptions Requests do not fulfil the criteria for granting of RoHS exemptions laid down in Article 5(1)(a) RoHS, and (ii) the Exemption Requests do not comply with the requirements set out in Annex V RoHS. The main arguments of Nanoco are as follows:

- Data submitted by the applicant Najing Technology Co. Ltd. to support the Exemption Requests are outdated, incorrect and technically flawed; and some of the Applicants' arguments are not 'verifiable and referenced' as required by Annex V(c) RoHS; and

- Even if the data were correct, granting of exemptions on the basis of the Exemption Requests would be against the RoHS principles.

These arguments are further elaborated below. In addition, in order to provide updated information on the latest state of development of alternative substances and technologies, Nanoco has provided its answers in the stakeholder consultation (see copy provided with this letter).

I. <u>EXEMPTION REQUESTS ARE BASED ON INCORRECT AND OUTDATED DATA</u>

The explanatory memorandum ('Memorandum')[1] to Commission Delegated Directive of August 7, 2017 that granted the current exemption for which the Applicants seek renewal provides that the current exemption was granted because Cd based QD: *"have an overall positive environmental impact due to their lower energy consumption compared with indium phosphide alternatives."* Thus, according to the Memorandum, the exemption was justified according to Article 5(1)(a), third criterion RoHS.

The Memorandum, however, also provides:

> *"The assessment carried out in preparation of the current delegated directive has also shown that, given the rapid technological progress and very dynamic market in this field, indium phosphide-based applications and, possibly, other emerging technologies may lead to rapid*

[1] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=PI_COM%3AAres%282017%29644052

performance enhancement of cadmium-free displays. Based on the above considerations, it is therefore justified to grant a shortened exemption only, of two years."

> This short period was also intended *"to avoid any adverse impacts on innovation and in particular the further development of equivalent cadmium free alternatives"*.

Thus, before granting any renewed or new exemption for Cd in these technologies, the European Commission (and the Oeko Institute) should assess updated data on the state of development of alternative technologies and of their environmental benefit (including energy efficiency).

Primarily, it is for the Applicants to provide such information. Annex V RoHS provides that applicants for granting, renewing and revoking exemptions must submit, among others:

> *(d) an analysis of possible alternative substances, materials or designs on a life-cycle basis, including, when available, information about independent research, peer-review studies and development activities by the applicant and an analysis of the availability of such alternatives;"*

Any information submitted must be *"verifiable and referenced"* (Annex V (c) RoHS).

However, the Applicants failed to provide such information, as further outlined below. Taking into consideration only the data on energy efficiency, the applicants provided the following data:

- OSRAM submitted comparative data related to energy efficiency (page 5) and colour gamut (page 7). However, this data relates to the comparison of phosphor-only LED and Cd QD, i.e. it does not compare Cd QD and non-Cd QD, which is the most relevant available alternative to Cd QD

- Data related to power consumption submitted by Lighting Europe (page 6 of the application and page 4 of the feedback) also compares Cd QD LED and conventional phosphor LED. The only comparison between Cd QDs and InP QD is included on page 15 but relates to colour performance (red portion), thus not to energy efficiency

- Only Najing provided data comparing energy efficiency of Cd QD and InP QD (page 9 of the application and page 3 of the follow-up document). Annex 1 to this letter lays down Nanoco's arguments that these data are incorrect, outdated and technically flawed. They use outdated products that have already been considered in the previous consultation, so the data cannot be considered as updated and used again in the new consultation. In addition, the data is not verifiable and referenced. The study set-up is not described in detail and the full test report is missing. It is unclear who did the study, i.e. an independent third party laboratory or not.

In addition, Najing provided outdated supporting documents that were already submitted to support the previous exemption, in particular:

- <u>University of Antwerp: Report Life Cycle assessment of a 3M QDEF-film</u>. This report was issued in <u>December 2015</u>. Only Section 3.2. deals with the use phase and it provides a comparison with non-Cd film. However, first, the report itself admits that *"no data was available on the non-Cd film",* it is thus very unclear what non-Cd technology was used for the comparison. Second, the report provides that "*for the avoided 1380 MJ, the average European electricity mix has been applied"*. The figures for such mix and their dates are not provided, however they are inevitably based on outdated data (see also the next bullet point).

- Socio-economic assessment for Cd QD displays: This report was issued in January 2016. The report bases itself on the following information provided by 3M: *"When a 3M Cd QD display was compared with commercial InP QD displays installed in two models of TV at constant luminance, but wider colour gamut than the Cd QD version, the Cd QD display TV consumed 14% and 22% less electricity"*. The report then calculated the environmental benefit, using the following energy mix: 30% electricity from coal, 3% from oil (page 7) – the date and source for these figures have not been provided.

  First, Nanoco points out that such comparison is clearly outdated as the energy efficiency of non-Cd QD technology has improved dramatically since January 2016 (see further below). Second, also the energy mix in the EU has changed to the benefit of renewables and to the detriment of coal. For example, the European Commission publication 'Statistical pocketbook 2018'[2] provides the 2016 figures for the EU energy mix (page 174). Hard fuels account for 132.3 Mte, whereas other sources (petroleum, gases, nuclear, renewables and wastes) account for 638 Mte. Thus, in 2016, the ratio of 'hard fuels' including coal was 20.7% only. In addition, it can be assumed that since 2016, this mix has further improved to the detriment of coal. Thus, the ratio 30% coal used in the Socio-economic assessment for Cd QD displays is clearly outdated.

- Supplemental Statement on Life Cycle Analysis and Comparison of Cadmium – This report was issued in October 2015 and mainly concerns the Toxicity of InP. Again this paper was already submitted in the previous consultation and responded to by Nanoco, demonstrating many flaws. Also here new data have become available from independent research papers, such as:
  - Broomfield, M., Hansen, S. F., & Pelsy, F. (2016). Support for 3rd regulatory review on nanomaterials – environmental legislation: Project Report. European Commission. https://doi.org/10.2779/49879
  - Kumar, V., Sharma, N., & Maitra, S. S. (2017). In vitro and in vivo toxicity assessment of nanoparticles: International Nano Letters (2017) 7:243–256. https://doi.org/10.1007/s40089-017-0221-3
  - Allocca, M., Mattera, L., Bauduin, A, Miedziak, B., Moros, M., De Trizio, L., Tino, A., Reiss, P., Ambrosone, A. & Tortiglione, C. (2019). An integrated multilevel analysis profiling biosafety and toxicity induced by Indium- and Cadmium-based quantum dots in vivo. Environmental Science & Technology. DOI: 10.1021/acs.est.9b00373. Publication Date (Web): 01 Mar 2019

  These continue to support the previous evidence demonstrating that Cd QD are toxic and are significantly more toxic than InP QDs.

In the previous consultation, Nanoco already provided responses[3] to the information in these papers to clearly demonstrate that the previous applicants' information in relation to energy efficiency were deeply flawed and massively exaggerated, including the associated reductions in Cadmium emissions from power generation. In particular we refer to the BiPRO report[4] submitted by Nanoco at the time, which concluded that the Cadmium emission saving per TV (even accepting the disputed energy efficiency improvement claimed) would be only 2.94mg based on EU average data for 2013, dropping

[2] https://publications.europa.eu/en/publication-detail/-/publication/99fc30eb-c06d-11e8-9893-01aa75ed71a1/language-en/format-PDF/source-77059768

[3] https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_10/Cd_Quantum_Dot_Evaluation/Nanoco_Technologies_RoHS_response_final_20160108.pdf

[4] https://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_Pack_10/Cd_Quantum_Dot_Evaluation/Nanoco_Cd_emissions_final_report_BiPRO.pdf

to 1.3mg by 2030. This amount is much less than the Cadmium used to manufacture the TV, so there is no net saving. Since then, the move away from coal has accelerated in Europe and emission controls continue to be improved, so the Cadmium emissions will be even lower.

Again, since these papers have all been previously submitted and considered under the past consultation they cannot be considered as updated information that can legitimately be used in the current consultation.

In Nanoco's view, in the fast growing technology areas such as the one at hand, such outdated documents should not be accepted and the Exemption Requests rejected as unsubstantiated, unverifiable and unreferenced also taking into account the data submitted by Nanoco in the Annexes to this letter.

In this respect, we note that the European Commission paper 'REACH and RoHS Commission paper agreed with MS'[5] provides:

> *"Moreover, the exemptions are time limited and will only be renewed after submission of the information listed in Annex V to RoHS, including updated details of the practicability and reliability of substitution, an analysis of possible alternatives and a timetable for action to develop /apply possible alternatives. All of these requirements may be seen as mirroring the substitution objective of the REACH authorisation procedure".*

In addition, in our view, the recent case-law of EU Courts has to be applied in the European Commission's decision making on this matter, in particular as regards the test method that has been used by the Applicants during the previous and also the current procedures, i.e. the 'swap test' which consists in swapping Cd/Cd-free films between different types of TVs. In particular, in the recent Dyson Case T-544/13 of November 8, 2018[6], the General Court held that the method of calculation of energy efficiency of vacuum cleaners must make it possible to measure the energy performance in conditions as close as possible to actual conditions of use. There is a strong interaction between the QD film design and the design of the other components in the display (LEDs, colour filters etc.) so that swapping QD films into displays that they have not been designed for is not close to the actual conditions of use.

Thus, the Oeko Institute and the European Commission should take into account primarily energy consumption data related to final products as available on the market. The actual energy consumption of TVs available to purchase in the EU with both Cd and non-Cd QD is available in Annex 2. The table compares both 55" and 65" TVs, which are the most popular sizes. For the 55", one Cd QD TV uses 5.8% less energy than the Cd-free QD TV, but the other uses 6.5% more. For the 65" the best Cd QD TV uses 37.2% more energy than the Cd-free QD TV, but the other uses 56.1% more! From these results it is clear that Cd-free QD technology is able to deliver equivalent or even more energy efficient displays compared to Cd QD technology. So, based on tests designed by the EC to represent energy performance in conditions as close as possible to actual conditions of use, **Cd QD technology does not deliver better energy efficiency compared to Cd-free QD technology.**

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[5] http://ec.europa.eu/DocsRoom/documents/5804/attachments/1/translations/en/renditions/native

[6] http://curia.europa.eu/juris/document/document.jsf?text=&docid=207462&pageIndex=0&doclang=EN&mode=lst&dir=&occ=first&part=1&cid=9580274

A final source of comparative performance data is Nanosys Inc. who were an applicant in previous applications to extend Exemption 39. In their current website section on their commercial products (https://www.nanosysinc.com/products), they provide a table to compare their Cd QD, low Cd QD (Hyperion) and Cd-free QD products:

Type of QD	TRADITIONAL		HYPERION		HEAVY METAL FREE	
Color Standard	Color Gamut	Relative Brightness	Color Gamut	Relative Brightness	Color Gamut	Relative Brightness
DCI-P3	>99%	100%	>99%	100%	>99%	100%
AdobeRGB	>99%	100%	>99%	100%	>99%	90%
NTSC	>100%	100%	>100%	100%	>100%	95%
BT2020	>90%	100%	>90%	100%	>85%	95%

Note: 1. Above performance has been verified using Nanosys Quantum Dot products with appropriate color filters. 2. Similar performance may not be achievable with non-Nanosys Quantum Dots. 3. Relative brightness is meaningful only within the same color gamut, not across different color gamut standards.

*DCI-P3/BT2020 uses coverage in CIE 1976; Adobe RGB uses coverage in CIE 1931; NTSC uses area in CIE 1931

Considering the performance using DCI P3 colour gamut (the most appropriate colour standard for EU consumer displays), the brightness of the Cd QD can be matched by both their low Cd and Cd-free QD technology when used in an appropriately designed display. This provides further updated evidence that even leading Cd QD producers accept that these alternative technologies can already achieve equivalent performance for both energy efficiency and colour gamut.

Finally, Annex V RoHS provides that applications shall include: *"the proposed actions to develop, request the development and/or to apply possible alternatives including a timetable for such actions by the applicant."*

Thus, companies that apply for exemptions should also contribute to the development and application of alternatives.[7] This is the case in most of the applications which typically contain a time table in which applicants demonstrate their gradual shift to alternative technology. The way that the Applicants approached this issue is, however, questionable. For example, OSRAM argued that the exemption is requested to further develop Cd based QD technologies, which is plainly against Annex V RoHS and the RoHS principles. Najing did not provide any substitution / R&D plan at all. For this reason alone the applications should be rejected.

[7]The character of RoHS exemptions is temporary and their purpose is a gradual phase-out of the use of hazardous substances (Recital 19 to RoHS). This is confirmed in the case at hand: Commission Decision 2010/122 which introduced Exemption 39 stated that *"research on cadmium-free technology is in progress and substitutes should become available within the next four to five years at the latest."* This is in line with Council Resolution of 25 January 1988 on a Community action program to combat environmental pollution by cadmium which provides that the strategies adopted should include *"limitation of the uses of cadmium to cases where suitable alternatives do not exist"* and *"stimulation of research and development of substitutes and technological derivatives."*

II. INCORRECT APPLICATION OF THE ROHS CRITERIA

The availability and reliability of alternatives has not been disputed in the Exemption Requests. Rather, energy efficiency and luminescent properties of non-Cd QD appear to be the main argument of the Exemption Requests. The summary of the Exemption Requests laid down in the Oeko Institute consultation questionnaire confirms: *In this respect the applicants' main justification for the exemption requests refers to the potential for savings in energy consumption in relation to similar EEE.*

In Nanoco's view, even if the data submitted by the applicants related to energy efficiency were complete, correct and up to date (which is not the case as outlined in the previous Section), any exemptions based on these criteria alone, in a situation where available and reliable alternatives are already available, would be:

1. In breach of the general principles of RoHS
2. Incorrect application of RoHS criteria in Article 5(1)(a) RoHS
3. Unacceptable in relation to impact on innovation.

1. Breach of general principles of RoHS

RoHS requires substitution of restricted substances whenever technically and economically feasible[8]. Furthermore, cadmium has a ten times lower threshold than other RoHS restricted substances and it is specifically addressed in Recital 5 RoHS: *"the use of cadmium should be limited to cases where suitable alternatives do not exist."*[9]

Similarly, Recital 4 of the RoHS Directive provides: *"Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste (5) gives first priority to prevention in waste legislation. Prevention is defined, inter alia, as measures that reduce the content of harmful substances in materials and products".*

Thus, the introduction of new products with cadmium would not appear to be permitted (as this would be against the prevention principle).

Settled case law on RoHS (e.g. Joined Cases C 14/06 and C 295/06) provide: *"as regards the objectives of Directive 2002/95 (*RoHS 1)*, it is clear (...) that the intention of the legislature is to prohibit products referred to in the directive and to grant exemptions only in accordance with carefully defined conditions. Such an objective, in compliance with Article 152 EC, according to which a high level of human health protection is to be ensured in the definition and implementation of all Community policies and activities (...) and in compliance with Article 174(2) EC, according to which Community policy on*

[8] Recital 8 RoHS.

[9] Cadmium is, among others, a carcinogen and reprotoxin and mutagen. It is also very toxic to the aquatic environment, with both acute and chronic effects (Part 3 of Annex VI to Regulation 1272/2008 (CLP Regulation). A key human exposure to cadmium occurs in waste recycling facilities. Environmental pollution with cadmium is another main concern: "cadmium pollution poses a complex and difficult problem since it is a 'multimedia' form of pollution, affecting all environmental sectors; whereas cadmium may be emitted into the environment at numerous points in the production, manufacturing, use and waste disposal processes, and can readily migrate between environmental sectors.

the environment is to aim at a high level of protection and is based on the principles of precaution and preventive action (...) justifies the strict interpretation of the conditions for exemption."

In Nanoco's view, the use of cadmium as a RoHS restricted substance in a situation where there are available and reliable alternatives to enable a certain function or property to an acceptable level (energy efficiency, colour gamut) is therefore not an acceptable cost. Any opposite interpretation would undermine the purpose of RoHS. It is clear that the available and much more widely used Cd-free QD technology can achieve A+ energy efficiency displays with 100% DCI colour gamut, fully meeting the requirements of performance, availability and reliability.

2. Incorrect application of RoHS criteria in Article 5(1)(a) RoHS

Article 5(1)(a) RoHS provides that any RoHS exemptions may only be granted if either of the following conditions is fulfilled:

(a) the elimination or substitution is scientifically or technically impracticable;
(b) the reliability of substitutes is not ensured;
(c) the total negative environmental, health and consumer safety impacts caused by substitution are likely to outweigh the total environmental health and consumer safety benefits thereof.

Ad a) + b)

As follows from the Exemption Requests themselves, and as further described in the submission in the consultation by Nanoco in **Annex 1**, alternatives both in terms of substances (InP QD, Nanoco's CFQD® quantum dots) and technologies (OLED and high performance phosphors) are available and reliable. Indeed, they are far more available than Cd QD products and their reliability has been demonstrated by their high level of market penetration – especially in segments where high performance is required, such as premium televisions.

Ad. c)

As regards the third criterion, in Nanoco's view, the environmental/health/consumer safety assessment cannot be limited to the question of energy efficiency which arguably leads to lower Cd and other emissions during energy generation. In fact, in Nanoco's view, this argument is irrelevant because RoHS restricts the use of substances (as follows from Recitals and purpose of RoHS). It does not consider other sources of these substances, such as incineration of coal. This is subject to environmental legislation related to industrial emissions.

If the Oeko Institute was to accept the argumentation by the applicants, it would be inconsistent with its previous decision making. In particular, in its report of 2014 on the same Cd exemption[10] (page 73) (that was supported by Oeko Institute because Cd-free substitutes were not yet available), the Oeko Institute provided: "*Furthermore, even if such products* (i.e. alternative cadmium-free QD) *may result in a certain decrease in performance (colour gamut; energy efficiency) as soon as this alternative is*

[10] http://rohs.exemptions.oeko.info/fileadmin/user_upload/RoHS_IX/20140422_RoHS2_Evaluation_Ex_Requests_2013-1-5_final.pdf

viewed to be available, it should be considered if a certain level of lesser performance would be acceptable, to allow the elimination of a RoHS regulated hazardous substance".

This approach is further confirmed in similar previous precedents. For example, in the application for prolongation of the exemption for mercury in fluorescent lamps[11] ('CFLs') (that was rejected in this case), the Oeko Institute accepted that as a result of the use of mercury, there is an energy saving which leads to the reduction in the emission of mercury. The Oeko Institute, however, stated: *"the goal of the RoHS Directive should be to restrict the amount of mercury used in the lamps as much as possible. This is currently the case as the allowed maximum limit is decreased gradually. In this respect, further environmental advantages within the different CFLs would need to be analysed carefully and compared to the possible negative impacts with regard to the environment, consumer safety and health. Here it has to be stated that LCA analysis has so far confirmed that the main environmental impacts of CFLs are associated with their energy need during use".* Thus: (i) the fact that less mercury is released due to the mercury technology under exemption is not relevant as RoHS aims at the restriction of restricted substances, (ii) the fact that a technology claims to have a positive effect on energy consumption is not sufficient to overcome the other negative impact from the continued use of the restricted substance.

In fact, energy efficiency is primarily governed by other EU legislation (Directives 2009/125 and 2010/30 on eco-design and energy labelling). Recital 13 to RoHS provides that Directive 2009/125 (Ecodesign Directive) is without prejudice to Union waste management legislation[10], including RoHS. Thus, the Union's interest in phasing-out hazardous substances supersedes the desire to improve the energy efficiency of electronic products. In other words, operators that wish to invest into the development of more energy efficient products should always stay within the RoHS limits without relying on exemptions.

3. Impact on innovation

Article 5(1)(a) RoHS provides that decisions on the RoHS exemptions should take into account any potential adverse impacts on innovation.

The Oeko Institute guidance document 'Standard application format and guidance document for RoHS exemption requests on the basis of Article 5(8) Directive 2011/65/EU'[12] clarifies that the assessment by the authorities should focus on *"impacts that the duration of an exemption may have on future efforts for developing possible substitutes."* In the case at hand, the extension of the exemption would create additional market entries and R&D opportunities for cadmium technologies, which is clearly against the RoHS principles. Likewise, the argument used by OSRAM that allowing (via the prolongation of an exemption) the development of new Cd based technologies is not permissible under Article 5(1)(a) RoHS, because it has an 'adverse impact on innovation'. The intended innovation is towards the removal of the restricted substances from products – not the reverse.

[11] Institute Report of 30/05/2011, Final Report, Page 33.

[12] http://ec.europa.eu/environment/waste/rohs_eee/pdf/Guidance_Document.pdf

III. CONCLUSION

As follows from the above, the Exemption Requests should be rejected because they are based on outdated, unsubstantiated, unverifiable and incorrect data, and granting of exemption would be against the RoHS principles.

If the European Commission ultimately grants these exemptions as requested, the European Commission could be considered as committing a manifest error of assessment and misuse of powers as defined in the settled case-law of EU Courts.

In Case T-89/13[13]Bilbaína de Alquitranes, SA v Commission, the General Court ruled that:

> *"where the EU authorities have a broad discretion, in particular as to the assessment of highly complex scientific and technical facts, review by the EU Courts must be limited to verifying whether there has been (...) However, even though such judicial review is of limited scope, it requires that the EU authorities which have adopted the act in question must be able to show before the EU Courts that, in adopting the act, they actually exercised their discretion, which presupposes the taking into consideration of all the relevant factors and circumstances of the situation which the act was intended to regulate."*

This principle was also formulated in Case T-456/11[14] in which the General Court stated that:

> *"where experts carry out a scientific evaluation of the risks, the Commission must be given sufficiently reliable and cogent information to allow it to understand the ramifications of the scientific question raised and decide upon a policy in full knowledge of the facts. Consequently, if it is not to adopt arbitrary measures, which cannot in any circumstances be rendered legitimate by the precautionary principle, the Commission must ensure that any measures that it takes, even preventive measures, are based on as thorough a scientific evaluation of the risks as possible, account being taken of the particular circumstances of the case at issue."*

Yours sincerely,

Andrew Gooda
Supply Chain & Compliance Director
Nanoco Technologies Ltd

[13]Bilbaína de Alquitranes, SA v Commission

[14]ICdA v. Commission

Annex 1

RoHS Cd Exemption Technical Data Reply

In the Najingtech Application document comparison data of commercial screens is presented as follows.

(B) Elimination/substitution:

1. Can the substance named under 0(A)1 be eliminated?

No. Justification:

Test was conducted to detect the performance difference between Cadmium based QD film and Cadmium free QD film. From energy saving perspective, Cadmium based QD film has saved 16% energy compared with Cadmium free QD film. Energy saving is the most attractive strength for mobile society and severe energy shortage human confronts.

TV	QD Film	Luminance(nit)	Power (W)	Luminance Efficiency (nits/W)	Energy saving	NTSC Area (1931)
TCL X3	CdSe-based	484.5	170	2.85	116%	110.32%
Samsung Q7C	InP-based	686	280	2.45	100%	99%|

We believe this to be an unfair comparison for the following reasons:

1. TCL X3 power consumption quoted is the same as stated on the TCL website (source: https://www.tcl.com/content/tcl-site/en/products/x3/x3-65.html). However the max power consumption stated for the equivalent screen size Samsung Q7C on the Samsung website appears to be significantly lower than quoted in the table at 225W (source: https://www.samsung.com/uk/tvs/qled-q7c/QE65Q7CAMTXXU/). Calculating the luminance efficiency using the Samsung stated power consumption value and the luminance quoted in the table gives us a value of 3.05, or 7% better energy efficiency than the equivalent TCL X3 model.

2. Power values stated fail to take into account the underlying power consumption of other systems in the TV, implying that 100% of the power is used in illuminating the screen. This is a particular issue for modern TVs due to additional features (such as smart capability and high end speakers) which will contribute to power consumption. A fair evaluation of screen efficiency could be produced by plotting a power v screen brightness curve and extrapolating the power consumption when the screen brightness is zero. This would give the background power consumption of the unit allowing for a calculation of the efficiency of the backlight unit (BLU) light output only.

3. TVs should be set to the same brightness output before comparing relative power consumption. Higher brightness values are generated by pumping the back light LEDs with more power which lead to higher heat generation. Elevated temperature reduces the efficiency of both the LEDs themselves and the colour converting medium (in this case QDs). Therefore TVs set to a lower brightness value should naturally appear more efficient.

4. Table implies that the BLU system in both TVs are the same and the only difference in efficiency would be caused by the comparative QD films. Other factors which may affect the BLU efficiency include: efficiency of the LEDs used, efficiency of the light guide plate, combination of optical films used.

We also question the QD film comparison data provided by Najingtech in their clarification documentation presented as follows.

TV product NO.	Hisense XT910	TCL55 X2			Samsung 55KS7300		
QD film's in-formation	3M (CdSe)	Najing (CdSe)			Samsung(Cd-free)		
Test fixture	TCL 55 X2	TCL 55 X2			TCL 55 X2		
Quantum effi-ciency (QE)	92.81%	89.56%			67.69%		
Relative QE ratio	100%	96.50%			72.93%		
NTSC(1931)		105.48%			89.01%		
DCI-P3		95.59%			91.43%		
		Luminance(nit)	x	y	L(nit)	x	y
White		432	0.2839	0.2966	324	0.2840	0.2964
R		92	0.6871	0.3004	64.97	0.6825	0.3093
G		293.33	0.2156	0.7146	227.55	0.2779	0.6547
B		45.16	0.1535	0.0613	32.7	0.1492	0.0685

Data presented in the table is from display technology that is 3 years old and fails to take into account the relative gains made in InP QD technology, in terms of both colour gamut and brightness. This is because CdSe QD technology is relatively mature and is no longer making significant improvements every year, while Cadmium-free QD technology is newer and still improving rapidly.

Brightness of the Samsung series of films has also been seen to increase over subsequent years. The table below shows data of QD films from different Samsung device models after the release of the KS7300 device. All films were measured on the same BLU set up using the same instrument to allow direct comparison.

Model	Year	x	y	L, nits
SUHD KS8000F	2016	0.2812	0.2558	3729
C32HG70	Early 2017	0.2853	0.2535	4050
QN55Q7F	2017	0.2600	0.2446	4196

Gains of >10% in brightness were seen in the space of 1 year on the technology with subsequent films expected to be brighter due to the enhanced performance and FWHM of emission of the dots. Since then the Samsung film technology has been improved further in 2018 and again in 2019, as their latest models have recently been launched on the EU market. These improvements will have further reduced or eliminated the claimed energy efficiency advantage for Cadmium based QD film.

Independently assessed gamut results from the Samsung TV range show that their 2018 model was capable of producing a DCI P3 colour gamut of 99.57 in the 1976 colour space (https://www.rtings.com/tv/reviews/samsung/q7fn-q7-q7f-qled-2018).

Annex 2

Comparison of EU Available QD TVs

Size	Tech	Brand	Model	Efficiency Class	Annual Power kWh	Link
55 inch	Cd QD	Cello	C55SFS4K QLED	A	145	https://www.amazon.co.uk/Cello-QLED-Superfast-4K-Freeview/dp/B07GT24LXG
55 inch	Cd QD	Hisense	55U7A	A	164	https://www.johnlewis.com/hisense-55u7a-uled-hdr-4k-ultra-hd-smart-tv-55-inch-with-freeview-play-ultra-hd-certified-black-silver/p3518053
55 inch	Cd-free QD	Samsung	QE55Q60RATXXU	A	154	https://www.johnlewis.com/samsung-qe55q60r-2019-qled-hdr-4k-ultra-hd-smart-tv-55-inch-with-tvplus-freesat-hd-charcoal-black/p4043592
65 inch	Cd QD	Hisense	65U9A	B	256	https://www.johnlewis.com/hisense-65u9a-uled-hdr-4k-ultra-hd-smart-tv-65-with-freeview-play-ultra-hd-premium-certified-black-silver/p3519088
65 inch	Cd QD	TCL	U65X9006X1	A	225	https://www.amazon.de/TCL-U65X9006-Fernseher-Triple-Tuner/dp/B077H5YZ51
65 inch	Cd-free QD	Samsung	QE65Q60RATXXU	A+	164	https://www.johnlewis.com/samsung-qe65q60r-2019-qled-hdr-4k-ultra-hd-smart-tv-65-inch-with-tvplus-freesat-hd-charcoal-black/p4045795