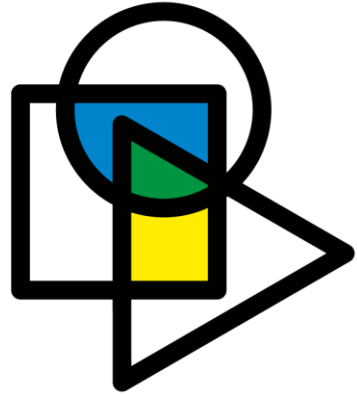


WORLD TELECOMMUNICATION
STANDARDIZATION ASSEMBLY



ITU WTSA-20

GENEVA2022

1- 9 March 2022
Geneva, Switzerland

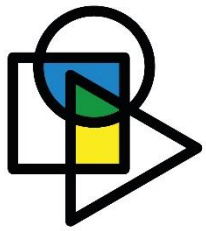
ITU-T STUDY GROUP 5

Environment, climate change and circular economy

Highlights of ITU-T SG5

Qi Shuguang – ITU-T SG5 Acting chairman, March 2022





SG5 Achievements Towards a Sustainable Future

Results 2017-2021

- 106 New Recommendations
- 62 Revised Recommendations
- 32 New Supplements
- 1 Technical papers and tutorials
- Over 35 events that raise awareness



Creating the Focus Group on Environmental Efficiency for AI and other Emerging Technologies (FG-AI4EE)

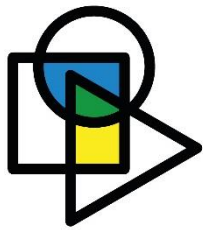


Setting the Environmental Standards of 5G



Strengthening the achievements of the Connect 2030 Agenda





Study Group 5 Key Topics

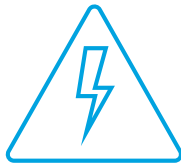
EMC, lightning protection, EMF

Protection, Reliability, Safety and Security



- **ITU-T K.120** “Lightning protection and earthing of a miniature base station”
- **ITU-T K.134** “Protection of small-size telecommunication installations with poor earthing conditions”
- **ITU-T K.151** “Electrical safety and lightning protection of medium voltage input and up to ± 400 VDC output power system in ICT data centres and telecommunication centres”

Resistibility



- **ITU-T K.44** “Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents – Basic Recommendation”

EMF



- **ITU-T K.91**, “Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields”
- **ITU-T K.Suppl.1 to K.91**, “Guide on electromagnetic fields and health”
- **Updates on the EMF Guide and mobile app** to include 5G references and updates on WHO and other guidelines.

Electromagnetic Compatibility



- **ITU-T K.136** “Electromagnetic compatibility requirements for radio telecommunication equipment”
- **ITU-T K.137** “Electromagnetic compatibility requirements and measurement methods for wireline telecommunication network equipment”

Recommendations Under Study

K.5G-Lightning:

Practical guide for lightning protection, earthing and bonding, and safety consideration of 5G radio base station

K.isolators:

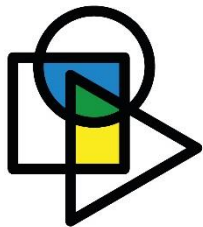
Integrated circuit isolators for telecommunications use

K.devices

RF EMF exposure assessment of the wireless radiocommunication devices operating close to the human body

K.power_emc

EMC requirements for power equipment in telecommunication facilities



Study Group 5 Key Topics

Towards a Sustainable Digital Transformation (1)

Environmental efficiency of digital technologies



- **ITU-T L.1317** “Guidelines on energy efficient blockchain systems”
- **ITU-T L.1331** “Assessment of mobile network energy efficiency”
- **ITU-T L.1050** “Methodology to identify the key equipment in order to assess the environmental impact and e-waste generation of different network architectures”

Power feeding and energy storage



- **ITU-T L.1210** “Sustainable power-feeding solutions for 5G networks”
- **ITU-T L.1221** “Innovative energy storage technology for stationary use - Part 2: Battery”

Sustainable Data Centres



- **ITU-T L.1304** “Procurement Criteria for Sustainable Data Centres”
- **ITU-T L.1305** “Data centre infrastructure management system based on big data and artificial intelligence technology”

Smart Energy Solutions



- **ITU-T L.1380:** Telecom Sites
- **ITU-T L.1381:** Data Centre
- **ITU-T L.1382:** Telecommunication Room
- **ITU-T L.1383:** City and home applications

Recommendations Under Study

L.BBU

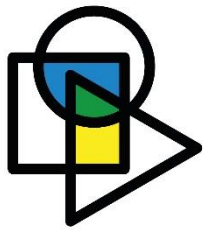
Requirements and use cases of liquid cooling solutions and high energy efficiency solutions for 5G BBU in C-RAN mode

L.ENV-KPI-5G-ARCH

Environmental KPIs/metrics for 5G architectures

L.MM&BP

Measurement methodology and Best Practices for decarbonization of Base Station sites; Data Centre and Telecommunication Room; Industrial Park in support of Net Zero



Study Group 5 Key Topics

Towards a Sustainable Digital Transformation (2)

Sustainable buildings



- **ITU-T L.1370** “Sustainable and intelligent building services”
- **ITU-T L.1371** “A methodology for assessing and scoring the sustainability performance of office buildings”

Sustainable management of E-waste and Supply Chain



- **ITU-T L.1015** “Criteria for evaluation of the environmental impact of mobile phones”
- **ITU-T L.1035** “Sustainable Management of Batteries”
- **ITU-T L.1060** “General principles for the green supply chain management of information and communication technology manufacturing industry”

Circular Economy



- **ITU-T L.1022** “Circular Economy: Definitions and concepts for material efficiency for Information and Communication Technology”
- **ITU-T L.1023** “Assessment method for circular scoring”

Assessment and Climate Actions towards Net Zero



- **ITU-T L.1450** “Methodologies for the assessment of the environmental impact of the ICT sector”
- **ITU-T L.1470** “GHG trajectories for the ICT sector compatible with the UNFCCC Paris Agreement”
- **ITU-T L.1471** “Guidance and criteria for ICT organizations on setting Net Zero targets and strategies”

Circular and sustainable cities and communities



- **ITU-T L.Suppl. 46:** “Definitions and Recent Trends in Circular Cities”

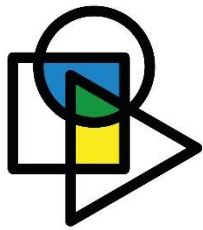
Recommendations Under Study

L.Mat_frame
Assessment of material efficiency of ICT network goods (circular economy) (5 parts)

L.Biodiversity_footprint
Methodology for the assessment of the footprint of an ICT organization on biodiversity

L.Enablement
Assessment of GHG emissions reductions enabled by ICT services in support of the Net Zero transition

L.SRDT_adaptation
Sustainable and Resilient Digital Technologies for Adaptation to Climate Change



Strengthening Collaboration and Implementation of Standards



Collaboration with other SDOs

ETSI



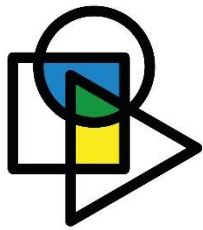
Collaboration Across UN Agencies



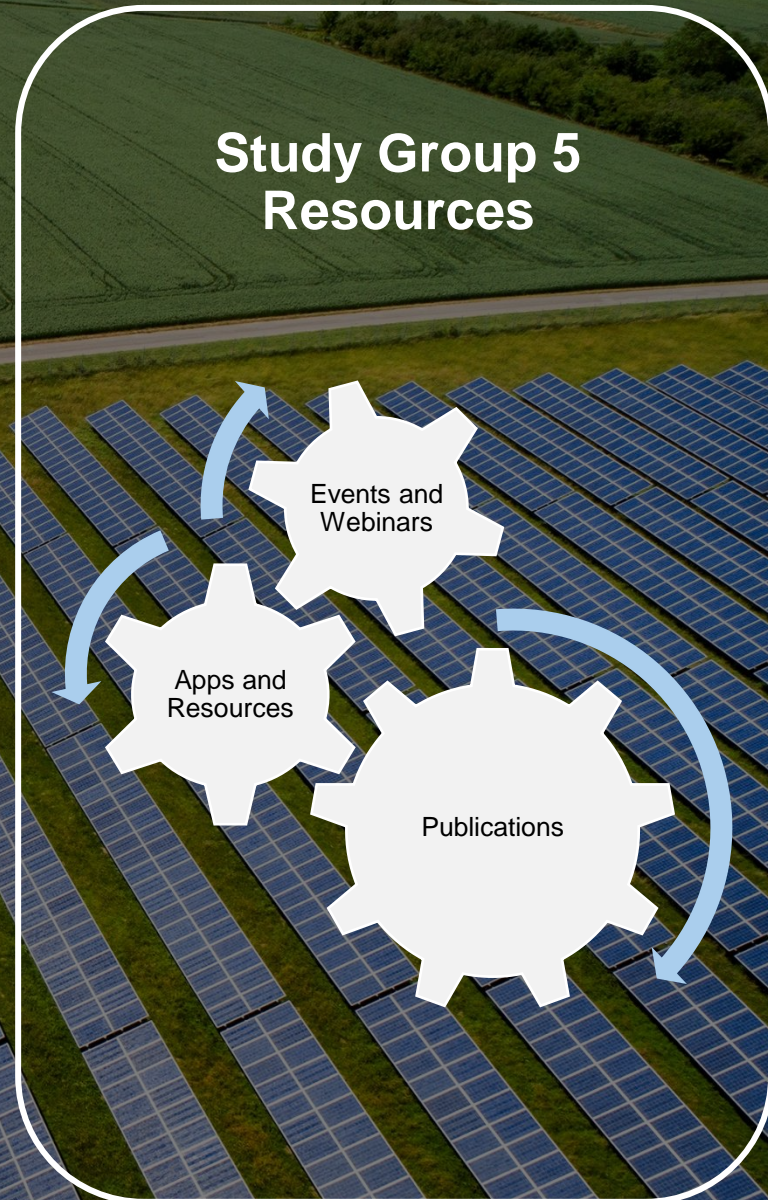
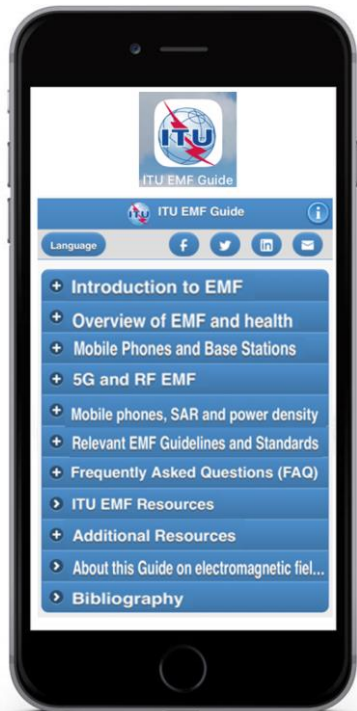
World Health Organization

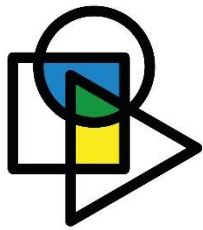


UNECE



Raising Awareness Towards Sustainable Digital Transformation





Advancing Climate Response and Enhancing Environmental Protection Future Work

ITU-T SG5 will continue to be the leading Study Group on topics related to:

EMF, EMC, and
ICT resistibility



The
environmental
aspects of digital
technologies



E-waste, the
circular economy
and supply chain
management



ICT effects in
other sectors and
societies to
achieve Net-zero



ICT impacts on
biodiversity



Becoming a
circular city

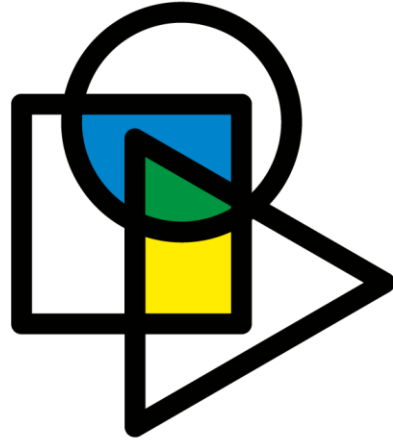


Key Items Being Worked On:

- Lightning protection for 5G
- RF EMF exposure assessment
- EMC requirements
- Sustainable procurement
- Digital product passport
- GHG in the ICT sector
- Carbon data intensity
- ICT positive effect in other sectors and countries
- More



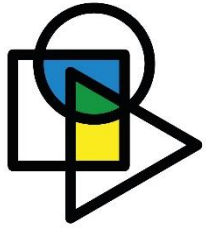
Thanks



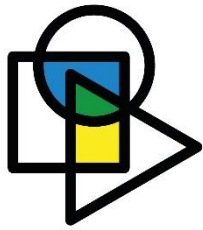
ITU WTSA-20
GENEVA2022

Setting the standard

1- 9 March 2022
Geneva, Switzerland



Additional Information



ITU-T SG5: Setting the environmental requirements for 5G (1)

Taking into consideration the development of 5G systems, ITU-T SG5 is developing a series of technical reports and international standards that study the following environmental aspects of 5G:

- **Electromagnetic compatibility (EMC):**

- Recommendation ITU-T K.116: "Electromagnetic compatibility requirements and test methods for radio telecommunication terminal equipment"
- ITU-T K.Suppl.10: "Analysis of electromagnetic compatibility aspects and definition of requirements for 5G systems"
- ITU-T K.Suppl.26 on "Analysis of electromagnetic compatibility requirements and test methods of 5G Active Antenna System base station"

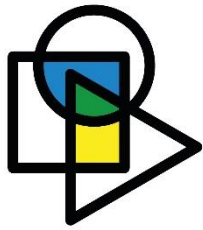
- **Electromagnetic fields (EMF):**

- ITU-T K.Suppl.1: "Guide on electromagnetic fields and health"
- ITU-T K.Suppl.4: "Electromagnetic field considerations SSCs"
- ITU-T K.Suppl.9: "5G technology and human exposure to RF EMF"
- ITU-T K.Suppl.14: "The impact of RF-EMF exposure limits stricter than the ICNIRP or IEEE guidelines on 4G and 5G mobile network deployment"
- ITU-T K.Suppl.16: "Electromagnetic field compliance assessments for 5G wireless networks "

- **Resistibility:**

- ITU-T K.Suppl.8: "Resistibility analysis of 5G systems"





ITU-T SG5: Setting the environmental requirements for 5G (2)

Taking into consideration the development of 5G systems, ITU-T SG5 is developing a series of technical reports and international standards that study the following environmental aspects of 5G:

- **Energy feeding and efficiency:**

- Recommendation ITU-T L.1210: "Sustainable power-feeding solutions for 5G networks"
- Recommendation ITU-T L.1220: "Innovative energy storage technology for stationary use - Part 1: Overview of energy storage"
- Recommendation ITU-T L.1221: "Innovative energy storage technology for stationary use - Part 2: Battery"
- Recommendation ITU-T L.1222: "Innovative energy storage technology for stationary use - Part 3: Supercapacitor technology"
- Recommendation ITU-T L.1331: "Assessment of mobile network energy efficiency"
- Recommendation ITU-T L.1350 on "Energy efficiency metrics of a base station site"
- Recommendation ITU-T L.1351 on "Energy efficiency measurement methodology for base station sites"
- Recommendation ITU-T L.1380: "Smart energy solution for telecom sites"
- Recommendation ITU-T L.1381: "Smart energy solution for data centres"
- Recommendation ITU-T L.1382: "Smart energy solution for telecommunication rooms"
- Recommendation ITU-T L.1383 on "Smart energy solutions for cities and home applications"
- ITU-T L.Suppl.36 to ITU-T L.1310: "Study on methods and metrics to evaluate energy efficiency for future 5G systems"
- ITU-T L.Suppl.43 to ITU-T L.Series on "Smart energy saving of 5G base station: Based on AI and other emerging technologies to forecast and optimize the management of 5G wireless network energy consumption"

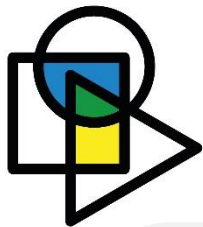
- **E-waste management**

- Recommendation ITU-T L.1050 "Methodology to identify the key equipment in order to assess the environmental impact and e-waste generation of different network architectures".

- **Assessment methodologies of ICTs and CO2 trajectories**

- Recommendation ITU-T L.1450 "Methodologies for the assessment of the environmental impact of the information and communication technology sector"





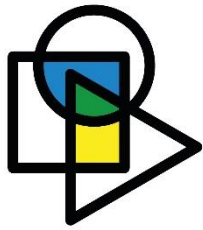
Connect 2030: An agenda to connect all to a better world



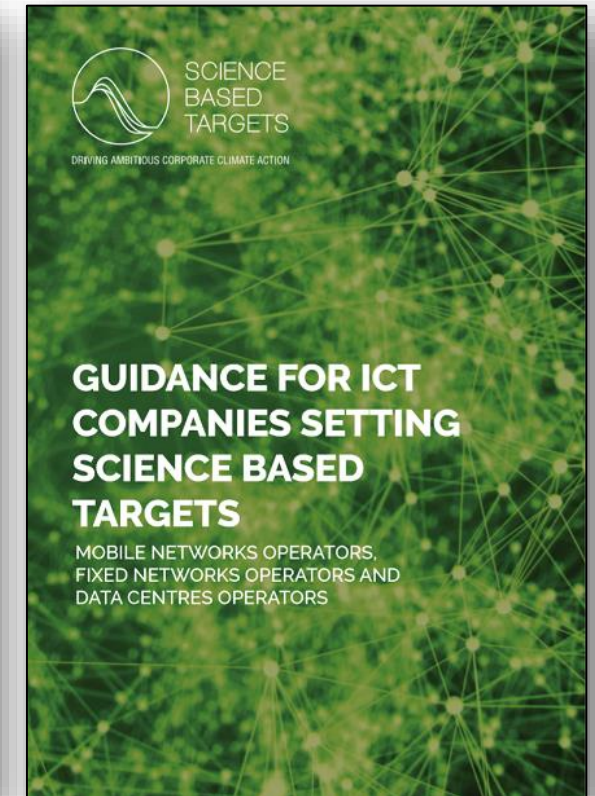
- Target 3.2: By 2023, increase the global e-waste recycling rate to 30%
- Target 3.3: By 2023, raise the percentage of countries with an e-waste legislation to 50%
- Target 3.4: By 2023, net telecommunication/ICT-enabled greenhouse gas abatement should have increased by 30% compared to the 2015 baseline

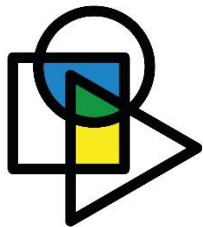
ITU-T Study Group 5 is contributing to the accomplishment of the Connect 2030 with Standards such as:

- **Recommendation ITU-T L.1031** which helps countries to reduce e-waste by 50%. This Recommendation provides a guidance on developing an e-waste inventory, approaches to design e-waste prevention and reduction programmes.
- **Recommendation ITU-T L.1460** provides guidance on how to decrease the GHG emissions generated by the telecommunication/ICT sector.



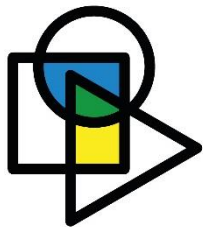
Publications and reports on Environment, Climate Change and Circular Economy - Study Period 2017-2020





List of Approved Recommendations (2017-2021) (1)

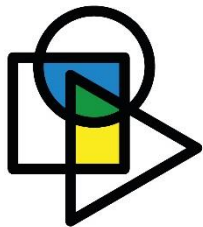
| Work item | Subject / Title |
|----------------------------|--|
| K.20 (rev) | Resistibility of telecommunication equipment installed in a telecommunication centre to overvoltages and overcurrents |
| K.21 (rev) | Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents |
| K.34 (rev) | Classification of electromagnetic environmental conditions for telecommunication equipment - Basic EMC Recommendation |
| K.35 | Bonding configurations and earthing at remote electronic sites |
| K.39 | Risk assessment of damages to telecommunication sites due to lightning discharges |
| K.40 (rev) | Protection against lightning electromagnetic pulses in telecommunication centres |
| K.44 (rev) | Resistibility tests for telecommunication equipment exposed to overvoltages and overcurrents - Basic Recommendation |
| K.45 (rev) | Resistibility of telecommunication equipment installed in the access and trunk networks to overvoltages and overcurrents |
| K.50 (rev) | Safe limits for operating voltages and currents in telecommunication systems powered over the network |
| K.52 (rev) | Guidance on complying with limits for human exposure to electromagnetic fields |
| K.56 (rev) | Protection of radio base stations against lightning discharges |
| K.61 | Guidance on measurement and numerical prediction of electromagnetic fields for compliance with human exposure limits for telecommunication installations |
| K.64 | Safe working practices for outside equipment installed in particular environments |
| K.66 | Protection of customer premises from overvoltages |
| K.70 | Mitigation techniques to limit human exposure to EMFs in the vicinity of radiocommunication stations |



List of Approved Recommendations (2017-2021) (2)

| Work item | Subject / Title |
|-----------------------------|--|
| K.73 | Shielding and bonding for cables between buildings |
| K.77 | Characteristics of metal oxide varistors for the protection of telecommunication installations |
| K.78 (rev) | High altitude electromagnetic pulse immunity guide for telecommunication centres |
| K.83 | Monitoring of electromagnetic field levels |
| K.90 | Evaluation techniques and working procedures for compliance with exposure limits of network operator personnel to power-frequency electromagnetic fields |
| K.91 (rev) | Guidance for assessment, evaluation and monitoring of human exposure to radio frequency electromagnetic fields |
| K.93 | Immunity of home network devices to electromagnetic disturbance |
| K.99 | Surge protective component application guide - Gas discharge tubes |
| K.100 (rev) | Measurement of radio frequency electromagnetic fields to determine compliance with human exposure limits when a base station is put into service |
| K.112 | Lightning protection, earthing and bonding: Practical procedures for radio base stations |
| K.116 | Electromagnetic compatibility requirements and test methods for radio telecommunication terminal equipment |
| K.117 | Primary protector parameters for the surge protection of equipment Ethernet ports |
| K.118 | Requirements for Lightning Protection of Fibre To The distribution point (FTTdp) Equipment |
| K.119 | Conformance Assessment of Radio Base Stations Regarding Lightning Protection and Earthing |

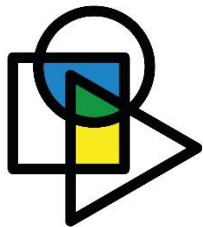
| Work item | Subject / Title |
|-----------------------|---|
| K.120 | Lightning Protection and Earthing of Miniature Base Station |
| K.121 | Guidance on the Environmental Management for Compliance with Radio Frequency EMF Limits for Radiocommunication Base Stations |
| K.122 | Exposure levels in the close proximity of the radiocommunication antennas |
| K.123 | Electromagnetic compatibility requirements for electrical equipment in telecommunication facilities |
| K.124 | Overview of particle radiation effects on telecommunications systems |
| K.125 | Dangerous effects and protective measures against electromagnetic disturbances when internet data centre is co-sited with high-voltage substation |
| K.126 | Surge protective component application guide - High frequency signal isolation transformers |
| K.127 | Immunity requirements for telecommunication equipment in close proximity use of wireless devices |
| K.128 | Surge protective component application guide - metal oxide varistor (MOV) components |
| K.129 | Characteristics and ratings of silicon PN junction voltage clamping components used for the protection of telecommunications installations |
| K.130 | Neutron irradiation test methods for telecommunications equipment |
| K.131 | Design methodologies for telecommunication systems applying soft error measures |
| K.132 | EMC requirements of electromagnetic disturbances from lighting equipment located in telecommunication facilities |



List of Approved Recommendations (2017-2021) (3)

| Work item | Subject / Title |
|-----------------------|--|
| K.133 | Electromagnetic (EM) environment of body worn equipment in the 2.4 GHz and 13.56MHz industrial, scientific and medical band |
| K.134 | Protection of small-size telecommunication installations with poor earthing conditions |
| K.135 | Technical parameters for residual current operated protective devices with automatic reclosing feature for telecom applications |
| K.136 | Electromagnetic Compatibility requirements for radio telecommunication equipment |
| K.137 | Electromagnetic compatibility requirements and measurement methods for wire-line telecommunication network equipment |
| K.138 | Quality estimation methods and application guidelines for mitigation measures based on particle radiation tests |
| K.139 | Reliability requirements for telecommunication systems affected by particle radiation |
| K.140 | Surge protective component application guide - Fuses |
| K.141 | Electromagnetic compatibility requirements for Information Perception Equipment |
| K.142 | Lightning protection and earthing of video surveillance system |
| K.143 | Guidance on safety relating to the use of surge protective devices and surge protective components in telecommunication terminal equipment |
| K.144 | Surge protective component application guide - Self-restoring thermally activated overcurrent protectors |
| K.145 | Assessment and management of compliance with RF EMF exposure limits for workers at radiocommunication sites and facilities |

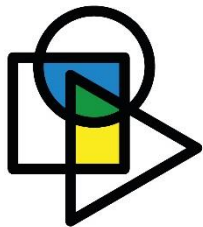
| Work item | Subject / Title |
|-----------------------|--|
| K.146 | Management of interferences on telecommunication transmissions on copper other than speech |
| K.147 | Ethernet port resistibility testing for overvoltages and overcurrents |
| K.148 | Multiservice surge protective device application guide |
| K.149 | Passive intermodulation test methods of array antenna systems in mobile communication systems |
| K.150 | Information of semiconductor devices required for design of telecommunication equipment applying soft error mitigation measures |
| K.151 | Electrical safety and lightning protection of medium voltage input and up to ± 400 VDC output power system in ICT data centre and telecommunication centre |



List of Approved Recommendations (2017-2021) (4)

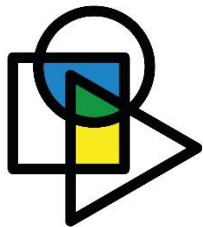
| Work item | Subject / Title |
|------------------------|--|
| L.1000 | Universal power adapter and charger solution for mobile terminals and other hand-held ICT devices |
| L.1006 | Test suites for assessment of the External universal power adapter solutions for stationary information and communication technology devices |
| L.1007 | Test suites for assessment of the External universal power adapter solutions for portable information and communication technology devices |
| L.1015 | Criteria for evaluation of the environmental impact of mobile phones |
| L.1016 | Method for Evaluation of the Environmental, Health and Safety Performance of True Wireless Stereo Headphones |
| L.1020 | Circular Economy: Guide for Operators and Suppliers on approaches to migrate towards circular ICT goods and networks |
| L.1021 | Extended producer responsibility - Guidelines for sustainable e-waste management |
| L.1022 | Circular Economy: Definitions and concepts for material efficiency for Information and Communication Technology |
| L.1024 | Effect for global ICT of the potential of selling services instead of equipment on the waste creation and environmental impacts |
| L.1030 | E-waste management framework for countries |
| L.1031 | Guideline on Implementing the E-waste Reduction Target of the Connect2020 Agenda |
| L.1032 | Guidelines and certification schemes for e-waste recyclers |
| L.1035 | Sustainable Management of Batteries |
| L.1036 | Scheduled waste management for base station (inclusive of e-waste) |

| Work item | Subject / Title |
|------------------------|---|
| L.1060 | General principles for the green supply chain management of ICT manufacturing industry |
| L.1205 | Interfacing of renewable energy or distributed power sources to up to 400 VDC power feeding systems |
| L.1206 | Impact on information and communication technology equipment architecture of multiple AC, -48 VDC or up to 400 VDC power inputs |
| L.1207 | Progressive migration of a telecommunication/information and communication technology site to 400 VDC sources and distribution |
| L.1210 | Sustainable power-feeding solutions for 5G networks |
| L.1220 | Innovative energy storage technology for stationary use - Part 1: Overview of energy storage |
| L.1221 | Innovative energy storage technology for stationary use - Part 2: Battery |
| L.1222 | Innovative energy storage technology for stationary use - Part 3: Supercapacitor technology |
| L.1303 | Functional requirements and framework of green data centre energy-saving management system |
| L.1304 | Procurement Criteria for Sustainable Data Centres |
| L.1305 | Data centre infrastructure management system based on big data and artificial intelligence technology |
| L.1310 | Energy efficiency metrics and measurement methods for telecommunication equipment |
| L.1315 | Standardization terms and trends in energy efficiency |
| L.1316 | Energy efficiency framework |
| L.1325 | Green ICT solutions for telecom network facilities |
| L.1331 | Assessment of mobile network energy efficiency |
| L.1332 | Total network infrastructure energy efficiency metrics |
| L.1351 | Base station site energy parameter measurement methodology |
| L.1360 | Energy control of SDN architecture |



List of Approved Recommendations (2017-2021) (5)

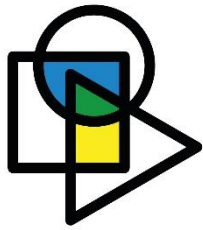
| Work item | Subject / Title |
|------------------------|---|
| L.1361 | Measurement method for energy efficiency of Network Function Virtualization |
| L.1362 | Interface for power management in network function virtualization environments – Green abstraction layer version 2 |
| L.1370 | Sustainable and intelligent building services |
| L.1371 | A methodology for assessing and scoring the sustainability performance of office buildings |
| L.1380 | Smart energy solution for telecom sites |
| L.1381 | Smart energy solution for data centre |
| L.1382 | Smart energy solution for telecommunication rooms |
| L.1450 | Methodologies for the assessment of the environmental impact of the information and communication technology sector |
| L.1451 | Methodology for assessing the aggregated positive sector-level impacts of ICT in other sectors |
| L.1460 | Connect 2020 greenhouse gases emissions – Guidelines |
| L.1470 | GHG emissions trajectories for the ICT sector compatible with the UNFCCC Paris Agreement |
| L.1471 | Guidance and criteria for ICT organisations on setting Net Zero targets and strategies |
| L.1504 | ICT and adaptation of agriculture to the effects of climate change |
| L.1505 | Information and communication technology and adaptation of the fisheries sector to the effects of climate change |
| L.1506 | Framework of climate change risk assessment for telecommunication and electrical facilities |
| L.1507 | Use of ICT sites to support environmental sensing |



List of Agreed Supplements and other informative texts (2017-2021) (1)

| Work item | Subject / Title |
|--|---|
| K.Suppl.1 to ITU-T K.91 | ITU-T K.91 - Guide on electromagnetic fields and health |
| K.Suppl.4 to ITU-T K.91 | Electromagnetic field considerations in smart sustainable cities |
| K.Suppl.7 to ITU-T K.44 | AC supply configurations |
| K.Suppl.8 | Resistibility analysis of 5G systems |
| K.Suppl.9 | 5G technology and human exposure to RF EMF |
| K.Suppl.10 | Analysis of EMC aspects and definition of requirements for 5G mobile systems |
| K.Suppl.11 to ITU-T K.131 | Soft error measures for field programmable gate arrays |
| K.Suppl.12 to ITU-T K.51 | Narrow pin spacing in connectors potential hazards |
| K.Suppl.13 | Radiofrequency electromagnetic field (RF-EMF) exposure levels from mobile and portable devices during different conditions of use |
| K.Sup.14 to ITU-T K-series Recommendations | The impact of RF-EMF exposure limits stricter than the ICNIRP or IEEE guidelines on 4G and 5G mobile network deployment |
| K.Suppl.15 to ITU-T K.20, K.21, K.44 | Internal DC powering interface surge testing factors |
| K.Suppl.16 to ITU-T K.series | Electromagnetic field compliance assessments for 5G wireless networks |

| Work item | Subject / Title |
|--|---|
| K.Sup.17 to ITU-T K.44 | Test conditions and methods information |
| K.Sup.18 to ITU-T K.44 | Causes of telecommunication system overvoltage and overcurrent conditions and their expected levels |
| K.Sup.19 to ITU-T K-series Recommendations | EMF strength inside subway train |
| K.Suppl.20 | RF Exposure evaluation around base station installed underground |
| K.Suppl.21 to Recommendation ITU-T K.21 | Rationale for setting resistibility requirements of telecommunication equipment installed in customer premises against lightning |
| K.Suppl.22 to Recommendation ITU-T K.45 | Rationale for setting resistibility requirements of telecommunication equipment installed in the access and trunk networks against lightning |
| K.Suppl.23 to Recommendation ITU-T K.147 | Ethernet port surge voltages and currents |
| L.Suppl.36 to ITU-T L.1310 | Study on methods and metrics to evaluate energy efficiency for future 5G systems |
| L.Suppl.37 to ITU-T L.1470 | Guidance to operators of mobile networks, fixed networks and data-centres on setting 1.5°C aligned targets compliant with Recommendation ITU-T L.1470 |
| L.Suppl.38 to Recommendation ITU-T L.1470 | Guidance to ICT manufacturers on setting 1.5°C aligned targets compliant with Recommendation ITU-T L.1470 |



List of Agreed Supplements and other informative texts (2017-2021) (2)

| Work item | Subject / Title |
|---|--|
| L.Suppl.40 to Recommendation ITU-T L.1371 | Scoring tool to assess the sustainability performance of office buildings |
| L.Suppl.41 | Requirements on energy efficiency measurement models and the role of artificial intelligence and big data |
| L.Suppl.42 | Guidelines on the environmental efficiency of machine learning processes in supply chain management |
| L.Suppl.43 | Smart energy saving of 5G base stations: Based on AI and other emerging technologies to forecast and optimize the management of 5G wireless network energy consumption |
| L.Suppl.44 | Guidelines on best practices and environment friendly policies for effective information and communication technology deployment methods |
| L.Suppl.45 | Radio base station site best practices |
| L.Suppl.46 | Definitions and Recent Trends in Circular Cities |
| LSTR.5GEE | Study on methods and metrics to evaluate energy efficiency for future 5G systems |