|  |  |  |
| --- | --- | --- |
|  | | Standardization Sector |
| ITU-T Focus Group Deliverable | |
| (12/2022) | |
|  | Focus Group on Environmental Efficiency for Artificial Intelligence and other Emerging Technologies  (FG-AI4EE) | |
|  | FG-AI4EE D.WG1-01  Standardized glossary of terms | |

|  |  |
| --- | --- |
| **ITUPublications** | **International Telecommunication Union** |

Logo, icon

Description automatically generated

|  |
| --- |
| ITU-T FG-AI4EE Deliverable  Standardized glossary of terms |

|  |
| --- |
| Summary  This Technical Report is a deliverable of the ITU-T Focus Group on Environmental Efficiency for Artificial Intelligence and other Emerging Technologies (FG-AI4EE).  It contains a baseline set of definitions of terms commonly used in the context of environmental efficiency for artificial intelligence and other emerging technologies. The definitions provide a basic characterization of the term, and where appropriate a note is included to provide additional clarity. The concept and rationale for some of the key terms and definitions is described in clause 7. |

|  |
| --- |
| Keywords  Definitions, glossary, terminology. |

Note

This is an informative ITU-T publication. Mandatory provisions, such as those found in ITU-T Recommendations, are outside the scope of this publication. This publication should only be referenced bibliographically in ITU-T Recommendations.

Change Log

This document contains Version 1.0 of the ITU-T Technical Report on *"Standardized glossary of terms"* approved at FG-AI4EE sixth meeting held in Ålesund, Norway, 1-2 December 2022.

|  |  |  |
| --- | --- | --- |
| **Editor:** | Malcolm Mason Sure Business Jersey (Channel Islands) | Tel: +44 1534 753374 Email: [malcolm.mason@sure.com](mailto:malcolm.mason@sure.com) |

© ITU 2023

All rights reserved. No part of this publication may be reproduced, by any means whatsoever, without the prior written permission of ITU.

**Table of Contents**

Page

1 Scope 1

2 References 2

3 Definitions 2

3.1 Terms defined elsewhere 2

3.2 Terms defined in this Technical Report 2

4 Abbreviations and acronyms 2

5 Conventions 5

6 Key points and rationale for the Focus Group 6

6.1 Introduction 6

6.2 Energy consumption challenges created through the use of artificial intelligence 6

6.3 Offsetting the energy consumption challenges 6

6.4 Sustainable development outcomes 7

7 Definitions 7

7.1 Terms defined in this Technical Report 7

7.2 Terms defined elsewhere 7

Bibliography 11

ITU-T FG-AI4EE Deliverable

Standardized glossary of terms

# 1 Scope

This Technical Report contains a dictionary of common terms and phrases used in the Focus Group's deliverables that is intended to help readers to have common definitions and frames of reference.

To aid understanding of papers submitted within the Focus Group, a glossary of terms has been created to aid readability. Each definition covers the term itself, and any illustration, mathematical or otherwise to enable understanding of the term used. Where terms are already standardized within the industry, a reference will refer to the underlying defined term.

The terms contained in this document are for the deliverables listed in the following table:

| Type | Number | Title |
| --- | --- | --- |
| Technical Report | FG-AI4EE D.WG1-02 | Solution scorecard for eco-friendly business processes and environmental behavioural influencers |
| Technical Specification | FG-AI4EE-D.WG1-04 | Key performance indicators for small and medium enterprises to assess the achievement of sustainable development goals |
| Technical Specification | FG-AI4EE-D.WG1-05 | Reporting artificial intelligence, augmented reality and machine learning |
| Technical Specification | FG-AI4EE D.WG1-06 | Neutral navigational matrix for AI-driven technologies for smart sustainable cities |
| Technical Report | FG-AI4EE D.WG1-08 | Driving artificial intelligence-Internet of things towards the United Nations Sustainable Development Goals |
| Technical Report | FG-AI4EE-D.WG1-09 | A method for intuitive human interaction with data model (ML and AI, etc.) |
| Technical Report | FG-AI4EE-D.WG1-10 | Guidelines on the use of digital twins of cities and communities for better climate change mitigation solutions |
| Technical Report | FG-AI4EE-D.WG1-11 | Best practices for graphical digital twins of smart cities |
| Technical Specification | FG-AI4EE-D.WG2-01 | Environmental impact self-check assessment |
| Technical Report | FG-AI4EE-D.WG2-02 | Computer processing, data management and energy perspective |
| Technical Report | FG-AI4EE-D.WG2-03 | Requirements on energy efficiency measurement models and the role of AI and big data |
| Technical Report | FG-AI4EE-D.WG2-04 | Effective use cases of artificial intelligence for smart sustainable cities |
| Technical Specification | FG-AI4EE-D.WG2-05 | Guidelines on energy efficient blockchain systems |
| Technical Report | FG-AI4EE-D.WG2-06 | Assessing environmentally efficient data centre and cloud computing in the framework of the UN sustainable development goals |
| Technical Report | FG-AI4EE-D.WG3-01 | Guidelines on the implementation of eco-friendly criteria for AI and other emerging technologies |
| Technical Report | FG-AI4EE-D.WG3-02 | 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 |
| Technical Report | FG-AI4EE-D.WG3-03 | Data centre energy-saving: Application of Al technology in improving energy efficiency of telecom equipment rooms and Internet data centre infrastructure |
| Technical Report | FG-AI4EE-D.WG3-05 | Best practice catalogue on environmentally efficient artificial intelligence and blockchain application |
| Technical Report | FG-AI4EE-D.WG3-06 | Guidelines on the environmental efficiency of 5G usage in smart water management |
| Technical Report | FG-AI4EE-D.WG3-07 | Guidelines on the environmental efficiency of machine learning processes in supply chain management |

# 2 References

None.

# 3 Definitions

## Terms defined elsewhere

Terms defined elsewhere are listed in clause 7.2.

## Terms defined in this Technical Report

Terms defined in this Technical Report are listed in clause 7.1.

# 4 Abbreviations and acronyms

This Technical Report uses the following abbreviations and acronyms:

4G 4th Generation of Wireless networks

5G 5th Generation of wireless networks

AA Autonomous Agents

AAU Active Antenna Unit

ACU Air Conditioning Unit

AI Artificial Intelligence

AI4PV Artificial Intelligence for the operation and maintenance of PhotoVoltaic plants

AIDEMAS AI-enabled demand-side management for energy sustainability

AIS Automatic Identification System

AISSI Integrated stand-alone programming for the semiconductor industry

API Application Programming Interface

AQI Air Quality Index

AR Augmented Reality

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers

BA Building Automation

BERT Bidirectional Encoder Representations from Transformers

BIM Building and road information

BMSBuilding Management System

BS Base Station

CDP Customer Data Platform

CEO Chief Executive Officer

CFD Computational Fluid Dynamics

CFO Chief Financial Officer

CFRP Carbon Fibre Reinforced Polymers

CIRCLES Congestion Impact Reduction via CAV-in-the-loop Lagrangian Energy Smoothing

COO Chief Operating Officer

CSO Chief Sustainability Officer

DC Data Center

DCIE Data Center Infrastructure Equipment

DCIM Data Center Infrastructure Management

DEFAINE AI-based design exploration framework for direct loaded engineering

DEM Domestic Energy Model

DLT Distributed Ledger Technology

DNN Deep Neural Network

DRL Deep Reinforcement Learning

DVFS Dynamic voltage/frequency scaling

eCPRI enhanced Common Public Radio Interface

EEI Energy Efficiency Indicator

EPA Environmental Protection Agency

EPR Extender Producer Responsibility

ESG Environmental, Social and Governance

FPGA Field-Programmable Gate Array

GB Gigabyte (Unit of storage on a computer)

GCA Global Cybersecurity Agenda

GGBR Global Green Building Research

GHG Greenhouse Gas

GPT-3 Generative Pre-trained Transformer 3

GPU Graphical Processing Unit

GSMA Global System for Mobile Communications Association

H-IoT Healthcare Internet of Things

HR Human Resources

HVAC Heating, Ventilation, and Air Conditioning

ICTs Information and Communication Technologies

IDC Internet Data Center

IDS Intrusion Detection system

IEC International Electrotechnical Commission

IoMT Internet of Medical Things

IOT Internet of Things

ISO International Organization for Standardization

IT Information Technology

ITS Intelligent Transportation Systems

IUCN International Union for Conservation of Nature

IVS Seismic vulnerability index

KPI Key Performance Indicator

KYC Know your customer

LSTM Long Short Term Memory

M2M Machine to Machine

MEC Mobile Edge Computing

MIMO Multiple Input Multiple Output

ML Machine Learning

MNO Mobile Network Operator

NFT Non-Fungible Token

NIST National Institute of Standards and Technology

NLP Natural Language Processing

NR New Radio

NSA Not Stand Alone

NYSDOT New York Department of Transport

OLT Optical Line Termination

ONU Optical Network Unit

OSAT Open Source Appropriate Technology

P2P Peer-to-peer

PBFT Practical Byzantine Fault Tolerance

PFAS Polyfluoroalkyl **Substances**

**PoA** Proof of Authority

PON Passive Optical Networks

PoS Proof of Stake

**PoUW Proof of Useful WOrk**

**PoW** Proof of Work

PRB Physical Resource Block

PUE Power Usage Effectiveness

R&D Research and Development

RDD Resilient Distributed Dataset

SCM Supply Chain Management

SDG Sustainable Development Goals

SDN Software Defined Networks

SG Smart Grid

SGD Stochastic Gradient Descent

SGX Software Guard Extension

SSC Smart Sustainable City

TDAI Trusted Decentralized Artificial Intelligence

TFEE Total Factor Energy Efficiency

TPU Tensor Processing Unit

TQEM Total Quality Environmental Management

U4SSC United for Smart Sustainable Cities

UAV Unmanned Autonomous Vehicles

UNOSAT The United Nations Satellite Centre

V2G Vehicle-to-Grid

V2I Vehicle-to-infrastructure

V2V vehicle-to-vehicle

VOC Volatile Organic Compound

WAN Wide Area Network

ZEB Zero Energy Building

# 5 Conventions

This Technical Report uses the following conventions:

CO2 CarbonDioxide, a potent greenhouse gas

CO2e Carbon Dioxide Equivalent

NOx Nitrogen Oxides

PMx Particulate Matter

SO2 Sulphur dioxide

SOx Sulphur Oxides

uCM micro-climate and air pollution assessment in an urban setting

# Key points and rationale for the Focus Group

## 6.1 Introduction

The use of data has evolved into a major and often critical element of our daily lives, irrespective of individual, business or governmental use. The use of digital stored data by humans has gone to a point where at the end of 2020, there were an estimated 64 Zettabytes (64'000'000'000'000'000'000 bytes) of data that had been created, copied or consumed worldwide, which is estimated to ramp to over 181 Zettabytes in 2025 [b-1]. In addition, there were an estimated 9 billion Internet of Things (IoT) devices in 2020, which will double by 2025 [b-2]. Compute power growth was an estimated 2x increase year on year.

Combining the volume, veracity and velocity of data with the evolution of computing power has enabled the field of AI to flourish to where, as of 2022, AI has superseded the capabilities of human intelligence for a great many tasks.

In many areas, statistical learning has now been superseded by deep neural networks due to their predictive and generative capabilities, which improve with larger volumes of data, albeit with diminishing returns aligned to compute power needed.

AI, more recently driven by subsets machine learning (statistical learning models) and deep learning (deep artificial neural networks), has evolved into a double-edged sword when evaluated from an environmental efficiency perspective.

## Energy consumption challenges created through the use of artificial intelligence

From an environmental perspective, immense energy consumption is now required to train current state of the art large deep artificial neural networks. For example, in 2020, the carbon dioxide (CO2) production for a car through its lifetime has been measured as a fifth of the CO2 produced in training the latest large scale natural language processing (NLP) transformer models once, albeit the trained model uses little consumption for Inferencing [b-3]. These trained models often enable higher performance than human decision-making accuracy in an increasing number of tasks.

Current algorithms used in deep learning often dictate that larger models offer improved accuracy, albeit with diminishing returns in terms of energy consumption. The growth in model size was in the region of 300,000 times between 2012 and 2018. While this may sound extreme, it should be considered that OpenAI's GPT-2 in 2019 had 1.5 billion parameters. Its successor, GPT-3, now has 175 billion parameters, and there is no sign of model growth slowing down in the continual pursuit of perfection [b-4]. It is very likely that the soon to be released GPT-4 model will continue this growth trend.

## Offsetting the energy consumption challenges

AI has the capability to drive a positive environmental impact on many aspects of society, particularly since 2010, when deep artificial neural networks entered the mainstream phase of evolution. Deep artificial neural networks have created the ability to enable increasingly accurate predictive and generative modelling on colossal data sets generated through both static, dynamic and IoT data. Whereas statistical artificial intelligence (AI) models pre-2010 hit an artificial accuracy ceiling, irrespective of training data. Post-2010 deep learning models have created the ability to drive increasingly higher accuracy through use of increasing quantities and variety of data from multiple sources.

The sheer size of current deep learning models and their widespread adoption would appear to create additional environmental energy consumption issues through increased adoption. However, the portability of open-sourced trained models has enabled businesses of all sizes to fine tune models with their own data. This is with very little environmental impact, using low-cost compute.

When considering how AI can create a positive environmental impact on society, generating AI models using data from disparate IoT data sources has enabled the evolution of smart data centres and smart cities, to name two examples, which both have the potential to significantly reduce carbon footprint. The use of smart data centres is self-fulfilling, where AI models can reduce power consumption overheads through creating the optimal environment for information technology (IT) to run efficiently. The use of digital twins enables smart cities to be created, which can deliver a significant positive impact on the environment. The outcome of using AI to train models on infinite scenarios in the digital twin using real world data can be used to enable a reduction of carbon footprint and improvement in air quality in the smart city.

## Sustainable development outcomes

AI, in particular the deep learning subset, continues to evolve at a pace where human level performance is being surpassed at an increasing rate for specific tasks. Essentially, more data and more performance mean bigger and more accurate models which, when combined with IoT, drives more data, demanding more compute power, requiring larger models to improve performance. This brings environmental challenges. However, the combination of compute, data and IoT to drive increasingly accurate outcomes offers the ability to address environmental challenges, which can only be tackled by the capabilities generated by AI now at our disposal.

This focus group has aimed to offer both technical reports and specifications as referenced in clause 1, scope of focus group deliverables, to address the challenges described in this clause 6.

# 7 Definitions

## 7.1 Terms defined in this Technical Report

This Technical Report defines the following terms:

**7.1.1 inferencing**: The use of a fully trained artificial intelligence model to make predictions or generate new output.

The following terms are based on the definitions given in the Focus Group deliverables:

**7.1.2 building automation** [b-2021-FG-AI4EE D.WG3-03]: The automatic centralized control of a building's HVAC (heating, ventilation and air conditioning), electrical, lighting, shading, access control, security systems, and other interrelated systems through a building management system (BMS) or building automation system (BAS).

**7.1.3 solution scorecard** [b-2021-FG-AI4EE D.WG1-02]: Scorecard is defined as a list or series of lists that provide either a quantitative or qualitive value for consumption in rating of self or processes of a company.

## 7.2 Terms defined elsewhere

The following industry standard terms have been defined in Focus Group deliverables :

### 7.2.1 Focus Group specific industry defined terms

**7.2.1.1 consensus mechanism** [b-2021-FG-AI4EE D.WG2-05]: Defines strict rules for creating new blocks and adding new data to them without favouring one participant over another.

**7.2.1.2 cryptography** [b-2021-FG-AI4EE D.WG2-05]: Originated from safety communication technology, which is a combination of mathematics, computer, and information theory.

**7.2.1.3 data center infrastructure management** [b-2021-FG-AI4EE D.WG3-03]: Integration of information technology (IT) and facility management disciplines to centralize monitoring, management, and intelligent capacity planning of a data center's critical systems.

**7.2.1.4 distributed ledger** [b-2021-FG-AI4EE D.WG2-05]: A type of ledger that is shared, replicated, and synchronized in a distributed and decentralized manner.

**7.2.1.5 electrical energy efficiency** [b-ITU-T L.1315]: The output of a device that is generated by a provided amount of power; the percentage of total energy input to a machine or equipment that is consumed in useful work and is not wasted as useless heat.

**7.2.1.6 energy carrier** [b-ISO/IEC 13273-1]: The substance or medium that can transport energy.

**7.2.1.7 energy consumption** [b-ISO/IEC 13273-1]: The quantity of energy applied.

**7.2.1.8 energy efficiency** [b-ISO/IEC 13273-1]: The ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy.

**7.2.1.9 energy efficiency improvement** [b-ISO/IEC 13273-1]: An increase in energy efficiency that comes from technological, design, behavioural or economic changes.

**7.2.1.10 energy efficiency indicator** [b-ISO/IEC 13273-1]: The value indicative of the energy efficiency.

**7.2.1.11 energy efficiency mechanism instrument** [b-ISO/IEC 13273-1]: The means that are used to create incentives or a supportive framework for market actors to follow an energy efficiency improvement programme or to provide energy efficiency services.

**7.2.1.12 energy intensity** [b-ISO/IEC 13273-1]: The total energy consumption per unit of economic output.

**7.2.1.13 energy management system** [b-ISO/IEC 13273-1]: A set of interrelated or interacting elements to establish an energy policy and energy objectives, as well as the processes to achieve those objectives.

**7.2.1.14 energy performance** [b-ISO/IEC 13273-1]: Measurable results related to energy efficiency, energy use and energy consumption.

**7.2.1.15 energy policy** [b-ISO/IEC 13273-1]: The statement by the organization of its overall intentions and direction of an organization related to its energy performance, as formally expressed by its top management.

**7.2.1.16 energy source** [b-ISO/IEC 13273-1]: Material, natural resource or technical system from which energy can be extracted or recovered.

**7.2.1.17 energy system** [b-ISO/IEC 13273-1]: a system that consists of all the components related to production, conversion, delivery, and use of energy.

**7.2.1.18 energy system models** [b-ISO/IEC 13273-1]: Conceptual tools that depict the structure and support the calculation of the technological performance and decision making for design, operation and control.

**7.2.1.19 extended reality** [b-2021-FG-AI4EE D.WG3-01]: Combines all forms of real-virtual environments and human-machine interactions, including but not limited to augmented reality, mixed reality, and virtual reality.

**7.2.1.20 ICT energy efficiency** [b-2021-FG-AI4EE D.WG2-03]: The ratio of energy consumed by specific ICT systems to the output produced or service performed by these systems.

**7.2.1.21 industry 4.0** [b-2021-FG-AI4EE D.WG3-01]: An industrial approach where one or more digital technologies are used throughout industrial processes in order to produce more and better.

**7.2.1.22 next generation networks** [b-2021-FG-AI4EE D.WG1-06]: Next-Generation Network (NGN) will be the dominant type of core network or telecommunication infrastructure for 5G and 6G networks. It is a packet switching network which is self-aware, self-managed, and self- configured.

**7.2.1.23 power usage effectiveness (pue)** [b-ISO/IEC 30134-2]: Ratio of the data centre's total energy consumption to information technology equipment energy consumption, calculated, measured or assessed across the same period.

**7.2.1.24 public key cryptography** [b-2021-FG-AI4EE D.WG2-05]: Also called asymmetric key is a milestone in the development of modern cryptography, which mainly includes a public key and a private key.

**7.2.1.25 smart contract** [b-2021-FG-AI4EE D.WG2-05]: A program written on a distributed ledger system, which encodes the rules for specific types of distributed ledger system transactions in a way that can be validated, and triggered by specific conditions; software program that it is executed automatically and capable of carrying out the terms of the agreement between parties without the need for human intervention; pieces of software that execute a specified action based on the state of the system or a transaction that occurs.

**7.2.1.26 smart sustainable cities** [b-ITU-T Y.4900]: An innovative city that uses information and communications technologies and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects.

**7.2.1.27 stateless contract** [b-2021-FG-AI4EE D.WG2-05]: A contract with specified states.

**7.2.1.28 TIMES** [b-2021-FG-AI4EE D.WG2-03]: Energy efficiency model based on a linear programming.

**7.2.1.29 token** [b-2021-FG-AI4EE D.WG2-05]: A digital representation of value on a shared distributed ledger that is owned and secured using cryptography to ensure its authenticity and prevent modification or tampering without the owner's consent.

**7.2.1.30 vehicle platooning** [b-2021-FG-AI4EE D.WG1-06]: In intelligent transportation, vehicle platooning is a method of vehicle to vehicle collaboration where a group of vehicles drive together in a group of 3 to 20 vehicles or trucks. Vehicles use artificial intelligence to collect, analyse, and share data for safety and vehicles can join and leave the platoon.

**7.2.1.31 vehicle to vehicle collaboration (V2V)** [b-2021-FG-AI4EE D.WG1-06]: In ITS and smart roads, Vehicle to vehicle collaboration (V2V) are vehicles equipped with sensors, cameras, algorithms, and other smart devices and exchange road conditions, speed, position, directions, hazards and threats with other vehicles.

**7.2.1.32 vehicle-to-infrastructure (V2I)** [b-2021-FG-AI4EE D.WG1-06]: Is a communication model in which vehicles use smart devices and algorithms to share and access information from traffic and road infrastructure. Used devices and infrastructure include traffic lights, RFID readers, cameras, sensors, lane markers, streetlights, signage and parking meters. Exchanged information include speed, position, road conditions, heading angle, and threats.

### 7.2.2 Industry standard terms

**7.2.2.1 artificial intelligence (ai)** [b-ITU-T F.749.13]: An interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning.

**7.2.2.2 augmented reality** [b-ITU-T J.301]: A type of mixed reality where graphical elements are integrated into the real world in order to enhance user experience and enrich information.

**7.2.2.3 big data** [b-ISO/IEC 20546]: Extensive datasets – primarily in the data characteristics of volume, variety, velocity, and/or variability – that require a scalable technology for efficient storage, manipulation, management, and analysis.

**7.2.2.4 bitcoin** [b-ITU-T X.1400]: An example of a blockchain using proof of work.

**7.2.2.5 blockchain** [b-ITU-T F.751.0]: A type of distributed ledger that is composed of digitally recorded data arranged as a successively growing chain of blocks with each block cryptographically linked and hardened against tampering and revision.

**7.2.2.6 cloud computing** [b-ITU-T Y.3500]: Paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand.

**7.2.2.7 data centre** [b-ITU-T X.1053]: A facility used to house computer systems and associated components, such as telecommunication and storage systems.

**7.2.2.8 deep learning** [b-ISO/IEC TR 29119-11]: Approach to creating rich hierarchical representations through the training of neural networks with one or more hidden layers.

**7.2.2.9 digital twin** [b-ISO/TR 24464]: Compound model composed of a physical asset, an avatar, and an interface.

**7.2.2.10 edge computing** [b-ISO/IEC TR 30164]: Distributed computing in which processing and storage takes place at or near the edge, where the nearness is defined by the system's requirements.

**7.2.2.11 infrastructure-as-a-service (IaaS)** [b-IEEE SDN]: A platform supporting the resources needed by other layers. IaaS can be "programmed" by utilizing provisioning tools. Because of this programming interface, even if IaaS is often (but not only) made of "physical" resources, IaaS can be considered as a component.

**7.2.2.12 internet of things** [b-ITU-T Y.4000]: A global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies.

**7.2.2.13 machine learning** [b-ITU-T Y.3172]: Processes that enable computational systems to understand data and gain knowledge from it without necessarily being explicitly programmed.

**7.2.2.14 mixed reality** [b-ISO/IEC 18038]: Merging of real and virtual worlds to generate new environments where physical and synthetic objects co-exist and interact.

**7.2.2.15 natural language prcessing (NLP)** [b-ITU-T F.746.3]: A method that analyses text in natural languages through several processes such as part-of-speech recognition, syntactic analysis and semantic analysis.

**7.2.2.16 platform-as-a-service (PaaS)** [b-IEEE SDN]: PaaS provides infrastructure, storage, database, information, and process as a service, along with well-defined APIs, and services for the management of the running applications, such as dashboards for monitoring and service composition.

**7.2.2.17 quantum computing** [b-ISO/TS 80004]: Use of quantum phenomena for computational purposes.

**7.2.2.18 smart sustainable cities** [b-ITU-T Y.4900]: is an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects.

**7.2.2.19 virtual reality** [b-ISO 9241-394]: Set of artificial conditions created by computer and dedicated electronic devices that simulate visual images and possibly other sensory information of a user's surrounding with which the user is allowed to interact.

Bibliography

[b-ITU-T F.746.3] Recommendation ITU-T F.746.3 (2015), *Intelligent question answering service framework*.  
<https://handle.itu.int/11.1002/1000/12619>

[b-ITU-T F.749.13] Recommendation ITU-T F.749.13 (2021), *Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence*.  
<https://handle.itu.int/11.1002/1000/14684>

[b-ITU-T F.751.0] Recommendation ITU-T F.751.0 (2020), *Requirements for distributed ledger systems.*  
<https://handle.itu.int/11.1002/1000/14332>

[b-ITU-T J.301] Recommendation ITU-T J.301 (2014), *Requirements for augmented reality smart television systems*.  
 [https://handle.itu.int/11.1002/1000/13145 )](%20https://handle.itu.int/11.1002/1000/13145%20))

[b-ITU-T L.1315] Recommendation ITU-T L.1315 (2017), *Standardization terms and trends in energy efficiency*.  
<https://handle.itu.int/11.1002/1000/13145>

[b- ITU-T X.1053] Recommendation ITU-T X.1053 (2017), *Code of practice for information security controls based on ITU-T X.1051 for small and medium-sized telecommunication organizations.*  
<https://handle.itu.int/11.1002/1000/13367>

[b-ITU-T X.1400] Recommendation ITU-T X.1400 (2020), *Terms and definitions for distributed ledger technology.*  
<https://handle.itu.int/11.1002/1000/14449>

[b-ITU-T Y.2060] Recommendation ITU-T Y.4000/Y.2060 (2012), *Overview of the Internet of things.*<https://handle.itu.int/11.1002/1000/11559>

[b-ITU-T Y.3172] Recommendation ITU-T Y.3172 (2019), *Architectural framework for machine learning in future networks including IMT‑2020*.  
<https://handle.itu.int/11.1002/1000/13894>

[b-ITU-T Y.3500] Recommendation ITU-T Y.3500 (2014), *Information technology – Cloud computing – Overview and vocabulary*.  
 <https://handle.itu.int/11.1002/1000/12210>

[b-ITU-T Y.4900] Recommendation ITU-T Y.4900/L.1600 2016), *Overview of key performance indicators in smart sustainable cities*.  
<https://handle.itu.int/11.1002/1000/12627> .

[b-ISO 9241-394] ISO 9241-394:2020; *Ergonomics of human-system interaction – Part 394: Ergonomic requirements for reducing undesirable biomedical effects of visually induced motion sickness during watching electronic images.*<https://www.iso.org/standard/73227.html>

[b-ISO/IEC 13273-1] ISO/IEC 13273-1:2015, *Energy efficiency and renewable energy sources – Common international terminology – Part 1: Energy efficiency.*https://www.iso.org/standard/62606.html

[b-ISO/IEC 18038] ISO/IEC 18038:2020, *Information technology – Computer graphics, image processing and environmental representation – Sensor representation in mixed and augmented reality*  
<https://www.iso.org/standard/70720.html>

[b-ISO/IEC 20546] ISO/IEC 20546:2019, *Information technology – Big data – Overview and vocabulary*  
<https://www.iso.org/standard/68305.html>

[b-ISO/IEC 30134-2] ISO/IEC 30134-2:2016*, Information technology – Data centres – Key performance indicators – Part 2: Power usage effectiveness (PUE).*  
<https://www.iso.org/standard/63451.html>

[b-ISO/IEC TR 29119-11] ISO/IEC AWI TS 29119-11:2020, *Software and systems engineering – Software testing – Part 11: Guidelines on the testing of AI-based* systems.  
<https://www.iso.org/standard/79016.html>

[b-ISO/IEC TR 30164] ISO/IEC TR 30164:2020, *Internet of things (IoT) – Edge computing*.  
<https://www.iso.org/standard/53284.html>

[b-ISO/TR 24464] ISO/TR 24464:2020, *Automation systems and integration – Industrial data – Visualization elements of digital twins*.  
<https://www.iso.org/standard/78836.html>

[b-ISO/TS 80004] ISO/TS 80004-1:2015, *Nanotechnologies – Vocabulary – Part 1: Core terms*.https://www.iso.org/standard/68058.html

[b-IEEE SDN] IEEE Software Defined Networks.  
<https://sdn.ieee.org/>

[b-2021-FG-AI4EE D.WG1-02] 2021-FG-AI4EE D.WG1-02, *Solution Scorecard for eco-friendly business processes and environmental behavioral influencer.*

[b-2021-FG-AI4EE D.WG1-06] 2021-FG-AI4EE D.WG1-06, *Neutral Navigational Matrix for AI-driven Technologies for Smart Sustainable Cities.*

[b-2021-FG-AI4EE D.WG2-03] 2021-FG-AI4EE D.WG2-03, *Requirements on energy efficiency measurement models and the role of AI and big data.*

[b-2021-FG-AI4EE D.WG2-05] 2021-FG-AI4EE D.WG2-05, *Guidelines on Energy Efficient Blockchain Systems.*

[b-2021-FG-AI4EE D.WG3-01] 2021-FG-AI4EE D.WG3-01, *Guidelines on the Implementation of Eco-friendly Criteria for AI and other Emerging Technologies.*

[b-2021-FG-AI4EE D.WG3-03] 2021-FG-AI4EE D.WG3-03, *Application of Al technology in improving energy efficiency of telecom equipment rooms and internet data center infrastructure.*

[b-1] *Volume of data/information created, captured, copied, and consumed worldwide from 2010 to 2020, with forecasts from 2021 to 2025.* <https://www.statista.com/statistics/871513/worldwide-data-created/>

[b-2] *Number of Internet of Things (IoT) connected devices worldwide from 2019 to 2021, with forecasts from 2022 to 2030*.  
<https://www.statista.com/statistics/1183457/iot-connected-devices-worldwide/#:~:text=The%20number%20of%20Internet%20of,around%205%20billion%20consumer%20devices>.

[b-3] *Energy and Policy Considerations for Deep Learning in NLP*.  
<https://arxiv.org/pdf/1906.02243.pdf>

[b-4] *Roundup of machine learning forecasts and market estimates, 2020*.  
<https://www.forbes.com/sites/louiscolumbus/2020/01/19/roundup-of-machine-learning-forecasts-and-market-estimates-2020/?sh=30acca465c02>

\_\_\_\_\_\_\_\_\_\_\_\_\_\_