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Technical Specification

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ITU-T Focus Group on Environmental Efficiency for Artificial Intelligence and other Emerging Technologies (FG-AI4EE)

FG-AI4EE D.WG1-05

Reporting templates on artificial intelligence, augmented reality and machine learning

Working Group 1 - Requirements of AI and other Emerging Technologies to Ensure Environmental Efficiency

Focus Group Technical Specification

Technical Specification ITU-T FG-AI4EE D.WG1-05

Reporting templates on artificial intelligence, augmented reality and machine learning

Summary

This example-based report focuses on how emerging technology solutions can be most impactful on environmental issues that cities dealt with. The data used is based on information gained from the United Nations "United for Smart Sustainable Cities" reports [b-U4SSC]. Internet of Things (IoT) and smart cities gather a lot of data in data lakes and present the insights generated by machine learning or artificial intelligence in custom proprietary dashboards or in open Application Programming Interface (APIs). It is a tedious task for stakeholders with low data literacy to capture so much information stemming from various data formats in a way that can inform their decisions and adapt their behaviours toward a more sustainable future. In light of the United Nations' Agenda 2030 and the European Commission's Fit-for-55 programmes, there is a critical need for a visualisation tool which can visualise and compare, in a consistent manner, the sustainability of smart cities where priorities can be identified and anchored at all decision-making levels and best practices can be scaled-up and replicated to other cities. The purpose of this document is thus to identify the emerging technologies which allow a prompt comparison between different cities and help identify low-hanging fruits and areas of high priority. For the sake of portability and reproducibility, attention is drawn to potential universal data formats.

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 Specification on "*Reporting templates on artificial intelligence, augmented reality and machine learning*" approved at FG-AI4EE sixth meeting held in Ålesund, Norway, 1-2 December 2022.

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Table of Contents

List of Tables

Technical Specification ITU-T FG-AI4EE D.WG1-05

Reporting templates on artificial intelligence, augmented reality and machine learning

1 Scope

This document generates as set of standard reporting templates/dashboards to visualize data produced from technology solutions such as Artificial Intelligence (AI), Augmented Reality (AR) and Machine Learning (ML), that employ defined eco-friendly practices. This document aims to display the results gained from FG-AI4EE deliverable D.WG1-04 in an instinctive way. The graphical interface will share a design language with FG-AI4EE deliverable D.WG1-09 which results are used in FG-AI4EE deliverables D.WG1-10 and D.WG1-11.

2 References

FG-AI4EE [2021]   D.WG1-04 List of Key Performance Indicators (KPIs) for small and medium enterprises to assess the achievement of sustainable development goals http://handle.itu.int/11.1002/pub/81a36bd6-en

FG-AI4EE [2021]   D.WG1-09 A method for intuitive human interaction with data model http://handle.itu.int/11.1002/pub/81a36bd9-en

FG-AI4EE [2022]   D.WG1-10 Guidelines on the use of digital twin of cities and communities for better climate mitigation solutions, http://handle.itu.int/11.1002/pub/81cf9006-en

FG-AI4EE [2021]   D.WG1-11 Best practices for graphical digital twins of smart cities http://handle.itu.int/11.1002/pub/81ac7747-e

FG-AI4EE [2021]   D.WG2-02 Computer processing, data management and energy perspective https://www.itu.int/pub/T-FG-AI4EE-2021-D.WG2.02

3 Definitions

3.1 Terms defined elsewhere

These Technical Specifications use the following terms defined elsewhere:

3.1.1 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).

The following industry standard terms as defined in Focus Group deliverables are below:

3.1.2 Cyber Physical Systems [NIST]: Smart systems that include engineered interacting networks of physical and computational components.

3.1.3 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.

3.1.4 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.

3.1.5   **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.

3.1.6   **Energy carrier [b-ISO/IEC 13273-1:2015]:** The substance or medium that can transport energy.

3.1.7   **Energy consumption [b-ISO/IEC 13273-1:2015]:** The quantity of energy applied.

3.1.8   **Energy efficiency [b-ISO/IEC 13273-1:2015]:** The ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy.

3.1.9   **Energy efficiency improvement [b-ISO/IEC 13273-1:2015]:** An increase in energy efficiency that comes from technological, design, behavioural or economic changes.

3.1.10   **Energy efficiency indicator [b-ISO/IEC 13273-1:2015]:** The value indicative of the energy efficiency.

3.1.11   **Energy efficiency mechanism instrument [b-ISO/IEC 13273-1:2015]:** 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.

3.1.12   **Energy intensity [b-ISO/IEC 13273-1:2015]:** The total energy consumption per unit of economic output.

3.1.13   **Energy management system [b-ISO/IEC 13273-1:2015]:** A set of interrelated or interacting elements to establish an energy policy and energy objectives, as well as the processes to achieve those objectives.

3.1.14   **Energy performance [b-ISO/IEC 13273-1:2015]:** Measurable results related to energy efficiency, energy use and energy consumption.

3.1.15   **Energy policy [b-ISO/IEC 13273-1:2015]:** 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.

3.1.16   **Energy source [b-ISO/IEC 13273-1:2015]:** Material, natural resource or technical system from which energy can be extracted or recovered.

3.1.17   **Energy system [b-ISO/IEC 13273-1:2015]:** a system that consists of all the components related to production, conversion, delivery, and use of energy.

3.1.18   **Energy system models [b-ISO/IEC 13273-1:2015]:** Conceptual tools that depict the structure and support the calculation of the technological performance and decision making for design, operation and control.

3.1.19   **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.

3.1.20   **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.

3.1.21   **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.

3.1.22 Power Usage Effectiveness (PUE) [b-ISO/IEC 30134-2:2016]: Ratio of the data centre's total energy consumption to information technology equipment energy consumption, calculated, measured or assessed across the same period.

3.1.21 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.

3.1.22 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.

3.1.23 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.

3.1.24 Stateless contract [b-2021-FG-AI4EE D.WG2-05]: A contract with specified states.

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

3.1.26 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.

3.1.27 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.

3.1.28 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.

3.1.29 Big data [b-ISO/IEC 20546:2019]: 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.

3.1.30 Bitcoin [b-ITU-T X.1400]: An example of a blockchain using proof of work.

3.1.31 Blockchain [b-ITU-T F.751]: 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.

3.1.32 Cloud computing [b-Recommendation 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.

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

3.1.34 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.

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

3.1.36 Infrastructure-as-a-Service (IaaS) [b-IEEE Software Defined Networks]: 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.

3.1.37 Internet of things [b-ITU-T Y.2060]: 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.

3.1.38 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.

3.1.39 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.

3.1.40 NLP [b-ITU-T X.1080.2]: A method that analyses text in natural languages through several processes such as part-of-speech recognition, syntactic analysis and semantic analysis.

3.1.41 Platform-as-a-Service (PaaS) [b-IEEE Software Defined Networks]: 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.

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

3.1.43 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.

4 Abbreviations and acronyms

These Technical Specifications use the following abbreviations and acronyms:

API: Application Programming Interface

CFO: Chief Financial Officer

COO: Chief Operation Officer

CO_2:   Carbon Dioxide, a potent greenhouse gas

CSO: Chief Sustainability Officer

ESG: Environmental, Social, and Governance

GB: Gigabyte (unit of storage on a computer)

HR: Human Resource

HVAC: Heating Ventilation Air Conditioning

ISO: International Organization for Standardization

IT: Information Technology

KPI: Key Performance Indicator

PUE: Power Usage Effectiveness

GHG: Greenhouse Gas Emissions

VOC: Volatile Organic Compounds

5   Conventions

None.

6   Structure of the Technical Specification

FG-AI4EE deliverables D.WG1-04, D.WG1-09, D.WG1-10, D.WG1-11 argue in favour of the usage of graphical digital twins to display sustainability report. The following sub-chapters propose a list of KPIs, together with their short description, their target audience and comment of their contextual benefit. For all the following KPIs, the CSO of the company (or anyone having her/his role) is responsible for providing accurate and updated figures.

6.1   Example of analysis from FG-AI4EE Technical Report D.WG2-02 Computer processing, data management and energy perspective

Name and Unit	Description	Target Audience	Comment
Power Usage Effectiveness (PUE) [-]	Data centre efficiency Aggregated on which method?	Management, Information Technology (IT), CFO	Pure metrics on how efficient the HVAC of data centres are, without connection to the purpose or usability of the data and calculations produce
Local Energy Mix [kgCO2e/kWh]	CO_2 equivalent in kg for each locally produced kWh of energy consumed by the company, without accounting for green certificates	CFO, ESG	"How green are the actual electrons" Aggregated on regional area and relevant period. Often provided by energy authorities. Companies sell green certificates to finance building carbon neutral infrastructure
Effective Energy Mix [kgCO2e/kWh]	CO_2 equivalent in kg for each locally produced kWh of energy consumed by the company, accounting for green certificates	CFO, ESG	"How green are the virtual electrons?" Companies buy green certificates to compensate for positive Carbon output
Percentage of Reused Training Parameters [-]	#Reused/#Total	CFO, Data scientists	Data scientists must be made aware of the environmental impact

Name and Unit	Description	Target Audience	Comment
			of retraining the algorithms
			Reusing trained parameters has the potential downside of the "double black box": algorithm+dataset. This hinders interpretability.
Percentage of Open Datasets Used in Training [-]	Size of Open Dataset [GB]/Total Size of Datasets [GB]	Academia	Using open data sets streamlines the reproducibility and simplifies the interpretability of results
Percentage of Training Datasets reviewed by Ethical Committee [-]	#Review/#Total	ESG, HR Department	HR Department must be made aware of potential biases and intended and unintended discrimination in the choice of the training data
Percentage of Open datasets published [-]	#Openly Published Datasets Created by the Company/#Datasets Created by the Company	Internal and External Data scientists, Academia,Public authorities	Transparency in data is a key element Publishing data can be a smart and inexpensive University Marketing tactic

Table 1 - Analysis FG-AI4EE Technical Report D.WG2-02

6.2 Example of analysis from the D.WG1-04 List of KPIs-metrics:

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
Percentage of Workers practicing physical activity at least 3 hours a week (%)		Management, HR, Employees, Municipal Administration	Stakeholders must be made aware of the mobility situation and the potential health improvements related to physical activity and active mobility Huge effect on well-being, life quality, life balance can be combined with cleaner transportation
Greenhouse gasses tons CO_2-equivalents)	Scope 1, 2, and 3	Management, Employees, Customers, ESG, Investors	Stakeholders need to be made aware of the company's footprint
Noise Level around facilities (dB)	Measured with sensors		Use AI/Digital Signal Processing to identify sources, categorize patterns, mitigate the consequences, and generate fines based on pollution periods
Number/Percentage of third-party environmentally labelled products used in production (no)	Should be split into the type of labels	**ESG, COO**	Used as sales and investor
Number of third-party certified suppliers (no)	Should be split into type of certificates	**ESG, COO**	Used as sales and investor
Percentage of procurement originating from second-hand retailers (%)	Promote Circular Business Models	**ESG, COO**	Used as sales and investor
Percentage of electronic equipment procured by second-hand retailers (%)	Promote Longer IT-Equipment Life	**ESG, COO**	Used as sales and investor
Proportion third-party environmentally labelled products and certified suppliers of total procurement costs (%)	Difficult must be split into a set of performance indicators/measurable parameters and	**ESG, COO**	Used as sales and investor

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
	combined in a formula		
Amount of paper and cardboard used (kg)	Purchased paper?	**ESG**	Limit unreusable packing solutions with a box in a box or cargo transporting air
Total use of fuel (l)	Should be split into type of fuels	**ESG, CFO**	Less fuel is good for the 3-bottom line
Number of travels by flight in the local region countries, in continent, in the rest of the world (no)		**ESG**	Stressing the lesser environmental profile of e-Meetings
CO2-emissions from flights (ton CO2)	Calculation model to be described	**ESG**	
Percentage of Employees using mobility with lower footprint	Use of public transport, walking, biking	**ESG, HR**	Stressing the benefits for the 3-bottom line: cheaper, healthier and more environmentally friendly
Percentage of employees with home office or flexible work hours		**ESG, HR, COO, CFO**	Stressing the benefits for the 3-bottom line: cheaper (less traffic, lower office rents), work-life balance and more environmentally friendly
Number of Parking Places Paid by the company per employee		**ESG, HR, COO, CFO**	Helping employees making environmentally choices
Energy use from different energy sources (%)	Should be split into renewables/non-renewables ~~energy sources~~	**COO, CFO, ESG**	Stressing the importance of source clean energy
Energy use for different purposes (kWh)	Should be split by category: Computing, HVAC, Production, Other	**COO, CFO, ESG**	Visualizing where the energy is used for can be an eye opener
Heated area (m^2)		**COO, CFO, ESG**	Can be compared with employee density and heating related costs.

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
Electricity Consumption by Category	HVAC, IT (on premise and cloud),	**COO, CFO, ESG**	Show indirect and direct electricity usage
Demand Response Adoption (%)	Number of sites with demand response adoption	**COO, CFO, ESG, IT**	Optimize energy consumption when the prices are most convenient.
Emissions of Greenhouse gasses (tons CO_2-equivalents)	Scope 1, 2, and 3	**COO, CFO, ESG, HR**	Educating a broader audience with greenhouse gas emissions (GHG) starts with opening the eyes of employees and where the GHG emission stem from in their own company
Emissions of NO_X (tons)	Scope 1, 2, and 3	**COO, CFO, ESG, HR**	Educating a broader audience with NOx starts with opening the eyes of employees and where the NOx emission stem from in their own company
Emissions of SO_2 (tons)	Scope 1, 2, and 3	**COO, CFO, ESG, HR**	Educating a broader audience with SOx starts with opening the eyes of employees and where the SOx emission stem from in their own company
Emissions of Volatile Organic Compounds (VOC) (tons)	Scope 1, 2, and 3	**COO, CFO, ESG, HR**	Educating a broader audience with VOC starts with opening the eyes of employees and where the VOC emission stem from in their own company
Emissions of particles/sot/dust (tons)	Scope 1, 2, and 3	**COO, CFO, ESG, HR**	Educating a broader audience with Particulate Matter starts with opening the eyes of employees and where the Particulate Matter emission stem from in their own company

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
Total volume of fresh water consumed	Increase water use efficiency for all	**COO, CFO, ESG, HR**	Educating a broader audience with water consumption starts with opening the eyes of employees and where the water consumption stems from in their own company
Total volume of wastewater (m3)		**COO, CFO, ESG, HR**	Educating a broader audience with water consumption starts with opening the eyes of employees and where the water consumption stems from in their own company
Pollution to open water bodies by organic matters, suspended solids, oil products, etc	Should be specified by type	**COO, ESG, HR**	Reputational Risk Mitigation (and removal)
Waste in different fractions (kg)	Should be split into waste categories (paper, plastics, etc), to recyclability, to incineration, etc, see below	**COO, ESG, HR**	Reputational Risk Mitigation (and removal)
Electric Waste	Kg	**COO, ESG, HR**	Raise awareness of electric waste and a source of revenue
Paper and cardboard (tons/Currency)	Measure the proportion of paper and cardboard in procurement. This includes also packaging		Use AI powered sorting robots or smart dust bins to sort waste, use it as bottom line for billing and reporting from waste collection company. Connect billing to environmental reporting. Certify origin and destination via smart contracts

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
			(distributed ledger technology)
			Use AR to visualize the flow of materials, their destination and sensibilize employees and procurement on the topic and use it as basis to compare performance with national level or previous years
Glass (tons)			Use AI powered sorting robots or smart dust bins to sort waste, use it as bottom line for billing and reporting from waste collection company. Connect billing to environmental reporting. Certify origin and destination via smart contracts (distributed ledger technology)
			Use AR to visualize the flow of materials, their destination and sensibilize employees and procurement on the topic and use it as basis to compare performance with national level or previous years
Plastics (tons)	Open-source 3D printing applied at community level can logically shift the metrics from tons to kgs.		Use AI-powered sorting robots or smart dust bins to sort waste and use it as the bottom line for billing and reporting from the waste collection company. Connect billing to environmental reporting. Certify

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
			origin and destination via smart contracts (distributed ledger technology)
			Use AR to visualize the flow of materials, their destination and sensibilize employees and procurement on the topic and use it to compare performance with national level or previous years.
			Use open-source 3D printing and recycling for small-scale manufacturing in support of sustainable self-directed development.[1] This coupled distributed recycling and manufacturing process reduces embodied energy by half while reducing substantially the cost of consumer products, so it has an economic incentive. 3D printing upcycles plastic waste into a filament through a recyclebot (open-source waste plastic extruder), to be further upcycled into valuable consumer products [b-Zhong]. Open tools also reduce maintenance costs, ie. If it breaks, a part can be repaired or built locally from the

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[1] https://reprap.org/wiki/Recyclebot

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
			design flies [b-Novak].
Metals (tons)			Use AI-powered sorting robots or smart dust bins to sort waste and use it as the bottom line for billing and reporting from the waste collection company. Connect billing to environmental reporting. Certify origin and destination via smart contracts (distributed ledger technology)
			Use AR to visualize the flow of materials, their destination and sensibilize employees and procurement on the topic and use it to compare performance with national level or previous years.
			Use open-source 3D printing and recycling for small-scale manufacturing to support sustainable self-directed development.[2] This coupled distributed recycling and manufacturing process reduces embodied energy by half while reducing the cost of consumer products substantially, so it has an economic incentive. 3D printing

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[2] https://reprap.org/wiki/Recyclebot

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
			upcycles plastic waste into a filament through a recyclebot (open-source waste plastic extruder), to be further upcycled into valuable consumer products [b-Zhong]. [3] Open tools also reduce maintenance costs, ie. If it breaks, a part can be repaired or built locally from the design flies [b-Novak].[4]
Hazardous waste (tons)			Connect billing to environmental reporting. Certify origin and destination via smart contracts (distributed ledger technology) Use AR to visualize the flow of materials, their destination and sensibilize employees and procurement on the topic and use it as a basis to compare performance with national level or previous years
Production waste sent to landfill (tons)			Connect billing to environmental reporting. Certify origin and destination via smart contracts (distributed ledger technology) Use AR to visualize the flow of materials, their destination and

Parameter/performance indicator /KPI	Description	Target Audiences	Comment
			sensibilize employees and procurement on the topic and use it as the basis to compare performance with national level or previous years
Waste sent to recycling (% of total)			Automatically connect to waster collecting company
			Use AI to incentivize eco-friendly behaviour.
			Visualize industry average, own current and past performance
Waste sent to incineration (% of total)			Automatically connect to waster collecting company
			Use AI to incentivize eco-friendly behaviour.
			Visualize industry average, own current and past performance

Table 2 - Analysis from D.WG1-04 List of KPIs-metrics

7 State of the art in environmental reporting

This section would present a short overview the state of the art in the domain environmental reporting based on International Organization for Standardization (ISO) standards, and provide an analysis of possible improvements to reach wider audiences.

8 Using graphical digital twins for environmental reporting

This section would present a short overview of the state of the art in the domain of artificial intelligence and machine learning for smart cities and earth observation and conclude with a list of unsolved challenges relative to stakeholders' involvement in the behaviour change and decision-making processes. This section would refer to 2021 - FG-AI4EE D.WG1-09 - A method for intuitive human interaction with data model (ML and AI, etc.) and 2021 - FG-AI4EE D.WG1-11 - Best practices for graphical digital twins of smart cities.

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[b-1]   Energy and Policy Considerations for Deep Learning in NLP https://arxiv.org/pdf/1906.02243.pdf.

[b-2]   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

[b-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]   Guidelines on Energy Efficient Blockchain Systems

[b-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]   Application of AI technology in improving energy efficiency of telecom equipment rooms and internet data center infrastructure

[b-ITU-T L.1315]   Standardization terms and trends in energy efficiency. L.1315 : Standardization terms and trends in energy efficiency (itu.int)

[b-ISO/IEC 13273-1:2015]   Energy efficiency and renewable energy sources — Common international terminology — Part 1: Energy efficiency

[b-ISO/IEC 30134-2:2016]   Information technology — Data centres — Key performance indicators — Part 2: Power usage effectiveness (PUE)

ISO - ISO/IEC 30134-2:2016 - Information technology — Data centres — Key performance indicators — Part 2: Power usage effectiveness (PUE)

[b-ITU-T Y.4900]   Recommendation ITU-T Y.4900/L.1600 gives a general guidance to cities and provides an overview of key performance indicators (KPIs) in the context of smart sustainable cities (SSCs).

ITU-T Recommendation database

[b-ITU-T F.749.13]   Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence

F.749.13 : Framework and requirements for civilian unmanned aerial vehicle flight control using artificial intelligence (itu.int)

[b-ITU-T J.301]   Requirements for augmented reality smart television systems

J.301 : Requirements for augmented reality smart television systems (itu.int)

[b-ISO/IEC 20546:2019]	Information technology — Big data — Overview and vocabulary
	[ISO - ISO/IEC 20546:2019 - Information technology — Big data — Overview and vocabulary](#)
[b-ITU-T X.1400]	Terms and definitions for distributed ledger technology
	[X.1400 : Terms and definitions for distributed ledger technology (itu.int)](#)
[b-ITU-T F.751]	Transmission characteristics and performance requirements of radio-relay systems for SDH-based networks
	[F.751 : Transmission characteristics and performance requirements of radio-relay systems for SDH-based networks (itu.int)](#)
[b-Recommendation ITU-T Y.3500]	Y.3500 : Information technology - Cloud computing - Overview and vocabulary
	[Y.3500 : Information technology - Cloud computing - Overview and vocabulary (itu.int)](#)
[b-Recommendation ITU-T X.1053]	X.1053 : Code of practice for information security controls based on ITU-T X.1051 for small and medium-sized telecommunication organizations
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[b-ISO/IEC TR 29119-11]	ISO/IEC AWI TS 29119-11
	Information technology — Artificial intelligence — Testing for AI systems — Part 11
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[b-ISO/TR 24464]	ISO/TR 24464:2020
	Automation systems and integration — Industrial data — Visualization elements of digital twins
	[ISO - ISO/TR 24464:2020 - Automation systems and integration — Industrial data — Visualization elements of digital twins](#)
[b-ISO/IEC TR30164]	ISO/IEC TR 30164:2020
	Internet of things (IoT) — Edge computing
	[ISO - ISO/IEC TR 30164:2020 - Internet of things (IoT) — Edge computing](#)
[b-IEEE Software Defined Networks]	[Home - IEEE Software Defined Networks](#)
[b-ITU-T Y.2060]	Y.2060 : Overview of the Internet of things
	[Y.2060 : Overview of the Internet of things (itu.int)](#)
[b-ITU-T Y.3172]	Y.3172 : Architectural framework for machine learning in future networks including IMT-2020
	[Y.3172 : Architectural framework for machine learning in future networks including IMT-2020 (itu.int)](#)
[b-ISO/IEC 18038]	ISO/IEC 18038:2020

Information technology — Computer graphics, image processing and environmental representation — Sensor representation in mixed and augmented reality

ISO - ISO/IEC 18038:2020 - Information technology — Computer graphics, image processing and environmental representation — Sensor representation in mixed and augmented reality

[b-ITU-T X.1080.2]	[712-PLEN] Draft text for Rec. ITU-T X.1080.2 (th2), Telebiometrics related to e-health - Part 2: Physics
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[b-ISO 9241-394]	ISO 9241-394:2020
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