NEW-6G

NANOELECTRONICS & WIRELESS FOR 6G

NEW-6G Initiative

(Nano Electronic & Wireless for 6G)

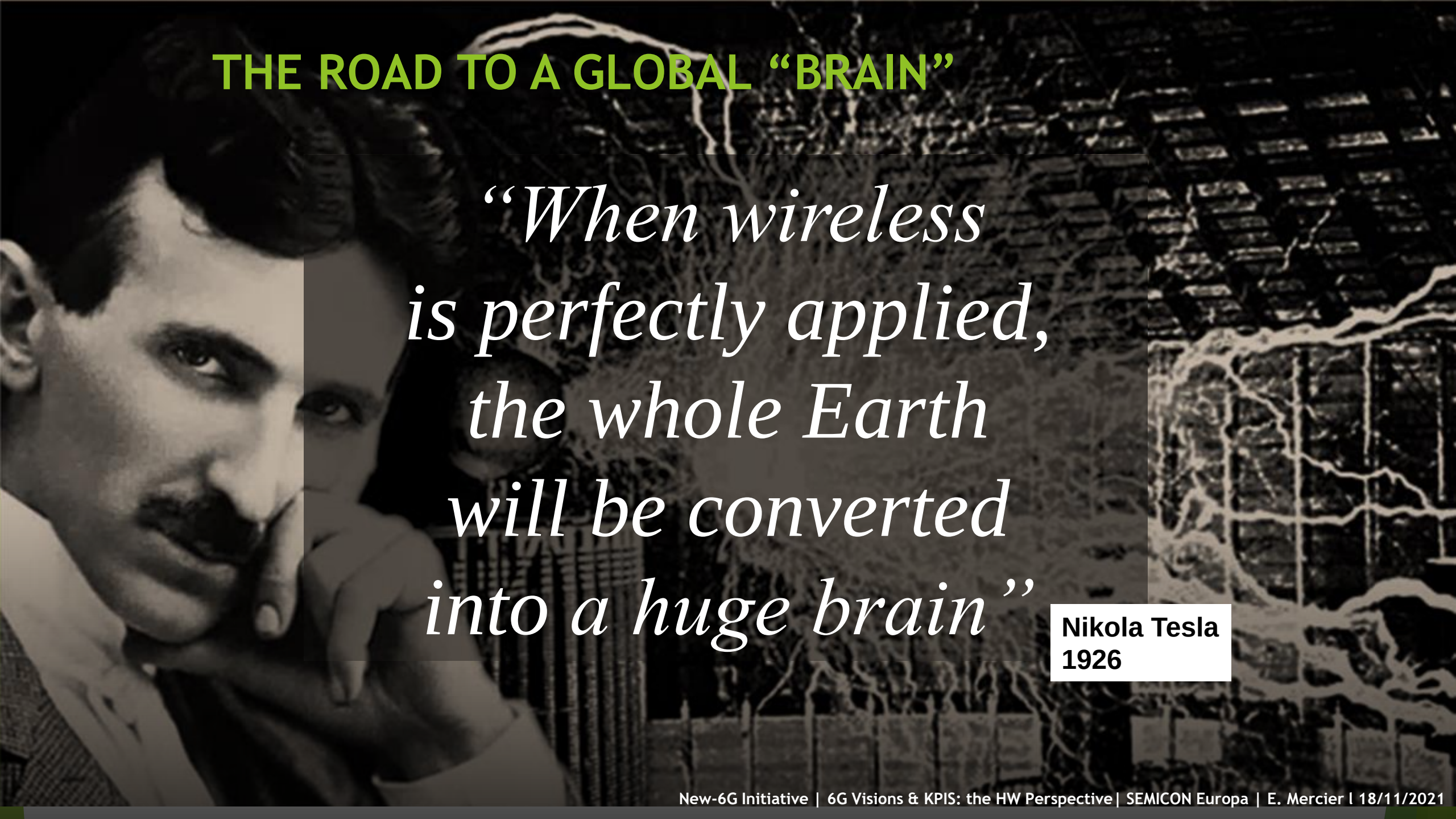
6G Visions and KPIs: the HW perspective

Eric Mercier, CEA Leti

Deputy Head of Wireless and Telecom Unit

eric.mercier@cea.fr

THE ROAD TO A GLOBAL "BRAIN"



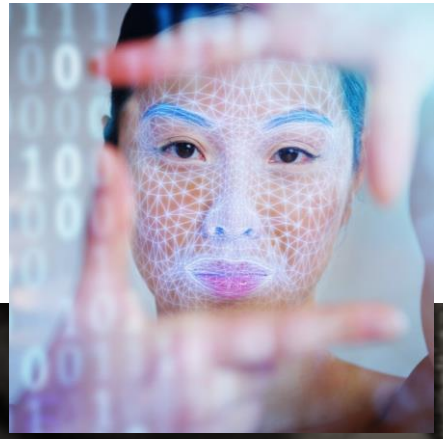
"When wireless is perfectly applied, the whole Earth will be converted into a huge brain"

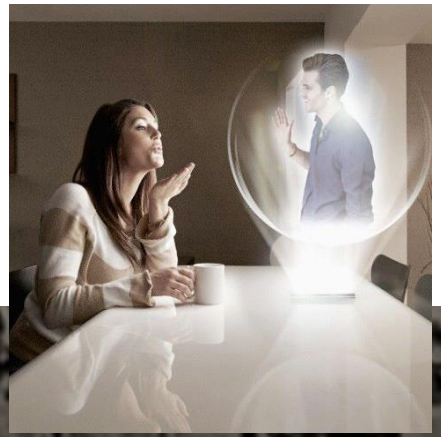
Nikola Tesla 1926

THE ROAD TO A GLOBAL "BRAIN"

By 2030, responding to fundamental **human and social needs** and based on the **expected progress in ICT,**

Tesla's prophecy may become a reality!





NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

NEW SERVICES DRIVING THE BEYOND 5G EVOLUTION

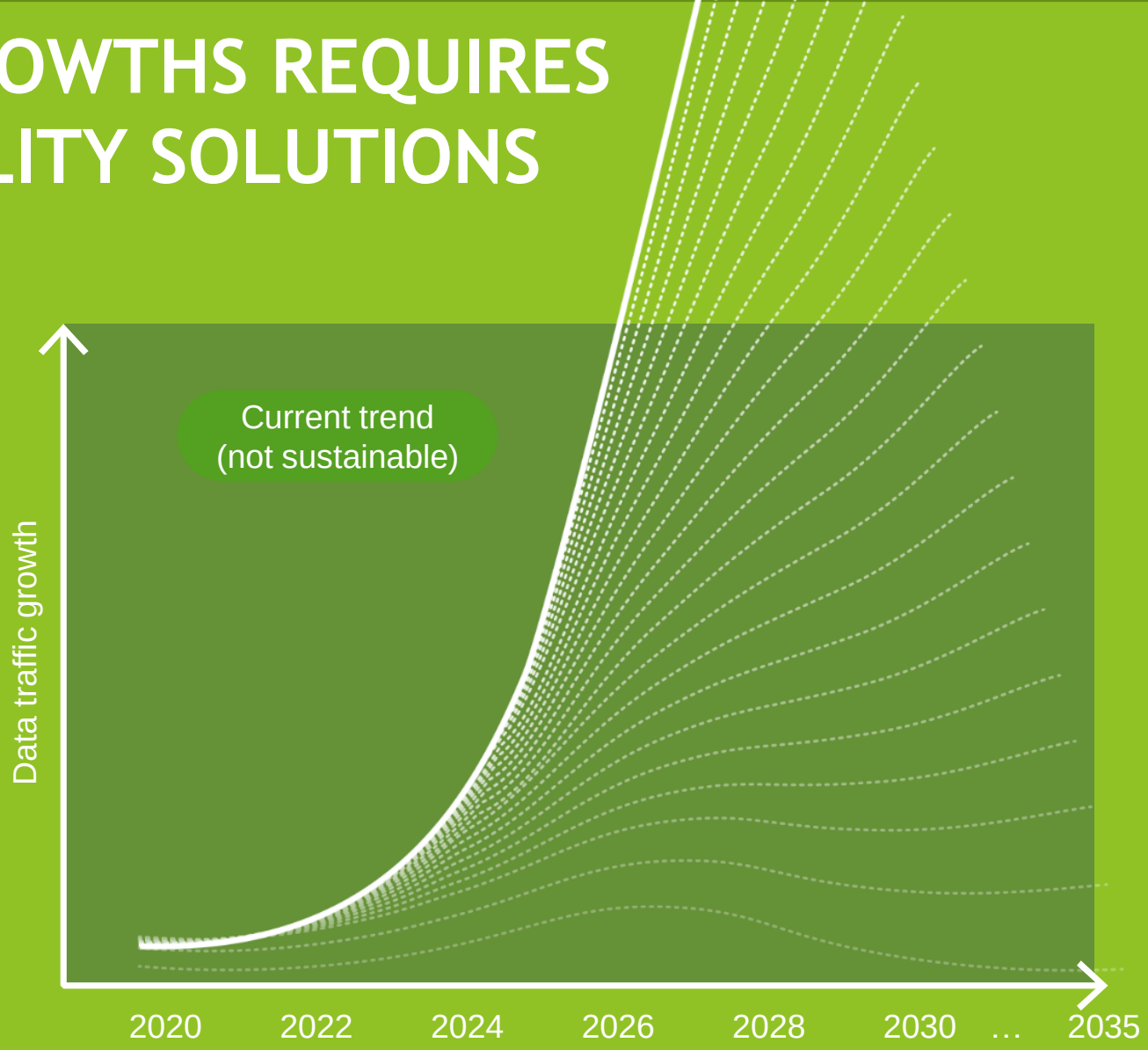
5 SENSES INTERACTIVE HOLOGRAM TECHNOLOGY

INTERACTIVE HAPTIC COMMUNICATIONS

- **Low Latency** (µs-ms)
- **AI Networking**: Autonomic **C**onnect-**C**ompute-**C**ache-**C**ontrol
- **Ultra-high capacity** (1-10 s Tbps)
- **Zero Power Communications** (1pj/bit)

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

EXPONENTIAL GROWTHS REQUIRES NEW SUSTAINABILITY SOLUTIONS



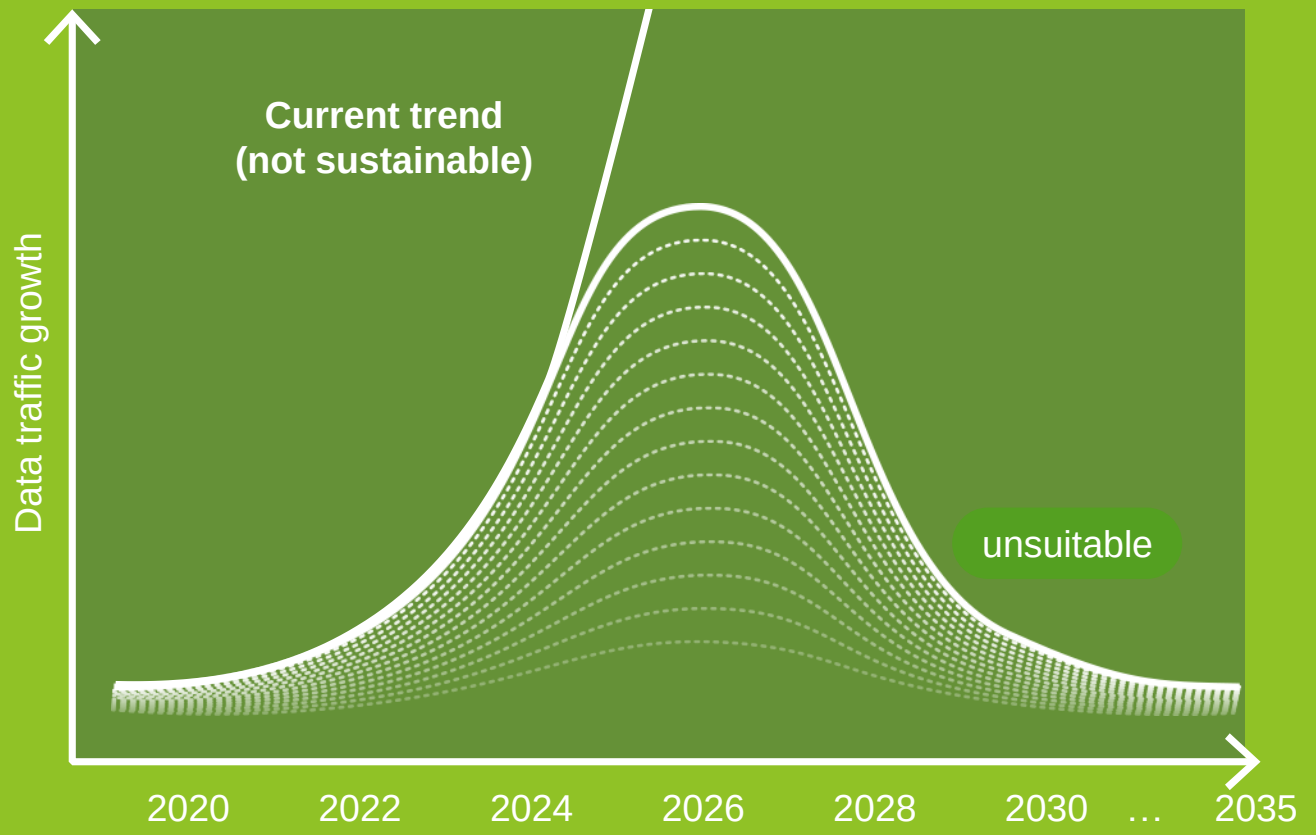
Data will consume 20% of world's energy

- 9 Billion of connected people on Earth
- 1 Trillion of connected devices
- Wireless communications and AI assistance will be a commodity
- The Cyber and Physical space fusion turn humans, things and events into information

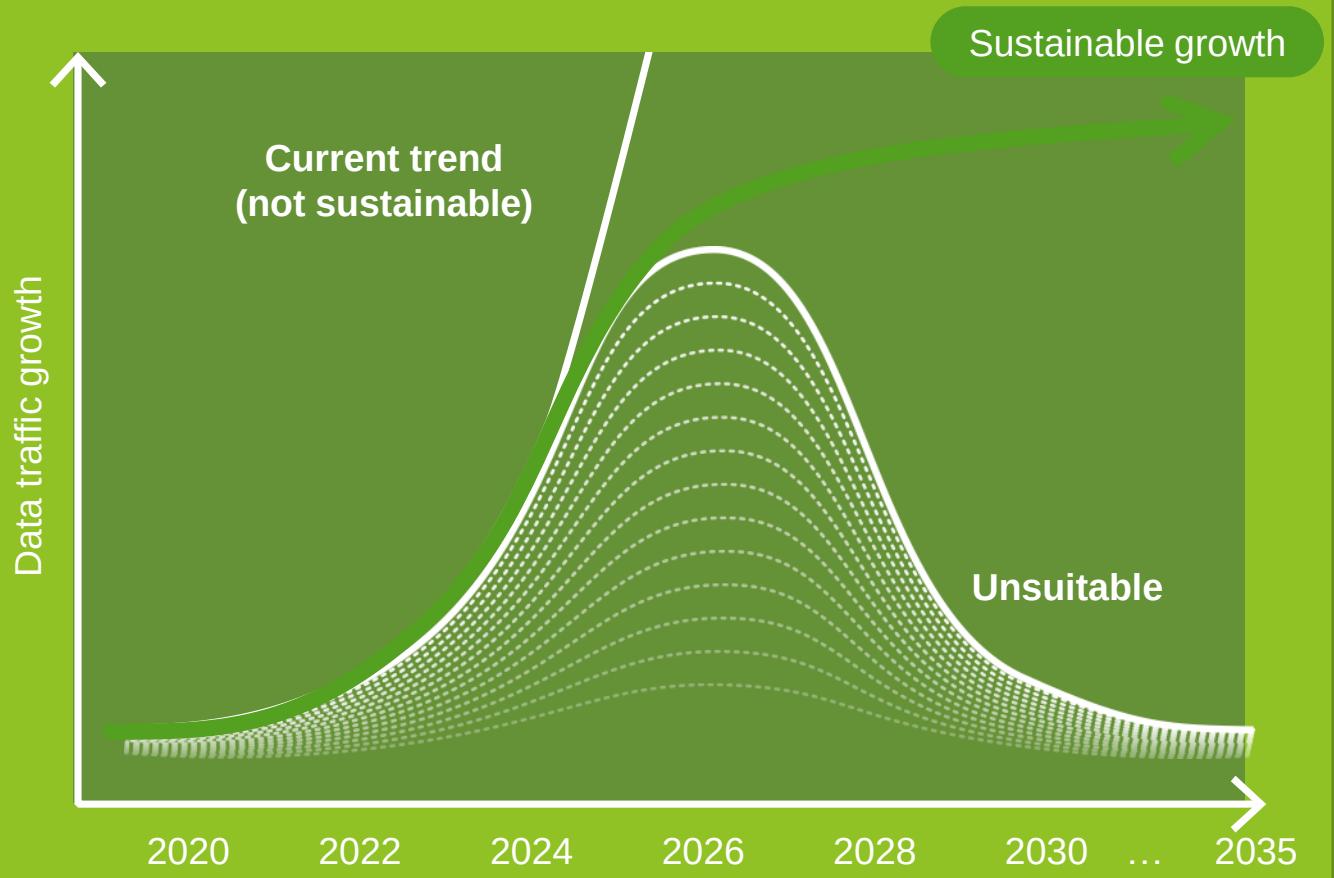
EXPONENTIAL GROWTHS REQUIRES NEW SUSTAINABILITY SOLUTIONS

Data will consume 20% of world's energy

- 9 Billion of connected people on Earth
- 1 Trillion of connected devices
- Wireless communications and AI assistance will be a commodity
- The Cyber and Physical space fusion turn humans, things and events into information



EXPONENTIAL GROWTHS REQUIRES NEW SUSTAINABILITY SOLUTIONS

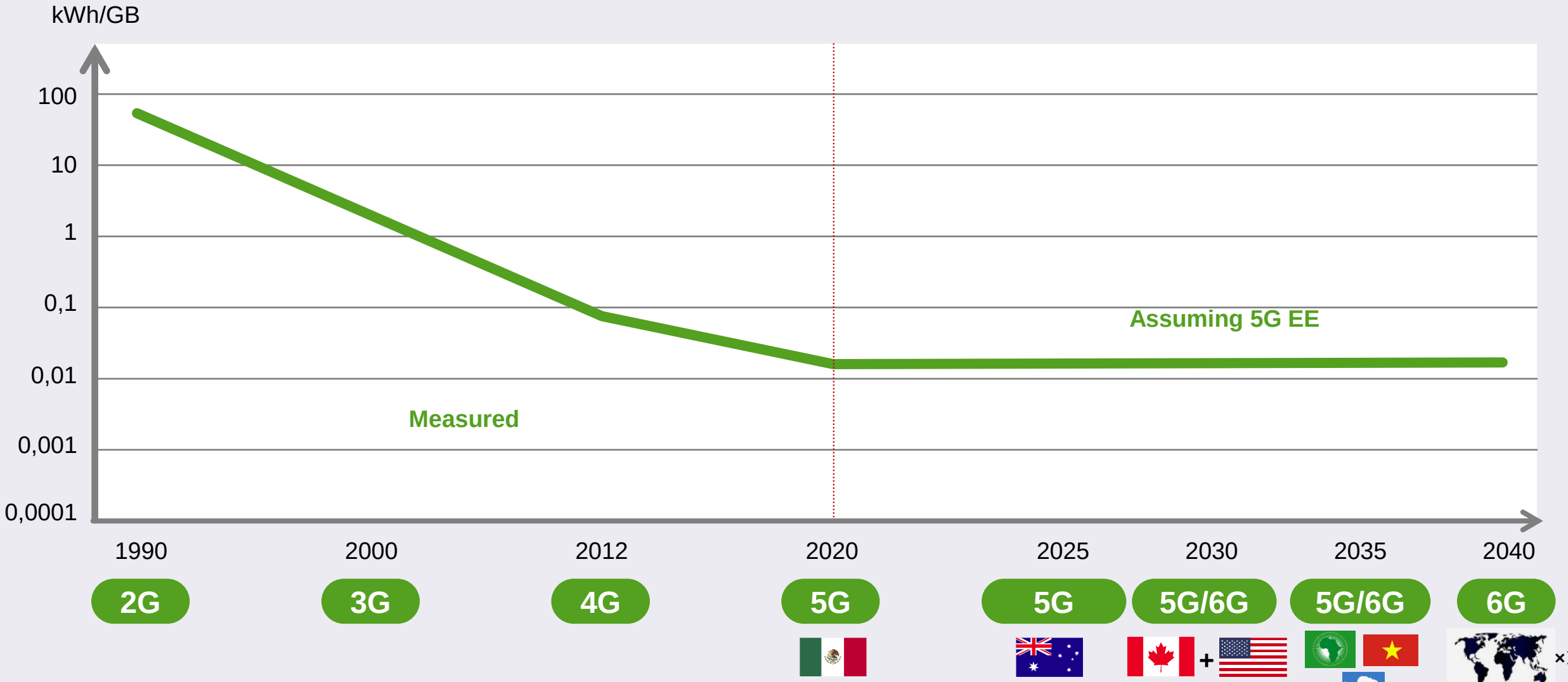


Data will consume 20% of world's energy

- 9 Billion of connected people on Earth
- 1 Trillion of connected devices
- Wireless communications and AI assistance will be a commodity
- The Cyber and Physical space fusion turn humans, things and events into information

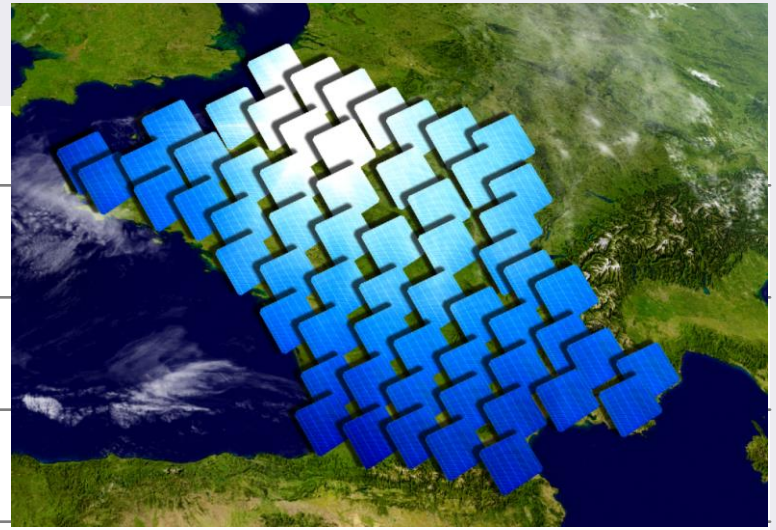
NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

WIRELESS NETWORKS' ENERGY CONSUMPTION



NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

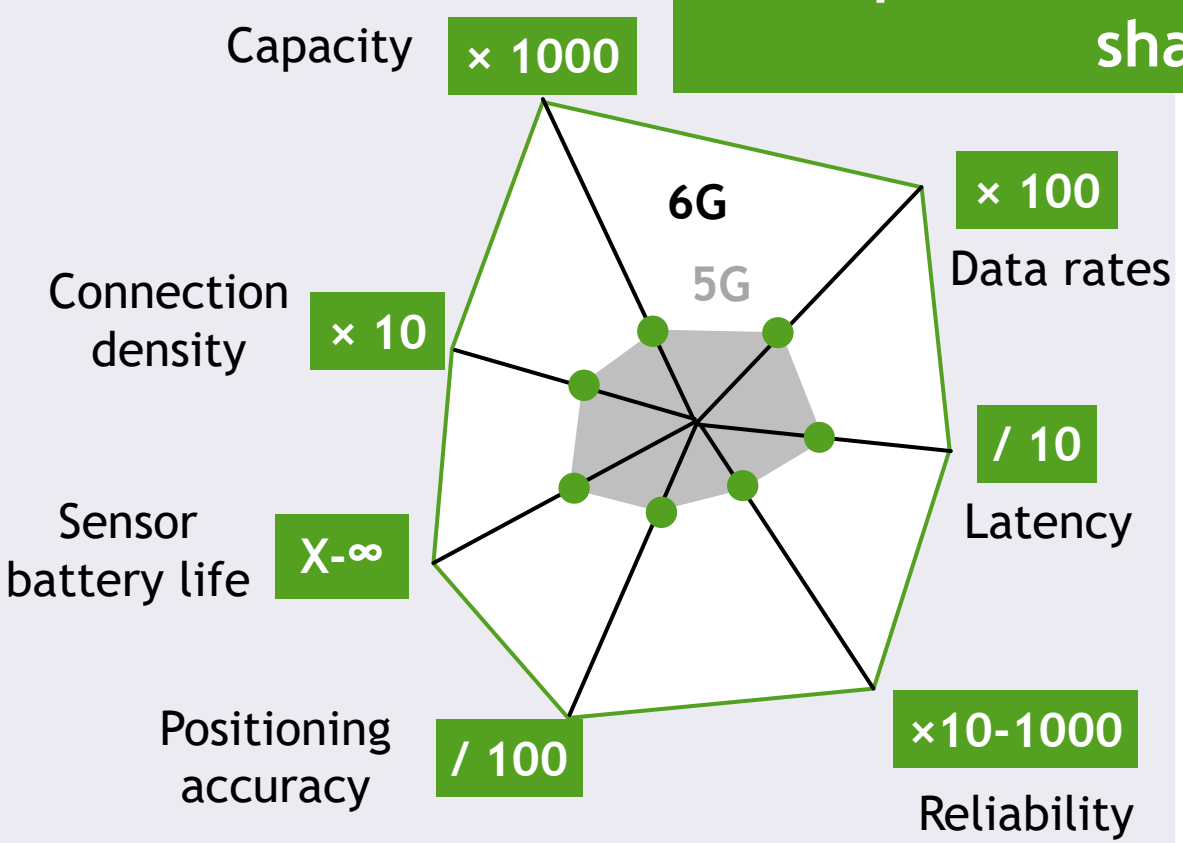
WIRELESS NETWORKS' ENERGY CONSUMPTION



NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

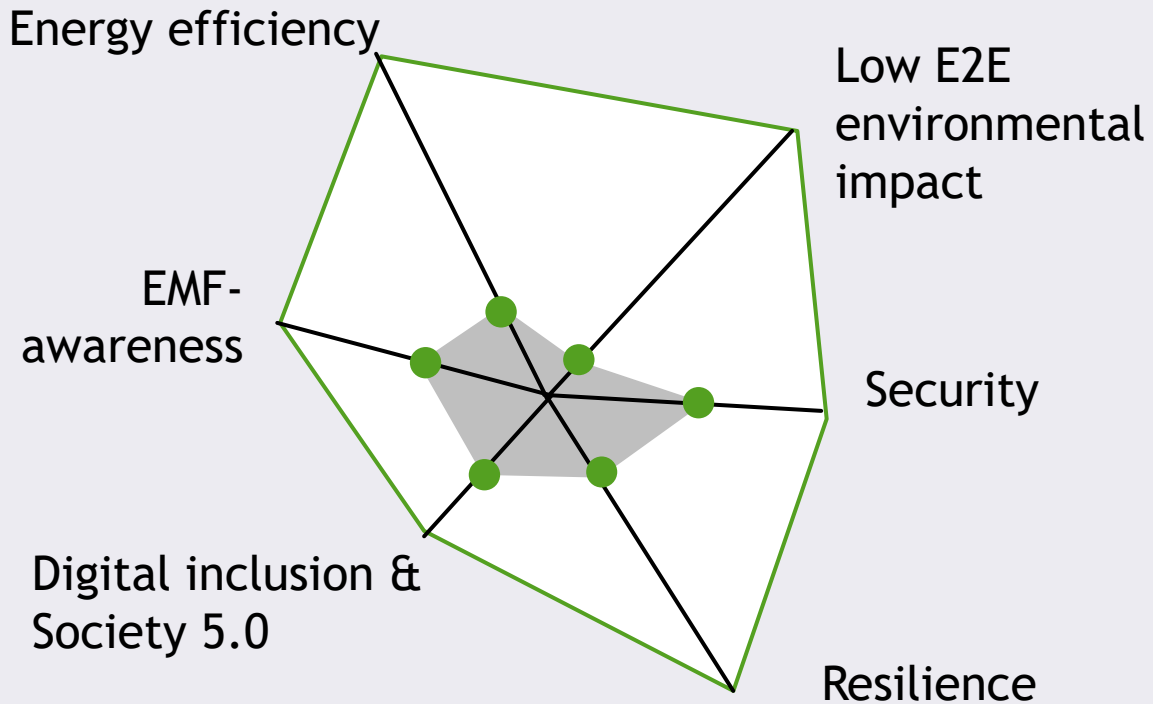
TECHNOLOGY EXPECTATION SHIFT AT 2035 HORIZON

6G target performance



New performance-societal requirements trade-offs shaping the system design

6G 2035+ societal needs



NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

6G KPIS: *THE SYSTEM LEVEL PERSPECTIVE*

5G improved system level KPIs

- To ensure the **conceptual continuity** with 5G
- To **extend performance** requirements on **already envisaged** sets of **KPIs** (x10 – x1000)

Entirely New 6G system level KPIs

- To support a ***connect-computation-intertwining of intelligence network***
- To extend to **connect-computer-store-control** capabilities to **NTN**
- To address **sustainability** (of technology, network operation, task, inference, EMF)

KPI	5G	6G
Traffic Capacity	10 Mbps/m^2	~ 1-10 Gbps/m^3
Data rate DL	20 Gbps	1 Tbps
Data rate UL	10 Gbps	1 Tbps
Uniform user experience	50 Mbps 2D everywhere	10 Gbps 3D everywhere
Latency (radio interface)	Up tp 1 msec	Up to 0.1 ms
Communication Reliability	Up to 10^{-5}	Up to 10^{-9}
Localization precision	10 cm on 2D	1 cm on 3D
Jitter	**NS**	**1 µsec**
Energy/bit	NS	pJ/bit
Energy/goal	NS	TBD
Inference reliability	NS	TBD
EMF	NS	TBD

Source: E. Calvanese Strinati and Barbarossa.,"6G Networks : Beyond Shannon Towards Semantic and Goal-Oriented Communications". Computer Networks Journal, Feb. 2021.

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

6G KPIS: *THE SYSTEM LEVEL PERSPECTIVE*

5G improved system level KPIs

- To ensure the **conceptual continuity** with 5G
- To **extend performance** requirements on **already envisaged** sets of **KPIs** (x10 – x1000)

Entirely New 6G system level KPIs

- To support a ***connect-computation-intertwining of intelligence network***:
- To extend of **connect-computer-store-control** capabilities to **NTN**
- To address **sustainability** (of technology, network operation, task, inference, EMF)

KPI	5G	6G
Traffic Capacity	10 Mbps/m^2	~ 1-10 Gbps/m^3
Data rate DL	20 Gbps	1 Tbps
Data rate UL	10 Gbps	1 Tbps
Uniform user experience	50 Mbps 2D everywhere	10 Gbps 3D everywhere
Latency (radio interface)	Up tp 1 msec	Up to 0.1 ms
Communication Reliability	Up to 10^{-5}	Up to 10^{-9}
Localizat	› How can we achieve them?	
Jitter	NS	1 µsec
Energy/bit	NS	pJ/bit
Energy/goal	NS	TBD
Inference reliability	NS	TBD
EMF	NS	TBD

Source: E. Calvanese Strinati and Barbarossa.,"6G Networks : Beyond Shannon Towards Semantic and Goal-Oriented Communications". Computer Networks Journal, Feb. 2021.

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

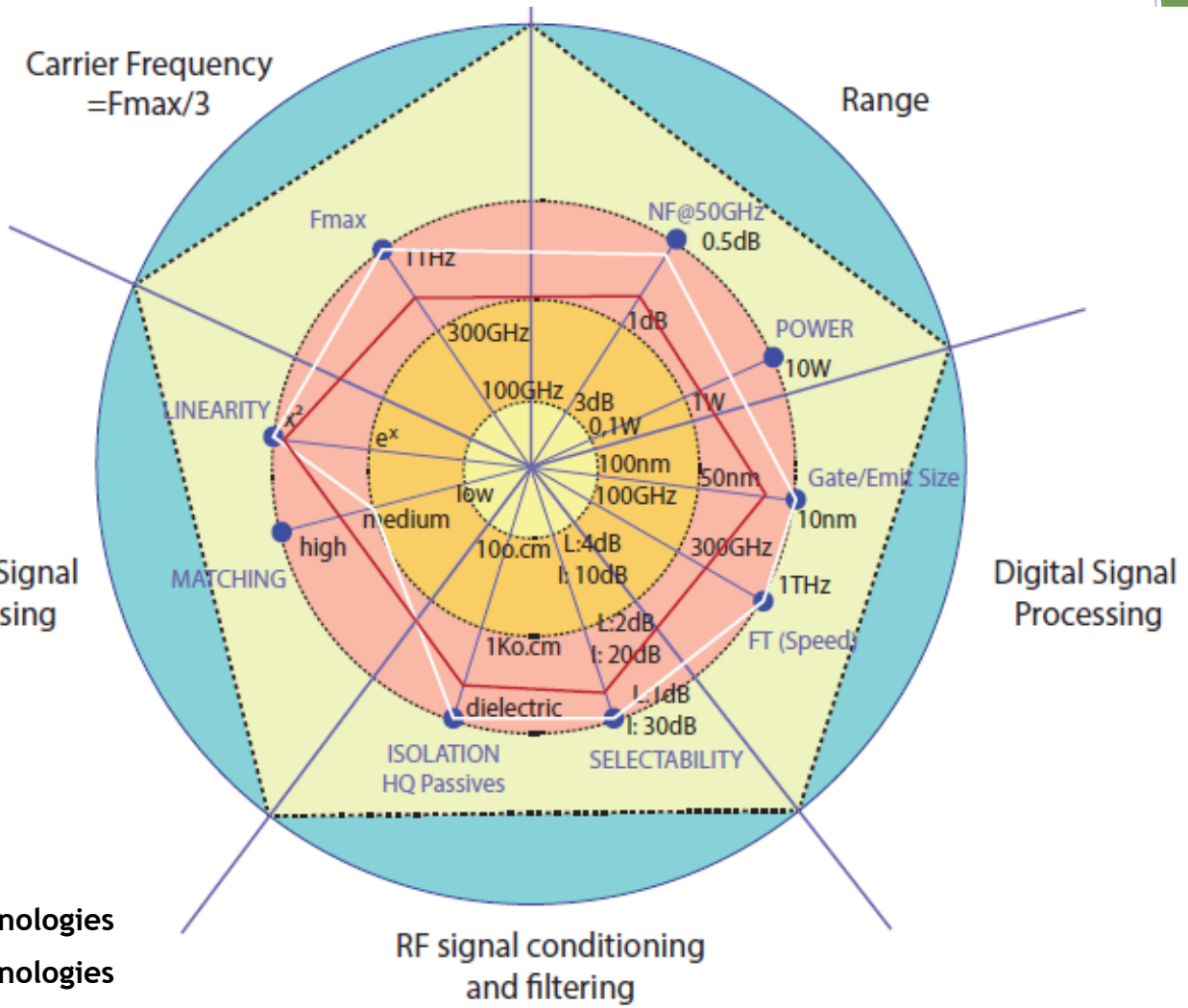
6G KPIS: THE HW PERSPECTIVES

New KPIs on HW & technology

- KPIs specifying the process technologies & required HW performance
- to support effective operation KPIs at system level

How to achieve the required performance?

- high out power
- selectability
- isolation
- acceptable EE (10-20%)
- High FMAX (Fmax/10 < F0< Fmax/3)
- …

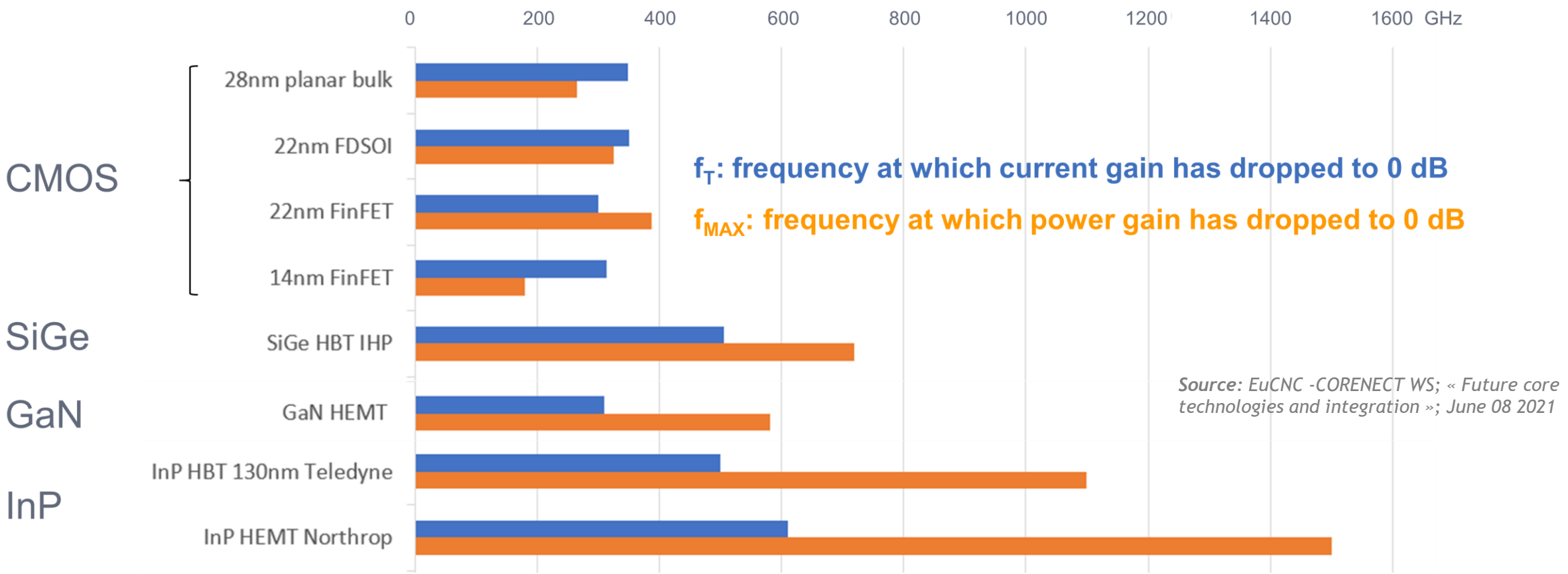


6G Technologies

5G Technologies

Source: E. Calvanese Strinati and et. al.,"Toward 6G: From New Hardware Design to Wireless Semantic and Goal-Oriented Communication Paradigms". (invited paper) ESSCIRC Conf 2021, Sept. 2021.

POSSIBLE SEMICONDUCTOR TECHNOLOGIES FOR 6G



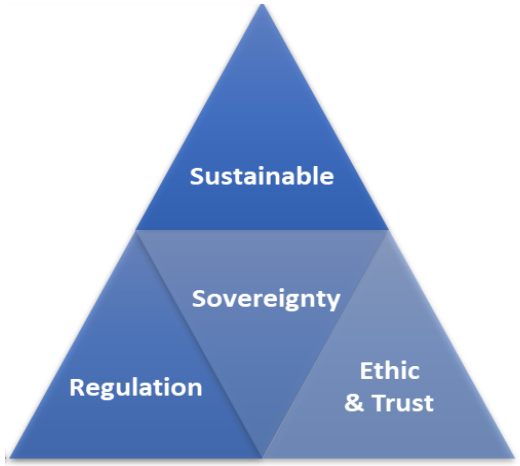
Source: EuCNC -CORENECT WS; « Future core technologies and integration »; June 08 2021

CMOS downscaling doesn't yield faster transistors anymore

- **SiGe** bipolar transistor faster than CMOS device
- **InP** beats all silicon devices in speed
- **GaN** not the fastest but the champion in power and efficiency

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

SOCIETAL EXPECTATIONS ON 6G



Societal Foundations

Sustainable

- **CAPEX** & long-term infrastructure deployment update
- **OPEX**
- Component **Eco-design**
- Enable **re-use of equipment's, components & materials**
- **Beyond terminal EE** & zero energy Connect-Compute operation
- Provision European Green deal enablers
- Impact on **Sustainability of ICT**

Future proofing & Regulations

- **Legislation** and **regulation** :EMF exposure, EE, use and sharing of spectrum, data protection, privacy, etc.
- Meet heterogeneous and evolving **international agreement**
- Guaranteeing wide **societal acceptance** of future B5G/6G networks

Trust & Privacy

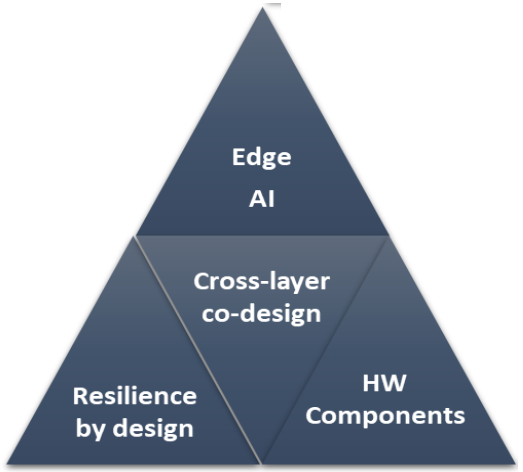
- Protect personal information use & spreading

European Sovereignty

- Promote technology procurement fairness and equity
- Make countries able to manage how data are handled
- Enable long-term availability of equipment's

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

6G KEY TECHNOLOGIES: THE SUSTAINABILITY-PERFORMANCE TRADE-OFF



Key Technologies & Skills

Edge AI

- **HW Technology** key to optimize data transfer & process for **C**onnect-**C**ompute-**C**ontrol
- Ultra lean and agile network reconfiguration with regards to its usage, load & momentary constraints (EE, EMF, QoS, QoE, Reliability, …)

Resilience by design

- Make functionalities insensitive to changing conditions across lifetime
- Maintain or regain network capacity anytime

HW & Components

- Enable optimized power consumption & adjusted performance
- Design HW solution with flexibility and sustainability targets

Cross-layering and E2E co-design

- Find best trade-off over power consumption related to the load
- Design solutions to optimize a set of KPI rather than individual ones

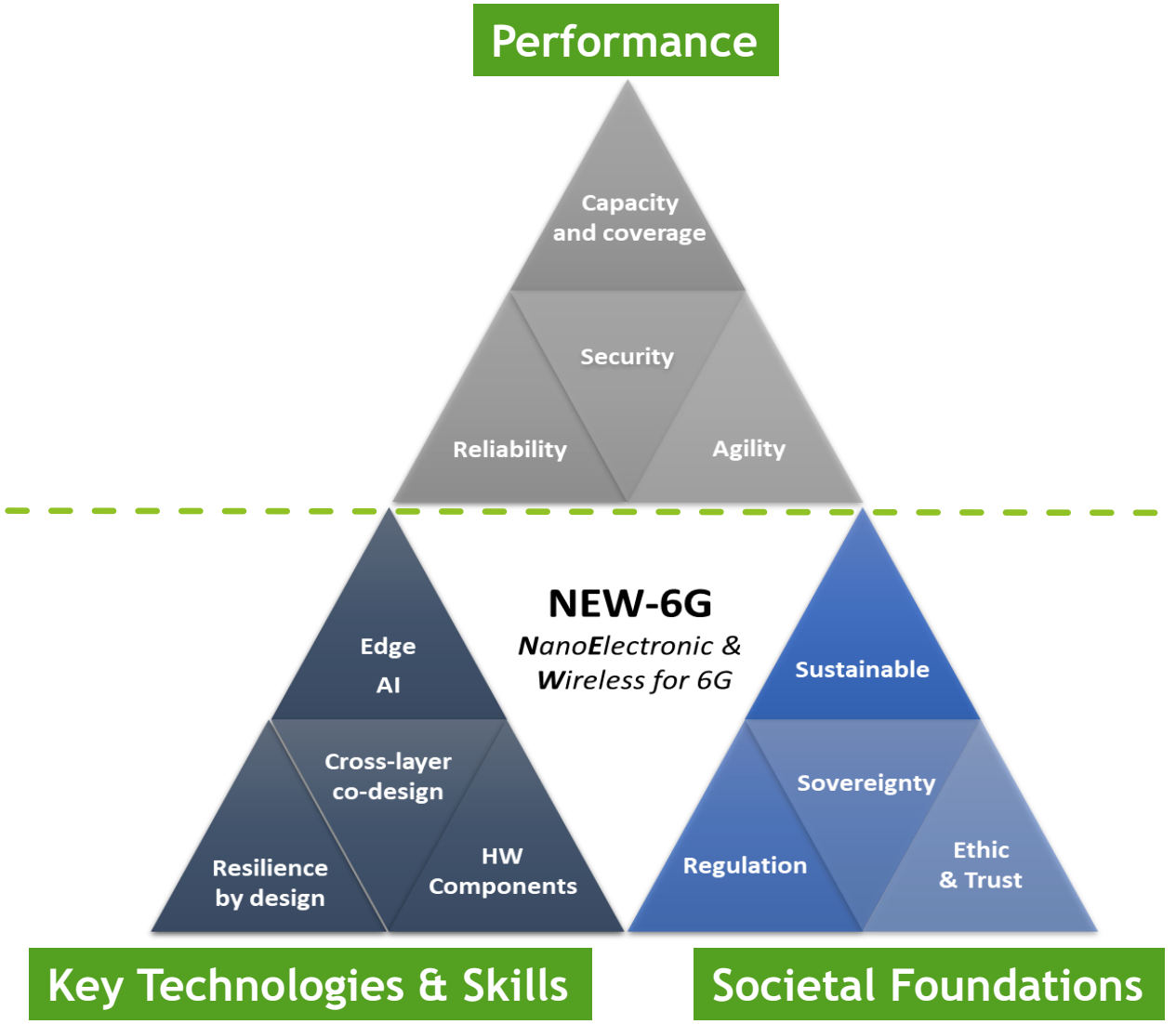
New HW design to bridge the gap between *desired system* level *performance* & sustainable *operational reality*…

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

WHY THE NEW-6G INITIATIVE?

6G Outcomes

6G Foundations



NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

NEW-6G: HOW ?

- The initiative brings together **industrial**, **institutional** and **academic** stakeholders to:
  - **Establish a roadmap** for industry, research and training (usages, societal impacts, technologies)
  - **Draw together the world of telecoms and microelectronics** to take up jointly the challenges of tomorrow and prepare the necessary technologies
  - **Encourage cooperation, share knowledge and emergence of innovative ideas**, thereby stimulating development of the sovereign technologies of change that will pave the way to 6G.

- First 2021 ambitions
  - **Sharing and listening**. How can the microelectronics and telecom industries claim to respond jointly to 6G requirements?
  - **Commitment**. What actions are necessary to provide efficient hardware and software technologies to set the foundation of 6G?
  - **Action**. What roadmaps must be drawn up at each partner's level to achieve the goals?

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

CONCLUSION

- 5G : New Business, new Digital revolution as expected by Industries
  - *But usages and benefits for Citizens and Industries are not yet clear …*
- 5G : Societal Impacts as prime challenge to be faced
  - *But not as day-one input from standardisation side …*
- 5G : Existing and mature technologies still considered in an iterative way
  - *But Moore's law runs out of steam …*

6G

Industry usage, citizenship needs and societal impacts must drive 6G Technology Researches

Moore's law and Natural Technology Evolution will not enhance anymore 5G evolution
Mandatory Cross-Fertilization between Research in Telecom and Microelectronics domains

NEW-6G ambitions to draw 6G roadmaps for Microelectronics & Telecom

NEW-6G
NANOELECTRONICS & WIRELESS FOR 6G

Join us !

#new-6g