NEXT G ALLIANCE
an ATIS initiative

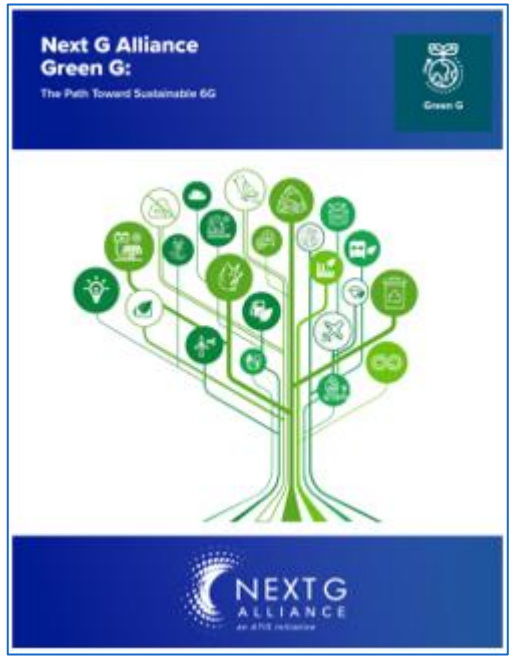
Green G Working Group Leadership:

Marie-Paule Odini, HPE, Chair
Micaela Giuhat, Microsoft, Vice-Chair
Colleen Josephson, VMware, Vice-Chair

March 25, 2022

Next G Alliance

The Path Toward Sustainable 6G Webinar



- Keynote speaker, Nada Golmie (NIST)
- Subject matter expert: Bhushan Joshi (Ericsson)
- Panel discussion with audience Q&A:
  - Panelists: Andrea Bohmholdt (MITRE), Clara Li (Intel), and Amy Zalman (Georgetown)
  - Moderator: Carsten Baumann (Schneider Electric)

White paper: *Green G: The Path Towards Sustainable 6G*
For more information: Green G – Next G Alliance

Any product or brand name mentioned in this presentation does not constitute an endorsement by NIST.

Towards Sustainable Next G

Challenges and Opportunities

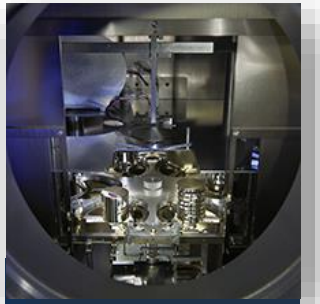
Nada Golmie

National Institute of Standards and Technology
U.S. Department of Commerce

CTL Communications Technology Laboratory

NIST Laboratories

Material Measurement Laboratory



Physical Measurement Laboratory

Engineering Laboratory

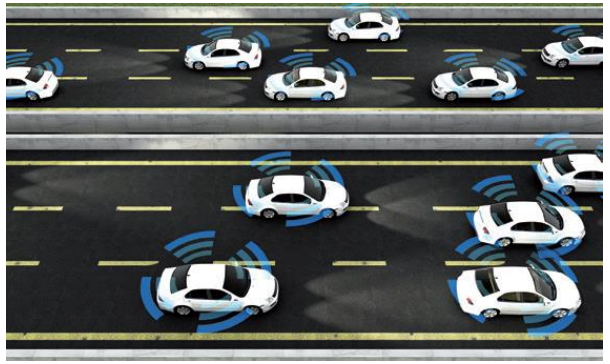
Information Technology Laboratory

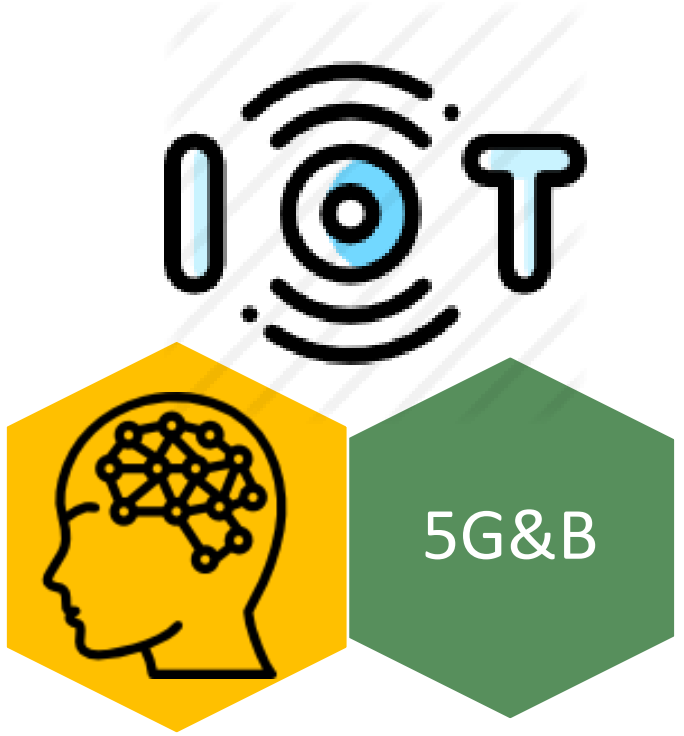
Communication Technology Laboratory

NIST Center for Neutron Research

Conduct and facilitate leading edge R&D in support of metrology and standards to accelerate the development and deployment of advanced communication systems

Towards Enhanced Connectivity

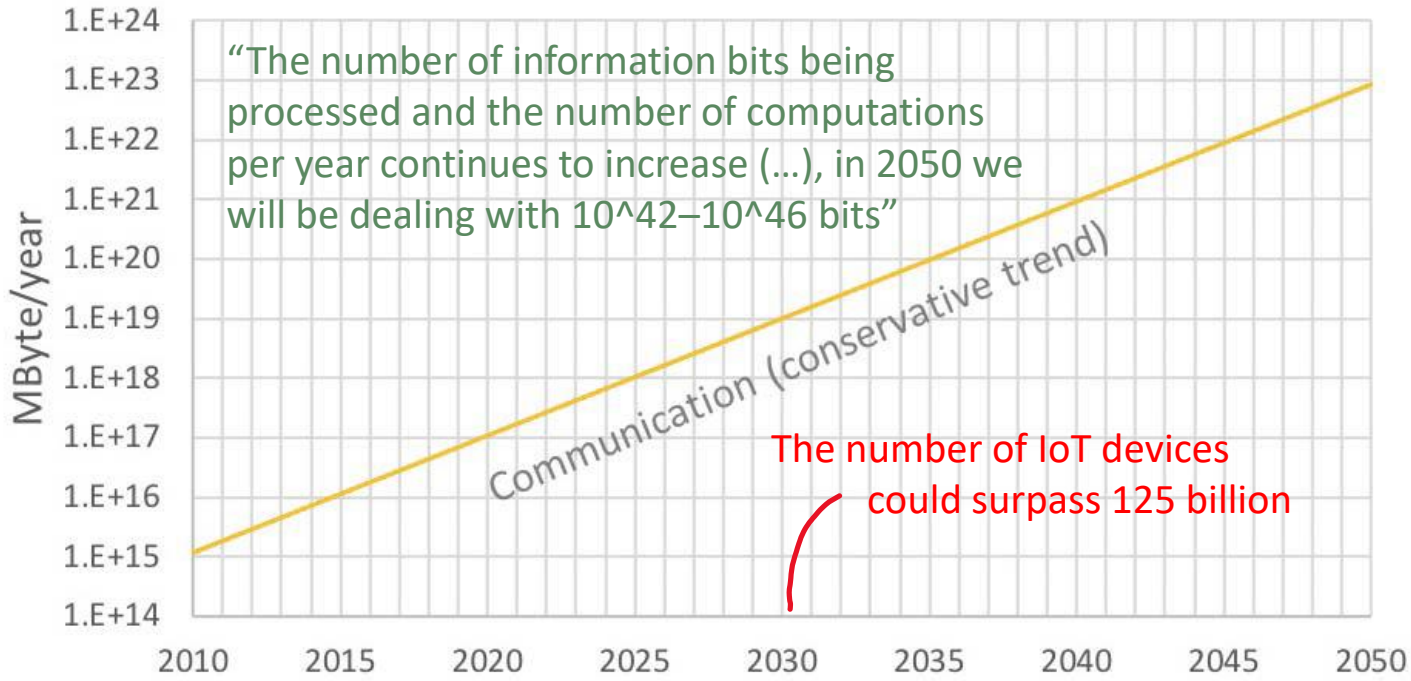




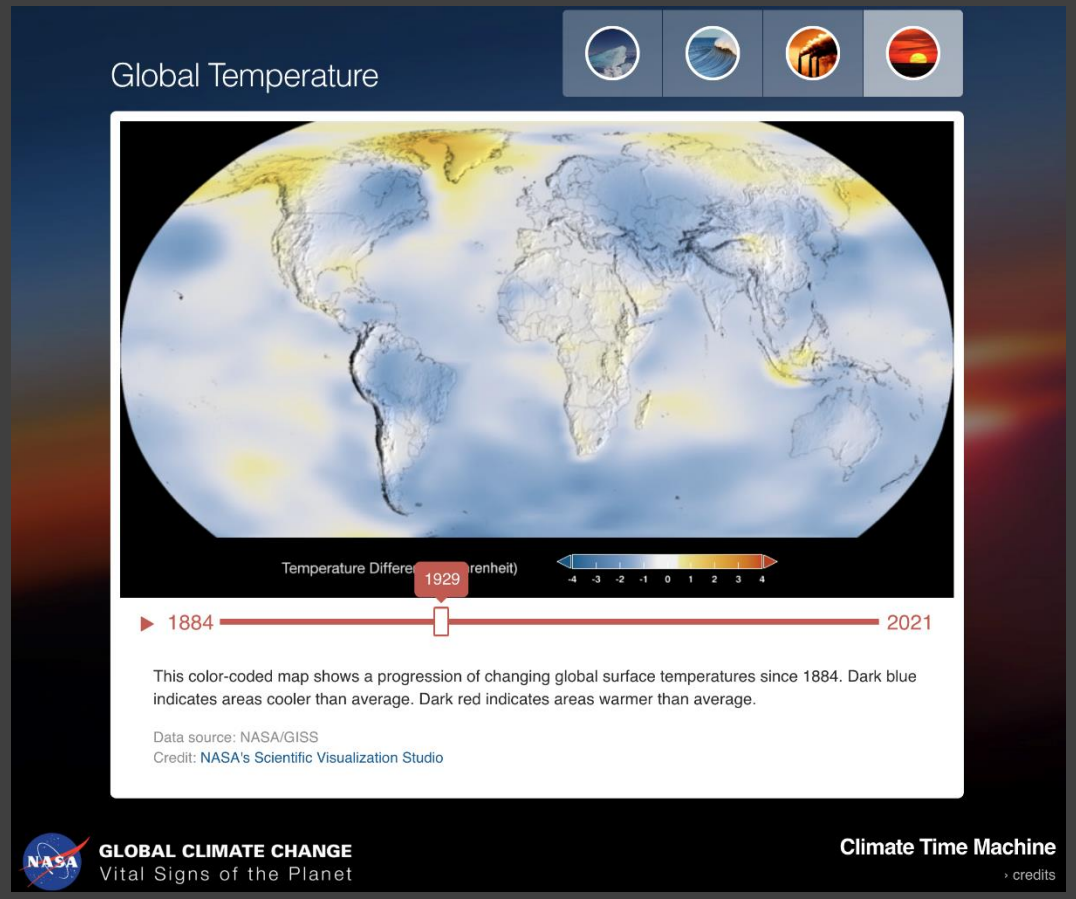
Enhanced Automation
Enhanced Control
Enhanced Intelligence
Enhanced Connectivity

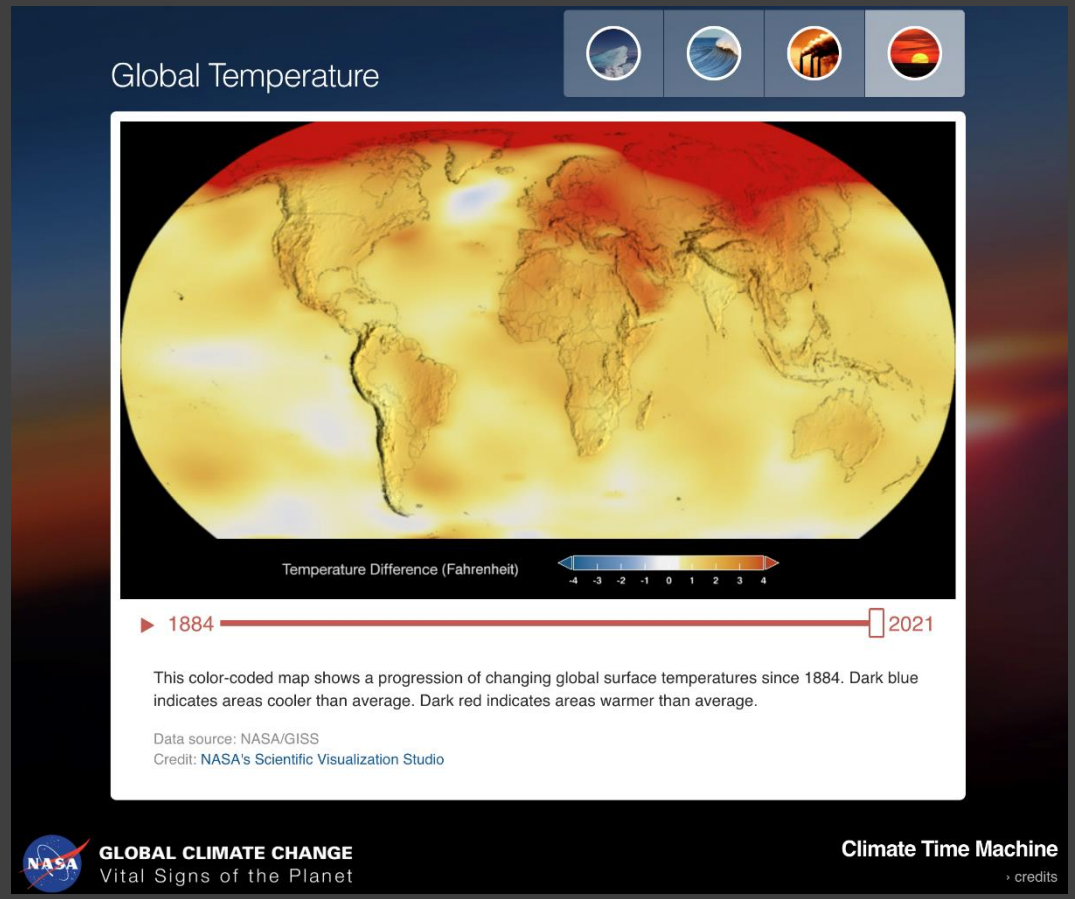
Impact of Enhanced Connectivity

- Industry 4.0
- Media / entertainment
- Retail
- Smart cities
- Transport
- Health
- Agriculture
- Financial services
- Construction
- Energy



M. Hilbert and P. Lopez, "The World's Technological Capacity to Store, Communicate, and Compute Information", Science 332 (2011) 60-65





Impact on the Planet

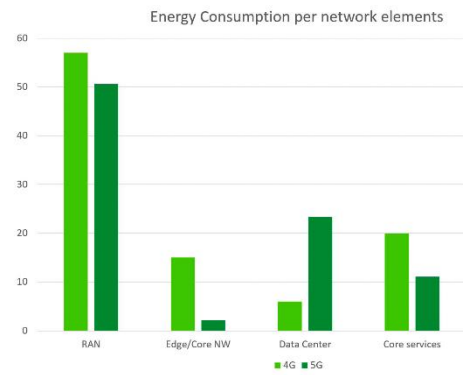
https://climate.nasa.gov/

Sustainability Goals for Next G

Era of virtually free and abundant energy is over!

- United Nations Intergovernmental Panel on Climate Change commits to limit increase in global surface temperature to 1.5 to 2°C by 2050.
  - Current level is at 1.2 °C.
- In 2020, the ICT industry set a Science-Based Pathway, to reach net-zero GHG emissions by 2050.

Energy Efficiency vs Consumption



Next G Alliance Green G report, 2022.

Demand is outpacing advances in Moore's Law (as we reach fundamental physical limits)

4G -> 5G---->Next G

- 16 times more throughput
- 5 times more bandwidth
- Extended battery life (target is greater than 10 years)
- 4 times more power consumption
- 2 to 3 times more (smaller) cells

Energy production is growing linearly by 2% every year.

Chip-level energy per one bit transition in processors is decreasing to about 10 attojoules (10-17 J).

Total energy consumption for computing is doubling every 3 years

Telecommunications specifically consumes 2-3% of the global electricity supply.

Electricity cost represents a third of a carriers' average operational costs

The ICT industry currently consumes 5-9%, but this may rise up to 20% by 2030.

Sustainability Paradox for Next G

Increase energy efficiency in network infrastructure

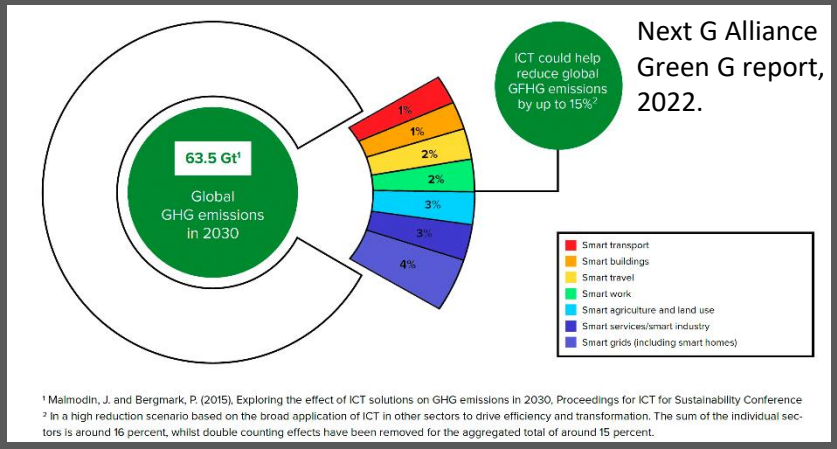
and

Reduce the amount of traffic going through it.

- Mitigate rebound effect: technological innovation offset by consumption increase.
- Reduce overconsumption and raise consumer awareness

The Enablement Effect , The impact of mobile communications technologies on carbon emission reductions, GSMA report 2019:

- *"The total annual emissions of the mobile sector are about 0.4% of total global emissions.*
- *[…] The level of avoided emissions enabled is 10 times greater – a tenfold positive impact. "*



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¹ Malmodin, J. and Bergmark, P. (2015), Exploring the effect of ICT solutions on GHG emissions in 2030, Proceedings for ICT for Sustainability Conference
² In a high reduction scenario based on the broad application of ICT in other sectors to drive efficiency and transformation. The sum of the individual sectors is around 16 percent, whilst double counting effects have been removed for the aggregated total of around 15 percent.

Sustainability R&D Opportunities for Next G

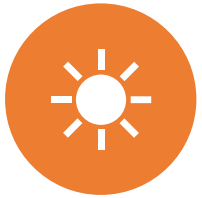
Energy consumption models

Energy-aware network planning and optimization

Directional antennas and reconfigurable intelligent surfaces

Use of AI/ML

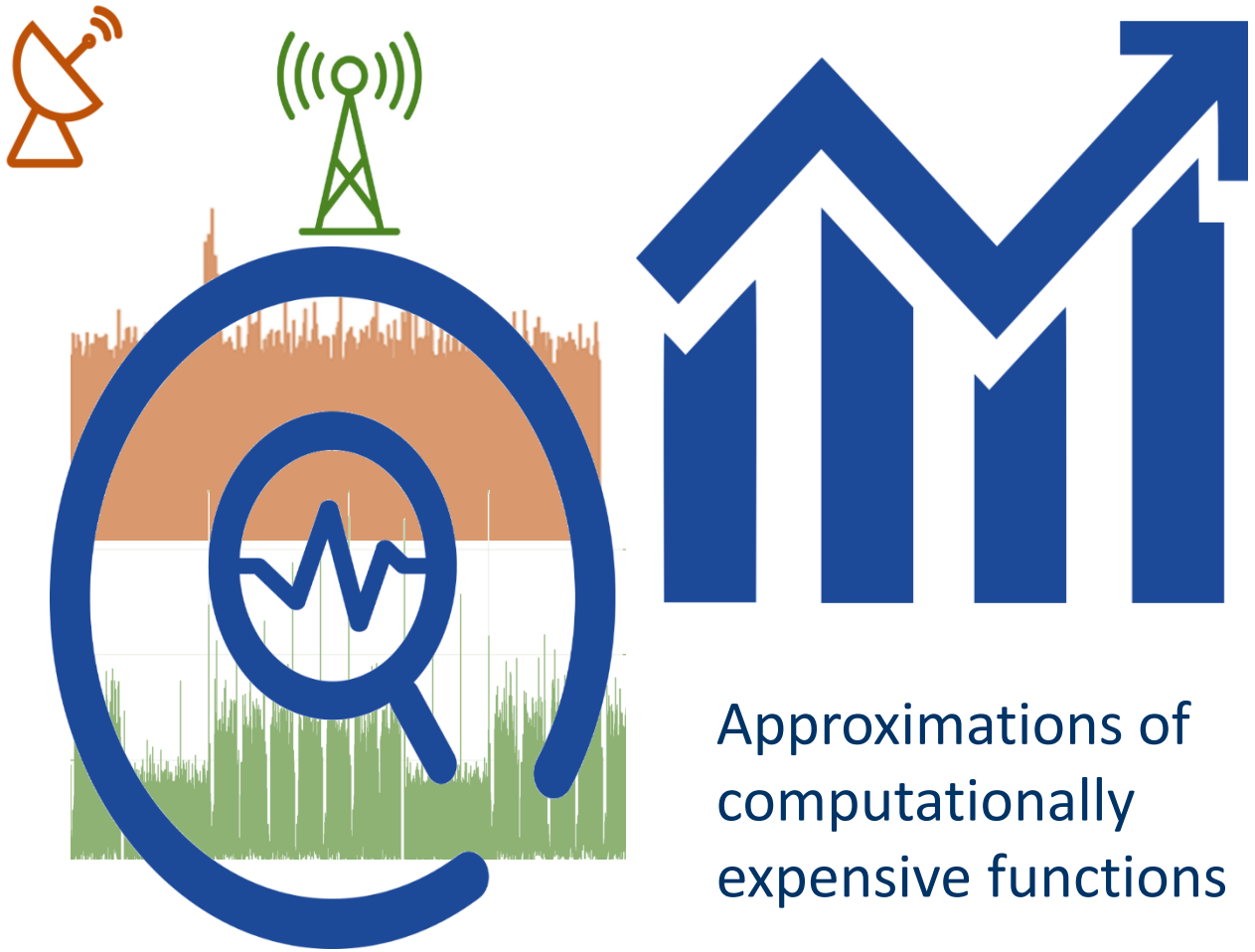
Radio resource management



Energy renewables

AI/ML in Support of Next G Sustainability

Solutions to Next G network optimization problems (over large sets of variables)

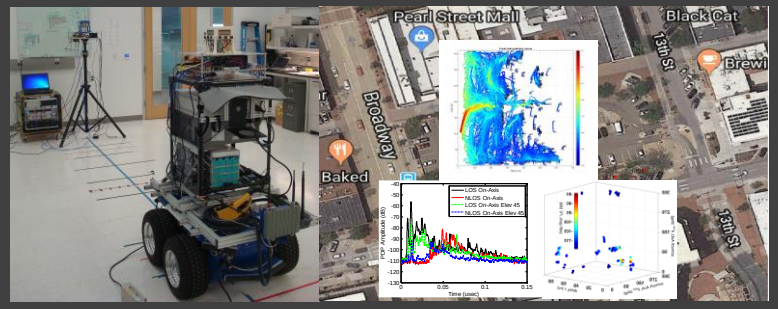


Approximations of computationally expensive functions

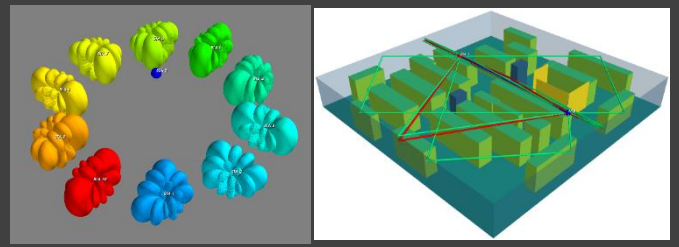
- RF signal detection
- Antenna configuration, beam steering, tracking
- MIMO system optimization
- Channel estimation / propagation
- Dynamic spectrum utilization
- End to end performance: QOE and QOS mapping
- RF Planning/ coverage

Energy-efficient training and inference

Measurements & Modeling for Enhanced (Communication) Intelligence



Channel propagation measurement and modeling, standards development



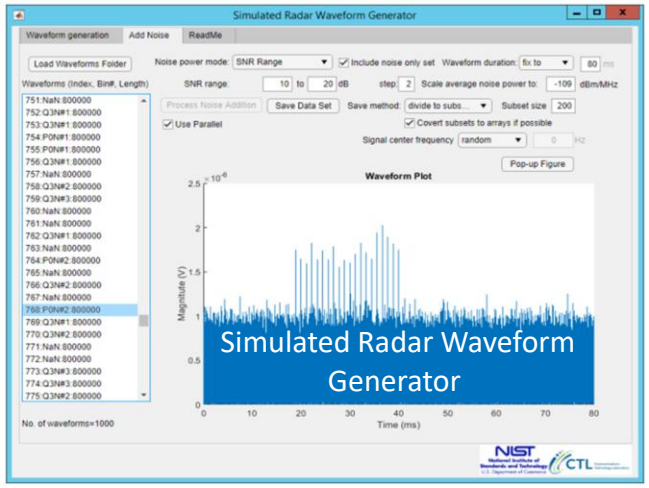
Beamforming modeling and system level performance evaluation

- Measurements
- Models
- Machine Learning
- Communications Datasets

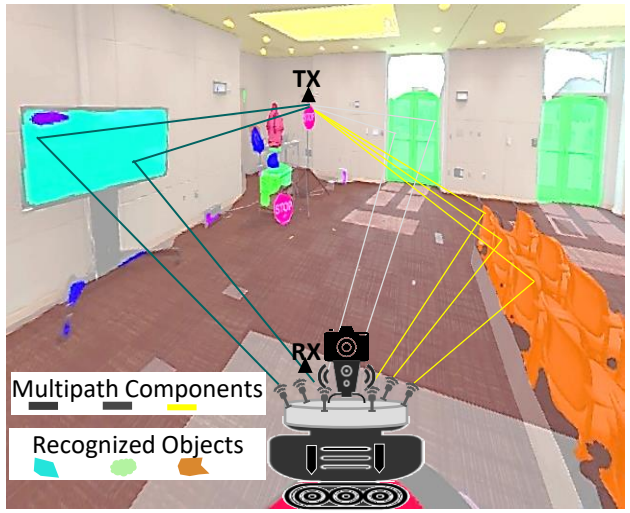
Measurement Data for AI/ML & AI-aided modeling

Radar detection

Radar waveforms dataset, software, methods and models published, https://doi.org/10.18434/M32229, https://git.io/RadarDL



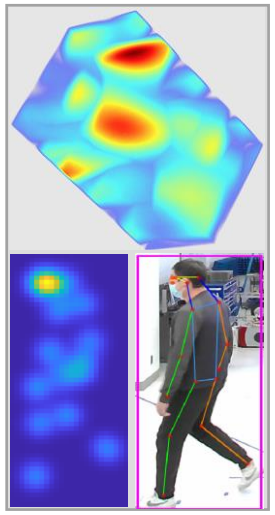
Channel Modeling



Object recognition to assist estimation of mmWave channel model parameters

- Parse the environment via object recognition and segmentation
- Automate the mapping of the multipath components to the objects

Human Sensing

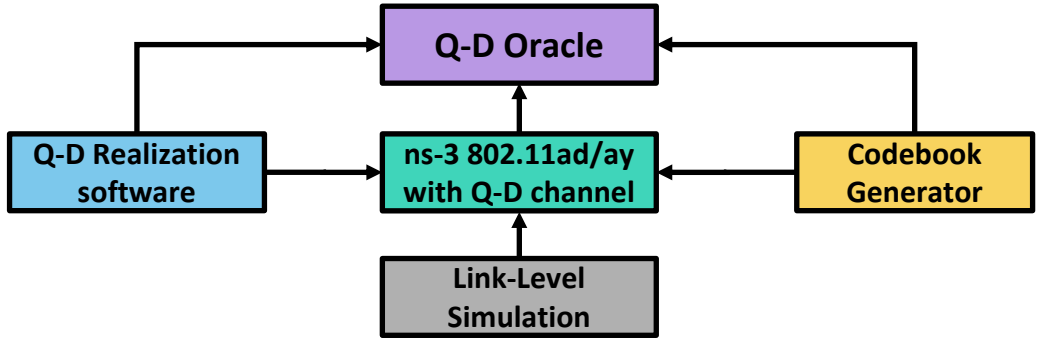


Deep learning algorithms for mmWave human body sensing

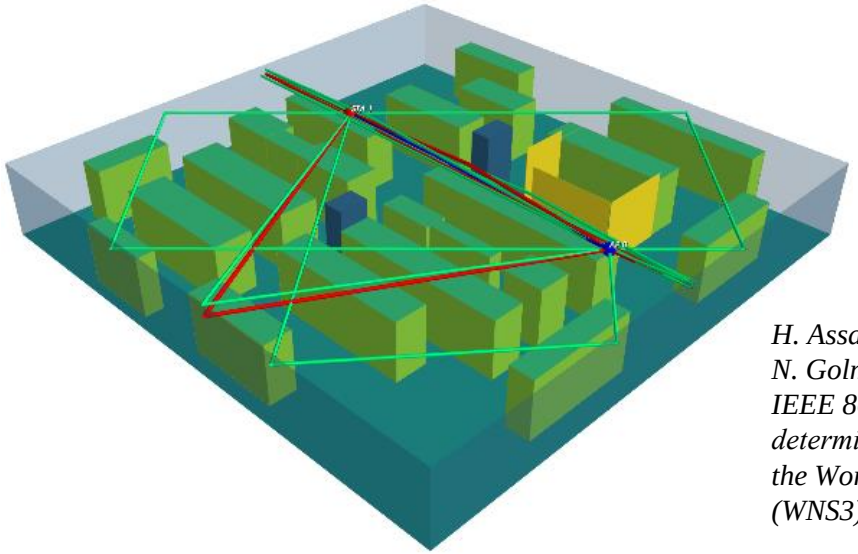
- Camera+lidar to estimate human body pose (e.g., keypoints) and location in 3d space
- Train deep learning algorithm to estimate human body pose from RF data

Measurement-based Modeling & Tools Suite

NIST Q-D Channel Framework



Beamforming training result for a transmitter/receiver pair (obtained using the Q-D framework developed by NIST)



- Publicly available Q-D framework with MIMO Q-D channels realization, error models and visualization implementations for IEEE 802.11ad/ay standards https://github.com/wigig-tools.

- Release of Q-D Oracle ➔ Standalone Beamforming Training and Tracking evaluation software ➔ Machine-Learning based Beamforming Training and Tracking algorithms tailored for IEEE 802.11ad/ay

H. Assasa, J. Widmer, T. Ropitault, A. Bodi, N. Golmie, "High Fidelity Simulation of IEEE 802.11ad in ns-3 Using a Quasi-deterministic Channel Model" presented at the Workshop on Next-Generation with ns-3 (WNS3), Florence, Italy, June 21, 2019

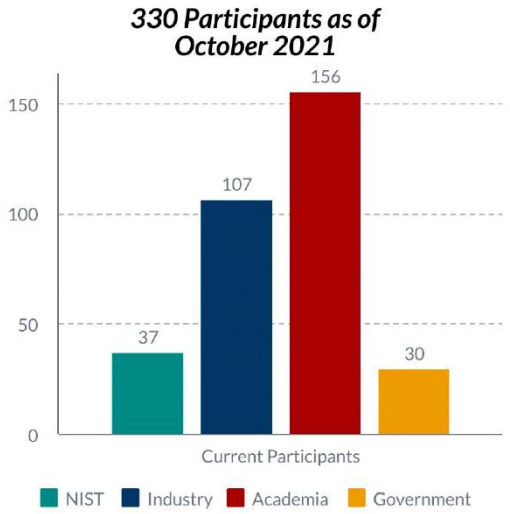
M. Kim, T. Ropitault, S. Lee, N. Golmie, Hanny Assassa, Jorg Widmer, "A Link Quality Estimation-based Beamforming Training Protocol for IEEE 802.11ay MU-MIMO Communications, in IEEE Transactions on Communications, doi: 10.1109/TCOMM.2020.3030956, October 2020.

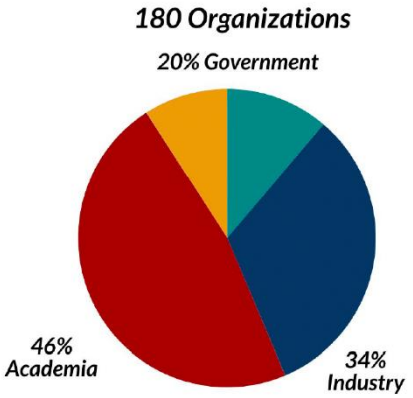
Next G Channel Model Alliance

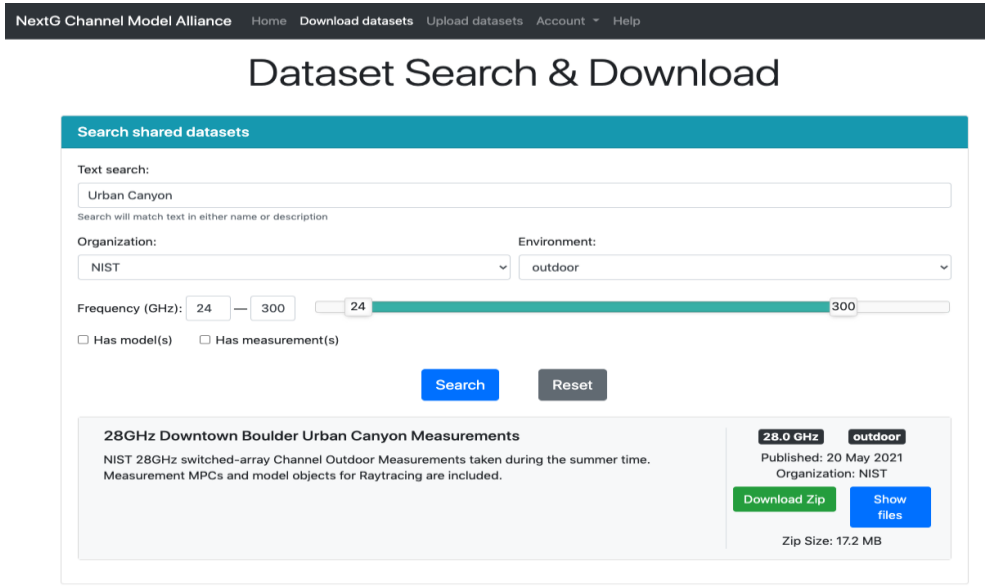
- Established user community for wireless signal propagation measurements and modeling

- Repository of data measurements and models available online: over 200 participants and 30 datasets.

- Monthly webinars, sponsored workshops and meetings co-located with major conferences & events: IEEE ICC, VTC, GLOBECOM, TIP and others.







Providing State-of-the-Art Testing Facilities

- Advanced Communications and Metrology Laboratory
- National Broadband Interoperability Test Bed
- 5G Cellular Metrology Network Testbed
- 5G Cybersecurity Reference Implementation

Tools for Industry: https://www.nist.gov/communications-technology-laboratory/wireless-networks-division/wireless-networks-division-tools

Partnerships and Collaborations

NASCTN

A multi-agency-chartered partnership hosted at NIST that organizes a national network of Federal, academic, and commercial test facilities performing spectrum research.

Public Safety Communications

Partner with FirstNet and first responder community to identify needs, and R&D priorities.

NIST invests in innovators to deliver technologies, products, and solutions.

Public Private Collaborations

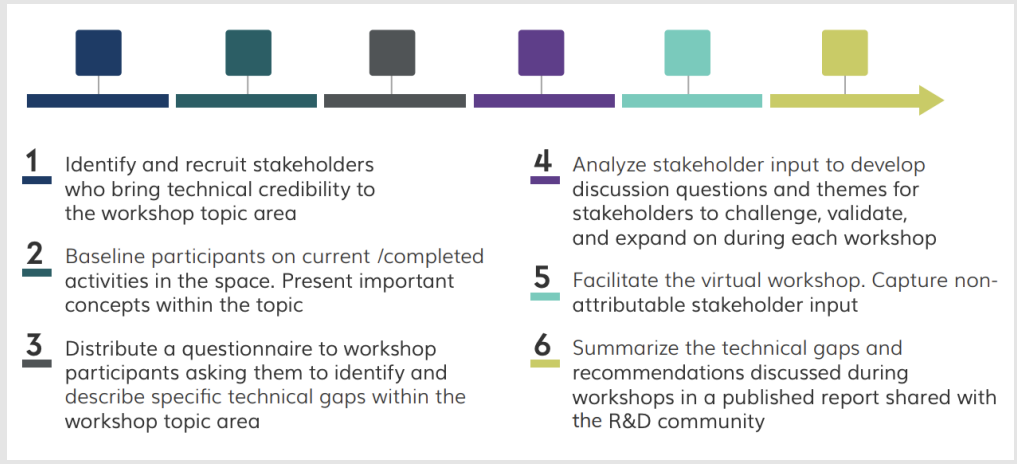
Next G Channel Model Alliance

NSF/NIST/DOD/Industry Resilient Intelligent Next Generation Systems

Next G Wireless R&D Gap Identification

Builds on NIST Future Generation Wireless Gaps Report published in 2018 (NIST SP 1219).

Planning a series of workshops on different topics such as:



1. Identify and recruit stakeholders who bring technical credibility to the workshop topic area
2. Baseline participants on current /completed activities in the space. Present important concepts within the topic
3. Distribute a questionnaire to workshop participants asking them to identify and describe specific technical gaps within the workshop topic area
4. Analyze stakeholder input to develop discussion questions and themes for stakeholders to challenge, validate, and expand on during each workshop
5. Facilitate the virtual workshop. Capture non-attributable stakeholder input
6. Summarize the technical gaps and recommendations discussed during workshops in a published report shared with the R&D community

If you or your colleagues are interested in participating in this effort, please contact Marc Leh (mleh@corneralliance.com) or Miller Higgins (mhiggins@corneralliance.com).

Thank you!

Questions?

nada.golmie@nist.gov

Next G Alliance Green G: The Path Toward Sustainable 6G

Bhushan Joshi
Head of Sustainability ad Corporate Responsivity for Ericsson North America

March 25, 2022

NGA Green G White Paper

Key Areas assessed

Structure of a typical mobile network

- 4G/5G Comparison of power consumption
- Future traffic growth, impact on power consumption

Sustainability of the Network and Data center

- Radio Access Network (RAN) Energy Consumption
- Core Network Energy Consumption
- Data center Environmental Footprint
- Autonomous Systems
- Edge Computing

Sustainability of Devices and Hardware Manufacturing

- Materials
- Operational Efficiencies
- Improvements in IoT, Battery, and Regenerative Technologies
- Sustainable and Circular Design Choices

Next-generation Mobile Networks as a Sustainability Enabler

Agenda

1 **Climate Change: A big challenge**
A code red of humanity and our future generations

2 **ICT industry is rising to the challenge**
Climate leadership is required across all sectors of our global economy

3 **Critical sustainability aspect to consider**
Energy, emissions, water use, waste/recycling are all material issues

4 **Decarbonization potential of connectivity**
Enabling the decarbonization of key economic sectors

5 **Recommendations and call to action**
Establish north American as leader in sustainable Next Generation Technologies

Climate change is an existential threat to humankind

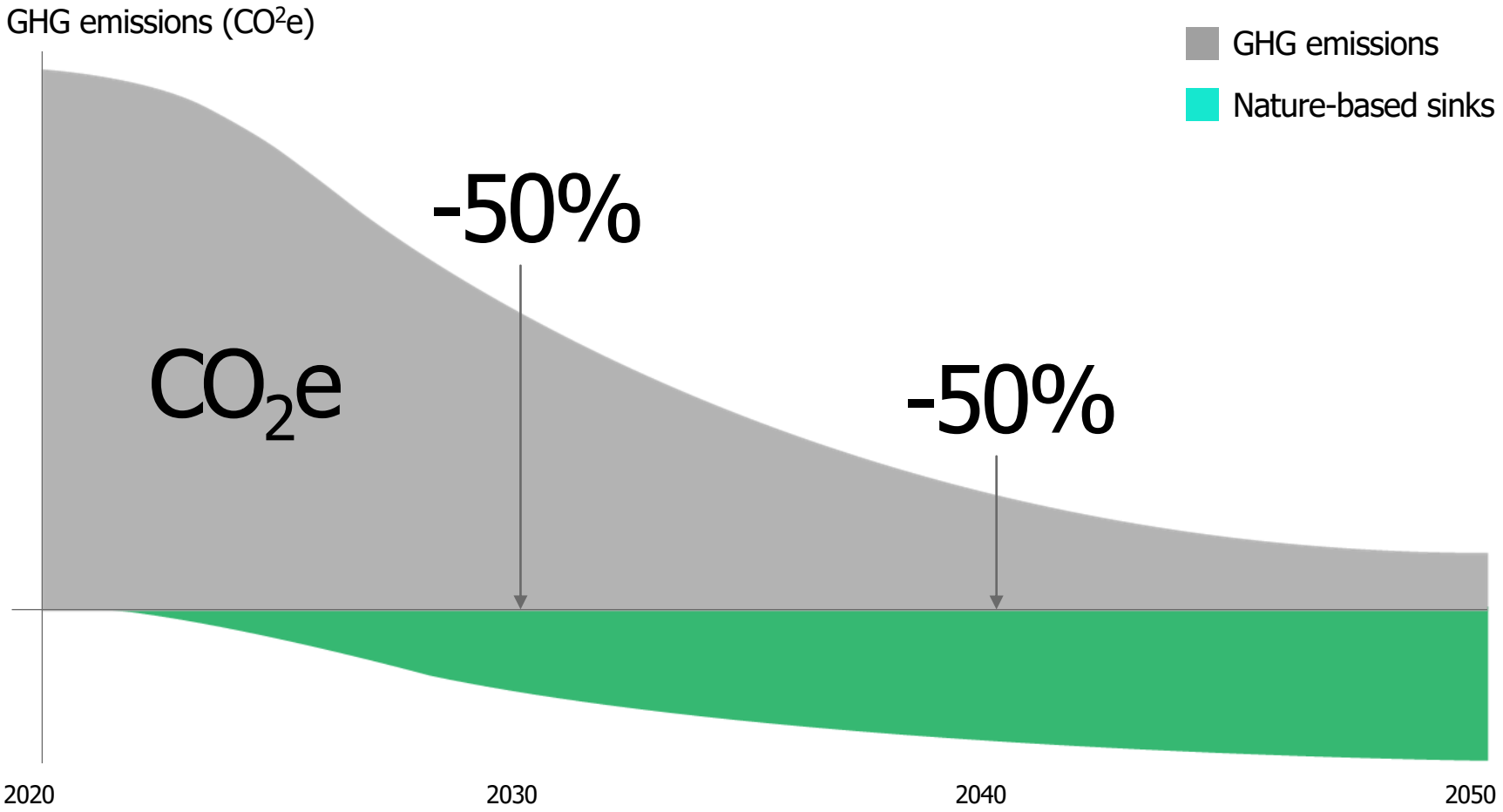
2013-2021

Warmest years on record since 1880

Undeniable

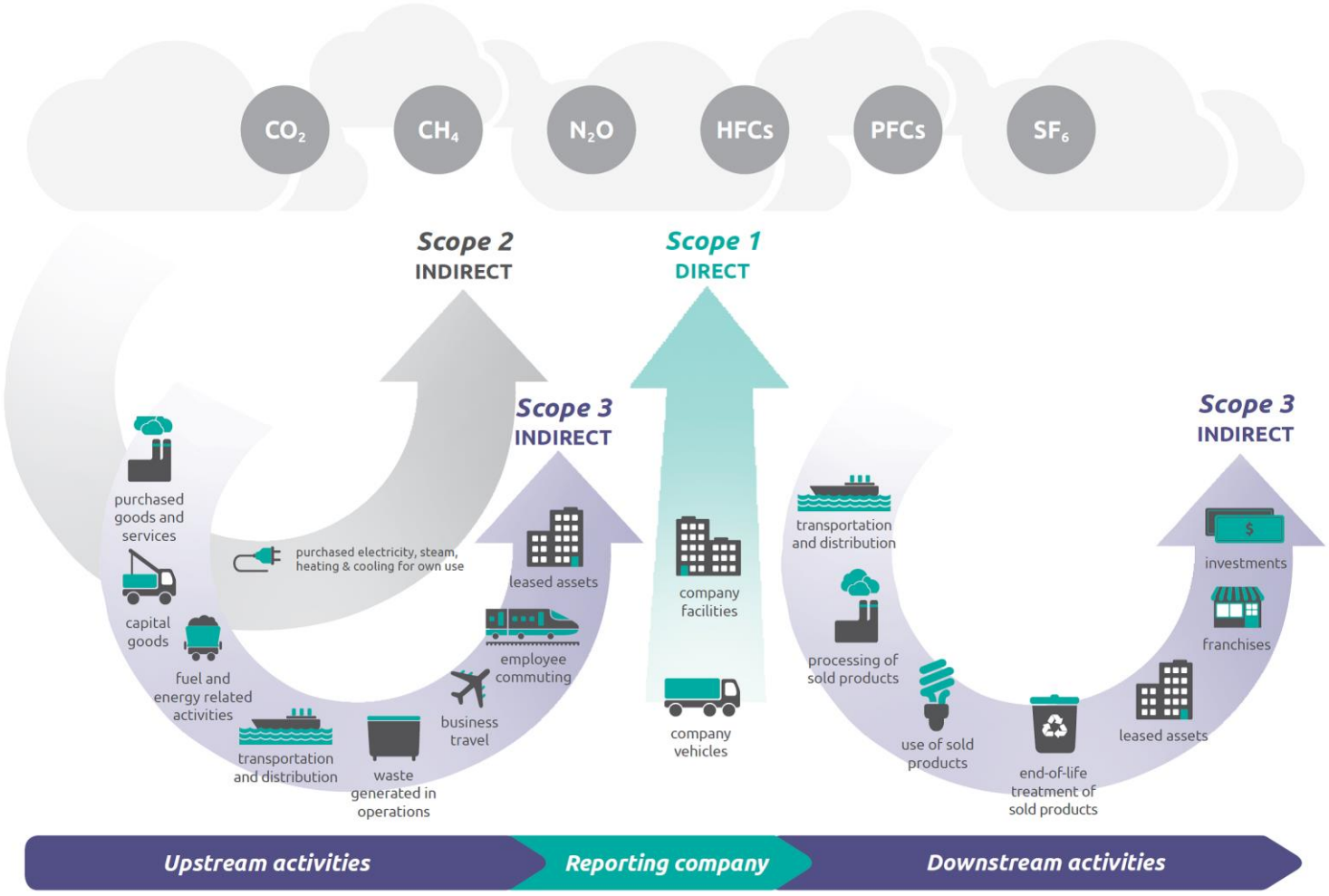
Human activity and fossil fuels cause global warming

Exponential Climate Action Required Now



Source: Exponential Roadmap Initiative

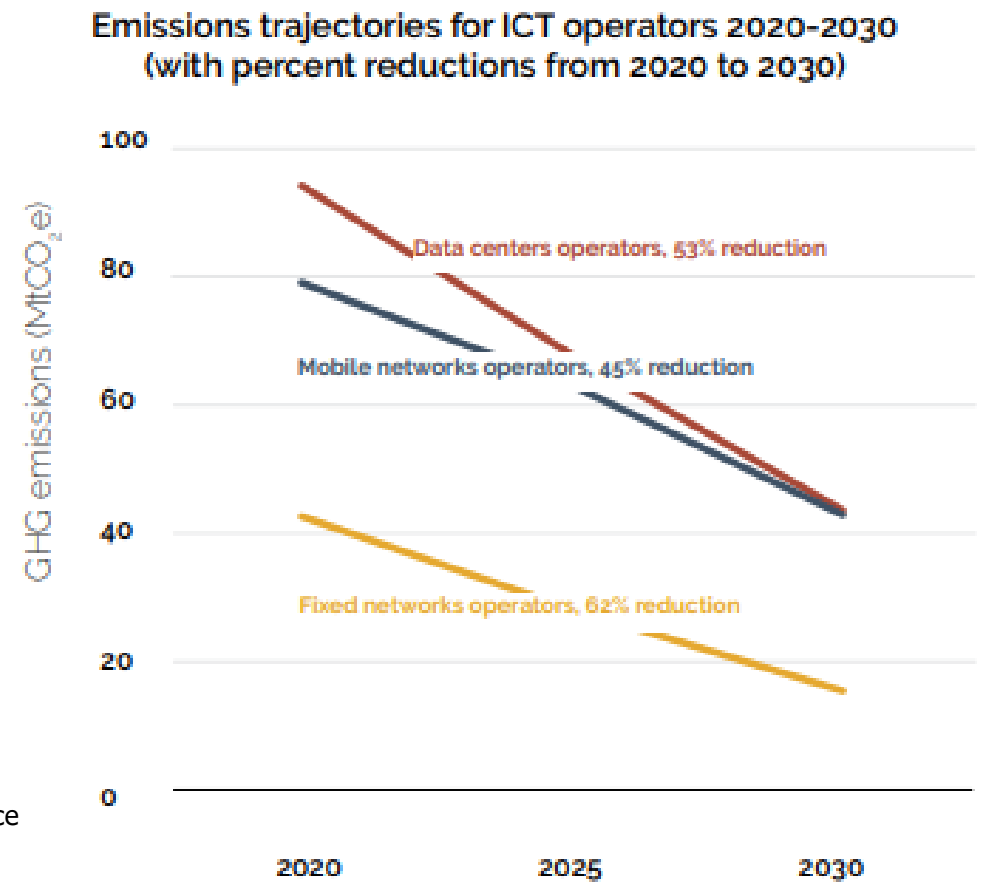
Addressing the Entire Value Chain is Critical



Source: WRI/WBCSD Corporate Value Chain (Scope 3) Accounting and Reporting Standard (PDF)

ICT Industry Aligned on Science-based Pathway to Reach Net Zero Emissions

- Pathway developed in consultation with ITU, SBTI, GSMA, GESI and ICT sector companies.
- Global mobile industry first industry to announce "breakthrough" in the Race to Zero emissions.
- **2030 interim target:**
  - Achieve fair share towards halving GHG emissions by 2030 compared to 2015
- Net Zero by 2050 or earlier:
  - Prioritize emission reduction
  - Switch to renewable power supply
  - Offset residual emissions



Source: UN Race to Zero ITU L.1471 Guidance

Energy and Carbon Footprint of Global ICT Networks

1.4%

ICT's portion of the global carbon footprint

~3%

ICT's portion of the global electricity consumption

70%

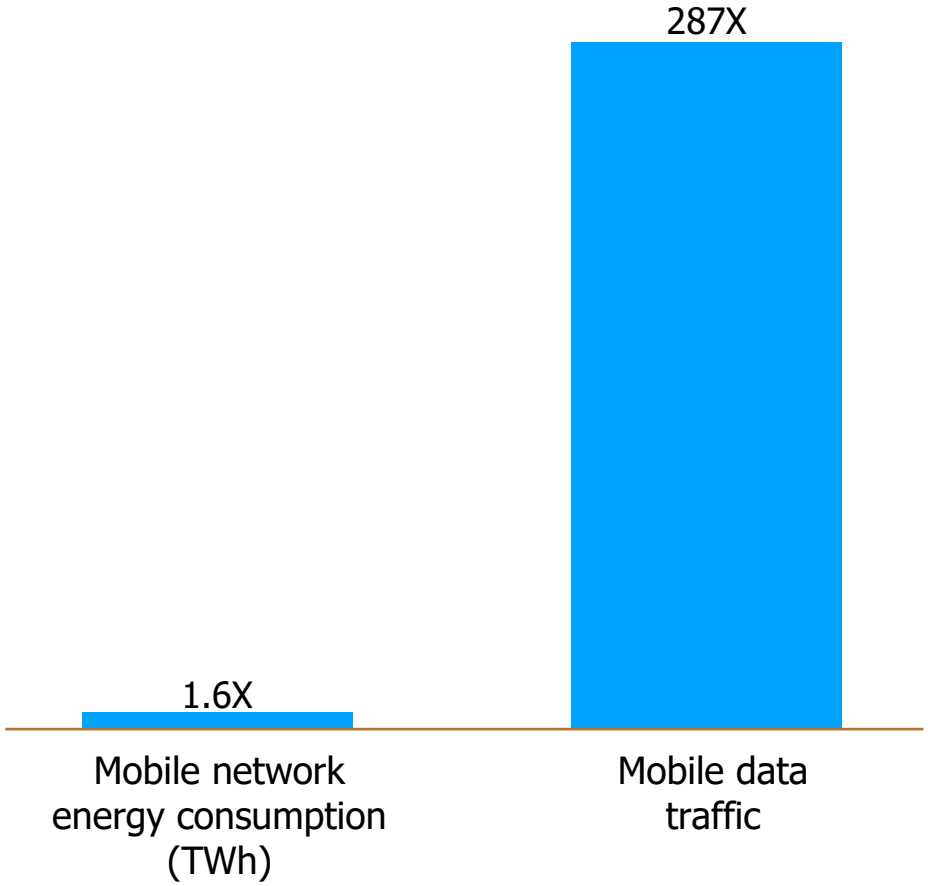
People globally use ICT services and solutions

287 X

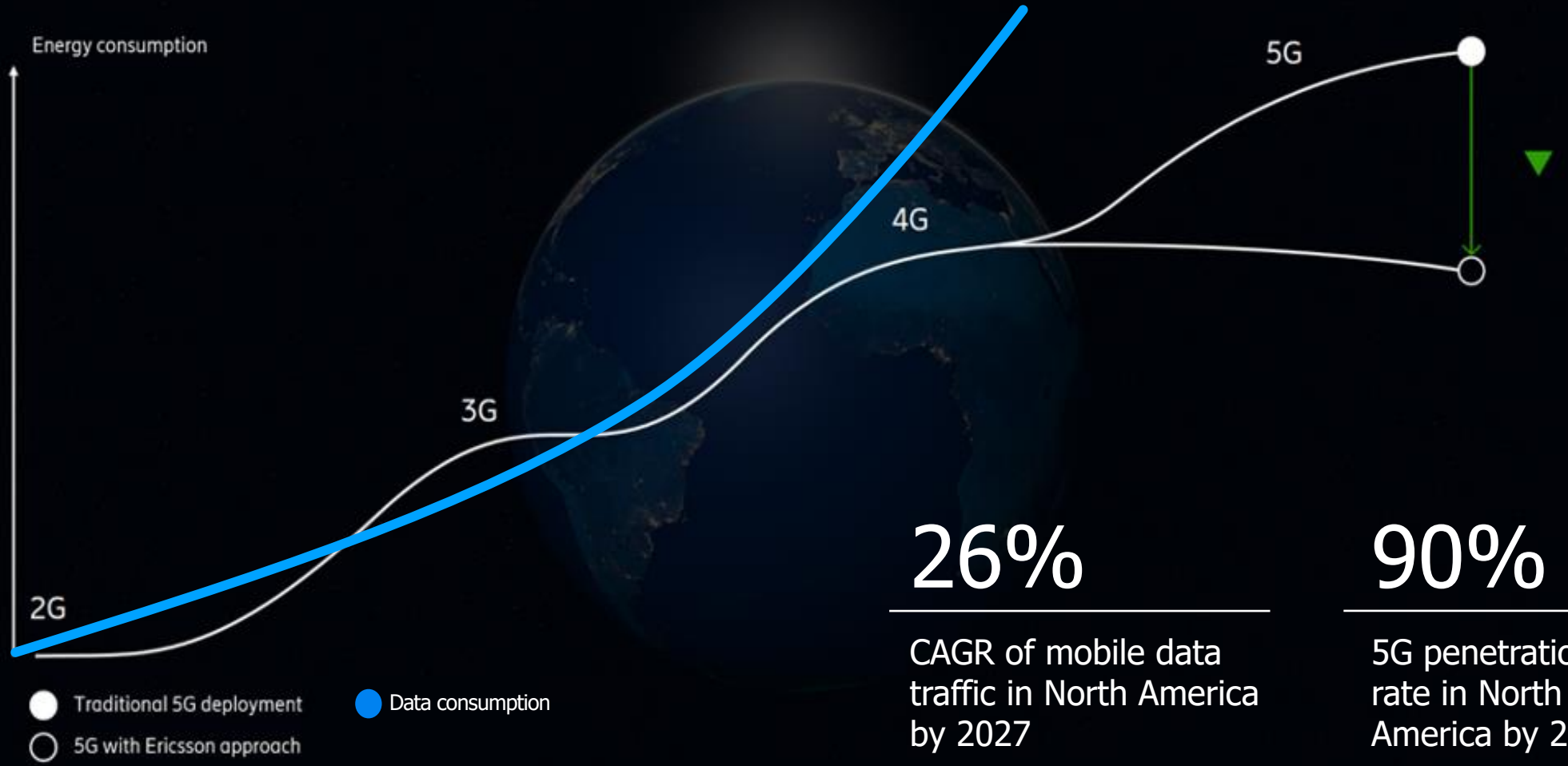
Growth in data traffic supported with modest increase network energy consumption

Source: Ericsson Mobility Report 2021 Ericsson guide to digital carbon footprint

10-year (2011- 2021) growth factors



Reducing the impact of digital networks



Source: Ericsson mobility and Breaking the Energy Curve reports

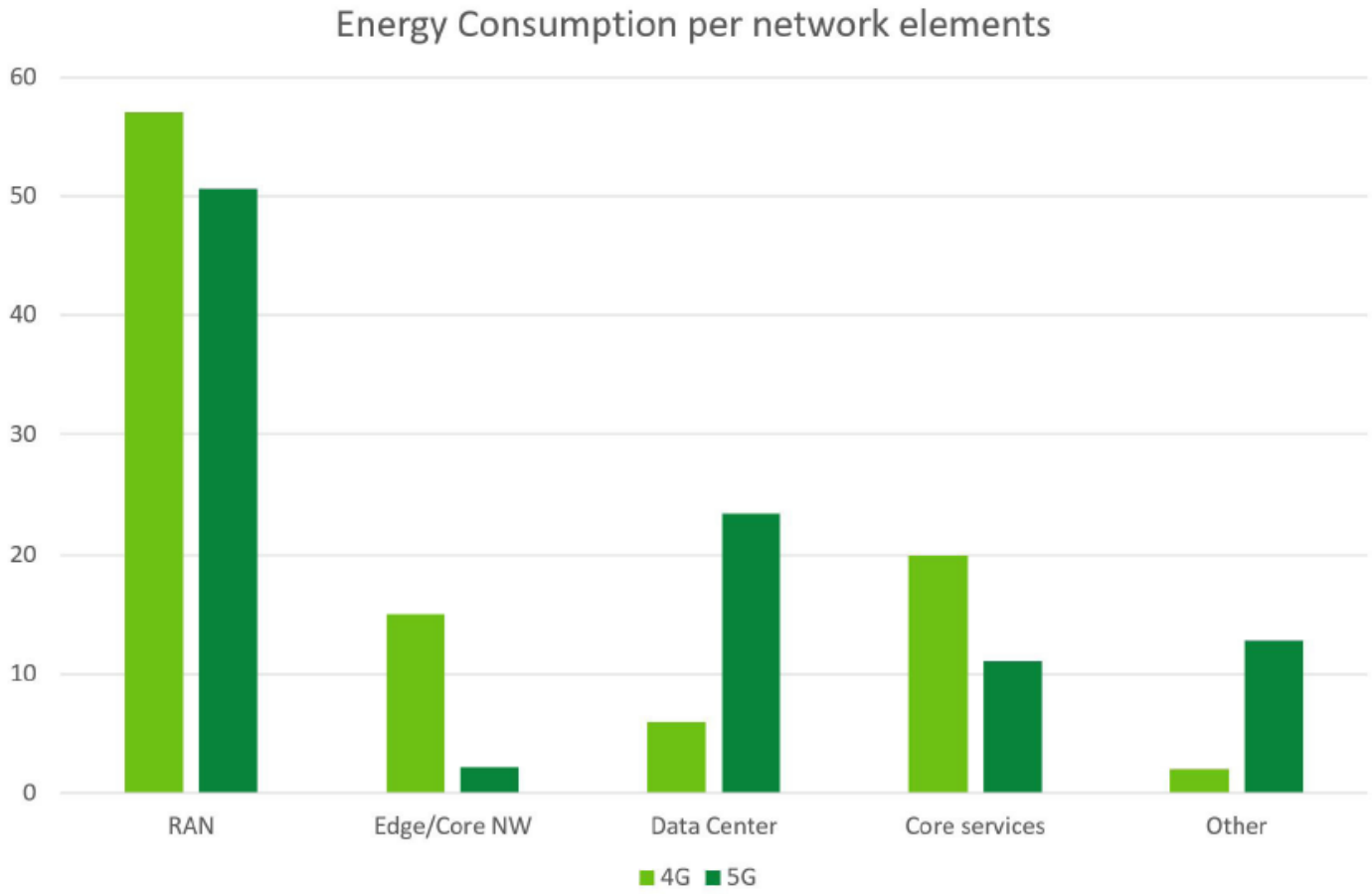
26%

CAGR of mobile data traffic in North America by 2027

90%

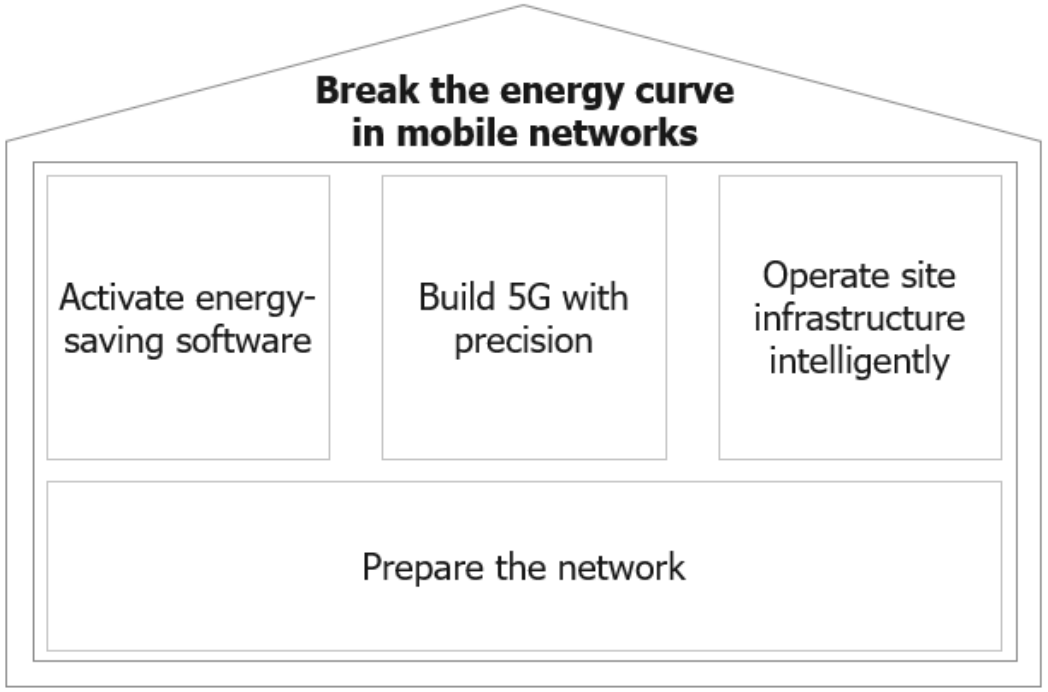
5G penetration rate in North America by 2027

Breakdown of energy consumption in mobile network



Source: Green G: The Path Toward Sustainable 6G

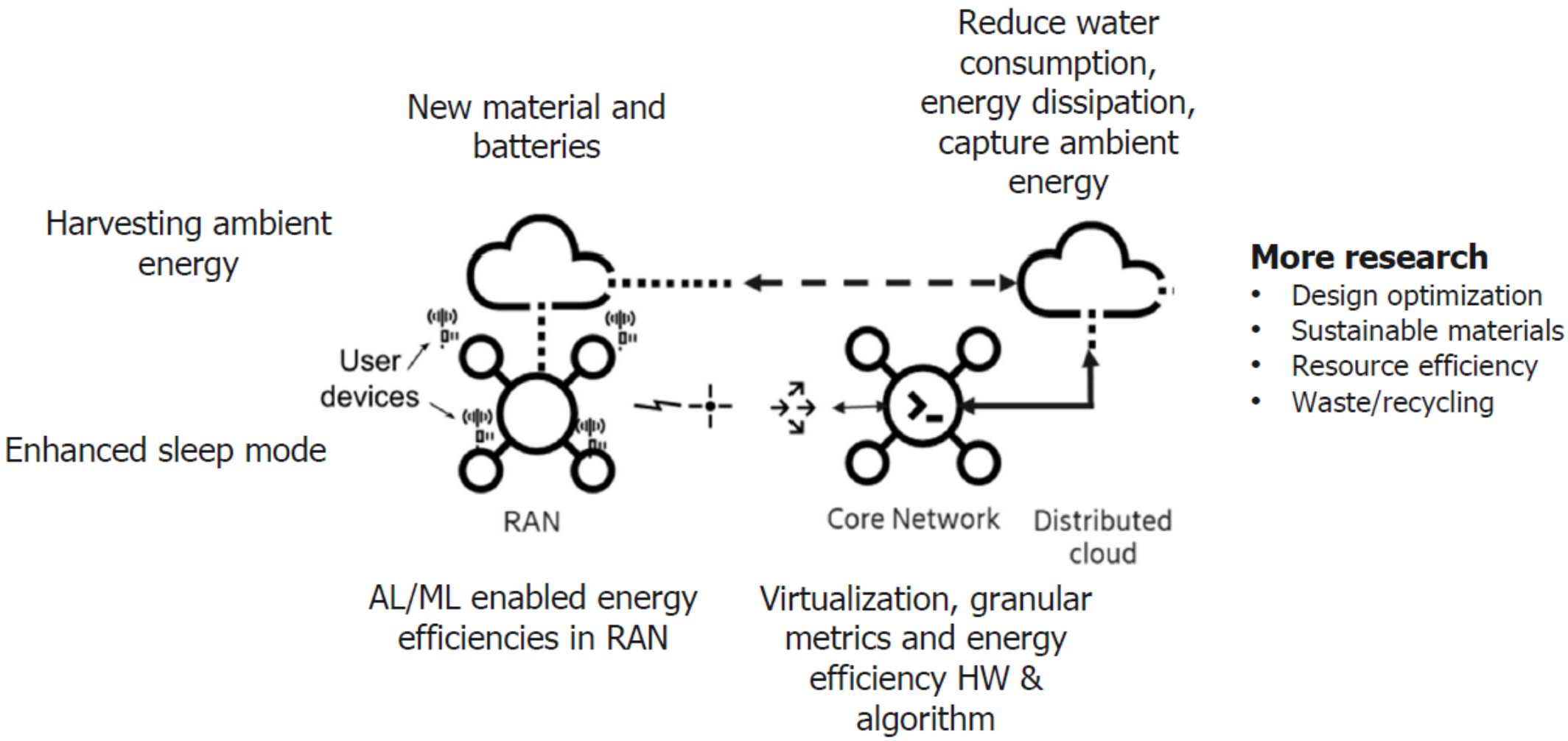
Holistic Approach Required for Securing Network Energy and Sustainability Performance



Benefits for service providers

- Manage traffic growth
- Reduce costs
- Be a technology leader
- Reduce environmental footprint

Act on the Entire Network



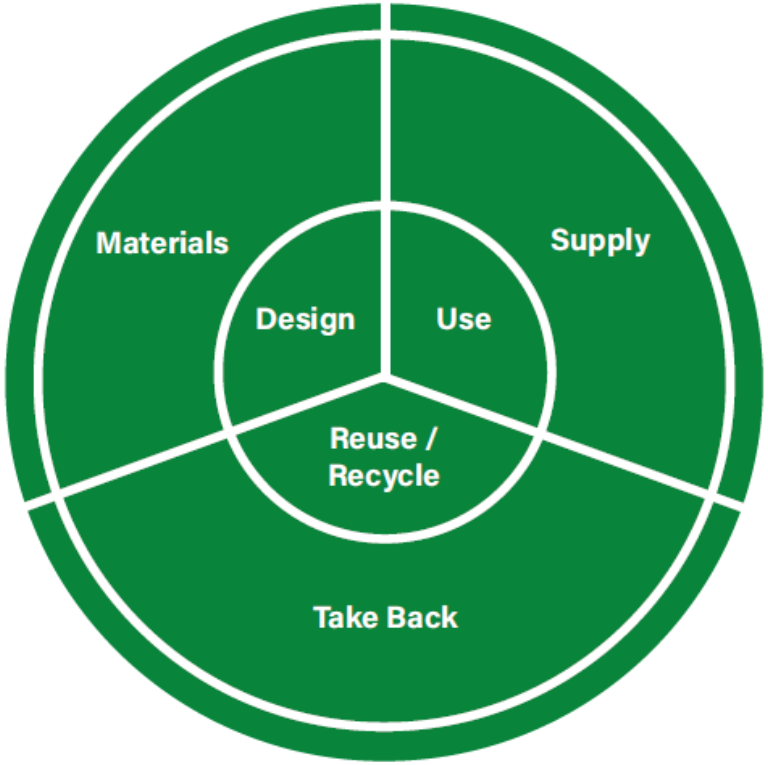
More research

- Design optimization
- Sustainable materials
- Resource efficiency
- Waste/recycling

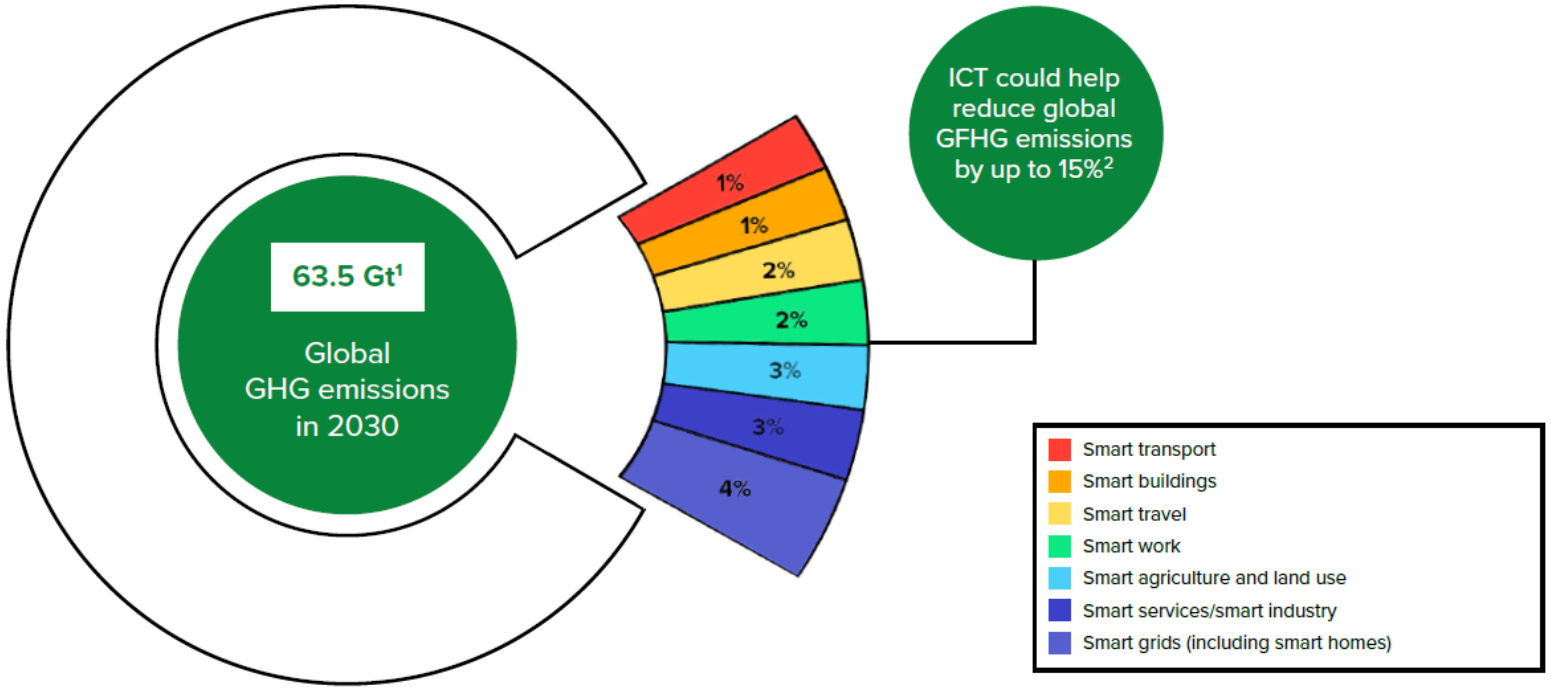
Sustainability is More than Emissions

Adopting a circular economy approach

- **Life Cycle Assessment**:
  - Methodology to evaluate the environmental impacts from cradle to end of life
- **Sustainable design**:
  - Transition from liner to a circular economy can minimize impacts of land and water
- **Aspects that need to be addressed**:
  - Materials
  - Water use
  - Land use
  - Waste/recycling



ICT sector can have a massive impact on decarbonization



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² In a high reduction scenario based on the broad application of ICT in other sectors to drive efficiency and transformation. The sum of the individual sectors is around 16 percent, whilst double counting effects have been removed for the aggregated total of around 15 percent.

Connectivity essential for transition to renewables and decarbonization of the energy sector

66%
global emissions for energy sector

85%
power from renewables by 2050

826 Gigawatts
new renewable capacity commitments

Reference: Exponential Climate Action Roadmap, Ericsson, UN summary for policy makers

Digitalization is critical for decarbonization of the industrial sector

32%
of global emissions

20%
reduction with real-time monitoring and control

Reference: Exponential Climate Action Roadmap, World Economic Forum

Recommendations and Call to Action for Leadership in Sustainable 6G

- Set science-based targets and reach Net Zero emissions latest by 2050.
- Transition to renewables and focus on reducing power and water consumption.
- Invest in sustainable supply chains and transition to a circular economy.
- Maximize the decarbonization potential of connectivity.

The Path Toward Sustainable 6G Webinar

White paper Link: Green G: The Path Towards Sustainable 6G

For more information: Green G – Next G Alliance

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an ATIS initiative

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March 25, 2022

Next G Alliance

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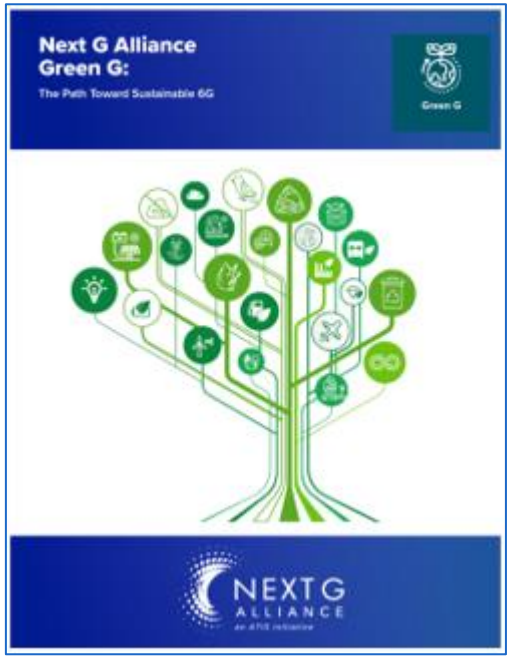

Thank you to the Webinar Speakers:

- Keynote speaker, Nada Golmie (NIST)
- Subject matter expert: Bhushan Joshi (Ericsson)
- Panel discussion with audience Q&A:
  - Panelists: Andrea Bohmholdt (MITRE), Clara Li (Intel), and Amy Zalman (Georgetown)
  - Moderator: Carsten Baumann (Schneider Electric)

For more information: Green G – Next G Alliance

Building the foundation for North American leadership in 6G and beyond