



Environmental sustainability and a greener economy: The transformative role of 5G



Qualcomm

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There's no Planet B

Climate change requires urgent action

Climate change is a social, economic, and environmental concern. We are all responsible for protecting our planet. We know change is needed, and we know it is possible. We need to move quickly and deliberately. 5G can help.

Climate change can no longer be considered theoretical

It is now an acute crisis. Climate and natural resource protection are becoming a fundamental area of concern within most every conscientious company's strategy. By 2050, the Earth's population is expected to increase from 7 to 10 billion and the world economy is projected to nearly quadruple, creating a growing demand for energy and natural resources. This new economy is projected to use 80% more energy by 2050. As the world's population grows, we further strain the planet's resources, consuming more goods while contributing to environmental waste, pollution, and decline.

Climate change requires a multi-sectoral, science-based approach to tackling the growing impact on our world and our communities

Industries and institutions need a foundation to digitize and transform their operations to achieve tangible sustainability benefits. 5G has the ability to serve as that foundation for combatting climate change. 5G enables us to manage and improve the sustainability trajectory of our planet in key areas such as greenhouse gas emissions, water use, reduction of pesticides, and energy efficiency, while providing an inherently lower CO₂ footprint than previous network deployments.

At Qualcomm, we see technology as a critical lever in helping to address the greatest global challenges and see climate change and natural resource protection as key areas of our corporate strategy.

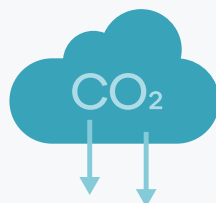
Working together, we can preserve the health of our planet.

5G enables a more sustainable future

5G - the next generation wireless data network - provides speeds as high as 20 times today's broadband networks. 5G's ultra-low latency and extreme reliability bring new forms of services, including everything from monitoring water usage in real time to reducing greenhouse gas (GHG) emissions.

5G delivers a ubiquitous broadband data network that enables a revolutionary opportunity for improvement in environmental sustainability and a tremendous opportunity for economic growth and new jobs in the United States.

GHG emissions reduction



370+
million

metric tons of
GHG emissions
avoided in 2025

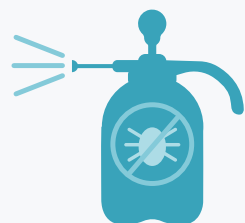
Optimal household water management



410
billion

gallons of water
saved annually

Pesticide use reduction



50% less
pesticide

Energy usage optimization



20%

Improvement in
fuel efficiency

Green jobs creation



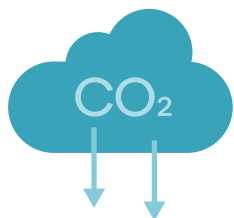
300K

new green jobs
by 2030

Citations on subsequent slides

5G enables a more sustainable future

GHG emissions reduction



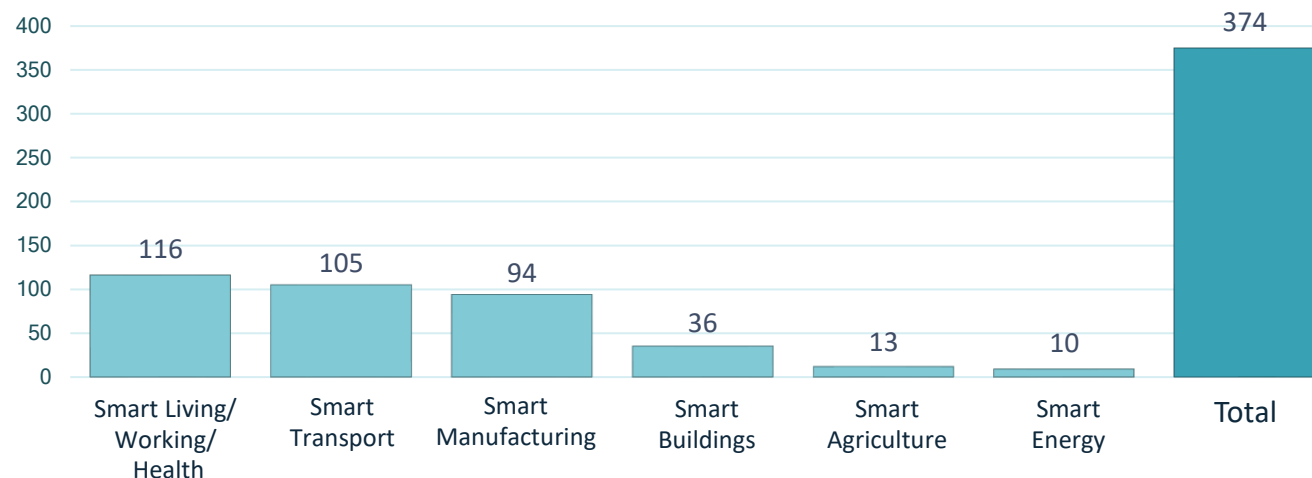
The ways 5G reduces emissions is expanding every day, and this development is inspiring hopes of an emissions-free future. Leveraging groundbreaking technologies such as 5G can

help us use natural resources more efficiently and reduce our carbon footprint.

The following use cases will benefit significantly from the deployment of 5G and their contribution to the reduction of GHG emissions in 2025 has been projected to be significant.

- Smart Living/Working/Health
- Smart Transport
- Smart Manufacturing
- Smart Buildings
- Smart Agriculture
- Smart Energy

5G Use Cases: avoids million metric tons of GHG emissions in 2025 in the United States¹



5G is expected to enable in 2025 the reduction of **374 million metric tons of GHG emissions in the United States** - approximately 6% of the annual emissions.

Emissions savings enabled by 5G are equivalent to

- Taking 81 million passenger vehicles off the U.S. roads for one year;
- Canceling U.S. aviation's 2018 CO₂ emissions twice;
- Greenhouse gas emissions avoided by 77,000 wind turbines running for one year; and
- Carbon sequestered by 460 million acres of U.S. forests for one year.

[1] Independent analysis based on data published by GSMA, "The Enablement Effect The Impact of Mobile Communications Technologies on Carbon Emission Reductions" (2019).
https://www.gsma.com/betterfuture/wpcontent/uploads/2019/12/GSMA_Enablement_Effect.pdf

5G enables a more sustainable future

Optimal household water management



The need for conservation of precious freshwater resources is gaining momentum. Water conservation is necessary for smart homes and intelligent cities to exist and function efficiently.

Meters, leak detectors, and other sensors within the utility's network can be securely connected for real-time access in both populated and difficult to reach regions. Requiring less power and providing for extended battery life means monitoring in near real-time is now possible even in the remotest of areas.

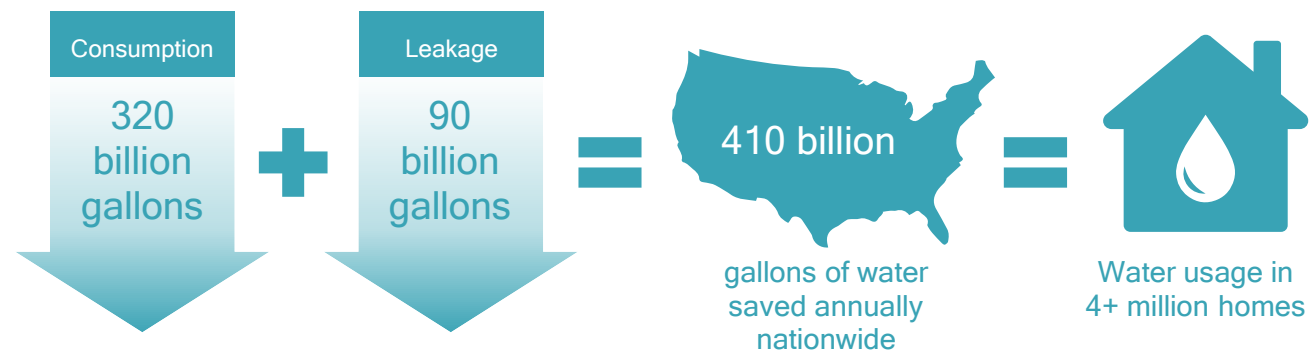
These devices can revolutionize the way that water providers can more efficiently deliver access to services, as there is no need for continued reliance on manual or semi-automated processes to understand consumer usage and water network behaviors.

- Smart water systems can provide up-to-the-minute data, thereby assessing the impact of problems by alerting consumers and water distributors the moment they are detected.
- Identifying consumption patterns is another important application. Smart water systems allow peak demand patterns and related issues to be monitored and managed efficiently. Consequently, the case for new services such as water storage on site or peak time tariffs to smooth the demand profile can be made.
- Smart water meters allow accurate billing based on consumption. Granular data collected through the sensors lead to more accurate household bills.

5G-enabled smart water systems will

reduce waste, consumption, and costs.

Annual Impact of Smart Water in the United States²



[2] Independent analysis based on data published by GSMA, "Smart Water: A Guide to Ensuring a Successful Mobile IoT Deployment" (2018), https://www.gsma.com/iot/wp-content/uploads/2018/01/miot_smart_water_01_18.pdf



The use of UAVs for remote sensing and spray application enables variable-rate application and can lead to a

50% decrease

in the amount of pesticide applied.³

5G enables a more sustainable future

Pesticide use reduction



Drones improve today's pesticide distribution methods in two ways. First, they protect farmworkers by keeping them at a safe distance from potentially harmful chemicals. Second, real-time data allows for more efficient and

accurate spraying, thereby reducing the amount and frequency of spraying. Ultimately, crops are covered with less pesticide residue.

A drone camera takes very accurate photos of the crop field. The images are sent via a mobile connection with 5G performance to an agricultural machine that then doses crops in real-time and with enhanced accuracy. Unmanned aerial vehicle (UAVs) are able to access steeply sloping cultivated areas that are hard to access with ground-based sprayers. UAVs have also been noted to reduce the time required to return to the mixing and loading site to continue spraying.

[3] Accenture, "The Impact of 5G on the European Economy" (2021), https://www.accenture.com/_acnmedia/PDF-144/Accenture-5G-WP-EU-Feb26.pdf; John Deere "See and Spray Select" <https://jdvirtualpavilion.com/see-and-spray-select/>

5G enables a more sustainable future

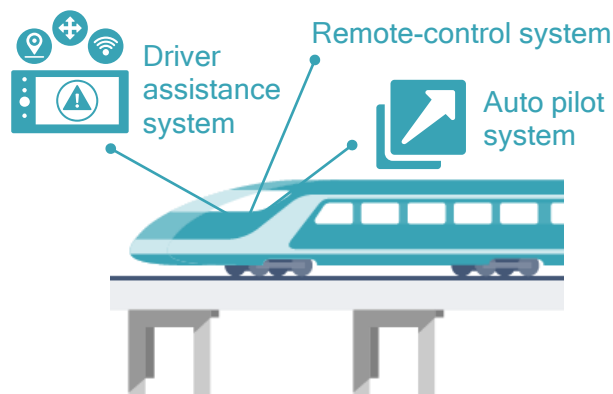
Energy usage optimization



5G-enabled applications can be employed for improving energy efficiency, increasing the share of renewable energy and reducing environmental impacts of energy usage.

- 5G technology will help unlock the next generation of smart energy grids. These will be more robust, more responsive and have greater capacity to efficiently deal with increasing demands. 5G sensors fitted along the grid will detect and respond to spikes in demand, reducing the chance of total power failure (blackouts) and voltage fluctuations (brownouts), which can damage sensitive equipment.
- C-V2X will serve as the foundation for vehicles to communicate with each other and everything around them - pedestrians, infrastructure, network - while providing enhanced autonomous driving. C-V2X applications control parameters such as lane change, speed, gear selection, and acceleration, which optimize traffic flow and fuel efficiency while reducing accidents.

- A typical automated train operation enabled by 5G can feature:
 - A driver assistance system, which provides situational awareness and is able to detect what is happening on the train and the track in order to make the right operational decisions.
 - An auto pilot system, described as the brain of the operation, which makes decisions during the journey and facilitates the shift from acting upon instructions to developing its own rules for safety and on-time arrivals while maximizing fuel efficiency.
 - A remote-control system, which offers direct and continuous communication from the train, even in remote locations.



5G-connected smart grids will
reduce gas and electricity consumption by 12%.⁴

Optimized use of lane management systems and traffic management systems enabled by C-V2X can account for
fuel savings up to 20%.⁵

Automated train operation will
reduce energy consumption by 20%.⁶

[4] O2, "The Value of 5G for Cities and Communities" (2018), <https://d10wc7q7re41fz.cloudfront.net/wp-content/uploads/2018/03/Smart-Cities-Report.pdf>

[5] Shailesh Patil, "Realizing the Potential Benefits of 5G NR C-V2X" (2019), https://docbox.etsi.org/Workshop/2019/201903_ITSWS/SESSION04/QUALCOMM_PATIL.pdf

[6] Accenture, "The Impact of 5G on the European Economy" (2021), https://www.accenture.com/_acnmedia/PDF-144/Accenture-5G-WP-EU-Feb26.pdf

5G enables a more sustainable future

Green jobs creation



Green jobs play a significant role in reducing the environmental impact of enterprises working to improve their utilization of raw materials, decarbonizing the economy, and reducing waste. The rapid growth

of green jobs will boost our economy by reducing unemployment, making America more competitive, and safeguarding public health - all of which are necessary for improving economic prosperity and productivity.

According to the Institute of Renewable Energy Agency, for example, IoT is a critical technology that will drive the energy transition. In the renewable energy sector, IoT applications will enable “smart grids” by enhancing the visibility and responsiveness of grid-connected devices.⁷ By connecting energy suppliers, consumers and grid infrastructure, IoT technology facilitates the flow of data and the operations of increasingly complex power systems.

IoT technologies and the data that the devices generate create automated control systems that result in optimizing operational systems for cleaner, more distributed, and increasingly “smart” grids.

The increasing adoption of industrial IoT solutions will create new green job opportunities. For these solutions and their data to be handled properly, a reskilled workforce will be in demand.

The roles of data scientist, data engineer and software engineer will gain traction, as companies rely more and more on the 5G data that emerging technologies will be gathering and machine learning will be informing.

Seizing green energy opportunities through increased investments in 5G will contribute to more green jobs in the United States.

According to internal economic modeling analysis, the deployment of 5G technologies will create in the U.S. as many as

**300,000 new
green jobs by 2030.**

The deployment of 5G technologies will increase the need for the following roles:



Data scientist



Data engineer

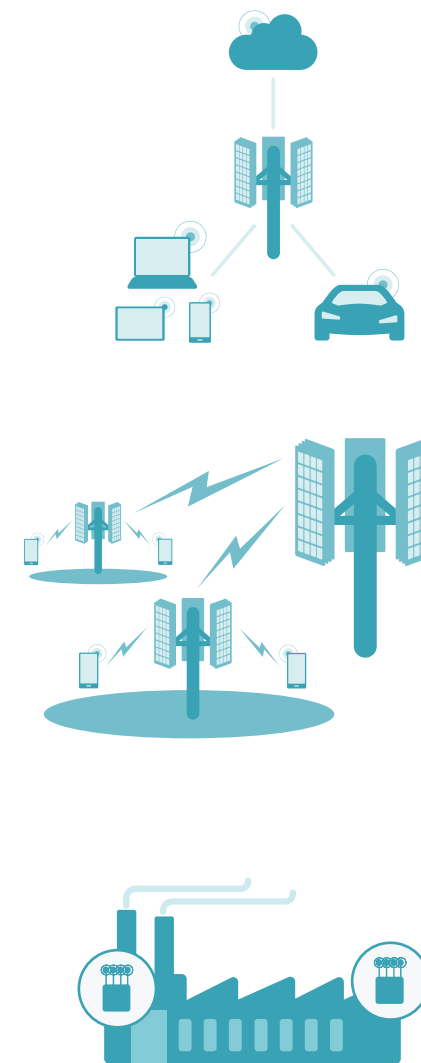


Software engineer

[7] IRENA, “Global Renewables Outlook: Energy transformation 2050” (2020), <https://www.irena.org/publications>

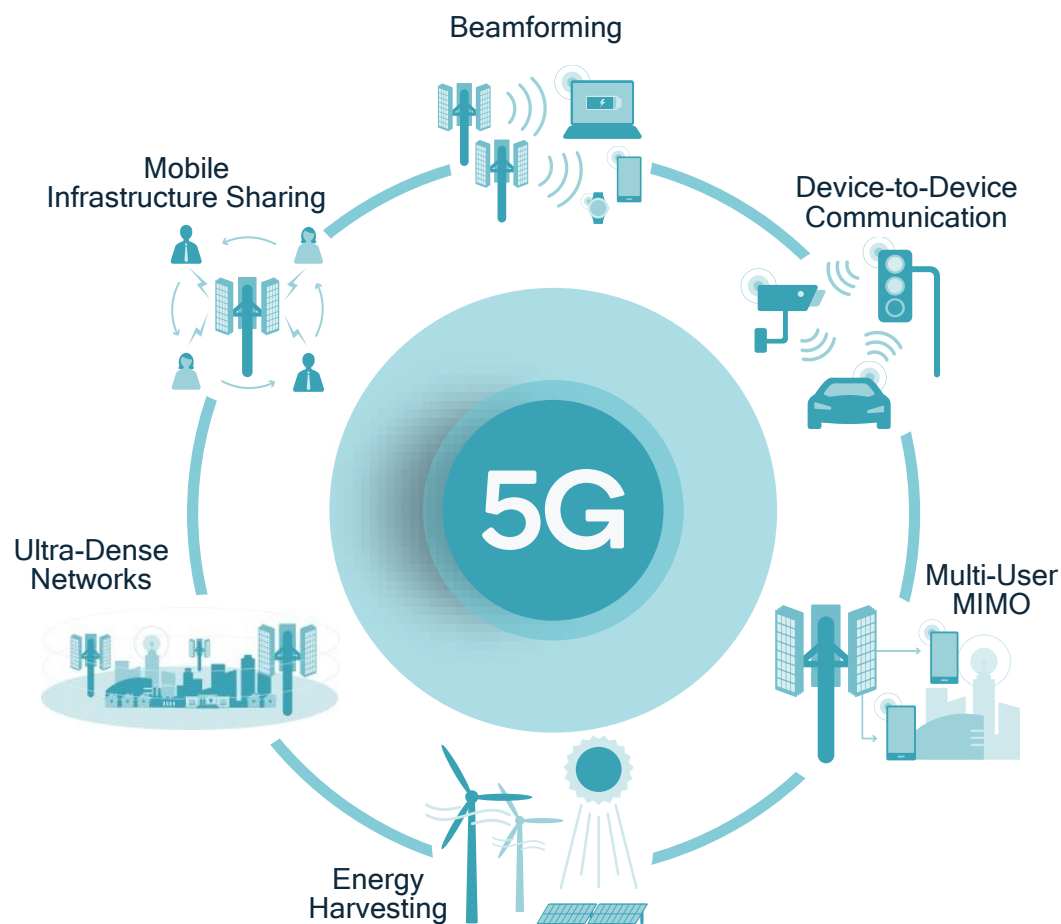
Energy efficiency of 5G networks

- ✓ Enhance energy efficiency by enabling separate handling of signalling traffic from data traffic.⁸
- ✓ Leverage simplification of signaling functions of wireless communications such as mobility, handover, location management, to reduce overall traffic and improve energy efficiency.
- ✓ Apply separate energy efficiency improvement mechanisms adapted to different traffic profiles, patterns, network and deployment scenarios (dense/urban/hotspot/indoor/rural).
- ✓ Enable energy saving operations such as “switch off” or “sleep” mode of redundant network nodes with no or low data traffic load.
- ✓ Dynamic management of energy resource depending on types of traffic, network functions, components and the user status (traffic/connection density, services/applications).
- ✓ Synchronize and coordinate the energy saving operations in different network nodes of 5G infrastructure (e.g., base stations, backhaul networks, core network, backbone).



[8] 3GPP, "Study on Energy Efficiency Aspects of 3GPP Standards (Release 15)" (2017). <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=3062>

Energy efficiency of 5G networks



Examples of how 5G core technologies move toward energy efficiency

Beamforming

Beamforming, which effectively reduces interferences and focuses the energy on the direction the user is present, results in highly directional mmWave and sub-6 GHz transmissions. Hybrid architectures involve a combination of digital and analog processing that enables improved network cell capacity and energy efficiency gains, respectively.

Device-to-Device Communication

Vehicles communicate directly with other vehicles as well as pedestrians and surrounding infrastructure. Device-to-device communication alleviates the necessity of involving base stations by offloading onto direct links in a 5G mobile system. Significant power-saving is achieved.

Mobile Infrastructure Sharing

Classified as either passive or active, infrastructure sharing can result in considerable energy gains while maintaining the quality that was achieved before the sharing. Passive refers to the sharing of physical equipment (e.g., radio masts, towers), while active refers to network (e.g., radio network, roaming).

Energy Harvesting

Network architectures with centralized functions (e.g., via open RAN technology) allow locating the network functions at centralized sites with easier access to renewable energy sources, as well as better resource multiplexing/pooling.

Industry opportunities

Smart Living/Working/Health



- **Smart Living:** 5G will enable individuals an even greater ability to perform most of their day-to-day activities remotely, thereby avoiding travel. 5G will further enable and facilitate the 'sharing' economy, reducing waste.
- **Smart Working:** 5G will be an important enabler of work-from-home in the post-Covid world. By providing high-speed connectivity that can be leveraged by employees in historically location-based occupations, 5G will enable more and more jobs to be performed remotely.
- **Smart Health:** 5G will allow transmission of large medical images, facilitate telehealth initiatives, and support remote patient monitoring tools – as well as enable more complex uses of AI/VR/AR, thereby reducing travel for health professionals and patients.

Smart Transport



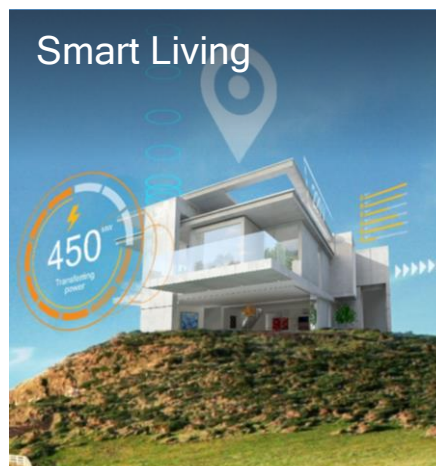
5G technology will enable smarter, safer, greener, and more efficient transportation through connected vehicles, transit infrastructure, and ride sharing.

Already, bike and scooter sharing in cities, enabled by cellular technologies, is helping replace travel that would have previously been done by car or public transport.

Smart Buildings



The deployment of smart sensors and intelligent edge devices facilitate the automation of building management systems, smart meters, HVAC (heating, ventilation and air conditioning) control systems, and increased consumption awareness through continuous monitoring.



5G-enabled sales: \$212 bn⁹



5G-enabled sales: \$217 bn



5G-enabled sales: \$250 bn

[9] Source for 5G-enabled sales (2021-2025): Accenture, "The Impact of 5G on the United States Economy" (2021), https://www.accenture.com/_acnmedia/PDF-146/Accenture-5G-WP-US.pdf#zoom=50

Industry opportunities

Smart Manufacturing



5G provides a level of secure, ultra low-latency connectivity that enables responsiveness, accuracy and precision in automated movement for synchronization and control in manufacturing not possible until now.

Manufacturers can use 5G enabled technologies to draw insights and improve productivity and efficiency. For example, inventory management systems supported by 5G reduce the overall level of inventory needed. As a result, less warehouse storage space is necessary, reducing energy needs for lighting and cooling.



5G-enabled sales: \$350 bn

Smart Agriculture



The rollout of 5G technology holds the promise of bringing farmers in the United States new environmental-friendly ways to optimize crop yields, conserve water, improve soil health and monitor livestock by leveraging 5G for its vastly improved

wireless capacity, reliability, and speed in rural America. 5G-enabled applications will be key in lessening the agricultural sector's impact on climate change while simultaneously tackling future food and fresh water scarcity concerns.



5G-enabled sales: \$36 bn

Smart Energy



The use of smart grids in the energy sector is delivering on the promise of greater efficiency of electricity distribution and increased availability of renewable energy. 5G, through sensors/IoT devices, enables accurate monitoring across the

entire grid and provides the flexibility to detect and respond to fluctuating demand. Using real-time information and advanced analytics in the two-way grid, 5G supports better responsiveness to peak demand to mitigate the risk of blackouts and brownouts.



5G-enabled sales: \$73 bn

5G environmentally sustainable innovations

Each industry will be transformed in its own way. 5G will impact every industry by creating new products and processes supporting environmental sustainability that benefit firms as well as society.

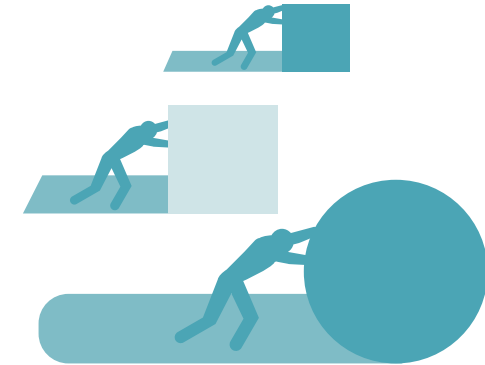
5G based solutions, which ensure environmental sustainability, have a massive potential to increase competitiveness of American firms. The resulting outcomes can be classified as:

a) economic, such as increased revenue, profit margins, productivity, etc. and b) non-economic, such as reputation, quality, customer and partner satisfaction.

The integration of 5G into products and processes will allow firms of all sizes and across all markets to gain various competitive advantages, while boosting environmental sustainability.

Industry opportunities:

How 5G environmentally-sustainable innovations can lead to a competitive advantage



Sustainability innovations



Competitiveness

Product and process

- Lower electricity use
- Reduced emissions
- Lower consumption of water, gas, coal
- Reduced hazardous material use

Economic outcomes

- Market share
- Profit margins
- Revenue
- Return on assets
- First-mover advantage
- Productivity
- Reduced costs

Non-economic outcomes

- Reputation
- Quality
- Customer and partner satisfaction
- Employee engagement

Industry opportunities

Qualcomm's commitment

As mobile technologies continue to benefit society in new and unexpected ways, it is important that companies like ours collaborate with key stakeholders to foster sustainability throughout the supply chain. Qualcomm is a member of the Responsible Business Alliance (RBA), formerly the Electronic Industry Citizenship Coalition (EICC), a nonprofit comprised of electronics, retail, auto and toy companies committed to supporting the rights and well-being of workers and communities worldwide who are part of the global supply chain. Qualcomm is also a member of Business for Social Responsibility (BSR) and The Climate Registry and participates in the United Nations Global Compact.

Qualcomm's sustainability goals

- We continually look for ways to conserve water, minimize energy consumption, lower emissions and reduce waste.
- We design energy efficiencies into our facilities infrastructure. Combined heat and power plants enable us to self-generate electricity to meet our site needs, while efficiently utilizing the waste heat to provide cooling to our headquarters' buildings.
- Our energy saving initiatives saved 59,577 megawatt hours of electricity and 16,495 tons of emissions.
- Measurement of our worldwide Scope 1 and 2 GHG emissions with the Climate Registry's best-in-class program achieved the third-party verification: Climate Registered Platinum Status.
- We are committed to a 30% reduction in absolute Scope 1 and 2 greenhouse gas emissions from our global operations, compared to a 2014 baseline, by 2025.
- Reduce power consumption by 10 percent, every year, in our flagship Qualcomm® Snapdragon™ Mobile Platform products.
- We have earned U.S. Green Building Council Leadership in Energy & Environmental Design (LEED) certification for five of our buildings. Our Pacific Center Corporate Campus, located in San Diego, was certified LEED Gold in 2008.
- Each year, we collect data from suppliers on supply chain GHG emissions and water use attributable to Qualcomm.
- In addition to innovation, we collaborate with stakeholders to effectively deploy and commercialize 5G solutions.

Call for action

Immediate and decisive action is required to reduce the risk of catastrophic climate change. Our generation has two choices. We can pass on the clearest path toward a sustainable economy - or face an increasingly destabilized climate which will have the harshest impact on the most economically vulnerable.

5G brings environmentally sustainable best practices to life - making it economically feasible and beneficial for industries and individuals to chart their paths toward reducing their pollution footprint and keeping energy resources and usage in equilibrium.

Since the US rejoined the Paris Agreement and the Administration has a plan to tackle the climate crisis at home and abroad, government and industry must work together to address climate change. The United States possesses the innovative spirit and technologies required to meet this challenge. As one of the world's leading wireless technology companies, Qualcomm is ready to play our part in the digital and green transformation of the industry, economy, and society.

Policy recommendations

Deploy 5G networks urgently

5G network deployment enables industries to curtail associated energy consumption and GHG emissions faster. The lack of a comprehensive 5G deployment plan inhibits 5G-enabled applications that contribute toward a greener economy. Existing network technologies aren't advanced enough to cope with the amount of data at the speeds required for sustainability applications. Both urban and rural communities benefit from increased funding for the technology improvements they need most to further green goals. The American Jobs Plan - to bring nationwide connectivity that includes deploying technologies like fixed wireless access leveraging 5G millimeter wave technology - will support these important efforts.

Accelerate 5G use cases

Further incentives related to specific 5G implementations across industry verticals to accelerate nationwide 5G deployment and use to support American manufacturing, agriculture, community anchor institutions, remote education, remote work, and telemedicine. Implementation would be enhanced by increased funding to STEM university and training programs. Specifically-skilled and diverse workers are needed to make the latest technology a daily reality for everyone. By working together, government and industry can help realize the full potential of 5G.

Invest in 5G technology leadership

Congress and the Administration can incentivize research and development and advance policies that sustain the United States' leadership in the continuing development of 5G standards and networks and accelerate the deployment of 5G infrastructure in urban and rural communities. For example, i) provide R&D grants such as those offered in the U.S. Innovation and Competition Act, ii) fund the USA Telecommunications Act to accelerate open RAN deployment, iii) strengthen patent protection to encourage further cutting-edge domestic innovation through policies including the STRONGER Patents Act and the IDEA Act, and iv) adopt policies that promote fair practices within SDOs, including the implementation of balanced governance rules.

Ensure a robust global semiconductor ecosystem

Shoring up a resilient, robust, and responsible global supply chain can be accomplished by evaluating mutual needs and developing more incentives (e.g., CHIPS Act, and tax incentives such as an Advanced Research Credit) to support commercial semiconductor fabrication, assembly, testing, advanced packaging, and R&D; setting a percentage target for onshoring leading-edge and mature node semiconductor supply.

It is time to unleash American workers and businesses to lead a clean energy revolution that will put the country on a clear path to becoming a greener economy.