Deep Dives and Case Studies for TELUS Priority Verticals: **Energy**

Adapted from: The Socio-Economic Impacts of 5G

Deetken Insight was commissioned by TELUS to complete a comprehensive review of published research about 5G and its potential socio-economic impacts, with a particular focus on Canada. Access the full report including a bibliography here: https://deetken.com/socio-economic-impacts-of-5g/. We provide no opinion, attestation, or other form of assurance with respect to the completeness, accuracy, fair presentation, and findings from research of others that are presented in the report.

Deetken Insight

500-210 West Broadway, Vancouver, BC

Ph: 1-604-731-4424

Email: info@deetken.com

Deetken Insight

Key Takeaways

- The energy sector in Canada accounts for approximately 9% of the nation's GDP and 1% of total jobs, yet the oil and gas and electricity sectors together account for approximately 35% of total GHG emissions in Canada. In comparison, emissions from the transportation sector, including airplanes, trains, trucks and passenger vehicles, account for 24% of total emissions

- 5G is a foundational component for addressing the many and diverse challenges facing the energy sector, including reducing emissions, meeting increasing demand for electricity at lowest cost, and providing the connectivity required to ensure electricity supply meets demand in a decentralized grid system that integrates a multitude of small-scale renewable electricity sources.

- Example 5G solutions and the benefits they bring to the energy industry include:
  - Smart grids that leverage artificial intelligence and predictive analytics to automatically react to changes in power demand
  - Smart meters that provide real-time data on consumption and enable demand shaping to optimize consumers' costs
  - Supervisory control and data acquisition (SCADA) systems that proactively detect infrastructure faults and supply interruptions
  - Drone surveillance to manage physical security risks
  - Optimized and automated drilling to increase well production and reduce emissions

- The International Energy Agency (IEA) estimates that the overall savings from digital services enabled by ubiquitous 5G connectivity could reach approximately US$80 billion per year from 2016 to 2040 for the power generation and distribution sector alone, or about 5% of its total costs. In Canada, 5G could generate approximately $1 to $2 billion in cost savings for Canada, as well as decrease emissions of oil and gas extraction activities by 10%, or about 3.5% of Canada's total GHG footprint.

Industry Overview: In Canada, energy production was equal to 10% of total Canadian GDP in the first quarter of 2022.[1] The current transformation underway in the energy sector is one of the most important challenges facing humankind. According to the U.S. Energy Information Administration (EIA), fossil fuels (petroleum and other liquids, natural gas, and coal) still

[1] Link to source: https://energy-information.canada.ca/en/subjects/energy-and-economy.

accounted for 80% of global primary energy consumption in 2018. Nuclear energy and renewables accounted for the remainder of energy consumption at 5% and 15%, respectively.[2] The overall demand for energy is expected to continue growing as the global population is anticipated to reach 9.7 billion by 2050.[3] Improving standards of living in developing markets will also play a critical role in the growth of energy consumption in these markets. The EIA projects nearly a 50% increase in world energy usage by 2050, led by growth in Asia.[4] Their projections indicate that, by 2050, fossil fuels will account for roughly 69% of global primary energy consumption, while nuclear energy and renewables will account for 4% and 28%, respectively.[5] The Intergovernmental Panel on Climate Change (IPCC) states that to limit global warming to 1.5 degrees, "global net human-caused emissions of carbon dioxide would need to fall by about 45% from 2010 levels by 2030 [and reach] 'net zero' around 2050."[6] This dichotomy puts the energy and electric utility sectors in the centre of a massive energy transition which will last for multiple decades as the world strives to wean itself off fossil fuels. In Canada, the oil and gas and electricity sectors together account for approximately 35% of total GHG emissions. As a point of comparison, emissions from transportation across all modes (aviation, rail, truck, passenger vehicles) account for 24% of total emissions.[7]

Given the oil and gas and electric utility sectors' highly diversified and complex operations, processes, infrastructure and technical workforce, as well as the magnitude of their economic and environmental footprint, it is expected these industries will drive the migration from Industry 3.0 to Industry 4.0 using 4G- and 5G-enabled digital solutions.[8] Widespread use of digital technologies in the oil and gas sector could decrease production costs between 10% and 20%, including through advanced processing of seismic data, the use of sensors and enhanced reservoir modelling.[9] According to the International Energy Agency (IEA), "technically recoverable oil and gas resources could be boosted by around 5% globally, with the greatest gains expected in shale gas."[10] The IEA estimates that "the overall savings from these digitally enabled measures could be in the order of US$80 billion per year over 2016-2040, or about 5% of total annual power generation costs."[11] Extrapolated to Canada, the cost savings would be approximately CAN$1 billion to $2 billion a year.[12] While power asset lifetime extensions enabled by digitalization are not yet known, the IEA estimates that if the lifetime of all global power assets were extended by

---

[2] Link to source: https://www.eia.gov/todayinenergy/detail.php?id=41433.

[3] Link to source: https://www.un.org/en/global-issues/population.

[4] Link to source: https://www.eia.gov/todayinenergy/detail.php?id=41433.

[5] Ibid.

[6] Link to source: https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments.

[7] Based on figures from 2020, Environment and Climate Change Canada (2022) National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada. Link to source: www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/inventory.html.

[8] Link to source: https://www.frost.com/frost-perspectives/5g-a-critical-enabler-for-digitalization-in-oil-and-gas-emerging-use-cases-and-opportunities/.

[9] Link to source: https://www.pwc.com/ca/en/media/release/digitization-decrease-production-cost-for-oil-and-gas-companies.html.

[10] Link to source: https://iea.blob.core.windows.net/assets/b1e6600c-4e40-4d9c-809d-1d1724c763d5/DigitalizationandEnergy3.pdf.

[11] Ibid.

[12] Based on Canada accounting for approximately 2% of total global GDP.

five years, "close to US$1.3 trillion of cumulative investment could be deferred over 2016-2040, or about 7% of total power sector investment in the [status quo] scenario."[13]

Challenges faced by the energy and electric utility industries:

1. **Increase in energy demand from population growth and rising living standards in developing economies:** As the global population continues to grow, it will drive increased energy demand from emerging markets and developing economies. Across all fuels and technologies, emerging markets will be instrumental in shaping global trends in the coming decades. According to the IEA's Stated Policies Scenario (STEPS)[14], "oil demand in these economies [will be] 12 million barrels per day higher in 2030 than in 2020 (an increase of nearly 30%), gas demand [will be higher] by 520bcm (a near 25% increase), and coal demand [will be higher] by 160 million tonnes of coal equivalent (a 4% rise)."[15] According to their Announced Pledges Scenario (APS),[16] "demand for fossil fuels in advanced economies falls … but announced pledges do not bend projected demand trends across much of the developing world."[17]

2. **Transitioning to renewable energy sources:** Converting the current energy system to one led by renewable energy will require significant flexibility in all parts of the power system from generation to transmission and distribution systems, storage and demand. Production of heat and synthetic gas (e.g., hydrogen) from renewable electricity will also be key for energy system decarbonization in the long-term, and, once in place, it can be a significant additional source of flexibility for the power system.

3. **Shift away from the traditional utility business model, in which monopolist power companies distribute their energy from large power plants to the end-user:** Decentralization of the energy utility market will look like a distributed energy network with a democratic business model in which energy consumers manage their own energy portfolios. Decentralization requires several technologies with different implications for the grid: distributed generation from renewable sources (primarily photovoltaic solar), which reduces demand during sunny hours of the day; distributed storage, which collects electrical energy locally for use during peak periods or as backup, flattening demand peaks and valleys; energy efficiency, which allows for reduced energy use while providing the same service, reducing overall demand; and demand response, which enables control of energy use during peak demand and high pricing periods, reducing peak demand. According to the World Economic Forum, "as more distributed energy resources come online, demand response programmes may become even more flexible and by some

[13] Ibid.

[14] The Stated Policies Scenario reflects current policy settings based on a sector-by-sector assessment of the specific policies that are in place, or have been announced, by governments around the world.

[15] Link to source: https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf.

[16] The Announced Pledges Scenario, introduced this year, aims to show to what extent the announced ambitions and targets, including the most recent ones, are on the path to deliver emissions reductions required to achieve net zero emissions by 2050. It includes all recent major national announcements of 2030 targets and longer-term net zero and other pledges, regardless of whether these have been anchored in implementing legislation or in updated NDCs. In the APS, countries fully implement their national targets to 2030 and 2050, and the outlook for exporters of fossil fuels and low emissions fuels like hydrogen is shaped by what full implementation means for global demand.

[17] Link to source: https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf.

estimates could reduce necessary annual investments in U.S. grid infrastructure by 10%."[18] Moreover, "demand flexibility creates value for customers and the grid by shrinking customer bills (by as much as 40%), reducing peak demand and shifting consumption to lower price, off-peak hours."[19] This new decentralized model, when fully scaled, should optimize renewable energy while also cutting transmission and distribution costs.[20] Unlike a centralized system where power is supplied when demand peaks, a decentralized system uses demand responses to manage supply and grid stability. However, this system would require coordination of an immense number of energy consumers, equipment and demand responses.[21]

4. **Increased variability caused by demand and supply of different energy sources:** New energy sources are creating complex dynamics between electricity, fuels and storage markets, and will continue to do so moving forward. These complex interactions will generate considerable variability on both the demand and supply sides of the energy market. For example, rising shares of wind and solar photovoltaic electricity generation will further necessitate robust grids and other flexible sources of supply due to the additional variability that these generation methods introduce.[22]

5. **Demanding ESG goals and increased regulatory oversight:** International agencies, governments and policy makers have intensified their scrutiny of the energy and electric utility sectors because of the environmental challenges related to these sectors. The oil and gas and electricity sectors are major consumers and producers of energy and are subject to increasingly stringent environmental regulations. These sectors are increasingly confronted with the need to develop and report their ESG targets that align with national and or international regulatory standards. This additional oversight is driving operators to redesign their extraction, production and transportation systems and processes to enhance their operational and regulatory effectiveness. Operators are also required to provide transparency in the environmental management of their activities. These considerations have become critical as these two sectors face accelerating change and increased activism.

6. **Wastage of energy during generation and consumption:** According to the EIA, approximately 60% to 66% of energy used for electricity generation is lost in conversion.[23] It is estimated that of the 66% lost, roughly 59 percent points are due to inefficiencies in the process of converting primary energy to electricity, 5 percent points are due to power plant operations and the remaining 10 percent points are lost during the delivery of electricity through the transportation and distribution system.[24]

[18] Link to source: https://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf.
[19] Ibid.
[20] Link to source: https://utilityanalytics.com/2021/08/energy-decentralization-why-its-a-big-deal-for-every-business/.
[21] Link to source: https://solutions.mhi.com/blog/the-energy-transition-depends-on-these-three-trends/.
[22] Link to source: https://iea.blob.core.windows.net/assets/4ed140c1-c3f3-4fd9-acae-789a4e14a23c/WorldEnergyOutlook2021.pdf.
[23] Link to source: https://www.eia.gov/todayinenergy/detail.php?id=44436.
[24] Link to source: https://www.enerdynamics.com/Energy-Currents_Blog/How-Much-Primary-Energy-Is-Wasted-Before-Consumers-See-Value-from-Electricity.aspx.

7. **Reducing costs to remain globally competitive:** One of the major challenges of the energy industry is the high cost to produce crude oil, gas and refined products. Optimizing extraction, conversion and distribution systems and processes is a priority for both energy and utility operators.

8. **Increasing operational complexity from distributed smaller scale energy solutions:** The move from centralized to decentralized energy generation is accelerating. As more renewable energy sources connect to the grid, they are creating hundreds or thousands of power generation points and types and are making the power grid more complex to operate. This is resulting in reduced revenue for operators, increased transmission and distribution system costs, and increased risk regarding grid reliability and cyber-security.

9. **Outdated extraction, generation and distribution plants and systems:** Both Canada's and the U.S.'s electric utility sectors face a pressing need to maintain aging facilities, and operators are tasked with integrating more intermittent generation from renewable sources and incorporating smarter grid systems. There are more than 35 electrical transmission interconnections between the Canadian and U.S. power systems with the two systems forming a highly integrated grid. This integration is set to continue expanding, with multiple cross-border transmission projects currently in various stages of development. Every Canadian province along the U.S. border is electrically interconnected with one or more neighboring U.S. states. For utilities, the aged infrastructure is causing frequent tripping and breakdown because of a poor distribution system. The oil and gas sector faces a similar challenge in the form of fugitive emissions[25] that account for approximately 5% of global emissions. Roughly 60% of fugitive emissions come from leaky valves; servicing, updating and replacing valves, as well as implementing new automation and monitoring technology, could address much of these fugitive emissions.[26]

10. **Climate change and the increase in natural disasters:** Increasing potential for incidents such as pipeline bursts and natural calamities like floods and earthquakes owing to climate change may also cause interruptions to electricity and energy supplies, as well as major spills and leaks.

11. **Asset protection from physical and cyber attacks:** The economic importance of oil and gas infrastructure means that they are a key target for terrorism and piracy, which can lead to high levels of damage.

Current oil and gas and electric utility business models will use 5G-enabled digital machines, devices, and technologies like AI, ML, BDA, digital twins, blockchain and others to optimize their operations and infrastructure. These new machines, devices, technologies and applications will improve the design, construction, and maintenance methods of oil and natural gas pipelines and electricity generation plants while simultaneously enhancing asset integrity and cost-efficiency

[25] Fugitive gas emissions are leaks or unwanted releases of gases and vapours into the atmosphere that can originate from storage tanks, pipelines, appliances, and other industrial pressurized equipment.

[26] Link to source: https://www.reuters.com/article/sponsored/capturing-fugitive-emissions-can-create-greener-more-cost-effective-operations.

and extending service life expectations. These innovative technologies will also further reduce environmental and work and safety incidents.

The proliferation of renewable energy sources will make our energy networks more complex. This increased complexity will be driven by factors such as multiple energy sources and decentralized grids. To manage this complexity, the energy and utility sectors will require intelligent solutions to monitor and manage fluctuating demand and supply, environmental impacts and operational performance. 5G-enabled digital tools will help energy and utility operators overcome these acute challenges and make the necessary changes.

5G technology enhances critical awareness and decision-making for a variety of situations. As an example, drone-mounted cameras can help monitor seismic changes, fires, and natural disasters more effectively; they can help terminal operators proactively inspect container ships before they even reach the port and operators of wind farms proactively detect problems with turbines. Video analytics could significantly enhance the security, and efficiency in the field by enabling intrusion detection, automatic fault detection, and control of robots. Similarly, search and rescue operations could leverage camera drones and video analytics to survey remote areas without human intervention.

Potential Digital Solutions Supported by 5G	Types of 5G Capabilities Leveraged
1. **VR, AR and MR (Mixed Reality)** can be used to support collaboration for diagnostics and maintenance, enhance employee training and productivity, and recreate real-life scenarios for workers to safely practice their skills. These digital solutions could even support remote work by allowing collaboration among employees in virtual spaces. Additionally, they could allow interaction with data, applications and the environment in new ways. Digital twins could create a virtual model of an oil and gas or power plant or even an entire grid, allowing employees to model different scenarios, make better decisions and improve efficiencies.[27] 2. **AI and predictive analytics** can be used to accelerate data clean-up and analysis of the massive volumes of data and reports generated by operational processes related to logistics, supply, and production. They can also be used to analyze and predict demand and adjust where power is drawn from on distributed grids.[28] 3. **Smart grids** can detect local changes in power usage and react automatically without the need for human intervention. They allow reliable real-time communication between consumers and utilities so consumers can tailor their energy consumption based on individual preference, such as price and/or environmental concerns. They enable more efficient transmission of electricity; quicker restoration of	1. **Ultra-low and predictable latencies with quality-of-service guarantees (URLLC)** even with a heavy load and many users by using network edge to optimize network traffic flows; Decentralization will drive the need for real-time control of the grid, and low latency requirements, which will also drive the need for more capable edge computing to support required latencies. 2. **Extremely high bandwidth for data transmission (eMBB),** which will enable the transfer and download of massive data files, high-resolution images, videos and supporting AR/VR. 3. **Massive IoT (mIoT)** - 5G will be able to facilitate a large network of IoT devices and sensors. 4. **Fixed wireless access (FWA)** - ubiquitous and low-cost networks in rural areas. 5. **More deployment flexibility** for sparse and dense options. 6. **Mobility capabilities to ensure a smooth handover** between base stations. 7. **Reliability of device interoperability** and low device cost at scale. 8. **Resilience and high availability** - All deployment scenarios must be able to ensure an elevated level of resilience and availability. To satisfy utilities' requirements, carriers may need to dedicate

[27] Link to source: https://www.frost.com/frost-perspectives/5g-a-critical-enabler-for-digitalization-in-oil-and-gas-emerging-use-cases-and-opportunities/.
[28] Link to source: https://www.analyticsinsight.net/top-10-applications-of-ai-and-robotics-in-the-energy-sector/.

electricity after power disturbances; reduced peak demand; increased integration of large-scale renewable energy systems; better integration of customer-owner power generation systems, including renewable energy systems; and improved security.[29, 30] 4. **Smart fleet management** with GPS, sensors and enhanced 5G connectivity will enable enhanced maintenance and fuel management; driver safety; telematics; geo-fencing and tracking; smart surveillance; vehicle-to-vehicle communications; optimal real-time routing; speed/idling real-time feedback; real-time cargo monitoring; and collision avoidance. "Through integrated planning, improved vehicle utilization, and route and speed optimization, oil companies have demonstrated 10% to 30% reductions in overall transportation costs."[31] 5. **Smart contracts stored on blockchain** are "self-executing, customizable and tamper-proof [in] nature [and] seen as a key technology for enabling the transition to a more efficient, transparent and transactive energy market. The applications of smart contracts include coordination of smart electric vehicle charging, automated demand-side response, peer-to-peer energy trading and allocation of the control duties amongst the network operators."[32] 6. **Drone video surveillance, notification and analytics** to manage the security of campuses of oil and gas and electric utility companies and drilling, generation and distribution infrastructure; alerting systems that send notifications directly to mobile devices. 7. **Supervisory control and data acquisition (SCADA) systems that can proactively detect leaks and other issues** provide an abundance of data about the functionality and health of equipment. They can indicate the level of pressure within each pipe, monitor durable valves, measure tank level, track flow monitoring and much more. In addition to alarm notifications, operators can create preventative maintenance alerts so they can be proactive about their equipment. 8. **Digital workforce management** with seamless real-time collaboration; connecting employees across locations and time zones, allowing instant access to document and file sharing, and streamlined communication. Digital workforce	spectrum, radios, packet core instances and edge computing to utility customers. These dedicated resources can be enabled through the 5G slicing feature set. **9. Location awareness** for navigating, real-time locating, and positioning.

[29] Link to source: https://www3.weforum.org/docs/WEF_The_Impact_of_5G_Report.pdf.

[30] Link to source: https://www3.weforum.org/docs/WEF_Future_of_Electricity_2017.pdf.

[31] Link to source: https://ihsmarkit.com/research-analysis/upstream-oil-and-gas-meeting-its-challenges-through-innovation.html.

[32] Link to source: https://www.sciencedirect.com/science/article/pii/S1364032121012764.

management will also enhance remote work support, sustainability and better AI integration. 9. **Electric vehicles** (EVs) – 5G will be critical to guaranteeing safety and reliability via network slicing, which will play an essential role in guaranteeing connectivity. Network slicing will allow the creation of individual network slices with their own SLA-grade requirements for EVs and their charging infrastructure. This will require operators to be better equipped to guarantee the low latency and reliability they need to adapt to changing scenarios. EVs will be able to automatically switch to 5G without disrupting or interrupting communication with charging stations and management systems; they will dynamically switch back to fixed connectivity. 10. **Smart meters** that will expose information about end-point energy consumption and generation and the quality of energy that is received from the distributor.[33] When this information is fed into the latest grid optimization tools, it shows distributors how to reconfigure their grids to reduce losses to heat and vibration and better use available capacity.	
Potential Operational Benefits	**Potential ESG Benefits**
1. **Optimized and automated drilling** with advanced analytics could increase drilling operations productivity by improving drilling speed by 25% or more.[34] Remote or semi-automatic drilling should also reduce the number of people required on the rig, driving down cost per well. Productive drilling time would increase to 94% from the current 90%. Together, drilling optimization and automation should drive a combined 5% to 10% reduction in cost per barrel of oil equivalent.[35] 2. **Reduced unplanned downtime** – "Oil and gas producers suffer 32 hours of unplanned downtime each month, on average, at the cost of $220,000 per hour – amounting to $84 million [annually] per facility. In refineries alone, losses to Fortune Global 500 constituents are estimated to total $47 billion from 213,000 downtime hours [annually]. 82% of oil and gas respondents [say] predictive maintenance [is] a strategic objective, the most of any sector	1. **Optimized and automated drilling** would reduce emissions from drilling activity by approximately 10%.[40] [U.N. SDG - 9 and 13] 2. **Optimized production** – Enhanced SCADA technologies will enable timely data collection across production systems substantially improving the performance of the plant, reducing the risk of leaks, and increasing public health safety. They should also create value by increasing throughput while also reducing the energy consumed and emissions produced.[41] [U.N. SDG - 9 and 13] 3. **Reduced health and safety incidents** – Augmenting workers with digital solutions can improve both their productivity as well as their workplace safety. A digitally enabled workforce can be 8.5% more productive while also reducing loss from health and safety incidents by 48%.[42]

33 Link to source: https://www.telit.com/blog/how-5g-enables-advanced-metering-infrastructure-smarter-utilities/.

34 Link to source: https://www.mckinsey.com/industries/oil-and-gas/our-insights/how-tapping-connectivity-in-oil-and-gas-can-fuel-higher-performance.

35 Ibid.

40 Link to report: https://www.mckinsey.com/industries/oil-and-gas/our-insights/how-tapping-connectivity-in-oil-and-gas-can-fuel-higher-performance.

41 Link to report: https://www.mckinsey.com/industries/oil-and-gas/our-insights/how-tapping-connectivity-in-oil-and-gas-can-fuel-higher-performance.

42 Link to source: https://www.ericsson.com/en/industries/offshore-and-processing.

surveyed."[36] Considering that 70% of companies lack awareness of when assets require maintenance, application of real-time asset condition monitoring and pre-emptive anomaly identification to pumps and compressors could reduce maintenance sessions and unplanned downtime by 25% and 32%, respectively, in addition to extending equipment lifetime by 25%.[37] Overall, this optimization could reduce maintenance costs by 20% to 40% and increase production by 3% to 5%.[38] 3. **Enhanced field operations and reduced operations costs driven by connected workers -** Digital twins, mobile device-accessible schematics and plans combined with features like push-to-video and smart integrated modeling will make workers more efficient both on and offsite. The increased effectiveness of digitally enhanced workers can result in an 8% reduction in operational spending.[39] 4. **Streamlined end-to-end supply and logistics** with improved demand management, transparent materials tracking and more efficient logistics operations. 5. **Reduced electricity theft, losses from transmission, distribution, etc.** from the development of smart grids. Smart grids can also reduce electricity costs, meter reading costs, operations and maintenance costs, and equipment failures by using automatic operation based on varying load conditions. The demand response of smart grids should decrease the stress on smart grid systems during peak conditions, which will reduce the probability of failure. Smart grids are also capable of meeting increased consumer demand without adding infrastructure. 6. **Digitization and standardization of regulatory compliance** processes should allow energy operators to support new business models and meet regulatory requirements while remaining competitive in the marketplace. It should also improve operating efficiencies and reduce the time for administrative regulatory tasks, thereby enabling legal and compliance functions to redirect their efforts to strategic initiatives and managing regulatory risk.	[U.N. SDG - 3 and 8] 4. **Reduced carbon dioxide emissions** by up to 12% with the Smart Grid.[43] [U.N. SDG - 12] 5. **Shift of skills** and access to better professional jobs; in-field AR support for e-learning and expert advice in remote areas. According to PWC's 22nd Annual Global CEO Survey, "76% of respondents from the energy, utilities and resources space expressed concern about the availability of skills, particularly digital skills, in the marketplace. It's becoming increasingly difficult for energy operators to find – and retain and engage – talent with key skill sets, including digital business strategy and data analytics."[44] [U.N. SDG - 8]

36 Link to source: https://pressreleases.responsesource.com/news/101458/world-s-largest-manufacturers-lose-almost-trillion-a-year-to/.

37 Link to source: https://www.ericsson.com/en/industries/offshore-and-processing.

38 Link to source: https://web-assets.bcg.com/img-src/BCG-Going-Digital-Is-Hard-for-Oil-and-Gas-Companies-but-the-Payoff-Is-Worth-It-Mar-2019_tcm9-215951.pdf.

39 Link to source: https://www.ericsson.com/en/industries/offshore-and-processing.

43 Link to source: https://www.frontiersin.org/articles/10.3389/fenrg.2021.681244/full.

44 Link to source: https://www.pwc.com/ca/en/industries/energyvisions/publications/774843-forward-together-whats-ahead-for-canadas-oil-and-gas-industry-part-3.pdf.

Estimated Economic Benefits	Example Metrics Potentially Impacted by 5G[45]
1. 5G applications in smart grids and meters could add US$209 billion to global GDP by 2030.[46]	1. Access to the 5G network 2. Number of 5G-enabled digital solutions implemented 3. Estimated total value realized from 5G enabled digital solutions that are implemented 4. Decrease in GHG emissions 5. Decrease in number/size of oil and/or gas leaks 6. Decrease in waste and fresh water used 7. Decrease in health and safety incidents 8. Decrease in physical and cyber attacks 9. Increase in workforce training and development 10. Increase in compliance with regulatory standards and reporting 11. Decrease in cost per megawatt produced 12. Decrease in maintenance cost per mile of pipe/line/cable 13. Decrease in average number of labor hours to complete a maintenance task 14. Decrease in average response time to fix breaks 15. Increase in crew productivity 16. Decrease in equipment failure or unavailability 17. Decrease in mean time to repair 18. Decrease in number of complaints received 19. Decrease in number of power failures per year 20. Decrease in number of staff per 1,000 customer connections 21. Decrease in outage time per event 22. Increase in billing accuracy and timeliness

Select case studies:

VR Training for Oil & Gas Operators[47]	
Background	▪ Saudi Aramco has established a "Fourth Industrial Revolution Centre", where technological and digital solutions are being developed to transform the ways in which the company runs its operations. ▪ Their "VR Zone" is used to develop, prototype and train for AR/VR applications. These applications enable plant assets to be visualized and provide workers with a live sense of the plant experience from a simulation booth. ▪ Their "3D Operator System Training Centre" provides real-world incident training in a safe and engaging VR-simulated environment. The system uses VR headsets and standard controls that allow operators to virtually walk through

[45] The following sources were used to inform the contents of this list: 1) https://www.sciencedirect.com/science/article/pii/S2351978917303785; and 2) https://www.spiderstrategies.com/kpi/industry/utilities/.

[46] Link to source: https://www.pwc.com/gx/en/tmt/5g/global-economic-impact-5g.pdf.

[47] Link to source: https://www3.weforum.org/docs/WEF_The_Impact_of_5G.pdf.

VR Training for Oil & Gas Operators[47]	
	three generic plant types: a gas-oil separation plant, a gas and condensate processing plant, and a water injection plant. During these training scenarios, operators encounter several process disruptions that they must address.
Improvement areas	▪ 5G-enabled immersive VR training for the workforce ensures accuracy and effectiveness in day-to-day operations. ▪ VR training is highly scalable and can thus reduce time and resources spent on training overall. ▪ VR training programs reduce the need to travel to receive training. ▪ Innovative learning through VR helps to uphold job satisfaction and retention.
Economic and societal impacts	▪ Reduction in training budgets and operational downtime, leading to increased profitability ▪ Increased skill capacity and job satisfaction of the workforce [U.N. SDG 8] ▪ Mitigation of risk and safety concerns [U.N. SDG 3] ▪ Reduced carbon emissions due to reduced travel requirements for training programmes.
5G capabilities used	▪ eMBB ▪ URLLC
CapEx requirements	▪ VR headsets, motion control devices, knowledge management platforms and digital infrastructure
Maturity timeline	▪ Current state: 4K streaming that ensures faster delivery of training programmes ▪ Short-term: gamification that leads to more immersive training programmes ▪ Long-term: volumetric video that further augments the immersion and effectiveness of VR training programmes

5G Smart Grids[48]	
Background	▪ China Southern Power Grid Co., Ltd. (CSG) operates power grids in five Chinese provinces and has connections with national or regional power grids in four neighbouring countries. CSG's total service area spans 1 million square kilometres and serves more than 254 million people. ▪ CSG and its digital partners have jointly pursued the innovative application of 5G smart grid technologies, and they have achieved breakthroughs in several technologies and services.
Improvement areas	▪ 5G networks enable drones to inspect power transmission lines and make the process up to 80 times more efficient. ▪ 5G technology allows power transformation substations to operate nearly three times more efficiently and enables accurate remote monitoring of equipment status. ▪ 5G technology minimizes fault detection and isolation times from minutes to milliseconds. ▪ Unlike 4G, 5G is capable of handling power consumption data collection from tens of millions of users and opens new avenues to create value for customers.

[48] Link to source: https://www.gsma.com/greater-china/wp-content/uploads/2021/02/5G-Use-Cases-for-Vertical-China-2021-EN.pdf.

5G Smart Grids[48]	
	▪ 5G-enabled end-to-end network slicing and chip encryption technology facilitates security isolation of power grids.
Economic and societal impacts	▪ Shortened power failures, improved power supply efficiency and lower electricity costs can minimize losses to society and save operating costs. [U.N. SDG 7] ▪ Rollout of these 5G-enabled smart grid innovations to the five provinces served by CSG is expected to generate economic and societal benefits of at least RMB 5 billion.[49]
5G capabilities used	▪ eMBB ▪ URLLC
CapEx requirements	▪ Unmanned drones, data analytics applications and digital infrastructure.
Maturity timeline	▪ Current state: grid infrastructure monitoring via unmanned drones and remote technology ▪ Short-term: integration of decentralized power grids and smart meters that provide additional information to end-users ▪ Long-term: predictive analytics that anticipate demand fluctuations and service outages and react accordingly in real-time

[49] Ibid.