

Natural Capital

We continue to increase financial value from natural or environmental capital-related business activities, while reducing our environmental footprint and potential risk factors related to environmental impacts. Comparable EBITDA from renewable energy generation in 2019 was \$341 million (2018 - \$342 million). Our revenue in 2019 from environmental attribute sales was \$27.6 million (2018 - \$21.6 million). In addition, in 2019 the sale of coal byproducts and waste-related recycling generated financial value in the range of \$25 million to \$35 million.

The following are key trends in our natural capital:

Year ended Dec. 31	2019	2018	2017
Renewable energy comparable EBITDA	341.0	342.0	289.0
Environmental attribute sales revenue	27.6	21.6	27.7
GHG emissions (million tonnes CO ₂ e)	20.6	20.8	29.9

Natural Capital Management

All energy sources used to generate electricity have some impact on the environment. While we are pursuing a business strategy that includes investing in renewable energy resources such as wind, hydro and solar, we also believe that natural gas will continue to play an important role in meeting energy needs as part of a clean electricity transition. Natural gas plays an important role in the electricity sector, providing low-emission baseload and peaking generation to support system demands and intermittent renewable generation. TransAlta operates simple and combined-cycle natural gas units and cogeneration facilities. We are planning to convert our Alberta coal units to natural gas in the 2020 to 2025 time frame, and by the end of 2025, our generation mix will be only from natural gas and renewable energy.

Regardless of the fuel type, we place significant importance on environmental compliance and continued environmental impact mitigation, while seeking to deliver low-cost and reliable electricity. The Corporation endeavours to be environmentally responsible and recognizes that the competitive pressures for economic growth and cost efficiency must be integrated with sound sustainability management, including environmental stewardship. The Corporation is subject to environmental laws and regulations that affect aspects of our operations, including air emissions, water quality, wastewater discharges and the generation, transport and disposal of waste and hazardous substances. The Corporation's activities have the potential to impair natural habitat, damage vegetation and wildlife, or cause contamination to land or water that may require remediation under applicable laws and regulations. These laws and regulations require the Corporation to obtain and comply with a variety of environmental registrations, licenses, permits and other approvals. Both public officials and private individuals may seek to enforce environmental laws and regulations against the Corporation. Currently the most material natural or environmental capital impacts to our business are GHG emissions, air emissions (pollutants, metals) and energy use. Other material impacts that we manage and track performance on via our environmental management systems include environmental incidents and spills, land use, water use and waste management.

Environmental Governance

TransAlta's Governance, Safety and Sustainability Committee assists the Board in fulfilling its oversight responsibilities with respect to the Corporation's monitoring of environmental, health and safety regulations and public policy changes and the establishment and adherence to environmental, health and safety practices, procedures and policies. More details on governance can be found in our Governance and Risk Management section of this MD&A.

Environmental Management Systems

All of our 73 facilities have Environmental Management Systems ("EMS") in place, the majority of which closely align with the internationally recognized ISO 14001 EMS standard. We have operated our facilities in line with ISO 14001 for over 20 years, and our systems and knowledge of management systems are therefore mature. Only two facilities do not have ISO 14001 aligned EMS in place, although these facilities do have a comparable EMS in place. This is due to commercial arrangements (TransAlta is not the operator of those two sites). Aligning with ISO 14001 provides assurance that our systems are designed to continuously improve performance.

Environmental Performance

Reducing the environmental impact of our activities benefits not only our operations and financial results, but also the communities in which we operate. We expect that increased scrutiny will be placed on environmental management and compliance, and we therefore have a proactive approach to minimizing risks to our results. Our Board provides oversight with respect to the Corporation's monitoring of environmental regulations and public policy changes and to the establishment and adherence to environmental practices, procedures and policies in response to legal/regulatory and industry compliance or best practices.

Our performance on managing environmental impacts, reducing our environmental impact and capitalizing on environmental initiatives includes the following.

Renewable Energy and Battery Storage

Since 2005, we have added approximately 1,300 MW in renewable energy capacity. We continue to operate over 900 MW of hydro energy and our experience with hydro operations spans over 100 years. In 2015, we made our first solar investment in a 21 MW solar facility in Massachusetts, and we continue to look for opportunities to develop and operate solar energy. Our production from renewable energy in 2019 offset the equivalent of approximately 1.6 million tonnes of carbon dioxide equivalent, or the removal of approximately 340,000 cars from the roads in 2019.

In 2020, we will commission the first utility-scale battery storage project in Alberta, located at our Summerview Wind Farm. The project will use Tesla battery technology and will have a capacity of 10 MW.

Natural Gas

Natural gas plays an important role in the electricity sector, providing low-emission baseload and peaking generation to support system demands and intermittent renewable generation. TransAlta operates simple cycle, combined-cycle, and cogeneration facilities in Canada and Australia. Natural gas facilities provide highly efficient electricity and, in the case of cogeneration, steam production, directly to customers and for the wholesale markets. TransAlta is a significant operator of natural gas electricity in Canada and Australia.

Coal Transition

Our coal-to-gas conversion plan in Alberta is expected to significantly reduce our environmental footprint. As a result of our coal-to-gas conversions, energy use, GHG emissions, air emissions, waste generation and water usage are expected to significantly decline. Conversion of coal-fired power generation to gas-fired generation will eliminate all mercury emissions, the majority of particulate and sulphur dioxide emissions ("SO₂") as well as significantly reducing our nitrogen dioxide emissions ("NO_x"). Converting GHG-intensive coal facilities to natural gas will support significant reductions in GHGs (approximately 40 per cent reduction), while supporting reliability, affordability and growth of renewable electricity in Alberta. Converted coal facilities will use lower carbon natural gas (new methane reduction regulations on flaring and venting will reduce GHG emissions for natural gas producers) while supporting our local gas producers through the use of up to 700,000 GJs of natural gas per day.

Environmental Incidents and Spills

Protecting the environment and minimizing our impact to the environment supports healthy ecosystems and mitigates our environmental compliance risk and reputational risk. We maintain procedures for environmental incidents similar to our safety practices, with tracking, analyzing and active management to minimize occurrences. With respect to biodiversity management (management of ecosystems, natural habitats and life in the areas we operate), we seek to establish robust environmental research and data collection to establish scientifically sound baselines of the natural environment around our facilities and closely monitor the air, land and water in these areas to identify and curtail potential impacts.

Environmental incidents are separated into two categories: significant environmental incidents and regulatory non-compliance environmental incidents. We define regulatory non-compliance environmental incidents as events that involved a non-compliance event but did not have an impact on the environment. For example, a technical issue with a computer system for gathering real-time data could cause us to be out of compliance with local regulation or our EMS, but there is no direct consequence for the physical environment. All other events are captured as significant environmental incidents and these are where we deem there to be a material impact to the environment. In 2019, we recorded three significant environmental incidents (2018 - one incident). We recorded six non-compliance environmental incidents in 2019 (2018 - six incidents).

Our three significant environmental incidents in 2019 occurred at two of our wind facilities in the US. At our Lakeswind wind facility in Minnesota, we discovered a bald eagle mortality. At our Wyoming wind facility, we discovered two golden eagle mortalities. Root cause analysis investigations were performed on each eagle mortality and we found no causal factors or root causes related to human behaviour or equipment failure being involved in the incidents. These incidents were unusual and we have not had an eagle mortality across our wind fleet since 2015. For all incidents we collaborated with authorities and there were no enforcement actions in respect of such mortalities. Despite inconclusive findings, in order to reduce the risks of future impacts to protected eagle species, we are working on indirect corrective actions that include reviewing the potential for an updated bird monitoring study to be conducted at Lakeswind and Wyoming wind or other at-risk sites.

The following are the significant environmental incidents by fuel types:

Year ended Dec. 31	2019	2018	2017
Coal	–	1	1
Gas and renewables	3	–	1
Total significant environmental incidents	3	1	2

The following outlines regulatory non-compliance environmental incidents by fuel types:

Year ended Dec. 31	2019	2018	2017
Coal	3	4	3
Gas and renewables	3	2	–
Total regulatory non-compliance environmental incidents	6	6	3

We also continue to track and manage all non-reportable (minor) environmental incidents, which helps us identify what causes an incident. Understanding the root cause of incidents helps with incident prevention planning and education.

Typical spills that could occur at our operation sites are hydrocarbon spills. Spills generally happen in low environmental impact areas and are almost always contained and fully recovered. It is extremely rare that we experience large spills, which would adversely impact the environment and the Corporation. Spills that do occur are always addressed with a critical time factor. The estimated volume of spills in 2019 was 530 m³ (2018 - 5 m³). Spill volumes in 2019 were higher due to a 527 m³ spill at our Sarnia cogeneration facility. This was not a traditional product spill and was a wastewater effluent limit exceedance from a sump. There was no enforcement action associated with this spill.

Air Emissions

Our coal facilities emit a number of air emissions that we track, analyze and report to regulatory bodies. We also work on mitigation solutions depending on the type of air emission. We report our major air emissions from coal, which includes NO_x, SO₂, particulate matter and mercury. We will continue to reduce air emissions in our existing fleet through our conversion and retirement of coal units in Alberta and Washington State. We are well underway and remain on track to achieve our target of 95 per cent SO₂ emission reductions over 2005 levels by 2030. Since 2005, we have reduced SO₂ emissions by 77 per cent. As noted above, we are on track to achieve our SO₂ target by 2025, well ahead of our 2030 goal. This allows flexibility as we convert coal facilities to natural gas and expand our natural gas fleet. We continue to model and evaluate this target to ensure a balance of growth and appropriate air emission reductions. We continue to capture 80 per cent of mercury emissions at our coal plants and by 2025, mercury emissions will be eliminated following the coal-to-gas conversions. Particulate matter and SO₂ emissions will also be virtually eliminated or considered negligible.

None of our Alberta coal facilities are located within 50 kilometres of dense or urban populations, but our Centralia coal facility in Washington State is 40 kilometres from a dense or urban population. As per guidance from SASB, "a facility is considered to be located near an area of dense population if it is located within 49 kilometres of an area of dense population" (being deemed to be a "minimum population of 50,000 persons"). The Centralia facility has two units and we are retiring one unit at the end of 2020 and the additional unit at the end of 2025, at which time air emissions from our coal facilities will be eliminated.

Our gas facilities emit low levels of NO_x that triggers reporting obligations to national regulatory bodies. These gas facilities also produce trace amounts of SO₂ and particulate matter, but at levels that are deemed negligible and do not trigger any reporting requirements or compliance issues. Many of our gas facilities are located in very remote and unpopulated regions, away from dense urban areas. Our Sarnia, Windsor, Ottawa and Fort Saskatchewan gas facilities are our only facilities with air emissions within 49 kilometres of dense or urban environments.

Our total air emissions in 2019 decreased compared with 2018 levels. Specifically, NO_x was reduced eight per cent, mercury was reduced three per cent, particulate matter was reduced one per cent and SO₂ was reduced 18 per cent over 2018 levels. Reduction in most emissions were largely due to an increase in co-firing (gas and coal) at our Alberta thermal facilities. Particulate matter emissions were adjusted historically to reflect our estimation on the level of PMs from road dust at our Alberta mining operations. We continue to mature our ability to estimate this data in line with guidance from Government of Canada.

Year ended Dec. 31	2019	2018	2017
Sulphur dioxide (tonnes)	15,900	19,300	36,200
Nitrogen dioxide (tonnes)	25,800	28,000	44,400
Particulate matter (tonnes)	8,200	8,400	11,400
Mercury (kilograms)	60	70	110

Water

Our principal water use is for cooling and steam generation in our coal and gas plants, but our hydro operations also require water flow for operations. Water for coal and gas operations is withdrawn primarily from rivers where we hold permits to withdraw water and must adhere to regulations on the quality of water that is discharged. The difference between withdrawal and discharge, representing consumption, is due to several factors, which includes evaporation loss and steam production for customers. Typically, TransAlta withdraws in the range of 220-240 million m³ of water across our fleet. In 2019 we withdrew 286 million m³ (2018 – 245 million m³) and returned approximately 218 million m³ (2018 – 208 million m³) back to its source or 76 per cent. Overall water consumption was 68 million m³ (2018 – 37 million m³). Water withdrawal and consumption was much higher in 2019 due to increased production at our Centralia coal facility. Production was up 1,787 GWh in 2019 compared to 2018, due mainly to higher merchant pricing in the first half of 2019 and timing of dispatch optimization.

Our historical 2017 water from environment volume was revised in 2019 as a result of an adjustment to water volumes from our South Hedland facility. South Hedland began commercial operations in 2017 and water data was reported in an incorrect unit. This adjustment resulted in our 2017 water from environment changing from 213 m³ to 211 m³. Subsequently, water consumption (water from environment minus water to environment) also changed as a result and was revised from 41 m³ to 39 m³.

The following represents our total water consumption (million m³) over the last three years:

Year ended Dec. 31	2019	2018	2017
Water withdrawal	286	245	211
Water discharge	218	208	172
Total water consumption	68	37	39

Our largest water withdrawal and discharge occurs at our Sarnia gas cogeneration facility (which produces both electricity and steam for our customer). The facility operates as a once-through non-contact cooling system for our steam turbines. This means large amounts of water flow in and out of the system, as opposed to more advanced technology, which recycles water in cooling towers (more of a closed system). Despite large withdrawals from the adjacent St. Clair River to support our Sarnia operations, we return approximately 93 per cent of the water withdrawn. Water from this source is currently at "low risk" as per analysis from the SASB-endorsed Aqueduct Water Risk Atlas tool.

The Aqueduct Water Risk Atlas tool also highlights that water risk is high at our interior and southern Western Australia facilities due to high interannual variability in the region. Interannual variability refers to wider variations in regional water supply from year to year. Our water supply at these facilities is provided at no cost under PPAs with our mining customers, hence our risk is significantly mitigated. In addition, conservation and re-use strategies aimed at recycling water for mining operational needs have been developed. All water used in the region is sourced from scheme water, and with gas and diesel turbine water use, water wash techniques and frequency of activities are continually modified to minimize consumption and environmental impact. At the South Hedland facility in Western Australia, water risk is also high due to the risk of flooding in the region. The South Hedland facility was built above normal flood levels to mitigate potential risk from flooding. During a recent category 4 cyclone event in the area and associated flooding in the region, the South Hedland facility stayed dry and continued to generate power for the region. In addition, the South Hedland facility has developed a Water Efficiency Management Plan with Water Corporation WA, the principal supplier of water, wastewater and drainage services in Western Australia. Initiatives are aimed at reducing water consumption and costs through innovative technology and efficiencies identified through plant management.

In southern Alberta, following the flood of 2013, our hydro facilities are being used for a greater water management role than they have played in the past. In 2016, we signed a five-year agreement with the Government of Alberta to manage water on the Bow River at our Ghost reservoir facility to aid in potential flood mitigation efforts, as well as at our Kananaskis Lakes System (which includes Interlakes, Pocaterra and Barrier) for drought mitigation efforts.

Land Use

The largest land use associated with our operations is for surface mining of coal. Of the three mines we have operated, the Whitewood mine in Alberta is completely reclaimed and the land certification process is ongoing. Our Centralia mine in Washington State is currently in the reclamation phase and we have adopted a target to fully reclaim this mine by 2040. Our Highvale mine in Alberta is actively mined with certain sections undergoing reclamation. Our reclamation plans at Highvale are set out on a life-cycle basis and include contouring disturbed areas, re-establishing drainage, replacing topsoil and subsoil, re-vegetation and land management. Our mining practice incorporates progressive reclamation where the final end use of the land is considered at all stages of planning and development.

In 2019, we reclaimed 114.9 acres (46.5 hectares) at our Highvale mine, which was above our target of 110 acres (45 hectares). We also reclaimed 160.6 acres (65 hectares) of land at our Centralia mine.

Across our mining operations, to date we have reclaimed approximately 12,000 acres (4,800 hectares), which is approximately 38 per cent of land disturbed. Since 1991, we have planted approximately 2.5 million trees as part of this reclamation work.

Waste

In 2019 our operations generated approximately 1.5 million tonnes of primarily non-hazardous waste (2018 - 1.6 million tonnes). Only 0.1 per cent of waste volumes are hazardous materials. In 2019, only 0.1 per cent of waste was directed to landfill. From the remaining 99.9 per cent, 50 per cent was returned to the mine (ash from coal combustion), 49 per cent was reused and the remaining 0.4 per cent was recycled. Historical 2018 waste volumes were revised in 2019 due to misreported volumes of ash disposal from our Keephills facility.

Our reuse waste or byproduct waste is generally sold to third parties. Byproduct sales and associated annual revenue generation typically ranges from \$25 million to \$35 million. Our operating teams are diligent at not only minimizing waste, but also maximizing recoverable value from waste. Over the years, we have invested in equipment to capture byproducts from the combustion of coal, such as fly ash, bottom ash, gypsum and cenospheres, for subsequent sale. These non-hazardous materials add value to products like cement and asphalt, wallboard, paints and plastics.

Energy Use

TransAlta uses energy in a number of different ways. We burn coal, gas and diesel to generate electricity. We harness the kinetic energy of water and wind to generate electricity. We also generate electricity from the sun. In addition to combustion of fuel sources, we also track combustion of gasoline or diesel in our vehicles and the electricity use and fuel use for heating (such as natural gas) in the buildings we occupy. Knowledge of how much energy we use allows us to optimize and create energy efficiencies. As an electricity generator, we continually and consistently look for ways to optimize or create efficiencies related to the use of energy. As an example, in 2019 we supported a study conducted by Stanford University to understand how to improve wind production. The research showed that angling turbines slightly away from the wind can boost energy produced and even out variable supply. Our coal-to-gas converted plants are also expected to see a reduction in total energy use, as the utilization of these plants is expected to be lower than historical utilization levels.

The following captures our energy use (millions of gigajoules). Energy use declined by four per cent over 2018 primarily as a result of reduced power production (lower plant utilization) at Alberta thermal.

Year ended Dec. 31	2019	2018	2017
Coal	296.0	309.8	447.4
Gas and renewables	49.1	48.6	49.4
Corporate	0.1	0.1	0.1
Total energy use	345.2	358.5	496.9

Weather

Abnormal weather events can impact our operations and give rise to risks. Due to the nature of our business, our earnings are sensitive to weather variations from period to period. Variations in winter weather affect the demand for electrical heating requirements. Variations in summer weather affect the demand for electrical cooling requirements. These variations in demand translate into spot market price volatility. Variations in precipitation also affect water supplies, which in turn affect our hydroelectric assets. Also, variations in sunlight conditions can have an effect on energy production levels from our solar farm. Variations in weather may be impacted by climate change resulting in sustained higher temperatures and rising sea levels, which could have an impact on our generating assets. Ice can accumulate on wind turbine blades in the winter months. The accumulation of ice on wind turbine blades depends on a number of factors, including temperature and ambient humidity. The accumulation of ice on wind turbine blades can have a significant impact on energy yields, and could result in the wind turbine experiencing more downtime. Extreme cold temperatures can also impact the ability of wind turbines to operate effectively and this could result in more downtime and reduced production. In addition, climate change could result in increased variability to our water and wind resources.

Our generation facilities and their operations are exposed to potential damage and partial or complete loss, resulting from environmental disasters (e.g. floods, high winds, fires and earthquakes), equipment failures and other events beyond our control. Climate change can increase the frequency and severity of these extreme weather events. The occurrence of a significant event that disrupts the operation or ability of the generation facilities to produce or sell power for an extended period, including events that preclude existing customers from purchasing electricity, could have a material adverse effect on us. Our generation facilities could be exposed to effects of severe weather conditions, natural or man-made disasters and other potentially catastrophic events such as a major accident or incident at our sites. In certain cases, there is the potential that some events may not excuse us from performing our obligations pursuant to agreements with third parties. The fact that several of our generation facilities are located in remote areas may make access for repair of damage difficult. Refer to the Governance and Risk Management section of this MD&A for further discussion on weather-related risk.

During the past five years, deviations from expected weather patterns had the following impacts on our annual financial results:

- Warm weather in Alberta in 2015 increased derates at our coal facilities due to its impact on the Sundance cooling ponds. These cooling ponds are susceptible to warm weather; however, we anticipate that decreased coal production from the retirement of Sundance Units 1 and 2, respectively, in the medium term will reduce the stress from such occurrence; and
- Our Highvale mine in Alberta was subjected to significant rain starting in August 2016, which resulted in several weeks of flooding and threatened our coal deliveries. We focused on improving drainage infrastructure and using stockpiles to mitigate future risks.

Climate Change

We believe in open and transparent reporting on material impacts relating to climate change. Our climate change reporting is structured as per guidance from the Financial Stability Board's Task Force on Climate-Related Financial Disclosure recommendations. The following highlights our management, performance and leadership of climate-change-related impacts. For more detailed information, please visit our Climate Change Management webpage at www.transalta.com/sustainability/climate-change-management.

Key Messages

- The GSSC includes in its mandate that it will review guidelines and practices relating to environmental protection and the Corporation's plans with respect to environmental impact;
- Our strategy involves moving away from GHG-intensive coal and achieving 100 per cent clean energy by 2025, represented by renewables and gas;
- Our business is showing resilience to two degrees of global warming by reducing GHG emissions – we have a target to reduce 19.7 million tonnes of CO₂e by 2030 over 2015 levels. To date we have achieved 59 per cent of this target;
- We are well positioned to build renewable energy facilities and lower-carbon gas facilities to support customer sustainability goals to decarbonize; and
- We have reduced 21 million tonnes of CO₂e since 2005, which is a 50 per cent reduction over the time period.

Governance

The highest level of oversight on climate-change-related business impacts is at our Board level, specifically by the GSSC and the AFRC. Macro issues and opportunities such as coal GHG emissions and the phase-out of coal power generation, cost-competitiveness of renewable energy and customer preferences toward lower carbon energy have been at the forefront of strategic discussions with our executive and Board and reflected in our actions to move away from coal, establish a 2030 GHG reduction target and grow our generation capacity from renewable energy and gas.

Our GSSC has oversight of climate-related issues as noted in the GSSC Charter. The GSSC meets on a quarterly basis. One of the mandates of the GSSC Charter is to monitor and assess climate change risks and compliance with associated legislation and public reporting. The GSSC also reviews guidelines and practices relating to environmental protection, including the mitigation of pollution and climate change and considers whether the Corporation's policies and practices relating to the environment are being effectively implemented and advises regarding the development of policies and practices regarding climate change, greenhouse gas and other pollutants".

Strategy

TransAlta, and the electricity sector in general, is at the forefront of reducing GHG emissions, utilizing innovation with lower-carbon and zero-carbon solutions (e.g., renewable energy, natural gas, distributed power generation, battery storage etc.) and are showing a path to resiliency in a low-carbon world. In addition to climate resiliency, front of mind for TransAlta and our sector is reliability of electricity supply and affordability for customers. To support our own path to reduce our GHG footprint and ensure climate resiliency, we have a corporate goal to reduce our GHG emissions by 60 per cent by 2030 over 2015 levels, while growing renewable energy and natural gas. We believe natural gas plays a strong role in supporting grid reliability and supporting customer goals of affordability. Scenario modelling of our GHG target shows that meeting our GHG target aligns us, under many scenarios, with science-based target setting. We have not officially validated a science-based target, but continue to monitor and model our future performance with the Sectoral Decarbonization Approach from the Science Based Targets Initiative.

Our business units and operations consistently seek energy-efficiency improvements, opportunities to integrate clean combustion technologies and development of emissions offset portfolios to achieve emissions reductions at competitive costs. We seek investment in climate-change-related mitigation solutions, such as renewable energy development, where we can maximize value creation for our shareholders, local communities and the environment. Conversion of our large coal fleet to gas-fired generation highlights this approach, which will allow us to run our assets longer than the federally mandated coal retirement schedule. Our goals for undertaking such actions are to enhance value for our shareholders, ensure low-cost and reliable power and reduce our GHG impact.

Our investments and growth in renewable electricity are highlighted by our diverse portfolio of renewable energy-generating assets. We currently operate close to 2,400 MW of hydro, wind and solar power. In 2019, we completed construction and commercial operation of an additional 119 MW of wind generation in the US. Today our diversified renewable fleet makes us one of the largest renewable producers in North America, one of the largest producers of wind power in Canada and the largest producer of hydro power in Alberta. Production from renewable electricity in 2019 resulted in avoidance of approximately 1.6 million tonnes of CO₂e, which is equivalent to removing over 620,000 vehicles from North American roads over the same year.

As previously noted, we seek to commoditize carbon through trading and the generation and sale of environmental attributes. Annual revenue generation from the sale of environmental attributes (Alberta carbon offsets and RECs) in 2019 was \$28 million.

Risk Management

Climate change risks are monitored through our company-wide risk management processes and are actively managed. Climate change risks and opportunities are identified at the Board level, executive and management level, business unit level (coal, gas, wind, solar and hydro) and through our corporate function (e.g. government relations, regulatory, emissions trading, sustainability, commercial, customer relations and investor relations). The business unit and corporate functions work closely together and provide information on risks and opportunities to management, the executive team and the Board.

Climate change risks at the asset or business unit level are identified through our Environmental Management Systems, asset management function and systems, our energy and trading business, active monitoring, active participation/communication with stakeholders, liaison with our corporate function, active participation in working groups and more.

Our climate change risks are divided into two major categories: (1) risks related to the transition to a lower-carbon economy, and (2) risks related to the physical impacts of climate change.

1. Transition Risks

We seek to understand the impact on our business as the world shifts to a lower carbon society. We participate in ongoing decisions related to climate policy and regulation.

Policy and Legal Risks

Ongoing and Recently Passed Environmental Legislation

Changes in current environmental legislation do have, and will continue to have, an impact upon our operations and our business. For further details, see below and the Governance and Risk Management section of this MD&A.

Canadian Federal Government

Federal Carbon Pricing on GHG

On June 21, 2018, the Canadian federal *Greenhouse Gas Pollution Pricing Act* ("GGPPA") came into force. Under the GGPPA, the Canadian federal government implemented a national price on GHG emissions. The price began at \$20 per tonne of CO₂e emissions in 2019, and will rise by \$10 per year until reaching \$50 per tonne in 2022. In 2022, there will be a review of the Output-Based Pricing Standard and other aspects of the GGPPA.

On Jan. 1, 2019, the GGPPA's backstop mechanisms came into force in provinces and territories that did not have an independent carbon pricing program or where the existing program was not deemed equivalent to the federal system. These included Ontario, Manitoba, New Brunswick, Saskatchewan, Prince Edward Island, Yukon and Nunavut. The backstop mechanism has two components: a carbon levy for small emitters ("Carbon Tax") and regulation for large emitters called the Output-Based Pricing Standard ("OBPS"). The Carbon Tax sets a carbon price per tonne of GHG emissions related to transportation fuels, heating fuels and other small emission sources.

The OBPS regulates large emitters' carbon intensity by setting a sectoral performance standard (benchmark) of GHG emissions per unit of production (e.g. tonnes CO₂e/MWh) for electricity generators. Emitters exceeding the benchmark generate carbon obligations and those emitters that perform below the benchmark generate emission performance credits. Emitters can meet their obligations by reducing their emission intensity, buying carbon credits from others (offsets or emission performance credits) or making compliance payment to the government.

Other jurisdictions were compliant with the GGPPA so did not have the backstop mechanism imposed in 2019. These jurisdictions must file and have their carbon pricing programs approved annually. Over future annual compliance periods, if parts or all of a province's GHG regulations fall out of compliance with the GGPPA, the federal government will impose its backstop mechanisms.

Gas Regulation

On Dec. 18, 2018, the federal government published the Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity. Under the regulations, new and significantly modified natural gas fired electricity facilities with a capacity greater than 150 MW must meet a standard of 420 tonnes CO₂e per gigawatt hour ("tonnes CO₂e/GWh") to operate. For units with a capacity between 25 MW and 150 MW, their standard was set at 550 tonnes CO₂e/GWh. Facilities with a capacity less than 25 MW have no standard.

Under the regulations, coal-to-gas conversions will also eventually have to meet a standard of 420 tonnes CO₂e/GWh. If the first year performance test after conversion meets certain emission standards it will not have to meet the 420 tonnes CO₂e/GWh standard for several additional years past the end of its useful life.

Coal Regulation

On Dec. 18, 2018, amendments to the *Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations* came into force under the *Canadian Environmental Protection Act, 1999*. The amended regulations will require coal units to meet an emission level of 420 tonnes CO₂e/GWh by the earlier of end-of-life under the 2012 regulations or Dec. 31, 2029.

Clean Fuel Standard

In 2016, the Canadian federal government announced plans to consult on the development of a Clean Fuel Standard ("CFS") to reduce Canada's GHG through the increased use of lower carbon fuels, energy sources and technologies. The objective of the regulation is to achieve 30 million metric tonnes of annual reductions in GHG emissions by 2030. The CFS will establish life-cycle carbon intensity requirements separately for liquid, gaseous and solid fuels that are used in transportation, industry and buildings. Under the proposed policy, coal combusted at facilities that are covered by coal-fired electricity regulations will be exempt from the regulation. Natural gas used for electricity production is currently expected to be included under the gaseous stream.

Consultation on the gaseous stream began in 2019 and will continue into 2020. Publication of the draft regulations for the gaseous stream will occur in late 2020 with final regulations expected in 2021. The gaseous stream regulation is currently expected to come into force by 2023. TransAlta continues to be engaged in the consultation process.

Alberta

Large Emitter Greenhouse Gas Regulations

On Jan. 1, 2018, the Alberta government transitioned from the *Specified Gas Emitters Regulation* ("SGER") to the *Carbon Competitiveness Incentive Regulation*. Under the CCIR, the regulatory compliance moved from a facility-specific compliance standard to a product or sectoral performance compliance standard. In 2019, the CCIR price was \$30/tonnes CO₂e, and the electricity sector performance standard was set at 0.370 tonnes CO₂e/MWh and set to decline annually. All renewable assets that received offset crediting under the SGER continued to receive credits under CCIR on a one-to-one basis. All other renewable assets that did not receive offset crediting under SGER were able to "opt-in" under CCIR and received carbon crediting up to the electricity sector performance standard until CCIR's termination at the end of 2019. Once wind projects' offset crediting standard under the SGER protocol ends, these projects will also be able to opt-in under CCIR system and be credited up to the performance standard.

On Apr. 16, 2019, the United Conservative Party ("UCP") won the Alberta provincial election with a majority government. The UCP committed to move from the CCIR to a new regulation called the *Technology Innovation and Emissions Reduction* ("TIER") regulation. TIER replaced CCIR on Jan. 1, 2020. For the electricity sector, there were negligible changes between CCIR and TIER with renewable facilities continuing to receive crediting. The carbon prices for TIER in 2020 will remain at \$30/tonnes CO₂e but Alberta has not yet confirmed future price increases in line with federal requirements. The performance standard benchmark remained at 0.370 tonnes CO₂e/MWh. A review of TIER is not expected until 2023.

Facilities with emissions above the set benchmark will need to comply with TIER by: i) paying into the TIER Fund; ii) making reductions at their facility; iii) remitting emission performance credits from other facilities; or iv) remitting emission offset credits.

As required by the GGPPA, the Alberta government filed the TIER program details with the federal government. TIER was passed by the Alberta government on Oct. 29, 2019 and on Dec. 6, 2019 the federal government accepted the TIER regulation as compliant with the GGPPA for 2020.

Federal Pollution Pricing Fuel Charge (Fuel Charge)

The new UCP government repealed the Alberta carbon levy on May 30, 2019. The federal government will replace the repealed carbon levy with the Fuel Charge on Jan. 1, 2020. Alberta TIER-covered facilities are exempt from the Fuel Charge.

British Columbia

Beginning Apr. 1, 2018, BC increased its carbon tax rate to \$35/tonnes CO₂e and committed to raise the price \$5 per year until it reaches \$50 per tonne in 2021.

Ontario

On Oct. 31, 2018, the Ontario government passed the *Cap and Trade Cancellation Act*. This Act removed all existing provincial carbon emission regulations and costs on large emitters.

Large Emitter Greenhouse Gas Regulations

The Canadian federal GGPPA requires provinces to have greenhouse gas regulations and prices in place that align with the federal GGPPA. On Oct. 23, 2019, the federal government announced that Ontario large emitters would be subject to the federal backstop OBPS regulation. All covered industry facilities with annual emissions over 50,000 tonnes CO₂e are automatically covered with an opt-in provision for those emitters between 10,000 and 50,000 tonnes CO₂e annually. Ontario large emitters are currently subject to the federal backstop OBPS regulation.

On July 4, 2019, the Government of Ontario released the final regulations for the provincial Greenhouse Gas EPS. The EPS establishes GHG emission limits on covered facilities. Large emitters generating over 50,000 tonnes CO₂e or more per year will be covered with an opt-in provision for those emitters between 10,000 and 50,000 tonnes CO₂e annually. The carbon emissions limit for electricity is set at 420 tonnes CO₂e/GWh. The program also provides a method that accounts for the carbon efficiency of cogeneration units. The federal government has not accepted the EPS as compliant with the GGPPA so the OPBS remains in force for reporting purposes for 2019 obligations.

Facilities with emissions above the set reduction requirements can comply by: i) buying excess emission units from the regulator; ii) making reductions at their facility; or iii) using emission performance units generated by facilities emitting below their emission intensity limit. The first compliance period under the EPS will begin on Jan. 1 in the year in which Ontario is removed from the list of provinces to which the federal OBPS applies. Ontario has submitted the EPS for federal review.

Federal Pollution Pricing Fuel Charge (Fuel Charge)

The federal government replaced the repealed Ontario carbon levy with the Fuel Charge on Jan. 1, 2019. Ontario facilities covered by OBPS are exempt from the Fuel Charge.

Washington

In 2010, the Washington Governor's office and State Department of Ecology negotiated agreements with TransAlta related to the operation of Centralia's two coal-fired electricity generating units. TransAlta agreed to retire its two Centralia coal units; one in 2020 and the other in 2025. This agreement is formally part of the state's climate change program. We currently believe that there will be no additional GHG regulatory burden on US Coal given these commitments. The related TransAlta Energy Transition Bill was signed into law in 2011 and provides a framework to transition from coal to other forms of generation in the State of Washington.

Massachusetts

The Solar Renewable Electricity Credit I (SREC I) program carved out from Massachusetts' Renewable Portfolio Standard (RPS) an initial quantity of 400 MW from small solar facilities of 10 MW or less. The initial SREC I program size was expanded and replaced by a lower-valued SREC II program. In 2018, the solar incentive program evolved into the current Solar Massachusetts Renewable Target Program that further reduced the incentive levels.

The initial SREC I program's volume target was achieved, and qualified projects under SREC I continue to generate SREC I credits for their first 10 years post-Commercial Operation Date. SREC I facilities then generate Class 1 RECs under the Massachusetts RPS for the remainder of their operational life.

Under Massachusetts' net metering program, qualified facilities connect with the local utility and generate net metering credits. Net metering credits offset the delivery, supply and customer charges and can be sold to customers from remote or on-site qualifying facilities. In 2016, the net metering program was updated to reduce the value of the net metering credits by reducing the offset to only energy costs. New projects are impacted once the net metering program volume reaches 1,600 MW. Existing facilities were grandfathered and continue to receive the full, original cost offset treatment for a period of 25 years from initial commercial operation.

Australia

On Dec. 13, 2014, the Australian government enacted legislation to implement the Emissions Reduction Fund (the "ERF"). The AUD\$2.55 billion ERF is the centrepiece of the Australian government's policy and provides a policy framework to cut emissions by five per cent below 2000 levels by 2020 and 26 to 28 per cent below 2005 emissions by 2030. The ERF's safeguard mechanism, commencing from July 1, 2016, is designed to ensure emissions reductions purchased by the Australian government through the ERF are not displaced by significant increases in emissions elsewhere in the economy. The ERF and its safeguard mechanism provide incentives to reduce emissions across the Australian economy.

The Australian government has also committed to develop a National Energy Productivity Plan with a target to improve Australia's energy productivity by 40 per cent between 2015 and 2030. The ERF is not expected to have a material impact on our Australian assets as a result of the Australian assets being primarily composed of gas-fired generation. In addition, on June 23, 2015, the federal Australian government also reformed the Renewable Energy Target ("RET") scheme. The RET should add at least 33,000 GWh of renewable sources by 2020. This would double the amount of large-scale renewable energy being delivered compared to current levels and result in approximately 23.5 per cent of Australia's electricity generation being sourced from renewable projects.

Technology Risks

Battery storage technology is an emerging risk to the large-scale power-generation model. Battery storage has the ability to enable greater adoption of renewables and result in a shift to a distributed power-generation model. We continue to evaluate battery storage for its financial viability, while monitoring the potential impact battery technology could have on natural gas power generation.

We have demonstrated upside in growing renewables and gas-powered generation. From 2000 to 2018, we have grown renewables capacity from approximately 900 MW to close to 2,400 MW.

Market Risks

Changing customer behaviour, reduced consumption and associated use of electricity could impact the demand for electricity; however, we believe this risk is mitigated somewhat by the global trend to increasingly electrify customer products, transport and more. Our low-carbon business model supports this type of future. Increased costs for natural gas supply from carbon pricing can impact us. Further discussion can be found in the Governance and Risk Management section of this MD&A. Use of renewable resources, such as the wind and sun, removes associated risk related to cost of supply.

Our Corporate function applies regionally specific carbon pricing, both current and anticipated, as a mechanism to manage future risks pertaining to uncertainty in the carbon market and as a safeguard to anticipate future impacts of regulatory changes on facilities. This information is directed to the business unit level for further integration. Identified climate change risks or opportunities and carbon pricing are recognized in the annual TransAlta long- and medium-range forecasting processes. We capture economic profit through generation of environmental attributes (such as carbon offsets and RECs) and through our emission trading function, which seeks to commoditize and profit from carbon trading.

Reputation Risks

Consumer trends appear to be moving in favour of renewable and cleaner electricity, which may make hydrocarbon options decreasingly popular. We are invested in natural gas as it provides vital support to the electricity system and is a lower-carbon fossil fuel. We already invest significantly in renewable energy and natural gas.

2. Physical Risks

As we learn more about the physical risks associated with climate change, and weather risk in general, we seek to understand further both acute and chronic risk, which could materially impact value creation from our operations.

Acute Risks

The TransAlta South Hedland facility in Western Australia was built with climate adaptation in mind. The plant is designed to withstand a category 5 cyclone, which can frequent the northwest region of Western Australia. Category 5 is the highest cyclone rating. Floods, which can occur in the area, have been mitigated by constructing the facility above the normal flood levels. In 2019, a category 4 cyclone hit this facility. Operations were not impacted and we were able to continue generating electricity through the storm, despite wide-spread flooding and shutdown of the nearby port and associated business activities.

Chronic Risks

We have not identified any chronic physical risks that could impact our operations. However, we continue to further our understanding and integration of climate modelling into our long-term planning.

Greenhouse Gas Emissions: Metrics and Targets

In 2019, we estimate that 20.6 million tonnes of GHGs with an intensity of 0.75 tonnes per MWh (2018 - 20.8 million tonnes of GHGs with an intensity of 0.77 tonnes per MWh) were emitted as a result of normal operating activities. Our reduction in GHG emissions is primarily the result of co-firing with gas and lower production volumes at our merchant Alberta coal facilities.

Our 2019 GHG data is reported to a number of different regulatory bodies throughout the year for regional compliance and as a result, may incur minor revisions as we review and report data. Any revisions would be reported historically in future reporting. As per the Kyoto Protocol, GHGs include carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, nitrogen trifluoride, hydrofluorocarbons and perfluorocarbons. Our exposure is limited to carbon dioxide, methane, nitrous oxide and a small amount of sulphur hexafluoride. The majority of our estimated GHG emissions are comprised of carbon dioxide emissions from stationary combustion from coal and natural gas power generation. Emissions intensity data has been aligned with the "Setting Organizational Boundaries: Operational Control" methodology set out in The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard developed by the World Resources Institute and the World Business Council for Sustainable Development. As per the methodology, TransAlta reports emissions on an operation control basis, which means that we report 100 per cent of emissions at facilities in which we are the operator. Emissions intensity is calculated by dividing total operational emissions by 100 per cent of production (MWh) from operated facilities, regardless of financial ownership.

The GHG Protocol Corporate Standard classifies a company's GHG emissions into three scopes. Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions. Scope 1 emissions in 2019 were estimated to be 20.4 million tonnes CO₂e and account for 99 per cent of emissions reported. All of our scope 1 emissions (100 per cent) are reported to national regulatory bodies in the country in which we operate. This includes: Australia (National Greenhouse Gas Emission Reporting), Canada (GHGPR) and the US (EPA). Scope 2 emissions were estimated to be 0.2 million tonnes CO₂e. We estimate our scope 3 emissions to be in the range of six million tonnes.

The following are our GHG emissions broken down by business unit and by scope 1 and 2 in million tonnes CO₂e:

Year ended Dec. 31	2019	2018	2017
Coal	18.1	18.3	27.4
Gas and renewables	2.5	2.5	2.5
Total GHG emissions	20.6	20.8	29.9

Year ended Dec. 31	2019	2018	2017
Scope 1	20.4	20.6	29.7
Scope 2	0.2	0.2	0.2
Total GHG emissions	20.6	20.8	29.9

All of our reported 2019 and historical GHG emissions are verified by Ernst & Young to a level of limited assurance. An assurance statement can be found in the back of this Integrated Annual report. In addition, GHG emissions are verified to a level of reasonable assurance in locations where we operate within a carbon regulatory framework. In Alberta we verify GHG emissions through the TIER program and as a result 51 per cent of our total scope 1 emissions are also verified to a level of reasonable assurance. Our GHG emissions are calculated using a number of different methodologies depending on the technologies available at our facilities.

Our target is to reduce 60 per cent or 19.7 million tonnes of GHG emissions by 2030 over 2015 levels, which is in line with UN Sustainable Development Goal Goal 13, Climate Action. Since 2015 we have reduced 11.6 million tonnes, which represents a reduction of 36 per cent. By 2030, we expect to have reduced close to 30 million tonnes over 2005 levels, after adjusting for any new growth over this period.

The following highlights our GHG emission reductions since 2005 and our targeted emissions in 2030 (in line with our GHG target). The actual GHG emissions for the Corporation in 2030 will vary from that presented below depending on, among other things, the growth of the Corporation, including its on-site generation business.

Year ended Dec. 31	2030	2019	2005
Total GHG emissions	12.5	20.6	41.9

In 2019, TransAlta maintained its scoring on the Carbon Disclosure Project Climate Change investor request. Our overall score was a B, which places us as ahead of most companies in North America. The average CDP score for North America was a C.