MEASURING GREENHOUSE GAS EMISSIONS IN THE SASKATCHEWAN CROP SECTOR

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INTRODUCTION

- Action towards reducing greenhouse gas (GHG) emissions have been steadily progressing in the Saskatchewan (SK) crop sector since the 1980s
- Adoption of sustainable farming practices has enhanced carbon sequestration and contributed to reducing GHG emissions
- This reduction helps Canada in meeting its commitment in the 21st Conference of the Parties (COP21) in Paris toward the United Nations Framework Convention on Climate Change (UNFCCC) to cut GHG emissions by 30 percent below 2005 emissions by 2030
- Land use, Land use change, and the forestry (LULUCF) sector are included in the measurement of national GHG inventories
  - This is important for SK, as the province accounts for approximately 38% of Canada's farmland or about 25 Mha

OVERVIEW: PAN-CANADIAN FRAMEWORK (PCF) ON CLEAN GROWTH AND CLIMATE CHANGE

- December 9, 2016: Pan-Canadian Framework on Clean Growth and Climate Change
- The PCF aims to grow the economy while reducing GHG emissions
- Pricing carbon pollution across Canada
- Provinces and territories have the flexibility to design their own pricing system
- Revenue generated from pricing carbon will remain in the province or territory of origin

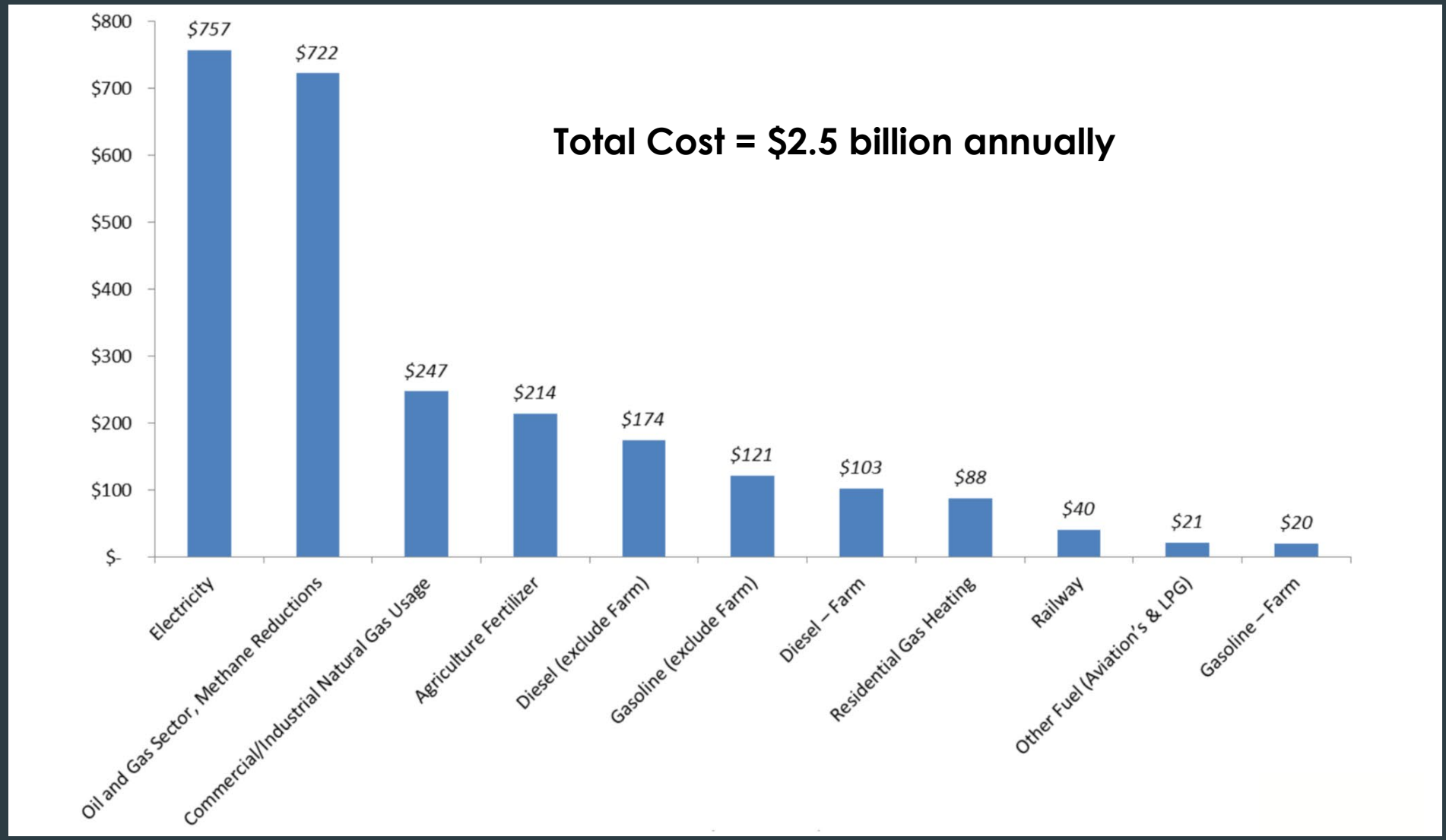
CARBON POLLUTION PRICING: PROVINCIAL

- Saskatchewan remains the only jurisdiction that has not joined the PCF
- Saskatchewan released "The Prairie Resilience: A Made in Saskatchewan Climate Change Strategy"
  - Natural systems
  - Infrastructure
  - Economic sustainability
- On August 29, 2018, SK released carbon pollution price, based on an output- based performance standards (https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/saskatchewan.html)
  - Implementation date: January 2019
  - Apply to large industrial facilities that emit more 25,000 tonne of CO_2-eq/year
  - exception of electricity generation and natural gas transmission pipelines
  - Cover 11% of the province's emissions

CARBON POLLUTION PRICING: FEDERAL

- The federal carbon pollution pricing system will be partially implemented in SK
  - Federal output-based pricing system (OBPS): apply to electricity generation and natural gas transmission pipelines in January 2019 & cover facilities that emit 50,000 tonne CO_2-eq/year (http://publications.gc.ca/collections/collection_2018/eccc/En1-77-2018-eng.pdf)
  - Federal fuel charge: apply in April 2019, the fuel charge price is \$20/tonne CO_2-eq in 2019, rising by \$10 per tonne annually to \$50/tonne in 2022 (fuel charge rates https://www.fin.gc.ca/n18/data/18-097_1-eng.asp)
- Federal carbon pricing will exempt gasoline and diesel fuel used by registered farmers in certain farming activities

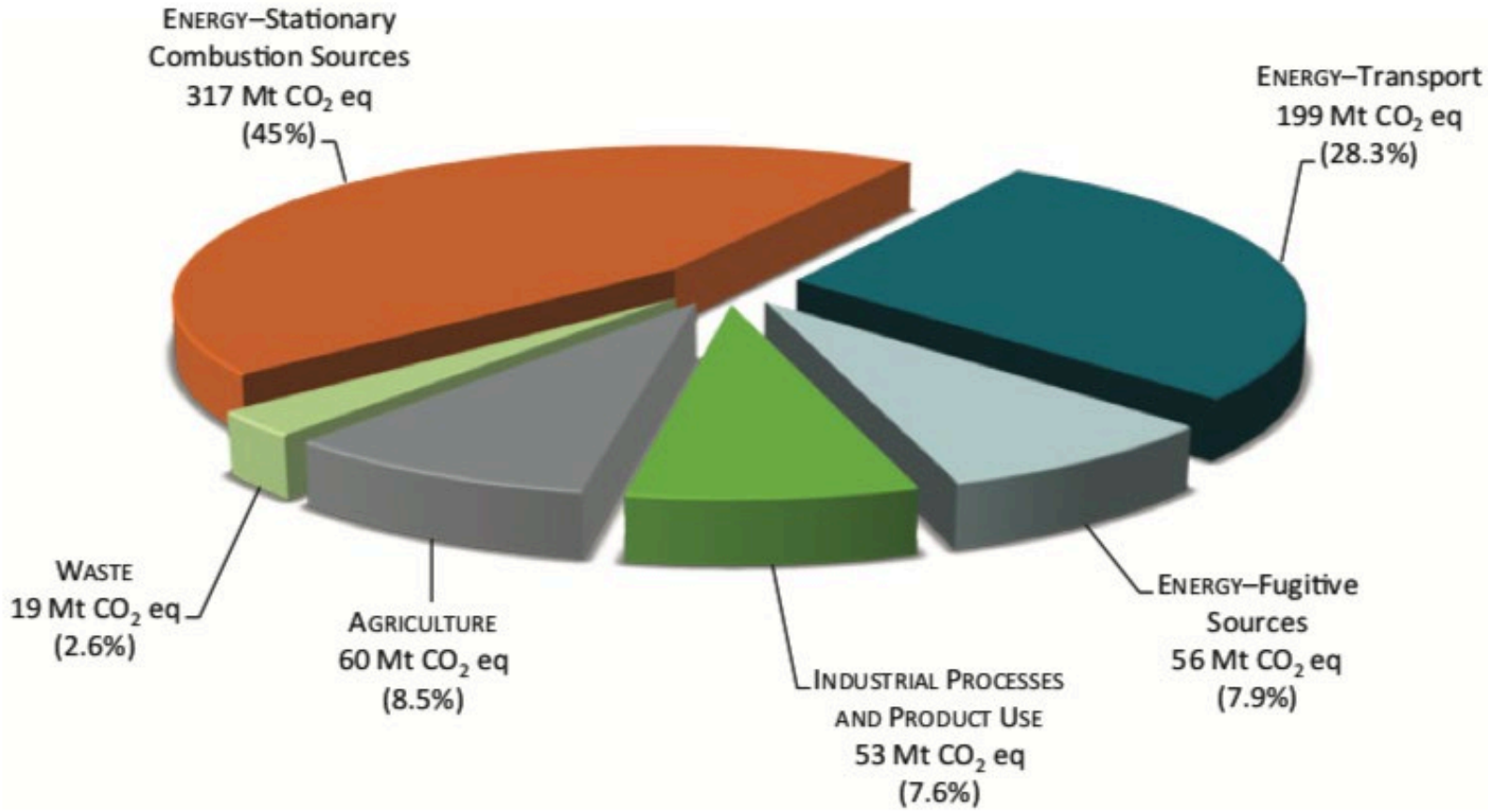
Figure 1. Impacts of $50 Carbon Tax on SK Economy ($ millions)



Source: Government of Saskatchewan, Climate change white paper. Oct 2017

Figure 2. Canada's GHG by Sector (2016)

Total Canada's GHG decreased from 732 in 2005 to 704 Mt CO2-eq in 2016 (-3.8%)

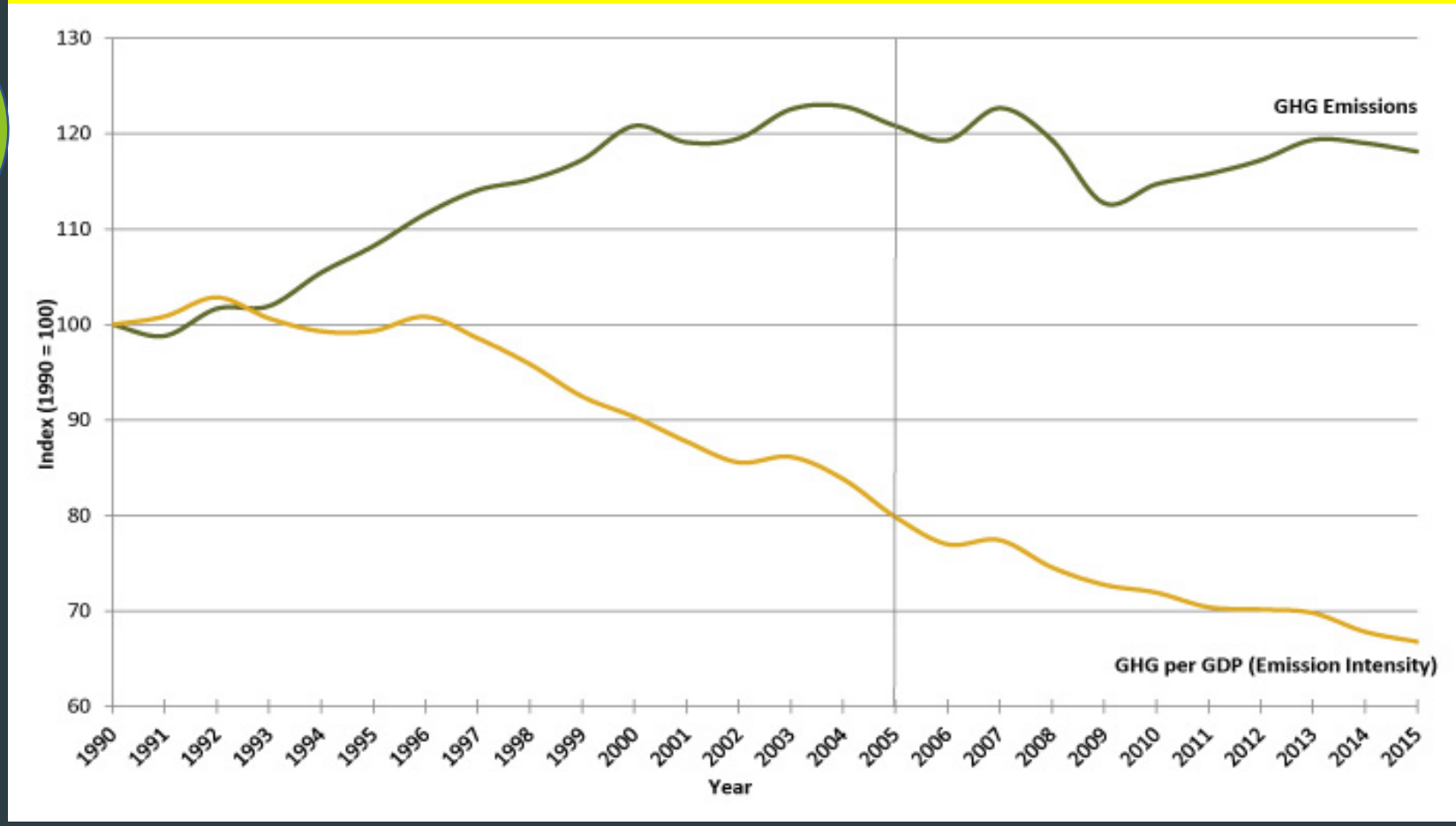


Source: Environment and Climate Change Canada. 2018. National Inventory Report 1990-2016

Figure 3. Indexed Trend in GHG Emissions and GHG/GDP (Emissions Intensity)

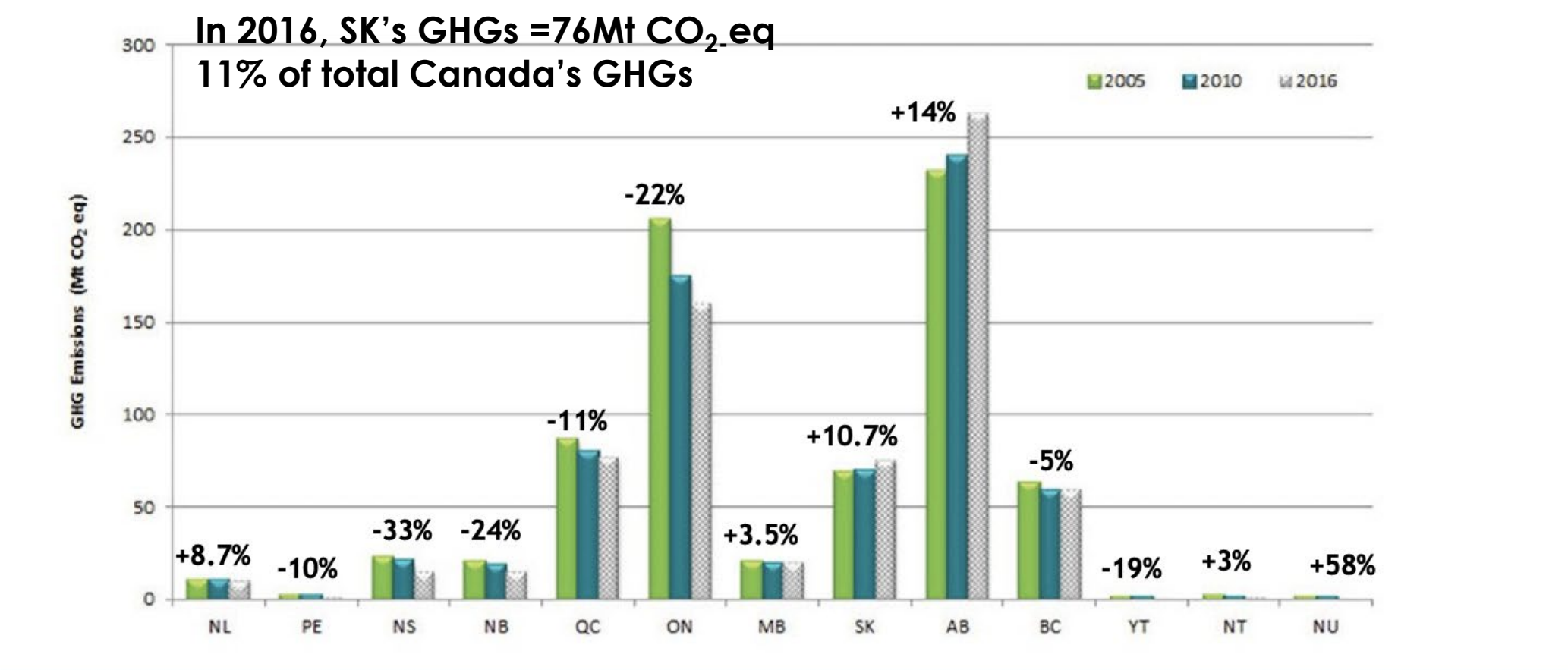
Canada's per capita emissions decreased from 22.7t in 2005 to 19.1t in 2016 (-16%)

GHG/GDP has declined by 35% since 1990 and 19% since 2005



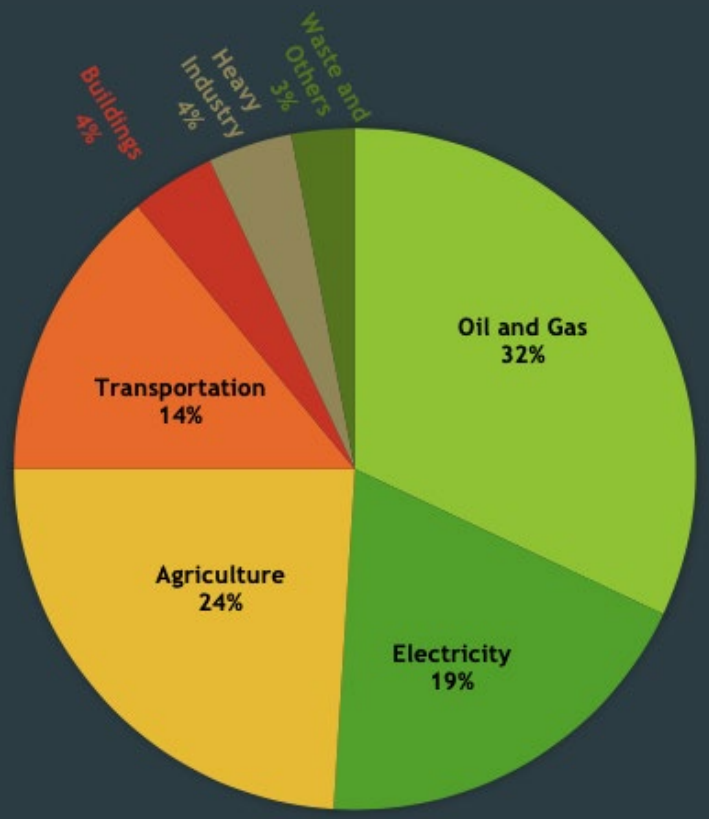
Source: Environment and Climate Change Canada. 2018. National Inventory Report 1990-2016

Figure 4. Provincial and Territorial GHG 2005-2016



Source: Environment and Climate Change Canada. 2018. National Inventory Report 1990-2016

Figure 5. Saskatchewan Greenhouse Gas Emissions by sectors



Source: Prairie Resilience: A Made-in-Saskatchewan Climate Change Strategy (2017)

MEASURING GHG IN THE SK CROP SECTOR

- **Quantify** the net GHG in the SK crop sector during the period 1985-2016
- Assessment of emission and sink of the main crop GHGs including:
- **Soil Carbon Sequestration/Carbon Sink (CO_2)**
- **Crop Production Emissions:**
  - ***N_2O Emission from Fertilizer Application***
  - ***N_2O Emission from Crop Residue***
  - ***N_2O Emissions from Summerfallow***
  - ***CO_2 Emission from Fuel Used on Farm and for Transportation***
- **Net GHG = Soil Carbon Sequestration - Crop Production Emissions**
- The 2016 estimates will be compared to those of 2005 and 1985 (base year) to track the historical changes in reducing SK GHG emissions in the crop sector

METHOD OF MEASUREMENT

- Conducted at crop districts which divides SK into nine and five soil-climate zones – brown, dark brown, thin black, thick black and gray
- Arable land suitable for the production of: cereal, oilseed, and pulse crops, and alfalfa, hay, grass, and pasture
- Apply the Prairie Crop Energy Model (PCEM) to allocate cropland to 122 cropping activities
- Each cropping activity can be produced by one of the three tillage practices, conventional tillage (CT), minimum tillage (MT) and no-till (NT), and be grown using fallow-crop rotation or crop-crop rotation

SOIL CARBON SEQUESTRATION IN THE SK CROP SECTOR

- Soils can be either a source of or sink for CO_2, depending on current and historical crop production practices
- Source-sink behaviour is primarily influenced by:
  - the processes of photosynthesis and incorporation of crop-residue organic matter into soils (CO_2 sink/sequestration)
  - the decomposition of that organic matter by soil organisms (CO_2 source)
- NT land management has enabled higher carbon return to soil through intensified crop rotations, residue retention, and lower SOM decomposition rates associated with reduced summerfallow and tillage practices
- NT enhances soil water storage capacity: increases SOM and soil biomass; increase in SOC stocks

SOIL CARBON SEQUESTRATION IN THE SK CROP SECTOR

$$(1)\ CS_t = \sum_{i=1}^{9}\sum_{j=1}^{122}[A_{ijt} \times RC_{ij}] \times \left[R_{ijt} \times RR_{ij}\right] \times CO_2MW$$

A_{ijt} is cropland (ha), RC_{ij} is sequestration rate, R_{ijt} is crop residue estimated using the total biomass produced from harvested yield, RR_{ij} is the rate of crop residue input C into soil, and CO_2MW is the ratio of molecular weight=44/12

Figure 6. Soil Carbon Sequestration in Saskatchewan's Crop Sector 1985-2016 (Mt CO_2-eq)

Total Carbon Sequestration = 125 Mt CO_2-eq

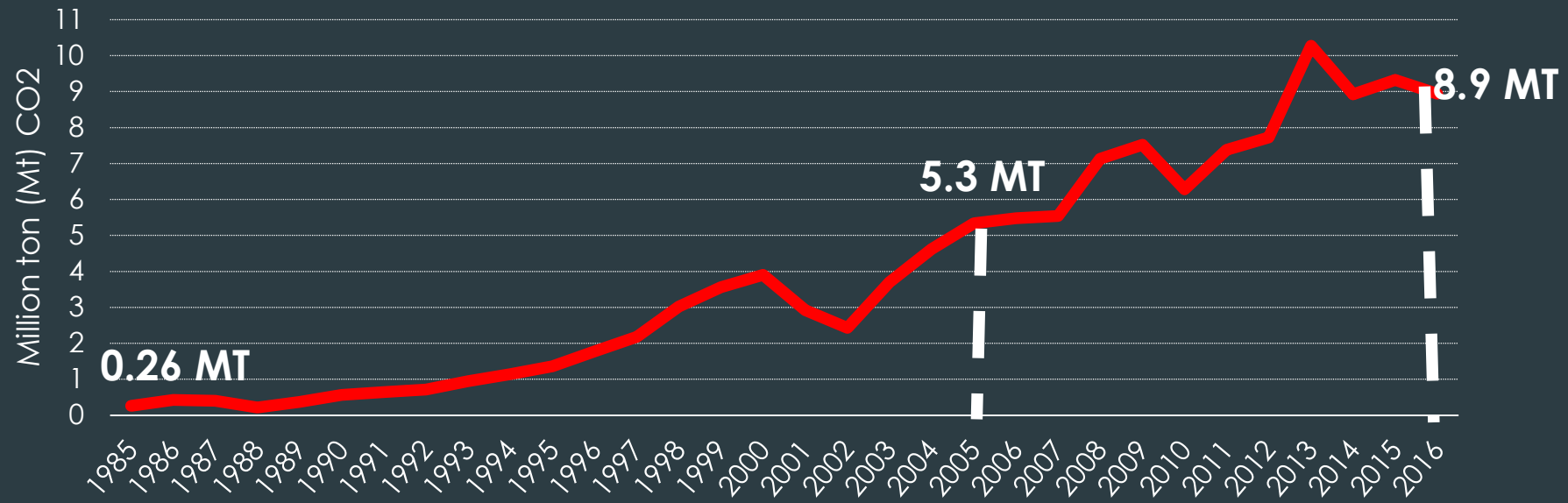
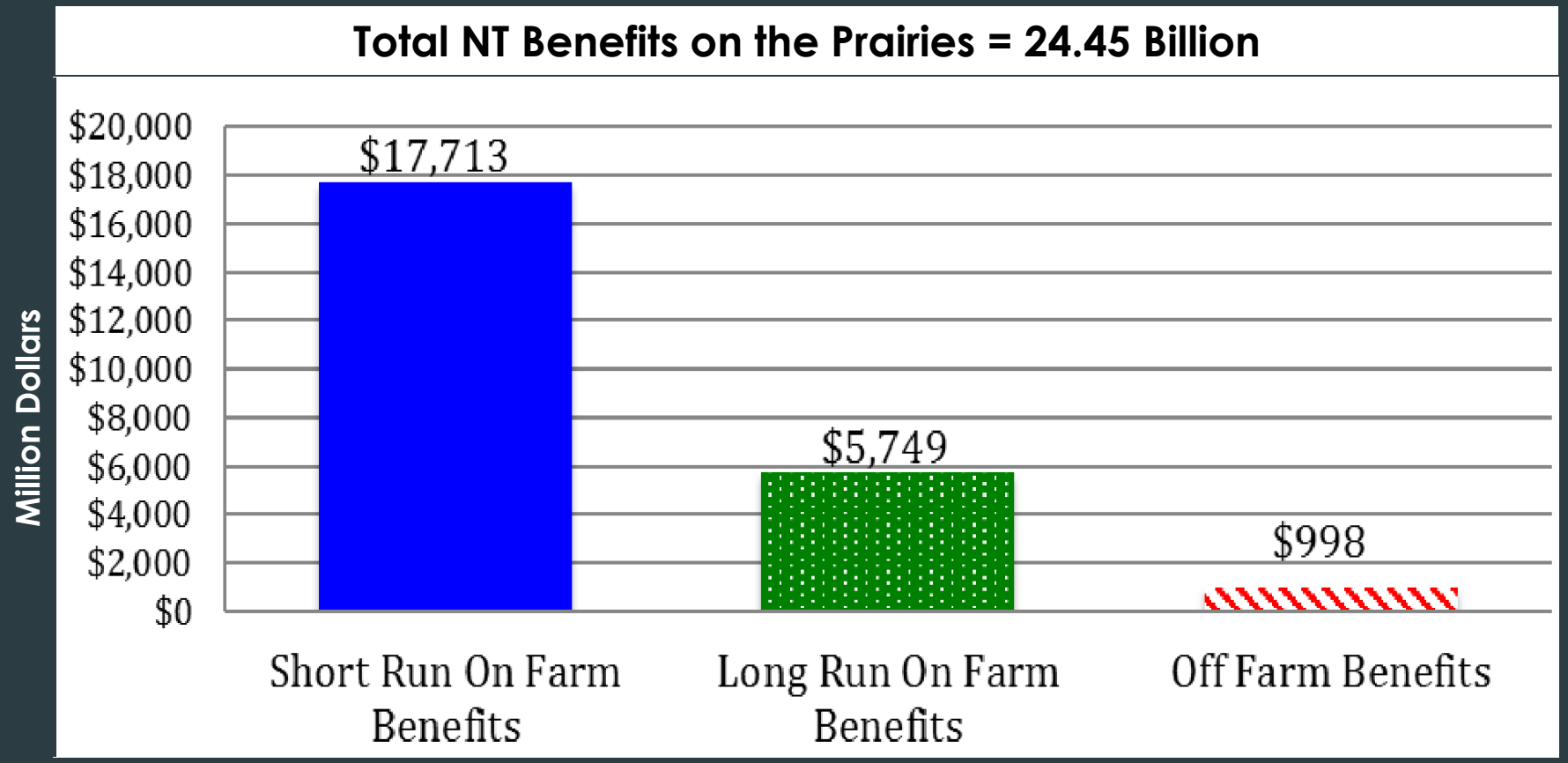


Table 1. Carbon Sequestration Value (2018 $Billion)

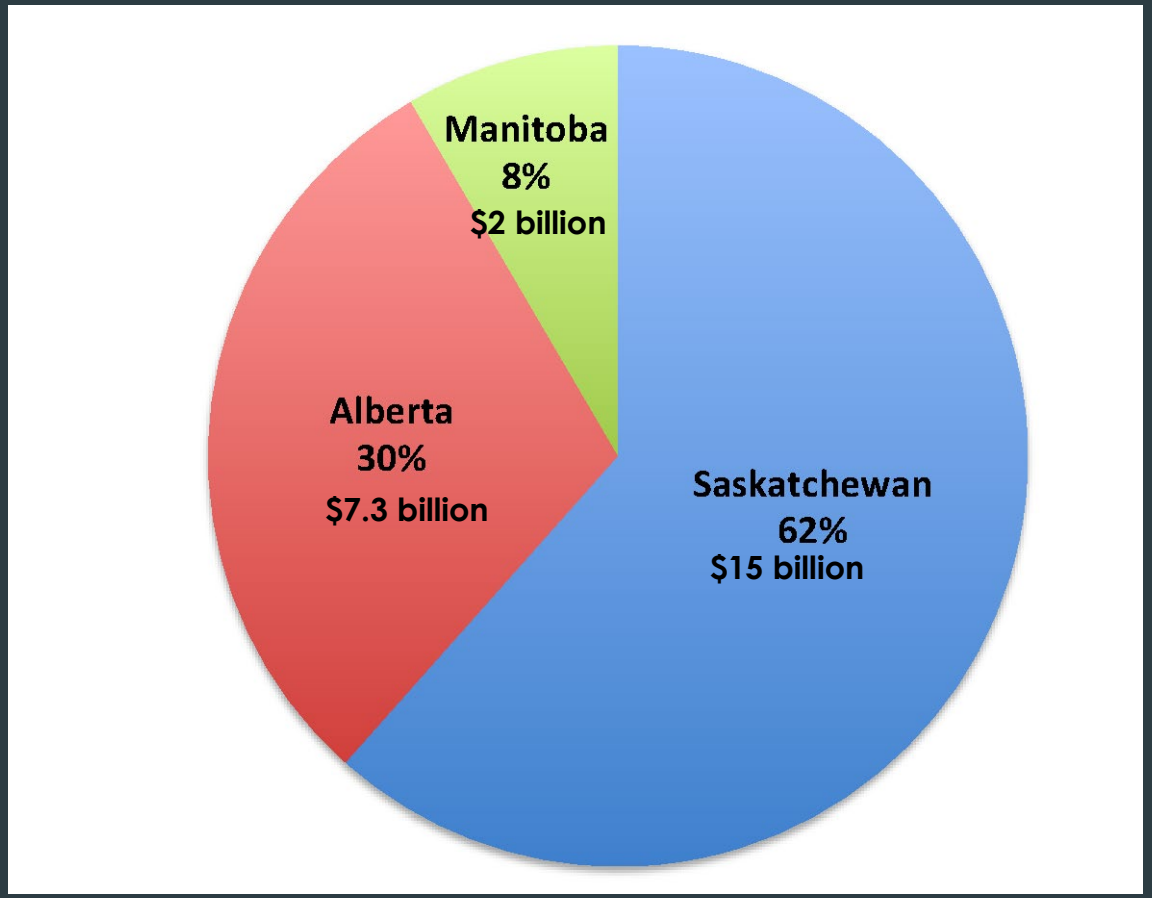
CO_2 /ton= $10.00	CO_2 /ton= $15.00
1.028	**1.543**

Figure 7. No-tillage Benefits on the Prairies 1985-2012 ($2014)



Source: Awada et al. (2015). Canadian Journal of Agricultural Economics 00 1–22

Figure 8. No-Tillage Benefits 1985-2012 ($2014)



Source: Awada et al. (2015). Canadian Journal of Agricultural Economics 00 1–22

CROP PRODUCTION EMISSIONS

- ***N_2O Emission from Fertilizer Application*:**

$$(2)\ \mathrm{N_2O}_t\_N_t = \sum_{i=1}^{9}\sum_{j=1}^{122} A_{ijt} \times N_{ij} \times NE_i \times N_2OMW$$

N_{ij} is nitrogen N rate-requirement, NE_i is emission rate, and N_2OMW is the ratio of molecular weights=44/28

- ***N_2O Emission from Crop Residue***

$$(3)\ N_2O\_R_t = \sum_{i=1}^{9}\sum_{j=1}^{122} R_{ijt} \times (NA_j \times RA_j + NB_j \times RB_j) \times NR \times N_2OMW$$

NA_j, NB_j, RA_j and RB_j are N content and ratio of residues to harvest yield of above-ground and below-ground, respectively

CROP PRODUCTION EMISSIONS (CONT.)

- ***N_2O Emissions from Summerfallow***

$$(4)\ N_2O\_S_t = \sum_{i}^{9} (N_2O\_N_{it} + N_2O\_R_{it}) \times FS_{it}$$

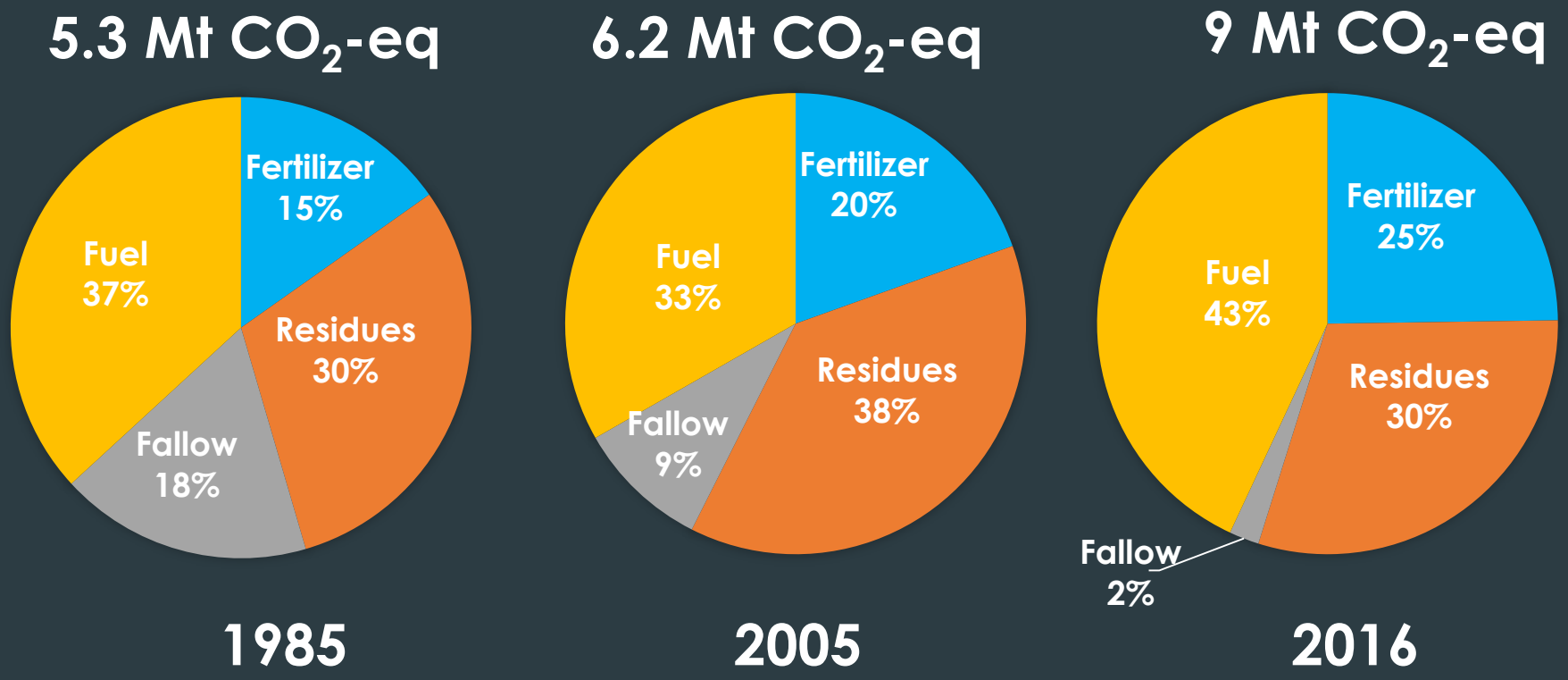
FS_{it} is fraction of cropland that is under summerfallow

- ***CO_2 Emission from Fuel Used on Farm and for Transportation***

$$(5)\ CO_{2_{F_t}} = \sum_{i=1}^{9} \sum_{j=1}^{122} [(A_{ijt} \times FC_1) + (A_{ijt} \text{ x } FC_2 + Y_{ijt} \text{ X } FC_3)] \text{ X } FCF$$

FC_s are rates of fuel consumption; FCF is emission factor of the amount of CO_2-eq emitted from powered equipment

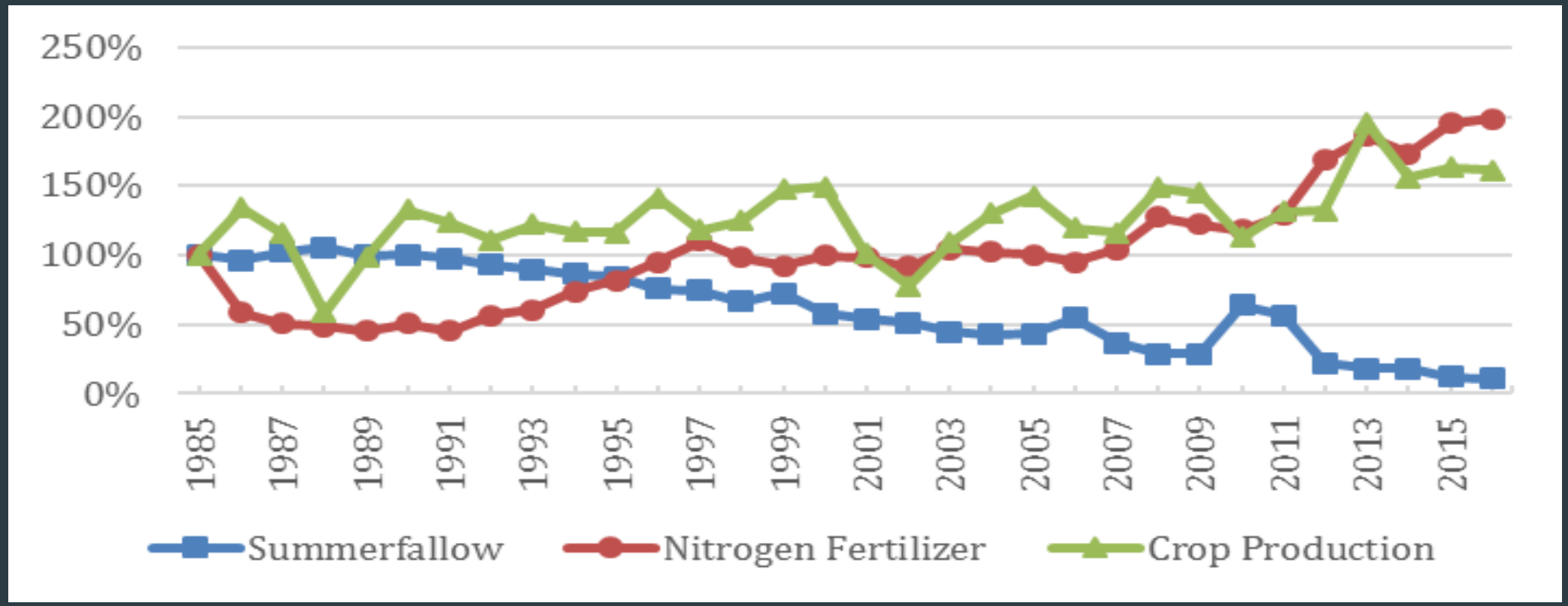
Figure 9. Crop Production Emissions (cont.)



CROP PRODUCTION EMISSIONS (CONT.)

Table 2. Crop Production Emissions (Mt CO_2-eq)					
Years	Residues	Fertilizer	Fallow	Fuel on farm	Fuel Transport
1985	1.510	0.759	0.883	1.837	0.274
2005	2.358	1.215	0.579	1.425	0.644
2016	2.728	2.246	0.190	1.258	2.645

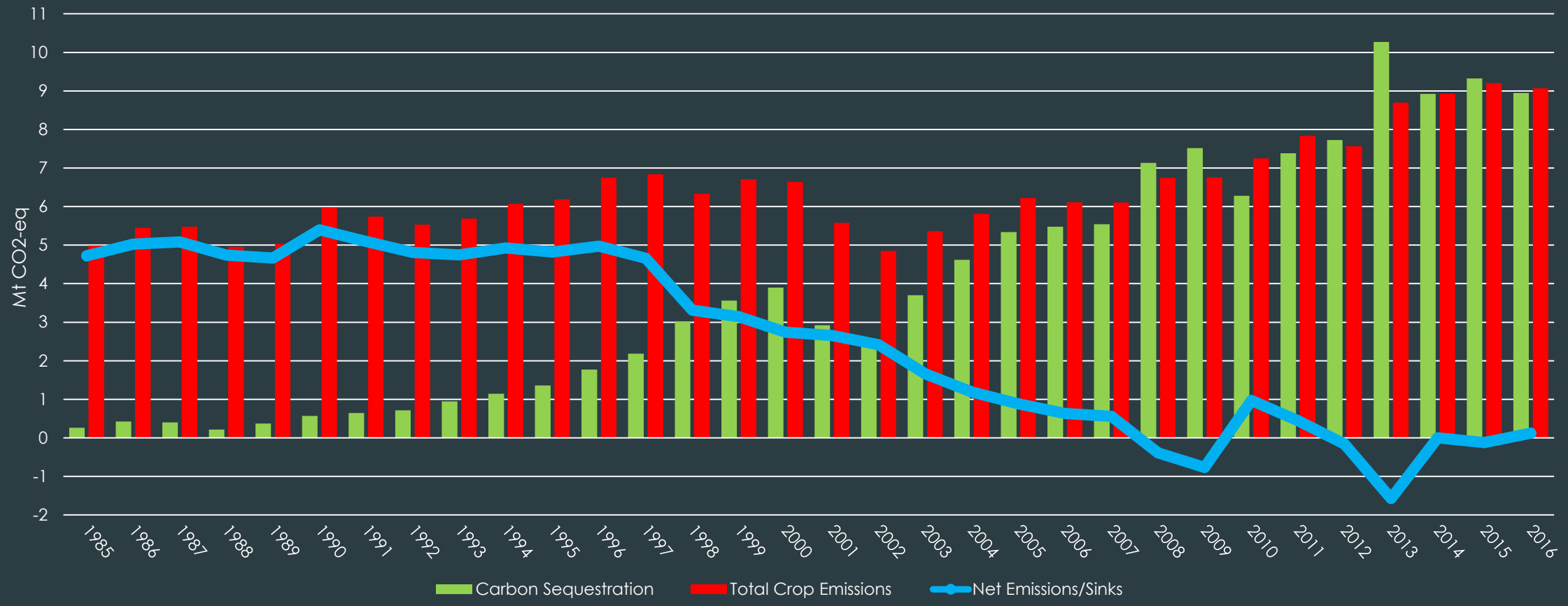
Figure 10. Crop production, nitrogen fertilizer use and summer-fallow area, 1985-2016 (% acre change) (1985=100)



FARM FUEL FOR TRANSPORTATION

- Increased farm size resulted in longer distances from farm yard to farm land, affecting fuel used supplying crop inputs and hauling harvested grain to the yard site
- Reduction in the number of grain bins in the field as farmers centralize operations
- Grain delivery points in Saskatchewan have been reduced from 1,031 in 1985 to 162 in 2016
- Consolidation of crop input suppliers as many of the grain delivery points also sell crop inputs

Figure 10. Net GHG Emission/Sink in the Sk Crop Sector 1985-2016



CONCLUSION

- Adoption of sustainable farming practices increased carbon sequestration and reduced net GHG emissions
- Carbon sequestration increased from 0.26 in 1985, to 5.3 in 2005, and to 9Mt CO_2-eq in 2016
- Decrease in net GHG emissions: which went from 5Mt CO_2-eq in 1985, to 0.9 in 2005, and to 0.1Mt CO_2-eq in 2016
- This decrease exceeds, by multifold, Canada's commitment toward COP21 to cut GHG emissions by 30% below 2005 emissions by 2030.
- The great efforts by the SK farmers since the 1985 should be recognized and compensated, as a large amount of carbon was mitigated before 2005.
- The results of this study provide evidence that might support the design of policies that encourage the adoption of sustainable practices to mitigate GHG emissions in agriculture

THANK YOU!