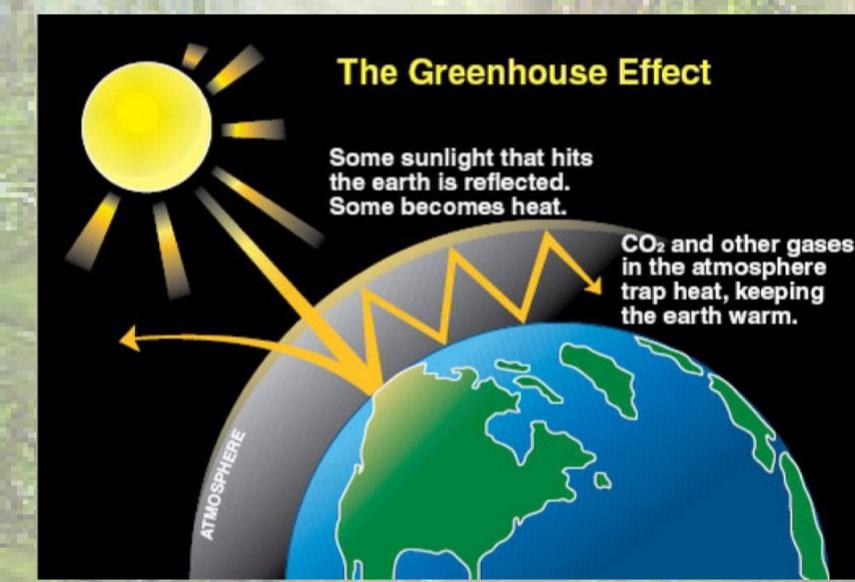


Before we look into what **Apple** is upto, lets understand how carbon footprint is affecting our environment.

What is Greenhouse Effect?

The greenhouse effect is the process through which the heat (radiated from the sun onto earth) some of which is trapped near Earth's surface by substances known as '**Greenhouse gases**'.



Greenhouse gases (also known as GHGs) are gases in the earth's atmosphere that trap heat.

Some of the greenhouse gases are:
Carbon dioxide (CO₂)
Methane (CH₄)
Nitrous oxide (N₂O)
Industrial
gases(chlorofluorocarbons):
Hydrofluorocarbons (HFCs)
Perfluorocarbons (PFCs)
Sulphur hexafluoride (SF₆)
Nitrogen trifluoride (NF₃)
Ozone
Water Vapour

Why Greenhouse effect is a major concern ?

Greenhouse gases are part of Earth's atmosphere and their concentrations of (esp. CO₂) in the atmosphere are naturally regulated through processes like photosynthesis etc. This natural greenhouse effect process, maintains an average temperature of 15 °C (59 °F).

However, human activities have led to an increased release of carbon dioxide and other greenhouse gases into the atmosphere which has disrupted the natural greenhouse effect's balance.

This imbalance between greenhouse gas emissions and the ability for natural processes to absorb those emissions has led to *Global Warming* (overall rise in global temperatures) leading to Global Climate Change, Melting Ice and Rising Sea Levels, Biodiversity Loss, Health Impacts etc.

How are we tackling the issue of Climate Change ?

To address this serious issue on Global Climate Change, the following international climate change agreements were adopted:

1. **United Nations Framework Convention on Climate Change (UNFCCC) on March 21, 1994**
2. **Kyoto Protocol in 1997**
3. **The Paris Agreement, adopted in 2015**

The Paris Agreement, is the most recent and widely recognized international climate agreement and represents a more comprehensive and ambitious global effort to address climate change by lowering the emissions and stabilizing greenhouse gas concentrations (using offsets) in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.

The goal is to keep the rise in mean global temperature to well below 2 °C (3.6 °F) and preferably limit the increase to 1.5 °C (2.7 °F).

How do we measure the Greenhouse effect ?

Global warming potential (GWP) is a measure of how much infrared thermal radiation a greenhouse gas added to the atmosphere would absorb over a given time frame, as a multiple of the radiation that would be absorbed by the same mass of added carbon dioxide (CO₂).

The time frame is usually 100 years but can be calculated for 20, 50 or any other years.

This measure helps understand the impact of different gases on global warming w.r.t CO₂

Carbon dioxide is the reference gas and has a GWP of 1. The GWP of other gases are measured with CO₂ as a reference.

For example, if a gas has a GWP of 25, over a given time period, it means it is 25 times more effective at trapping heat than CO₂ over that given time period.

Carbon Footprint

Carbon footprint is the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by human activities and are usually reported in kilograms or metric tons of emissions of carbon dioxide equivalents (CO₂e or CO₂-equivalent) per unit comparision.

This measure is a measure of the direct emissions of carbon dioxide (or equivalent greenhouse gases) associated with an activity, product, or organization

Other important terminologies

Carbon Sequestration is the act of removing carbon oxide from the atmosphere and then storing it.

Carbon Offset or Carbon Credit is a strategy/tool used to counteract greenhouse gas emissions by investing in projects or activities that reduce or remove carbon dioxide or other greenhouse gases from the atmosphere. For eg. afforestation, renewable energy etc.

Gross Emissions is the total amount of greenhouse gases emitted into the atmosphere, without considering any offsetting or reduction efforts.

Net Emissions is the total emissions produced and any reductions or removals of greenhouse gases that offset these emissions.

Net Zero Emission or Carbon Neutrality is a strategy that places much more focus on reducing carbon emissions as much as possible first, and only offsetting unavoidable, residual CO₂ as a last resort.

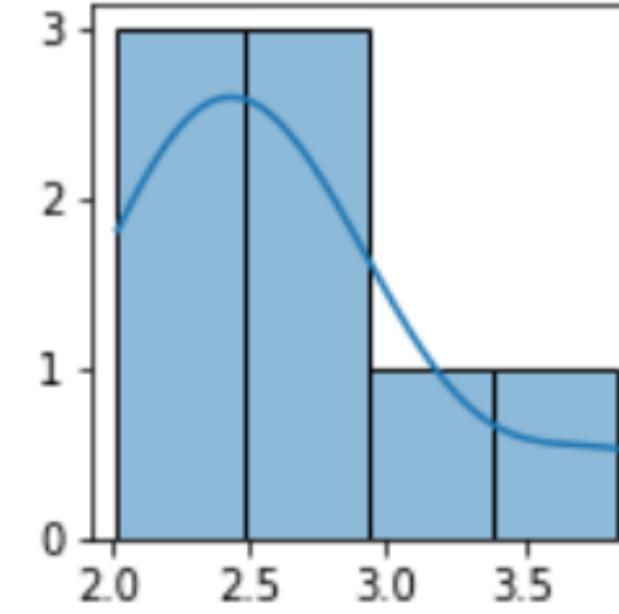
Gross Zero Emission refers to industry sectors (such as the energy sector) aiming to completely eliminate carbon emissions from their operations.

Apple has taken a strong decision and has set some serious goals to mitigate their impact on global emissions.

Average Emission over the years

Since the data is skewed, the median can be used as a measure of the average emissions over the years which is:

25.08M
metric tons CO₂e



Baseline Emission - An emissions baseline is the reference point against which a business or country's greenhouse gas (GHG) emissions will be measured going forward.

To achieve this goal, they set their emissions for 2015 (38.4 million metric tons CO₂e) as the baseline

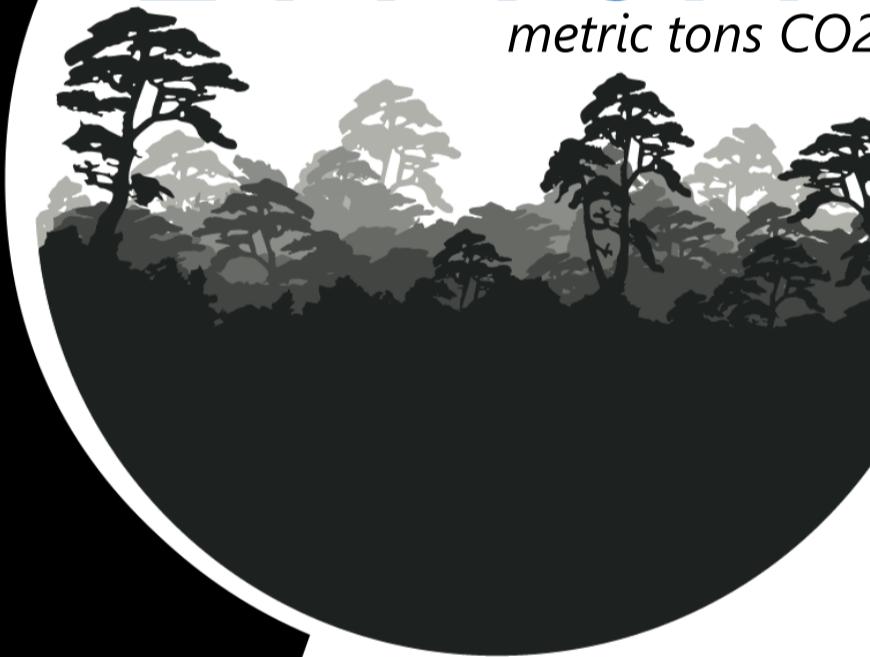


GOAL

Achieve carbon neutrality by 2030.

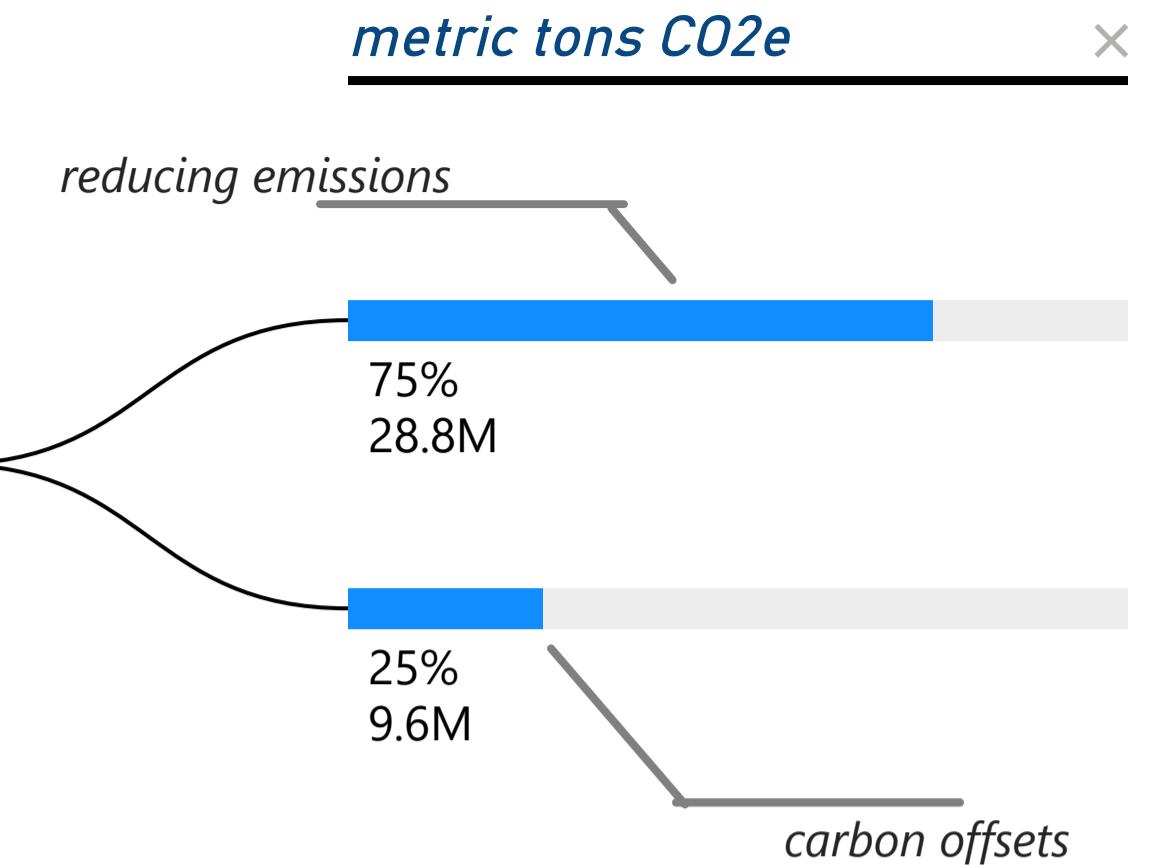
Apple has committed to achieving carbon neutrality across their entire value chain by 2030 — reducing emissions by 75% compared to 2015 and balancing the remaining 25% residual emissions with high-quality carbon removal or carbon offsets.

Total Gross Emissions till 2022
211.93M
metric tons CO₂e



using Carbon Offsets

Decarbonized
- 1.06M
metric tons CO₂e



Scope 1

0.18%

Scope 1 Emissions are all direct emissions which include emissions from Natural gas, diesel, propane, Fleet vehicles, R&D processes and refrigerant leaks. This is <1% of the gross emissions.

Scope 2 (market-based)

0.06%

Scope 2 Emissions are indirect GHG emissions which are Market based. These include emissions from Electricity, Steam, heating, cooling purchased from district energy. This is also <1% of the gross emissions.

Scope 3

99.76%

Scope 3 Emissions are emissions from product manufacturing, product life cycle, value and supply chain, business commute etc. Scope 3 Emissions contribute a staggering 99% of the gross emissions produced by Apple.

M - represents million

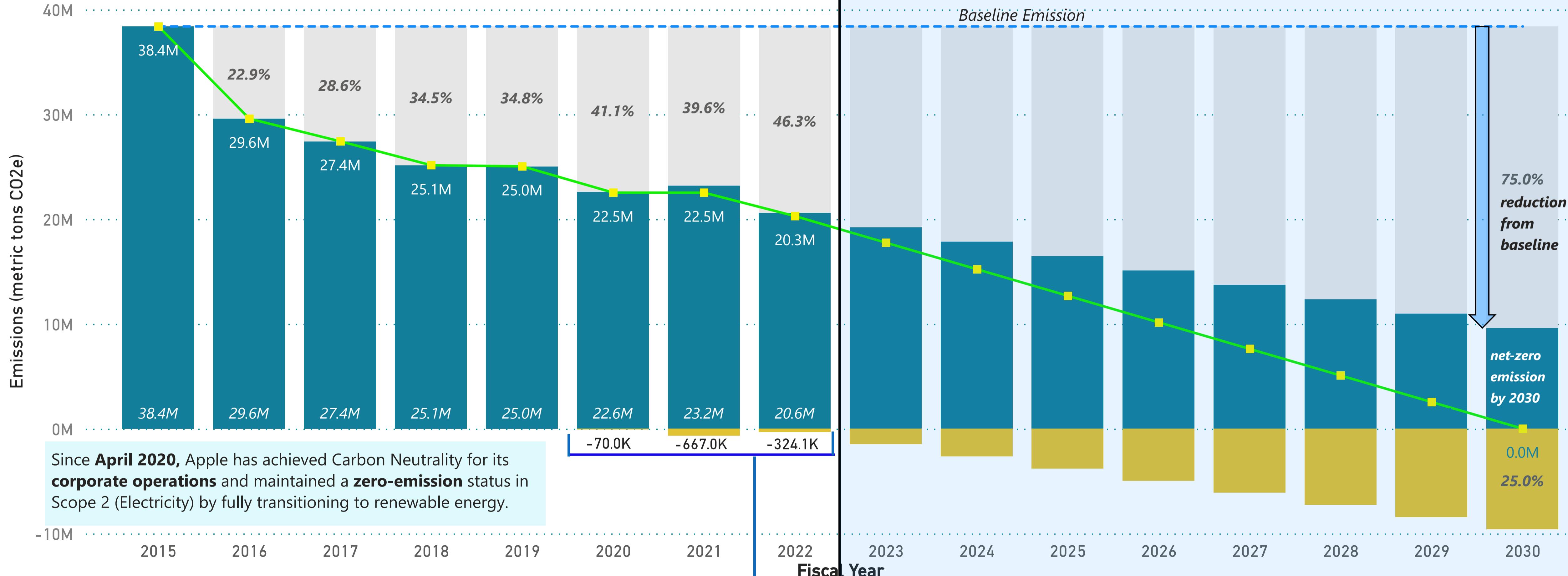
Excellent progress in their emission reduction can be seen and it shows that their emission reduction strategies are very effective. Within the initial **8-year** period, they have successfully **slashed 46% of their emissions** since **2015**. This substantial progress serves as a **positive indicator** of their ability to attain their **2030 goal of 75% reduction**.

Actual

Projected

Projected emissions are just illustrative and will likely not be linear. It portrays the vision of Apple's goal to achieve net-zero emissions.

● Gross Emissions ● Carbon Offsets ● % Reduction (from Baseline) ■ Net Emissions — Baseline Emission



Carbon Offsets are used to neutralize the residual emissions. Only **0.3%** of **2020** emissions were neutralized using offsets, whereas in **2021**, **3%** of the the emissions were neutralized which shows increased investments in offsets, but again in **2022** we could see a decline and only **1.6%** of the emissions that year were neutralized. To neutralize **25%** of their residual emissions by **2030** could be a challenging ride for **Apple** and requires huge and careful investments.

Experts believe that offsetting provides an excuse for avoiding real emission reductions and can create a dangerous mirage of 'climate neutrality' when emissions are actually rising. So, to increase credibility of carbon offsets, further research and innovation could prove helpful.

M - represents million
K - represents thousands

Overview of Emissions by Category, Scope and Sub-Categories for all years (2015 to 2022)

M - represents million

K - represents thousands

Gross Emissions (metric tons CO₂e)

150M

Scope 1

377.53K
metric tons CO₂e

0.18 %

0.07M

0.29M

0.02M

0.13M

0.01M

Fleet vehicles

Natural gas, diesel, propane
Other (R&D processes & refrigerant leaks)

Electricity
Steam, heating, and cooling

1.33M

1.26M

0.00M

0.00M

0.01M

0.01M

1.17M

Business travel

Employee commute
Third-party cloud (market-based)

Transmission and distribution loss (market-based)

Upstream fuel
Work from home (market-based)

End-of-life processing

Manufact... (purchased goods and services)

11.85M

39.19M

Scope 1

Scope 2 (market-based)

Scope 3

211.42M
metric tons CO₂e

99.76 %

Product transpor... (upstream and downstream)

Product use (use of sold products)

3.12M

Total Gross Emissions

211.93M

156.60M

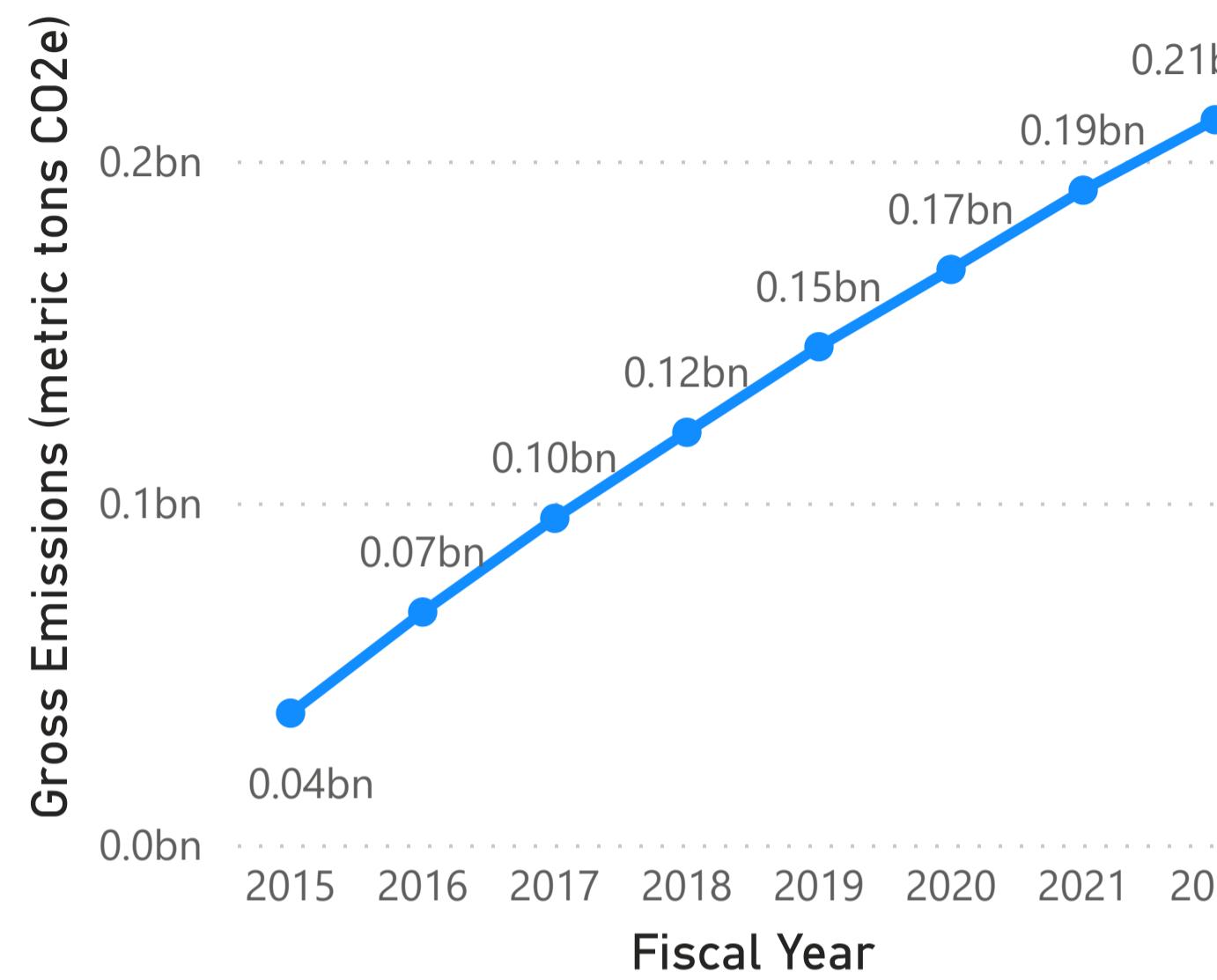
208.81M

Corporate emissions

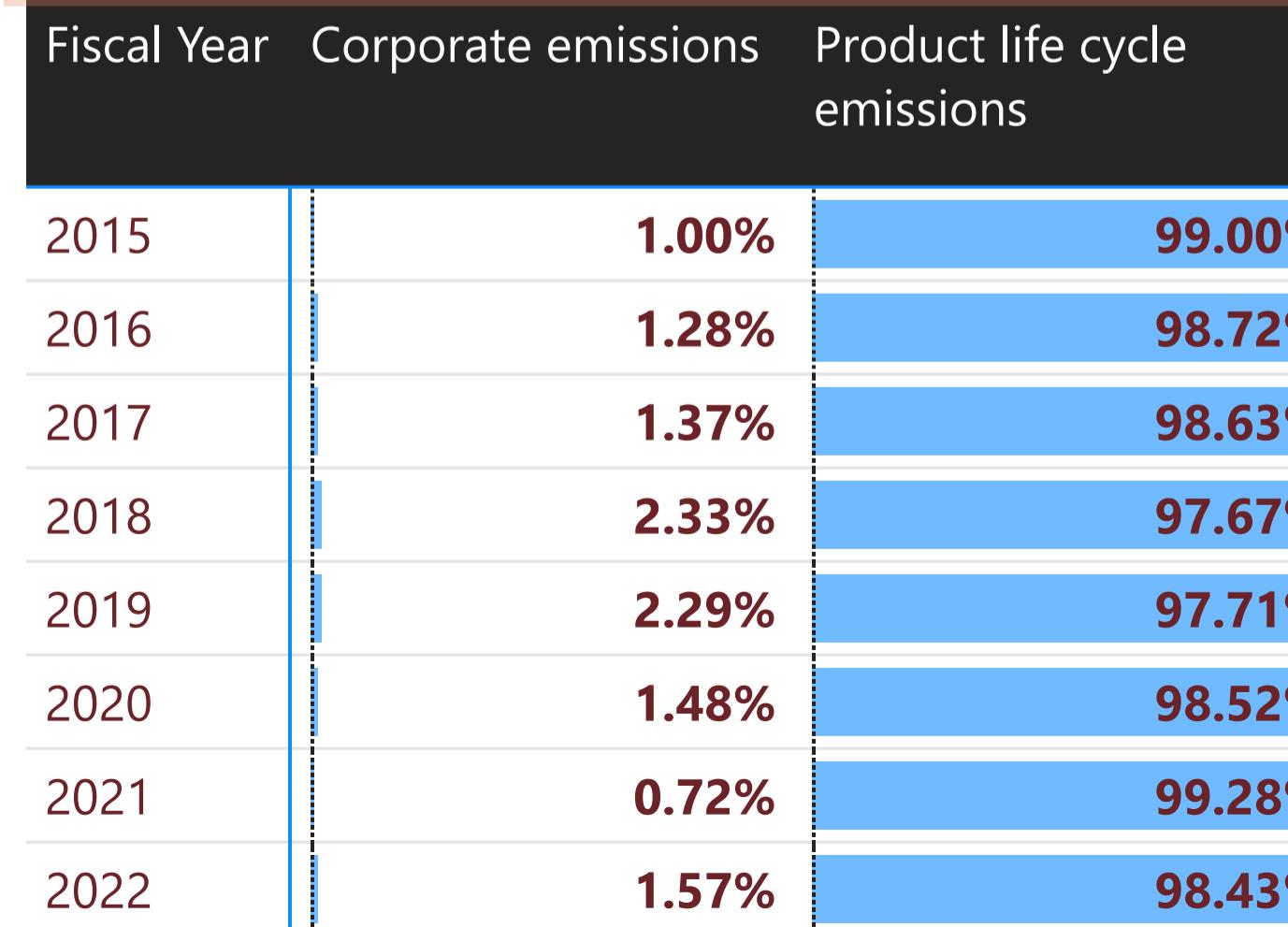
Product life cycle emissions

Cumulative emission is linear which is sign of steady/consistent pattern of improvement, which, in our case, is decrease in the emissions.

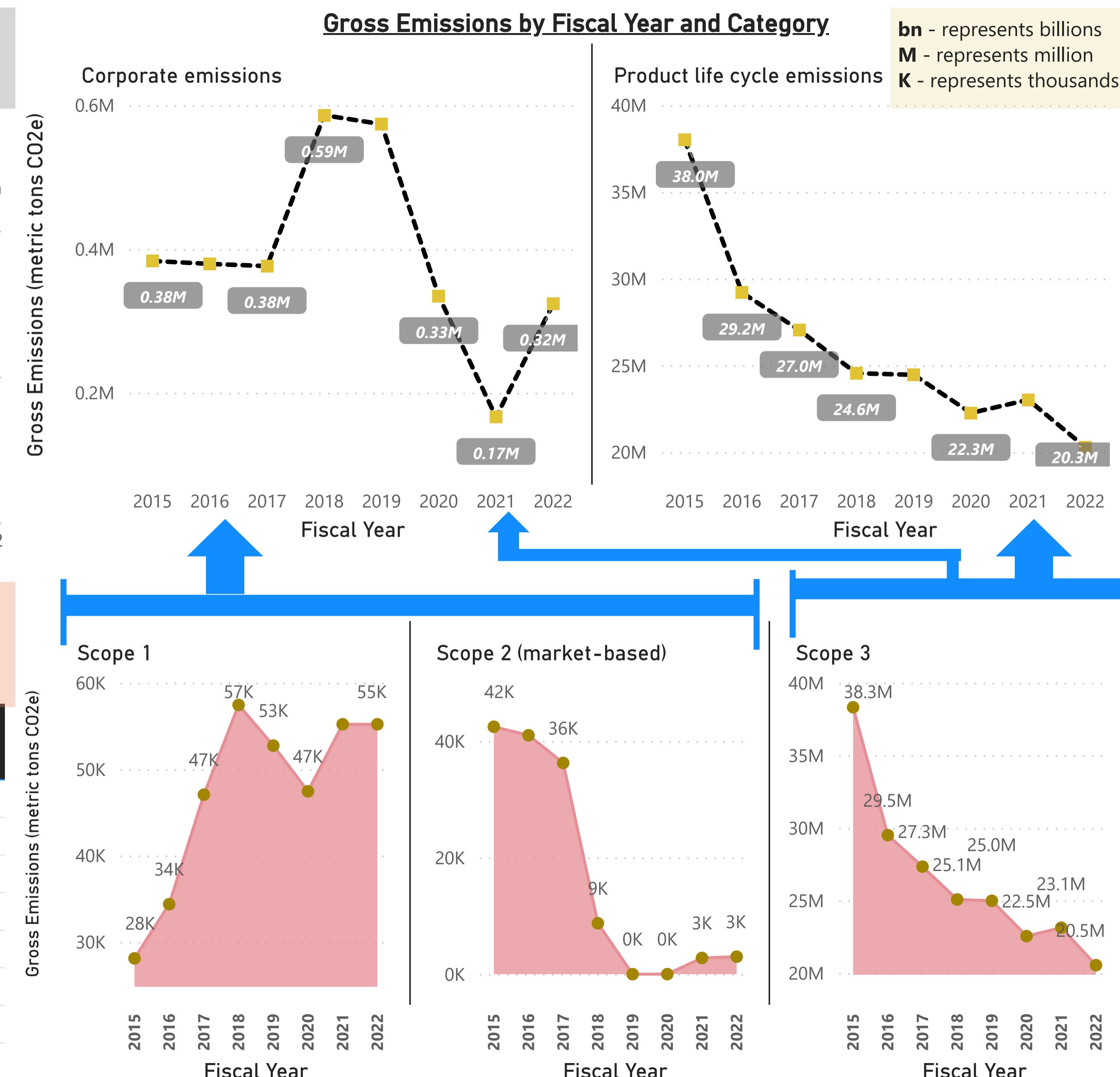
Cumulative Gross Emissions



Scope 1 emissions are direct emissions from sources owned or controlled by Apple, which can be seen rising until **2018** and plunging in **2020**. After **2020**, we could see the emissions rising.



Gross Emissions by Fiscal Year and Category

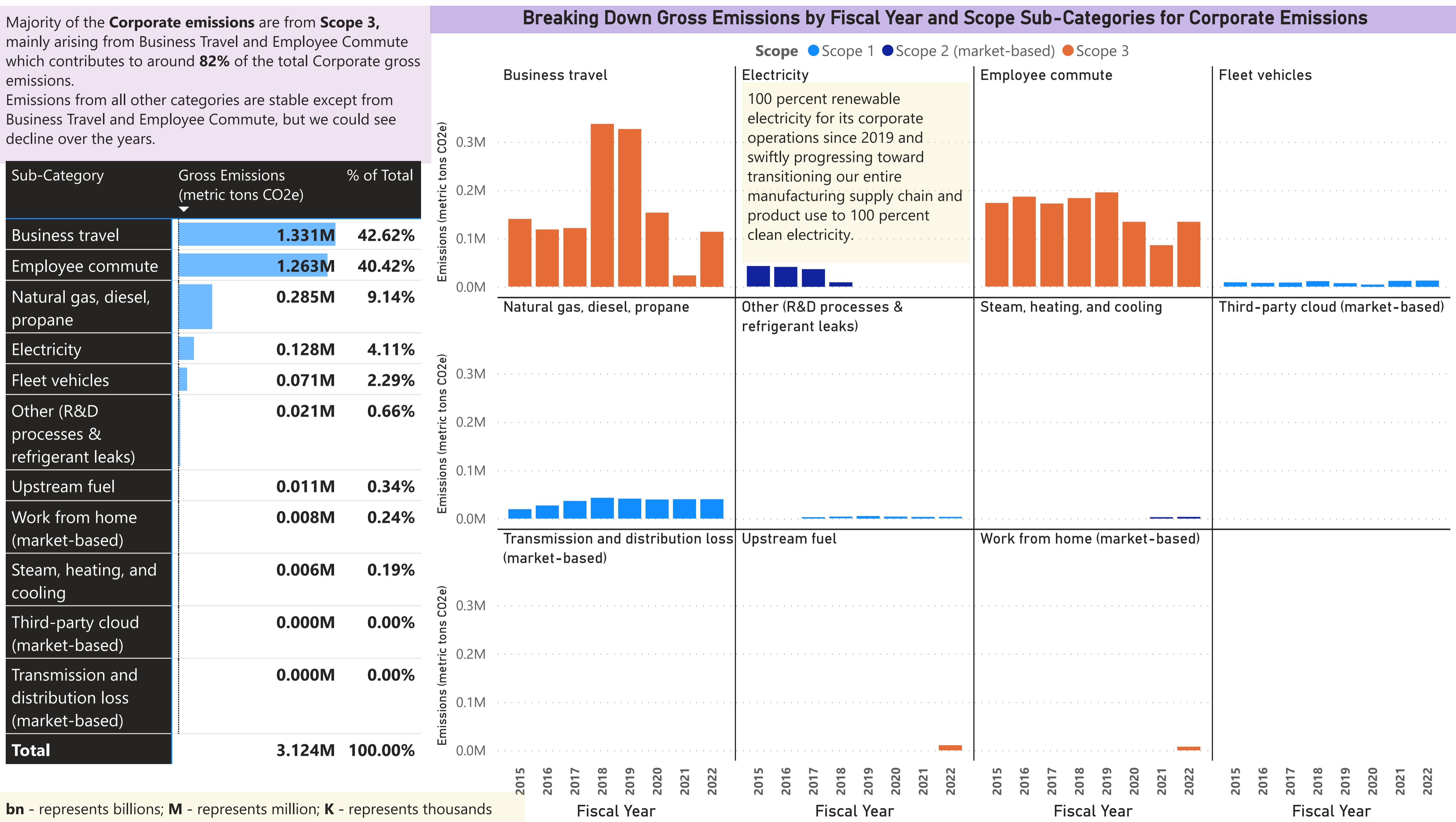


Apple appears to prioritize efforts primarily aimed at addressing **Scope 2** and **Scope 3** emissions.

99% of the gross emissions every year is from **product** life cycle (product category) and only around **2%** are from **corporate** operations. **Corporate** operations were on rise in 2018 and 2019 and dropped in 2020 and 2021 could be due to COVID, and again increased in 2022. Corporate emissions are consolidated from **Scope 1, Scope 2 and Scope 3**.

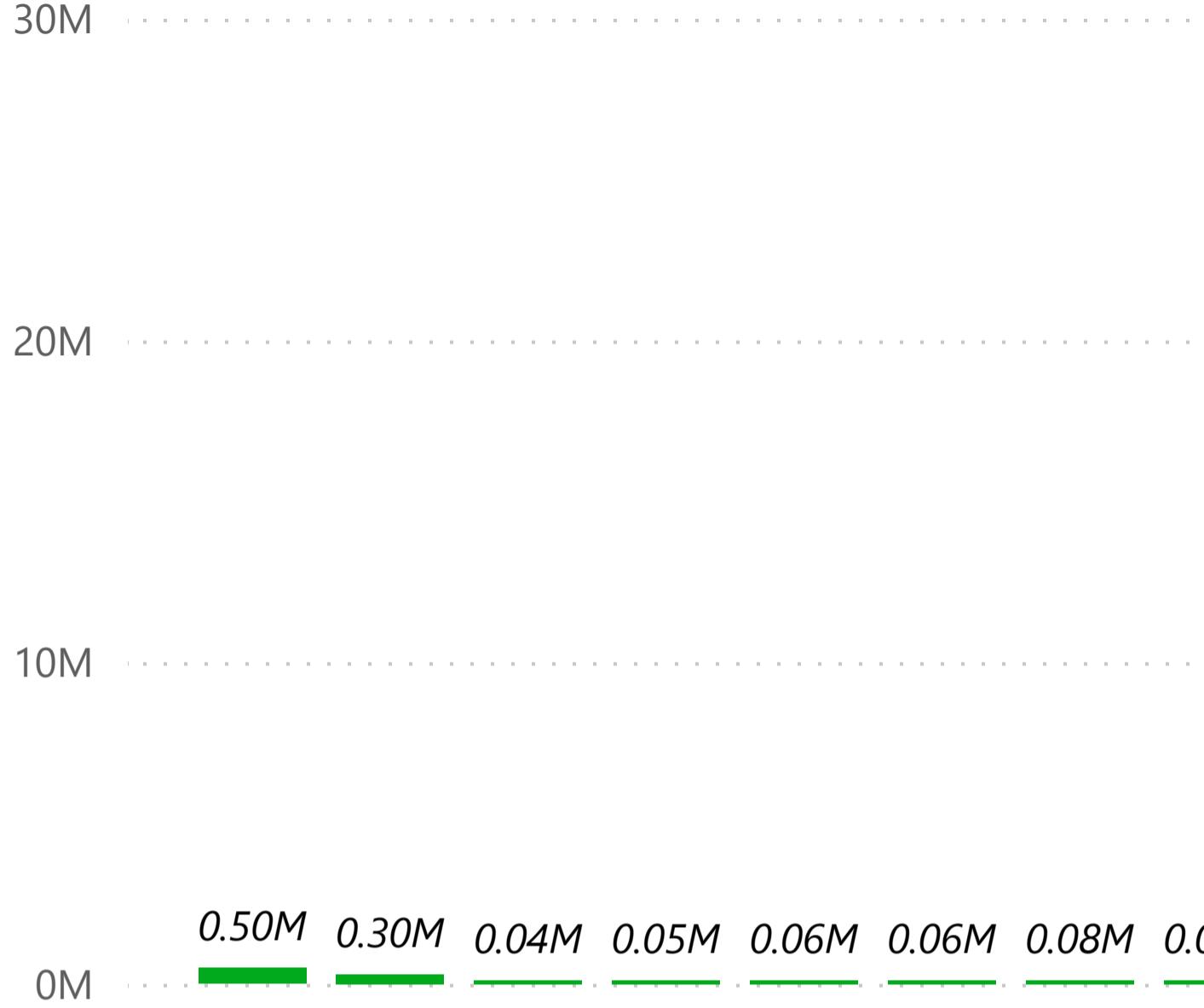
Scope 2 emissions are indirect emissions and have been dropping since Apple took a decision of transitioning to **100%** renewable energy, which they have achieved in **2019-2020**.

Scope 3 emissions contain a part of corporate and product life cycle emissions and is dropping at a steady rate, significantly reducing the emissions.

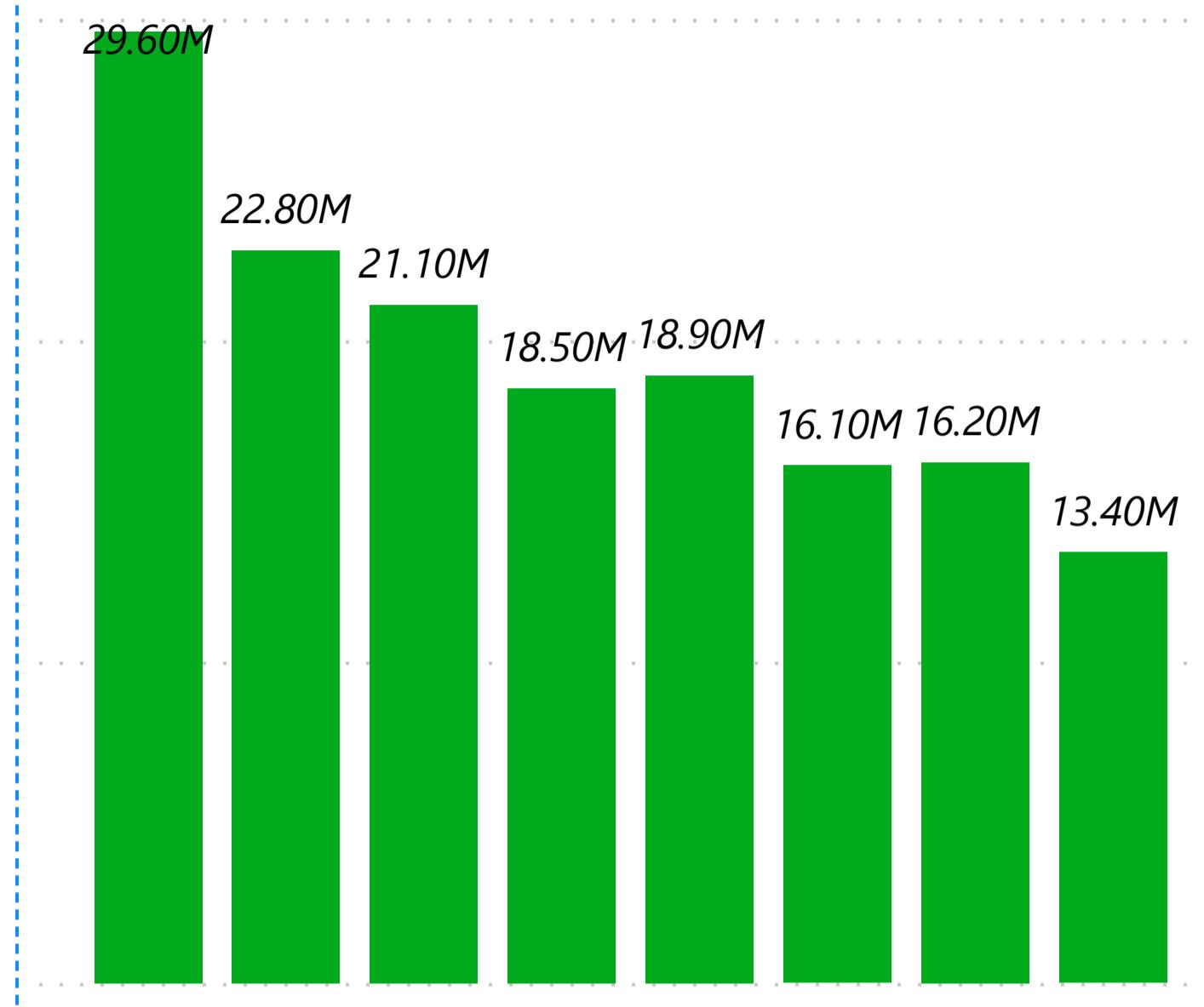


Breaking Down Gross Emissions by Fiscal Year and Categories for Product Life Cycle Emissions

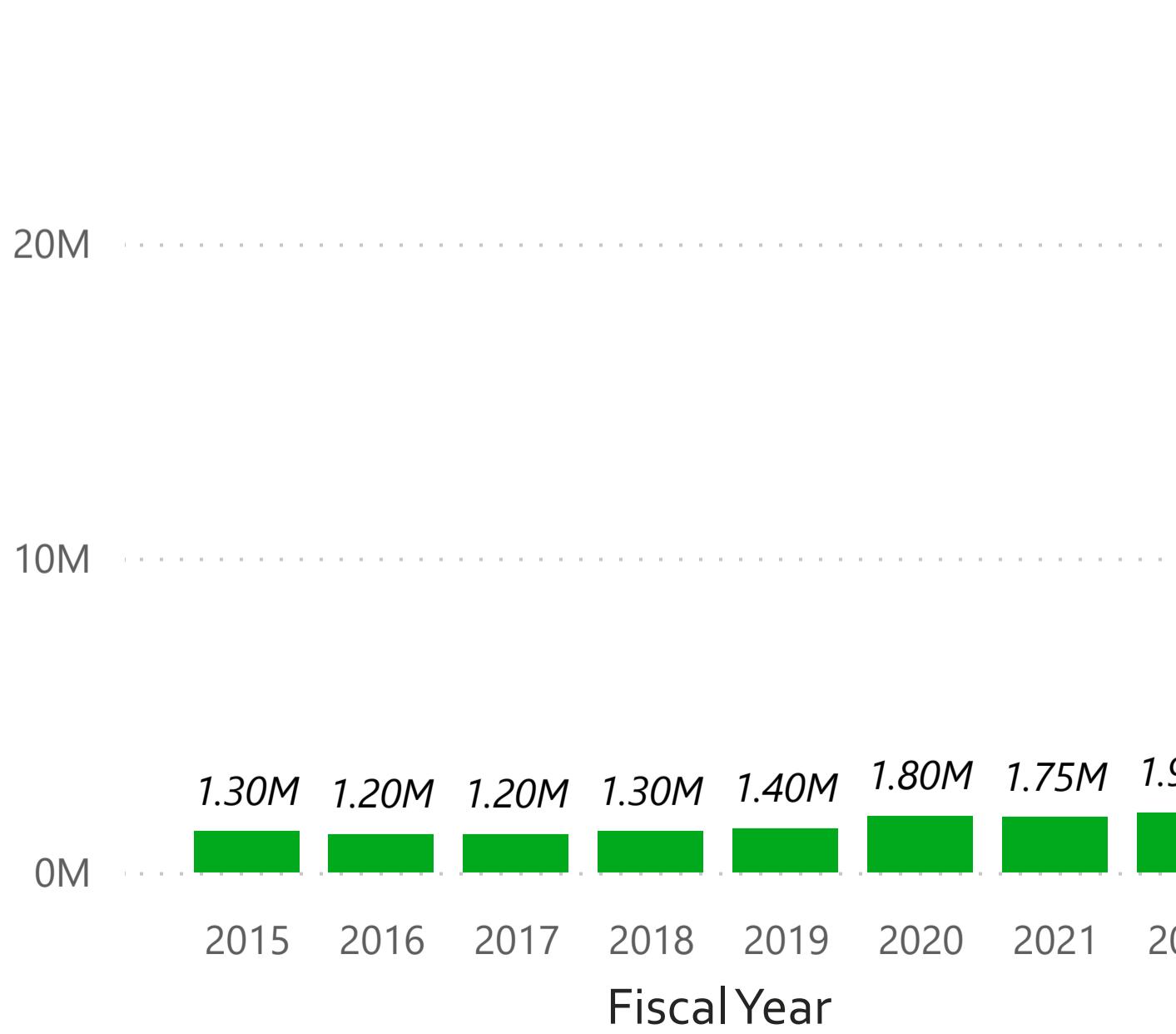
End-of-life processing



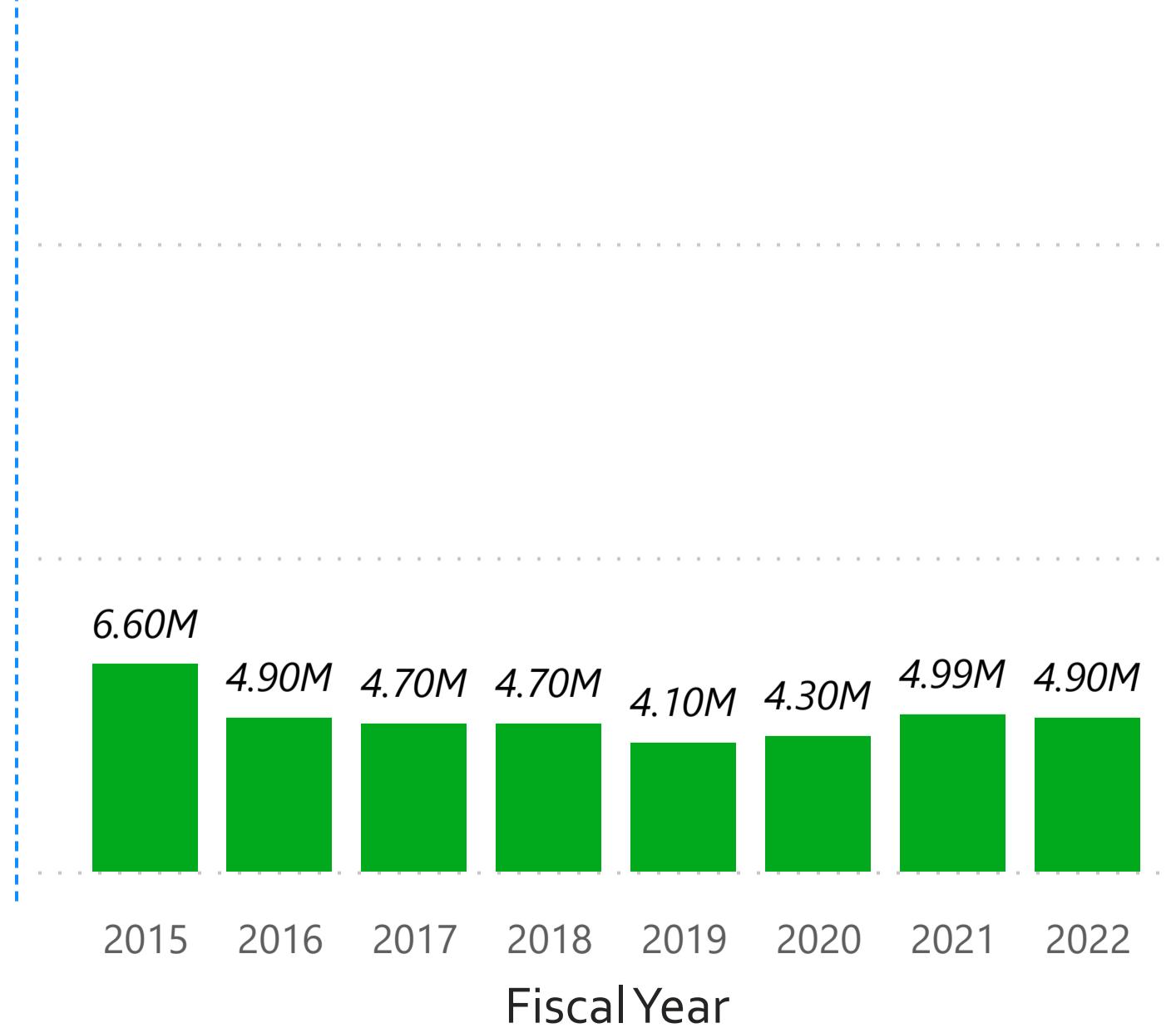
Manufacturing (purchased goods and services)



Product transportation (upstream and downstream)



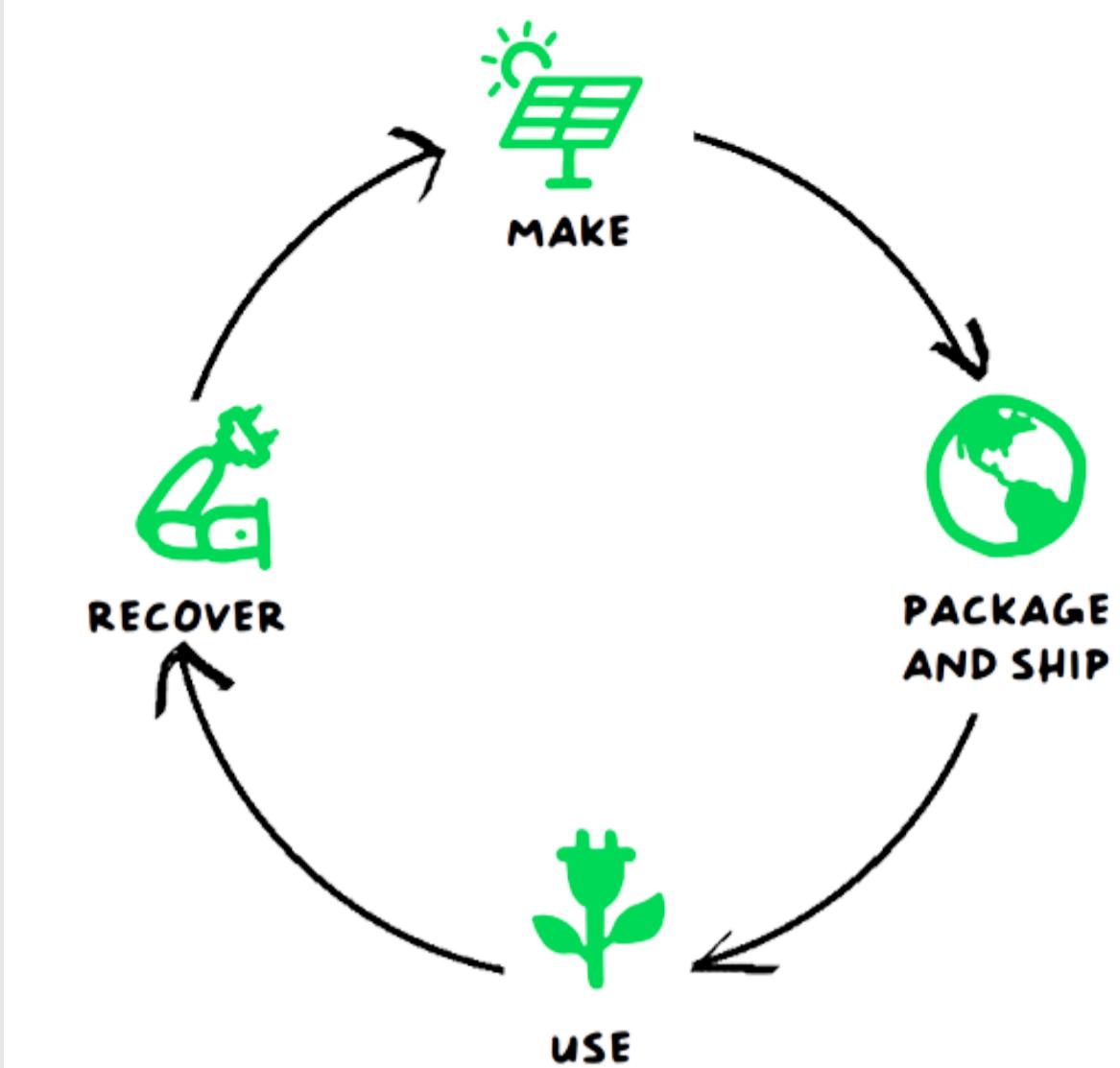
Product use (use of sold products)



Product Life Cycle emission is categorised into 4 components:

1. Manufacturing
2. Transportation
3. Product Use
4. End-of-Life Processing

Emissions for each of these categories are calculated with Global Warming Potential (GWP 100 years) in CO₂ equivalency factors (CO₂e).



Description	Gross Emissions (metric tons CO ₂ e)	% of Total
End-of-life processing	1.17M	0.56%
Manufacturing (purchased goods and services)	156.60M	75.00%
Product transportation (upstream and downstream)	11.85M	5.68%
Product use (use of sold products)	39.19M	18.77%
Total	208.81M	100.00%

Manufacturing accounts for 75% of **Product Life Cycle** Emissions and has been steadily decreasing since 2015.

But, we could see the emissions from product transportation slowly increasing.

The emissions from product use is balanced, no significant increase or decrease after 2015.

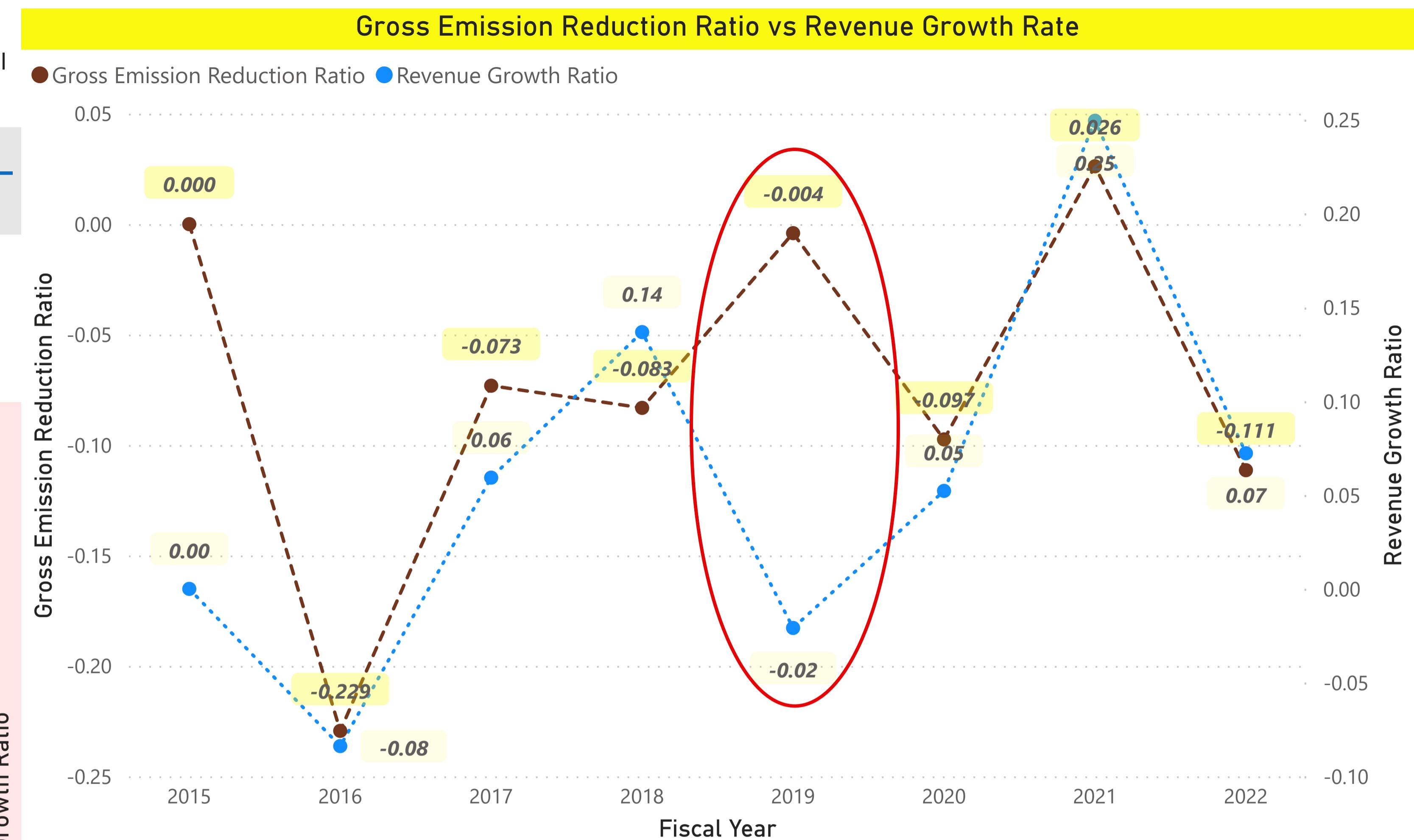
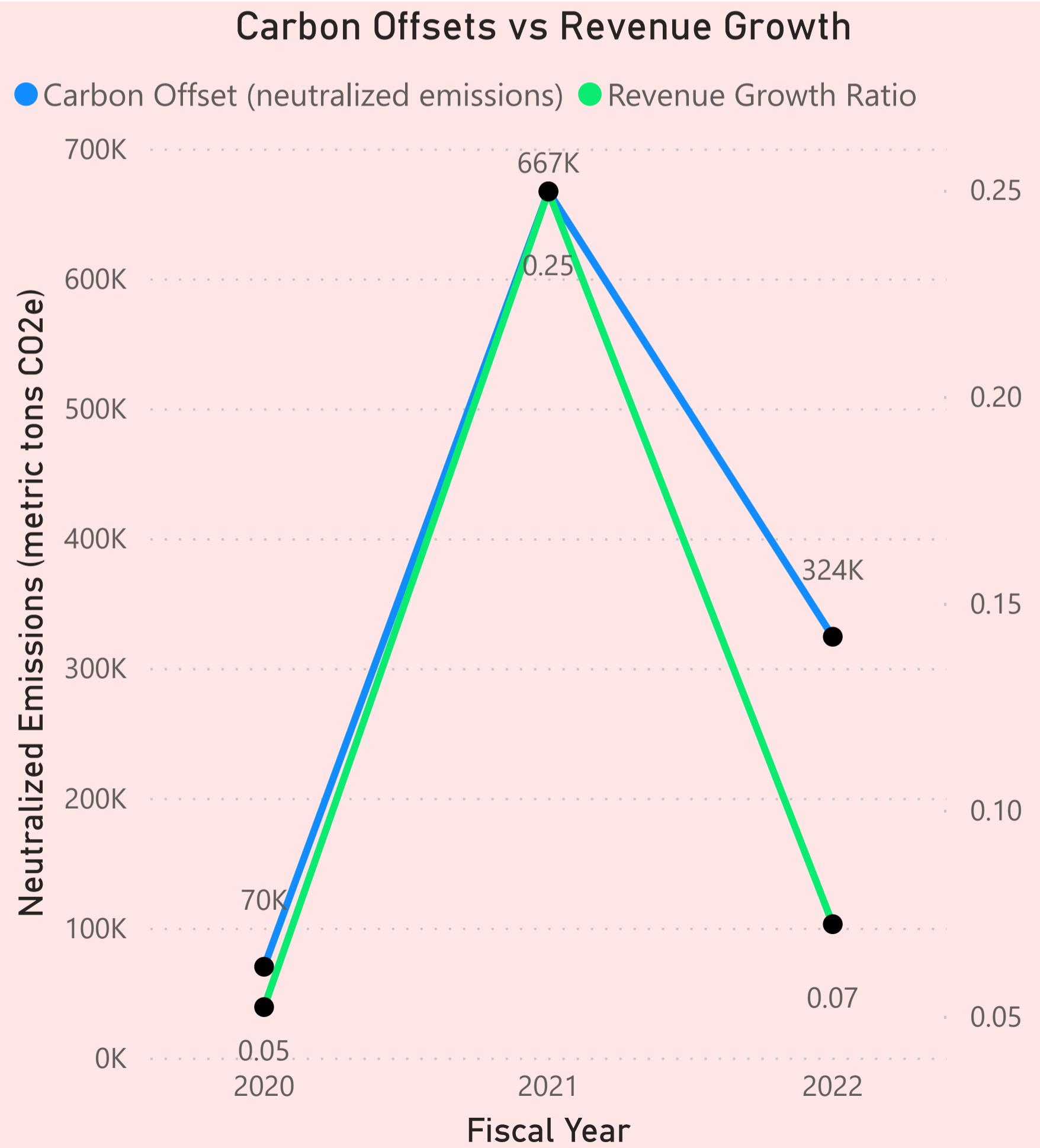
We can disregard the increase in emissions from other categories due to the significant overall reduction in emissions, as these categories may contain factors that are unavoidable residual emissions which can be offset using carbon credits.

bn - represents billions
M - represents million
K - represents thousands

Revenue Growth Ratio is a metric that indicates the degree of increase or decrease in a company's revenue over a specific period. It serves as a crucial indicator of the company's financial well-being and performance.

$$\text{Revenue Growth Ratio} = \frac{\text{Current Year's Revenue} - \text{Previous Year's Revenue}}{\text{Previous Year's Revenue}}$$

Apple has been using carbon offsets since 2020 and when comparing the emissions neutralized using carbon offsets with Revenue Growth for 2020, 2021 and 2022, it is observed that that emissions neutralized by offsets is directly proportional to the revenue growth ratio of the organisation, which suggests that its investment on Offsets depends on its Revenue Growth.



Gross Emission Reduction Ratio

$$\text{Current Year's Gross Emissions} - \text{Previous Year's Gross Emissions}$$

$$\text{Previous Year's Gross Emissions}$$

Gross Emission Reduction Ratio is a measure which indicates the degree of rise or fall in the gross emissions over a given period. This measurement aids in assessing the effectiveness of emission reduction initiatives.

Gross Emission Reduction Ratio also seems to be related to the **Revenue Growth Ratio**. It is noticeable that a lower growth ratio corresponds to a lower gross emission reduction, while a higher growth ratio corresponds to a higher gross emission reduction, except for year 2019 which is where the growth ratio plunges from to - 0.02, the emissions increased from previous year.

This indicates that the pace of revenue growth has an impact on the emissions generated, yet Apple remains on track to achieve its reduction target.

bn - represents billions; **M** - represents million; **K** - represents thousands

Predicting the Gross Emission Reduction Rate (Baseline)

The aim is to predict the baseline's emission reduction rate for any given Price-to-Sales ratio using linear regression. Positive reduction rate from the baseline is used, as opposed to the previously employed negative reduction ratio.

In the previous graph, the intention was to demonstrate how revenue impacts the reduction ratio. In this case, however, for forecasting, the positive value of rate of reduction from baseline is considered.

The values used for prediction are from fiscal years 2016, 2017, 2018, 2019, 2021, and 2022. The 2020 data would be used as test data to assess the accuracy.

Since 2015 serves as the baseline with a reduction rate of "0", this data will not be utilized.

The calculated correlation coefficient for the aforementioned (**training**) data is **0.86**, indicating a strong positive correlation.

The **R-squared** value is calculated as **0.73**, indicating that approximately **73%** of the variability in the data is accounted for by the regression model.

Running predictions for the test data (**2020**) yields a gross emission reduction rate (baseline) of **41.70**, which is approximately close to the actual data of **41.13**. Assuming that the relationship between the predictor and the response variable remains constant beyond the observed range, for a price to sales ratio of **6.9** the gross emission reduction rate from baseline will be approximately close to **44.75**.

Fiscal Year	Price to Sales	Gross Emission Reduction Rate (Baseline)
2016	2.78	22.94
2017	3.23	28.57
2018	3.13	34.51
2019	4.19	34.78
2021	6.70	39.59
2022	6.31	46.32

Test Data

Fiscal Year	Price to Sales	Gross Emission Reduction Rate (Baseline)
2020	6.27	41.13

This is just a prediction and the the rate may be much higher. With additional data, we might potentially enhance our ability to predict with increased precision.

This shows that the company's revenue does not affect its emission reduction goals, indicating a consistent and upward trajectory in their efforts

Gross Emission Reduction Rate from Baseline

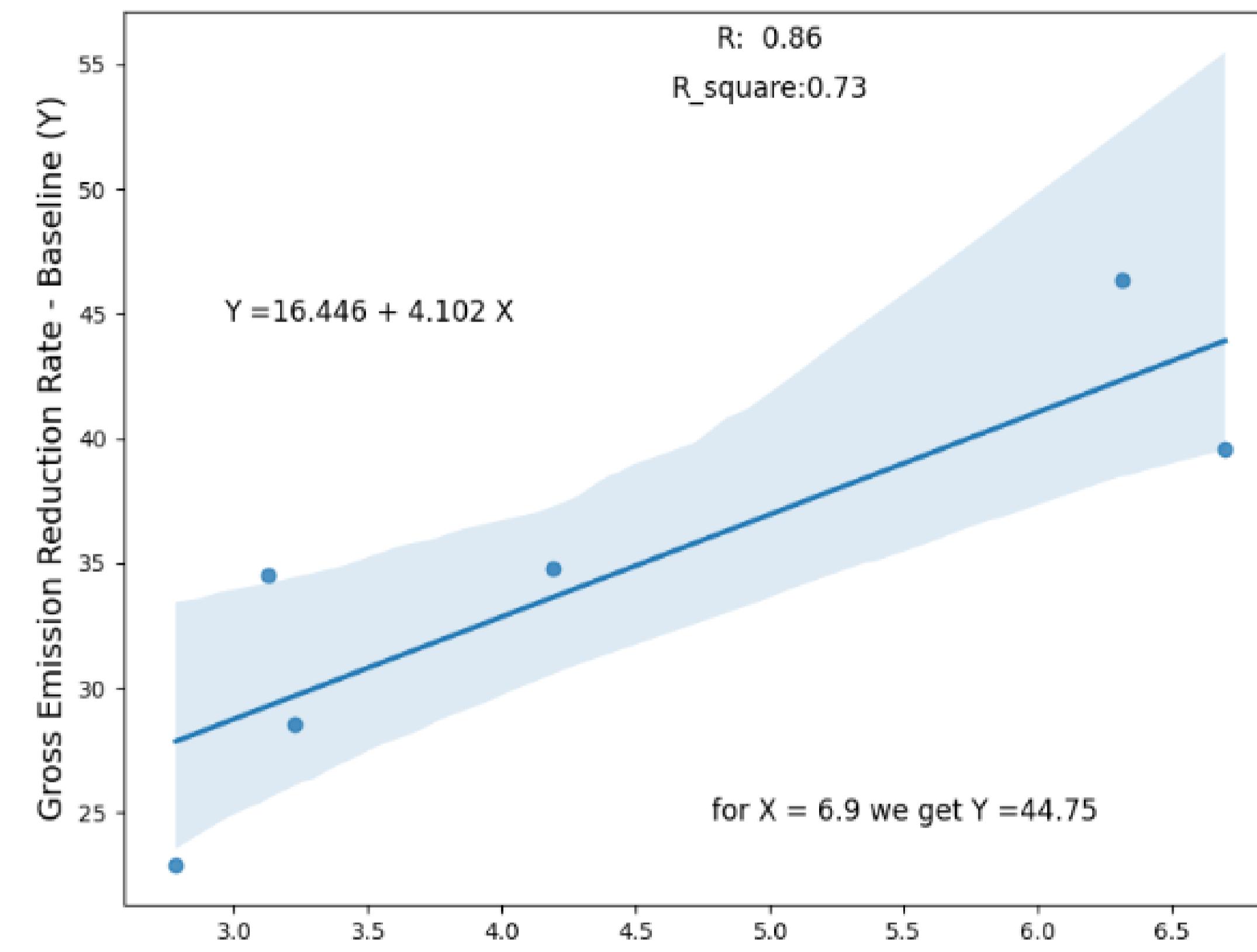
Baseline Gross Emissions - Current Year's Gross Emissions

x 100

Baseline Gross Emissions

Gross Emission Reduction Ratio is a measure which indicates the degree of rise or fall in the gross emissions from a given baseline. This measurement also helps to assess the effectiveness of emission reduction initiatives.

Price to Sales vs Gross Emission Reduction Rate (Baseline)

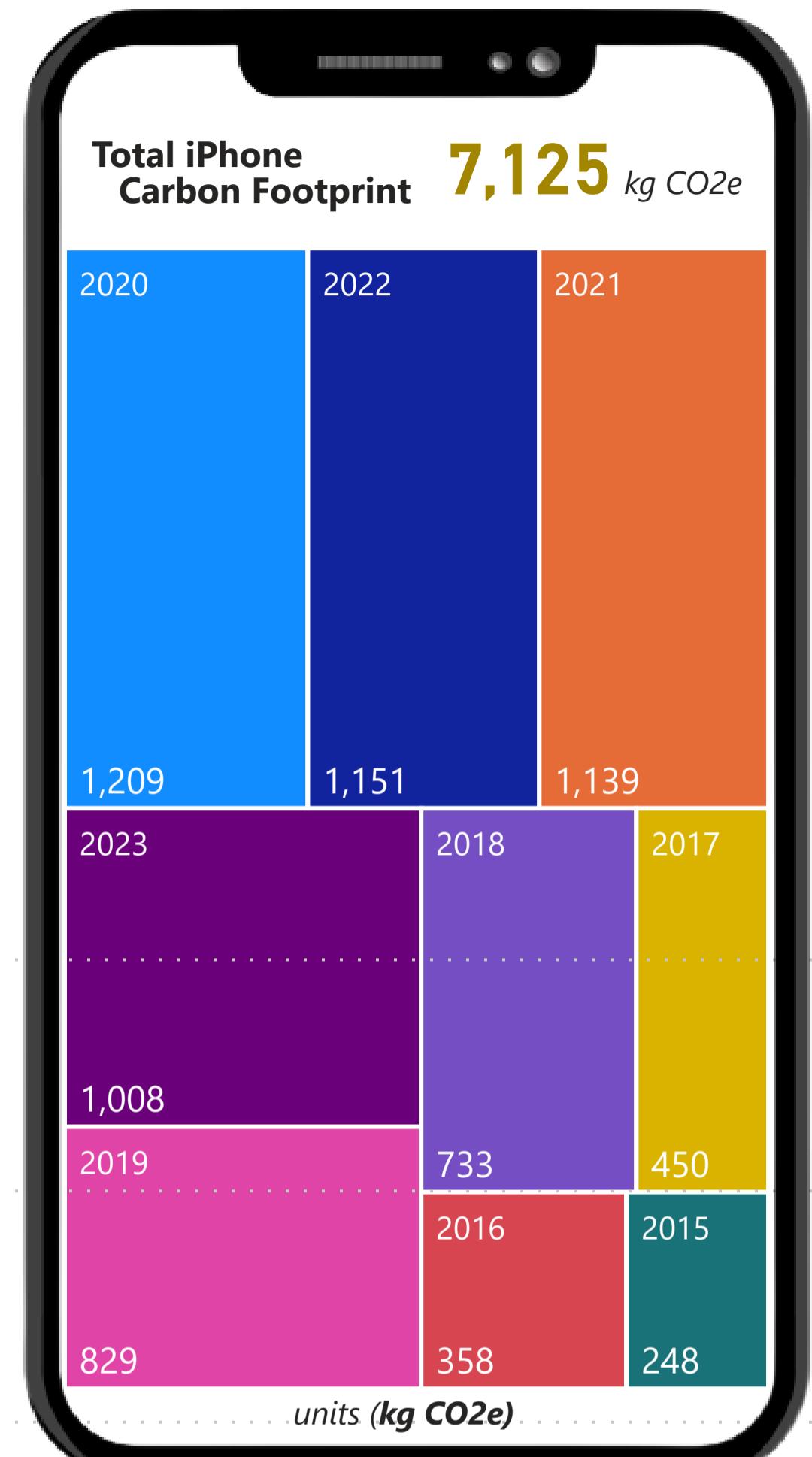


Price-to-Sales Ratio

Baseline Gross Emissions - Current Year's Gross Emissions

Baseline Gross Emissions

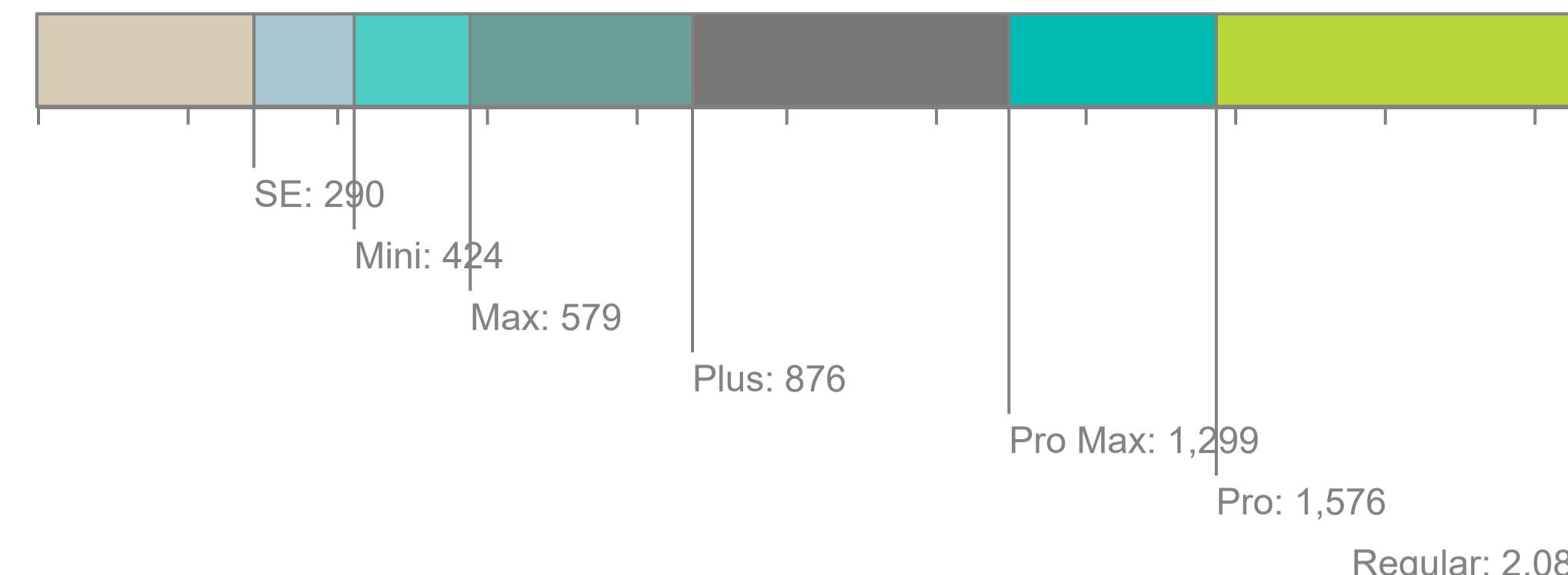
The price-to-sales (P/S) ratio is a valuation ratio that is calculated by dividing the company's market capitalization by its total sales or revenue over a specific period.. The P/S ratio is often used by investors to evaluate a company's valuation relative to its sales.



It is evident from the data that Apple is working to reduce its iPhone carbon footprint. There has been a substantial decline in **2023**, which is a positive sign.

Furthermore, discontinuing the baseline storage variants up to 128 GB has contributed to the decline in carbon footprint.

Sum of Carbon Footprint by Model

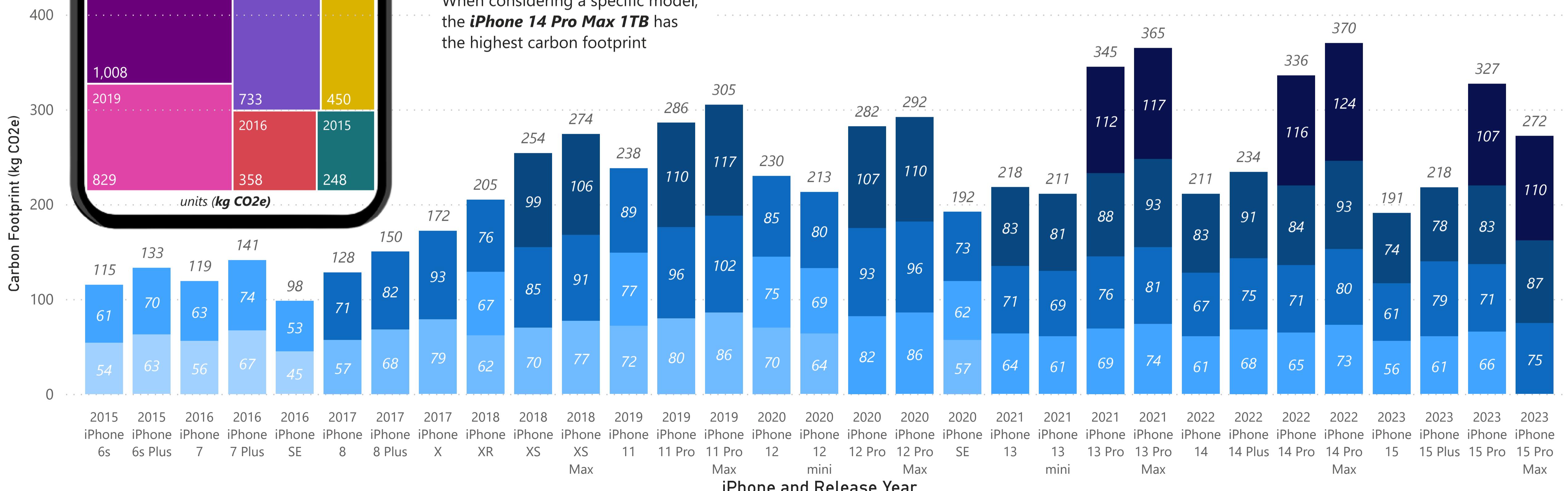


The regular version of iPhones have the highest share of Carbon Footprint.

Carbon Footprint by Release Year, iPhone and Storage (in GB)

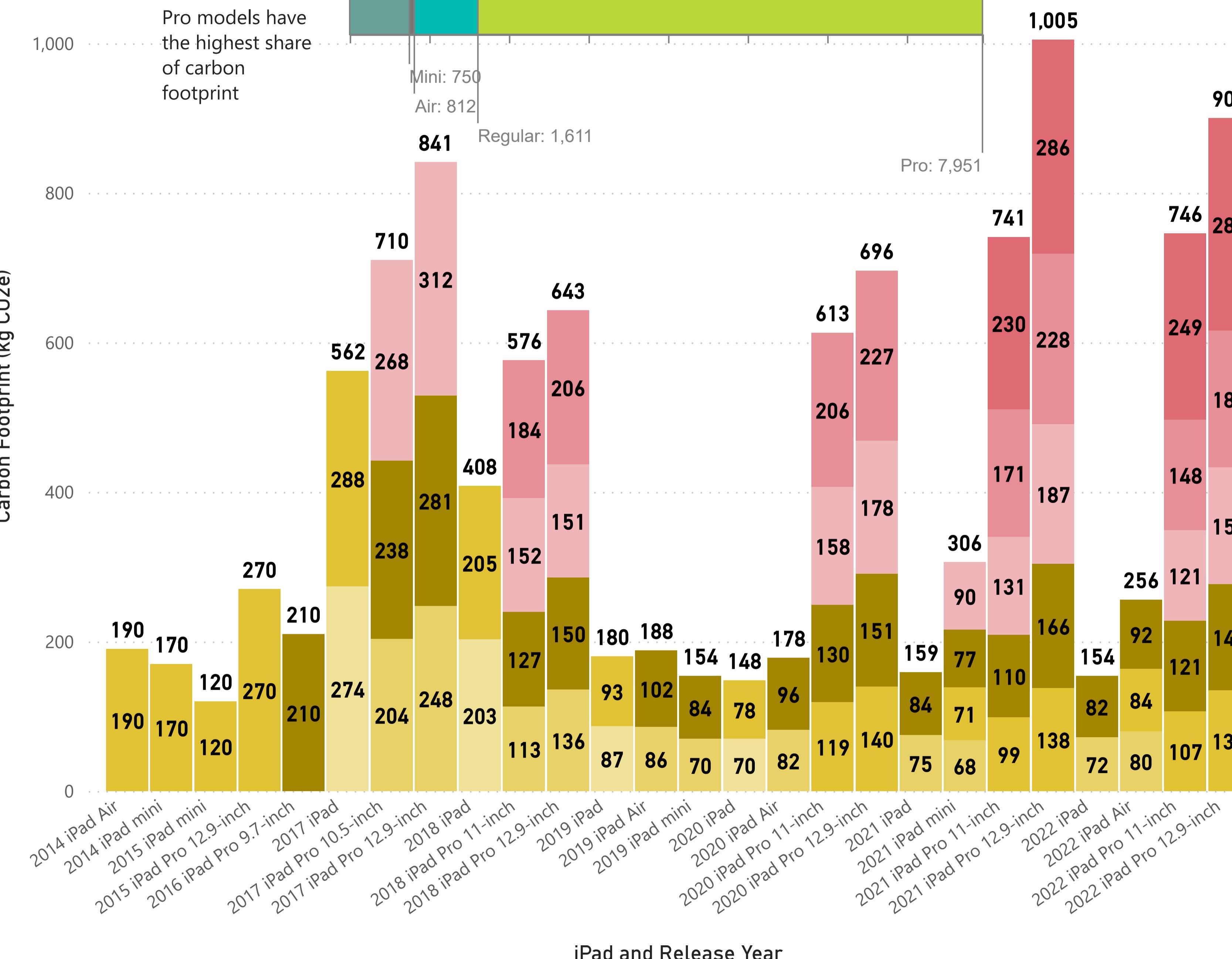
When considering a specific model, the **iPhone 14 Pro Max 1TB** has the highest carbon footprint

Storage (in GB) ● 32 ● 64 ● 128 ● 256 ● 512 ● 1024

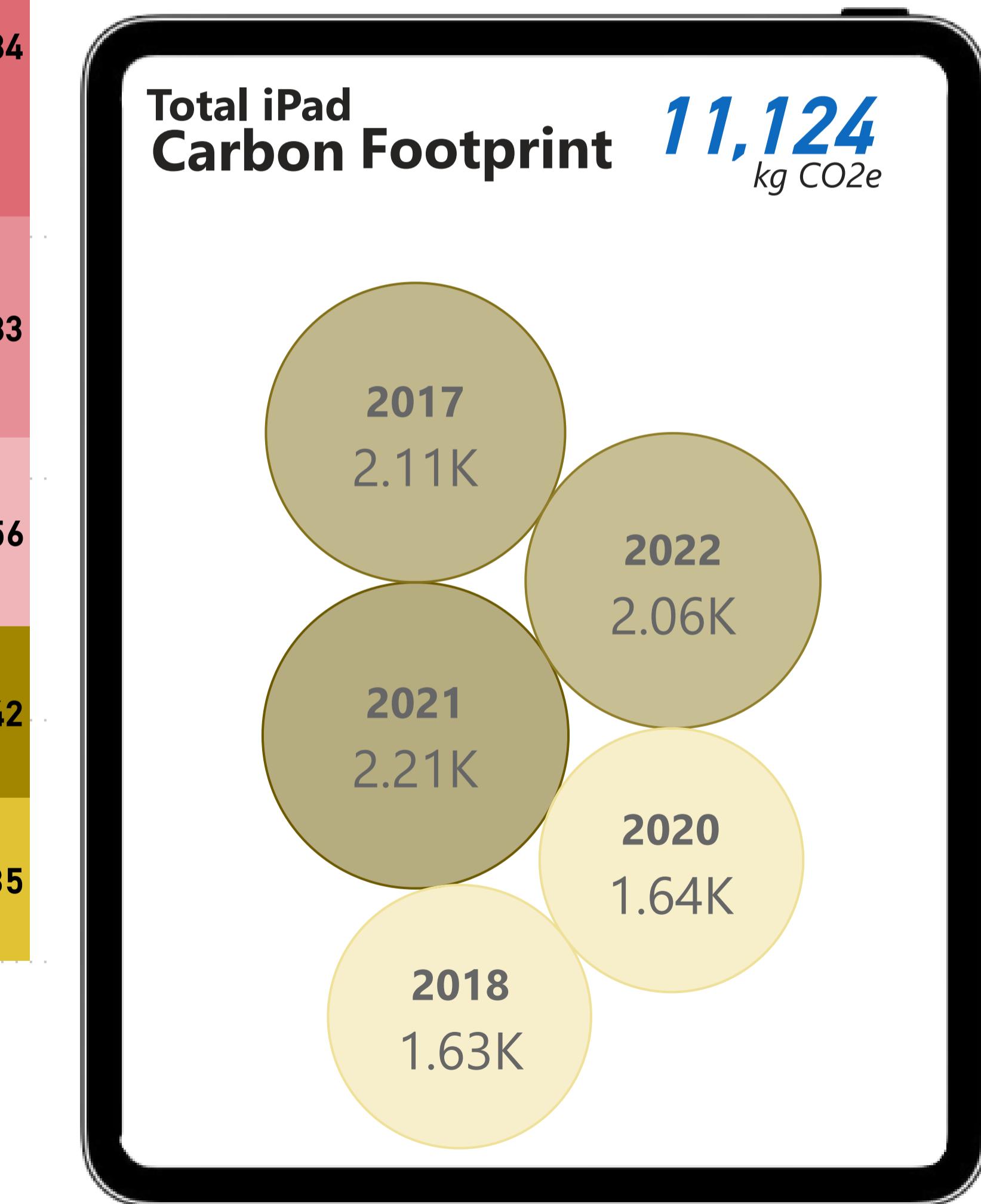


Carbon Footprint by Release Year, iPad and Storage (in GB)

Storage (in GB) ● 32 ● 64 ● 128 ● 256 ● 512 ● 1024 ● 2048

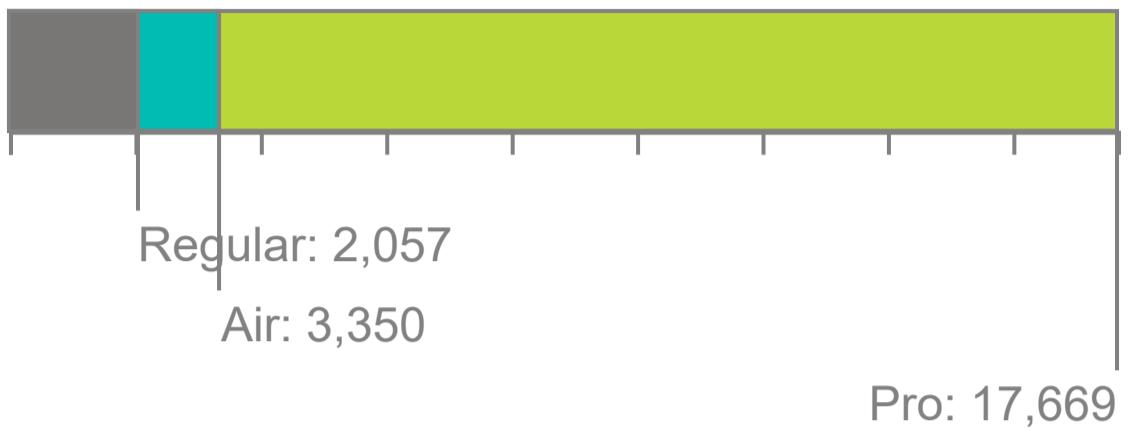
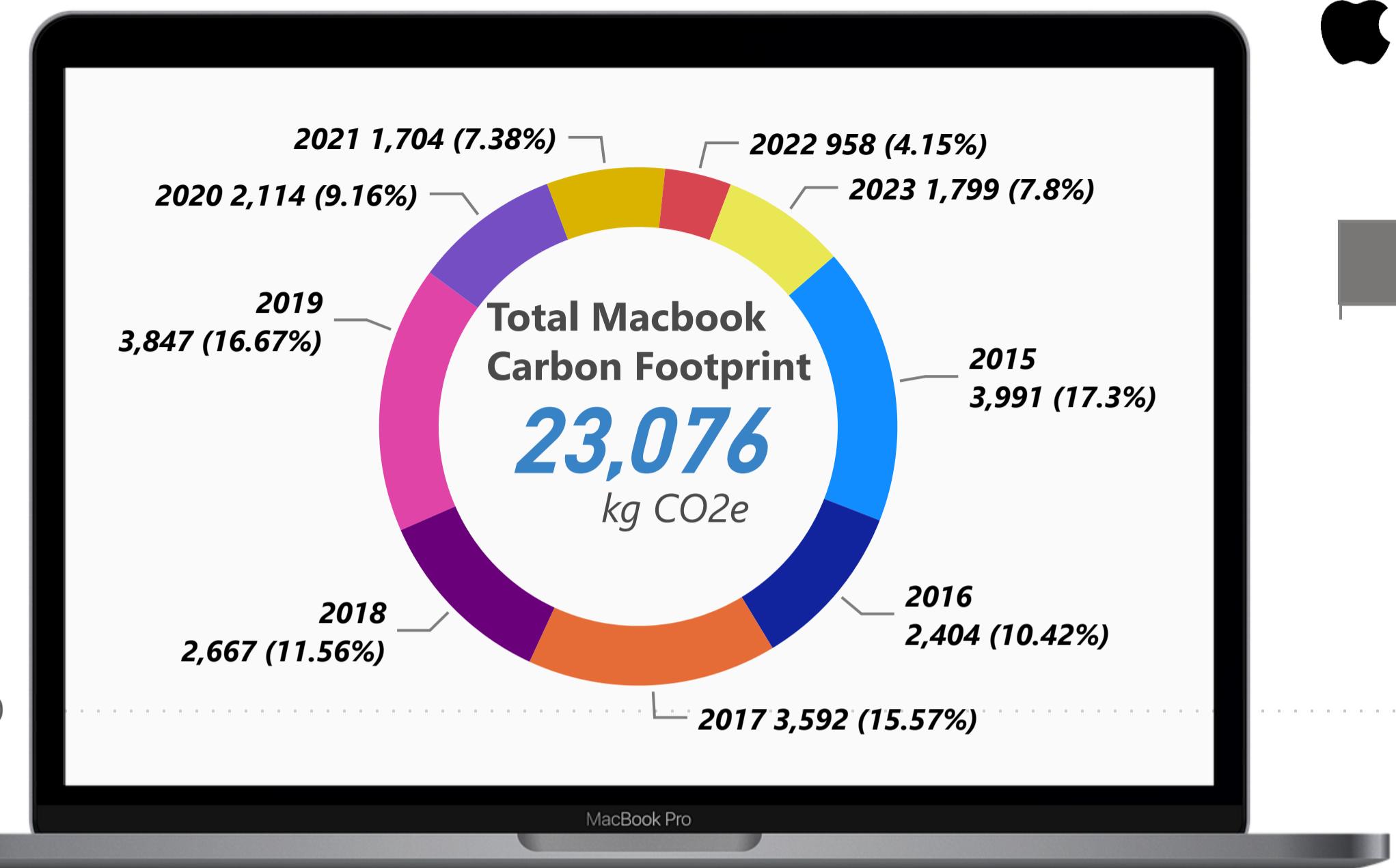


The iPad carbon footprint has a different story. With the introduction of various storage variants, the carbon footprint of iPads has increased. However, when comparing the 2022 iPads with those from 2021, we observe a decline in the carbon footprint.



MacBook

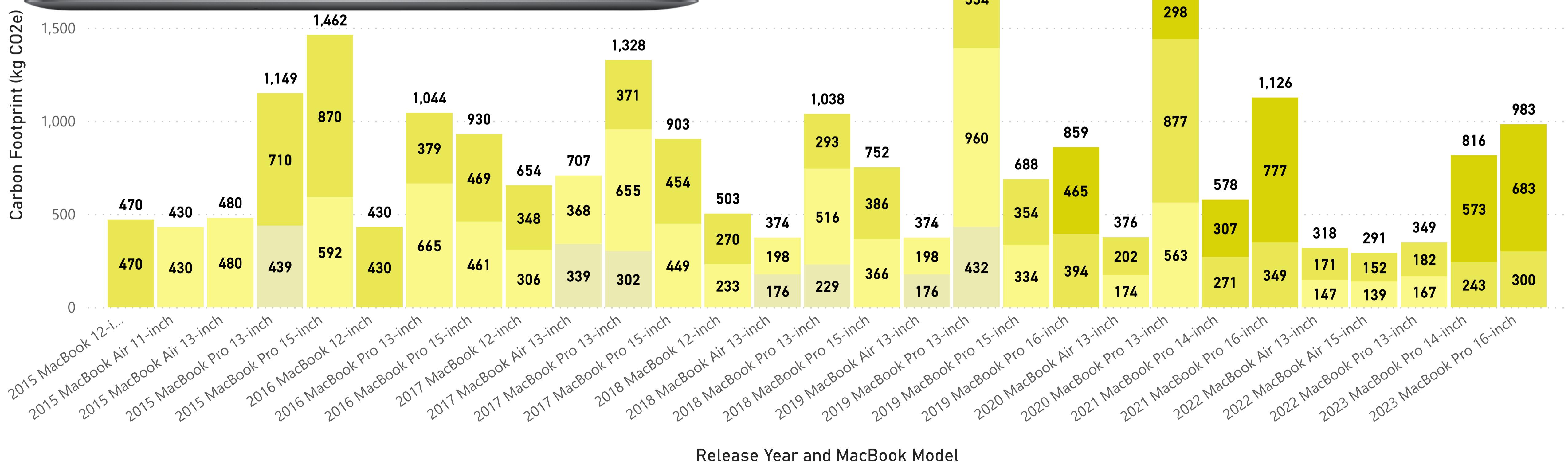
The 2023 models have shown a decline in the overall carbon footprint, but when compared to the products released the previous year, there has been an increase. However, considering the overall emissions, there has been progress in reduction.



Pro's have the highest share of Carbon Footprint.

Carbon Footprint by Release Year, MacBook and Storage (in GB)

Storage (in GB) ● 128 ● 256 ● 512 ● 1024



Conclusion

Concluding this analysis, it can be seen that there are minor fluctuations in emissions and carbon footprints within certain sub-categories and products. However, the overall progress in emission reduction by Apple is remarkable, demonstrating the effectiveness of their strategies.

Over the span of 8 years, Apple has successfully decreased its emissions by an impressive 45% from the baseline, displaying a steadfast commitment to their goal of reducing emissions by 75% from the baseline. Notably, the forecasted baseline reduction rate indicates that Apple's increase in revenue has not hindered their efforts to reduce emissions. On the contrary, it suggests a promising trend of even higher reduction rates with increased revenue.

Apple's commitment to sustainability and the environment is evident in their tangible efforts to minimize their carbon footprint. With a dedicated focus on innovation, sustainability and environmental responsibility, Apple continues to set an example for the technology industry, showcasing that successful business growth can indeed go hand in hand with substantial reductions in emissions.