**Historical Data for 2010-2014 (NATIONAL UNIVERSITY OF COSTA RICA):**

| **Year** | **SNM** | **CT** | **D** | **RSC** | **RS** | **PL** | **NEW** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **2010** | **10** | **10** | **10** | **22** | **17** | **15** | **12** |
| **2011** | **15** | **21** | **21** | **30** | **30** | **30** | **18** |
| **2012** | **18** | **24** | **24** | **35** | **42** | **42** | **24** |
| **2013** | **30** | **30** | **30** | **48** | **48** | **48** | **30** |
| **2014** | **33** | **33** | **33** | **52** | **51** | **55** | **35** |

**S1.Number of Laboratories Performing Six Waste Minimization Practices (2015-2050)**

| **Year** | **SNM** | **CT** | **D** | **RSC** | **RS** | **PL** | **NEW** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **2015** | 39.5 | 40.1 | 40.1 | 60.8 | 63.4 | 67.4 | 40.3 |
| **2016** | 45.6 | 45.6 | 45.6 | 68.6 | 72.0 | 77.2 | 45.6 |
| **2017** | 51.7 | 51.1 | 51.1 | 76.4 | 80.6 | 87.0 | 51.0 |
| **2018** | 57.8 | 56.6 | 56.6 | 84.2 | 89.2 | 96.8 | 56.3 |
| **2019** | 63.9 | 62.1 | 62.1 | 92.0 | 97.8 | 106.6 | 61.6 |
| **2020** | 70.0 | 67.6 | 67.6 | 99.8 | 106.4 | 116.4 | 66.9 |
| **2021** | 76.1 | 73.1 | 73.1 | 107.6 | 115.0 | 126.2 | 72.3 |
| **2022** | 82.2 | 78.6 | 78.6 | 115.4 | 123.6 | 136.0 | 77.6 |
| **2023** | 88.3 | 84.1 | 84.1 | 123.2 | 132.2 | 145.8 | 83.0 |
| **2024** | 94.4 | 89.6 | 89.6 | 131.0 | 140.8 | 155.6 | 88.3 |
| **2025** | 100.5 | 95.1 | 95.1 | 138.8 | 149.4 | 165.4 | 93.6 |
| **2026** | 106.6 | 100.6 | 100.6 | 146.6 | 158.0 | 175.2 | 98.9 |
| **2027** | 112.7 | 106.1 | 106.1 | 154.4 | 166.6 | 185.0 | 104.2 |
| **2028** | 118.8 | 111.6 | 111.6 | 162.2 | 175.2 | 194.8 | 109.5 |
| **2029** | 124.9 | 117.1 | 117.1 | 170.0 | 183.8 | 204.6 | 114.8 |
| **2030** | 131.0 | 122.6 | 122.6 | 177.8 | 192.4 | 214.4 | 120.1 |
| **2031** | 137.1 | 128.1 | 128.1 | 185.6 | 201.0 | 224.2 | 125.4 |
| **2032** | 143.2 | 133.6 | 133.6 | 193.4 | 209.6 | 234.0 | 130.7 |
| **2033** | 149.3 | 139.1 | 139.1 | 201.2 | 218.2 | 243.8 | 136.0 |
| **2034** | 155.4 | 144.6 | 144.6 | 209.0 | 226.8 | 253.6 | 141.3 |
| **2035** | 161.5 | 150.1 | 150.1 | 216.8 | 235.4 | 263.4 | 146.6 |
| **2036** | 167.6 | 155.6 | 155.6 | 224.6 | 244.0 | 273.2 | 151.9 |
| **2037** | 173.7 | 161.1 | 161.1 | 232.4 | 252.6 | 283.0 | 157.2 |
| **2038** | 179.8 | 166.6 | 166.6 | 240.2 | 261.2 | 292.8 | 162.5 |
| **2039** | 185.9 | 172.1 | 172.1 | 248.0 | 269.8 | 302.6 | 167.8 |
| **2040** | 192.0 | 177.6 | 177.6 | 255.8 | 278.4 | 312.4 | 173.1 |
| **2041** | 198.1 | 183.1 | 183.1 | 263.6 | 287.0 | 322.2 | 178.4 |
| **2042** | 204.2 | 188.6 | 188.6 | 271.4 | 295.6 | 332.0 | 183.7 |
| **2043** | 210.3 | 194.1 | 194.1 | 279.2 | 304.2 | 341.8 | 189.0 |
| **2044** | 216.4 | 199.6 | 199.6 | 287.0 | 312.8 | 351.6 | 194.3 |
| **2045** | 222.5 | 205.1 | 205.1 | 294.8 | 321.4 | 361.4 | 199.6 |
| **2046** | 228.6 | 210.6 | 210.6 | 302.6 | 330.0 | 371.2 | 204.9 |
| **2047** | 234.7 | 216.1 | 216.1 | 310.4 | 338.6 | 381.0 | 210.2 |
| **2048** | 240.8 | 221.6 | 221.6 | 318.2 | 347.2 | 390.8 | 215.5 |
| **2049** | 246.9 | 227.1 | 227.1 | 326.0 | 355.8 | 400.6 | 220.8 |
| **2050** | 253.0 | 232.6 | 232.6 | 333.8 | 364.4 | 410.4 | 226.1 |

**S2.Number of Laboratories Performing Five Waste Minimization Practices (2015-2050)**

| **Year** | **SNM** | **CT** | **D** | **RSC** | **RS** | **PL** |
| --- | --- | --- | --- | --- | --- | --- |
| **2015** | 39.5 | 40.1 | 40.1 | 60.8 | 63.4 | 67.4 |
| **2016** | 45.6 | 45.6 | 45.6 | 68.6 | 72.0 | 77.2 |
| **2017** | 51.7 | 51.1 | 51.1 | 76.4 | 80.6 | 87.0 |
| **2018** | 57.8 | 56.6 | 56.6 | 84.2 | 89.2 | 96.8 |
| **2019** | 63.9 | 62.1 | 62.1 | 92.0 | 97.8 | 106.6 |
| **2020** | 70.0 | 67.6 | 67.6 | 99.8 | 106.4 | 116.4 |
| **2021** | 76.1 | 73.1 | 73.1 | 107.6 | 115.0 | 126.2 |
| **2022** | 82.2 | 78.6 | 78.6 | 115.4 | 123.6 | 136.0 |
| **2023** | 88.3 | 84.1 | 84.1 | 123.2 | 132.2 | 145.8 |
| **2024** | 94.4 | 89.6 | 89.6 | 131.0 | 140.8 | 155.6 |
| **2025** | 100.5 | 95.1 | 95.1 | 138.8 | 149.4 | 165.4 |
| **2026** | 106.6 | 100.6 | 100.6 | 146.6 | 158.0 | 175.2 |
| **2027** | 112.7 | 106.1 | 106.1 | 154.4 | 166.6 | 185.0 |
| **2028** | 118.8 | 111.6 | 111.6 | 162.2 | 175.2 | 194.8 |
| **2029** | 124.9 | 117.1 | 117.1 | 170.0 | 183.8 | 204.6 |
| **2030** | 131.0 | 122.6 | 122.6 | 177.8 | 192.4 | 214.4 |
| **2031** | 137.1 | 128.1 | 128.1 | 185.6 | 201.0 | 224.2 |
| **2032** | 143.2 | 133.6 | 133.6 | 193.4 | 209.6 | 234.0 |
| **2033** | 149.3 | 139.1 | 139.1 | 201.2 | 218.2 | 243.8 |
| **2034** | 155.4 | 144.6 | 144.6 | 209.0 | 226.8 | 253.6 |
| **2035** | 161.5 | 150.1 | 150.1 | 216.8 | 235.4 | 263.4 |
| **2036** | 167.6 | 155.6 | 155.6 | 224.6 | 244.0 | 273.2 |
| **2037** | 173.7 | 161.1 | 161.1 | 232.4 | 252.6 | 283.0 |
| **2038** | 179.8 | 166.6 | 166.6 | 240.2 | 261.2 | 292.8 |
| **2039** | 185.9 | 172.1 | 172.1 | 248.0 | 269.8 | 302.6 |
| **2040** | 192.0 | 177.6 | 177.6 | 255.8 | 278.4 | 312.4 |
| **2041** | 198.1 | 183.1 | 183.1 | 263.6 | 287.0 | 322.2 |
| **2042** | 204.2 | 188.6 | 188.6 | 271.4 | 295.6 | 332.0 |
| **2043** | 210.3 | 194.1 | 194.1 | 279.2 | 304.2 | 341.8 |
| **2044** | 216.4 | 199.6 | 199.6 | 287.0 | 312.8 | 351.6 |
| **2045** | 222.5 | 205.1 | 205.1 | 294.8 | 321.4 | 361.4 |
| **2046** | 228.6 | 210.6 | 210.6 | 302.6 | 330.0 | 371.2 |
| **2047** | 234.7 | 216.1 | 216.1 | 310.4 | 338.6 | 381.0 |
| **2048** | 240.8 | 221.6 | 221.6 | 318.2 | 347.2 | 390.8 |
| **2049** | 246.9 | 227.1 | 227.1 | 326.0 | 355.8 | 400.6 |
| **2050** | 253.0 | 232.6 | 232.6 | 333.8 | 364.4 | 410.4 |

**S3.Annual Percentage Variation for Six Waste Minimization Practices (2015-2050)**

| **Year** | **SNM (%)** | **CT (%)** | **D (%)** | **RSC (%)** | **RS (%)** | **PL (%)** |
| --- | --- | --- | --- | --- | --- | --- |
| **2015** | 19.7 | 21.5 | 21.5 | 16.9 | 24.3 | 22.5 |
| **2016** | 15.4 | 13.7 | 13.7 | 12.8 | 13.6 | 14.5 |
| **2017** | 13.4 | 12.1 | 12.1 | 11.4 | 11.9 | 12.7 |
| **2018** | 11.8 | 10.8 | 10.8 | 10.2 | 10.7 | 11.3 |
| **2019** | 10.6 | 9.7 | 9.7 | 9.3 | 9.6 | 10.1 |
| **2020** | 9.5 | 8.9 | 8.9 | 8.5 | 8.8 | 9.2 |
| **2021** | 8.7 | 8.1 | 8.1 | 7.8 | 8.1 | 8.4 |
| **2022** | 8.0 | 7.5 | 7.5 | 7.2 | 7.5 | 7.8 |
| **2023** | 7.4 | 7.0 | 7.0 | 6.8 | 7.0 | 7.2 |
| **2024** | 6.9 | 6.5 | 6.5 | 6.3 | 6.5 | 6.7 |
| **2025** | 6.5 | 6.1 | 6.1 | 6.0 | 6.1 | 6.3 |
| **2026** | 6.1 | 5.8 | 5.8 | 5.6 | 5.8 | 5.9 |
| **2027** | 5.7 | 5.5 | 5.5 | 5.3 | 5.4 | 5.6 |
| **2028** | 5.4 | 5.2 | 5.2 | 5.1 | 5.2 | 5.3 |
| **2029** | 5.1 | 4.9 | 4.9 | 4.8 | 4.9 | 5.0 |
| **2030** | 4.9 | 4.7 | 4.7 | 4.6 | 4.7 | 4.8 |
| **2031** | 4.7 | 4.5 | 4.5 | 4.4 | 4.5 | 4.6 |
| **2032** | 4.4 | 4.3 | 4.3 | 4.2 | 4.3 | 4.4 |
| **2033** | 4.3 | 4.1 | 4.1 | 4.0 | 4.1 | 4.2 |
| **2034** | 4.1 | 4.0 | 4.0 | 3.9 | 3.9 | 4.0 |
| **2035** | 3.9 | 3.8 | 3.8 | 3.7 | 3.8 | 3.9 |
| **2036** | 3.8 | 3.7 | 3.7 | 3.6 | 3.7 | 3.7 |
| **2037** | 3.6 | 3.5 | 3.5 | 3.5 | 3.5 | 3.6 |
| **2038** | 3.5 | 3.4 | 3.4 | 3.4 | 3.4 | 3.5 |
| **2039** | 3.4 | 3.3 | 3.3 | 3.2 | 3.3 | 3.3 |
| **2040** | 3.3 | 3.2 | 3.2 | 3.1 | 3.2 | 3.2 |
| **2041** | 3.2 | 3.1 | 3.1 | 3.0 | 3.1 | 3.1 |
| **2042** | 3.1 | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 |
| **2043** | 3.0 | 2.9 | 2.9 | 2.9 | 2.9 | 3.0 |
| **2044** | 2.9 | 2.8 | 2.8 | 2.8 | 2.8 | 2.9 |
| **2045** | 2.8 | 2.8 | 2.8 | 2.7 | 2.7 | 2.8 |
| **2046** | 2.7 | 2.7 | 2.7 | 2.6 | 2.7 | 2.7 |
| **2047** | 2.7 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 |
| **2048** | 2.6 | 2.5 | 2.5 | 2.5 | 2.5 | 2.6 |
| **2049** | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| **2050** | 2.5 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 |

**S4.Annual Percentage Variation for Five Waste Minimization Practices (2015-2050)**

| **Year** | **SNM (%)** | **CT (%)** | **D (%)** | **RSC (%)** | **RS (%)** | **PL (%)** |
| --- | --- | --- | --- | --- | --- | --- |
| **2016** | **15.44** | **13.88** | **13.88** | **12.86** | **13.49** | **14.56** |
| **2017** | **13.38** | **11.95** | **11.95** | **11.31** | **11.86** | **12.48** |
| **2018** | **11.67** | **10.74** | **10.74** | **10.21** | **10.66** | **11.25** |
| **2019** | **10.57** | **9.63** | **9.63** | **8.71** | **8.83** | **10.02** |
| **2020** | **9.67** | **8.85** | **8.85** | **8.54** | **8.79** | **9.17** |
| **2021** | **8.78** | **8.06** | **8.06** | **7.84** | **7.99** | **8.55** |
| **2022** | **8.12** | **7.61** | **7.61** | **7.23** | **7.52** | **7.74** |
| **2023** | **7.56** | **7.01** | **7.01** | **6.82** | **6.93** | **6.88** |
| **2024** | **6.60** | **6.64** | **6.64** | **6.45** | **6.60** | **6.71** |
| **2025** | **6.37** | **5.99** | **5.99** | **5.82** | **5.91** | **5.94** |
| **2026** | **5.87** | **5.70** | **5.70** | **5.58** | **5.77** | **5.77** |
| **2027** | **5.70** | **5.27** | **5.27** | **5.23** | **5.08** | **5.51** |
| **2028** | **5.39** | **5.23** | **5.23** | **5.17** | **5.16** | **5.35** |
| **2029** | **5.22** | **5.00** | **5.00** | **4.74** | **4.83** | **5.18** |
| **2030** | **5.38** | **4.77** | **4.77** | **4.45** | **4.85** | **5.11** |
| **2031** | **5.22** | **4.69** | **4.69** | **4.44** | **4.61** | **4.76** |
| **2032** | **5.21** | **4.49** | **4.49** | **4.29** | **4.48** | **4.47** |
| **2033** | **5.13** | **4.48** | **4.48** | **4.27** | **4.25** | **4.09** |
| **2034** | **5.42** | **4.52** | **4.52** | **4.16** | **4.27** | **3.72** |
| **2035** | **5.00** | **4.55** | **4.55** | **4.10** | **3.75** | **3.58** |
| **2036** | **5.24** | **4.59** | **4.59** | **3.82** | **3.57** | **3.32** |
| **2037** | **4.86** | **4.64** | **4.64** | **3.98** | **3.37** | **3.09** |
| **2038** | **4.53** | **4.69** | **4.69** | **3.65** | **3.21** | **2.95** |
| **2039** | **4.62** | **4.55** | **4.55** | **3.52** | **3.15** | **2.90** |
| **2040** | **4.47** | **4.53** | **4.53** | **3.58** | **3.07** | **2.86** |
| **2041** | **4.44** | **4.41** | **4.41** | **3.61** | **2.95** | **2.76** |
| **2042** | **4.46** | **4.31** | **4.31** | **3.63** | **2.92** | **2.71** |
| **2043** | **4.30** | **4.27** | **4.27** | **3.62** | **2.84** | **2.68** |
| **2044** | **4.29** | **4.18** | **4.18** | **3.55** | **2.77** | **2.68** |
| **2045** | **4.24** | **4.14** | **4.14** | **3.50** | **2.72** | **2.62** |
| **2046** | **4.25** | **4.10** | **4.10** | **3.48** | **2.69** | **2.60** |
| **2047** | **4.23** | **4.09** | **4.09** | **3.48** | **2.67** | **2.60** |
| **2048** | **4.09** | **4.05** | **4.05** | **3.44** | **2.63** | **2.58** |
| **2049** | **4.01** | **4.02** | **4.02** | **3.37** | **2.57** | **2.56** |
| **2050** | **3.95** | **4.02** | **4.02** | **3.35** | **2.53** | **2.53** |

**S6: Waste Management Innovation Index Table**

| **Country** | **Technological Advancements** | **Policy Innovation** | **Public Engagement** | **Infrastructure Development** | **Sustainability Impact** | **Overall Index Score** |
| --- | --- | --- | --- | --- | --- | --- |
| **Germany** | **High: Advanced WtE facilities, extensive recycling technologies.** | **High: Strong regulations, Pfand system for containers, Green Dot system.** | **High: High public involvement, effective waste separation practices ingrained in daily life.** | **High: Comprehensive infrastructure for recycling, WtE, and landfill management.** | **High: Leading sustainability outcomes, significant reduction in landfill use, high recycling rate (67%).** | **9/10** |
| **United States** | **Moderate: Variability in technological adoption across states, limited WtE use.** | **Moderate: Mixed policy landscape with strong state-level variations, EPR in some areas.** | **Moderate: Public engagement varies significantly by region, with strong recycling culture in some states and weak participation in others.** | **Moderate: Developed infrastructure, but significant state-level disparities in recycling and waste management capabilities.** | **Moderate: Mixed sustainability outcomes due to high landfill dependency and uneven adoption of advanced practices, recycling rate of 21%.** | **6/10** |
| **Japan** | **High: Advanced waste sorting and incineration technologies, focus on reducing landfill use.** | **High: Robust policy frameworks, 3R (Reduce, Reuse, Recycle) initiative, strict waste separation laws.** | **High: Strong cultural norms around meticulous waste sorting, high public participation in recycling.** | **Moderate: Strong incineration infrastructure, but limited space for landfills and recycling facilities.** | **Moderate: High incineration rates with some sustainability concerns, but effective waste management with a recycling rate of 19.6%.** | **8/10** |
| **Brazil** | **Low: Limited adoption of advanced technologies, reliance on informal sector for recycling.** | **Low: Weak policy enforcement, limited formal infrastructure, heavy reliance on informal waste pickers.** | **Low: Low public engagement, with most recycling driven by the informal sector, and limited government-led initiatives.** | **Low: Inadequate infrastructure, especially in rural areas, leading to significant environmental issues like open dumps.** | **Low: Poor sustainability outcomes with a recycling rate of 4%, significant challenges in waste management and environmental health.** | **3/10** |
| **South Korea** | **High: Advanced waste sorting systems, extensive use of WtE technologies.** | **High: Strong policy support, pay-as-you-throw (PAYT) system, rigorous enforcement of recycling regulations.** | **High: High public involvement, strong cultural norms around waste reduction and recycling.** | **High: Well-developed infrastructure with a focus on minimizing landfill use, comprehensive recycling facilities.** | **High: Significant sustainability outcomes, high recycling rate of 69%, and reduced landfill dependency.** | **9/10** |
| **Sweden** | **High: High integration of WtE technologies, focus on reducing landfill use to near zero.** | **High: Progressive policies encouraging recycling, strong enforcement of environmental regulations.** | **High: Strong public engagement, with a cultural focus on sustainability and recycling as a norm.** | **High: Advanced infrastructure with extensive WtE facilities and well-established recycling systems.** | **High: Exceptional sustainability outcomes, recycling rate of 50%, minimal landfill use, and significant contributions to renewable energy.** | **9/10** |
| **Costa Rica** | **Low: Emerging composting and recycling initiatives, minimal adoption of WtE technologies.** | **Moderate: Strong legal framework with the Law for Integrated Waste Management, but challenges in enforcement and practical implementation.** | **Moderate: Growing public awareness and participation in recycling efforts, but infrastructure limitations hinder effectiveness.** | **Low: Inadequate infrastructure, with 93% of waste ending up in landfills, and limited selective collection programs.** | **Low: Recent efforts like the National Plan for Integrated Waste Management show potential, but effectiveness is yet to be seen; recycling rate at 7%.** | **4/10** |

**References:** Germany: Federal Ministry for the Environment, Nature Conservation, Nuclear Safety, and Consumer Protection (BMUV). (2023). *Waste management in Germany 2023: Facts, data, figures*. BMUV. Retrieved from [BMUV website](https://www.bmuv.de/en/publications).

Eighmy, T. T., & Kosson, D. S. (1996). *U.S.A. National overview on waste management*. Waste Management, 16(5-6), 361-366. <https://doi.org/10.1016/S0956-053X(96)00080-3>

Lino, F. A. M., Ismail, K. A. R., & Castañeda-Ayarza, J. A. (2023). *Municipal solid waste treatment in Brazil: A comprehensive review*. Energy Nexus, 11, 100232.<https://doi.org/10.1016/j.nexus.2023.100232>

Kwon, Y., Lee, S., Bae, J., Park, S., Moon, H., Lee, T., Kim, K., Kang, J., & Jeon, T. (2024). *Evaluation of incinerator performance and policy framework for effective waste management and energy recovery: A case study of South Korea*. Sustainability, 16(1), 448.<https://doi.org/10.3390/su16010448>

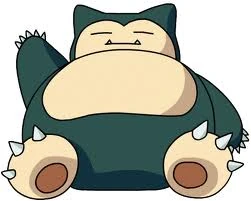
Sandhi, A., & Rosenlund, J. (2024). *Municipal solid waste management in Scandinavia and key factors for improved waste segregation: A review*. Cleaner Waste Systems, 8, 100144.<https://doi.org/10.1016/j.clwas.2024.100144>

**Arias**. (2024). **Challenges and opportunities in waste management: Perspectives from Costa Rica for the world recycling day**. Arias Knowledge Center. Retrieved from<https://ariasknowledgecenter.com>

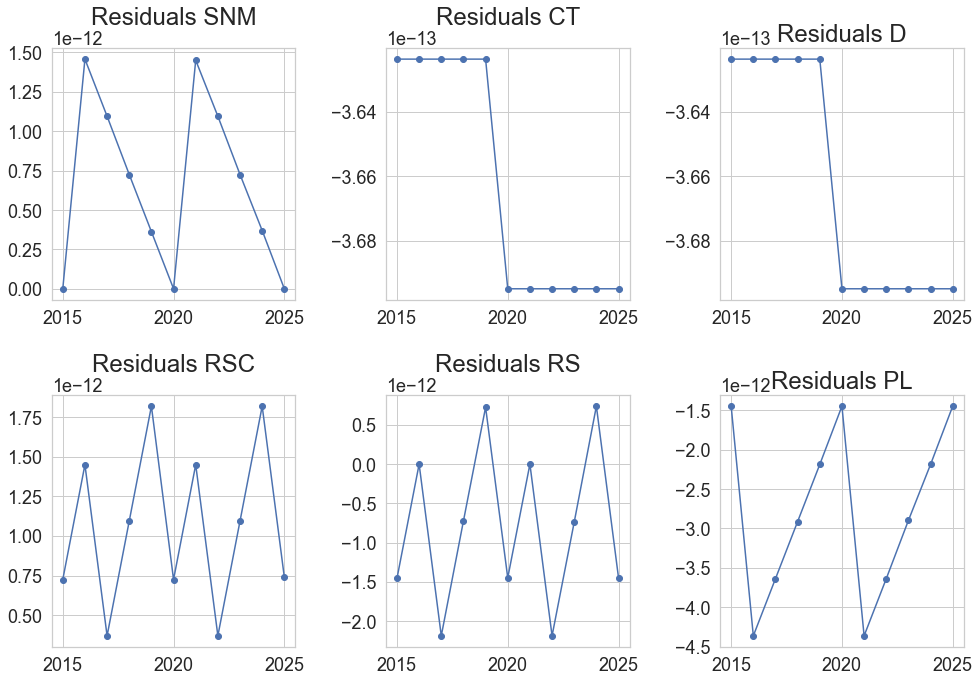
**ESTADO DE LA NACION**

**S7:Generación de Gases con efecto invernadero asociados al sector residuos sólidos  
 *(Miles de Toneladas CO2 e)***

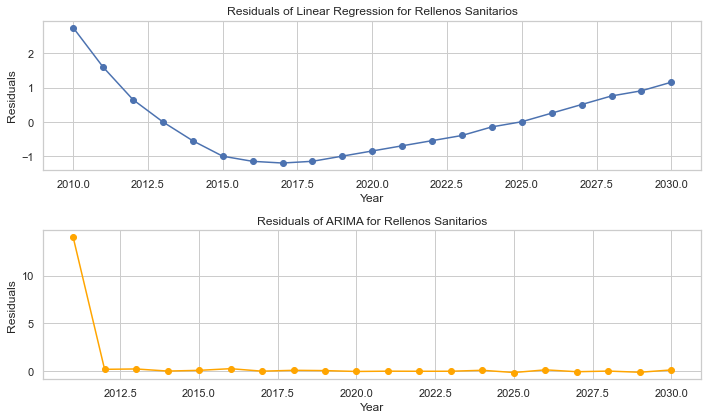
| **Año** | **Rellenos Sanitarios** | **Reciclaje** |
| --- | --- | --- |
| **2010** | **1.195,3** | **-17,5** |
| **2011** | **1.209,6** | **-17,7** |
| **2012** | **1.224,1** | **-17,9** |
| **2013** | **1.238,9** | **-18,1** |
| **2014** | **1.253,8** | **-18,4** |
| **2015** | **1.268,8** | **-18,6** |
| **2016** | **1.284,1** | **-18,8** |
| **2017** | **1.299,5** | **-19,0** |
| **2018** | **1.315,0** | **-19,2** |
| **2019** | **1.330,6** | **-19,4** |
| **2020** | **1.346,2** | **-19,6** |
| **2021** | **1.361,8** | **-19,8** |
| **2022** | **1.377,4** | **-20,0** |
| **2023** | **1.393,0** | **-20,2** |
| **2024** | **1.408,7** | **-20,4** |
| **2025** | **1.424,3** | **-20,6** |
| **2026** | **1.440,0** | **-20,8** |
| **2027** | **1.455,7** | **-21,0** |
| **2028** | **1.471,4** | **-21,2** |
| **2029** | **1.487,0** | **-21,4** |
| **2030** | **1.502,7** | **-21,6** |

**CONTINUES… **

**Supplementary Figure 1**.

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**Supplementary Figure 2**

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