Impacts of COVID-19 on Energy and Environmental Emissions in Various Parts of the World: the EU, Singapore and Russian Federation




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EUROPEAN UNION
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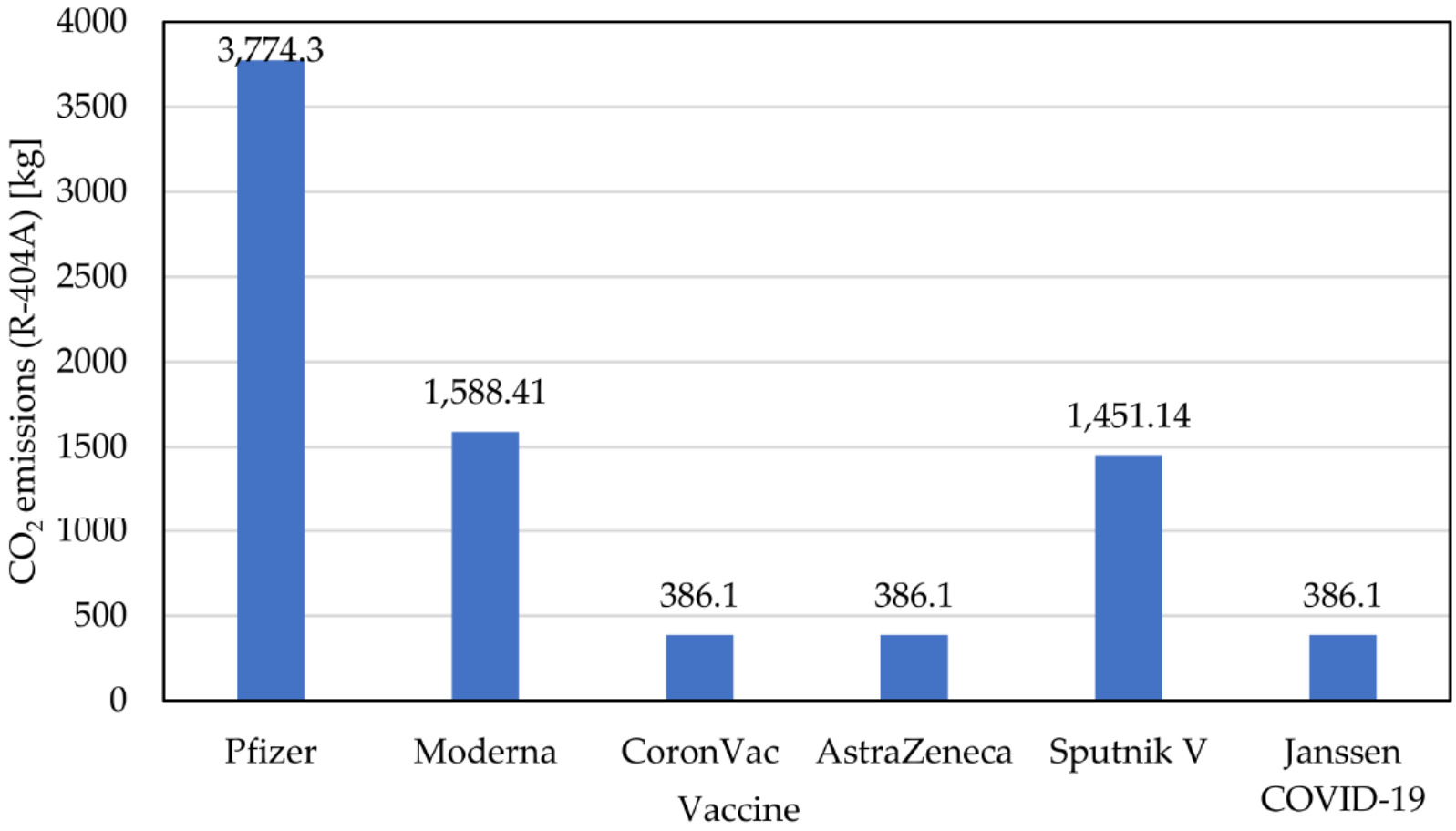
MINISTRY OF EDUCATION, YOUTH AND SPORTS

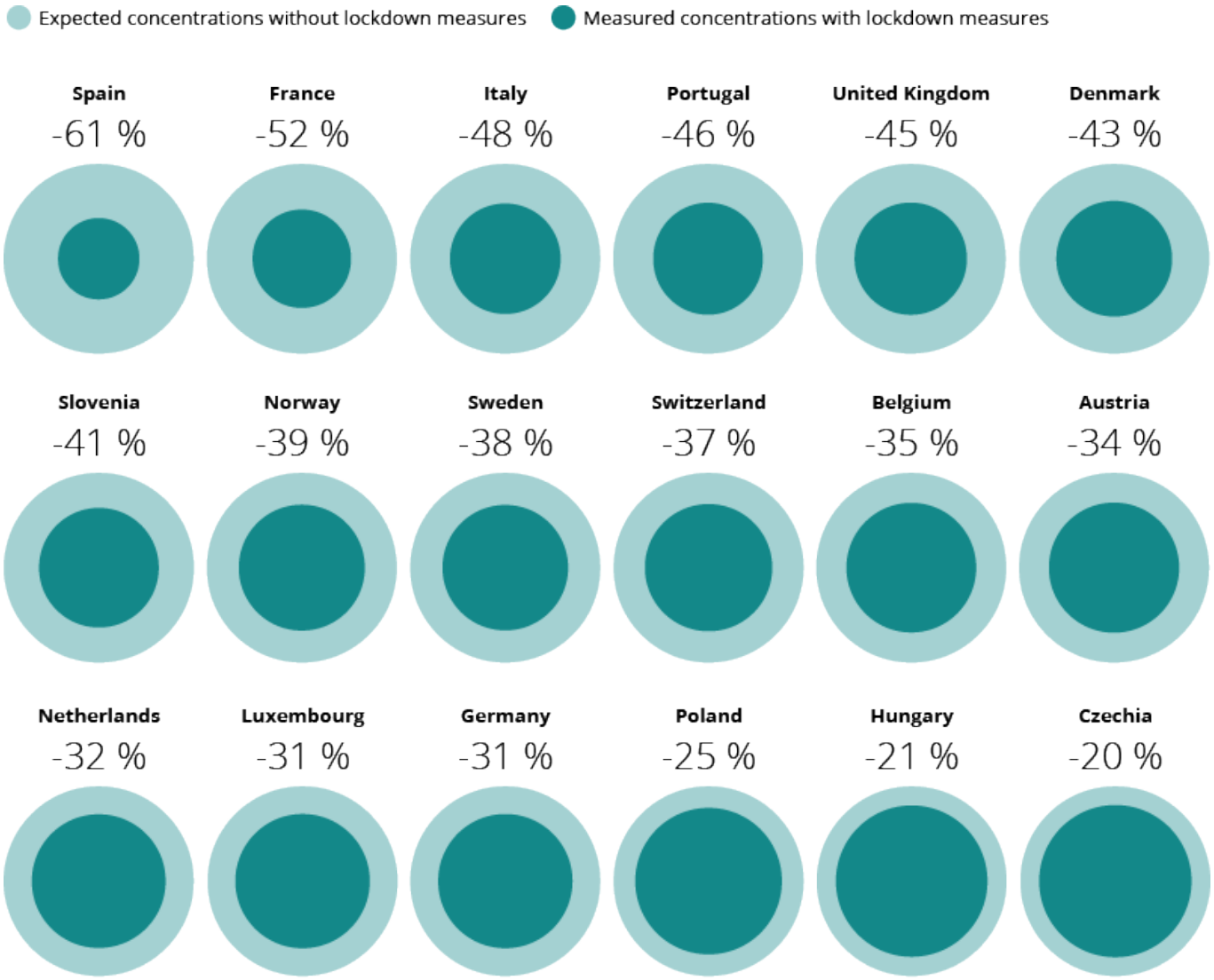
3rd International Scientific Conference «Sustainable and Efficient Use of Energy, Water and Natural Resources»,19-24 April 2021, St Petersburg, Russian Federation

CO_2 Emission of Vaccine – Refrigerant Load



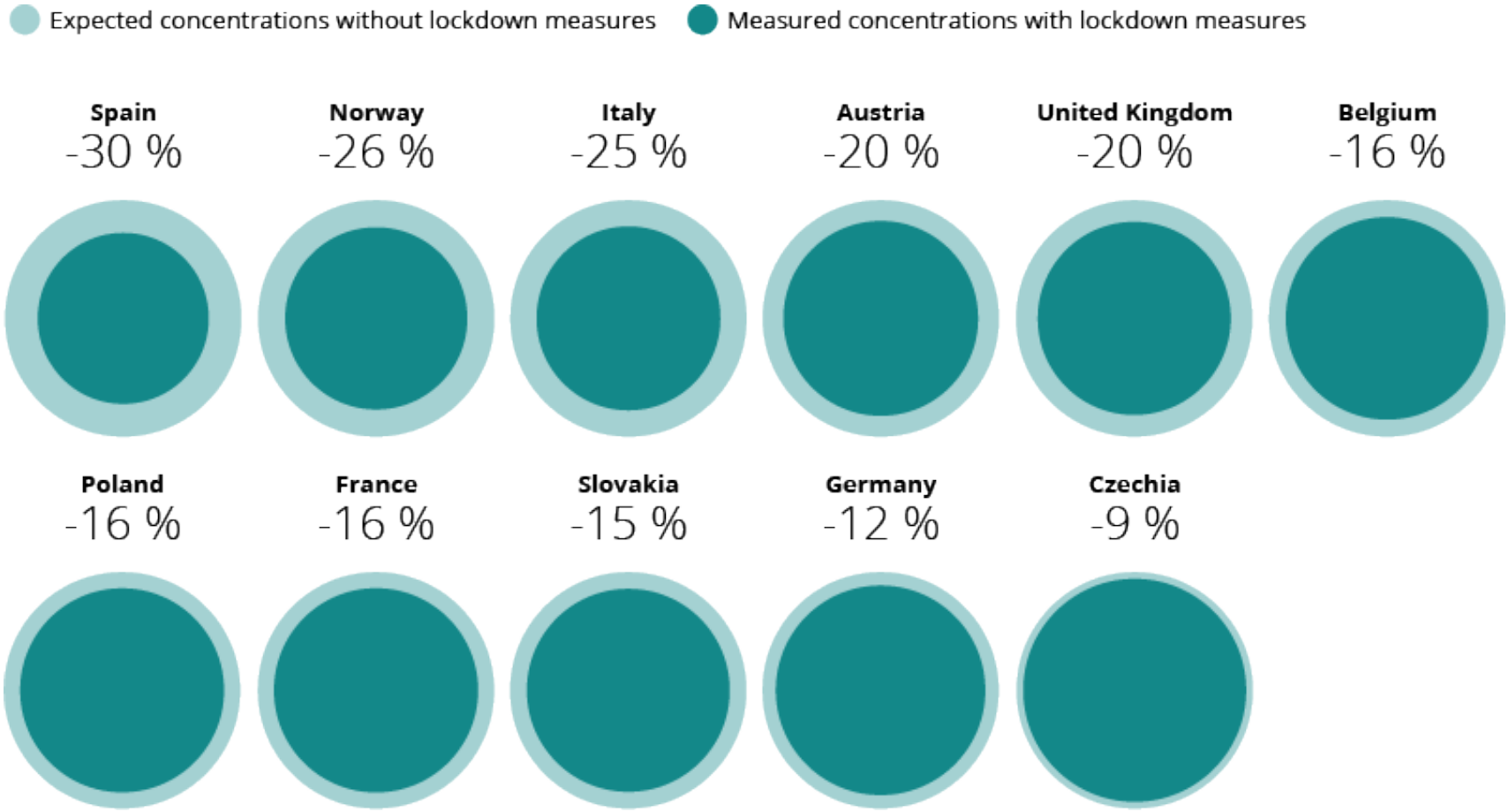
Santos, A. F., Gaspar, P. D., de Souza, H. J. (2021). Refrigeration of COVID-19 Vaccines: Ideal Storage Characteristics, Energy Efficiency and Environmental Impacts of Various Vaccine Options. Energies, 14(7), 1849.

Short-term Positive Impact - NO_2 in the EU



<www.eea.europa.eu/publications/covid-19-and-europe-s/covid-19-and-europes-environment>

Short-term Positive Impact - PM_{10} in the EU



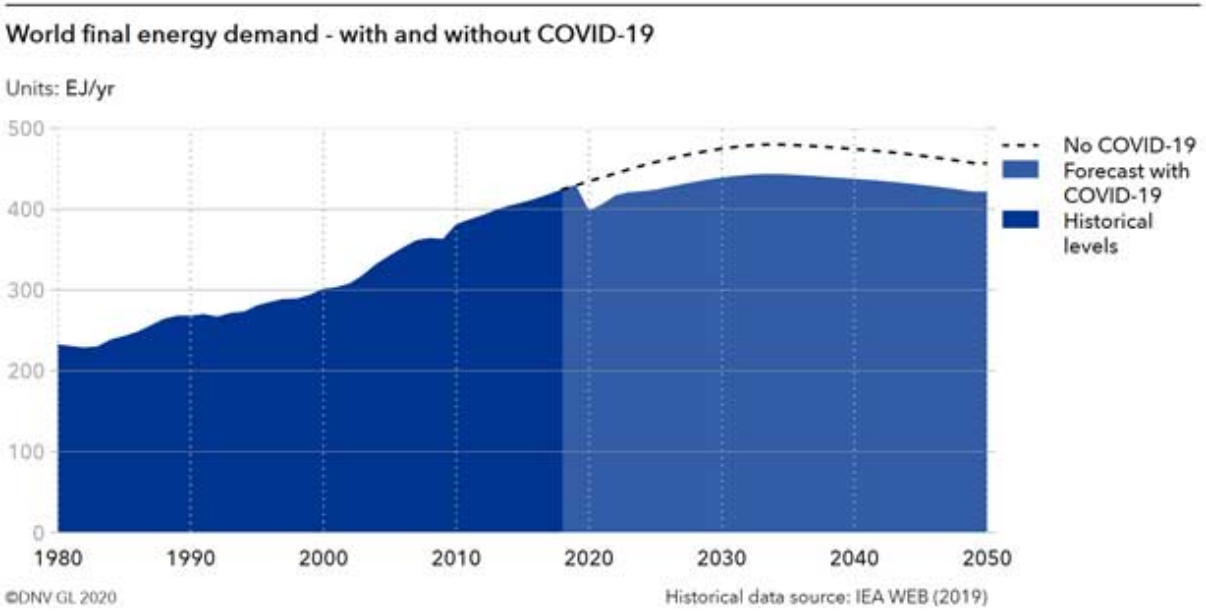
<www.eea.europa.eu/publications/covid-19-and-europe-s/covid-19-and-europes-environment>

Consumption and Resource Use

- The COVID-19 pandemic has caused significant changes in the production and consumption of plastics, and in plastic waste.
- Surge in global demand for personal protective equipment (PPE)
- Consumption of single-use plastic packaging and products
- Reduced economic activity has seen sharp falls in global oil prices. Significantly cheaper for manufacturers to produce plastic goods from virgin, fossil-based material than recycled plastic

https://www.eea.europa.eu/post-corona-planet/explore/#search-the-database

Energy Demand – Projection (Impacted by COVID-19)



Before the pandemic, prediction in 2050 = 456 exajoules (EJ)

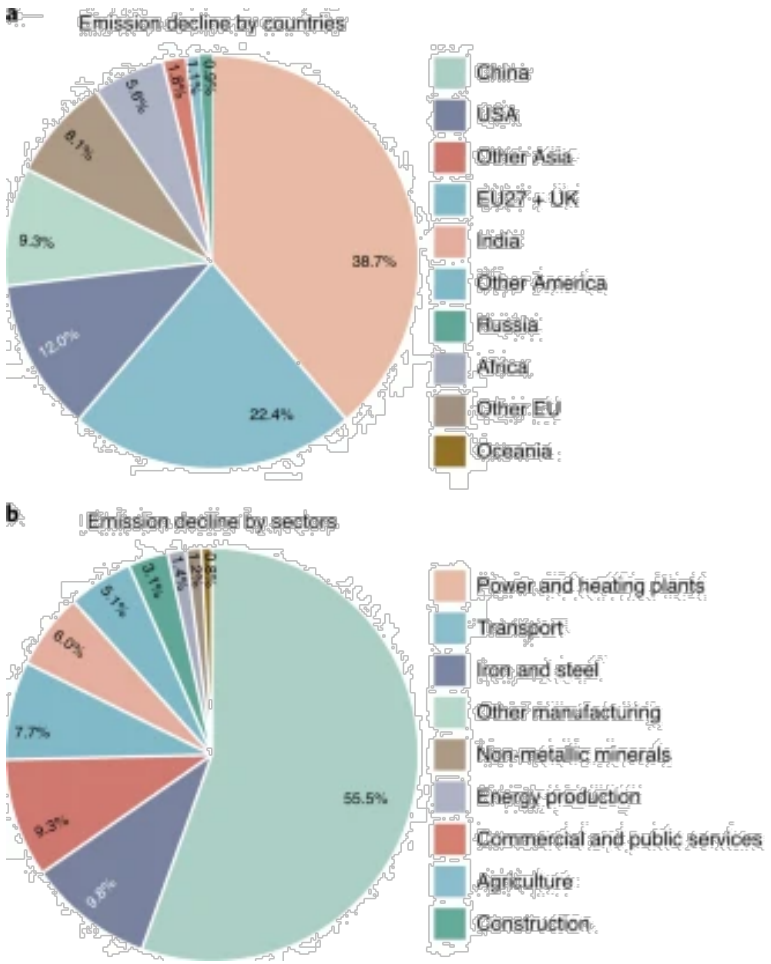
Now, pandemic will reduce energy demand through to 2050 by 8%, resulting in energy demand in 2050 at almost exactly the level it was in 2018.

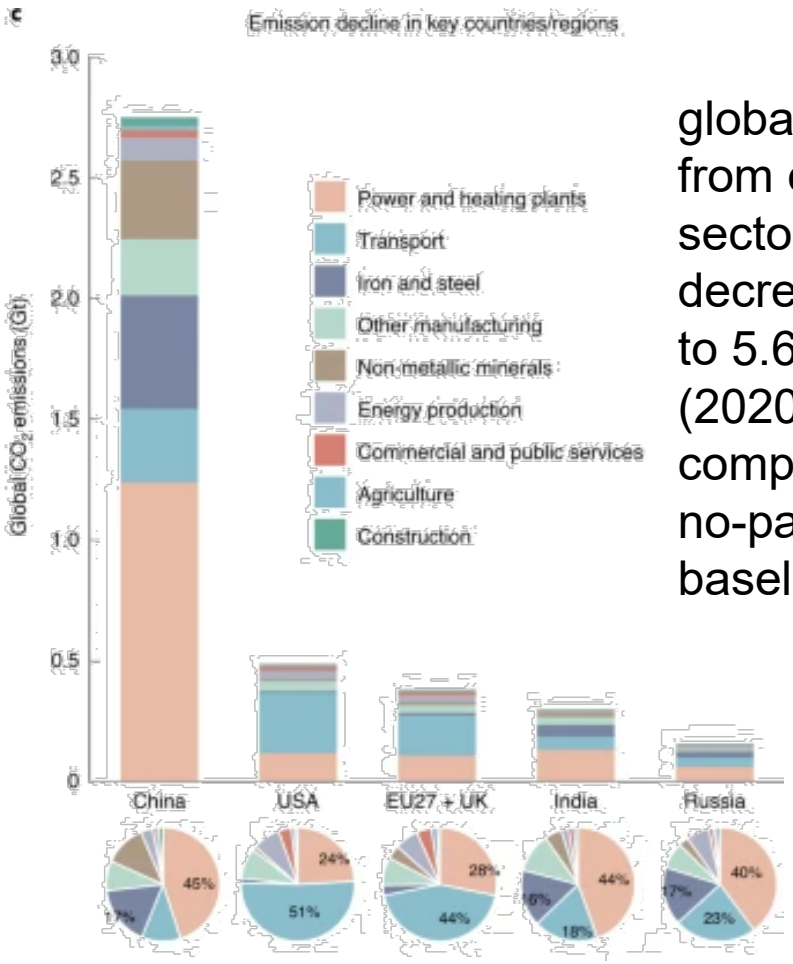
?

Improvements in energy intensity will remain the most important factor in reducing energy demand in the coming decades

<www.dnv.com/energy-transition/impact-of-covid19-on-the-energy-transition.html>

Impacts of COVID-19 on Global Emissions

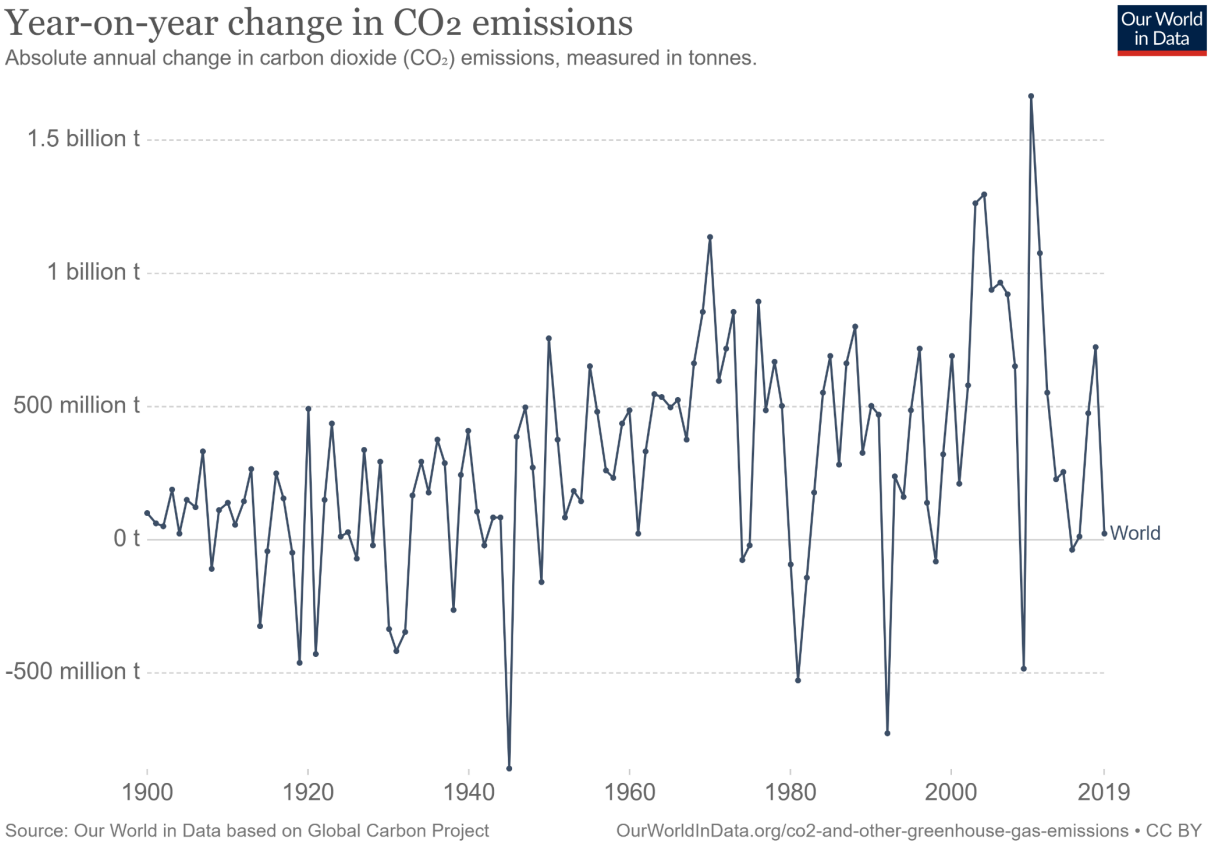




global emissions from economic sectors will decrease by 3.9 to 5.6% in 5 years (2020 to 2024) compared with a no-pandemic baseline scenario

Shan, Y., Ou, J., Wang, D., Zeng, Z., Zhang, S., Guan, D., Hubacek, K. (2020). Impacts of COVID-19 and fiscal stimuli on global emissions and the Paris Agreement. *Nature Climate Change*, 1-7.

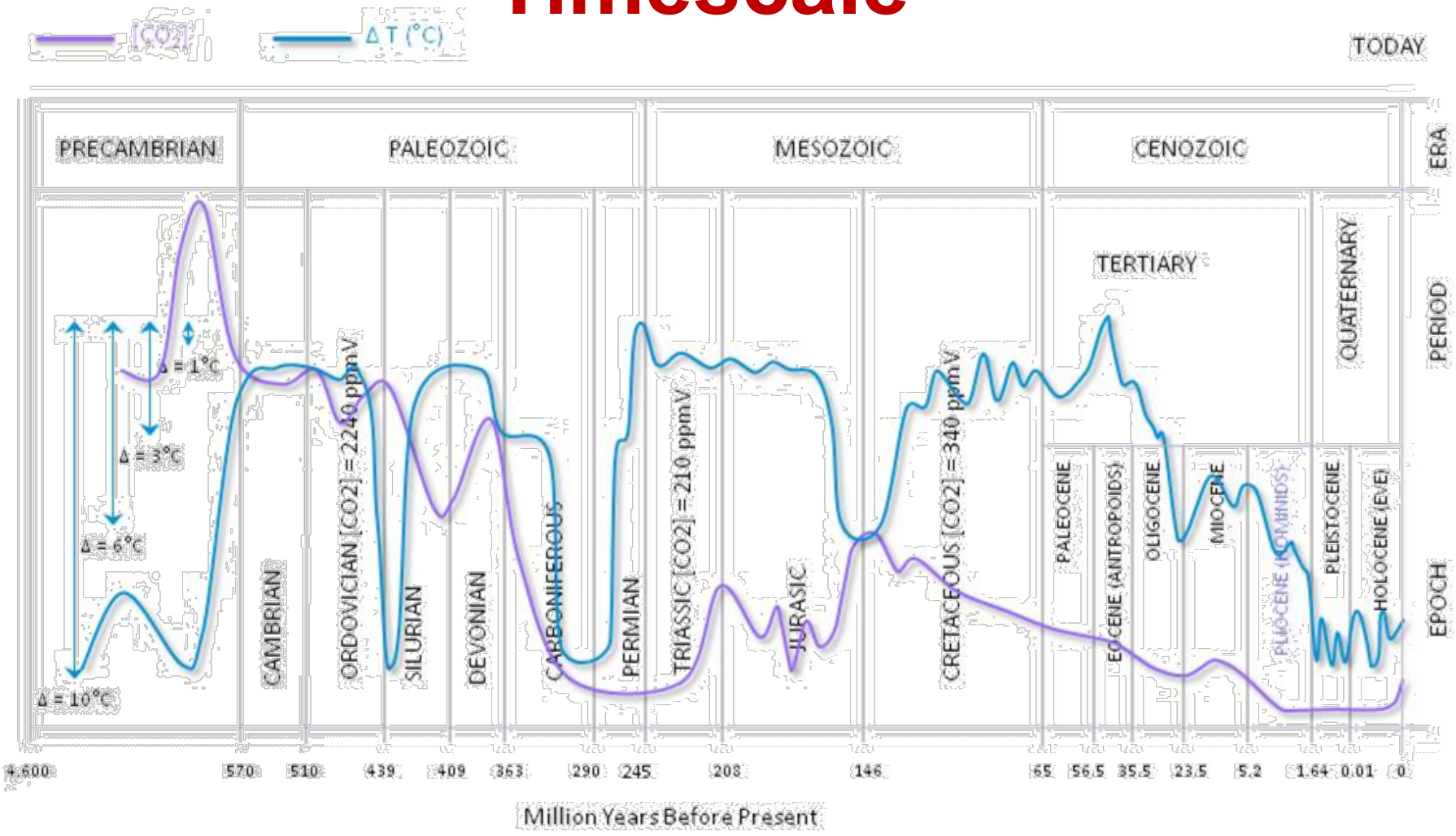
Changes in Carbon Dioxide



A positive figure in a given year indicates that emissions were higher than the previous year. A negative figure indicates they were lower than the year before.

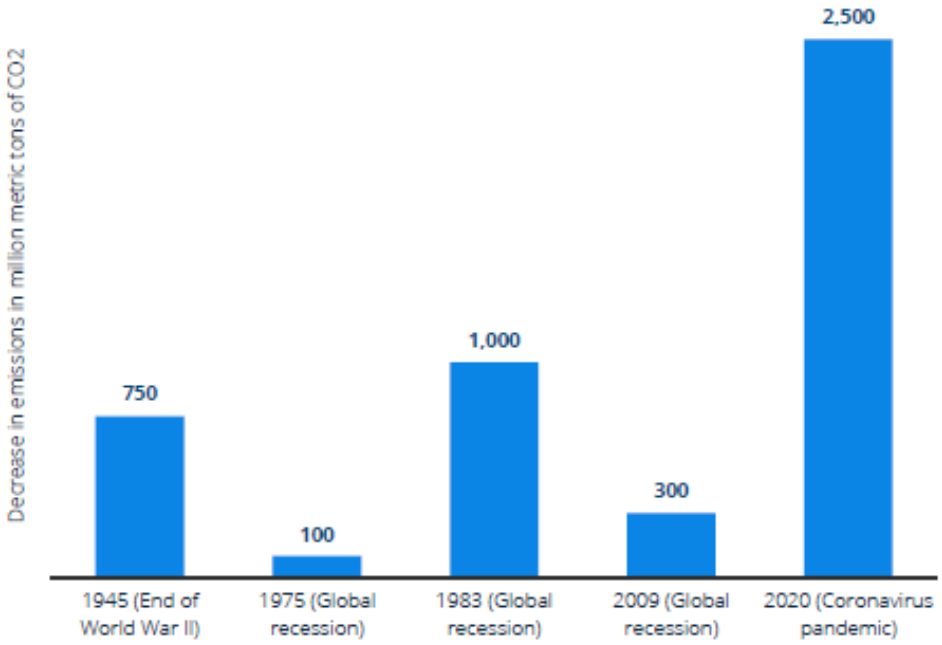
<ourworldindata.org/co2-emissions>

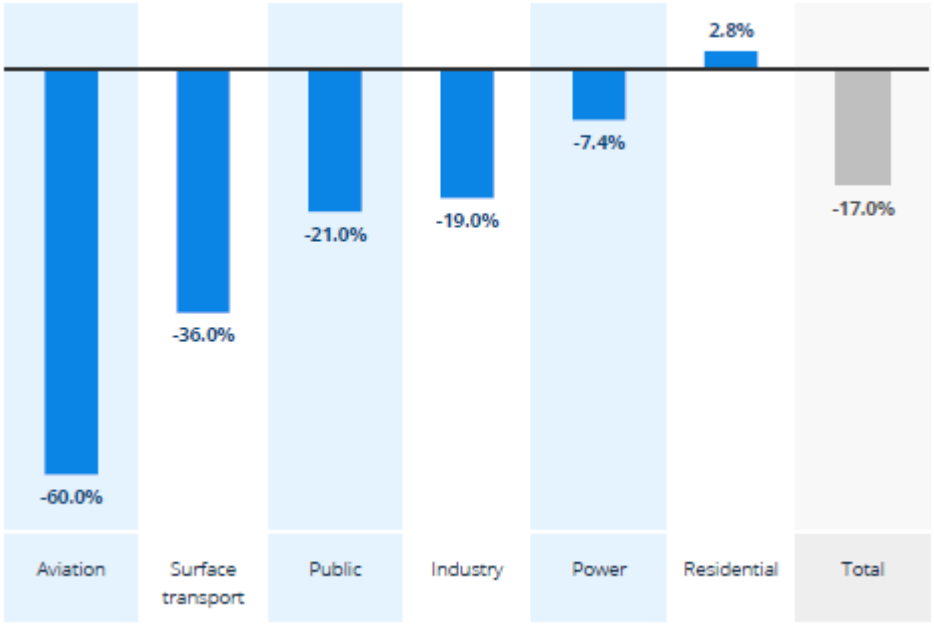
CO_2 and Temperature Fluctuations – Geological Timescale



Nasif Nahle. 2007. Cycles of Global Climate Change. Biology Cabinet Journal Online. Article no. 295.
http://www.biocab.org/Climate_Geologic_Timescale.html

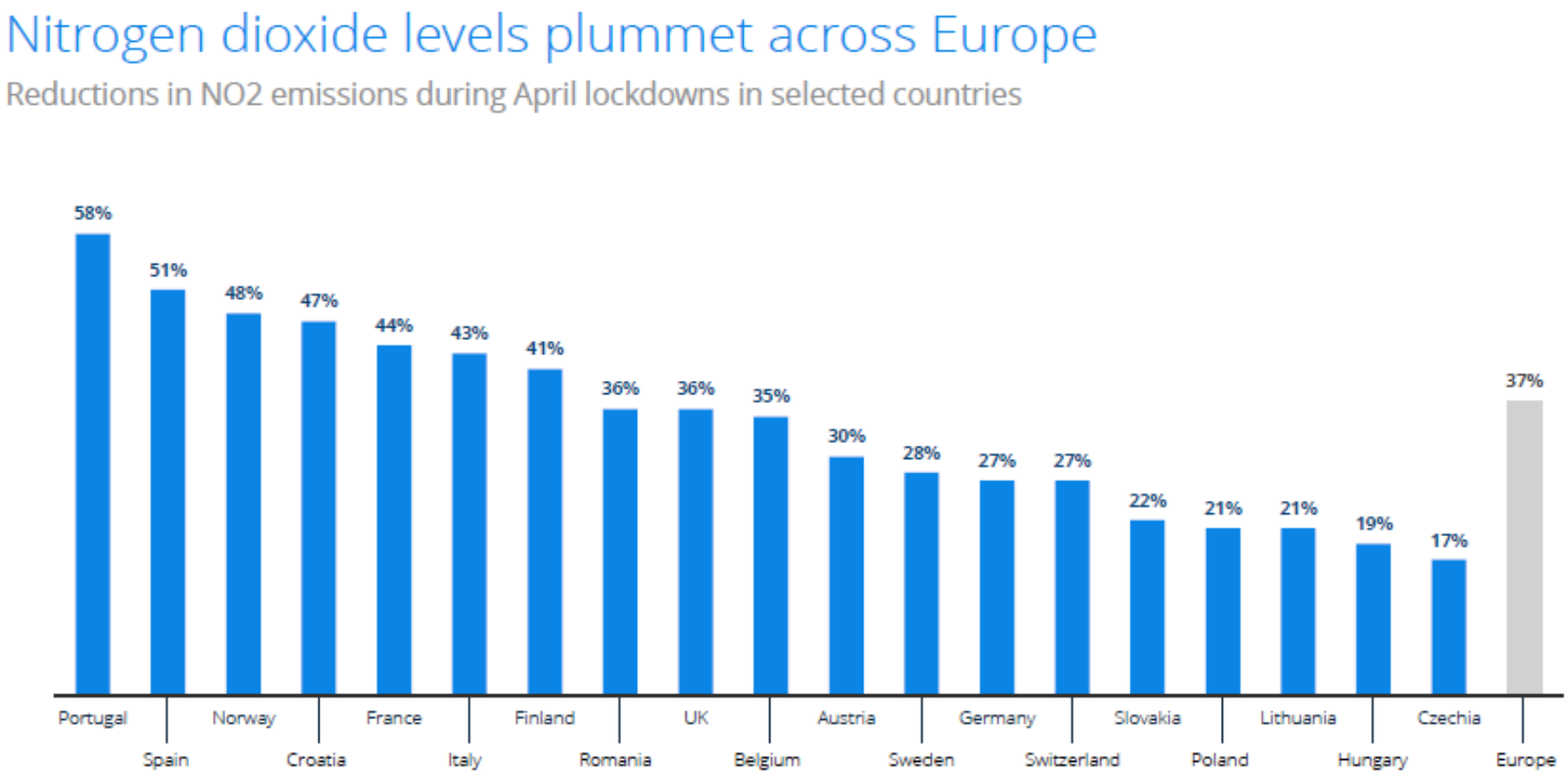
Impact of Travel Bans on CO_2 Emissions





<www.statista.com/study/79011/environmental-effects-of-covid-19/>

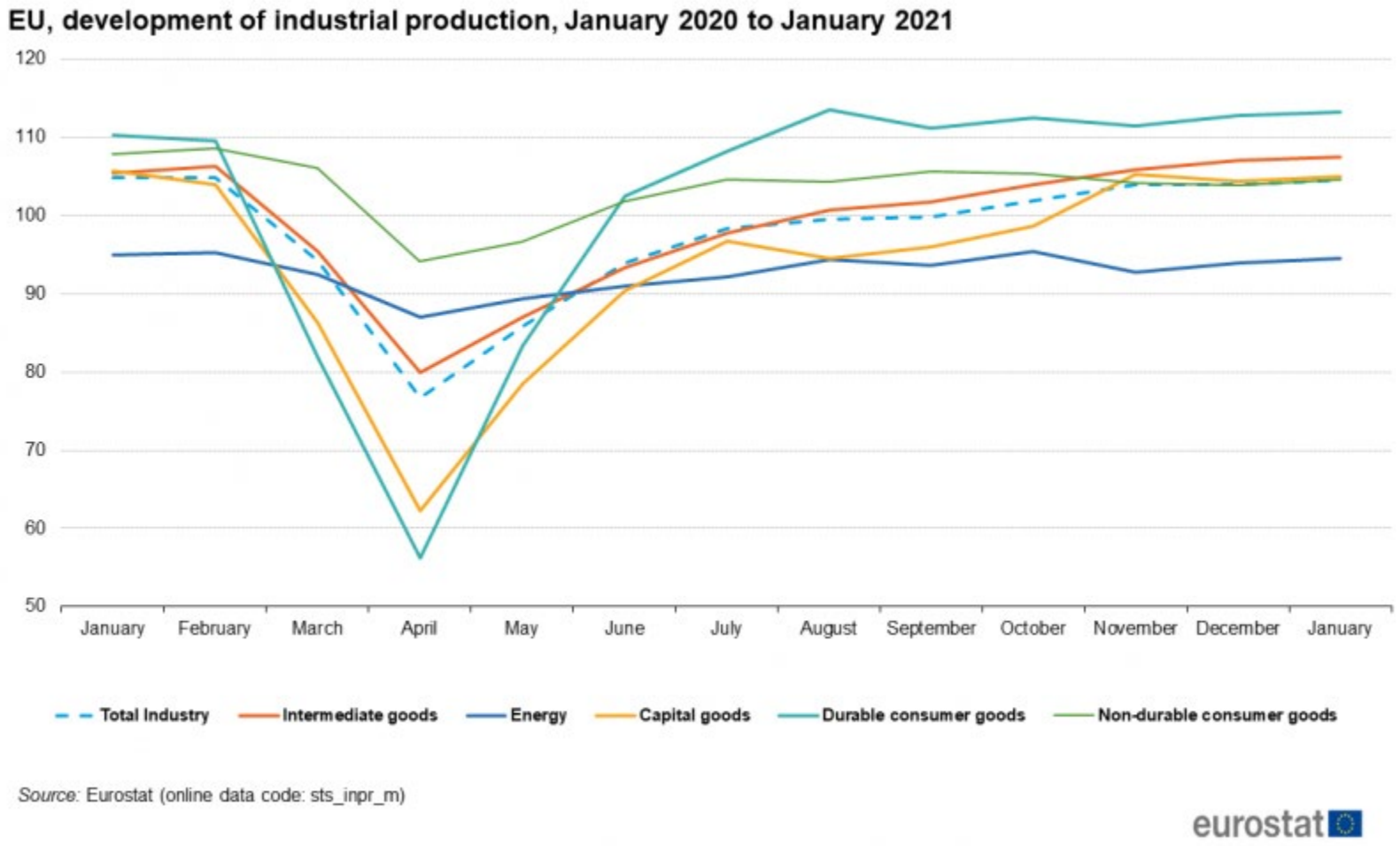
NO_2 across Europe (2020)



Temporary or….

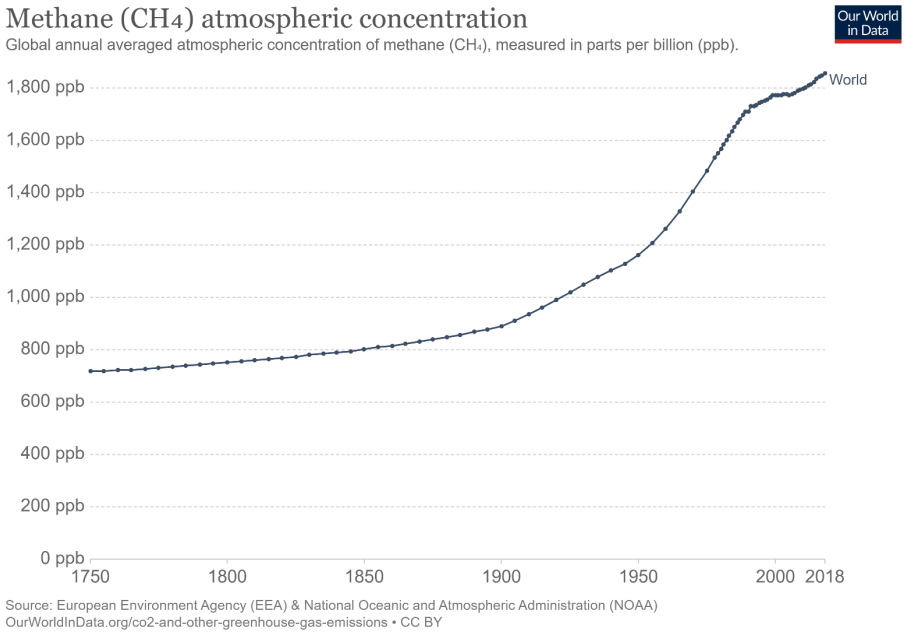
<www.statista.com/study/79011/environmental-effects-of-covid-19/>

Industrial Production (2020 vs 2021)

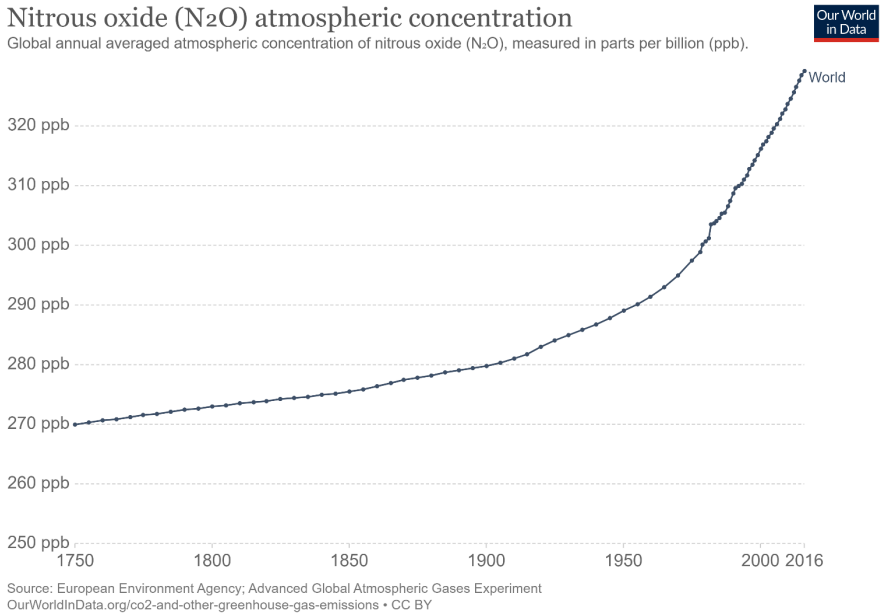


<ec.europa.eu/eurostat/statistics-explained/index.php/Impact_of_Covid-19_crisis_on_industrial_production>

CH_4 and N_2O Emission



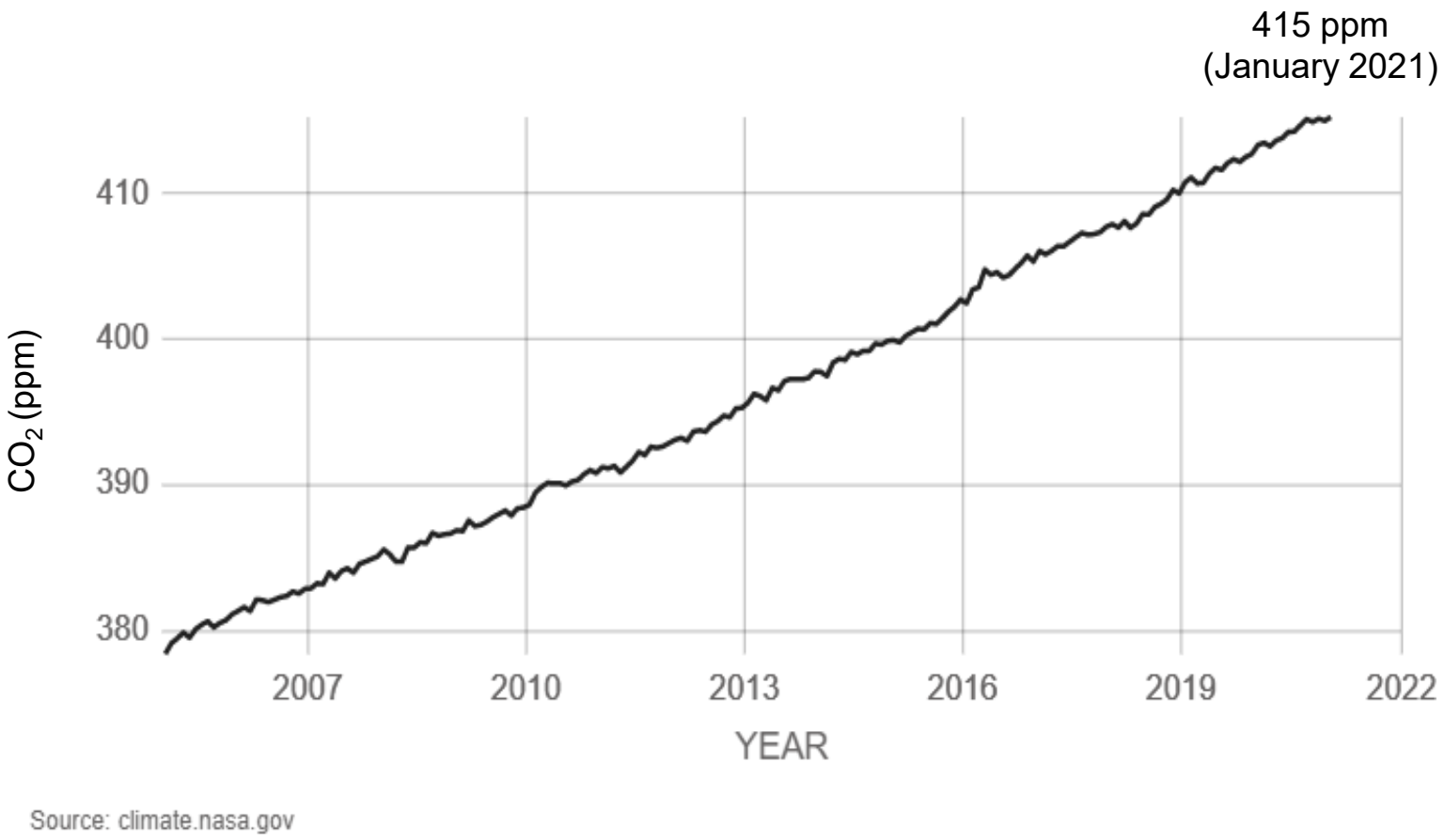
- from 1900 to the year 2000, atmospheric methane doubled – from around 900 to 1800 ppb.



- Concentrations increased significantly throughout the 20th century, and particularly sharply in the second half.
- Coincides with the rise of the use of nitrogenous fertilizers and large increases in global food production.

<ourworldindata.org/atmospheric-concentrations>

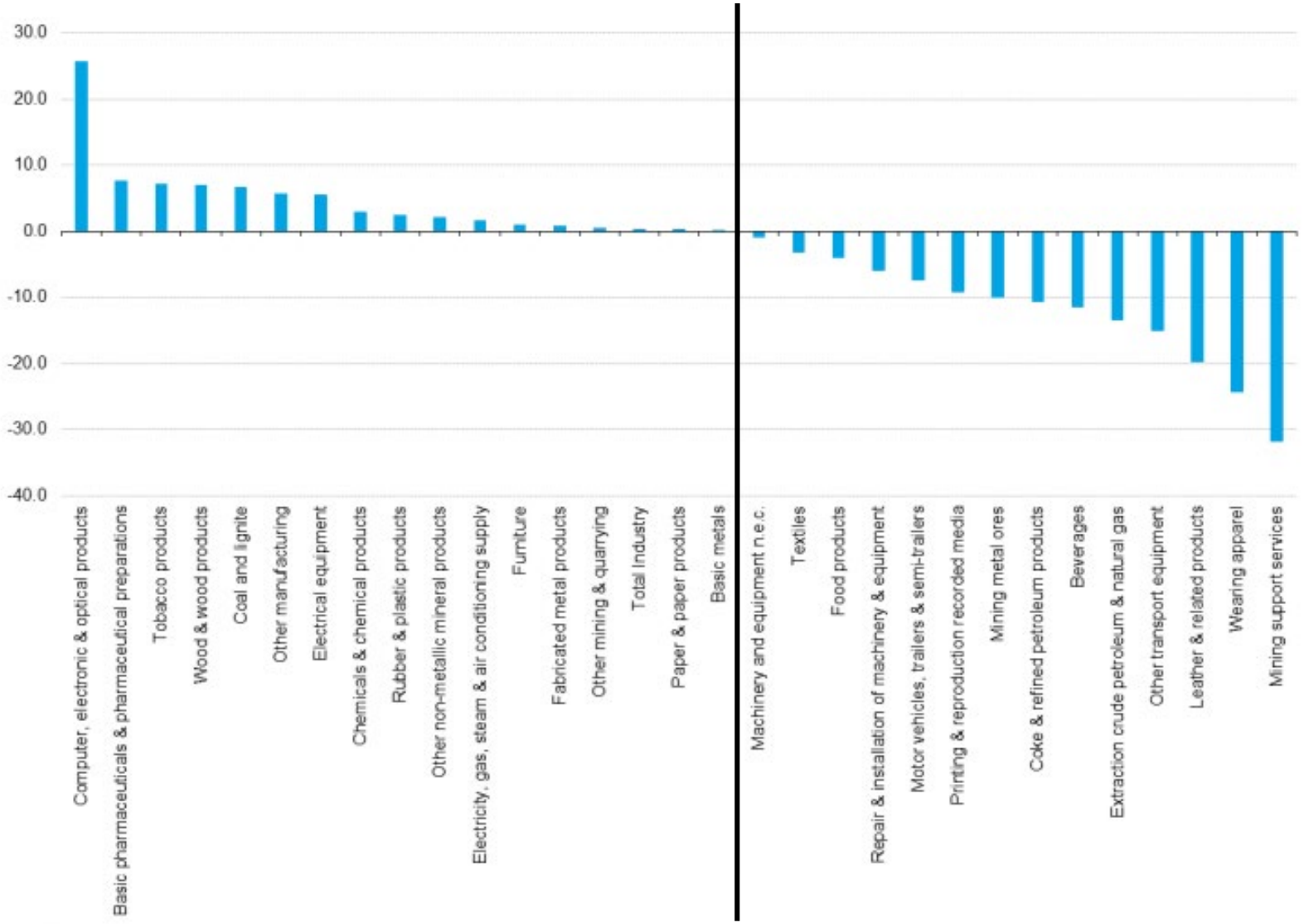
Concentration of Carbon Dioxide



Source: climate.nasa.gov

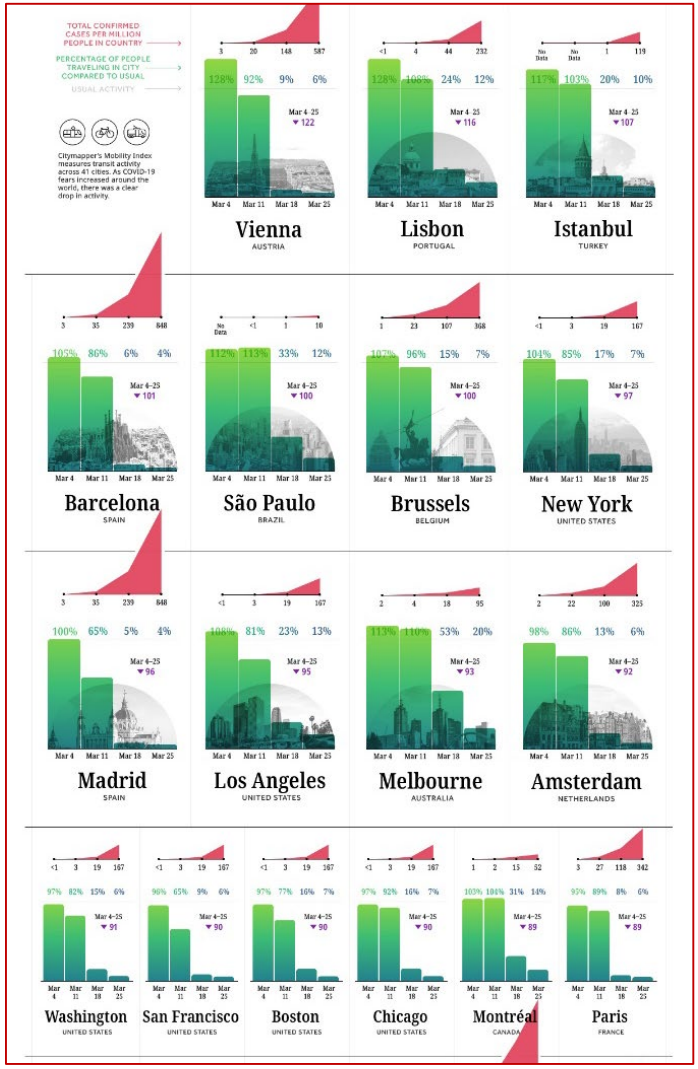
<climate.nasa.gov/vital-signs/carbon-dioxide/>

Growth Rates (2020 vs 2021)



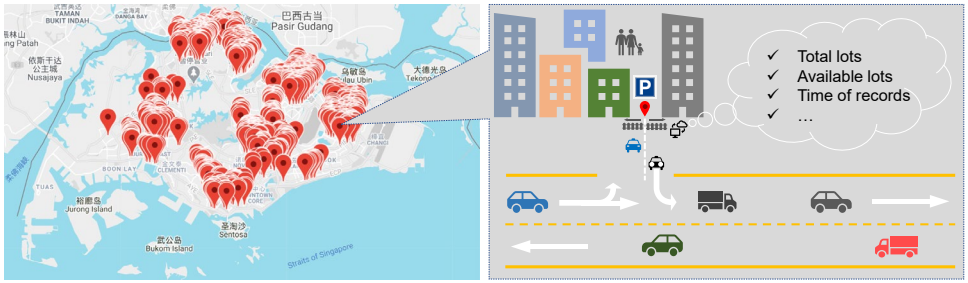
<ec.europa.eu/eurostat/statistics-explained/index.php/Impact_of_Covid-19_crisis_on_industrial_production>

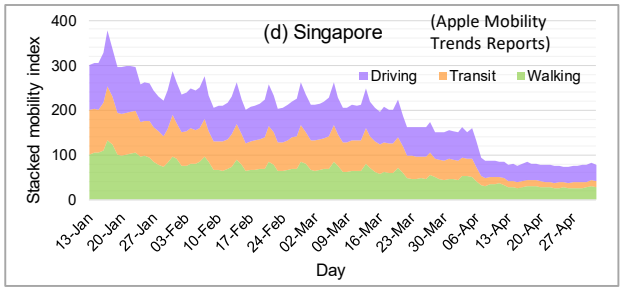
Global Mobility Changes Due to COVID-19



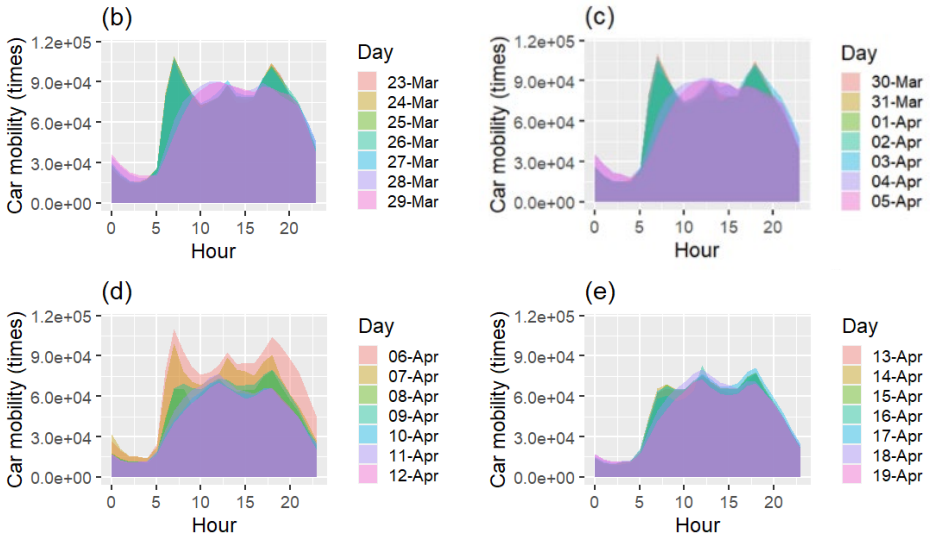
Ghosh, I., 2020. Global shutdown: Visualising commuter activity in the world's cities.

Big Data Analytics on COVID-19 Mitigation in Singapore





Approximate population mobility

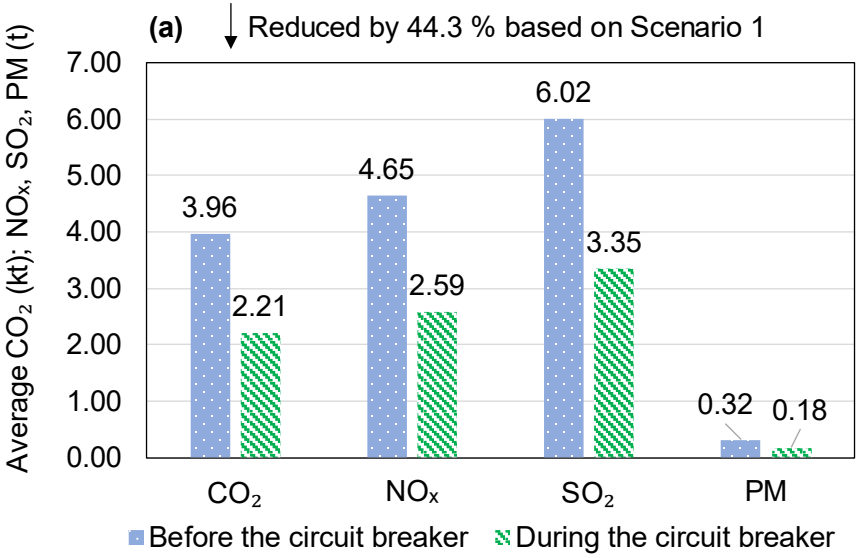


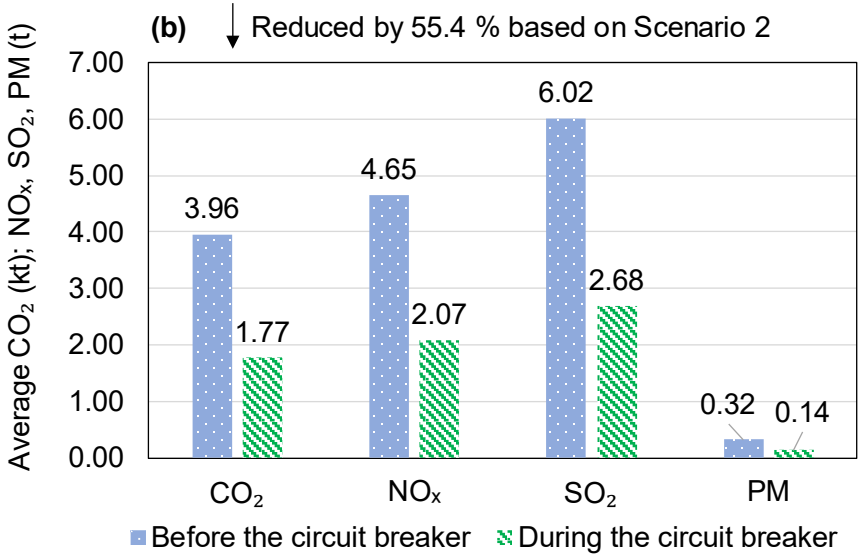
Changes of mobility patterns in Singapore

- ✓ Singapore has close to 1 M vehicle population;
- ✓ The 1,904 car parks are located in 31 regions in Singapore. The resident population in the 31 regions covers 99.3 % of Singapore;
- ✓ More than 3 M pieces of real-time data records (e.g. name, time of records, total lots and available lots) are saved every day.

Jiang, P., Fu, X., Fan, Y.V., Klemeš, J. J., Chen, P., Ma, S., Zhang, W., 2021. Spatial-temporal potential exposure risk analytics and urban sustainability impacts related to COVID-19 mitigation: A perspective from car mobility behaviour. *Journal of Cleaner Production*, 279, 123673.

Air Emissions Changes Based on Mobility in Singapore





The comparison of the transportation-related average air emissions estimation before and during the circuit breaker under (a) the 25.0 % (Scenario 1) and (b) the 40.0 % (Scenario 2) reduction in average distance travelled.

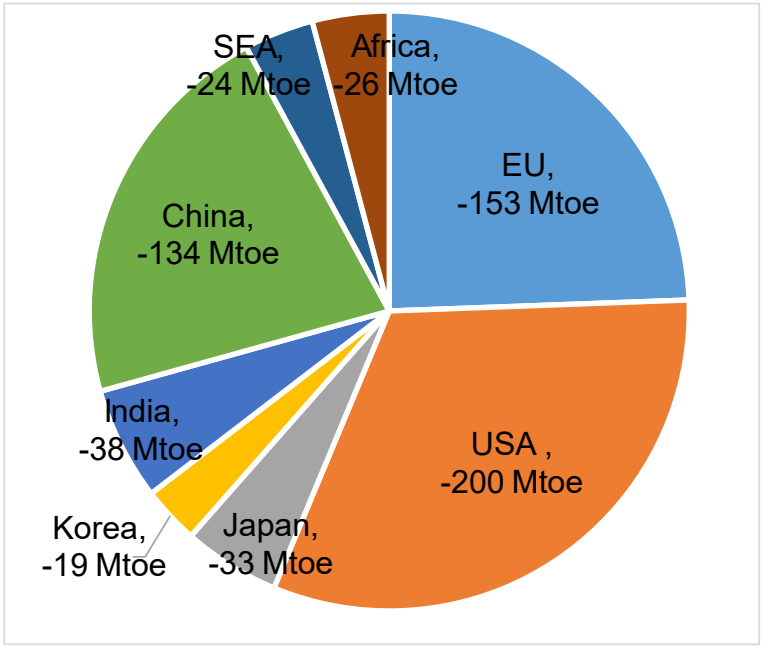
Jiang, P., Fu, X., Fan, Y.V., Klemeš, J. J., Chen, P., Ma, S., Zhang, W., 2021. Spatial-temporal potential exposure risk analytics and urban sustainability impacts related to COVID-19 mitigation: A perspective from car mobility behaviour. *Journal of Cleaner Production*, 279, 123673.

Vaccination in Russian Federation

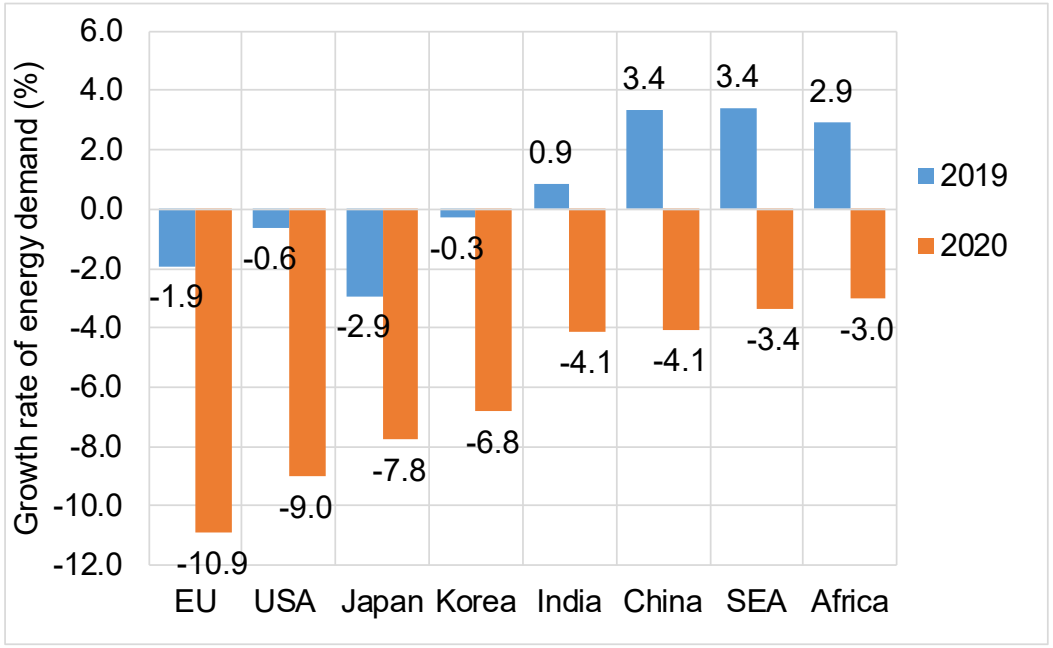
- 8,735,310 (5.98% of the population) – vaccinated with 1 dose
- 5,419,537 (3.71% of the population) - fully vaccinated (data for 1 region is missing)
- 14,154,847 - all vaccinations are made on average on the basis of data for the last week
- 167,380 day (0.11% of the population)
- At this rate, 50% of the population should be vaccinated in 385 days
- 280,993 units/d - the number of completed vaccinations

Kantchev, G., Russian Covid-19 Vaccine Was Highly Effective in Trial, Boosting Moscow's Rollout Ambitions, www.wsj.com, The Wall Street Journal (02.02.2021)
https://gogov.ru/articles/covid-v-stats february 2, 2021, accessed 10.04.2021
Can Sputnik V reverse the course of vaccination in the EU? Figures and facts, ttps://www.dw.com/ru/mozhet-li-sputn ...
https://gogov.ru/articles/covid-v-stats, accessed 14.04.2021

Energy Demand 2020 vs 2019



(a)

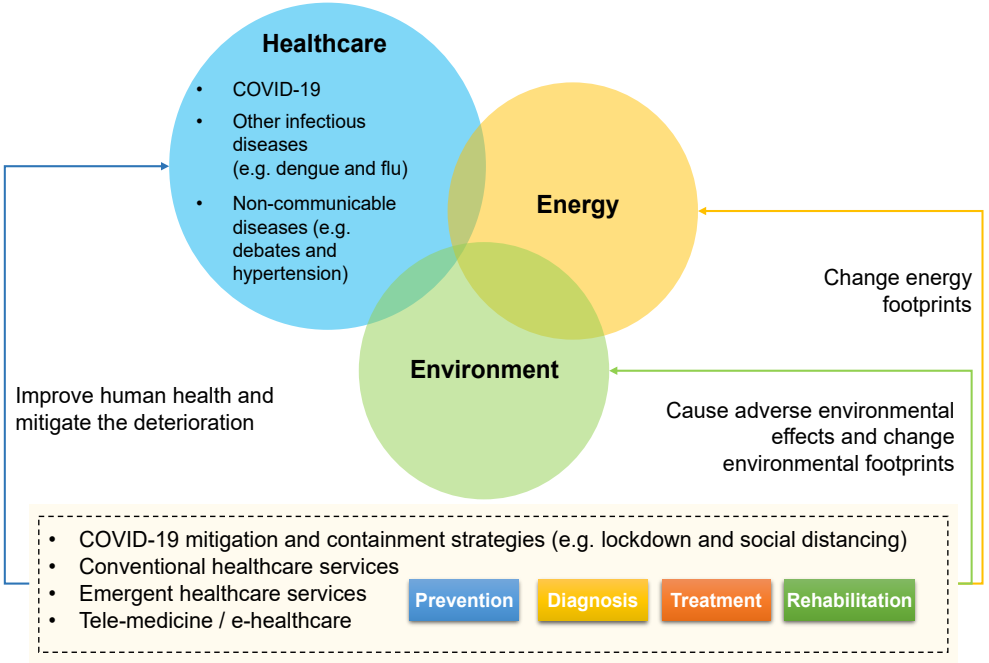


(b)

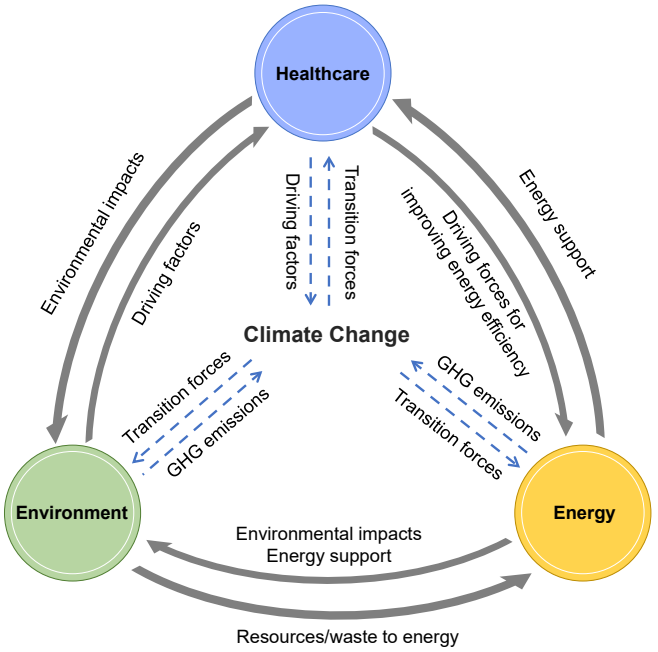
Energy demand development. (a) The projected drops of energy demand by regions in the whole year of 2020, (b) The year-on-year growth rates of energy demand in 2019 and 2020 (projected).

Jiang, P., Fan, Y.V., Klemeš, J.J., 2021. Impacts of COVID-19 on energy demand and consumption: Challenges, lessons and emerging opportunities. *Applied Energy*, 285, 116441.

Healthcare-Energy-Environment Nexus



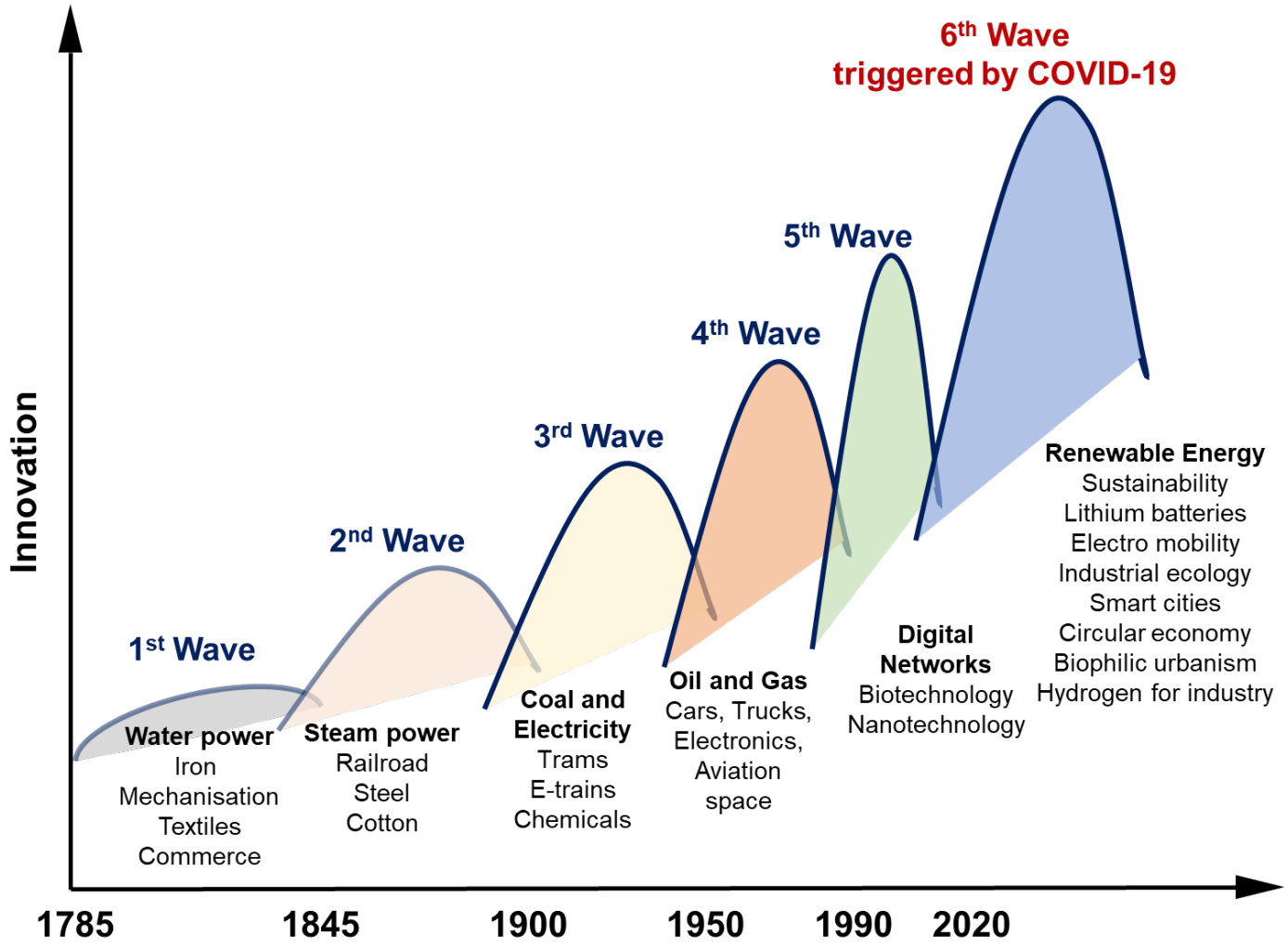
Healthcare-energy-environment system during the COVID-19 pandemic.



The conceptual diagram of the healthcare-energy-environment nexus under climate change constraints.

Jiang, P., Klemeš, J.J.*, Fan, Y.V., Fu, X., Bee, Y.M., 2021. More is not enough: A deeper understanding of the COVID-19 impacts on healthcare, energy and environment is crucial. *International Journal of Environmental Research and Public Health*. 18(2), 684.

The Sixth Wave of Innovation Triggered by COVID-19



Klemeš, J. J., Fan, Y.V., Jiang, P., 2020. COVID-19 pandemic facilitating energy transition opportunities. *International Journal of Energy Research*. Doi:10.1002/er.6007

Representative Work

About this Attention Score

In the top 5% of all research outputs scored by Altmetric

MORE...

Mentioned by

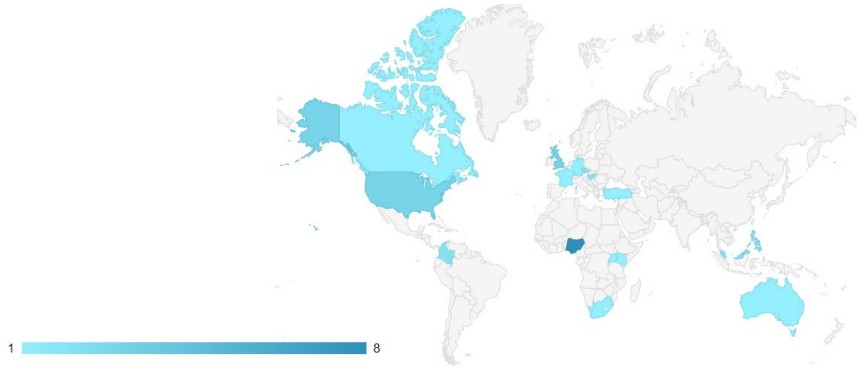
- **36** news outlets
- **1** blog
- **74** tweeters
- **1** Wikipedia page

Citations

- **151** Dimensions

Readers on

- **647** Mendeley



Geographical breakdown

Country	Count	As %
Nigeria	8	11%
United States	3	4%
United Kingdom	3	4%
Colombia	2	3%
Malaysia	2	3%
Czechia	2	3%
Hungary	2	3%
Philippines	2	3%
Kenya	1	1%
Other	7	9%
Unknown	42	57%

Demographic breakdown

Type	Count	As %
Members of the public	57	77%
Scientists	14	19%
Practitioners (doctors, other healthcare professionals)	1	1%
Unknown	2	3%

Overview of attention for article published in *Renewable & Sustainable Energy Reviews*, July 2020 #Altimetric

Klemeš, J. J., Fan, Y. V., Tan, R. R., Jiang, P., 2020. Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19. ***Renewable and Sustainable Energy Reviews***, 127, 109883.

Representative Work

36 news outlets, 3 institution special reports, 1 blog, and 74 tweeters have cited/reported this work.

Klemeš, J. J., Fan, Y. V., Tan, R. R., Jiang, P., 2020. Minimising the present and future plastic waste, energy and environmental footprints related to COVID-19. ***Renewable and Sustainable Energy Reviews***, 127, 109883.

Energy and Environmental Footprints of PPE & Disinfection

Potential Increase of Energy Consumption Owing to COVID-19

Hospital Building and Equipment utilisation → 22.2 M cases and 34 % hospitalisation = **~356 PJ**

Test Kits
- Nylon-plastic Swabs
- Plastic Vials

→ 390 M test conducted = **~168 TJ**
- Chemical Reagents Bottle etc.

Personal Protective Equipment
- Shield → **3.9 TJ/month**
- Masks → **4.6 PJ/month**
- Gloves → **7.0 TJ/month**

Ethanol Production related to disinfectants

12.3 % growth in demand = **~181 PJ**

Packaging

Waste Disposal/ Treatment

Emergency transporting, by e.g. plane, consumes more energy where the supply chain is usually not being optimised

Diversifying Solution
- vital strategy to improve the susceptibility to unexpected events.
- provides flexibility in optimising energy consumption and environmental footprints without compromise on the effectiveness of diseases outbreak measures

N95 Mask

~0.05 $kgCO_2eq$/single use (exclude transporting)

Surgical Mask

~0.059 $kgCO_2eq$/single use (include transporting)

~7.4 x 10^{-3} $kgCO_2eq$/filter efficiency

Cloth Mask

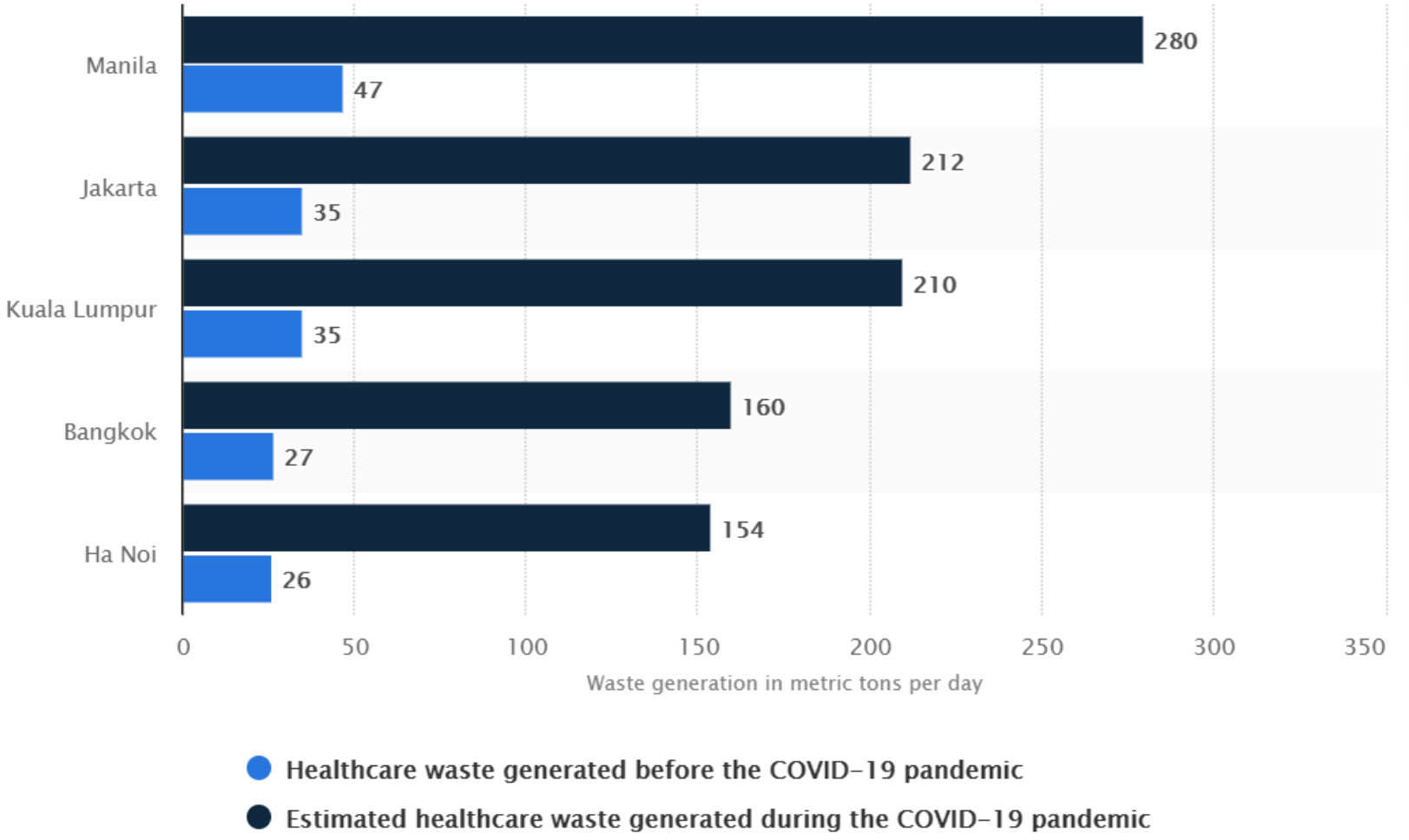
~0.06 $kgCO_2eq$/pcs (exclude washing)

~0.036 $kgCO_2eq$/usage (including washing)

~7.2 x 10^{-3} $kgCO_2eq$/filter efficiency

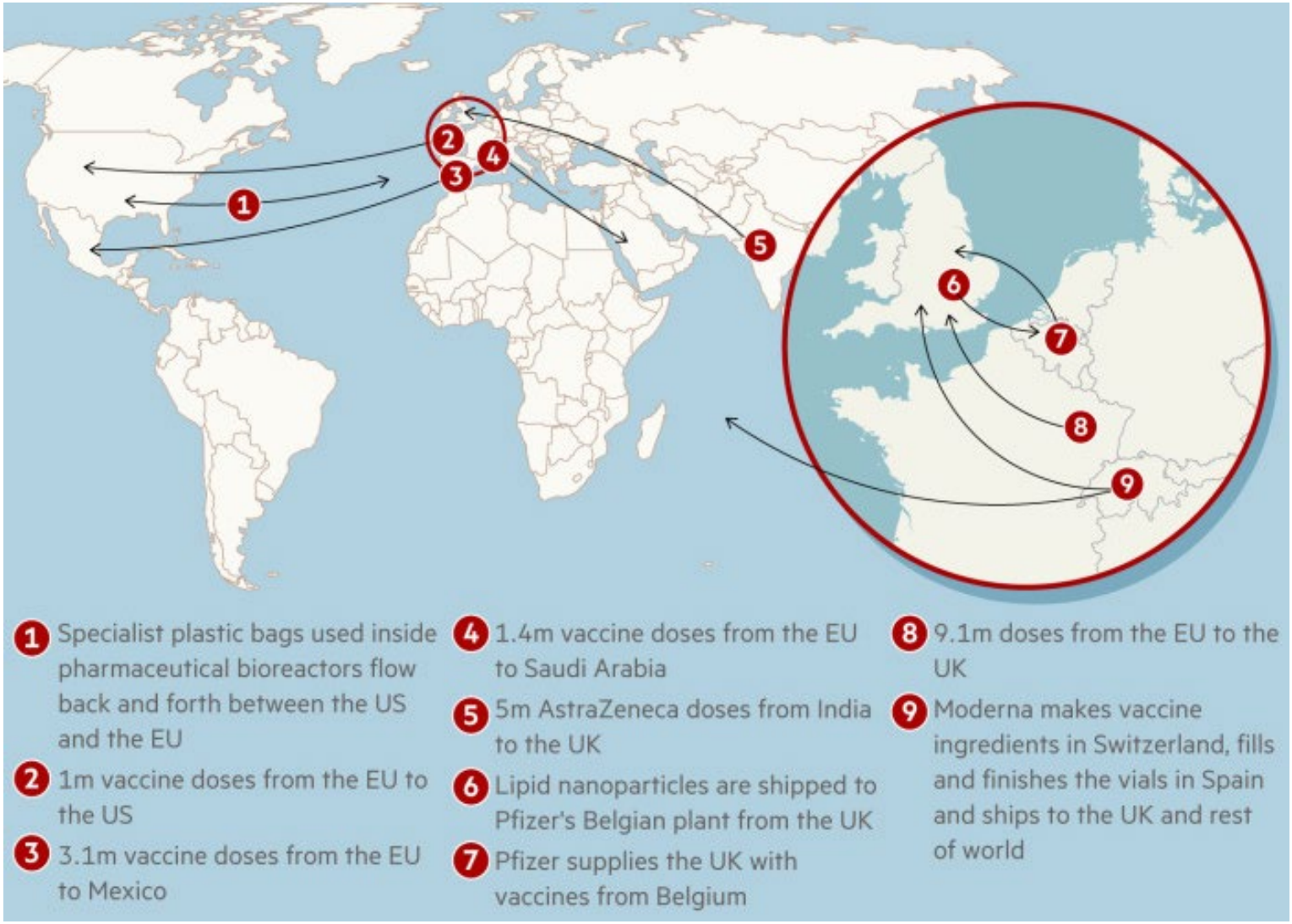
Klemeš, J. J., Fan, Y.V., Jiang, P., 2020. The energy and environmental footprints of COVID-19 fighting measures–PPE, disinfection, supply chains. *Energy*, 211, 118701.

Estimated Healthcare Waste



<www.statista.com/statistics/1167512/healthcare-waste-generation-before-during-covid-19-asia-by-city/>

Supplies of Vaccine and Ingredients: EU



<www.ft.com/content/773245da-900a-468e-aaf3-96ec8c43341f>

Specific Heat Loss during Transportation and Storage (per dosage)

Vaccine company	European Union T_{amb}=20.3℃	Russian Federation T_{amb}=3.8℃	Singapore T_{amb}=27.6℃
	$q_{ref.dose}$, 10^{-5}W/h/dose	$q_{ref.dose}$, 10^{-5}W/h/dose	$q_{ref.dose}$, 10^{-5}W/h/dose
Pfizer T_{stor}=–70 ℃	447.9	366.0	484.1
Moderna T_{stor}=–20 ℃	199.9	118.0	236.1
Sinovac T_{stor}=2 ℃	90.8	8.9	127.0
Sinopharm T_{stor}=2 ℃	90.8	8.9	127.0
Sputnik V T_{stor}= –18 ℃	190.0	108.1	226.2

Estimated by the authors based on several information and equation collected from the literature

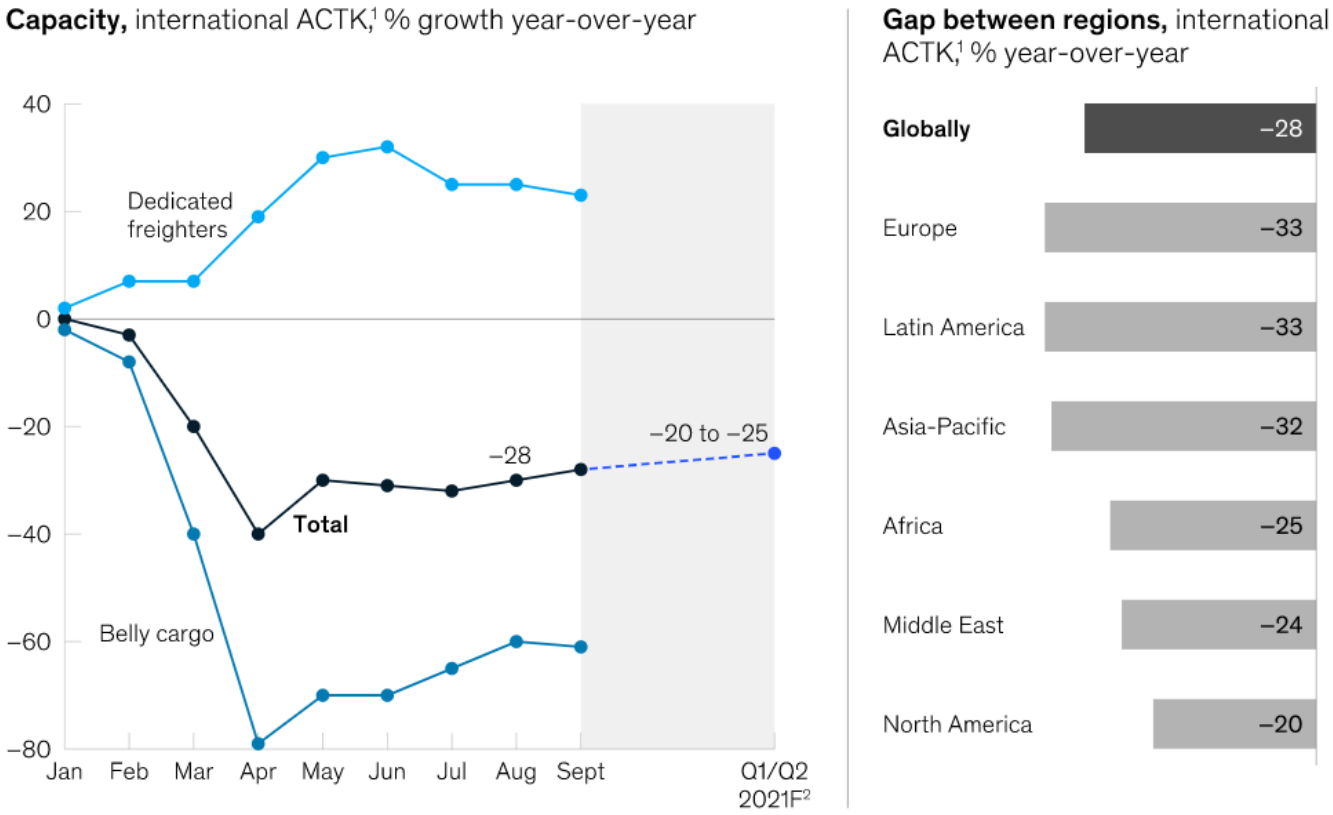
Specific Electrical Power Used to Maintain the Temperature (per dosage)

Vaccine company	European Union		Russian Federation		Singapore	
	COP	$W_{el.dose}$, 10^{-5}W/h/dose	COP	$W_{el.dose}$, 10^{-5}W/h/dose	COP	$W_{el.dose}$, 10^{-5}W/h/dose
Pfizer	0.7	639.8	0.7	522.9	0.7	691.6
Moderna	2.1	95.2	2.1	56.2	1.5	157.4
Sinovac	3.7	24.5	3.7	2.4	2.6	48.8
Sinopharm	3.7	24.5	3.7	2.4	2.6	48.8
Sputnik V	2.2	86.3	2.2	49.1	1.6	141.4

Estimated by the authors based on several information and equation collected from the literature

Air Cargo

Air cargo capacity is still down significantly with no rebound expected in time for vaccine distribution.

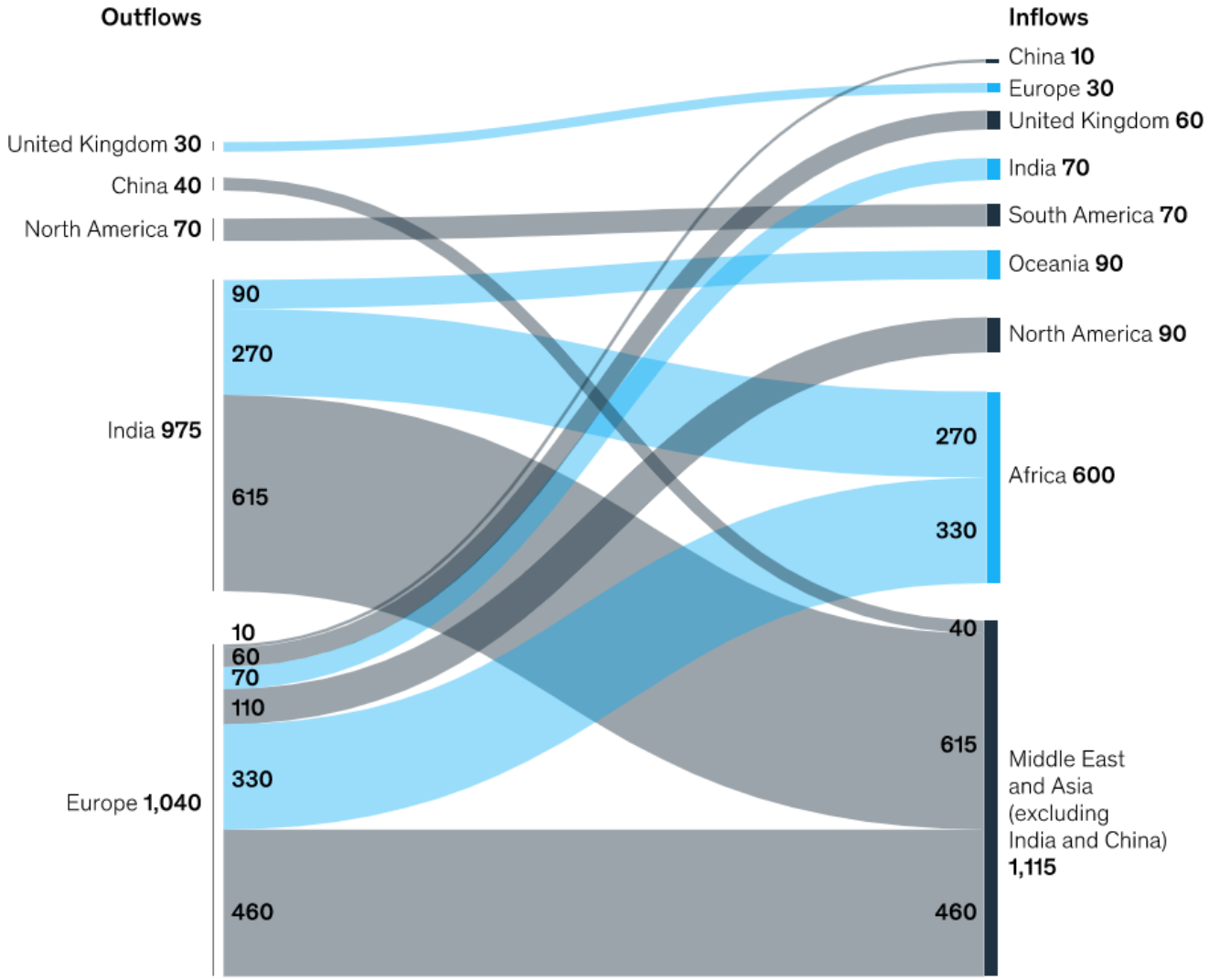


[1]Available cargo tonnes-kilometers.
[2]Forecast based on industry experts.
Source: Air Cargo Analysis, Clive; IHS Markit; International Air Transport Association; Oxford Economics; Seabury Consulting; ; World Trade Service data; McKinsey COVID-19 Trade Flow Recovery Model; McKinsey Global Institute

Efficiency?

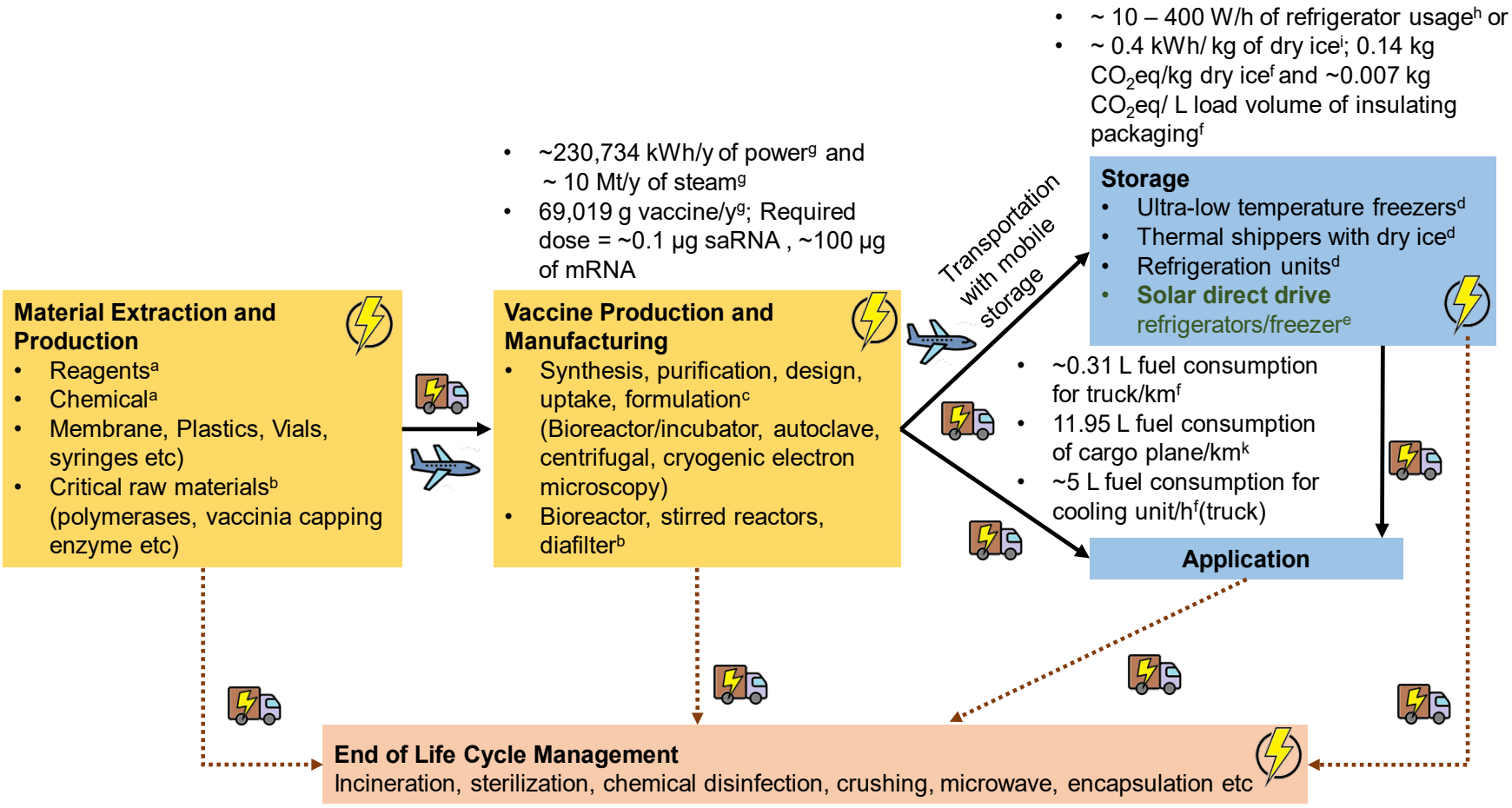
<www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/is-the-world-up-to-the-challenge-of-mass-covid-19-vaccination#>

Vaccine Flows (10^6 doses)



<www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/is-the-world-up-to-the-challenge-of-mass-covid-19-vaccination#>

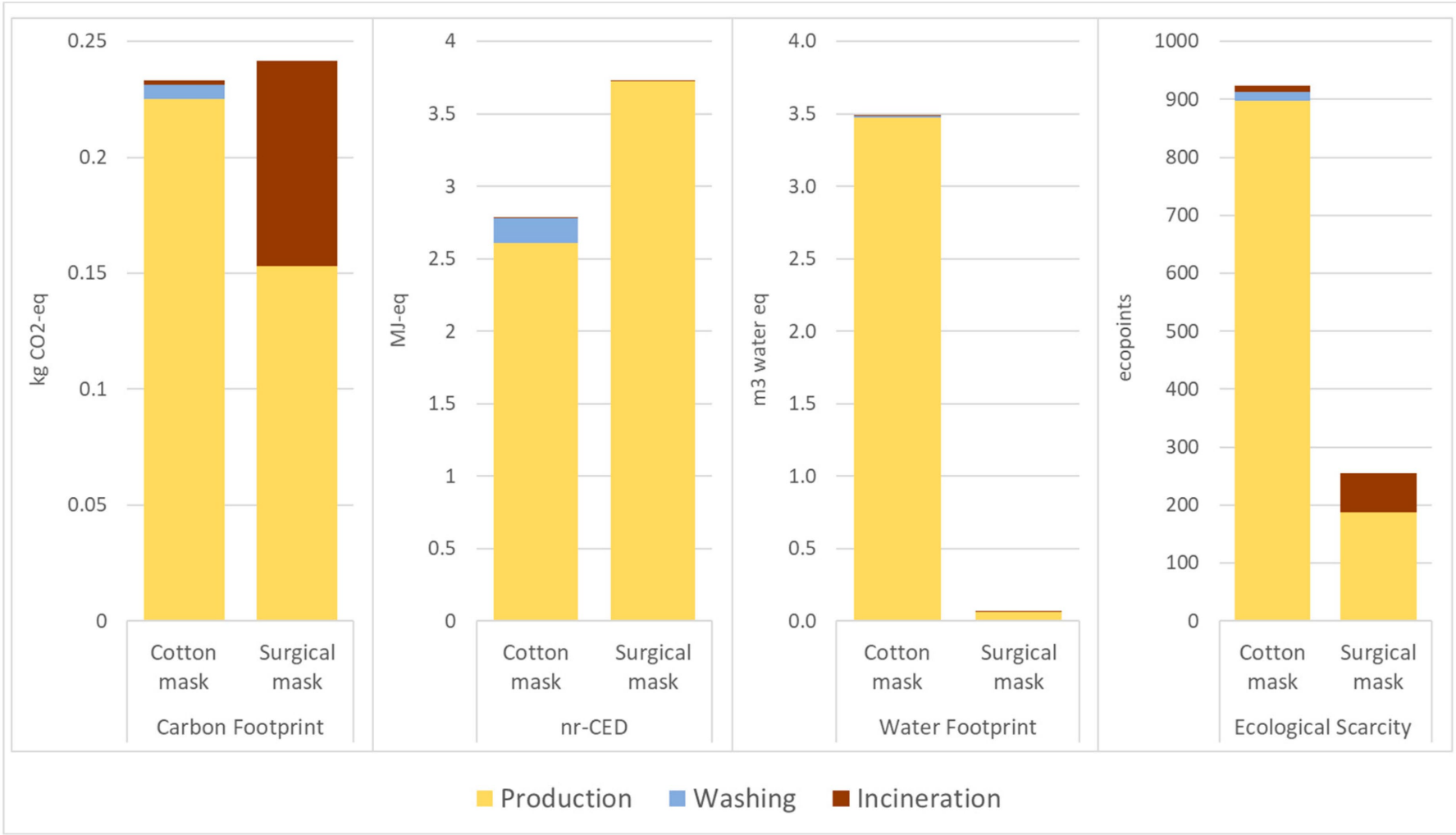
Vaccine Life Cycle



- **Potential recovered pyrolytic oil = average gross calorific value of ~40 MJ/kg (Plastic Medical Waste for vaccination)[j]**

<By the authors –under preparation>

Cotton vs Surgical Masks



Schmutz M, Hischier R, Batt T, Wick P, Nowack B, Wäger P, Som C. Cotton and Surgical Masks—What Ecological Factors Are Relevant for Their Sustainability? *Sustainability*. 2020; 12(24):10245. https://doi.org/10.3390/su122410245

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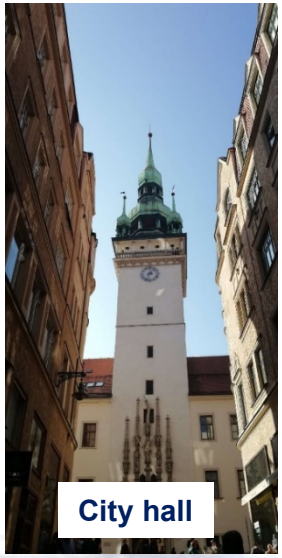
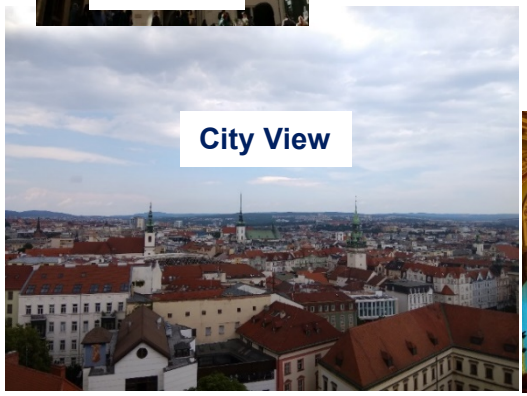

City hall


Villa Tugendhat


Moravian Karst

1st public building in the world to use Thomas Edison's electric lamps


City View


Mahen Theatre


Medlánky

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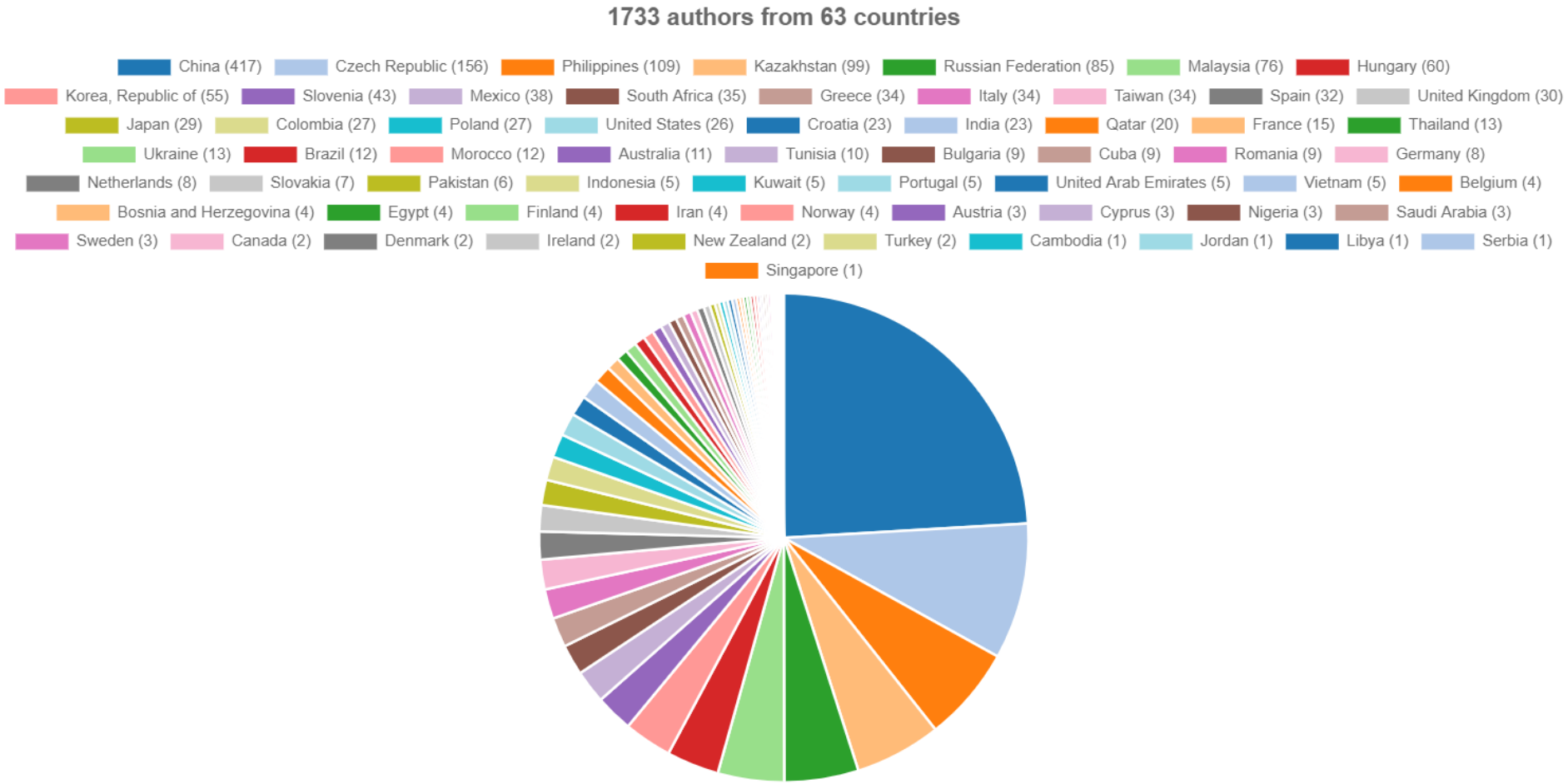

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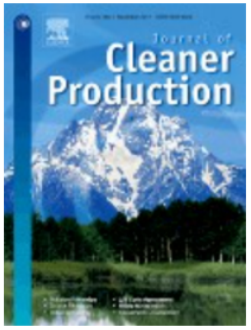

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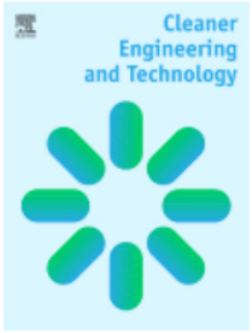

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Acknowledgements

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