OVERVIEW

Air Pollution Impact Model for Electricity Supply

AIRPOLIM-ES

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NEW CLIMATE INSTITUTE

Ambition to Action

Before we start…

Who we are and project context

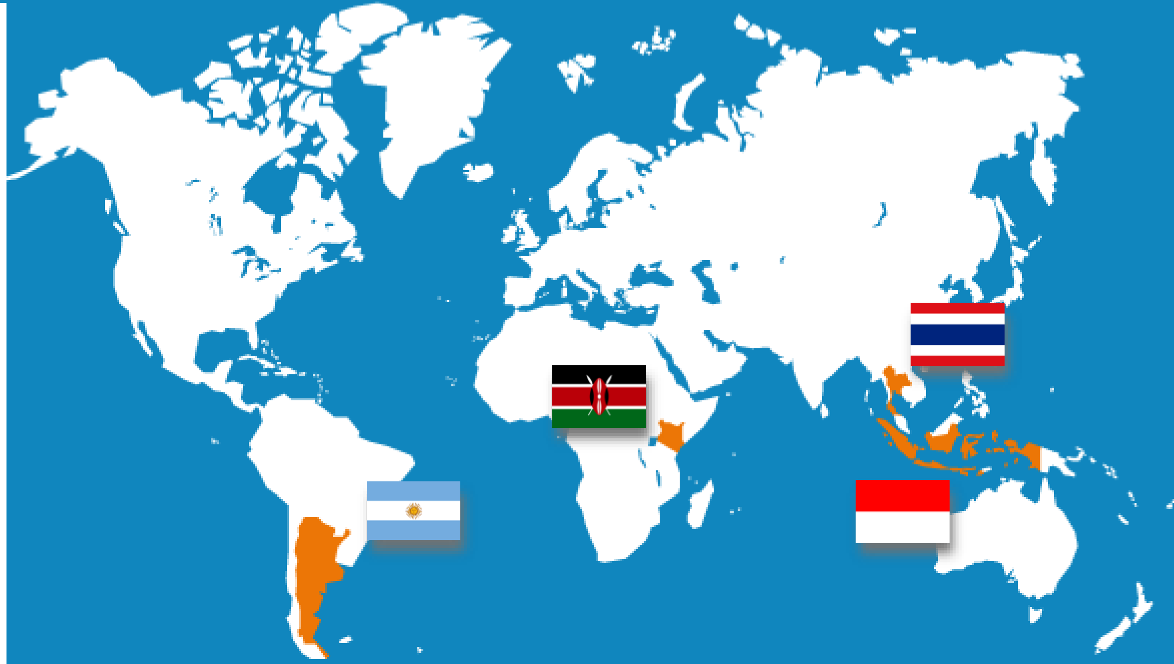
NEW CLIMATE INSTITUTE

NewClimate Institute:
Germany-based research institute/ think tank active in international climate policy

Ambition to Action

Ambition to Action:
3-year project funded under the German International Climate Initiative (IKI) implemented by NewClimate Institute and ECN, part of TNO

Objectives:
Support and accelerate further development and implementation of NDCs in four partner countries

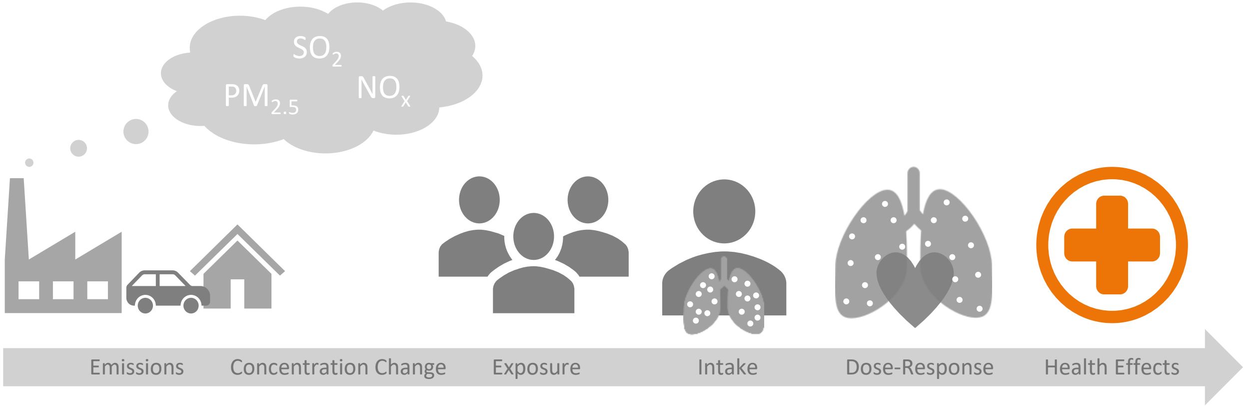


MEASURING THE HEALTHS IMPACTS OF AIR POLLUTION

Methodology and data inputs

Introduction

From air pollutants to health effects



Sources of air pollutants

Energy and air pollution

Non-energy

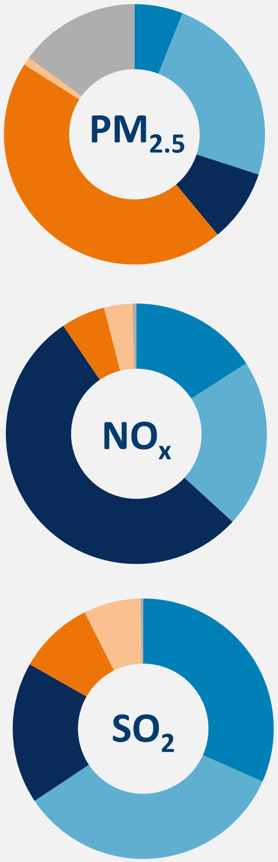
Agriculture; solvents; and waste

Fuel supply

Extraction, storage, transport, and transformation of fossil fuels

Buildings

Cooking, heating, and lighting



Power

Combustion of coal, oil, gas, bioenergy, and waste

Industry

Fuel combustion; process emissions

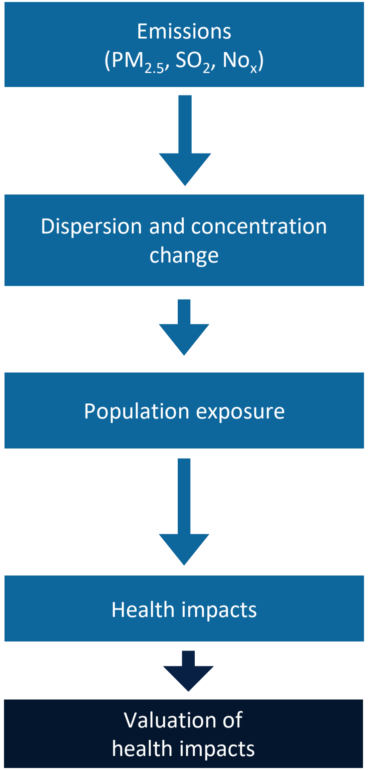
Transport

Exhaust fumes; brake, tyre and road wear; and fuel evaporation

Source: Own creation based on 'World Energy Outlook Special Report: Energy and Air Pollution', 2016

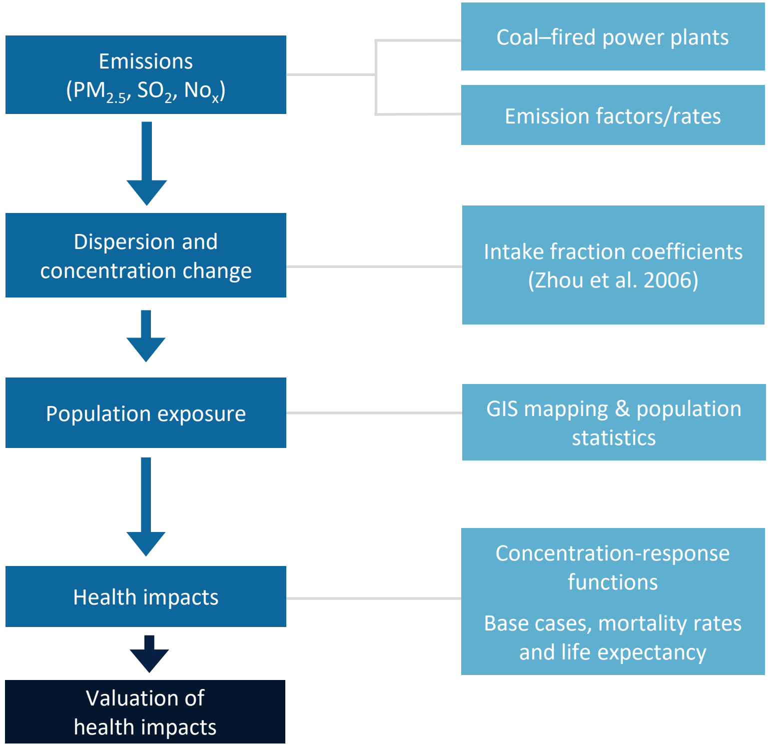
Impact Pathway Approach

Methodological framework



Impact Pathway Approach

Methodological framework



$$\textbf{Intake Fraction} = \frac{\sum_i^N P_i \times \Delta C_i \times BR}{Q}$$

- i = location
- P_i = population at this location
- ΔC_i = change in the concentration of $PM_{2.5}$ caused by emissions from specific source
- BR = population average breathing rate
- Q = total emission rate of the pollutant

Zhou et al. 2006 coefficients

Intake fraction coefficients for population residing within bands of 0–100 km, 100–500 km, 500–1,000 km, and 1,000–3,300 km from emission source

→ interpretation of coefficients: if population increases by 1 million, the intake fraction increases by x

(Zhou et al. methodology: Step 1: Estimation of intake fractions through dispersion modelling for 29 Chinese coal power plants and population mapping; Step 2: Regression with estimated intake fraction as dependent and population within distance bands as independent variable)

Widely used approach, e.g. in the following studies: IMF (2014) Getting Energy Prices Right, Greenpeace International (2014) South Africa Study, Cropper et al. (2012) The Health Effects of Coal Electricity Generation in India

Key data inputs required in the model

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Plant data

Lifetime

Installed capacity

Capacity factor

Heat rate (efficiency)

Emissions control

Location

Population mapping

Gridded population data

GIS Mapping

Population data

Country-specific mortality rates

Share of population per age category

Life expectancy at specific age

Population growth estimates

Input data

Inside the Excel tool

Plant data

Source: Global Coal Plant Tracker (2020), WorldPop, GIS mapping results

Count of plants / units
10

Enter "1" if power plant should be included in analysis, "0" if not

Enter the start year for calculations

WorldPopYear
2020

If start date unknown selects date based on status

Enter average lifetime below, if phase-out date is unknown assume:

40
AveragePlant Lifetime

Enter "Averag Enter "default" if not known

Plant_List	Plant_ID	Scenario_List	ıclude_Switch	Plant_Fuel	Plant_Type	Plant_Country	Plant_Status			
Plant	**Plant ID**	**Scenario**	**Include in analysis**	**Fuel**	**Type**	**Country**	**Status**	**Capacity**	**Actual start of operations**	**Actual end of operations**
text	*text*	*text*	*text*	*text*	*text*	*text*	*text*	*MW*	*date*	*date*
Adaro Aluminum Smelter power station	IDN1	SimpleMW	1	Coal	Coal	Indonesia	operating	100.00	2020	2045
Adaro East Kalimantan power station Unit 1	IDN2	SimpleMW	1	Coal	Coal	Indonesia	operating	100.00	2020	2045
Adaro East Kalimantan power station Unit 2	IDN3	SimpleMW	1	Coal	Coal	Indonesia	operating	100.00	2020	2045
Adipala power station Unit 1	IDN4	SimpleMW	1	Coal	Coal	Indonesia	operating	100.00	2020	2045
Amamapare Port power station Unit 1	IDN5	SimpleMW	1	Coal	Coal	Indonesia	operating	100.00	2020	2045
Amamapare Port power station Unit 2	IDN6	SimpleMW	1	Coal	Coal	Indonesia	operating	100.00	2020	2045

Plant_List	Plant_StartDate		Plant_Lifetime		Plant_EmissionControl	Plant_PM2.5	Plant_NOx	Plant_SO2	Plant_CO2	Plant_Lat	Plant_Long	Plant_Eff
Plant	**Start of operations**	**End of operations**	**Remaining lifetime**	**Heat rate**	**Emissions control**	**PM2.5 emissions factor**	**NOx emissions factor**	**SO2 emissions factor**	**CO2 emissions factor**	**Latitude**	**Longitude**	**Plant efficiency**
text	*date*	*date*	*years*	*Btu/KWh*	*text*	*t/GWh-th*	*t/GWh-th*	*t/GWh-th*	*t/GWh-th*	*degrees (°)*	*degrees (°)*	*%*
Adaro Aluminum Smelter power station	2020	2045	40	8605	Average	default	default	default	default	2.5280	117.8580	40%
Adaro East Kalimantan power station Unit 1	2020	2045	40	9466	Average	default	default	default	default	0.1000	116.4000	36%
Adaro East Kalimantan power station Unit 2	2020	2045	40	9466	Average	default	default	default	default	0.1000	116.4000	36%
Adipala power station Unit 1	2020	2045	40	8409	Average	default	default	default	default	- 7.6859	109.1376	41%
Amamapare Port power station Unit 1	2020	2045	40	12183	Average	default	default	default	default	- 4.8278	136.8391	28%
Amamapare Port power station Unit 2	2020	2045	40	12183	Average	default	default	default	default	- 4.8278	136.8391	28%

Population input

PlantList			Incountry100km	try100km500km	y500km1000km	1000km3300km	countries100km	ies100km500km	s500km1000km	1000km3300km		
			In-country	*In-country*	*In-country*	*In-country*	*All countries*	*All countries*	*All countries*	*All countries*		
Unit	**Country**	**Plant_ID**	**In-country population within radius** 100 km	**In-country population within radius** 100 - 500 km	**In-country population within radius** 500 - 1000 km	**In-country population within radius** 1000 - 3300	**All country population within radius** 100 km	**All country population within radius** 100 - 500 km	**All country population within radius** 500 - 1000 km	**All country population within radius** 1000 - 3300	**Population over** 25	**Exposed population over** 25
text	*text*	*text*	*million*	*million*	*million*	*million*	*million*	*million*	*million*	*million*	*share*	*million*
Adaro Aluminum Smelter power station	Indonesia	IDN1	0.56	6.52	29.23	247.91	0.56	12.20	47.06	1,236.89	57%	163
Adaro East Kalimantan power station Unit 1	Indonesia	IDN2	0.61	14.04	59.11	210.46	0.61	14.32	67.69	1,026.04	57%	163
Adaro East Kalimantan power station Unit 2	Indonesia	IDN3	0.61	14.04	59.11	210.46	0.61	14.32	67.69	1,026.04	57%	163
Adipala power station Unit 1	Indonesia	IDN4	14.71	137.32	48.15	78.75	14.71	137.32	48.19	473.58	57%	160
Amamapare Port power station Unit 1	Indonesia	IDN5	0.68	5.16	3.15	129.76	0.68	5.16	6.05	253.75	57%	79
Amamapare Port power station Unit 2	Indonesia	IDN6	0.68	5.16	3.15	129.76	0.68	5.16	6.05	253.75	57%	79

Data Sources: Plant data

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Plant data

Lifetime

Installed capacity

Capacity factor

Heat rate (efficiency)

Emissions control

Location

Using individual data or the Global Coal Plant Tracker data base

ENDCOAL
ENDCOAL.ORG
GLOBAL COAL PLANT TRACKER

Using individual data or country-specific emission factors (GAINS)

IIASA
GAINS Online
Greenhouse Gas - Air Pollution Interactions and Synergies

Data sources: Population mapping

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Population mapping

Gridded population data

GIS Mapping

Open source population data set and GIS software

GIS mapping visual results

Data sources: Population data

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Population data

Country- and age-specific mortality rates

Share of population per age category

Life expectancy at specific age

Population growth estimates

IHME

Global Health Data Exchange | GHDx | Institute for Health Metrics and Evaluation

WDI DataFinder

UNITED NATIONS
DESA / POPULATION DIVISION

World Population Prospects

AIR POLLUTION HEALTH IMPACT INDICATORS

Illustrative results

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Outputs

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Emissions

Annual and lifetime emissions for:

- *$PM_{2.5}$*
- *NO_x*
- *SO_2*

Health Impacts

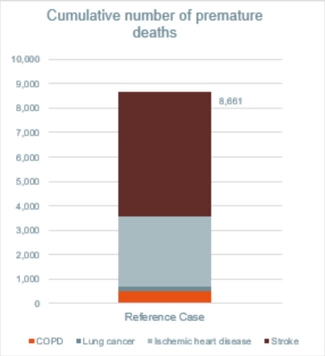
Annual and lifetime premature deaths and years of life lost for:

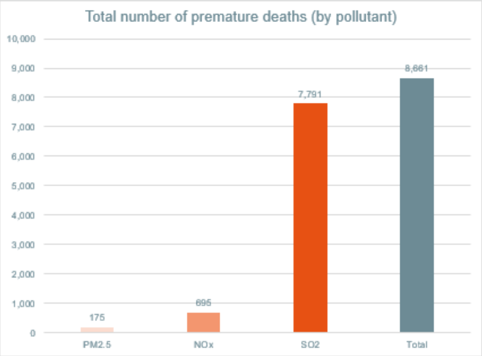
- *Lung cancer*
- *Chronic obstructive pulmonary disease*
- *Ischemic heart disease*
- *Stroke*

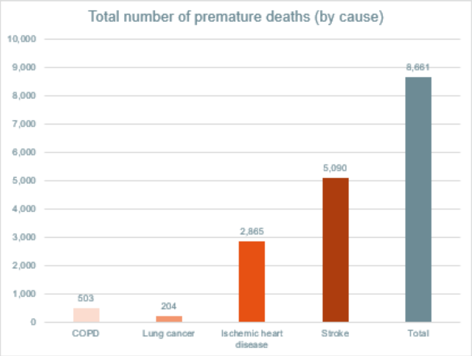
Available on plant, scenario and country level
&
restricted to country population or for all affected population

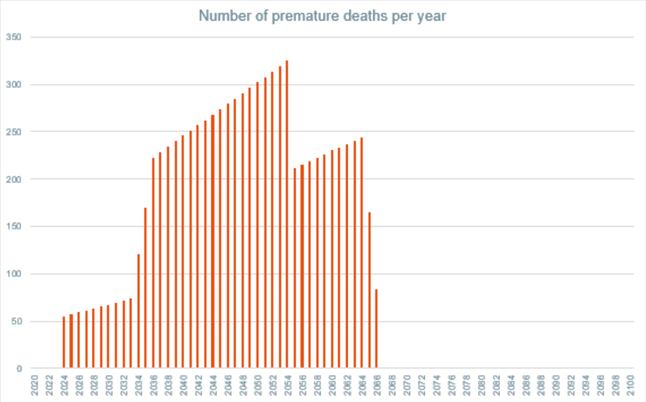
Number of premature deaths

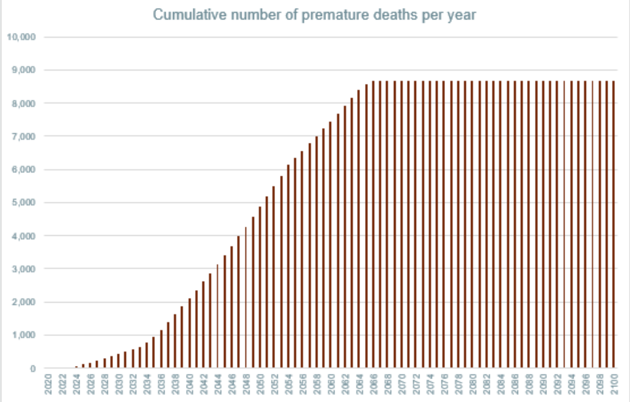
Illustrative results











Result Set-Up

Scenario

Choose scenario of interest

Reference Case

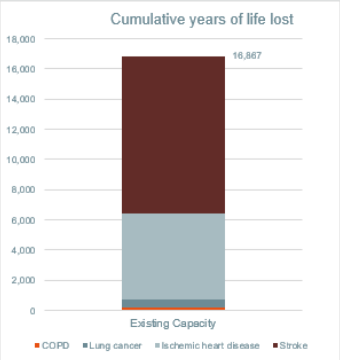
Population coverage

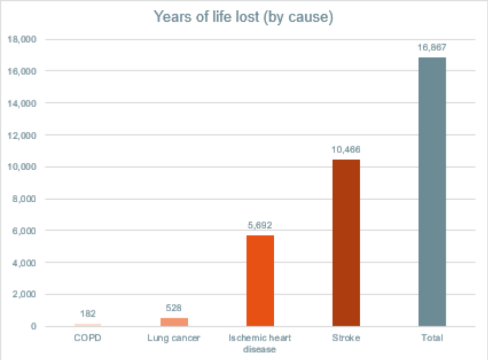
In-country

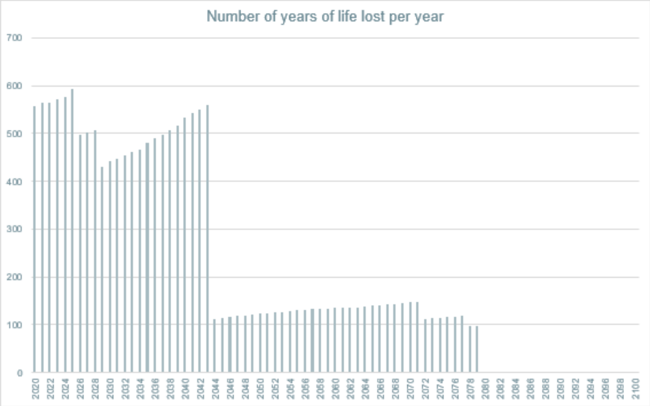
PopCoverage

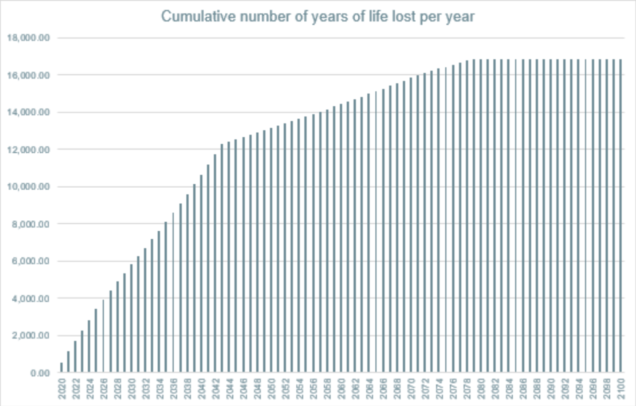
Number of years of life lost

Illustrative results



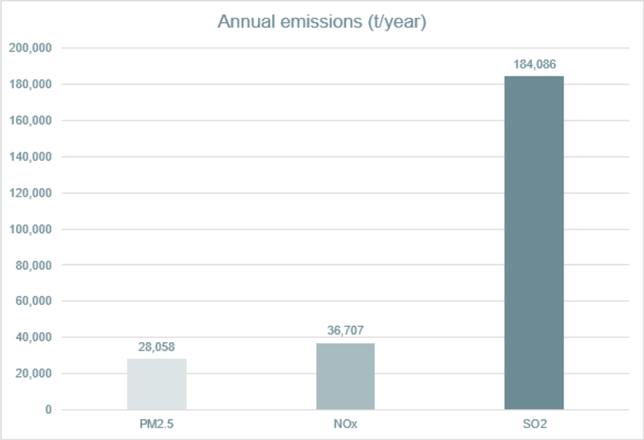


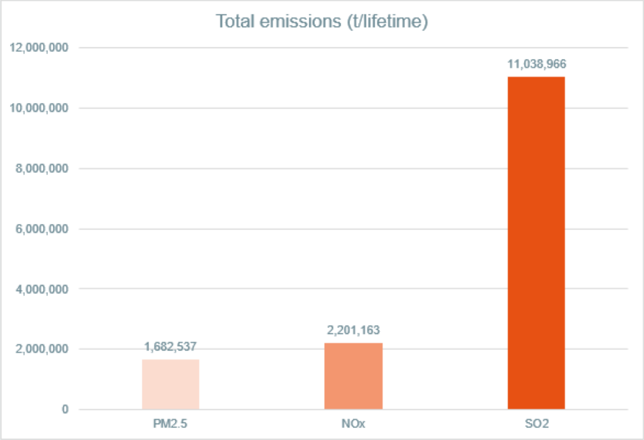




Emissions

Illustrative results





APPLICATIONS OF AIRPOLIM-ES

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Published and ongoing application of AIRPOLIM-ES

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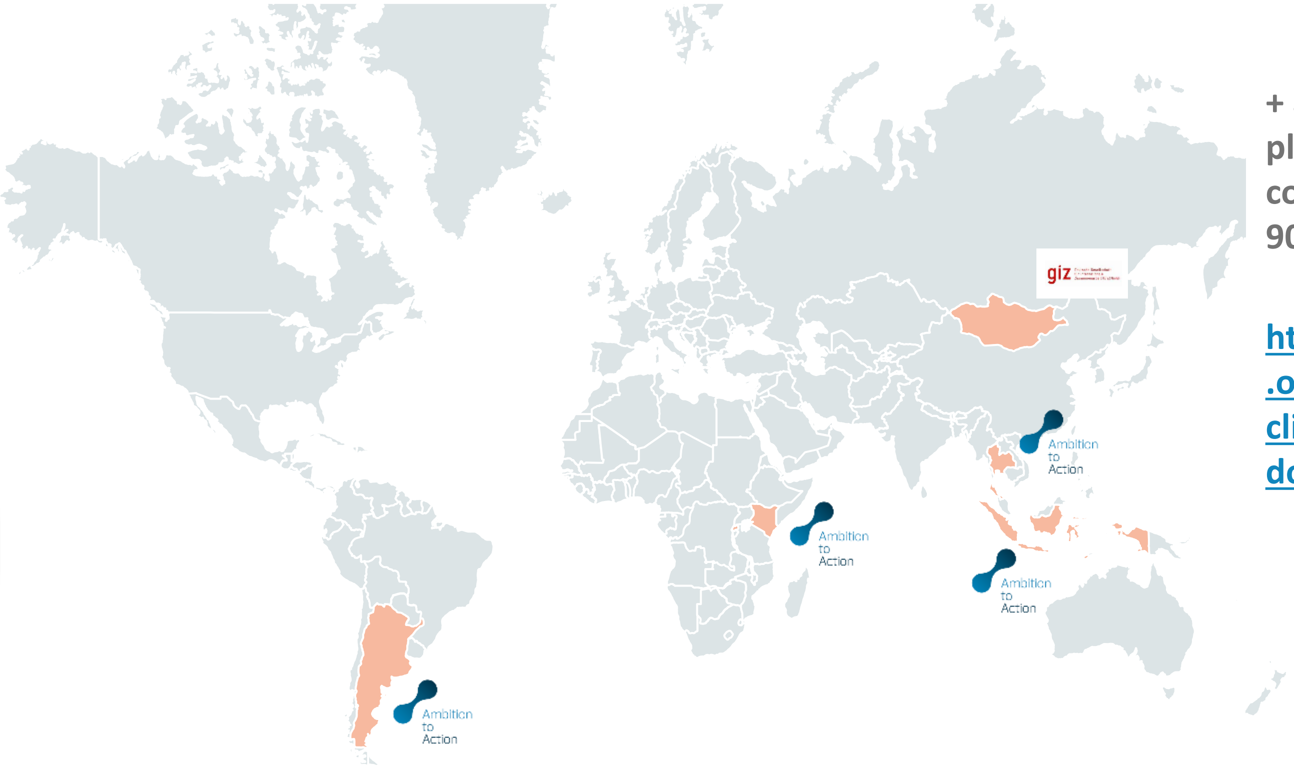
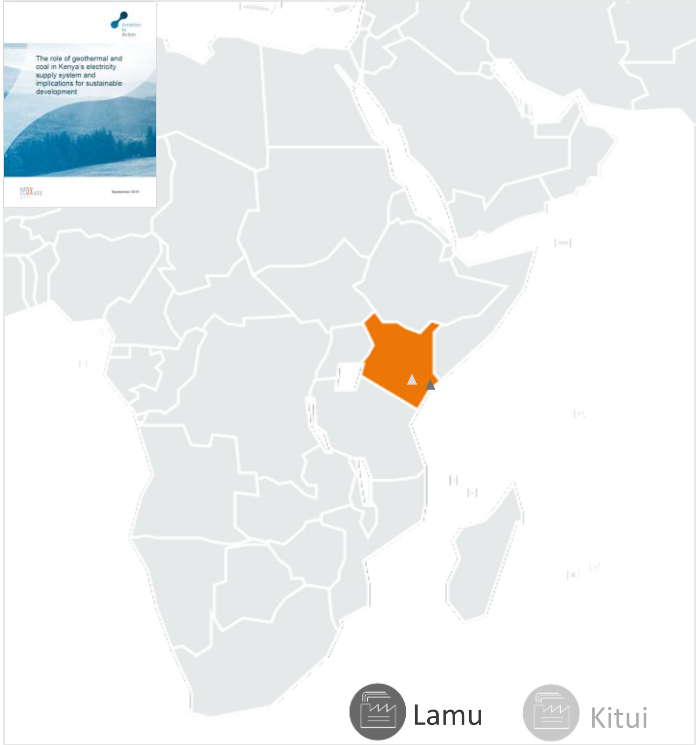


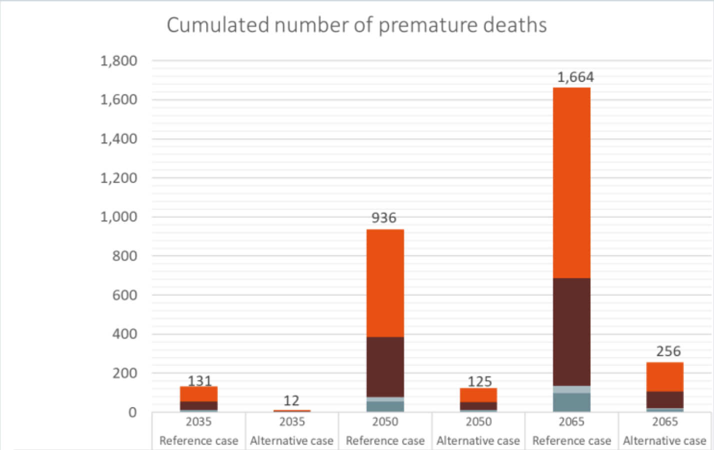
+ analysis of coal plants in 24 countries, covering 90% of global fleet

https://newclimate.org/news/the-climate-and-health-double-dividend

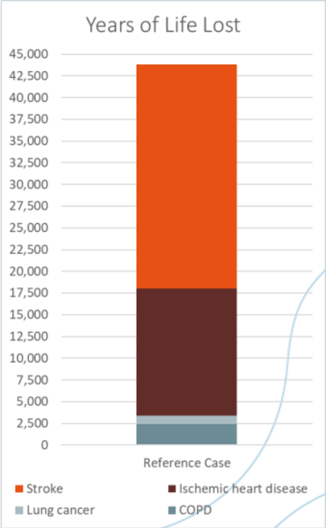
Air pollution health impact assessment in Kenya

Illustrative results



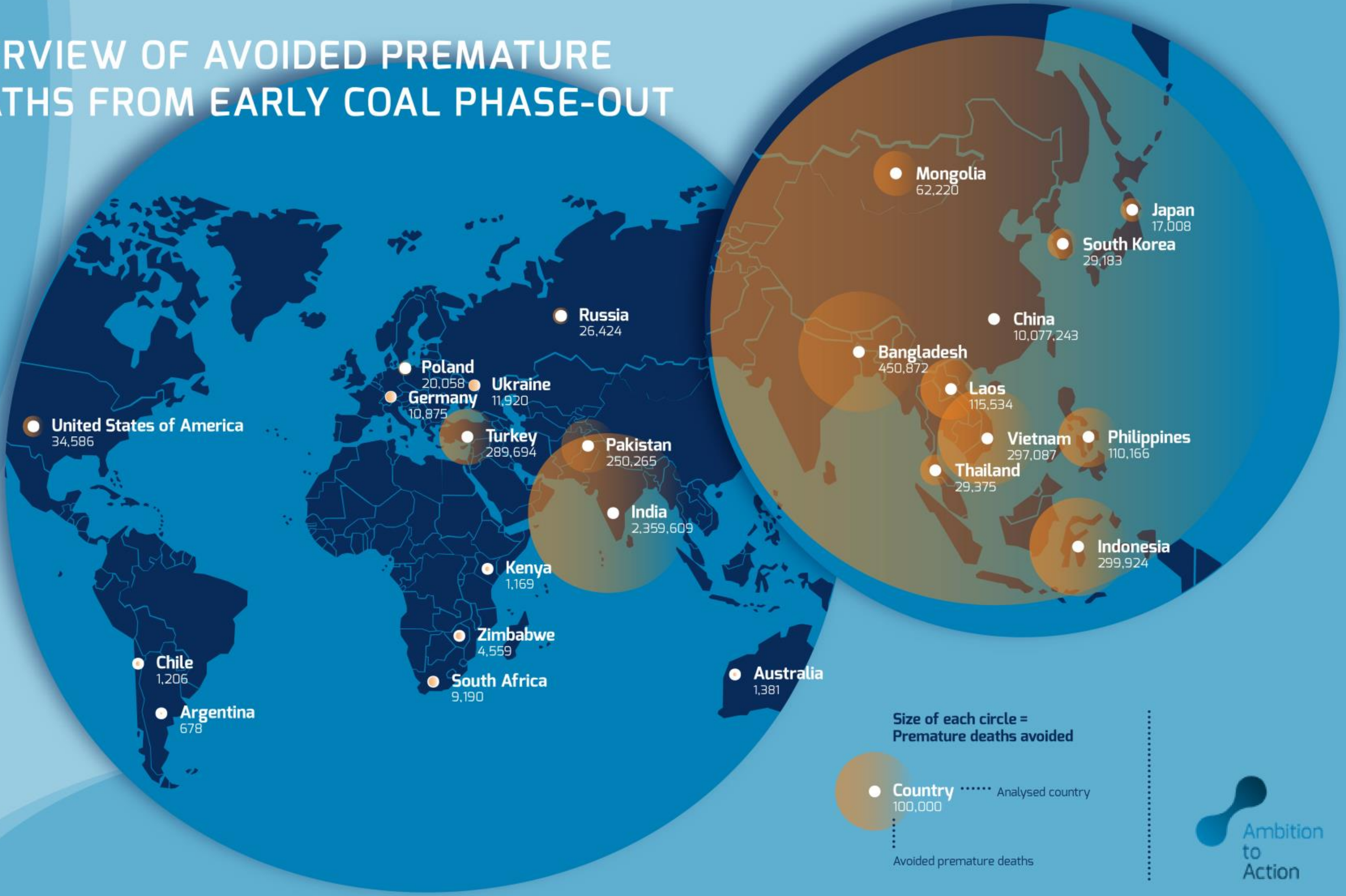


	2035 Reference case	2035 Alternative case	2050 Reference case	2050 Alternative case	2065 Reference case	2065 Alternative case
Stroke	77	7	550	73	978	151
Ischemic heart disease	43	4	309	41	550	85
Lung cancer	3	0	22	3	39	6
COPD	8	1	54	7	97	15



* **Reference case:** Lamu power station: 981 MW (start: 2024), Kitui power station: 960 MW (start: 2034); **Alternative case:** Lamu power station: 450 MW (start: 2034); **assumed lifetime** of all coal-fired power plants is 30 years

OVERVIEW OF AVOIDED PREMATURE DEATHS FROM EARLY COAL PHASE-OUT



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DISCUSSION

Limitations and challenges

Considerations for the accuracy and interpretation of results

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ZHOU ET AL. (2006) COEFFICIENTS

Limitations: Not taking into account stack height, meteorological conditions and other location specific factors

EMISSION FACTORS

Limitations: Only provide approximate emission estimations, however plant-specific factors can be entered if available

LINEAR CONCENTRATION RESPONSE FUNCTIONS FROM GLOBAL BURDEN OF DISEASE STUDY

Limitations: Concentration response functions are assumed to be linear in a way that health effects are independent from the initial level of pollution. This is a simplified approach used in many other studies.

HEALTH IMPACT ESTIMATES FOR POPULATION OUTSIDE OF ANALYSIS COUNTRY

Limitations: Those estimates do not take into account country-specific characteristics (including population growth, mortality rates and age shares) but assume those of the country where the power plant is located.

GIS KNOWLEDGE

Estimating population exposure requires at least basic knowledge of geographic information system software

EXCEL KNOWLEDGE

Using the model requires intermediate Excel knowledge / experience

QUESTIONS / COMMENTS / FEEDBACK

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