OVERVIEW

Air Pollution Impact Model for Electricity Supply

AIRPOLIM-ES

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October 2019

Ambition to Action

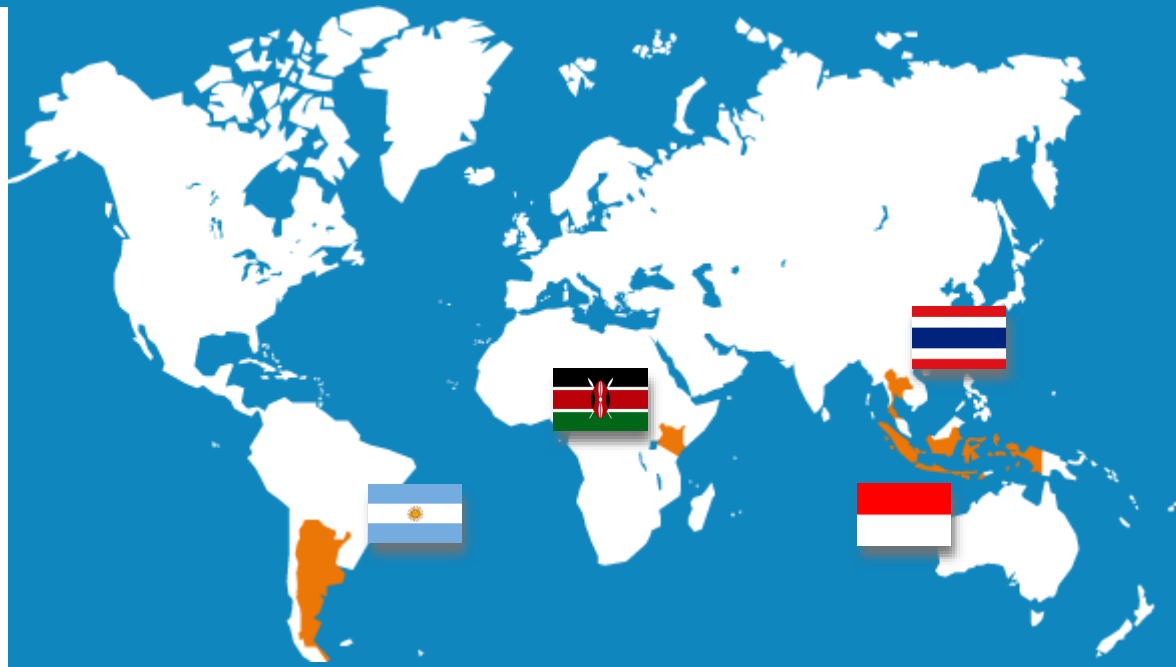
Before we start…

Who we are and project context

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

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

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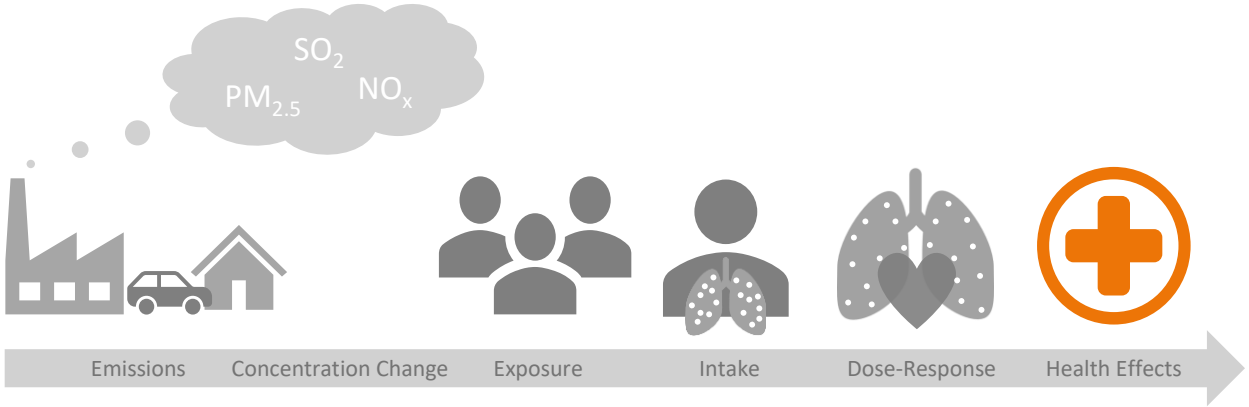
Introduction

From air pollutants to health effects



Sources of air pollutants

Energy and air pollution

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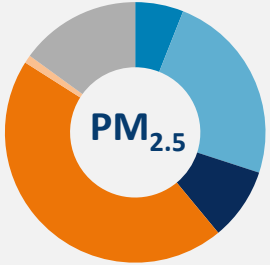
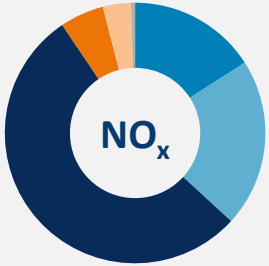


Non-energy

Agriculture; solvents; and waste

Power

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



Fuel supply

Extraction, storage, transport, and transformation of fossil fuels

Industry

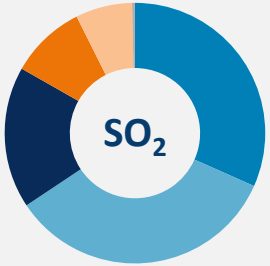
Fuel combustion; process emissions

Buildings

Cooking, heating, and lighting

Transport

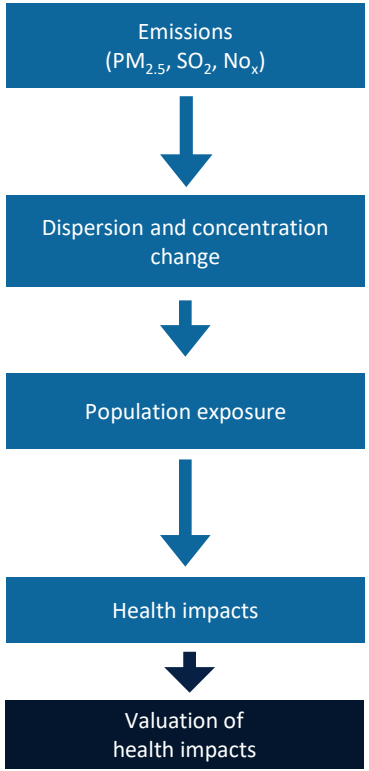
Exhaust fumes; brake, tyre and road wear; and fuel evaporation



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

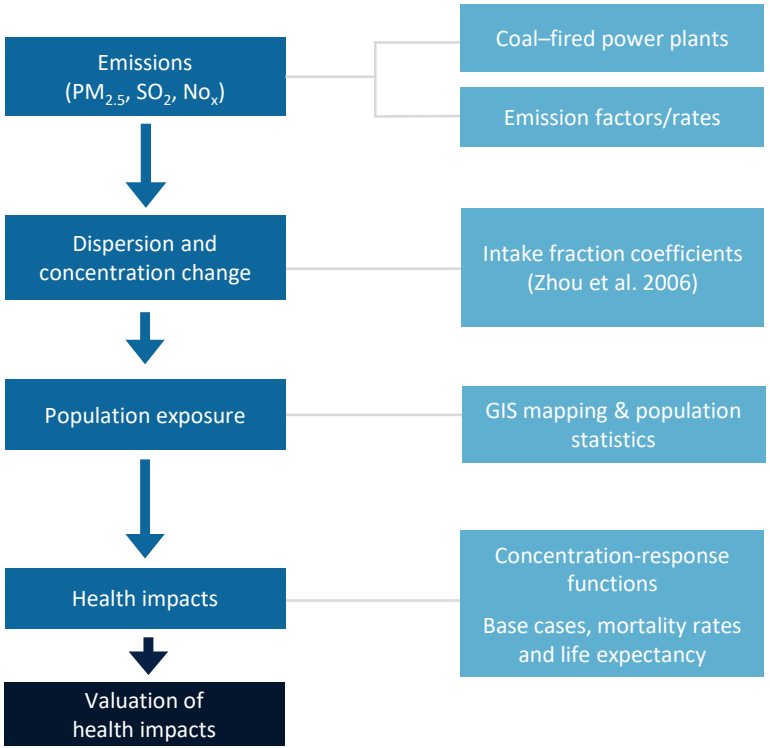
Impact Pathway Approach

Methodological framework



Impact Pathway Approach

Methodological framework



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

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Plant data

Source: Global Coal Plant Tracker (2019), WorldPop, GIS mapping results

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

Do not enter value below 2020

Enter "default" if not known

Enter "default" if not known

Plant_List	Plant_ID	Scenario_List	de_Switch	lant_Fuel	lant_Type	ant_Country	Plant_Status	ant_StartDate	t_Lifetime	Plant_Cap		Plant_EmissionControl	Plant_PM2.5	Plant_NOx	Plant_SO2	Plant_Lat	Plant_Long	Plant_Eff	t_AnnualGen	Plant_LifeGen
Plant	ID	Scenario	Include	Fuel	Type	Country	Status	Start of operations	Lifetime	Capacity	Capacity factor	Heat rate	Emissions control	PM2.5 emissions factor	Nox emissions factor	SO2 emissions factor	Latitude	Longitude	Plant efficiency	Annual electricity generation	Lifetime electricity generation
text	text			text	text	text	text	date	years	MW	%	Btu/KWh	text	t/GWh-th	t/GWh-th	t/GWh-th	degrees (°)	degrees (°)	%	GWh	GWh
Baganuur Pauer LLC	BAG	New Capacity	1	Coal	Coal	Mongolia	Announced	2023	60	700	65%	9,250	Average	default	default	default	47.7839	108.3722	37%	3,986	239,148
Capacity expansion of Choiba	CHO2	New Capacity	1	Coal	Coal	Mongolia	Announced	2022	60	50	65%	10,576	Average	default	default	default	48.0899	114.5416	32%	285	17,082
Choibalsan CHP	CHO	Existing Capacity	1	Coal	Coal	Mongolia	Announced	2019	57	36	65%	10,576	Average	default	default	default	48.0899	114.5416	32%	205	11,684
CHP 3	CHP3a	Existing Capacity	1	Coal	Coal	Mongolia	Announced	2019	8	157	65%	10,576	Average	default	default	default	47.8956	106.8651	32%	894	7,152
CHP 3 Extention	CHP3b	New Capacity	1	Coal	Coal	Mongolia	Announced	2023	60	250	65%	10,576	Average	default	default	default	47.8956	106.8651	32%	1,424	85,410
CHP 3 Extention 2	CHP3c	New Capacity	1	Coal	Coal	Mongolia	Announced	2023	60	75	65%	10,576	Average	default	default	default	47.8956	106.8651	32%	427	25,623

Population

Source: WorldPop, GIS mapping results, Zhou et al. (2006)

Population coverage: In-country

PopCoverage_Switch

WorldPop year: 2020

Plant_ID	Plant_Country	In-country	In-country	In-country	In-country	All countries	All countries	All countries	All countries		
Plant	ID	Country	In-country population within radius	In-country population within radius	In-country population within radius	In-country population within radius	All country population within radius	All country population within radius	All country population within radius	All country population within radius	Population over	Exposed population over
			100 km	100 - 500 km	500 - 1000 km	1000 - 3300 km	100 km	100 - 500 km	500 - 1000 km	1000 - 3300 km	25	25
text	text	text	million	million	million	million	million	million	million	million	share	million
Lamu power station Reference	REF1	Kenya	0.27	22.28	23.71	0.06	0.37	35.06	111.35	612.06	41%	18.760
Kitui power station Unit 1 Refere	REF2	Kenya	1.68	42.04	2.60	-	2.27	61.52	161.43	636.29	41%	18.760
Kitui power station Unit 2 Refere	REF3	Kenya	1.68	42.04	2.60	-	2.27	61.52	161.43	636.29	41%	18.760
Kitui power station Unit 3 Refere	REF4	Kenya	1.68	42.04	2.60	-	2.27	61.52	161.43	636.29	41%	18.760

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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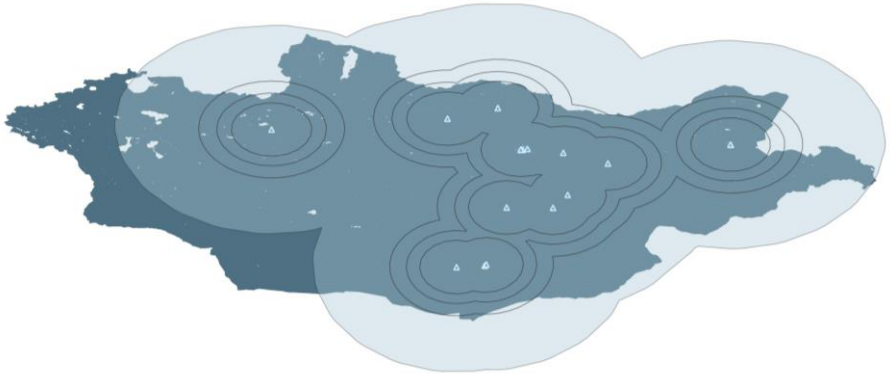
Population mapping

Gridded population data

GIS Mapping

Open source population data set and GIS software	worldpop QGIS
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

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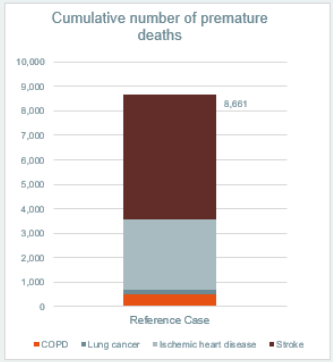
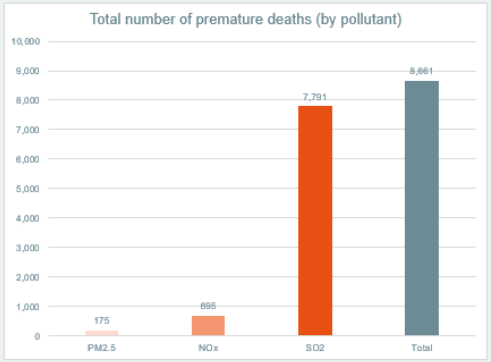
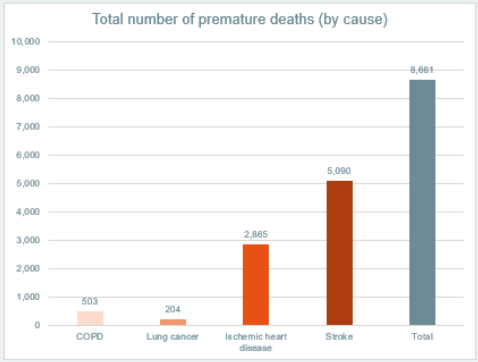
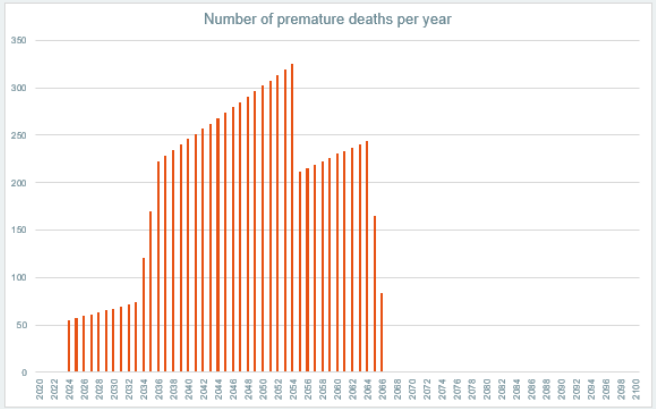
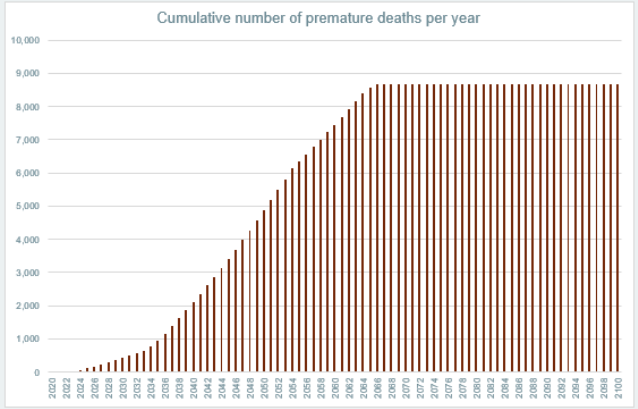
Illustrative results











Result Set-Up

Scenario

Choose scenario of interest

Reference Case

Population coverage

In-country

PopCoverage

Number of years of life lost

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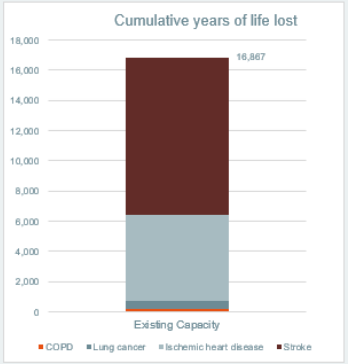
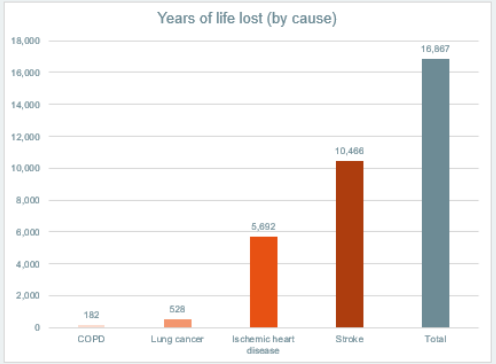
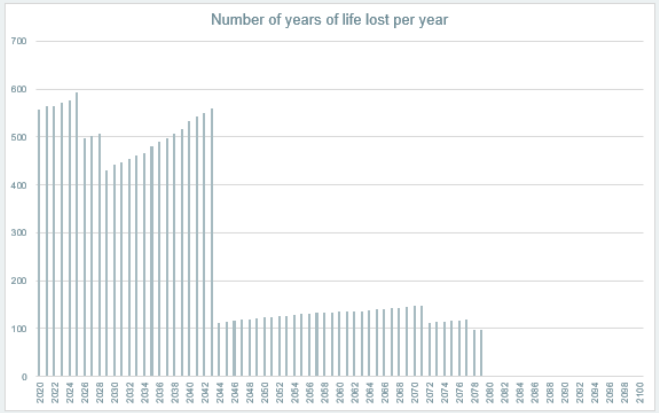
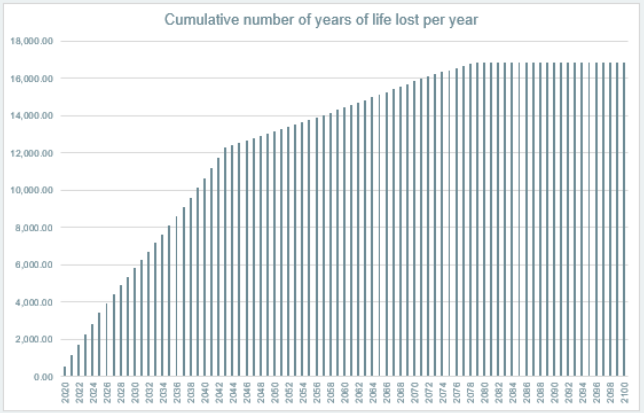
Illustrative results









Emissions

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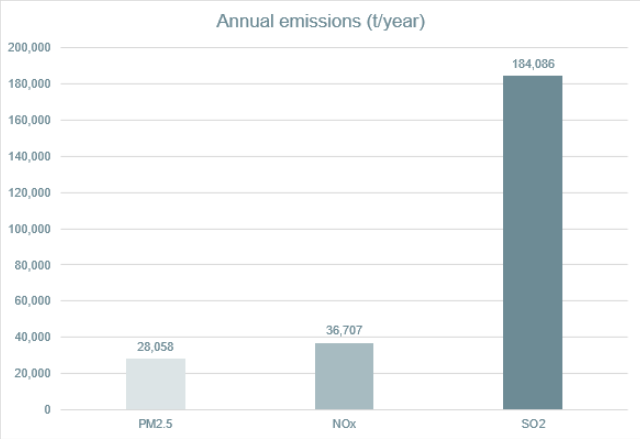
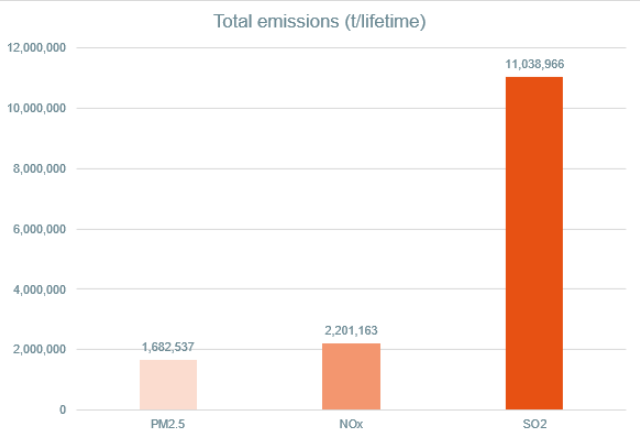
Illustrative results





APPLICATIONS OF AIRPOLIM-ES

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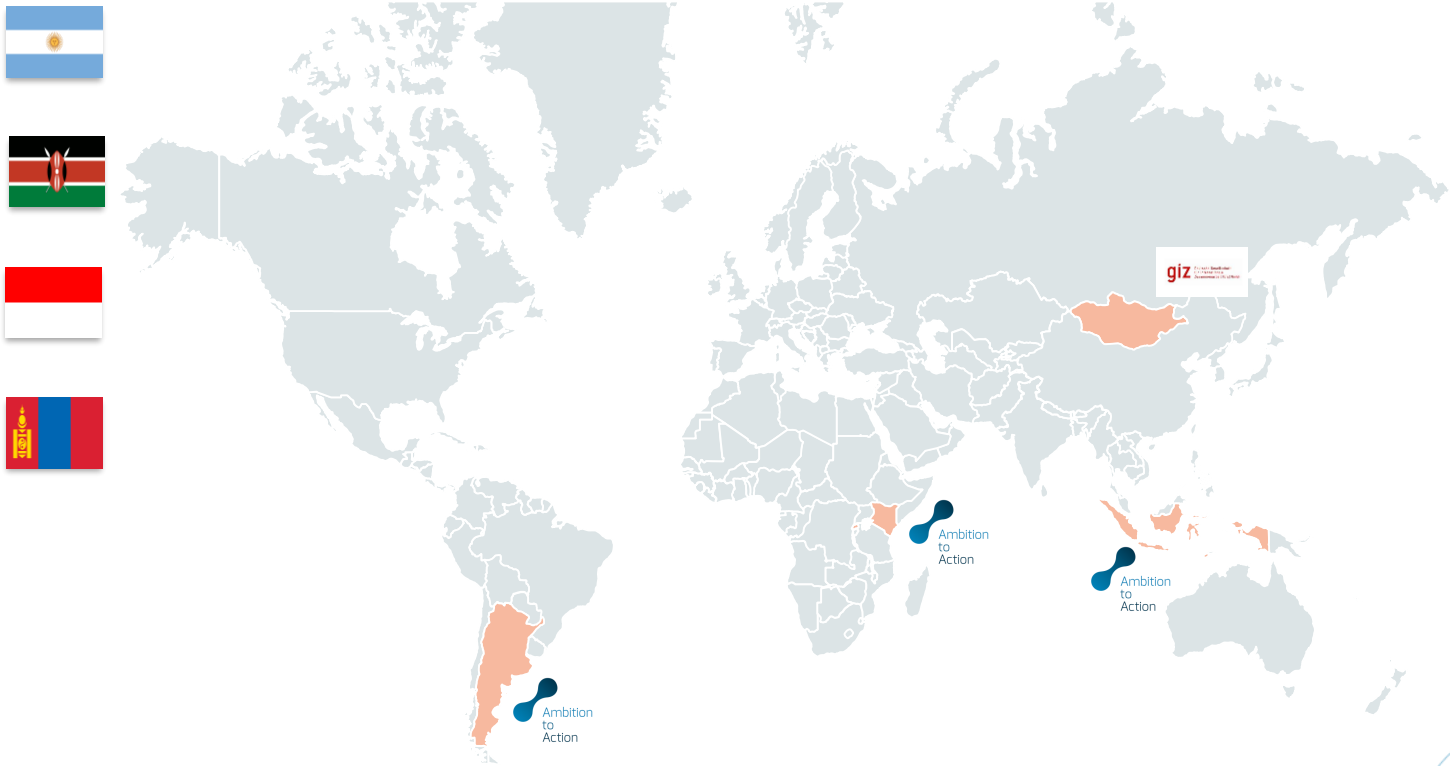
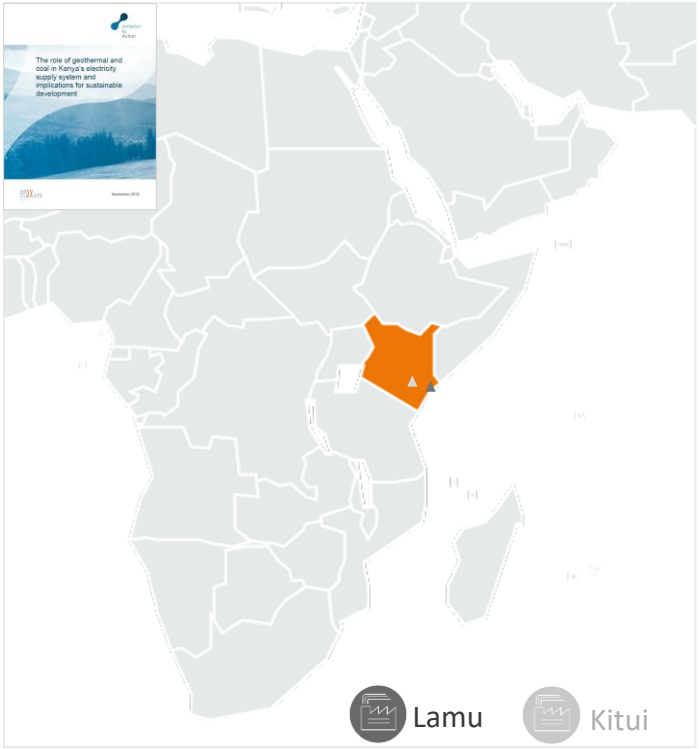
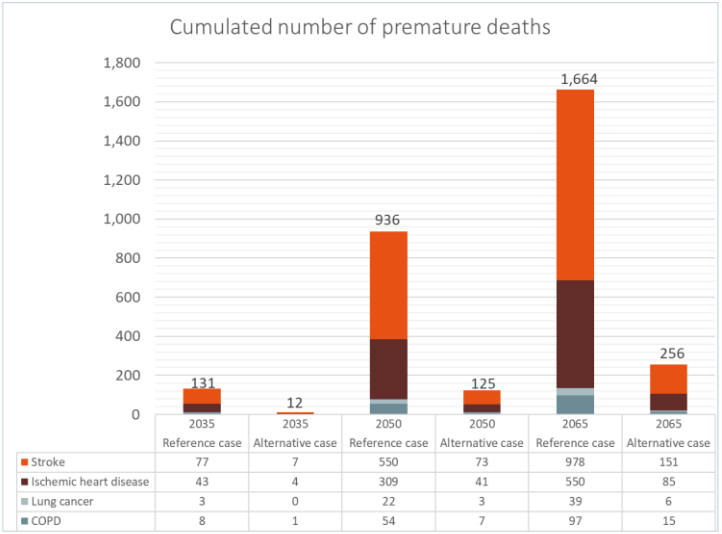
Published and ongoing application of AIRPOLIM-ES

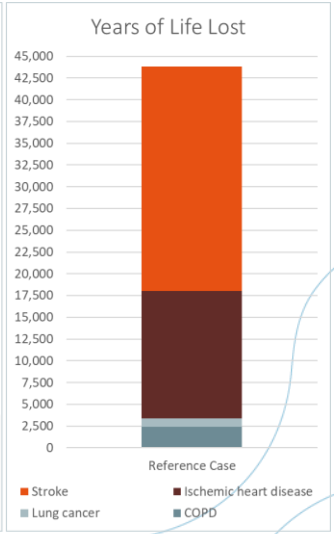


Air pollution health impact assessment in Kenya

Illustrative results







* **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

DISCUSSION

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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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NEW CLIMATE INSTITUTE

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