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PLATFORM

PUBLIC HEALTH IMPACTS AND ECONOMIC COST OF COAL-FIRED AFŞİN ELBİSTAN A THERMAL POWER PLANT EXPANSION PROJECT

About the Right to Clean Air Platform

The Right to Clean Air Platform (THHP) was established in 2015 through the collaboration of 15 non-governmental organizations and professional groups specializing in health, nature preservation, and climate. The primary objective of the platform is to actively address the reduction of air pollution particularly originating from energy and industry. This initiative aims to safeguard public health and advocate for the fundamental right to clean air.

Platform Members

Association for the Right to Clean Air
Association of Occupational Diseases Specialists
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We thank Greenpeace for the provided pollutant dispersion model data.

September 2024

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Contents

Key findings

- This study calculates the impacts following the projected 688 MW expansion of the Afşin Elbistan A power plant in Kahramanmaraş Province, Türkiye on air pollution, public health, and the economy.
- In the first year of operation, 2028, the 688 MW expansion at Afşin Elbistan A will lead to an estimated 42 deaths, 43 asthma emergency room visits, 87 children suffering from asthma, 27 preterm births, 15 low birthweight births, and 16,917 days of work absences.
- As a result of these health impacts, air pollution from the added capacity of Afşin Elbistan A will cost the economy an estimated USD 58.1 million in the first year of operation.
- Assuming the unit will be in operation for 35 years, from 2028 to 2063, the cumulative health impacts of the added capacity will equate to 2,268 deaths, 1,714 asthma emergency room visits, 626 new cases of asthma in children, 2,896 children suffering from asthma, 907 preterm births, 514 low birthweight births, and 755,904 sick leave days.
- Consequently, air pollution from the added capacity of Afşin Elbistan A will cost the economy USD 2.6 billion over the entire operating period from 2028 to 2063.
- This is a significant economic cost to society, and is equivalent to the construction of 29 hospitals, each including 500 beds, with a total of 14,500 hospital beds.

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Introduction

Air pollution significantly harms the global environment, public health, and economy. Exposure to air pollutants, such as particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), and sulphur dioxide (SO_2), adversely affects nearly all major systems and organs of the human body, including the respiratory, cardiovascular, and reproductive systems, as well as the brain, heart, and lungs. Health outcomes include asthma in adults and children, preterm and underweight births, work absences, and death from diseases such as ischaemic heart disease, chronic obstructive pulmonary disease, lung cancer, lower respiratory infections, and diabetes (Lelieveld et al., 2019; Di et al., 2017; WHO, 2021). Each year globally, exposure to air pollution leads to two million paediatric asthma cases (Annenberg et al., 2022), one billion days of work absences, (OECD, 2016), and over six million deaths (Lelieveld et al., 2019). A large fraction of air pollution originates from the burning of fossil fuels, such as coal-fired power stations (McDuffie et al., 2021).

The Afsin-Elbistan power plants, located in Kahramanmaraş Province, Türkiye, has a capacity of over 2,460 MW (GEM, 2024), making it one of the largest coal-fired power plant complexes in the country. The complex includes the Afşin Elbistan A and Afşin B power plants, with proposals to expand Afşin Elbistan A by adding 688 MW by 2028 (GEM, 2024). The region has a long history of environmental and public health issues linked to the operation of these plants. Since the inception of the first power plant in the complex in 1984, the Elbistan Plain has experienced severe environmental degradation and significant public health impacts (GEM, 2024).

The Afşin-Elbistan power plant complex has been the subject of legal challenges, particularly regarding an environmental impact assessment (EIA) report for the Afşin Elbistan A expansion (Myllyvirta et al., 2022). Concerns have been raised about the substantial increase in air pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen oxides (NO_x), sulphur dioxide (SO_2), and mercury (Hg). These pollutants can travel long distances in the atmosphere, causing widespread environmental and health impacts.

A recent report has already documented the health impacts that would occur if the Afşin Elbistan A expansion were to go ahead (Myllyvirta et al., 2022). That study found that air pollution from the Afşin Elbistan A expansion would worsen public health, through for example, the loss of 1,900 (1,200–2,500) lives. However, the public health impacts of pollution also have a negative impact on the economy.

Worldwide each year, health impacts due to exposure to air pollution cost the global economy USD 8 trillion (World Bank, 2022). In 2019, Türkiye's GDP was USD 761 billion, and

the cost of air pollution was estimated to be USD 27.61 billion[1] (EUR 24.65 billion), meaning air pollution could be costing Türkiye up to 3% of its GDP annually (Büke and Köne, 2022). This underscores the economic burden that air pollution has on the country, affecting both public health and the economy.

The economic costs associated with the negative impacts of air pollution caused by power plants are substantial, including direct, indirect, and social costs. In practice, the monetary costs of mortality may include healthcare expenses due to hospital admissions and other medical expenses, which lead to lost productivity and work absences and on the other hand, affect workplaces and the economy with sick leave days. The estimation of economic impacts caused by health implications due to air pollution also includes the estimation of the value of statistical life (VSL). VSL is an estimate of damage costs based on how much people are willing to pay for a reduction in their risk of dying from adverse health conditions. The methods of estimating the damage or 'external' costs associated with the impacts of industrial pollution on human health, ecosystems, infrastructure, and climate continue to evolve and become more accurate.

In this study, we analyse the health and economic impacts of air pollution from the proposed expansion of the Afşin A power plant. To estimate this, we simulate how emissions arising from the increased capacity affect atmospheric concentrations of the pollutants, fine particulate matter ($PM_{2.5}$), sulphur dioxide (SO_2), and nitrogen oxides (NO_x), using the CALPUFF air dispersion model, which is a widely acknowledged industry-standard model for air pollution dispersion simulation. The resulting maps of air pollution, together with external sources of data, are then used to calculate the associated impacts on human health and the economy, using the methodology outlined in Myllyvirta et al. (2020)..

[1] Based on average EUR to USD exchange rate of 1.1199 in 2019

Results

The impacts of air pollution from the Afşin A power plant expansion on public health and the economy for the first year of operation are shown in Table 1. In 2028, the projected first year of operation, pollution from the facility will have a significant impact on public health and the economy. For example, through a variety of different diseases, air pollution will cause 42 (95% confidence interval: 26–66) deaths. In addition to mortality, air pollution from these units will also cause morbidity outcomes, meaning non-fatal illnesses. This includes 43 (25–60) asthma-related emergency room visits, 87 (23–182) children suffering from asthma, and 27 (13–28) women experiencing preterm births. As a result of a variety of illnesses, exposure to this pollution will lead to nearly 17,000 (14,391–19,426) sick leave days, indicating economic productivity losses to employers and businesses. Pollution from this source will lead to 41 (14–78) years lived with a disability, and 226 (109–465) years of life lost. Overall, the health impacts due to pollution from the expanded capacity of Afşin A in the first year of operation will cost USD 58.1 million (35.7–92.0), which places a significant burden on both the local and national economy.

Table 1 - Projected annual health impacts of expanded Afşin A unit in first year of operation (2028)

Health outcome	Pollutant	Number (central value and 95% confidence interval)
Number of cases		
Deaths	All	42 (26–66)
Asthma emergency room visits	$PM_{2.5}$	43 (25–60)
Number of children suffering from asthma	NO_2	87 (23–182)
New cases of asthma in children	NO_2	19 (4–41)
Low birthweight births	$PM_{2.5}$	15 (5–27)
Preterm births	$PM_{2.5}$	27 (13–28)
Work absences (sick leave days)	$PM_{2.5}$	16,917 (14,391–19,426)

Health outcome	Pollutant	Number (central value and 95% confidence interval)
Years of lives lost		
All causes from NO_2 exposure	NO_2	129 (53–312)
All causes from SO_2 exposure	SO_2	97 (55–153)
Years lived with disability		
Chronic obstructive pulmonary disease	$PM_{2.5}$	23 (8–41)
Diabetes	$PM_{2.5}$	0 (0-0)
Stroke	$PM_{2.5}$	18 (6–37)
Total economic cost		
USD million	All	58.1 (35.7–92.0) USD
Turkish lira million*	All	1.975,4 (1.213,8-3.128) TRY

* USD /TRY = 34,00 (September, 2024)

Figure 1 shows the cumulative deaths and health costs from pollution from the expansion of Afşin A over the estimated 35-year operating period. Each estimated health impact increases over time, driven primarily by rapid projected increases in population. Towards the end of the operating period, in 2063, annual deaths are projected to increase to 88 (55–140), and the total economic cost is projected to reach USD 77.2 (47.5–123.0) million.

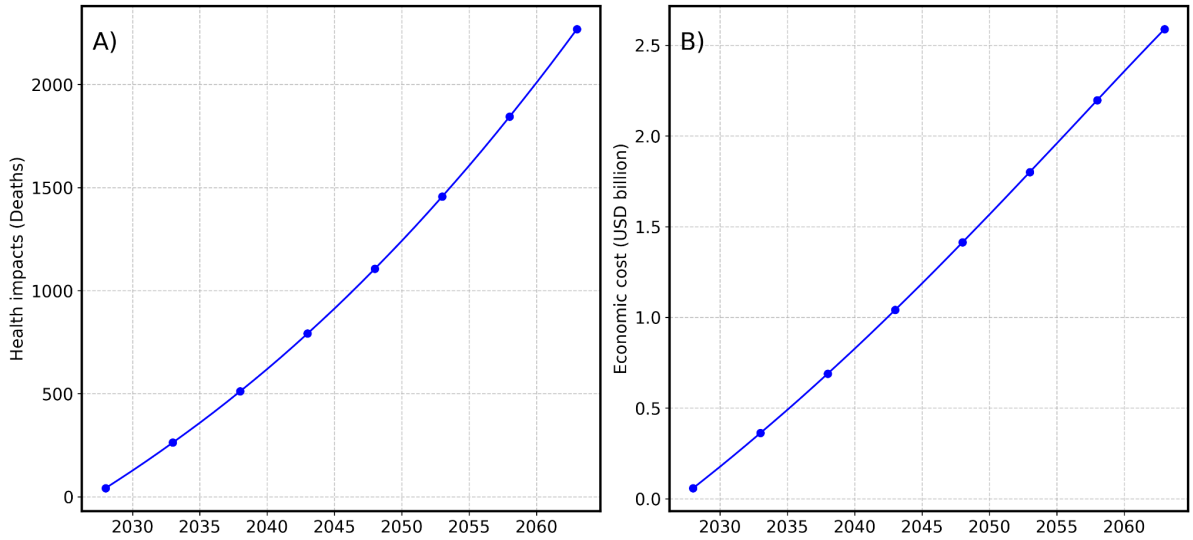

Figure 1 - Projected cumulative annual deaths (a) and total economic costs (b) of the Afşin A coal plant/station expansion (central values)

Table 2 shows the impacts of the added capacity to Afşin A on public health and the economy, accumulated over the whole lifetime of the facility. Over this whole time period, pollution from this facility will lead to over 2,000 deaths, over 1,700 (1,028–2,393) emergency room visits due to asthma, 907 (439–963) preterm births, 514 (159–893) low birthweight births, 755,904 (643,048–868,005) sick leave days, and 2,256 (793–4,310) years lived with disability.

Table 2 - Cumulative health impacts of the Afşin A coal plant expansion

Health outcome	Pollutant	Number (central value and 95% confidence interval)
Number of cases		
Deaths	All	2,268 (1,410–3,605)
Asthma emergency room visits	$PM_{2.5}$	1,714 (1,028–2,393)
Number of children suffering from asthma	NO_2	2,896 (764–6,035)
New cases of asthma in children	NO_2	626 (140–1,363)
Low birthweight births	$PM_{2.5}$	514 (159–893)
Preterm births	$PM_{2.5}$	907 (439–963)
Work absences (sick leave days)	$PM_{2.5}$	755,904 (643,048–868,005)
Years of lives lost		
All causes from NO_2 exposure	NO_2	6,944 (2,856–16,803)
All causes from SO_2 exposure	SO_2	5,247 (2,994–8,323)
Years lived with disability		
Chronic obstructive pulmonary disease	$PM_{2.5}$	1,225 (449–2,246)
Diabetes	$PM_{2.5}$	0 (0–0)
Stroke	$PM_{2.5}$	1,032 (344–2,064)
Total economic cost		
USD billion	All	2.6 (1.6–4.1)
Turkish lira billion*	All	88,4 (54,4-139,4) TL

* USD /TRY = 34,00 (September, 2024)

Comparison of the economic cost of health effects

This study calculates the air quality impacts following the projected 688 MW expansion of the Afşin A power plant. Air pollution from this facility will lead to a wide range of health impacts, which will damage the economy, through costs to local communities, businesses, and the state. In total, we estimate these damages to cost USD 2.6 billion (1.6–4.1) billion, which is a significant burden to society, especially when compared to public investments in local communities.

The Turkish government invested USD 443 million in the construction of five hospitals in the Kahramanmaraş region: Kahramanmaraş Public Hospital, Kahramanmaraş Afşin Public Hospital, Kahramanmaraş Türkoğlu Emergency Hospital, Kahramanmaraş Yörükselim City Hospital, and Kahramanmaraş Emergency Hospital. Together, these facilities provide a total of 2,120 hospital beds, translating to an average cost of USD 89 million per hospital and approximately USD 0.18 million per hospital bed. By extrapolating this data, we estimate that the USD is equivalent to the construction of 29 hospitals, each including 500 beds, with a total of 14,500 hospital beds. Expanding Afşin Elbistan A thus represents a double blow to public health and the economy—not only does it exacerbate the public health burden and increase economic costs to society, but it also diminishes the public funds available to strengthen healthcare systems.

Methodology

Pollutant emissions

We use the same estimate of pollutant emissions as in Myllyvirta et al. (2022). For this, we assume that the new units at Afşin A coal plant will be compliant with Turkish regulations, achieving SO_X, NO_X, and PM flue gas concentrations of 200, 200, and 30 mg/m^3, respectively. This results in SO_X, NO_X, and PM hourly emissions of 665, 665, and 99.8 kg/h, respectively.

Air dispersion model

We simulated air pollutant concentrations using the CALPUFF air dispersion model, version 7 (Scire et al., 2000; Exponent, 2015). CALPUFF has been a widely-used industry standard model for long-range air quality impacts of point sources, and used by regulators, such as the US Environmental Protection Agency (US EPA) (US EPA, 2023), and in academic research (Zhang et al., 2020). Due to its capability of capturing the complex chemical processes and atmospheric transport of pollutants in the atmosphere, the US EPA officially approves the use of the CALPUFF model to investigate cases where an emission source is expected to lead to the long-range transport of pollution (US EPA, 2023). The model has been evaluated extensively by the US Environmental Protection Agency, is open-source, and fully documented. The CALPUFF model has been applied in many regions around the world, including the United States (Rzeszutek, 2019), Europe (Holnicki et al., 2016), Central America (Hernández-Garcés et al., 2021), South America (Arregocés and Rojano, 2023), the Middle East (Ghannam and El-Fadel, 2013), Asia (Zhou et al., 2003; Jittra et al., 2015), and Africa (Affum et al., 2016).

Health and economic impact assessment

Based on the simulated distribution of pollutants ($PM_{2.5}$, NO_2, and SO_2) from CALPUFF, we applied corresponding public health and economic impacts for the year 2028 and projected the cumulative impact until 2063. We use the same method that is described in Myllyvirta et al. (2020). This framework takes information from epidemiological studies (e.g., air pollution concentration-response functions) and data from reliable public sources (e.g., incident rate, population, and country-wide GDP) to estimate the corresponding health endpoints associated with target air pollutants.

In general, health outcomes are evaluated using qualified concentration-response functions from peer-reviewed literature. This method is widely accepted and applied to air pollution-related health investigations across varying geographies and exposure levels. We use the concentration-response functions to estimate the associated health endpoints including adult deaths due to all related diseases, deaths of children under 5 years old, low birthweight births, asthma (emergency room visits and new cases in children), preterm births, workday absences due to illness, years lived with disability (COPD, diabetes, and stroke), and years of life lost. Details of these functions and data sources can be found in scientific research papers and open data sources (Burnett et al., 2018; Lelieveld et al., 2019; IHME, 2020). The calculation of health impacts follows a standard epidemiological calculation:

$$\Delta cases = Pop \times \sum_{age} \left[Frac_{age} \times Incidence_{age} \times \frac{RR_{c,age} - 1}{RR_{c,age}} \right],$$

Where:

Pop is the total population in the grid location;

age is the analysed age group; in the case of age-dependent concentration-response functions, a 5-year age segment; in other cases, the total age range to which the function is applicable;

$Frac_{age}$ is the fraction of the population belonging to the analysed age group;

Incidence is the baseline incidence of the analysed health condition;

c is the pollutant concentration with c_{base} referring to the baseline concentration or current ambient concentration; and,

$RR_{conc,\ age}$ is the function giving the risk ratio of the analysed health outcome at the given concentration for the given age group compared with clean air. In the case of a log-linear, non-age-specific concentration-response function, the RR function becomes:

$$RR(c) = RR_0 c - c_0 \Delta c_0 \ when\ c > c_0, 1\ \text{otherwise}$$

Where:

RR_0 is the risk ratio found in epidemiological research;

Δc_0 is the concentration change that RR_0 refers to; and,

c_0 is the assumed no-harm concentration - in general, the lowest concentration found in study data.

Data on the total population and population age structure was taken from the Global Burden of Disease results for 2019 (Murray et al., 2020), which was accessed by the Institute for Health Metrics and Evaluation (IHME, 2020). The spatial distribution of the population within each city and country, as projected for 2020, was based on the Gridded Population of the World v4 from the Center for International Earth Science Information Network (CIESIN, 2018). Adverse effects from air pollution induce lower life quality and economic productivity for people affected, and it increases the cost of healthcare. Economic costs due to air pollution were estimated using the methods outlined in Myllyvirta et al. (2020). The valuation of deaths was updated to the values derived by Viscusi & Masterman (2017). The Global Burden of Disease project has quantified the degree of disability caused by each disease into a 'disability weight' that can be used to compare the costs of different illnesses. The economic cost of disability and reduced quality of life caused by these diseases and disabilities are assessed based on disability weights, combined with the economic valuation of disability used by the UK environmental regulator DEFRA (Birchby et al., 2019). Since economic conditions vary between countries, we adjust the valuations using the Gross National Income (GNI) adjusted by Purchasing Power Parity (PPP) specific to Turkey.

Based on the annual public health and economic impacts for 2028, we then calculate the cumulative effects over the entire period of 2028 to 2063. We assume that the pollution concentrations remain the same as in the base year (2028) and apply it to future years (2028–2063) with the implementation of the projected population and costs per health impact. This calculation does not account for any changes in emissions (application of new techniques in the facility), base pollution level (pollution from other sources), or climatic changes.

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