Planlanan Afşin A Santrali Genişletme Projesinin Gelecekteki Hava Kalitesi ve Sağlık Etkileri

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Bu rapordaki emisyon projeksiyonları, hava kalitesi ve sağlık etkileri modellemeleri, Greenpeace Akdeniz için CREA tarafından yapılmıştır.

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Kahramanmaraş kömürlü termik santrallerden çok çekmiş bir şehir. Afşin - Elbistan ilçeleri civarında ilk kömürlü termik santralin ve açık kömür madeninin açıldığı 1984 yılından itibaren, başta Elbistan Ovası olmak üzere bölge eşine az rastlanır bir bir çevre tahribatına maruz kalıyor ve büyük halk sağlığı sorunları ortaya çıkıyor. Santraller, bölgenin havasını zehirliyor, beslenme ve geçim kaynağı olan tarımsal üretimi zayıflatıyor ve Ceyhan Havzası'nın can suyu olan Ceyhan Nehri'nin debisini santral başına saniyede çektiği 3er litre su ile düşürüyor, kaynağını zayıflatıyor.

Afşin - Elbistan'a ödetilen bedel:
Greenpeace Akdeniz olarak gerçekleştirdiğimiz çalışmalarla, bölgedeki iki aktif santral olan Afşin A ve Afşin B'nin yarattığı tahribatı ortaya koyduk:

- 2018'de yaptığımız çalışma, bu iki santralin, faaliyete geçişlerinden 2018'e kadar tahminen toplam 17 bin erken ölüme neden olduğunu,
- Planlanan 6 ek santralin ekonomik ömürleri boyunca çalıştığı koşulun eklenmesi ile bu sayının 32 bine yükselebileceğini ortaya koymuştu.[1]

Devletin resmi rakamlarının da bu çalışmayı desteklediği düşünülebilir. 17 Mayıs 2001'de, Sağlık Bakanlığı'na bağlı Elbistan Sağlık Grup Başkanlığı'nın, Ankara Onkoloji Başhekimliği'nden bölgedeki kanser hastalarıyla ilgili bulunduğu bilgi talebine, Başhekimliğin verdiği cevap çok çarpıcı:

Çizelge 19 : Afşin-Elbistan çevresinden Ankara Onkoloji Hastanesine Tedavi amaçlı olarak giden hasta sayısının yıllara göre dağılımı(Ank.Onk.Hast.Raporu)

YILLAR	1980	1981	1982	1983	1984	1985	1986	1987	1988
HASTA SAYISI	17	27	11	12	11	16	23	11	8
YILLAR	1989	1990	1991	1992	1993	1994	1995	1996	1997
HASTA SAYISI	59	97	68	57	94	50	81	61	80

[1] Afşin'de Kömürlü Termik Santrallerin Bedeli - https://www.greenpeace.org/static/planet4-turkey-stateless/2019/09/a6735e23-a6735e23-afsinde-komurlu-termik-santrallerin-bedeli.pdf

Ankara Onkoloji Hastanesi'nin raporunda yer alan bu çizelgeye göre, Afşin - Elbistan çevresinden Ankara Onkoloji Hastanesi'ne tedavi için giden hasta sayısı,1980'lerde yılda ortalama 10-12 iken; Afşin A santralinin faaliyete geçişinin 5. senesinde (1989) 8'den 59'a fırlıyor. 1990'lı yıllarla beraber ise bu sayının ortalaması 80'e çıkıyor. 1984 ile 1993 arasındaki dönemdeki artış 8 kattan fazla.[2]

Bu, Afşin A santralinin, bölgedeki kanser riskini artırmış olabileceğini gösteriyor. Buna rağmen, resmi makamların bu santrallerin faaliyetini durdurmaması ise gerçekten acı verici ve sorumluluk yaratan bir görev ihmali. 17 bin erken ölüm, kaybolan hayatlar, parçalanan aileler, mahvolan doğa, bozulan iklim.

Elbistan Ovası ve krize sokulan iklim:
Sorun bununla sınırlı değil. Santraller, etki sahası başta olmak üzere çevre bölgelerin ortalama sıcaklıklarının artmasıyla ilişkilenidirilmiş durumda. Bu etkiyi araştıran bir çalışmaya göre:

- 1984'te ova içerisinde gözlenen sıcaklıklar 33 derece iken, 2010 yılında 38 dereceye yükselmiştir.
- A sektörü içerisinde 1984'te gözlenen en düşük sıcaklık 21,5 derece iken, 2010 yılında en düşük değer 31,2 derece ölçülmüştür. Sektör içerisinde en yüksek sıcaklıklar özellikle kömür taşıma bantları çevresinde 2003 ve 2010 yıllarında ortalama 49 derece ölçülmektedir.[3]

Bu korkutucu rakamlara rağmen, bölge halkı santrallerle yaşamaya mecbur bırakılmış, santralin emisyonları nedeniyle tarımsal ürün ve gelir kaybına uğrayan çiftçiler ise, 2011 yılından itibaren tazminat alamıyor.[4]

Filmin devamı: filtre oyunları, genişletme planları
Afşin A santrali, yerel hareketlerin ve sivil toplumun yürüttüğü ısrarlı ve yoğun kampanyalar sonucu 1 Ocak 2020 itibariyle çevre yatırımlarını tamamlamadığı için, aynı durumdaki 12 santralle birlikte kapatıldı. Aynı yılın Haziran ayında, sacece 6 ay sonra,

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[2] Afşin Elbistan Santrali'nin Çevresel Etkileri. Mehmet Ekici – Yüksek Lisans Tezi
[3] "Afşin-Elbistan Termik Santrali Çevresinde Yer Yüzey Sıcaklıklarının Değişimi" (Muhterem KÜÇÜKÖNDER, Murat KARABULUT, Mehmet Ali ÇELİK)
[4] https://yesilgazete.org/kuller-ve-kokler-1-yuzde-5-icin/

öngörülen izin süresi olan 6 yıl boyunca tamamlamadığı yatırımlarını gerçekleştirdiği iddiasıyla, 2 ünitesi ile yeniden faaliyete başladı.[5]

Greenpeace Akdeniz olarak, Santral sahibinin gerekli baca gazı kükürt giderim filtre sistemlerini tamamladığını iddia ettiği 2020 yılının Ekim - Kasım ayları içinde, santrallerin etki sahası içinde 1 ay süren bir hava kalitesi ölçümü gerçekleştirdik.[6] Bu ölçümde:

- En yüksek 24 saatlik PM10 değeri (320µg/m^3), Dünya Sağlık Örgütü'nün (DSÖ) önerdiği 24 saatlik PM10 rehber değerinin 7 katından yüksek,
- En yüksek 24 saatlik PM2,5 değeri (105µg/m^3) ise, Dünya Sağlık Örgütü'nün (DSÖ) önerdiği 24 saatlik PM2,5 rehber değerinin 7 katı çıktı.

Bu sonuçlara ve Sanayi Kaynaklı Hava Kirliliğinin Kontrolü Yönetmeliği'nde belirtilen limitleri hayli aşan parçacık madde kaynaklı emisyon seviyelerine rağmen, rağmen tesisin yasal izinlerinde herhangi bir değişiklik olmadı ve santral, artan performansta çalışmaya, bölgeyi zehirlemeye devam ediyor.

Bu raporun incelediği konu olan Afşin A santralinin genişletme projesini, tüm bu gerçekler ile birlikte düşünmek zorundayız. Afşin A santrali, faaliyete geçtiği 1984 yılından itibaren bölgede toplamda on binlerce ölüm ve hastalık vakasına neden olmuş, doğaya geri dönüşümü neredeyse imkansız yıkımlar getirmiştir. Bu tesis, bölge halkının, hayat hikayelerini, santral öncesi yaşamlarına dair hafızalarını karartmıştır.

Afşin A hemen başucuna kurulmadan önce, Çoğulhan, 8 bin nüfuslu, kalabalık, yanıbaşındaki Elbistan Ovası'nın verimli topraklarıyla beslenen ve geçinen, sosyal mekanları ve hatta bir sineması bulunan, yaşam dolu bir yerleşim yeriydi. Santral sonrasında kanser ve diğer hastalıklarla dolup taşan, tarımsal üretimi önemli ölçüde gerileyen, hayvancılığı bitme noktasına gelen ve nihayet nüfusu 1500'e kadar düşen bir hayalet kasabaya dönüştü. Çoğulhan'dan ve aynı kaderi paylaşan birçok yakın yerleşim yerinden ayrılmaya gücü yetmeyen insanlar ise bu dayanılmaz şartlarla baş başa kaldı. Genişletilmek istenen, iste bu şartları yaratan santraldir ve bu projenin ÇED başvuru dosyasındaki[7] verilere dayanan bu raporun ortaya koyduğu üzere, tahmini olarak:

- Yılda 50, ekonomik ömrü boyunca 1900 erken ölüme neden olacaktır

[5] *2013 yılında, Elektrik Piyasası Kanunu'nun Geçici 8. Maddesi ile 10 santrale, baca gazı arıtma tesisi başta olmak üzere çevre yatırımlarını 2019 yılına kadar erteleme izni verildi.*

[6] https://www.greenpeace.org/turkey/raporlar/hava-kalitesi-olcum-raporu-afsin-elbistan-a-ve-b/

[7] http://eced.csb.gov.tr/ced/jsp/ek1/32162#

- Yarısı çalışılan alan üzerinde (1500e 1500 km. lik) olmak üzere yılda toplam 960 kg. cıva birikimi yaratacaktır
- Çocuklarda her yıl 1860 astım ve bronşit semptomu yaratacaktır
- Yılda 870 ton kömür tozu ve uçucu kül açığa çıkaracaktır
- Yılda 74 bin hasta geçirilecek güne, 8 bin 280 iş günü kaybına neden olacaktır

These are the impacts from the expansion project alone and do not include the impacts of the existing coal power plants.

Bular sadece eklenmesi planlanan iki üniteden kaynaklanacak olan etkilerdir ve mevcut kömürlü termik santralleri etkisini içermemektedir.

Paris Anlaşması öncesi, Paris Anlaşması sonrası
Türkiye, 6 Ekim 2021'de Paris Anlaşması'nın TBMM'de onayladı ve iklim değişikliğine karşı süren küresel mücadelede sorumluluk sözü vermiş oldu. Bu olumlu gelişmeye rağmen Türkiye'nin bu anlaşmanın gereklerini yerine getirecek gibi göründüğünü ileri sürmek zor. Çünkü ülkenin henüz bir kömürden çıkış planı yok ve yeni kömürlü termik santraller için ÇED süreçleri işletilmeye devam ediliyor.

Bu senenin Şubat ayında gerçekleşen ve Türkiye'nin iklim değişikliği ile mücadelesinin temelini atmak gibi gibi büyük bir iddiada bulunan İklim Şurası ise hayal kırıklığı ile sonuçlandı. Şuranın çalışma komisyonlarından olan Sera Gazı Azaltım - 1 Komisyonu'nun "kömürden kademeli çıkış" üzerindeki konsensus, Şura'nın nihai kararlarından çıkarıldı. Böylece, Türkiye iklim kriziyle mücadelenin ana zemini olan kömürden çıkışa çevirmiş oldu. Yetmedi, hemen sonrasında, 1 Mart 2022'de Maden Yasası'nda yapılan bir yönetmelik değişikliği ile, elektrik üretimi için gerekli madenlerin bulunduğu zeytinliklerde madencilik faaliyetinin önünü açan bir adım atıldı.

Uluslararası Enerji Ajansı'nın verilerine göre, kömür yakımı kaynaklı karbondioksit salımları, sanayi devrimleri öncesi dönemlere kıyasla yaşadığımız sıcaklık artışının yüzde 30'undan fazlasından sorumlu.[8] IPCC raporları da, Türkiye'nin içinde bulunduğu Akdeniz Havzası'nın, iklim değişikliğinden en çok etkilenecek bölge olduğunu ifade ediyor. Durum buyken yaşanan bu gelişmeler, sadece karşı karşıya bulunduğumuz bu tehdidi derinleştirmeye yarayacaktır. 2021 yazında yaşadığımız orman yangını fırtınası hafızalarımızda henüz çok taze.

[8] https://www.iea.org/reports/global-energy-co2-status-report-2019/emissions

Bitirirken

İklim krizi çağındayız ve attığımız her adımı çok dikkatli belirlememiz gerekiyor. İklim krizinde ayakta kalabilmek istiyorsak fosil yakıtları mutlak olarak tarih sahnesinden indirmemiz gerekiyor -hem kendi ülkemizin sınırlarında, hem gezegenin tamamında.

Greenpeace Akdeniz olarak, gerek bulunduğu bölgeyi, gerek çevre illeri, gerekse Türkiye'yi ve tüm gezegeni iklim krizinin etkilerine karşı dirençsiz kılacak bu genişletme projesinin kalıcı olarak iptal edilmesini talep ediyoruz. Bununla birlikte, bölgede inşa edilmek üzere ÇED süreçleri devam eden Afşin C ve Akbayır santrallerinden de vazgeçilmesini talep ediyoruz. Halk sağlığı, insanların, hayvanların ve tüm canlıların yaşam hakkı tüm yatırımların, tüm politikaların üstündedir. Dengeli bir iklimi amaçlayan politika yapımı ve karar alımı ise, günümüzde bu gerçeğin merkezinde duruyor. Bu hedefe yönelen tüm çalışmalarımızın, karar vericilere, iklim krizi ve halk sağlığı bağlamında alınacak kararlarda katkı sağlamasını umuyoruz.

Onur Akgül
Greenpeace Akdeniz İklim ve Enerji Proje Sorumlusu

Summary

The Afşin-Elbistan area in eastern Turkey contains the largest concentration of operating coal-fired power plants in the country. These coal-fired power plants are major point sources of air pollution, with remarkably high air pollutant emission rates and impacts on communities and ecosystems both locally and for hundreds of kilometres around.

This case study provides an analysis of the air quality, toxic and health impacts of the proposed expansion of the lignite power plant Afşin A, combining detailed atmospheric modelling with existing epidemiological data and literature.

The emissions from the studied power plant would elevate the levels of toxic particles and gases in the air over the region, increasing the risk of diseases such as stroke, lung cancer, heart and respiratory diseases in adults, as well as respiratory infections in children.

The emissions from the power plant expansion are estimated to result in 50 premature deaths per year due to exposure to $PM_{2.5}$ and NO_2 (95% confidence interval: 30–60). Over the operating life of the plant, the cumulative toll on health is estimated at 1,900 premature deaths (95% confidence interval: 1,200–2,500).

The additional units at the plant would emit an estimated 960 kg/year of mercury, of which approximately 500 kg would be deposited within the study area, increasing toxic mercury levels. The deposition from the new plant alone would exceed the European average level in areas with 500,000 inhabitants (GMA 2018).

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Introduction

Air pollution can lead to severe adverse effects on human health, including premature death (WHO HRAPIE, 2013). It is the fourth leading risk factor for premature death globally (HEI, 2020) which makes it the greatest environmental risk factor for premature death (WHO, 2021). Every year, more than 4 million people worldwide die prematurely due to exposure to ambient $PM_{2.5}$ (dust particles with a diameter below 2.5 µm; WHO, 2021). In Turkey, air pollution shortens life expectancy by a year and seven months, on average (Lee & Greenstone, 2021).

There are large domestic reserves of coal in Turkey, much of which is formed of lignite, a low grade coal, also known as brown coal. The Turkish government currently plans to exploit these reserves as part of its strategy to reduce reliance on imported energy sources (IEA, 2021).

However, the production and use of coal, and in particular lignite, for electricity generation is a source of both air pollutants and greenhouse gases. Coal burning was responsible for 43% of Turkey's energy-related CO_2 emissions in 2018 and Turkey's coal-related CO_2 emissions have increased by nearly 32% in the last decade (IEA, 2021).

When coal is burned in power plants, a large range of harmful substances are emitted into the environment. These include nitrogen oxides (NO and NO_2, jointly referred to as NO_x), sulphur dioxide (SO_2) and fine particulate matter (PM2.5) which contribute to respiratory illnesses, mercury and other heavy metals (which have been linked to both neurological and developmental damage in humans) and fly ash and bottom ash (which are residues created when power plants burn coal). These pollutants can travel hundreds of kilometres through the air and can cause adverse environmental and health impacts in the surrounding areas.

Turkish coal-fired power plants had an installed capacity of 19.7 GW at the end of 2018 (Euracoal, 2022) and by 2027 Turkey wants to add new lignite power generation capacity of 7.5 GW (IEA, 2021). Any increase in capacity will lead to greater emissions of atmospheric pollutants with subsequent adverse consequences for air quality, climate and health.

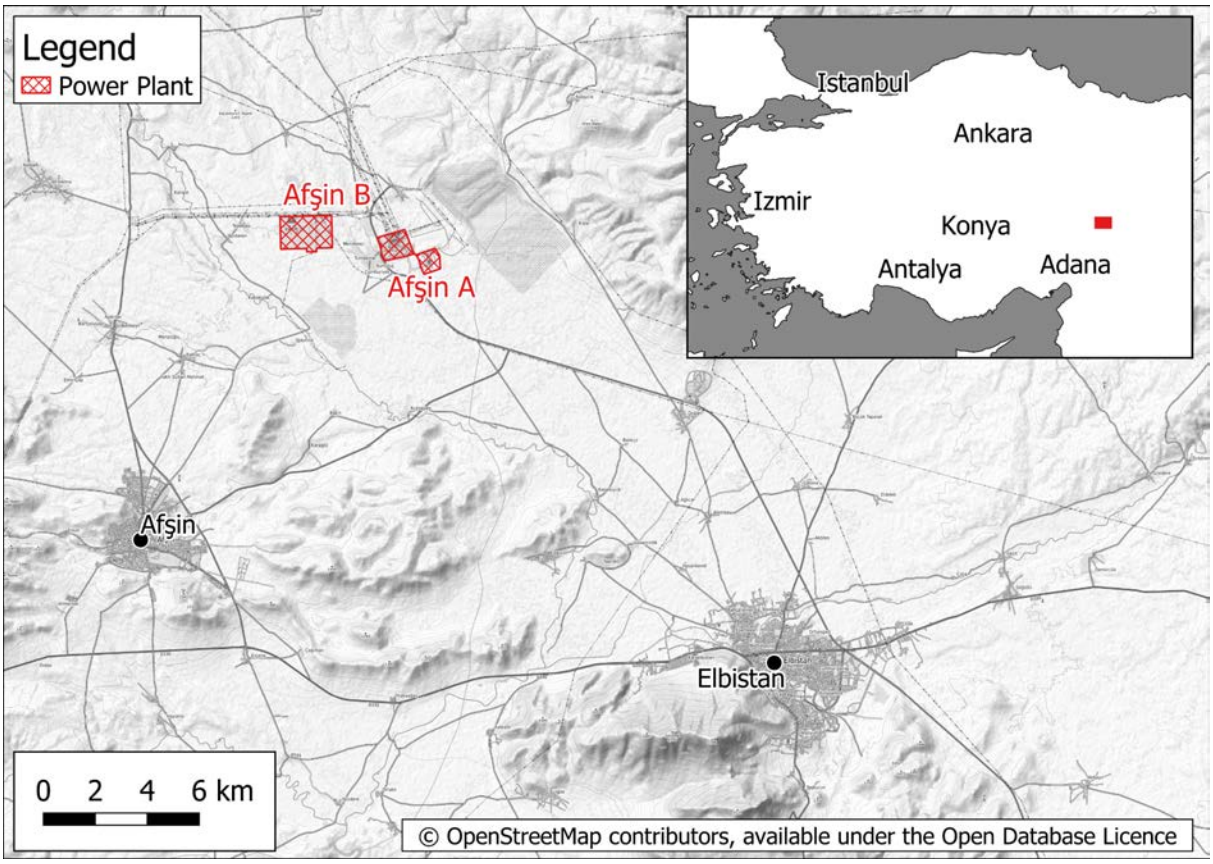

Figure 1. Location Map: *The Afşin A and B power plants are located in Kahramanmaraş Province in eastern Turkey.*

The Afşin power plant complex is located in Kahramanmaraş Province, Turkey. It consists of two operational plants, Afşin A and Afşin B (Figure 1). Afşin A began operating in 1984–87, and Afşin B in 2005–2006.

There are currently four power generating units at Afşin A, which are fired with lignite from the adjacent Kışlaköy coal mine. At Afşin B there are a further 4 units, units 1, 2 and 4 are fired with lignite, while unit 3 has been converted for firing with fossil gas (GEM, 2022).

It has been proposed by Afşin Elbistan Electricity Generation Inc. that Afşin A is expanded with two additional lignite fired power generation units (Çınar, 2022). This report assesses the potential for future health impacts should the proposed expansion of Afşin A go ahead. Emissions from the existing power plants are not included in the assessment, but have been recently investigated elsewhere (HEAL, 2021).

Separate official proposals exist for two additional plants, Afşin C, and Akbayır on an adjacent site. The potential impacts of these two plants are not studied in this report.

The assessment of the Afşin A expansion uses an atmospheric dispersion model to estimate near-surface pollutant concentrations resulting from the operation of the two proposed units over the surrounding region. In addition to air pollutant concentrations, this report also estimates deposition of the potent neurotoxin mercury. The modelled pollutant concentrations are then used toquantify the ways in which pollution from the power stations affects the health of the affected population by applying risk functions from WHO HRAPIE (2013), Dadvand et al. (2013) and Huscher et al. (2017). Full details of the dispersion modelling approach and health impact assessment are provided in the Appendix.

Results

Air Pollution

The air quality impacts of emissions from the plants were modelled using the CALPUFF dispersion model, which uses detailed hourly data on wind and other atmospheric conditions to track the transport, chemical transformation and deposition of pollutants, and is widely used to assess the short and long range impacts of emissions from industrial point sources and area sources. The model projects the increases in hourly, daily and annual pollutant concentrations caused by emissions from the studied source.

Emissions from the power plant contribute to ambient concentrations of $PM_{2.5}$, NO_2 and SO_2, causing increases in the risk of both acute and chronic diseases and symptoms.

The modelling results indicate that the expansion of the power plant would adversely affect air quality in the entire region from the Gulf of İskenderun in the south to the Black Sea coast in the north. The worst impacts take place 10–30 km northeast to northwest of the plant. The highest 24-hour incremental $PM_{2.5}$, SO_2 and NO_2 concentrations reach one third of the World Health Organization's Air Quality Guidelines (Figures 2, 3, 4). Given that these guidelines are already being breached due to the emissions from the existing power plants (HEAL, 2021), the expansion would worsen the situation and increase the number of exceedances and the extent of the area where they occur.

![GREENPEACE]

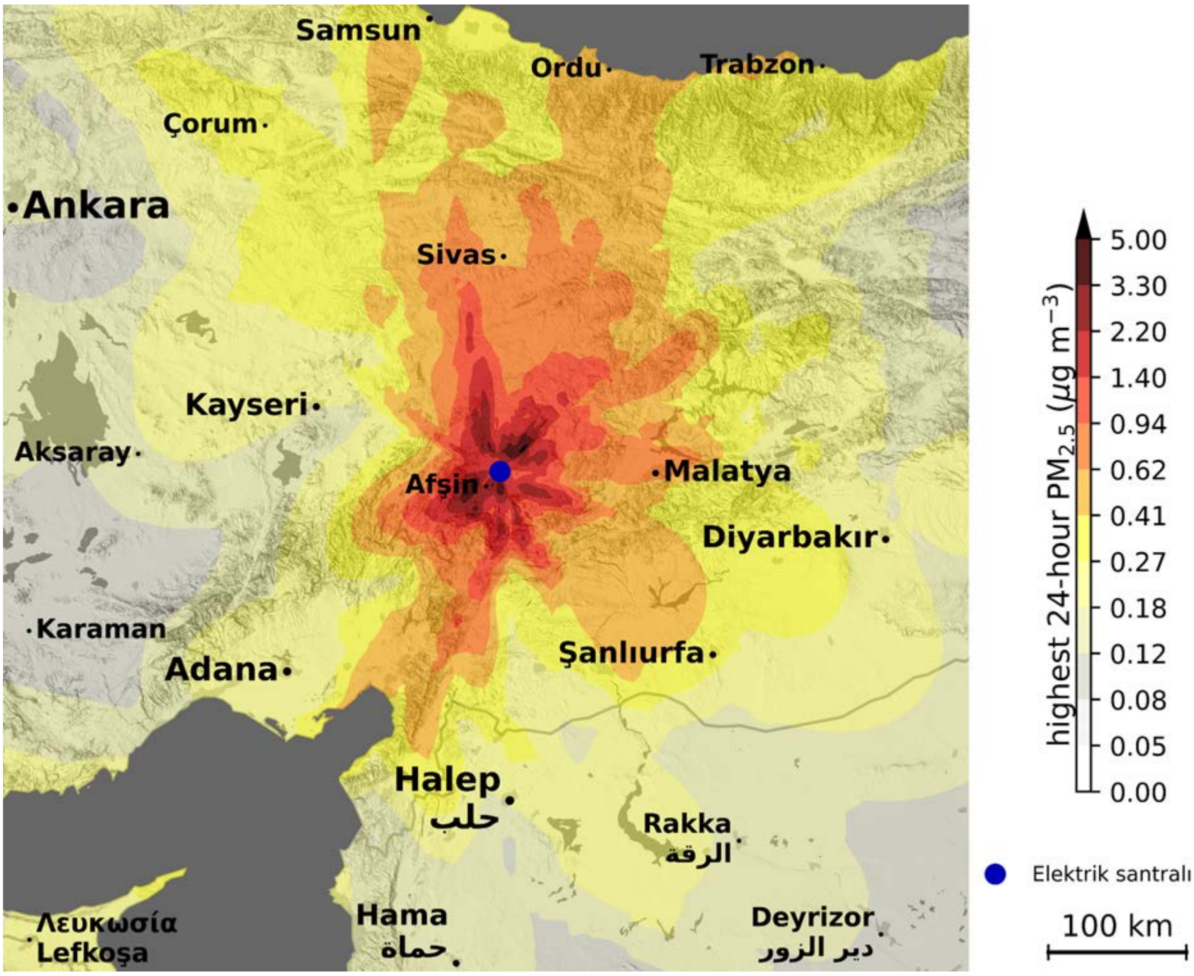

Figure 2. *The projected highest 24-hour mean $PM_{2.5}$ concentrations attributable to emissions from the Afşin A expansion.*

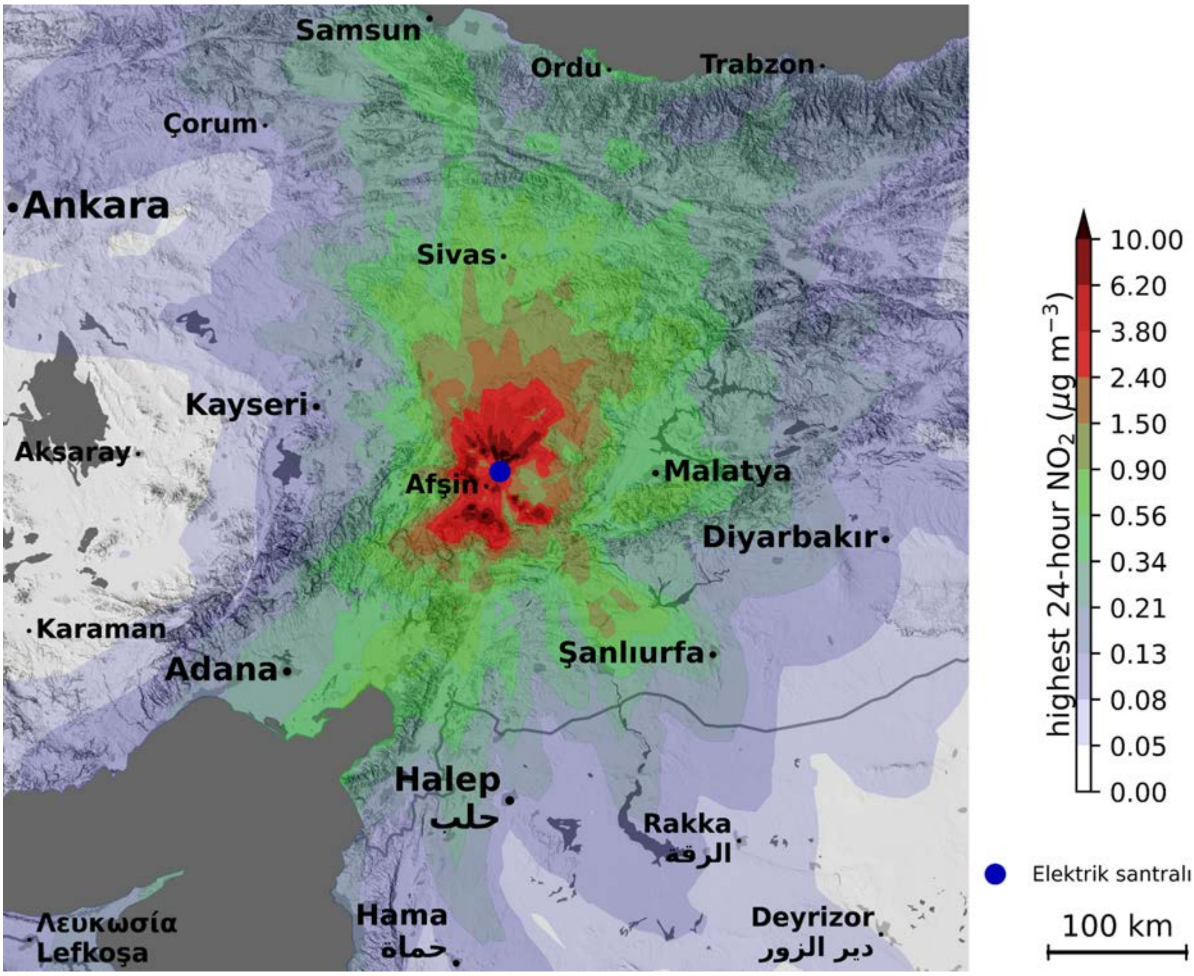

Figure 3. *The projected highest 24-hour mean NO_2 concentrations attributable to emissions from the Afşin A expansion.*

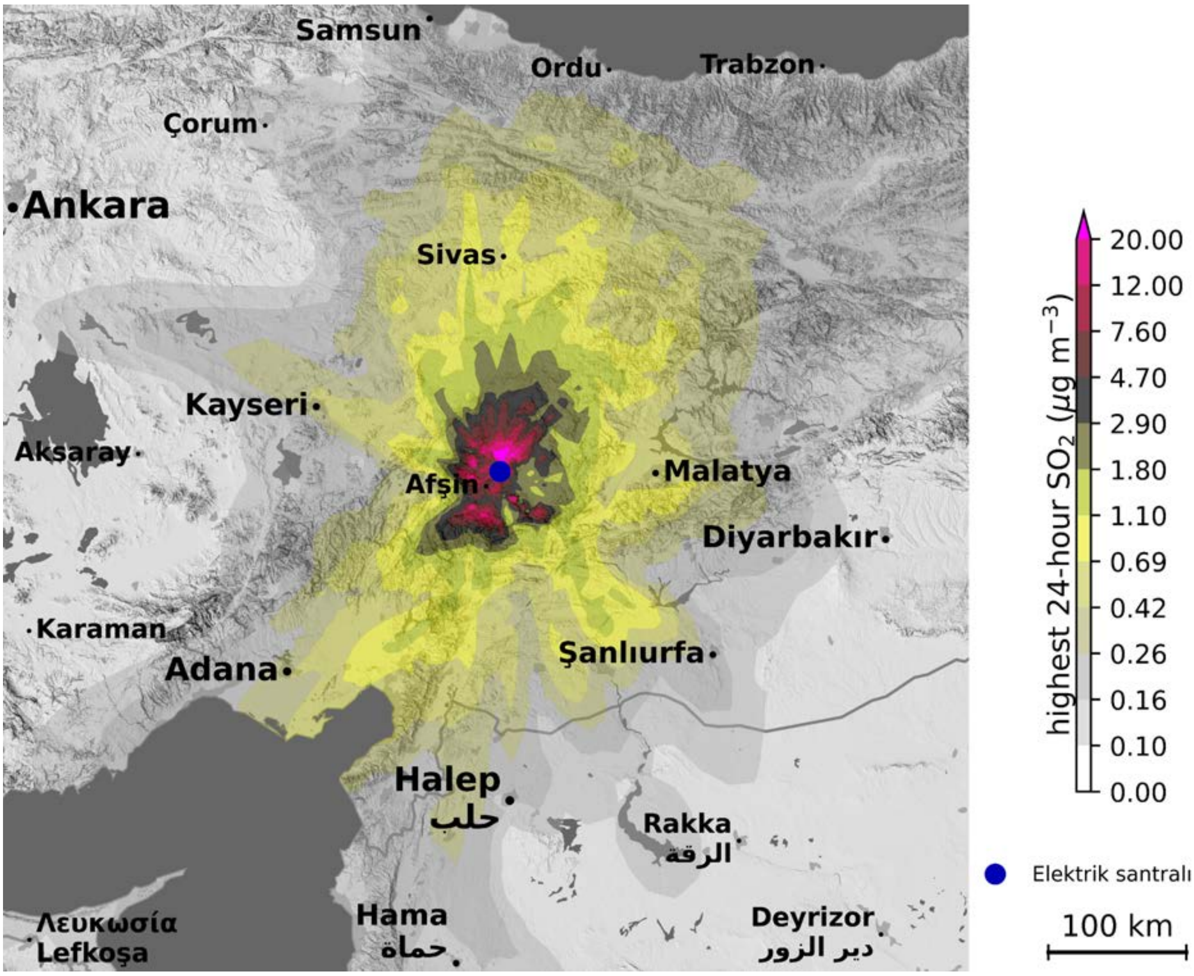

Figure 4. *The projected highest 24-hour mean SO_2 concentrations attributable to emissions from the Afşin A expansion.*

Annual average concentrations of $PM_{2.5}$ and NO_2 would also be affected across the entire region (Figures 5 and 6). The projected contributions to the $PM_{2.5}$, and NO_2 annual mean concentrations and the potential health consequences of these contributions are discussed in the Health Impacts section below.

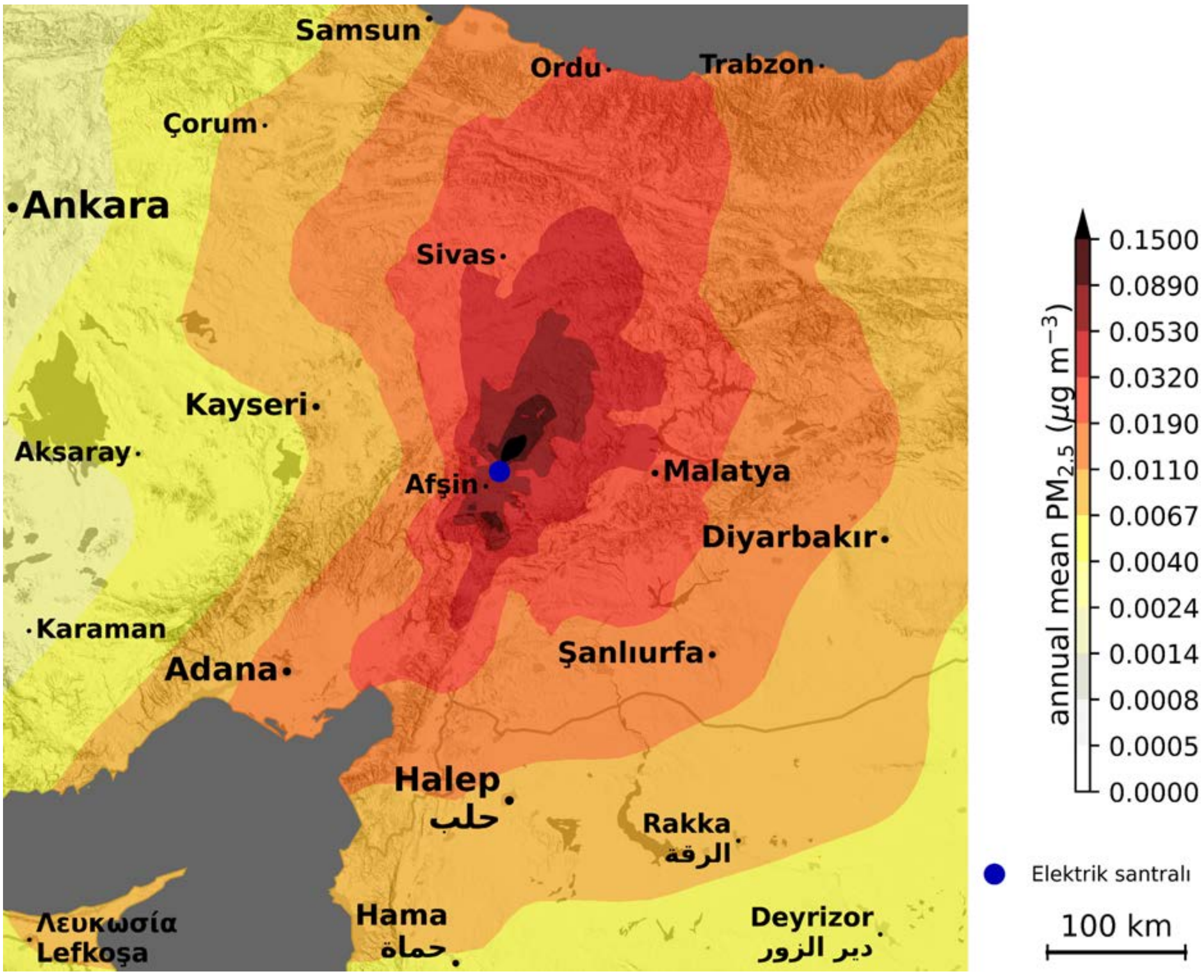

Figure 5. *The projected annual mean $PM_{2.5}$ concentrations attributable to emissions from the Afşin A expansion.*

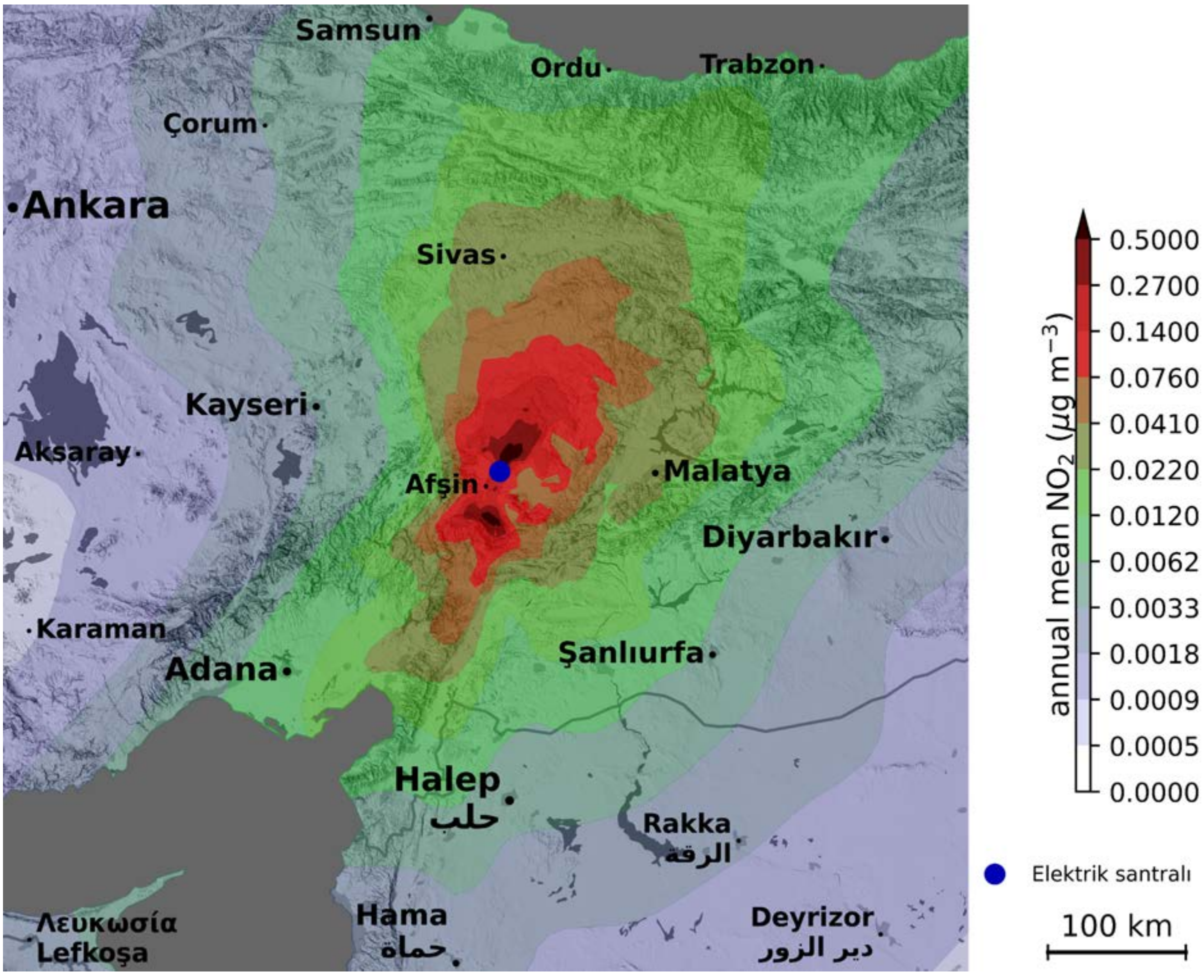

Figure 6. *The projected annual mean NO_2 concentrations attributable to emissions from the Afşin A expansion.*

Toxic Deposition

If the Afşin A power plant expansion were to go ahead, it would emit an estimated 960 kg of mercury per year and 870 tons of heavy metal-containing particulate matter (coal dust and fly ash) per year.

Approximately 500 kg per year of the mercury that would be emitted by the plants is projected to be deposited into land and freshwater ecosystems inside the 1500-by-1500 km modelling domain, the remaining 460 kg of mercury would be transported elsewhere and continue to circulate in the global environment. The largest increases in mercury deposition are projected to occur to the north of the plants with some areas experiencing deposition rate increases of over 100 µg/m^2/year and over 200 µg/m^2/year in the worst affected areas (Figure 7). To put this in context, the average anthropogenic mercury deposition rate in Europe is estimated to be around 5 µg/m^2/year (GMA 2018). The model results indicate that the deposition from the new power plant expansion alone would exceed this value in an area with around 500,000 inhabitants.

Increasing the rate of mercury deposition will lead to it accumulating in the environment, including accumulation in fish (Harris et al 2007). While actual mercury uptake and biomagnification depends very strongly on local chemistry, hydrology and biology, the predicted mercury deposition rates here are a cause for serious concern and an assessment of the impacts and of measures to reduce mercury emissions is needed, especially as the cumulative impact with the existing plants is much larger than the impact of the expansion alone.

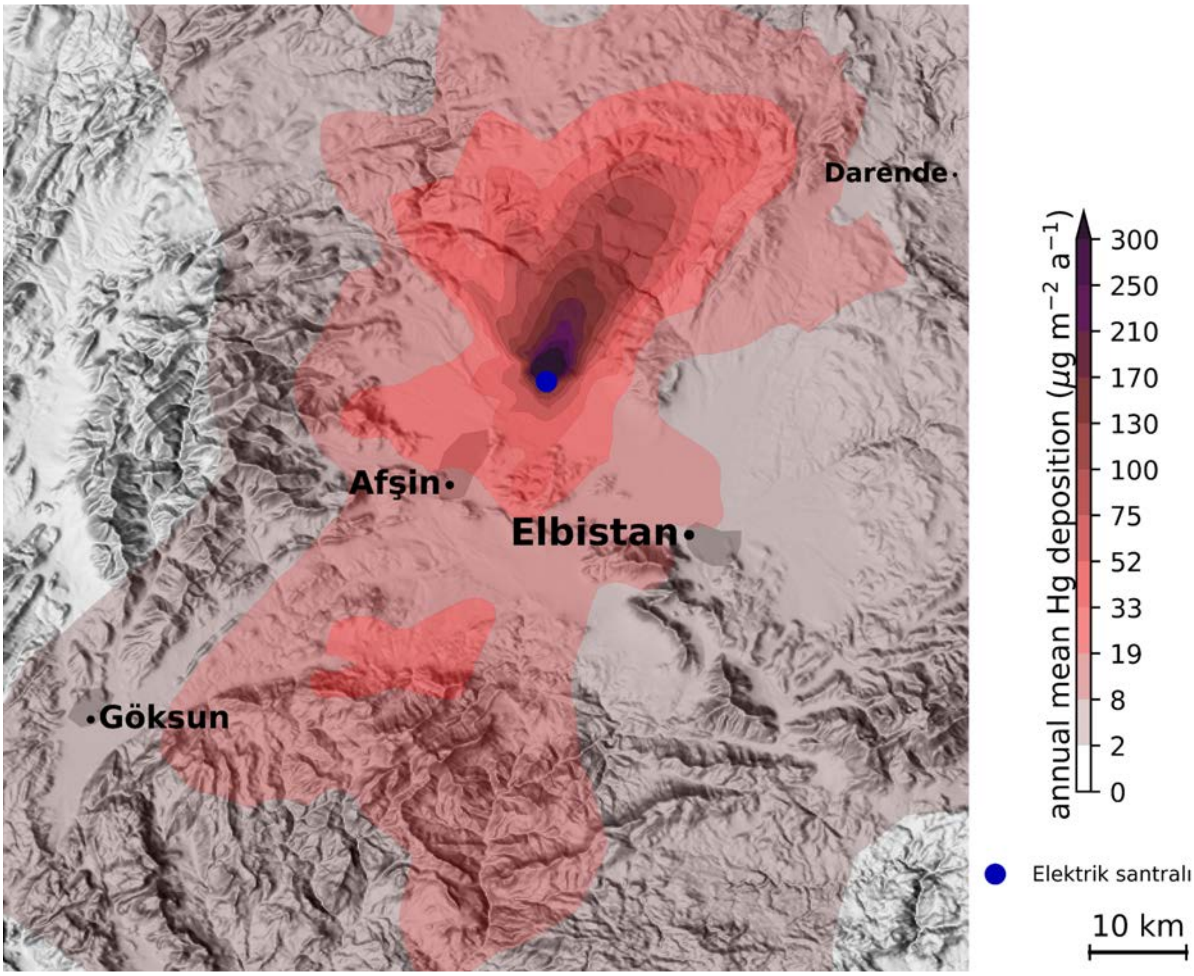

Figure 7. *The projected annual mean mercury deposition attributable to emissions from the Afşin A expansion.*

Health Impacts

The emissions from the power plant expansion are estimated to result in about 50 premature deaths per year due to exposure to $PM_{2.5}$ and NO_2 (95%-confidence interval: 30–60). Over an assumed 30-year operating time of the units, the cumulative toll on health of the local population through air pollution is estimated at about 1,900 premature deaths (95% confidence interval: 1,200–2,500). Other projected cumulative health impacts include about 530 low weight births, 720 new cases of chronic bronchitis in adults, 4,300 cases of bronchitis in children, 1,550 hospital admissions and 280,000 lost working days over the 30 years.

Table 2. *Projected health impacts during the first year of operation.*

Effect	Pollutant	Unit	Total	95%-confidence interval
premature deaths	$PM_{2.5}$	cases per year	31	(20 – 42)
premature deaths	NO_2	cases per year	15	(8 – 21)
low birth weight	$PM_{2.5}$	births per year	16	(5 – 27)
asthmatic and bronchitis symptoms in children	PM_{10}	cases per year	1,160	(251 – 2,090)
chronic bronchitis in adults	PM_{10}	new cases per year	21	(7 – 33)
bronchitis in children	PM_{10}	cases	129	(-34 – 292)
hospital admissions	$PM_{2.5}$	cases per year	36	(1 – 71)
hospital admissions	NO_2	cases per year	10	(7 – 14)
sickness days	$PM_{2.5}$	person days per year	74,300	(66,500 – 83,500)
lost working days	$PM_{2.5}$	person days per year	8,280	(7,040 – 9,510)

Table 3. *Projected cumulative health impacts over the assumed operating life of the units of 30 years.*

Effect	Pollutant	Unit	Total	95%-confidence interval
premature deaths	$PM_{2.5}$	cases	1,280	(834 – 1,700)
premature deaths	NO_2	cases	586	(334 – 842)
low birth weight	$PM_{2.5}$	births	527	(164 – 916)
asthmatic and bronchitis symptoms in children	PM_{10}	cases	38,700	(8,380 – 69,600)
chronic bronchitis in adults	PM_{10}	new cases	719	(255 – 1,120)
bronchitis in children	PM_{10}	cases	4,290	(-1,130 – 9,700)
hospital admissions	$PM_{2.5}$	cases	1,220	(50 – 2,390)
hospital admissions	NO_2	cases	335	(214 – 454)
sickness days	$PM_{2.5}$	person-days	2,510,000	(2,250,000 – 2,820,000)
lost working days	$PM_{2.5}$	person-days	292,000	(249,000 – 336,000)

Appendix

Emission calculations

Emissions from the planned power plant units were calculated based on the following equation for emissions rate:

$$ER = CAP / EFF \times SFGV \times FGC,$$

where CAP is the electric output capacity of the power generating unit, EFF is thermal efficiency, SFGV is the specific flue gas volume of the fuel per energy unit (in Nm^3/GJ) and FGC is the pollutant concentration in flue gas, based on the Turkish regulated emissions limit values. In other words, the effect of emissions control technologies that the plant will be required to install to comply with regulation is taken into account in the research. The basis for the other values is given in Table 4 below.

SFGV was calculated from the ultimate analysis of Afşin lignite given in EUAS (2004), using the stoichiometric formula given in ISO EN-12952-15 (Eq. 8.3-60, p. 42):

$$SFGV_{kg} = 8.8930\ C + 20.9724\ H + 3.3190\ S + 2.6424\ O + 0.7997\ N,$$

where $SFGV_{kg}$ is the normalised dry flue gas volume per kg of fuel, and the variables on the right-hand side of the equation are the concentrations of different elements in the as-received fuel. Further,

$$SFGV = SFGV_{kg} / NCV \times AF,$$

where NCV is the net calorific value of the fuel, again given in EUAS (2004), and AF is the air factor, based on 6% excess oxygen in the flue gas.

Mercury emissions were calculated as:

$$ER_{Hg} = CC \times C_{Hg} \times (1 - CE),$$

where CC is the plant's coal consumption (t/h), C_{Hg} is the mercury content of the coal, and CE is the capture efficiency, with the values for Turkish lignite and for lignite-fired power plants equipped with flue gas desulfurization and electrostatic precipitators taken from UNEP (2017).

The dust emission estimates were converted to PM_{10} using a PM_{10}/TSP ratio[9] of 54/80 and to $PM_{2.5}$ emissions using a $PM_{2.5}/PM_{10}$ ratio of 24/54, based on the U.S. EPA (1998) AP-42

[9] TSP: total suspended particulate matter

default emissions factors for electrostatic precipitators at coal-fired utility boilers. The speciation of airborne mercury from lignite firing was based on Lu et al. (2009).

Table 4. *Emission and source-characteristic data used for the atmospheric modelling.*

Parameter		Value	Source/basis
Unit characteristics	Latitude	38.346	Location of existing units
	Longitude	37.026	
	Capacity, MW	688	Environmental impact assessment (Çınar, 2022)
	Units	2	
	Average utilisation	86%	Environmental impact assessment (Çınar, 2022)
	Thermal efficiency	38.7%	Calculated
	Coal calorific value (kcal/kg)	1050	EUAS 2004
	Coal use (t/h)	1458	Environmental impact assessment (Çınar, 2022)
	Hg content in fuel (µg/kg)	110	UNEP 2017
	Mercury retention rate	20%	UNEP 2017
Flue gas release	height above ground, m	150	Assumed based on information for other new projects in Afşin-Elbistan
	stack inner diameter at top, m	7.2	Calculated from flue gas volume an exit velocity
	exit velocity, m/s	14	Assumed based on information for other new projects in Afşin-Elbistan
	exit temperature, C	70	Assumed based on information for other new projects in Afşin-Elbistan
	Flue Gas Volume, Nm^3/GJ	519	Calculated from EUAS data (Afşin-Elbistan A rehabilitation project EIA)
	Flue Gas Volume, Nm^3/h	3,327,039	Calculated
Emission Limit Value, mg/Nm^3	SO_2	200	Turkish regulation
	NO_x	200	Turkish regulation
	dust	30	Turkish regulation

Pollutant emission, kg/h	SO_2	665	Calculated
	NO_x	665	Calculated
	dust	99.8	Calculated
	Hg	0.13	Calculated

Atmospheric modelling

Atmospheric dispersion modelling for the study was carried out using version 7 (June 2015) of the CALPUFF modelling system. CALPUFF is an advanced non-steady-state meteorological and air quality modelling system.

3-dimensional meteorological data was generated using the TAPM modelling system, developed by Australia's national science agency CSIRO, and cross-validated against the observational data. TAPM uses as its inputs global weather data from the GASP model of the Australian Bureau of Meteorology, combined with higher-resolution terrain data. TAPM outputs were converted into formats accepted by CALPUFF's meteorological preprocessor, CALMET, using the CALTAPM utility, and the meteorological data were then prepared for CALPUFF execution using CALMET. CALMET generates a set of time-varying micrometeorological parameters (hourly 3-dimensional temperature fields, and hourly gridded stability class, surface friction velocity, mixing height, Monin-Obukhov length, convective velocity scale, air density, short-wave solar radiation, surface relative humidity and temperature, precipitation code, and precipitation rate) for input to CALPUFF.

Terrain height and land-use data were also prepared using the TAPM system and global datasets made available by CSIRO. A set of nested grids with 50x50 grid cells each at 30 km, 10 km, 5 km and 2.5 km horizontal resolutions and 12 vertical levels was used, centred on the power plants.

Chemical transformation of sulphur and nitrogen species was modelled using the ISORROPIA II chemistry module within CALPUFF, and required data on ambient ozone levels was processed from measurements reported by the Turkish government to the European Environmental Agency. Other required atmospheric chemistry parameters (monthly average ammonia and H_2O_2 levels) for the modelling domain were imported into the model from baseline simulations using the MSC-W atmospheric model (Huscher et al. 2017). The CALPUFF results were reprocessed using the POSTUTIL utility to repartition different nitrogen species (NO, NO_2, NO_3 and HNO_3) based on background ammonia concentrations.

Health Impact Assessment

The health impacts resulting from the increase in $PM_{2.5}$ concentrations, compared with the baseline simulation with no coal power emissions, were evaluated by assessing the resulting population exposure, based on high-resolution gridded population data for 2015 from CIESIN (2018), scaled to national population totals in 2019, and then applying the health impact assessment recommendations of WHO HRAPIE (2013) as implemented in Huescher et al. (2017), and with low birth weight births quantified using the concentration-response relationship established by Dadvand et al. (2013). Baseline incidence and prevalence data for Turkey and neighbouring countries for different health conditions were obtained from the Global Burden of Disease (GBD 2020), birth rates and incidence of low birth weight from World Bank (undated). For future predictions of population growth and death rates, data from UNPD (2019) was used. Table 5 shows the relative risk values used in the health impact assessment.

Table 5. *Relative risks (RRs) used for the health impact assessment, for a 10 µg/m^3 change in annual average pollutant concentration.*

Effect	Pollutant	RR	RR: low estimate	RR: high estimate
bronchitis in children	PM_{10}	1.08	0.98	1.19
asthma symptoms in asthmatic children	PM_{10}	1.028	1.006	1.051
incidence of chronic bronchitis in adults	PM_{10}	1.117	1.04	1.189
long-term mortality, all causes	$PM_{2.5}$	1.062	1.04	1.083
cardiovascular hospital admissions	$PM_{2.5}$	1.0091	1.0017	1.0166
respiratory hospital admissions	$PM_{2.5}$	1.019	0.9982	1.0402
restricted activity days (applied to non-working age population)	$PM_{2.5}$	1.047	1.042	1.053
work days lost	$PM_{2.5}$	1.046	1.039	1.053
bronchitic symptoms in asthmatic children	NO_2	1.021	0.99	1.06
respiratory hospital admissions	NO_2	1.018	1.0115	1.0245
long term mortality, all causes[10]	NO_2	1.055	1.031	1.08
preterm birth	$PM_{2.5}$	1.15	1.07	1.16

[10] To avoid the possible overlap identified with $PM_{2.5}$ mortality impacts identified by WHO (2013), ⅔ of the NO_2 mortality is included in the central estimates of total premature deaths, as well as in the low end of the confidence intervals, while the full mortality is included in the high end of the confidence interval.

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