

## THE BOTTOM LINE

Turkey began tapping its high-temperature geothermal resources to generate electricity in 1984, and geothermal energy remains an important option in the country's clean energy transition. At the time of commissioning, CO<sub>2</sub> emission factors from Turkish geothermal plants have been measured in the 400 to 1,300 g/kWh range, significantly higher than the reported global average (121 g/kWh). The good news is that despite these unusually high initial emission factors most, if not all, Turkish geothermal power plants show a steady decline in CO<sub>2</sub> emissions over time, based on available data.

Predictive models developed under the World Bank-financed Geothermal Development Project show that estimated average lifetime emissions from Turkey's geothermal power plants are aligned with the global average. These results justify further investments in the development of geothermal energy in Turkey, along with additional research on how best to manage CO<sub>2</sub> emissions.

# Understanding CO<sub>2</sub> Emissions from Geothermal Power Generation in Turkey

**What is Turkey's geothermal potential—and what does CO<sub>2</sub> have to do with it?**

**Anatolia is endowed with great geothermal potential, which it has used since ancient times and now exploits as a sustainable resource for generating electricity**

Since the 1960s, 239 geothermal fields have been identified in Turkey, representing an estimated potential of 60,000 megawatts thermal (MWt). The fields are spread across the country, though most are situated in Western Anatolia (78 percent), followed by Central Anatolia (9 percent), Marmara Region (7 percent), and Eastern Anatolia (5 percent).

A share of these geothermal resources (representing about 20,000 MWt) possess low to medium enthalpy—a property of a thermodynamic system defined as the sum of the system's internal energy and the product of its pressure and volume—making them

suitable for direct uses such as heating, certain industrial processes, and thermal tourism.<sup>1</sup> But about 10 percent of the fields, representing an estimated 40,000 MWt, have temperatures high enough to be suitable for electricity generation using current technologies (MTA 2019), enabling a total potential electrical output of up to 4,000 megawatts electric (MWe). Turkey currently operates 54 geothermal power plants, which reached an installed capacity of 1,576 MWe in October 2020. CO<sub>2</sub> tends to be present in the high-enthalpy fluids and provides much of the pressure that makes the fluids easy to extract for power generation, while it is not a relevant enabling factor for direct uses.

Turkey is among the world's twenty largest economies. With a growing economy and population, the country's electricity demand has increased by approximately 7 percent each year since 2005. Domestic resources meet only about half of total energy demand. As a local, renewable substitute for fossil-fuel generation, geothermal energy is a key component of Turkey's low-carbon transition.

1. Currently Turkey has installed capacity of around 3,600 MWt in direct uses.



**Yasemin Orucu** is a senior energy specialist at the World Bank.



**Elin Hallgrimsdottir** is a senior energy specialist at the World Bank.



**Almudena Mateos Merino** is a senior energy specialist at the World Bank.

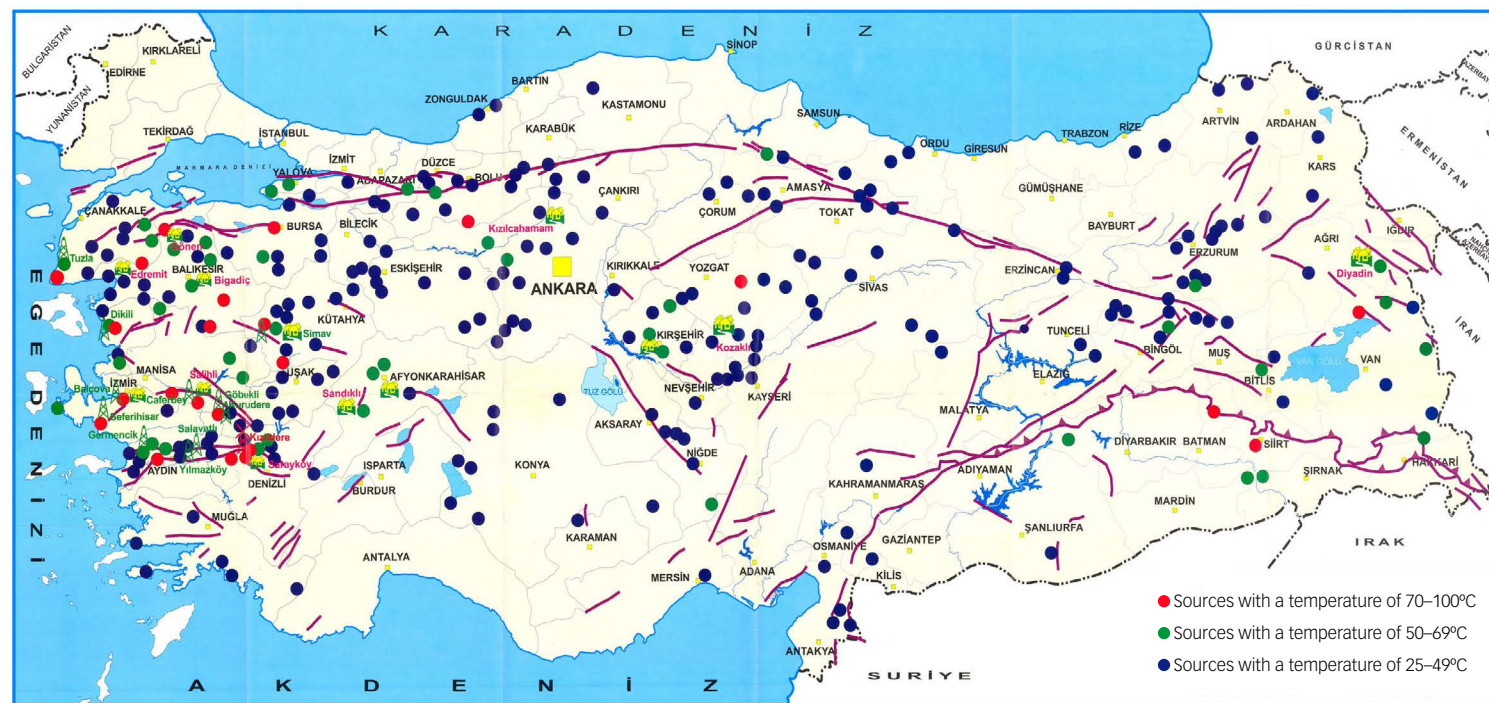


**Serhat Akin** is professor of petroleum and natural gas engineering at Middle East Technical University.



**Oumaima Idrissi** is an intern at the World Bank.

Figure 1. Geothermal resources and applications in Turkey



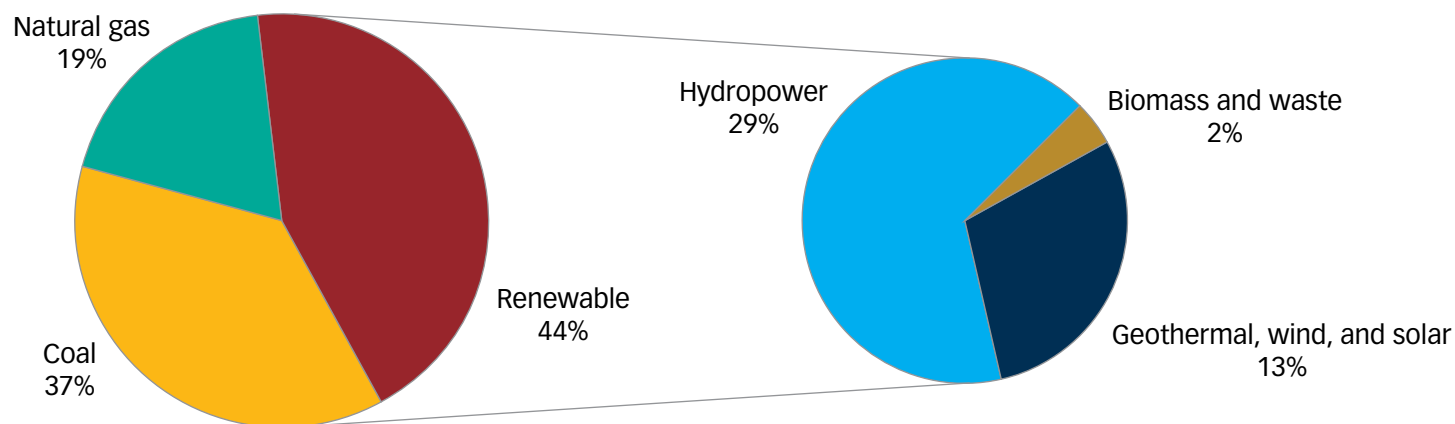
Source: MTA, <https://www.mta.gov.tr/v3.0/hizmetler/jeotermal-harita>; World Bank cartography unit.

The purpose of this Live Wire is to examine changes in CO<sub>2</sub> emissions levels over time in Turkey and to determine whether those levels are dropping fast enough and far enough to justify the use of climate change finance or multilateral clean energy financing for geothermal development.

Maximizing exploitation of domestic primary energy resources and securing reliable and affordable energy for a growing economy in an environmentally sustainable manner are core energy policy priorities of Turkey's government, which has a legislative framework of strategies, plans, and laws to advance renewable energy, including geothermal. Among the mechanisms of support are purchase guarantees, feed-in tariffs (FiTs), and energy financing through international financial institutions.

In 2014, the government set a target to increase the share of electricity from renewable energy—including wind, hydro, solar, and geothermal—to 30 percent of total installed capacity by 2023. This was exceeded in 2020 with a share of 44 percent (figure 2).

The Geothermal Law of 2007 set out the initial rules and principles for effective exploration, development, production, and protection of geothermal and natural mineral water resources. Licensing procedures were also clarified under the law. The 2007 law was reinforced by a 2010 amendment of the Renewable Energy Law of 2005, which established a FiT specifically for geothermal power. As a result of these regulatory changes and the availability of concessional financing, the sector grew from 15 MW in 2005 to more than 1,550 MW by the end of 2020. When the 2023 target for geothermal generation (1,000 MW) was exceeded, Turkey's Ministry of Energy and Natural Resources announced a new target of 4,000 MW by 2030.

**Figure 2.** Share of electricity generation by technology, 2020

Source: TEIAS.

As a local, renewable substitute for fossil-fuel generation, geothermal energy is a key component of Turkey's low-carbon transition.

Additional legislative changes are aimed at facilitating the licensing and permitting process and at enhancing the management of environmental and social impacts of geothermal investments. The government also recently approved a five-year FIT for renewable energy to take effect upon expiration of the current regime (June 30, 2021).

Continued investment in renewable energy is key to reducing reliance on fossil fuels; ensuring security of supply and affordability; and electrifying other energy-intensive sectors, such as transport and industry.

### How do CO<sub>2</sub> emissions from Turkish geothermal power plants compare with the global average?

#### The Turkish geothermal power plants emit higher concentrations of CO<sub>2</sub>

Geothermal energy is considered a clean and reliable energy source with respect to the release of greenhouse gases to the atmosphere during power production. Yet, geothermal power plants exploiting high-temperature fields in Turkey may emit high levels of CO<sub>2</sub>, the

greenhouse gas that contributes the most to global warming.<sup>2</sup>

Bertani and Thain (2002) reported CO<sub>2</sub> emission factors from 85 geothermal power plants worldwide that ranged from 4 g/kWh to 740 g/kWh, with the weighted average being 122 g/kWh. In the case of Turkey, observed CO<sub>2</sub> emission factors from many geothermal plants have been at least as high as emission factors from coal-fired power plants (Fridriksson et al. 2016). Recent studies (Akın 2017; Herrera Martinez et al. 2016; Aksoy et al. 2015; Haizlip et al. 2013) showed that initial emission factors from geothermal power plants located in the Büyük Menderes and Gediz grabens, where Turkey's geothermal power plants are concentrated, ranged from 400 g/kWh to 1,300 g/kWh.<sup>3</sup> Using 2015 data gathered from 12 geothermal power plants in Turkey, Herrera Martinez et al. (2016) reported a weighted CO<sub>2</sub> emissions average of 887 g/kWh—far more than the global average. But accumulated data suggest that the gas content of geothermal wells changes over the lifetime of the power plants.

2. Hydrogen sulfide may also be released, which has negative local effects due to its corrosive nature, odor, and toxicity in high concentrations.

3. A graben is a geological formation in which a piece of the Earth's crust has shifted downward and is bordered by two faults.

---

Thermal breakdown of carbonate rocks in the roots of geothermal systems can result in the formation of CO<sub>2</sub> gas that migrates up to the geothermal reservoir. The higher CO<sub>2</sub> content raises the pressure of the geothermal brine, inducing a more efficient flow of energy.

---

The purpose of this Live Wire is to examine changes in CO<sub>2</sub> emission factors over time for Turkish geothermal power plants and to determine whether those levels are dropping fast enough and far enough to justify the use of multilateral clean energy financing for geothermal development.

There are currently no regulatory limits for CO<sub>2</sub> emissions from geothermal power plants in Turkey, and developers are not required to monitor or report their emissions. However, multilateral development banks have adopted a joint policy on CO<sub>2</sub> accounting that requires them to measure CO<sub>2</sub> emissions from the projects they finance (AfDB et al. 2020). In the medium to long term, monitoring requirements or emissions restrictions for geothermal projects may be introduced by Turkey's government, but some geothermal investors are already considering options to reduce their CO<sub>2</sub> emissions, either by turning the emissions into a commercially viable product to be supplied to the food industry or greenhouses, or by reinjecting it into the geothermal reservoirs.

The high CO<sub>2</sub> emissions from the geothermal power plants in the Büyük Menderes and Gediz grabens reflect unusual geological characteristics. The carbonate-dominated metamorphic rocks of these two grabens are common sedimentary rocks, composed mainly of calcite, aragonite, and dolomite. Carbonate rocks are biogenic sedimentary rocks formed in relatively shallow waters from skeletal fragments of marine organisms. In contrast to marble, which forms by recrystallization of carbonate rocks at high temperatures and pressures, carbonate rocks are formed at relatively high temperatures but *relatively low pressure*, conditions prevailing near shallow magma intrusions or in the roots of high temperature geothermal systems, where the carbonate minerals react with silicates to form calcium or magnesium silicates and CO<sub>2</sub> gas.

Thermal breakdown of carbonate rocks in the roots of geothermal systems can result in the formation of CO<sub>2</sub> gas that migrates up to the geothermal reservoir. Similarly, as calcite, quartz, and wollastonite reach equilibrium in high-temperature geothermal reservoirs, high concentrations of CO<sub>2</sub> are dissolved in the geothermal fluid. The higher CO<sub>2</sub> content raises the pressure of the geothermal brine, inducing a more efficient flow of energy. With lower pressures, pumps are required to access the energy-laden fluids. The high CO<sub>2</sub> content of Turkey's geothermal resources allows for artesian flow from wells at much lower temperatures than in reservoirs with

lower gas content, lowering the cost of development of geothermal projects compared with projects in reservoirs having similar temperature conditions but lower gas content.

CO<sub>2</sub> concentrations drop as energy is used to generate power and CO<sub>2</sub> is released to the atmosphere. This may lead to lower well productivity as the energy-bearing fluid lacks the added boost of pressure and cannot reach the surface as easily as before. The precise effects of this loss of productivity will vary depending on the resource temperature and residual pressure. The effect can be partially mitigated through reinjection of gases and the installation of pumps. However, reinjection of CO<sub>2</sub> is still in the research and development stage but the European Union, under its Horizon 2020 program, is supporting a pilot whose objective is to develop a CO<sub>2</sub> capture and reinjection plant in Turkey to demonstrate the viability of the process. A full-scale facility is currently in operation in Iceland.

There are two types of well pumps. Surface-based line-shaft pumps can reach down 300 meters; submersible pumps can reach approximately 800 meters, with the exact depth and capacity depending on the manufacturer and the conditions in the reservoir. The size of the pump and thus the casing will influence the achievable flow rate. Reinjection wells must be strategically located so as not to lower the temperature in the production wells. A strategy for optimized reinjection and pumping must be devised to arrive at the most economical and renewable solution.

## How have CO<sub>2</sub> emissions from Turkish geothermal power plants changed over time?

### Most plants are showing sharp declines in CO<sub>2</sub> emissions

The lifecycle of a geothermal field can be divided into four parts: development, sustainment, decline, and renewal (Lovekin 1998). The development period encompasses the construction and drilling of production and injection wells and the commissioning of the power plant. This is followed by the sustainment period, during which the output of the geothermal field remains steady for a period of time. The duration depends on the reservoir characteristics, the degree of exploitation in relation to the size of the reservoir, and the reinjection strategy adopted to restore fluids (and possibly CO<sub>2</sub>) back into the

---

As part of the World Bank–financed Geothermal Development Project, we studied 14 geothermal power plants in the Büyük Menderes and Gediz grabens. All plants seemed to be experiencing declines in emissions owing to reductions in CO<sub>2</sub> concentrations in the reservoirs.

---

geothermal field. In the decline period, the geothermal reservoir will suffer a loss of pressure, which will affect well productivity. Depending on the size of the reservoir and the rate of exploitation, the decline may be small or large—from an annual drop of 2 percent to as high as 20 percent. In either case, make-up wells must be drilled to maintain the required levels of geothermal production. In the renewal stage, if natural recharge and net withdrawals are equal, the CO<sub>2</sub> concentration of the geothermal fluid should remain stable for a long time.

As part of the World Bank–financed Geothermal Development Project, Akin and co-authors (2020) studied 14 geothermal power plants in the Büyük Menderes and Gediz grabens. All plants seemed to be experiencing declines in emissions owing to reductions in CO<sub>2</sub> concentrations in the reservoirs. As noted, Herrera Martinez et al. (2016) reported a weighted average of 887 g/kWh of CO<sub>2</sub> emissions using data obtained from 12 geothermal power plants in 2015. Their model predicted that total emissions of geothermal plants in Turkey would reach 5.9 MtCO<sub>2</sub> by 2023, with a constant 3.5 percent annual decline (assuming power production remained at 634 MWe). The geothermal power plants we investigated represent more than 36 percent of total installed capacity, with data collected through the end of 2019. Data were collected from eight “binary” plants (194.8 MW) and six “flash” plants (352.4 MW) covering a total of 100 production wells. Initial and current average CO<sub>2</sub> production rates of these geothermal power plants were estimated at 37.3 and 18.7 tons/hour, respectively. The power-weighted average of initial and current CO<sub>2</sub> production rates was somewhat higher, at 54 and 25 tons/hour, respectively. The power-weighted and arithmetic averages of these plants were 582 and 596 gCO<sub>2</sub>/kWh, significantly lower than the arithmetic average of 887 gCO<sub>2</sub>/kWh previously reported by Herrera Martinez et al. (2016).

Most of the decline we observed can be explained by two factors. First, Turkey’s geothermal power plants vent non-condensable gases into the atmosphere, depleting CO<sub>2</sub> concentrations in the reservoirs. Second, in many cases there is good hydraulic connectivity between reinjection and production wells. Several fields located in the Büyük Menderes and Gediz grabens clearly show this behavior. Invasions of cooler, less gaseous peripheral waters into the reservoir in response to production-induced drawdown may also occur,

reducing reservoir gas concentrations. If the hydraulic connection in the reservoir between the reinjection and the production wells is negligible, then CO<sub>2</sub> concentration rates in the geothermal fluid will not be as affected. Typically, make-up wells are drilled inside an already confirmed reservoir to maintain geothermal production at a certain level.

Yet another reason for declining emissions is that, if the rate of CO<sub>2</sub> emissions stemming from power plant operations exceeds the natural rate of recharge of gas into the subsurface reservoir, gas levels in the reservoir are likely to decrease over time. This effect may explain most of the cases of CO<sub>2</sub> depletion, as the working (installed) capacity ratios of the 14 plants are somewhat low for geothermal power plants globally.

If make-up wells are drilled inside an already diluted section of the field, they will not change the CO<sub>2</sub> emission rates. This is quite commonly observed in most fields in Turkey since CO<sub>2</sub> emission rates do not increase at all, even though several make-up wells have already been drilled. On the contrary, if make-up wells are drilled in a virgin section of the field where CO<sub>2</sub> concentration is higher than in the rest of the field, CO<sub>2</sub> emission rates will rise somewhat, depending on the rate of production.

To model the observed decline in CO<sub>2</sub> concentration and to understand the relationship between this decline and measurements of production and reinjection, the following data are required:

- Time series of production and injection rates for individual wells and cumulative production and reinjection rates for the reservoirs
- Measured CO<sub>2</sub> concentration in total discharges from production wells
- Total CO<sub>2</sub> emission rates measured from power plants
- Chemical monitoring data showing return of reinjected brine to production wells
- Temperature and pressure data from observation wells to establish conditions in the reservoir
- Well-head pressure
- Indicators of the volume of the reservoirs (including aerial extent, thickness, and porosity).

Our models predict (with a 95 percent confidence interval) that for a geothermal power plant in the Büyük Menderes or Gediz grabens showing initial emissions of 1,200 gCO<sub>2</sub>/kWh, the levels after 25 years of operation will be 0 gCO<sub>2</sub>/kWh for the first region and 95 gCO<sub>2</sub>/kWh for the second, with an upper prediction interval of 200 gCO<sub>2</sub>/kWh and 166 gCO<sub>2</sub>/kWh, respectively.

The methodology used to develop models of CO<sub>2</sub> emission changes from geothermal wells involves the application of decline curve analysis, an approach developed from empirical evidence in the oil and gas industry that has previously been used with good results on geothermal wells (Herrera Martinez et al. 2016). In our study, however, since data completeness varied from field to field and some measurements lacked information on the ratio of CO<sub>2</sub> to non-condensable gases, we used Dalton's Law (otherwise known as the partial pressure method) in some cases to calculate CO<sub>2</sub> content depending on provided well data.

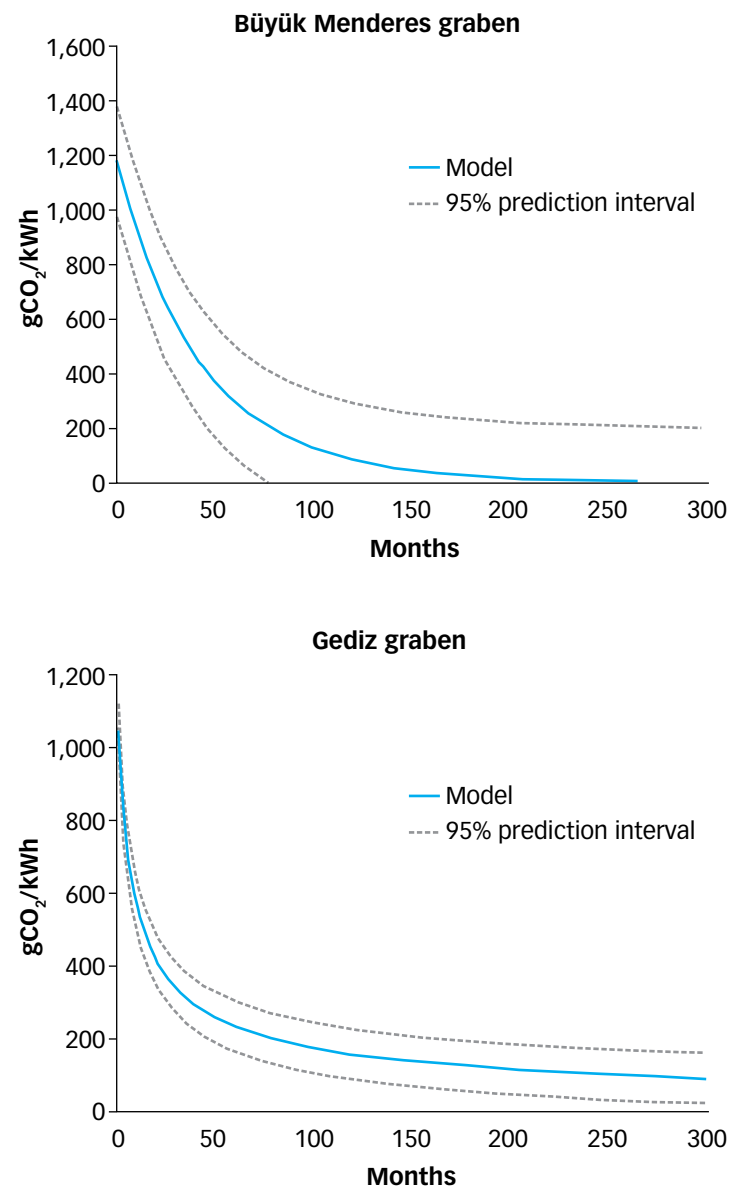
### Can the evolution of CO<sub>2</sub> emissions from geothermal power plants be predicted?

#### CO<sub>2</sub> emissions can be predicted within limits, but they must be monitored

From the data on the 14 geothermal power plants collected under the World Bank-financed Geothermal Development Project, we used decline curve analysis to develop predictive models for the Büyük Menderes and Gediz grabens (figure 3). Predicting future values entails uncertainty, which may be due to a variation in the modeling procedure or to the natural variation of measured CO<sub>2</sub> emissions. The models predict (with a 95 percent prediction interval) that for a geothermal power plant in the Büyük Menderes or Gediz grabens showing initial emissions of 1,200 gCO<sub>2</sub>/kWh, the levels after 25 years of operation will be 0 gCO<sub>2</sub>/kWh for the first region and 95 gCO<sub>2</sub>/kWh for the second, with an upper prediction interval of 200 gCO<sub>2</sub>/kWh and 166 gCO<sub>2</sub>/kWh, respectively. This means that a plant in Büyük Menderes with initial emissions of 1,200 gCO<sub>2</sub>/kWh is predicted to emit between 0 and 200 gCO<sub>2</sub>/kWh after 25 years of operation, with the most likely value being on the lower side. A plant in Gediz with the same initial emissions is predicted to emit between 30 and 166 gCO<sub>2</sub>/kWh after 25 years of operation, the most likely value being 95 gCO<sub>2</sub>/kWh.

Using these models for the 14 analyzed power plants, the power-weighted average emissions after 5, 10, 20, and 30 years of geothermal production were predicted to be 247, 146, 79, and 36 gCO<sub>2</sub>/kWh, respectively, assuming production levels are kept constant. Arithmetic average emissions for the same period were estimated to be 142, 68, 45, and 24 gCO<sub>2</sub>/kWh (figure 4).

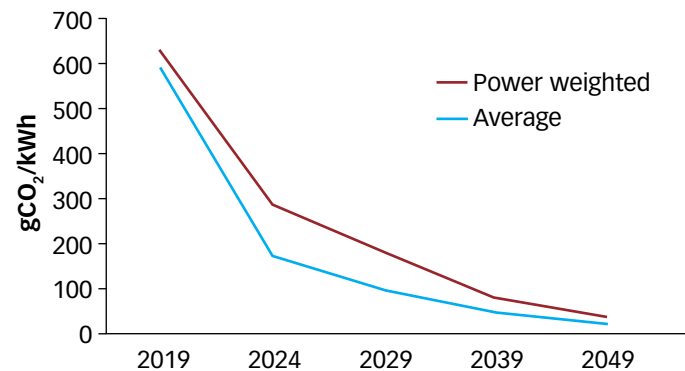
**Figure 3.** Predictive CO<sub>2</sub> emission models for the Büyük Menderes and the Gediz grabens



Source: Authors' original analysis.

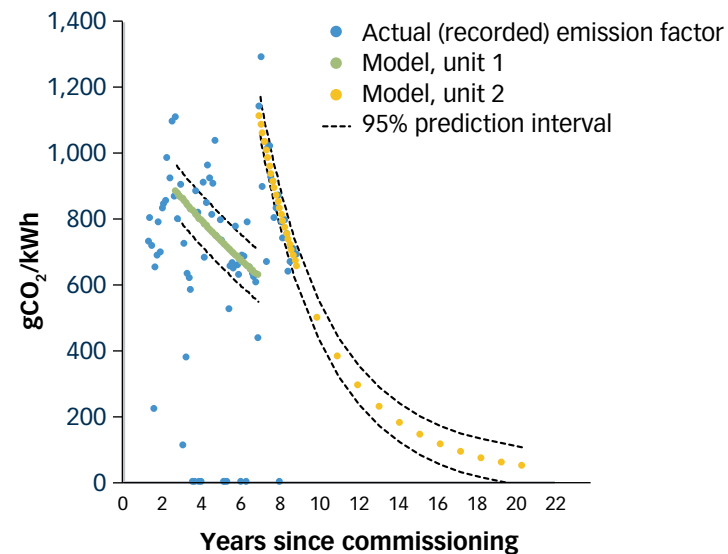
One of the main challenges to accessing financing for geothermal power plants in Turkey has been high initial CO<sub>2</sub> emissions. The World Bank study presented in this Live Wire demonstrates that emissions drop significantly over time and that average lifetime emission factors at Turkish plants are predicted to be below the global average of 122 gCO<sub>2</sub>/kWh.

**Figure 4.** Power weighted and average decline in CO<sub>2</sub> emissions for 14 geothermal power plants, 2019–49



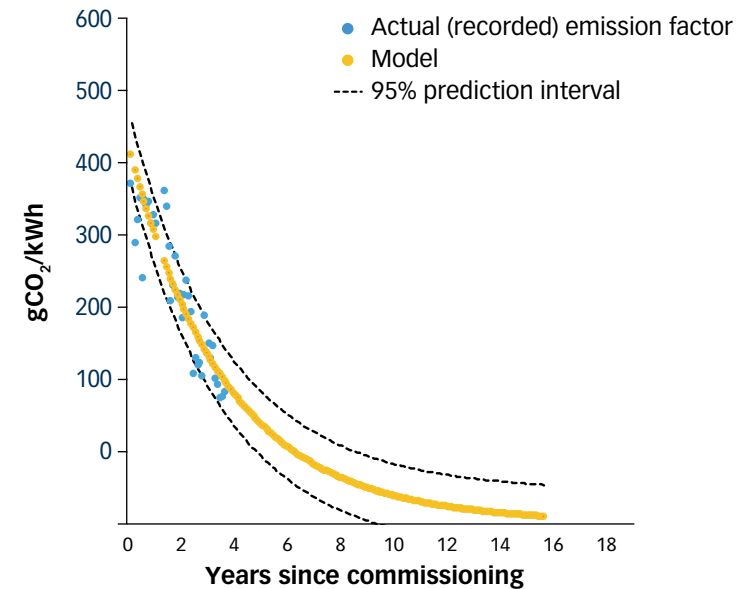
Source: Authors' original analysis.

**Figure 5.** Historical and projected evolution of CO<sub>2</sub> emission factors for a geothermal power plant in the Büyük Menderes graben



Source: Authors' original analysis.

**Figure 6.** Historical and projected evolution of CO<sub>2</sub> emission factors for a geothermal power plant in the Gediz graben



Source: Authors' original analysis.

The modeling confirmed that CO<sub>2</sub> emission factors from these geothermal projects in the Büyük Menderes and Gediz grabens declined significantly over time, as observed in the historical data, and that they are expected to continue falling, though at slower rates.

Figures 5 and 6 show the historical and projected evolution of CO<sub>2</sub> emissions for two of the geothermal power plants supported by the World Bank–financed Geothermal Development Project.

Our study demonstrates that CO<sub>2</sub> emissions can be predicted. However, continuous monitoring is necessary in order to gather actual data, and analyses should be regularly updated.

One of the main challenges to accessing financing for geothermal power plants in Turkey has been high initial CO<sub>2</sub> emissions. The World Bank study presented in this Live Wire demonstrates that emissions drop significantly over time and that average lifetime emission factors at Turkish plants are predicted to be below the global average of 122 gCO<sub>2</sub>/kWh. We recommend a follow-up study to monitor how actual CO<sub>2</sub> emission factors continue to evolve for

## MAKE FURTHER CONNECTIONS

Live Wire 2014/5. "Understanding CO<sub>2</sub> Emissions from the Global Energy Sector," by Vivien Foster and Daron Bedrosyan.

Live Wire 2017/71. "Mobilizing Risk Capital to Unlock the Global Potential of Geothermal Power," by Roberto La Rocca, Peter Johansen, Laura Berman, and Migara Jayawardena.

Live Wire 2017/81. "The Effects of Carbon Limits on Electricity Generation and Coal Production: An Integrated Planning Approach Applied to Poland," by Debabrata Chattopadhyay, Jacek Filipowski, Michael Stanley, and Samuel Oguah.

Live Wire 2019/99. "Beyond the Last Mile: Piloting High-Efficiency, Low-Emissions Heating Technologies in Central Asia," by Yabei Zhang, Norma Adams, and Crispin Pemberton-Pigott.

Find these and the entire Live Wire archive at [www.worldbank.org/energy/livewire](http://www.worldbank.org/energy/livewire).

each location and power plant to verify the findings of this report and adjust the predictive models over time. It would also be beneficial for the Turkish geothermal sector to gather data from additional geothermal power plants, including those in new locations, to develop predictive models for less-studied geothermal locations.

The findings of the World Bank study will enable developers to estimate, for the Büyük Menderes and Gediz grabens, the average lifetime emission factors of geothermal projects, and thus prove to financing institutions the environmental benefits of geothermal energy in Turkey.

*This Live Wire was peer reviewed by Pierre Audinet and Joeri de Wit.*

## References

AfDB (African Development Bank), Asian Development Bank, Asian Infrastructure Investment Bank, European Bank for Reconstruction and Development, European Investment Bank, Inter-American Development Bank Group, Islamic Development Bank, and World Bank Group. 2020. *2019 Joint Report on Multilateral Development Banks' Climate Finance*. London: European Bank for Reconstruction and Development.

Akin, S., Y. Orucu, T. Fridriksson, E. Hallgrimsdottir. 2020. "Characterizing the declining CO<sub>2</sub> emissions from Turkish geothermal power plants." Unpublished report, World Bank.

Akin, S. 2017. "Estimation of long-term CO<sub>2</sub> decline during operation of geothermal power plants." International Geothermal Congress, Turkey, Izmir, 22-24 May 2017.

Aksoy, N., Ö.S. Gök, H. Mutlu, and G. Kılınç. 2015. "CO<sub>2</sub> emission from geothermal power plants in Turkey." Proceedings of World Geothermal Congress, Melbourne, Australia, April 19–25.

Bertani, R., and I. Thain. 2002. "Geothermal power generating plant CO<sub>2</sub> emission survey." *IGA News* 49: 1–3.

Fridriksson, T., A. Mateos, P. Audinet, and Y. Orucu. 2016. "Greenhouse gases from geothermal power production." ESMAP Technical Report 009/16, World Bank, Washington, DC.

Haizlip, J. R., F. T. Haklıdır, and S. K. Garg. 2013. "Comparison of reservoir conditions in high non-condensable gas geothermal systems." Proceedings, Thirty-Eighth Workshop on Geothermal Reservoir Engineering, Stanford University.

Herrera Martinez, A., H. Groenenberg, P. Noothout, J. Koornneef, T. Baloglu, G. Rencberoglu, O. Ozbulak, and S. Akin. 2016. "Assessing the use of CO<sub>2</sub> from natural sources for commercial purposes in Turkey." European Bank for Reconstruction and Development, London.

Lovekin, J. W. 2000. "The economics of sustainable geothermal development." Proceedings of the World Geothermal Congress 2000, Kyushu–Tohoku, Japan, May 28–June 10.

MTA (General Directorate of Mineral Research and Exploration). 2019. <https://www.mta.gov.tr/v3.0/arastirmalar/geotermal-enerji-arastirmalari>, accessed April 25, 2019.

# An invitation to World Bank Group staff

## Contribute to **liveWire**

### Do you have something to say? Say it in *Live Wire*!

Those working on the front lines of energy and extractives development in emerging economies have a wealth of technical knowledge and case experience to share with their colleagues but may not have the time to write for publication.

*Live Wire* offers prospective authors a support system to make it easier to share their knowledge:

- Staff from the Energy and Extractives Global Practice are available to assist operations staff in drafting *Live Wire* stories.
- User-friendly guidelines help authors mold their contribution to the expectations of the *Live Wire* audience.
- A professional editor ensures that the writing is punchy and accessible.
- A professional graphic designer assures that the final product looks great—a feather in your cap!

Since 2014 the Energy and Extractives Global Practice has produced more than a hundred *Live Wire* briefs under the bylines of 300 staff authors. *Live Wire* briefs have been downloaded thousands of times from the World Bank's Open Knowledge Repository and circulated in printed form for countless meetings and events.

*Live Wire* aims to raise the profile of operational staff with practical knowledge to share—wherever they are based.



If you can't spare the time to contribute to *Live Wire* but have an idea for a topic or case we should cover, let us know!

We welcome your ideas through any of the following channels:

Via the Communities of Practice in which you are active

By participating in the Energy and Extractives Global Practice's annual *Live Wire* series review meeting

By communicating directly with Jonathan Davidar, executive editor of the *Live Wire* series ([jdavidar@worldbankgroup.org](mailto:jdavidar@worldbankgroup.org))



# Get Connected to Live Wire

The *Live Wire* series of online knowledge notes, an initiative of the World Bank Group's Energy and Extractives Global Practice, offers rich insights from project and analytical work done by the World Bank Group. The series is edited by Jonathan Davidar (j davidar@worldbankgroup.org).

Every day, Bank Group experts apply their knowledge and expertise to solve practical problems in client countries. *Live Wire* captures the rich insights gained in the field, allowing authors to share their findings with other practitioners, policy makers, and planners.

*Shouldn't you be connected to Live Wire?*

Since 2014, the briefs in the series, now numbering more than a hundred, have dealt with vital topics such as energy demand and supply; renewable energy; energy efficiency; energy policy; economic growth; environmental protection; climate change mitigation; power systems; rural and urban development; access to energy; infrastructure economics; private sector participation; access to finance; and regulation.

- **Topic briefs** offer technical knowledge on key energy issues.
- **Case studies** highlight lessons from experience in implementation, often with insights from private sector engagement.
- Briefs on **global trends** provide analytical overviews of key energy data and developments.
- **Bank views** portray the Bank Group's energy and extractives sector activities.

The format is accessible, rigorous, and concise enough to be easily shared. The 6–12 pages of each brief make ample use of graphics. Briefs are peer-reviewed by seasoned practitioners within the World Bank Group and professionally edited and produced. While their main channel of dissemination is online, Live Wires are available in print-ready files for specific client needs.

“Live Wire is designed for practitioners, policy makers, and planners inside and outside the World Bank Group. It is a resource to share with clients, colleagues, and counterparts.”



Please visit the World Bank Group's Open Knowledge Repository to browse the Live Wire collection and download the issues important to you: [www.worldbank.org/energy/livewire](http://www.worldbank.org/energy/livewire)



Live Wire briefs are designed for easy reading on the screen and for downloading and self-printing in color or black and white.



For World Bank Group employees: Professional printing can be done on a customized basis for meetings and events by contacting GSDPM Customer Service Center at (202) 458-7479, or sending a written request to [cgsdpm@worldbank.org](mailto:cgsdpm@worldbank.org).

