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317 Report by Pio Baake, Astrid Cullmann, Claudia Kemfert, Tim Kleineberg, Georg Meran, and Christian von Hirschhausen

Water withdrawal rights for commercial use: regional auctions could make allocation more efficient

- Study proposes auctioning commercial water withdrawals to use groundwater more efficiently
- The water volume set by authorities would be adjusted regularly and auctioned off regionally
- Auctions should be considered, especially in regions with groundwater stress

LEGAL AND EDITORIAL DETAILS

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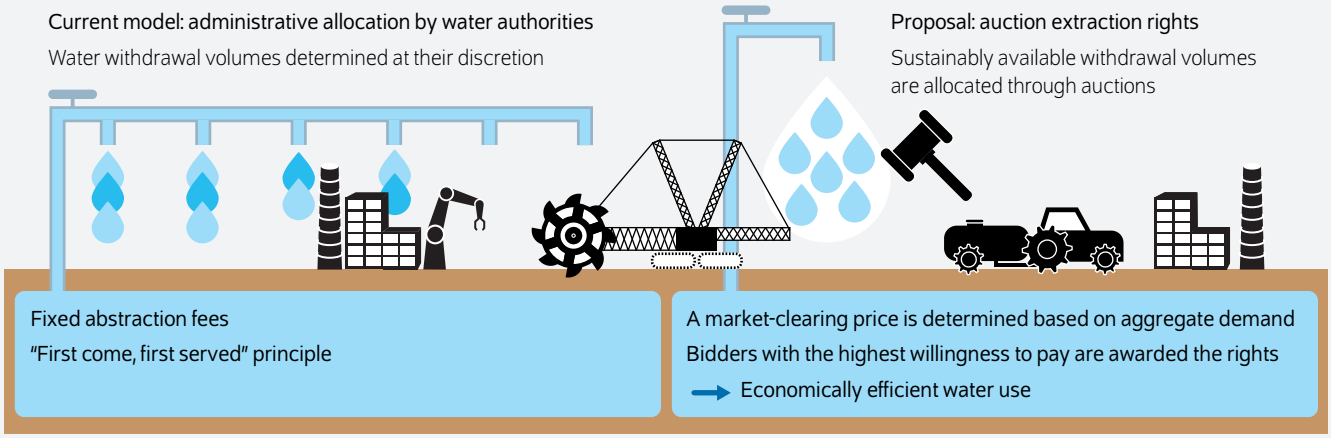
AT A GLANCE

Water withdrawal rights for commercial use: regional auctions could make allocation more efficient

By Pio Baake, Astrid Cullmann, Claudia Kemfert, Tim Kleineberg, Georg Meran, and Christian von Hirschhausen

- To use groundwater more efficiently, this study proposes auctioning commercial water withdrawal rights instead of the current administrative allocation system
- The sustainably available water volume, as determined by authorities, would be regularly adjusted and auctioned off regionally
- Buyers would specify the volume they wish to purchase at various prices; the price would then be determined based on aggregated demand and the available volume
- A combination of government-controlled volume management and market-based allocation would be economically efficient and sustainable
- Volume-based allocation procedures via auctions should be examined, particularly in regions with groundwater stress and high commercial withdrawal

Water scarcity: auctioning groundwater withdrawal rights for commercial use can increase efficiency



Source: Author's own illustration.

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FROM THE AUTHORS

"Where groundwater is becoming scarce, managing scarcity alone is no longer sufficient. Thus, in regions with high groundwater stress, limited withdrawal rights should be auctioned off to ensure that available water is not only used sustainably but also economically efficiently."

— Pio Baake —

MEDIA

Audio Interview with Pio Baake (in German)
www.diw.de/mediathek

Water withdrawal rights for commercial use: regional auctions could make allocation more efficient

By Pio Baake, Astrid Cullmann, Claudia Kemfert, Tim Kleineberg, Georg Meran, and Christian von Hirschhausen

ABSTRACT

2026's hot summer intensified the debate over the extraction and distribution of scarce water resources. This applies to both surface water in lakes and rivers as well as groundwater. While strong seasonal fluctuations limit the use of surface water, medium- to long-term trends must be taken into account for groundwater. Although the ratio of water abstraction to groundwater recharge has remained largely constant nationwide in recent years, significant regional differences and declining groundwater bodies can be observed. To ensure hydrologically and ecologically sustainable use, withdrawals must be reduced. To date, regional authorities have allocated withdrawal rights for non-public water users (agriculture, mining, and industry) at their administrative discretion and often according to the "first come, first served" principle. To allocate the sustainably available withdrawal volumes more efficiently and to relieve pressure on regions with high groundwater stress in particular, withdrawal rights for commercial use could be awarded through auctions.

Water scarcity, exacerbated by climate change, will require measures on both the supply and demand sides in the future.[1] Infrastructure measures (land-intensive water retention areas, such as wetlands and floodplains) could stabilize the water supply. On the demand side, for example, on-site water recycling facilities, new closed-loop systems, and drip irrigation in agriculture can increase water use efficiency, thus reducing demand. While this could reduce competition between different uses—whether commercial uses such as industry and agriculture or public water supply—it cannot completely resolve the issue.

This report focuses on the direct use of groundwater by agriculture, mining, and industry, rather than on public water supply, which generally takes priority over commercial use. The focus is on mechanisms that can be used to ensure the efficient allocation of groundwater resources within these aforementioned sectors. The question of how to determine the sustainably available quantities is not part of the analysis in this report. Regional groundwater bodies, watersheds, and sustainability aspects are relevant to this determination.[2]

Groundwater in many regions is under increasing pressure

Like public drinking water supply, non-public water users draw water from both surface water bodies and groundwater. Withdrawals from surface water bodies have declined significantly in recent years. This is primarily due to the energy sector, which obtains most of its cooling water from rivers and lakes. With the ongoing decline in coal- and nuclear-powered generation, less water is required. In contrast, no decline has been observed for groundwater use. Furthermore, new applications could further boost demand, whether the cooling of data centers, the production of hydrogen production,

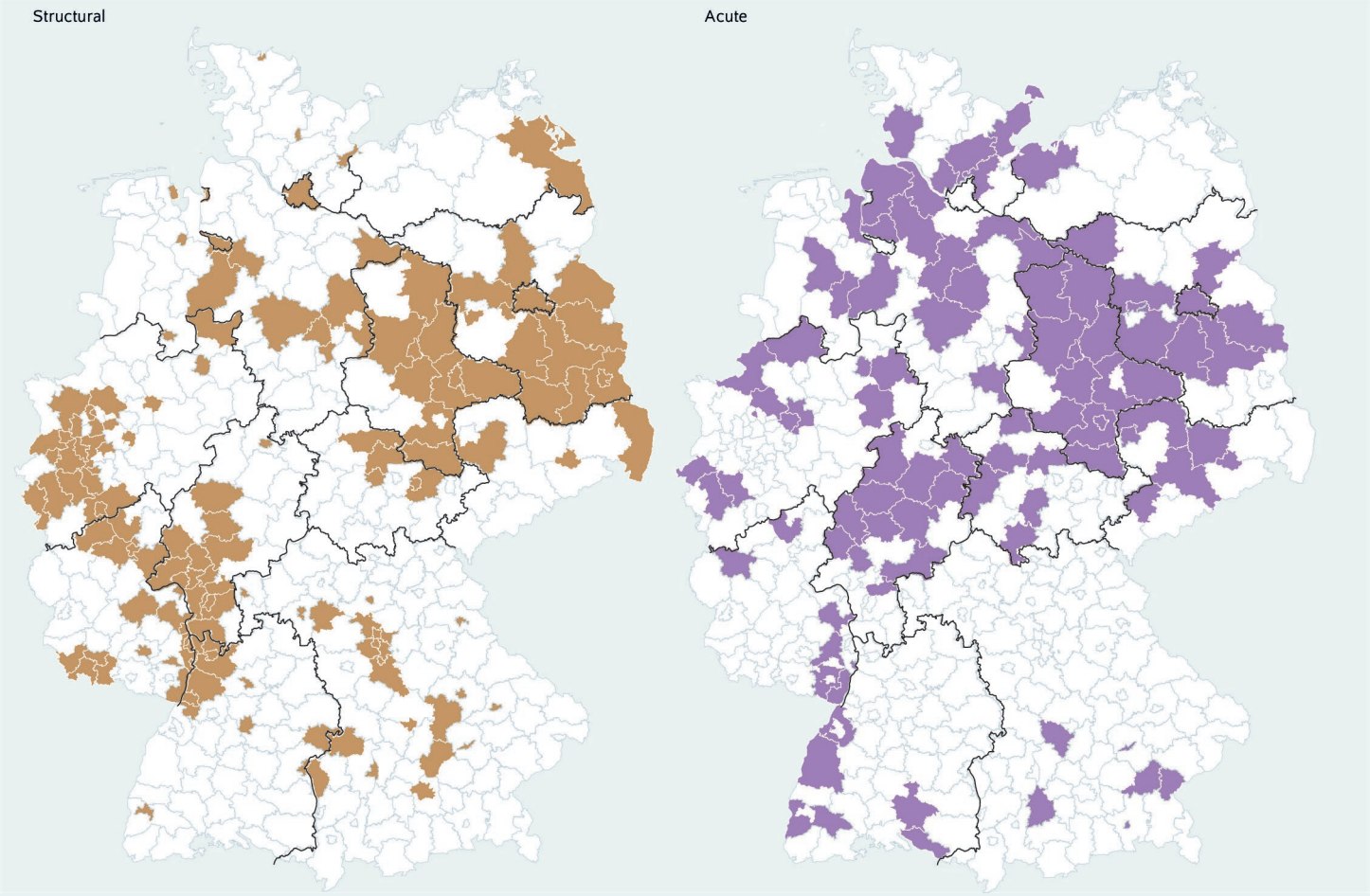
1 Water availability refers to the usable amount of freshwater available from the natural water cycle over a specific period of time. See Umweltbundesamt: Glossar (in German; available online, accessed October 20, 2026. This also applies to all other online sources cited in this report, unless otherwise noted).

2 The authors express their sincere thanks to Ina Sieber for her extensive support in the preparation of this report and for her helpful discussions.

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Figure 1

Groundwater Stress in Germany
By counties and independent cities



Note: Structural groundwater stress is defined as the ratio of the average groundwater withdrawal from 2004 to 2019 to the average groundwater recharge (1991–2020). If the groundwater withdrawal exceeds 20 percent of groundwater recharge, the county is considered affected. Acute groundwater stress is present if the number of low groundwater levels increased significantly between 2012 and 2021. Significance is determined using the Mann-Kendall test.

Source: Institute for Social-Ecological Research (ISOE); own presentation.

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About half of the counties suffer from structural or acute groundwater stress, particularly in eastern and northern Germany.

or the climate-driven increase in agricultural irrigation needs. Regional shortages have become apparent, especially during the dry years of 2018, 2019, and 2020.

Regions across Germany are affected

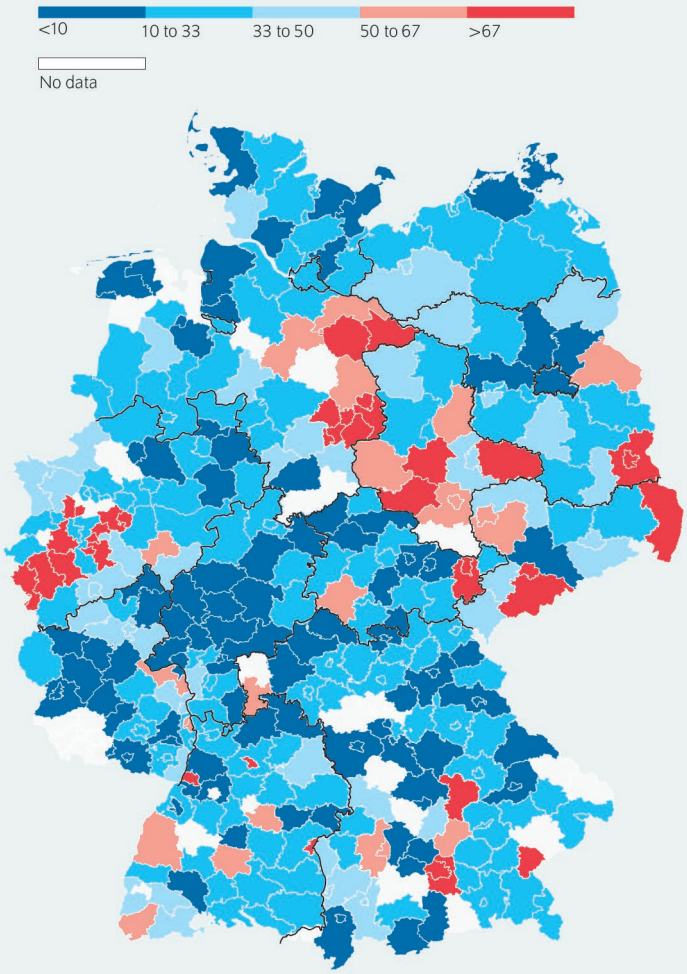
A study by the Institute for Social-Ecological Research (ISOE), commissioned by Friends of the Earth Germany (BUND), shows just how widespread groundwater scarcity already is in Germany (Figure 1).[3] According to the study, 201 out of 401 counties and independent cities are potentially affected by groundwater stress.[4] The areas most affected are in eastern and northern Germany, along the Upper Rhine, and in parts of southwestern Germany. In addition to climate change and withdrawals for public water supply, the study cites non-public withdrawals by industry as one of the causes.

3 Robert Lütkemeier and David Kuhn (2025): Grundwasserstress in Deutschland. Überblicksstudie: Struktureller und akuter Grundwasserstress durch öffentliche und nicht-öffentliche Entnahmen auf Ebene der Landkreise. Institute for Social-Ecological Research (ISOE) on behalf of BUND (in German; available online).

4 If the long-term average rate of groundwater abstraction exceeds 20 percent of groundwater recharge, a county is considered to be affected by structural groundwater stress. Acute groundwater stress is present when the number of groundwater low points has increased significantly.

Figure 2

Share of non-public groundwater abstraction in total abstraction
In percent



Note: Data for 2019 (latest available data). The percentages were calculated using the Groundwater Abstraction Index (GWGI) from the Federal Environment Agency, as the index distinguishes between public and non-public abstraction.

Source: Federal Environment Agency; own calculations.

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In about one-quarter of the districts, the share of non-public withdrawals in total withdrawals exceeded 33 percent.

Share of total water withdrawals attributable to non-public water users varies considerably across regions

To estimate the extent to which non-public withdrawals place a strain on groundwater, the groundwater extraction index from the German Federal Environment Agency (*Umweltbundesamt* (UBA)) can be used.[5] The share of non-public withdrawals in total withdrawals varies greatly by region (Figure 2). In those regions where the volumes withdrawn exceed those for public water supply, specific efforts should be made to reduce non-public withdrawals and allocate water withdrawal rights more efficiently —especially since public water supply is generally given priority.[6]

Key elements of the regulatory framework

Central to the regulatory framework for the management of surface water and groundwater in Germany are the EU's Water Framework Directive (WFD) and Germany's Water Resources Act (WHG).[7] The goal of the WFD is to protect surface waters and groundwater such that they are in "good status."[8] Among the fundamental measures that can be taken to achieve this objective are limits on the abstraction of surface freshwater and groundwater.[9] In addition, the EU directive provides for the creation of incentives for efficient water use and the internalization of environmental costs in accordance with the polluter-pays principle. One way to achieve this is through water abstraction fees (or water use fees), which are often earmarked for water protection.

Existing water withdrawal rights only take limited account of economic aspects

In Germany, water withdrawals require authorization under water law in the form of a permit or approval from the competent water authority.[10] In this context, the authorities have what is known as "management discretion."[11] Within this framework, they can balance different types of use against the ecological protection of water, but may also reject permit applications.[12] To date, there is no uniform nationwide regulation for prioritizing types of use and water withdrawals.[13] As part of the National Water Strategy adopted in 2023, a uniform framework for regional prioritization decisions is to be established.[14] Currently, policymakers are developing nationally coordinated guidelines.

5 See Ulf Stein et al. (2024): Auswirkung des Klimawandels auf die Wasserverfügbarkeit – Anpassung an Trockenheit und Dürre in Deutschland (WADKlim). Umweltbundesamt (ed.) (in German; available online).

6 See Michael Reinhardt (2019):): Der Vorrang der öffentlichen Wasserversorgung. Einfach-gesetzliche und verfassungsrechtliche Grundlagen, normative Umsetzung im geltenden Recht und Auswirkungen auf kommunizierende Rechtsbereiche. Rechtsgutachten. Institut für Deutsches und Europäisches Wasserwirtschaftsrecht (in German; available online).

7 Directive 2000/60/EC of the European Parliament and of the Council (available online); Water Resources Act (Wasserhaushaltsgesetz – WHG) (in German; available online).

8 For groundwater, the quantitative status is considered good if, among other things, the long-term average annual groundwater abstraction does not exceed the usable groundwater resource.

9 Directive 2000/60/EC of the European Parliament and of the Council, Art. 11(3)(e) (available online).

10 See Section 8(1) in conjunction with Section 9(1)(1) and (5) of the Water Resources Act. While a permit may be revoked at any time, each individual authorization is granted for a specific period and, in principle, may only be revoked in exchange for compensation.

11 Under the WFD, authorities must draw up management plans, which they must also take into account when evaluating permit applications.

12 See Section 12(2) of the Water Resources Act.

13 In some cases, the priority of public drinking water supply is enshrined in law; see Art. 31 of the Bavarian Water Act and § 37 of the North Rhine-Westphalia State Water Act. In isolated cases, more complex selection criteria also exist, such as the public interest or significance for the national economy; see § 18 of the Berlin Water Act.

14 See the website of the Federal Ministry for the Environment, Climate Action, Nature Conservation, and Nuclear Safety: National Water Strategy (available online).

Box 1

Direct Volume Control and Rights Trading as Alternatives—International Examples

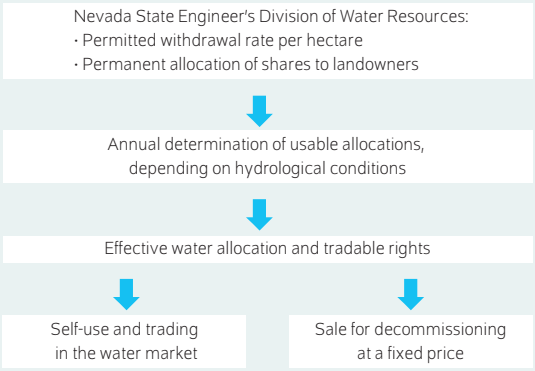
One way to use water resources more efficiently is through a combination of government volume control and market-based allocation via a rights trading system. After determining the sustainably available water volume of a watershed, usage rights or withdrawal quotas are allocated, taking into account existing rights, historical usage, as well as criteria of social equity and distribution. Within this volume-limited framework—which is set annually based on the available water supply—the rights and quotas can be traded among users, much like the EU Emissions Trading System (EU-ETS). The market mechanism enables an economically efficient reallocation of scarce resources, while the upstream volume control takes sustainability and distributional goals into account.

A well-established example is the Murray-Darling Basin in Australia, where long-term water rights (entitlements) and annual water allocations are traded within a government-regulated system. Long-term water rights secure a claim to a share of available water resources but do not guarantee a fixed annual water volume. The actual usable water volumes are allocated annually based on water availability and can be traded independently of the long-term water rights.[1]

Another example is the Groundwater Management Plan (GMP) in Diamond Valley (Nevada), which focuses on groundwater management.[2] Its goal is to gradually reduce groundwater withdrawals there to a long-term sustainable level within 35 years as well as to stabilize groundwater levels.[3] The GMP takes a hybrid approach that combines administrative volume control with market-based elements (Figure). To this end, landowners' existing water rights are converted into shares and associated water volumes. The number of allocated shares is determined by the water right, its historically established priority, and the annually available water supply. The annually usable water volume per share is gradually reduced according to a predetermined path aligned with climate trends.

Figure

Institutional Structure of Nevada's groundwater management plan



Source: Author's own illustration.

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The annually allocated water volumes can be transferred and traded. In addition to using the water themselves or selling it, landowners also have the option to permanently set their rights aside. For this voluntary waiver of use, the water rights law provided for compensation of $800 per acre-foot (approximately 1,233 m³) in 2024 in 2024.[4]

In both cases, government regulation remains essential: Water authorities must continuously monitor market activity and water withdrawals, thus ensuring that trading does not lead to overuse of the resource, ecological damage, or impairment of the watershed's hydrological functionality.

However, for water rights trading to function efficiently, there must be a sufficiently large number of market participants and appropriate trading platforms must be established. In addition, trading transactions must be registered in order to track the permitted withdrawal volumes for each user.[5]

1 See Australian Competition and Consumer Commission (2021): Murray–Darling Basin Water Markets Inquiry (available online); The Bureau of Meteorology (2023): Australian Water Markets Report 2021–22. Australian Government (available online).

2 In the eastern United States, water rights are typically tied to land ownership (riparian rights), whereas in the west they are often separate from the land and transferable (prior appropriation doctrine). See Laurel Saito et al. (2025): Rethinking water scarcity, energy, and agriculture: Coupling agrivoltaics with addressing groundwater depletion. JAWRA Journal of the American Water Resources Association, 61(2), e70021.

3 See Thomas J. Ott et al. (2024): Toward field-scale groundwater pumping and improved groundwater management using remote sensing and climate data. Agricultural Water Management, 302, 109000.

4 Central Nevada Regional Water Authority (CNRWA) (2024): Applications again open for voluntary water rights retirements in Diamond Valley. Press release dated July 9, 2024 (available online).

5 In Australia, there are privately operated trading platforms for this purpose, such as the Waterexchange. In addition, water registries are maintained, where changes in ownership and withdrawals are reviewed and registered by the authorities. See Australian Competition and Consumer Commission (2021), ibid.

Thus, currently the granting of water withdrawal rights still depends on respective state laws and the discretionary decisions of the responsible municipal water authorities. For non-public self-supply by commercial users, this means that there are no uniform guidelines and that an economically oriented assessment is not required when granting abstraction rights. Rather, authorities often decide based on the "first come, first served" principle, under which abstraction rights are granted according to the date the application was submitted.

Water withdrawal fees as a control mechanism lack precision

Water withdrawal fees in Germany are set at the state level and vary significantly from region to region, depending on usage, volume, and intended purpose. For example, groundwater abstraction fees amount to 31 cents per cubic meter in Berlin, 11.5 cents in Brandenburg, and 10.0 cents in Mecklenburg-Western Pomerania.[15] In many places, there are exemptions for uses that do not require a permit and are therefore exempt from fees due to low abstraction volumes, as well as for certain types of use such as hydropower, fishing, or the use of water as cooling water that is subsequently discharged back into the environment.[16]

However, with regard to the efficient use of water and the volumes abstracted, the actual incentive effect of the charges levied is difficult to assess. On the one hand, the effect depends on how strongly users react to the charges; on the other hand, exemptions and waivers reduce the environmental policy incentive effect of charges on the volumes of groundwater abstracted.[17] Furthermore, the charges are generally not adjusted to reflect the availability and overuse of regional groundwater bodies. In this regard, regulatory decisions on extraction applications play a far more significant role.

Auctions can be an efficient alternative for allocating water withdrawal rights

An alternative to the administrative allocation of water withdrawal rights and the imposition of fees for water withdrawal is a combination of government-regulated volume control and market-based allocation. Under this approach, the water authorities in charge first determine the sustainably available water volume of a watershed based on hydrological conditions. Thereafter, various options for market-based allocation are available. On the one hand, tradable usage or withdrawal rights can be granted, as is already practiced in Australia and some regions of the United States (Box 1). On the other hand, tenders or auctions are suitable for the non-public water supply sector. In this process, withdrawal volumes predetermined by the authorities are put out to tender. Bids can be submitted in the form of demand curves, through which users indicate the quantity they wish to withdraw and at what price. The market-clearing price—at which demand equals supply—is determined using the aggregated demand.[18]

A problem with auctions for the allocation of withdrawal rights under consideration here is that these are regional auctions in which the number of users (bidders) may be small. In such cases, bidders can assume that their bids influence the price and that lower bids will result not only in smaller (allocated) quantities but also in lower prices. To prevent bidders from underbidding, however, the payments that bidders must make at the end of the auction can be adjusted so that strategic bidding is no longer worthwhile from the bidders' perspective (Box 2).[19] For bidders, this adjustment also means that their actual payments are lower than the payments resulting from price multiplied by quantity.

Compared to the previous, administratively driven allocation of withdrawal rights, auctions have the advantage of enabling an economically efficient allocation: Bidders' bids are based on their willingness to pay, and the auction guarantees allocation to the bidders with the highest marginal willingness to pay. This is generally not the case with administrative allocation based on the "first come, first served" principle and the collection of withdrawal fees.[20]

The allocation of withdrawal rights for predetermined quantities also has the advantage that not only can the quantities for non-public supply be adjusted over time to hydrological conditions and other priority uses but are also made transparent. Regional (scarcity) prices for non-public water withdrawal result from the auction outcome and require no additional regulation.

Withdrawal fees and auctions can be combined

The auctions described here and the water withdrawal fees levied to date can be used complementarily: If fees continue to be levied, they reduce the bids in the auction. In regions where there is no water stress and withdrawals do not need to be reduced, the auction price would be very low, if not zero. If withdrawals are to be reduced, the auction price would be correspondingly higher, but still lower than the auction price without withdrawal fees. Thus, the efficient allocation resulting from the auction and the intended internalization of environmental costs through the collection of withdrawal fees are not mutually exclusive.

When auction prices are particularly high, issues of distribution and the protection of existing rights may arise beyond purely economic considerations. For example, if the willingness to pay among agricultural operations and industry

15 BUND (2025): Wasserentnahmeentgelte der Länder (in German; available online).

16 Federal Environment Agency (2026): Übersicht über die Länderregelungen zu Wasserentnahmeentgelten (in German; available online); see also Harald Ginzky (2005): Ausnahmen zu den Bewirtschaftungszielen im Wasserrecht. Voraussetzungen, Zuständigkeiten, offene Anwendungsfragen. Zeitschrift für Umweltrecht, 16, 515–524.

17 For a discussion of the effects of water withdrawal fees in the public water supply sector, see Gero Frank Scheck et al. (2025): Wasserkonflikte im Spreegebiet durch Anpassung der Wasserentnahmeentgelte und Renaturierung lösbar. DIW Wochenbericht Nr. 21, 303–311 (in German; available online).

18 See Vijay Krishna (2002): Auction Theory. San Diego.

19 Exaggeration can be worthwhile for individual bidders (companies) if they can thereby increase their competitors' costs, thus gaining competitive advantages that more than offset their own cost increases. In the framework considered here, however, this requires relatively strict conditions. See Steven C. Salop and David T. Scheffman (1983): Raising rivals' costs. The American Economic Review 73(2), 267–271.

20 If, in an administrative allocation, all users receive the quantities they requested, their actual withdrawals will depend on the fees. If the same (aggregate withdrawn) quantities were specified in an auction, the auction price would equal the fee.

Box 2

Incentive-Compatible Auctions for Water Withdrawal Rights

The auction proposed here is a "multi-unit, private value" auction in which demand functions are submitted as bids. The bids yield the aggregate demand and, given a specified total available withdrawal volume, the market-clearing price (equilibrium price) is determined. Let $\sum_{i=1}^{N} X_i(p)$ be the bids of all participating bidders and P be the clearing price; then the payment for bidder i

$$Z_i(P) = PX_i(P) - \int_{P_{-i}}^{P} \left[X^A - \sum_{j=1, j\neq i}^{N} X_j(p) \right] dp,$$

where P_{-i} denotes the clearing price without bidder i and X^A denotes the quantity to be auctioned. The payment $Z_i(P)$ results from the product of the price and the quantity demanded at that price, plus a payment

$$\int_{P_{-i}}^{P} \left[X^A - \sum_{j=1, j\neq i}^{N} X_j(p) \right] dp,$$

which captures the effect that the participation of bidder i has on all other bidders. Essentially, this term reflects the change in the price and payments of all other bidders caused by bidder i.[1] In principle, this means that all bidders have an interest in achieving an efficient allocation given the demand functions of all other bidders and, thus, an incentive to submit their true demand functions as bids.

1 This approach is based on the Vickrey-Clarke-Groves auction. For a detailed formal derivation, see Pio Baake, Christian von Hirschhausen, and Sebastian Schwenen (2023): Local Energy Markets. The Journal of Industrial Economics 71(3), 855–882.

differs significantly, auctions can be conducted separately[21] or by type of use. This achieves efficient allocations within the sectors; however, the total of the respective allocated quantities should continue to be guided by the need for hydrologically and ecologically sustainable groundwater use.

21 If individual companies are excluded from the auction and previously granted permits are extended beyond their current term, this would amount to company-specific subsidies, which would need to be justified in terms of industrial and competition policy.

Conclusion: make the allocation of water withdrawal rights more transparent and efficient

In light of increasing water scarcity, surface water and groundwater must be managed in an ecologically sustainable and efficient manner in the future. The allocation of abstraction rights for the direct use of groundwater by industry, agriculture, and mining plays an important role in this context. Focusing on non-public (groundwater) abstraction allows for an economically oriented analysis that prioritizes the efficient allocation of available quantities. To date, allocation has been carried out administratively, without systematically taking economic aspects of use into account.

The allocation via auctions discussed in this report is based on users' willingness to pay. This enables an economically efficient allocation of available quantities. Since groundwater stress and the significance of non-public withdrawals vary greatly from region to region, auctions can be particularly helpful as an allocation mechanism in regions with high demand and significant competition for water use.

When allocating resources through auctions, the sustainably available withdrawal volume must first be determined through political and water management decisions, while ecological minimum requirements and priority uses must be taken into account. The permissible withdrawal volumes should be regularly adjusted to reflect hydrological conditions and trends in groundwater recharge. This requires reliable data on available water volumes and actual withdrawals, as well as continuous monitoring of the affected groundwater bodies.

Administrative and political decisions remain necessary to properly prioritize the various types of use. Auctions come into play only when allocating the remaining non-public withdrawal volumes. Water withdrawal fees and auctions are not mutually exclusive. While fees can specifically incorporate environmental and resource costs, auctions govern the allocation of a previously determined scarce withdrawal volume. This presents policymakers with a task: In regions with high groundwater stress and a significant share of non-public withdrawals, it should be examined under what legal and institutional conditions volume-based allocation procedures via auctions can be introduced.

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