Focusing on gas storage levels distracts from what really matters: using less gas

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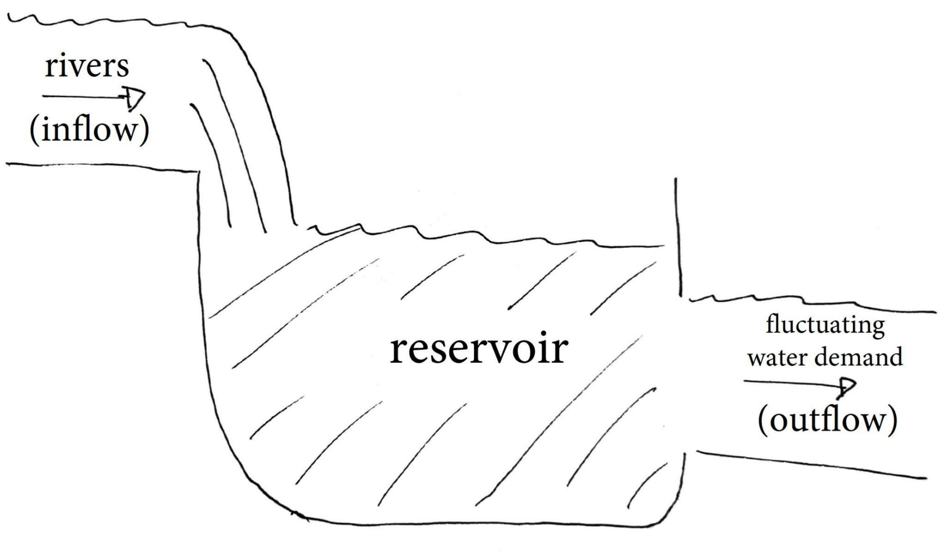
Abstract

As European countries approach winter, much of the media and popular debate are fixated on gas storage levels and supposed milestones of reaching 75%, 85% storage capacity are being celebrated. This short paper uses an analogy between gas storage and a water reservoir to explain why focusing on gas storage levels (a stock in percentage terms) can be a distraction. Instead, the key for Europe to get through the winter without Russian gas is for its citizens and firms to reduce gas demand (a flow). Encouragingly, substantial demand reduction has already taken place and the necessary further decline in gas usage is feasible. While "gas-storage optimism" is out of place, "gas-demand and gas-substitution optimism" are instead warranted.

1. The Water Reservoir Analogy

Gas storage is like a small water reservoir. This reservoir is fed by some large rivers (the inflows) and balances a large, fluctuating water demand, say for showering and irrigation (the outflows). Figure 1 illustrates such a reservoir.

Figure 1: Gas storage is like a small water reservoir

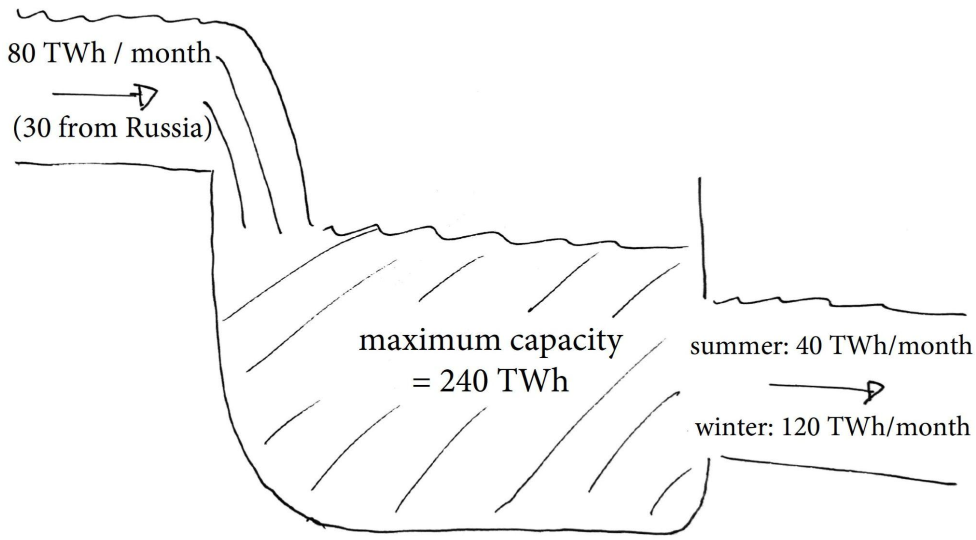


*This short paper is an expanded and improved writeup of a Twitter thread by the author https://twitter.com/ben_moll/status/1559220780692606978?s=20&t=68HOtiH74hlOs9EQSIPiaw. It incorporates some of the feedback I received on Twitter and provides a more detailed treatment of some issues. I am grateful to Andreas Peichl and Moritz Kuhn for useful discussions and to Christian Endt, Markus Epp, Aurel Wünsch and anonymous Twitter user @Kwak05822769 for comments.

The analogy is hopefully clear. Water demand is gas demand. The rivers are gas imports from abroad, with Russia having been the largest river, a new LNG terminal corresponding to a new river, and so on. Importantly, the words "small" and "large" are chosen deliberately because they reflect the typical reality in the case of inflows into, outflows from, and total capacity of gas storage.

Figure 2 uses the same schematic as Figure 1 but adds these quantities in terawatt-hours (TWh), roughly corresponding to those for Germany in past years. More precisely, I took numbers from our recent paper (Bachmann et al., 2022) and rounded them in such a way to simplify calculations.[1]

Figure 2: Rough magnitudes for Germany



Note: the underlying numbers are from Bachmann et al (2022). These were rounded to make calculations easier.

Importantly, the total German storage capacity of about 240 TWh is small relative to both inflows and outflows.[2] For example, the storage capacity equals “only” the gas consumption of about two winter months (120 TWh per month) and gas imports of about three months (80 TWh per month). What these numbers make clear is that both inflows and outflows quantitatively swamp storage. For example:

[1] The goal here is not to provide exact numbers but instead to give a sense of the magnitudes, which is what the points made in this paper rely on. Some more information on the underlying numbers from Bachmann et al (2022): outflows (gas demand) are an average of this quantity for previous years (see in particular Bachmann et al’s Figure 2). In contrast, the inflows (gas imports) already take into account some diversification of imports from countries other than Russia that has happened since early 2022 and the construction of new LNG terminals. In previous years, dependence on Russian gas imports was substantially higher than 30/80 = 37.5%.

[2] The gas storage facilities are effectively even a bit smaller than the official maximum capacity because you cannot empty them too much for technical reasons. See https://twitter.com/GeorgZachmann/status/1558728177647763458?s=20&t=FmhRIv5n6JoQCib2iXyQUw and Fraunhofer (2022).

- As just noted, without inflows, storage would be exhausted in only about two winter months: storage capacity - 2*outflows = 240TWh - 2*120TWh = 0TWh.
- With inflows, this time period increases from two to six winter months: storage capacity + 6*(inflows - outflows) = 240TWh + 6*(80TWh - 120TWh) = 0TWh.

2. What to do if the main river feeding the reservoir may stop flowing?

Back to the water reservoir. The main question I will discuss going forward is: What to do if the main river – let's call it "Nordstream 1" – may stop flowing completely ahead of a period with very high water demand? As I will explain momentarily, an unhelpful strategy is to focus on the reservoir level (the stock) and declare success when it reaches 75%, 85%, and so on. Instead a much better strategy is to start using less gas immediately, i.e. to reduce gas demand (the outflow). More precisely, the key is to substantially reduce gas usage during the high-demand period (the winter in the case of gas).[3]

Why? The reservoir is simply not large enough. The large reduction in inflows means that even a reservoir at 100% capacity just isn't enough to make it through the high-demand period. To see this, consider the quantities in Figure 2, assume a reservoir at 100% capacity, that “Nordstream 1” stops flowing so that inflows are reduced from 80 to 50, that water usage (the outflow) does not decline, and that the high-demand period lasts for six months. Then the reservoir runs out quickly:

- after one month, the reservoir level is 170 (= 240+50-120),
- after two months, it is 100 (= 170+50-120),
- after three months, it is 30 (= 100+50-120),
- … and the reservoir is exhausted early in month four.

Similarly, it does not really matter whether the reservoir is at 75%, 85% or 100% at the beginning of the high-demand period: the reservoir will run out quickly regardless. With a 75% reservoir level of 180, i.e. 25% below maximum capacity, it will run out in the middle of month three (180 + 3*(50-120) = -30).

In contrast, a reduction in water demand is powerful. To see this consider a 25% demand reduction from 120 to 90. Then the reservoir lasts for the entire six-month high-demand period: 240 - 6*(50 - 90) = 0. Alternatively, the necessary demand reduction can be found as follows: the water usage without demand reduction is 6*120 = 720; storage capacity plus inflows other than “Nordstream 1” is 240 + 6*50 = 540. Therefore the amount of water that needs to be saved is 720-540=180 which corresponds to a 25% demand reduction since 180/720 = 25%. On a conceptual level, this is precisely how we calculated the necessary gas demand reduction in Bachmann et al. (2022).

[3] Even though the main goal is to reduce gas demand in the high-demand winter months it is likely nevertheless important to “start using less gas immediately.” The reason is that it likely takes some time for demand to decline, i.e. demand elasticities increase with time (the "le Chatelier principle"), so we better start the process early enough.

As these considerations show, focusing on the water reservoir level distracts from what really matters: using less water. The situation is the same with European gas storage.

3. A stock-flow fallacy and the problem with reporting gas storage in percentage terms

The key in the water reservoir analogy is, of course, that it forces us to think about stocks and flows. The excessive focus on the gas storage levels is a classic "stock-flow fallacy": while stocks may sound important, they often get swamped by the flows.

To be clear: of course storing gas (the flow) is a good thing. But this will happen automatically when we reduce demand. What's problematic is the excessive focus on the storage levels (the stock), in particular the idea that with 100% storage we will be fine going through the winter: the quantities are just off. We need to focus on reducing demand (the outflow); if we manage, storage levels (the stock) will take care of itself.

Another way of looking at things is that the problem is that gas storage levels are reported in percentage terms. This obscures the small size of gas storage levels in absolute terms. A 90% storage level sounds large. But 90% of a small number is still a small number! If gas storage levels were reported in TWh instead of percentage terms and people had a sense of the cumulative gas demand over the winter months in TWh, they would likely never have gotten as fixated on the gas storage levels (see also the phone battery analogy in section 5).

For example, Bachmann et al (2022) calculate that cumulative German gas demand over the period August to the end of April (the end of the heating period) was 829 TWh in previous years. The entire gas storage capacity of 243 TWh is less than 30% of the cumulative demand until end of the heating period. The problem is that there is not enough awareness of these quantities.

The quantities in the preceding paragraph can be used to calculate a rule of thumb that again makes the point that the excessive focus on gas storage levels is a distraction:

- 1% storage level yields 0.3% less necessary demand reduction
- vice versa, 1% demand reduction is worth 3.5% storage

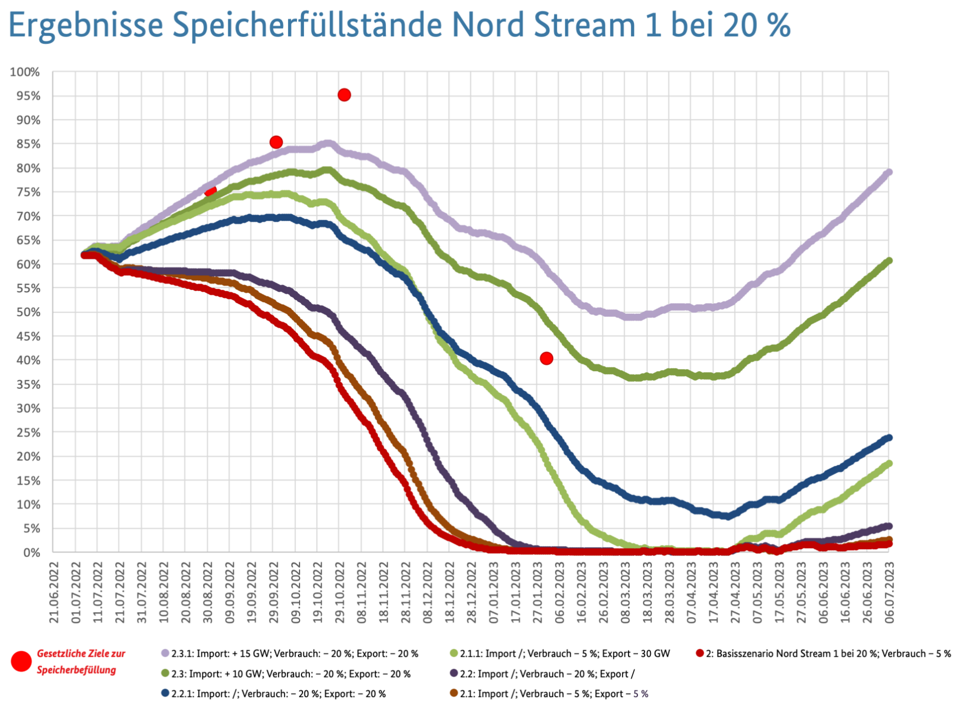
Therefore, using less gas is in a sense more than 3 times as important as the storage levels. For example, as the next section explains, Germany needs to reduce gas demand by about 25% until the end of the heating period. How much smaller would the required demand reduction be if storage levels were 10% higher? Answer using the “factor of 0.3” rule of thumb: a 10% higher storage level means a 3% smaller demand reduction, i.e. 22% instead of 25%. These 3% are of course “not nothing” but many people think that a 10% higher storage level would make a bigger difference.

The logic for the rule of thumb is simple: over the next 9 months, Germany needs to save sufficient gas so that the gas storage facilities are not empty toward the end of the heating period. Every terrawatt hour that is in the storage today can be used later. Therefore a

10TWh higher storage level, which is 4% = 10/243, means a 10TWh smaller demand reduction, which is 1.2% = 10/829. Similarly, 1% storage level yields 243/829 = 0.3% less necessary demand reduction. Vice versa, 1% demand reduction is worth 829/243 = 3.5% storage.

That German gas storage facilities are small relative to the corresponding inflows and outflows comes through very clearly also in the scenario analyses of the German network regulator Bundesnetzagentur (2022). One of these is reproduced in Figure 3. It shows that even small changes in assumptions about the future evolutions about gas imports, exports, and demand (i.e. the flows) lead to drastic differences in the evolution of the gas storage filling levels (i.e. the stock). How can that be? The answer is simple: the gas storage facilities are small relative to the flows!

Figure 3: the stock-flow issue is clearly visible in Bundesnetzagentur calculations



Note: the figure is copied from Bundesnetzagentur (2022). It shows different scenarios for the evolution of German gas storages, for example the most pessimistic scenario 2 (the red line) is the "basis scenario" with "Norstream 1 at 20%; Consumption: -5%" and the most optimistic scenario 2.3.1 (the lilac line) assumes "Imports: +15 GW; Consumption: - 20%; Exports: -20%". Even small changes in assumptions about the future evolutions about gas imports, exports, and demand (i.e. the flows) lead to drastic differences in the evolution of the gas storage filling levels (i.e. the stock). The explanation is that the gas storage facilities are small relative to the flows.

There is, of course, also a good reason why the gas storage facilities are small relative to the flows. After all, their entire purpose is to balance out seasonal and other fluctuations in gas demand (just like in the water reservoir analogy). Their purpose is *not* and has never been to store enough gas so as to be able to get through the winter with no or substantially reduced gas imports. So the inability of gas storage to deliver on this task is *by design.*

4. The necessary demand reduction is feasible

As we have seen, the key for Europe to get through the winter without Russian gas is for its citizens and firms to reduce gas demand (a flow). Focussing on gas storage levels (a stock) is mostly a distraction. But is the necessary demand reduction feasible?

In our recent paper (Bachmann et al, 2022) we argue that the answer is “yes.” We calculate that a 25% demand reduction is needed for Germany to make it through the winter without Russian gas and show “how it can be done” (the paper’s title) by listing concrete margins along which gas demand can be reduced. It is also important to note that the demand reduction is already well on the way, especially in industry: there are by now many cases of industry cutting gas consumption and substituting gas and gas-intensive inputs by significant amounts, see Bachmann et al (2022).[4]

An interesting question is what to make of the policy implemented by the German Ministry of Economic Affairs and Climate Action to increase gas storage targets relative to previous years. My view, and that of a number of other economists, is that this is good policy. Why do I say that despite writing above that gas storage levels are a distraction? The answer is: because it helps with reducing gas demand. The policy instructs storage providers to take gas off the market which increases gas prices and encourages demand reduction.

5. Other analogies and the paper’s message

Besides the water reservoir analogy, there are a number of alternative stock-flow analogies that can be used to make the same point:

- Mobile phone battery: you can now only charge it every other night. So you better start preserving battery, e.g. by spending less time using energy-intensive applications.
- Office water cooler: it gets refilled only half as often so you better drink less water.
- Water supplies on a boat.
- Pocket money from your grandparents that now arrives less frequently.
- Your saving account (though it does not feature a natural maximum capacity so it does not make sense to say that “my saving account is at 90% capacity.”)
- Even your toilet water tank.

The phone battery analogy is particularly useful to make the following point: the likely root cause of the excessive focus on gas storage levels is that people do not have a good sense of their capacity in absolute terms and of the relative size of stocks and flows. In contrast, everyone knows roughly for how long their phone battery lasts and has the intuition "my phone battery likely won't last for two days so I better use my phone less to preserve battery." This reasoning needs to become similarly obvious for the case of gas.

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[4] Also see the growing list of cases in this Twitter thread https://twitter.com/ben_moll/status/1548004135294754817?s=20&t=sx3C-q3wNi8IT15QzuH1aA. McWilliams and Zachmann (2022) have conducted calculations of the necessary demand reductions similar to those in Bachmann et al. (2022) for other European countries.

To conclude, let me state one thing clearly: this paper's message is *not* that Europe is doomed because the gas storage levels will not be enough to make it through the winter. Quite the opposite. Its main message is fundamentally optimistic: if we focus on the right thing, using less gas, and implement the right policies,[5] the necessary demand reduction is very much feasible. Therefore, while "gas-storage optimism" is out of place, "gas-demand and gas-substitution optimism" are instead warranted.

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[5] Policy decisions like those of the German government to reduce the value-added tax on gas consumption from 19% to 7% are, of course, exactly the wrong thing to do and counterproductive. It is absolutely crucial to support households, especially economically weaker ones, in the face of rising gas prices. However this should be done by means of transfers that are not directly tied to gas consumption and that preserve incentives for reducing gas demand.