

Power-to-Heat thermal storage – Green and affordable process heat for our industries

Herbert Piereder

This article discusses how Thermal Energy Storage technology, applied in a Power-to-Heat configuration (P2H-TES), will be instrumental in providing green process heat to industries at attractive tariffs. And – at the same time – help replace gas and support the further roll-out of renewable generation.

The underlying idea of P2H-TES is to capture the energy behind peaks from renewable electricity generation and shift it – out of the electricity network – into an industrial heat network.

This will help decarbonise our industries at highly competitive tariffs for process heat and support Renewables by improving the performance and cost-efficiency of the grid.

1 Introduction

May you live in interesting times!

Just when we should actually earn back all the money that we spent during Covid, Europe finds itself in an economic crisis, where the recent developments in the gas market, not just the high tariffs but also the uncertainty of future tariffs, triggered a massive interest from process industries for alternative solutions. And, of course, there is the rising CO₂-price.

Industries need solutions, like now, to relax the distress and it better be green!

Otherwise, we will soon be bouncing back to burning fossil fuels.

Process heat, that is mostly steam but also hot oil or hot air. The field that we are focusing on is up to a temperature of 500 °C, which makes for about 15 % of the total energy consumption in Europe. And the better part of it is still produced by burning gas. This may, at a first glance, not sound a lot but covers a wide range of industries such as chemical, pharmaceutical, refineries, food processing, breweries, distilleries, pulp & paper, hospitals and farming.

Offering alternatives in this field is therefore highly relevant!

At the same time we see rising tariffs for renewable electricity. This is mainly driven by its intermittent nature. The dips require balancing services from non-renewable sources and a growing population of batteries. And the peaks demand vast investments into grid capacity and increasingly curtailment of generators. All this is reflected in climbing network charges and we haven't seen the end of this.

Wouldn't it be great to bring the two challenges together and relax them both at the same time!? This is where thermal storage comes in.

2 Main part

When people talk about Renewables, the first line one always hears is: "Yes, but what if the wind's not blowing or the sun don't shine?" This is certainly a challenge – but the other end, those peaks, are a problem, too. To be able to feed them into the grid, high investments into network capacity are required. And very often generators have to be curtailed. So, whilst the cost of renewable generation has gone down significantly over the past 20 years, rapidly climbing network charges are causing high electricity tariffs. And with a growing population of renewables generation they will keep rising.

In the center part of Figure 1 below you see your typical annual pattern of a mix of renewable generation.

The underlying concept of P2H-TES is to capture the energy behind those peaks and shift it – out of the electricity network – into a heat network. And by doing so provide CO₂-free process heat when it's needed and at highly competitive tariffs, like in the good old gas days.

The remaining band of renewable electricity, that is now being fed into the network is much steadier, to the effect of less demand for network investment and balancing services. These two together help reduce network charges and there is now more headroom for new connection of Renewables. Wind and PV project developers can claim lower connection costs and avoid curtailment.

So, P2H-TES acts on the one hand like a relief valve for the grid and on the other replaces gas.

Of course, appreciating electrical energy from the spot market, to heat up the store, at low or negative price levels or from providing balancing load to the electrical network operator are further attractive options.

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Sector Soupling at Source

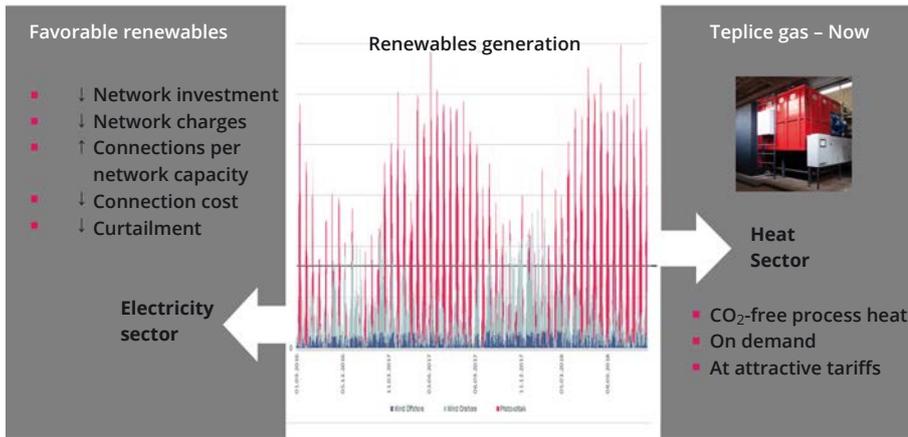


Fig. 1. Sector coupling.



- Feasibility study at Highland Park Distillery funded through BEIS Greening Distilleries Competition
- Turn otherwise curtailed wind energy (27 GWh p.a.) into CO₂-free steam (Replace diesel)

Fig. 2. Whisky Distillery.

In the following three typical applications:

The first one is a **Scottish whisky distillery**, that we looked at in the course of the UK Government funded Greening Distilleries Competition (Figure 2).

The Orkney Islands – far in the North of Scotland – are the miracle wonderland of wind farming! A significant number of windfarms is already installed – and there is potential for much more. But the bottleneck is the grid capacity, so that currently every year 27GWh of the potential wind power generation are being curtailed.

The concept is simple. Tap into that otherwise curtailed electricity at attractive tariffs and turn it into steam at an efficiency of >90%. And at the same time help to better balance the existing grid and get more out of it.

The second example is a fossil fueled **Combined Heat & Power** scheme, as you can find them with many industries and industry parks (Figure 3).

Typically, their operation will follow the steam demand which can be rather volatile. Hence, the plant never runs at its point of maximum efficiency.

What we are proposing here, is to have a P2H-TES alongside the original plant and bring more flexibility into its operation via a combination of the following:

The most obvious one is peak shaving. When there is a peak in steam demand, it comes out of the P2H-TES rather than the CHP.



Fig. 3. Combined heat & Power scheme.

Thus, the plant can be run more steadily and closer to the maximum efficiency.

Secondly, and this becomes more and more important, the operator can now flexibly decide, which fuel to burn – gas or electricity – depending on tariffs.

Thirdly, many CHP plant are already in the business of providing frequency response services to network operators by feeding electricity into the network when the frequency goes down. Now, it can also work in the opposite direction, providing a quickly switchable, purely resistive load to the network operator, when there's too much electricity in the network. With a growing population of Renewables one of the two situations will always be the case.

What we call “Transitioning” here is the fact that, by adding more thermal storage over time – without altering the original plant – the asset can be adapted to the various market developments.

And, thirdly, on **offshore wind**.

Here one of the key challenges, again, has to be the intermittency of wind generation with those peaks being fed through a landing substation into the utility network. For the onshore electricity network to be able to accept this energy, significant investment in re-inforcing the network are a precondition. In addition to this, substantial amounts of balancing power, required to manage network frequency, add to the energy costs.

Many of the offshore wind projects are currently on hold due to increased costs and investors are looking for ways to improve the overall business case through bringing down costs and finding new revenue streams.

P2H-TES offer a robust case here. Imagine an industry park around the landing substation with a simple but strong message to industries:

De-carbonise & flex fossil fueled power plant

Parallelen of existing CHP-plant and P2H TES

Increase efficiency through peak shaving

- Fuel flexibility
- Bi-directional balancing services
- Transitioning

“If you invest here in your production facilities, we will provide you with 100% green process heat, at tariffs like in the good old gas days and we can guarantee these tariffs over a period of 10 to 15 years.”

3 Summary

Is thermal storage going to solve the whole problem, will it decarbonize the whole industry? Certainly not!

But it is an immediate one, P2H-TES solutions are available now, and sensible step in the right direction. It will increase the much-needed flexibility in our energy systems, give our industries a competitive edge and – on top of it – save and create jobs in Europe.

The situation in the gas market also poses a new strategic opportunity. What used to be called the “gas market” and is actually the “process heat market” is, for the first time in decades, approachable. It’s big and it’s profitable and there are already new entrants popping up who offer “heat as a service”.

No article without mentioning hydrogen these days. Should producing green hydrogen, shipping, storing and burning it to produce process heat ever become economically viable, it will not be in time for currently distressed companies.

And finally, an appeal to all policy makers out there:

“If you are really serious about reducing our dependency on gas – then, please, free thermal storage from network charges!”

Disclaimer: One of the author’s clients is Berlin-based Lumenion GmbH (<https://lumenion.com/en/>) who developed a thermal storage technology and the author carries out business development activities for them. |

Kurzfassung

Power-to-Heat-Wärmespeicher – Grüne und bezahlbare Prozesswärme für die Industrie

In diesem Artikel wird behandelt, wie thermische Energiespeicher in einer Power-to-Heat Konfiguration (P2H-TES) zunehmend bei der Versorgung von Industrien mit Prozesswärme eine Schlüsselrolle spielen. Sie bieten eine wettbewerbsfähige Alternative zu Gas und unterstützen gleichzeitig den weiteren Ausbau von Erneuerbaren.

Das Grundkonzept ist, die Energie hinter den intermittierenden Erzeugungsspitzen erneuerbarer Energie – aus dem Stromnetz heraus – in ein industrielles Wärmenetz zu verschieben.

Dadurch wird nicht nur eine Dekarbonisierung der Industrie zu attraktiven Tarifen erreicht, sondern auch der weitere Ausbau der Erneuerbaren durch Verbesserung der Performance und Kostenstruktur der Stromnetze unterstützt. |

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vgbe-Standard VGBE-S-010-00-2023-08-EN

Feed Water, Boiler Water and Steam Quality for Power Plants/Industrial Plants formerly VGB-S-010-T-00;2011-12.EN

154 S., 46 Abb., 24 Tab., vgbe energy e.V. & vgbe energy service GmbH, Essen, Deutschland (2023) print/e-book, English and German edition available

Price for vgbe-members* 240.- €, non-members 360.- €, + postage, package and VAT

vgbe energy e.V. hereby presents a revised version of the VGB-Standard VGB-S-010 for “Feed Water, Boiler Water and Steam Quality for Power Plants/Industrial Plants”. This vgbe-Standard replaces the edition 2011.

The present vgbe-Standard summarises the latest and updated experiences gained within water-steam chemistry worldwide and is the work of an international task group organized by the vgbe Technical Committee “Chemistry and Emission Control” (CEC).

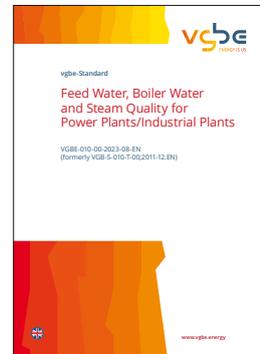
This task group identified and agreed on more than 80 single topics to be revised, or to be rewritten for further precision or also to be integrated as new/additional information in order to deliver the most actual information, state of the art and recent technical developments.

It needs to be emphasized again, that this standard is also valid and applicable for any kind of industrial power plants with process steam production for all pressure ranges.

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