Enhanced Steam Extraction for Carbon Capture Units

Solutions for Energy-from-Waste Plants, Biomass Plants, and Industrial Applications

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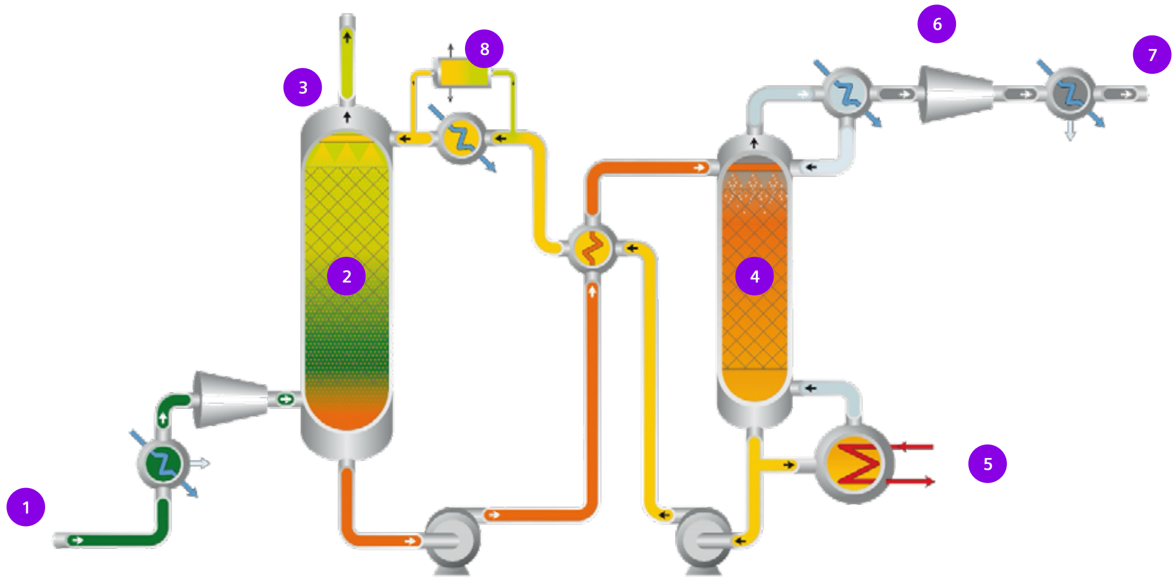
Carbon capture and storage

Carbon capture and storage (CCS) is a critical technology aimed at mitigating climate change by capturing carbon dioxide (CO2) emissions from industrial processes and energy generation. This process involves capturing CO2 directly from emission sources, followed by its compression, transportation, and long-term storage, effectively removing it from the natural carbon cycle.

As nations strive to meet ambitious decarbonization targets, the integration of CCS into existing energy systems becomes increasingly vital, necessitating a compre-hensive understanding of the thermal demands associated with these technologies. However, in discussions about carbon capture technology, it is mportant to understand that the carbon capture units require a considerable amount of extra heat and steam to be operated effectively. This article explores potential solutions for plant operators, with a particular emphasis on addressing the challenge of excess heat in the operation of carbon capture units.

For Post Combustion Flue Gas Carbon Capture, Amine (solvent) based is most mature for large commercial scale (other technologies are available and being scaled up)

Cleaned flue gas released to atmosphere



1. Flue gas from power plant is cooled and fed to the absorption column
2. Flue gas encounters the solvent which captures the CO_2 from the flue gas and clean flue gas can be released to atmosphere
3. The solvent is circulated between the absorption and desorption columns, with the CO_2-reacted solvent being heated in the desorption column to release almost pure CO_2 for disposal before the solvent returns to the absorption column and the process begins again

- 1 Flue gas inlet (from power plant)
- 2 CO_2 Absorption
- 3 Washing step
- 4 CO_2 Desorption
- 5 Steam
- 6 CO_2 Compression
- 7 CO_2 Outlet (high concentration)
- 8 Solvent Reclaiming

The UK's Decarbonization Strategy for Energy from Waste

In the UK, the government is poised to expand its emissions trading scheme (UK-ETS) to encompass waste combustion and Energy from Waste (EfW) facilities by 2028. This regulatory shift underscores the urgency of decarbonizing the EfW sector, which plays a significant role in the nation's energy landscape. EfW processes convert residual waste into energy, generating approximately 3.2% of the UK's total power output while contributing around 3.5% (14.4 Mt CO_2) of the country's net annual greenhouse gas emissions as of 2022[1]. The integration of CCS into EfW facilities not only supports the transition to sustainable, low-carbon energy but also aligns with the UK's broader emission reduction goals.

The Challenge of Heat Extraction for Carbon Capture

Implementing a carbon capture unit in an existing EfW facility presents unique challenges, particularly regarding the need for additional heat extraction. A recent case study involving a 30 MW condensing steam turbine (type: SST-300) illustrates this challenge. In a significant move towards sustainability, the existing waste incineration plant is set to be enhanced with a new carbon capture unit. Currently powered by an SST-300 steam turbine, the facility will need to allocate 30 to 40% of its existing steam flow at 3 to 5 bar(g) to operate the carbon capture technology. This presents a complex challenge for the operator, who must find a way to generate the additional steam required without disrupting the ongoing waste incineration process. Balancing operational efficiency with environmental responsibility will be crucial as the plant navigates this transition.

Evaluating Solutions: Two Scenarios

To address the increased steam demand, Siemens Energy service experts, in cooperation with an operator of a waste incineration plant, evaluated two potential solutions:

- **Scenario 1: Installation of an additional backpressure steam turbine to cover the extra heat demand**

One potential solution to the steam supply challenge is the installation of an additional steam turbine within the existing plant infrastructure. While this option promises to enhance operational efficiency, it comes with significant demands, including a larger footprint and the need for extensive installation work. Despite these challenges, the operator stands to gain a state-of-the-art turbine that could greatly improve the plant's overall performance and sustainability efforts.

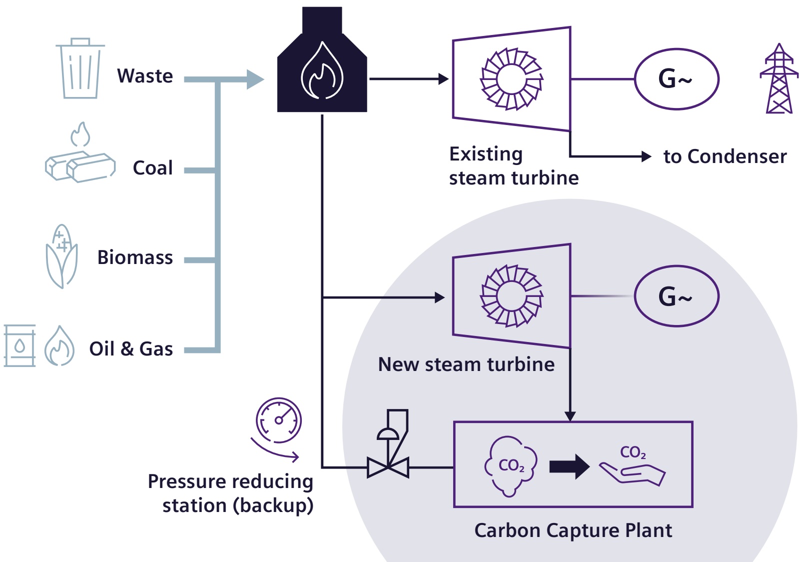


Figure 2: Scenario 1 installation of an additional steam turbine

1 Carbon capture from energy-from-waste (EfW): A low-hanging fruit for CCS deployment in the UK? The Oxford Institute for Energy Studies www.oxfordenergy.org/wpcms/wp-content/uploads/2024/05/CM09-Carbon-capture-from-energy-from-waste-EfW-Final.pdf

- **Scenario 2: Modification of the existing steam turbine**

Another option worth exploring is the modification of the existing steam turbine, despite its years of operation. There is potential for enhancements that could enable the turbine to handle the additional steam input required for the new carbon capture unit and required additional steam extraction. This approach not only leverages existing infrastructure but also minimizes the need for extensive new installations, potentially offering a cost-effective solution that aligns with the plant's sustainability goals while maximizing operational efficiency and minimizing cost.

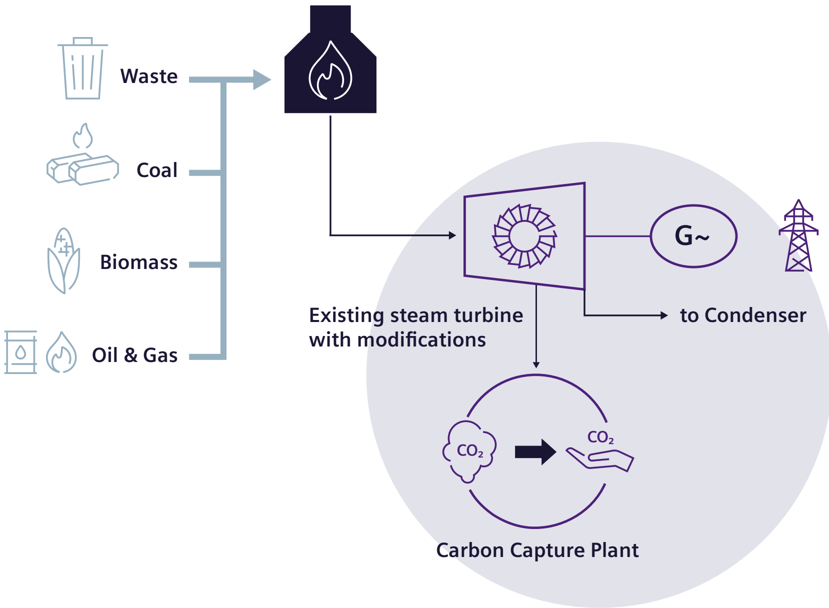
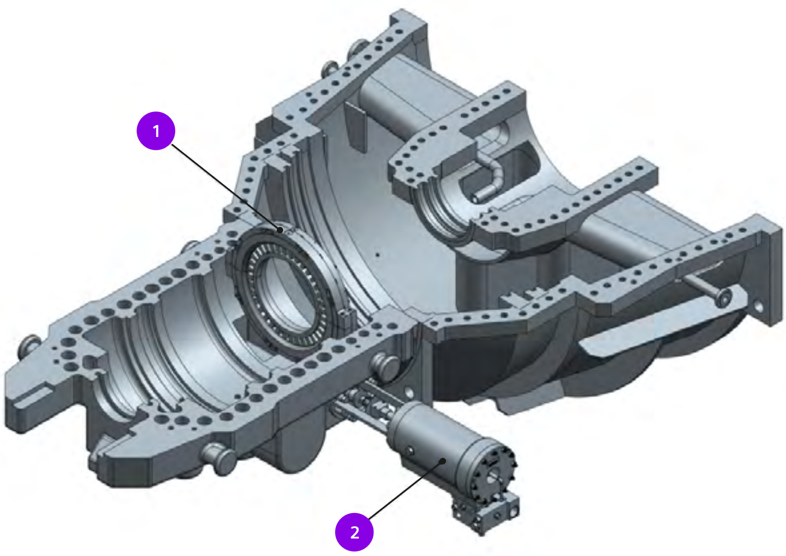


Figure 3: Modification of an existing steam turbine

Following a comprehensive evaluation of both options – in this case –, the decision has been made by the operator to modify the existing steam turbine. This strategy presents multiple advantages, including reduced capital and operational expenditures, as well as minimized space requirements – an important consideration given the additional footprint needed for the carbon capture unit. Furthermore, this approach promises to optimize the overall operation of the turbine, enhancing efficiency while aligning with the plant's sustainability objectives. The modifications involved:

- Adding a connection for additional steam extraction to the existing steam turbine.
- Supplying the necessary heat to the new carbon capture plant.
- Optimizing the existing steam turbine for the new operating regime.



1. New extraction valve (adaptive stage)
2. Drive for adaptive stage

Figure 4: Modified steam turbine

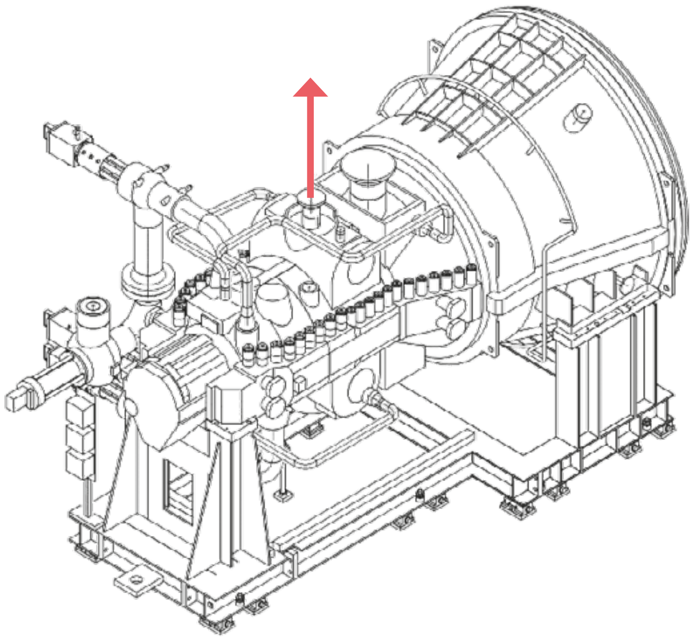


Figure 5: New Extraction (added) (to Carbon Capture Plant)

Tailored Solutions for Carbon Capture: Evaluating Steam Turbine Modifications vs. New Installations

In conclusion, the decision between modifying an existing steam turbine or adding a new one for enhanced steam extraction in carbon capture units is not straightforward, as both options present distinct advantages and challenges. A thorough analysis of the customer's specific situation is essential to determine the most effective solution. In the example discussed, modifying the existing turbine appears to be the most viable choice.

The modification of the existing steam turbine not only facilitates the integration of the carbon capture unit but also enhances the overall efficiency of the plant. By leveraging existing infrastructure, the facility can achieve greater output with lower capital investment and a reduced physical footprint. In the context of retrofitting an existing plant, the challenge of space becomes even more pronounced. The new carbon capture unit already demands additional room, and introducing an extra turbo set would further exacerbate the issue. Often, the necessary space is either unavailable or difficult and costly to acquire, making it a significant hurdle for operators. By opting to modify the existing steam turbine, the plant can not only streamline operations but also avoid the complexities and expenses associated with expanding its physical footprint, ensuring a more efficient and sustainable transition.

Conclusion

As the UK and other nations work towards ambitious decarbonization targets, the integration of carbon capture technologies in Energy from Waste facilities will be crucial in this endeavor. The modification of existing steam turbines to accommodate additional heat extraction represents a viable pathway to enhance the sustainability of EfW operations while contributing to significant reductions in greenhouse gas emissions and therefore should be considered during development and evaluation of different scenarios prioritizing this approach, operators can leverage existing infrastructure to meet regulatory demands and achieve operational efficiencies, ultimately supporting the transition to a low-carbon future in a cost efficient and therefore profitable way.

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