

EPPSA's CO₂ Capture Ready Recommendations

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EPPSA feels it necessary to define “Capture Ready” as this term is increasingly used without clarity of its meaning. EPPSA wants to contribute by highlighting some of the different challenges linked to the issue as seen by the suppliers of this technology. This document focuses on technical aspects and will not look into costs of operation or any other financial impact that CO₂ capture preparation may bring. It is a living document and shall evolve to incorporate advancements in Capture Ready technologies as they are developed.

The term “Capture Ready” may be applied in the context of:

- (i) an existing power plant;
- (ii) plants being renovated or retrofitted (for example with a new boiler or turbine);
- (iii) a new power plant.

There is particular interest in items (ii) and (iii). A plant being renovated and a new plant may be designed such that CO₂ capture and storage can be added later.

The list below covers criteria for all kinds of fossil fuel power plants, including:

- Various kinds of fuel, such as coal (hard, brown), gas, oil, and biomass;
- Various types of plants, classified as pulverised coal or fluidised bed combustion steam plants, Combined Cycle plants;
- The major types of CO₂ Capture and Storage Plants as listed below – see item 2.

The criteria discussed below are subject to change due to the continuing evolution of CO₂ capture technologies.

The following sections provide EPPSA's recommendations for CO₂ capture ready plant design criteria.

1. Power Plant Efficiency

1.1. Facts

The addition of CO₂ capture and storage to a power plant reduces the efficiency of the overall plant with consequential increases in both specific fuel usage (KJ/kwh) and cost of electricity generated. The “efficiency penalty” varies from 4 to 12 percentage points, depending on the capture technology and the type of power plant.

The following example is for a capture technology (without replacement power) with an 8 percentage point efficiency penalty:

- For an existing power station in Europe with an average fleet efficiency of 35% (LHV¹):
 - This would be reduced to 27% after adding CO₂ capture, resulting in increased specific fuel consumption of 29.6% and giving net CO₂ abatement of 87%².
- For a state-of-the-art power station in Europe with a net LHV efficiency of 45% (LHV):
 - The efficiency would be reduced to 37% after adding CO₂ capture, resulting in increased specific fuel consumption of 22% and giving a net CO₂ abatement of 88% (or 90.6% if the new plant replaced an existing 35% efficiency plant).
- For a future 700°C power plant with an expected net LHV efficiency of 50% (LHV):
 - This would be reduced to 42% after adding CO₂ capture resulting in increased specific fuel consumption of 19% (but still 16% less than a 35% plant) and giving a net CO₂ abatement of 88% (or 92% if the new plant replaced an existing one with 35% efficiency).

1.2. Recommendation

Efficiency improvement is the least costly method for direct CO₂ reduction and also minimises the capital and operation costs for the CO₂ capture equipment by reducing the flue gas/ CO₂ volume that the equipment needs to handle. It is therefore commercially beneficial for a CO₂ capture and storage project to consider thermal efficiency improvements that will lead to a reduction in the net cost of CO₂ capture.

2. Types of Power Plants and types of CO₂ - Capture and Storage Plants: How do they fit together?

2.1 Facts

There is a choice of CO₂ - Capture processes, depending on the power plant type.

2.2. Recommendations

The following table gives an overview of the major technologies:

Power Plant Type:	Post-Combustion: Solvent Scrubbing	Pre-Combustion:	Oxyfuel firing:
Pulverised Coal Steam Plant	Feasible	Not Applicable	Feasible
Fluidised Bed Steam Plant	Feasible	Not Applicable	Feasible
IGCC ³	Feasible	Feasible ^{4,5}	Non compatible technology: not feasible
CCGT ⁶	Feasible	Feasible ^{4,5}	Feasible

¹ Low heating value (LHV) In Europe this is the conventional definition for the fuel energy content.

² It is considered that a CO₂ removal of 90% of the total stream will be carried out.

³ IGCC – Integrated Gasification Combined Cycle

⁴ New gas turbine design necessary in order to burn H₂

⁵ Shift reactor and CO₂/H₂ separation are needed gas conversion and CO₂ remediation (capture) are necessary.

⁶ CCGT – Combined Cycle Gas Turbine

3. Space for Additional System and Components

3.1. Facts

The key requirement of a capture-ready design is the provision/availability of space for the CO₂ capture equipment of the type or types that may be used.

3.2 Recommendation

Space requirements should be planned taking into account:

- (i) the need for improved cleaning of flue gas where necessary (for post-combustion capture);
- (ii) the space for air separation units (ASU) for IGCC and Oxyfuel firing;
- (iii) the space for CO₂ cleaning and compression equipment;
- (iv) the space for extension of cooling water systems (up to 30%);
- (v) the space for flue gas recirculation ductwork for Oxyfuel firing.

Additional space may be required for:

- (i) oxygen storage if this is needed to balance generation and demand during load changes;
- (ii) temporary storage of compressed CO₂.

4. Compatibility of Power Plant Systems and Components with new process parameters after adding a CO₂ Capture and Storage Plant.

4.1 Facts

The addition of a CO₂ capture plant has implications for the existing plant and these must be taken into account during the design of the capture-ready plant.

4.2 Recommendation

- (i) For Pre-combustion capture on an IGCC, the properties of the gas stream through the gas turbine, heat recovery steam generator, and respective auxiliaries are substantially different and plants must be designed accordingly;
- (ii) For Post-combustion capture, the heat demand necessary for the desorption process during solvent scrubbing has to be recognised in the steam cycle design;
- (iii) For Oxyfuel firing, a flue gas recirculation system must be fitted, the combustion system may need to be modified, and the furnace/boiler designed to accommodate the CO₂ rich flue gases.

5. Location

5.1 Facts

The concentrated CO₂ has to be compressed (liquefied) and eventually transported to the final storage location or consumption point. CO₂ transport is a relatively low-cost part of the CO₂ capture and storage chain.

5.2 Recommendation

Ideally, the Power Plant will be located near an existing CO₂ pipeline infrastructure or storage site, or located in such a way that the necessary infrastructure can be installed with no major obstacles. However, plant integration with the electric grid, access to cooling water and acceptable noise levels are of greater importance than the location of the plant for proximity to a storage site or existing pipeline. Thus, locating the Power Plant close to the storage or transport facility can be done only where grid and water access are suitable at such a location. If this is not possible, then a plan needs to be developed that shows that CO₂ pipeline transport and storage is feasible for this plant location.

6. General Criteria: Facts and Recommendations

The following criteria are general and do not depend on a specific technology:

- For commercial reasons a minimisation of the **plant outage time**, in order to add CO₂ Capture and Storage Plant systems and components, is to be taken into account.
- **Plant size** must be such to economically justify all of the add-on measures (minimum plant size depends on specific situation).
- The authorisation process should allow the plant **to run with or without CO₂ capture**. This includes the design of bypasses as well as solutions for **carrying out the transfer** from capture mode to the non-capture mode. Ideally, the transfer should be made by keeping the unit operational. Transfer can also be made by shutting down the unit, but not the plant. In all cases, **specific control system** structures have to be developed and demonstrated.
- In order to label a plant as being “capture ready”, **a target abatement % (or g/kWh emitted)** of the produced CO₂ must be defined beforehand. The selection criteria could be linked to national emission plans depending on whether the capture process is added as retrofit or if the Plant will be a new build. In order to encourage the retrofitting of old plants, any abatement of CO₂ should be supported.
- The **impact on the plant’s net output** and thermal efficiency after conversion to CO₂ capture should be estimated before the plant is built.
- The plant should be designed with the **flexibility** to take advantage of improvements in CO₂ capture technology at the time of conversion.
- The plant should be designed to minimise the impacts of CO₂ and chemical reactants on **plant safety**.