

# Impact Estimation Höchst

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## 1 Assumptions & Resulting Numbers

For the quantification of the impact of the inclusion of technologies into the industry park Höchst, Scope 1,2 & 3 goals were provided. The technologies with corresponding association to the scope can be seen in Figure 1 below. The Matlab Script used for the quantification is connected to this report.

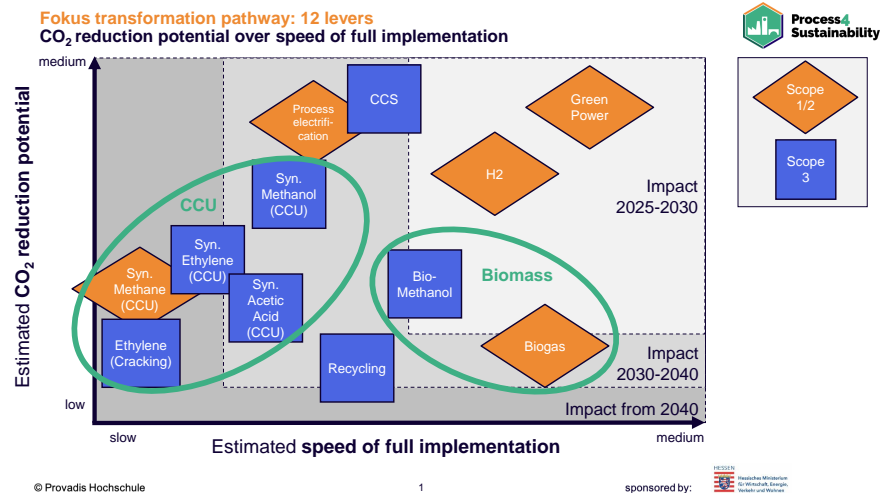


Figure 1: Focussed transformation pathways: 12 levers

Scope 1 is direct impacts, Scope 2 is indirect impacts and Scope 3 is induced impacts.

**For the call, the goals are 10% energy reduction, 20% material reduction and 30% CO<sub>2</sub> reduction.**

To quantify roughly the impact of different syntheses with carbon capture and energy reduction with H<sub>2</sub> and Green Power, the Carbon Footprint-Bericht Infraser Höchst 2010, (<https://www.infraserv.com/media/content/unternehmen/nachhaltigkeit/carbon-footprint.pdf>), for Scope 1 & 2, as well as rough

numbers of an LCA for Scope 3 were provided by Marcel.

From the carbon footprint report the numbers of yearly total energy demand, and the emissions connected from its production, follow.

[GWh/year]	Demand	Total Goal (10%)	Goal per year over 4 years
Electricity	1,794	179.4	44.85
Heat	3,784	378.4	94.6
Total	5,578	557.8	139.45

Table 1: Energy Demand [Unit: GWh/year]

[tons/year]	Emissions	Total Goal (30%)	Goal per year over 4 years
Scope 1	975,300	292,590	73,147.5
Scope 2	25,592	7,677.6	1,919.4
Scope 3	303,730	91,119	22,779.75
Total	1,304,622	391,386.6	97,846.65

Table 2:  $CO_2$  Equivalent [Unit: tons/year]

H2, Biogas, Green Power, Process electrification and synthesis of methane should target Scope 1 and 2. Therefore, with these measures in this call an **energy reduction of 139.45 GWh/year over 4 years and in a total of 557.8 GWh/year** needs to be achieved.

Correspondingly, as these measures target Scope 1 & 2, **75,067.9 tons/year of  $CO_2$  over 4 years should be reduced, so it results in a total of 300,267.6 tons/year.**

The provided numbers of the LCA for Scope 3 and the inclusion of carbon capture are shown below. In general for **1 Million tons/year bought total input** of methane, ethylene, acetic acid, methanol and others, **3 Million tons/year of  $CO_2$**  are emitted. The impact shares of these inputs to the total of 1 Million tons/year are also known.

Chemicals	Methane	Ethylene	Acetic Acid	Methanol	Others
Impact Share	19%	46%	8%	21%	6%
Input [tons/year]	190,000	460,000	80,000	210,000	60,000
Input over 4 years [tons/year]	47,500	115,000	20,000	52,500	15,000
$CO_2$ Emission [tons/year]	570,000	1,380,000	240,000	630,000	180,000
$CO_2$ Emission over 4 years [tons/year]	142,500	345,000	60,000	157,500	45,000

Table 3: Impact Shares, Input and  $CO_2$  Emissions for Scope 3

Looking at the potential material reduction and emission reduction one can see that they are connected by a multiplication factor of 3. Therefore, as the

goal of the  $CO_2$  reduction is higher than the material percentage, a combination of the syntheses of methane, ethylene, acetic acid, methanol or others can be used to achieve 30%  $CO_2$  emission reduction and with that at least 20% material reduction bought for input from third parties. It follows that **over 4 years in total 900,000 tons/year  $CO_2$  and at least 200,000 tons/year of material need to be reduced. This means a reduction per year over a span of 4 years of 225,000 tons/year of  $CO_2$  is required, which results in 300,000 tons/year in total material reduction and in a reduction per year over a span of 4 years of 75 tons/year of chemicals/material.**

This needs to be achieved with the implementation of one or multiple syntheses. To achieve the goal one can use the numbers in Table 3 and Table 4 below to match the set goals.

[tons/year]	Methane	Ethylene	Acetic Acid	Methanol	Others
Total Goal Material (30%)	57,000	138,000	24,000	63,000	18,000
Material (30%) Goal over 4 years	14,250	34,500	6,000	15,750	4,500
Total Goal $CO_2$ Reduction (30%)	171,000	414,000	72,000	189,000	54,000
$CO_2$ Reduction Goal over 4 years (30%)	42,750	103,500	18,000	47,250	13,500

Table 4: Material and  $CO_2$  reduction per syntheses [tons/year] for the goal of 30%  $CO_2$  reduction

To match the set goals one can combine one process completely with the numbers for 4 years in Table 3 or to 30% replacement with the numbers in Table 4. Either way, the sum of the syntheses combination needs to be larger or equal to the set total reduction goals. For example, a 100% implementation of Ethylene would cover the 900,000 tons/year total reduction of  $CO_2$  with 1,380,000 tons/year and 345,000 tons/year over 4 years. The goal would also be achieved with an implementation of a 30% replacement of all chemicals and implementation from Table 4. So one can decide on the own combination and set goals.