Response to the Roadmap for an EU Smart Sector Integration Strategy

Efficient use of resources could provide a moderate environmental benefit and potentially some reductions in greenhouse gas emissions. By expanding the electricity grid, improving electricity distribution, developing smart grids and integrating demand response in the power market we can build a more resilient and low-carbon energy system. However, smart sector integration – particularly in sectors such as energy intensive industries - only results in climate change mitigation under certain conditions. It is therefore important to note that in addition to smart sector integration actions, the transformation of energy intensive industries will call for other direct climate change mitigation efforts.

Key points: Climate screening criteria for Smart Sector Integration

To ensure that smart sector integration actions actually contribute to emission reductions, we recommend the use of the following screening criteria and their respective metrics for the initial climate evaluation of Smart Sector Integration actions:

1. **Evaluate efficiency of climate change mitigation per input of energy, in CO_2t/kWh**

It is important to recognise that not all smart sector integration activities will deliver the same result from a climate point of view. Direct uses of electricity which deliver the largest decarbonisation per input of energy should be prioritised where possible. As electricity needs increase, it will be important to prioritise its efficient use to manage the demand. Where possible, direct electrification measures such as heat pumps or vehicles with electric drivetrains should be prioritised[i].

2. **Evaluate the use of resources and do not discount 'waste' carbon flows to the atmosphere:**
   - **Use of electricity or energy resources, in *gCO_2/kWh of respective national grid* (unless directly connected with RES).**
   - **Use of liquid or gaseous fuels, scientific emission factor for fuel in *tCO_2/TJ***
   - **Use of waste, mass balance and flows in *metric unit for mass kg, t, kt, Mt***

   Tracking the carbon flows through and out of the industrial system into the atmosphere is crucial for the assessment of the climate impact of smart sector integration. For instance, industrial clusters can use resources very efficiently, but still could have a large emission point at the end of life of the production line. The suggested metrics can account for the most significant indirect emissions associated with a particular project, coming from either energy use, electricity use or the use of waste whose end-of-life fate has to be accounted for.

3. **Do not include emissions avoided elsewhere in the system into the calculation of greenhouse gas emission reductions.**

   To retain the possibility to monitor reductions and avoid creative accounting, the scale of emissions mitigated by the smart sector integration action should be assessed only directly at the point source. Avoided emissions shouldn't be accounted for elsewhere in the system[ii] - only reductions on site and attributed to a given smart sector integration action should be accounted for.

4. **Do not use data which does not reflect real-life and real-time emissions in the system.**

   The GHG criteria in the Innovation fund use zero-carbon electricity from 2050 for projects because they assume that they will be scaled up in the future. This **must not be used as a precedent** for calculating the impact of projects, as it does not reflect real-life emissions.

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By estimating the net flows of CO_2 to the atmosphere, these metrics will help quantify the climate impact of cross-sector initiatives which have been advertised even though their impact has not been thoroughly evaluated.

Measuring the effects of Smart Sector Integration will be challenging. Apart from initial screening criteria, a robust greenhouse gas methodology will be needed to assess their impact. Such quantification mechanisms will be crucial in parts of the European Green Deal, such as in Improving measurement, modelling and policy tools needed to capture synergies between the circular economy and climate change mitigation (2020) and Industry led industrial symbiosis reporting and certification system (2022).

Greenhouse gas methodology

Prior to large-scale deployment of smart sector integration projects in energy intensive industries, the EU should:

- ✓ **Develop a robust quantification methodology to measure the climate impact of smart sector integration**.

A robust quantification methodology should ensure that the overall, system-wide use of resources is reduced. For instance, a measurement is needed for the direct replacement and reduction of fossil fuels in the energy system caused by smart sector integration. Causation must be proven before climate benefit is rewarded, otherwise the strategy leaves room for gaming and creative accounting where real reductions do not happen in reality.

- ✓ **Ensure that the life-cycle assessment guidelines (LCA) for the REDII delegated acts account for all direct and indirect emissions, from cradle-to-grave.**

This includes the fossil carbon embedded in the inputs for the fuels. For low-carbon gases, both the electricity and/or energy source and the source of carbon (if any) should be accounted for. Since low-carbon liquid and gaseous fuels require significant resources to produce, these resources and their origin (fossil or renewable) must be taken into account. A full LCA ensures that all of these resource inputs are taken into account.

- ✓ **Exclude any 'avoided emissions' from the calculations if there is no direct causation between the smart sector integration action and the reduced use of fossil materials or fuels.**

Including avoided emissions in the calculation of the GHG footprint of a certain smart sector integration action can potentially recognise emission reductions that are not there in reality.

- ✓ **Not additionally reward existing industrial symbiosis for climate change mitigation if it does not lead to any additional and significant drop in emissions.**

If greenhouse gases are still being emitted in interconnected and symbiotic industrial clusters, giving an additional recognition of 'emission reductions' to these facilities reduces ambition for further emission reductions. In other words, wherever there are existing flows of carbon to the atmosphere, they should not be discounted because of the reuse of resources on site.

Smart Sector Integration applications in EIIs

The main section of this response is structured according to the main categories of smart sector integration identified in the Roadmap for an EU Smart Sector Integration Strategy; (i) electrification, (ii) use of renewable and decarbonised gases and fuels and (iii) a more circular and efficient energy system. The three categories are analysed through the lens of applications in energy intensive industries.

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Increased use of renewable electricity in energy intensive industries

Distributing electricity to direct uses and increasing RES capacity in Europe will be one of the most important tools for climate change mitigation in most sectors. An increase in cross-border transmission capacity and grid connections[iii] will be crucial for reducing GHG emissions, particularly in the coming decade.

In addition to developments in transmission infrastructure, most of the required investment is required at distribution level[iv]. Further integration of technologies such as heat pumps and electric vehicles into the power system[v,vi] could play a vital role in balancing out the grid.

Direct use of renewable electricity should be encouraged where possible to maximise its climate change mitigation potential. For energy intensive industries, the greatest potential lies in the most efficient direct applications:

- high TRL, commonplace technologies such as
  - electric arc furnaces[vii]
  - low-temperature heating and cooling of facilities[viii]
  - lighting and electrical processes[ix]
  - raw material preparation and processing[x]
- providing additional RES in regions with existing use of electricity in heavy industry, for e.g. extraction of aluminium oxides via electrolysis

Coupling greening grids with industrial clusters which are already large consumers of electricity in a certain region and making that use of electricity more efficient will yield the best results in terms of climate change mitigation. If the given project is not directly connected to dedicated RES, the emissions should be calculated according to the electricity mix of the respective country[xi].

To distribute renewable electricity, infrastructure must be built or expanded for the power grid, taking into account and encouraging any potential prosumers and smart grid developments (e.g. electric vehicle smart charging networks). Large infrastructure projects facilitating climate change mitigation in industry go across borders and need political engagement, both on EU and member state side. Necessary infrastructure not only includes power lines, but also dedicated hydrogen pipelines and storage and CO_2 pipelines, transport and storage networks[x].

Low TRL technologies such as electric steam crackers[xii] and plasma technology for cement production[xiii] can be considered in areas where there is surplus RES. Nevertheless, it should be noted that they do not have the potential to eliminate all emissions, since fossil fuels still exit the cracker and process emissions still exit the cement kiln.

Some innovative technologies such as solid state ammonia synthesis have the potential to fully eliminate greenhouse gas emissions from industries, but are still in the research phase and not commercially available[xiv].

In addition to the efforts in direct electrification, continued investments in unabated gas must be discontinued, as they will preclude climate effective deployment of innovative electrification options. Furthermore, it would be harmful to the innovation efforts of the EU and would compromise its current position as a global leader in certain low-carbon technologies (e.g. electrolyser research and deployment for the production of green hydrogen).

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Recommendations:

- Invest in necessary infrastructure, including power lines, grid interconnectors and distribution to accelerate and improve the uptake of renewable electricity sources.
- Use funding mechanisms such as the CEF to support grid expansion, interconnection and distribution and forego new investments in the gas sector. Apart from financial support, making planning, approval and permitting of such projects simpler will also remove some of the bottlenecks the industry is currently facing.
- Focus on incorporating renewable electricity sources into the regions with a high level of use in industry. Where possible, retrofit or equip new industrial facilities with efficient systems enabling the direct use of such renewable electricity, such as efficient heating and cooling mechanisms, e.g. heat pumps.

Use of renewable and decarbonised gases and fuels in energy intensive industries

Scientific research has shown that technologies such as electrolytic hydrogen and industrial electrification will have to be rapidly scaled up substantially during the coming decades.[xv]

However, low- and zero-carbon fuels (synthetic hydrogen, ammonia, methane and other hydrocarbons) will be a valuable and scarce resource in the future due to their resource requirements. In the case of synthetic liquid and gaseous fuels, the energy-intensive production process will be crucial for their climate impact. [xvi]

Since these fuels will require significant resources to produce, the environmental criteria for their production should be determined prior to their large-scale deployment.

The following factors should be assessed to estimate the climate impact of such low-carbon fuels (a non-exhaustive list):

Type of 'low carbon' gas/fuel (examples)	Energy and electricity input	Associated indirect emissions or carbon inputs
Hydrogen (SMR+CCS)	Energy use for carbon capture	Upstream methane emissions
Hydrogen (electrolysis)	Electricity used for electrolysis	/
Synthetic gas (CH_4)	Energy use for carbon capture Electricity used for electrolysis	Fossil carbon, Biogenic carbon (+ ILUC impacts), Atmospheric carbon (+ carbon capture energy use)
Fossil waste gases or fuels	Additional H_2 or energy input	Fossil carbon,

		Biogenic carbon (+ILUC impacts), Atmospheric carbon (+ carbon capture energy use)

For hydrogen produced via electrolysis, the electricity going into the process determines the GHG intensity of the hydrogen. Identifying break-even points compared to other fossil fuels would help identify hydrogen which is genuinely compatible with climate goals. If pointed out clearly, some **break-even points would help to define gaseous and liquid fuels which are genuinely compatible with climate goals.**

For instance, the UCL Energy institute in the UK in defining green hydrogen from electrolysis require deeply decarbonised electricity of 50 g CO_2/KWh to be used by 2050. [xvii]

The following table summarises the thresholds relevant for hydrogen from electrolysis:

Technology	**Electricity Carbon Intensity production**	**Carbon intensity / energy provided**
Comparison of hydrogen carbon footprint with low- and high-carbon electricity		
Hydrogen produced via electrolysis, low carbon electricity	~100 gCO_2/kWh	~138 $gCO_2/kWh_{thermal}$
Hydrogen produced via electrolysis, high carbon electricity	~440 gCO_2/kWh	~551 $gCO_2/kWh_{thermal}$
Comparison with hydrogen from natural gas		
Hydrogen electrolysis (break-even)	~260 gCO_2/kWh	~326 $gCO_2/kWh_{thermal}$
Grey hydrogen (from fossil natural gas)	n/a	~328 $gCO_2/kWh_{thermal}$
Comparison with natural gas		
Hydrogen from electrolysis (break-even)	~149 gCO_2/kWh	~204 $gCO_2/kWh_{thermal}$
Natural gas	n/a	~204 $gCO2/kWh_{thermal}$

Table 1: Climate footprint of hydrogen from electrolysis, compared to fossil hydrogen and natural gas.

Compared to natural gas, the green hydrogen will provide the same energy service at the same carbon intensity when produced in a low-carbon grid emitting 149gCO_2/KWh.

The use of dynamic and declining thresholds for carbon intensity, such as the 100gCO_{2eq}/kWh (to 0gCO_{2eq}/kWh by 2050) by the Technical Expert Group (TEG) on Sustainable Finance can ensure the sustainability of low-carbon hydrogen.

Adding similar thresholds both to the Smart Sector Integration Roadmap and the Clean Hydrogen Strategy would ensure that fuels produced with renewable energy sources comply with the climate goals of the EU.

For synthetic hydrocarbons, meeting these thresholds calls for an even cleaner grid. Creating fuels such as synthetic kerosene and diesel requires lower carbon intensity of the grid (in gCO_2/KWh) due to the additional efficiency loss in the process. Taking the synthetic fuel product as a synthetic diesel replacement, such as aviation diesel, the literature estimates a breakeven of less than 100 g CO_2/KWh with grid electricity. Bringezu and Turnhau (2018) estimate that reaching a break-even point with conventional fossil products requires a minimum 86% renewable power input[xviii] (other estimates by Giesen et al.[xix] and Falter et al.[xx]).

The carbon source in synthetic hydrocarbons also influences its overall carbon intensity. Synthetic liquid and gaseous fuels still emit CO_2 when they are burned. Hence, the climate effect of synthetic hydrocarbon fuels is not only dependent on the CO_2 intensity of hydrogen production, but also on the energy for capture of the CO_2, the energy lost in chemical synthesis of the fuels and source of the CO_2 (e.g. atmospheric or fossil origin). If the latter is fossil, it could disincentivise the decarbonisation of other sectors; for instance, if taken from energy intensive industries, the CO_2 of fossil origin would simply be transferred to a different sector and emitted. If installations within the EU ETS would get credit for such a transfer, they would lose incentives to reduce their emissions. Due to such issues, ''the carbon dioxide must originate from the atmosphere or from sustainably produced biomass.''[xxi]. Specifying the source of the carbon when talking about synthetic fuels would help in defining the robust environmental criteria for liquid and gaseous synthetic fuels.

Recommendations

Production of low-carbon fuels

- The following emissions should be taken into account:
    - the carbon intensity of the electricity used to produce the fuel, **in gCO_2/kWh of respective national grid (unless directly connected to RES).**
- Using breakeven points and clear definitions of elements of a truly low carbon fuel could be a way to strengthen current prerequisites for the production of these fuels in the document.
    - **less than ~149gCO_2/kWh for hydrogen via electrolysis (estimated breakeven point with fossil natural gas)**
    - **less than ~90gCO_2/kWh for synthetic hydrocarbons (estimated breakeven point with fossil counterparts)[1]**
  - the carbon added or embedded into the feedstock for the fuel, fossil (e.g. plastic waste) or atmospheric (e.g. CO_2 from direct air capture) + the energy used to capture the carbon
- To ensure the compatibility with climate goals **declining thresholds for carbon intensity (e.g. 100gCO_{2eq}/kWh to 0gCO_{2eq}/kWh by 2050)** should be used for financial mechanisms supporting low-carbon fuels.
- **Predictions of the emission factor of the electricity grid in 2030 and 2050 should not be used** to calculate the climate impact of electrolytic hydrogen or any electricity-based fuel today.

[1] Precise gCO2/kWh thresholds vary due to the variety of types of fuels and conversion technologies. The estimate in this document is based on assessments from van der Giesen et al. (2014), Falter et al. (2016) and Bringezu and Turnhau (2018).

Use of low-carbon fuels

- Precise and targeted use of truly low-carbon gaseous and liquid fuels (meeting criteria above) where direct electrification is not an option or is very difficult
- Dedicated infrastructure for handling and transport of low-carbon fuels (e.g. hydrogen and ammonia)

Following the 'energy efficiency first' principle in industry and the power sector

While efficient use of renewable electricity and energy is clearly beneficial for the climate, efficient use of fossil energy and fossil wastes doesn't result in similar benefits.

The efficient use of a fossil resources is not compatible with climate goals, as it still results in a net increase of fossil emissions to the atmosphere. For example, the production and refining of chemicals for the production of plastic products has become very efficient in the past few decades, but the product itself will never be low-carbon and still causes significant emissions elsewhere in the system[xxii].

Waste-based fuels coming from industry are just as incompatible with climate goals as fossil materials and fuels. The efficient use of e.g. waste gases from energy intensive industries would not prevent the same amount of CO_2 from entering the atmosphere.

Some stakeholder using selective life cycle assessment (LCA) (with narrow boundaries such as cradle-to-gate or gate-to-gate), allows for the CO_2 emissions from the end-of-life phase of the product to be lost, giving the false impression that almost no GHGs will be emitted to the atmosphere.

Efficient and 'circular' use of resources must result in a direct decrease of carbon flows to the atmosphere, particularly fossil ones.

Relabelling waste of one industry as a carbon neutral input of another doesn't change the carbon content of the material or prevent the carbon from those same wastes from entering the atmosphere. In other words, despite the potential reuse of fossil waste heat, energy, materials or fuels from industry, the carbon flows throughout the system still must be tracked.

Ultimately, climate change mitigation is about the flow of fossil CO_2 to the atmosphere. Efficient use of resources helps, but should not to disincentivise the reduction of these emissions.

Recommendations

- Emissions from waste should be accounted for, particularly if the waste is of fossil origin and the net-carbon flows to the atmosphere are still increasing.
- To account for the full emissions of a particular smart sector integration, a cradle-to-grave LCA which takes into account both the fossil origin of the 'waste' and the emissions caused by the final combustion or disposal should be strongly preferred.[xxiii]

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