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Some methodology priniples for quantifying GHG emissions savings under the Innovation Fund

Robert Edwards, JRC Ispra

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This is JRC's proposed method for ReFuNoBiOs and Carbon Capture Fuels in RED2

- JRC provides independent science support to EU policy makers
- An earlier version of this methodology was used for calculating "default values" for ReFuNoBiOs* proposed by industry under the **F**uel **Q**uality **D**irective.
  - Applied to confidential data on 12 industry projects, to calculate 7 "default values" (actually formulae as a function of electricity emissions, scale, etc.)
- (but the FQD was absorbed into RED2 before the "default values" were published)
- We will try to align the Innovation Fund methodology with the one we are proposing for ReFuNoBiOs* and Carbon Capture Fuels in RED2

* ReFuNoBiOs = Renewable Fuels of Non-Biological Origin

Differences between Innovation Fund and FQD or RED2

- FQD/RED2 applies to **products** (transport fuels), whereas the Innovation fund applies to **projects**, which may not involve new products.
- RED2 mandates emissions savings in **transport**; the innovation fund does not care which **sector** the savings are in.
- Innovation Fund overlaps more with ETS: try to use ETS data where possible
- Innovation Fund also includes costs: main indicator is CO2e saved per €
- Innovation Fund includes CCS-based projects, electricity storage…

* ReFuNoBiOs = Renewable Fuels of Non-Biological Origin

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Existing LCA standards don't help much

- e.g. ISO 14040/44, ILCD handbook*, PEF
- Are mostly about transparency
- Some important methodological choices are left to the user
- Do not give unambiguous LCA results
- Studies often falsely claim to follow ISO
- (e.g. PEF has a non-ISO hierarchy of allocation methods)
- They help guide disinterested scientists
- No good for legislation

*http://eplca.jrc.ec.europa.eu/?page_id=86#

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In FQD, the method was used on two types of CCU fuels:

1. Power-to-fuels (electrofuels) that borrow CO_2

- …use only renewable electricity (RE) as an energy source
- captured CO_2 is released again at the tailpipe
  - So no fundamental difference with RE-hydrogen in vehicles

2. Industrial exhaust-streams to fuels (e.g. blast furnace gas)

- some of the energy in the fuel can come from industrial gas streams
- They usually need much electricity, too

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THE METHOD

1. General Provisions
2. GHG intensity of feedstocks
3. Accounting for CO_2 capture
4. Allocation to multiple products
5. Electricity as a feedstock

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1. General provisions of the method

- For simplification, the emissions for construction are not counted
- But we *do* consider CO_2, CH_4 and N_2O emissions arising from:
  - supplying and processing the feedstocks
  - process emissions
  - transport and distribution
- Miscellaneous input chemicals: GHGi from the published input data for RED2 default calculations for biofuels (etc.)
- To find % savings, the total emissions per MJ of CCU road transport fuel are compared to the "fossil fuel comparator" (FFC) = 94 gCO_{2e}/MJ

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2. GHG INTENSITY OF FEEDSTOCKS

IT DOESN'T MATTER WHAT YOU CALL YOUR FEEDSTOCK…

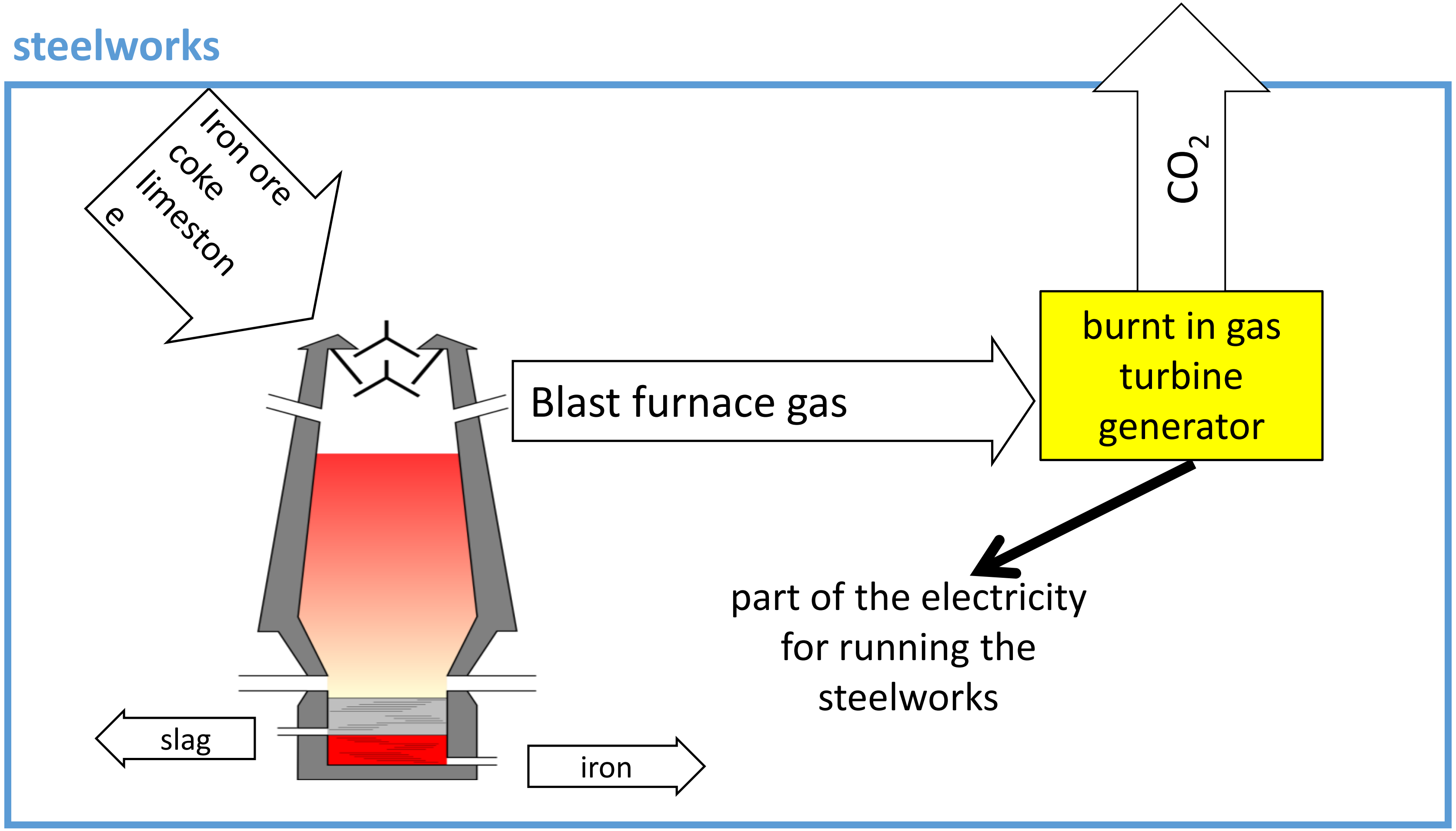
- To calculate GHG intensity of a feedstock for a fuel process…

- it **doesn't matter** what you call it (product, waste, residue, by-product, co-product, intermediate product…)

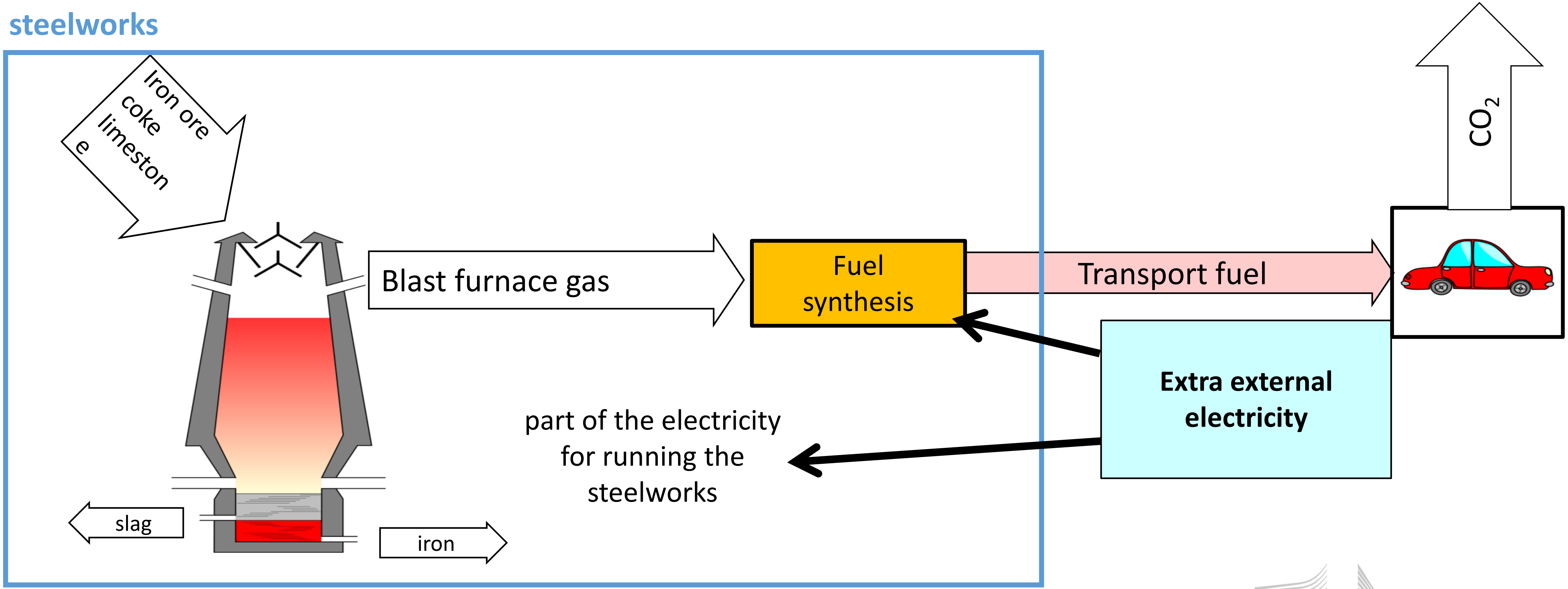
- The first question is…
  "is the source **elastic or rigid**?"

Let's start with an example….

RIGID FEEDSTOCK
e.g. Blast furnace gas which is presently burnt to generate electricity for use inside the steelworks



(Diverted blast furnace gas) + electricity = transport gas



Attributional LCA result (by energy-allocation): GHGi of blast furnace gas ~230 gCO_2/MJ

1. Find the **total GHG emissions** from the steel mill + transport fuel process.
2. Add the **upstream emissions** for providing the coal, iron ore, scrap, electricity, etc.
3. **Allocate** the total GHG emissions between products. (there is no basis for allocation market value because blast furnace gas does not leave the steelworks) according to their LHV energy content**:
    1. steel (theoretical LHV = 6.6 GJ/tonne, practical LHV = 0)
    2. slag? (sold at ~5 to ~100 Eur/tonne)
    3. Blast furnace gas

- The allocation rule means all products get the same emissions per MJ (LHV).
- …and as steel is by far the biggest product…

emissions for blast furnace gas ≈ emissions for steel
≈ 230 g CO_{2e}/MJ!

…on the other hand if you say blast furnace gas is a “waste or residue” its emissions are zero in RED: a game of semantics.

** (there is no basis for allocation by market value because blast furnace gas is used entirely inside the steelworks)

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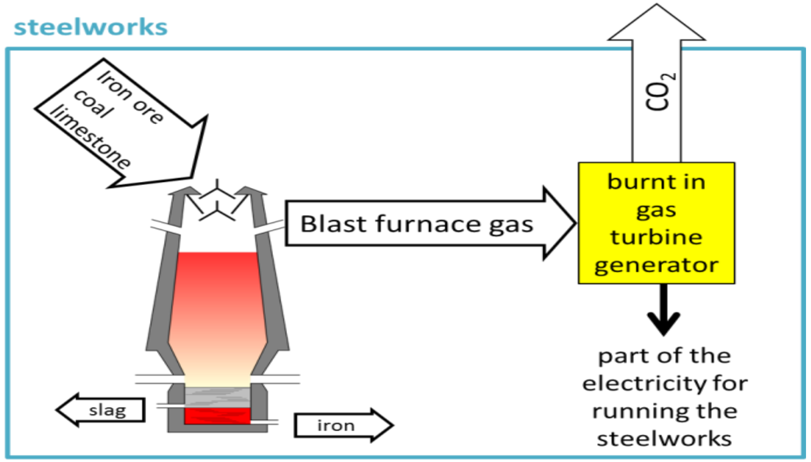
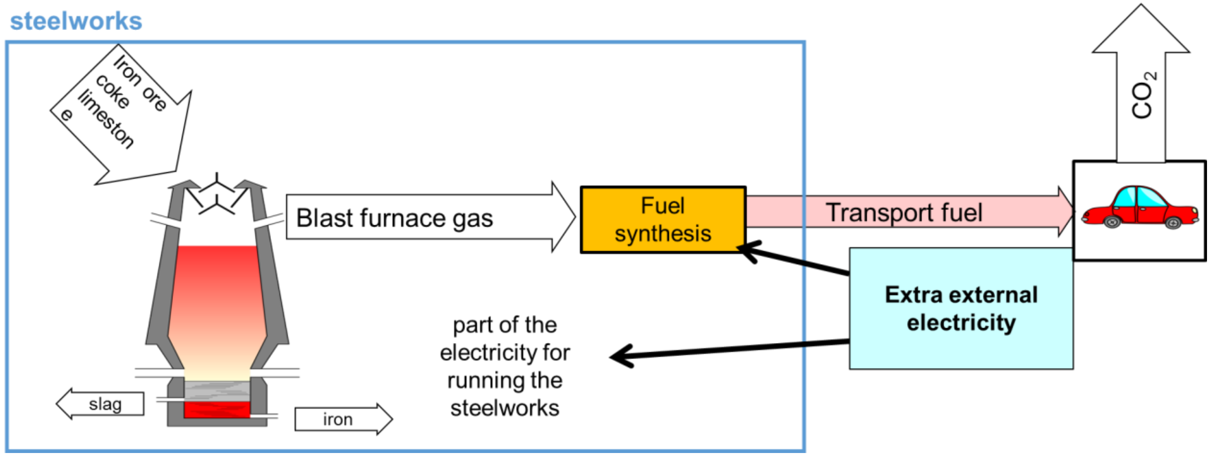
...and if we use common sense?....



BEFORE



AFTER

...we only added external electricity

Carbon intensity of transport-fuel	=	emissions from providing the extra external electricity

For rigid feedstock, we look at the emissions saved in its existing use.
In this case, it means the difference between “before” and “after” use for fuel production.

Elastic vs. rigid feedstocks

- **Elastic** if the supply expands with increasing demand:
  - e.g. crude oil, crops, algae
  - ➢ **Estimate the emissions for increasing the supply**

- **Rigid** if the supply doesn't expand if you increase the demand:

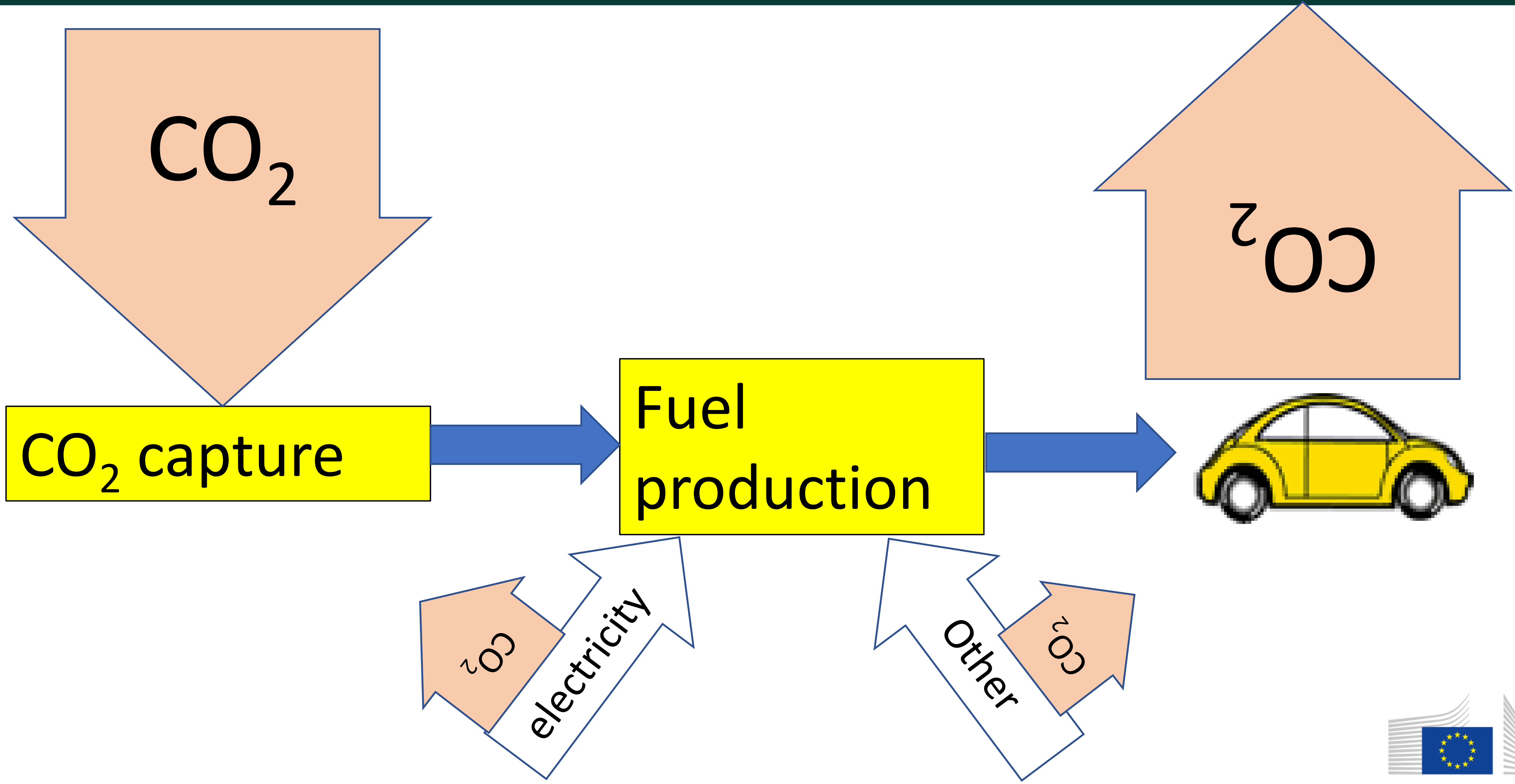
  e.g.
  - Municipal waste
  - intermediate products of existing processes, e.g. blast furnace gas
  - by-products that don't change the process profitability much

  - Therefore it can only be diverted from an existing use
  - ➢ **the GHG intensity is the emissions saved in its existing use**
    - can be negative: e.g. if municipal waste is otherwise burnt without energy recovery
    - can also be very high, if the existing use saves lots of GHG

Rigid feedstocks not all wastes!

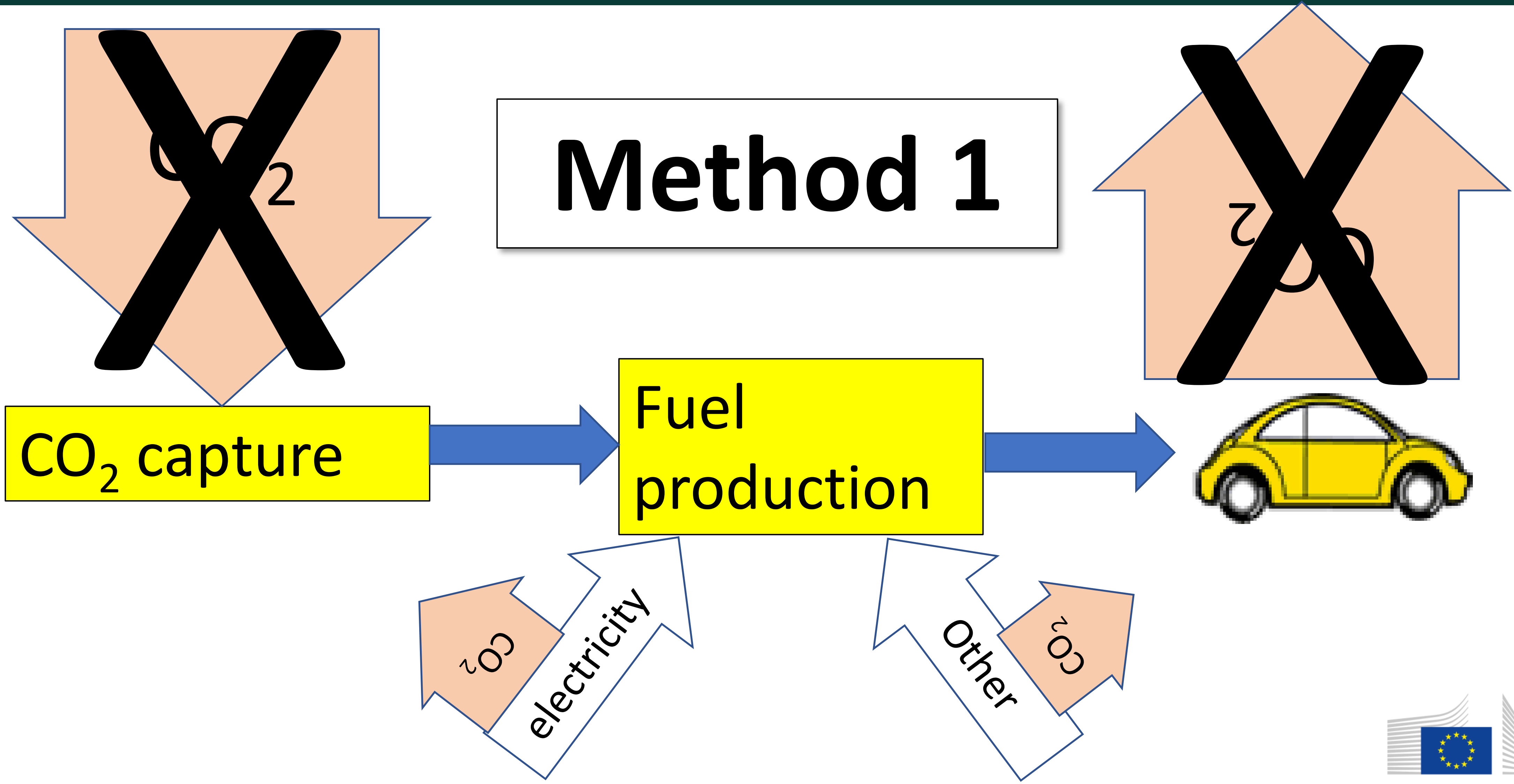
3. Accounting for CO_2 capture

Straight electrofuel: CO_2 captured = CO_2 from car



Accounting for CO_2 capture

Straight electrofuel: CO_2 captured = CO_2 from car



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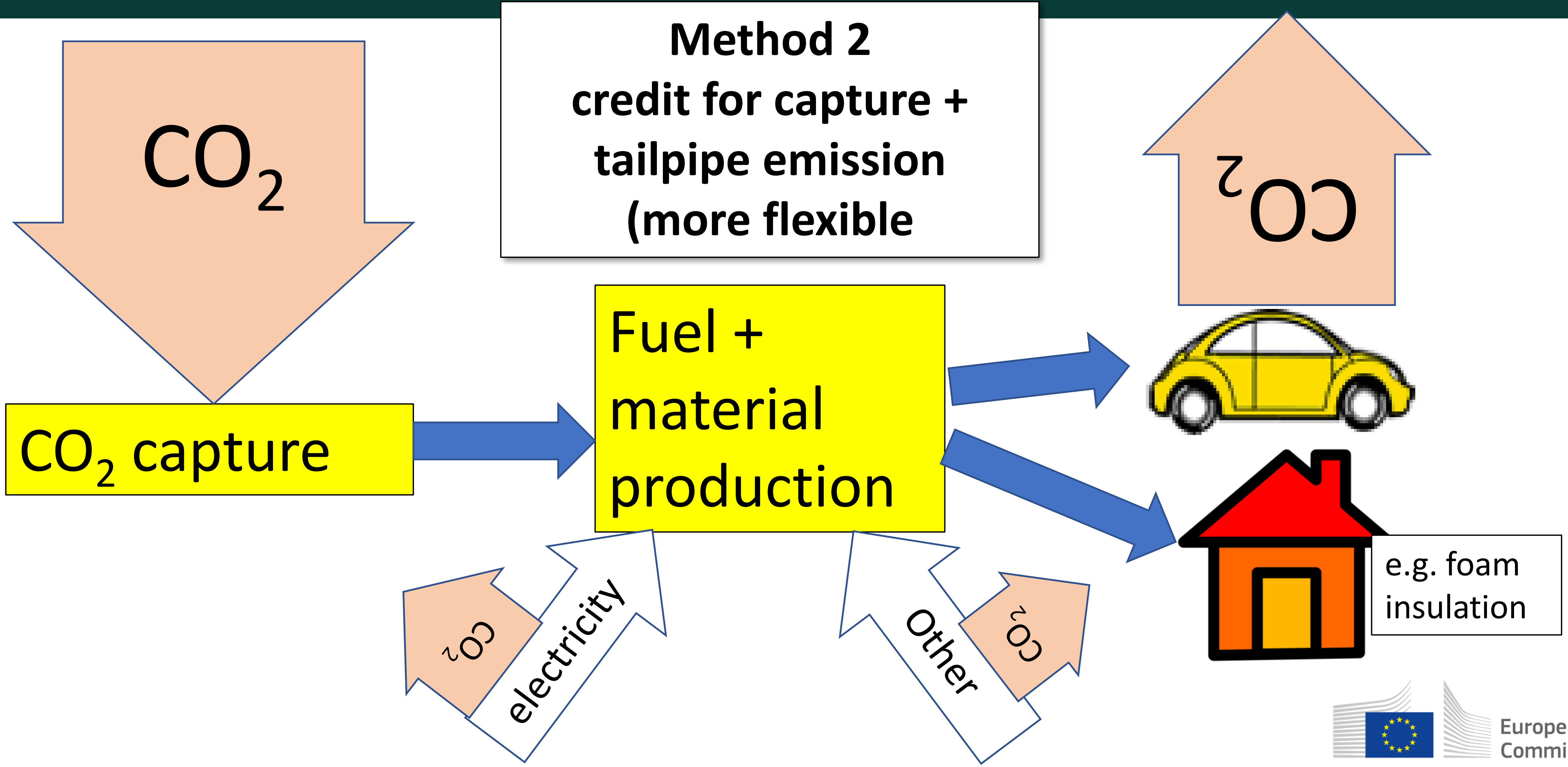
If there is a permanent CCU by-product, you need a CO_2 credit, and also count combustion emissions



Does the CO_2 capture have to come from the air?

Direct air capture makes sense for …
Stranded renewable electricity +
… no local CO2 emission sources

But <u>should it be **incentivized** over CO2 capture from flue gas?</u>

In the short/medium term: no

In the long term: yes, but…

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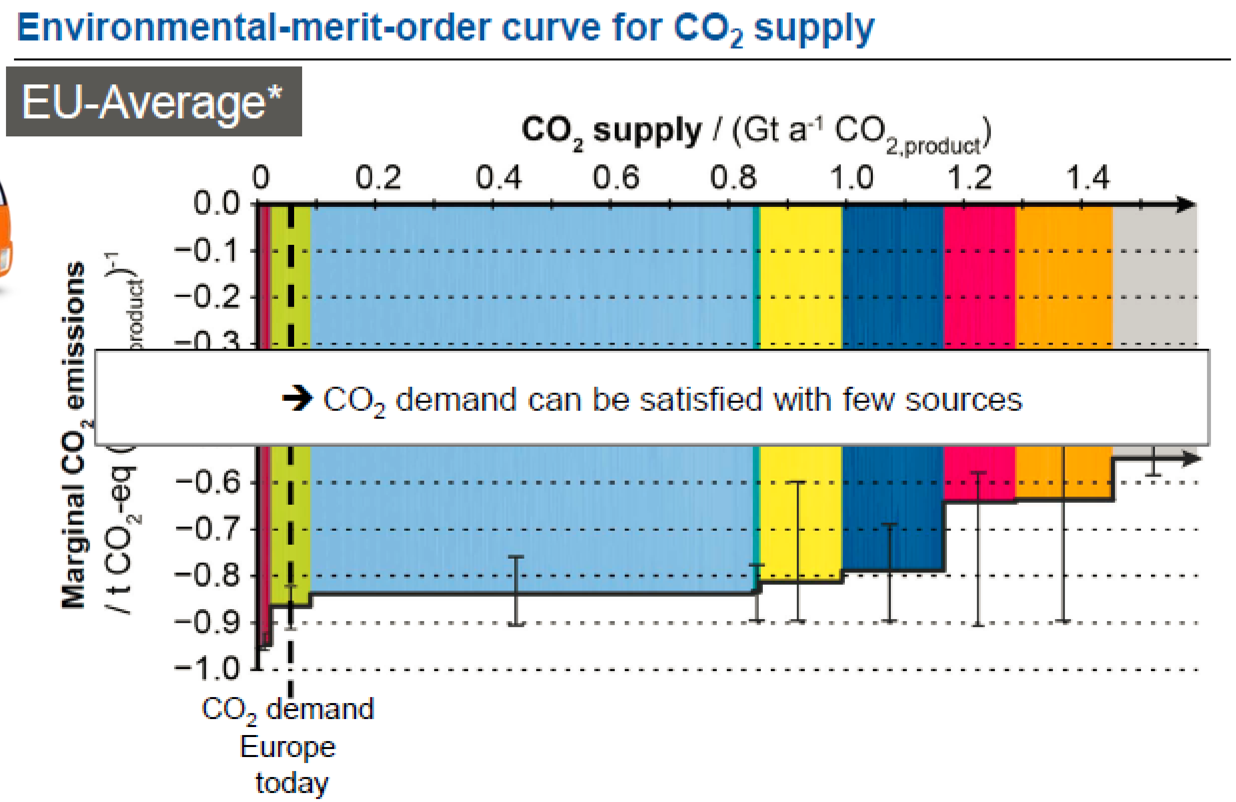
In the short term, no: industrial CO_2 is always captured from sources that would otherwise emit it

All industrial CO_2 sold in EU comes from processes that would otherwise release it to the atmosphere.

- Much more concentrated-CO_2 is available than the market can use.
- So an increase in industrial CO_2 **demand** will result in more capture.
- CO2 from air capture uses ~4x more energy than from flue gas

So AT THE MOMENT air-capture for recycled carbon fuels has no advantages in EU industrial context



Reference: N. von der Assen, L.J. Müller, A. Steingrube, P. Voll, A. Bardow, Environ. Sci. Technol., 2016, 50 (3), pp 1093–1101

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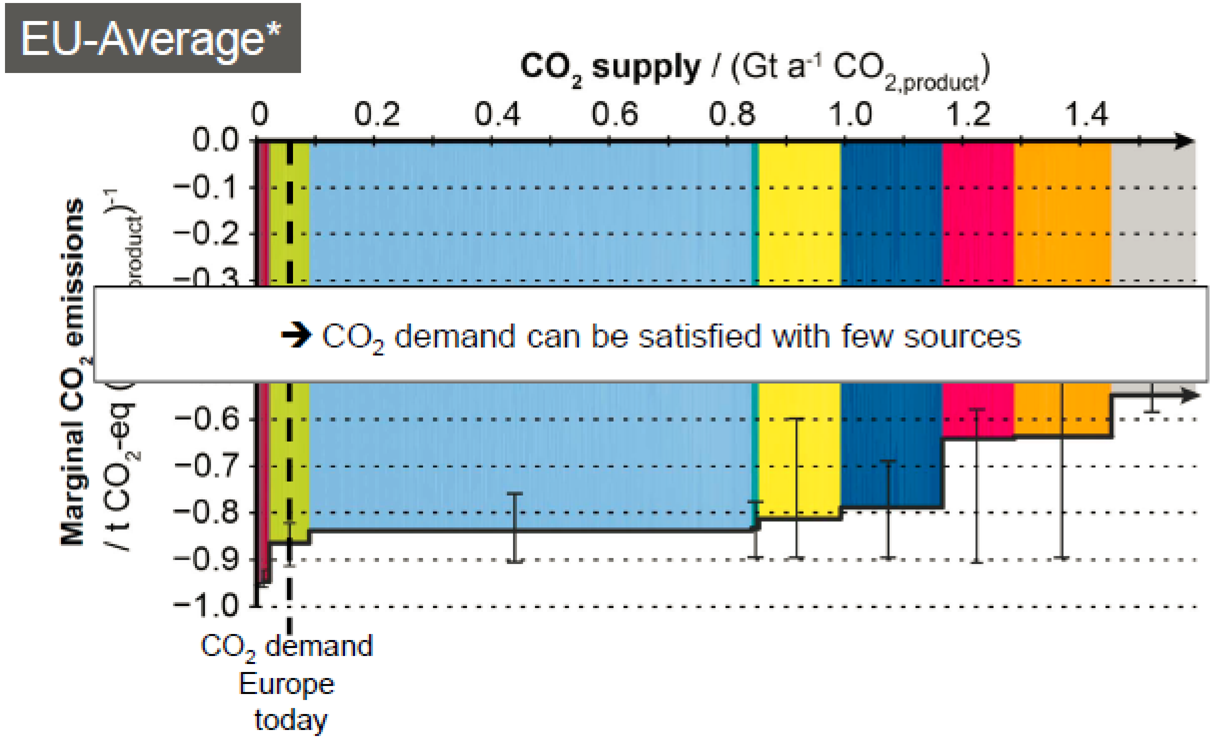
Recycling of CO_2 is limited by the *demand* for CO_2

There is much more concentrated-CO_2 available than the market can use.

- Therefore, incentives should be for the ***use*** of captured CO_2 to replace fossil C.

- (Just incentivizing the *capture* would only displace CO_2 already captured elsewhere.)

Environmental-merit-order curve for CO_2 supply



Reference: N. von der Assen, L.J. Müller, A. Steingrube, P. Voll, A. Bardow, Environ. Sci. Technol., 2016, 50 (3), pp 1093–1101

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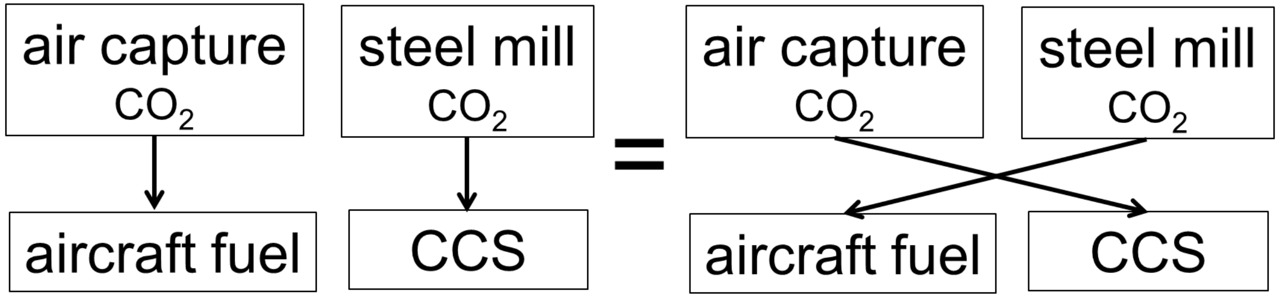
Arguments for air capture IN THE FUTURE:

- "It will allow CO_2 emitters (like coal power stations) to stay open"

  No: as the CO2 capture is credited to the **user** of the CO2, it will not help the GHG balance of the power station.

- "The "unavoidable" concentrated CO2 sources should be used for CCS"

  …. **but** the "unavoidable" sources may not be on geology suitable for CCS, and anyway…



Conclusion:
"yes, we will need air capture, but it does not have to be at the CCU plants"

- If aeroplanes will still emit CO2, we will need air capture to reach net zero emissions by 2100

  … yes, but it doesn't have to be at the fuel plant

- Anyway this is a planning question, not a methodology question

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4. Allocation to multiple products

Allocation to multiple products in draft RED2 method

- **Substitution** (= "system expansion") means giving a credit to one product for the emissions saved by its co-products.
  - It is inclined to large errors when the product considered is only a small part of the production
  - It attributes all the emissions saved by the project to one product (e.g. transport fuel)
    - So it can attribute to transport emissions, savings that are made in other sectors
    - **This matters in RED legislation**, because emissions savings in transport are much more heavily incentivized

- **Allocation** allocates the plant and upstream emissions to co-products proportional to various properties:
- The appropriate property depends on the process and nature of co-products:

  (e.g. for transport emissions, mass-allocation is usually correct (unless volume-limited))
  - For process-heat and electricity, the only workable method may be exergy-allocation (used in RED)
  - For products with a clear market price, carbon intensity is best allocated by economic value.

Therefore we suggested…

- First allocate between heat, electricity and (all other material/fuel products as a group) by exergy
- Then allocate between the material/fuel products by economic value (av. 3-10 yrs)

Allocation to multiple products in draft RED2 method

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But

- the Innovation Fund is for projects, not a products
- It does not care which sector generates the GHG savings

➢ So system expansion is arguably better

➢ But then the method will not be aligned with RED2

5. ELECTRICITY AS A FEEDSTOCK

You don’t save emissions by diverting renewable electricity from other users

The same logic: is your renewable electricity rigid or elastic?

- **Rigid** if it is already counted towards renewable electricity targets (then it is just being diverted from other users)
  - ➢ Its GHG intensity is that of the extra grid electricity that replaces the diverted RE
- **Elastic** if it is **additional** to what would have been consumed anyway: e.g. from peak-shaving, or not grid connected, ….or potentially an improved guarantees-of-origin scheme e.g. similar to GOplus (©Oekoinstituut)
  - ➢ Its GHG intensity is that of the renewable source

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Emissions for allowed Renewable electricity

ADDITIONALITY of renewable electricity in RED2 para 90:

"…The Commission should develop, by means of delegated acts, a reliable Union methodology to be applied where such electricity is taken from the grid. That methodology should ensure that there is a temporal and geographical correlation between the electricity production unit with which the producer has a bilateral renewables power purchase agreement and the fuel production. For example, renewable fuels of non-biologica origin cannot be counted as fully renewable if they are produced when the contracted renewable generation unit is not generating electricity. Another example is the case of electricity grid congestion, where fuels can be counted as fully renewable only when both the electricity generation and the fuel production plants are located on the same side in respect of the congestion. Furthermore, there should be an element of additionality, meaning that the fuel producer is adding to the renewable deployment or to the financing of renewable energy."

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RED article 27.3

However, electricity obtained from direct connection to an installation generating renewable electricity may be fully counted as renewable electricity where it is used for the production of renewable liquid and gaseous transport fuels of non-biological origin, provided that the installation: (a) **comes into operation after, or at the same time as, the installation producing the renewable liquid and gaseous transport fuels of non-biological origin**; and (b) is not connected to the grid or is connected to the grid but evidence can be provided that the electricity concerned has been supplied without taking electricity from the grid. Electricity that has been taken from the grid may be counted as fully renewable provided that it is produced exclusively from renewable sources and the renewable properties and other appropriate criteria have been demonstrated, **ensuring that the renewable properties of that electricity are claimed only once and only in one end-use sector**.

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My proposed interpretation of RED2 additionality criteria

Grid-connected Renewable Electricity is OK only if …

- it does not count towards national RE targets
- the RE installation is part of the project
- It is only used when the RE installation is producing that electricity
- it's produced inside the same electricity trading block, and in fact close enough to the fuel plant that it does not contribute to grid congestion

Average grid-electricity emissions

- …used for grid electricity or “renewable electricity” that is ***not additional***

For the FQD “Discussion document” , JRC calculated the **average** GHG intensity of electricity **consumed** in each EU member state.

That means, including not only 2015 power-station emissions ([IEA 2017], but also…

– upstream emissions for supplying the fuel
- transmission losses
- accounting for power station own-use and heat export
- accounting for trade between states NOW IMPROVED

Until the next IEA data is published, Member States can adjust for emission improvements since 2015 by the simple approximation:

…1% less GENERATING emissions (as reported to Eurostat) = 1% less consumption emissions.

5. RED2 method works also for CCU-materials

- Unlike fuels, CCU-materials may sequester their carbon for long periods
- However, if the materials directly replace fossil materials with the same lifetime, the fossil materials sequestered carbon for the same time.
- So the carbon-sequestration of the CCU-materials is described completely by the CO_2 captured during production.
- So there is no need for time-dependent carbon accounting here
- …so the JRC method works also for CCU-materials that directly replace existing ones.
- You *do* need carbon time-accounting if the CCU products have a different lifetime to the products they replace.

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Differences between Innovation Fund and FQD or RED2

- FQD/RED2 applies to **products** (transport fuels), whereas the Innovation fund applies to **projects**, which may not involve new products.
- RED2 mandates emissions savings in **transport**; the innovation fund does not care which **sector** the savings are in.
- Innovation Fund overlaps more with ETS: try to use ETS data where possible
- Innovation Fund also includes costs: main indicator is CO2e saved per €
- Innovation Fund includes CCS-based projects, **electricity storage…**
- **So we also need to calculate the CO2 value of electricity storage!**

* ReFuNoBiOs = Renewable Fuels of Non-Biological Origin

The END

Any questions?

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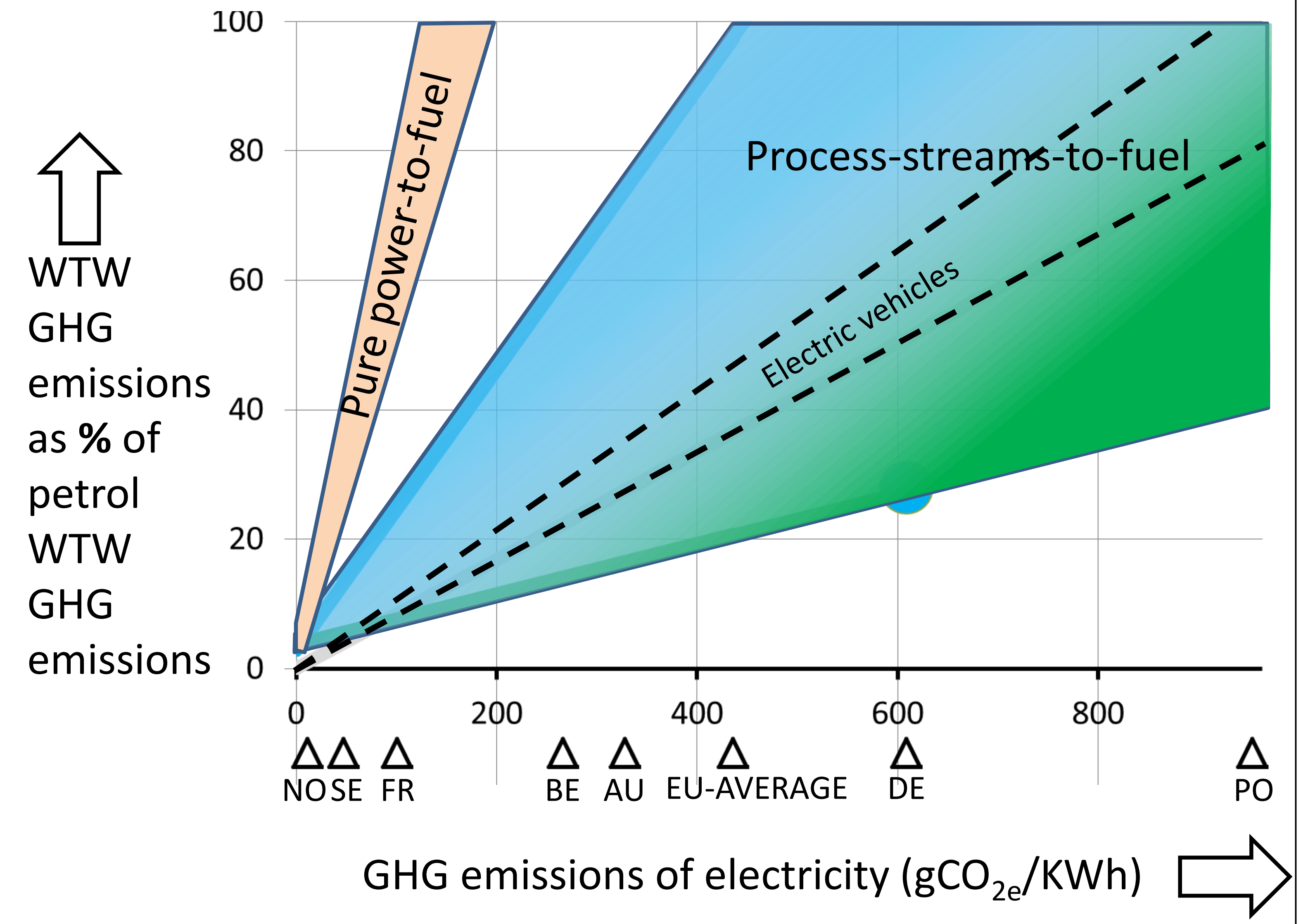
Spare slides (cut to save time)

What’s the best use of renewable electricity in transport sector?

Range of results calculated applying JRC draft method to industrial ReNuFoBiOs submitted to FQD



- **Pure electrofuels save less GHG than electric cars using the same electricity**
- Using energy in exhaust gases *can* save more GHG than EVs.
- It depends on the alternative use of the gas.

- My graph shows an indicative range of emissions for projects proposed to Commission.
- WTW emissions: battery production emissions etc. not included
- Approximate EV/gasoline comparison based on similar vehicles
- National emissions are for **consumed** electricity, but need to be updated.

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But electrofuels have other advantages…

- They can export renewable fuels from regions with excess renewable electricity that can't be exported, at least without large transmission losses.(e.g. Iceland, arguably ?Sweden??)

- They can stabilize the grid over longer periods than electric cars,

(by part-time electrolysis + hydrogen storage)

- Electric aeroplanes are unlikely

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Elastic or rigid: where do we draw the line?

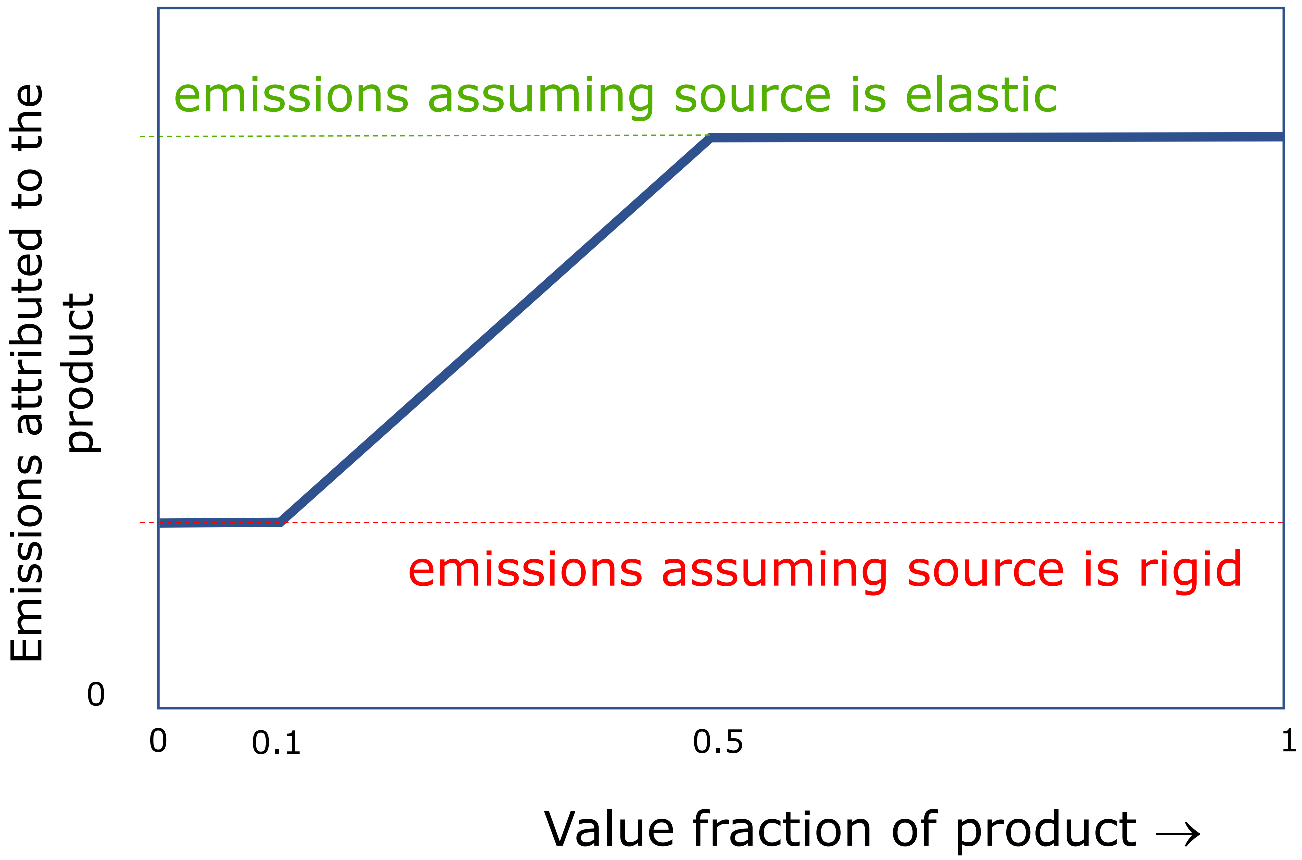
Most feedstocks or inputs are clearly either mostly elastic or rigid, but there are always borderline cases with co-products.

The parameter describing the elasticity of the supply of co-product "A" can be defined as the fraction *of A in the total value of the products of the process*.

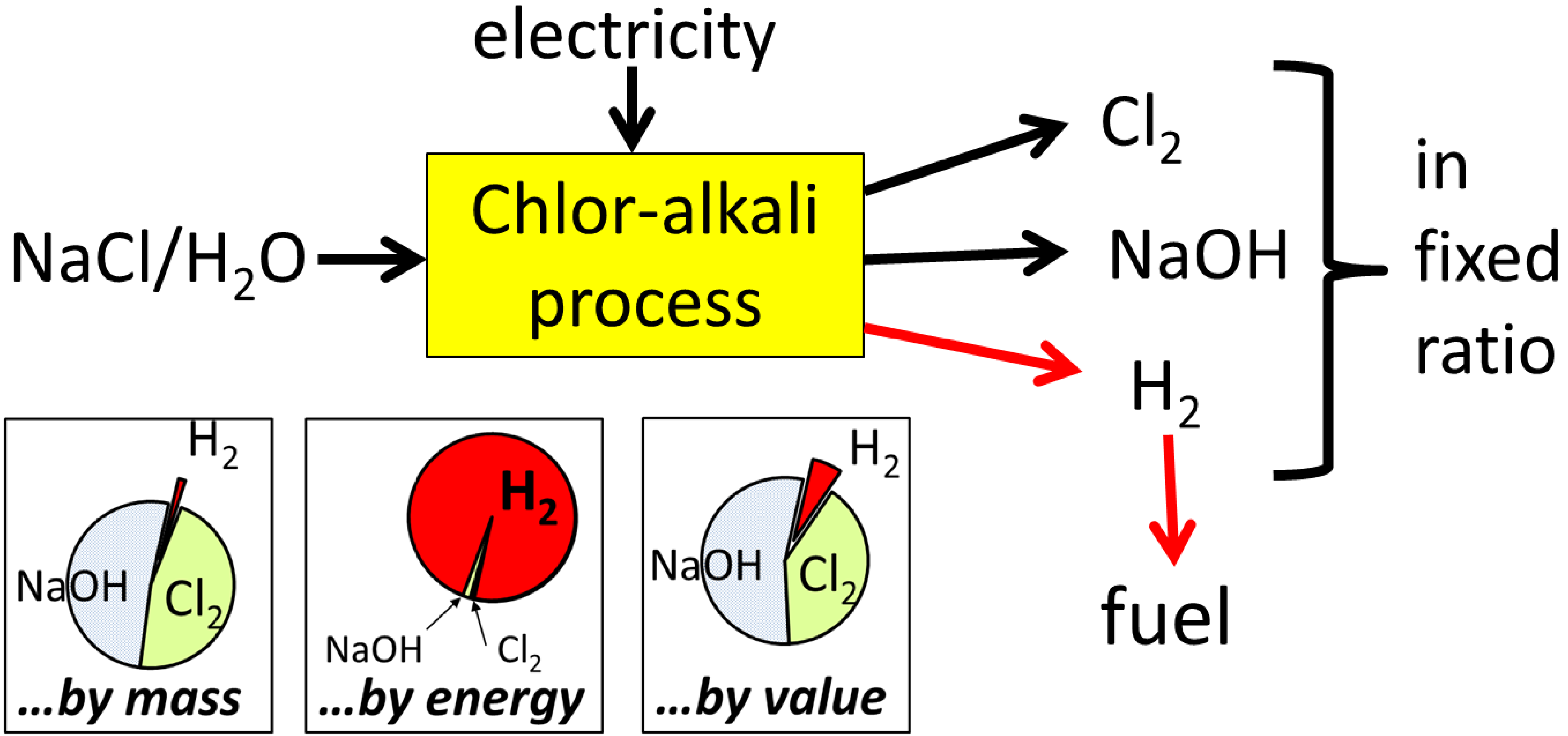
A *sudden* transition from "rigid" to elastic" will give problems in borderline cases.

To avoid a sudden transition, but to keep most feedstocks/inputs either elastic or rigid, we envisage a "transition region".

Emissions for feedstocks/inputs in the transition region get a proportional mix of the rigid and elastic results.



PEF allocation rules don't work… e.g. they prefer mass or energy allocation to economic allocation



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Details of JRC calculation of average emissions for grid electricity consumed in member states

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GHG intensity of electricity CONSUMED in Member states (calculated from IEA 2017 data, for 2015) in gCO2e/kWh

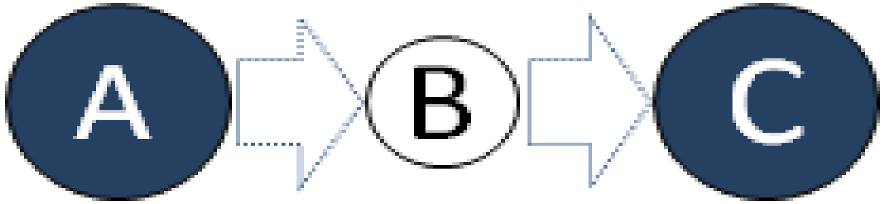
	Med. Voltage	Low Voltage
Austria	302	309
Belgium	326	334
Bulgaria	601	637
Croatia	497	523
Cyprus	800	821
Czech Rep.	651	673
Denmark	186	191
Estonia	810	847
Finland	122	124
France	77	80
Germany	529	541
Greece	648	677
Hungary	397	415
Ireland	547	569
Italy	416	429

	Med. Voltage	Low Voltage
Latvia	487	504
Lithuania	444	460
Luxembourg	480	486
Malta	688	717
Netherlands	581	594
Poland	879	911
Portugal	460	483
Romania	445	478
Slovakia	411	421
Slovenia	349	361
Spain	381	402
Sweden	23	24
UK	466	487
Average EU	**398**	**412**

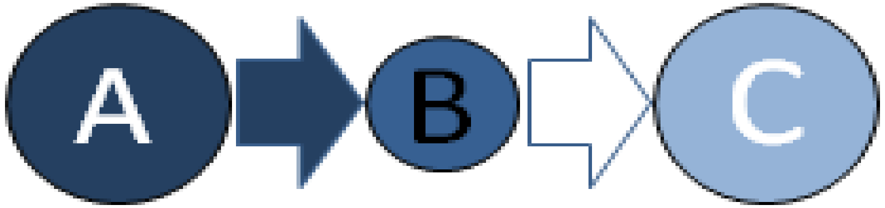
Improved treatment trade in calculating average GHGi of electricity consumed; 1 of 2

Text Box 1:
Problem with the previous method for accounting electricity trade

Consider a small country B, generating low C.I. electricity, neighboured by two countries with high generating emissions



In the previous methodology, the exports were simply given the CI of the exporting country's generating (+upstream) emissions:



After the trade correction, B's low emissions were largely passed on to C, and B received high emissions from A. The result, according to the previous methodology, is that B now apparently has a larger C.I. than C, but is exporting cleaner electricity.
The problem is that we have not taken into account that part of B's exports probably came from electricity it imported from A.

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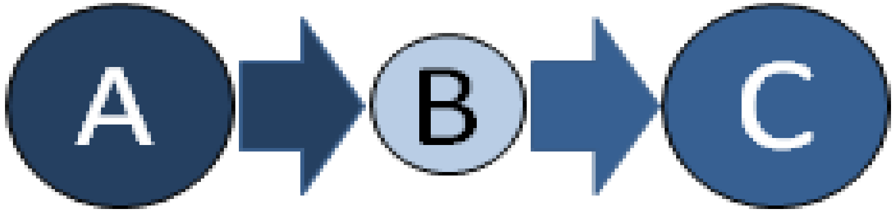
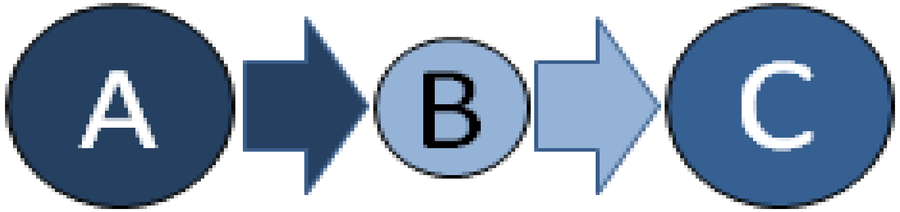
Improved treatment trade in calculating average GHGi of electricity consumed; 2 of 2

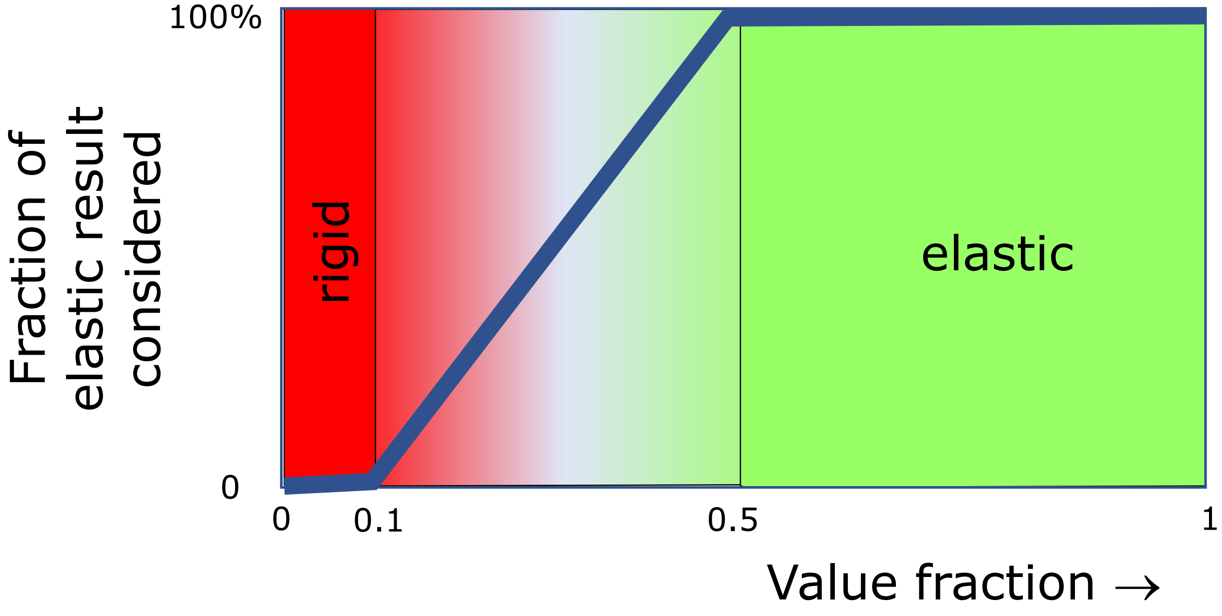
Text box 2:
Improved methodology for accounting for unidirectional electricity trade

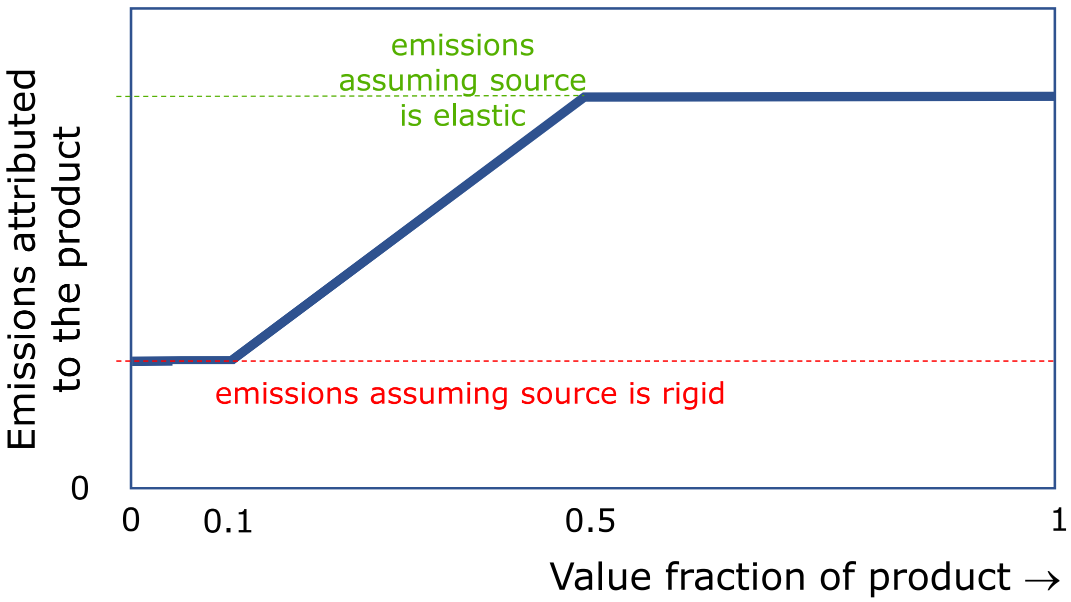
The problem with the previous method was that B's exports probably came from electricity it imported from A. However, we have no data on how big that part is. The best assumption we can make is that the C.I. attributed to B's exports is the same as attributed to the electricity mix distributed within country B itself. This is given by the weighted average of its domestic generation and its imports. As a first estimate...



But re-calculating the trade effects have now somewhat decreased the C.I. of the electricity distributed inside B (because some of the high emissions from A have been exported to C); so it is now less than was just attributed to B's exports. So we need to recalculate, replacing the previous C.I. of B's exports with the new estimate of the C.I. of its domestic electricity use. If we now keep iterating, B's export C.I. converges with its domestic C.I.:




100%
0
Fraction of elastic result considered
rigid
elastic
0
0.1
0.5
1
Value fraction →


emissions
assuming source
is elastic
emissions assuming source is rigid
Emissions attributed
to the product
0
0
0.1
0.5
1
Value fraction of product →

Two types of CCU fuels in RED2 draft:*

*yet to be approved

1. **'Renewable liquid and gaseous transport fuels of non-biological origin' (ReFuNoBiO):**

- **energy content comes from renewable energy sources**
  ...other than biomass;
    - Excludes bio-electricity or biogas for electrofuels
- Includes H_2 and **electrofuels** from (wind or solar electricity + CO_2)
- **Minimum 70% GHG saving set by RED2 draft**

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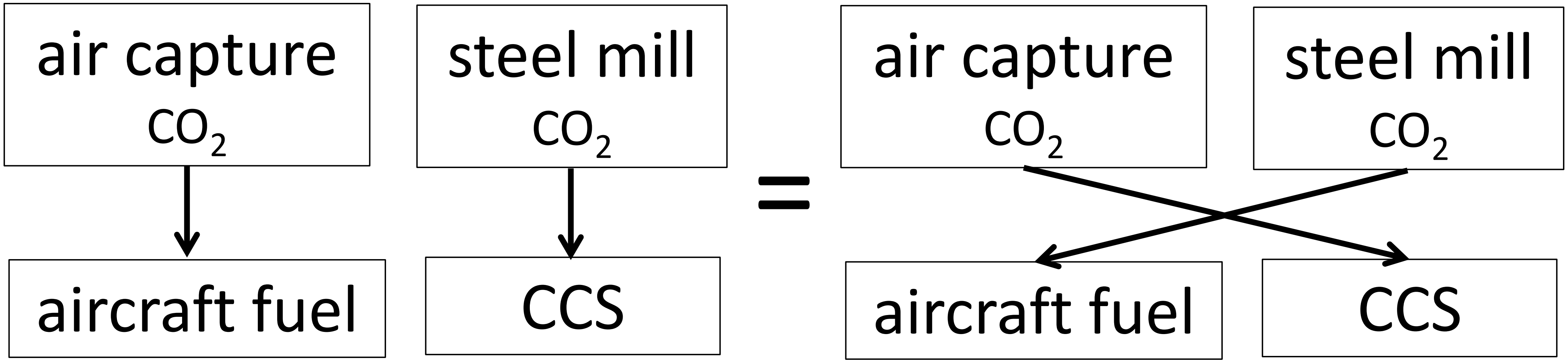
Two types of CCU fuels in RED2

2. “recycled carbon fuels” (RCFs) can incorporate energy from industrial exhaust streams

'**recycled carbon fuels**’ means liquid and gaseous fuels that are produced from liquid or solid waste streams of non-renewable origin which are not suited for material recovery in line with Article 4 of Directive 2008/98/EC and waste processing gases and exhaust gases of non-renewable origin which are produced as an unavoidable and not intentional consequence of the production process in industrial installations

Commission to fix methodology for calculations and <u>GHG savings threshold</u>


air capture
CO_2
steel mill
CO_2
aircraft fuel
CCS
=
air capture
CO_2
steel mill
CO_2
aircraft fuel
CCS