Innovation Fund

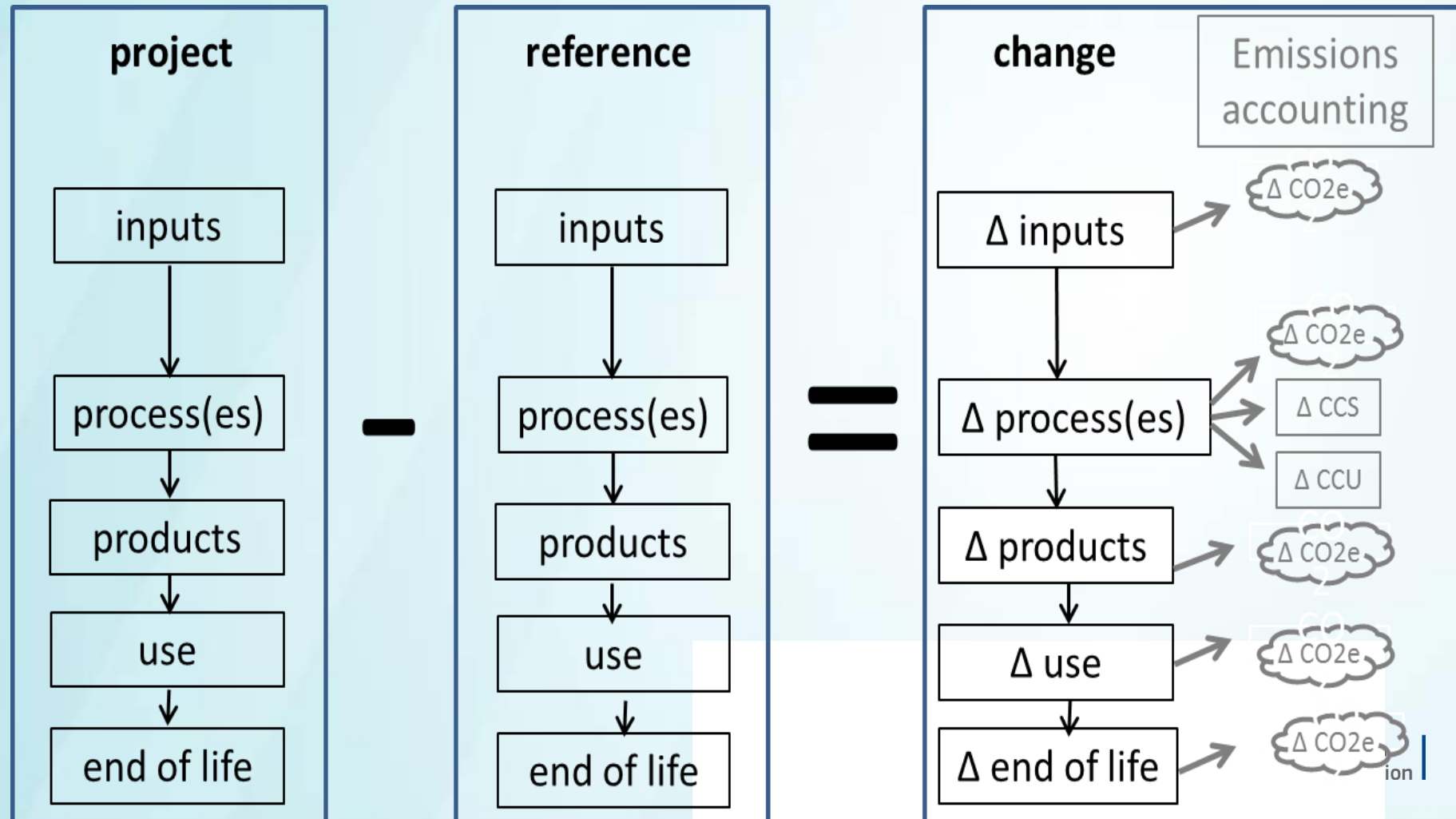GHG emission calculations for Energy Intensive Industries

by JRC

Energy-intensive industries, incl. substitute products, bio-refineries and CCU
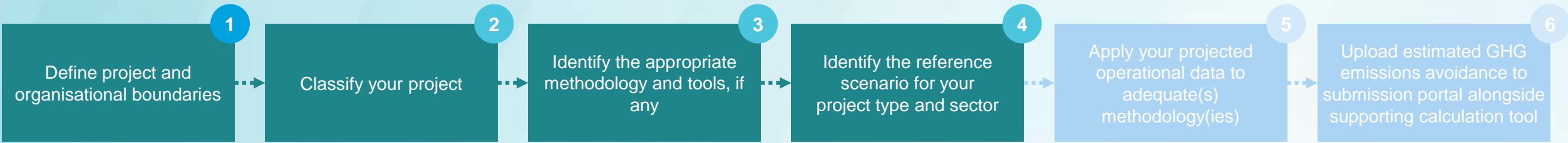
Overall principle: changes in emissions of project compared to reference scenario over first 10 years

"*Processes*":
- Produce the "principal products"
- Are under the control of the applicant
- Use EU ETS calculation rules and MRV

Emissions can be ignored if they don't change (in any of the boxes!)

	1		2		3		4		5		6
Define project and organisational boundaries		Classify your project		Identify the appropriate methodology and tools, if any		Identify the reference scenario for your project type and sector		Apply your projected operational data to adequate(s) methodology(ies)		Upload estimated GHG emissions avoidance to submission portal alongside supporting calculation tool	

The GHG emissions that would occur in the absence of the project are calculated based on the assumption that, in the reference scenario, the **product** would be delivered under the following circumstances:

Sector	Reference scenario
Energy Intensive Industry	EU ETS benchmark(s) for the product
Bio fuels	Fossil fuel comparators (Table 2.1 in Annex C)
Renewable electricity	Expected 2030 electricity mix
Renewable heat	Natural gas boiler
Energy storage	Single-cycle natural gas turbine (peaking power)

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Energy-Intensive Industries

Reference scenario

- Reference for new processes uses EU ETS benchmarks (where possible)
- Reference for modifying existing plant may be existing plant, if EU ETS benchmarks are met overall
- Fuel products are judged against fossil fuel comparators

Simplification of emissions for INPUTS at different stages of the application

1st stage: inputs with joint emissions <10% of the total emissions ascribed to the inputs: may be neglected

inputs with joint emissions **<30%:** take emissions from literature

other inputs: actual emissions calculation if possible

2nd stage: inputs with joint emissions **<5%** of the total emissions ascribed to the inputs: may be neglected

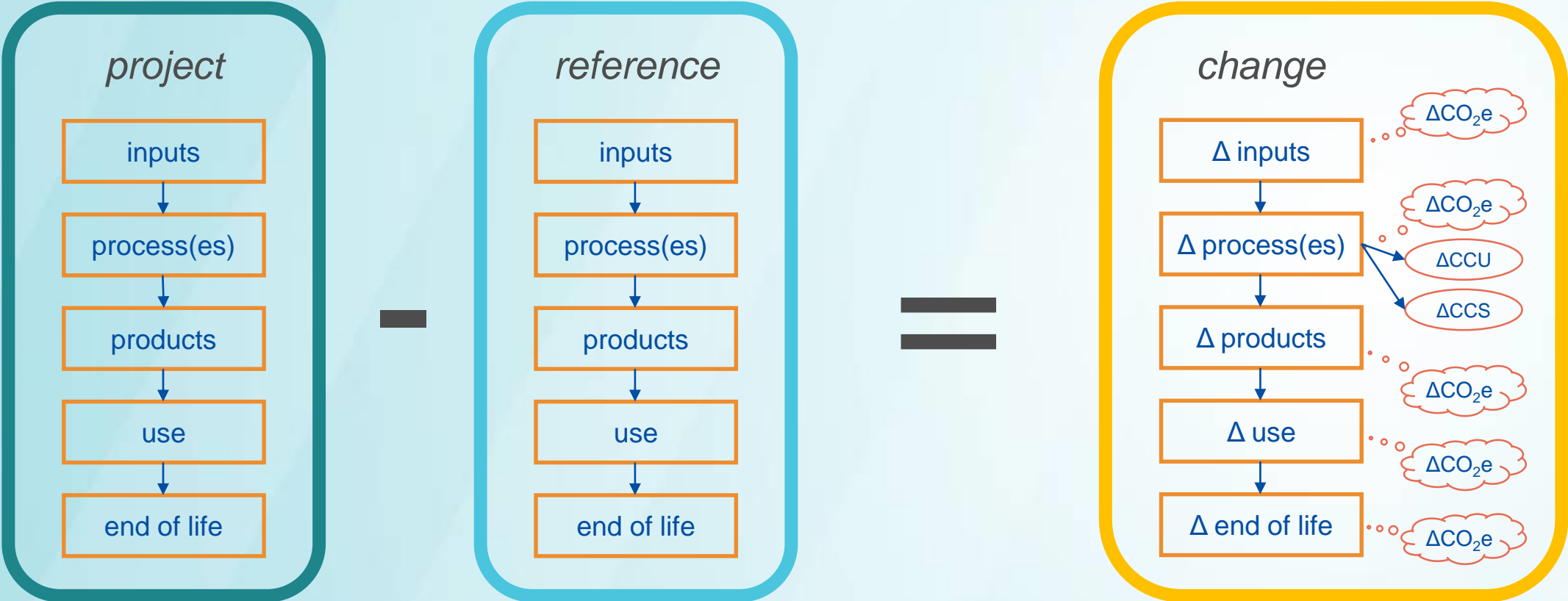inputs with joint emissions **<15%:** take emissions from literature

other inputs: actual emissions calculation if possible

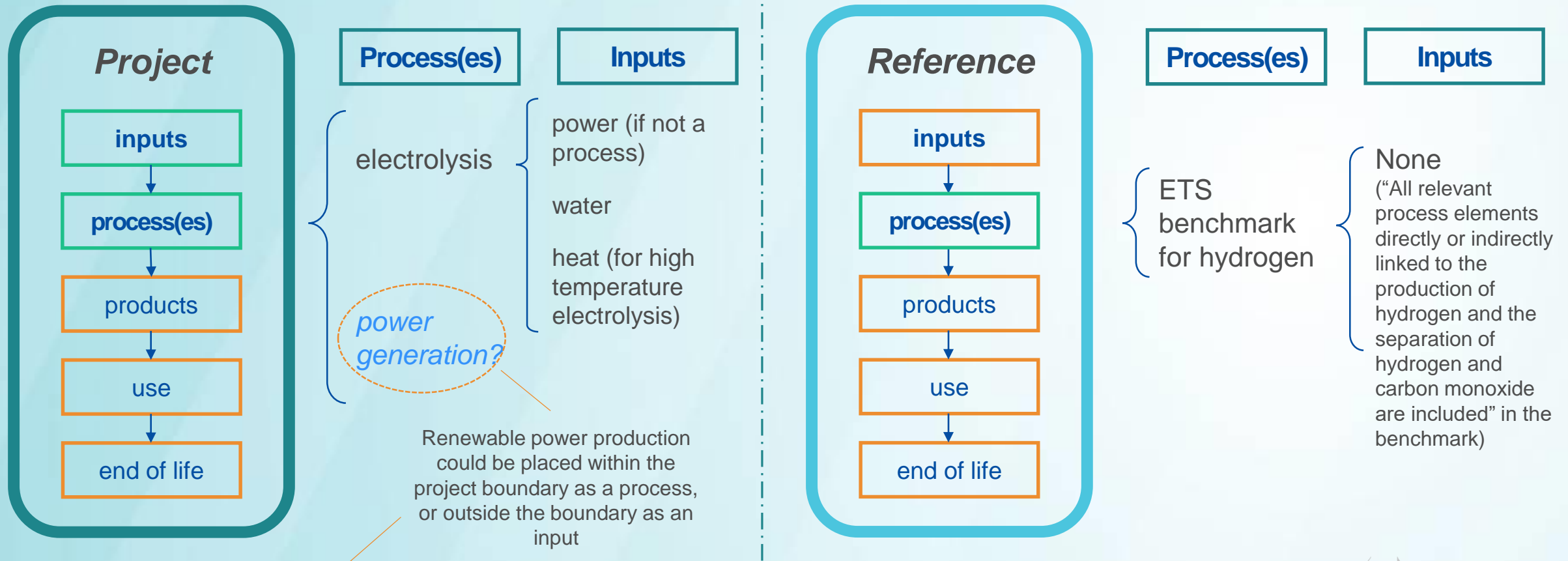European Commission

Calculation examples

Example: Green Hydrogen

- The following example is **intended to show important aspects of how the methodology works in practice.** The slides are included purely for illustrative purposes

- The example could be from other energy intensive industries, **and we expect projects from many industries and sectors**

  - Consider a project to produce **Green Hydrogen**. Note this;

    - Falls within Energy Intensive Industry

    - Hydrogen as the only (and therefore principal) product

    - The sector (Annex C Appendix C1) is hydrogen

    - Assume hydrogen is supplied for industrial use

- Based around NREL model for "Future Central Hydrogen Production from Solid Oxide Electrolysis" (B. James, D. DeSantis, J. Moton, G. Saur; http://www.hydrogen.energy.gov/h2a_production.html)

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Identify Processes and Inputs

Project

- inputs
- process(es)
- products
- use
- end of life

Process(es)

electrolysis

power generation?

Inputs

- power (if not a process)
- water
- heat (for high temperature electrolysis)

Renewable power production could be placed within the project boundary as a process, or outside the boundary as an input

Emission factor for electricity consumed is zero either way (assumed 2050 grid electricity GHG intensity)

Reference

- inputs
- process(es)
- products
- use
- end of life

Process(es)

ETS benchmark for hydrogen

Inputs

None ("All relevant process elements directly or indirectly linked to the production of hydrogen and the separation of hydrogen and carbon monoxide are included" in the benchmark)

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Focus on Heat

- Heat is required for high temperature electrolysis. Options:

  - Heat generated by direct fossil fuel combustion -> include those combustion emissions as part of electrolysis process -> **no heat as an 'input'**

  - Heat supplied from outside the project unit -> **identify source and assess as an input**

    - Heat as by-product from other process -> treat as rigid input, identify any emissions due to diversion

    - Otherwise, treat heat as elastic input, assess actual GHG emissions of heat generation

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Process(es) boxes (cf. "Guidance for GHG emission avoidance potential calculations for projects falling in the sectors of energy intensive industries" page 6)
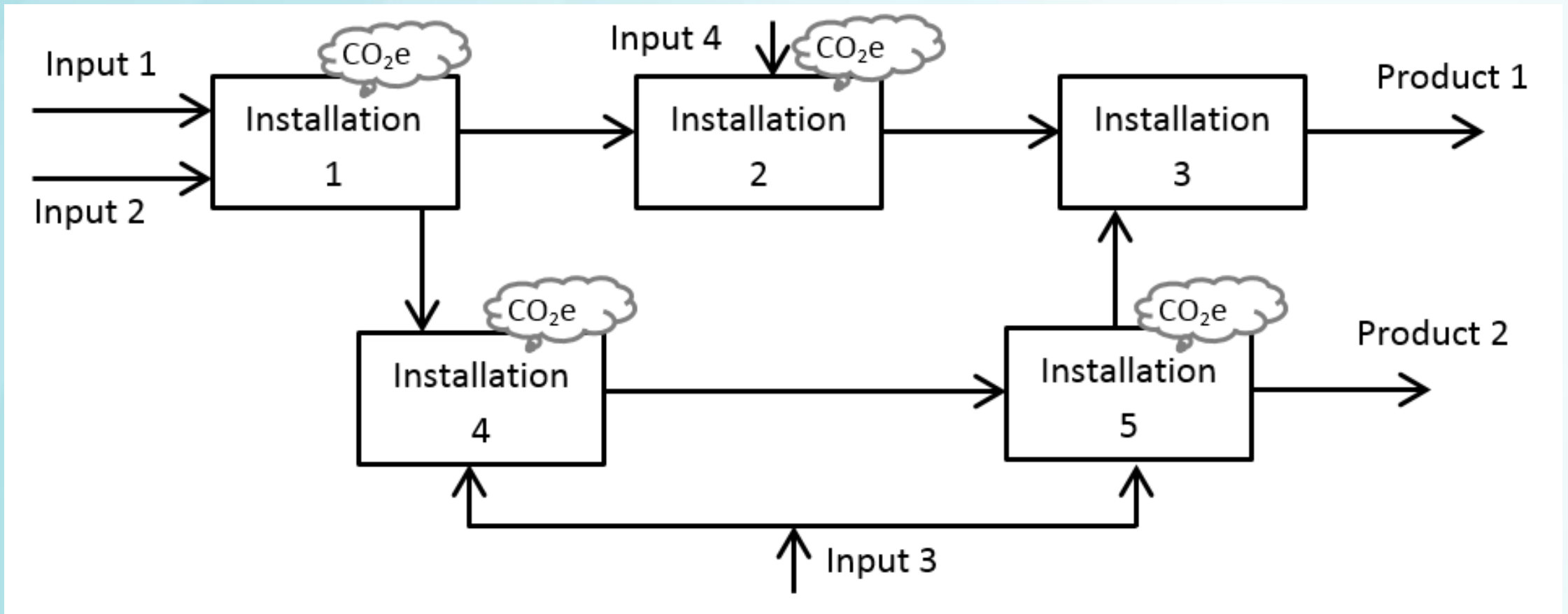
Process(es) Boxes (cf. "Guidance for GHG emission avoidance potential calculations for projects falling in the sectors of energy intensive industries" page 6)
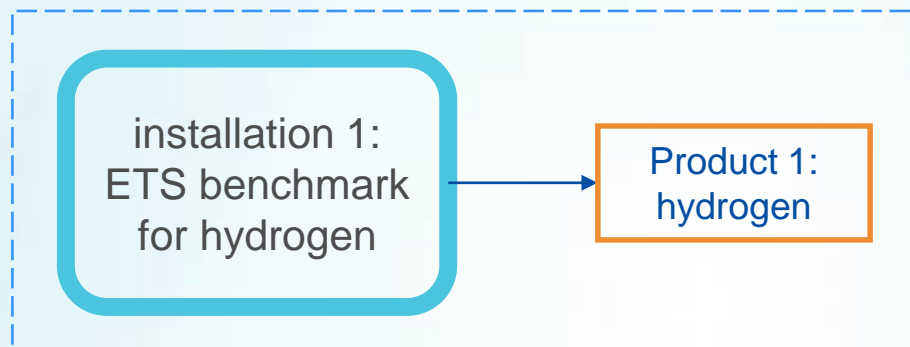
Project
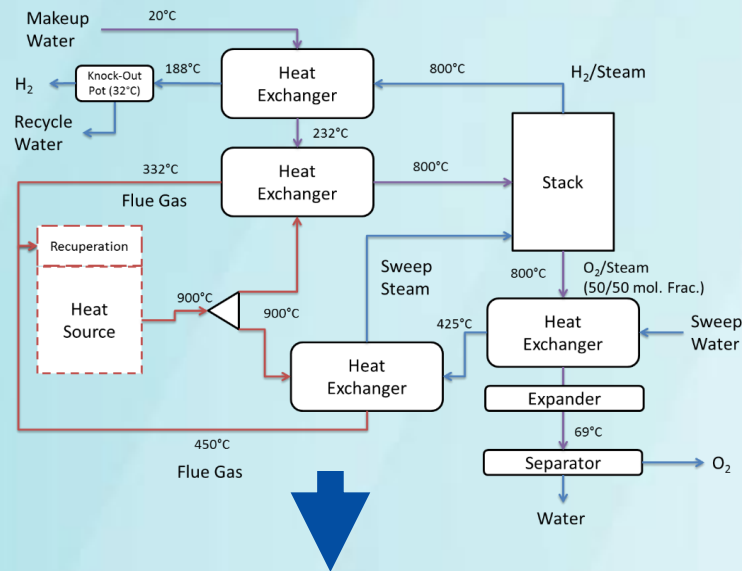
Reference

installation 1: ETS benchmark for hydrogen → Product 1: hydrogen

Change

- All inputs are new (Δ input$_i$ = -input$_i$)
- The processes have changed completely (Δ process(es) = GHG$_{ETS\ H2}$ – GHG$_{electrolyser}$)
- There is no change in product (Δ products = 0)

Emissions for Processes and Inputs
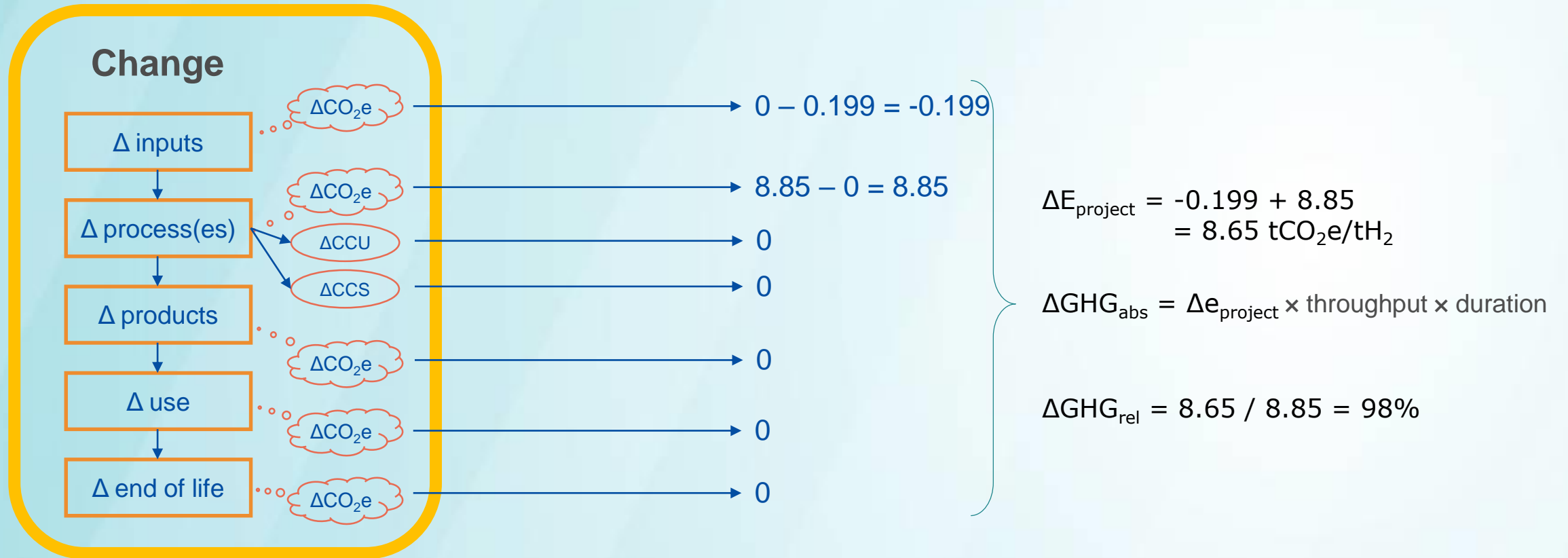
- **Reference**

  - Process 1, ETS benchmark for hydrogen: 8.85 tCO_2e/tH_2

- **Project**

  - Input 1, power: 0 tCO_2e/tH_2

  - Input 2, water: "emissions for water provision may be neglected"

  - Input 3, heat: must assess GHG intensity (ETS heat benchmark is 62.3 $tCO_2e/TJ \times 0.0032$ $TJ/tH_2 = 0.199$ tCO_2e/tH_2)

Overall Change in Emissions

(assuming heat supplied at ETS benchmark GHG value)

Change

Δ inputs — ΔCO_2e → $0 - 0.199 = -0.199$

Δ process(es) — ΔCO_2e → $8.85 - 0 = 8.85$

ΔCCU → 0

ΔCCS → 0

Δ products — ΔCO_2e → 0

Δ use — ΔCO_2e → 0

Δ end of life — ΔCO_2e → 0

$\Delta E_{project} = -0.199 + 8.85$
$= 8.65 \ tCO_2e/tH_2$

$\Delta GHG_{abs} = \Delta e_{project} \times throughput \times duration$

$\Delta GHG_{rel} = 8.65 \ / \ 8.85 = 98\%$

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Variation 1: add a fuel synthesis step

- Still an EII project

- Sector changes: hydrogen -> **refineries (e-fuels)**

- Product changes -> e-fuels. Output products could include*:

  - Synthetic aviation kerosene

  - Synthetic diesel

  - Synthetic gasoline

- Choose one fuel as principal product (generally that with highest yield by expected revenue)
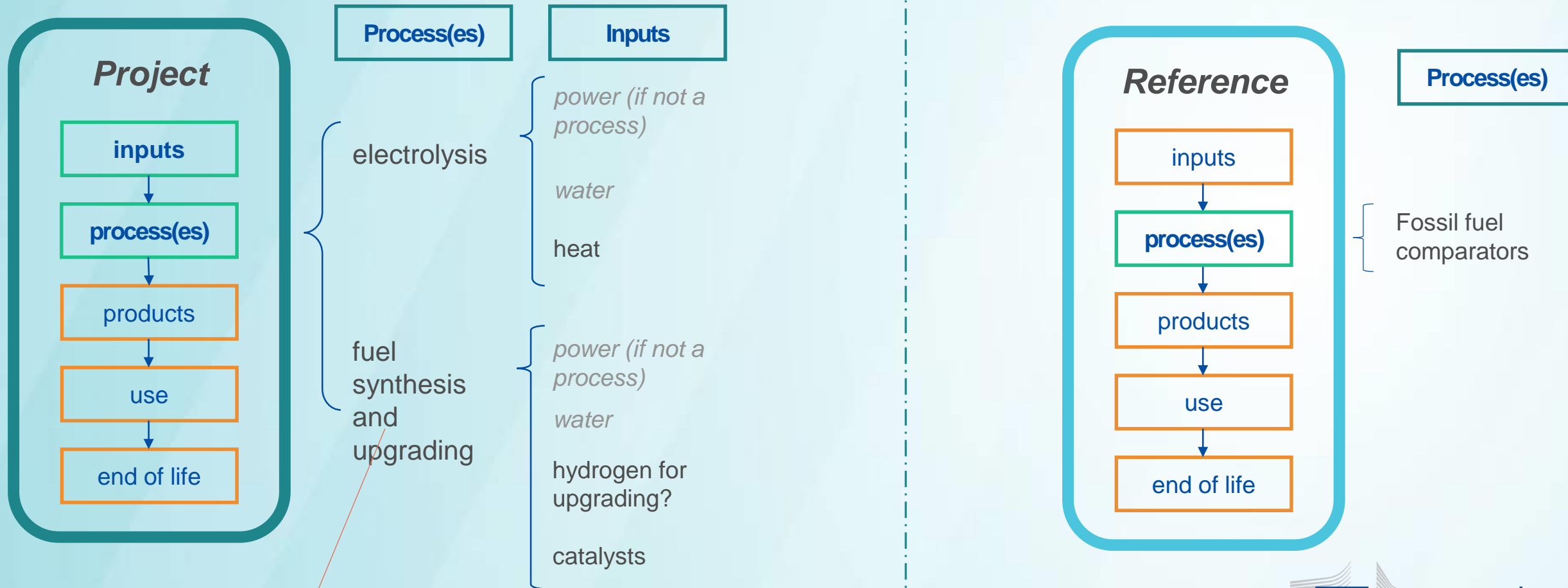
* Output product mix will vary according to synthesis technology and upgrading choices

Setting the Reference

- Now that the project is for e-fuel, production falls under renewable fuels of non-biological origin (RFNBOs)

- Use the appropriate fossil fuel comparators instead of an ETS benchmark:

  - Aviation kerosene: 78.3 gCO2e/MJ (figure provided in updated Annex C)

  - Diesel: 80.4 gCO2e/MJ

  - Gasoline: 78.9 gCO2e/MJ

- Again, all reference emissions fall within the process(es) box of the schematic (so no 'inputs' emissions in the reference scenario)

- If heat is exported by the fuel synthesis facility, include equivalent heat production (ETS heat benchmark)

- No change in emissions for products, use or end of life*

Unless claiming a higher H/C ratio -> lower combustion emissions

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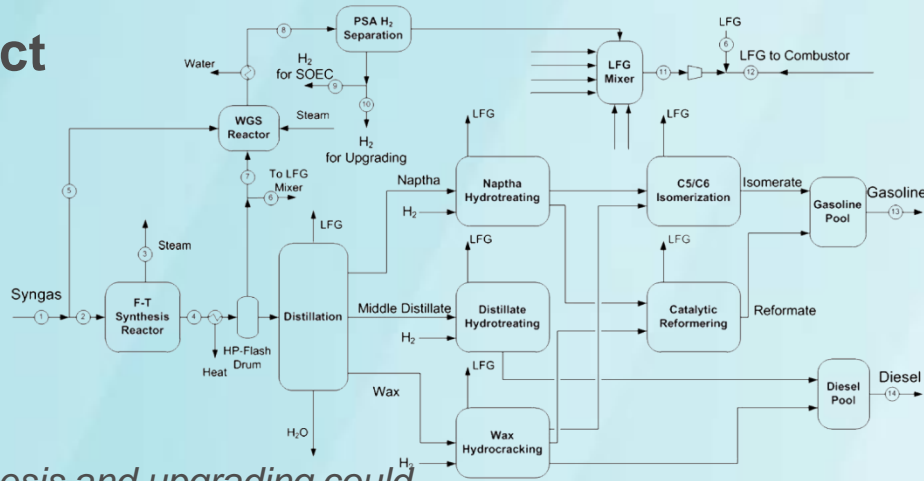
Identify Processes and Inputs (project)

	Process(es)	Inputs

Project

- inputs
- process(es)
- products
- use
- end of life

electrolysis
- *power (if not a process)*
- *water*
- heat

fuel synthesis and upgrading
- *power (if not a process)*
- *water*
- hydrogen for upgrading?
- catalysts

* Upgrading to transport fuels must be included in order to use FFCs on comparable products

Reference

Process(es)

- inputs
- process(es)
- products
- use
- end of life

Fossil fuel comparators
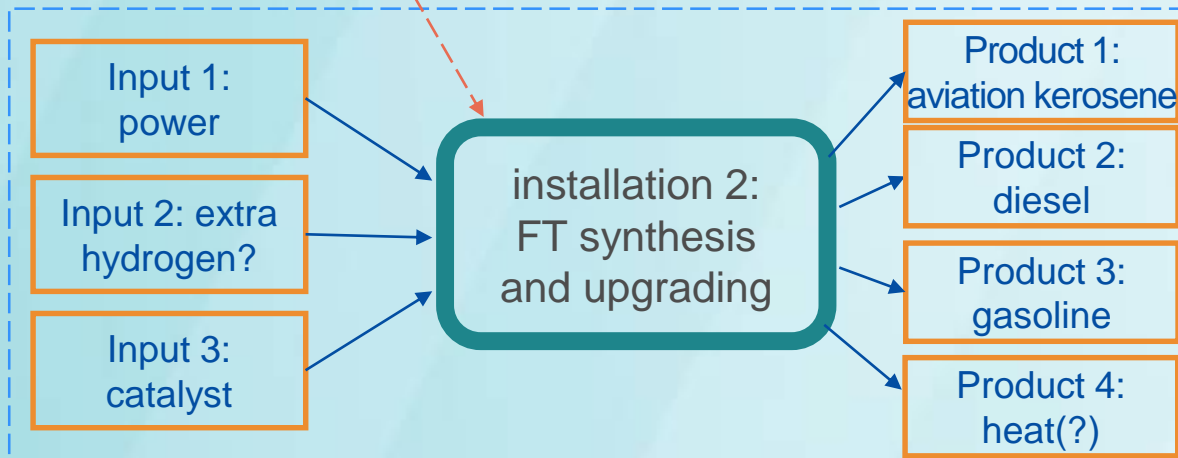
Process(es) boxes (cf. see previous example)

Project

*Synthesis and upgrading could equally be treated as two processes*
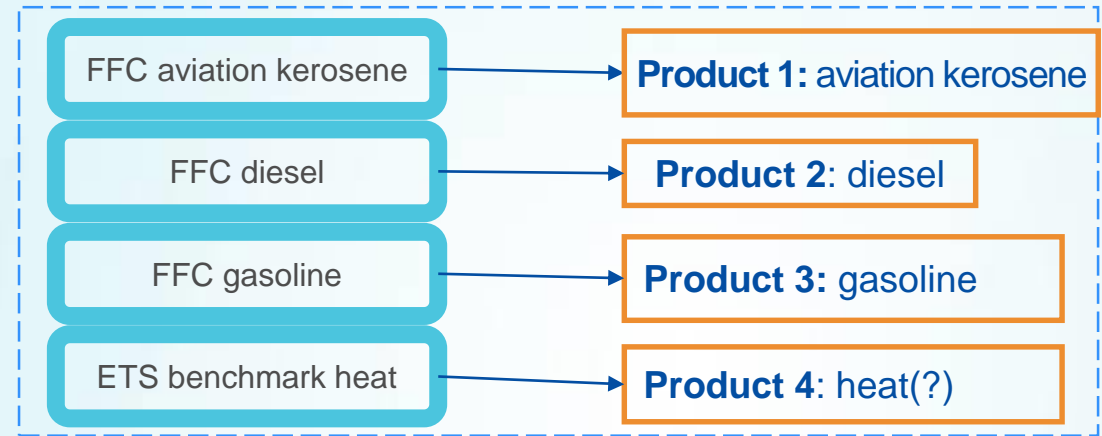
Input 1: power		Product 1: aviation kerosene
Input 2: extra hydrogen?	installation 2: FT synthesis and upgrading	Product 2: diesel
Input 3: catalyst		Product 3: gasoline
		Product 4: heat(?)

Reference

FFC aviation kerosene	→	**Product 1:** aviation kerosene
FFC diesel	→	**Product 2:** diesel
FFC gasoline	→	**Product 3:** gasoline
ETS benchmark heat	→	**Product 4:** heat(?)

Change

- All inputs are new (Δ input$_i$ = -input$_i$)
- The processes have changed completely (Δ process(es) = GHG$_{FFCs}$ − [GHG$_{electrolyser}$+GHG$_{FT}$]
- There is no change in product (Δ products = 0)

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Variation 2: hydrogen supplied for refuelling fuel cell vehicles

- Still an EII project

- Sector changes: hydrogen -> refineries (fuels)

- Product is still hydrogen, but it will be supplied to replace a transport function, and so the reference product changes:

  - Synthetic gasoline*

  - Synthetic diesel*

Upgrading to transport fuels must be included in order to use FFCs on comparable products

Identify processes and inputs (project)
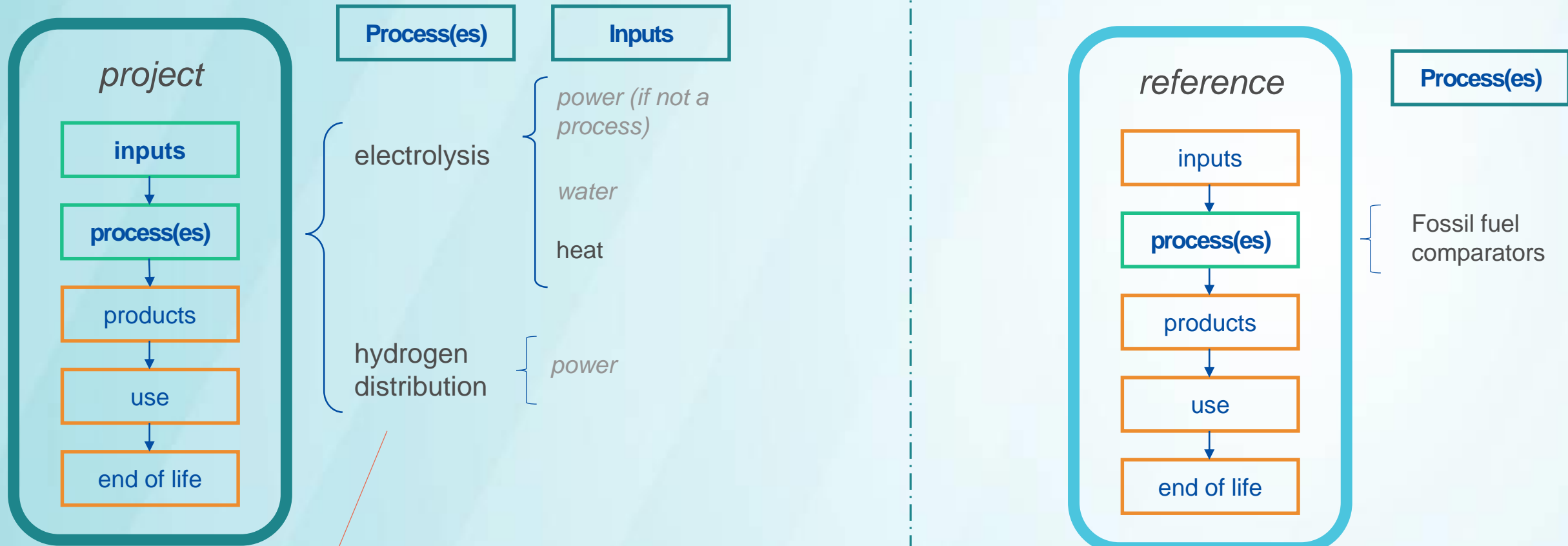
* Must now include any emissions to supply hydrogen to vehicles

# Including Vehicle Efficiency

- Hydrogen fuel cell vehicles have greater energy efficiency than conventional vehicles:

    - E.g. WTW v4 has an energy efficiency ratio ~ 2.8:1 fuel cell to spark ignition (NEDC cycle)

    - Applicants should use WTW v5 values when available

- Multiply fossil fuel production in reference scenario by correct energy efficiency ratio to give like-for-like comparison

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Innovation fund GHG calculation example: ethylene

- Consider a project to produce ethylene from biomass

    - Falls within energy intensive industry

    - The sector (Annex C Appendix C1) is chemicals

    - Bio-ethylene as principal product (example of "organic basic chemicals")

    - Wheat ethanol as feedstock for ethylene production

- For the example, assume ethanol production is within the project boundary but wheat farming is not

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Identify processes and inputs (project)
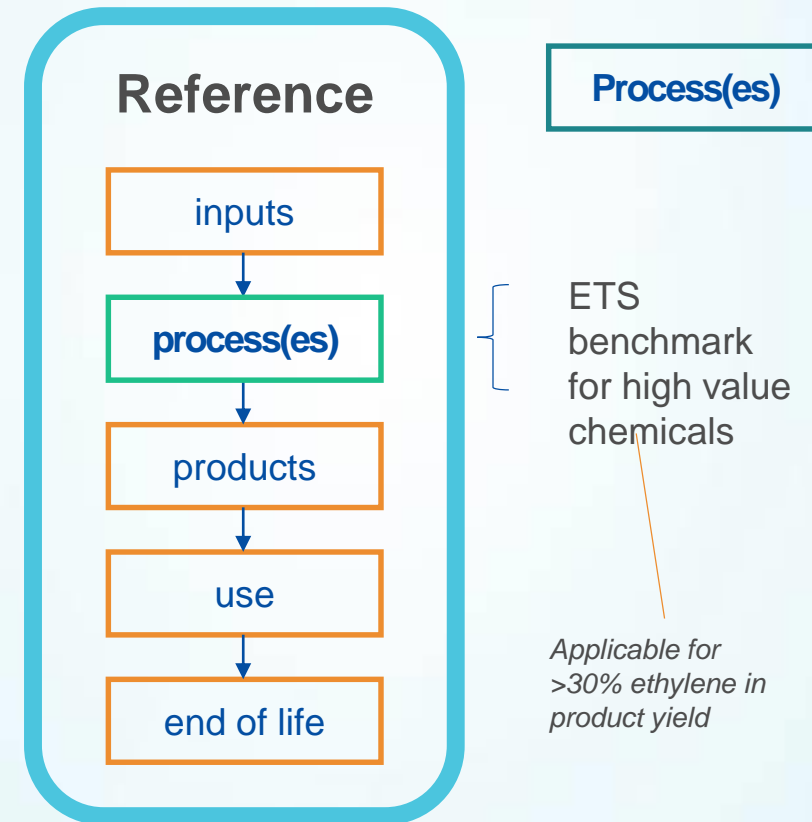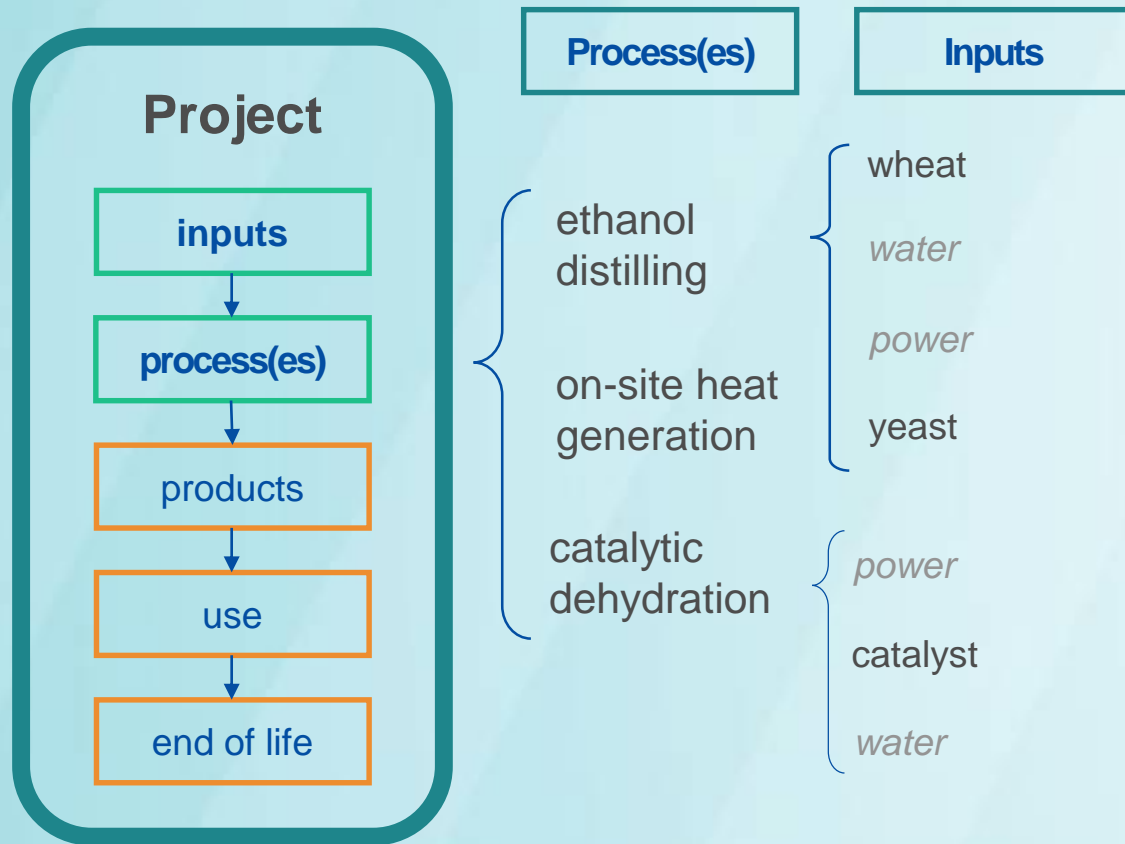
Status of Inputs

- Wheat – "the emissions factor for biomass, biogas, biomethane, bioliquid or biofuels from an indeterminate supplier, are the default emissions tabulated in Annex V and VI of REDII, generally diminished by 15%"

  - Cultivation: 14.1 $gCO_2e/MJ_{ethanol}$

- Inputs to wheat production do not need to be individually assessed

- Yeast and catalysts – likely to be de minimis inputs (no need to assess)

- Water and power – as before, treat as zero

- Assume heat is generated on-site – assessed as part of process(es) box

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$\Delta E_{products} + \Delta E_{use} + \Delta E_{EoL}$

- If wheat ethanol production is brought within the system boundary, then some emissions should be attributed to the distillers' grains co-product, giving a credit within $\Delta e_{products}$

- Bio-ethylene is chemically identical to fossil ethylene so ΔE_{use} is expected to be 0

- At end of life, in the reference scenario it can be assumed that the carbon in ethylene would be released as carbon dioxide (landfilled waste is treated in IF GHG assessment as if incinerated). Biogenic CO_2 emissions are rated as zero, so ΔE_{EoL} is an emission credit for avoided end of life CO_2 release

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Other points of note

Expanded Fossil Fuel comparator (new Table 2.1)

- Expanded range of FFCs, calculated on the same basis as the diesel, gasoline and LPG values as specified in original Table 2.1
- Now includes aviation and marine fuel FFCs.

Substituted fossil transport fuel	IF Fossil Fuel Comparator (g CO_{2eq} / MJ)	LHV (NVC (MJ/kg)
Diesel	80.4	43.0
Gasoline	78.9	44.3
LPG	65.4	47.3
Aviation kerosene	78.3	44.1
Aviation gasoline	78.9	44.3
Marine fuel (incl. gas oil and fuel oil)	78	42.8

Forecasting of Grid Electricity
For calculations of emissions due to generation and use

Sector	Grid electricity substituted by net electricity export or discharging, for energy storage	Net grid electricity consumed or charging, for energy storage
Energy intensive industry / CCS	Expected 2030 electricity mix	Expected 2050 electricity mix*
Renewable electricity / heat	Expected 2030 electricity mix for net export	Expected 2050 electricity mix for net import (in heat projects)
Energy storage	Emissions for electricity produced with single-cycle NG turbine (used for peaking power)	Expected 2050 electricity mix

Electricity is treated as zero carbon presuming full decarbonisation of the electricity mix by 2050

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Forecasting of Grid Electricity - related questions

Question: What emissions should be used for green hydrogen production? Gridmix 2030? Gridmix 2050? Will hydrogen always be zero emissions in the Innovation Fund calculations?

Answer: Regarding the GHG emissions for electricity used as an input, it is treated as having zero carbon emissions which is based on the presumption that there will be full decarbonisation of the electricity mix by 2050. Regarding the question on the likely GHG emissions for hydrogen, they will not always be zero, the level of GHG emissions will depend on how the hydrogen is made. In addition, it is worth noting that it would be important for the applicant to include details of the plan to support additional renewable power and to include such detail in the project documentation. This will be considered under Degree of Innovation criterion in the second stage

Boundaries

Boundaries vary depending on the sector of the project
Overall, the following emissions are included for all projects:

- Fuel combustion in stationary and on-site vehicles
- Fugitive emissions in geothermal power plants and CCS projects
- Emissions from the supply of biomass-based fuels

Emissions generally excluded

- Capital goods
- Extraction, processing, transportation and storage of fossil fuel
- Combustion emissions of biomass, biogas, biomethane, biofuels and bioliquids
- Indirect land use change

- Decommissioning of the power plant and machinery at the end-of-life
- Employee commuting, business travels and waste generation at administrative offices
- Fugitive emissions due to well testing and well bleeding in geothermal power plants

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Questions and Answers

Boundaries – related questions

Question: Green hydrogen will be used as an input for the production of SAF. The hydrogen will be produced with an elektrolyser which will obtain its electricity from a new to build windfarm at sea. A PPA will be in place for the production of hydrogen. Is hydrogen considered an input?

Answer: If the electrolyser is under the control of the applicant, which appears to be the case from the question, it should be treated as part of the process. Only if the hydrogen enters the production system from 'outside' the system boundary would it be treated as an input – in which case (subject to confirmation against the threshold condition for <30% of total input related GHGs) it would likely qualify as a minor input.

Classification - related questions

Question: a project which intends to substitute a current coal boiler by a Refused Derived Fuel (RDF boiler), diverting RDF from its current destination (landfill) should be classified as a Renewable Heat project or an Energy Intensive Industries project?

Answer: It is up to the applicant to select the category in which the project belongs and to justify this choice. If the project is to replace a boiler at an installation that falls within the energy intensive industries, the project could be classified as an EII project. In the case the RDF boiler project is presented as a Renewable heat project, the project would qualify as a hybrid project. The choice will subsequently define the calculation of the relevant emissions.

Classification - related questions

Question: Project aims to treat BFG from steel industry, extract CO_2 for storage and offer the remaining BFG (higher calorific value) to internal installations, the remainder of which is offered to a nearby power plant. Are the emissions from the installations considered part of the ETS product benchmark of the core product (hot metal)? An alternative is that these new installations outside the scope of the Hot Metal product benchmark are seen as heat / fuel products subject to ETS (linked to the core product). Which sector should be selected?

Answer: This project could fall under an Energy Intensive Industry (EII) or Carbon Capture and Storage (CCS).

Reference Scenario - related questions

Question: If a project product (bio-based product) can substitute two conventional products, which conventional product can be used as a product reference for the calculation of the GHG emissions avoidance? For example, in case of the bio based Poly Lactic Acid (PLA), PLA can replace several different conventional fossil based plastics, such as polyethylene (PE), polypropylene (PE) and styrene, depending on the application. Which one/ones should be selected as benchmarks?

Answer: More than one product benchmark may be used but the applicant needs to justify it by explaining the sales plan. Draft contracts or at the very least letters of intent by the prospective buyers should be presented. Then the emissions savings can be calculated in accordance with the final use.