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Crude Tall Oil – Too valuable to burn

Pine Chemicals Association – 2010 International Conference

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With the courtesy of Arizona Chemical

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Sustainability is amongst the critical mega-trends expected to increasingly shape the world over the coming years

Generation Y

Population growth

Global Warming

Dwindling resources

Government policies

Multiple reporting

- *Ledger*
- *EHS*
- *Social responsibility*

Sustainability is amongst the critical mega-trends expected to increasingly shape the world over the coming years

- Sustainability is hot, be it in politics, business, administration or education, sustainability is one of the most important and fundamental megatrends expected to increasingly shape the world in the coming years
- The increased attention paid to sustainability, making it a true megatrend is driven by fundamental developments including:
  - Dwindling traditional feedstock reserves threatening the current world as we know it – the question being when rather than if fossil derived feedstocks reserves will eventually be exhausted
  - A continuing population growth further increasing pressure on feedstock reserves
  - The threat of possible natural disasters as a consequence of global warning, which is increasing public concerns on environmental related issues
  - The election of younger political leaders reflecting the ambitions and aspirations of “Generation Y”, whose values include:
    - Global thinking
    - Willingness to adopt new technologies
    - Passion for ethics and sustainability

Sustainability represents for the pine chemical industry both a threat and an opportunity

Threats

Opportunities

Threats:

- CTO as a biofuel

- Emission reduction targets

Opportunities:

- Competitive advantage through cost reductions

- Competitive advantage over less e benign substitutes

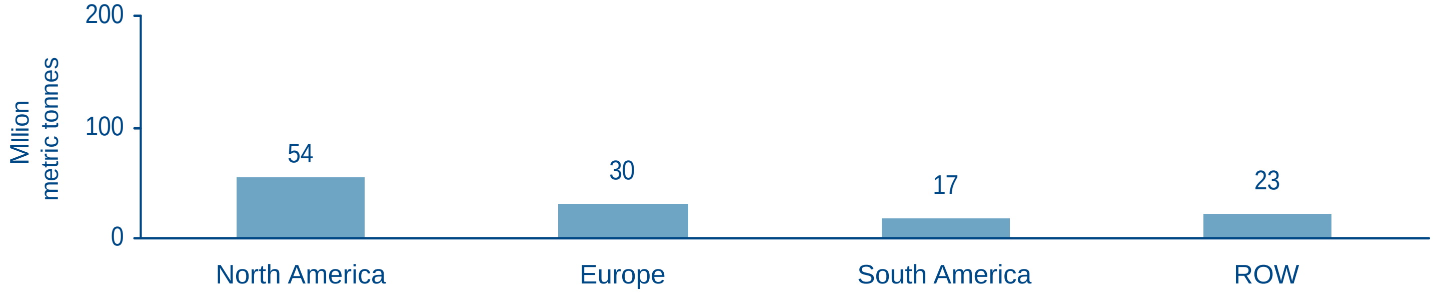
- Increased sales given increased consumer pull for green products

Sustainability implies for the pine chemical industry both a threat and an opportunity

- For CTO fractionators, sustainability can be both a threat as well as an opportunity:
  - Opportunities:
    - To outpace competition:
      - Promotion of the lower environmental footprint of CTO derivatives compared to their less environmentally benign substitutes
      - Cutting of energy consumption and hence costs
    - To increase sales, given an increasing consumer pull for green products
  - Threats of the recognition of CTO as a biofuel:
    - Several countries however are trying to increase the share of biofuels in their total energy consumption bill – in an attempt to reduce dependency on fossil fuels. Hence they are defining a list of products to be acknowledged as a biofuel, among which possibly CTO

CTO availability is limited

Kraft pulp



Full capacity utilization

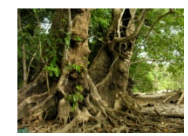
100% recovery rates

60% softwood

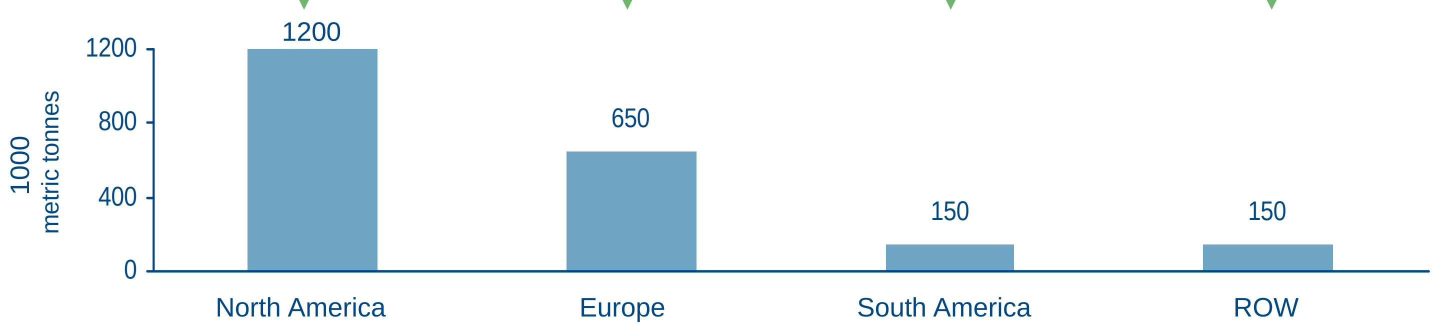
70% softwood

30% softwood

Mostly hardwood



CTO



Source: FAO - UNECE/FAO

a) Including CIS, New Zealand and South Africa

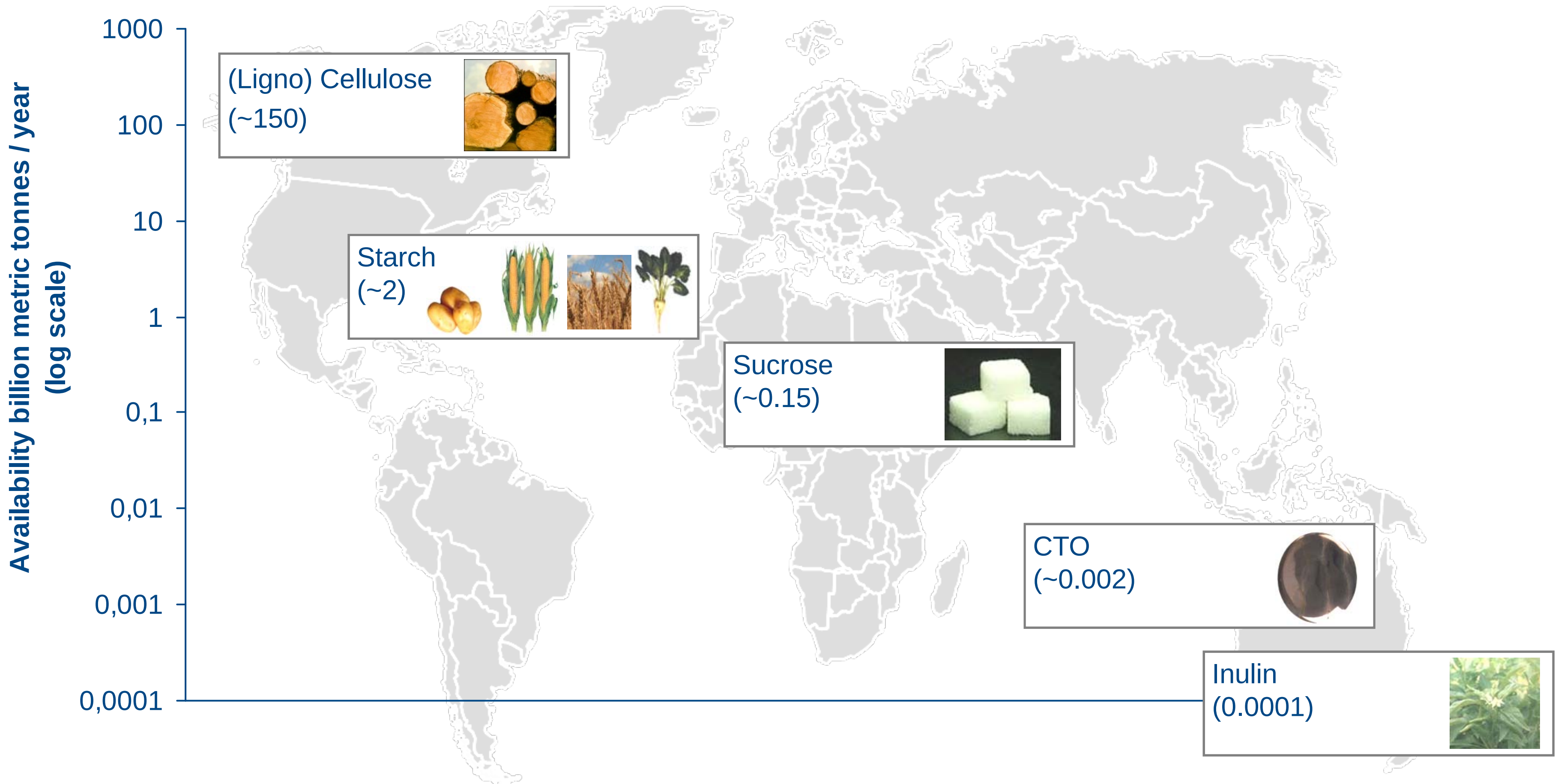
b) Given average recovery rate of 80%

CTO availability is limited

- In 2007, total world Kraft pulp production was around 124 million metric tonnes, subdivided into (million mt):
  - Europe: ~30
  - North America: ~54
  - Latin America: ~17
  - ROW: ~23
- Taking into account the type of trees used for pulping in the various regions – namely:
  - In Europe: around 70% of pulp production deriving from softwood
  - In North America: around 60% of pulp production is based on softwood
  - In Latin America: 30% comes from softwood
  - In Rest of the World: mostly hardwood except in countries such as CIS

  total CTO availability assuming 100% capacity utilization and complete recovery rates can be estimated to be around 2.1-2.3 million metric tonnes:
  - Europe: ~650-700 k mt
  - North America: ~1200 k mt
  - Latin America: ~150-200 k mt
  - ROW: 150 -200 k mt
- Given an average recovery rate of about 80%, global CTO availability corresponds to about 1.8 million meteric tonnes. With total capacity for CTO refining of 1.7 million metric tonnes installed worldwide, global CTO availability is limited

From a macro perspective, the use of CTO as a renewable fuel is only of anecdotal evidence



From a macro perspective, the use of CTO as a renewable fuel is only of anecdotal evidence

- Together with (ligno) cellulose, starch is one of the main components of vegetable biomass – their functionality being to provide for:
  - Cellulose – structural properties – acting as a molecular skeleton for the plant
  - Starch – energy storage under the form of a carbohydrate polymer in view of its subsequent utilization by the plant metabolism when photosynthetic activity is inadequate
- Other types of energy storage are carbohydrates including sucrose – contained in some plants like sugar cane and sugar beets – as well as inulin found in chicory
- In terms of availability starch is second only to (ligno) cellulose – the yearly production of this carbohydrate through plant photosynthesis being in the order of 2 billion metric tonnes*
- CTO as a biofuel will not make a significant difference to the overall renewables pool – global CTO availability only being a fraction of yearly production of starch: i.e. 1000 times less
- Given availability as well as ease of hydrolysis starch is an increasingly important renewable feedstock

* Based on total cereal output of 2.8 billion metric tonnes and average starch content of 70%

The amount of renewable energy contained in CTO is of limited significance in comparison to global consumption levels

2 million metric tonnes of CTO [a]

=

1.03 million t oil equivalents (net of pitch used as bio-liquid)

OR

8.4 x 10^6 oil barrels

Amount of time CTO can provide sufficient energy for the entire population of:

 < 1 hour

 ± 4 hours

 ± 5 hours

 3 days

(a) Assuming 100% capacity utilization

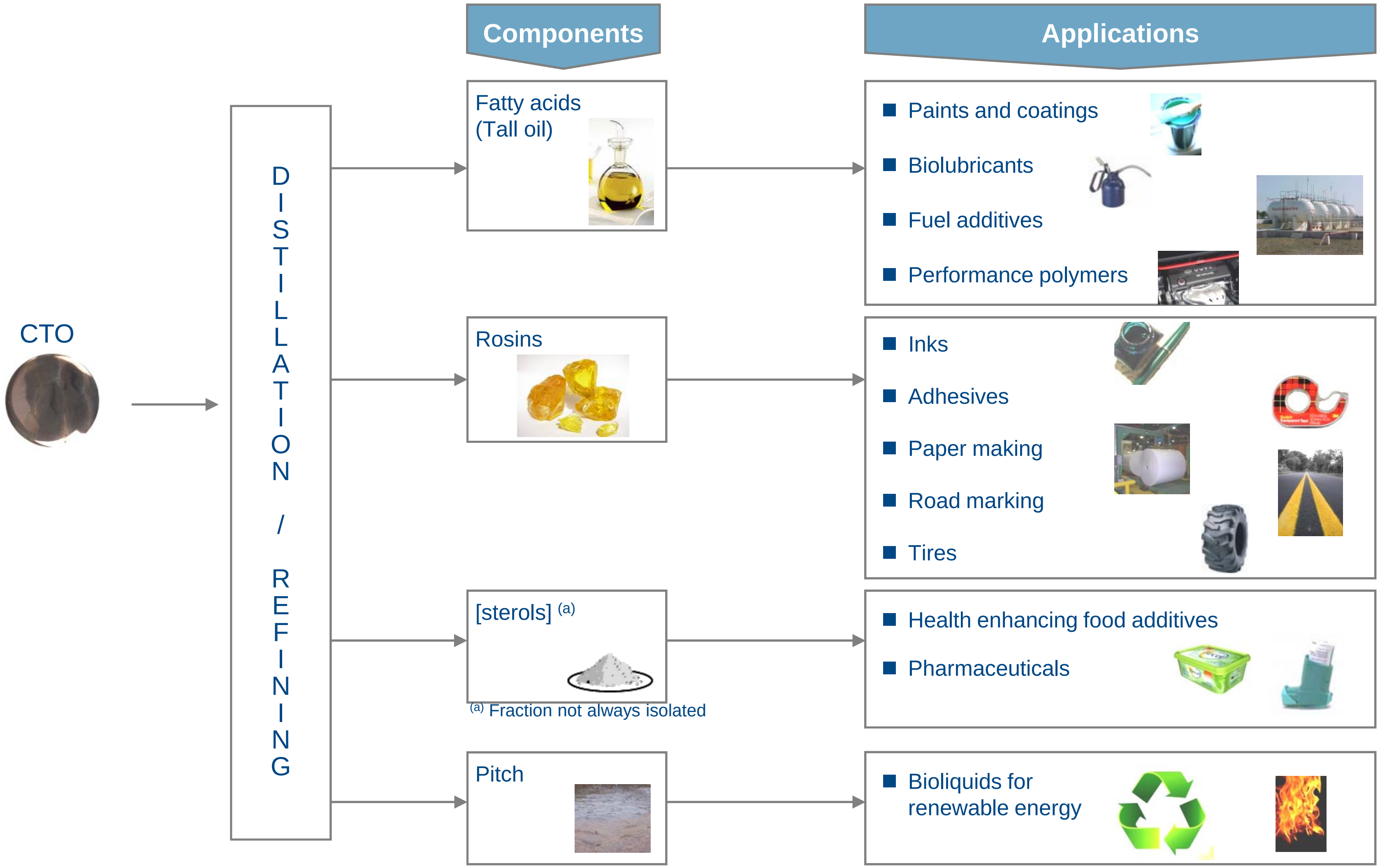
(b) Assuming full consumption of globally produced CTO

The amount of renewable energy contained in CTO is of limited significance in comparison to global consumption levels

- Assuming an average recycling rate as bio-liquids of 40% of the 2 million metric tonnes of CTO fractionated globally – the amount of renewable energy "diverted" corresponds to 1.03 million t of oil equivalents or 43.2 x 10^6 GJ
- Whilst prima facie large numbers – these have to be compared to the total energy consumption:
  - CTO being able to take up 0.04% of total US energy consumption
  - 0.06 % of total EU energy consumption corresponding to total CTO availability
  - Florida consumption would be covered for 0.9% by CTO

  Clearly indicating that the quantity of renewable energy used by CTO fractionation is almost negligible at a macro level:
  - CTO not even being able to cover 1 hour of the global energy consumption
  - US citizens being able to consume energy for about 4 hours, if all would be supplied by CTO
  - The European population lasting almost 5 hours with the energy provided by the CTO globally available
  - CTO supplying Florida with energy for 3 days

From an economical perspective refining and processing CTO is a much sounder option than using it as a biofuel



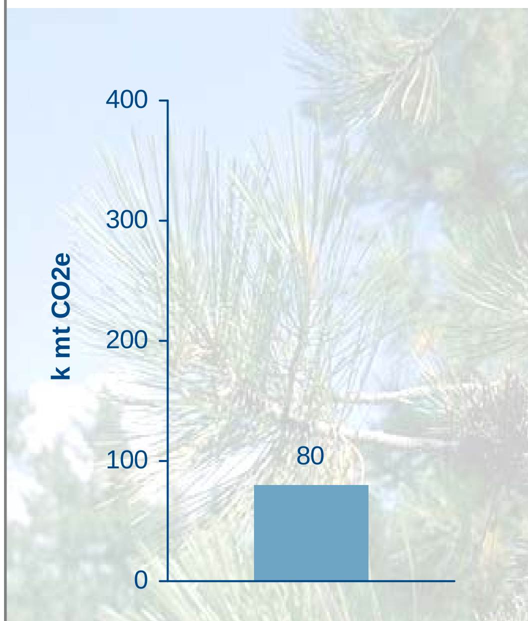
From an economical perspective refining and processing CTO is a much sounder option than using it as a biofuel

- The CTO is fractionated through vacuum distillation into its various constituents, namely:
  - Tall oil fatty acids used in various outlets, including alkyd based paints, biolubricants for applications where low environmental impact is key, fuel additives as lubricants in low sulphur diesel and many more
  - Rosin acids finding their way directly in paper making as sizing agents or after derivatization as resins for adhesives, printing inks etc.
  - The sterol fraction – when isolated –used for the synthesis of steroids – a widely used class of pharmaceutical agents used in cancer treatment, dermatology, fertility control or respiratory diseases – and for the preparation of cholesterol lowering formulations like Benecol as health enhancing ingredients
  - Pitch being used as a biofuel

The use of end products of the CTO fractionation industry has a positive impact on global warming

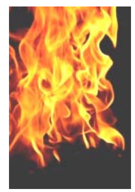
Case study: Arizona Chemical Nordic Operations

Cradle-to-gate emissions from CTO derivatives

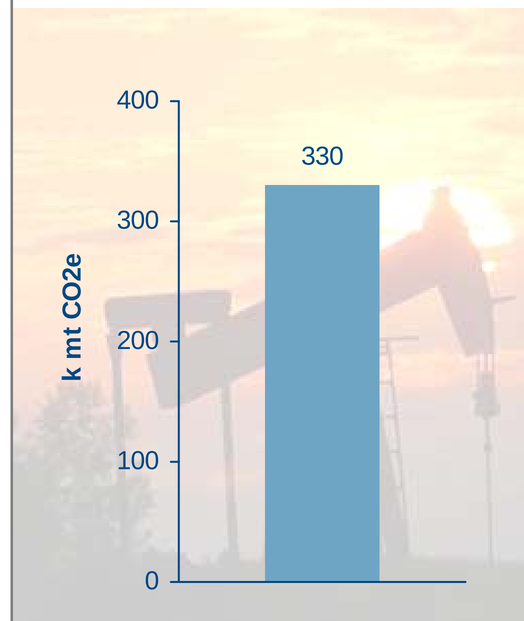


Arizona CHEMICAL

Nordic operations: Finland & Sweden



Cradle-to-gate emissions from substitutes

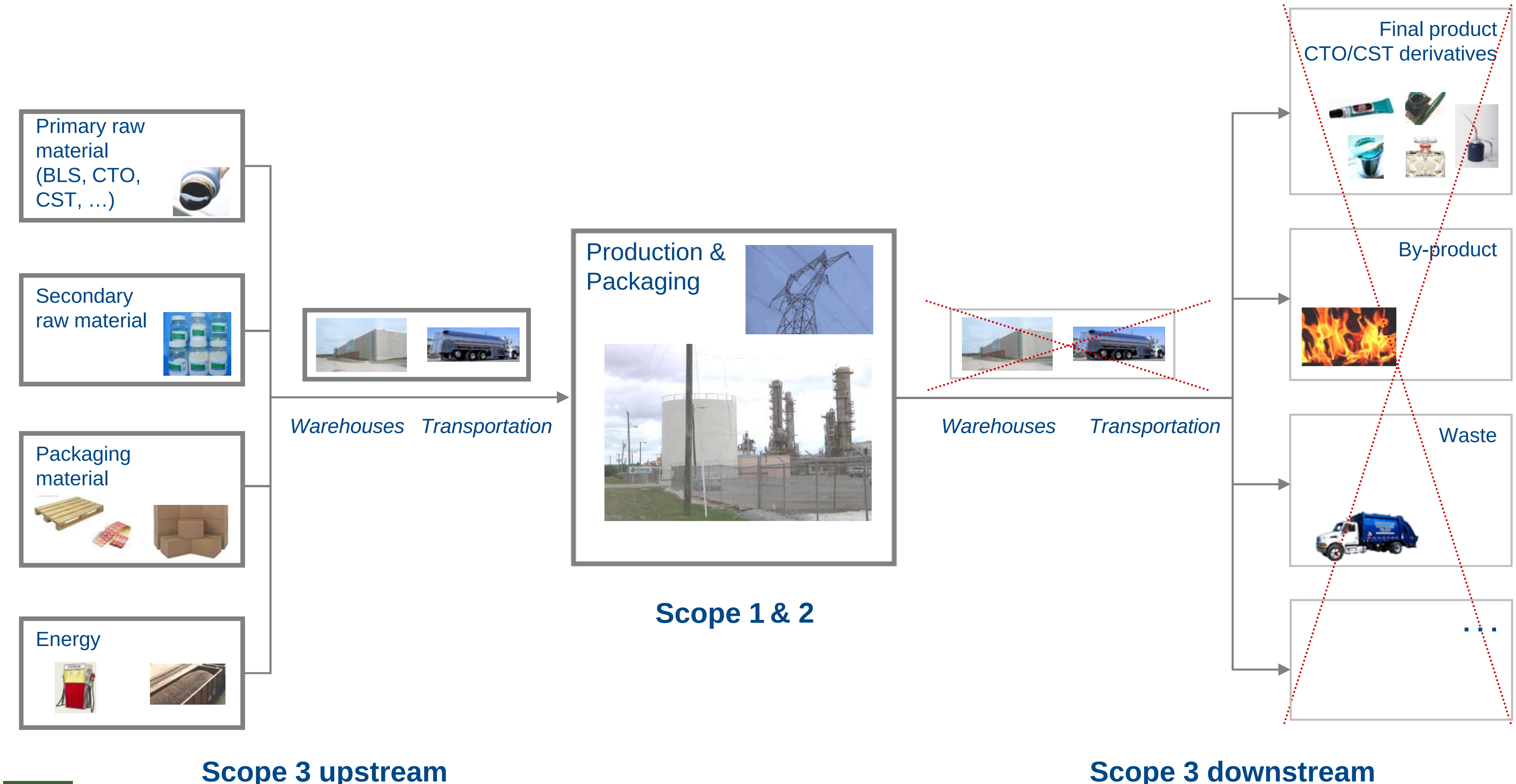


Based on an estimation of the most likely mix of substitutes

The use of end products of the CTO fractionation industry has a positive impact on global warming

- Total GHG emissions resulting from the production and processing of the various inputs into the CTO derivatives (the so called “cradle-to-gate footprint”) out of Arizona Chemical's Finnish and Swedish operations being around 80 k metric tonnes CO2e
- This has to be compared with the 330 k metric tonnes CO2e emissions associated with their non CTO substitutes
- The use of CTO derivatives allowing therefore to substantially reduce GHG emissions – just taking into account Arizona Chemical's output this abatement corresponding to 250 k metric tonnes CO2e

The "Cradle-to-gate" footprint consists of upstream emissions as well as processing by own operations



The "Cradle-to-gate" footprint consists of upstream emissions as well as processing by own operations

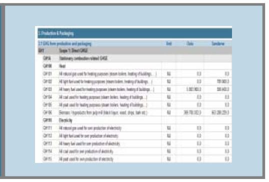
- Green House Gas (GHG) emissions are calculated according to international reference standards and guidelines [a], which have defined three main classes of GHG emissions:
  - **Scope 1: Direct GHG** emissions covering emissions deriving from sources owned or controlled by the organization such as on-site power generation, space heating systems, transport and packaging, …
  - **Scope 2: Energy indirect GHG emissions,** namely emissions associated with the generation of electricity as well as heat and steam purchased from third parties
  - **Scope 3: Other indirect GHG emissions**, emission falling outside the direct control, but associated with own activities, including: GHG resulting from the production and transportation of purchased materials/inputs like fuels, raw materials, etc.
- Since the complexity of the chemical industry and the wide range of applications makes it very difficult to provide meaningful data for downstream activities, guidelines believe a cradle-to-gate methodology for the chemical industry – and thus also CTO refining – is most appropriate

a) WBCSD GHG protocol and The Climate Registry (TCR) protocol

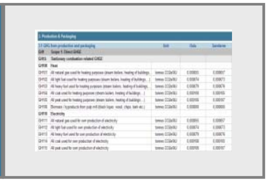
GHG emissions are calculated based on the collected data and appropriate associated emission factors

Input

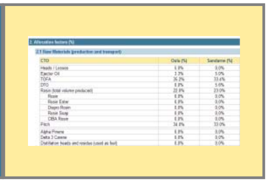
Activity Data



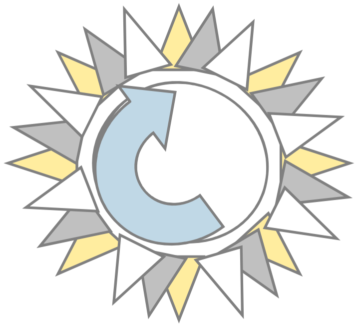
Emission Factors



Allocation Factors



Tool



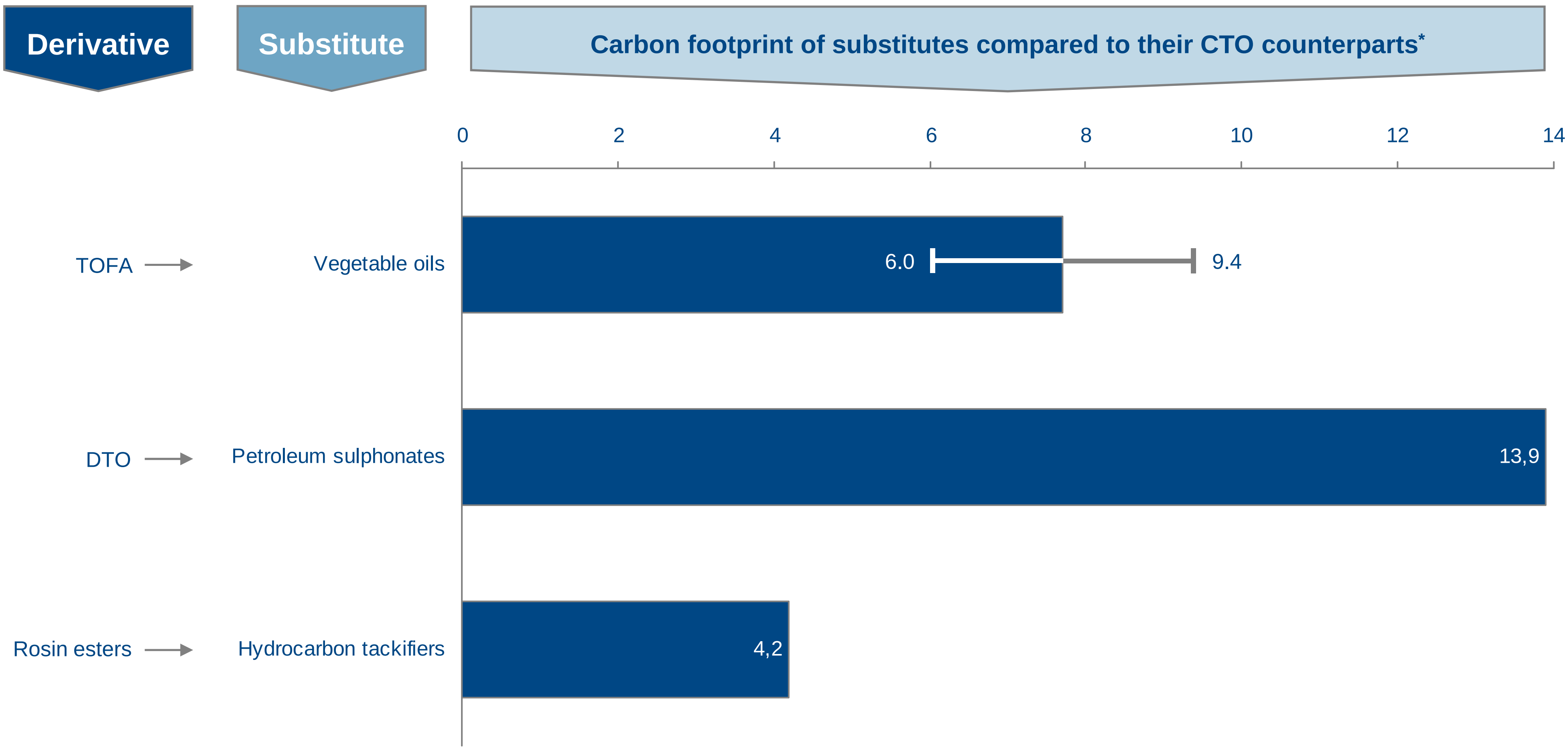
Output

- GHG emissions Scope 1 & 2
- GHG emissions for each individual CTO derivative
- Comparison of GHG footprint of CTO derivatives with relevant substitutes

GHG emissions are calculated based on the collected data and appropriate associated emission factors

- Carbon emission can be measured by means of two distinct methods:
  - "Direct Measurement Method": sensors measuring actual emissions from operations
  - "Emission Factor Method": calculating emissions, by far the easiest and least capital intensive way of defining carbon emissions
- The emission factor method uses three different types of input:
  - Activity data delivered by the company – e.g. amount of natural gas burned by the company / plant as a whole
  - Allocation factors defined in agreement with the company, allocating corporate / plant level activity data to specific product lines – e.g. % of total amount of natural gas burned to be allocated to TOFA
  - Emission factors from internationally recognized databases, expressing the amount of CO_2e emitted per unit of activity date – e.g. 55 g CO_2e / MJ of natural gas burned in Finland
- A tool tailor-made for each industry and company defines the carbon footprint by consolidating each of the three inputs

CTO based products have a significantly lower carbon emission footprint compared to their substitutes

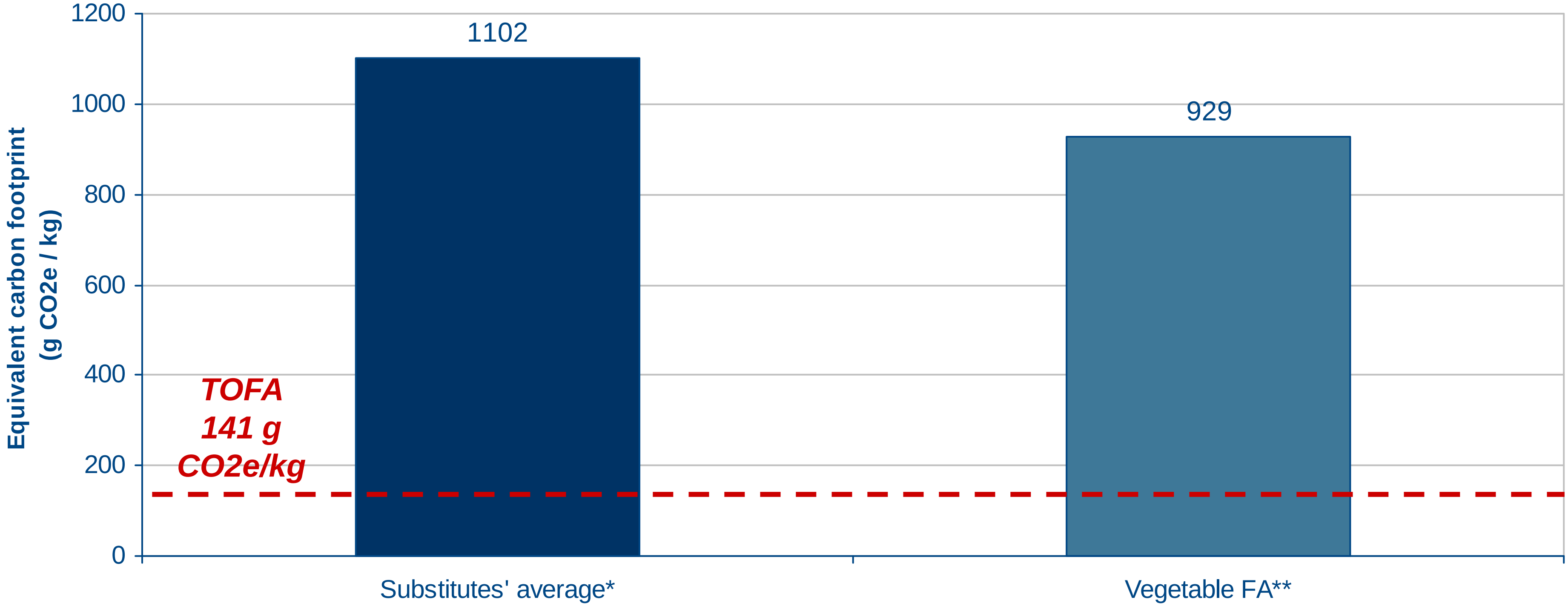


*Expressed per unit of functionality provided

CTO based products have a significantly lower carbon emission footprint compared to their substitutes

- Even excluding end of life emissions – the carbon footprint expressed per unit of functionality provided associated with CTO derivatives is substantially lower compared to their substitutes including:
  - Vegetable oil derivatives reflecting the number and volume of inputs required for their culture
  - Fossil feedstock derived materials
- The use of CTO derivatives enables thereby to reduce global warming gases emissions contributing to the fight against climate changes

Regardless of the application, TOFA has a lower carbon footprint compared to vegetable oil substitutes



Main outlets

Lubricant

Alkyd resins

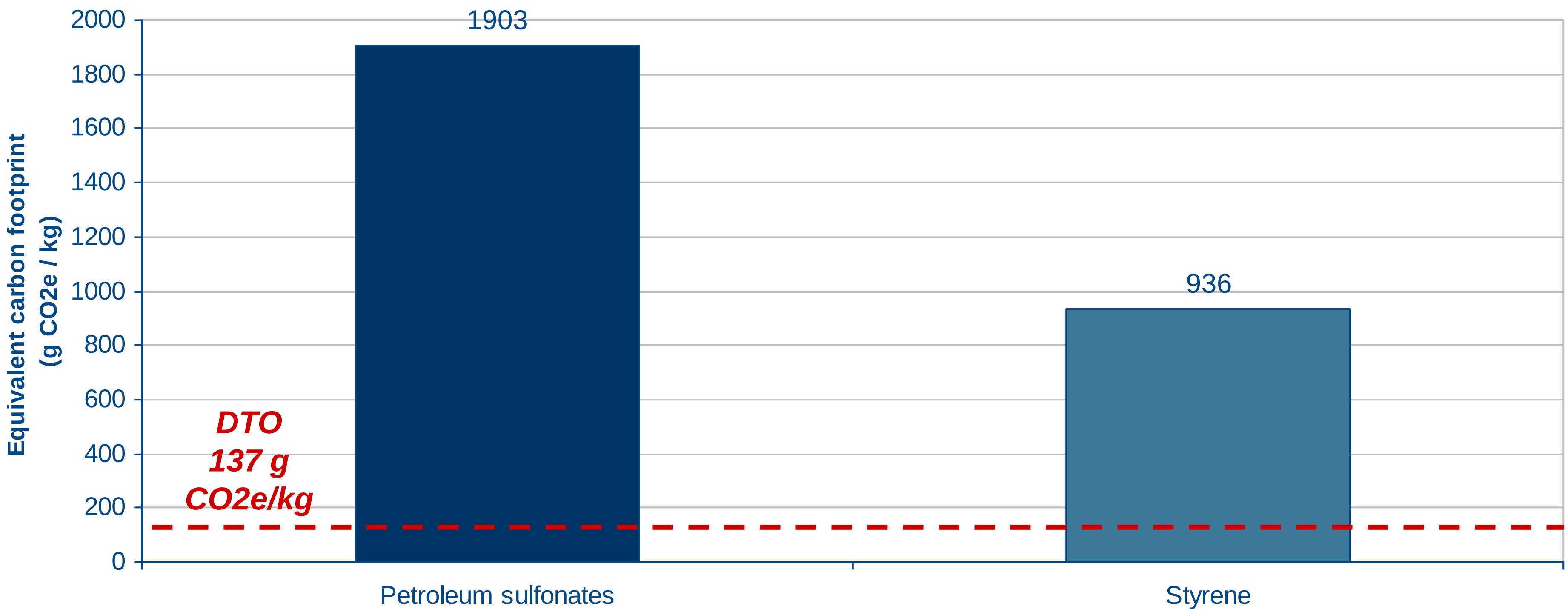
* The substitutes' average carbon footprint has been calculated based on the substitutes' most likely mix carbon footprint: mono acid of vegetable FA, glycerol esters of vegetable FA, ethoxylated vegetable dimers, polyisobutene maleic esters and diethanol amine derivative of vegetable FA

** Vegetable FA considered here are soybean oil FA and sunflower oil FA

Regardless of the application, TOFA has a lower carbon footprint compared to vegetable oil substitutes

- Tall Oil Fatty Acids replace mainly vegetable oil and vegetable oil fatty acids in various applications, such as:
  - Lubricants for low sulfur diesel:
    - Replacing a mix of various vegetable oil derivatives and hydrocarbon based esters: mono acid of vegetable FA, glycerol esters of vegetable FA, ethoxylated vegetable dimers, polyisobutene maleic esters and diethanol amine derivative of vegetable FA
  - Solvent based alkyd resins:
    - If not produced from TOFA, the most likely substitution would be from soybean and sunflower FA
    - Replacement of TOFA however would imply giving up other benefits including shorter process time, drying cycle as well as superior gloss and hardness of the dried coating
- Even though almost all TOFA substitutes are vegetable based, they have a remarkably higher carbon footprint – associated with the carbon emissions resulting from plowing, harvesting, production of fertilizers, etc. All of these elements have a considerable carbon footprint
- Next to the aforementioned disadvantages of replacing TOFA by vegetable oil based substitutes, it is also noteworthy to take into account that soybean and sunflower oil can also be used in food and feed applications whilst TOFA is not soluble for these outlets

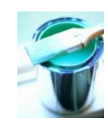
As an emulsifier in metalworking fluids, DTO has a much lower carbon footprint compared to its substitute



Main outlets

Metalworking fluids

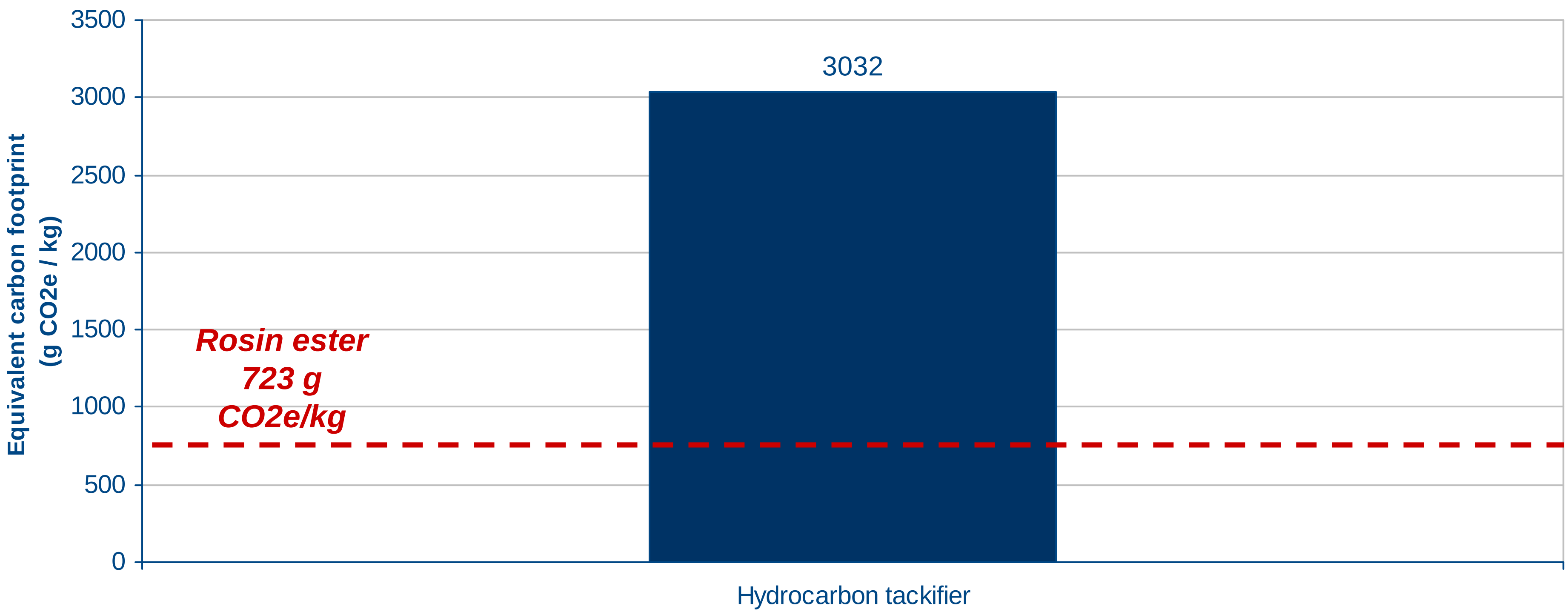
Alkyd resins



As an emulsifier in metalworking fluids, DTO has a much lower carbon footprint compared to its substitute

- DTO is mainly sold for use in the metalworking fluids outlet:
  - As part of the emulsifier package
  - DTO will most likely be replaced by petroleum sulfonates, which have a significantly higher carbon footprint
- For use in alkyd / resin formulations:
  - Contributing to the coating hardness and reducing the drying time
  - 2 kg of DTO can be replaced by only 1 kg of styrene, as in the calculations comparisons are always on a functional equivalence base, carbon footprint of styrene was halved
- It is important to note however that the carbon footprints considered here are only cradle-to-gate, taking into account only emissions related to the production of the product:
  - Emissions from end-of-life operations, such as burning, are hence not included
  - Including them would make the gap between vegetable based and hydrocarbon based raw materials even larger, as burning of biomass based materials is considered to be carbon neutral

Rosin esters have a carbon footprint, which is more than 4 times less the one of its substitutes



Main outlets

Adhesives

Rosin esters have a carbon footprint, which is more than 4 times less the one of its substitutes

- One of the applications of rosin esters is in adhesives, here the resins function as the tacky binder compounded with polymers in hot melt adhesives
- In this application it can be replaced by hydrocarbon tackifiers. Again, hydrocarbon tackifiers have in this comparison the advantage that end-of-life emissions are not taken into account

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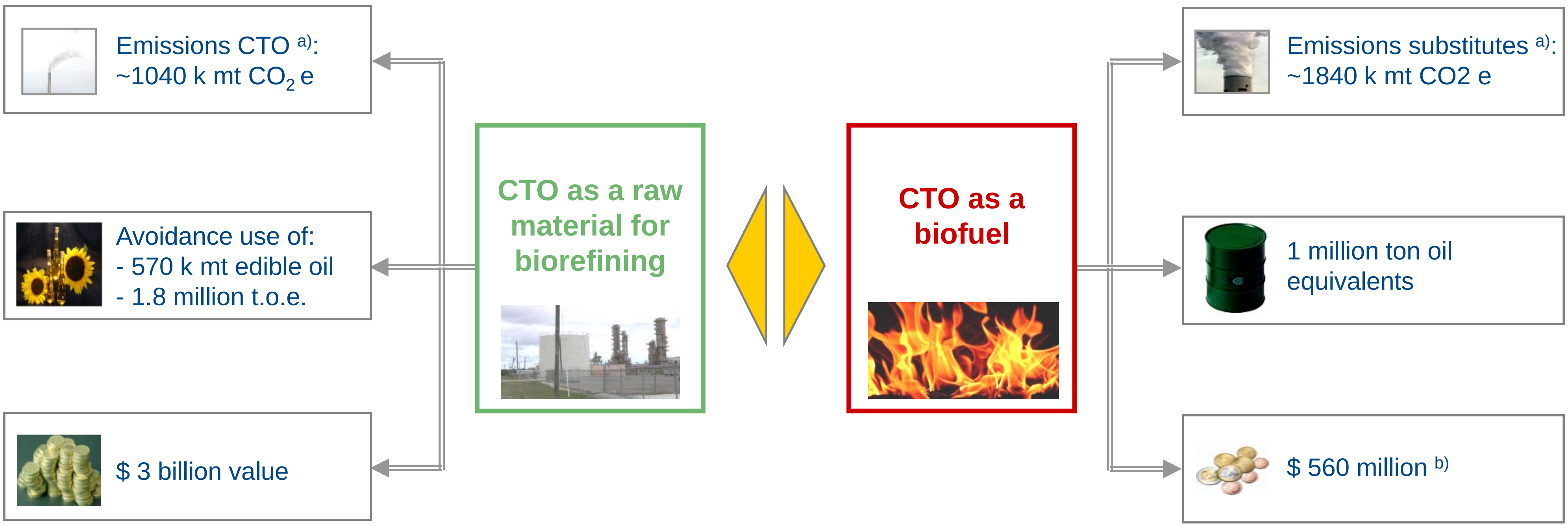
Incentivizing the direct energy use of CTO is detrimental from the global warming, sustainability as well as the economic perspective



a) In US and EU

b) 8 million bbl @ 70 US$/bbl

Incentivizing the direct energy use of CTO is detrimental from the global warming, sustainability as well as the economic perspective

- The use of CTO as a biofuel has the potential to contribute a maximum of about 1 million t oil equivalent – 0.04% and 0.06% respectively of total US and EU energy requirements – overall an insignificant figure
- Depriving the global CTO refining industry from a competitive access to this material – as it would be inevitably be the case should its use as bio-liquid be encouraged – will have major detrimental effects:
  - Resulting in increased cradle-to-gate global warming gases emissions of 800 k mt CO_2 e- corresponding to those of about a quarter million of cars
  - Triggering substitution of CTO derived products with less environmentally friendly alternatives – mostly based on non-renewable raw materials - the use of CTO enabling to avoid the consumption of:
    - 1.8 million tons of oil equivalents
    - 570 k mt of edible vegetable oil
  - Causing damage to the competitiveness of an important industrial biorefining sector significantly contributing to local economies in often disadvantaged regions - leading also to foregoing up to $ 3 billion value added created by this industry