IEA Bioenergy
Technology Collaboration Programme

TU WIEN ICEBE IMAGINEERING NATURE

Bioeconomy Synergies Project Progress & Prospect Report 2019-2021

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IEA Bioenergy TCP Task 40

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Nomenclature

Bioeconomy:
All anthropological activities on the nexus biosphere & technosphere including the primary economic sectors agri-,silvi- and aquaculture, intermediary processes and distribution, food-, material and energy use.

Synergies:
Based on the Latin words “sun” (together) and “ergon” (work) most definitions of synergy include the notion of a success through cooperation which is greater than the sum of the separate successes without cooperation.

Supply chain:
A path of (Bioeconomy) activities connecting primary feedstock sourcing until final conversion (“consumption”) with possible intermediary steps such as collecting, supply to a densification plant, pre-treatment, densification, storage & distribution to end users.

Supply networks:
extends the linear illustration of supply chains with a network character including nodes such as industrial sites with various inputs and outputs connected via edges to various suppliers and selling a product portfolio to different end users.

1 + 1 > 2

(if ?)

Kick-start the discussion on Circular Bioeconomy Synergies:

(1) Discuss cases for synergies between food/feed, material and energy utilization of biomass

(2) Create a first resource flow database version for modelling synergies in a Circular Bioeconomy

(3) Derive insights for the modelling of Bioeconomy supply networks, policy recommendations and the strategic orientation of IEA Bioenergy Task40 including follow-up projects

supporting information & references to most slides can be found in the presenters notes and a literature slide at the end of this presentation

WP1 - Synergy case #1

Food & feed supplements & bulk

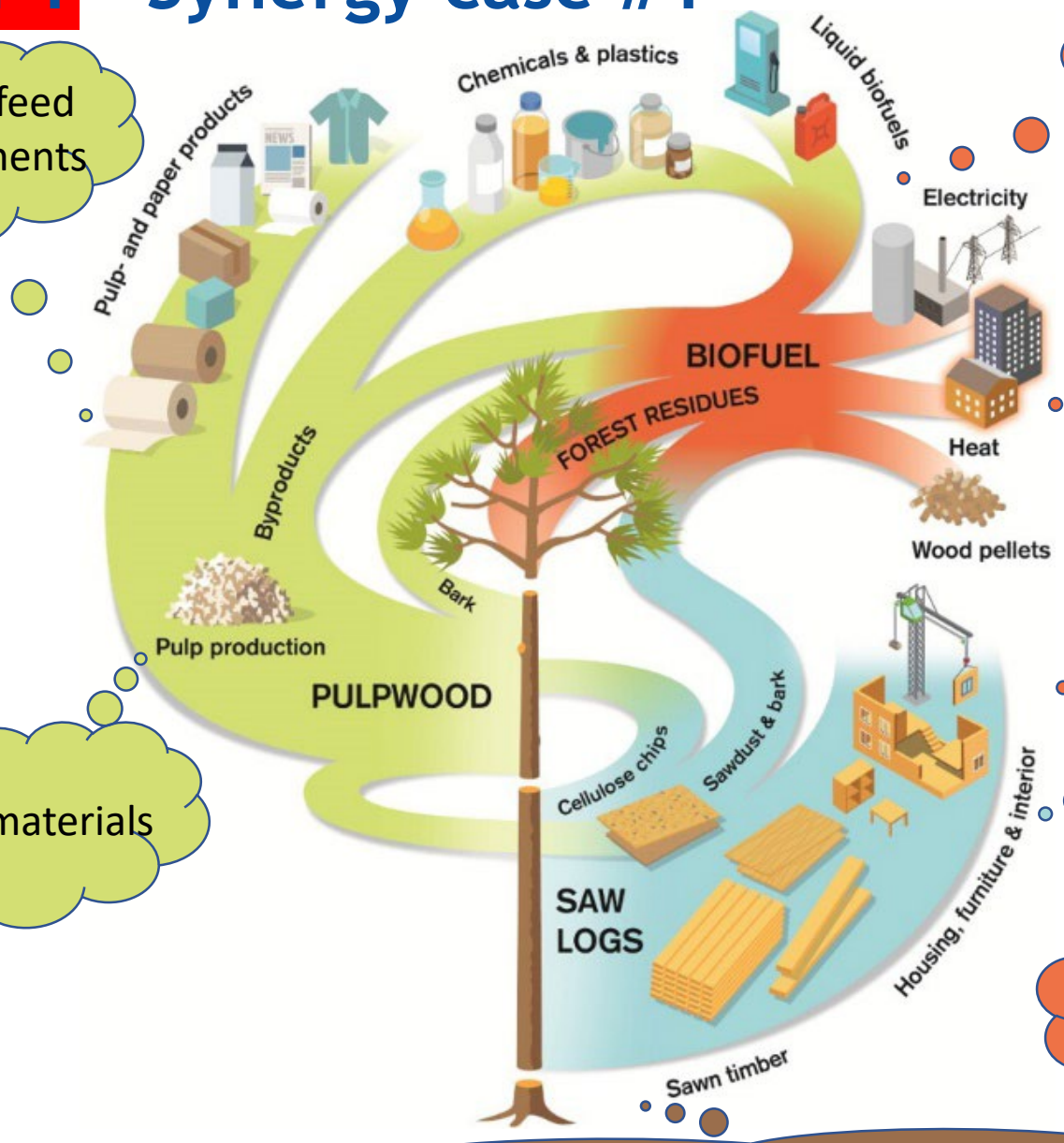
BECCUS

Process carbon & heat

Engineering Wood Products (EWP)

Nano-materials

Soil conditioning



Trends in **forest biomass** availability & demand?

Primary feedstock
- Saw timber
- Pulpwood

Secondary feedstock
- Processing residues
- Forestry residues

Tertiary feedstock
- Post-consumer wood
- Recycling & downcycling

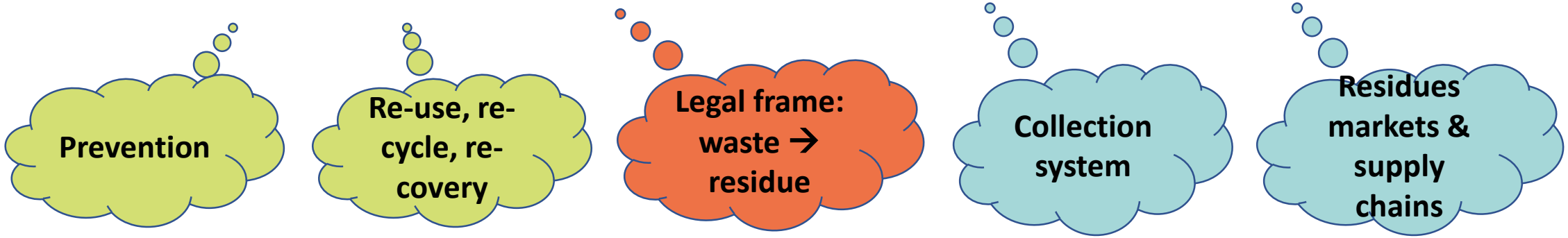
Figure: adopted from Skogsindustrierna in (Sikkema et al., 2017)

Stand management Sustainable Forestry
Ecosystem services: cultural, provisioning, regulating and supporting services

WP1 – Synergy case #2

Trends in **other biomass residues** availability & demand?

- Households
- Food processing industries
- Grocery stores / markets
- Municipal parks and gardens
- Vertical/urban farms
- Urban nature based solutions
- municipal solid waste
- food waste
- used cooking oil & fats
- landscape conservation material
- gardening waste
- sewage sludge

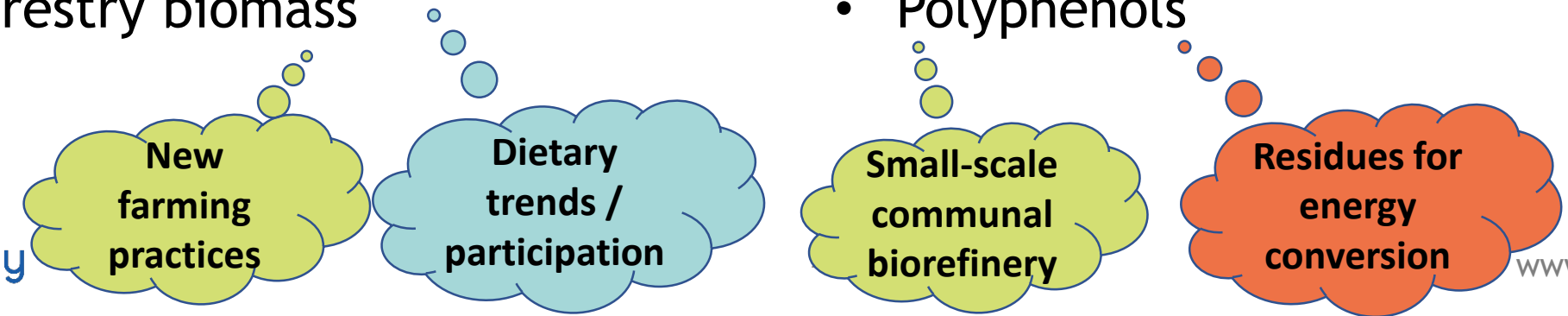


WP1 – Synergy case #3

Trends in **alternative foods** production?

- Grasses & herbaceous perennials
- Algae (micro & macro)
- Fungi
- Wild edible plants
- Pseudocereal and grain
- Edible flowers
- Edible insects
- Forestry biomass

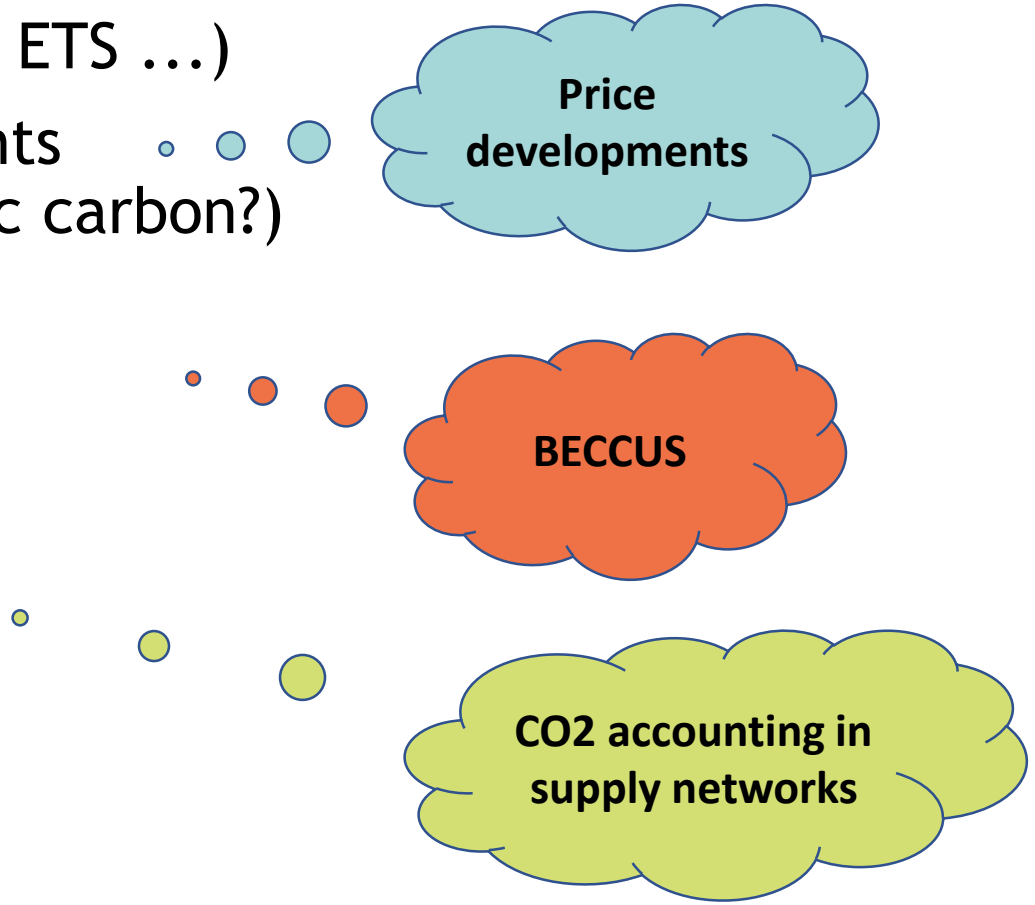
- Protein
- Lipids
- Carbohydrates
- Dietary Fiber
- Minerals
- Vitamins
- Carotenoids
- Polyphenols



WP1 – Synergy economics

Trends in the **value for biobased carbon**?

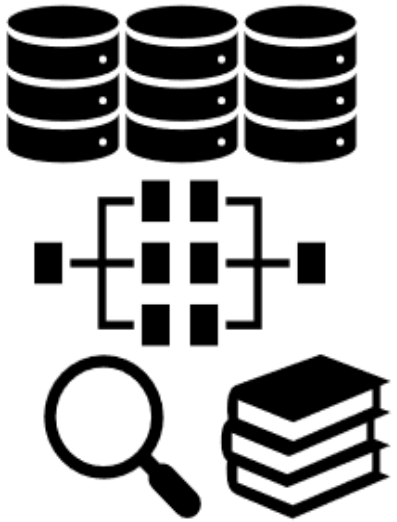
- Carbon pricing instruments (taxes, ETS …)
- Systemic scope of policy instruments (included sectors?, trade?, biogenic carbon?)
- Re-investment of revenues
- Effects of pricing instruments
  - on innovation
  - phase-out of fossil fuels
  - GHG emissions
  - biomass component focus
  - agriculture, forestry, aquaculture



WP2 - Resource Flow Database

EU28 case study for 2018 based on openly available data

Development of a database and Sankey representation of all material and energy flows that have to be addressed for illustrating the transformation towards a Circular Bioeconomy



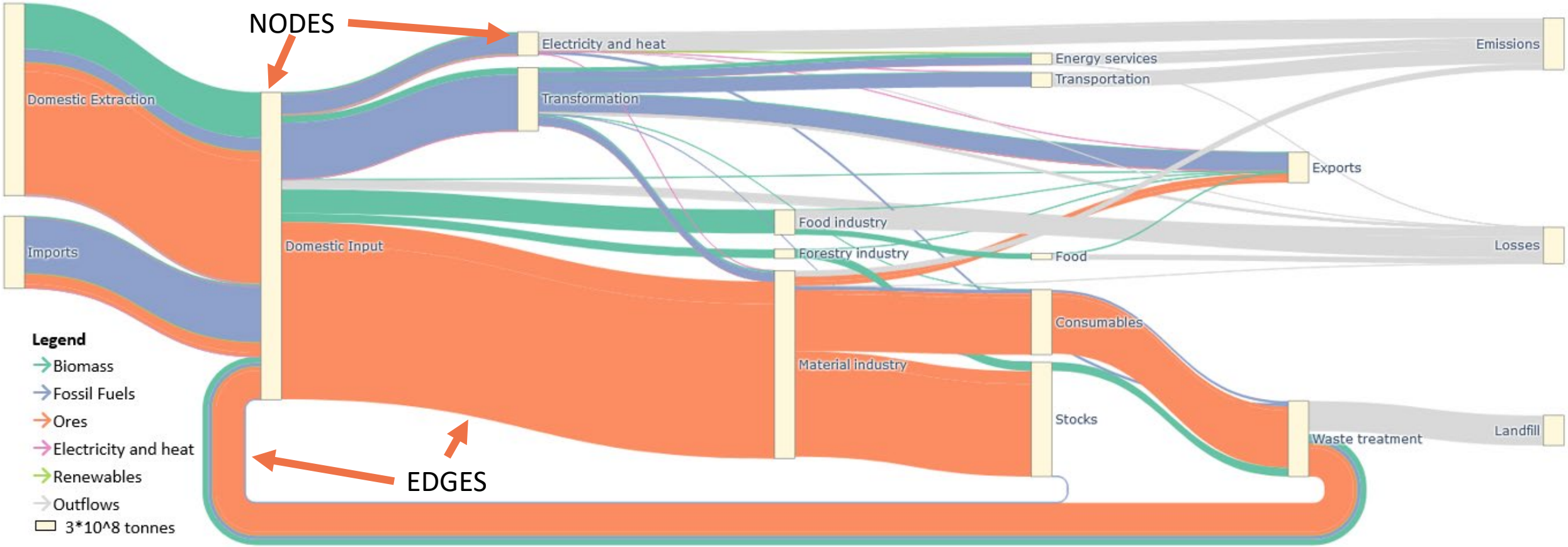
1. Unifying datasets from Eurostat; Material, energy and biomass flows
2. Development of a joint, interactive, open-source Sankey diagram
3. Discussing limitations for the illustration of transformation strategies

WP2 - Resource Flow Database

Combining all energy and mass resource flows puts biomass flows (in green) **into perspective**:

- A 1:1 substitution of fossil fuels (blue) or mineral and iron ores (orange) with biomass is unfeasible
- Circularity gap (emissions, landfill and losses) as well as built up stock need to be considered

Figure: unified EU27 material flows in 2018 in mass volumes (Schipfer et al., under review)



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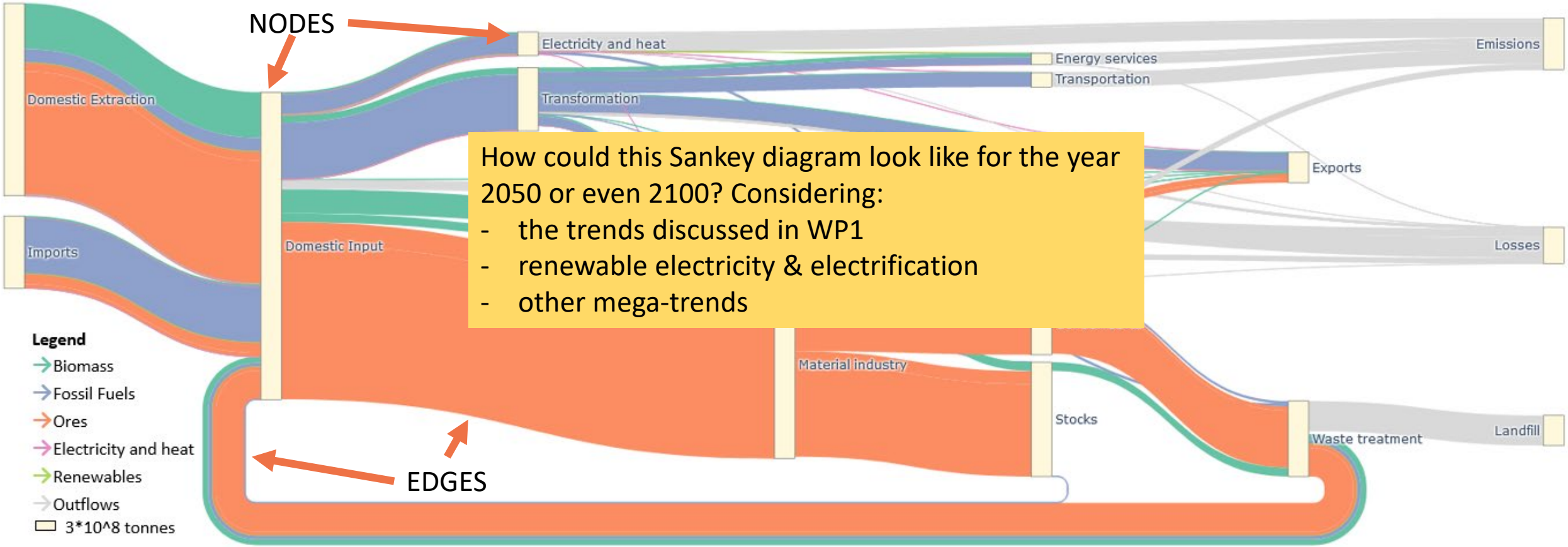

WP2 - Resource Flow Database (RFD)

RFD Version 2022:

- Included
- Research gap

Node levels and nodes

- Sourcing
  - Imports
  - Domestic extraction
- Availability
  - Domestic inputs
- Pre-processing
  - Electricity and heat
  - Transformation
- Processing
  - Food industry
  - Forestry industry
  - Material industry
- Societal needs
  - Transportation
  - Energy services
  - Food
  - Consumables
  - Stocks
- Loopbacks
  - Exports
  - Waste treatment
- Outflows
  - Emissions
  - Losses & Landfill

Edge levels and edges

- Fossil fuels
  - Liquid fossil fuels
  - Gaseous fossil fuels
  - Solid fossil fuels
  - Other fossil fuels
- Electricity and heat
  - from fossil fuels
  - from nuclear power
  - from renewables
- Minerals
  - Mineral ores
  - Non-metallic ores
- Biomass
  - Forestry biomass
  - Agriculture biomass
  - Fisheries biomass
- Carbon dioxide
  - from fossil fuels
  - from biomass

Relevant measurement units

- Natural resources
  - Mass
  - Energy
  - Moisture content
  - Bulk water
  - CO2 and other GHG
  - Air
  - Land-use
- Anthropological resources
  - Monetary
  - Work force
  - Infrastructure
  - Technology & Knowledge

Relevant indicators

- Circularity indicators
- Substance Concentration Efficiency*
- Stock consistency & Dynamic representation
- Scenarios

WP3 - Insights and prospects for research

Circular Bioeconomy Modelling

We need to account for the added-value of coupling the biosphere and the technosphere

→ we propose to model bioeconomy networks, their efficiency and stability

→ system resilience engineering through different types of resource flexibility

- Spatial flexibility (via tradeable biogenic intermediaries)
- Temporal flexibility (via storable biogenic intermediaries)
- Sectoral flexibility (via feedstock flexibility and/or el., heat, chemicals product flexibility

The added-value of a well-functioning Bioeconomy lies in its flexibility. Shifting abundant resources in space, time or between sectors to cover scarcities requires dynamic system thinking.

WP3 - Insights and prospects for policy and industry

Bioeconomy policies

Cohesion policies are required to

- Implement market mechanism valorising resource flexibility, for different types of flexibility and resources
- allow for dynamic shifting of resources within the bioeconomy network
- create synergies between renewable electrification/hydrogen and bioeconomy developments
  → broader system coupling beyond the power grid

Societal and environmental stability depends on if and how we manage to deploy a balanced mix of synthetic (i.e., including fuels and materials based on renewable electricity) and bio-based technologies.

Support industry & business

- resilient positioning in bioeconomy networks ← dynamic system assessment
- how to refund a Bioeconomy actors' contribution to the broader system?
- synthetic processes will quickly outcompete bioeconomy on operational expenditures (OPEX) basis
  → BUT these OPEX are invested into societal, environmental and structural stability !!

WP3 - Insights and prospects for the IEA Bioenergy Task40

Task40 Triennium 2022-2024

Focus on flexible supply networks for a sustainable circular Bioeconomy

→ Deriving resilience indicators and testing on selected examples

- based on biorefinery concepts (see e.g. Task42 factsheets)
- feedstock flexibility including seasonal & occurrence schedules
- ... tbd ...

(+) continuing the interdisciplinary discussion on Bioeconomy visions

Special Interdisciplinary Issue in Energy, Sustainability and Society
Submit now
https://energsustainsoc.biomedcentral.com/circularbioeconomy

Thank you for your attention

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Literature

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