The Austrian participation in Tasks 42 of IEA Bioenergy is financed by the Federal Ministry for Transport, Innovation and Technology / Department for Energy and Environmental Technologies

IEA Bioenergy
Task 42 Biorefining

JOANNEUM RESEARCH RESOURCES

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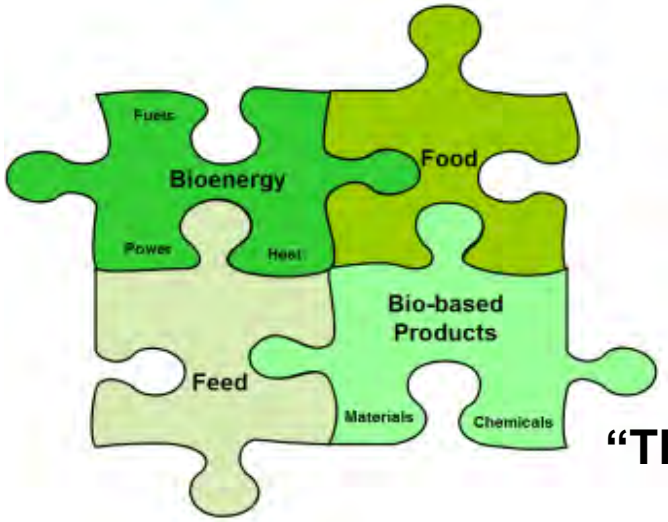

Approach for the Integration of Biorefineries in the Existing Industrial Infrastructures

Gerfried Jungmeier

Workshop @i-SUP2014

"The role of industry in a transition towards the BioEconomy in relation to biorefinery"

September 3, 2014 Antwerp/Belgium

This is Biomass for Biorefineries in the BioEconomy

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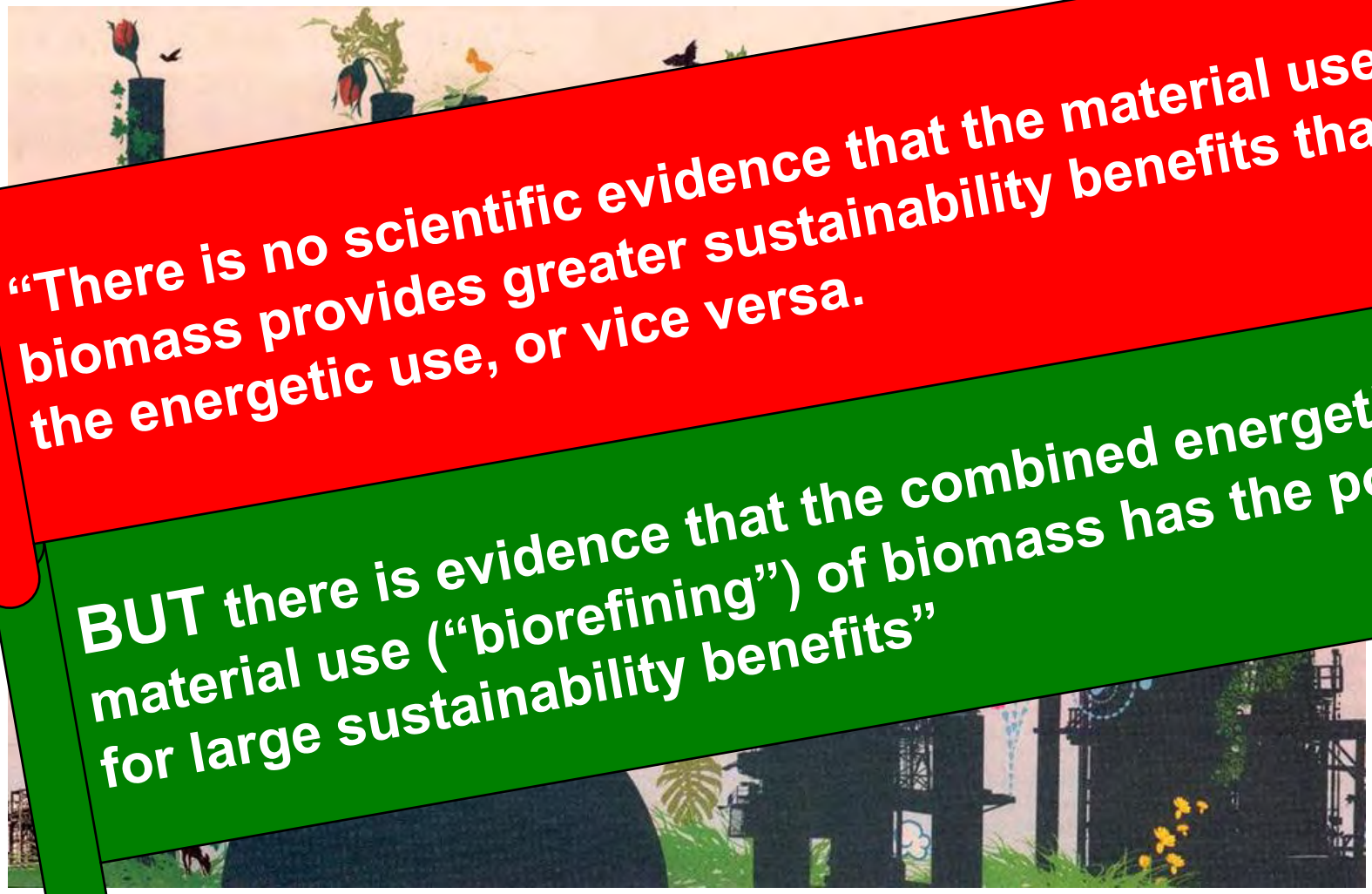
There is Competition for Different Biomass Uses

A Statement



"There is no scientific evidence that the material use of biomass provides greater sustainability benefits than the energetic use, or vice versa.

BUT there is evidence that the combined energetic and material use ("biorefining") of biomass has the potential for large sustainability benefits"

The New Way in BioEconomy: From Competition to Integration

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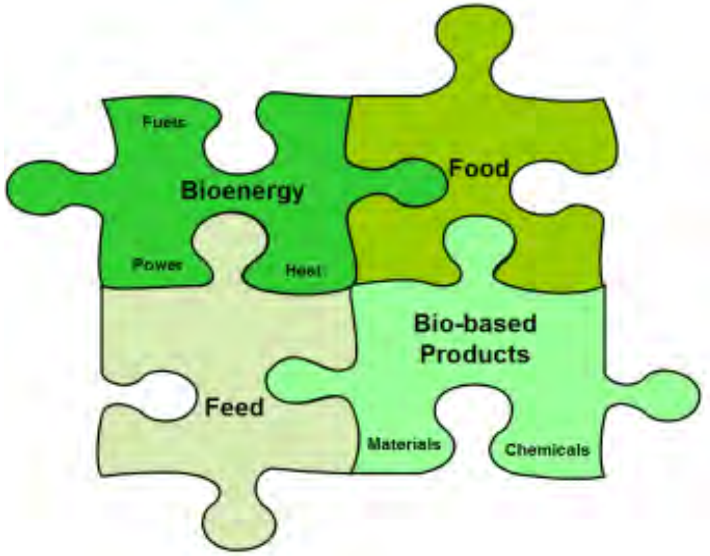
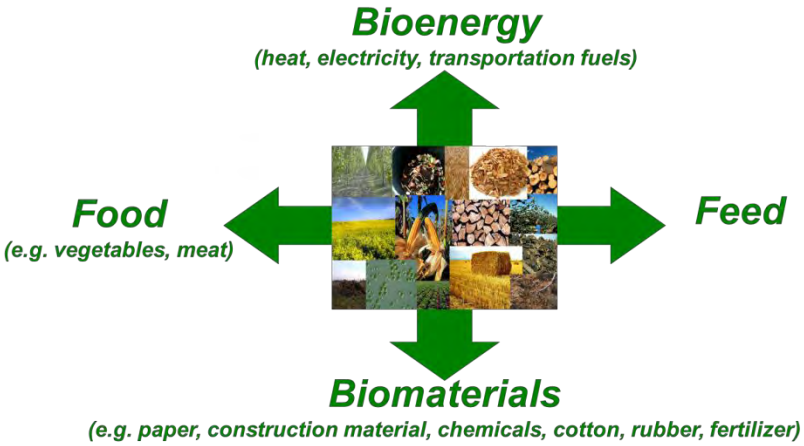
Integration



Towards BioEconomy

Competition



This is a Biorefinery

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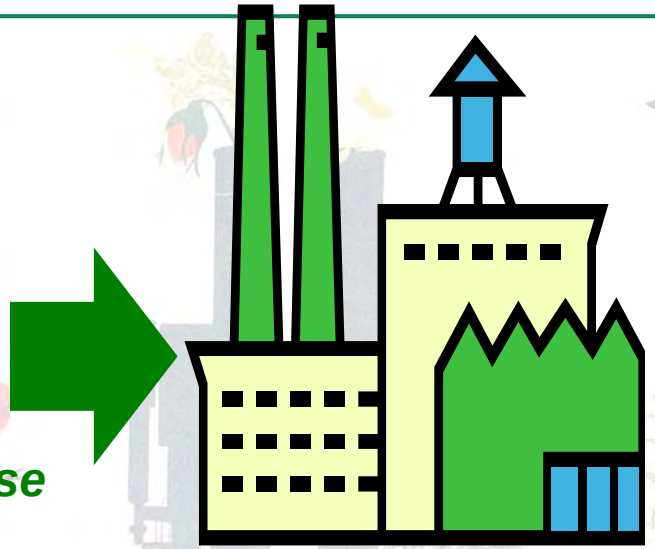
Biomass Resources
- *oil*
- *starch*
- *sugar*
- *lignocellulose*
- *….*



Biorefinery

Bioenergy

- ***liquid/gaseous transport biofuels***
- ***electricity***
- ***heat***
- ***solid fuels***

Bioproducts

- ***bulk chemicals***
- ***fine chemicals***
- *animal feed*
- *food*
- ***pulp&paper***
- ***materials***
- ***fertilizer***
- ***gases***
- ***……***

Based on different conversion processes
- ***Bio-chemical***
- ***Thermo-chemical***
- ***Physical-chemical***
- ***Others***

"Biorefinery is the sustainable processing of biomass into a spectrum of marketable products"

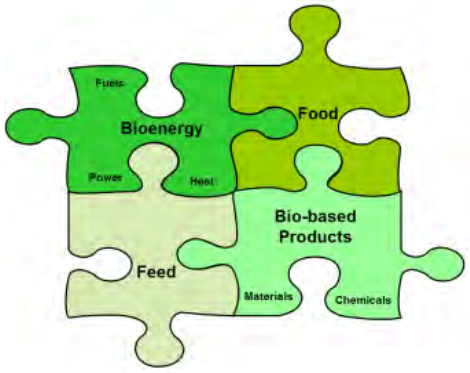
Outline

Outlook& summary

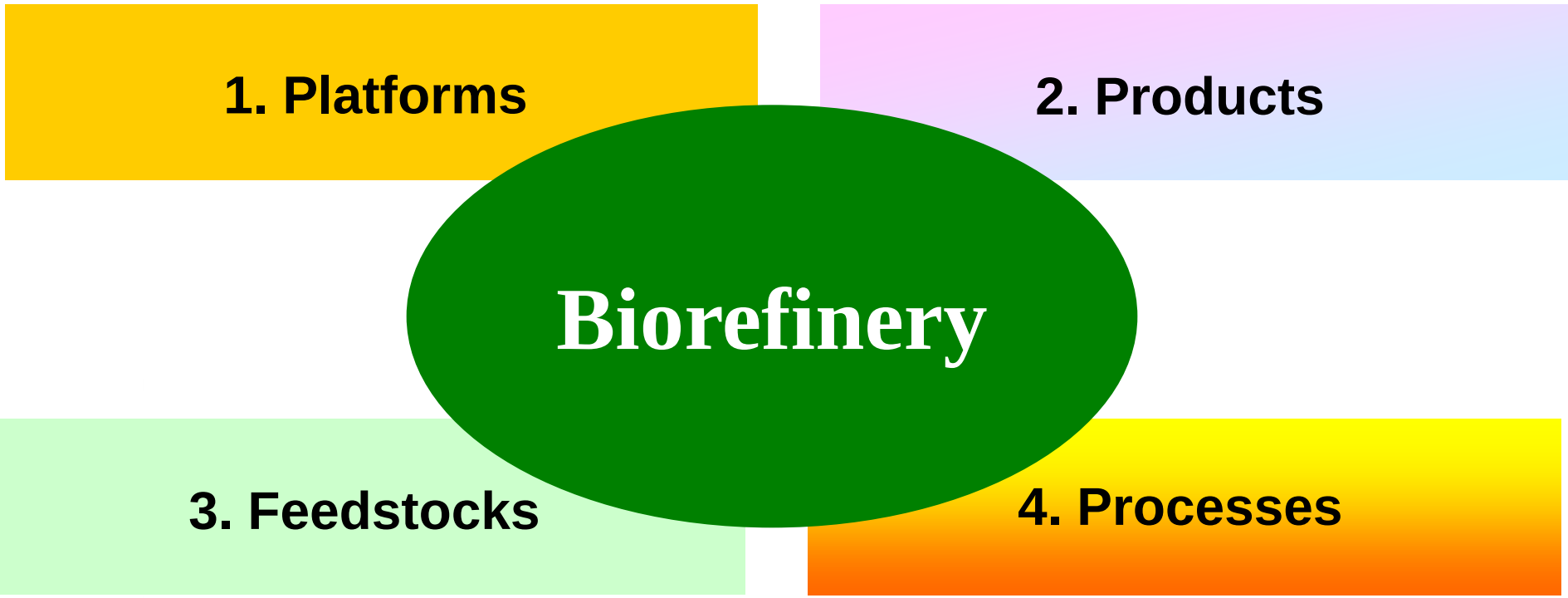
Examples for Integration

Integration in industrial infrastructure

Introduction Biorefineries



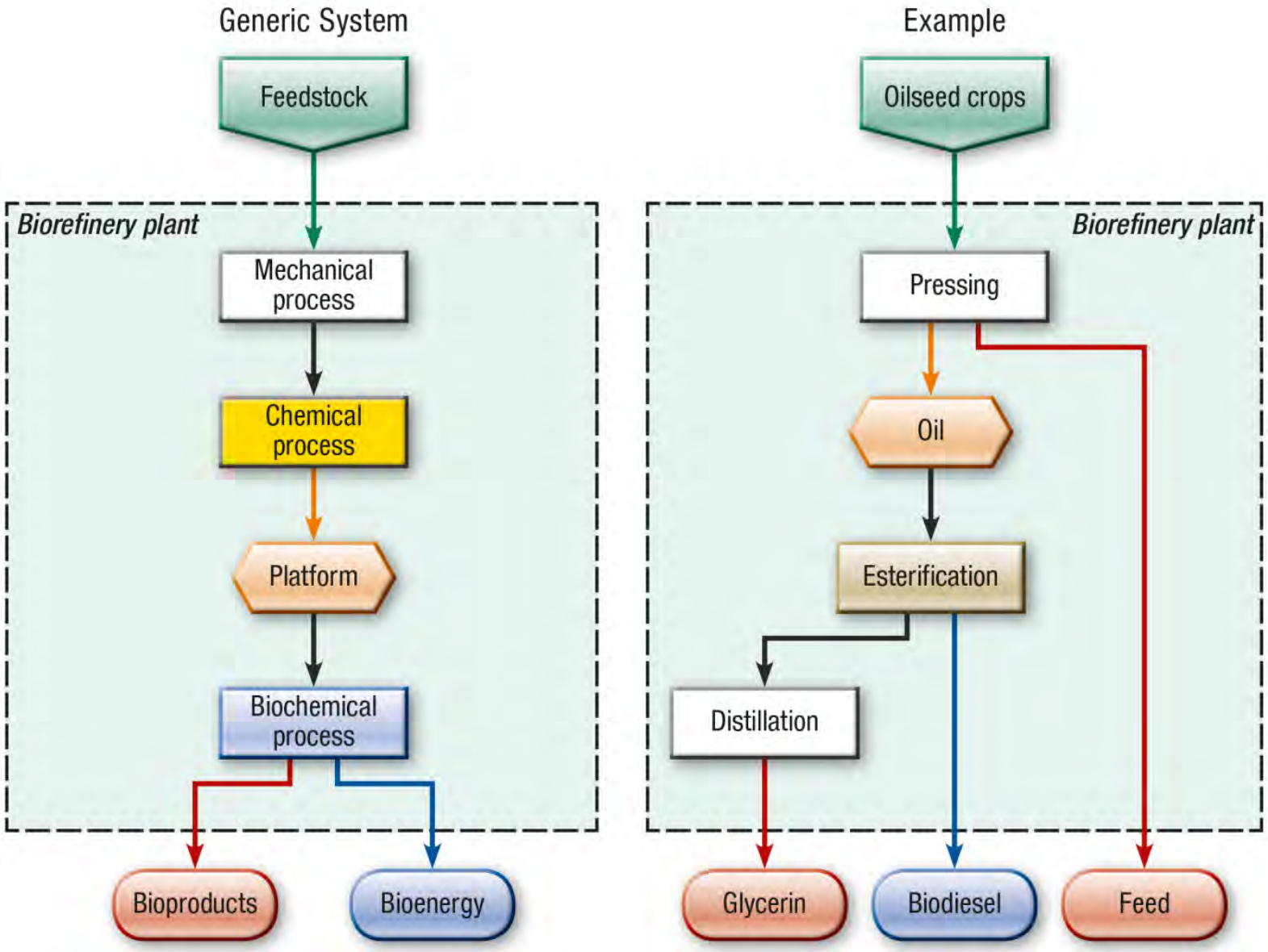
The 4 Features to Characterise A Biorefinery Systems



Naming:

- *Number platforms (Name of platforms)/Feedstock/Products/Processes*
- ***e.g. 2-platform (electricity&heat, syngas) biorefinery/wood chips/FT-biofuels, electricity, heat, waxes/steam gasification***

Application of Classification System



Classification System is Now in Use ….

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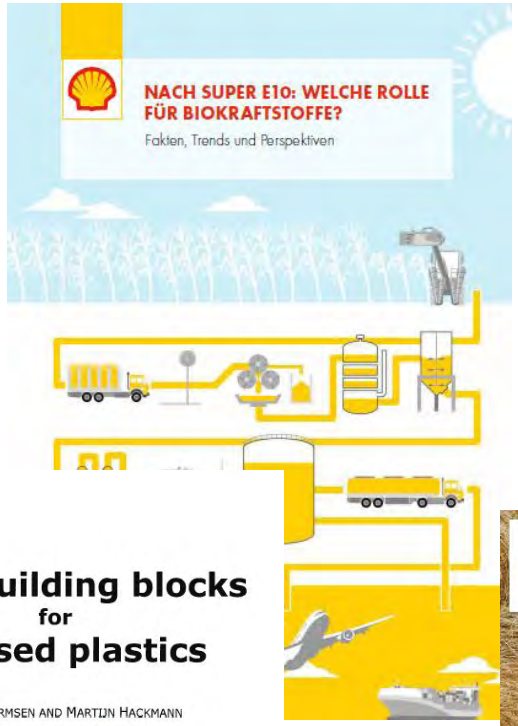

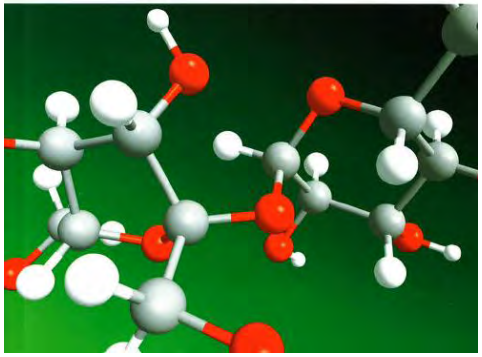

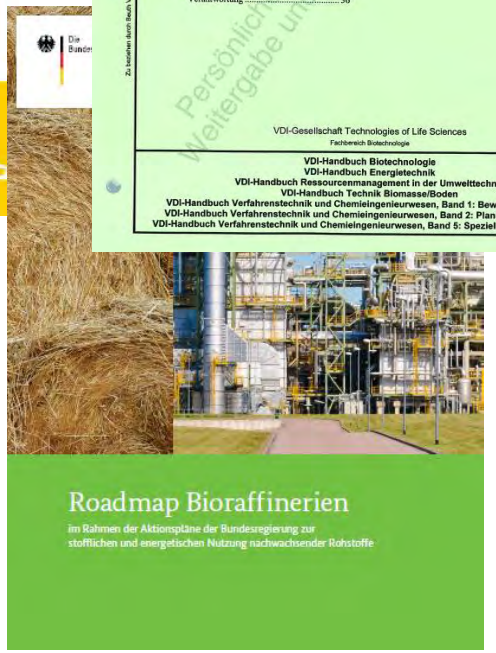

14 Biofuel-driven Biorefineries for Biobased Economy in 2025

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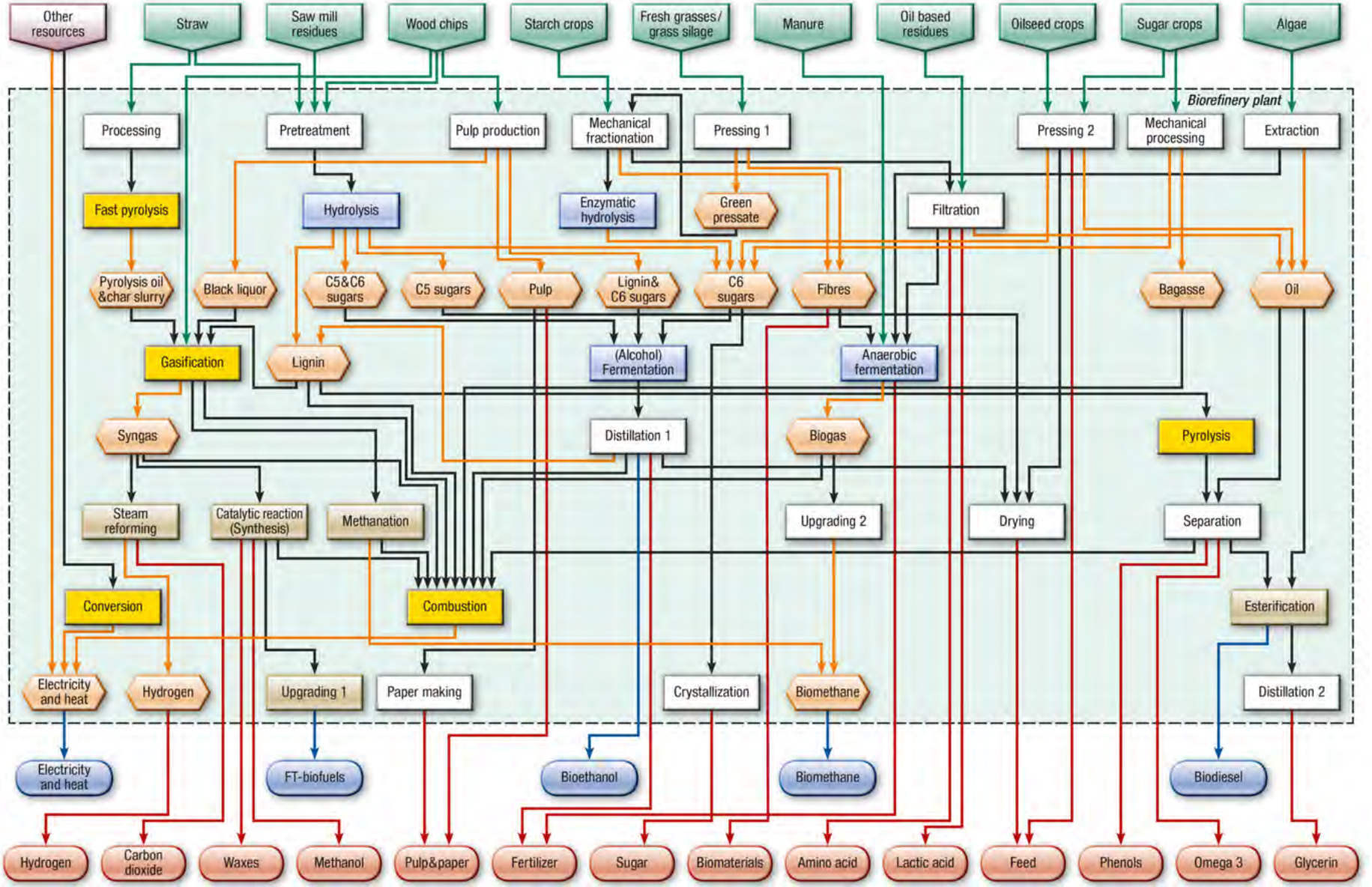
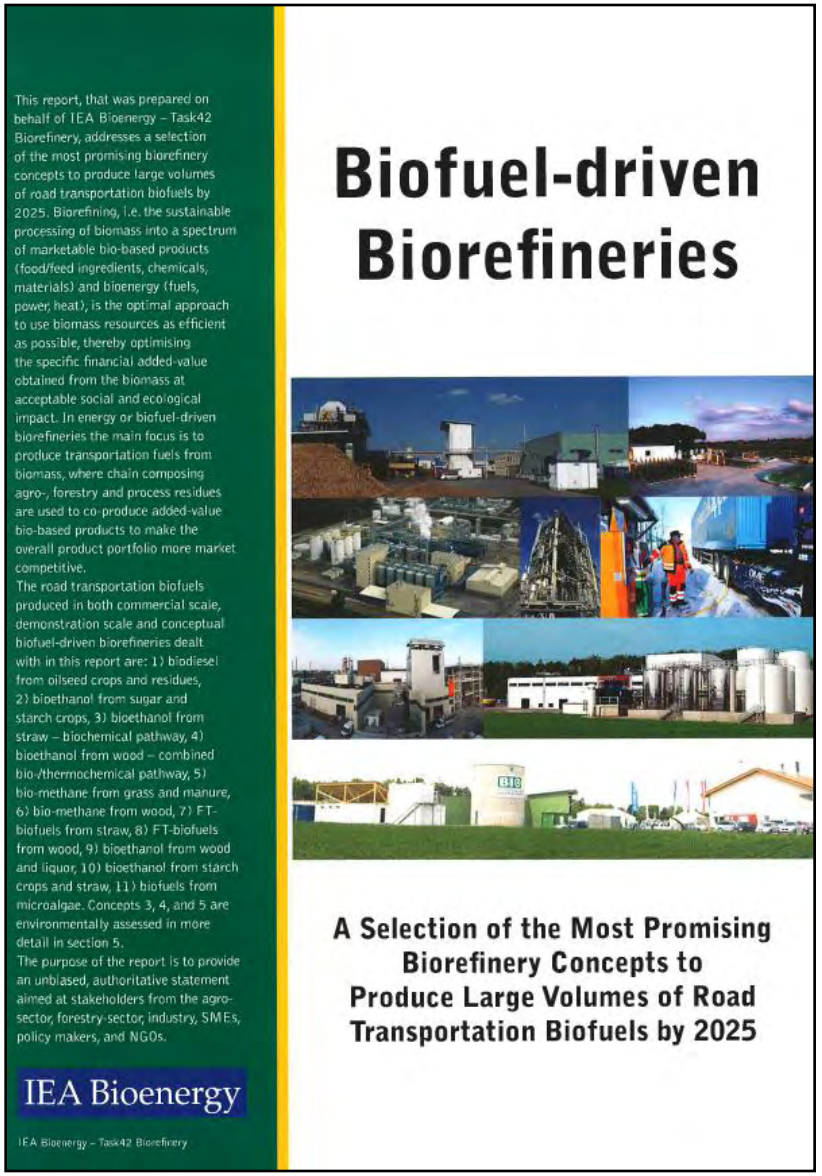


Report on "Biofuel-driven Biorefineries"



…..Based on this ***first selection of most promising biorefinery concepts to produce large volumes of road transportation biofuels by 2025*** *the Task 42 is assessing the sustainability of these biorefinery concepts by analyzing economic, environmental and social aspects in comparison to conventional processes and products.*

In a next step a "biorefinery fact sheet" *for each of these selected "energy driven" biorefineries is developed, key characteristics for a specific production capacity of road transportation biofuel ……."*

www.iea-bioenergy.task42-biorefineries.com

Purpose of the Biorefinery Fact Sheet

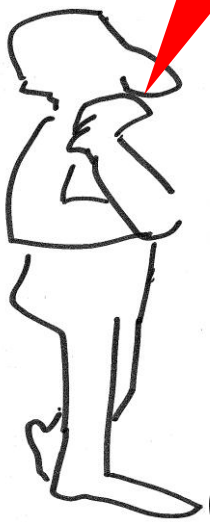
IEA Bioenergy
Task 42 Biorefining

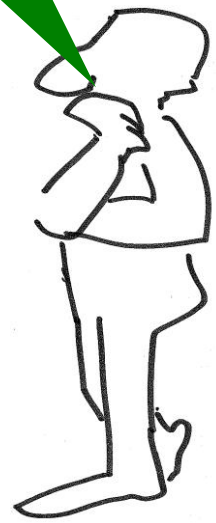
*What are the **facts & figures** of different biorefineries?*

*Look here, you find **facts & figures** in our Biorefinery Fact Sheet*

*„Biorefinery Fact Sheets“ is **linking element** of Task 42 activities:*

- ✓ ***Market deployment aspects for biorefineries*** *(success factors, changing technologies, central/decentral processing, Biorefinery-Complexity-Index)*
- ✓ ***Stakeholder support for future BioEconomy*** *(integration in existing industrial infrastructures, Factsheets major biorefineries, National case-studies, added-value products)*
- ✓ ***Optimal sustainable biomass valorization*** *(supply chains, biomass demand, optimal biomass valorisation)*
- ✓ ***Policy&decision advice*** *(roadmap, policies, country reporting)*
- ✓ ***Dissemination&training activities*** *(task&stakeholder meetings, website incl. data-base biorefineries, newsletters, reports, brochures & leaflets, presentations, training course)*





Overview
Biorefinery Fact Sheet

JOANNEUM RESEARCH RESOURCES

IEA Bioenergy
Task 42 Biorefining

Part A: Biorefinery Plant

Biorefinery FACT SHEET

"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"

Part A: Biorefinery plant

The demonstration scale energy driven biorefinery "2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification" is shown in Figure 11.

Within the "2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification" the wood chips are gasified with steam to produce a product gas, which is used to produce raw FT-biofuels via a catalytic reaction (FT-synthesis). The final quality of the transportation FT biofuel is reached in the upgrading step, e.g. hydroprocessing. The process residues are combusted to produce electricity and heat. As a further product waxes are produced.

Depending on the further successful development beside the steam gasification of wood, which is suitable for smaller to medium sized gasifiers also the gasification with oxygen for large applications (e.g. entrained flow gasification) might become interesting. The large amount of syngas will then be an optimal starting point to produce additional synthetic products depending on the market demand for biomass based chemicals, e.g. methanol.

Case study, example

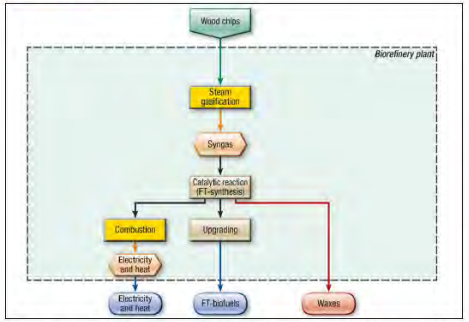


Figure 11: 2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification

Table 3: Key characteristics of biorefinery plant – Austrian feasibility study

Biorefinery plant				
Biorefinery Complexity Index (Products/Platform/Feedstock/Processes)			14.5 (4.5/3/2/5)	
State of technology:	conceptual			
Products			Auxiliaries (external)	
FT-diesel	105 [kt/a]		electricity	0 [PJ/a]
FT-gasoline	70 [kt/a]		heat	0 [PJ/a]
heat	0.3 [PJ/a]			
waxes	10 [kt/a]		materials	29 [kt/a]
Feedstock			Costs	
wood chips	1,459 [kt/a]		investment	500 [Mio €]
water content	45% [%]		feedstock	100 [€/t]
Efficiencies			mass	energy
input to products			12.4%	54%
input to transportation biofuel			11.8%	49%

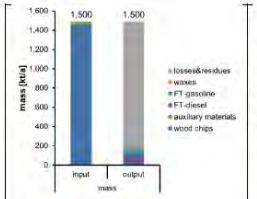


Figure 12: Mass balance of biorefinery plant

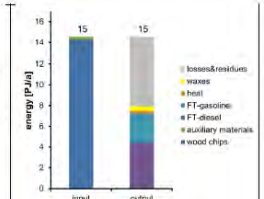


Figure 13: Energy balance of biorefinery plant

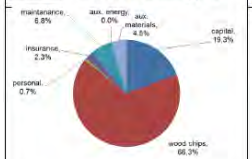


Figure 14: Share of costs

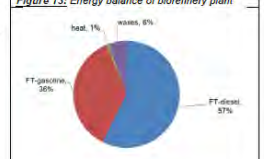


Figure 15: Share of revenues

Part B: Value Chain Assessment

Part B: Value Chain Sustainability Assessment

The method of the sustainability assessment - economic and environmental – is given in Annex 1. The main assumptions and modelling choices are documented in Annex 2.

In future the following improvements of the assessment might be possible:

- Reduction of investment costs
- Use of renewable energy for auxiliary energy
- Further products made from glycerine with higher revenues
- Lower area demand due to an yield increase
- Using of straw for various products

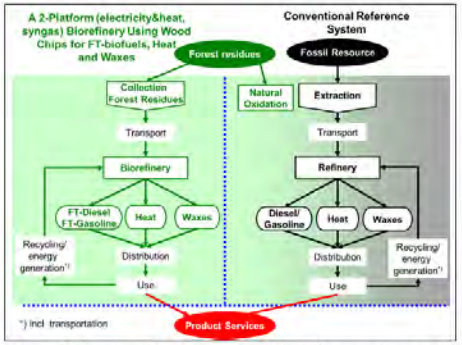


Figure 16: Comparison of biorefinery with conventional reference system on whole value chain (incl. "end of life treatment")

Table 4: Key characteristics of biorefinery value chain – generic example

Whole value chain			
Greenhouse gas emissions	range		
biorefinery	70 (66 to 91)		[kt CO_2-eq/a]
reference system	660 (640 to 700)		[kt CO_2-eq/a]
saving	-90 (-87 to -92)		[%]
Cumulated energy demand			
fossil			
biorefinery	0.6 (0.56 to 0.69)		[PJ/a]
reference system	9.2 (8.5 to 11)		[PJ/a]
saving	-93 (-92 to -95)		[%]
total			
biorefinery	14.9 (14 to 17)		[PJ/a]
reference system	9.6 (9.1 to 11)		[PJ/a]
change	52 (27 to 87)		[%]
Agricultural area demand			
feedstock	(0 to 0)		[ha/a]
Costs			
annual costs	220 (200 to 250)		[Mio €/a]
specific costs	1,200 (1100 to 1400)		[€/t]
Revenues			
annual revenues	224 (210 to 260)		[Mio €/a]
specific revenues	1,200 (1100 to 1400)		[€/t]

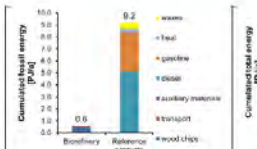


Figure 17: Estimated cumulated fossil energy demand of biorefinery and reference products

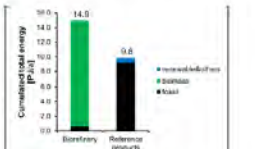


Figure 18: Estimated cumulated energy demand of biorefinery and reference products

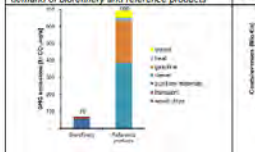


Figure 19: Estimated greenhouse gas emissions of biorefinery and reference products

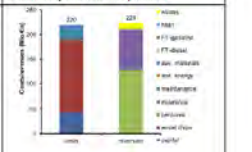


Figure 20: Estimated cost and revenues of biorefinery plant

Annex:

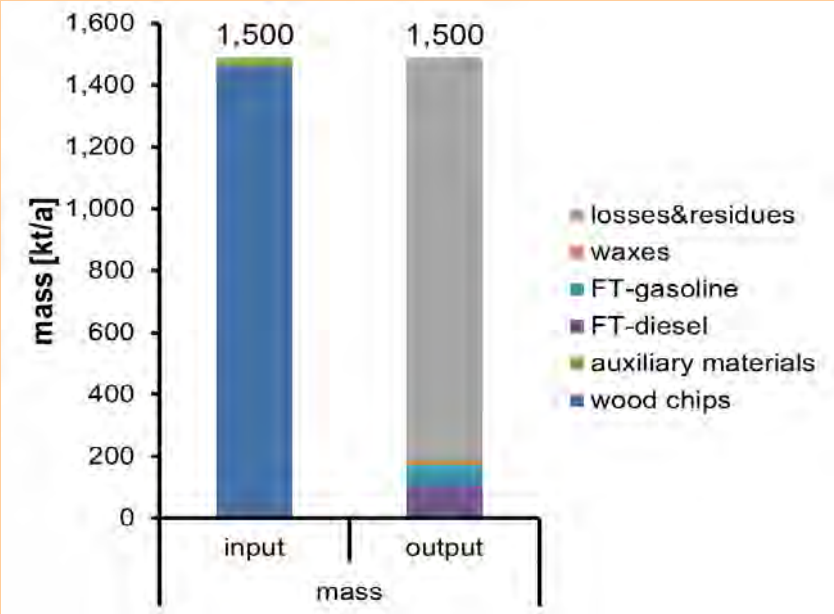
Methodology of sustainability assessment and data with references

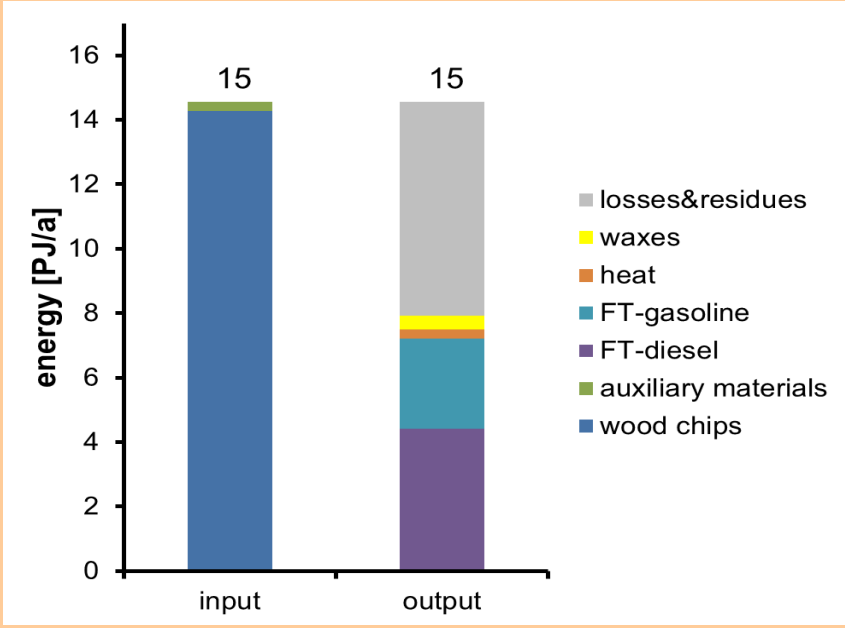
Part A: Biorefinery Plant Mass and Energy Balance

Biorefinery plant					
Biorefinery Complexity Index (Products/Platform/Feedstock/Processes)				**14.5 (4.5/3/2/5)**	
State of technology:	conceptual				
Products			**Auxiliaries (external)**		
FT-diesel	105	[kt/a]	electricity	0	[PJ/a]
FT-gasoline	70	[kt/a]	heat	0	[PJ/a]
heat	0.3	[PJ/a]			
waxes	10	[kt/a]	materials	29	[kt/a]
Feedstock			**Costs**		
wood chips	1,459	[kt/a]	investment	500	[Mio €]
water content	45%	[%]	feedstock	100	[€/t]
Efficiencies			**mass**	**energy**	
input to products			12.4%	54%	
input to transportation biofuel			11.8%	49%	

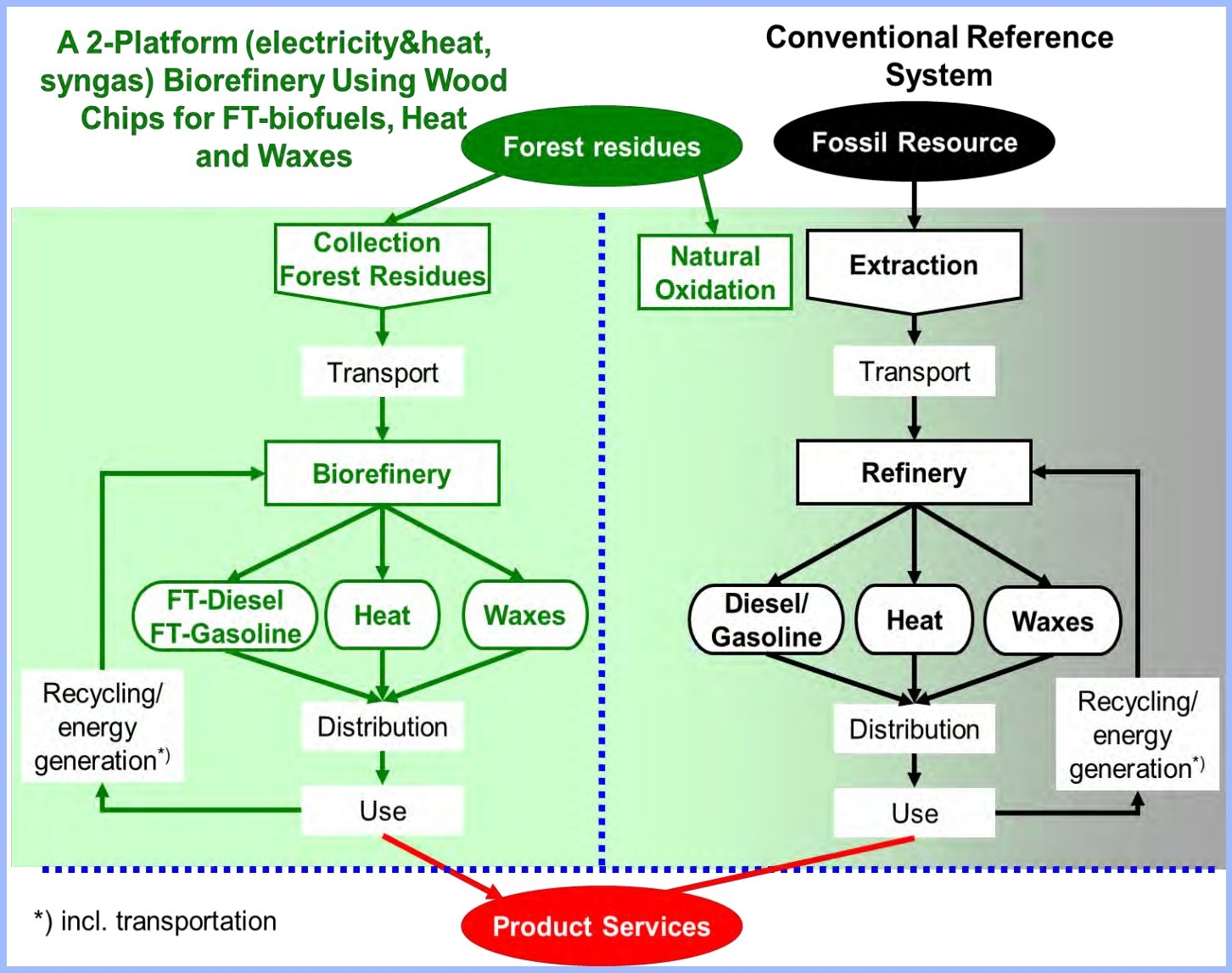
"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"

Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)





Part B: Value Chain Assessment System Boundaries&Reference System



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Part B: Value Chain Assessment Overview

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"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"

Whole value chain			
Greenhouse gas emissions		range	
biorefinery	70	(66 to 81)	[kt CO_2-eq/a]
reference system	690	(640 to 790)	[kt CO_2-eq/a]
saving	-90	(-87 to -92)	[
Cumulated energy demand			
fossil			
biorefinery	0.6	(0.56 to 0.69)	[PJ/a]
reference system	9.2	(8.5 to 11)	[PJ/a]
saving	-93	(-92 to -95)	[%]
total			
biorefinery	14.9	(14 to 17)	[
reference system	9.8	(9.1 to 11)	[P
change	52	(27 to 87)	[%]
Agricultural area demand			
feedstock	-	(0 to 0)	[ha/a]
Costs			
annual costs	220	(200 to 250)	[Mio €/a]
specific costs	1,200	(1100 to 1400)	[€/t]
Revenues			
annual revenues	224	(210 to 260)	[Mio €/a]
specific revenues	1,200	(1100 to 1400)	[€/t]

Communication in typical ranges & orders of magnitude!

Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)

Part B: Value Chain Assessment Primary Energy&GHG Emissions

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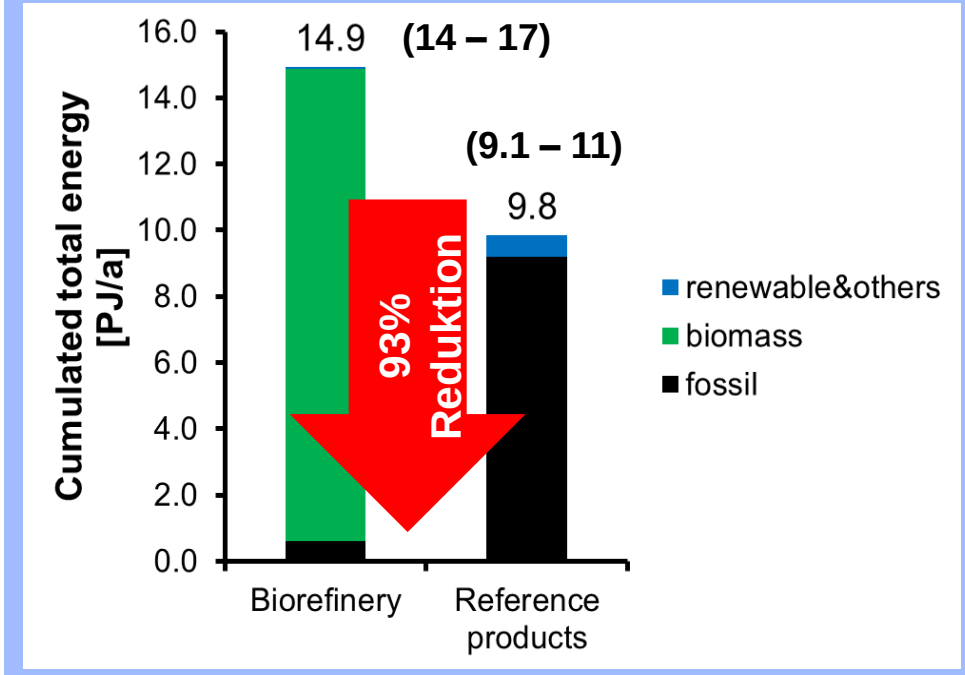
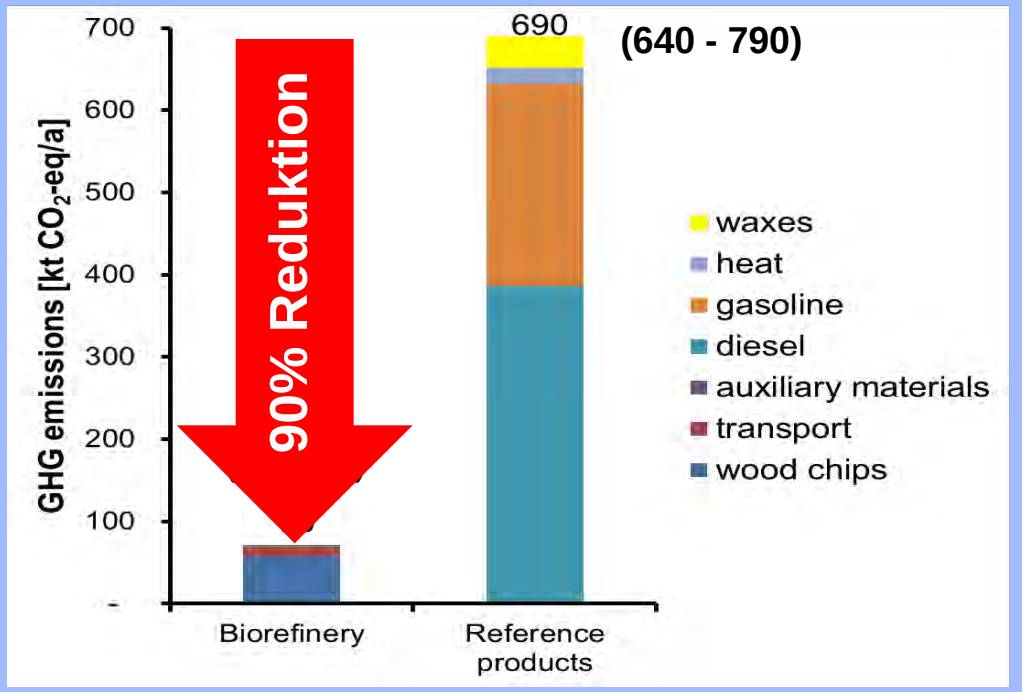
"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"

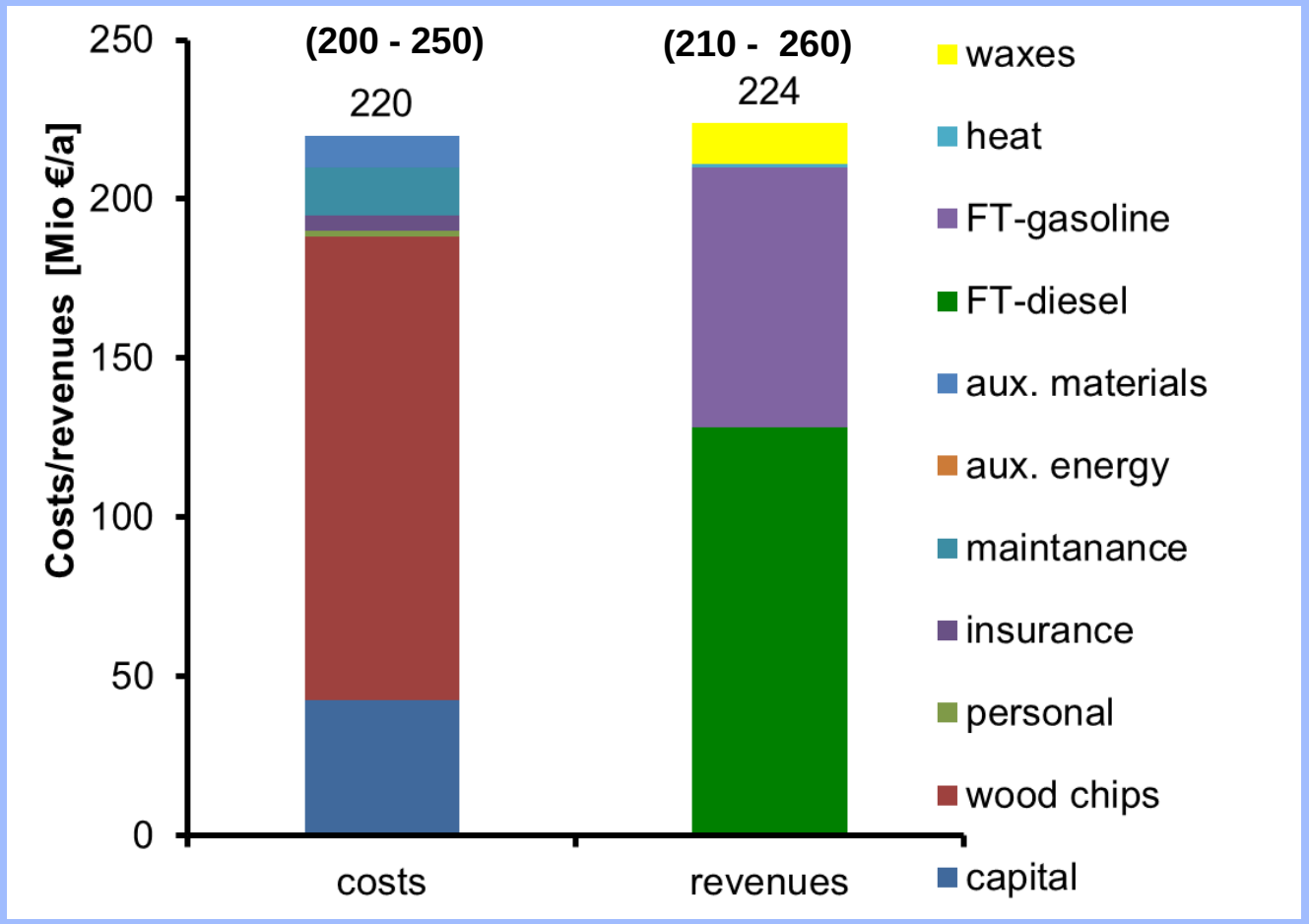




Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)

Part B: Value Chain Assessment Cost and Revenues

"2-platform (electricity&heat, syngas) biorefinery using wood chips for FT-biofuels, electricity, heat and waxes with steam gasification"



Own calculations based on Austrian feasibility study (Hofbauer et al. 2008)

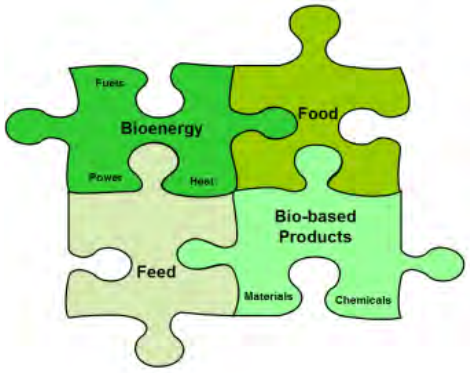
Outline

Outlook& summary

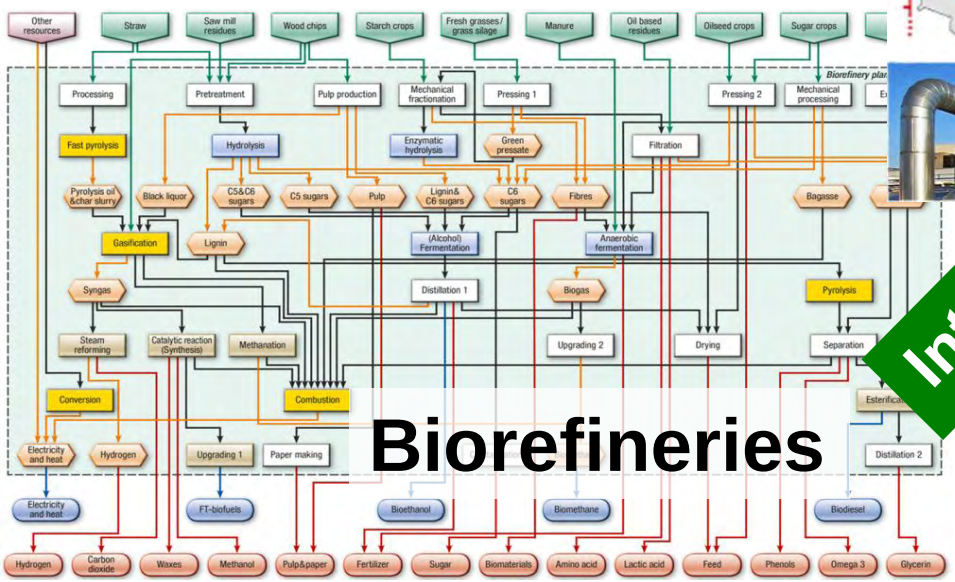
Examples for Integration

Integration in industrial infrastructure

Introduction Biorefineries



Upgrading Strategies Infrastructures to BioEconomy



Biorefineries

Integration

Infrastructure

Classification of Existing Industrial Infrastructure

1. Power and CHP plants
2. Biofuel plants
3. Oil refineries
4. Pulp and paper industry
5. Wood industry
6. Biogas/Biomethane plants
7. Chemical industry
8. Waste treatment plants
9. Food industry
10. Others

10 Main industry sectors with 31 subsectors

classified by

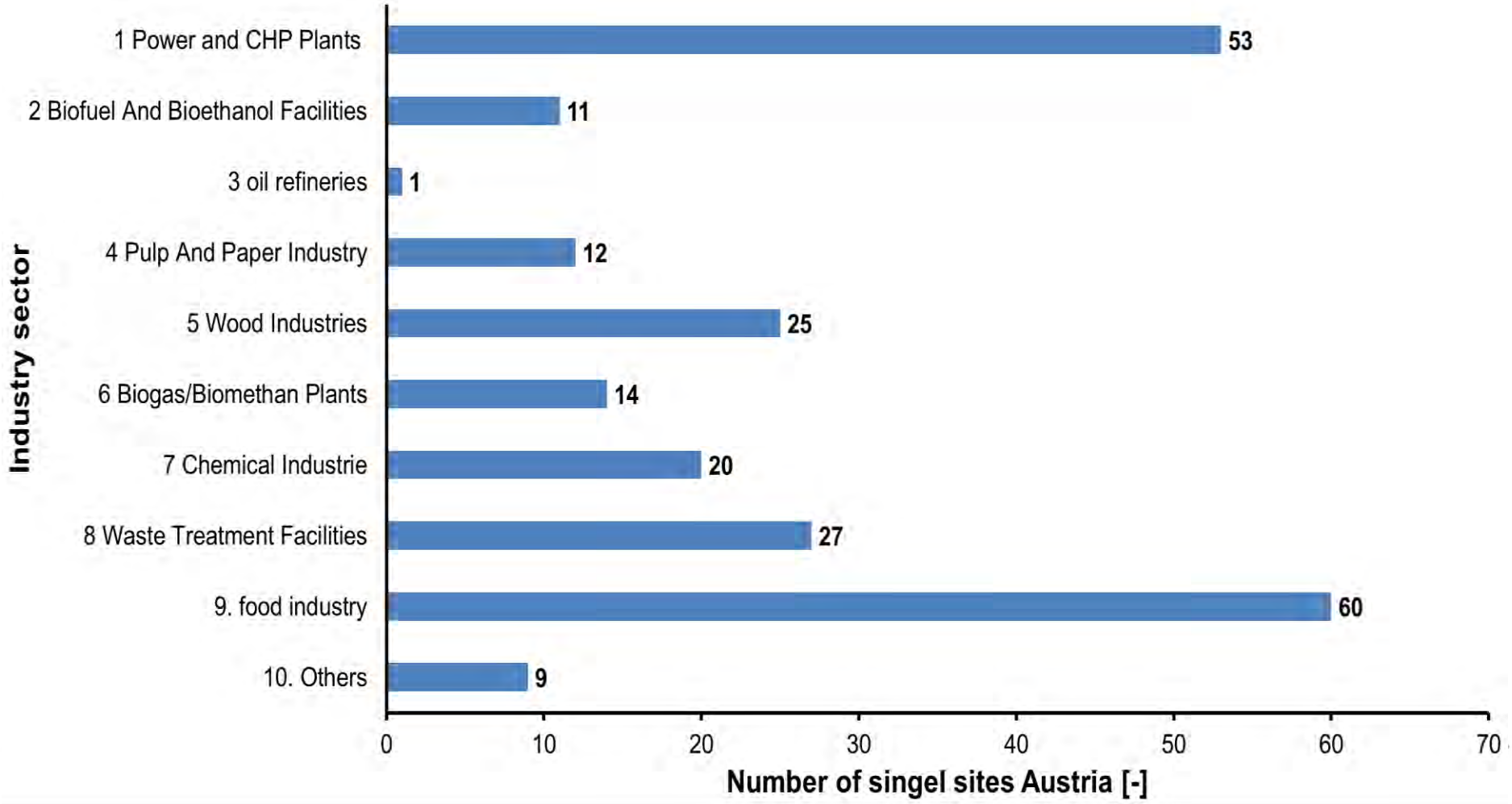
- ***feedstock***
- ***platforms***
- ***products***
- ***processes***

Database of Existing Industrial Infrastructure

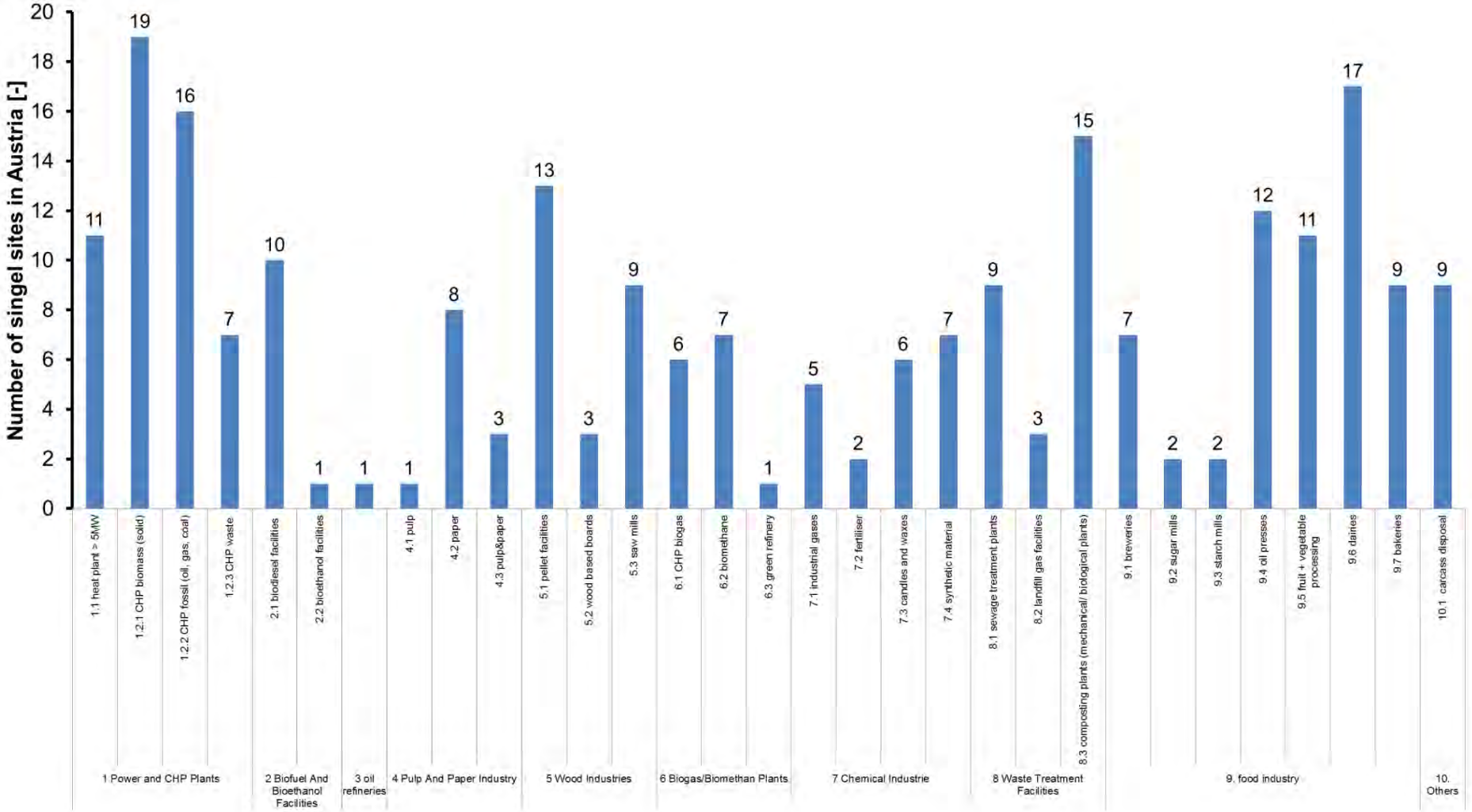
- **1 Power and CHP plants**
  - 1.1 heating plant
  - 1.2 CHP plant
    - 1.2.1 biomass
    - 1.2.2 fossil (oil, gas, coal)
    - 1.2.3 waste
- **2 Biofuel facilities**
  - 2.1 biodiesel facilities
  - 2.2 bioethanol facilities
- **3 Oil refineries**
- **4 Pulp and paper industry**
  - 4.1 pulp
  - 4.2 paper
  - 4.3 pulp and paper
- **5 Wood industry**
  - 5.1 pellet facilities
  - 5.2 wood based boards
  - 5.3 saw mill
- **6 Biogas/Biomethane plants**
  - 6.1 biogas CHP
  - 6.2 biomethane
  - 6.3 green refinery
- **7 Chemical industry**
  - 7.1 anorganic and organic chemicals
  - 7.2 industrial gases
  - 7.3 fertiliser
  - 7.4 candles and waxes
  - 7.5 synthetic material production
  - 7.6 food and animal feed additives
- **8 Waste treatment facilities**
  - 8.1 sewage treatment plants
  - 8.2 landfill gas facilities
  - 8.3 composting plants
- **9. Food industry**
  - 9.1 breweries
  - 9.2 sugar mills
  - 9.3 starch mills
  - 9.4 oil presses
  - 9.6 fruit + vegetable processing
  - 9.7 creameries
  - 9.8 bakeries
- **10. Others**

feedstock, processes, platforms, products

Example Austria: 232 Sites in the 10 Main Industry Sectors



Example Austria: Number of Sites in the 31 Industry Subsectors



Identifying Upgrading Opportunities Towards Biorefineries in the Biobased Industry

Integration opportunities: same features in industrial infrastructure and the biorefineries

Existing Industrial infrastructures are described based on 4 features

Biorefineries are described based on 4 features

Result

High number of common features gives a high possibility for upgrading

Importance of Features for Integration

feedstocks&products **≥** ***platforms*** **≥** ***products***

Feedstocks: very strong

Products: very strong

Platforms: strong

Processes: possible

Example Austria

10 industry sectors and
14 biofuel-driven biorefineris

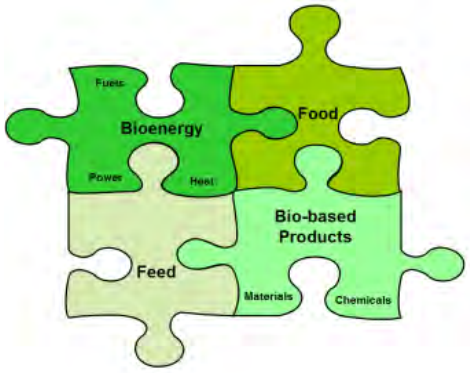
Outline

Outlook& summary

Examples for Integration

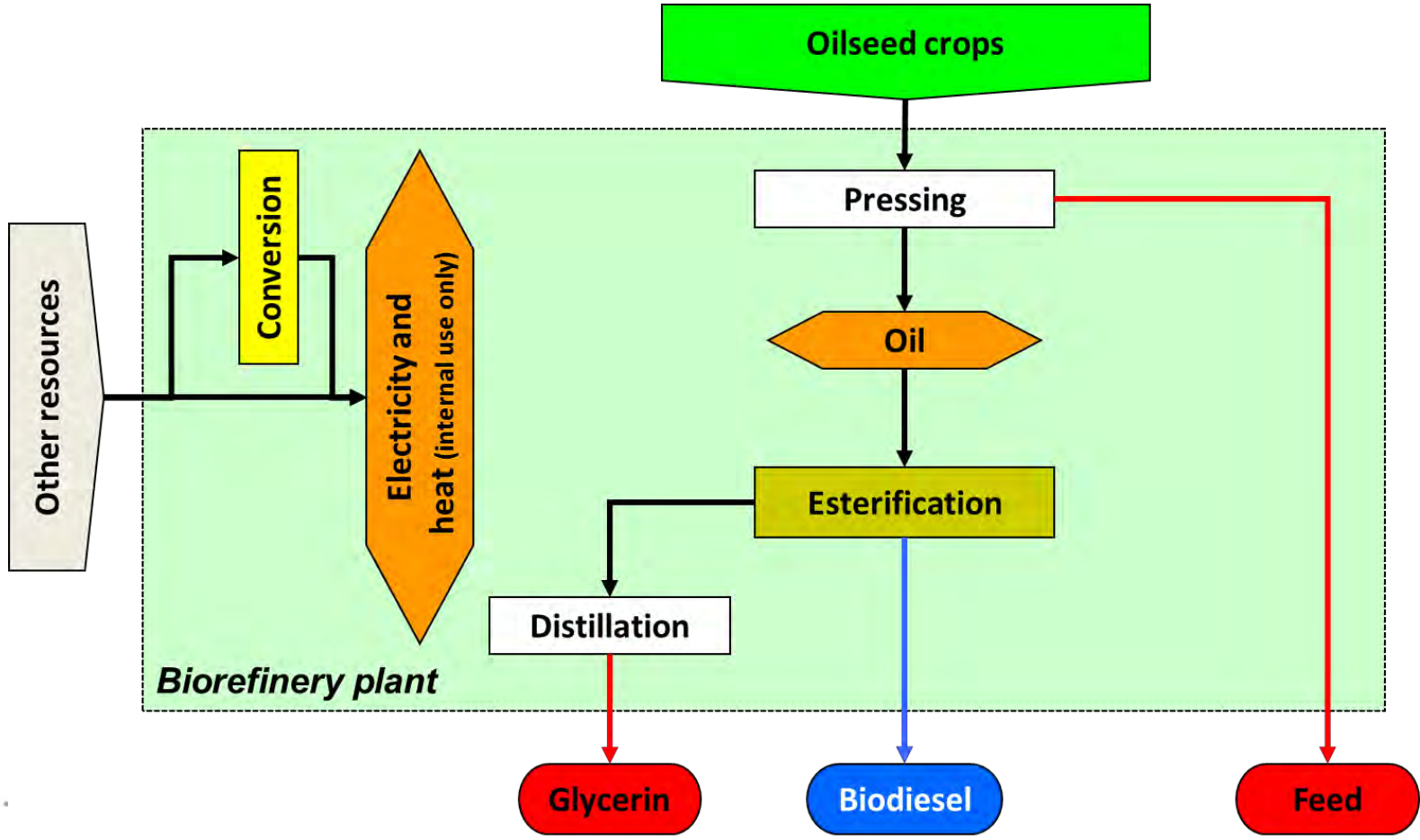
Integration in industrial infrastructure

Introduction Biorefineries

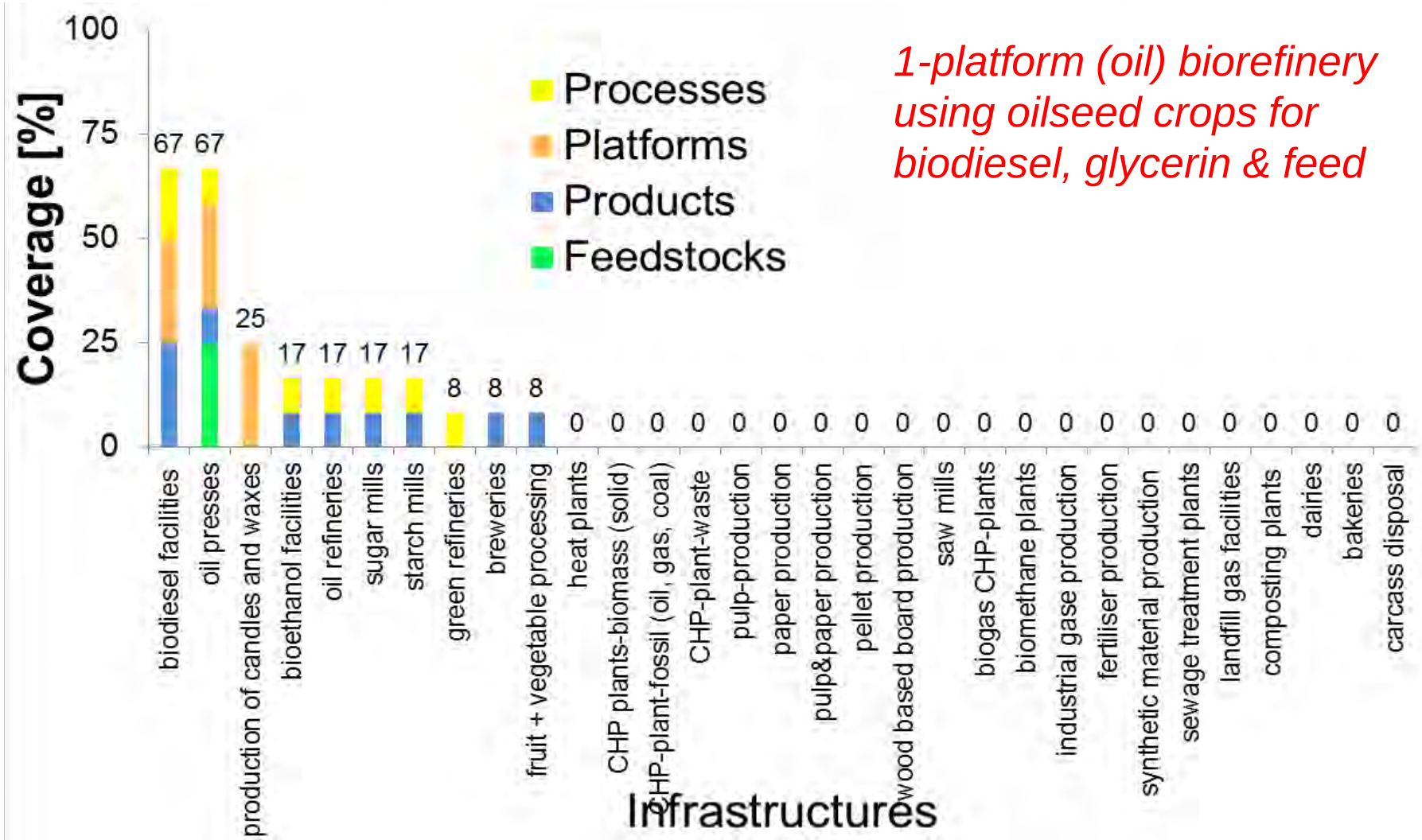


Example I: How to Integrate this Biorefinery?

1-platform (oil) biorefinery using oil crops for biodiesel, glycerin and feed



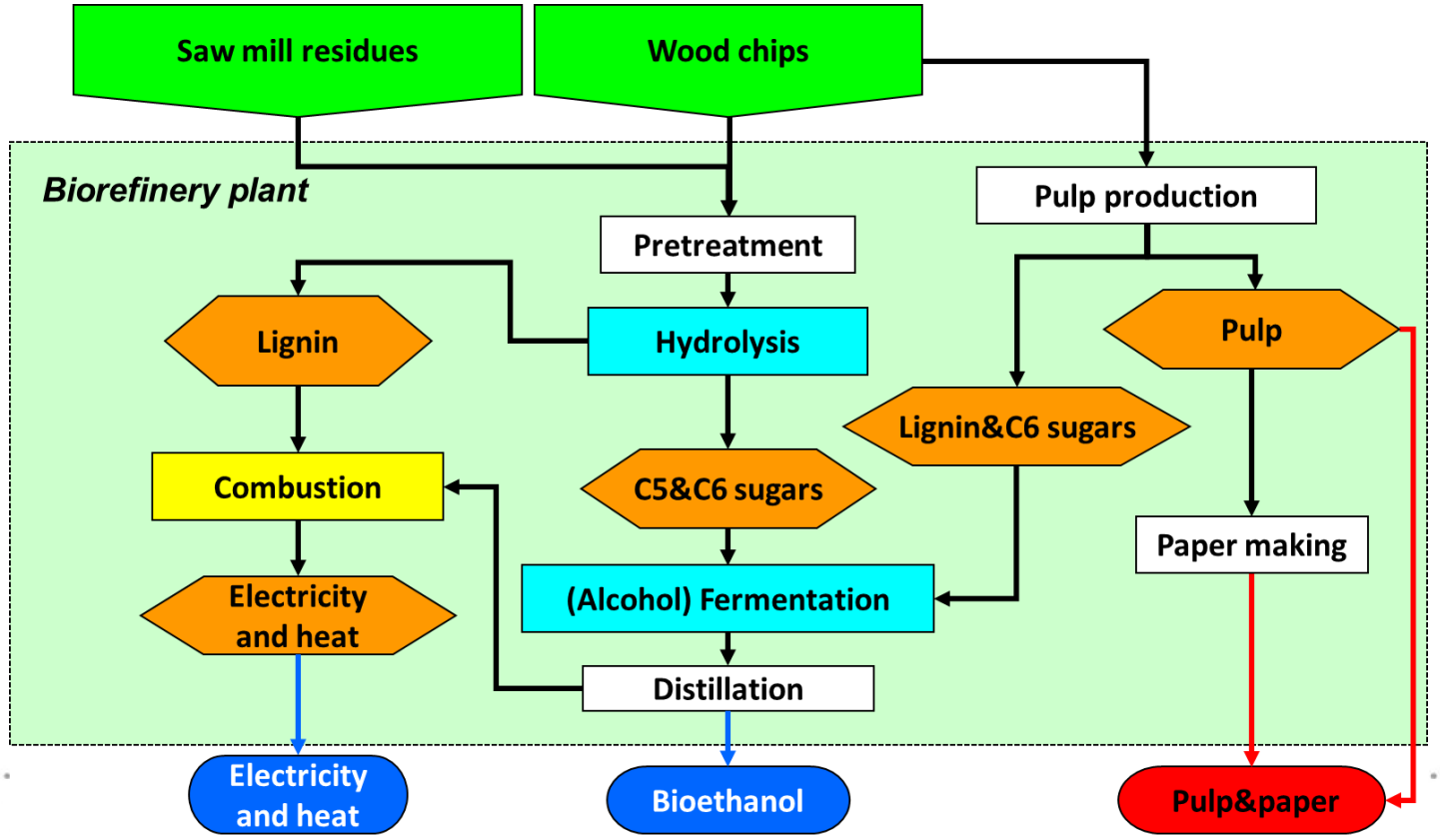
Example I: 1 Biorefinery and 31 Industry Subsectors



1-platform (oil) biorefinery using oilseed crops for biodiesel, glycerin & feed

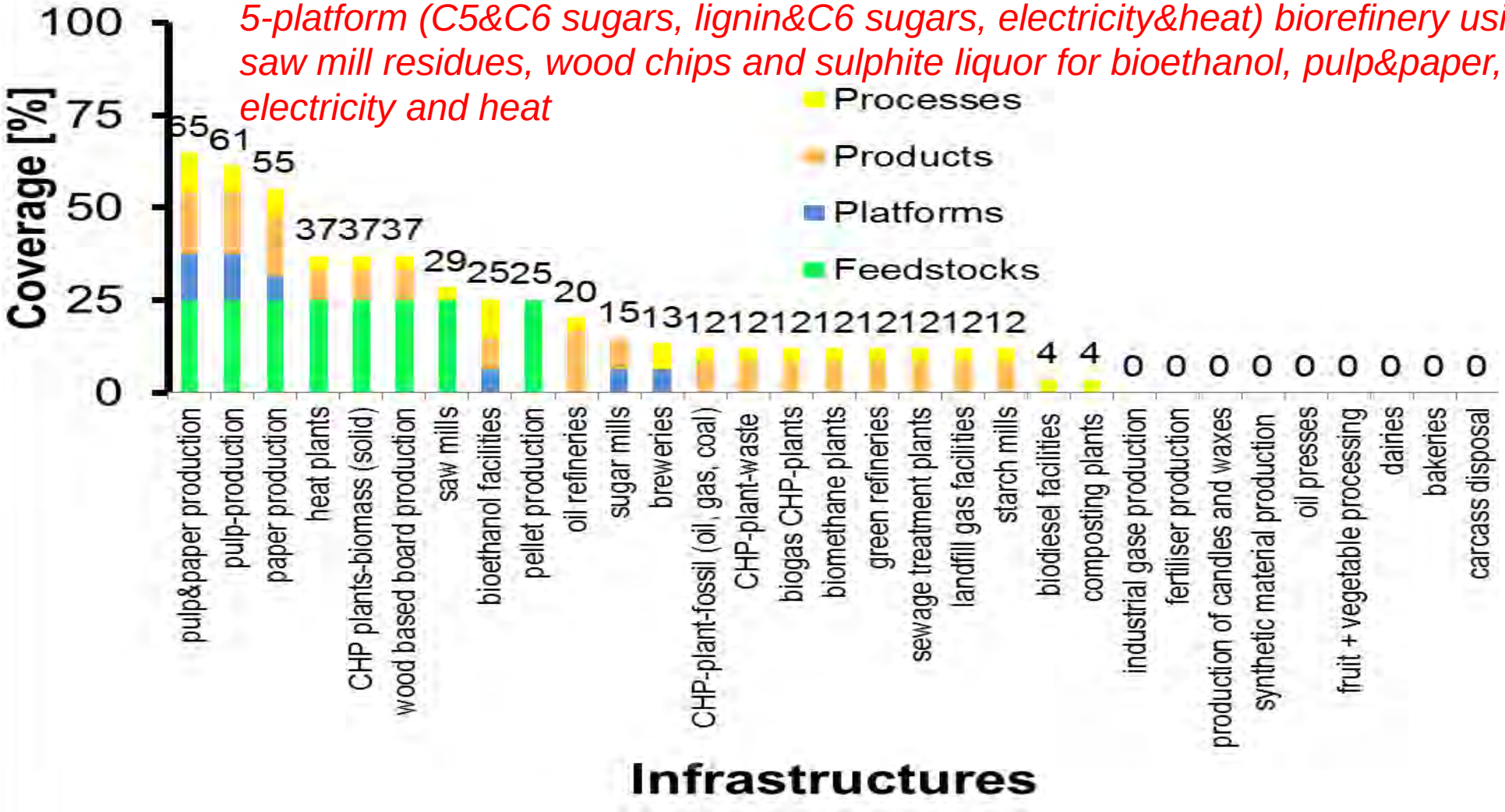
Example II: How to Integrate this Biorefinery?

5-platform (C6&C5 sugar, lignin&C6 sugar, electricity&heat) biorefinery using saw mill residues, wood chips and sulfite liquor for bioethanol, pulp&paper, electricity&heat



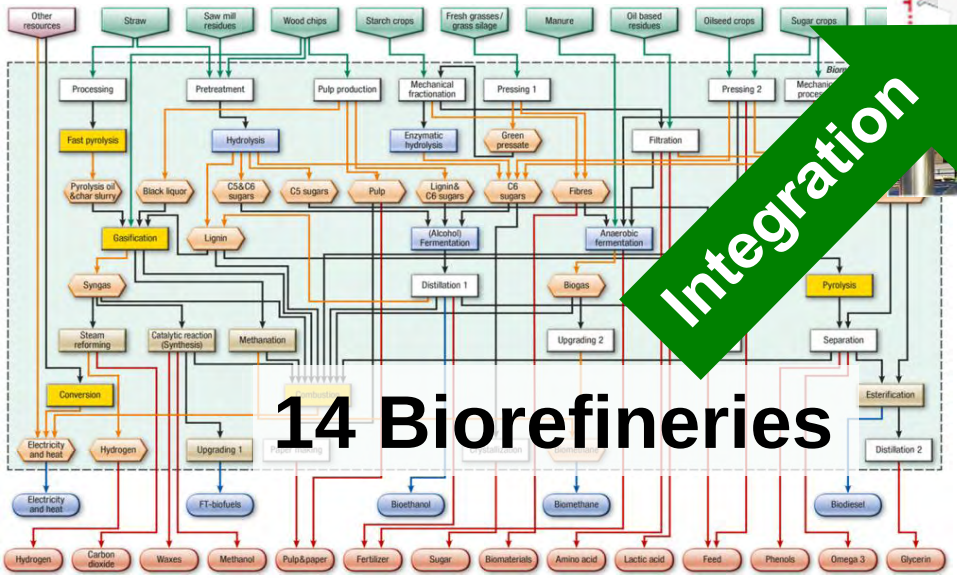
Example II: 1 Biorefinery and 31 Industry Subsectors

5-platform (C5&C6 sugars, lignin&C6 sugars, electricity&heat) biorefinery using saw mill residues, wood chips and sulphite liquor for bioethanol, pulp&paper, electricity and heat



How to Upgrade an existing Industrial Infrastructures to one of the 14 Biorefineries?

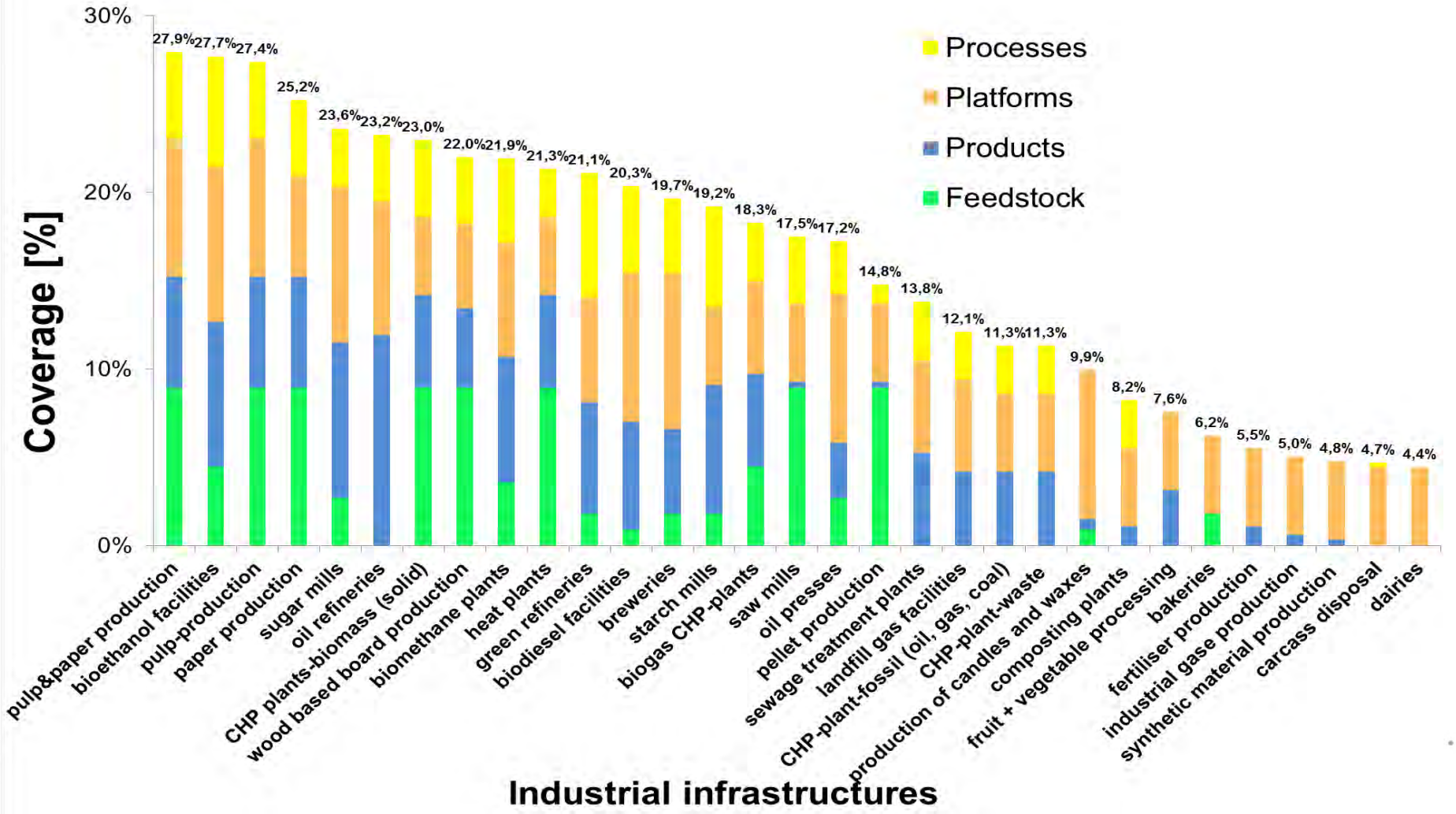
Infrastructure in 31 industry subsectors



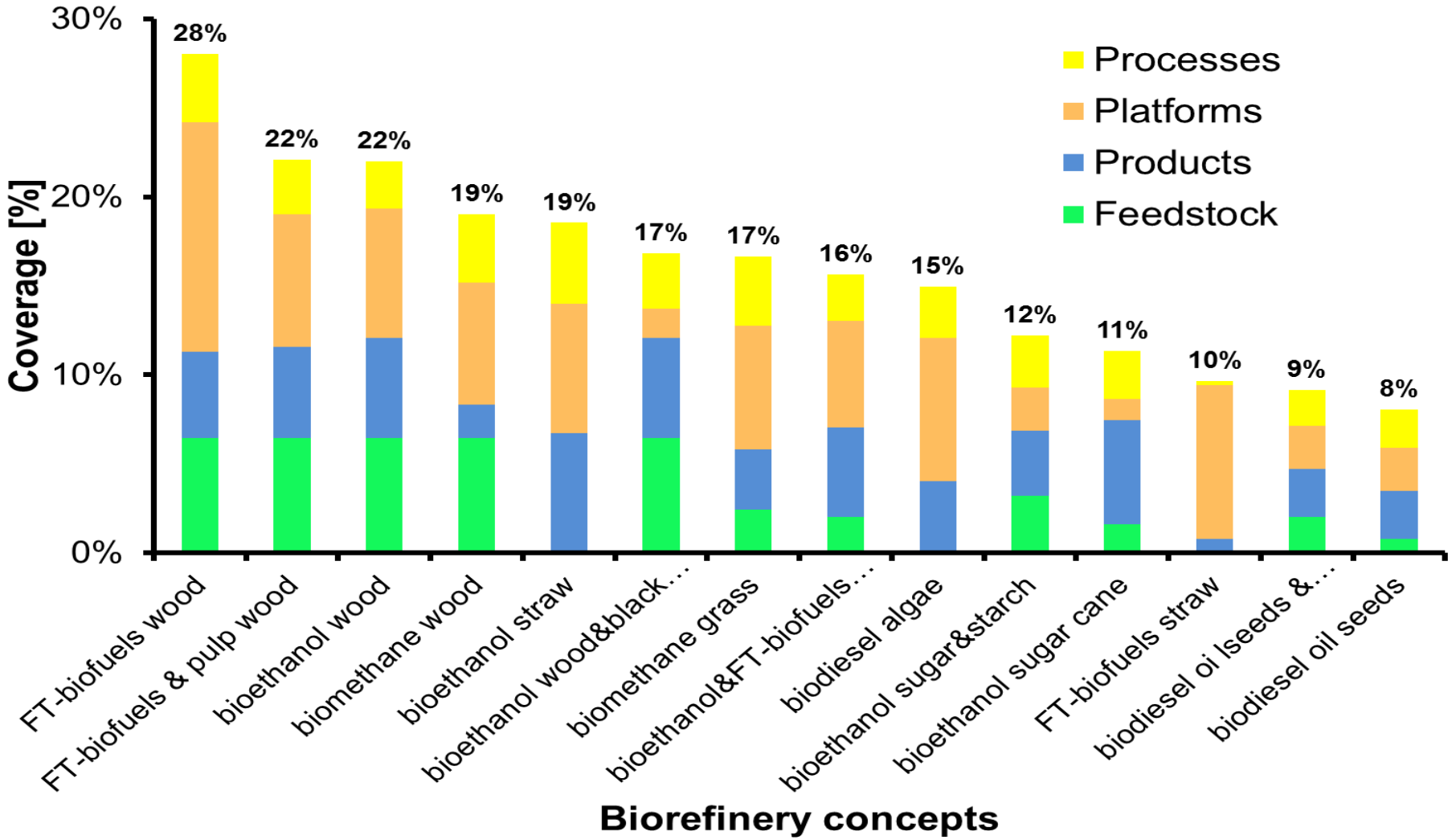
Integration

14 Biorefineries

Coverage: 14 Biorefineries and 31 Industry Subsectors



Coverage: 31 Industry Subsectors and 14 Biorefineries



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Examples for Integration

Integration in industrial infrastructure

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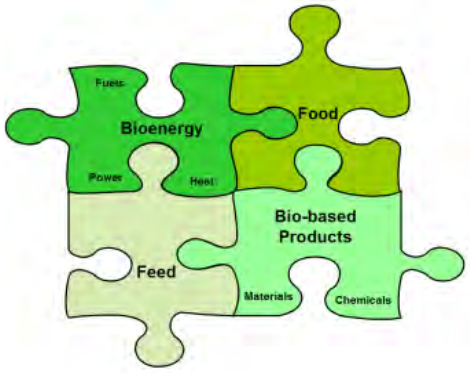

Outlook

1. Discussion to further develop this approach

2. Apply to other countries and biorefineries

3. Extend “Biorefinery Fact Sheet” to the most promising integration options

Summary

*Assist **stakeholders** in developing a **BioEconomy** to minimize technical, economic&financial risks*

***Integration opportunities**: High number of common features in industrial infrastructure & biorefineries*

*Database of **existing industrial infrastructure** with 10 main industry sectors and 31 subsectors*

***Biorefinery integration** in industrial infrastructure: feedstocks&products ≥ platforms ≥ processes*

***Biorefinery Fact Sheet** gives facts&figures on biorefinery plant and value chain sustainability assessment*

*Selection of interesting **"Biofuel-driven Biorefineries"** for Biobased Economy 2025 by IEA Bioenergy Task 42 "Biorefinery"*

***Classification of biorefineries** via 4 features: platforms, products, feedstocks, processes*

IEA Bioenergy
Task 42 Biorefining

IEA Bioenergy aims to facilitate the commercialisation and market deployment of environmentally sound, socially acceptable, and cost competitive bioenergy systems and technologies

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JOANNEUM RESEARCH RESOURCES

Activities

- Knowledge dissemination
- Market deployment
- Stakeholder positioning
- Sustainable biomass valorisation
- Policy advice
- Training

News

New map of US biorefineries available
March 28, 2014

Project results presented at conference
February 17, 2014

Tomorrow' Euro… …eting in Graz …e online
…ber 6, 2013

Biofuel-driven Biorefineries Report 2013
February 1, 2013

Poster IEA Bioenergy Task42

Calendar

April 8, 201…
7th '… …gne,

…4 - Conference
…2014: A Conference for a Low Carbon Future - Edmonton, Canada

May 12, 2014 - Conference
9th Biopolymer Symposium- Philadelphia, USA

More calendar

Recent publications

Green Building Blocks for

Austrian Team Leader

Gerfried Jungmeier
JOANNEUM RESEARCH
gerfried.jungmeier@joanneum.at

Challenges to be tackled

- Develop industry legitimacy and a level-playing field for sustainable biomass use
- Multi-sectoral stakeholder involvment in the development and implementation of sustainable value chains
- Technology development and biorefinery scale-up using best