



SCAR Bioéconomie

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Table 2 Primary scenario skeleton summaries – with added explanations of factors that have specific interpretations in each scenario

	Consumption Patterns	Environmental Degradation	Poverty and Economic Inequality	Social and Technical Innovation	Urban and Rural Population Dynamics	Power and Market Concentration	Trade Agreements	Resource Use
Fed up Europe	High animal products, high sugar/processed food (unhealthy meat eaters)	Biodiversity loss, water pollution, soil degradation etc. continued environmental decline	Low poverty high inequality – few are truly poor, but some are extremely rich	Low innovation, private sector driven – public and private sectors are inert, despite interest in change among a minority in the private sector	Increase in both urban and rural populations	Extreme concentration: several companies dominate the entire market worldwide	Free markets (more free trade agreements, removal of subsidisation)	Resource crisis
The Retrotopia	Low animal products, high sugar/processed food (unhealthy vegans and vegetarians)	Environmental degradation is reversed	Low poverty, low inequality	High innovation, public sector driven	Decrease in both urban and rural populations	Healthy competition exists in all sectors – significant role for SMEs	Protected markets (less free trade more subsidies)	Significant reduction in resource use/demand
The Protein Union	Meat consumption, low sugar/processed food – strong innovation on animal proteins, e.g. insects	Environment is stabilized but at lower levels than today	High poverty, low inequality – people have less assets but strong state support.	High innovation, public sector driven – the public sector stimulates innovation, but there is an important role for the private sector	Decrease in rural, increase in urban	Some sectors dominated by a few global players, others less concentrated	Protected markets (less free trade more subsidies)	Resource scarcity
The Price Of Health	Low animal products, low sugar/processed food (healthy vegans and vegetarians)	Environment is stabilized	High poverty, high inequality – incomes are low, but quality of life has been decoupled from income through other means of subsistence; the rich lead very different lives	High innovation, needs driven, bottom-up – local initiatives, local businesses and local governments	Increase in rural decrease in urban	Extreme decentralisation dominated by SMEs	Protected markets (less free trade more subsidies)	Significant reduction in resource use/demand



Sustainable Agriculture, Forestry and Fisheries in the Bioeconomy A Challenge for Europe

4th SCAR Foresight Exercise



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Purpose

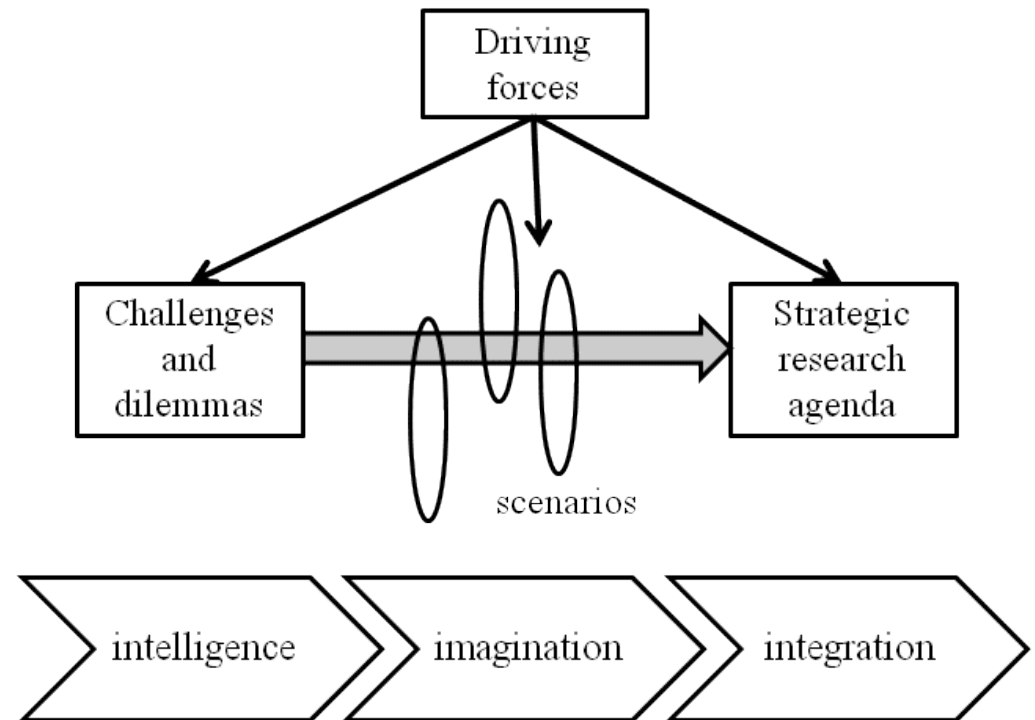
- To identify **emerging research questions**
- To anticipate future **innovation challenges**
- To support the implementation of the European **Bioeconomy strategy**
- To explore what might happen by developing the Bioeconomy Paradigm within the fundamental constraint of **sustainability**

Key questions

- How are the primary sectors affected by/can they contribute to/ the implementation of the Bioeconomy Strategy and CAP reform?
- How can the bioeconomy improve food security, environmental quality and other societal challenges?
- How should innovation in the bioeconomy be implemented? What are the opportunities and risks for the different sectors, social groups and regions?

Process

- Strong trends and dogmas + critical uncertainties = global scenarios
- Dilemmas & challenges as criteria
- Derive implications for research agenda



Structure of the report

1. Introduction
2. Transition to a sustainable European bioeconomy: premises and conditions
3. State of play in the bioeconomy
4. Scenarios
5. Recommendations

Note

- Use of word 'biomass' to refer to output of primary sectors and all by-products and waste streams
- May mask differences in underlying values and qualities
- Hence not neutral

2. The sustainable bioeconomy: premises and preconditions

- In 2012 EC launched the strategy for “Innovating for sustainable growth: A bioeconomy for Europe”, aiming *“to pave the way to a more innovative, resource efficient and competitive society that reconciles food security with the sustainable use of renewable resources for industrial purposes, while ensuring environmental protection”*.
- Two premises:
 1. Current biomass is being underexploited as many waste streams are not used in an optimal way. More feed, materials and energy can be extracted from current biomass streams.
 2. Biomass potential can be upgraded by increasing current yields by closing the yield gap and introducing new or improved species.

The bioeconomy concept

- Bio-economy or bio-based economy “... *encompasses the production of **renewable resources** and their conversion into food, feed, bio-based products and bio-energy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries*” (EC, 2012)
- However, bio-economy is more than simple addition of sub-sectors: set of existing relations between human societies and the **biosphere** in several aspects:
 - provision of goods and services,
 - emission of pollutions and negative externalities
 - but also of positive externalities
 - in order to keep biosphere capacities and functionalities viable and sustainable for future generations.

Two premises

1. Biomass **is underexploited**:
 1. Too much waste not used optimally
 2. More material and energy can be extracted from current biomass streams
2. The biomass potential **can be upgraded** by
 1. Closing yield gaps
 2. Introducing new or improved species
 3. Introducing new and improved extraction and processing technologies

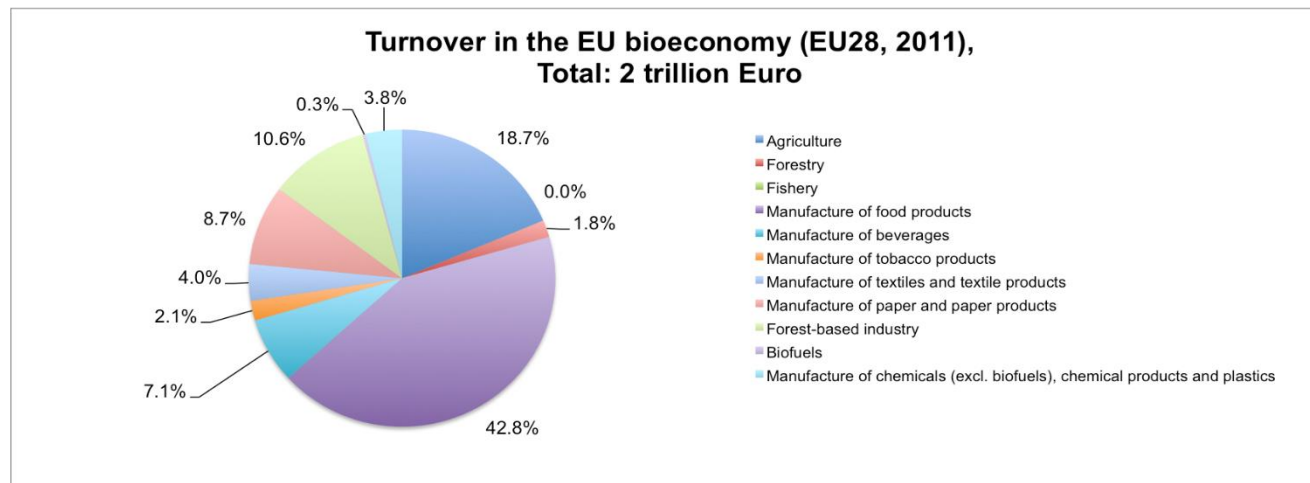
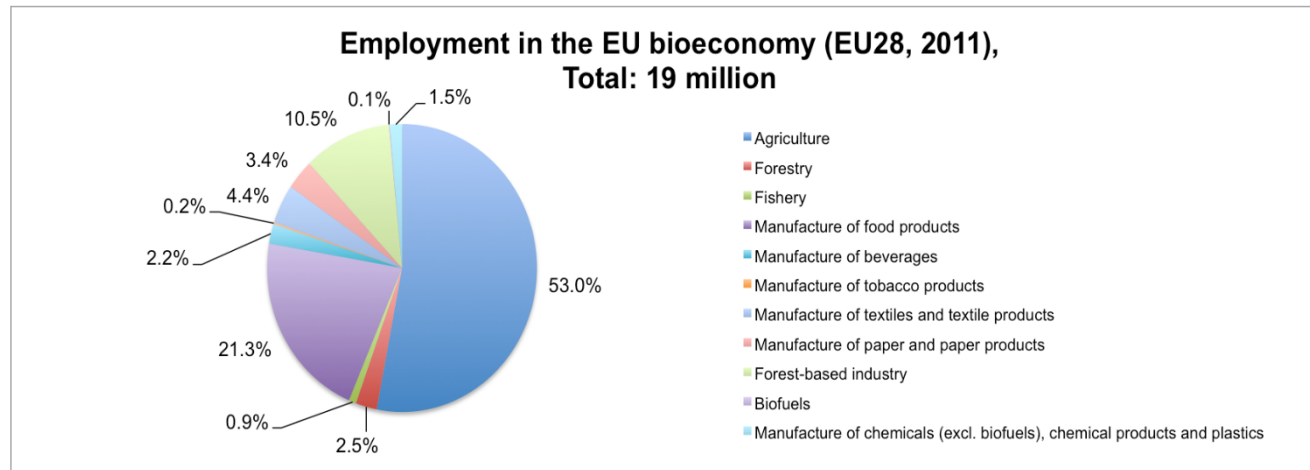
Potential benefits and concerns: values

- Predominantly positive perception
- Concerns:
 - global food security and resource overexploitation (LDCs)
 - tension between policy focus on quality production and rural development versus cheap biomass as feedstock for non-food uses
 - impact of large-scale exploitation of feedstocks on primary sectors

Addressing societal challenges

- Ensuring food security
- Managing natural resources sustainably:
 - New region-specific balance between production and ecosystem carrying capacity:
 - Sustainable intensification in areas with growth potential
 - Sustainable extensification in areas with high negative externalities
 - Better use of waste: circular economy
- Reducing dependence on non-renewable resources
- Mitigating and adapting to climate change
- Creating jobs and maintaining competitiveness

Estimated employment and turnover in EU-28 in 2011



Five key principles for a sustainable bioeconomy

- **Food first:** ensure the primacy of food security
- **Sustainable yields:** amount harvested < regrowth → agriculture?
- **Cascading approach:** sequential use of biomass according to 'value added'
- **Circularity:** reduce/reuse/recycle
- **Diversity:** systems are diverse, using context-specific practices at different scales, producing a diversity of outputs

3. State of play

1. Introduction
2. Current supply and demand of biomass
3. Current state of the environment
4. Food and feed
5. Biobased chemicals and materials
6. Bio-energy
7. Policy framework for the bioeconomy

Food & feed (incl. fish)

- Food for humans, feed for animals that are producing for humans: **feed is a land use multiplier**
- **Changes in the diet** in emerging economies: more meat and milk → more land. Not in Europe
- Market is globalising and **prices are more volatile**
- **There is more competition**
- Supply chains and retail are **concentrating**
- The **digital** revolution could change the game

Evolution of international prices

nova-indices

January 1980 = 100 %

All raw materials are equally weighted in all indices

nova-Index 18

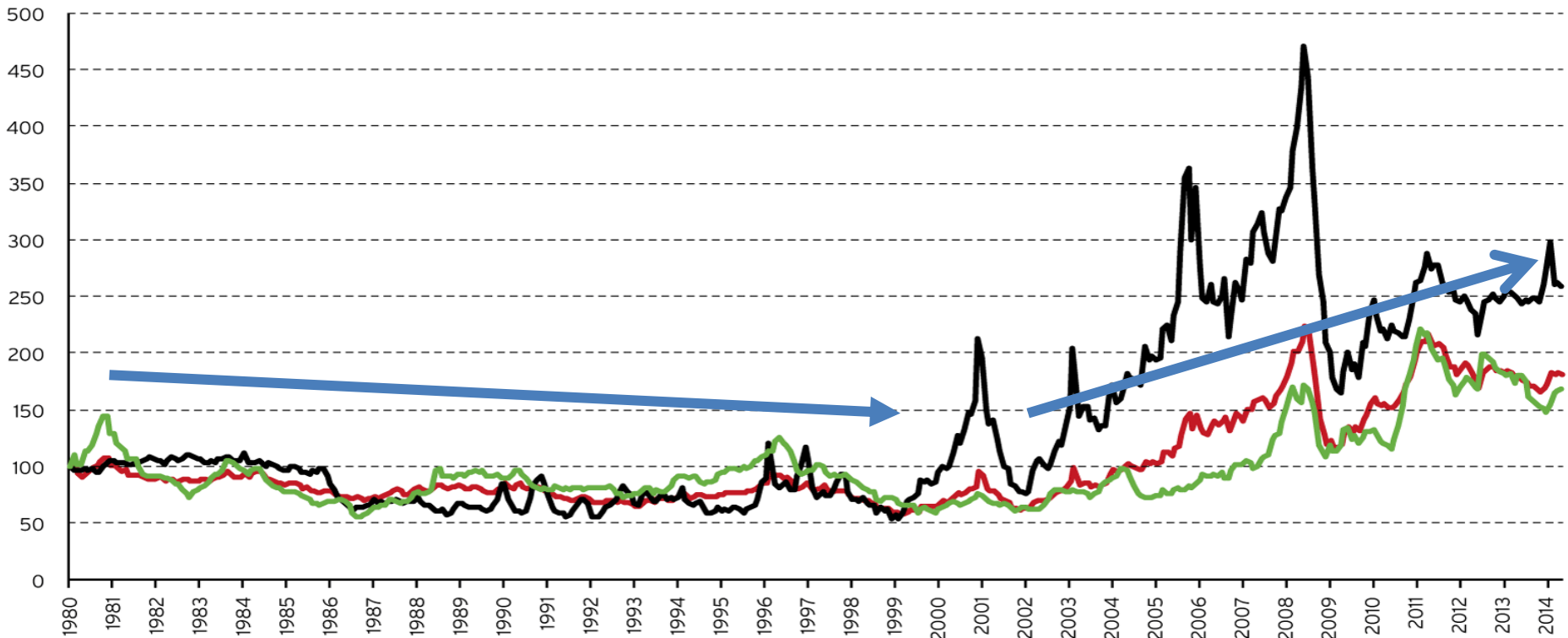
Beef	Gold	Pork
Cocoa	Heating oil	Silver
Coffee	Maize	Soybeans
Copper	Natural gas	Sugar
Cotton	Orange juice	Uranium
Crude Oil	Platinum	Wheat

nova-Index Energy

Crude oil
Heating oil
Natural gas
Uranium

nova-Index Agriculture

Cotton
Maize
Soybeans
Sugar
Wheat



Fish

- Sustainable management of marine fish stocks and fishing industry (e.g., by-catch and discards, processing efficiency)
- Shift from overexploited marine fish stocks to aquaculture → new challenges and opportunities
- Blue Growth: marine biotechnology, blue energy, aquaculture

Biobased materials and chemicals

- **Current uses of biomass:** animal bedding, construction, pulp & paper, textiles, chemical & plastic industry
- A lot of innovation in pulp & chemical industry: longstanding experience in biomass conversion
- Importance of cellulose and lignin
- **Future scarcity of oil**, then plastics → demand to biomass
- **Transition from oil refineries to biorefineries:**
 - Transport cost of the starting biomass relatively high
 - Mixed mode of operation needs research

Two strategies for biobased chemicals

Criteria	Drop-in strategy	Dedicated emerging strategy
Value chain & infrastructure	Existing value chains and infrastructure of the petrochemical industry are used	New value chains, new processes (e.g., industrial biotechnology)
Implementation	Fast, low investment	Low, high investment
Markets	Mature markets	Emerging markets
Biomass utilisation efficiency	Low, 20 – 50% (mostly C)	High, 50 - 100% (C, O, H, N)
Biomass	All kinds, including organic waste and side-streams	Dedicated biomass
Products	Same as petrochemicals and standard polymers	New building blocks and polymers with new properties
Competitive price	Mostly more expensive than petrochemicals, except those from very cheap biomass	Often more expensive than petrochemicals, in special applications competitive with new properties
Research agenda	Not in the focus of the research agenda	In the focus of the research agenda

Forestry

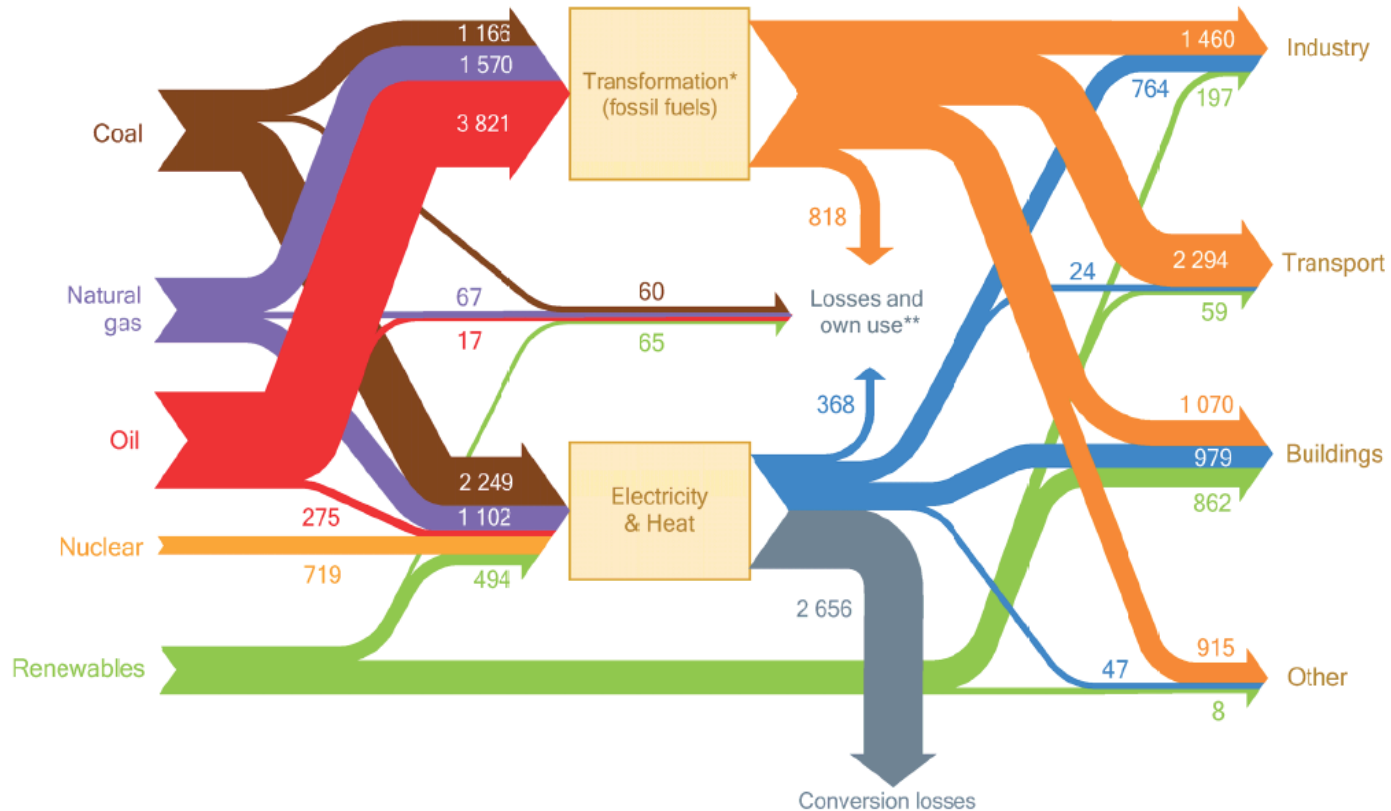
- Large differences in productivity
- Need to prepare forest to **multiple uses**: fuel, construction, materials, chemicals, furniture, landscape, recreation, ecosystem services...
- Need to prepare forests to **increase production: energy, biomaterials**
- Need to prepare for **climate change**
- Need for more nutrition management
- Need for a more ecologically approach of wood harvesting

Bioenergy

- **Role in the transition from fossils to renewables but with uncertain perspectives**
- Particularly for **transport** (liquid fuels or electricity)
- **Multiple uses of biomass for energy**: methane (CH₄), thermal gasification, pelletisation, pyrolysis
- **Competition for carbon use**: fuel vs crop residues for soils (dilemma)
- **The sooner solar and wind energy will be available and low cost** (photovoltaic → H₂ → electricity, renewable methane, liquid fuels, etc.), the better for alleviating competition for biomass

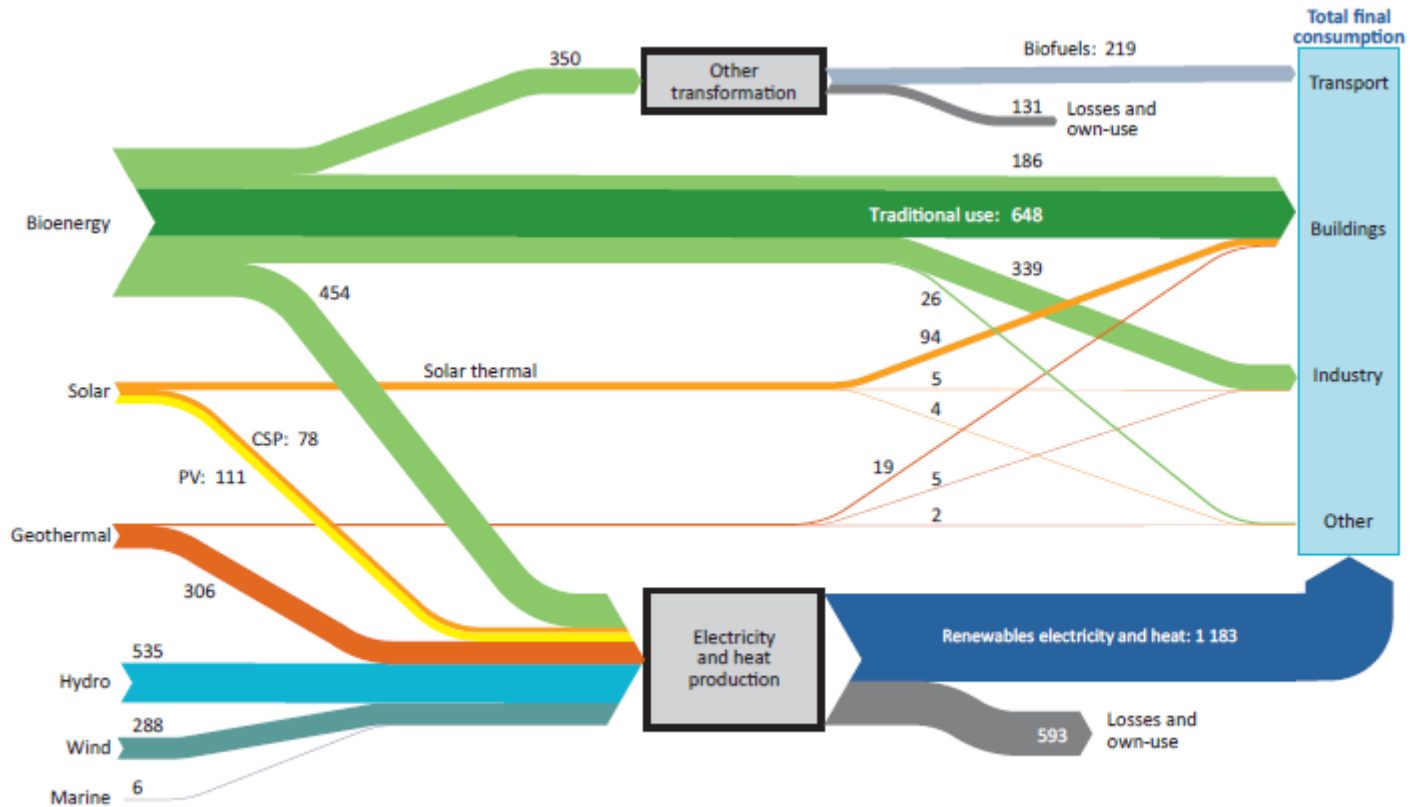
Energy: current

Figure 2.8 ▷ The global energy system, 2010 (Mtoe)



* Transformation of fossil fuels from primary energy into a form that can be used in the final consuming sectors. ** Includes losses and fuel consumed in oil and gas production, transformation losses and own use, generation lost or consumed in the process of electricity production, and transmission and distribution losses.

Energy: renewable future



Notes: Other transformation includes bio-refining (processing of bioenergy to make biofuels). CSP = concentrating solar power; PV = photovoltaics.

Source: IEA 2014

Biofuels

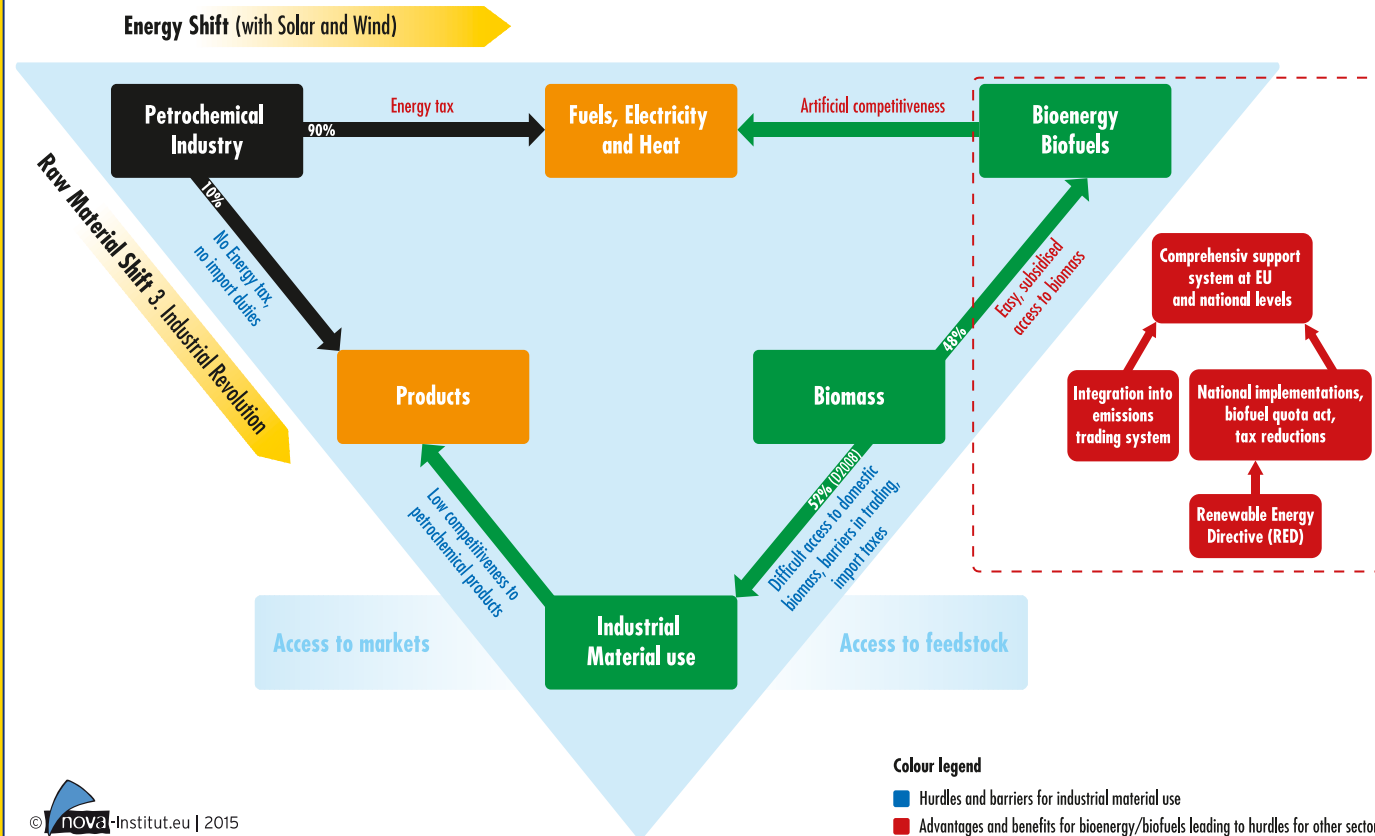
- First generation: edible products – competition with food
- Second generation: ethanol from cellulose, biodiesel from biorefineries – cost issues
- Third generation: (micro)algae as factories – cost and environmental issues

Policy frameworks

- Many regulations and strategies in Europe: CAP, EU forest strategy, Common fisheries policy, Blue growth agenda, New EU framework for aquaculture, quality schemes, Renewable Energy Directive, 2030 framework for climate and energy, standards for bio-based products and circular economy,...
- **Conflicting interests but need for coherence: an integrated policy framework**

Example

The competition triangle: No level playing field for bio-based chemicals and products



4. Scenarios

- Develop robust strategies for the future by:
 - Identifying uncertainties and their implications
 - Identifying success potentials
- Strategic planners *should not look only for a single visionary view that most likely corresponds with their expectations. Instead, they should try to acquire multiple views that describe a whole “window of opportunities”* (Fink & Schlake, 2000).
- Anticipate multiple possible futures

Key questions

- Is the current research & innovation (and policy) agenda **robust** across all scenarios?
- Do scenarios offer **new** opportunities and/or challenges specific to that scenario?
- Do scenarios have different **implications** for actors, sectors, regions, ecosystems, etc.?
- At what **geographical** level do scenarios apply: world/EU/region/local?

Scenarios

- Future is not known: uncertainties
- Explore critical uncertainties through scenarios:
 - Demand growth for biomass for material and energy
 - Supply growth of biomass (primary sectors – agriculture, forestry, fisheries & aquaculture)

Bioeconomy scenarios

		Supply growth of biomass		
		Low	medium	high
Demand growth for biomass for materials & energy	low		A – BIO-MODESTY	
	medium			
	high	C – BIO-SCARCITY		B – BIO-BOOM

Scenario A: BIOMODESTY

- Modest growth in demand for biomass for non-food use
- Possible reasons:
 - Biobased solutions not competitive
 - Alternative solutions break through fast (e.g., cheap solar)

Scenario B: BIOBOOM

- High growth in demand for non-food uses and high growth in supply of biomass
- Possible reasons:
 - Alternative technologies slow and biobased technologies competitive
 - Limited resistance towards new technologies and products (e.g., insects, algae)
 - Africa rising
 - ...

Scenario C: BIO-SCARCITY

- High growth in demand for non-food uses, but low growth in supply of biomass
- Possible reasons:
 - Alternative technologies slow and biobased technologies competitive
 - Climate change negative impact on supply
 - Resistance against biotech, insects, etc.
 - ...

Simulation/scoping (billion tonnes dry matter)

Sector	Status 2011	Scenario A: BIO-MODESTY	Scenario B: BIO-BOOM	Scenario C: BIO-SCARCITY
Food	1.75 (14%)	2.2	2.2	2.2
Feed	7.06 (58%)	8.3	8.3	8.3
Bio-based chemicals & materials	1.24 (10%)	2.4	5,7	1.0
Bioenergy	2.98 (16%)	4.3	4.2	1.5
Biofuels	0.15 (1%)	1.0	3.5	0
Total supply of biomass	12.18 (99%)	18.2	23.9	13.0
Total demand for biomass	12.18	18.2	23.9	23.9

Conclusions from scenarios

- Topics are **robust** – no new topics are to be put on the agenda
- However, **priorities** will be different in different scenarios, as they represent different challenges and opportunities related to the bioeconomy
- Key insight is the importance of **governance**
- Important **regional** differences apply

Conclusions from scenarios

- **Bio-modesty:** pull-effect of bioeconomy disappears, urgency to develop bio-based technologies decreases, other ('third') pathways (next to fossil and bio) exist
- **Bio-scarcity:** governance extremely important, social and political issues high on agenda
- **Bio-boom:** high-throughput system, ecosystem carrying capacity high on agenda

5. Recommendations

- New insights following exploration of what bioeconomy may mean for primary sectors
- Messages of 3rd Foresight Exercise still valid + reinforced (**productivism** versus **sufficiency**)
- Three types of recommendations
 - Principles underpinning research & innovation
 - Scope and emerging themes
 - Organisational principles of research & innovation

Bioeconomy Principles

Bioeconomy principles should be reflected in research & innovation agenda:

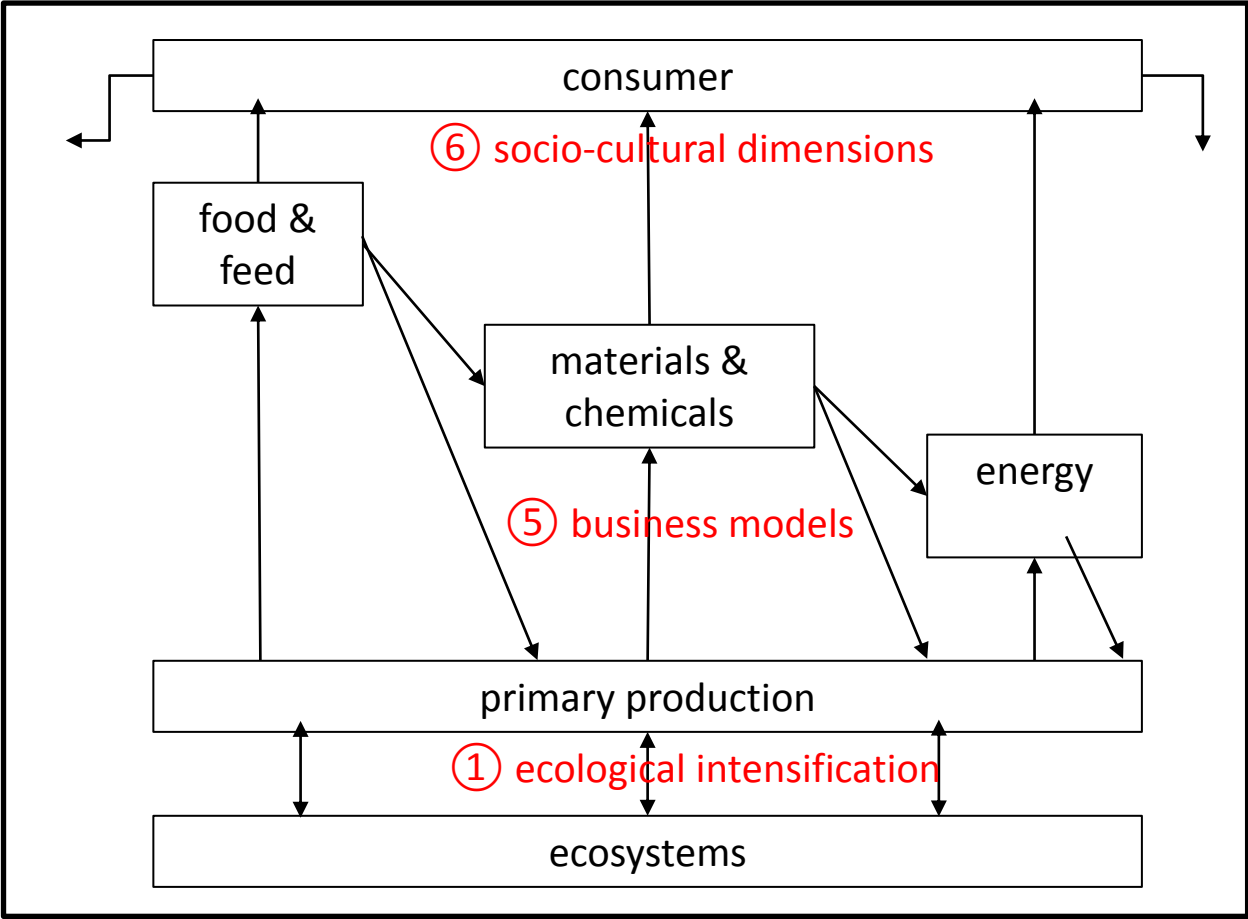
- **Food first**
- **Sustainable yields**
- **Cascading**
- **Circularity**
- **Diversity**

Scope & Themes

- Broadening scope
 - **Horizontally**: simultaneous consideration of all sources of biomass to optimize synergies and minimize threats
 - **Vertically**: integration of upstream and downstream sectors into research addressing primary sectors
- Thematic areas: 8 themes



② digital revolution



③ resilience



④ new energy landscape

⑦ governance

⑧ foresight

time

1. Ecological intensification

- Using regulating functions of nature (functional ecology)
- From input substitution (e.g. predator instead of pesticide, biomimicry, new molecules) to landscape-level agroecosystem design
- From mono-species/environment studies to the study of groups of organisms in relation to each other and the environment (community ecology)
- To be supported by –omics and big data

2. The digital revolution

- Beyond precision agriculture (remote sensing, sensors, ...)
- Factories of the future (mechatronics, photonics, robotics, additive manufacturing, ...)
- Enabler for dealing with diversity, different qualities, etc.

3. Resilience for a sustainable bioeconomy

- Hazards → increased coordination and integration of different sub-sectors → effects on animal, plant and human health hazards as well as adaptation and risk reduction strategies
- What is the impact of the bioeconomy on resilience?
- What new solutions and systems can be developed that are more resilient, from a biological, technological and social perspective?
- How can changes in consumption create opportunities for the bioeconomy?

4. The new energy landscape

- Future = renewable electricity + heat generation
- Impact for inputs for primary production (fertilizer, pesticides, machinery,...)
- Direct impact on primary production
- The role of biomass will be locally specific

5. Business models for the bioeconomy

- Circularity = new ways of designing and manufacturing products, new relationships between economic actors, new ways of recycling components and waste, etc.
- Actors and activities will be reassembled in time and in space
- Different production models in terms of scope and size should not co-exist and work together
- Public goods are part of the new production (ecosystem services) and could involve public sector

6. Socio-cultural dimensions of the bioeconomy

- Knowledge on impacts and mechanisms of social change should **co-evolve** with technology
- All **stakeholders** should be fully involved in governance of bioeconomy
- Science may radically **change food production and consumption patterns**, with potential to reduce pressure on ecosystems
- This may break established routines and create **resistance**, which needs to be better understood.
- Approaches have **legal** implications that need to be understood and addressed by research.

7. Governance and the political economy of the bioeconomy

- Outcomes of bioeconomy will depend on the rules put in place to **regulate** the system.
- Bio-based materials and bio-energy may create pressure on natural resources and on **social inequalities** in a scarcity-dominated world.
- Bioeconomy involves both positive and negative **externalities** influencing the future of the biosphere and the ways in which societies will use it
- So bioeconomy **governance** is critical
- **Research** should help develop framework aimed at fostering the bioeconomy - policies that are coherent, create a level playing field, avoid the overexploitation of natural resources and foster a diversity of practices

8. Foresight for the biosphere

- Foresight should go **beyond forecast**-based modelling platforms, with comparative-static approaches
- Efforts are being done to expand these platforms into the **non-food** dimensions of the bioeconomy
- **Integrate** data and dynamic and flexible tools, in order to avoid lock-ins and **monitor** the sustainability and resilience of the bioeconomy and the **biosphere** as a whole

Organisational principles: KIS for the bioeconomy

“The old paradigm of scientific discovery (‘Mode 1’) – characterized by the hegemony of theoretical or, at any rate, experimental science; by an internally-driven taxonomy of disciplines; and by the autonomy of scientists and their host institutions, the universities – was being superseded by a new paradigm of knowledge production (‘Mode 2’), which was socially distributed, application-oriented, trans-disciplinary, and subject to multiple accountabilities”

Nowotny et al., 2003, p. 179

KIS for the bioeconomy

- **Challenge-oriented** in addition to curiosity-driven
- **Transdisciplinary** = transcending pre-existing disciplines and methodologies
- **Socially distributed** = knowledge creation in diverse forms, in diverse places and by diverse actors → socially inclusive
- **Reflexive** = research as dialogic process and co-creation between all actors ('multi-actor')
- **New rewarding and assessment systems** = quality control transcending classical peer review, old taxonomies in science + multi-actor means multi-quality
- **Competencies** for researchers, extensionists, policymakers, end-users → important role for education + resources to be invested by actors

Thank you to EC, SCAR, SCAR Foresight Group and all participants of the workshops, expert meetings and working groups for their input

