

Supplementary Material File S1 of the Article

Reflecting regional conditions in circular bioeconomy scenarios: a multi-criteria approach for matching technologies and regions

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Table S1: Selected peer-reviewed journal publications used to identify success criteria for the implementation of CBE technologies

Nr.	Reference	First Author	Year	Title	Context
1	[1]	Ding	2021	Development of Biorefineries in the Bioeconomy: A Fuzzy-Set Qualitative Comparative Analysis among European Countries	identification and analysis of configurational conditions for the establishment of biorefineries in 20 European countries
2	[2]	Donner	2021	Innovative Circular Business Models in the Olive Oil Sector for Sustainable Mediterranean Agrifood Systems.	review of Mediterranean entrepreneurial initiatives creating value from olive waste and by-products via CBE approaches: business drivers, value creation mechanisms, and conversion pathways.
3	[3]	Donner	2021	How to innovate business models for a circular bioeconomy?	investigation of 8 European business model innovations for a sustainable CBE within the agrifood sector through valorization of agricultural waste and by-products. Investigation of innovation drivers and elements.
4	[4]	Donner	2023	Innovative Business Models for a Sustainable Circular Bioeconomy in the French Agrifood Domain	investigation of 44 local, collaborative, and small-scale innovative CBE business models in the French agrifood domain concerning main drivers, business model elements, circular economy principles, enablers and barriers, and sustainability benefits.
5	[5]	Falcone	2020	Towards a sustainable forest-based bioeconomy in Italy: Findings from a SWOT analysis	SWOT multi-level perspective framework: understanding potential drivers and barriers of the transition of the Italian forest sector towards a CBE and derivation of effective transition strategies
6	[6]	Fytili	2022	Organizational, societal, knowledge and skills capacity for a low carbon energy transition in a Circular Waste Bioeconomy (CWBE): Observational evidence of the Thessaly region in Greece	exploration of the main barriers, challenges, opportunities, and the context in which agro-biomass and agro-industrial waste valorization can accelerate a low carbon economy in the Thessaly region in Greece.
7	[7]	Gottinger	2020	Studying the Transition towards a Circular Bioeconomy - A Systematic Literature Review on Transition Studies and Existing Barriers	review: identification and classification of transition drivers and barriers towards a sustainable CBE, global
8	[8]	Kapoor	2020	Valorization of agricultural waste for biogas based circular economy in India: A research outlook	review: discussion of the potentials of biogas production from agricultural waste along with the government initiatives and policy regulations as well as barriers that impede the development towards agri-waste to biogas-based CBE in India.
9	[9]	Kardung	2021	Development of the Circular Bioeconomy: Drivers and Indicators	Proposal of a conceptual analysis framework to quantify and analyze the development of the EU BE: identification of driving factors and outline of a set of monitoring indicators linked to objectives of EU BE strategy.
10	[10]	Karuppiah	2022	Towards Sustainability: Mapping Interrelationships among Barriers to Circular Bio-Economy in the Indian Leather Industry	identification and evaluation of 25 barriers to CBE practices in the Indian leather industry and their interrelationships
11	[11]	Khan	2022	Moving towards a sustainable circular bio-economy in the agriculture sector of a developing country	determination of a sustainable agricultural waste management technique using SWOT & TOPSIS in a country from the Global South
12	[12]	Lange	2021	Developing a Sustainable and Circular Bio-Based Economy in EU: By Partnering Across Sectors, Upscaling and Using New Knowledge Faste, and For the Benefit of Climate, Environment & Biodiversity, and People & Business	review: overview of the development of the EU CBE through the description of product portfolio and pillars of CBE as well as the analysis of drivers of CBE.
13	[13]	Marone	2021	Using fuzzy cognitive maps to identify better policy strategies to valorize organic waste flows: An Italian case study	understanding barriers to effective adoption of CBE technologies (use of biodegradable MSW as feedstock) and identification of effective policy strategies
14	[14]	Näyhä	2020	Finnish forest-based companies in transition to the circular bioeconomy - drivers, organizational resources and innovations	identification of drivers and resources that forest-based companies highlight as significant in the transition to the sustainable and competitive CBE in Finland.
15	[15]	Ossei-Bremag	2021	A decision support system for the selection of sustainable biomass resources for bioenergy production	multicriteria decision making by FTOPSIS for the selection of sustainable biomass resources for bioenergy in Ghana
16	[16]	Paes	2019	Organic solid waste management in a circular economy perspective - A systematic review and SWOT analysis	review: identification of the state of the art and the SWOT of organic waste management through CE principles

17	[17]	Qin	2021	Resource recovery and biorefinery potential of apple orchard waste in the circular bioeconomy	review: environmental & economic feasibility analysis and prospects & challenges of apple orchard waste biorefinery
18	[18]	Rao	2023	Understanding the phenomenon of food waste valorisation for the perspective of supply chain actors engaged in it	identification of the current state of the food supply chain and of barriers and enablers in terms of a transition towards CBE through the valorization of surplus food and food processing by-products in the Netherlands
19	[19]	Salvador	2022	How to advance regional circular bioeconomy systems? Identifying barriers, challenges, drivers, and opportunities	review: identification of drivers, opportunities, challenges & barriers for businesses in CBE; regional differences in different continents (Africa, America, Australia, Europe)
20	[20]	Salvador	2022	Current Panorama, Practice Gaps, and Recommendations to Accelerate the Transition to a Circular Bioeconomy in Latin America and the Caribbean	review: drivers and opportunities for CBE in Latin America & Caribbean
21	[21]	Usmani	2021	Lignocellulosic biorefineries: The current state of challenges and strategies for efficient commercialization	review: examination of the global drivers towards the advancements of lignocellulosic biorefineries, technical and operational challenges for industrialization and future directions towards overcoming them.
22	[22]	Yadav	2022	Barriers in biogas production from the organic fraction of municipal solid waste: A circular bioeconomy perspective	identification and categorization of 20 barriers for biogas-based CBE (biogas production from organic MSW) in countries from the Global South

* MSW: municipal solid waste; SWOT: strengths, weaknesses, opportunities, and threats; (F)TOPSIS: (fuzzy) technique for order preference by similarity to ideal solution

Table S2: Selected (peer-reviewed) journal publications used to identify aspects influencing the social acceptance and consumer awareness for a CBE technology within a region

Nr.	Reference	First Author	Year	Title	Context
1	[23]	Brohmann	2007	Factors influencing the societal acceptance of new, renewable and energy efficiency technologies: Meta-analysis or recent European projects	Identification of contextual and process-related factors influencing the level of societal acceptance and techno-economic successfulness achieved in energy projects that aim to mitigate climate change in different geographic, institutional, and cultural contexts.
2	[24]	Bugge	2016	What is the bioeconomy? A review of the literature	Review: Enhancement of the understanding of what the notion of bioeconomy means by exploring the origins, uptake, and contents of the term "bioeconomy" in the academic literature and Identification of three visions of the bioeconomy: biotechnology, bio-resource, and bio-ecology vision
3	[25]	Dieken	2021	The multitudes of bioeconomies: a systematic review of stakeholder's bioeconomy perceptions	Review: Systematic literature review of stakeholder's bioeconomy perceptions by means of a mixed-methods approach based on inductive coding of research articles
4	[26]	Eversberg	2020	Bioeconomy as a deployment of polarized social conflicts? On the distribution of socio-ecological mentalities in the German population in 2018 and and potentials for support and resistance to bio-based transformations (German language, Working paper, not peer reviewed)	Development of a typology of eleven different patterns of socio-ecological attitudes of mentalities in the German population to investigate to what extent the transformation to a bioeconomy may cause increasing tensions or conflicts within society by means of factor and cluster analysis of representative survey data
5	[27]	Eversberg	2022	Bioeconomy as a societal transformation: mentalities, conflicts and social practices	Exploration of social conflicts and coalitions for and against bio-based, post-fossil transformation within the general population in GER by mapping different socio-ecological mentalities along three dimensions (growth/sufficiency, high-tech-focused/techno-skeptical and fossilist/post fossilist) by means of a relational analysis of representative survey data
6	[28]	Farstad	2023	Socio-cultural conditions for social acceptance of bioeconomy transitions: the case of Norway	Identification of critical enabling conditions in Norway that may be necessary to foster social acceptance for a bioeconomy transition in other countries as well.
7	[29]	Fridahl	2018	Bioenergy with carbon capture and storage (BECCS): Global potential, investment preferences, and deployment barriers	Exploration of the influences of expertise, actor type, and origin on the preference to (1) invest in BECCS*, (2) the view on BECCS as mitigation strategy and (3) the assessment of barriers to BECCS by means of statistically analyzing questionnaire data from UN climate change conferences
8	[30]	Hausknot	2017	A transition to which bioeconomy? An exploration of diverging techno-political choices	Identification of different types of narratives constructed around the concept of bioeconomy and mapping of these narratives in a two-dimensional option space (industrial biotechnology/agro-ecology and sufficiency/capitalist growth) by analysis of policy documents, stakeholder interviews, and biophysical modelling scenarios
9	[31]	Hempel	2019	Bioeconomy from the population's perspective – Thuenen Working Paper 115 (German language, Working paper, not peer reviewed)	Assessment of people's opinions, attitudes, and doubts on the transformation to a sustainable, bio-based economy by means of a Q-study about the societal perspectives concerning bioeconomy in general, focus group discussion with a focus on consumption followed by a representative online survey in GER
10	[32]	Hempel	2019	Societal perspectives on a bio-economy in Germany: An explorative study using Q methodology	Empirical assessment of people's perspective on bioeconomy in GER by means of Q-type factor analysis and identification of

					three perspectives: “sufficiency and close affinity to nature”, “technological progress”, and “not at any price”
11	[33]	Kokkinos	2018	Fuzzy cognitive map-based modeling of social acceptance to overcome uncertainties in establishing waste biorefinery facilities	Proposal of a novel FCM** modeling approach to analyze the socio-economic implications and to overcome uncertainties occurring in waste biorefinery development and implementation
12	[34]	Macht	2023	Don't forget the locals: Understanding citizens' acceptance of bio-based technologies (preprint, not peer reviewed)	Exploration of the level and determinants of citizen's general and local acceptance of two technologies (biorefineries and aquaponics) in two regions (transition vs. non-transition region in GER) by testing hypothesis based on the data of an online survey with 1989 German participants
13	[35]	Macht	2022	German citizens' perception of the transition towards a sustainable bioeconomy: a glimpse into the Rheinische Revier	Exploration of how citizens perceive the transition process toward a bioeconomy and which factors influence their perception in the context of the phasing out of lignite mining in the Rheinische Revier, GER, by means qualitative content analysis of focus group discussions
14	[36]	Marciano	2014	Factors affecting public support for forest-based biorefineries: A comparison of mill towns and the general public in Maine, USA	Exploration of the social acceptability of forest-based biorefineries in Maine, USA, with focus on the interaction of project attributes and citizens characteristics to affect level of support, by means of random utility modeling to analyze a mail survey with a statewide sample and a subsample of mill towns
15	[37]	Nagy	2021	Social acceptance of forest-based bioeconomy – Swedish consumers' perspectives on a low carbon transition	Contribution to the understanding of the social acceptance and consumer awareness of the forest-based bioeconomy at the example of wooden multi-story buildings in SE
16	[38]	Ranacher	2020	Social dimension of a forest-based bioeconomy: a summary and synthesis	Exploration of the social dimensions of the forest-based bioeconomy by reviewing literature focusing on discourses and perceptions of different actor groups (political decision makers, stakeholders, experts, public, media, and students) in EUR
17	[39]	Zander	2022	Societal Evaluation of Bioeconomy Scenarios for Germany	Gaining an understanding of how citizens in GER assess possible developments associated with transitioning to a bioeconomy by means of a quantitative online survey, in which German citizens were asked to evaluate scenarios modelling the impacts on people's day-to-day lives.

* BECCS: bioenergy with carbon capture and storage; **FCM: fuzzy cognitive map

Table S3: Selected peer-reviewed journal publications used to identify aspects influencing the availability and the supply chain of biomass for the utilization of a CBE technology within a region

Nr.	Reference	First Author	Year	Title	Context
1	[40]	Ahmed	2019	Management of next-generation energy using a triple bottom line approach under a supply chain framework	A multi-objective model (carbon emission, total costs, jobs) is proposed to structure a sustainable supply chain for second-generation biorefineries
2	[41]	Akhtari	2014	The effects of variations in supply accessibility and amount on the economics of using regional forest biomass for generating district heat	Investigation of the impact of forest biomass availability variability throughout the year on the feasibility of meeting the fuel demand of a district heating system in Williams Lake, CAN
3	[42]	Auer	2021	Wood supply chain risks and risk mitigation strategies: A systematic review focusing on the Northern hemisphere	Review: systematic literature review on risks affecting wood supply security and risk mitigation strategies by quantitative and qualitative data analysis with focus on the Northern hemisphere
4	[43]	Black	2016	Developing database criteria for the assessment of biomass supply chains for biorefinery development	Presentation of a database with key criteria required to develop biomass supply chains covering origin, logistics, technical suitability, and policy criteria with focus on agricultural, forestry and processing by-products used for bioenergy, biofuel and bio-based products conversion in biorefineries.
5	[44]	Burli	2021	Farmer characteristics and decision-making: A model for bioenergy crop adaption	Development of an agent-based model to simulate farmer's adoption behavior considering the provision of crop residues or energy crops for bioenergy markets in region covering counties in Nebraska, Kansas, and Colorado, USA.
6	[45]	Charis	2018	A critical taxonomy of socio-economic studies around biomass and bio-waste to energy projects	Review: classification of socio-economic studies on biomass or bio-waste to energy systems as “qualitative” vs. “quantitative & systematic” and “viability” vs. “impact” studies.
7	[46]	Fernández-Puratich	2021	Bi-objective optimization of multiple agro-industrial wastes supply to a cogeneration system promoting local circular bioeconomy	Proposal of an optimization model to evaluate the supply of different biomasses (olive pomace, fruit pits, vineyard pruning) to a CHP system in CHL regarding CO2 emission & costs
8	[47]	Haller	2022	Towards a resilient and resource-efficient local food system based on industrial symbiosis in Härnösand: A Swedish case study	Assessing opportunities and challenges of using sub-exploited waste and by-products (lignocellulosic residues, rock dust, food processing wastes) for innovative food production, facilitated by industrial symbiosis; case study in Härnösand, SE
9	[48]	Kerby	2017	An overview of the utilization of brewery by-products as generated by British craft breweries	Investigation of the utilization/disposal methods British craft breweries apply to their by-products by means of surveys and interviews and comparison of urban vs. rural breweries
10	[49]	Ko	2019	Economic, social, and environmental cost optimization of biomass transportation: a regional model for transportation analysis in plant location processes	Building of a MILP* model based on region-specific data to minimize sustainable transportation costs for alternative bio-energy plant locations; case study in Wisconsin, USA.

11	[50]	Morales	2022	Circularity effect in the viability of bio-based industrial symbiosis: Tackling extraordinary events in value chains	Scenario analysis at mesoscale to identify conditions to implement circularity in the sugar-beet value chain in bio-based industrial symbiosis by means of system dynamic with a focus on the impact of extraordinary events (COVID 19, climate change) case study of the Bazancourt-Pomacle biorefinery, FRA
12	[51]	Nandi	2023	A resource-based and institutional theory-driven model of large-scale biomass-based bioethanol supply chains: An emerging economy policy perspective	Feasibility assessment of setting-up large-scale supply chain of bioethanol based on the regional availability of agricultural residues by means of a supply chain model using the lenses of resource-based view and institutional theory; case study of Punjab State, IND
13	[52]	Raimondo	2018	Making virtue out of necessity: Managing the citrus waste supply chain for bioeconomy applications	Analysis of the current management of citrus waste and Identification of the determinants and barriers that affect an entrepreneur's choice in the destination of citrus waste in south ITA
14	[53]	Sánchez-García	2017	A GIS methodology for optimal location of a wood-fired power plant: Quantification of available woodfuel, supply chain costs and GHG emissions	Establishing a GIS** methodology based on WISDOM database to analyze the viability and optimal location of a new wood-fired power plant in a specific region considering physical and legal accessibility of the resources calculating costs and GHG emissions of the supply chain.
15	[54]	Santibañez-Aguilar	2018	Facilities location for residual biomass production system using geographic information system under uncertainty	Presentation of an GIS-based approach to determine viable facility locations for supply chains based on residual biomass considering environmental, social and geographic restrictions; case study in MEX
16	[55]	Schipfer	2022	Strategies for the mobilization and deployment of local low-value, heterogeneous biomass resources for a circular bioeconomy	Analysis of the challenges and opportunities of feasible strategies for mobilizing and deploying local, low-value and heterogeneous biomass resources for a local circular bioeconomy on the basis on the three assessment levels: the legislative framework, technological innovation, and market creation; with a focus on EUR
17	[56]	Shah	2016	A techno-economic analysis of the corn stover feedstock supply system for cellulosic biorefineries	Stochastic analysis of the techno-economics (resource requirements, like equipment, labor fuel & consumables; and costs) of corn stover supply system for a large scale cellulosic biorefinery in Iowa, USA, using production-scale experimental field data
18	[57]	Sjølie	2016	Willingness of nonindustrial private forest owners in Norway to supply logging residues for wood energy	Investigation of the willingness of nonindustrial private forest owners in NOR to extract logging residues from their forest to supply it to energy production by means of a representative survey.
19	[58]	Tyndall	2011	Woody biomass in the U.S. Cornbelt? Constraints and opportunities in the supply	Exploratory spatial assessment of the availability and accessibility of wood biomass from natural forests and the existing timber industry as well as its potential from short-rotation woody crop plantations in two-ecoregions Mississippi River corridor, USA, using existing forest/timer inventories and in-depth interviews with large regional sawmills
20	[59]	Vacchiano	2018	Assessing the availability of forest biomass for bioenergy by publicly available satellite imagery	Test of an algorithm to predict forest biomass (aboveground live tree volume) using publicly available Landsat satellite imagery and an artificial neural network; case study for the Liguria region, ITA
21	[60]	Valente	2014	Mountain forest wood fuel supply chains: comparative studies between Norway and Italy	Assessment and comparison of two mountain forest wood supply chains, one in NOR and one in ITA considering GHG*** emissions and costs by means of LCA**** and cost analysis
22	[61]	Yazan	2016	Design of sustainable second-generation biomass supply chains	Assessment of the economic and environmental sustainability of different supply chain scenarios for second-generation biomass (lignocellulosic: landscape wood, reed & roadside grass); case study for Overijssel region, NE compares three pyrolysis scenarios (1. mobile pyrolysis & regional upgrading of pyrolysis oil to biofuel; 2. regional pyrolysis & upgrading; 3. mobile pyrolysis & upgrading outside the region) with a biomass-to-electricity plant.
23	[62]	Zimmer	2017	Modeling the impact of competing utilization paths on biomass-to-liquid (BtL) supply chains	Investigation of the impact of established utilization paths on the costs of a large-scale biofuel production value chain by means of a MILP model. For a case study on six regions in CHL, the model first allocates biomass to established CHP plants & domestic consumers and then determines the optimum configuration of the biofuel supply chain (location & capacities of conversion plants, feedstock procurement and transportation)

* MILP: mixed integer linear programming; ** GIS: Geographical Information System; ***GHG greenhouse gas emissions; **** LCA: Life Cycle Assessment

Table S4: Comparison of the CBE criteria catalog before and after the changes resulting from the expert survey. Additions based on expert comments are indicated by solid underlining and deletions by dashed underlining.

- criteria added according to expert comments

- criteria deleted according to expert comments

CRITERIA CATEGORY	main criterion - sub-criterion (no. of publications mentioning criterium) {expert comments (no. of experts)}	collected expert comments	comments on how we implemented the proposed changes
BIOMASS RE-SOURCE	biomass availability (20) <ul style="list-style-type: none"> - sustainably available biomass (5) {should be first (2)} - temporal fluctuation in biomass availability (7) - competing biomass uses security of biomass supply in long term (7) - <u>distribution of biomass availability (point vs. non-point sources*)</u> (1) - local biomass availability (1) {is important (1); should be fourth (1)} 	<ul style="list-style-type: none"> - rank sustainability of biomass first - rank sustainability of biomass first - temporal fluctuations not relevant in forestry - local biomass availability is very important (transportation distances are low, below 150km) - put "distribution of biomass availability (point vs. non-point sources*)" and local biomass availability (1) to the logistics section. - local biomass availability" comes fourth (perishability of biomass and special needs for transportation) 	
	biomass quality (6) <ul style="list-style-type: none"> - no standardization of qualities <u>changes in composition</u> (1) {is important (1)} - <u>changes in composition and qualities</u> (1) - sensitivity to toxicants in biomass (1) 	<ul style="list-style-type: none"> - biomass quality needs depend on end-user. - it is all about standardization of quality. - "no standardization of inputs" and "changes in composition and qualities" could be merged 	
TECHNO-LOGICAL	logistic & supply chain (17) <ul style="list-style-type: none"> - storage and transportation (5) - <u>bulk density of biomass</u> {should be added (1)} - <u>loading and offloading of biomass</u> {should be added (1)} - space for/ position of facility (4) - waste <u>by-product separation</u> and collection systems (4) - <u>waste separation</u> (1) - <u>distribution of biomass availability (point vs. non-point sources*)</u> (1) {should be moved from biomass availability to here (1)} - <u>high demands: electricity, water...</u> (1) 	<ul style="list-style-type: none"> - combine waste collection systems and waste separation. - add bulk density of biomass as a sub criterion for transportation. - loading and offloading of biomass a sub criterion for transportation. - wording: better "by-product" instead of "waste" 	
	availability of technology (17) <ul style="list-style-type: none"> - technology efficiency conversion rates (5) {should be first (1)} - complexity of technology ease of adoption (1) {should be second after maturity (1)} - successful technology showcases (3) {should be ranked higher (1)} - maturity of technology need for scale up (7) - <u>availability of processing industry & start-ups in the region</u> {should be added (1)} 	<ul style="list-style-type: none"> - add availability of processing industry in the region - add availability of start-ups - "efficiency" first - "showcases" should be in a more relevant position. - "complexity of technology ease of adoption" comes second. - "complexity of technology ease of adoption" should be ranked higher 	
	availability of knowledge/expertise R&D (11) <ul style="list-style-type: none"> - local tradition of knowledge (1) {should be first (2)} - locally based scientific institutions (2) - advances in sciences (e.g., biological and CIT) (1) 	<ul style="list-style-type: none"> - "local tradition of knowledge", entrepreneurial skills operators who know their work are most important. - "local tradition of knowledge" comes first 	

ENVIRON- MENTAL	<p>potential to mitigate/increase environmental issues** (14) {sub-criteria should not be ranked (3)}</p> <ul style="list-style-type: none"> - climate change - biodiversity ecosystems - land use (change) - soil- and water quality - waste generation - resource scarcity (resource efficiency circularity) - <u>water depletion</u> 	<ul style="list-style-type: none"> - evaluation and ranking are difficult since a possible increased pressure and the possible mitigation potential are combined in one category. - ranking depends on different biomass resources. - waste generation and resource efficiency do not seem relevant in this context. - impacts should not be ranked in order of importance as they are biomass specific. - add water availability (e.g., for irrigation in competition to other sectors) 	<ul style="list-style-type: none"> - instead of ranking the criteria by relevance we ordered them content wise and deleted the information about the no. of studies mentioning the criteria. - rather MFA indicators instead of LCA indicators that are also important to assess circular bioeconomies. Added that it refers to the LCA impact category resource scarcity.
	<p>sensitivity towards environmental changes/ issues*** (3)</p> <ul style="list-style-type: none"> - climate change <ul style="list-style-type: none"> - <u>potential for adapting to climate change through plant breeding</u> - soil conditions - water scarcity - <u>land availability</u> 	<ul style="list-style-type: none"> - water scarcity is regionally dependent. - ranking in a general way is difficult. - breeding potential of plants for climate change adoption impacts should not be ranked in order of importance as they are biomass specific. - add water availability and land availability 	<ul style="list-style-type: none"> - water availability is included in water scarcity
ECO-NOMIC	<p>profitability & markets (18)</p> <ul style="list-style-type: none"> - knowledge of customer's needs (3) {should be first (1)} - market demand unfavorable markets (6) {should be second (1)} - competitiveness (with fossil counterparts) (7) {should be third (1)} <ul style="list-style-type: none"> - fluctuations in fossil fuel's prices (1) - value creation from waste/ by-products (4) {should be fourth (1)} - cost-effectiveness (6) {should be fifth (1)} - economic benefits due to multiple product output (3) {should be sixth (1)} - immature markets need to develop new market (4) {should be seventh (1)} - business diversification (3) {should be eighth (1)} 	<ul style="list-style-type: none"> - policy measures: e.g. incentives, subsidies, e.g. carbon costs, blending mandates. - the prioritization should be the following: - knowledge of customer's needs; market demand unfavorable markets; competitiveness (with fossil counterparts); value creation from waste/ by-products; cost-effectiveness; economic benefits due to multiple product output; immature markets need to develop new market; business diversification 	<ul style="list-style-type: none"> - is included in political criteria
	<p>investment (15)</p> <ul style="list-style-type: none"> - need for financial investment <u>lack of financial resources</u> (9) - public incentives and subsidies (8) - private investor's interest (5) - <u>lack of financial resources</u> (2) 	<ul style="list-style-type: none"> - overlap of "lack of financial resources" and "need of financial investment" 	
	<p>operational costs (9)</p> <ul style="list-style-type: none"> - costs of raw material, esp. biomass (6) <ul style="list-style-type: none"> - <u>costs of harvesting biomass</u> {should be added (1)} - supply chain costs, esp. logistic costs (4) <ul style="list-style-type: none"> - <u>costs of loading/offloading</u> {should be added (1)} - <u>costs of storing and handling biomass</u> {should be added (1)} - <u>costs of waste disposal</u> {should be added (1)} - <u>personnel costs</u> {should be added (1)} 	<ul style="list-style-type: none"> - add costs of harvesting, storing, and handling - add loading/offloading of biomass. - costs of biomass are often underestimated (50% of total costs) - personal costs are a further factor, but less important when processes are highly automated. - costs of processing, costs of waste disposal, water demand etc. 	<ul style="list-style-type: none"> - we rephrased the sub-categories "cost of biomass" into "costs of raw material, esp. biomass" and "logistic costs" into "supply chain costs, esp. logistic costs", to generalize them.
	<p>general socio-economic development (3)</p> <ul style="list-style-type: none"> - population development (2) - economic crises (1) {should be equal to first (1)} - <u>prioritization of local economy</u> {should be added (1)} 	<ul style="list-style-type: none"> - rank population development and economic crises equal - "prioritization of local economy" could be included 	

POLITICAL & LEGISLATION	<p>policies, legislation & standards (18)</p> <ul style="list-style-type: none"> - <u>existence</u> lack of supporting policies and legislation (15) <ul style="list-style-type: none"> - <u>carbon costs</u> (should be added (1)) - <u>blending mandates</u> (should be added (1)) - unfavorable inadequate <u>inconsistent</u> policies and legislation (10) - <u>inconsistent policies and legislation</u> (1) - normative tools such as technical standards and certifications (1) - availability and direction of regional policies and legislation (1) 	<ul style="list-style-type: none"> - avoid overlaps: combine “missing policies and legislations and “inconsistent policies and legislation” with other criteria. - move “uncertainties in future legislation (...)” here. - European vs. national/regional legislation - “supporting policies and legislation”, “unfavorable inadequate policies and legislation”, “inconsistent policies and legislation” are similar and strongly interconnected 	<ul style="list-style-type: none"> - we combined it instead with “unfavorable and inadequate policies...” - we see it rather as a policy implementation issue and keep it there. - is included in “inconsistent policies and legislation”
	<p>policy implementation (8)</p> <ul style="list-style-type: none"> - uncertainties in future legislation (predictable, less turbulent) (3) (should be first (1)) - ineffectual execution (4) - excessive bureaucracy (2) 	<ul style="list-style-type: none"> - “uncertainties in future legislation” should be ranked highest, political risks are hated by markets 	
SOCIAL	<p>jobs & labor (15) (should be first (1))</p> <ul style="list-style-type: none"> - availability of skilled labor & <u>trainings</u> (10) (is important (1)) - job creation (in rural areas) (6) - labor conditions (1) 	<ul style="list-style-type: none"> - new order of main criteria - jobs and labor, social acceptance, company/regional culture, consumer awareness, cooperation - add training, e.g., as second priority. 	
	<p>social acceptance (production) (12) (should be second (1))</p> <ul style="list-style-type: none"> - <u>public acceptance</u> (7) - competition for biomass with food production (5) - interfering civil society <u>culture of participation</u> (3) - promotion <u>information</u> <u>involvement</u> to increase acceptance (3) - <u>interfering civil society</u> <u>promotion to increase acceptance</u> (5) - <u>NIMBYism</u> (2) - impacts on human health (1) 	<ul style="list-style-type: none"> - “competition for food production” as sub-criterion of “public acceptance” - separate “interfering social society” and “promotion to increase acceptance.” - Normal forest practices are not perceived as sustainable from certain environmental groups. - Do “impacts on human health” belong here, or only in the “environmental” dimension? 	<ul style="list-style-type: none"> - we deleted “public acceptance” as sub-criterion and extracted instead a further sub-criterion “NIMBYism” from the literature. - we separated as proposed and added items to the promotion criteria. - as proposed in the cooperation main criteria, we added the civil society sub-criteria the culture of participation. - as human health rather considers the society than the environment, we keep it here as social criterion
	<p>company culture regional culture (11) (should be third (1))</p> <ul style="list-style-type: none"> - commitment to sustainability, esp. environ. protection (4) - vision-driven culture willingness to change (4) - willingness to cooperate (2) - closed-loop thinking (2) - innovative, agile, imaginative & creative (1) - <u>non-hierarchical</u> (1) 	<ul style="list-style-type: none"> - difficult to understand “non-hierarchical”; better “flat hierarchy”? In any case it does not belong here. 	
	<p>consumer awareness (product) (14) (should be fourth (1))</p> <ul style="list-style-type: none"> - consumer’s perception of product quality (e.g., non-primary cycle) (4) (should be first (1)) - consumer reluctance to change (1) (should be second (1)) - green consumerism (bio-based and waste valorization) (9) <ul style="list-style-type: none"> - <u>willingness to pay a premium for “green” products</u> (should be added (1)) - awareness of CBE products (6) - regionality of products (2) 	<ul style="list-style-type: none"> - explanations “bio-based & waste valorization” is confusing. - add willingness to pay a premium for “green” products. - first two should be: “consumer’s perception of product quality (e.g., non-primary cycle)”, “consumer reluctance to change” 	

	cooperation (16) {should be fifth (1)} - stakeholder involvement (7) - <u>cooperation between primary producers</u> {should be added (1)} - clusters & networks (7)	- culture of participation, as it can differ in regions (e.g., low in Eastern Europe) - add cooperation between primary producers to gain biomass from huge geographical area
METHODO-LOGICAL	uncertainties in environmental & economic assessment (3) - availability of data for econ./ environ. evaluation (2) {should be first (1)} - availability of (standardized) methodologies (3) - availability of results (1)	- rank "availability of data ..." first, as it is necessary for standardization development. - ongoing work to define what is sustainable forest practices, and how this should be integrated into legislation. - difficult to understand

Table S5: Attribution of region- and technology-specific sub-criteria to the four criteria clusters biomass supply chain, environmental impacts, policies & legislation, and social acceptance & consumer awareness

BIOMASS SUPPLY CHAIN (37)	ENVIRONMENTAL IMPACTS (17)						
<ul style="list-style-type: none"> - sustainably available BM (5) - competing BM uses security of BM supply (7) - local BM availability (1) - storage & transportation of BM (5) - waste & by-product separation & collection (4) - distribution of BM availability (1) - space for facility position of facility (4) - successful technology showcases (3) - availability of processing industry in region - availability of start-ups in region - local tradition of technological knowledge (1) - cost of BM (incl. supply chain costs) (6) 	<ul style="list-style-type: none"> - potential to influence the environment (14): <ul style="list-style-type: none"> - biodiversity ecosystems - land use (change) - soil- & water quality - water depletion - waste generation - sensitivity to environmental change (3): <ul style="list-style-type: none"> - climate change - soil conditions - water scarcity - availability of land 						
POLICIES & LEGISLATION (1)	SOCIAL ACCEPTANCE & CONSUMER AWARENESS (61)						
<ul style="list-style-type: none"> - availability & direction of regional policies (1) - availability & direction of regional legislation 	<ul style="list-style-type: none"> - social acceptance: <ul style="list-style-type: none"> - competition for BM with food production (5) - interfering civil society participation culture (3) - promotion information involvement (3) - NIMBYism (2) - impacts on human health (1) - consumer awareness: <ul style="list-style-type: none"> - perception of product quality (4) - consumer's reluctance to change (1) - green consumerism (9) - awareness of CBE products (6) - regionality of products (2) - knowledge of customer's needs (3) - market demand unfavorable markets (6) - personnel costs - availability of skilled labor & trainings (10) - job creation (in rural areas) (6) 						
CRITERIA CATEGORIZATION: <table style="display: inline-table; vertical-align: middle; margin-left: 10px;"> <tr> <td style="background-color: #d9ead3; padding: 2px;">BIOMASS RESOURCE</td> <td style="background-color: #d9ead3; padding: 2px;">POLITICAL & LEGISLAT.</td> <td style="background-color: #d9ead3; padding: 2px;">ENVIRONMENTAL</td> </tr> <tr> <td style="background-color: #d9ead3; padding: 2px;">TECHNOLOGICAL</td> <td style="background-color: #d9ead3; padding: 2px;">ECONOMIC</td> <td style="background-color: #d9ead3; padding: 2px;">SOCIAL</td> </tr> </table>		BIOMASS RESOURCE	POLITICAL & LEGISLAT.	ENVIRONMENTAL	TECHNOLOGICAL	ECONOMIC	SOCIAL
BIOMASS RESOURCE	POLITICAL & LEGISLAT.	ENVIRONMENTAL					
TECHNOLOGICAL	ECONOMIC	SOCIAL					

* Numbers in brackets besides the criteria indicate the number of publications mentioning the criterion (see table 1 in the main paper). Numbers in brackets below the criteria cluster are the sums of the numbers from the sub-criteria belonging to the cluster.

<p>ECOSOCIAL CAMP ~ 33% of population in GER</p> <ul style="list-style-type: none"> clearly pro-ecological and pro-transformative mentalities mentalities mostly sceptical of economic growth mentalities identify with far-reaching ideas of a post-fossil transformation 	<p>LIBERAL-ESCALATORY CAMP ~ 40% of population in GER</p> <ul style="list-style-type: none"> mentalities mostly holding contented and optimistic views ...consumerist attitudes and positive stances on growth ideas about transformations that could impact one's personal mode of living are eyed with reluctance; changes are only seen as acceptable if they promise to come with ongoing economic growth and increasing material prosperity (green growth) 	<p>AUTHORITARIAN-FOSSILIST CAMP ~ 25% of population in GER</p> <ul style="list-style-type: none"> Dominated by feelings of loss and the perception of omnipresent threats ...by fervent opposition to any kind of change; ideal: unconditional preservation of the status quo, or even a return to outdated economic and social models of the 20th century Largely irreconcilable with any kind of bio-based transition
<p>ACTIVE ECOSOCIAL CITIZENSHIP 11%</p> <ul style="list-style-type: none"> Strong advocacy of socio-ecological motivated change, willingness to reform, support for ecosocial positions at the level of everyday practice and through active political action. View that collective and conflictual political action is necessary and that societal, supra-individual structures need to change; Critical of growth, differentiation from consumerist orientations Tendency to see themselves as an active player, focus on their own everyday practice, high tendency to actively engage in ecological causes (online campaigns, local change initiatives, demonstrations, practical, financial and idealistic participation in the expansion of RE infrastructure far above average); interested in their own advancement <u>Everyday practice</u>: the majority buy green electricity, organic food and environmentally friendly products more often than in other clusters. Everyday mobility often designed to be environmentally friendly, number of cars is well below average, ϕ-CO₂ emissions only slightly below average, mainly due to the practice of flying, not below average. 	<p>INERT CONTENTMENT 11%</p> <ul style="list-style-type: none"> No active support for socio-ecological concerns, but no principled, ideological rejection, pragmatic view with regard to own benefit/harm; adherence to unsustainable practices, declared ignorance of the need for change, at best cautious, well-considered change in own practice; expectation of politics to manage the necessary change in the economy with strength without affecting own way of life. Differentiation from consumer-materialistic attitude (against running after perceived trends) Low willingness to engage in various forms of engagement. Forms of engagement, especially accompanied by active public positioning (demonstrations, petitions, participation in initiatives), but often participation in planning and approval procedures, quite active part of civil society, especially in rural areas Optimistic assessment of own situation and politics, moderately conservative <u>Everyday practice</u>: ϕ-CO₂ approx. sample ϕ, tendency to use more cars, more frequent avoidance of environmentally friendly forms of transport, $\frac{1}{4}$ no flights for private purposes within a year, more meat, frequent purchase of energy-efficient appliances 	<p>OVERSTRAINED REGRESSION 9%</p> <ul style="list-style-type: none"> Environmental changes perceived as highly threatening; (catastrophe that can hardly be averted); change is viewed critically, especially if it has a potentially negative impact on one's own social situation (unfairly distributed burdens, rising costs, loss of jobs due to structural change), market and logic of constant growth. Growth seen critically, techno-optimized ideas appear to be hubris Privatistic withdrawal: resignation, sometimes active resistance to change, often regressive, resentment-based perceptions. Opportunities to exert influence are not seen. Far below average in commitment to ecological concerns. Feeling of disadvantage, subjective overburdening with perceived social change, 2/3 see themselves as missing out in the social distribution of wealth. <u>Everyday practice</u>: ϕ-CO₂ forced below average; few to barely average number of cars, environmentally friendly mobility, partly forced, more frequent; often-very often no flights for private purposes, often high meat consumption, strong preference for energy-efficient appliances, purchase of products with environmental seal and organic food, purchase of green electricity, construction of RE plants, financial investments in RE funds/projects rare
<p>INDIVIDUALIST ALTERNATIVE MILIEU 9%</p> <ul style="list-style-type: none"> Pro-ecological attitude and objectives, policy options and concrete measures find unconditional support, clearly in favor of a post-fossil change; rather no demand for binding societal rules to overcome the fixation on growth, (intuitively perceived as a restriction rather than an enabling structure), small-scale individualistic ecological orientation, possibilities for societal transformation primarily at the level of everyday practice; societal change as the sum of small-scale everyday change, political and societal transformation primarily at the level of everyday practice, political commitment considerably higher than in the overall sample, clearly behind socially active groups, participation in Protest against wind power or power line significantly increased Optimism <u>Everyday practice</u>: comparatively sufficient lifestyles; few cars, often no animal products, low energy consumption), partly more pronounced than in active ecosocial civic, but less politically framed, significantly fewer respondents have not flown for private purposes, and more once or twice, ϕ-CO₂ significantly below average than in active ecosocial civic 	<p>CONTENTED UNSUSTAINABILITY 13%</p> <ul style="list-style-type: none"> verbally pro-ecological attitude; ecologically motivated forms of change are not rejected, but met with an open mind, concrete measures find little approval; change recognized as necessary as a purely technical challenge, it should have no effect on one's own life, hardly any willingness to reform. Consumerism. Tendency to elevate one's own actions to a legitimate guideline for action. Change should have no effect on one's own life. Green growth. Preference for technical solutions There is practically no active engagement, very low participation in demonstrations, change initiative Optimism <u>Everyday practice</u>: ϕ-CO₂ significantly above average, above-average number of cars per household with comparatively high mileage; rarely no flying for private purposes within a year, more often several times; below-average environmentally friendly transportation, significantly often always or mostly eating meat. Little interest in energy-efficient appliances; above-average purchase of EE systems and investment in EE 	<p>PSEUDOAFFIRMATIVE INERTIA 8%</p> <ul style="list-style-type: none"> Strong tendency to affirm everything; strong tendency to adhere to growth-oriented thought patterns and to resist change in own life as a result of ecological reform movement; agreement with "persistence" items (no regulations, sustainable raw material use less important, climate change less threatening, growth at the expense of the environment more often supported, market is trusted more than average). ; negative attitude towards incorporating ecological aspects into one's own actions. Strong rejection of the energy turnaround in specific aspects Private life as a separate sphere of sovereignty, society as threatening or disruptive, low tendency towards commitment and denial of the importance of politics for one's own life; perception of the world characterized by fears and feelings of threat, decline of reliable structures. <u>Everyday practice</u>: ϕ-CO₂ just above average, slightly more cars but short distances, little use of environmentally friendly transportation, more often not flown for private purposes; high proportion of frequent/always meat, organic and eco-labelled products not avoided or preferred, strong preference for energy-efficient appliances.
<p>ECOSOCIAL CONTENTMENT 13%</p> <ul style="list-style-type: none"> Pro-ecological stance, more than clear support for socio-ecological concerns, declared openness to change (willingness to reform), necessity of far-reaching change is recognized and also accepted in its possible effects on one's own life Pronounced tendency to withdraw into the private sphere, little willingness to actively engage, increased participation in online campaigns, no increased participation in demonstrations or local transformation initiatives, rarely direct influence via approval procedures and energy cooperatives Optimistic view of the world and of one's own situation and future <u>Everyday practice</u>: ϕ-CO₂ approx. ϕ of the ecosocial camp, little car driving, living space below average, preference for energy-efficient products, rarely meat, meatless little in comparison to other ecosocials, hardly any frequent flying, but none significantly lower flight frequency than in the sample ϕ 	<p>ECOSOCIAL IGNORANCE 8%</p> <ul style="list-style-type: none"> (Very) strong tendency towards disinterest or rejection of ecological concerns; very strong orientation towards realization of own wishes, restrictions on living standards are rejected, responsibility for social issues is not seen; uncritical support of market and growth as a means of increasing own prosperity. Active, intentional ignoring, deprioritizing and suppression of ecological issues (perceived as unimportant); belief in technical solvability of all problems Optimistic, firm belief in own ability to master life with confidence Commitment to ecological goals far below average, interest in power and influence, but not in engagement. <u>Everyday practice</u>: ϕ-CO₂ very high, number of cars average to above average; frequent to very frequent avoidance of environmentally friendly transportation, max. $\frac{1}{2}$ of respondents have not flown, up to 1/3 have flown several times for private purposes, far fewer buy organic or eco-labelled products, significantly more than 1/3 eat meat most of the time or always, little interest in energy-efficient appliances, few use green electricity, electricity consumption is rated as low, appliances, few use green electricity, electricity consumption is considered high 	<p>IDEOLOGICAL ANTI-ECOLOGISM 8%</p> <ul style="list-style-type: none"> Particularly aggressive, defensive attitude against socio-ecological ideas, ideological anti-ecological and anti-change disposition, against cosmopolitan targeted anti-consumerism, opposition to the energy transition, especially in its specific manifestation, ecological behavioral demands trigger anger far more often, clearly more willing to prosper at the expense of the environment, only 1/10 for exit from fossil fuels, savings in their own lives are rejected; $\frac{1}{4}$ (double compared with average) feel disturbed by wind power in the surrounding area. Anti-authoritarian, racist and reactionary attitudes; perception of precarity, only 40% think they have received a fair share of prosperity, commitment to ecological concerns rare <u>Everyday practice</u>: ϕ-CO₂ above average, number of cars relatively high, rarely or never environmentally friendly. Transportation, significantly lower propensity to fly (3/4 never flew), pronounced aversion to organic and eco-labelled foodstuffs, energy efficient appliances significantly lower, electricity consumption high, high meat consumption matter of course for 1/3.

Figure S1: Description of social camps and mentalities from our own compilation of information taken from [27] and [26]

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