

Regional development opportunities based on flexible biomass value networks by the BioSyn Working group on lifting Bioeconomy Synergy potentials

**Collaboration workshop between IEA Bioenergy TCP Task 40, 42, 43, 44, 45 and the Horizon 2020
BRANCHES project**

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INTRODUCTION AND SETTING

An intertask working group (BioSyn) was initiated following up on the discussions at the [IEA Bioenergy Task 43 and BioEast Initiative Workshop](#) (2019 October 10th) and the [IEA Bioenergy Conference 2021 session on biomass mobilization](#) (2021 November 30th). The working group set out to further explore possible overlapping research questions, especially concerning small to medium scale Bioeconomy enterprises (SMBEs), mobilizing low-value, heterogeneous biomass while providing benefits to regional communities. Table 1 summarizes the most current pre-projects providing the basis and initial intertask perspectives for this working group:

Table 1: Basis for the discussions in the intertask working group.

<p>Task 43 on Biomass Mobilization (Biljana KULIŠIĆ)</p> <p>Kulisc, B., Brown, M., Dimitriou, I., Gagnon, B., Murphy, K., Task 43 and BioEast Workshop Summary Report. 2020 https://task43.ieabioenergy.com/wp-content/uploads/sites/11/2020/04/TR2020_01-Sopron_T43_workshop_REPORT_final.pdf</p> <p>Nasso, S. and Sweazey (Stratos), B. Bio-hubs as Keys to Successful Biomass Supply for the Bioeconomy (Canada) Report from Joint IEA Bioenergy Task 43 and Natural Resources Canada Workshop 2020. https://task43.ieabioenergy.com/wp-content/uploads/sites/11/2020/07/Canadian-Bio-hubs-Workshop-Report-Task-43-FINAL_LP-002.pdf</p> <p>Kulisc, B.; Gagnon, B.; Schweinle, J.; Van Holsbeeck, S.; Brown, M.; Simurina, J.; Dimitriou, I.; McDonald, H. The Contributions of Biomass Supply for Bioenergy in the Post-COVID-19 Recovery. <i>Energies</i> 2021, 14, 8415. https://doi.org/10.3390/en14248415</p> <p>Kulisc, B., Radic, T., Njavro, M. Strategies for post-harvesting management systems to transition to bio-hubs. <i>Energies</i> 2022, 14, x. https://doi.org/10.3390/xxxx</p>
<p>Task 40 on the Deployment of Biobased Value Chains (Fabian SCHIPFER)</p> <p>Results from the Task 40 Regional Transitions Project WP2. Schipfer, F., Pfeiffer, A., Hoefnagels, R., 2021. Strategies for the Mobilization and Deployment of Local Low-Value, Heterogeneous Biomass Resources for a Circular Bioeconomy. https://doi.org/10.20944/preprints202112.0129.v1</p> <p>Results from the Task 40 Bioeconomy Synergies Project. Schipfer, F., Burli, P., Hennig, C., Fritsche, U., Li, C., Wild, M., Bioeconomy Synergies Project Progress & Prospects Report 2019-2021. https://task40.ieabioenergy.com/wp-content/uploads/sites/29/2022/08/Task40_Bioeconomy_Synergies_2019-2021.pdf</p>
<p>Task 44 on Flexible Bioenergy and System Integration (Fabian SCHIPFER)</p> <p>Schipfer, F., Mäki, E., Schmieder, U., Lange, N., Schildhauer, T., Hennig, C., Thrän, D., 2022. Status of and expectations for flexible bioenergy to support resource efficiency and to accelerate the energy transition. <i>Renewable and Sustainable Energy Reviews</i> 158, 112094. https://doi.org/10.1016/j.rser.2022.112094</p>

To reflect on the findings of the BioSyn working group and to gather the perspectives from other related Tasks and experts of the IEA Bioenergy community, all "strategic" (as opposed to technical) IEA Bioenergy TCPs (Tasks 40, 42, 43, 44 and 45) agreed to participate in a joint online workshop on 2022 November 2nd. While the technical IEA Bioenergy TCPs (Task 32, 33, 34, 36 and 39) hold valuable perspectives to flexible Bioeconomy value networks too, the working group decided to involve them only in, the follow-up to this workshop, and after initiating the discussion in the smaller round. The organizers warmly thank all participants, listed in Table 2, and signed-up, but excused experts, for their interest, and for sharing personal insights and presenting perspectives from the Tasks. Next to the task leaders of Task 40, 43, and 44, also Task leaders and representatives of the following tasks and an external project joined the workshop:

[Task 42 on Biorefining in a Circular Economy](#)

[Task 45 on Climate and Sustainability Effects of Bioenergy within the broader Bioeconomy](#)

[BRANCHES \(Horizon 2020 CSA\) on Boosting Rural Bioeconomy Networks Following Multi-Actor Approaches \(Grant Agreement number 101000375\)](#)

Table 2: Invited experts for the 2022 November 2nd workshop on collaboration potentials concerning regional, flexible, Bioeconomy value networks.

IEA Bioenergy Tasks/EU projects	Participating (13 individuals holding 17 IEA Bioenergy TCP functions) and signed-up, but excused experts (6 individuals)
Task 40	<p>Participants:</p> <ul style="list-style-type: none"> • Christiane Hennig (presentation on the Task 40 perspectives) DBFZ - Deutsches Biomasse Forschungszentrum (Germany) • Nora Lange DBFZ - Deutsches Biomasse Forschungszentrum (Germany) • Fabian Schipfer TUW - Technische Universität Wien (Austria) • Birger Kerckow FNR - Fachagentur Nachwachsende Rohstoffe (Germany) <p>Signed-up, but excused:</p> <ul style="list-style-type: none"> • Uwe Fritsche IINAS - International Institute for Sustainability Analysis and Strategy (Germany) • Ric Hoefnagels UU - Utrecht University (Netherlands) • Bettina Muster AEE - Institute for Sustainable Technologies(Austria) • Judith Buchmaier AEE - Institute for Sustainable Technologies(Austria)
Task 42	<ul style="list-style-type: none"> • Bert Annevelink (presentation on the Task 42 perspectives) WUR - Wageningen University and Research (Netherlands)
Task 43	<ul style="list-style-type: none"> • Bruno Gagnon (presentation on the Task 43 perspectives)

	<p>NRC - National Resources Canada (Canada)</p> <ul style="list-style-type: none"> • Jörg Schweinle Thünen Institute of International Forestry and Forest Economics (Germany) • Dan Bergström SLU - Swedish University of Agricultural Sciences (Sweden) • Keith L. Kline ORNL - Oak Ridge National Laboratory (United States) • Biljana Kulišić EC - European Commission (Belgium)
Task 44	<p>Participants:</p> <ul style="list-style-type: none"> • Elina Maki (presentation on the Task 44 perspectives) VTT- Technical Research Centre of Finland (Finland) • Christiane Hennig DBFZ - Deutsches Biomasse Forschungszentrum (Germany) • Nora Lange DBFZ - Deutsches Biomasse Forschungszentrum (Germany) • Fabian Schipfer TUV - Technische Universität Wien (Austria) <p>Signed-up but excused:</p> <ul style="list-style-type: none"> • Markus Gölles BEST - Bioenergy and Sustainable Technologies GmbH (Austria)
Task 45	<p>Participants:</p> <ul style="list-style-type: none"> • David Styles (presentation on the Task 45 perspectives) UL - University of Limerick (Ireland) • Jörg Schweinle Thünen Institute of International Forestry and Forest Economics (Germany) <p>Signed-up but excused:</p> <ul style="list-style-type: none"> • Uwe Fritsche IINAS - International Institute for Sustainability Analysis and Strategy (Germany) • Göran Berndes Chalmers University of Technology (Sweden)
BRANCHES project	<ul style="list-style-type: none"> • Laura Garcia (presentation on the BRANCHES project perspectives) DBFZ - Deutsches Biomasse Forschungszentrum (Germany) • Elina Maki (presentation on the BRANCHES project perspectives) VTT- Technical Research Centre of Finland (Finland)

The 2 hours online workshop was used to:

- present the preliminary results of the working group,
- for introducing the Tasks and topic-specific perspectives by the Task leaders and one external project,
- the discussion of collaboration opportunities between the Tasks and beyond,
- and possibly relevant key performance indicators for measuring the success of regional, flexible, Bioeconomy networks.

In the following, we provide a short overview of the presented results of the working group and conclude with a comprehensive mapping of collaboration opportunities between the IEA Bioenergy TCP Tasks and beyond, derived from the workshop discussions.

RESULTS OF THE BIOSYN WORKING GROUP

The workshop was seeded with a presentation providing a preliminary overview of the discussion of the working group on regional, flexible bioeconomy value networks, using multiple feedstocks (including wastes and residues) to provide multiple products, including bioenergy. A SWOT analysis for switching from linear supply chains to bioeconomy value networks is shown in Table 3.

Table 3: A SWOT analysis for switching from linear supply chains to Bioeconomy value networks.

	Strengths	Weaknesses
Internal factors	<ul style="list-style-type: none"> • Multipurpose infrastructure • Jobs & skilled labor & stakeholder diversity • Efficient valorization of residues • Flexibility concerning harvest output • Flexibility concerning product demand • Improved reliability & efficiency 	<ul style="list-style-type: none"> • Additional investments will be needed • Topping the operational costs • Knowledge on biotechnology required • Need for precise & responsible nutrient cycling • Coupled supply risks • Coupled demand risks • Higher complexity
	Opportunities	Threats
External factors	<ul style="list-style-type: none"> • Food system resilience • "Sustainability" or "Circularity" premium • Standardization & certification of <u>biobased</u> products creating new commodity markets • Similar policy push for Biorefinery communities as for energy communities • Trend towards precision farming & value network digitalization • Wider deployment of biomass for bioenergy 	<ul style="list-style-type: none"> • Limited knowledge capture capacity of operators • Difficulties unlocking premium willingness to pay • High costs of standardization & certification • Too narrow standards / legal barriers • Weak regional structures, lack of CSBE ecosystem at place • Lack & non-transparency of data (potentials, structural, inventory, GIS) • Lack of digital infrastructure

A winery case study was used to discuss strengths, weaknesses, opportunities, and threats based on specific examples. Namely, from the body of research that is focused on the food supply resilience, post-harvest management systems were identified as single entry points to improve the food resilience through more efficient use of the existing infrastructure. In parallel, Task 43's research showed expanding post-harvest management systems to agri-bio-hubs as a better alternative to a greenfield investment to collect, store and sell secondary biomass and waste from agriculture to the market. A theoretical econometric analysis on the mobilization of residues and by-products from wine production contrasts the additional mobilization costs with additional revenue streams. This can be a decision making aid to the post-harvest management system operator on engaging in the transition.

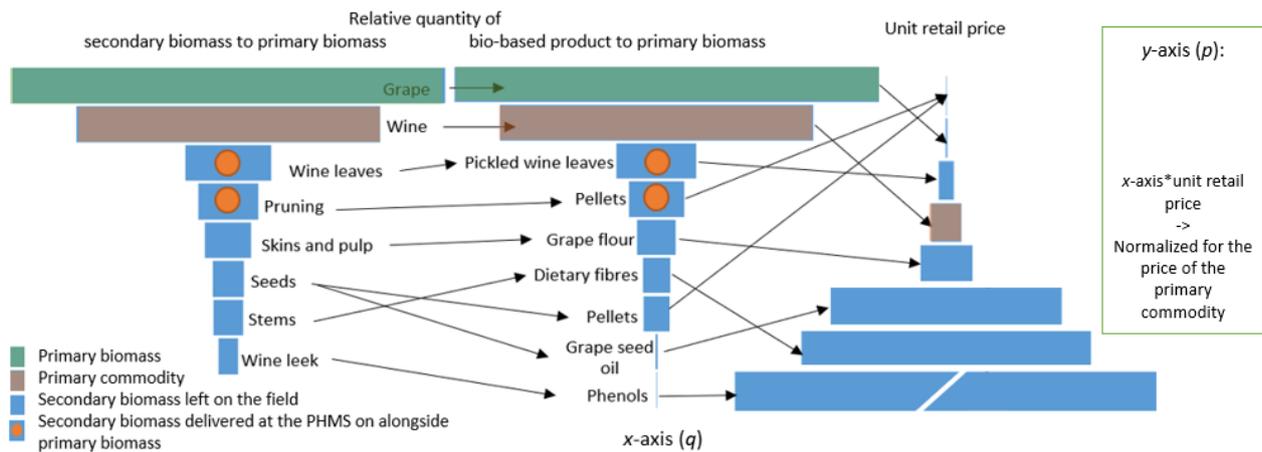


Figure 1: Winery case study analyzing the economic effects of mobilizing residues and by-products for multiple bio-based products.

Then, we significantly **increased the abstraction level** to probe the causes of potential benefits beyond the economic net-profit of residue mobilization. We denoted the shift from linear supply chains to Bioeconomy value networks as "system integration." We addressed the elephant in the room for measuring the potential benefits of system integration, which would finally allow us to design market and policy frameworks to reward those benefits accordingly. As presented in Figure 2, we can only uncover identified gaps in measuring and rewarding the benefits of system integration.

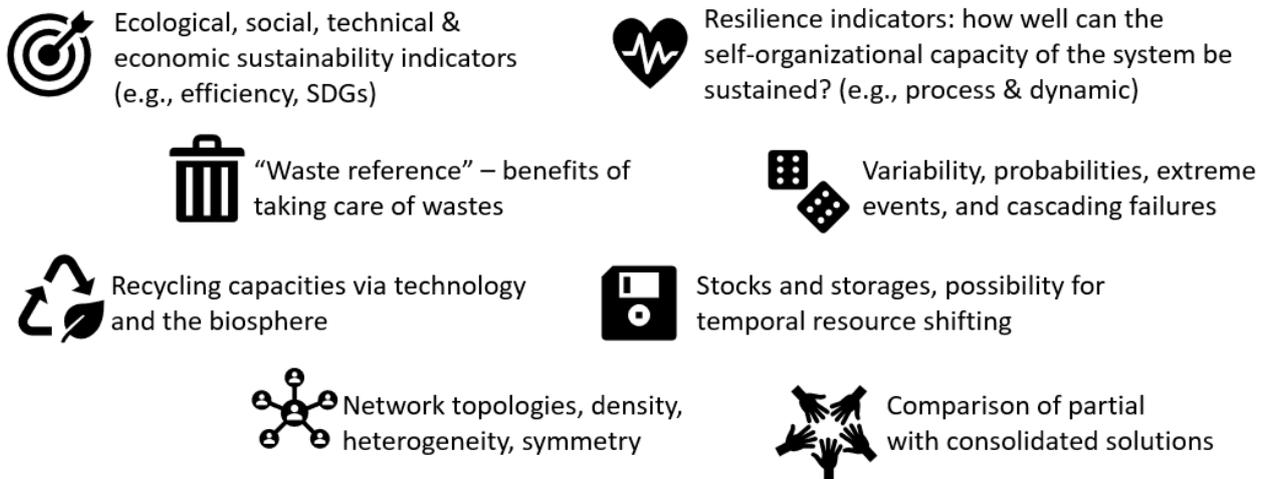


Figure 2: Identified gaps in the capacity to measure and consequently of framework designs to reward the benefits of system integration.

OUTCOME AND COLLABORATION OPPORTUNITIES BETWEEN THE TASKS AND BEYOND

The workshop's primary goal was to share the preliminary results of the working group and identify possible collaboration opportunities. Respective opportunities were mentioned in the presentations by the Task leaders, gathered in the open discussion, chat, and a short mentimeter exercise at the end of the workshop. For this report, we cluster the collaboration opportunities in five thematic areas; (1) potentially relevant case studies, (2) regions, regional considerations, small- and medium-sized Bioeconomy enterprises, (3) key-performance indicator (KPI) discussions (4) modeling work and (5) framework design. The opportunities are listed in the following, where possible and useful starting with the Task number and expert mentioning the respective opportunity (first letter of surname and first name):

(1) Case studies potentially relevant for the flexible, regional, Bioeconomy, value network discussion

- Task 42: Fact sheets (TL: AT).
- Task 42 (BA): Biorefineries as an important link in networks, albeit considered large-scale
- Task 42 (BA): T3.2: Green Biorefinery status report (TL: DK)
- Task 43 (BG): Characterization of biomass (inputs) and commodities (outputs) through innovative biohubs
- Task 44 (EM): Best flexible bioenergy practices from D1.2
- Task 45 (KK): Pellet industry offers an example of functioning biohubs supporting biomass commodity markets - will the expansion of the biohubs concept depend on (1) assured market pull and (2) clear specifications for required qualities of commodities?
- Task 45 (DS): Example biorefinery case studies from Ireland (grass & bio-waste feedstocks)
- BRANCHES (EM)- WP3 practice abstracts (e.g., olive cake gasification)
- Potential ITP (EM): Discussion between T39, T42, and T44 in 2021 on title level: "Biorefineries with flexible production of multiple products."

(2) Regions, regional considerations, small- and medium-sized Bioeconomy enterprises (SMBEs)

- Task 42 (BA): Working on a catalogue for small-scale biorefineries in the recently started HE-MainstreamBIO project
- BRANCHES (LG): WP4 - What are the tipping points in regional development that can be affected by whom?
- Power4Bio project (DBFZ, WUR)
- Ireland (DS): We need to plant trees but unclear what to do with them. > cascading use of wood, storage + substitution effects buying time until storage is fit. Biohubs are exciting for grass in Ireland, diversifying away from animal products. But how to make the diversification decision? Business models would be helpful.

(3) Key-performance indicator (KPI) discussions

- Task 40: KPI discussion might be a part of the regional transitions project
- Task 43 (BG): D3.1 Improved biomass supply quantity, quality, and reliability through effective, sustainable, and circular economy-based biohubs.
- Task 44 (EM): TEE assessment using the methodology of Task 42 could supply data on costs and revenues
- Task 45: WP1 & WP2 Metrics, methods, and tools for assessing climate change effects and sustainability of bioenergy
- Task 45 (DS): Provide an assessment of wider environmental sustainability of entire value networks (expanded boundary LCA approach) and role in climate-neutral pathways
- ITP Synergies ITP (CH): Synergies of green hydrogen and bio-based value chains deployment

(4) Quantitative modeling

- (BA): Not in Task 42 but also together with Wolter Elbersen - supply network modeling. Furthermore, in the H2020 Agrolnlog project an optimization tool was developed for the combination of food and non-food value chains (<http://agroinlog-h2020.eu/en/home/>)
- Task 43 (BG), also in T43 modeling on supply chains, is planned
- Task 44 (EM): D2.1 "D2.1 Workshop on flexibility in energy system modeling and a workshop report Combined with Synergies ITP WS"
- Task 45 (DS): WP1 (lead Patrick Lamers) zooming into regions with supply chain modeling,

- (BA): Stellingwerf HM, Guo X, Annevelink E and Behdani B (2022) Logistics and Supply Chain Modelling for the Biobased Economy: A Systematic Literature Review and Research Agenda. Front. Chem. Eng. 4:778315. doi: 10.3389/fceng.2022.778315

(5) Framework design

- Task 40 (CH): Bioeconomy synergy considerations - analysis of bio-based value chains design development due to changing criteria/conditions and implications for the market.
- Task 44 (EM): D3.2 "Value of flexibility"
- Task 44 (EM): Develop the framework for (hopefully in the end) quantitative assessment of the value of "complexity," i.e., the complex network and services for the system
- Task 45 (DS): WP3 on the role of institutions
- BRANCHES (LG): WP4 - What are the tipping points in regional development that can be affected by whom?

For an extensive discussion of the last point of the agenda, time was unfortunately too short. Again, we used the Mentimeter tool to gather first ideas and impressions on the following question:

Which KPIs must be considered to measure the benefits of system integration?

The following answers were provided by the participants and organizers in Mentimeter within 1-2 minutes before the workshop closed on time:

- Level of cascade use implementation - the interconnectedness of sectors and their sub-products
- Variability of combined revenues versus individual ones
- Sustainability criteria stipulated in REDII
- Nutrient use efficiency (across systems) is a key metric for sustainability
- Comparison with non-integrated situation
- Real benefits for rural actors (farmers and foresters)
- Potential value added along the value chain
- Reliability for utilization of infrastructure capacity
- National metrics (national inventory GHG balance through time) are very important for out-scaled scenarios - how can such networks support climate neutrality objectives? need to be forward-looking 2050+ (back-casting)
- Reliability of supply
- Rural benefits
- Circularity
- Contributions to the SDGs
- Identification of relevant sustainability criteria and indicators

The workshop was perceived very well among the participants and organizers. It was deemed as "excellent," "fruitful," and "what we need, getting to know other[s] around some defined topics." A high level of respect between the workshop participants concerning different disciplinary approaches and jargon rendered the discussion very enjoyable. The organizers hope that this perception is shared among the participants and that everybody felt free to express their perspectives and feelings openly.

NEXT STEPS

The timing for this collaboration workshop was deliberately set for 2022 Q4. The current Triennium started almost a year ago. Task- and intertask project responsibilities are well defined, but their content and some financial allocations still hold room for collaboration and cross fertilization of the work.

In Figure 3, we illustrate a strategic chronology of research foci. The next logical step after providing the problem statement for flexible, regional, bioeconomy value networks in the initial intertask working group and the collaborative workshop would be to define key performance indicators (KPIs) capable of measuring the benefits of system integration. Demonstration of the KPIs and their reflection in case studies and models would then provide qualitative and quantitative insights to allow us to finally redesign policy and market frameworks for them to reward the multiple benefits of system integration and, potentially more complex, value network operations.

However, keeping in mind that relevant collaboration opportunities and projects are running simultaneously, Figure 3 illustrates the arrows in dashed lines. The main next, although coinciding, steps include:

- (1) Initiation of the continuation of the Task 40 Bioeconomy Synergies (BioSyn) project. Based on the identified research needs, this project is best to be used as a vehicle to accommodate the KPI discussion efforts in other projects and ITPs.
- (2) Work for Task 44, "Modeling of flexibility and system integration," is already ongoing, and a first modeling review discussion document has been drafted by Fabian Schipfer and distributed. A workshop is planned for 2023 Q3.
- (3) Interesting case studies for testing the KPIs and concepts are manifold. With the collaboration workshop, the organizers could make the participants aware of their research focus and interest. Further involvement of the workshop organizers in the case studies is encouraged to test the findings on real-world data.
- (4) Policy and market framework design to reward the benefits of system integration and flexibilization will be a topic in the Task 44 "Value of flexibility" study. Collaboration with Task 45 work on "the role of institutions" can also be envisioned. And finally, the organizers would like to use the findings of this workshop and the ongoing work in the current Triennium to start planning a collaborative Intertask project in the next Triennium 2025-2027.

A special issue in the journal Energy, Sustainability and Society will be published to collect perspectives and results along the way of this process. Please access the following link for further information:

<https://energysustainsoc.biomedcentral.com/circularbioeconomy>

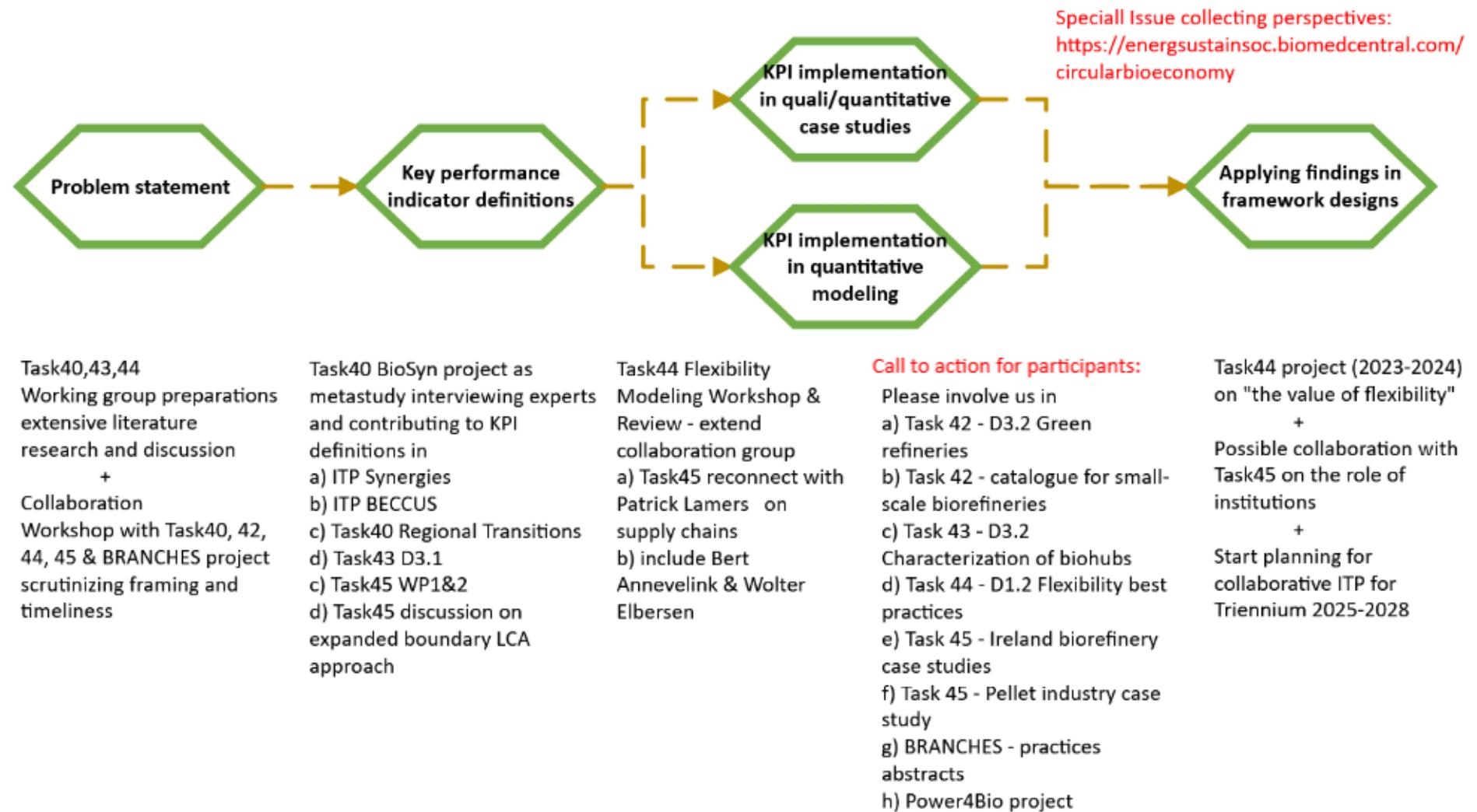


Figure 3: A possible way forward for regional, flexible, Bioeconomy value networks in the IEA Bioenergy TCP. The arrows indicate a strategic chronology. However, they are illustrated as dashed lines since the respective projects are running simultaneously over the course of the current Triennium.