IEA Bioenergy

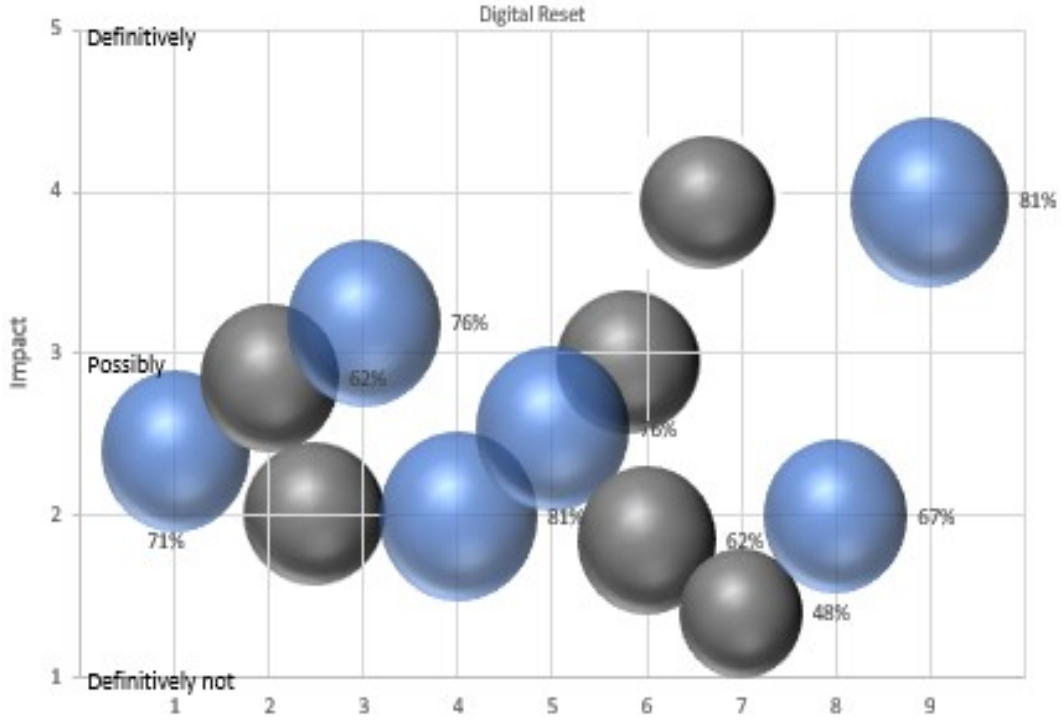
Technology Collaboration Programme

The Role of Biomass Supply Chains for Bioenergy in the Post-COVID-19 Economy

Report

IEA Bioenergy

September 2021



The Role of Biomass Supply Chains for Bioenergy in the Post-COVID-19 Economy

Report

Kulisic, B.; MacDonald, H.; Gagnon, B.; Schweinle, J.; Van Holsbeeck, S.; Brown, M.; Šimurina J.; Di-mitriou, I., Mandarić, A.

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The authors thank to the audience for the helpful questions at the earlier presentation of this research to the IEA Webinar Series.

Abbreviations

BSCh – biomass supply chains

Executive Summary

In March 2020, an IEA Bioenergy Task 43 team started research to investigate how biomass supply chains could contribute to the post-COVID19 recovery, without assuming the impact or the length of the pandemic. The aim of research was to provide evidence – based advice, supported by the expert opinion, that would aid policy framing related to biomass supply chains in a recovery programme and beyond.

The research continues the IEA Sustainable Recovery World Energy Outlook Special Report, published in June 2020 in a response to calls from governments around the world. The Report was looking into the actions that can be taken in the next three years, advocating that the pandemic gives to the governments "once-in-a-lifetime opportunity to reboot their economies and bring a wave of new employment opportunities while accelerating the shift to a more resilient and cleaner energy future" (Dr. Faith Birol, IEA Executive Director). The Report was done in co-operation with the International Monetary Fund (IMF) and was looking at six key sectors (electricity, transport, industry, buildings, fuels and emerging low-carbon technologies), taking into account national and international objectives for long-term growth, jobs and sustainable development goals. As such, the Sustainable Recovery Plan focused at three main goals: boosting economic growth, creating jobs and building more resilient and cleaner energy systems.

The IEA Bioenergy Task 43 research adds to the Report by investigating how investments in biomass supply chains can contribute to the post-COVID19 recovery in terms of affecting those three goals in four possible futures (scenarios) that would occur short- (by 2023) and long- (by 2030) term. The IEA Sustainable Recovery Report timeframe defined the first, short-term future time reference and the international policy milestones, such as the Agenda 2030, gave the long term time frame in the biomass supply chain related research. Scenario planning for a post-COVID-19 world by prof. M.R. Wade (2020) was among the first available research on how pandemic could influence the government policies, published at the OECD website in May 2020.

The experts' opinion indicates that the strongest impact from investment in biomass supply chains would be in economic growth, followed by contribution to the resilient and cleaner energy systems and job creation. Contribution to jobs from investments in biomass supply chains would be the least affected dimension of the post-COVID19 recovery and expected only in long term timeframe. Although bioenergy generates more jobs than the other renewable energy sources, especially in the part of biomass supply, this is not the greatest contribution that investments in biomass supply would generate. Experts anticipate stronger impacts from investments in biomass supply chains in economic growth and resilience of energy systems. On the other side, increased bioenergy demand contributes to the increased resilience of the energy system, given its local availability as a renewable biofuel.

Investments that experts have flagged with the most impact to the recovery are investments that improve biomass material efficiency and circularity, from forestry and agriculture biomass short-supply chains, in longer time frame, including dedicated crops:

- Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain;
- Investment programs for preferred bioenergy technologies coupled with targeted biomass supply chains;
- Investments in biomass logistic-distribution centres (bio-hubs);
- Investments in upgrading the existing agricultural collection and processing centres (e.g. flour mills, oil mills, vineries, dry fruits and nuts…) into bio-hubs.

This research provides advice what the governments can do and what would be the probable effects if certain investments into biomass supply chains are made.

A research section was presented at the IEA Bioenergy Webinar series – Resilient Biomass Supply Chains in the Post-COVID Recovery, 03 June 2021, available at:

https://www.ieabioenergy.com/blog/publications/iea-bioenergy-webinar-resilient-biomass-supply-chains-in-the-post-covid-recovery/ .

Highlights of this research has been reported IEA Bioenergy News Volume 33(1) – June 2021: https://www.ieabioenergy.com/wp-content/uploads/2021/07/IEA-Bioenergy-News-Volume-331---June-2021-1.pdf .

This Report is a supporting document to the paper Kulisic, B.; Gagnon, B.; Schweinle, J.; Van Holsbeeck, S.; Brown, M.; Šimurina J.; Dimitriou, I.; MacDonald, H. The contributions of biomass supply for bioenergy in the post-COVID19 recovery. Sustainability 2021, 13, x. **https://doi.org/10.3390/en14248415**

1 Introduction

COVID19 has impacted economies worldwide in a way never recorded before in modern history. Most economies have suffered a decline in growth, loss of workplaces and increased governmental healthcare-related expenditures. In many countries the pandemic caused a rapid society-wide transition to digitalization and limited mobility. In turn, this has affected the mix of energy sources, reducing use of fossil fuels related to travel as people were ordered to remain in place to slow the spread of COVID 19. The pandemic has increased the awareness on leadership and the role of the government in society with a strong interconnection between health and economic systems. The countries are considering a range of recovery strategies for the post-COVID-19 economy.

While governments provide and adapt health services and financial support to people during the pandemic as much as they can, governments and other agencies are preparing and announcing recovery plans to re-start the economy. Following the recession in 2008, governments boosted investment in emerging technologies such as CCUs. Research indicates that the best recovery investments have a short production cycle, are based on the available inputs, and exhibit a high multiplier effect which combination would allow fast return of the invested money into the economy. Indeed, the IEA concluded that spending in biofuels had the highest multipliers because of the labour intensity of processing feedstocks (IEA, 2020).

The purpose of this research is to highlight options how investments and policies towards enhancing sustainable biomass supply chains could contribute to the short and long-term economic recovery with a faster and more financially sustainable energy transition. In the absence of any statistical data or trends upon which serve as base for qualitative forecasting methods, this research relies on Delphi method that projects expert opinion on various scenarios developed for the post-COVID19 world (Wade, 2020). Given the fact that this research has started (March 2020) and was completed while the pandemic was still on (March 2021), it had two insecurities: a dynamic present and dynamic future. To capture the present moment, a worldwide survey to collect information on the effect of the pandemic measures, such as lockdowns of different strictness, on behaviour on the biomass supply chains in general, given the fact that biomass for bioenergy is usually sourced from co-productive systems or cascading use of biomass. The uncertainty for the future economies is mitigated by asking the experts to set the biomass supply chains in different scenarios that attempt to identify a set of possible future frameworks. The main goal of this forecast is to investigate the impact of investments in biomass supply chains for bioenergy, within the broader bioeconomy, on economic growth, creating jobs and building more resilient and cleaner energy systems. These three goals are taken from IEA Sustainable Recovery document (IEA, 2020). In response to calls from governments around the world, the IEA has produced a Sustainable Recovery Plan (2020) for actions that can be taken over in a short-term, by 2023. This detailed plan is focused on cost-effective measures that could be implemented during the specific timeframe of 2021 to 2023. The plan considers national and international objectives for long-term growth, future-proofed jobs, and sustainable development goals. While the Recovery Plan outlined policies and targeted investments coupled with measures for each key energy sector (electricity, transport, industry, buildings, fuels and emerging low-carbon technologies), this research focuses on contributions of biomass supply chains for bioenergy, within the broader bioeconomy, to those goals as a complementing material.

This research investigates how well the current policy landscape is suitable for the future challenges and where to direct limited recovery funds to invest in options that are more likely than the other, generate a positive contribution from biomass supply chains in the post-COVID19 economy.

Governments are set to make major decisions that will affect huge amounts of investment and shape infrastructure and industries for decades to come.

The research has been conducted from three different stands (figure 1): SWOT analysis of possible positive contributions of biomass supply chains in the post-COVID-19 recovery, which served to create

both Delphi questionnaire and a questionnaire for a short survey to collect information on behaviour of biomass supply chains in pandemic.

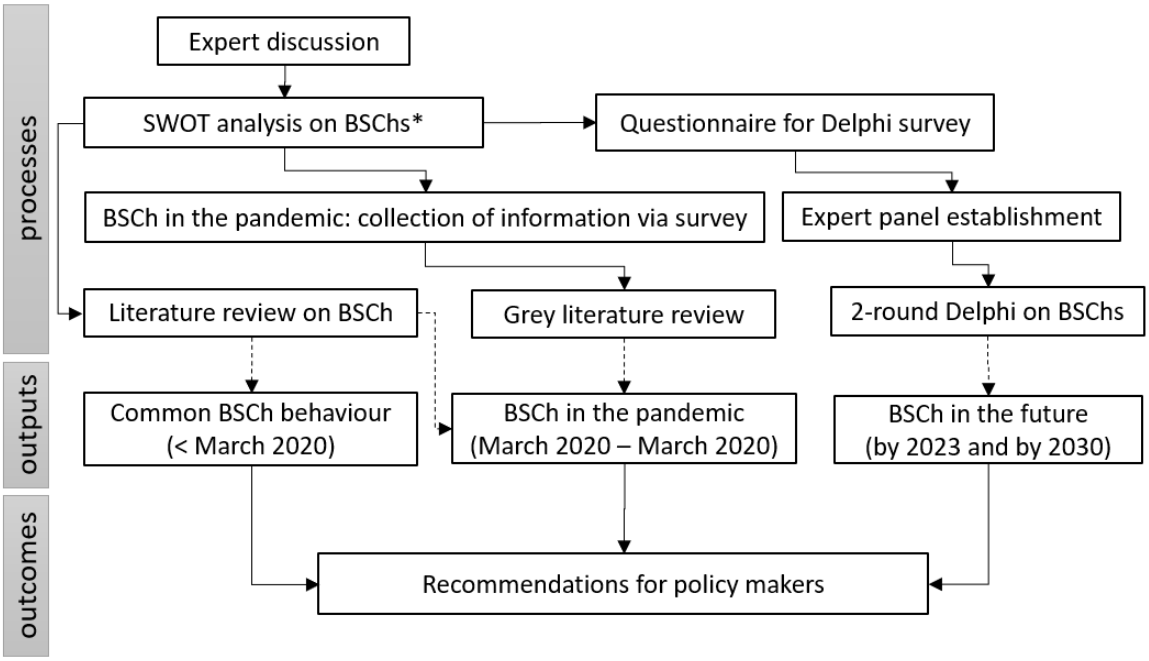


Figure 1 Study design (BSCh = biomass supply chains)

The original study design was formed in March 2020, a week after World Health Organization (WHO) announced the global pandemic. Our study includes a 2-round Delphi foresight study, informed by a SWOT (S – strengths, W – weaknesses, O – opportunities, T – threats) analysis on BSChs. The project timeline was extended in August 2020 given the severity of the ongoing pandemic that was evolving along with the research (Figure 2). The Delphi foresight study had two main uncertainties: a dynamic starting position and unseen futures.

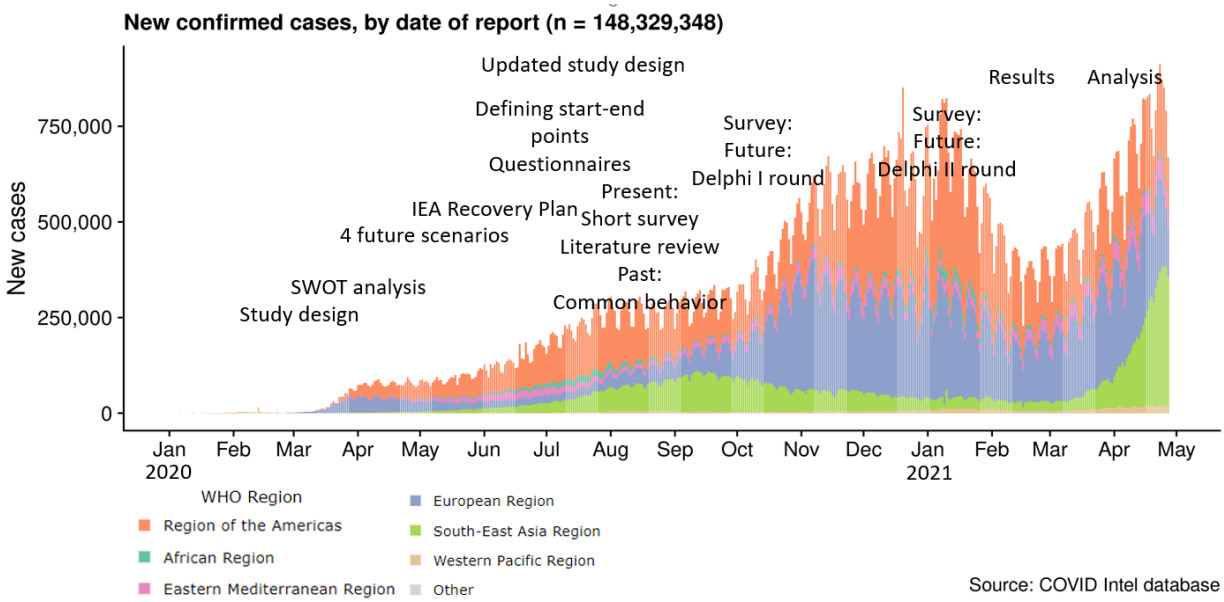


Figure 2 Timeframe of foresight research and pandemic developments (source WHO, adjusted by authors)

The structure of report is:

1. **Position of biomass supply chains in an economy** where the aim is to identify the effects of pandemic on biomass supply chains for bioenergy in broader bioeconomy. The results make the starting point for discussion on future contributions of biomass supply chain.
2. **SWOT analysis on biomass supply chains** where the aim is to identify how biomass supply chains can contribute from demand and supply chains to post-COVID19 recovery. The SWOT analysis is a poll of statements that would introduce to the Delphi survey.
3. **Forecasting on contribution of biomass supply chains for bioenergy in broader bioeconomy could contribute to the post-COVID19 recovery (Delphi survey)**

2 Position of Biomass Supply Chains in an Economy

The goal of the survey was to collect information from experts from a wide range of economies across multiple continents with respect to how resilient biomass supply chains for bioenergy were during the lockdown period.

A network of biomass related experts was invited to help collect the records on behaviour of biomass supply chains in different countries for bioenergy during the COVID-19 outbreak until September 2020: "*We understand that there is a lack of reliable statistics on the impacts of the COVID-19 pandemic to support the answers to the questions below and that trends are difficult to identify in the moment. Yet, we want to detect how resilient biomass supply chains for bioenergy were during the lockdown (or in the period from the beginning of 2020 until present). We ask you, as a biomass expert, to answer the question to your best knowledge and judgement, based on the information you have at hand.*"

A survey across 3 continents was sent out on to collect recording the reaction of biomass supply chains across the countries with biomass use to generate modern bioenergy forms. Questionnaire was completed by 61 experts with a 45.9% response rate or 28 complete surveys. Only complete surveys were analysed.

The aim of this step in the study design was to identify the main difficulties of biomass supply chains in the COVID-19 crisis and, after assessing trade-offs, help proposing how biomass supply chains could positively and sustainably contribute to the recovery period after COVID-19 lockdown.

Figure 3 Countries that answers were reflecting

Since the primary focus was to identify the behaviour of biomass supply chains, regardless on the end-use (food, feed, fuel, fiber), the experts profile contacted was broad (Fig.4). The choice for having of broad experts' profile is the fact that biomass for bioenergy often originates from co-productive systems in a form of by-product or waste from primary production such as wood chips from harvesting wood for timber or manure from livestock breeding.

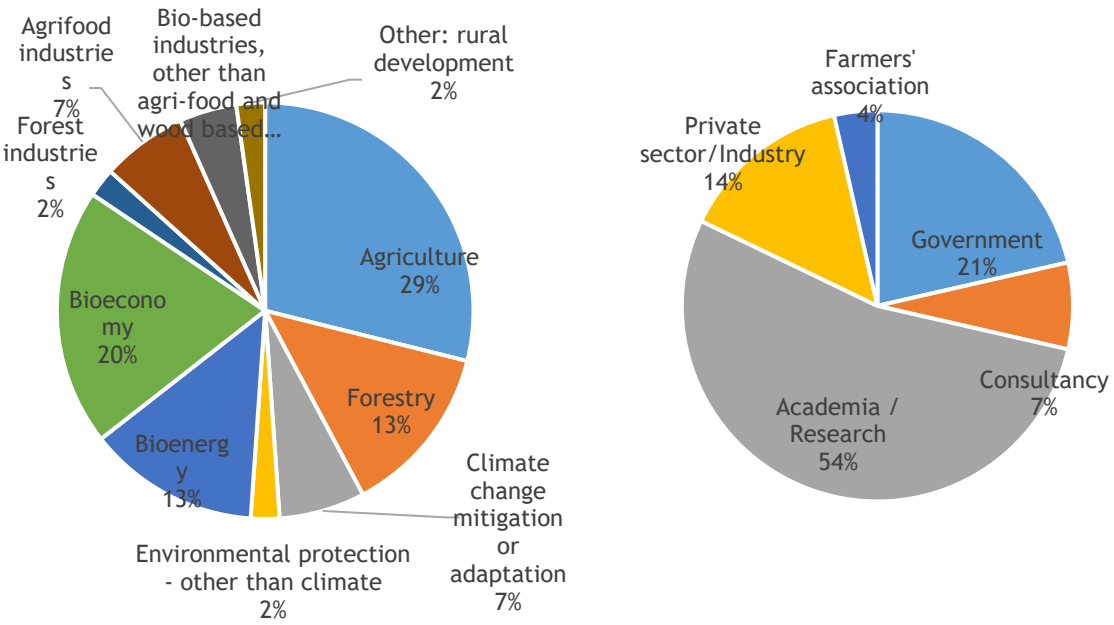


Figure 4 Experts' profiles

A third of the experts had over 15 years' experience in the field and 57% had more than 10 years of the experience in the field that was a good portfolio of expertise (Fig 5).

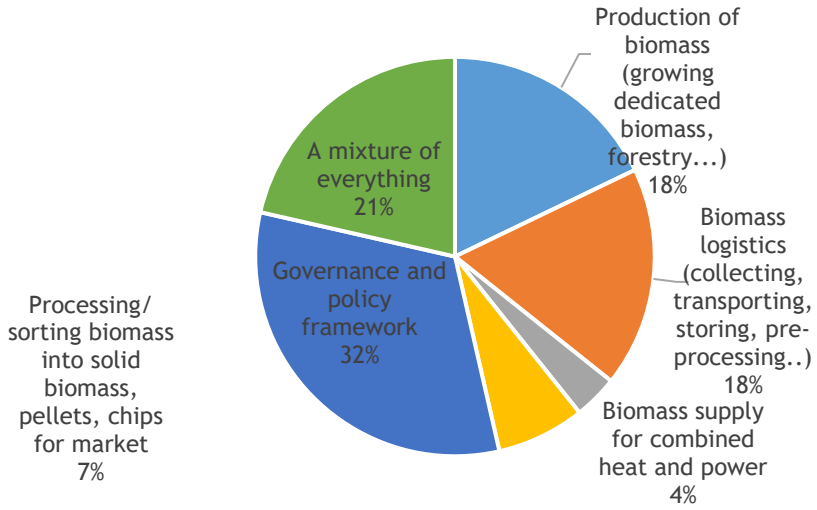


Figure 5 Expertise portfolio

2.1 DISRUPTIONS IN THE ENERGY SECTOR DURING THE PANDEMIC

No shortages in energy supply, in any sector were reported. Narrowing down to bioenergy supply, 93% reported no shortages while 1 record was related to both shortages of solid fuel supply (pellets, briquettes, chips) and Gaseous biofuels (e.g., biomethane).

2.2 ECONOMIC DISTURBANCES IN BIOMASS SUPPLY CHAINS FROM THE SUPPLY SIDE

The aim was to investigate if biomass supply chains were affected by COVID-19 outbreak in term of shortages or surpluses for all kinds of inputs related to biomass production. They can vary from lack of mineral fertiliser to grow crops in agriculture; lack of labour given the restricted mobility; reduced wood residue due to the reduced demand for lumber or furniture...or increased demand in paper-based hygiene products, increased food consumption at home... The answers should record the situation in your country/region; not the global situation.

While 31% of the answers were, in average, reported as "I don't know" (the highest lack of record in pulp and paper industry (44%) and the least in crop production industry (23%).

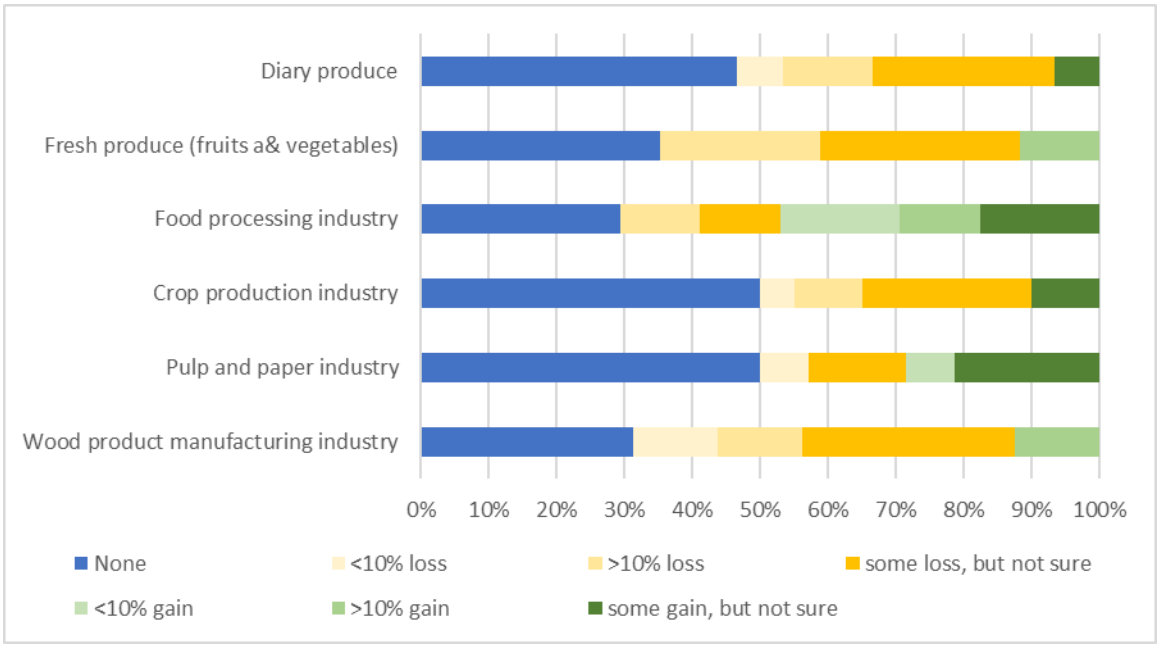


Figure 6 Records on economic disturbances in biomass supply chains from the supply side, by supply chain

According to the reports, fresh produce and wood product manufacturing industry related supply chains were mostly affected with pandemic with 53% and 56% of different levels of loss, respectively.

Reports on biomass supply chains for food processing industry and pulp and paper record 47% and 29% of different levels of gain, respectively.

Crop production industry and Dairy produce supply chains record most reports in "no impact" with 50% and 47%, respectively. The next largest record cluster was loss of different levels with 40% and 47% for Crop production industry and Dairy produce supply chains, respectively.

At aggregated level, about the same 40% records report either none or loss, where "some loss but not sure" is the largest represented subcategory with 57%. Gain (47% some gain but not sure) is reported in 19% of countries.

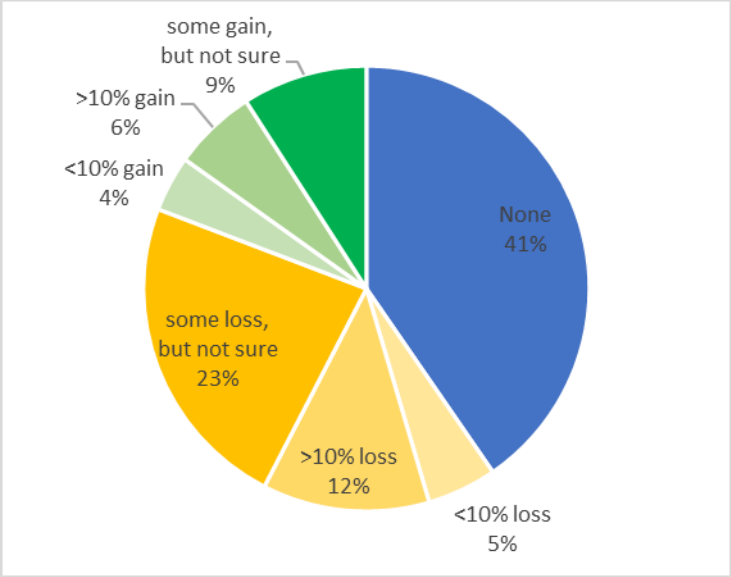


Figure 7 Aggregated reports on economic disturbances in biomass supply chains from the supply side

The next question was aimed in detecting shortages in biomass supply to different industries. In average, 44% biomass supply chains towards industries did not report any shortages. 27% reported not knowing if there are any shortages or their origin. The least reason for shortages of biomass supply were restrictions on biomass imports due to the lockdown measures and were related to fresh produce (reduced availability of fresh fruit and vegetables range); food processing industry (reduced ingredients of foreign origin) and wood processing industry. Lack of workers and prohibited mobility were reported with the similar occurrence: 14% and 13%, respectively.

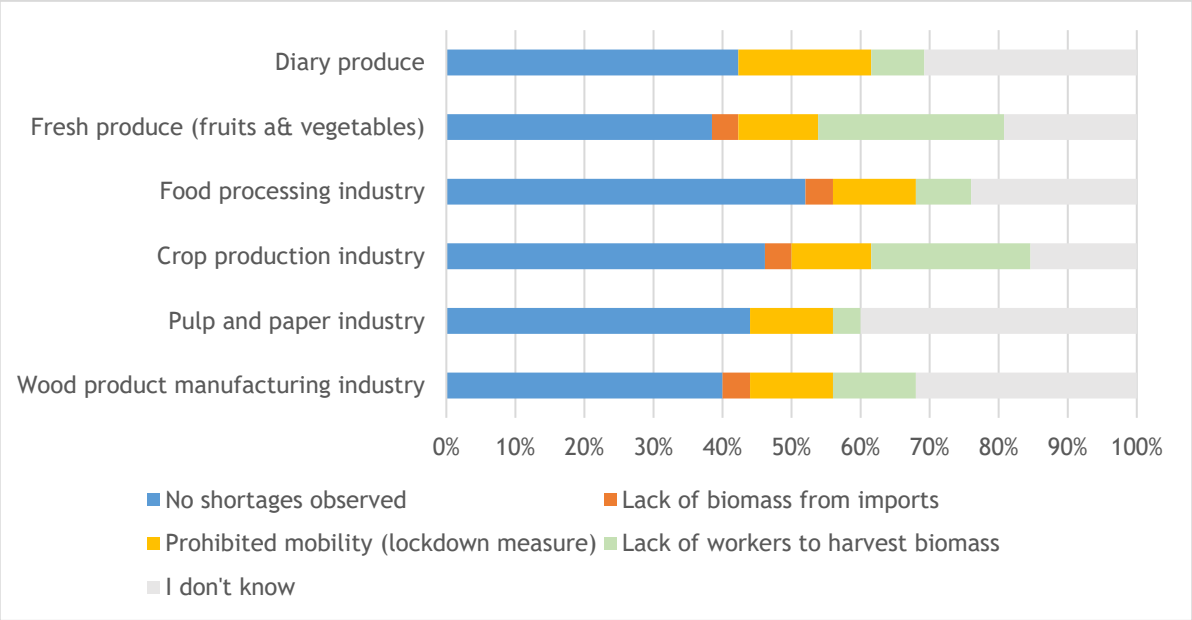


Figure 8 Distribution of reasons of shortages from biomass supply side, if any

2.3 ECONOMIC DISTURBANCES IN BIOMASS SUPPLY CHAINS FROM THE DEMAND SIDE

Economic disturbances in biomass supply chains from the demand side (biomass supply changes due to the loss of markets for co-productive systems, less demand for bio-based products in general...) aim in investigating if biomass supply chains were affected by COVID-19 outbreak in terms of market share changes for all kinds of outputs related to the biomass production. They can vary from reduced demand for lumber or furniture that affected biomass supply chains from co-productive systems (e.g., sawmill residues) or increased demand for hygiene products such as tissues and toilet paper in pulp and paper industry.

Experts reported in 37%, in average, of not knowing if any disruptions occurred in bio-based industry due to the disruptions in markets during the COVID19 outbreak. From those that have sent records, 40% reported no change in production due to the disruptions in markets during the COVID19 outbreak. Most disturbances were recorded in wood product manufacturing industry and fresh produce (both 56% of the cases) and crop production industry (50%).

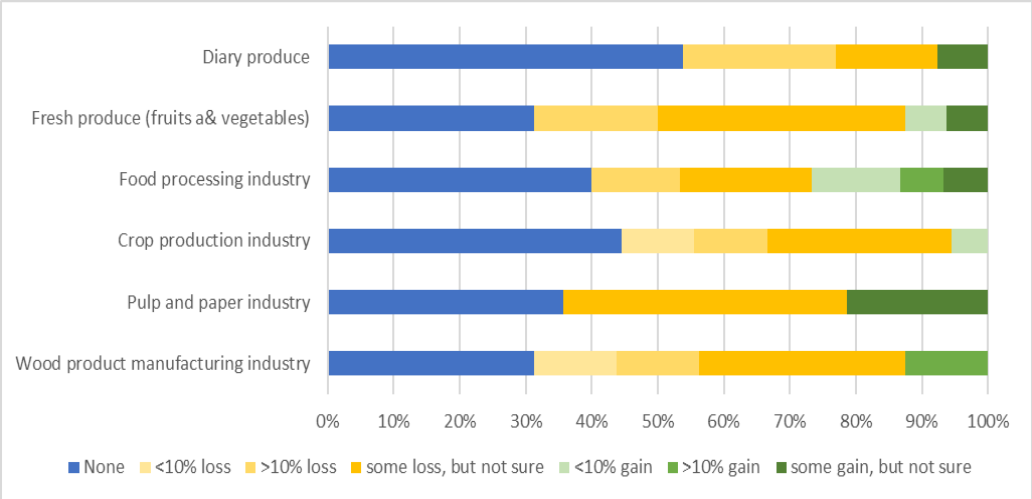


Figure 9 Economic disturbances in biomass supply chains from the demand side, by supply chain

At aggregated level, about 40% records report either none or loss, where “some loss but not sure” is the largest represented subcategory with 57%. Gain (47% some gain but not sure) is reported in 19% of countries.

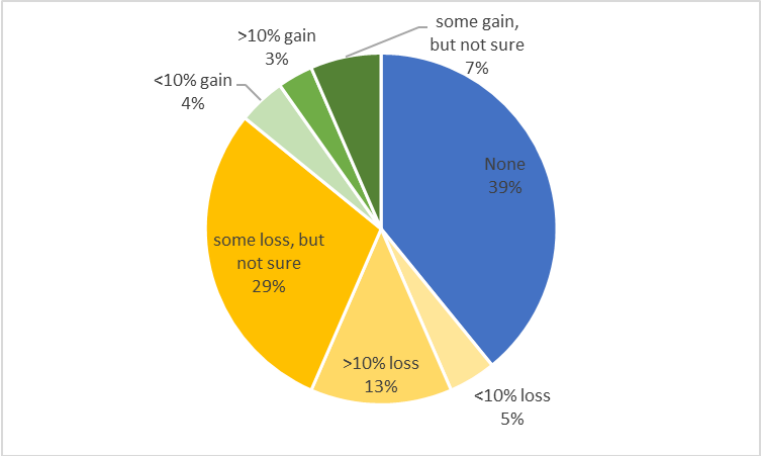


Figure 10 Aggregated reports on economic disturbances in biomass supply chains from the demand side

When asked to detail the reasons behind the negative disturbances, the answers that reported no disturbances by supply chain were most attached to the crop production industry and dairy produce, both 52%. Most disturbances are reported in relation not the fresh produce supply chain and food processing industry, 32% and 36%, respectively. Food processing industry is also recording the most gain due to the pandemic with the same record as “no changes observed” or 32%. None of the supply chains recorded any reduced or stopped supply of biomass from imports. Only 1 reply was registered to have reduced or stopped supply of other inputs than biomass: in crop production industry.

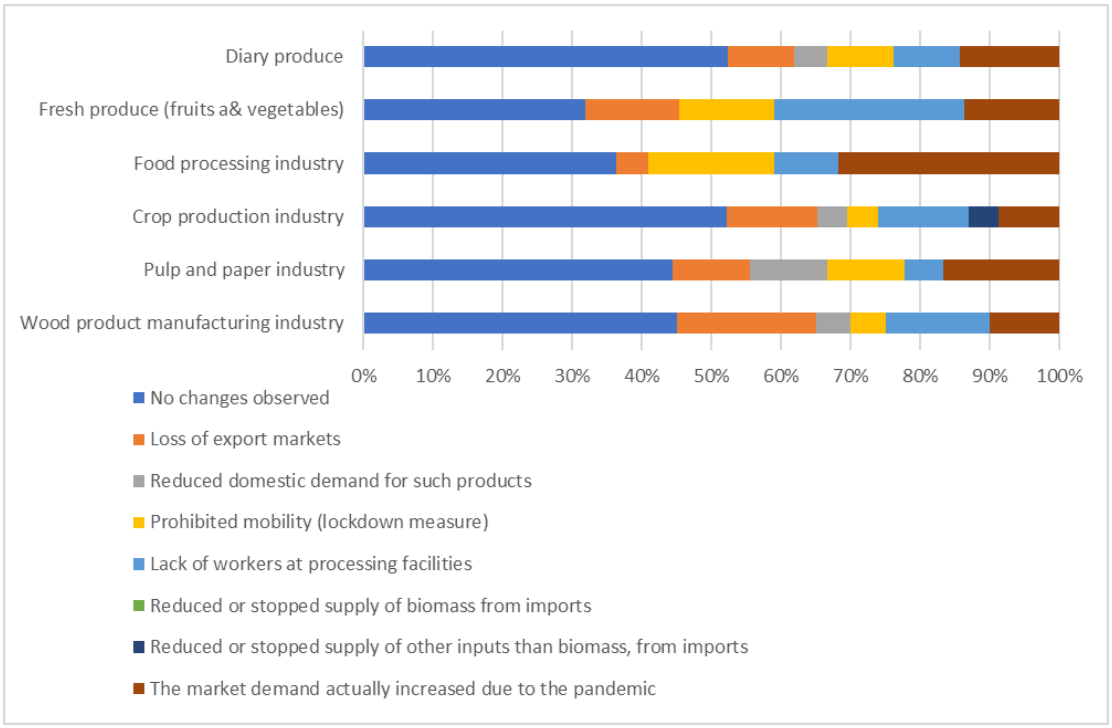


Figure 11 Reason for the changes in market demand by supply chain

Aggregated reasons for economic disturbances in biomass supply chains from the demand side were reported as: 44:16:40 where No changes observed: Reasons for increased market demand: Reasons for reduced market demand. Among the reasons, lack of workers at processing facilities and reduced demand loss of export markets were mostly reported reasons from about a third of the respondents.

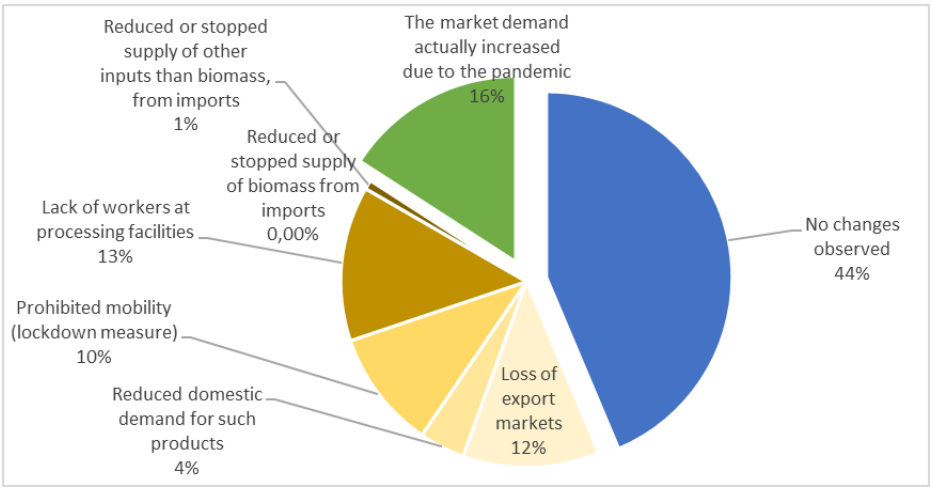


Figure 12 Aggregated reasons on economic disturbances in biomass supply chains from the demand side

3 SWOT analysis on biomass supply chains

A SWOT analysis on possible contributions of BSChs for bioenergy within the broader bioeconomy was conducted 22 - 30 March 2020. A key stakeholder group of nine international bioenergy experts – IEA Bioenergy national task leaders (NTLs) and associates of IEA Bioenergy Task 43: Biomass supply for bioenergy within bioeconomy, mapped relevant internal and external risks and their impacts, together with the main driving factors on BSCh and markets. IEA Bioenergy National Task Leaders of Task 43 are experts appointed by the governments to seek for evidence-based advice to create biomass for bioenergy related policies. The nine countries represented are characterized by a modern bioenergy use (Australia, Canada, Croatia, Finland, Belgium, Germany, Sweden, United States of America) and different biomass supply streams (including forestry and forest industry, agriculture and food industry, and dedicated energy crops).[1] behave differently in both supply & demand behavior, and across net energy importers and net energy exporters.

In which way biomass supply could contribute to the revival of the economy?

Short run: immediate reaction

1. Increase in pellet production due to the improved forest management.
2. Bioelectricity can be used to balance the grid if the share is sufficient.
3. Promoting pellet use and stove industry &services.
4. Labour intensive, highly distributed: job generation tool?
5. Develop skills and training how to mobilise & process biomass.
6. Any measure that reducing tax/fiscal burden on biomass.
7. Co-firing or replacement of coal fired CHPs with biomass, if biomass readily available.
8. Inventory of CO2 demand and renewable CO2 supply and present options to the industry.
9. Biomass from co-productive systems increases the productivity and has short production cycle that can yield income faster than the others.
10. Mature technology

Long run: requires policy adaptation

1. BECCSU will replace all the fossil CO2.
2. Bioelectricity can be used to balance the grid if the share is sufficient.
3. Biomass supply for bioenergy will be used as a tool to absorb atmospheric CO2 and keep the fossil CO2 unused.
4. Higher share of biofuels in transport fuel demand (air industry)
5. Diversify energy supply to ensure energy security
6. Decarbonization/SDGs/Paris Agreement – NDC
7. Bioeconomy where bioenergy plants convert to biorefineries
8. Invest in R&D in renewable CO2 supply (BECCSU) and with the options to the industry.
9. Invest in R&D for valorization of by-products of bioenergy.

Bioenergy comes to the market in three end -use forms: bioheat, bioelectricity and biofuel – all

[1] "Biomass produced in a sustainable way—the so-called modern bio-mass—excludes traditional uses of biomass as fuelwood and includes electricity generation and heat production, as well as transportation fuels, from agricultural and forest residues and solid waste. On the other hand, ''traditional biomass'' is produced in an unsustainable way, and it is used as a non-commercial source—usually with very low efficiencies for cooking in many countries." (Goldemberg et al., 2004)

Table 1 SWOT of biomass supply chains in respect to mobilising and placing biomass to the market

Strengths	Weaknesses
Inferior good at the heat market Locally available source of renewable energy Market for low value material to enhance forest management goals Farmer and forest owners are increasing productivity per unit of land/livestock unit by valorizing side-streams of the primary production. Industry associated with biomass, remained non disrupted (AUS) Lockdown didn't force any energy provider to stop operating (DE, SE) Short supply chain Supplying biomass from the forests and field is not a COVID19 risk activity. Heterogeneity of biomass	Imbalance between demand & supply of biomass Storage costs Storage and handling losses Heterogeneity of biomass Unstable properties of a single biomass supply chain The quality of biomass is not valorized Price inelastic Dependence on the co-productive sectors (livestock, crop, woodbased industry) Not market competitive Overlapping legislation, not necessarily concerted in a policy Local particle emissions Decreasing in forest management reduces volumes for biomass supply Failure of 1G biofuels to achieve the expected GHG emission savings contributions is reducing the overall attractiveness of bioenergy Strict lockdown prevented mobility to mobilise and supply biomass which resulted in placing on market poor quality biomass that wasn't not a long-term option.
Opportunities	**Threats**
If categorised and labelled, market value of biomass supplied can be increased Untapped potential Interest in native private forests that are unmanaged, to sell residues as bioenergy product Removal of harvest residues Forest fire management tool A 7.66 B$ global CO2 market, with 3.4% growth by 2027, mostly from enhanced oil recovery¸ source of renewable CO2 Integration to bioeconomy with new value chains A good opportunity to abandon fossil fuel subsidies Disrupted coal supply opens space for alternative fuels Grid balancing service Valorization of bioenergy by-products (plants evolving towards biorefineries) BECCSU Raising industry awareness on new value chains and synergies	Reduced demand on biofuels CO2 taxation or related CO2 limiting policy Losing carbon neutrality position Low fossil prices Attached controversies about bioenergy Lack of concerted policy to ensure environmental and social aspects of sustainability BECCSU too low at TRL scale Electricity is preferred to other decarbonisation pathways Lack of demand for bioenergy

In which way biomass supply could contribute to the revival of the economy?

Short run: immediate reaction

1. Increase in pellet production due to the improved forest management.
2. Bioelectricity can be used to balance the grid if the share is sufficient.
3. Promoting pellet use and stove industry &services.
4. Labour intensive, highly distributed: job generation tool?
5. Develop skills and training how to mobilise & process biomass.
6. Any measure that reducing tax/fiscal burden on biomass.
7. Co-firing or replacement of coal fired CHPs with biomass, if biomass readily available.
8. Inventory of CO2 demand and renewable CO2 supply and present options to the industry.
9. Biomass from co-productive systems increases the productivity and has short production cycle that can yield income faster than the others.
10. Mature technology

Long run: requires policy adaptation

1. BECCSU will replace the all of the fossil CO2.
2. Bioelectricity can be used to balance the grid if the share is sufficient.
3. Biomass supply for bioenergy will be used as a tool to absorb atmospheric CO2 and keep the fossil CO2 unused.
4. Higher share of biofuels in transport fuel demand (air industry)
5. Diversify energy supply to ensure energy security
6. Decarbonization/SDGs/Paris Agreement – NDC
7. Bioeconomy where bioenergy plants convert to biorefineries
8. Invest in R&D in renewable CO2 supply (BECCSU) and with the options to the industry.
9. Invest in R&D for valorization of by-products of bioenergy.

Table 2 SWOT of biomass supply chains in respect to market demand for biomass

Strengths	Weaknesses
Renewable base bioenergy	Price inelastic
Inferior good at the heat market	In CHP, bioelectricity is valorised while heat rarely
Locally available renewable energy	CHP by-products not valorised (digestate, ash, CO2, sulphur)
Mature technology for bioheat and bioelectricity	Reduced demand on biofuels
Pellet market can increase to substitute for firewood (local particle emissions reduction)	Dependence on the co-productive sectors (livestock, crop, wood based industry)
Market for low value material to enhance forest management goals	The willingness to pay higher price for bioelectricity is lower than for the fuelless technologies
Security of supply	Not market competitive
Increasing productivity per unit of land/livestock unit	Complex
Untapped potential	Local particle emissions
Industry associated with bm, remained non disrupted (AUS)	Decreasing in forest management reduces volumes for biomass supply
Lockdown didn't force any energy provider to stop operating (DE, SE)	Failure of 1G biofuels to achieve the expected GHG emission savings contributions
Opportunities	**Threats**
Interest in native private forests that are unmanaged, to sell residues as bioenergy product	CO2 taxation or related CO2 limiting policy
Forest fire management tool	Losing carbon neutrality position
A 7.66 B$ global CO2 market, with 3.4% growth by 2027, mostly from enhanced oil recovery¸ source of renewable CO2	Low fossil prices
Integration to bioeconomy with new value chains	Attached controversies about bioenergy
A good opportunity to abandon fossil fuel subsidies	Lack of concerted policy to ensure environmental and social aspects of sustainability
Disrupted coal supply opens space for alternative fuels	BECCSU too low at TRL scale
Grid balancing service	Electricity is preferred to other decarbonisation pathways
Valorization of bioenergy by-products (plants evolving towards biorefineries)	Lack of demand for bioenergy
BECCSU	
Raising industry awareness on new value chains and synergies	

The SWOT results concerning BSChs (Table 3) was used to generate a Delphi questionnaire, with a short- and long-run strategies of aspirational biomass supply contributions to the post-COVID-19 economy.

Table 3 BSChs features that could contribute to the post-COVID-19 recovery

Short run: immediate reaction	Long run: requires policy adaptation
Increase in pellet production due to improved forest management. Bioelectricity use to balance the grid if the share is sufficient. Promoting pellet use and stove industry &services. Labor intensive, highly distributed: job generation tool. Develop skills and training on how to mobilize & process biomass. Any measure reducing tax/fiscal burden on biomass. Co-firing or replacement of coal-fired CHP units** with biomass if biomass readily available. Inventory of CO2 demand and renewable CO2 supply and present options to the industry. Biomass from co-productive systems increases productivity and has a short production cycle that can yield income faster than the others. Mature technology.	BECCSU* could replace all forms of fossil CO2. Bioelectricity can be used to balance the grid if the share is sufficient. Biomass supply for bioenergy will be used as a tool to absorb atmospheric CO2 and keep the fossil CO2 unused. A higher share of biofuels in transport fuel demand (air industry) Diversify energy supply to ensure energy security Defossilization/SDGs of Agenda 2030 /Paris Agreement and Nationally Determined Contributions (Blair et al. 2021) Bioeconomy where bioenergy plants convert to biorefineries Invest in R&D in renewable CO2 supply (BECCSU) and with the options to the industry. Invest in R&D for valorization of by-products of bioenergy.

*BECCSU – bioenergy combined with carbon capture, storage and use

** CHP – combined heat and power

4 Foresight on Contribution of Biomass Supply Chains for Bioenergy in Broader Bioeconomy to the Post-COVID19 Recovery (Delphi)

The Delphi method is an accepted approach to surveying expert opinion (Flostrand et al, 2020), particularly in situations where evidence is sparse or contentious (Barrios et al, 2021), which has been in use for more than half a century (Ziglio, 1996). The method utilizes multiple survey rounds or iterations in which experts are given a chance to recalibrate their original answers based on "controlled opinion feedback" (Ziglio, 1996, p. 3), in theory, until consensus is reached among experts. The definition of consensus used for Delphi-type surveys varies widely. According to Barrios et al (2021), published papers have utilized a wide range from 50-97%. This method is suitable for policy questions where little information is available, but where expedient decisions are necessary. The Delphi method has been applied in health sciences (Freitas et al, 2018; Turner et al, 2017), social policy (Ziglio, 1996), energy policy (Hussler et al, 2011), and economic forecasting (Flostrand et al, 2020), among other fields.

Broadly, experts possess knowledge, authority, and insight with respect to the issue (Gutierrez 1989). The number of experts necessary is related to the homogeneity of the group; Delphi surveys with a very homogeneous group of experts can be done with 10-15 people, whereas surveys of hundreds of diverse experts have also been documented (Flostrand et al, 2020). Based on twelve systematic reviews in the health field, the median number of experts for Delphi-type surveys was 17 (Niederberger & Spranger, 2020). In a review of 57 studies from 2015 to 2018, 45.6% of Delphi-type surveys used 11 to 40 experts (Zartha Sossa et al, 2019).

Strategic foresight exercises using Delphi or other methods are useful to stress-test and future proof policy options. Asking how well current or proposed policies would perform under different future conditions can help make policies more robust and adaptive. Experts may be able to identify hitherto unforeseen challenges and/or opportunities and possible options for mitigating challenges or enhancing the potential of opportunities.

This exercise was conducted to identify the best forward-looking policy actions and strategies by which to advance societal goals. The COVID-19 pandemic and resulting cascading impacts have thrust the world into an altered state with novel challenges and opportunities. Given the fact that the research was conducted within the time of the COVID-19 pandemic (March 2020 - March 2021), the forecasting had two uncertainties: a dynamic starting position, as well as uncertain future options. While it was obvious that the global economy experienced an abrupt, severe contraction, the behaviour of individual elements of that global economy was uncertain. The survey investigated how resilient biomass supply chains for bioenergy were during the lockdown period (specifically, in the period from the beginning of 2020 until October 2020) across different sectors. Taken collectively, these conditions formed the moving ground that formed the starting point of this Delphi analysis.

The survey instrument assessed expert opinion with respect to the impact of various investments on the goals of the IEA Sustainable Recovery Plan (2020):

1. boosting economic growth;
2. creating jobs; and
3. building more resilient and cleaner energy systems.

The term "INVESTMENT" in this exercise covers a wide range of investments needed - from the investments in equipment and infrastructure to investments in R&D, know-how and education, soft loans and other types of market support to facilitate a policy since any market intervention is coupled with a cost. In particular, experts were asked to reflect on the efficacy of various investment instruments under four distinct future scenarios, defined by the International Institute for Management Development (2020):

- **Global Marketplace: short-term virus longevity, global acceptance, digital acceleration**

In this scenario, the world quickly moves on from the COVID-19 pandemic. People realize that the virus was just a temporary health event, with no deeper economic, political, or social roots. There is a general sense of the importance of 'getting back to business'. Therefore, borders reopen and trade resumes as before. Widespread usage of digital technologies during the crisis leads to a new wave of digital innovation. This digital renaissance does not just occur in Silicon Valley, but across the world. **As borders open and trade barriers are removed, people start to live and work more in other countries.**

- **Back-to-Basics**: **long-term virus longevity; global rejection; digital skepticism**

In this scenario, COVID-19 infections and deaths fail to slow down, even after the so-called flattening of the curve. People become distrustful and skeptical about threats from outside their immediate environments. Tourism fails to reignite, as people choose to travel close to home, and **global supply chains are dismantled to avoid vulnerabilities to future shocks**. People become deeply suspicious of people and products from other parts of the world. Digital technologies become too invasive and pervasive for many people, and thus they often disengage. Even young people retreat from the constancy of being online.

- **Digital Reset scenario: long-term viral longevity; global acceptance; digital skepticism**

In this scenario, infections and deaths from the virus fail to dissipate. National governments realize that unilateral responses are failing, so a massive multilateral effort is undertaken to slow down the spread of the virus. After some time and effort, progress is made, and a large part of the success is credited to the globally coordinated response. As soon as travel restrictions are lifted, people start to move again, tourism picks up quickly, and **global supply chains are reopened**. At the same time, people start to realize that the pandemic, even though it was responsible for many thousands of deaths, was made much worse due to the constant flow of sensationalized misinformation. Therefore, **many people restrict their exposure to digital media and generally retreat from an over-exposure to digital technologies.**

- **Walled Gardens short-term virus longevity; global rejection; digital acceleration**

In this scenario, the virus dissipates quickly, so the immediate threat of infection and death disappears in most parts of the world. However, lingering suspicions remain about the dangers of pandemics from foreign lands. The invocation of the Defense Production Act in the US, and similar legislation elsewhere that prioritized national interests during the height of the virus outbreak leads **to a local-first, isolationist mentality. Nations prioritize themselves over the global collective good. National patriotism grows along with pressure to limit immigration**. Tourism fails to pick up as many foreign destinations lose their allure and local trips and events become more popular. Technology remains pervasive but people become less interested in global themes and celebrities. Local versions of global apps and software products make gains against the digital giants.

The survey instrument solicited expert opinion on the three aspects of the IEA Recovery plan within four scenarios of post-COVID19 economy. The survey asked experts to forecast the impact of a range of investments on economic growth, jobs, as well as the impact of investments on a green and resilient energy sector, by 2023, as well as farther into the future, 2030. Experts rated whether investments in biomass supply chains would definitely, possibly, or definitely would not increase economic growth. With respect to technology and infrastructure investments, experts assessed the impact of each investment as very strong, strong, moderately strong, moderately weak, or weak. Regarding employment impacts, experts evaluated whether investments would definitely, possibly, or definitely not increase jobs. Finally, experts were asked if they strongly disagreed, disagreed, were undecided, agreed, or strongly agreed that various investments would help create cleaner, more resilient energy systems.

While most of the questions of the survey pertained to general outcomes of investments, the first survey question was specific to the expert's home country and was not included in Delphi method. The term "investment" in this exercise covers a wide range of investments needed - from the investments in equipment and infrastructure to investments in R&D, know-how and education, soft loans and other types of market support to facilitate a policy since any market intervention is coupled with a cost.

Table 4 Survey sections, investment statements, and verbal equivalents of the 5-point Likert-scale to collect experts' opinion, both in short- (by 2023) and long-term (by 2030)

Survey Section (IEA, 2020)	Questions and statements	Likert-scale verbal equivalents (1-5)
Economic Growth	Where do you think the investments in BSChs would have the strongest impact on economic growth? (5 investment options)	1 -no impact
		2 - weak impact
		3 -moderate impact
	Where do you think the technology and infrastructure investments in BSChs would have the strongest impact on economic growth? (6 investment options)	4 - strong impact
		5 -very strong impact
	Increasing specific bioenergy demand (bioheat, bioelectricity, liquid or gaseous biofuels for transport) would generate sufficient economic growth through investments.	1 - strongly disagree
		2 - disagree
		3 - undecided
Jobs	Increasing specific bioenergy demand such as bioheat, electricity, liquid or gaseous biofuels for transport would generate sufficient job growth through investments.	4 -agree
		5 - strongly agree
	Which investments related to the BSChs are more likely to create jobs under different scenarios? (9 investment options)	1 - definitively not
		2 - probably not
		3 - possibly
		4 - probably
		5 - definitively
Cleaner, Resilient Energy Sectors	Increasing specific bioenergy demand such as bioheat, electricity, liquid or gaseous biofuels for transport would generate more resilient and cleaner energy systems through investments.	1 - strongly disagree
		2 - disagree
		3 - undecided
	Where do you think bioenergy-related investments would contribute most to supporting and building the resilient and cleaner energy systems under different scenarios? (9 investment options)	4 -agree
		5 - strongly agree

We have defined "consensus" as a range of connected ratings rather than as a single rating, particularly since the two values at both ends of a Likert scale (a 4 versus 5 or 1 versus 2) are generally indicative of a negative or positive orientation. Depending on the number of modes and their position, expert consensus was reached under a range of conditions (Table 5).

Table 5 Conditions constituting consensus

Consensus level	Description
1	The most frequent answer, together with the upper and lower value encompassed >60% of the experts' opinion
2	The most frequent answer is at the end of the Likert scale: 1 or 5, the next answer two, either upper (for 1) or lower (for 5) was considered as valid range to reach the >60% consensus of expert opinion
3	If the spread above and below the most frequent answer did reach a consensus or if it collected more of the experts' opinion, the spread was extended towards the upper range and lower range ends from the mode. A consensus was achieved if >60% of expert opinions are within that spread.
4	If the answer had 2 modes, that were within the 3 value distance (say the modes are: 1 and 3; 2 and 4; 3 and 5; with the middle value) and that spread collects >60% of the experts' opinions, the consensus was reached
5	If the answer had 3 modes, they must be in linked with the Likert scale order (say: 1,2,3; 2,3,4 etc.) and represent >60% of the experts' opinions.

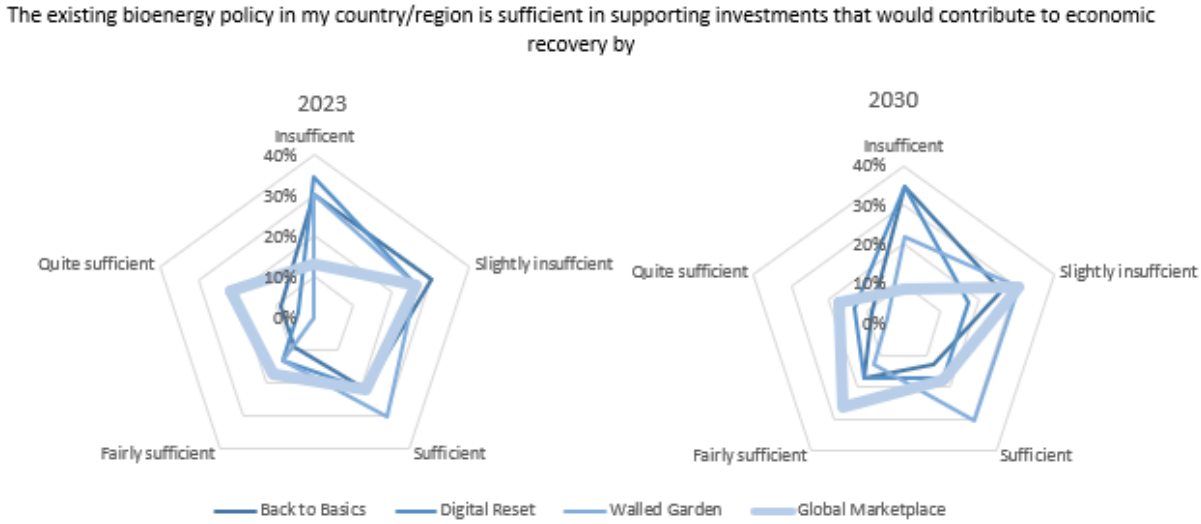
In reporting results, the mode was used to characterize the nature of each consensus if the response mode approximately equals one of the defined options. If the mode fell between two defined points on the scale, the consensus was defined as between the closest two points on the scale. For instance, a consensus where the modal score fell between strong and very strong was described as "Strong – Very Strong".

The statements where expert opinion failed to reach a consensus or had multiple modes were individually tailored for 23 experts for the second round. Two survey waves were implemented, which is consistent with a review finding that two rounds were common in Delphi-type studies (Sossa et al, 2019). The first survey consisted of 248 questions (see Appendix B). The second survey only included statements where experts did not reach a consensus, or where a respondent did not agree with the consensus. In the second survey, investments were repeated only for those questions where respondents did not agree with the consensus. The limited information presented in the second round of the survey was intentional; information presented in subsequent surveys can cause opinion change (Barrios et al., 2021).

In the final step of the analysis went beyond the 60% threshold for consensus and targeted a range of three consecutive values that would cover the maximum expert opinion to see how strong this recommendation is.

4.1 POSITION OF BIOMASS SUPPLY CHAINS IN AN ECONOMY

The bridging-over question to verify is whether the existing bioenergy policies in specific countries with a modern bioenergy use are sufficient in supporting investments that would contribute to economic recovery.

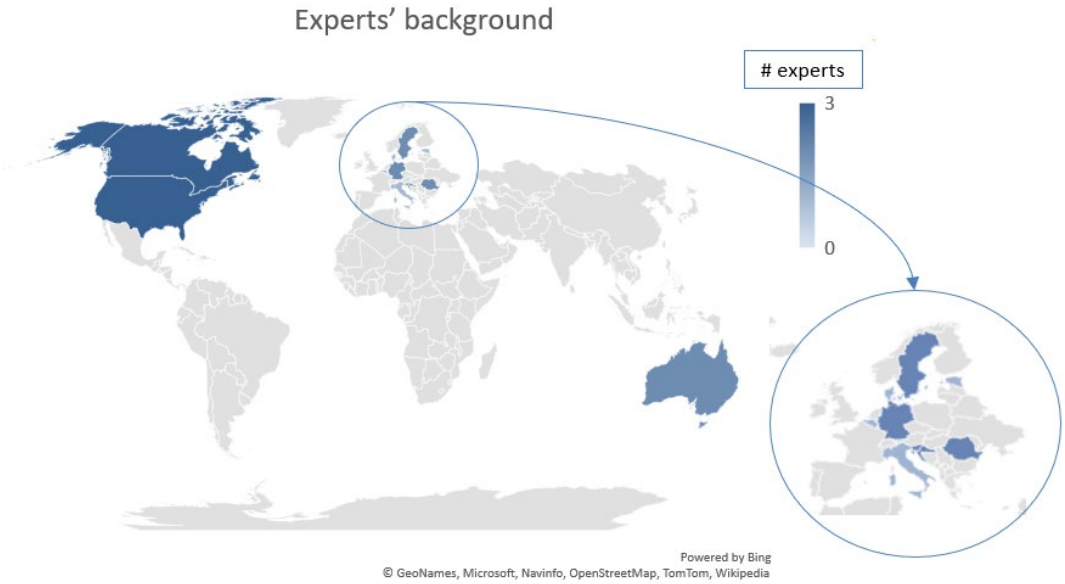


It shows that the experts agree on the existing bioenergy policy being in a range from range of "sufficiency" in both time frames for the Global Marketplace scenario, which is reflecting most of the world as we used to know it. In all other scenarios, in both time frames, experts agree in the opinion that the existing bioenergy policies are insufficient to slightly insufficient to support investments that would contribute to economic recovery. [2]

When asked the extent to which existing national bioenergy policies were sufficient in supporting investments that would contribute to the economic recovery under different scenarios, a consensus indicated that if future conditions were relatively favourable ("Global Marketplace"), then current national investments were moderately sufficient (CA, DE, RO) towards quite sufficient (SE, DK, EE, SI) by 2023. In contrast, under the remaining three (more challenging) scenarios, a consensus agreed that existing biomass policies were insufficient to sufficient (US, HR, AU, IT, BE) by 2023. However, current levels of investment were not as strongly endorsed to position a strong recovery by 2030 even under a Global Marketplace scenario.

[2] This was the only country specific question and we will serve to frame as a country specific context of the other results.

4.2 2-ROUND DELPHI RESULTS



In wave 1 of the survey, 23 experts reached a consensus in 208 of 248 statements (84%). Consensus regarding the sufficiency of current national bioenergy investments was reached for all scenarios both by 2023 and 2030 (61-83%). As shown in Table 6, experts reached consensus about the impact of 15 of 20 biomass supply chains investments on economic growth by 2023 versus 13 of 20 investments by 2030. In contrast, experts reached consensus about the effect of investments in technology and infrastructure on economic growth for 18 of 24 investments by 2023 and 21 of 24 investments by 2030. Experts reached consensus about the effect of investments in biomass supply chains on jobs for 33 of 36 investments by 2023, and 27 of 36 investments by 2030. With respect to creating cleaner, more resilient energy systems, experts reached consensus for more than 90% of investments in biomass supply chains for both 2023 and 2030.

Table 6 Number of Investment-related Questions where Consensus was Reached, as well as the range in percentage agreement) by Survey Section

Survey Section	Expert consensus			
	Wave 1		Wave 2	
	By 2023	By 2030	By 2023	By 2030
Economic Growth - Biomass Supply Chain Investments	15/20	13/20	20/20	19/20
Economic Growth - Investments in Technology and Infrastructure	18/24	21/24	24/24	24/24
Jobs - Investments in Biomass Supply Chains	33/36	27/36	36/36	34/36
Cleaner, Resilient Energy Sectors	33/36	34/36	36/36	36/36

The round 2 of the survey, 13 or 56% experts provided feedback, helping in forming of a consensus of expert opinions for 245 of 248 statements (98.8%).

The next figures are showing expert opinions on the statements. The structure of the next sections is as follows:

- aggregated results on the investments according to the survey section;

- results per each investment where the blue bubbles represent consensus in expert opinion, while the grey bubbles did not reach 60% expert agreement to achieve consensus. They were returned to the experts in the 2nd round.

4.2.1 Economic Growth

4.2.1.1 Biomass Supply Chain Investments

Wave 1 of the survey resulted in a consensus for 15 of 20 supply chain investments by 2023 and 13 by 2030. Incorporating wave 2 survey results, consensus was reach about all but one investment. Most experts rated investments in forest and agricultural biomass supply chains as probably increasing economic growth under most scenarios by 2023. As well, under the Global Marketplace and Walled Gardens scenarios, a consensus of experts detected investments in biomass supply chains from waste and by-streams as possibly to probably contributing to economic growth by 2023.

By 2030, experts reached consensus on a broader range of positive investment options in addition to agricultural and forest-based biomass supply chains. A consensus of experts expected investments in terrestrial biomass and waste and waste by-streams to possibly or probably increase economic growth in all scenarios by 2030.

Table 7 Expert Consensus on Biomass Supply Chain Investments Impact on Economic Growth by 2023 or by 2030

Investments	Short term				Long-term			
	Global Market place	Back to Basics	Digital Reset	Walled Gardens	Global Market place	Back to Basics	Digital Reset	Walled Gardens
Forest biomass supply chains	↑	↗	↗	↗	↑	↗	↑	↑
Agricultural supply chains	↗	↗	↗	↗	-	↗	↗	↑
Growing terrestrial biomass (e.g., energy crops)	↘	↘	↓	↘	↗	→	↗	↗
New biomass supply chains from waste and by-streams	↗	↘	↘	→	↑	→	→	→
Aquatic biomass (e.g., algae)	↘	↓	↓	↓	↘	↓	↘	↓

Legend:

Definitively, definitively to probably yes	↑
Probably, probably - possibly	↗
Possibly	→
Possibly - Probably not; probably not	↘
Probably – definitively not; definitively not	↓

Detailed results:

By 2023, where do you think the investments in biomass supply chains would have the strongest impact on economic growth? Please answer in general, not country specific.

Investment options legend:

1 Investments towards unlocking new biomass supply chains from waste and by-streams

2 Investments in growing terrestrial biomass (dedicated biomass such as short rotation coppice, energy crops...) to supply biomass for the market

3 Investments in improving forest biomass supply chains

4 Investments in improving agricultural biomass supply chains

5 Investments in growing aquatic biomass (such as algae...) to supply biomass for the market

All reached consensus in the expert opinion, between 70 and 96%, in average 79% agreement.

In all scenarios, experts agreed that **Investments in improving forest biomass supply chains scored would probably yes have the strongest impact on the economic growth.**

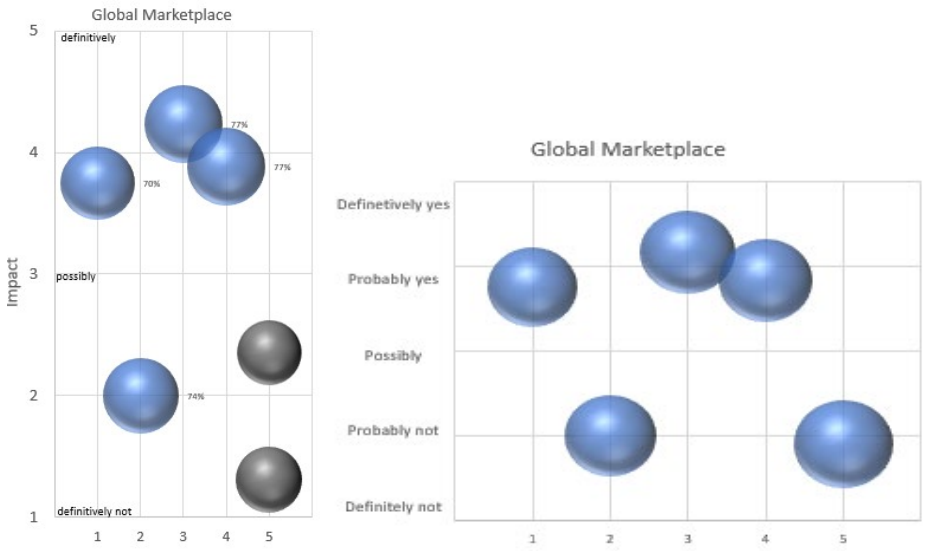


Figure 13 Round 1 (left) and round 2 (right)

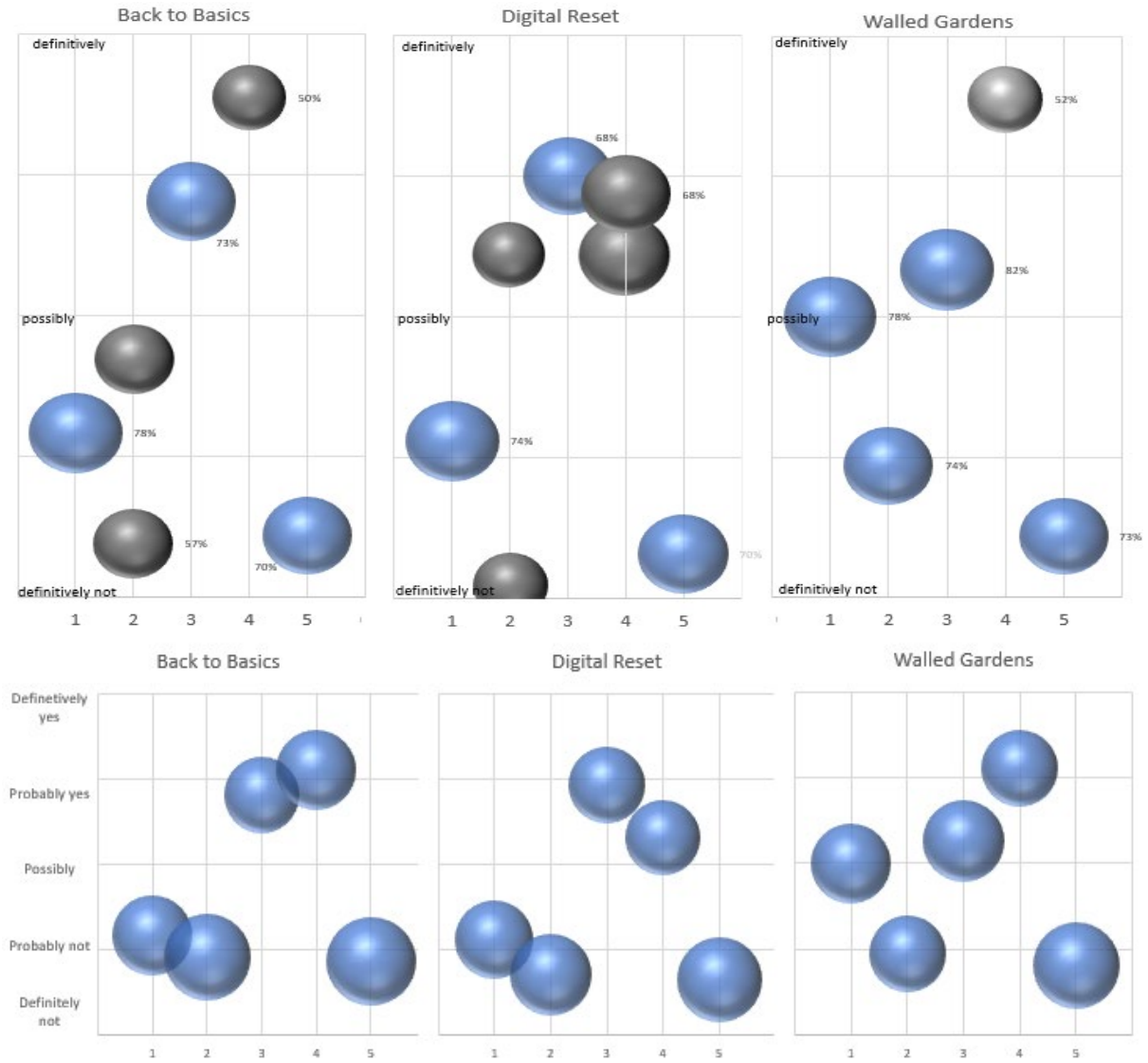


Figure 14 Round 1 (up) and round 2 (down)

Comments:

Back to basic scenario:

"probably" Investments in improving agricultural biomass supply chains will have impact on economic growth-by 2023.

I confess that I struggle a bit to follow the bubble figure. In my opinion, in the frame of a global acceptance, investments on biomass in Italy or more generally EU would find tremendous competition from biomass imported. Thus, I see little chance to have the economic growth.

The idea has value, but there's a significant challenge in attracting the operators of the supply chain. In Canada, there's currently a huge gap to fill with regards to machine operators in forestry and few people interested in taking over the farming business in the agricultural sector.

The status of bioenergy, particularly in Australia and Oceania, is already uncertain and is getting worse. The timetable to 2023 is not enough time to even develop then build a plant. So the opportunity for positive impact in my region in your timetable is, at best, possible as I stated previously.

Definitely not: I cannot determine a reply based on information provided because all options are not listed. So how can one determine which is strongest? In general, investments in biomass supply chains under "back to basics" are unlikely to have strong or beneficial impact on economic growth because fabric of society is falling apart. In this horrid scenario, investments must be made in education and building trust and understanding and support for science.

Digital reset scenario:

“probably not” Investments in improving agricultural biomass supply chains will have impact on economic growth-

I confess that I struggle a bit to follow the bubble figure. In my opinion, in the frame of a global acceptance, investments on biomass in Italy or more generally EU would find tremendous competition from biomass imported

By 2030, where do you think the investments in biomass supply chains would have the strongest impact on economic growth? Please answer in general, not country specific.

Investment options legend:

1 Investments towards unlocking new biomass supply chains from waste and by-streams

2 Investments in growing terrestrial biomass (dedicated biomass such as short rotation coppice, energy crops...) to supply biomass for the market

3 Investments in improving forest biomass supply chains

4 Investments in improving agricultural biomass supply chains

5 Investments in growing aquatic biomass (such as algae...) to supply biomass for the market

All reached consensus in the expert opinion, between 68 and 91%, in average 78% agreement.

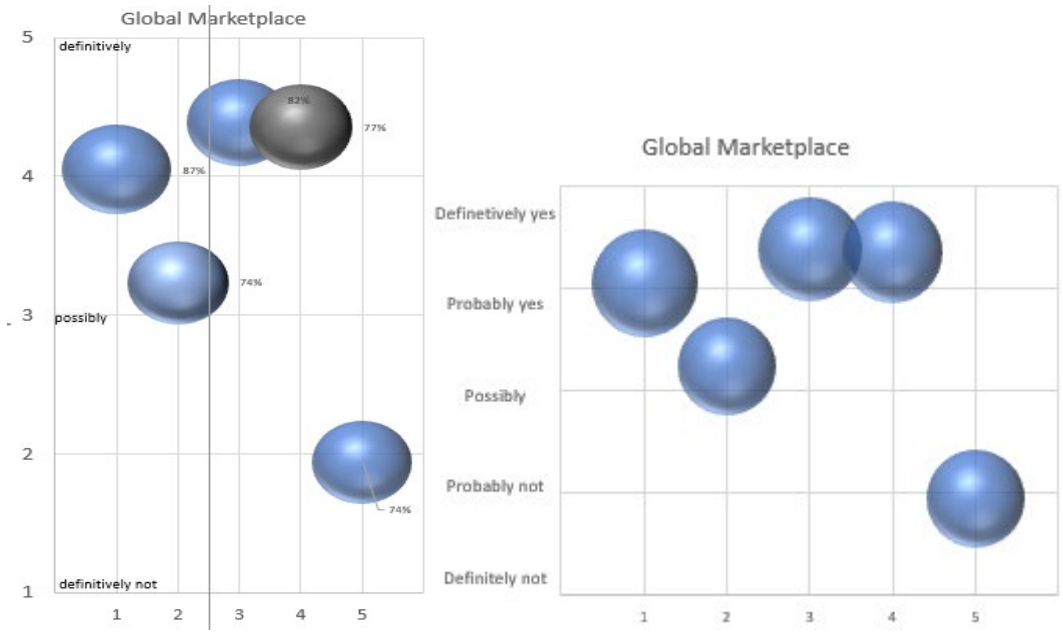


Figure 15 Round 1 (left) and round 2 (right)

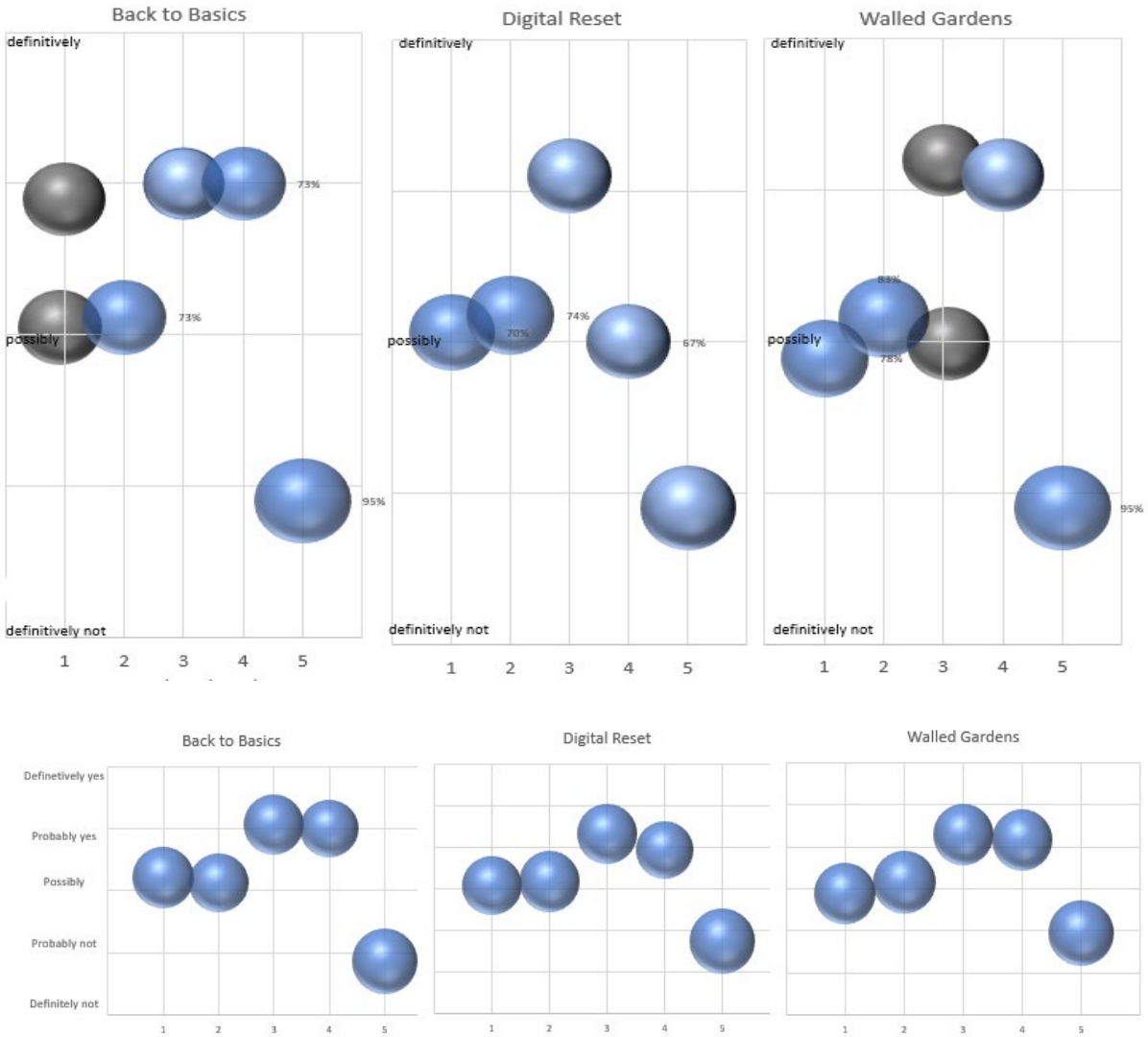


Figure 16 Round 1 (up) and round 2 (down)

Comments:

Back to Basic scenario

"probably" Investments in improving agricultural biomass supply chains will have impact on economic growth-by 2030

Keep existing result. The issues facing bioenergy are way beyond just supply chains.

R&D investments in the supply chains I look at will not be positively influenced enough to turn around the viability of a given project. The most I can hope for is a successful due diligence outcome by educating people that the supply chain I propose is in fact viable. Put differently, I do not expect or need sophisticated outcomes, I hope for high school level education of deal-blockers.

Digital reset scenario

Probably not Investments in improving forest biomass supply chains will have impact on economic growth

The digital reset scenario undermines public confidence well beyond just digital media, and that general undermining means innovative changes with bioenergy are less likely to have a receptive environment for their uptake.

4.2.1.2 Investments in Technology and Infrastructure

Overall, experts viewed prospects for economic growth prospects linked technology and infrastructure investments more positively by 2030 than 2023 (Table 4). Even under a Back-to-Basics scenario, a consensus of experts expected benefits of most investments by 2030. Under the Walled Gardens scenario, experts reached a consensus that three investments would increase economic growth by 2030. In particular, strong to very strong economic growth was predicted from investments in small scale, decentralised bioenergy facilities coupled with substitution of fossil fuel use fit for a local supply chain under this scenario by 2030.

Under a Digital Reset scenario, experts reached a positive consensus that several of the investments would increase economic growth by 2023, but only by a slight to moderate amount. Under a Digital Reset, experts rated investments in small-scale, decentralized bioenergy facilities and biomass logistic-distribution centres as having a moderate to strong impact on economic growth by 2023. In contrast, by 2030, under Digital Reset conditions, experts endorsed bioenergy technologies coupled with targeted biomass supply chains, small-scale, de-centralized bioenergy facilities, and upgrading the existing agricultural collection and processing centres into bio-hubs as having moderate to strong impacts on economic growth.

Table 8 Expert Consensus on Technology or Infrastructure Investment impact on Economic Growth by 2023 or by 2030.

Investment	Short-term				Long-term			
	Global Marketplace	Back to Basics	Digital Reset	Walled Gardens	Global Marketplace	Back to Basics	Digital Reset	Walled Gardens
1 Investment programs for preferred bioenergy technologies coupled with targeted biomass supply chains	↗	↘	→	↗	↑	↗	↗	→
2 Programs supporting all technologies and biomass supply chains	↗	↘	→	→	↑	→	→	→
3 Investment in biomass logistic-distribution centres (bio-hubs)	↗	→	↘	→	↗	↗	↗	↗
4 Investments in upgrading the existing agricultural collection and processing centres into bio-hubs	→	→	↘	→	↗	↗	↗	↗
5 Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain	↗	→	↗	→	↗	↗	↗	↑
6 Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery	→	↘	↘	→	↗	↘	↗	→

Legend:

Very strong impact, strong to very strong impact	↑
Strong impact, strong to moderate impact	↗
Moderate impact	→
Slight impact, slight to moderate impact	↘
Weak to slight impact	↓

By 2023, where do you think the technology and infrastructure investments in would have the strongest impact on economic growth?

Investment options legend:

1 Investment programs for preferred bioenergy technologies coupled with targeted biomass supply chains

2 Programs supporting all technologies and biomass supply chains

3 Investment in biomass logistic-distribution centres (bio-hubs)

4 Investments in upgrading the existing agricultural collection and processing centres into bio-hubs

5 Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain

6 Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery

All reached consensus in the expert opinion, between 65 and 91%, in average 77% agreement.

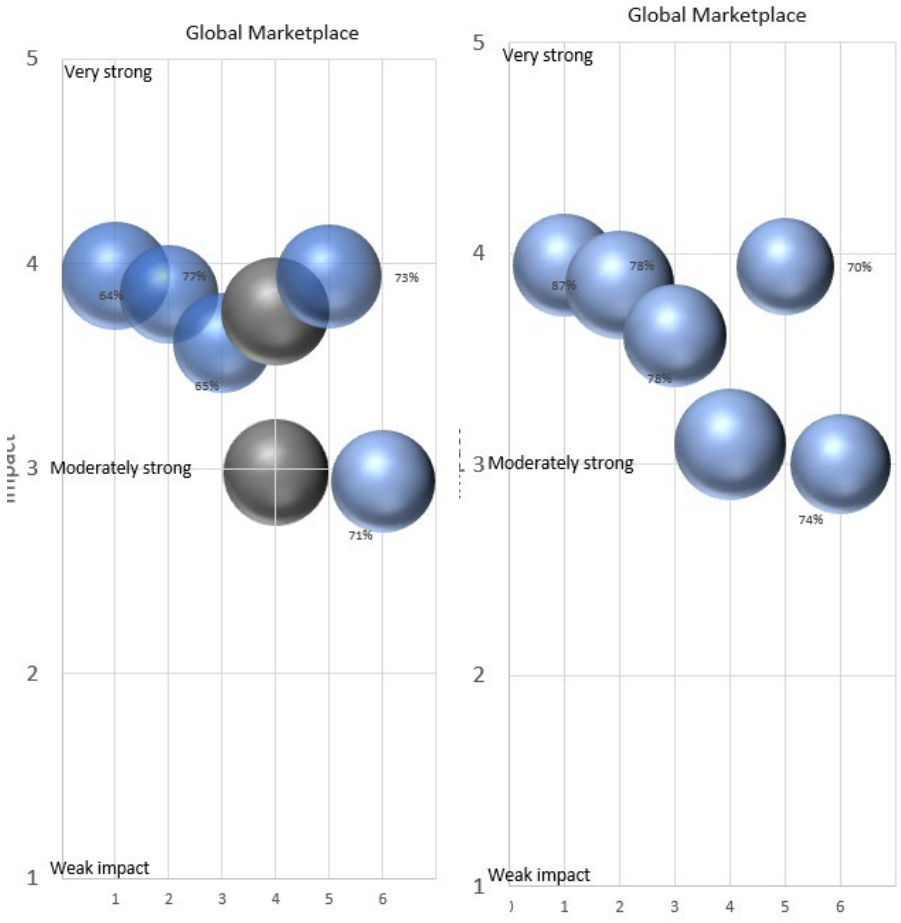


Figure 17 Round 1 (left) and round 2 (right)

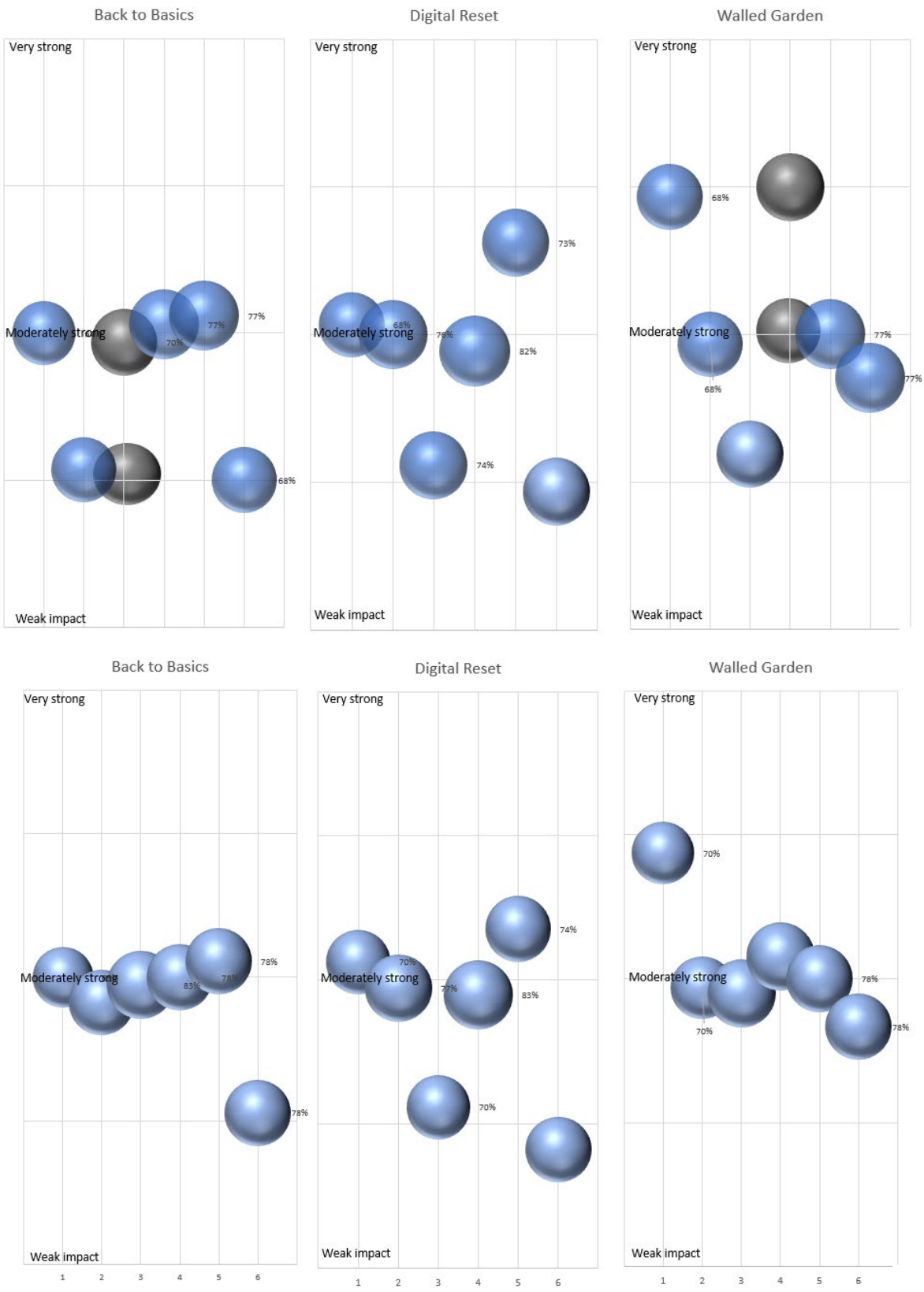


Figure 18 Round 1 (up) and round 2 (down)

Comments

Back to Basic scenario:

Weak impact from Programs supporting all technologies and biomass supply chains by 2023: In general, investments in biomass supply chains under "back to basics" are unlikely to have strong or beneficial impact on economic growth because fabric of society is falling apart. In this horrid scenario, investments must be made in education and building trust and understanding and support for science.

Strong impact from Programs supporting all technologies and biomass supply chains by 2023Local investments will have to occur, climate mitigation issues will have to occur, and existing well-working biomass investments will have to be further optimised, therefore I believe the impact will be strong when considering that other kinds of investments will probably not be promoted in the Back to Basics scenario

I still consider that in case of low import of biomass, investments in the sector solving the problems (air pollution from small combustors, efficient supply chains for residues, improvement of quality, etc.) will lead to the best impact for biomass supply chains.

Digital reset scenario:

Moderately strong impact from Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery: It's called economy of scale! Standard rule of thumb in such an industry is an exponent of around 0.6, so if a given plant costs $1M, a plant four times the size would only cost 4 to the 0.6 exponent as much, or $2.3M. Big savings on operating labour too.

Very strong impact: May be jurisdiction specific, but believe there will be a shift.

By 2030, where do you think the technology and infrastructure investments in would have the strongest impact on economic growth?

Investment options legend:

1 Investment programs for preferred bioenergy technologies coupled with targeted biomass supply chains

2 Programs supporting all technologies and biomass supply chains

3 Investment in biomass logistic-distribution centres (bio-hubs)

4 Investments in upgrading the existing agricultural collection and processing centres into bio-hubs

5 Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain

6 Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery

All reached consensus in the expert opinion, between 68 and 91%, in average 81% agreement.

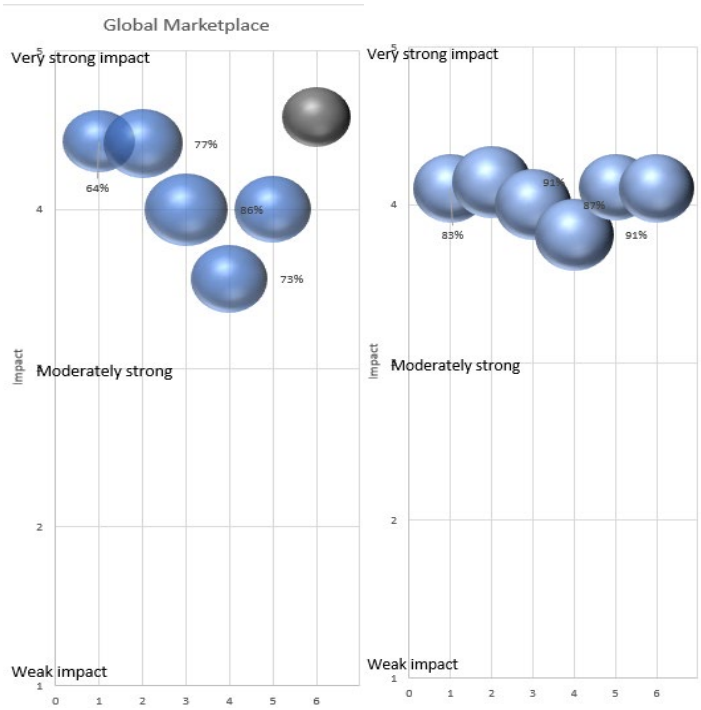


Figure 19 Round 1 (left) and round 2 (right)

Comments

Moderately strong impact on economc growth by 2030 in Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain

I keep my rate. Maybe we are thinking in something different for "small scale". In Italy this mainly means 1 MWe generators (such as gasifiers) with little use of heat. I do not see them as very sustainable from the environmental but also from the economic point of view. If you had in mind district heatings (es. 3-8 MWt) in villages or small towns with or without (better) electricity generation, then I would agree with 4 or 5 rating

Moderately strong impact on economc growth by 2030 in Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery

Large scale power plants survive with subsidies, at least in Italy. Maybe biorefineries would do better, but at the moment there is no such technology in the market. And in case that by 2030 real

biorefineries were operative (e.g. producing building blocks) they would be built in areas with cheap and abundant biomass and low salary costs (e.g. Brazil), same as pulpmill did in the past.

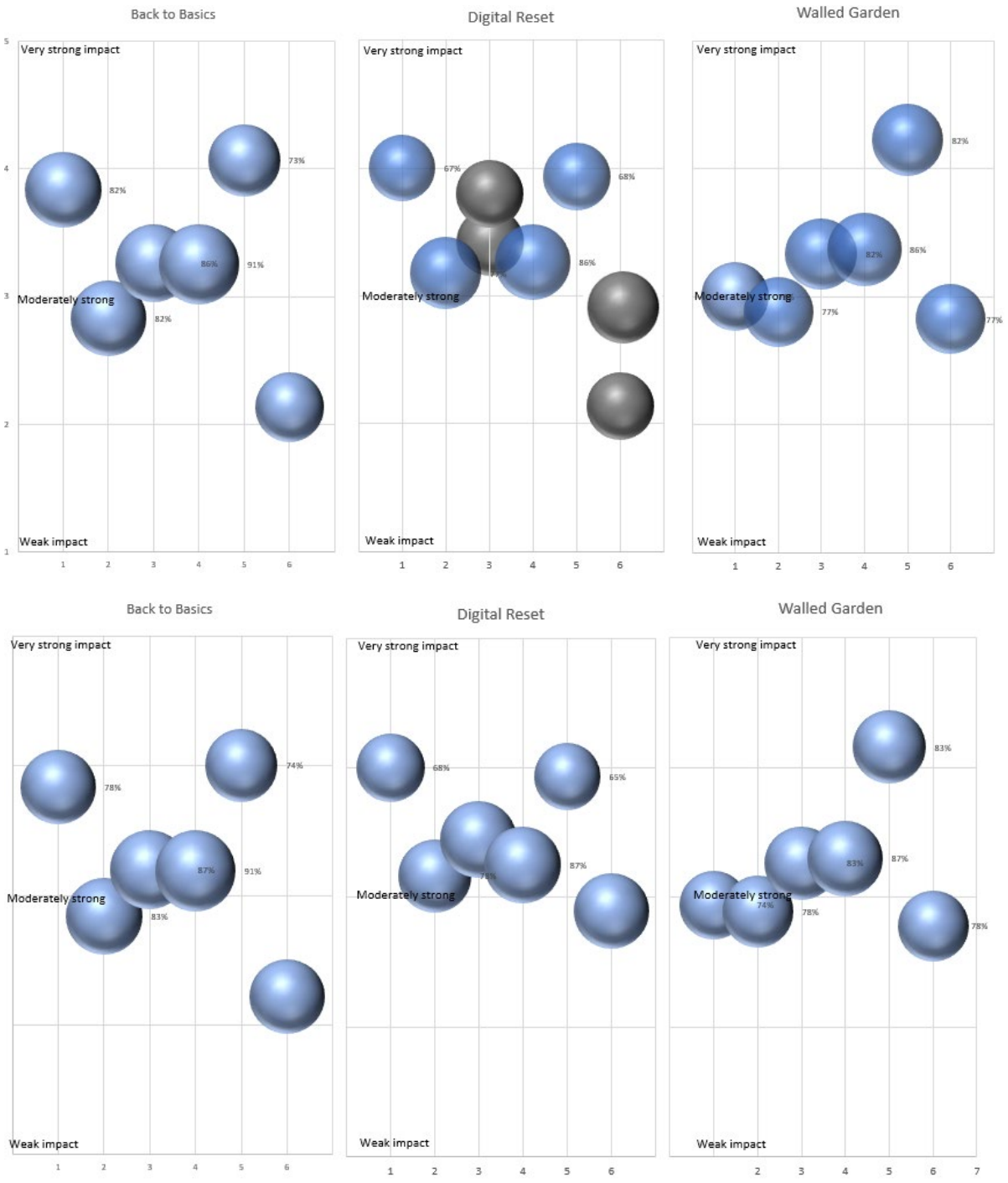


Figure 20 Round 1 (up) and round 2 (down)

<u>Digital reset comment</u>:

Slight impact from Investment in biomass logistic-distribution centres (bio-hubs) by 2030.

I may reconsider slightly my opinion (rising to 2). Yet, logistic centres would distribute imported biomass, and I do not see much economic growth in this.

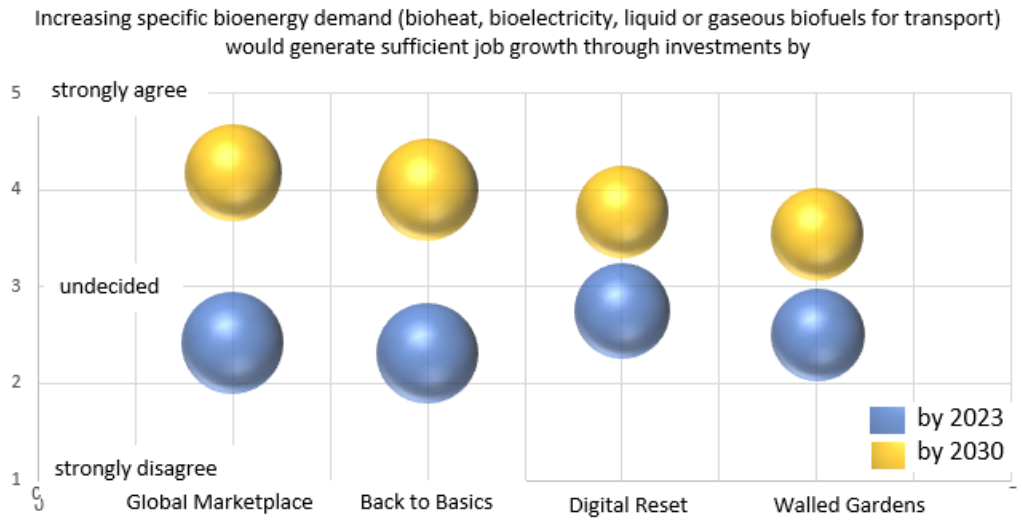
4.2.2 Job Creation

4.2.2.1 Investments in increasing Biomass Demand to Create Jobs

Experts agree that increasing specific bioenergy demand such as bioheat, electricity, liquid or gaseous biofuels for transport would generate sufficient job growth through investments in long term, in all scenarios. The strongest positive consensus (agree-strongly agree) was in Global Marketplace scenario and the least positive (agree-undecided) in Walled Garden scenario.

This statement intended to highlight that biomass can provide a wide range of energy end-use and tradable liquid, gaseous and solid biofuels. Increasing biomass demand in general, without identifying which one is the most suitable for the country energy mix and biomass availability for sustainable supply, would also lead to competition for biomass among the bioenergy sector itself, inflating the price of biomass and scattering the investment effect across many end-uses and fuel markets.

To what extent do you agree with the following statements under the different scenarios?



2023: Consensus in the first round: 62-76%, in average 70%

2030: Consensus in the first round: 62-76%, in average 67%

Please explain your view about stimulating demand in bioenergy in few sentences.

ID	Response
7	incentives to use biomass as a sustainable energy source a key for bioenergy implementation
14	Any stimulation of bioenergy demand needs to be in the context of highest value use demand first and where bioenergy is a sustainable and economic renewable energy option
18	It depends on the goals. If the primary goal is to reduce GHG-emissions, the technology that provides maximum GHG savings with least costs is the most favourable. This might be bioenergy or others. If the primary goal is the create jobs in rural areas or to support farmers and forest owners, policies targeted to increase demand for domestic bioenergy are favourable. A one size fits all policy that can do all, does not exist.
19	In order for demand to be stimulated there needs to be a sufficiently large market in order for the market to exist. Otherwise, intervention is needed to create the market, however it has to be

	sustainable beyond intervention. This is achievable through two main channels, one is financial viability for consumers, and/or to a part of global environmental solution for carbon capture.
24	Marketplace needs to be created with specific and progressive policies mandating minimum renewable content in liquid fuels (gasoline, diesel, natural gas, heavy oil) above 10%
28	Stimulating demand seems to depend on policy related initiatives that account for external costs that the market place often does not. This can direct private investment in significant ways to increase the bioeconomy. Therefore it is up to governments to create markets and then let private investment take the lead.
30	Question here (as many above) is far too vague and subjective to provide useful result. What is "sufficient"? Why would 7 years make a difference? Responses depend on so many assumed variables, and how demand is stimulated, what incentives, what size of incentives. Responses therefore are not comparable. This concern applies to the entire questionnaire.
31	The demand is and will be there even increased in the future, supply needs to be ensured but large-scale investments will probably not be extensively available the first years after covid-19, maybe more investments in small-scale smaller infrastructure, for 2030 probably this trend will change with more investments
36	At the moment, it is highly political-driven. Unless we change it and make it consumer-driven, I do not see very bright future.
40	Demand is depending on taxation and legal conditions of fossil energy, development of new technologies and price of new technologies and societal willingness to "turn green".
41	Stimulating demand in bioenergy should be done through government involvement in the beginning in order to be cost effective compared with fossil fuel. In time these incentives should be reduced and the economy will follow its own rules.
42	The bioeconomy growth will require increased demand of biomass for different production purposes and innovation in these fields will stimulate the demand of sustainable produced biomass.
43	Bioenergy will have to be a priority area in post-covid Europe 19
46	Higher targets for the RES in heating sector and transport may increase the demand. In power sector we foresee a steady growth of bioenergy.
51	Promote local use and recovery of residues. Diversify use of biomass according to quality (energy, bioproducts, etc.). For energy generation, there is future only if will be developed combustion systems not affecting air quality.
52	Biomass must be cascaded, and the energy obtained must be high value, like aviation fuel

4.2.2.2 **Investments in Biomass Supply Chains to create jobs**

A consensus of experts indicated that demand for bioenergy was the biggest driving factor in creating jobs (Investment #9 in Table 5). Under three of the four future scenarios, experts ranked demand for bioenergy as having the largest potential to create jobs by 2023. In contrast, there was a consensus that market incentive programmes for replacing fossil fuel heating and cooling with biomass in agriculture and primary processing (e.g. dairy, juices, spirits…) might increase jobs by 2023, except under Walled Gardens where experts viewed such incentives as effective in increasing

employment. A consensus of experts agreed that re-skilling of unemployed workers due to the COVID-19 for biomass supply would not create jobs under a Global Marketplace or Digital Reset scenario by 2023, but might do so under a Back to Basics or Walled Gardens scenario.

Under a Back to Basics scenario, however, a consensus of experts agreed that four of out nine investments under this scenario would not increase jobs.

A consensus of experts rated seven investments as increasing jobs by 2030 compared to only three by 2023. However, most of these investments were rated as increasing jobs only under the Global Marketplace scenario.

Table 9 Expert Consensus on Investment impact on Job Creation by 2023 or by 2030

Investment	Short-term				Long-term			
	Global Marketplace	Back to Basics	Digital Reset	Walled Gardens	Global Marketplace	Back to Basics	Digital Reset	Walled Gardens
1 Investment in information exchange points to inform the market players how to add value to the unused biomass with a portfolio of financing schemes	→	↓	→	→	→	→	→	→
2 Market incentive programmes for replacing fossil fuel heating and cooling with biomass in agriculture (e.g., stables, greenhouses), post-harvest (e.g., drying, cooling), primary processing (e.g., dairy, juices, spirits)	→	→	→	↑	↑	→	→	-
3 Investments in replacing fossil fuels in public institutions with a biofuel with the highest multiplier effect in jobs	→	→	→	→	↑	→	→	→
4 Investment in re-skilling of unemployed workers due to the COVID-19 for biomass supply related jobs	↓	→	↓	→	→	→	→	→
5 Investments in establishment of biomass logistic-distribution centres to stabilise the biomass supply market: secure supply, quality, price, and sustainability	→	→	→	→	→	↗	→	→
6 Investments in planting biomass for bioenergy within a bioeconomy, in general	→	↓	↓	→	↑	→	-	→
7 Investments in planting biomass for bioenergy within a bioeconomy at non utilised agricultural land	→	↓	↓	→	↑	→	↘	→
8 Investments in planting additional biomass as a part sustainable intensification of agriculture (intercropping, agroforestry…)	↘	↓	↓	→	↑	→	→	→
9 Increased demand for bioenergy would increase jobs in biomass supply chains	↑	→	↑	↗	↑	→	↑	→

Definitively, definitively to probably yes	↑
Probably, probably - possibly	↗
Possibly	→
Possibly - Probably not; probably not	↘
Probably – definitively not; definitively not	↓

By 2023, which investments related to the biomass supply chains are more likely to create jobs under different scenarios?

Investments options legend:

1 Investment in information exchange points to inform the market players how to add value to the unused biomass with a portfolio of financing schemes

2 Market incentive programmes for replacing fossil fuel heating and cooling with biomass in agriculture (e.g. stables, greenhouses…), post-harvest (e.g. drying, cooling…) and primary processing (e.g. dairy, juices, spirits…)

3 Investments in replacing fossil fuels in public institutions with a biofuel with the highest multiplier effect in jobs

4 Investment in re-skilling of unemployed workers due to the COVID-19 for biomass supply related jobs

5 Investments in establishment of biomass logistic-distribution centres to stabilise the biomass supply market: secure supply, quality, price and sustainability

6 Investments in planting biomass for bioenergy within a bioeconomy, in general

7 Investments in planting biomass for bioenergy within a bioeconomy at non utilised agricultural land

8 Investments in planting additional biomass as a part sustainable intensification of agriculture (intercropping, agro-forestry…)

9 Increased demand for bioenergy would increase jobs in biomass supply chains. All reached consensus in the expert opinion, between 73 and 95%, in average 82% agreement. Consensus reached in Back to basics scenario in 1st round.

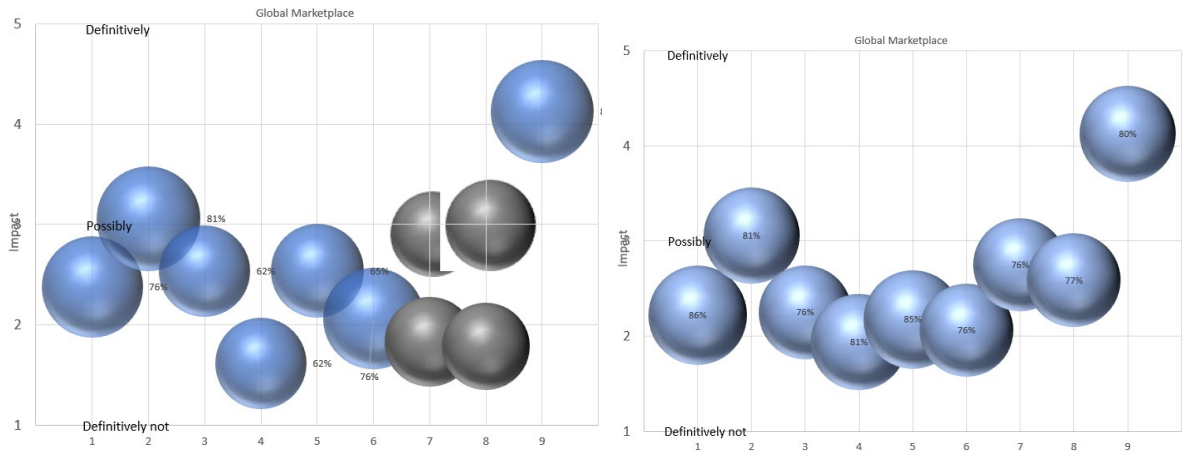


Figure 21 Round 1 (left) and round 2 (right)

Comments:

Definitively not Investments in planting biomass for bioenergy within a bioeconomy at non utilised agricultural land will make jobs.

Maybe it would create jobs in some non-EU country. Marginal land is generally non used because non fertile or suffering other problems. Energy crops are normally not competitive per-se, if they are grown on marginal land they will produce less and be even less competitive. I do not see these

investments as effective unless for a medium-large user to secure its feedstock (as the case of IKEA in Slovakia)

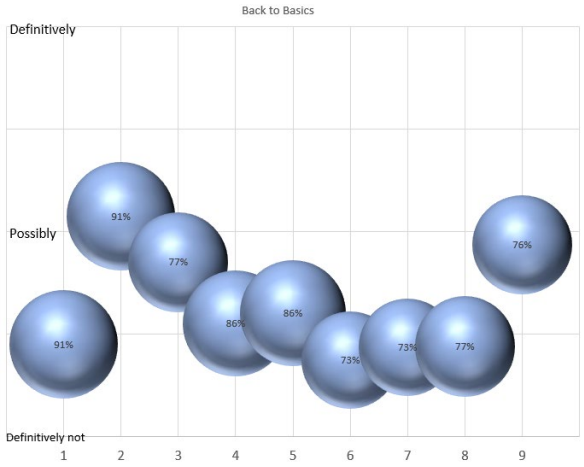


Figure 22 Round 1

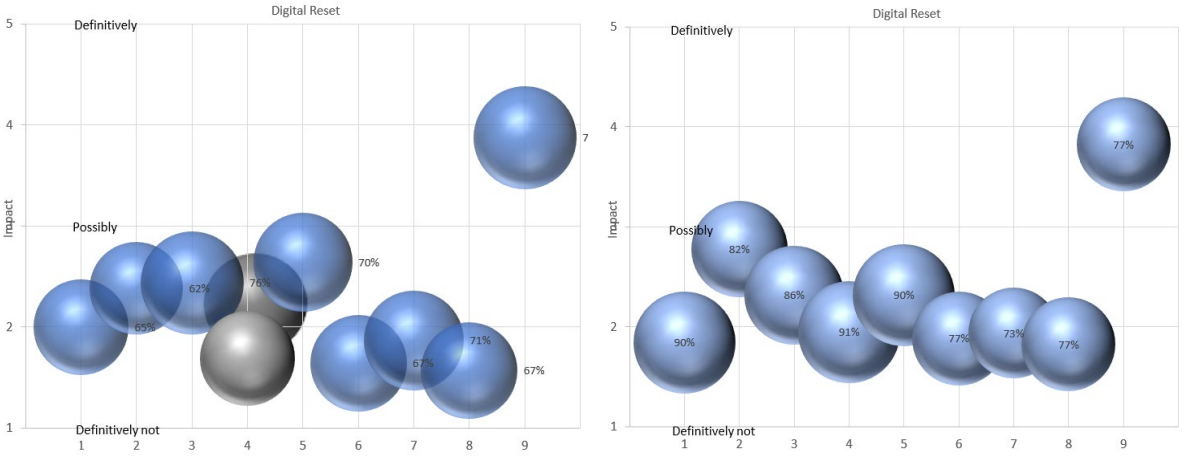


Figure 23 Round 1 (left) and round 2 (right)

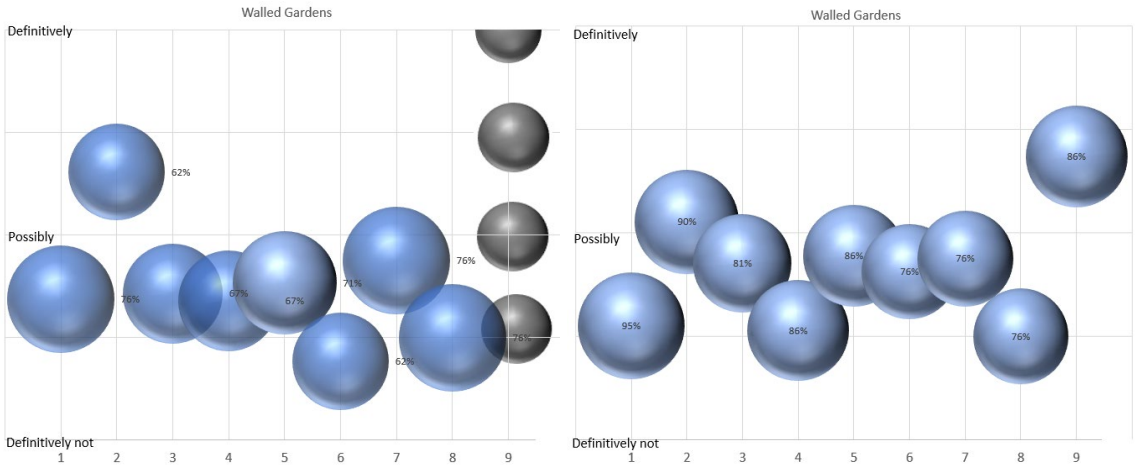


Figure 24 Round 1 (left) and round 2 (right)

By 2030, which investments related to the biomass supply chains are more likely to create jobs under different scenarios?

Investments options legend:

1 Investment in information exchange points to inform the market players how to add value to the unused biomass with a portfolio of financing schemes

2 Market incentive programmes for replacing fossil fuel heating and cooling with biomass in agriculture (e.g. stables, greenhouses…), post-harvest (e.g. drying, cooling…) and primary processing (e.g. dairy, juices, spirits…)

3 Investments in replacing fossil fuels in public institutions with a biofuel with the highest multiplier effect in jobs

4 Investment in re-skilling of unemployed workers due to the COVID-19 for biomass supply related jobs

5 Investments in establishment of biomass logistic-distribution centres to stabilise the biomass supply market: secure supply, quality, price and sustainability

6 Investments in planting biomass for bioenergy within a bioeconomy, in general

7 Investments in planting biomass for bioenergy within a bioeconomy at non utilised agricultural land

8 Investments in planting additional biomass as a part sustainable intensification of agriculture (intercropping, agro-forestry…)

9 Increased demand for bioenergy would increase jobs in biomass supply chains

All reached consensus in the expert opinion, between 64 and 95%, in average 76% agreement. Consensus reached in Global Marketplace scenario in 1st round. No consensus after 2nd round in Digital Reset and Walled Gardens scenario.

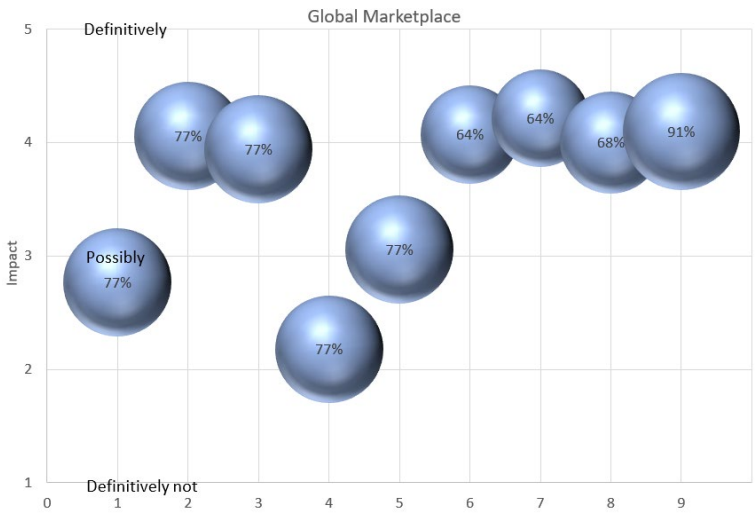
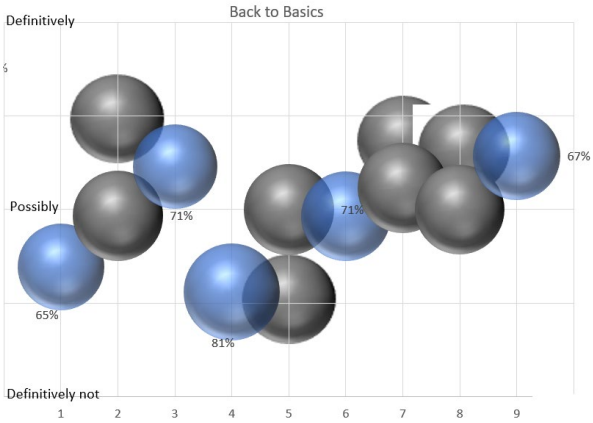


Figure 25 Round 1



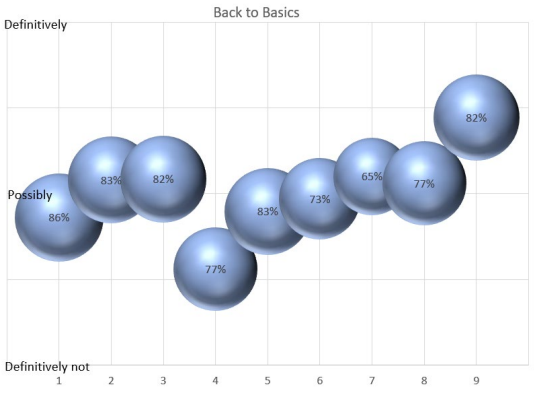
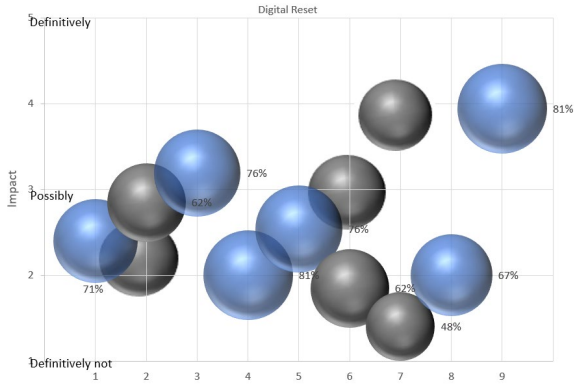


Figure 26 Round 1 (left) and round 2 (right)



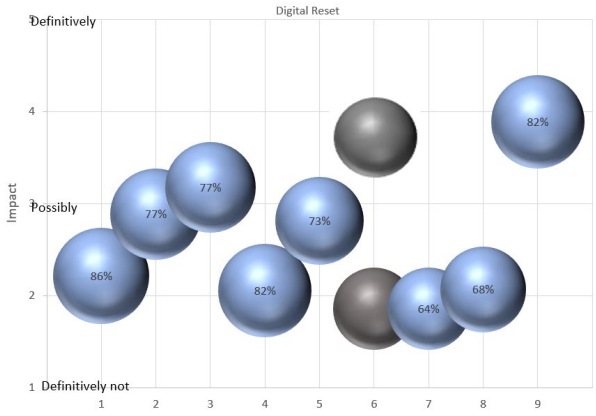
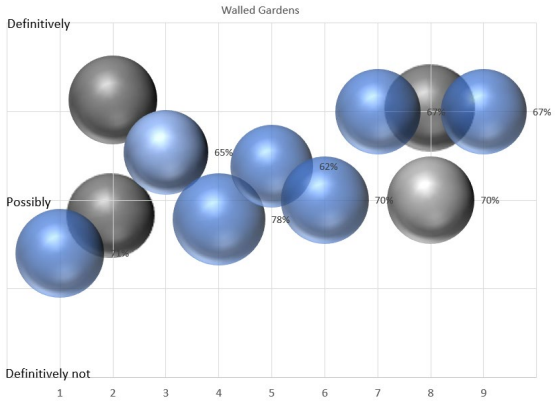


Figure 27 Round 1 (left) and round 2 (right)



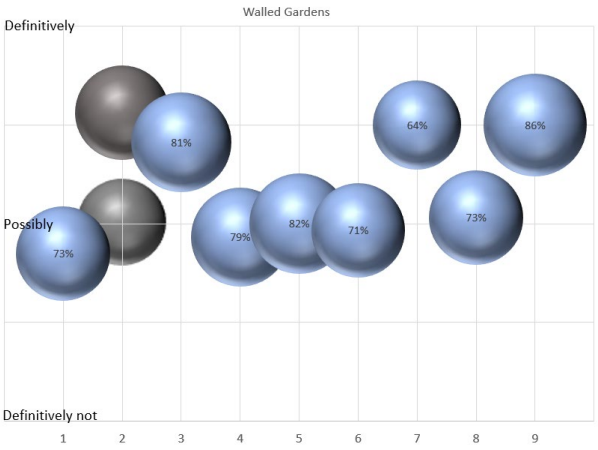


Figure 28 Round 1 (left) and round 2 (right)

<u>Comments Back to Basic:</u>

Definitively not will create jobs by 2030 Investments in planting biomass for bioenergy within a bioeconomy at non utilised agricultural land

Even if not suffering competition from import, planted biomass for energy is not competitive with crops. And it does not grow on marginal land (the idea that energy crops grow well where food crops do not is a very common mistake with few exceptions).

4.2.3 Clean, Resilient Energy Sector

Experts were undecided if increasing specific bioenergy demand would generate more resilient and cleaner energy systems through investments in different future scenarios in a short run. In Digital Reset scenario, a consensus in expert opinion was not reached and both options are in the area between "undecided" and "strongly disagree".

In Global Marketplace, experts agree and, in Back to Basic and Walled Gardens scenarios, experts cautiously agree that investments in specific bioenergy demand would generate more resilient and cleaner energy systems through investments by 2030. Consensus not reached in the 2nd round in Digital reset by 2023.

Among the reached consensus in the expert opinion, between 65 and 75%, in average 69% agreement. All scenarios reached consensus in the expert opinion, between 70 and 84%, in average 80% agreement.

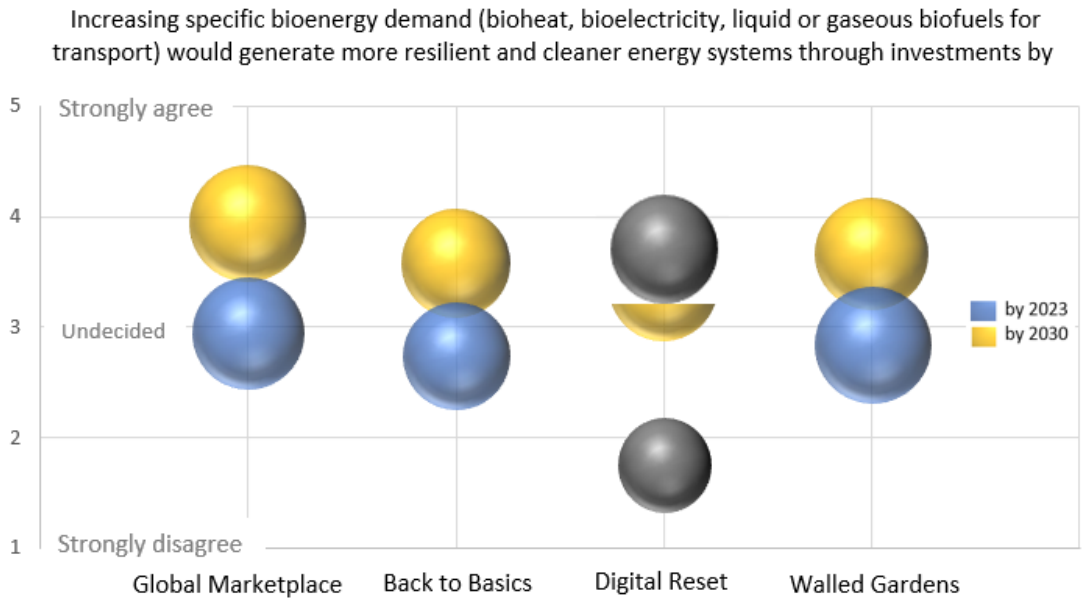


Figure 29 Round 1

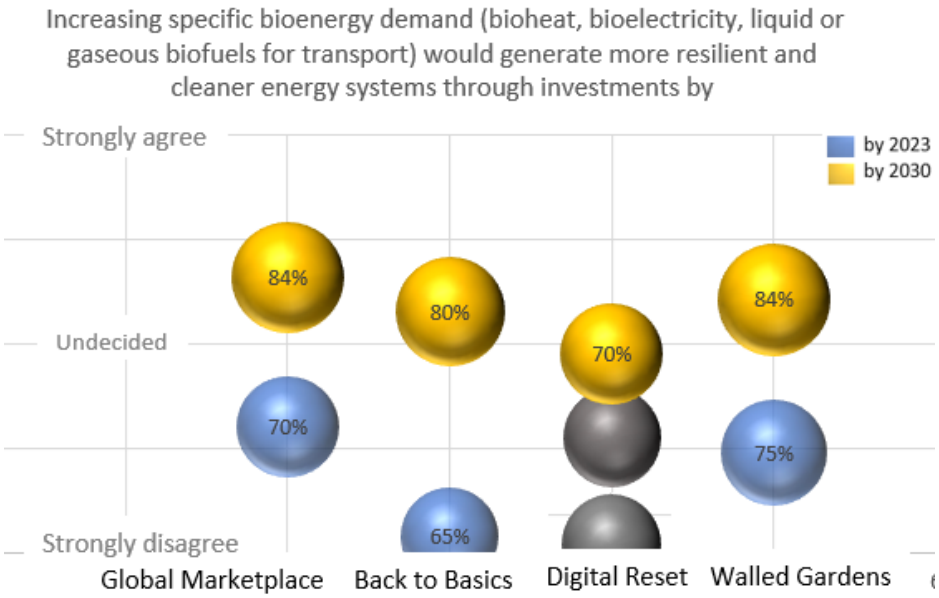


Figure 30 Round 2

For the most part, experts were unconvinced that investments would produce a cleaner, more resilient energy system by 2023 (see Table 6). By 2030, however, under a "Global Marketplace" scenario, four investments (2 – establishment of locally available biomass supply chains, 6 – bioenergy technologies coupled with targeted biomass supply chains, 8 – small scale, decentralised bioenergy facilities, and 9 – large scale, centralised bioenergy facilities) were viewed by a consensus of experts as contributing to cleaner and more resilient energy system. In comparison, under a Back-to-Basics scenario, experts viewed 4 – R&D on energy efficiency in the bioenergy system and 8 – small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, as contributing to cleaner and more resilient energy systems by 2030.

Under a Digital Reset scenario, experts were undecided as a group as to what investments would lead to a cleaner and more resilient energy system, even by 2030. Under the "Walled Gardens" scenario, a consensus agreed that 2 (locally available biomass supply chains), 4 (R&D to increase efficiency in the bioenergy system), 8 (small scale, decentralised bioenergy facilities), and 9 (large scale, centralised bioenergy facilities) would create a cleaner, more resilient energy system by 2030. **The strongest investment for creating clean, sustainable energy systems by 2030 was small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain.**

Table 10 Expert Consensus on Effect of Investments on Creating a Clean, Resilient Energy Sector

Investment	Short-term				Long-term			
	Global Marketplace	Back to Basics	Digital Reset	Walled Gardens	Global Marketplace	Back to Basics	Digital Reset	Walled Gardens
1 Investing in research to select biomass supply chains appropriate for a country	→	↘	↘	↘	→	↗	→	↗
2 Investment in establishment of locally available biomass supply chains to facilitate a targeted fossil fuel replacement or power grid flexibility	↘	↘	↘	↘	↗	↗	→	↑
3 Investment in diversification of conversion technologies to accommodate local biomass supply	→	→	→	↘	→	↗	↗	↗
4 Investment in R&D to increase efficiency in the bioenergy system relying on local biomass supply	↘	↘	↘	↘	→	↗	→	↗
5 Investment in biomass logistic-distribution centres (bio-hubs) to stabilise the biomass supply market: secure supply, quality, price, and sustainability	↗	↘	→	↘	↗	→	↗	↗
6 Investment programs for preferred bioenergy technologies coupled with targeted biomass supply chains	↗	↘	→	↘	↗	↗	↗	↗
7 Investments in upgrading the existing agricultural collection and processing centres (e.g., flour mills, oil mills, vineries, dry fruits, and nuts…) into bio-hubs to mobilise waste- and side-streams	↘	↘	↘	↘	↗	↗	↗	↗
8 Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain	↗	↘	↘	↘	↗	↗	↗	↑
9 Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery	↗	→	↘	↘	↑	↗	→	↑

Strongly agree, strongly agree to agree	↑
Agree, agree to undecided	↗
Undecided	→
Disagree to undecided, disagree	↘
Disagree to strongly disagree, strongly disagree	↓

By 2023, where do you think bioenergy-related investments would contribute most to supporting and building the resilient and cleaner energy systems under different scenarios?

Investment options legend:

1 Investing in research to select biomass supply chains appropriate for a country

2 Investment in establishment of locally available biomass supply chains to facilitate a targeted fossil fuel replacement or power grid flexibility

3 Investment in diversification of conversion technologies to accommodate local biomass supply

4 Investment in R&D to increase efficiency in the bioenergy system relying on local biomass supply

5 Investment in biomass logistic-distribution centres (bio-hubs) to stabilise the biomass supply market: secure supply, quality, price and sustainability

6 Investment programs for preferred bioenergy technologies coupled with targeted biomass supply chains

7 Investments in upgrading the existing agricultural collection and processing centres (e.g. flour mills, oil mills, vineries, dry fruits and nuts…) into bio-hubs to mobilise waste- and side-streams

8 Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain

9 Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery, fit to achieve economies of scale, regardless on the biomass supply chain

All reached consensus in the expert opinion, between 76 and 95%, in average 86% agreement. Consensus reached in Global Marketplace and Walled Gardens scenario in 1st round but was adjusted for missed answers. No consensus after 2nd round in Digital Reset and Walled Gardens scenario.

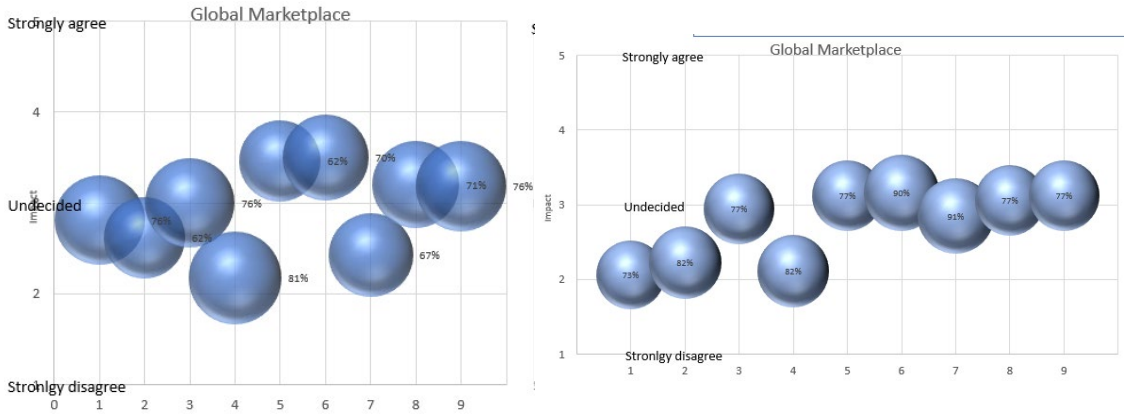


Figure 31 Round 1 (left) and round 2 (right)

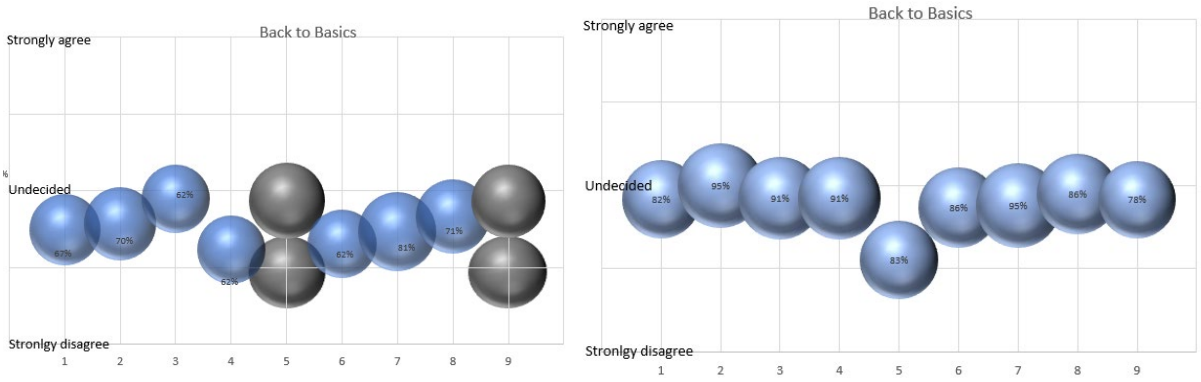


Figure 32 Round 1 (left) and round 2 (right)

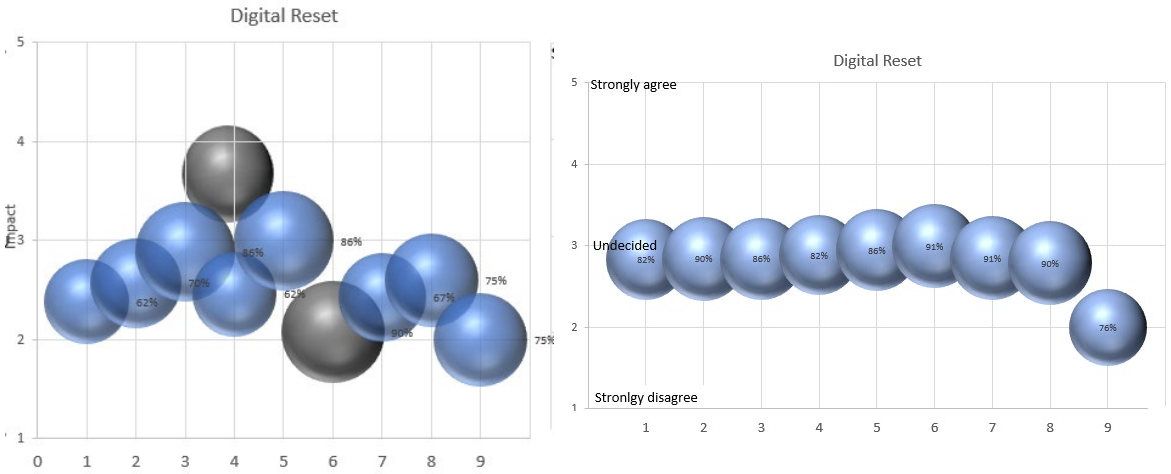


Figure 33 Round 1 (left) and round 2 (right)

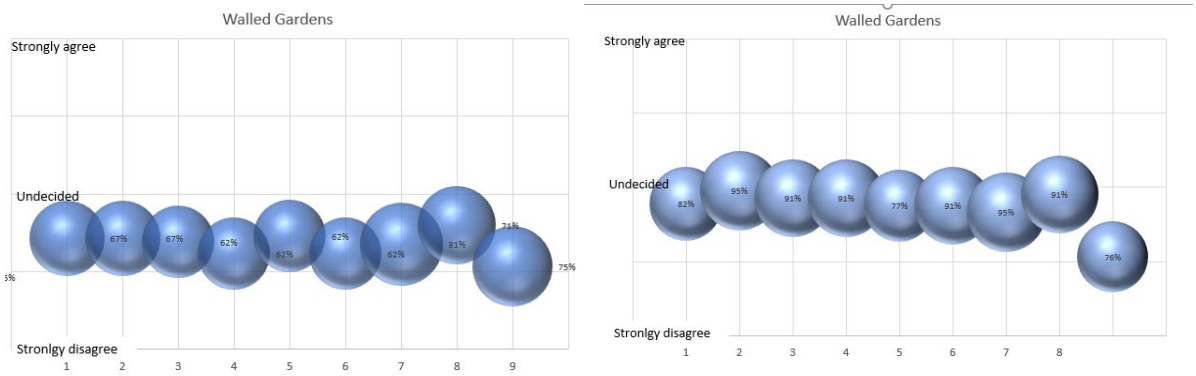


Figure 34 Round 1 (left) and round 2 (right)

Comments

Back to Basic

Strongly disagree that Investment in biomass logistic-distribution centres (bio-hubs) to stabilise the biomass supply market: secure supply, quality, price and sustainability would contribute to supporting and building the resilient and cleaner energy systems

I do not see the role of bio-hubs as useful. Probably investment in road network infrastructure, redesigned to include also numerous small, multi-purpose storage yards, would be a much more effective solution.

Agree that Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery, fit to achieve economies of scale, regardless on the biomass supply chain would contribute to supporting and building the resilient and cleaner energy systems.

Investable bioenergy has a smaller carbon footprint than fossil fuels. That is a fundamental aspect of the industry, and it amazes me that anyone within the industry would question it.

By 2030, where do you think bioenergy-related investments would contribute most to supporting and building the resilient and cleaner energy systems under different scenarios?

Investment options legend:

1 Investing in research to select biomass supply chains appropriate for a country

2 Investment in establishment of locally available biomass supply chains to facilitate a targeted fossil fuel replacement or power grid flexibility

3 Investment in diversification of conversion technologies to accommodate local biomass supply

4 Investment in R&D to increase efficiency in the bioenergy system relying on local biomass supply

5 Investment in biomass logistic-distribution centres (bio-hubs) to stabilise the biomass supply market: secure supply, quality, price and sustainability

6 Investment programs for preferred bioenergy technologies coupled with targeted biomass supply chains

7 Investments in upgrading the existing agricultural collection and processing centres (e.g. flour mills, oil mills, vineries, dry fruits and nuts…) into bio-hubs to mobilise waste- and side-streams

8 Investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain

9 Investments in large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery, fit to achieve economies of scale, regardless on the biomass supply chain

All reached consensus in the expert opinion, between 75 and 95%, in average 83% agreement. Consensus reached in Global Marketplace and Walled Gardens scenario in 1st round but was adjusted for missed answers.

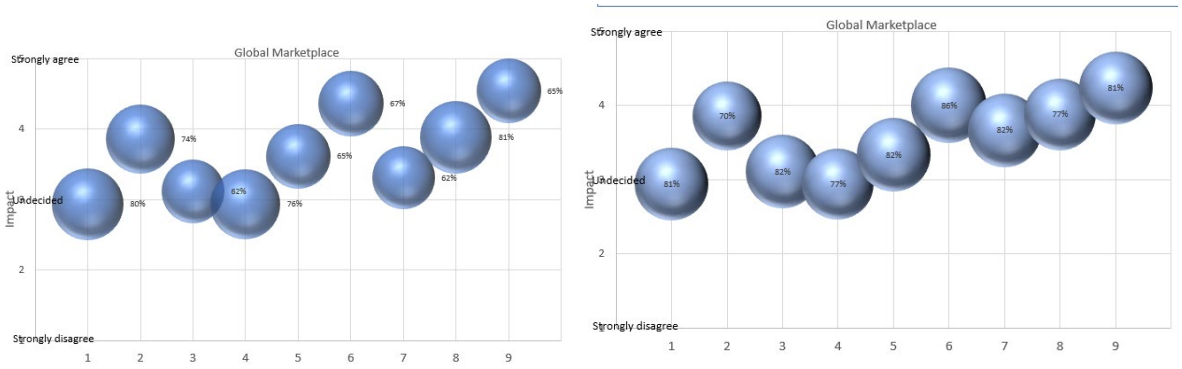


Figure 35 Round 1 (left) and round 2 (right)

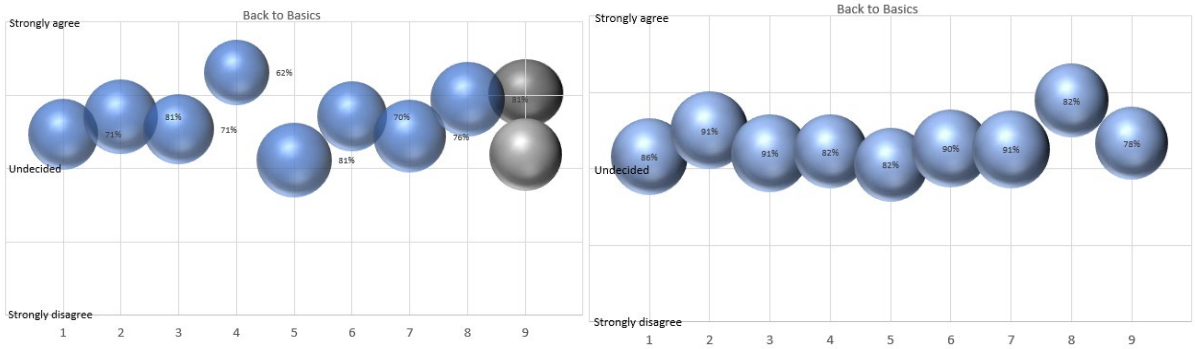


Figure 36 Round 1 (left) and round 2 (right)

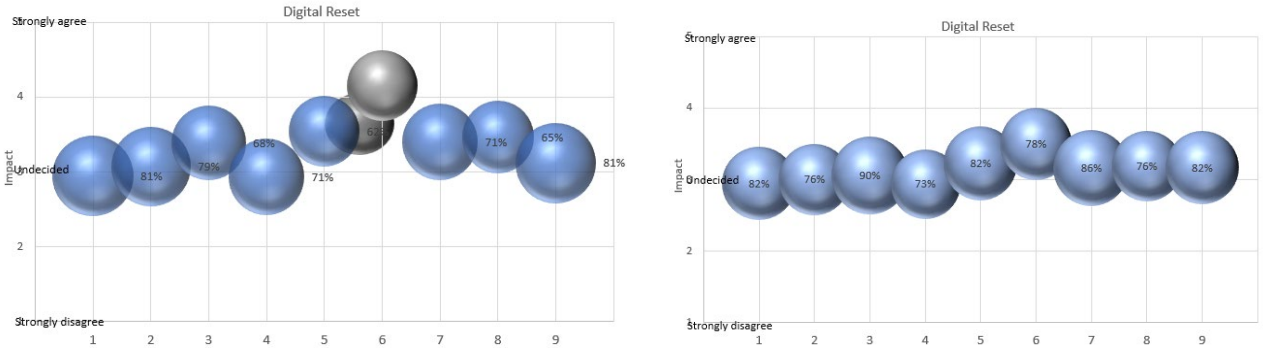


Figure 37 Round 1 (left) and round 2 (right)

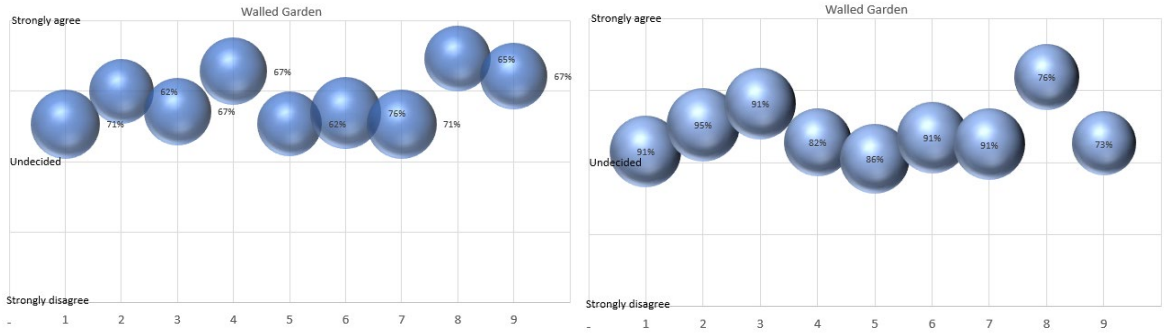


Figure 38 Round 1 (left) and round 2 (right)

5 Conclusions

Governments are set to make major decisions that will affect huge amounts of investment and shape infrastructure and industries for decades to come and this report facilitates decision-making in respect of investments in biomass supply chains. While time perspective of the IEA Recovery Plan is set to the next three years, this paper also looks further in the future, to 2030, under four future scenarios.

This exercise was conducted to identify the best forward-looking policy actions and strategies by which to advance societal goals. The COVID-19 pandemic and resulting cascading impacts have thrust the world into an altered state with novel challenges and opportunities. Overall, experts indicated greater benefits of investments by 2030 compared to 2023. For instance, while eight of twenty biomass supply chain investments were viewed by a consensus of experts as increasing economic growth by 2023, ten investments were seen as similarly doing so by 2030. With respect to employment, a consensus of experts rated seven investments as increasing jobs by 2030 compared to only three by 2023. Finally, experts agreed that 10 of 18 investments would contribute to cleaner energy systems by 2030 compared to none of the same investments by 2023.

According to our experts, demand for bioenergy is the biggest driver for creating jobs in biomass supply chains. Regardless, by 2030 under a Global Marketplace scenario, experts rated most investments as likely to increase employment. However, investments such as incentives for replacing fossils fuels with biomass in primary processing and agriculture was only viewed by experts as possibly increasing employment under most scenarios. Under the Walled Gardens scenario, market incentive programmes for replacing fossil fuel heating and cooling with biomass in agriculture (e.g. stables, greenhouses…), post-harvest (e.g. drying, cooling…) and primary processing (e.g. dairy, juices, spirits…) were viewed by experts as increasing employment by 2023.

Experts reached a consensus that investments in forest and agricultural biomass supply chains would probably increase economic growth in all scenarios by 2023. In contrast, investments in aquatic biomass such as algae were viewed as not increasing economic growth by a consensus of experts.

Experts were unconvinced that those investments listed in this survey would result in cleaner, more resilient energy systems by 2023. However, by 2030, experts agreed that investments in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain would support cleaner, more resilient energy systems. Experts also agreed that large scale, centralised bioenergy facilities, coupled with substitution of fossil fuel power plants (coal, gas) or a biorefinery would help produce cleaner, more resilient energy systems under a Global Marketplace or even a Walled Gardens scenario. In comparison, experts viewed investment in R&D to increase efficiency in the bioenergy system relying on local biomass supply as contributing to cleaner, more resilient energy systems by 2030 under a Back to Basics or Walled Gardens scenario.

Expert consensus favoured investments in technology and infrastructure to support biomass supply chains. For instance, investment in small scale, decentralised bioenergy facilities, coupled with substitution of fossil fuel use, fit for a local supply chain were viewed as strongly contributing to economic growth under all future scenarios by 2030.

The results of our foresight exercise indicate where specific investments would stimulate economic growth and create cleaner and more resilient energy systems even under a more drawn-out pandemic. Resilience in the biomass supply chains, which emerged as a finding of the SWOT analysis, is also predicted by experts particularly in biomass supply chains that could accelerate transition to the sustainable and carbon neutral society, hopefully without the challenges of the pandemic. Some of them, like investments to improve biomass supply from forestry and agriculture, as well as those investments that support short supply chains with specialized approach instead of general measures in supporting all bio-mass investments, regardless on the supply chain and end-use, indicate positive eco-nomic growth outcomes in all scenarios and timeframes, with different intensity. In-vesting in ways to include secondary biomass from primary production in the economy could offset the loss of income in rural areas, given the adaptation measures need-ed due to climate change.

It is clear is that the existing policy refurbishment towards supplying biomass to the economy is vital, not only for post-COVID-19 recovery but also to accelerate sustainable renewable carbon supply to the economy in the era of evident climate change . The information collected in this study can act as a blueprint to inform in-vestments through a mix of economic and social futures.

The question on how the COVID-19 pandemic will end is still open ended at the moment this Report is published. According to the WHO Coronavirus (COVID-19) Dashboard, “Globally, as of 6:47pm CEST, 13 August 2021, there have been 205,338,159 confirmed cases of COVID-19, including 4,333,094 deaths, reported to WHO. The first vaccines against COVID-19 were approved in early 2021; as of 12 Au-gust 2021, a total of 4,428,168,759 vaccine doses had been administered. WHO high-lights that the vaccines will not stop the pandemic but rather vaccinations that are fairly and equitable shared across the countries, regardless of the income status. As COVID-19 vaccines are rolled out across the world, there are growing concerns about the roles that trust, belief in conspiracy theories, and spread of misinformation through social media play on vaccine hesitancy .

As of September 1, 2021, the fourth wave of COVID-19 had begun in countries surveyed for our research. On August 24 2021, the WHO reported that Europe and the Americas had the highest weekly case and deaths incidence rates per 100 000 population. Therefore, the Global Marketplace and Walled Gardens scenarios posed in this Delphi survey were too optimistic, in that these two scenarios assumed a virus longevity of one year or less. This brings some cause for concern; a consensus of experts from modern biomass sectors rated current national investments in the biomass supply chain as slightly insufficient to insufficient. However, the world economy is on track for strong growth in 2021, despite the recovery being uneven between countries, and sectors closely tied to bioenergy (agriculture and wood product manufacturing) coping better than most other sectors..

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