Flexible bioenergy policies in different countries Summary report

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Summary report

In energy systems with dramatically increasing share of variable energy sources (VRE) like solar and wind, bioenergy has an increasingly important role to play, particularly in fields where alternative renewable energy sources are difficult or costly to provide. Climate-efficient and cost-effective flexibility of bioenergy is key, for example when providing flexible electricity, and also in different energy system services such as biofuels provision, renewable heat implementation as well as carbon capture and utilization options and the reduction of grid operation costs. However, to unlock the enormous potential of flexible bioenergy's contribution to the transformation of the energy system, favorable policy conditions are necessary (as they are for the whole energy system transformation).

This paper summarises the findings from a detailed investigation of flexible bioenergy policies (Thrän et al (2024): Implementation of flexible bioenergy in different countries and Thrän et al (2025): Expectations on flexible bioenergy in different countries) analysing the developments in flexible bioenergy implementation in 14 countries and the European Union with different shares and pattern of renewable energy provision and bioenergy contribution between 260.610 TJ/a and 12.148.736 TJ/a (Figure 1). The investigation was mainly based on questionnaires completed by bioenergy experts in the countries, who were contacted trough the IEA bioenergy network. Even though all surveyed countries are OECD members, the status, policy framework and examples are heterogeneous and give different priorities to short-term flexible bioenergy, multiproduct systems and longer-term flexibility services.

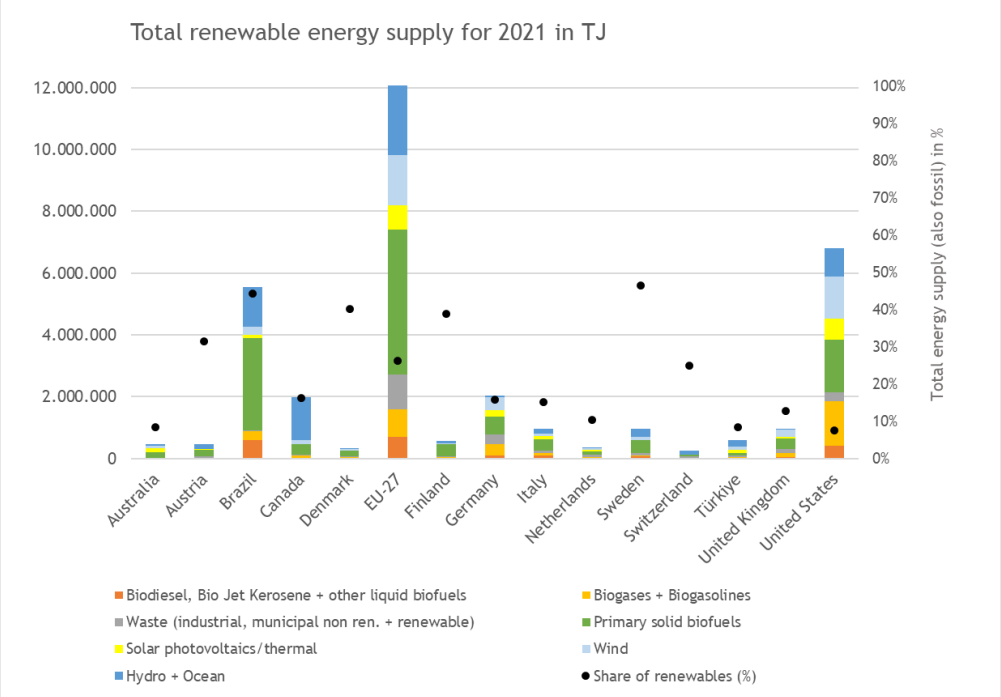

Figure 1: Total energy supply from renewables and biomass in 14 countries and the EU for year 2021. Data from IEA Key World Statistics. Modified version of Figure 1 of Implementation report 2024.

Flexible bioenergy is considered in many different fields of application. Increasing efforts for flexible bioenergy production and/or the simultaneous production of electricity, heat, and fuels in the past three years are stated with adoption of strategies, investment support and also adjustment of energy legislation. Many of these efforts are linked to Bioenergy with carbon capture and use or storage (BECCU/BECCS), which have entered the policy field in almost all of the investigated countries. Concerning flexible power provision, countries largely differ in their focus and approach, e.g. emphasizing day-to-day flexibility or seasonal flexibility, poly-generation, combination with excess energy, hydrogen and/or power-to-X. Moreover, efforts mainly are in a research, development and pilot stage; implementation support for those flexibility options is rare. (Figure 2).

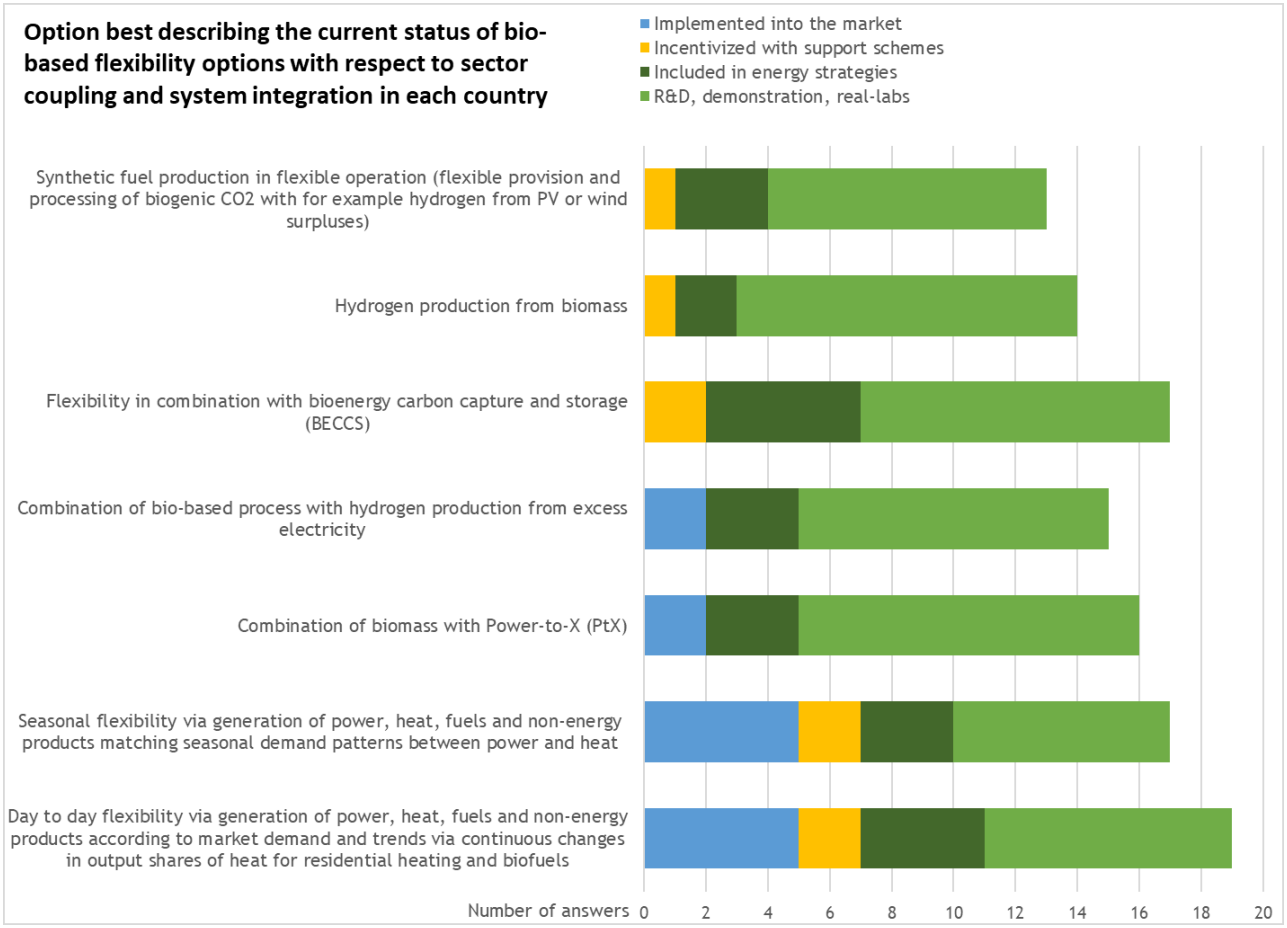

Figure 2: Current status of bio-based flexibility options with respect to sector coupling and system integration in 13 countries and EU; Brazil not included. Figure 11 of Implementation report 2024.

Flexibility in the power sector is of increasing relevance due to rising share of variable renewable energy (VRES). Flexibility issues in the power provision field have entered the agenda during the last three years. Almost all of the investigated countries are expecting to invest or are already investing in flexibility. Statistics on and monitoring of flexible bioenergy are also of increasing interest. However, there are still very different approaches in describing flexible capacities between the countries, so that a clear definition and procedure could improve the comparability of the numbers. Advanced technologies to ensure reliability are expected in more than half of the investigated countries until 2030. In many countries different flexibility options are currently in implementation, mainly driven by research and development and pilot and demonstration plants, but also already in the market in some cases. The comparison of the different renewable flexibility options shows that, across the countries, an innovation and implementation pipeline for flexible power generation is visible. However, this is more prominent for hydrogen and hydropower than for biogas and solid biofuels.

Concerning market barriers and opportunities for the introduction of flexible bioenergy, countries were asked to rank five categories from strongly positive influence, slightly positive, no influence, slightly negative to strongly negative influence. They were asked to assume that high energy prices, high raw material prices, sustainability requirements and energy security requirements influence the introduction of flexible bioenergy. The results in Figure 3 show that feedstock prices have the strongest negative influence. Energy requirements have a more positive influence on the introduction of flexible bioenergy.

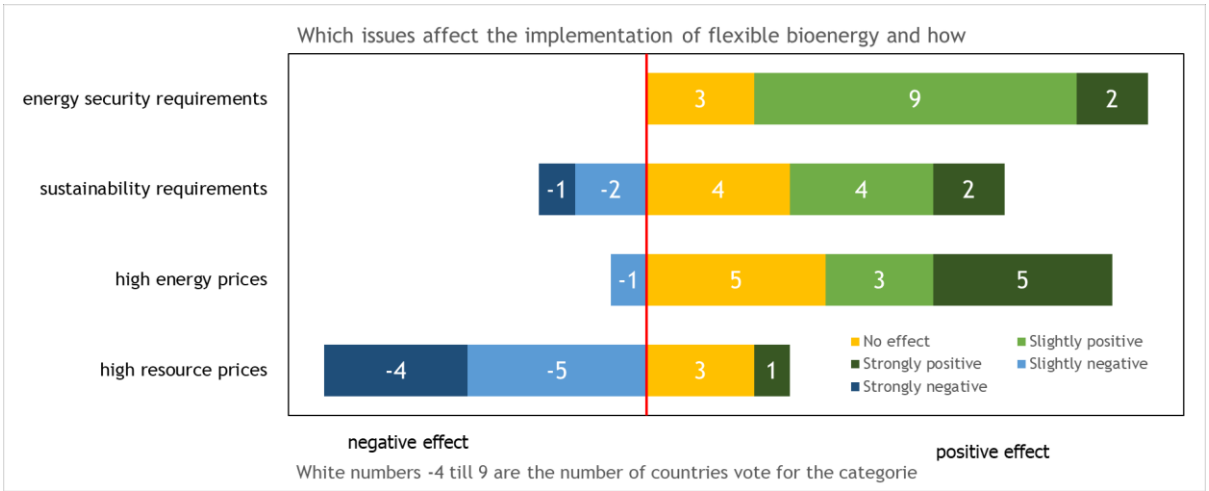

Figure 3: Information on which short-term market obstacles and/or opportunities influence the introduction of flexible bioenergy. Answers provided from 13 countries and EU. Some questions are without information. Brazil not included. Modified version of Figure 22 of Implementation report 2024.

Many support mechanisms for the implementation of renewable energy production are stated, where most of them only support flexible bioenergy and system integration indirectly. Direct policy support is stated from Austria, Denmark, Germany, Italy, the Netherlands, Sweden, Switzerland, and Türkiye. Those mechanisms support the creation of flexible bioenergy capacities on biogas plants (in Germany), feed in tariffs and premiums for flexible bioenergy (Austria and Denmark) or focus Capex and Opex contribution to biobased CHPs (Switzerland). However, the effect of those mechanisms also depends on the level of support. This is why indirect mechanisms, i.e. carbon pricing or emission trading, are not necessarily second-best option.

Beyond insufficient policy instruments and market mechanisms, which are seen as main barriers in almost all investigated countries, in some countries also technical barriers (in the United States of America) and acceptance issues (in the Netherlands) are dominant. Competition with other flexibility options is of increasing importance. However infrastructural aspects are not stated as a barrier, which might distinguish flexible bioenergy from other options of system integration and can be clearly concluded as an advantage in short-term implementation.

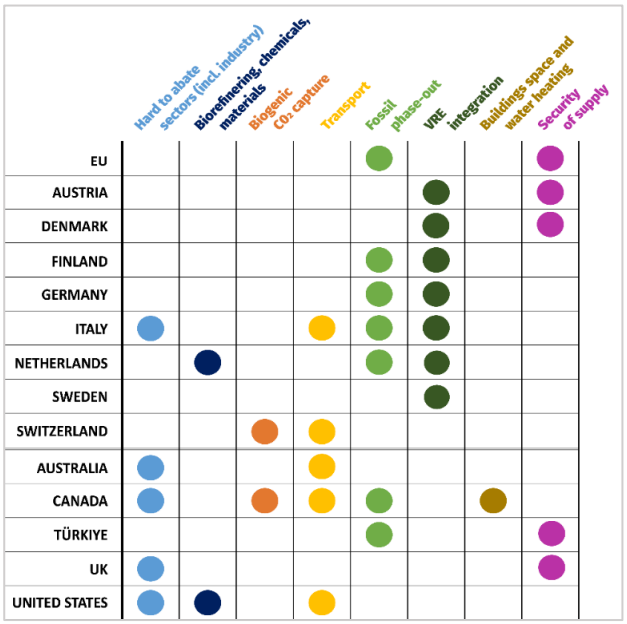

Figure 4: Strongest needs for flexible bioenergy in respondent countries. Brazil not included. Figure 2 of Expectations report 2025.

For a successful energy transition, flexible bioenergy is identified as a key contributor to energy security, particularly in supporting the transition from fossil-based to renewable energy systems (Figure 4). E.g., countries like Denmark and Austria emphasize its role in buffering uncertainties and maintaining electricity supply amidst increasing reliance on variable renewable energy (VRE). Bioenergy is also expected as a key factor for decarbonizing hard-to-abate sectors, with Canada, the UK, and others highlighting its importance for industrial heat, heavy transport, and the integration with carbon capture and storage (CCS) technologies (Bioenergy with carbon capture and storage, BECCS). Despite its potential, flexible bioenergy is inconsistently addressed in national strategies, often overshadowed by broader renewable energy targets or limited by biomass resource availability.

Overall, international cooperation and clear policy frameworks are necessary to unlock bioenergy's flexibility benefits at scale. While some countries, such as Denmark and Sweden, recognize the importance of flexibility in their energy strategies, explicit references to flexible bioenergy remain limited in most policy documents.

Countries identified key opportunities for flexible bioenergy systems over two timeframes. For 2020–2030, priorities include utilizing biogenic residues, complementing renewables usage, and supporting industrial energy needs. For 2030–2050, the focus shifts to hydrogen synergies, CCUS, and e-fuels, highlighting their role in decarbonizing heavy industry and enhancing renewable energy storage. Providing sustainable fuels remains crucial across both periods, while biogenic residue valorisation diminishes in relevance by 2050. Overall, the shift reflects a move from short-term adoption to long-term integration within broader decarbonization strategies. However, uncertainties in biomass availability make its potential impact unclear in many countries. Also, differences in energy transition progress exist between countries, compounded by uncertainties around competing technologies such as electric mobility for heavy transport, bi-directional charging in the electric vehicle sector, and high-temperature heat pumps for industry.

To unlock the potential of flexible bioenergy, policy should take coordinated action at both national and international level. This includes clarifying biomass potential, enhancing energy system modelling to better understand the need for flexibility in energy and material systems, determining how flexibility can be provided, developing supportive policies, and aligning technological advancements across sectors. In addition, policy strategies for flexible bioenergy should consider the link with green hydrogen strategies, which is evaluated in more and more energy scenarios (see Figure 5), to unlock the synergies from flexible biomass and green hydrogen.

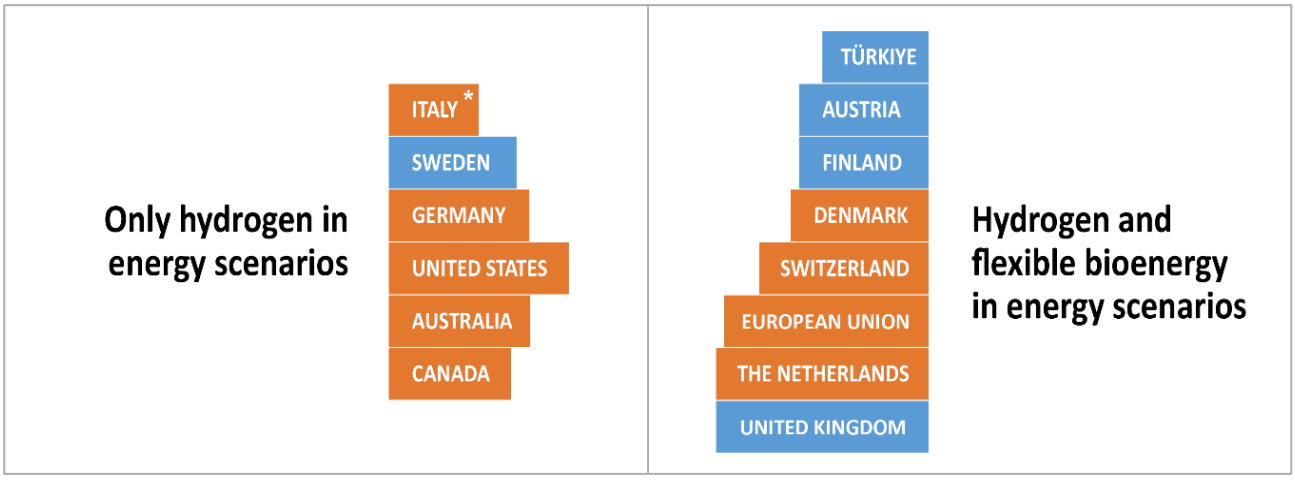

Figure 5: Overview of hydrogen and/or flexible bioenergy integrated in energy scenarios in different countries. Colours distinguish between countries, which see a link between flexible bioenergy and hydrogen (in blue) and countries which do not see this link (in orange). Brazil not included. Modified Figure 14 of Expectations report 2025.
* Italy updated its National Energy and Climate Plan (NECP) in 2024, introducing significant changes, particularly in recognizing hydrogen of biological origin for use in the transport sector, either directly or for biofuel production. As a result, a current update would see Italy change position in the graphic to “Hydrogen and flexible bioenergy in energy scenarios” box.

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IEA Bioenergy Task 44 collects Best Practice examples of flexible bioenergy to increase knowledge of potential solutions for different end uses. Best Practices are collected along the entire value chain: from feedstock flexibility through energy carriers and operational flexibility to product flexibility; they present both planned and existing solutions. Best Practice examples can be found here:

https://task44.ieabioenergy.com/best-practices/
and in Appendix A “Supplementary data” of publication
https://www.sciencedirect.com/science/article/pii/S1364032122000247#appsec1.

Please provide ideas for potential Best Practices in your country, including a reference to send to: nora.lange[at]dbfz.de.

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