

# Bioenergy System Integration for Aligning Sustainability with Security

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IEA Bioenergy TCP Task44

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## List of Contracting Parties to the IEA Bioenergy Agreement

Ministries and energy agencies from 20+ countries, Including the European Commission, Research institutions and industry associations

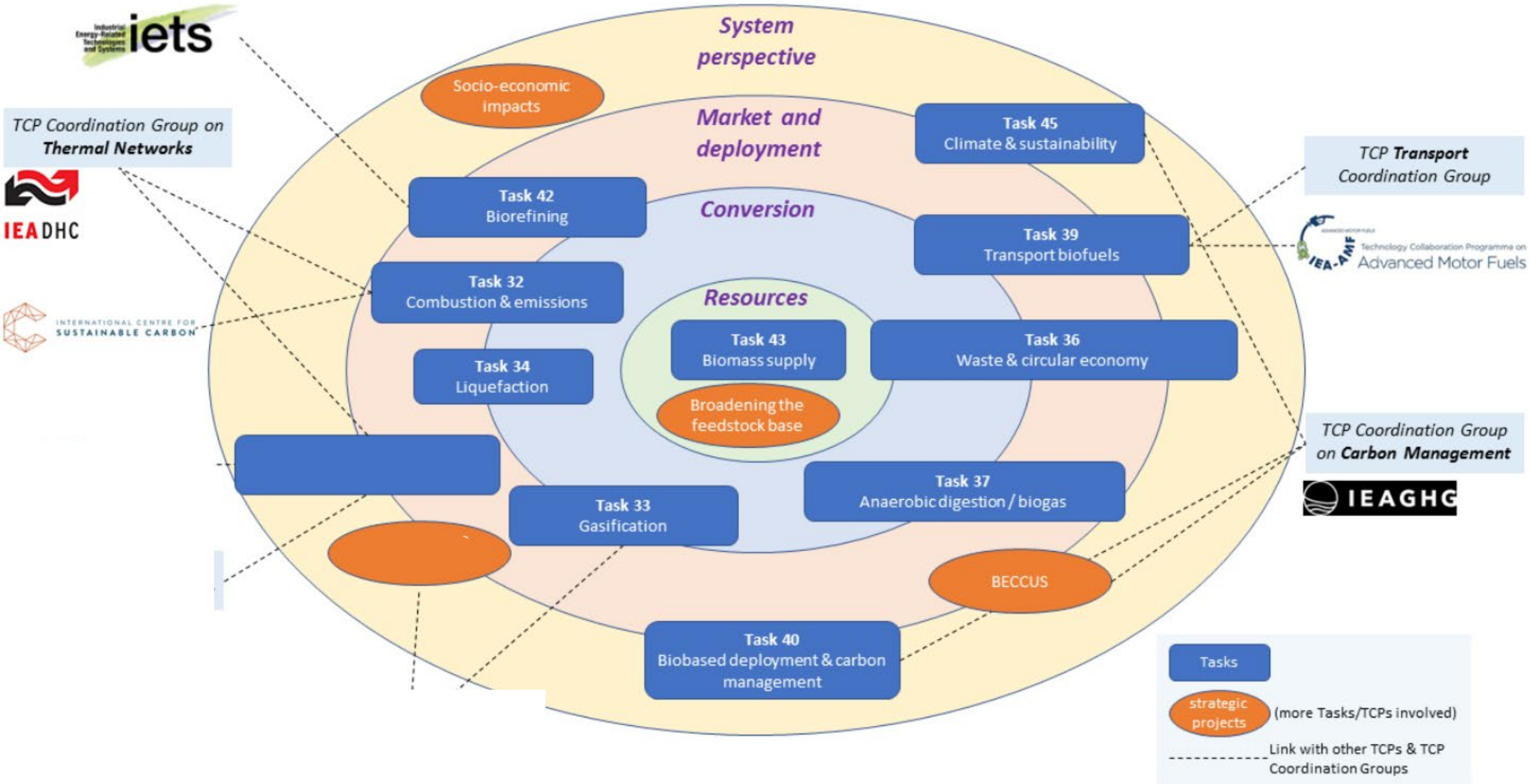
BIOENERGY REVIEW

# How bioenergy contributes to a sustainable future

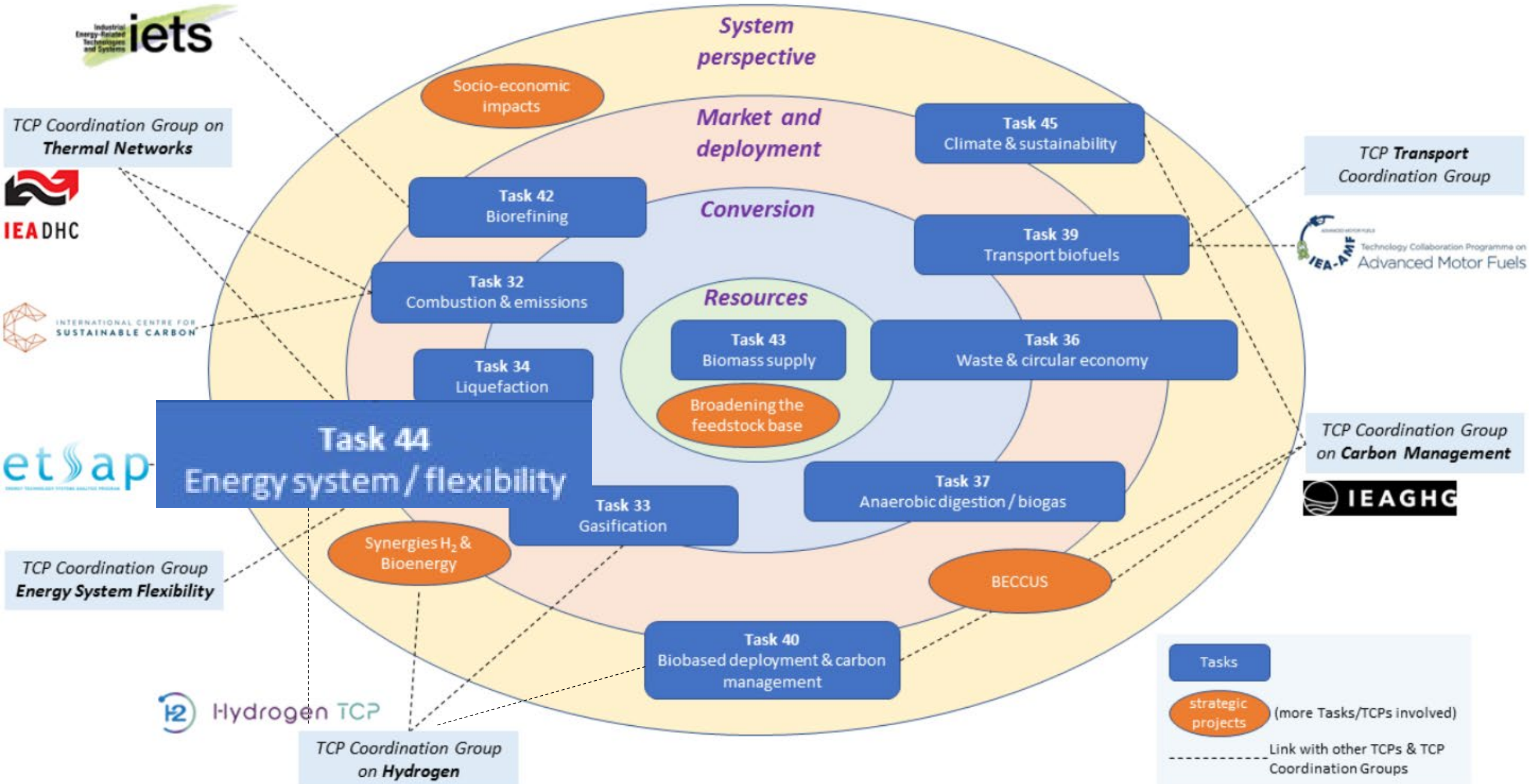
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# IEA Bioenergy Technology Collaboration Programme



# IEA Bioenergy Technology Collaboration Programme



# Flexibilizing our „baseload lifestyles“

## Electricity sector flexibility

- Batteries, fly wheels, heat storage, creative storage solutions
- Demand side management, demand response, smart meters, load management
- Sector coupling, expansion and improvement of power grids

# Flexibilizing our „baseload lifestyles“

## Electricity sector flexibility

- Batteries, fly wheels, heat storage, creative storage solutions
- Demand side management, demand response, smart meters, load management
- Sector coupling, expansion and improvement of power grids

... supported by existing capacities

- Flexible bioenergy for heat, power, transport fuels, industry
- Established infrastructures that can support power grids
- Established multi-sector coupling that supports electrification
- Replacement of traditional with modern and flexible bioenergy

# IEA Bioenergy TCP Task44 on Flexible Bioenergy

What is „flexibility,“ how is it defined, calculated, valorised, marketed ?

- Since 2019;
- Collaboration with sister TCPs (e.g. Wind power, Hydrogen, Solar Heating and Cooling, Energy System Modelling, Energy Storage, ..)
- Policy and industry discussions for best frameworks and KPIs
- Collection of technology descriptions in flexibility compendium
- Curated best practices list
- Workshops and publication track record in scientific journals
- Own modelling and assessment capacities
- Definitions, language, narratives ...
- ...

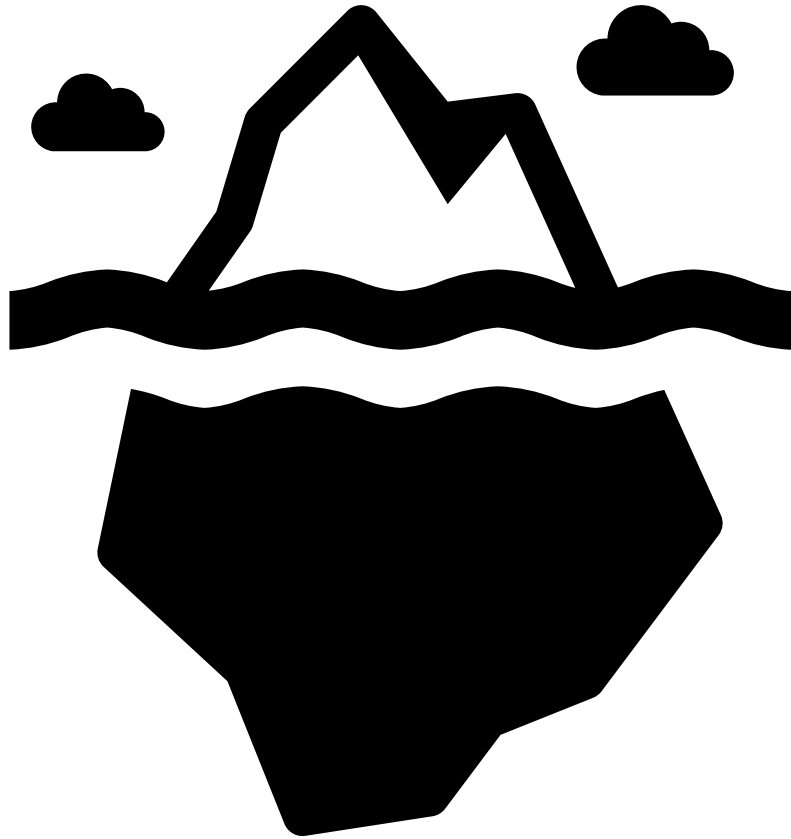
A large, jagged iceberg floats in the middle of a dark, choppy sea under a grey, overcast sky. The iceberg's surface is textured with various ridges and grooves. In the far distance, another smaller iceberg is visible on the horizon.

**Synergies between bioenergy and  
renewable electricity from PV and wind**

**? ... and ... ?**

*Picture by Lars Bugge Aarset  
from pexels.com*

# Flexible biopower +



- Baseload biopower
- Flexible biopower balancing short- to medium term variabilities

~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~ ~

- Seasonal and long-term flexibility
- Grids and trade routes reaching secluded villages and crossing oceans
- Ready interfaces for H<sub>2</sub> and CO<sub>2</sub> economies
- Synergies with water, food, building materials ...

# Integration enables flexibility

# Integration enables flexibility

- Do you need flexibility ? What, where & when can you integrate ?
- Are you already good in integrating different resource flows (e.g. biorefineries), why not go a step further → flexibilize them !

**Integration:** Combination of two, previously separate entities. Synonyms include sector coupling, industrial symbiosis, process intensification, collaboration, etc. ...

**Flexibility:** Shifting of resources, through time (e.g. batteries & pellets), space (e.g. grids & trade), between sectors (e.g. electrification & waste management).

*Schipfer F. et al. 2026. Are we ready to plan for synergies? System Integration Impact Assessment in the Austrian energy system modelling community. Energy Research & Social Science, Volume 131, 2026, 104505, ISSN 2214-6296, [<https://doi.org/10.1016/j.erss.2025.104505>]*

# Circular Bioeconomy - integration power house

Some integration opportunities:

- Hydrogen <> Biogas/Gasification
- Bioplastics <> Biofuels <> E-fuels
- Waste treatment <> Bioenergy
- Sanitation <> Nature-based solutions
- Landscape management <> Bioheat
- Biosecurity, health, critical infrastructure
- Servicing ecosystems
- ...

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What synergies are you supporting? What flexibilities do you provide? For the energy system, for food, and material provisioning, to other sectors?

# Overcoming **barriers** - overcoming **biases**

## Current biases

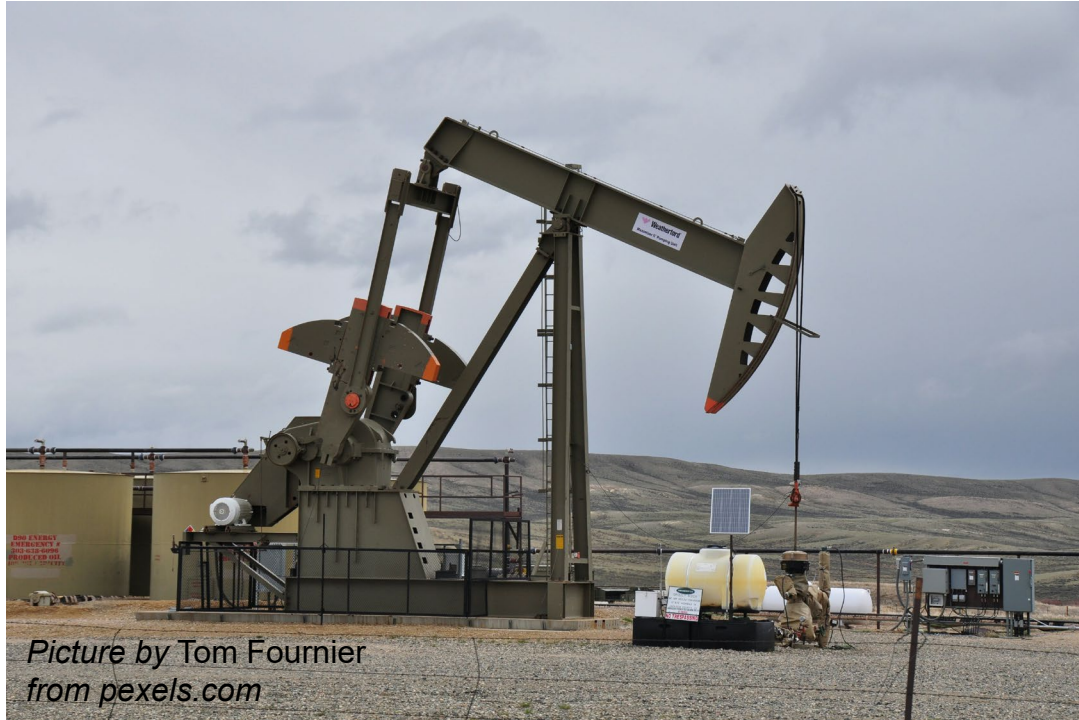
- Complexity is a barrier
- Diversity creates risks
- Conflicts between bioeconomy sectors
- Low automatization/value extraction potential
- Too many factors and decision makers involved
- Nature-based solutions are not max. efficient
- ...

# Overcoming **barriers** - overcoming **biases**

Current biases → require balanced perspectives

- Complexity is a barrier → complexity can become a driver
- Diversity creates risks → Risks have upsides and downsides
- Conflicts between bioeconomy sectors → spotlight synergies
- Low automatization/value extraction potential → distributed added-value
- Too many factors and decision makers involved → broad participation
- Nature-based solutions are not max. efficient → but adequate + robust
- **Trade-off between efficiency and reliability → flexibility can improve both**

# Currently loudest voices for (short-term) energy security



Picture by Tom Fournier  
from pexels.com



Picture by  
Engin Akyurt  
from  
pexels.com



Picture by Shuaizhi Tian  
from pexels.com



Picture by Guzel Sadykova  
from pexels.com


# We want sustainable security !

- **Diversification** in renewable energy production portfolios
- **Diversification** of renewable energy storage and infrastructure
  - electricity, heat, biomass, gases, fuels
- **Strategic integration**
  - between PV, wind, and bioenergy
  - between bioenergy technologies
  - between bioeconomy sectors
  - between countries, autonomous regions, multi-level governance
- **Flexible operation**
  - turning abundance into reliability
  - simultaneously improving efficiency/sustainability and security



<https://task44.ieabioenergy.com/>

## Task 44: Flexible Bioenergy and System Integration

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- ✓ 20+ reports, policy briefs, workshops, and questionnaires analysis  
<https://task44.ieabioenergy.com/iea-publications/>



Austria



Canada

- ✓ Initiation and coordination of inter-task projects and inter-TCP activities
  - > [Synergies of green hydrogen and bioenergy](#)
  - > [Energy Technology Systems Analysis Program](#)
  - > Bioeconomy Synergies across energy, materials, and food
  - > [Inter-TCP Coordination Group on flexibility](#)
  - > Inter-TCP Coordination Group on thermal networks



EC



Finland



the Netherlands

- ✓ Scientific publications including technology, policy, market, literature reviews on flexible bioenergy  
<https://doi.org/10.1016/j.rser.2022.112094> (Schipfer, Mäki, Schmieder, Lange, Schildhauer, Hennig, Thrän)  
<https://doi.org/10.1002/bbb.2649> (Mäki, Hennig, Thrän, Lange, Schildhauer, Schipfer)  
<https://doi.org/10.1186/s13705-024-00461-4> (Schipfer, Burli, Fritsche, Hennig, Proskurina et al.)  
<https://doi.org/10.1016/j.erss.2025.104505> (Schipfer, Kraxner, Thrän, Aliabadi, et al.)  
<https://dx.doi.org/10.2139/ssrn.6439058> (Gutjahr, Thrän, Aliabadi)



Germany

- ✓ 12+ Best Practices, integration and flexibility aspects - real world examples on T44 relevance  
<https://task44.ieabioenergy.com/best-practices/>



Sweden

- ✓ Participation in innovative communication formats  
<https://www.ieabioenergyreview.org/>

# Bioenergy synergies with fundamental security needs (report forthcoming)

## Food & feed security

- Food processing industry support
- Sustainable agriculture
- Nutrient cycle support (back to field/forest/desert)
- (Protein recovery)

## Biobased material supply security

- Pulp, Paper & wood industry enabling
- Biochemicals and plastics
- Waste management & circular economy
- Biogenic carbon security

## Ecosystem resilience

- GHG mitigation
- Land and soil support
- Maintenance for extreme weather preparedness
- Habitat protection



## Biosecurity & health protection

- Biohazard mitigation
- Contaminant mitigation
- Air quality improvement
- Water quality improvement

## Critical infrastructure resilience

- Landscape management
- Infrastructure management
- Urban water body management

# Flexible Bioenergy: Unlocking System Value for the Renewable Transition - Foundation for added system value

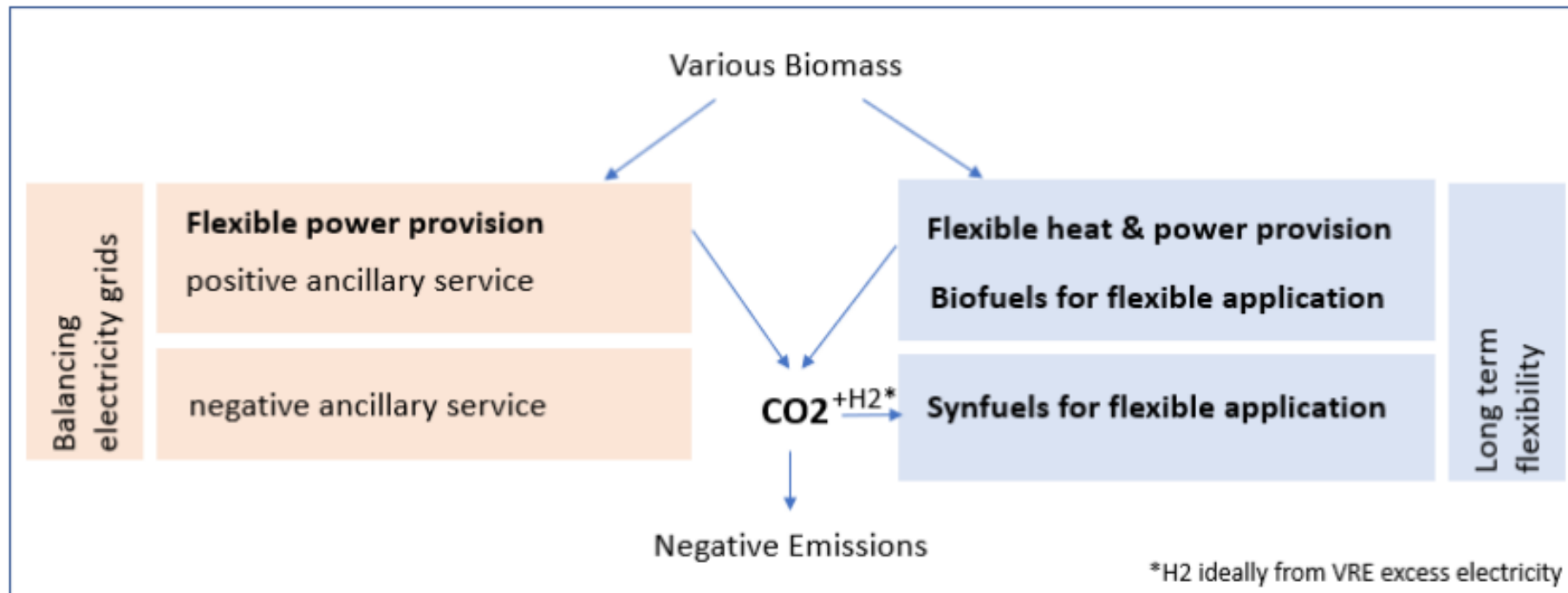
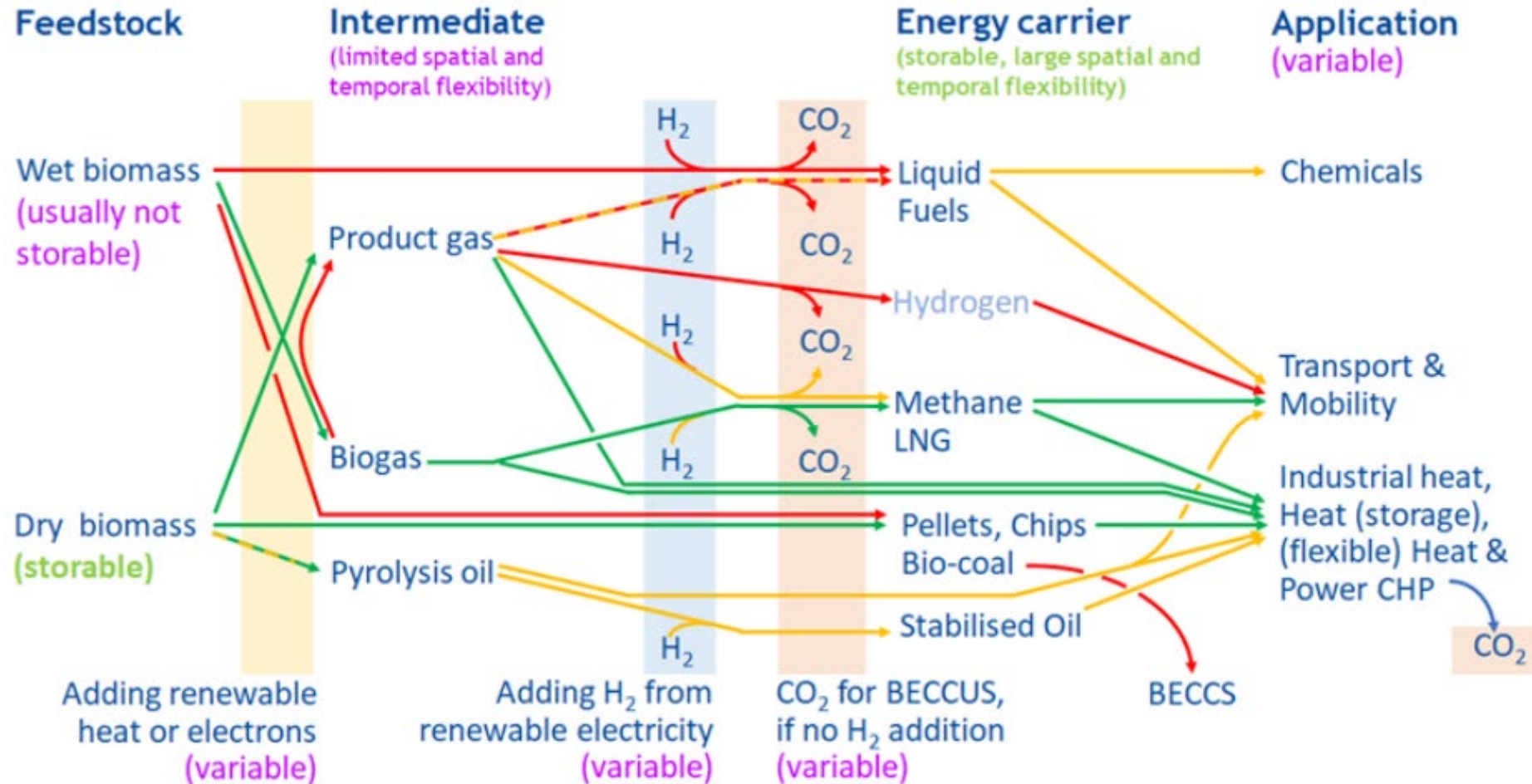


Figure 1: System integration in the renewable energy system and resulting energy and climate system services from bioenergy.

[https://task44.ieabioenergy.com/wp-content/uploads/sites/12/2026/04/IEA-Bioenergy\\_Task-44\\_Foundation-and-way-forward-1.pdf](https://task44.ieabioenergy.com/wp-content/uploads/sites/12/2026/04/IEA-Bioenergy_Task-44_Foundation-and-way-forward-1.pdf)

# Technologies for Flexible Bioenergy (Updated)



[https://task44.ieabioenergy.com/wp-content/uploads/sites/12/2025/04/IEAB-Task-44\\_2025\\_Report-Technologies-for-Flexible-Bioenergy-Update.pdf](https://task44.ieabioenergy.com/wp-content/uploads/sites/12/2025/04/IEAB-Task-44_2025_Report-Technologies-for-Flexible-Bioenergy-Update.pdf)

# International Policy review

Expectations on flexible bioenergy in different countries

<https://task44.ieabioenergy.com/publications/expectations-on-flexible-bioenergy-in-different-countries/>

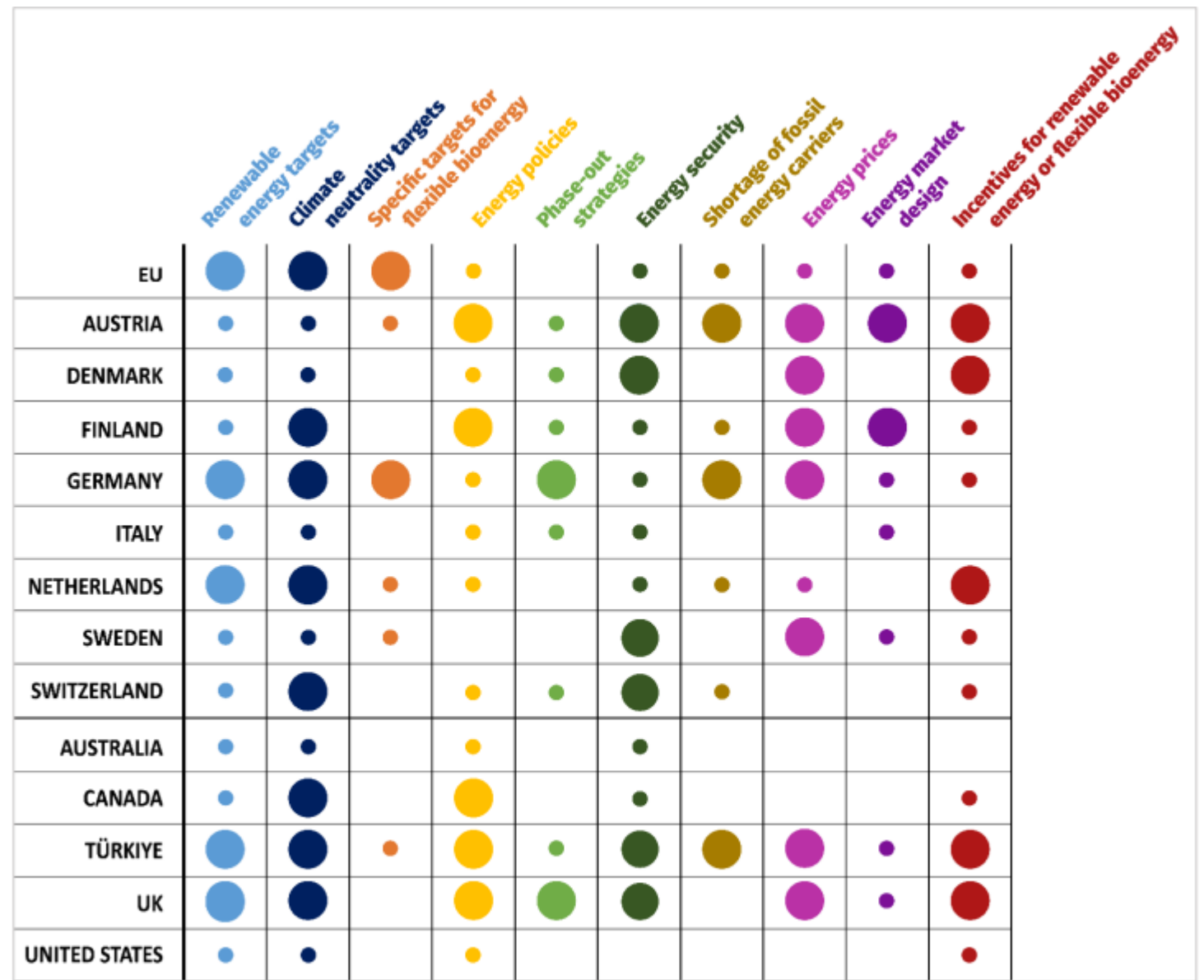


Figure 6: Strength of different drivers for flexible bioenergy implementation during 2020-2022 in different countries. Large bubbles represent strong drivers, small bubbles are weak drivers. Brazil not included.

# Flexible bioenergy best practices

<https://task44.ieabioenergy.com/best-practices/>



# Exemplary integration: Bioenergy <> Hydrogen

<https://task44.ieabioenergy.com/>

[inter-task-project-on-hydrogen-and-bio-based-value-chains/](https://task44.ieabioenergy.com/inter-task-project-on-hydrogen-and-bio-based-value-chains/)

**Extensive collaboration over 4 years  
between most IEA Bioenergy TCPs and Hydrogen TCP**

Both technologies are metabolic,  
that means, they operationally rely on inputs (incl. electricity, biomass, water),  
creating outputs (incl. energy carriers, emissions)

→ need for infrastructures, conversion tech, storages, derivatives, standards, emerging markets

→ integration opportunities

- knowledge and experience transfer
- joint use of infrastructures
- hydrogen improving bioenergy products (H<sub>2</sub> + Biogas)
- hydrogen produced from biomass



# Integration creates flexibility – flexibility needs to be managed (report forthcoming)

To provide the flexibility needed we require **control strategies**, able to  
→ handle strongly varying operating conditions (fuel variations, load modulation, etc.) automatically

Implementation of control strategies needed on

- **System level** – scheduling of controllable producers, storages and consumers
- **Technology level** – flexibilization of biomass conversion technologies by means of control

**optimal operation**  
(efficiency, CO<sub>2</sub> emissions, ...)

**predicting volatility**  
of production and consumption

**modulating in variation range**  
of the configurations

# Managing flexibility – operational aspects

## Modular, predictive, optimization-based supervisory control of multi-energy systems

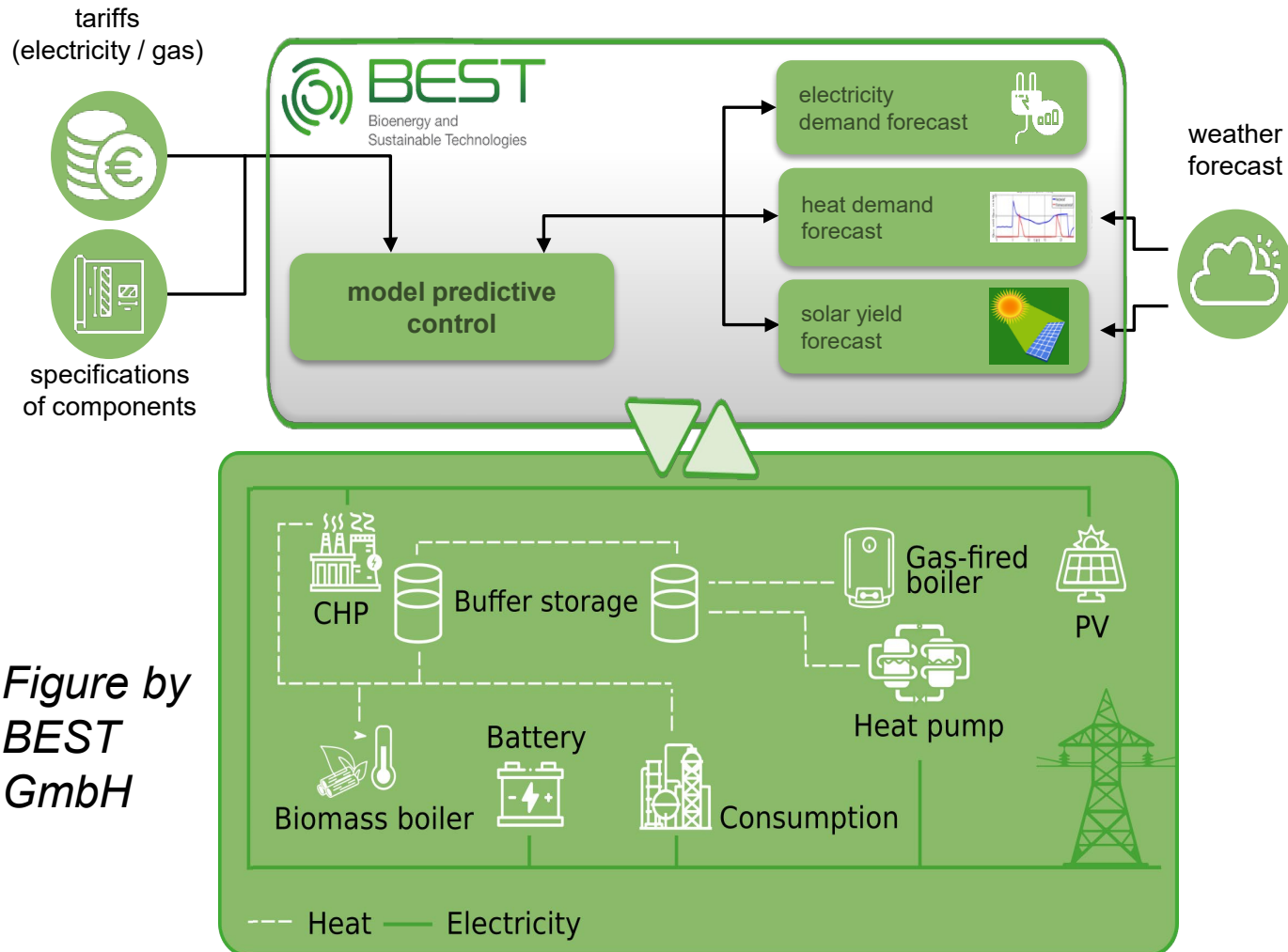


Figure by  
BEST  
GmbH

## Implementation & tests

- Coupled, cross-ownership district heating grid
- Biogas CHP plant connected to DH
- Fixed-bed biomass gasification CHP plants

## Special session at CEBC:

- 📅 **Date:** 22 January 2025, 14:00 – 15:30
- 📍 **Location:** Messe Graz, Austria
- 🔗 Organized by IEA Bioenergy Task 44 – Markus Göllés (BEST)

# A definition of Flexibility



*Energy System Flexibility Coordination Group*

*Michele de Nigris & Andreas Hauer*

*Involved IEA TCPs: 4E, Bioenergy, EBC, ES TCP, ETSAP, FBC, Geothermal, GHG, HPT, H2, Hydro, IETS, ISGAN, SolarPACES, USERS, Wind*

**Flexibility** of an energy system is the ability to adjust supply, transmission, distribution & storage, and demand, across all relevant time and geographical scales considering all energy vectors, in response to changing conditions or policy objectives.

Best compromise but no unanimous agreement:

- It overcomes the existing definition «confined» to power systems
- No unanimity with respect to the necessity to outline a threat «changing conditions or policy objectives»

# Current list of Contracting Parties to the IEA Bioenergy Agreement

Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Australia)  
The Republic of Austria  
The Government of Belgium  
The Department of Biofuels of the Ministry of Mines and Energy (Brazil)  
Natural Resources Canada  
Energy Research Institute ERI (China)  
The Ministry of Transport and Energy, Danish Energy Authority  
Commission of the European Union  
L'Agence de l'Environnement et de la Maîtrise de l'Énergie (ADEME) (France)  
Agence de la Transition Écologique (ADEME) (France)  
Innovation Funding Agency Business Finland  
Danish Energy Agency – the Ministry of Climate, Energy and Utilities (Denmark)  
Federal Ministry of Food and Agriculture (Germany)  
Federal Ministry of Agriculture, Food and Regional Identity (Germany)  
Ministry of Petroleum & Natural Gas (India)  
The Sustainable Energy Authority of Ireland (SEAI)  
Gestore dei Servizi Energetici – GSE (Italy)  
The New Energy and Industrial Technology Development Organization (NEDO) (Japan)  
Ministry of Trade, Industry & Energy, the Republic of Korea  
NL Enterprise Agency (The Netherlands)  
New Zealand Institute for Bioeconomy Science Limited  
The Research Council of Norway  
South African National Energy Research Institute (SANERI)  
Institute for Energy Diversification and Saving (IDAE) (Spain)  
South African National Energy Development Institute (SANEDI) (South Africa)  
Swedish Energy Agency  
The Swiss Federal Office of Energy  
Department for Energy Security and Net Zero (United Kingdom)  
The United States Department of Energy

Your country is not on this list?

Recommended steps:

- 1) contact the IEA Bioenergy Secretary –  
Andrea Rossi  
<https://www.ieabioenergy.com/directory/>
- 2) Contact your ministries and national funding agencies (for membership fees)
- 3) Become an officially delegated National Team Lead (NTL)