
# Reframing flexibility beyond power

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IEA Bioenergy TCP Task40 & Task44

ITP Synergies green hydrogen and biobased value chain

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# All deterministic models undervalue the impacts of increasing flexibility.

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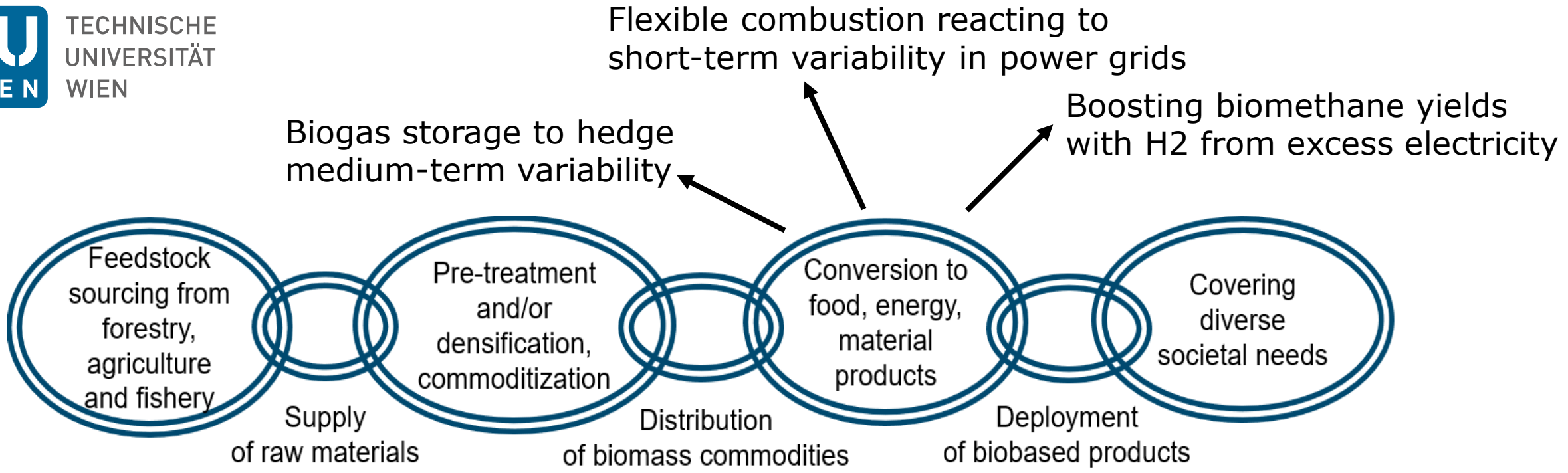


# Bioenergy Supply Chains

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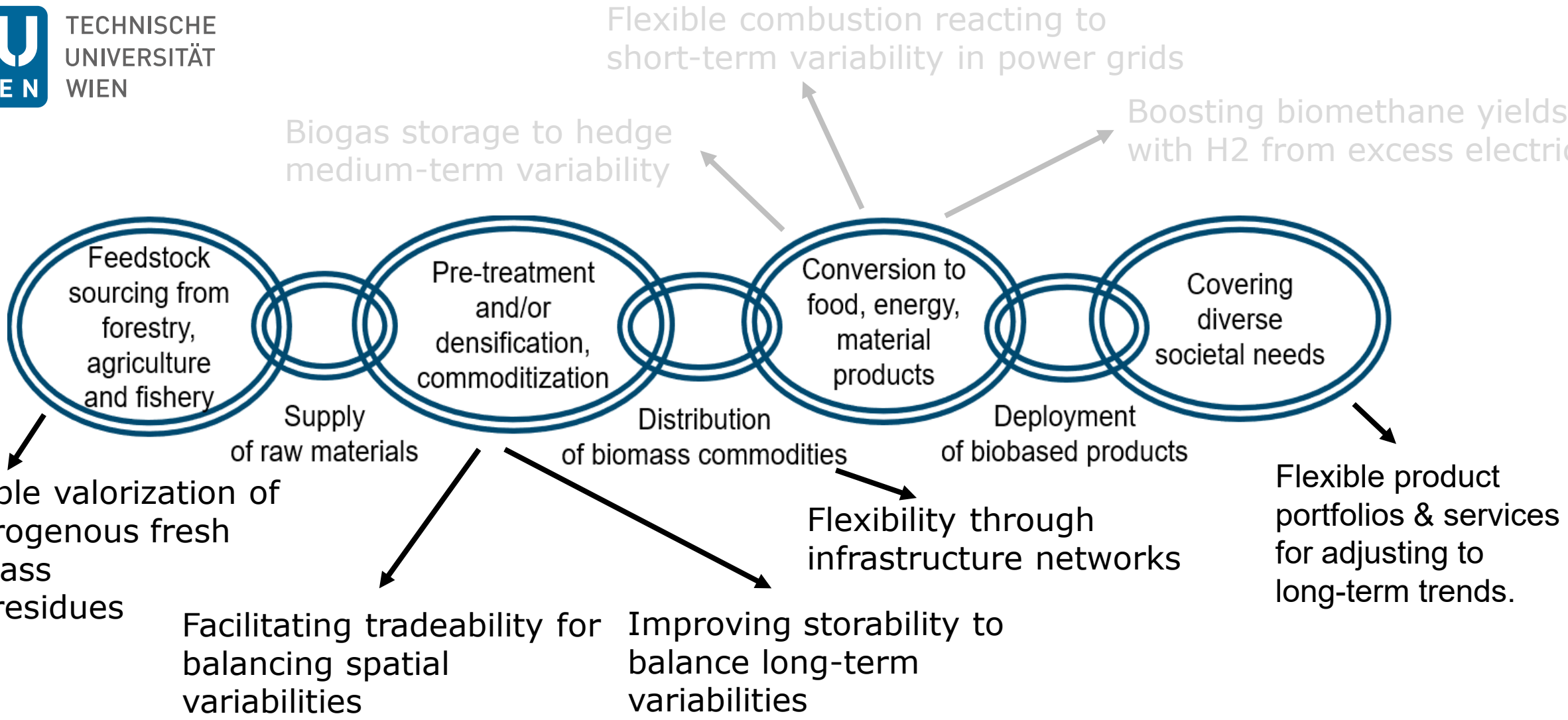


Schipfer, F., Mäki, E., Schmieder, U., Lange, N., Schildhauer, T., Hennig, C., Thrän, D., 2022. Status of and expectations for flexible bioenergy to support resource efficiency and to accelerate the energy transition. Renewable and Sustainable Energy Reviews 158, 112094. https://doi.org/10.1016/j.rser.2022.112094 **IEA Bioenergy TCP Task44 "Flexibility & System Integration" Results of 1st Triennium**

# Multi-faceted aspects of Bioenergy flexibility

← selected examples on the previous slide.

Broadening the definition of “flexibility”:

**Ability to <u>shift resources</u>**

- **through time,**
- **through space,**
- **between sectors &**
- **between markets.**

# Multi-faceted aspects of Bioenergy flexibility

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Broadening the definition of "flexibility":

**Ability to <u>shift resources</u>**

- **through time,** ← short-, medium-, long-term storage
- **through space,** ← via networks & trade
- **between sectors &** ← via multi-sector coupling
- **between markets.** ← via commodification

"Flexibilisiation" = increasing the ability ...

# Multi-faceted aspects of Bioenergy flexibility

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**How to evaluate this ability?**

**How to evaluate changes in this ability?**

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# Why shift resources?

**… to balance scarcities with surpluses**

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# Why shift resources?

## … to balance scarcities with surpluses

Suitable assessment criteria for (beneficial) impacts of increased flexibility:

- Improved surplus valorization
- Improved scarcities mitigation
- Improved synergies between both (balancing)

# Why shift resources?

**… to balance scarcities with surpluses**

(1) Mitigate shortages
→ system reliability/resilience

(2) Efficient valorisation of surpluses
→ resource efficiency

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(3) Via balancing
→ connecting (1) & (2)

# Flexibility assessment:

To assess the contributions of ...

- Combined Bioenergy heat & power
- Storage of renewable gases
- Storage and trade of wood pellets
- H2 production & trade
- Coupling power grids & mobility
- Biorefineries for materials & energy
- ....
- ....
- Diversification of feedstock portfolio
- Diversification of power generation- / product portfolio

Evaluate the ability to shift resources through time, through space, between sectors & between markets.

# Flexibility assessment:

$f($  ,  $)$

**System reliability/resilience**

**Resource efficiency**

- Overall costs, revenue, share of wasted energy, wasted biomass, emissions ...
- Optimisation problem
- Competitive market equilibrium for optimal resource allocation

# Flexibility assessment:

**System reliability/resilience**

“It´s basically probability”
Sugababes, Overloaded, 2000

**Resource efficiency**

- Overall costs, revenue, share of wasted energy, wasted biomass, emissions ...
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# Measuring reliability ….

**A vast body of literature:**

for concepts of reliability, resilience, stability, security, safety, continuity, health, persistence, robustness ....

in multiple established and upcoming disciplines and research areas including

- Process safety domains > Safe & Sustainable by Design
- Resilience Engineering
- Graph and network theory > applications in Ecosystem Modelling
- Disaster Risk Management
- Decision-making Under Deep Uncertainty
- U.S. MultiSector Dynamics Modelling Community of Practice (CoP)
- ...

# Measuring reliability ….

**Broadening the flexibility concept == Broadening uncertainty spaces**

**Uncertainty …**

**expressions:** Variabilities and fluctuations, uncertain trends, extremes, cascades

**causes:** Nature, infrastructure, technologies, society (incl. market)

**types:** Reducible (epistemic) and (practically) irreducible (aleatory)

**duality:** Detrimental outcomes (e.g., scarcities)+ beneficial ones (e.g., oversupply)

**anticipation:** Sensitivities, scenarios, qualitative, linguistics, deliberate ignorance

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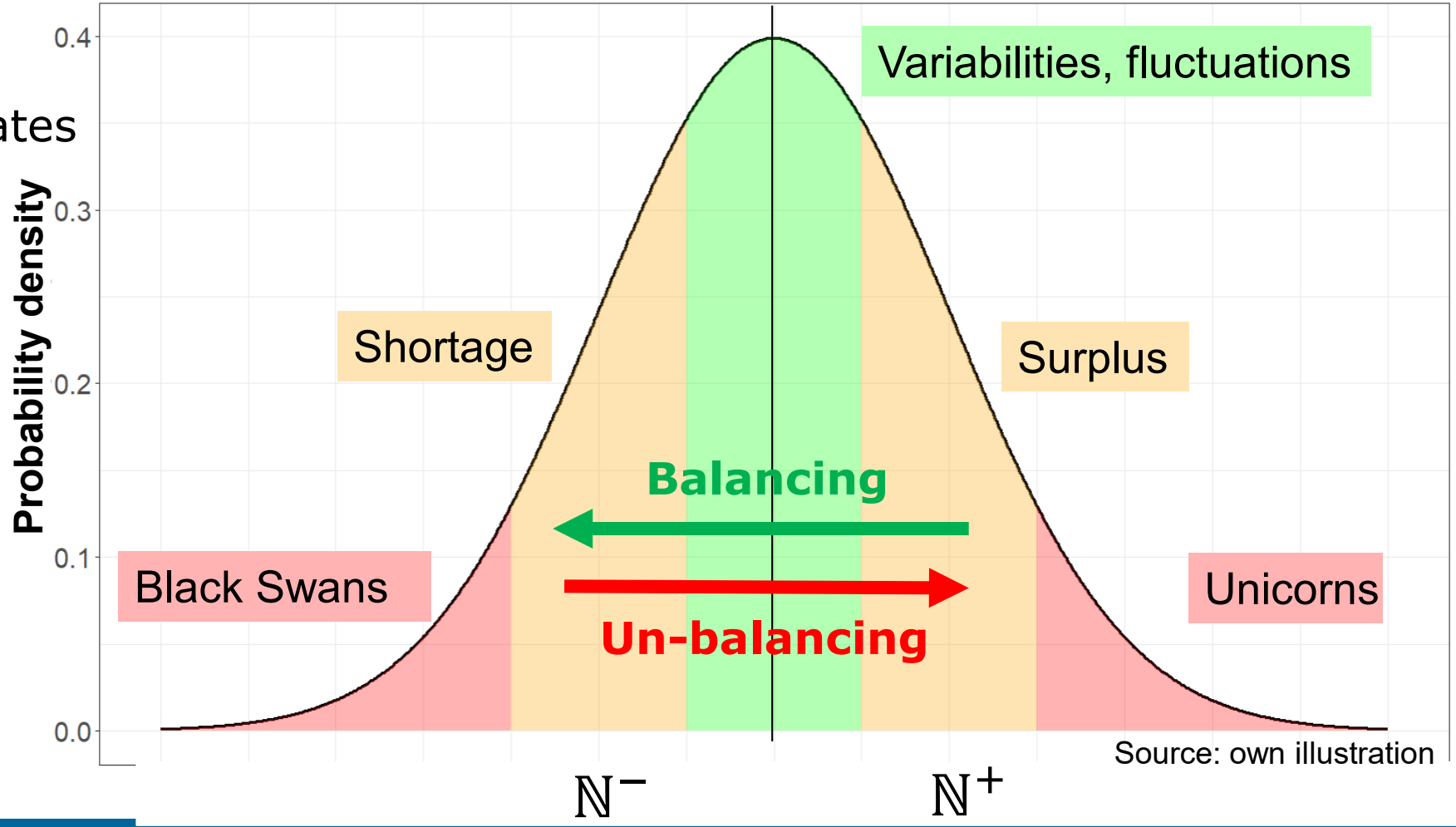
**Opportunities ← and dangers →** **of increasing flexibility**

Flexibility e.g., through multi-sector coupling creates **also system risks**

Modelling to anticipate Opportunities & dangers, synergies & trade-offs, of multi-sector coupling!

**Illustrative example of (un)balancing scarcities & surpluses**




Source: own illustration

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# Summary

1. Bioenergy/Bioeconomy supply chains are often quite flexible already
   → regarding multi-faceted aspects beyond power

2. Broader flexibility definition required including
   → temporal, spatial, inter-sectoral **balancing** of scarcities with oversupply

3. Objective evaluation of flexibilisation impacts
   → contributions to system's efficiency **and** reliability **and** their synergies
   → contributions to increased systemic risks
   (e.g., cascadic failures between sectors)

**How to account for probabilistic (un)balancing effects in existing models?**

# Relevant ongoing projects

1. **IEA Bioenergy Technology Collaboration Programme – Flexibilisation & system integration**
   **[IEAB Task44]** | funding for AT participation by FFG #890453 | 01.2022 – 12.2024
   Partner, BEST Research is Country Lead
   Research Instituts from DE, FI, AUS, NL, CH, DG RTD, SVEBIO, US DOE
   https://task44.ieabioenergy.com/

2. **IEA Bioenergy Technology Collaboration Programme – Biobased supply chains**
   **[IEAB Task40]** | funding for AT participation by FFG #895544 | 01.2022 – 12.2024
   Country Lead, Institut für Nachhaltige Technologien (AEE Intec), Michael Wild & Partner KG
   Research Institutes from DE, DK, SE, NL, US, RWE Generation, US DOE
   https://task40.ieabioenergy.com/

3. **Integrative energy infrastructure planning tools for cross-sectoral resilience and flexibilisation concepts.**
   [BioFlex Project] | funding by FFG #905734 | 12.2023 – 11.2024
   Lead, together with Universität für Bodenkultur (BOKU) & International Institute of Applied Systems Analysis (IIASA)

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**IEA Bioenergy Task44:**
https://task44.ieabioenergy.com/

**IEA Bioenergy Task40:**
https://task40.ieabioenergy.com/

# Thank you for your attention

**Submit your manuscript here:**
**https://energsustainsoc.biomedcentral.com/circularbioeconomy**

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# Collaborative webinar design

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IEA Bioenergy TCP Task40 & Task44

ITP Synergies green hydrogen and biobased value chain

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HTTPS://COLAB.TUWIEN.AC.AT/DISPLAY/CD/1.5.+VORLAGEN

# Collaborative design of the February 2024 flexibility webinar

Background & objectives

- Exchange in Torino today: discuss and describe the status of flexible bioenergy/flexibility and renewable hydrogen within energy system models > **overview**
- Webinar in February 2024 > **detailed exchange**
  proposed objectives:
  - describing the role and potential of flexibility and renewable hydrogen
  - exploring how a comprehensive assessment of flexible technologies and infrastructure in energy system models can be facilitated. This involves overall system efficiency and reliability and also inherent risks (such as safety concerns, security vulnerabilities)
  - discussing and describing how flexible bioenergy/flexibility and renewable hydrogen interact (possible benefits?)
  - **…??**
- Now discussing potential additional experts for the February webinar and the key research questions

# Collaborative design of the February 2024 flexibility webinar

## → Identification of related modelling topics

**Start: Bioenergy**

- Electricity markets
- Power network expansion planning
- Heating, Transport (sector coupling)
- Disaster risks reduction
- Uncertainty evaluation
- Modelling extremes
- Bioeconomy (food, materials, energy)
- Circular economy (incl. metals, ores)
- Integrated assessment (multi sector coupling)

**Industrial symbiosis** **Safe & sustainable by design (processes)** **....??**

# Collaborative design of the February 2024 flexibility webinar

## → Identification of experts

**Electricity markets**

**Power network expansion planning**

**Heating, Transport (sector coupling)**

- Peter Kohlhepp (KIT): **Modelling & application flexibility from heating integration**
- Tara Esterl (AIT): **Modelling flexibility in the power sector**
- Sebastian Busch (JRC): **Flexibility requirements of the EU power sector**
- Verena Heinisch (Chalmers): **Heating coupling, mobility coupling**
- Harry Van Der Weijde, (Edinburgh) Benjamin Hobbs (John Hopkins): **Flexibility & uncertainty in power grid expansion planning**
- Jinye Zhao, Tongxin Zheng, Eugene Litvinov (ISO New England): **Measuring flexibility in the power system**
- **…… ?**

# Collaborative design of the February 2024 flexibility webinar

## → Identification of experts

**Disaster risks reduction**

**Uncertainty evaluation**

**Modelling extremes**

- Johannes Schmidt (BOKU Wien): **Modelling extreme events in power sector**
- Paul Reed (Cornell University): **US MultiSector Dynamics Modelling Community of Practice**
- Xiufeng Yue, Brian O. Gallachoir (Cork): **Uncertainty assessment in energy system optimization models**
- Matthias Kirchner (BOKU Wien): **Modelling uncertainty**
- David L. McCollum, Ajay Gambhir, Joeri Rogelj, Charlie Wilson (EPRI, IIASA): **Exploring extremes in models**
- **…. ??**

# Collaborative design of the February 2024 flexibility webinar

→ **Identification of experts**

**Bioeconomy (food, materials, energy)**

**Circular economy (incl. metals, ores)**

**Integrated assessment (multi sector coupling)**

- Lisa Göransson (Chalmers): **Bioenergy flexibility, CHP, BECCS**
- Martin Scheepers, Ayla Uslu (TNO): **Network requirements, Bioeconomy**
- Tiina Koljonen (VTT), Anna Krook-Riekola (LTU) **Modelling bioenergy**
- Vassilis Daioglou (UU): **IAM IMAGE**
- Andrew Welfle, Patricia Thornley, Mirjam Röder (Supergen BE Hub): **IAM & Bioenergy limitations**
- A Pyka (Hohenheim): **IAM & Bioeconomy limitations**
- Stefan Giljum (WU Wien): **IAM & Material flow modelling limitations**
- Will Usher (KTH): **European Climate and Modelling Forum (ECEMF)**
- Danial Esmaeilialiabadi, Matthias Jordan, Martin Dotzauer (UFZ, DBFZ): **Modelling seasonal bioenergy, BECCUS**
- **…. ??**

# Collaborative design of the February 2024 flexibility webinar

## → Identification of experts

**Experts that have already indicated interest in sharing their research:**
Martin Scheepers, Ayla Uslu (TNO) > “model analyzes of energy transition pathways in which a transition is made from fossil fuels to green hydrogen and biomass to cover the future energy demand and feedstock use for production of sustainable materials”

**Other related modelling topics:**

**Experts for green hydrogen modelling: Hydrogen TCP, ….**
**Industrial symbiosis**

**Safe & sustainable by design (processes)**
**consequential LCA ...**

**.... ??**