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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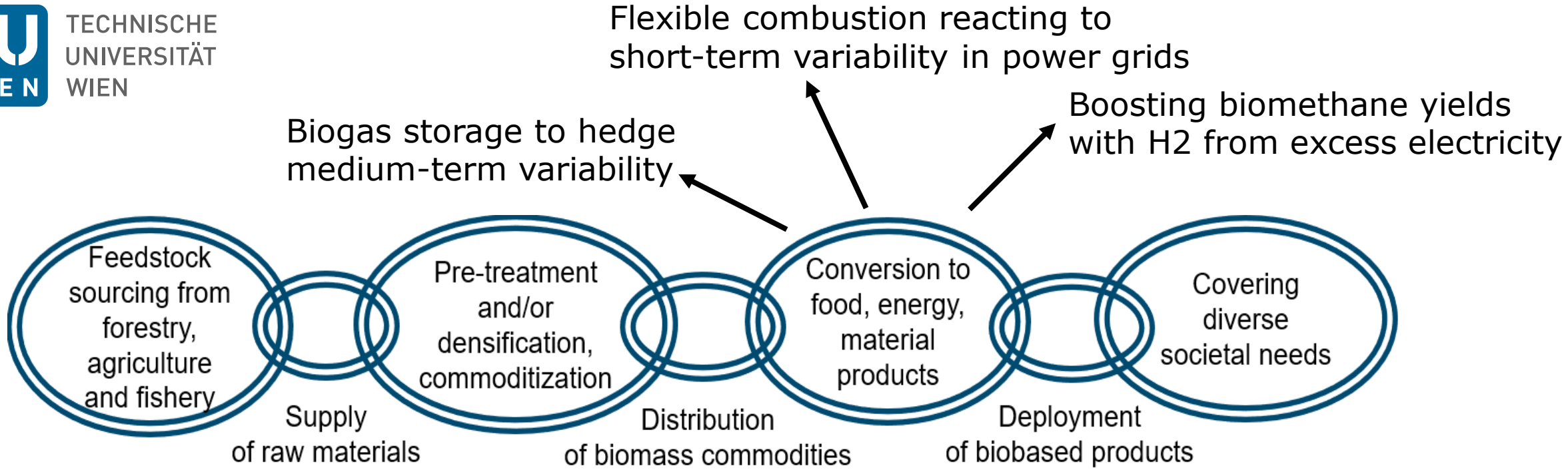
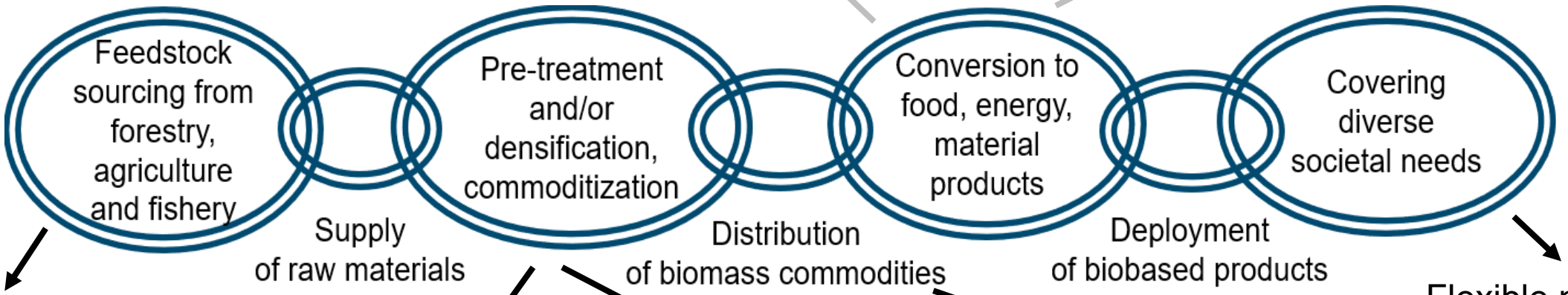


Bioenergy Supply Chains

Flexible combustion reacting to short-term variability in power grids

Biogas storage to hedge medium-term variability

Boosting biomethane yields with H2 from excess electric



Flexible valorization of heterogenous fresh biomass and residues

Facilitating tradeability for balancing spatial variabilities

Improving storability to balance long-term variabilities

Flexibility through infrastructure networks

Flexible product portfolios & services for adjusting to long-term trends.

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

← selected examples on the previous slide.

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:

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 ...
- Optimisation problem
- Competitive market equilibrium for optimal resource allocation

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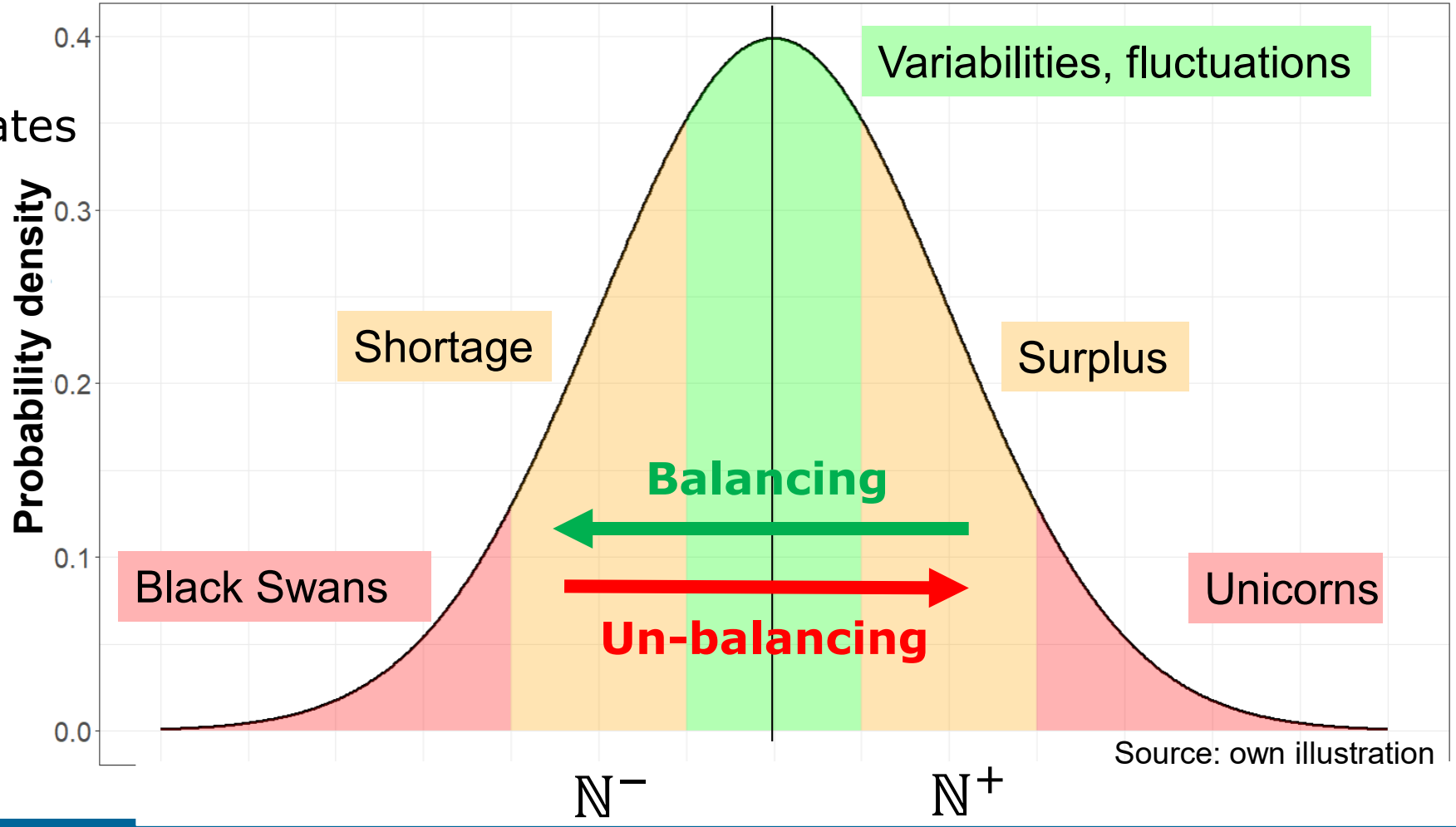
Opportunities ← and dangers → **of increasing flexibility**

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/

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