IEA Bioenergy TCP

IEA ETSAP TCP Workshop

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International Institute for Applied Systems Analysis (IIASA)

Helsinki, 25/11/2025

IIASA - Founded during the Cold War to build bridges based on international interdisciplinary science and cooperation

Today this mission is more relevant than ever ….

International Institute for Applied Systems Analysis

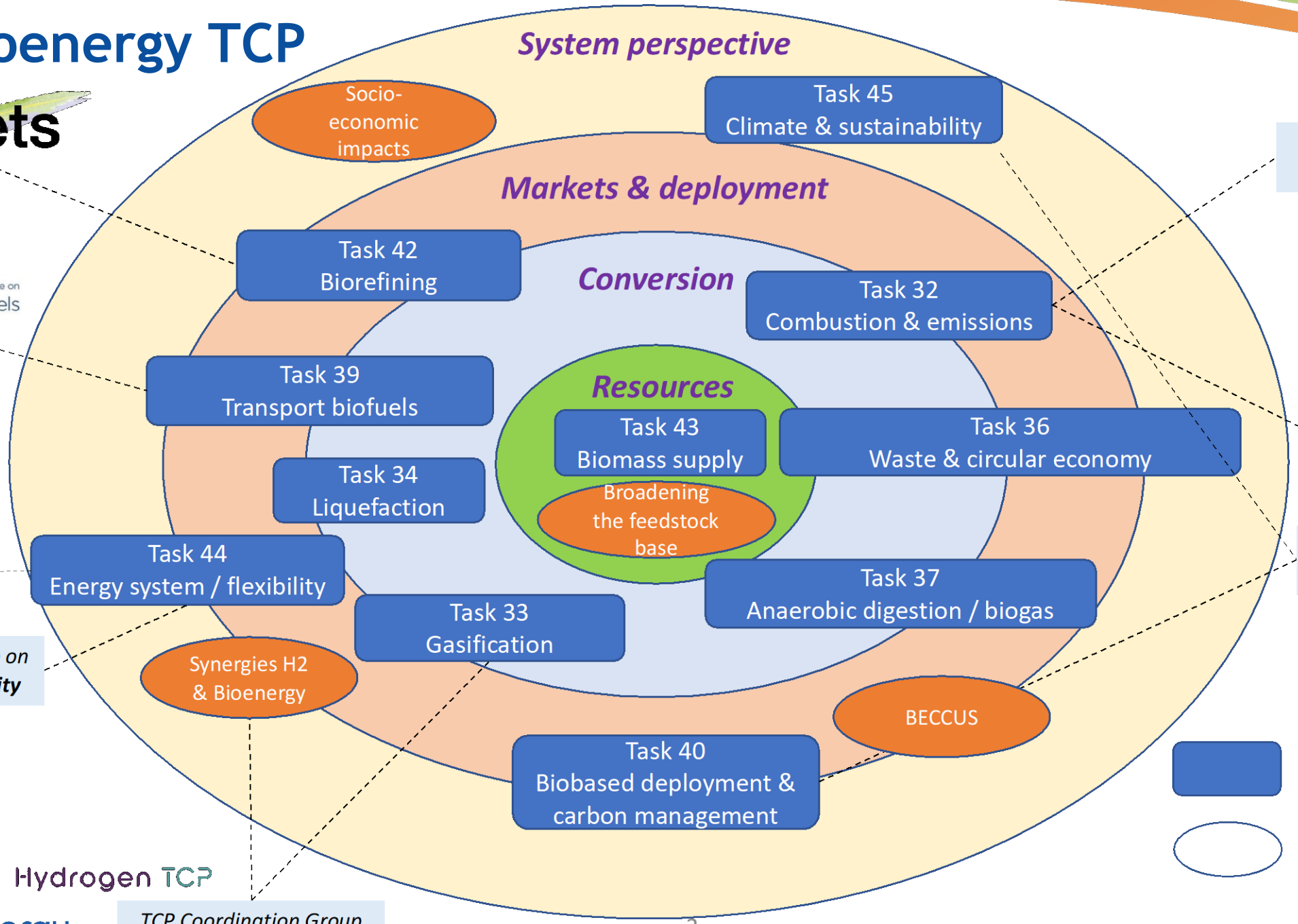
IIASA

Member states (accession dates)

Austria (1973)	Ukraine (1994)	Iran (2016)	Room at the table for more
Finland (1976)	Norway (1996)	South Kor…	…
Germany (1972)	China (200…)		
Japan (1972)			
Russia (1972)		(2017)	
Sweden (1976)		Sub-Saharan Africa (2022)	
USA (1972)		United Kingdom (2015)	
		India (2007)	

Are you a PhD student?
Join our Young Scientists Summer Program!
https://iiasa.ac.at/early-career/yssp

IEA Bioenergy TCP



iets

Technology Collaboration Programme on Advanced Motor Fuels

*TCP Coordination Group on **Thermal Networks***

IEA DHC

INTERNATIONAL CENTRE FOR SUSTAINABLE CARBON

*TCP Coordination Group on **Carbon Management***

IEAGHG

*Coordination Group on **rgy System Flexibility***

Tasks

Strategic projects (more Tasks/TCPs involved)

Link with other TCPs & TCP Coordination Groups

IEA Hydrogen TCP

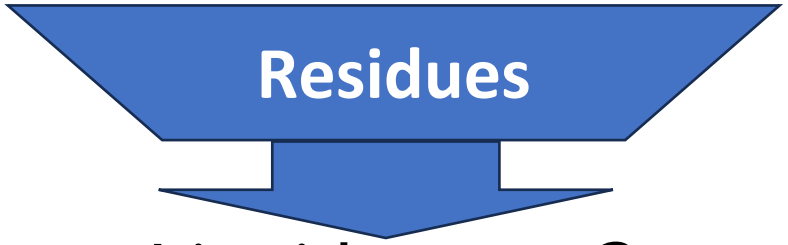
IEA Bioenergy

*TCP Coordination Group on **Hydrogen***

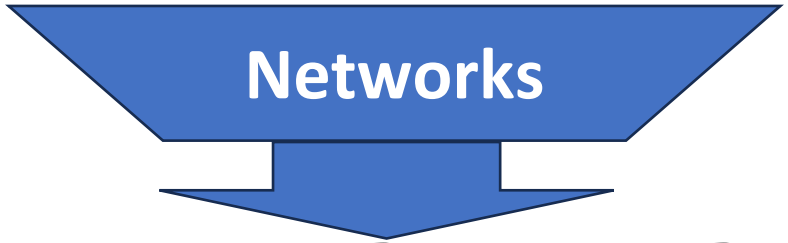
IEA Bioenergy ExCo96 – 17-18.Nov 2025
Research Council of Norway, Oslo

Bioenergy carriers & technology pathways - manifoldness

Provisioning systems: Food | Materials | Energy | Other (e.g., Infra-maintainance, landscape …)



Bioenergy carriers: Solid | Liquid | Gaseous | Hybrid (mixed with other renewables)



Energy needs: Cooking | Heat | Power | Propulsion | Solar Carbon

Bioenergy carriers & technology pathways - manifoldness

Simplified examples:

Construction wood > shavings > pellets > via road > res. heating

Sugar cane > fermentation > ethanol > refinery blending > transport

Wheat farm > straw > gasification > heat & power grids > heat & light

Consumed food > waste-water > biogas > gas grid > industrial heat

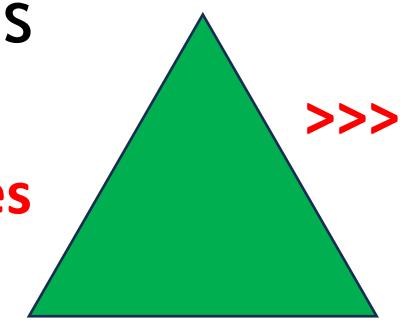
....

Societal contributions of these pathways

Food-materials-energy services:
Highly intertwined, the one needs the other, more synergies than trade-offs

IPBES Framework

Bioenergy processes



>>> Natures Contribution to People

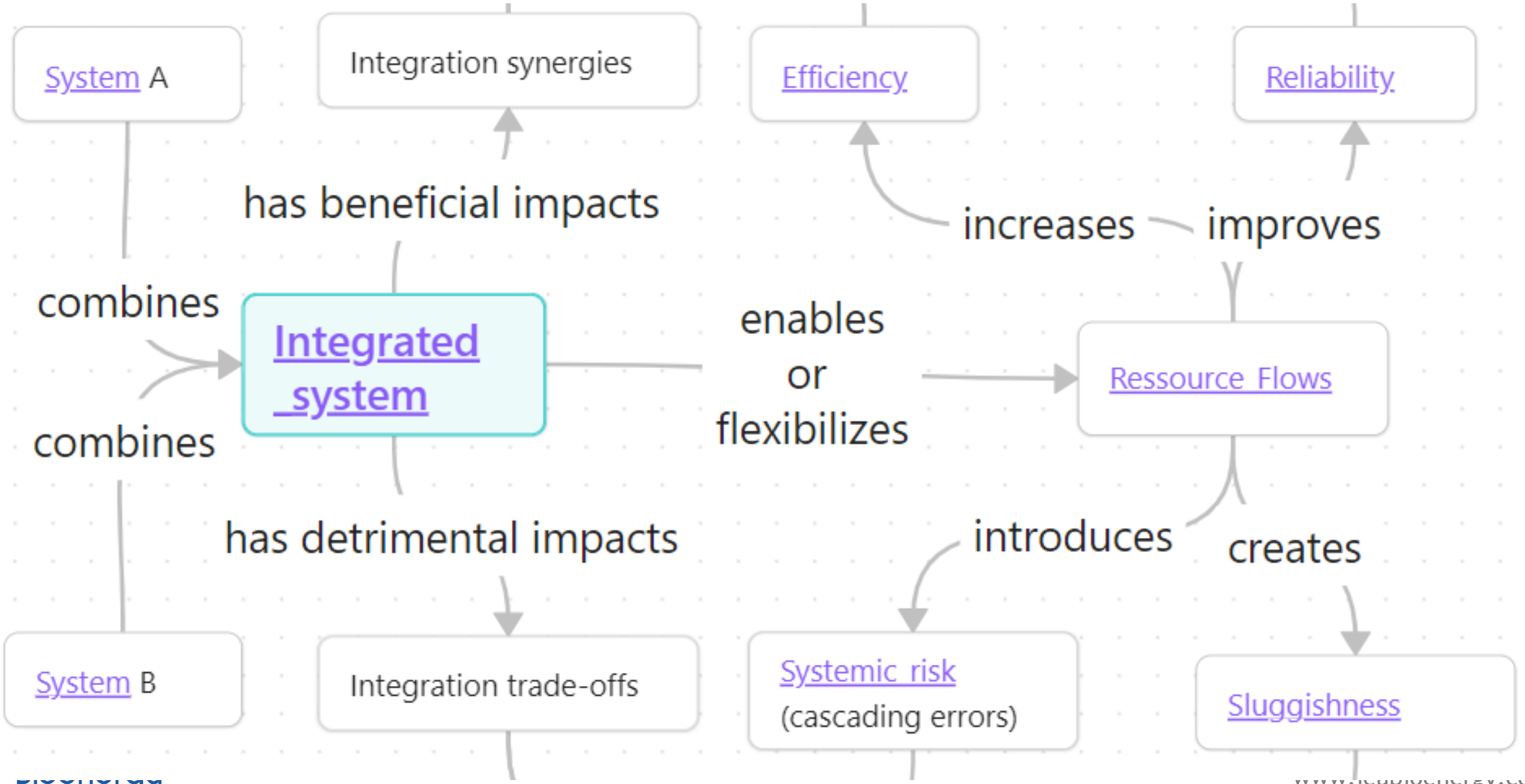
>>> Extension to nature

Non-tangible services:
Socio-economic, autonomous governance, education, connection to nature …

Regulating services:
Recirculation of cleaned water, energy storage, short-, medium-, long term flexibility, carbon removal, …

https://seea.un.org/content/update-classification-nature%E2%80%99s-contributions-people-intergovernmental-science-policy

Regulating contributions - through system integration



System integration scopes

Scope 1

Process integration:

- On-site
- Process intensification
- Heat-network synthesis
- Hydrogen plus solar carbon
- …

Scope 2

Industrial symbiosis:

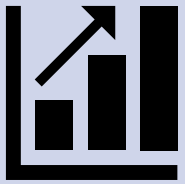
- Between-sites
- Residues from one resources for other
- Heat, CO2, waste-water pipelines
- Cascading and circular paths
- …

Scope 3

Networks of networks:

- Between SDGs
- Multi-sector coupling
- Multi-level governance coupling
- PV, wind + bioenergy
- Energy-food-water nexus
- …

Regulating contributions for managing risks

	Uncertain trends	Uncertain variabilities	Uncertain extremes
Earth system *Considered uncertainties in ESMs*	*e.g. on global warming* 	e.g. *on weather seasonality and day-nighttime* 	*e.g. on climate extremes* 
Human system *Considered uncertainties in ESMs*	e.g. *on socio-economic trends*	e.g. *on costs and prices, on trade*	e.g. *on accidents, market crashes, wars, cyber-threats*

Decreasing Modelling Readiness Levels – potential evolution?

Schipfer, F., Harasek, M., Tiwari, S., Kraxner, F., Schmidt, J., Wehrle, S., Asasian Kolur, N., Thrän, D., Esmaeili Aliabadi, D., & Breunig, H. (2025). Modelling Readiness Level for System Integration Impact Assessment – based on the case of the Austrian energy system modelling community. Zenodo. https://doi.org/10.5281/zenodo.17085016

Exemplary synergies
Bioenergy <> Hydrogen

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

Both technologies are metabolic,
i.e. operationally rely on inputs (incl. water),
creating outputs (incl. emissions)
>>> need for infrastructures, conversion tech, storages, derivates, standards, emerging markets >>> complex integration opportunities

- knoweldge and experience transfer
- joint use of infrastructures
- hydrogen improving bioenergy products (H2 + Biogas)
- hydrogen produced from biomass

Exemplary synergies

Bioenergy <> Biogenic (solar) carbon removal

Starting into the 3rd triennium phase

https://task40.ieabioenergy.com/inter-task-beccus-2-0/

Solid, liquid, gaseous bioenergy & CO2 capture & more

- Biomass combustion for heat and electricity + CO2
- Biomass gasification > CHP or CH4 or fuels + CO2
- Biomass liquefaction > crude biooil + CO2
- Anaerobic digestion > waste-water treatment > CHP or CH4 + CO2
- CO2 to store (BECCS, storage) or to use (BECCU, utilization)
- Biochar for carbon circulation and soil enhancement

Examples for the automation of flexibility

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

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

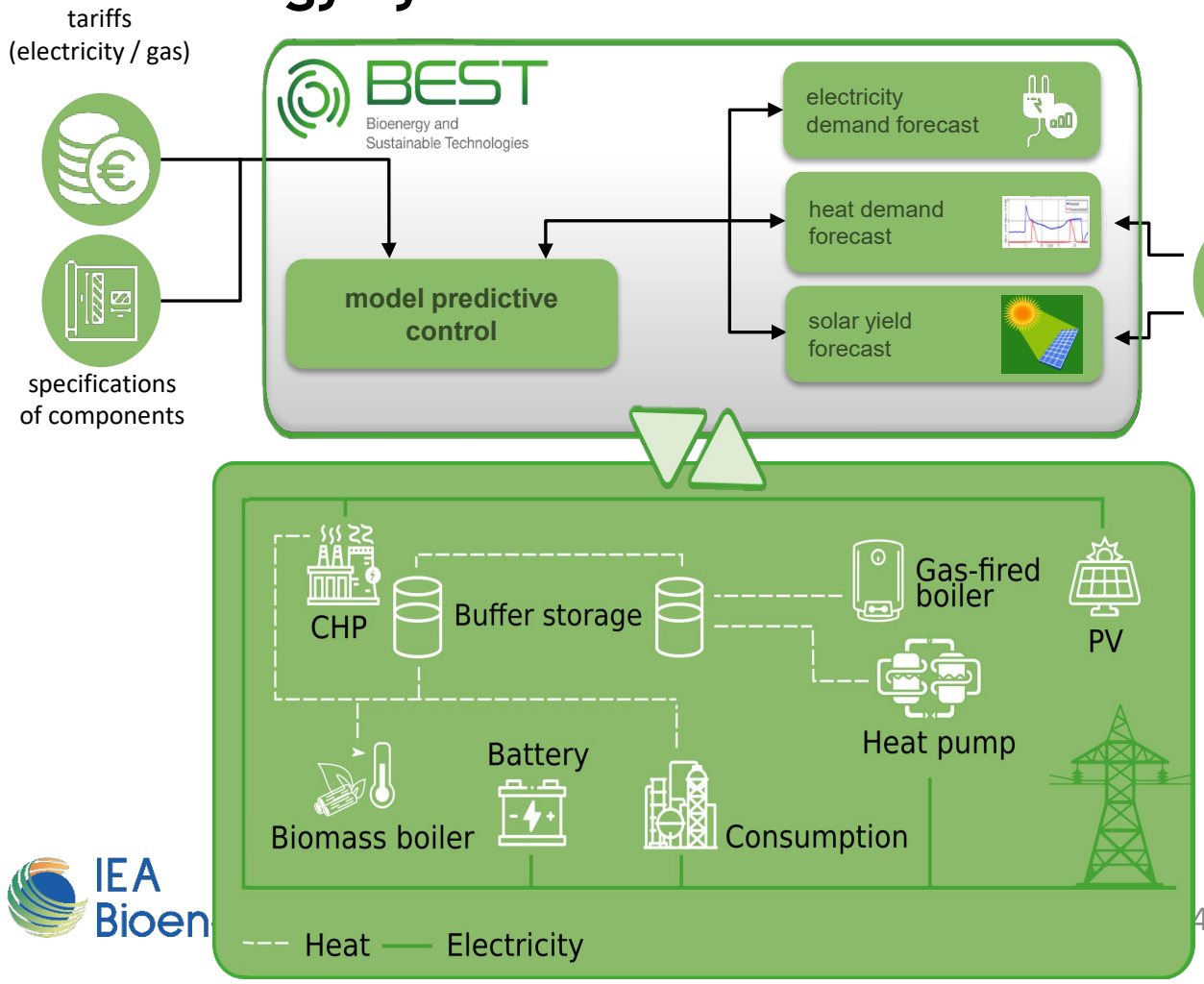
optimal operation
(efficiency, CO_2 emissions, …)

predicting volatility
of production and consumption

modulating in variation range
of the configurations

Examples for the automation of flexibility

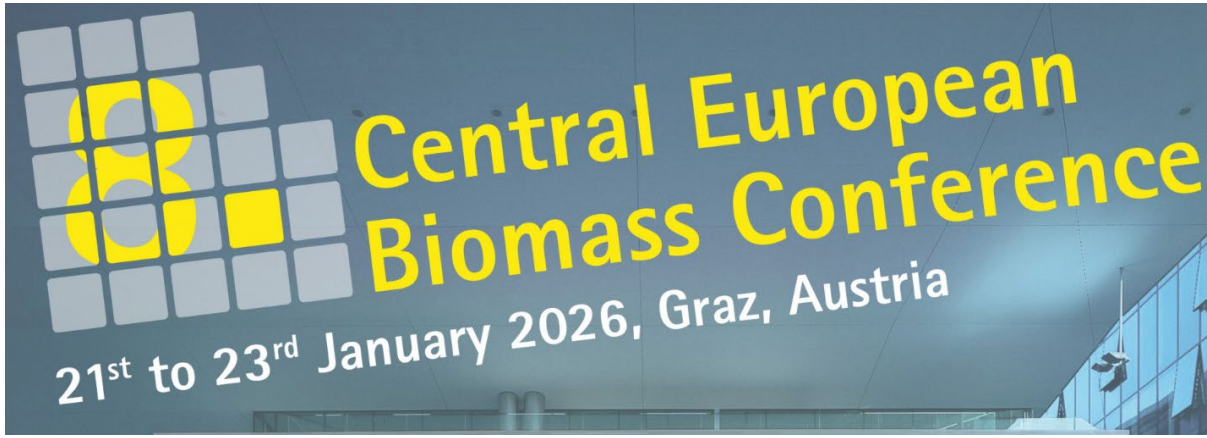
Modular, predictive, optimization-based supervisory control of multi-energy systems



Implementation & tests

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

Automation workshop at CEBC:



Call to action

Bioenergy paths are connectors

→ ~~competitive advantage~~ synergistic advantage of bioenergy

→ enables efficient risk management (e.g., portfolio effect)

Bioenergy domain experts must reduce bioenergy complexity without loosing the synergistic advantages & tradeoff-risks

←

→

Modelling experts must advance methodologies from assessing uncertain trends, to operations, to extremes enabling models to anticipate integration impacts

Elevating sustainable development toward reliable development

Including and beyond bioenergy: Hydrogen, BECCUS, Circular economy, sustainability <> security, modelling for investor decision making

Thank you!

Bioenergy system integration and flexibilization: Technology guidebook, Case studies, Policy mapping, Value discussions, Automatization insights (soon)
https://task44.ieabioenergy.com/iea-publications/

Synergies between bioenergy and hydrogen – all reports online
https://task44.ieabioenergy.com/inter-task-project-on-hydrogen-and-bio-based-value-chains/

Synergies between bioenergy and carbon removal (ongoing)
https://task40.ieabioenergy.com/inter-task-beccus-2-0/