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DBFZ

Potential roles of bioenergy in the German Energiewende

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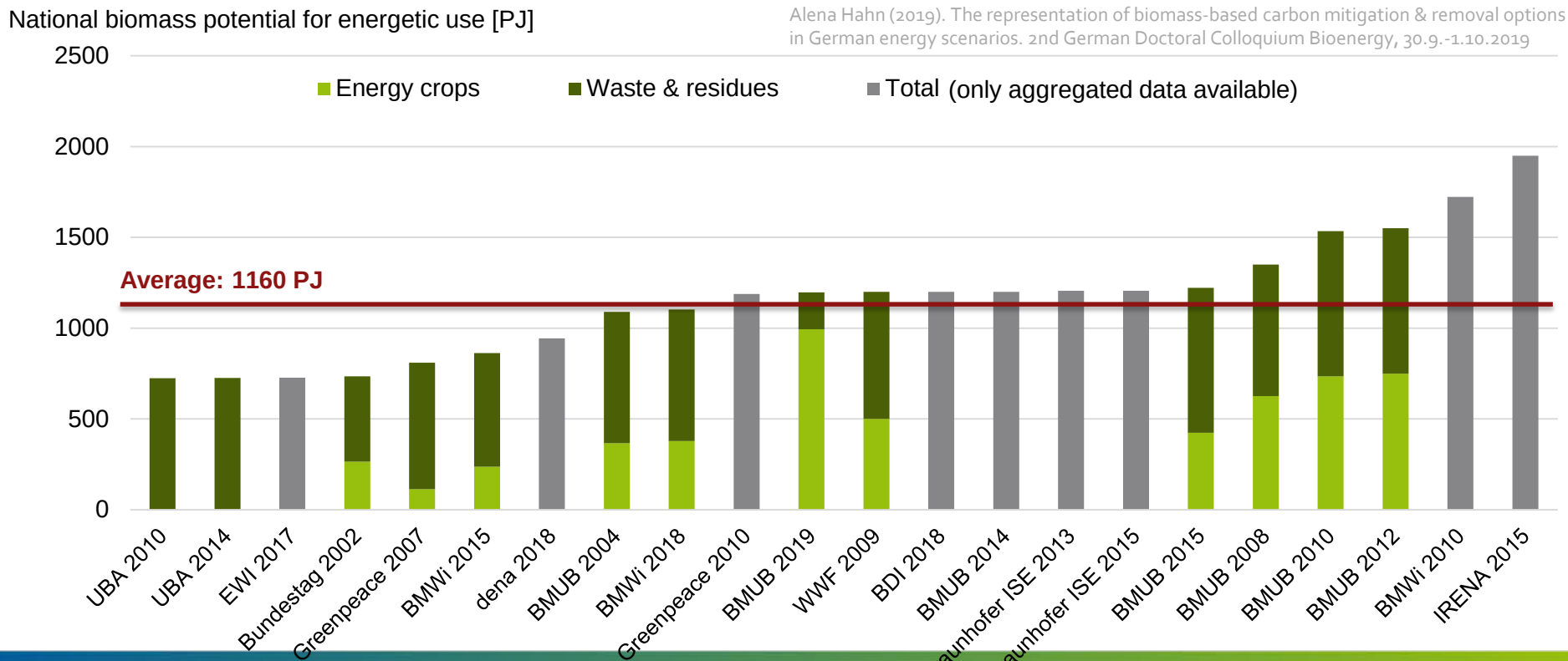
Background

- Germany has national targets of reducing GHG emissions by at least 80% up to 95% in 2050 compared to 1990
- Several long term studies have been published analysing the transition
- The role of biomass is seldom depicted in detail



Background

In order to acheive more details on biomass usage within long term energy scenarios, the German Federal Ministry for Economic Affairs and Energy (BMWi) initiated a project.

Goal: Cost-optimal allocation of national biomass potentials for energetic usage in scenarios until 2050.
Sectors: **Power, Heat and Transport**, further divided into sub-sectors. Demand set by long-term scenarios.
Biomass: **Residues and crops** (+ some import), **n=21**
Technologies: High detail in input-output and costs, **m=28**, **m(n)=133**
Scenarios: Land available (1/2.6/4 Mha) x GHG-target (80/95%)
Method: BioENergy OPTimisation model (BENOPT), GAMS/CPLEX

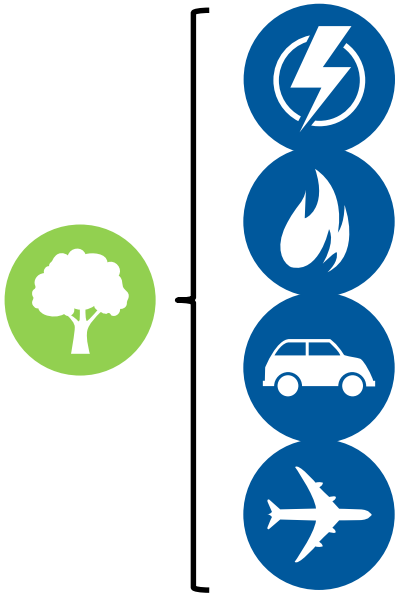
Biomass potential and cost

- Potentials of **residues** included ca **950 PJ** (**7% of total** primary energy demand), of which **75% wood**-based
- Assumed yields of crops used range from 84 and 115 GJ/ha (rape seed and wheat) to 254, 298 and 317 GJ/ha (sugar beet, silage maize, miscanthus)
- Current arable land used for bioenergy **2.35 Mha** (**20% of total** arable land): @ 300 GJ/ha [= PJ/Mha] → max. ca. **700 PJ**
- **H_2** assumed available for increasing the yield in Power-to-BtL and PtBME

- Costs: baseline increase 2% (4Mha), 3% (2.6 Mha), 4% (1Mha)
- For crops, the same income per hectare has to be achieved for each crop as for the baseline crop (wheat)

BioENergy OPTimisation model

- BENOPT: GAMS-based, CPLEX-Solver
- Goal function: Minimizing total costs while acheiving given constraints
- Exogenously given energy supply targets have to be met
- Available capacities are considered sunk cost
- All input-output and capital costs were included
- Not spatially explicit



Results

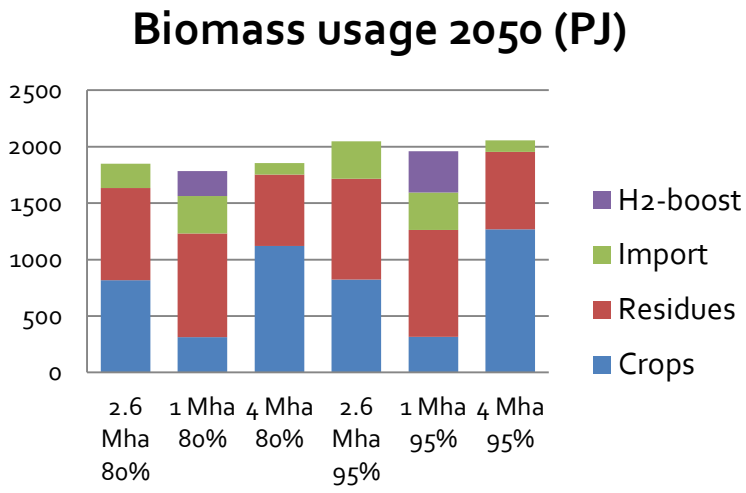
- Wood used mainly for industrial heat and CHP (+fuels in 95%)
- Fermentables used for CHP (+fuels in 95%)
- Miscanthus (+ maize in 80%) used for fuels
- Scarcity leads to more usage of expensive H_2-"booster" (for aviation)

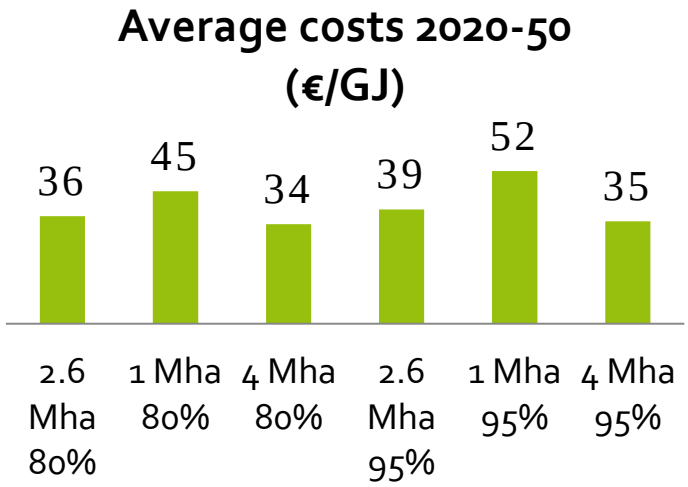
Hurdles/uncertainties:

- gaseous fuels
- perennials
- advanced fuels

Leverage options:

- arable land
- electrofuels & EVs
- demand reduction





Thank you!

Project team:

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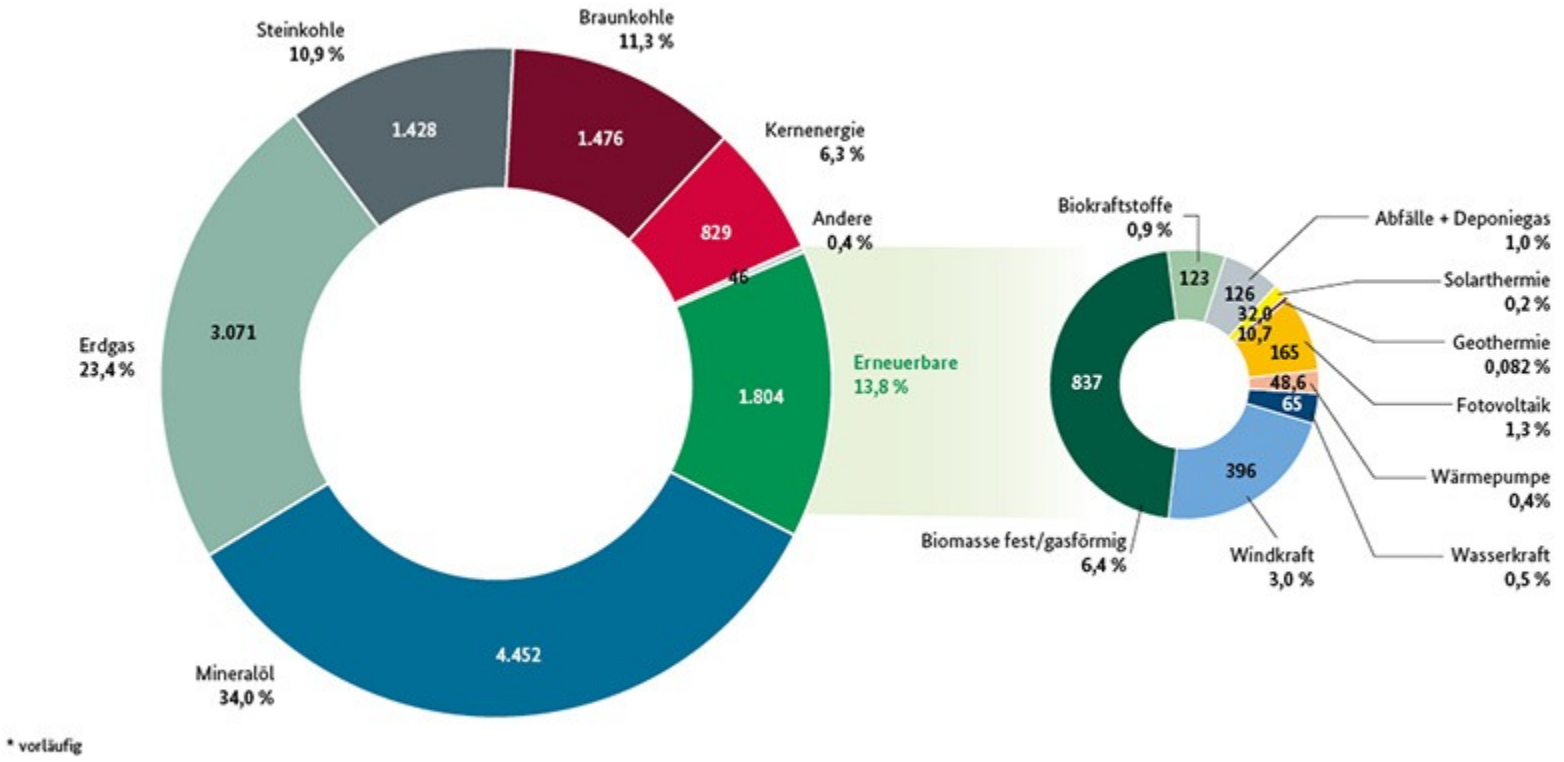
Back-up



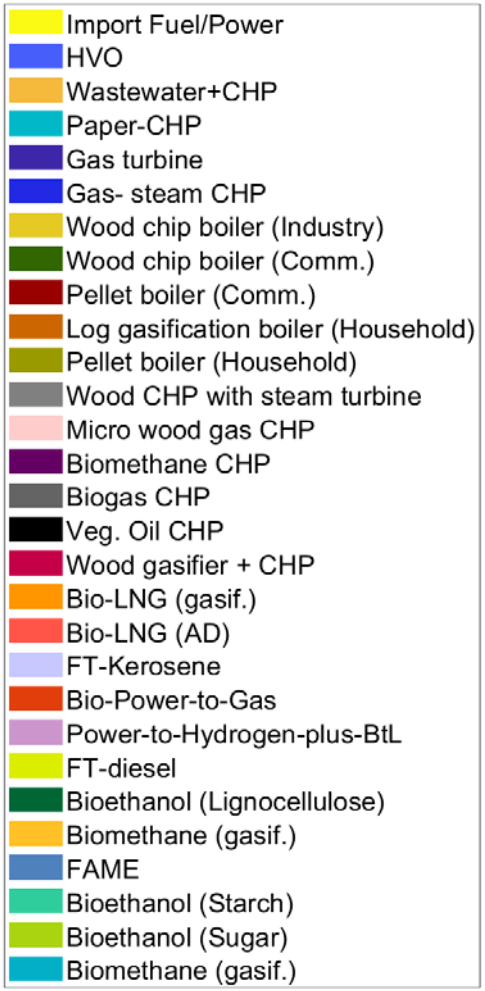
* vorläufig

Results

Industrial heat

Transport

PBtL



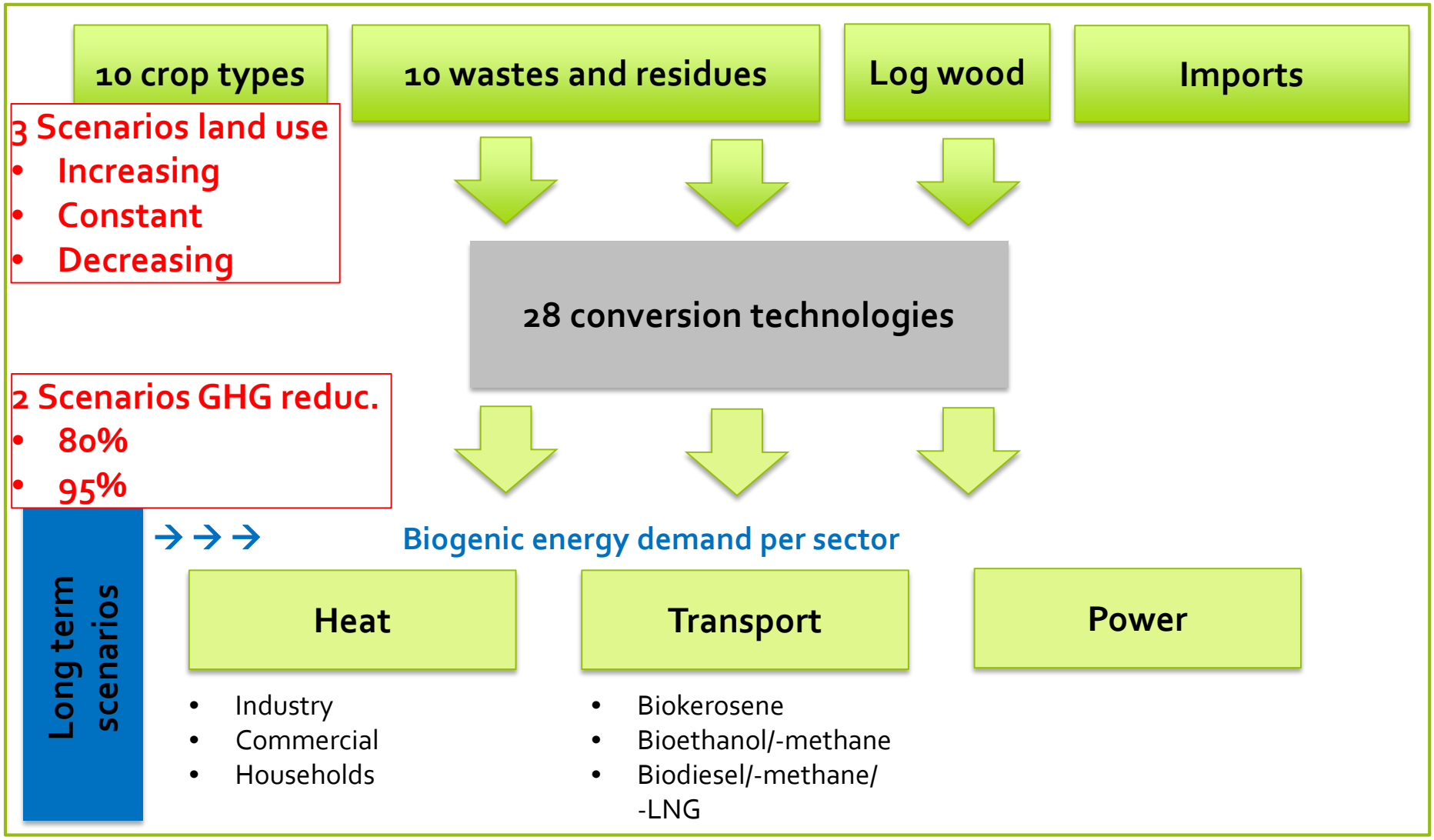
- Wood used mainly for industrial heat and CHP
- Fermentables used for CHP
- Miscanthus and Maize used for fuels

- + fuels
- + fuels
- Miscanthus only

„Stoffstrommatrix“

Sektor	Technologie	Anwendung	Energieträger	Anbaubiomasse											Abfall- und Reststoffe									
				Raps	Mais	Getreide	Ackergras	Grünland	KUP	Miscanthus	Zuckerrübe	Blühmischungen	Algen	Scheitholz	Stroh	Gülle + Mist	Waldrestholz	Industrierestholz	Used cooking oil	Bioabfall	ind. Reststoffe	Schwarzlauge	Altholz	Klärschlamm
Industrie (Wärme)	Biomethan-BHKW * 1	KWK	Biomethan		X	X	X	X			X	X	X			X				X	X			
	Holzhackschnitzelkessel - IND	Wärme	feste Biomasse						x								x	x						
GHD (Wärme)	Pelletkessel - GHD	Wärme	feste Biomasse														x	x						
	Holzhackschnitzelkessel - GHD	Wärme	feste Biomasse						x	x							x	x						
Gebäude (Wärme)	Scheitholzvergaserkessel	Wärme	feste Biomasse											X										
	Pelletkessel - GBD	Wärme	feste Biomasse														x	x						
	Mikro-Holzgas-BHKW	KWK	feste Biomasse						x	x							x	x						
Verkehr (Kraftstoffe)	Bioethanol (Zucker)	Kraftstoff	Bioethanol								X		X											
	Bioethanol (Lignocellulose)	Kraftstoff	Bioethanol						x	x					x		x	x						
	Bioethanol (Stärke)	Kraftstoff	Bioethanol			X																		
	Biomethan (aus Biogas)	Kraftstoff	Biomethan		X	X	X	X			X	X	X			X				X	X			
	Biomethan (Bio-Power-to-Gas)	Kraftstoff	Biomethan		X	X	X	X			X	X	X			X				X	X			
	Biodiesel (RME)	Kraftstoff	Biodiesel	X															X					
	HVO/ HEFA	Kraftstoff	Biodiesel/ -kerosin	X									X						X					
	FT-Diesel (BtL)	Kraftstoff	Biodiesel						x	x					x		x	x						
	FT-Kerosin (BtL)	Kraftstoff	Biokerosin						x	x					x		x	x						
	Power-to-Hydrogen-plus-BtL (PBtL)	Kraftstoff	Biokerosin						x	x					x		x	x						
	Biomethan (SNG)	Kraftstoff	Biomethan						x	x					x		x	x						
	Bio-LNG (aus Biomethan)	Kraftstoff	Bio-LNG		X	X	X	X			X	X	X			X				X	X			
	Bio-LNG (SNG)	Kraftstoff	Bio-LNG						x	x					x		x	x						
Energie-wirtschaft (Strom und/ oder Wärme)	Biogas + BHKW	KWK	Biogas		X	X	X	X			X	X				X				X	X			
	Biomethan GuD-Kraftwerk	KWK	Biomethan		X	X	X	X			X	X	X			X				X	X			
	Biomethan Gasturbine	Strom	Biomethan		X	X	X	X			X	X	X			X				X	X			
	Klärschlammfaulung +BHKW	KWK	Klärgas																					X
	Holzvergaser + BHKW	KWK	Holzgas						x	x							x	x						
	Papier-Zellstoff-KWK	KWK	Schwarzlauge																			X		
	Pflanzenöl-BHWK	KWK	Pflanzenöl	X																				
	Holzheizkraftwerk mit Dampfturbine	KWK	feste Biomasse						x								x	x					X	

Approach


10 crop types
10 wastes and residues
Log wood
Imports
3 Scenarios land use
• Increasing
• Constant
• Decreasing
28 conversion technologies
2 Scenarios GHG reduc.
• 80%
• 95%
Long term scenarios
→ → →
Biogenic energy demand per sector
Heat
Transport
Power
• Industry
• Commercial
• Households
• Biokerosene
• Bioethanol/-methane
• Biodiesel/-methane/ -LNG