

Sustainable Biomass Energy: Technologies for Electricity and Heat

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Divisions (Research Areas)

**Energy &
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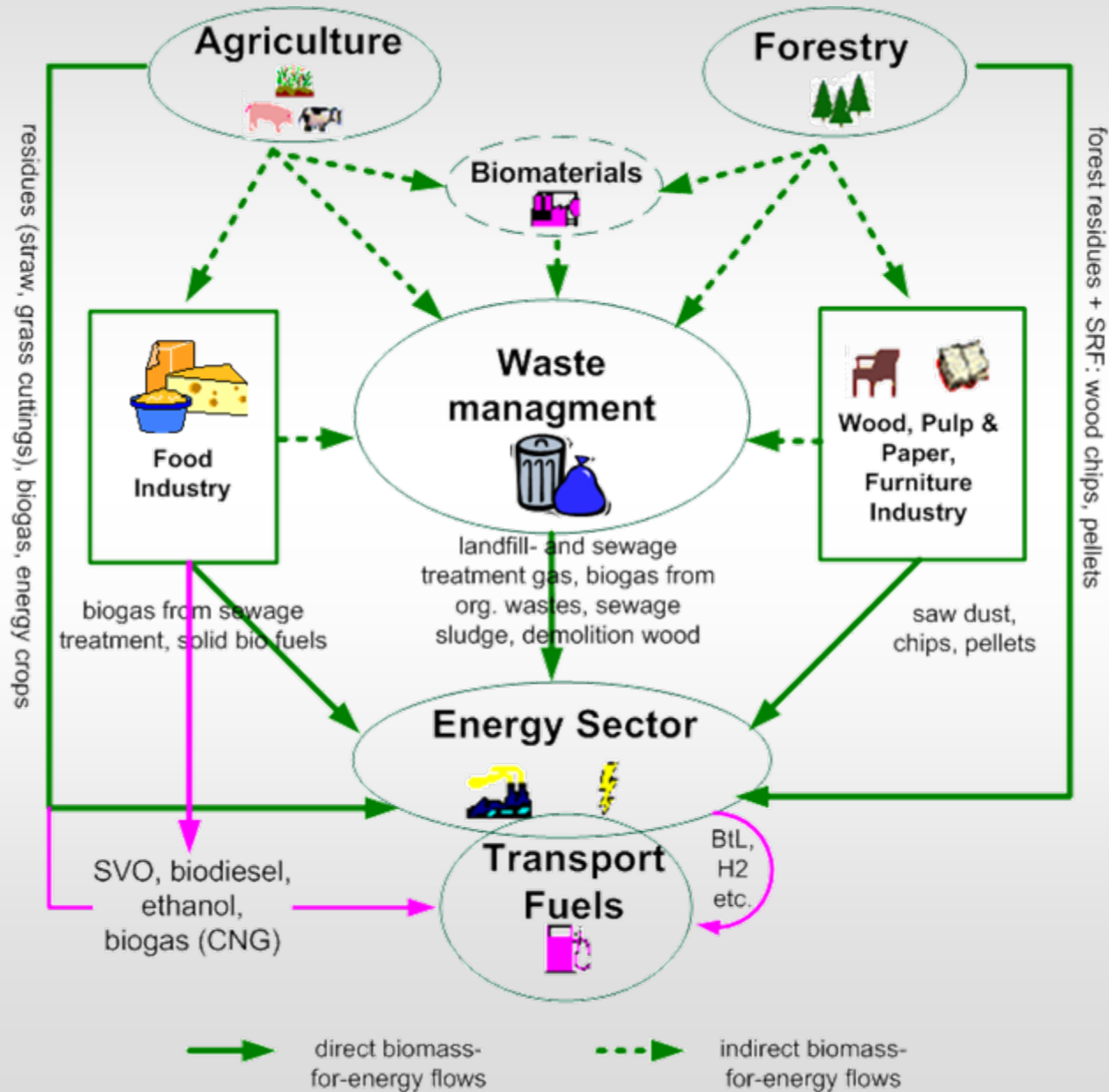
**Industry &
Infrastructure**

**Products &
Material Flows**

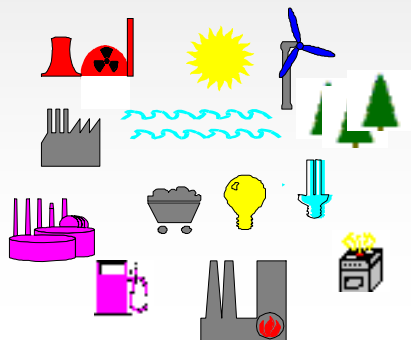
**Environmental
Law**

Öko-Institut e.V. is a private, non-profit environmental research organization founded in 1977; staff > 100, local to global scope of (net)work

- **Integrated** analysis of **all** biomass flows from agriculture, forestry, waste
- **Land potential** for energy crops (competition food + nature conservation)
- Future technology development (**learning curves**) for **all** technologies
- Analysis of **human labor** flows (direct + indirect employment); potential income from local use, and/or exports
- **Complexity**: transparent, **reviewed data**



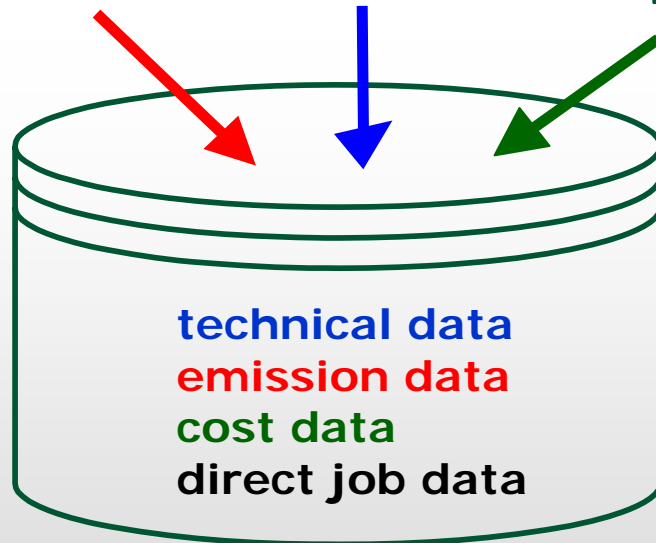
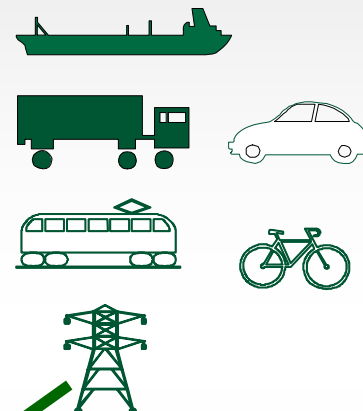
Energy



Materials



Transport



	costs 2010 c/kWh _{el}	2030	jobs pers./TWh _{el}	CO ₂ -eq. g/kWh _{el}	SO ₂ -eq.
fossile reference systems					
natural gas CC	4,9	5,7	79	420	0,4
hard coal (import) ST	5,0	4,4	142	913	1,4
biogas from wastes					
c+p-300-ICE-cogen-25	14,0	10,0	1.468	-329	1,5
c+p-300-ICE-cogen-100	12,7	8,6	1.476	-269	1,4
c+p-300-ICE-cogen-200	11,0	7,6	1.186	-296	1,4
c+p-1500-ICE-cogen-200	7,8	5,5	746	-317	1,4
c+p-1500-ICE-cogen-500	6,9	4,5	642	-241	1,3
c+p-1500-ICE-cogen-1000	6,6	4,6	585	-212	1,2
biowaste-only-ICE-cogen-500	8,1	5,9	522	-372	0,7
manure-only-ICE-cogen-500	9,6	8,1	898	-240	1,1
biowaste-4000-ICE-cogen-500	3,5	2,0	539	-339	0,6
manure+maize-ICE-cogen	18,5	15,2	518	-187	1,9
manure+maize-org.-ICE-cogen	24,0	19,9	920	-233	1,2
"wet route" ICE-cogen	10,2	7,7	5.233	-182	1,6

Data include bonus for cogenerated heat (based on gas); cost @ 7% real interest

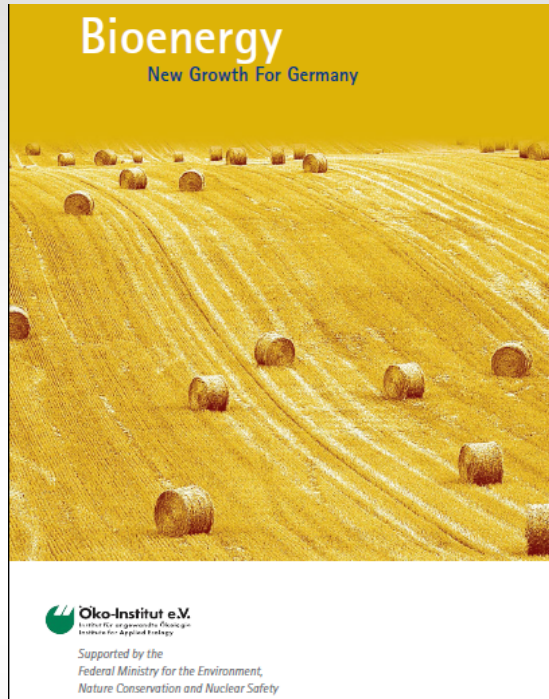
material flow/technology	costs 2010	2030	jobs	CO ₂ -eq.	SO ₂ -eq.
	c/kWh _{el}	c/kWh _{el}	pers./TWh _{el}	g/kWh _{el}	
natural gas CC	4,9	5,7	79	420	0,4
hard coal (import) ST	5,0	4,4	142	913	1,4
forest residues					
chips cofiring coal-cogen	5,3	5,3	97	38	0,4
chips SE-cogen	10,9	8,6	368	-1329	1,3
chips ORC-cogen	10,8	8,0	23	-1625	1,5
pellet stirling-cogen	25,6	20,4	144	-1010	1,4
FB-ICE-cogen	19,3	14,6	1.426	-273	0,7
FB-micro-GT-cogen	17,8	12,6	1.446	-191	0,4
aCFB-ICE-cogen	8,8	6,5	291	-274	0,6
pCFB-CC	9,6	8,2	394	219	0,9
SG-FC-SO-cogen	13,1	11,9	683	312	0,5
syngas-FC-SO-cogen	11,4	10,7	625	8	0,2
short-rotation forestry					
chips cofiring coal-cogen	8,8	8,8	2.203	71	0,7
chips SE-cogen	22,6	19,5	5.712	-1205	3,7
chips ORC-cogen	23,4	19,7	4.615	-1343	3,9
FB-ICE-cogen	26,3	21,0	4.538	-203	1,2
FB-micro-GT-cogen	24,7	18,6	2.706	-124	0,9
aCFB-ICE-cogen	14,0	11,5	1.966	-224	1,1
pCFB-CC	13,1	11,9	1.908	272	1,4
SG-FC-SO-cogen	17,2	14,3	-184	346	0,7

Data include bonus for cogenerated heat (based on gas); cost @ 7% real interest

	costs 2010	2030	jobs	CO ₂ -eq.	SO ₂ -eq.
	c/kWh _{th}		pers./TWh _{th}	g/kWh _{th}	
gas heating 10 kW	10,2	11,4	266	296	0,36
oil heating 10 kW	10,6	11,2	333	383	0,42
wood residues					
chips heating 10 kW	7,6	7,5	378	29	0,5
chips heating 50 kW	6,1	6,1	289	29	0,5
pellet heating 10 kW	11,3	11,5	446	34	0,4
pellet heating 50 kW	10,9	11,1	420	33	0,4
pellet heatplant 0.5 MW + grid	8,3	8,7	796	40	0,4
chips heatplant 1 MW + grid	5,3	5,3	340	33	0,4
chips heatplant 5 MW + grid	5,4	4,8	358	32	0,4
SRF-poplar/Miscanthus					
pellet heating 10 kW	13,7	14,1	1.322	56	0,6
pellet heating 50 kW	13,2	13,7	1.277	55	0,6
pellet heatplant 0.5 MW + grid	10,8	11,4	1.728	64	0,6
chips heatplant 1 MW + grid	6,9	7,1	1.275	52	0,6
chips heatplant 5 MW + grid	6,7	7,0	1.272	50	0,6
miscanth.heatplant 1 MW + grid	6,4	6,6	413	53	1,5
miscanth.heatplant 5 MW + grid	7,0	7,3	430	47	1,0

Cost data @ 7% real interest

- Cogeneration is **key**, needs heat users
- **Co-firing** cost-effective with CO₂ trading
- Small-to medium-scale biomass heat often competitive (→ air emission!)
- Additional **RT&D** program for medium **gasifier** (BIG-ICE + BIG-STIG/BIG-CC)
- Bioenergy cropping **needs environmental “guardrail”** (priority species + practices)
- **Imports** could be interesting **in addition**: international standards needed



**Brochure, full report,
appendix, and all data:
www.oeko.de/service/bio**

**Model + database (freely available):
www.gemis.de**

**Languages: German, English, Czech, Spanish
(possibly also French in the future)**