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Energy balances of bio-energy systems; the relative position of biogas production.

- Workshop: Energy Crops & Biogas, 'pathways to success?, Organized by Cropgen & IEA task 37, Utrecht, the Netherlands, September 22, 2005' -

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Issues

- Development of digestion so far.
- Digestion as waste treatment option in waste treatment infrastructure.
- Some notions on energy crops.
- Final remarks on energy crops & digestion

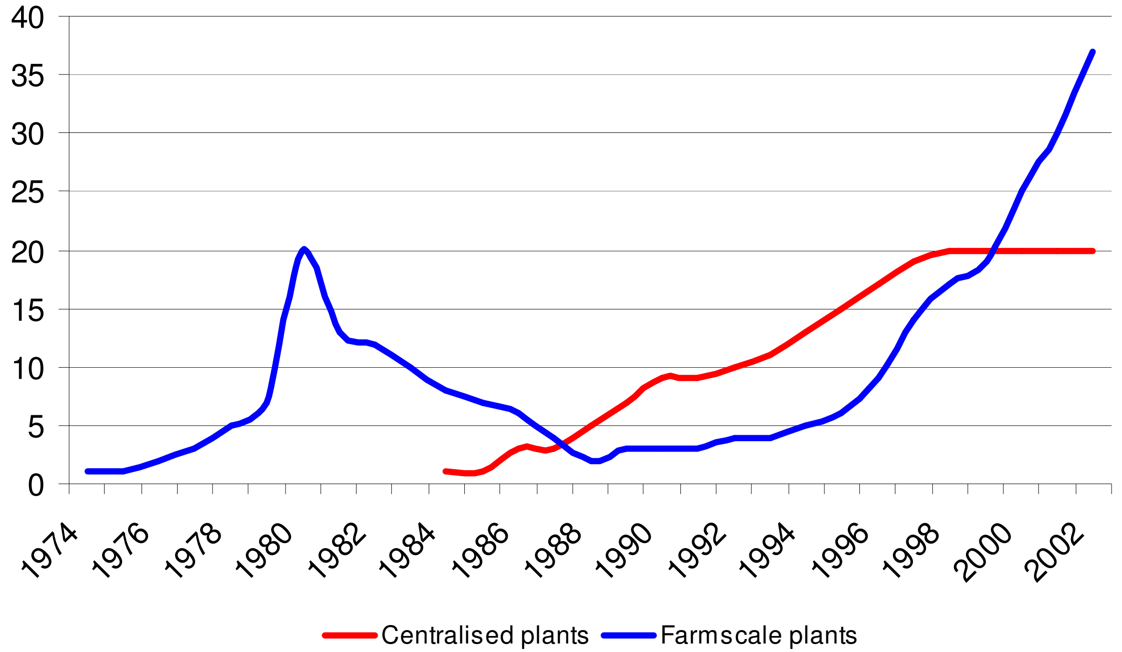
State-of-the-art

Central digestor in Studsgard

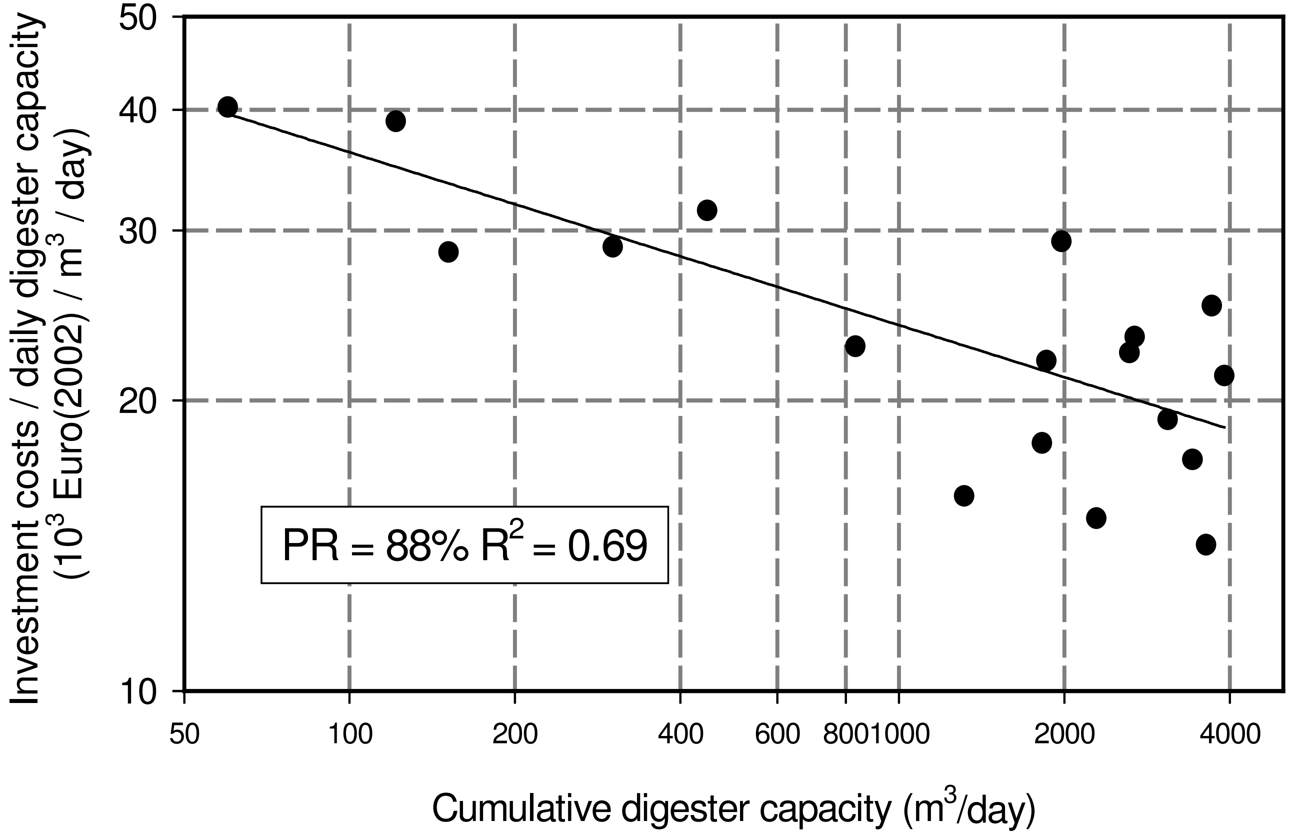
Denmark…

Denemark is successful:

- 40 farm systems
- 20 centralised systems
- High market penetration

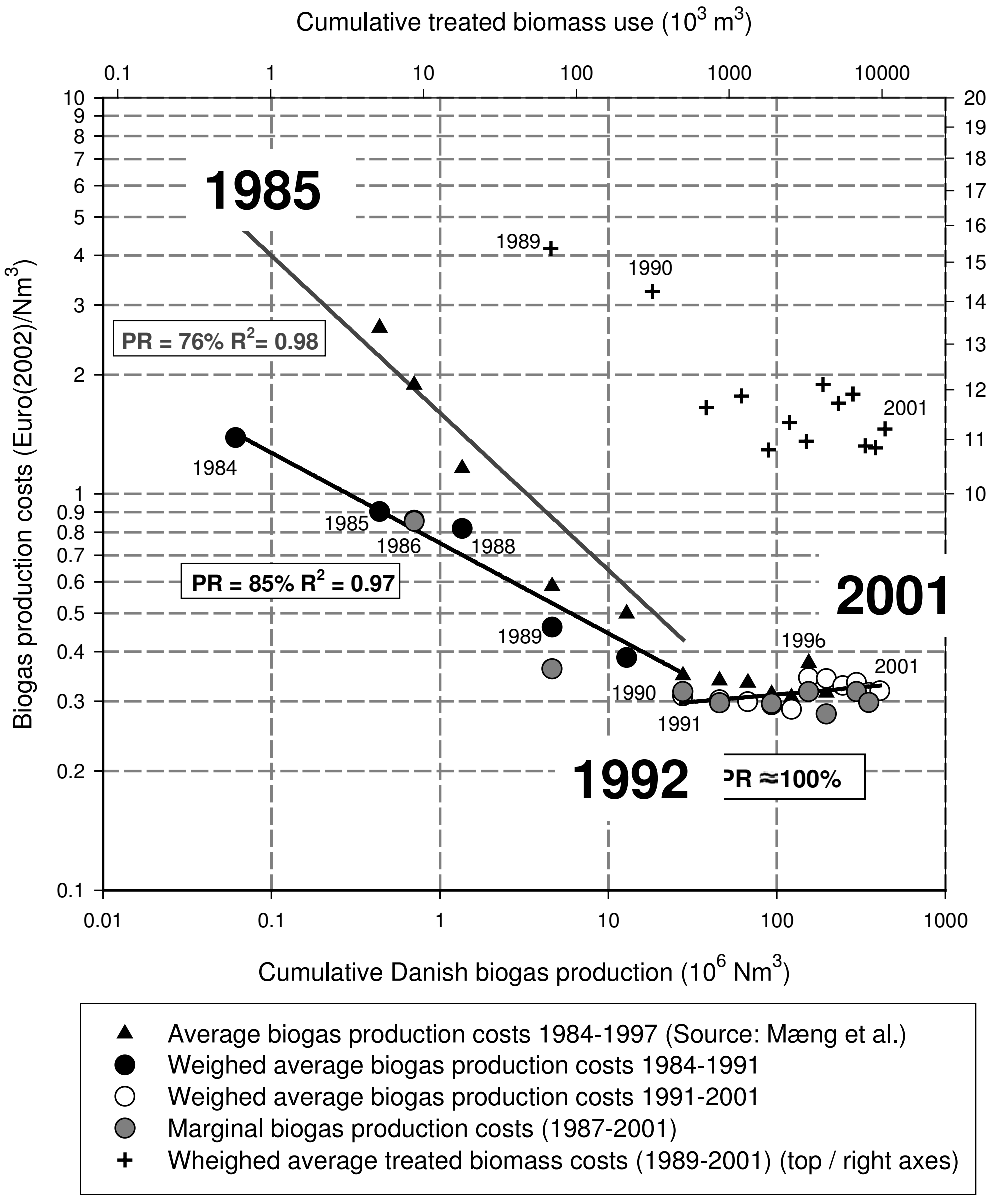


Een leercurve voor de investeringskosten van Deense biogas centrales

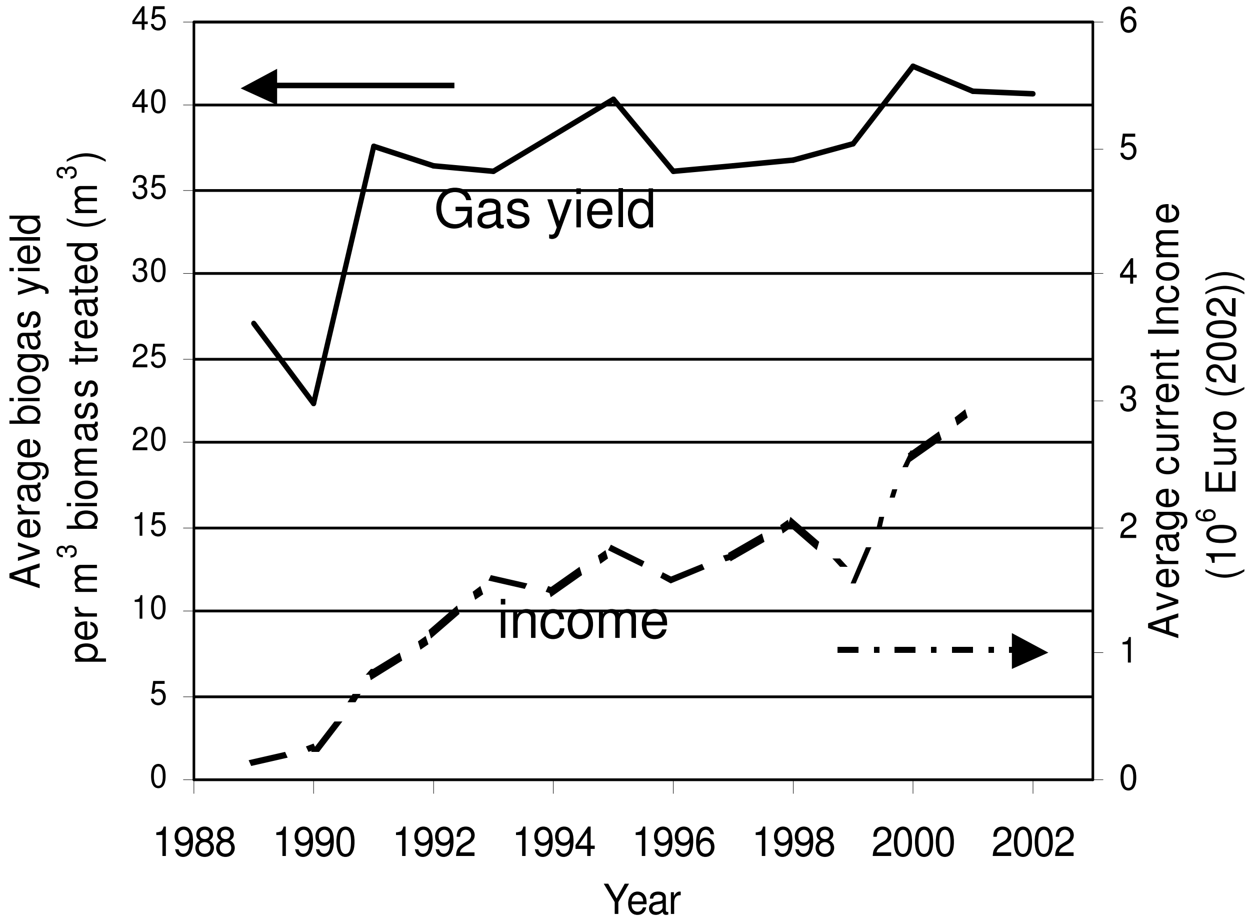


A learning curve for Danish biogas production

Based on 20 large scale grootschalige biogas plants in Denmark 1985-2001



Development of average biogas yield and income of Danish manure digestors.

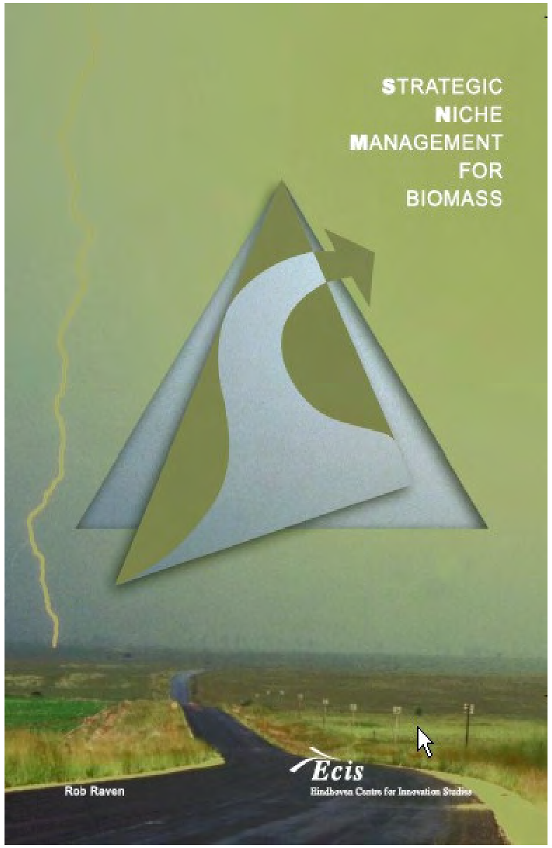


Some remarks:

- Digestion has reached sound maturity level (significant learning achieved over past decades).
- Further cost reductions hampered by scarcity of co-digestate, stalling of scale-up and market liberalisation.
- Continuity/stability of government policy very important.

More information on digestion:

Learning in renewable energy technology development (Martin Junginger)



Strategic Niche Management for Biomass (Rob Raven)

National waste treatment infrastructure; optimalisation

- Optimalisation model; maximizing energy yield or minimizing costs.
- Performance of waste treatment and separation options in relation to scale (efficiencies, costs, heat (distribution), logistics).
- Waste supply and characteristics (moisture, contamination!).
- Boundary conditions (defaults energy system and materials).
- Analysis of different system lay outs (scenario’s).

Structure optimalisation model

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Invoergegevens
o.a. afvalaanbod, technologieën, logistieke kengetallen
→ energie, kosten

↓

Vastgelegd hergebruik
niet brandbare stromen
→ energie, kosten

↓ Nieuw aanbod

Bestaande verwerkingsinstallaties
→ energie, kosten

↓ Nieuw aanbod

Optimalisatie
naar energie of kosten

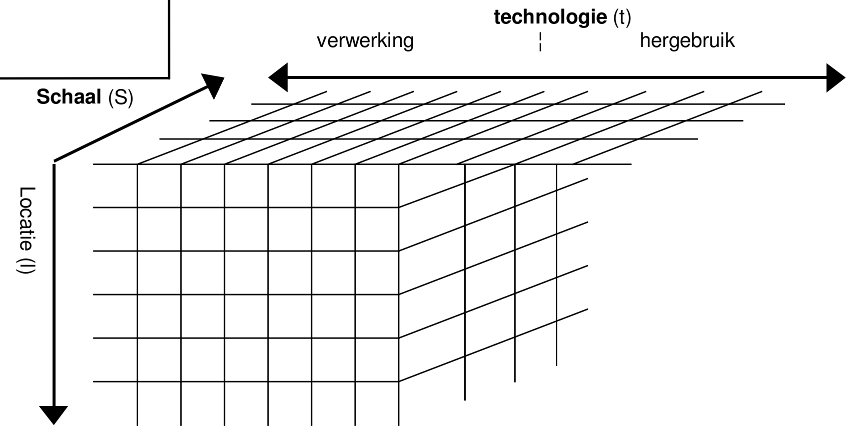
t/m aanbod = 0	**Nieuwe bewerkingsoptie** (hergebruik of verwerkingsinstallatie)

→ energie, kosten

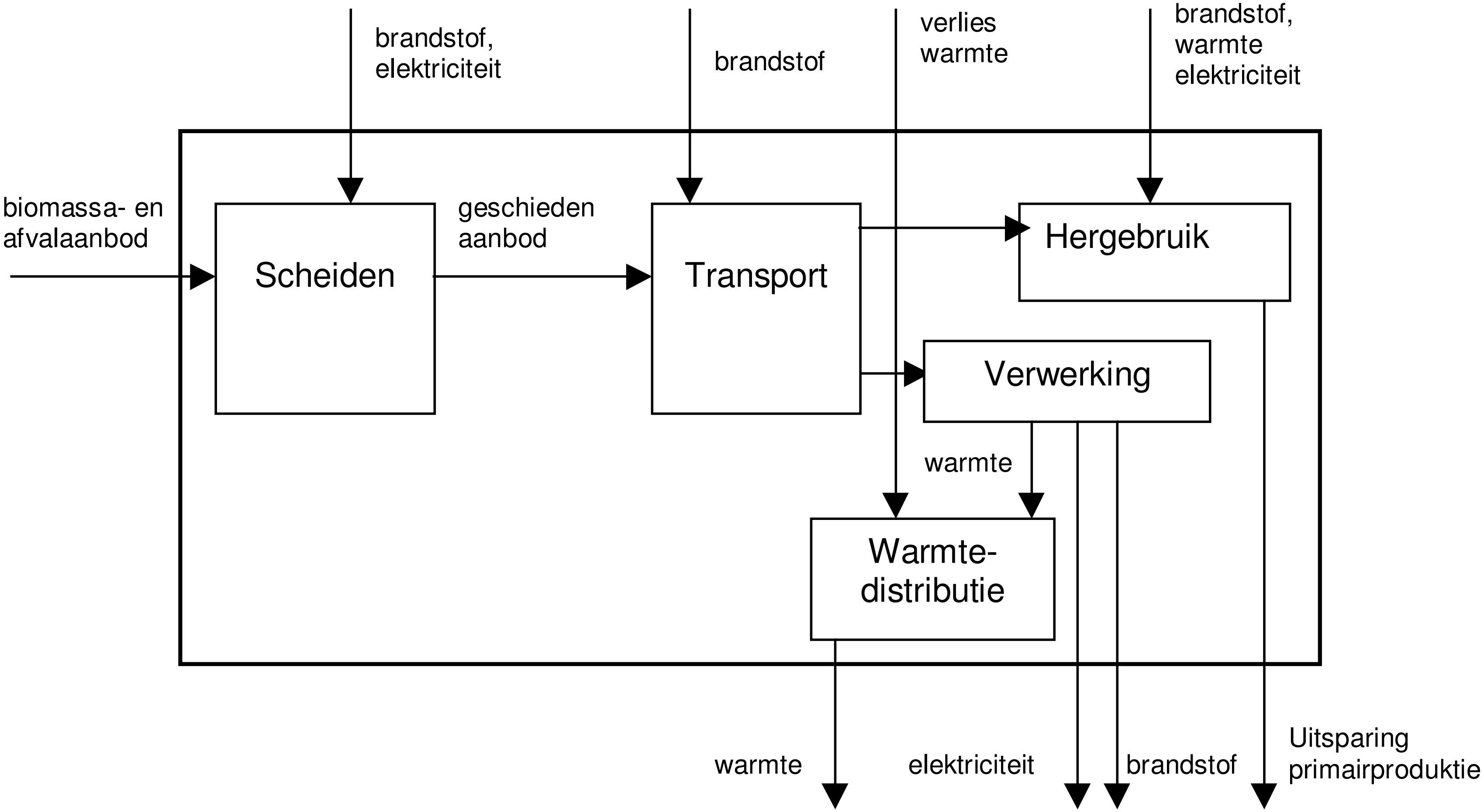
↓

Afvalbewerkingsstructuur
Aantal opties (hergebruik en verwerking)
energie en kosten

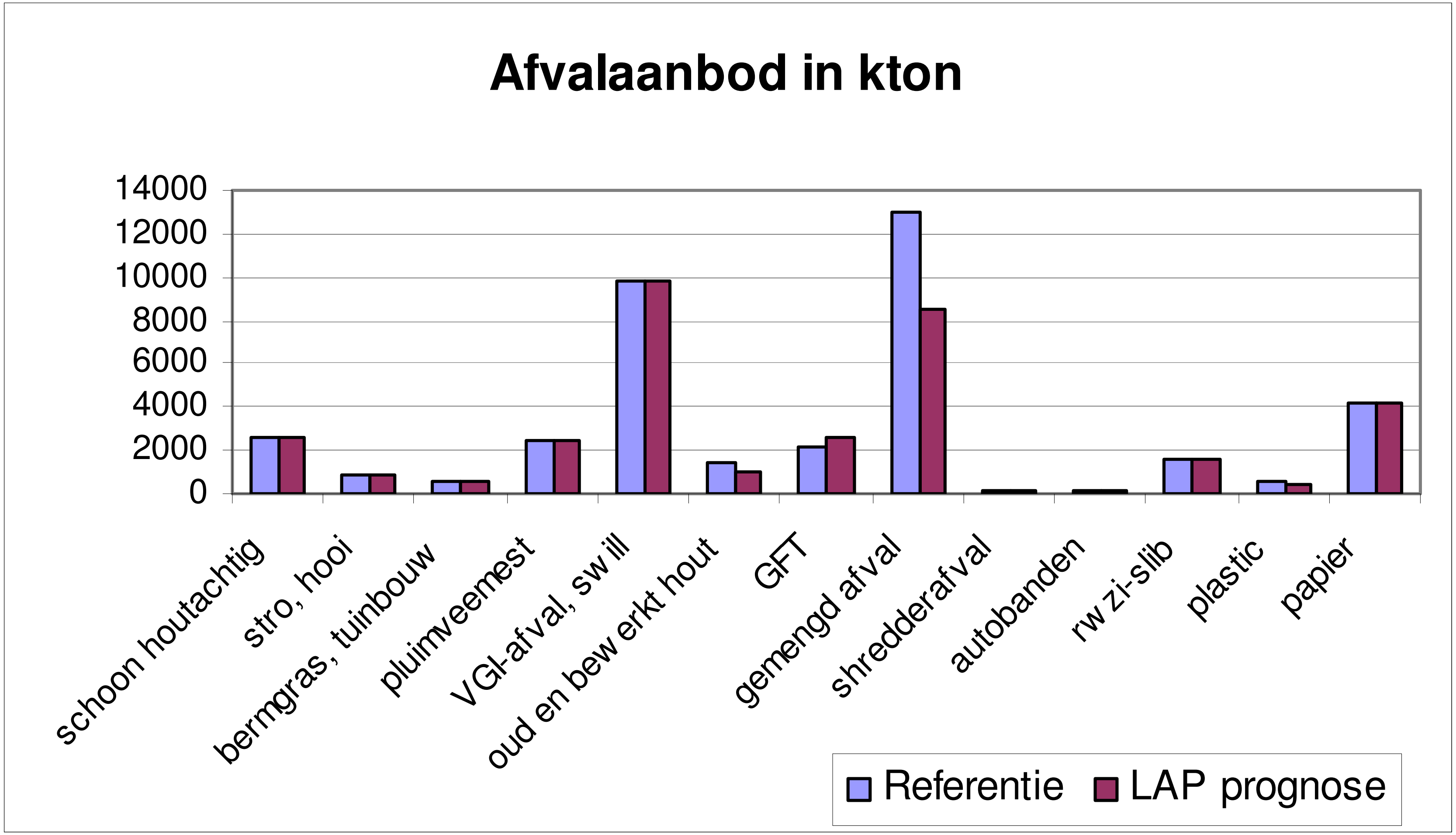
Matrix model calculations:
f (scale, technology, location)



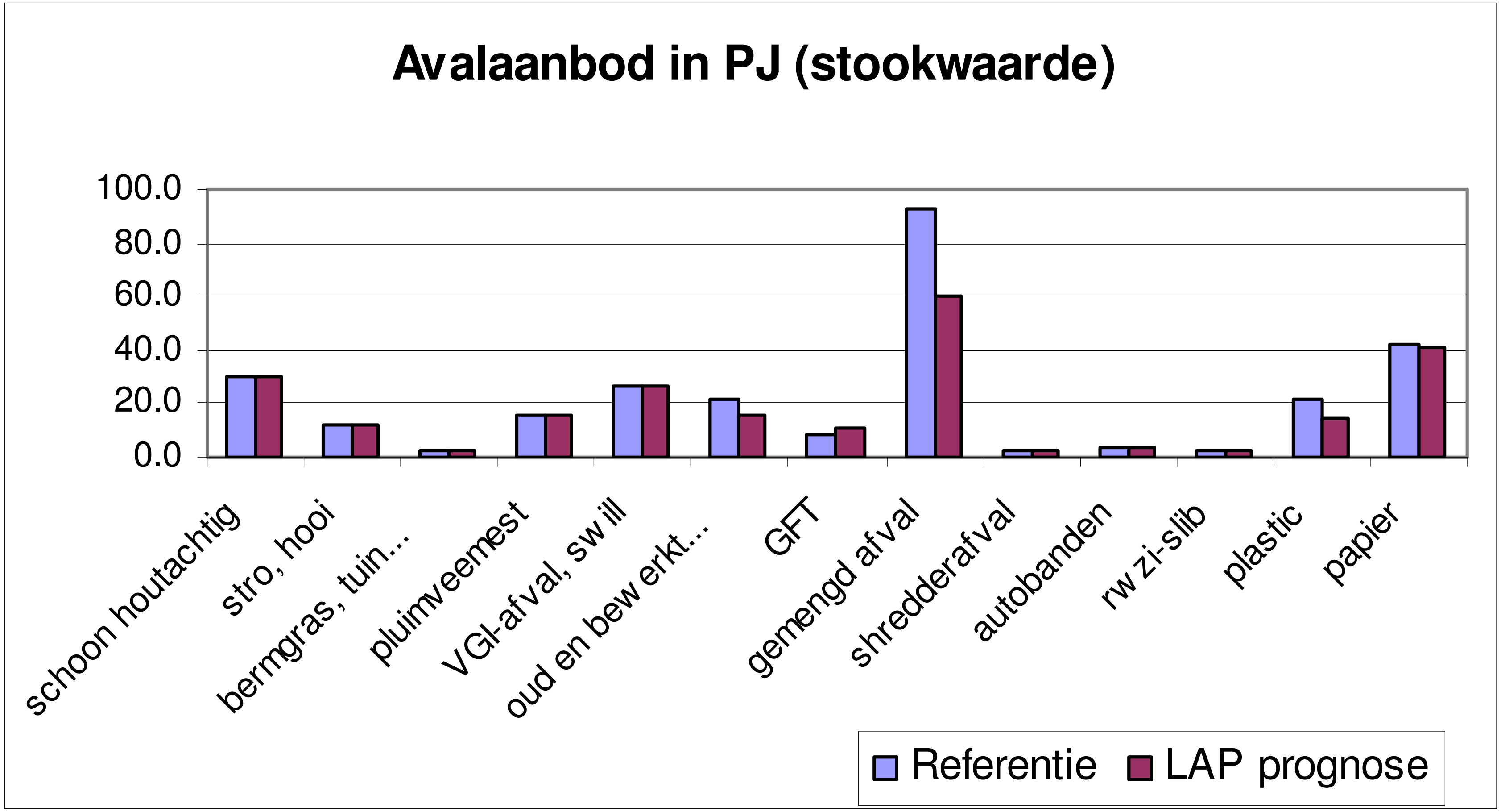
System boundaries



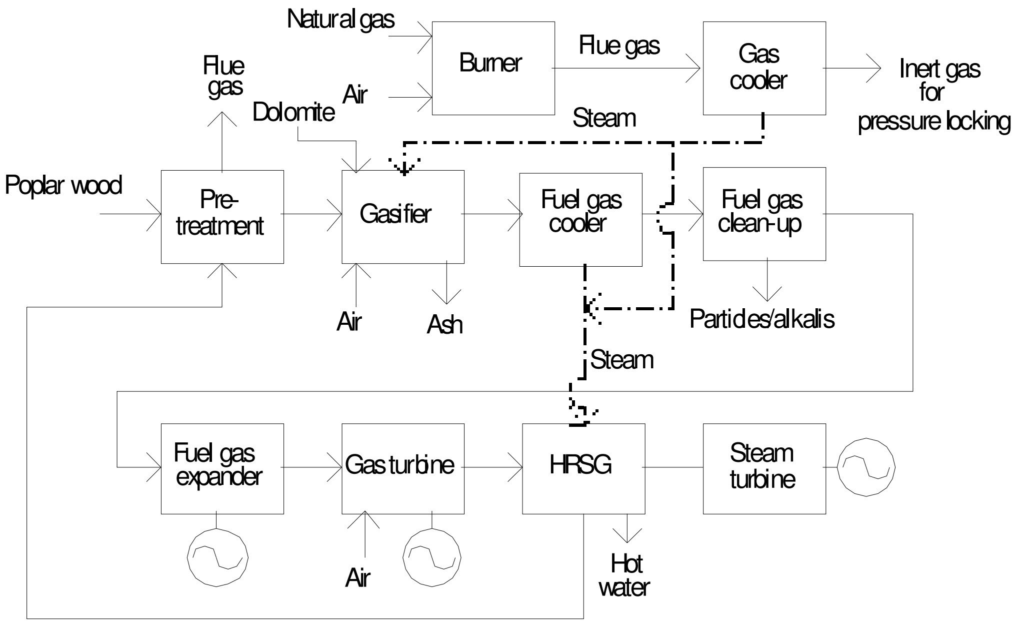
Waste supply for 2 scenario's (kton)



Waste supply for 2 scenario's in PJ

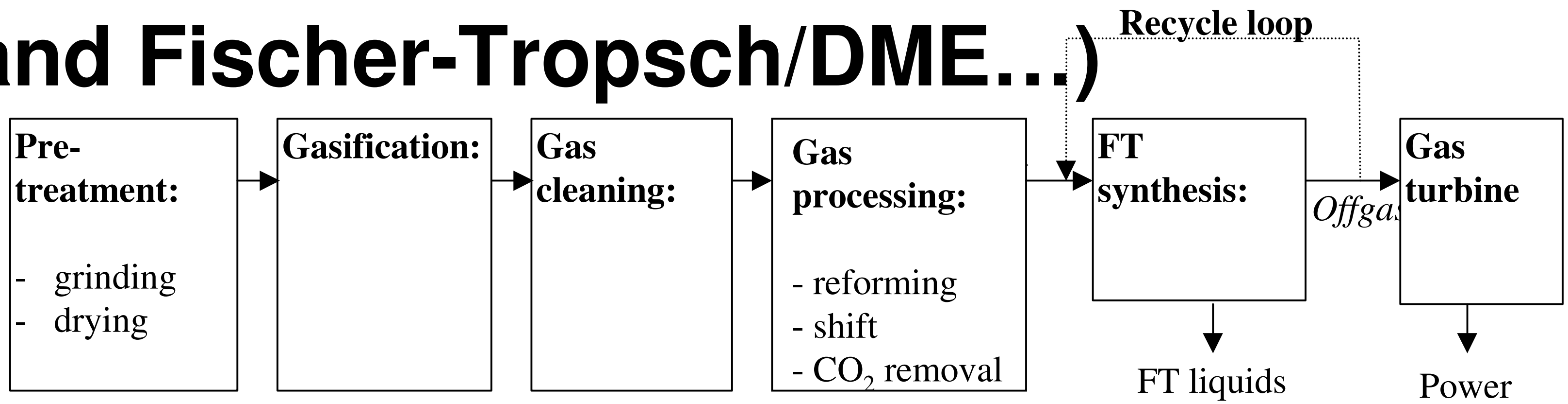


Gasification technologies: BIG/CC…



- Now: ACFB ~3500 U$/kWe, 30% eff., ~10 Mwe
- M.T.: ACFB ~1500 U$/kWe, 50% eff., >100 MWe
- L.T.: PCFB + HT, ~1000 U$/kWe, 55% eff., >200 MWe

and Fischer-Tropsch/DME…)



Performance technologies vs. capacity (costs)

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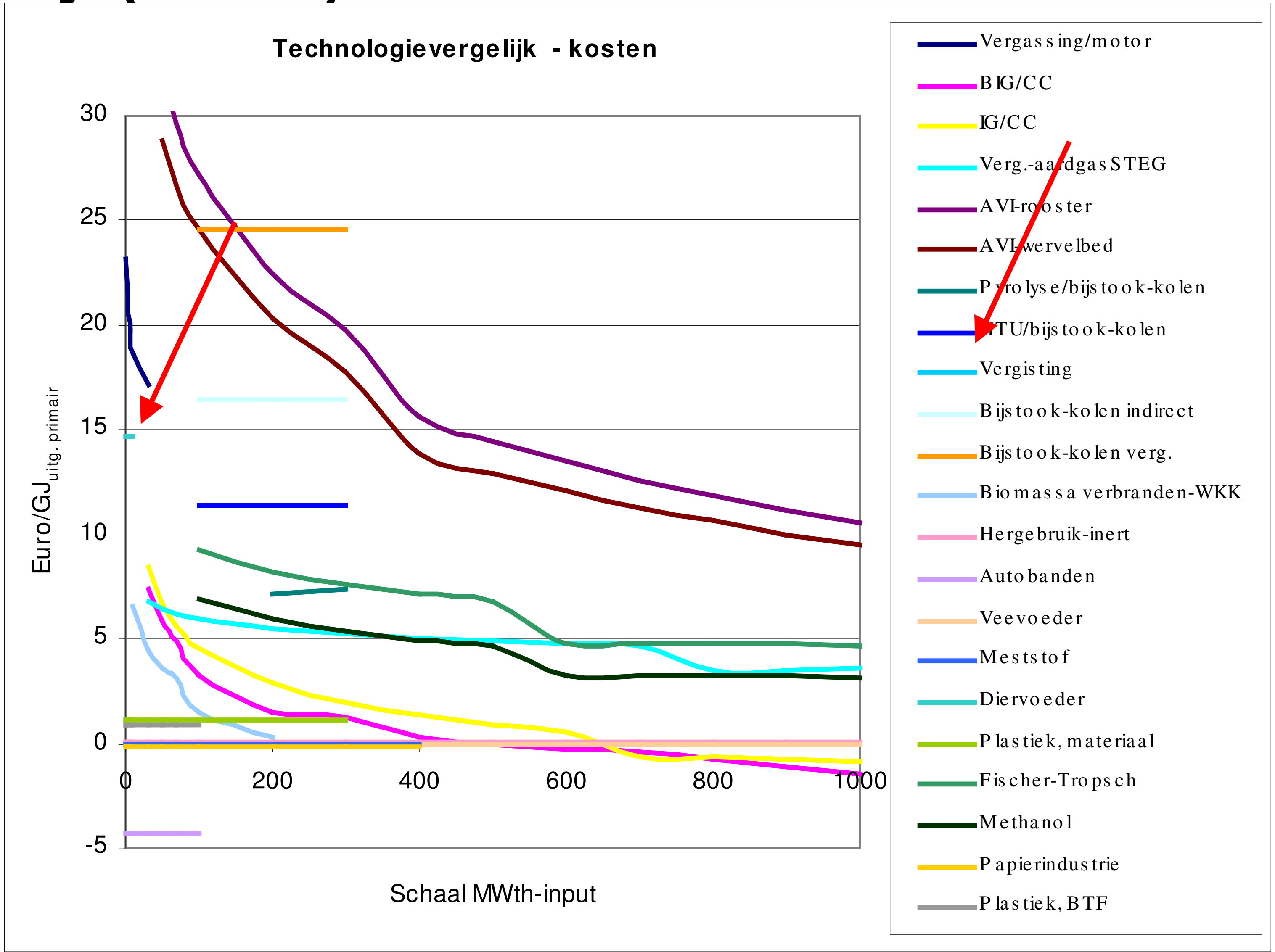
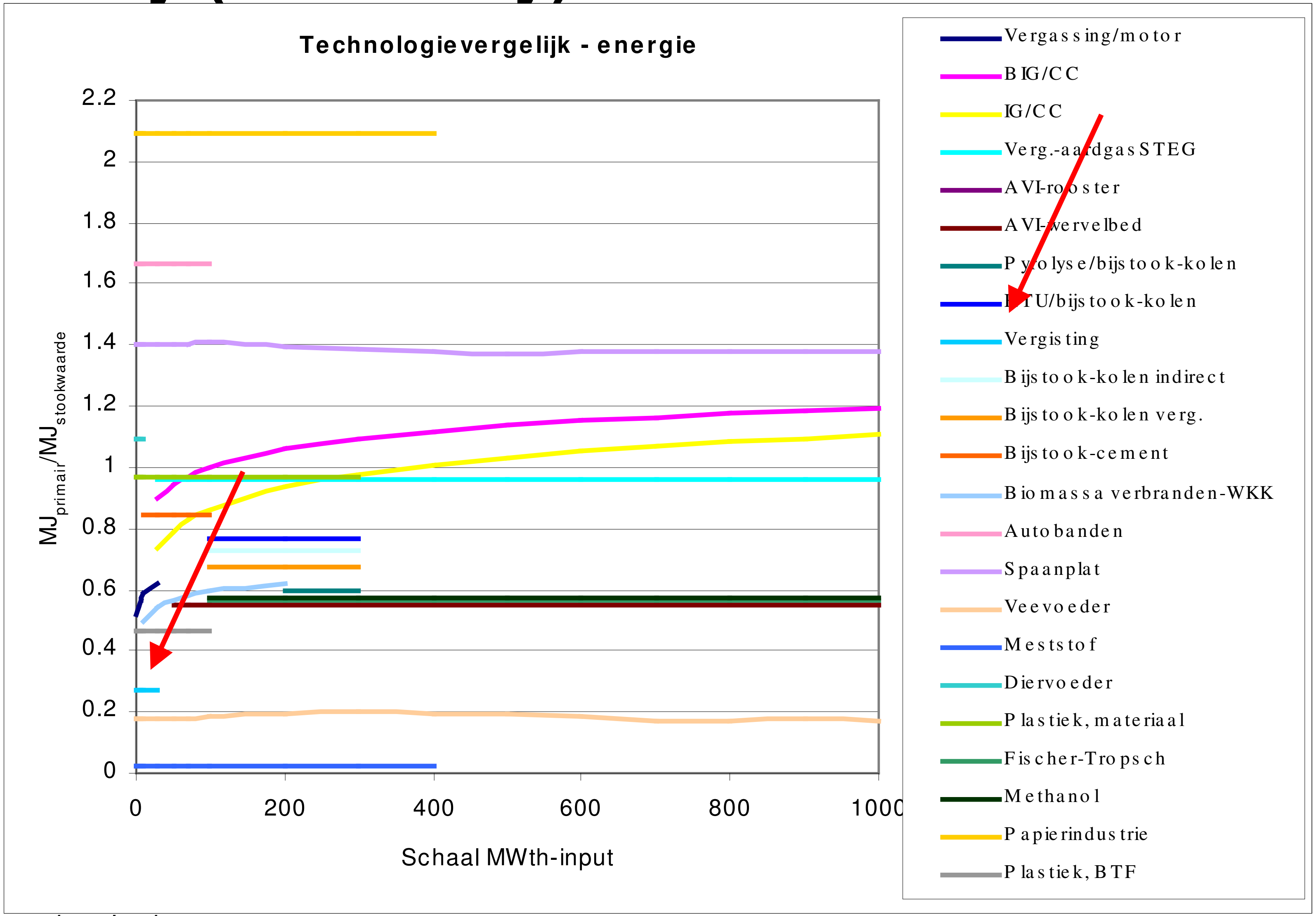


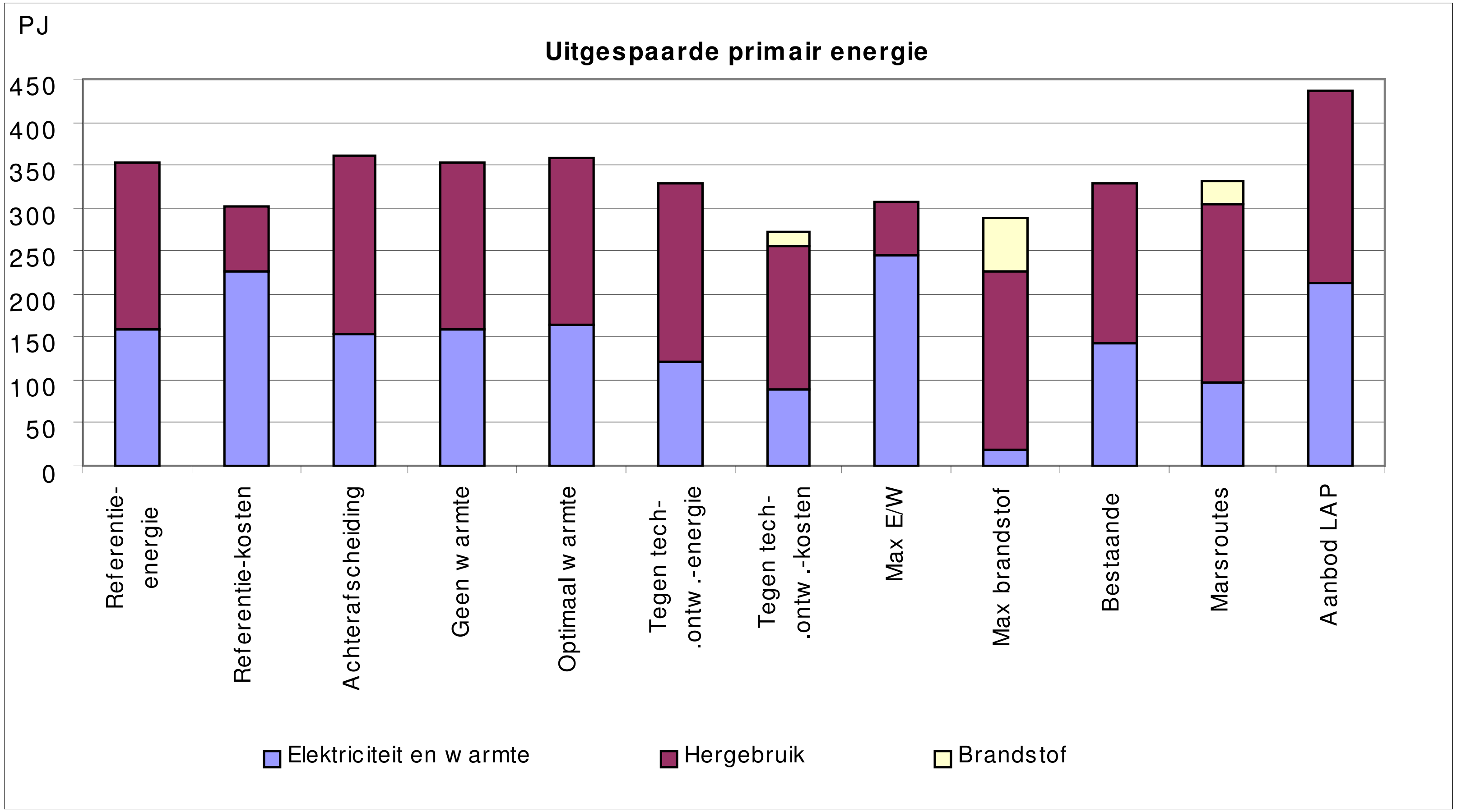
Performance technologies vs. capacity (efficiency)



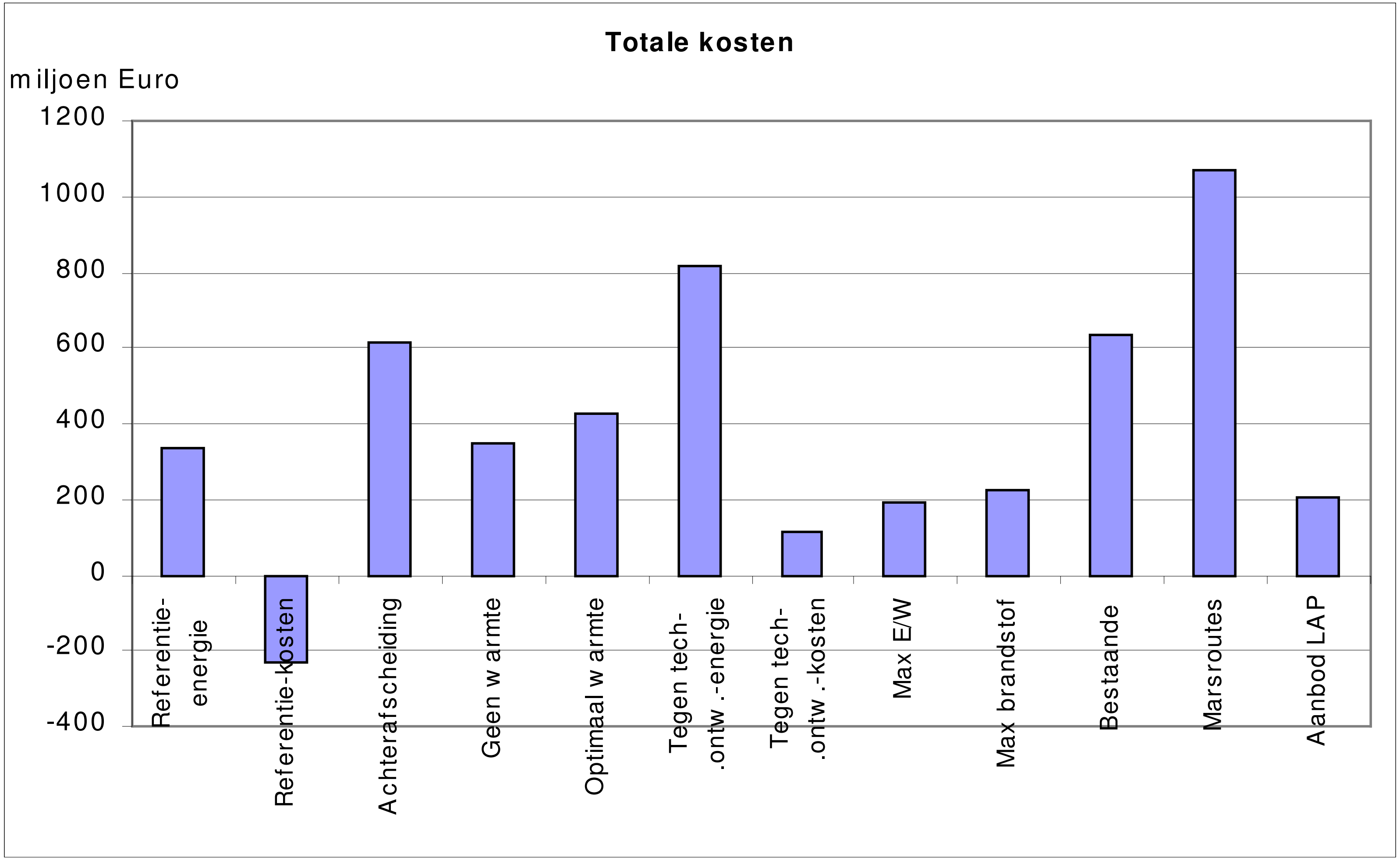
Overview main characteristics waste treatment infrastructure

naam	aanbod	achteraf scheiden	warmte	technologieën	Bestaande installaties	optimalisatie
Ref_energie	referentie	geen	referentie	geen beperking	groene wei	energie
Ref_kosten	referentie	geen	referentie	geen beperking		kosten
Achter_RDF	referentie	plastiek in RDF	referentie	geen beperking	groene wei	energie
Achter_plastiek	referentie	plastiek apart	referentie	geen beperking	groene wei	energie
Geen_WKK	referentie	geen	geen warmtevraag	geen beperking	groene wei	energie
Optimaal_WKK	referentie	geen	onbeperkte warmtevraag	geen beperking	groene wei	energie
Tegenval-energie	referentie	geen	referentie	BIG/CC slechter, geen HTU	groene wei	energie
Tegenval-kosten	referentie	geen	referentie	BIG/CC slechter, geen HTU	groene wei	kosten
Max_elektr./warmte	referentie	geen	referentie	geen hergebruik en brandstofproductie	groene wei	energie
Bestaande	referentie	geen	referentie	geen beperking	bestaande installaties	energie
Marsroutes	Referentie, kosten verwerking	geen	referentie	BIG/CC slechter, bijstook additonele kosten, toepasbarheid zoals marsroutes	bestaande installaties	energie

Primary energy saved in different scenario's

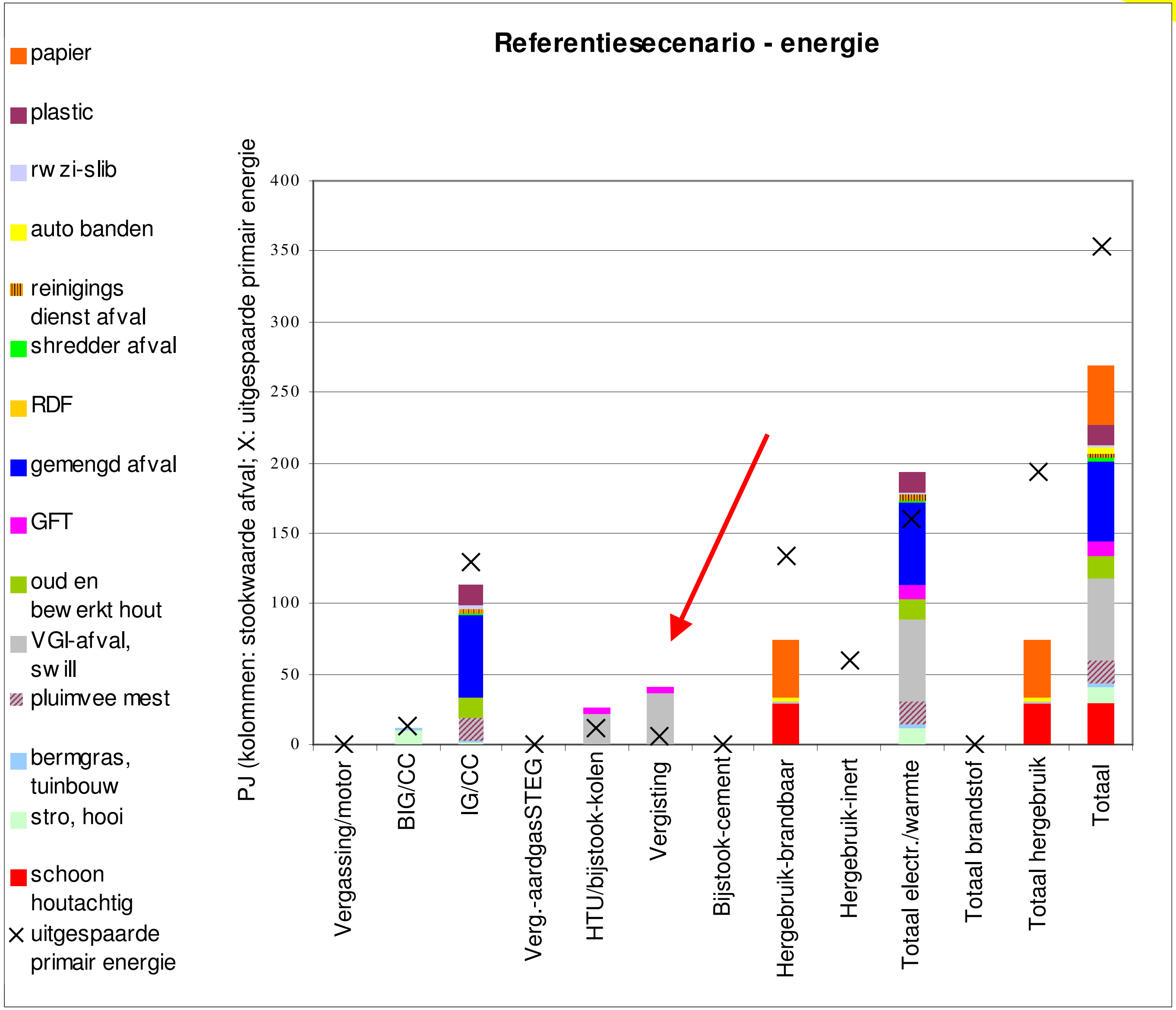


Total waste treatment costs of different scenario's



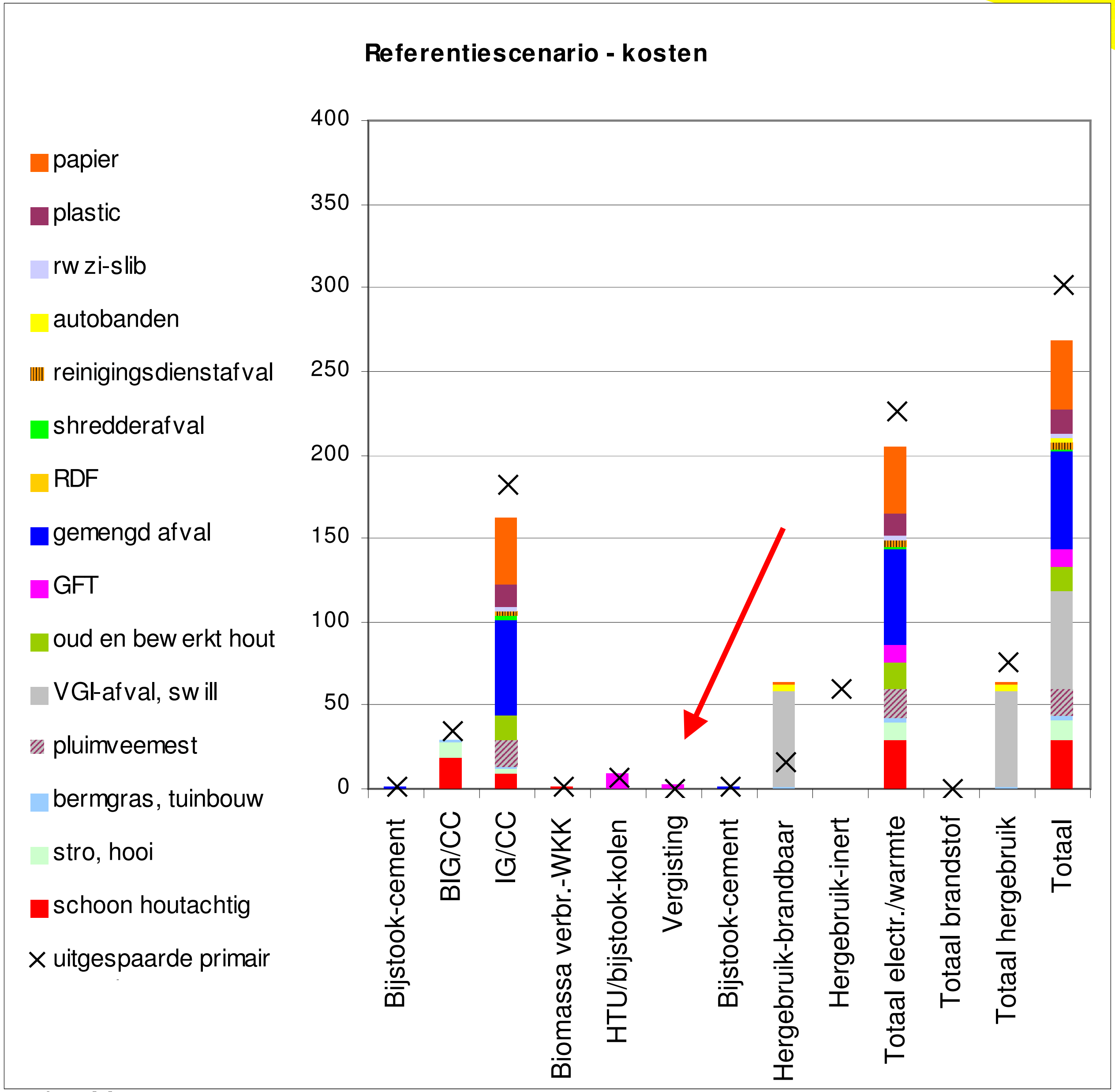
Results reference scenario-energy

Saved primary energy and technology mix



Results reference scenario-costs

Costs and technology mix



Some findings

- Depending on boundary conditions, large shifts between electricity and heat, savings by recycling and transport fuels (high sensitivities).
- Key advanced technologies: 1: (B)IG/CC, 2: co-firing and gasification with NGCC, 3: Separate collection & Waste separation, 4: HTU for wet streams (possibly strong alternative for digestion).
- Large scale facilities generally more attractive.
- Increasing heat utilisation has significant potential but strongly competes with NG and possibly efficiency measures.

Biomass production performance data for various types of crops and conditions

Crop & global conditions.	Energy ratio	Yield (dry tonne/ha*yr)	Net energy yield (GJ/ha*yr)
SRC (US, Europe) (e.g. Willow and Hybrid Poplar) - short term - longer term	 10:1 20:1	 10-12 12-15	 180-200 220-260
Tropical plantations (e.g. Eucalyptus): 1. No genetic improvement, fertilizer use & irrigation. 2. Genetic improvement and fertilizer use. 3. Genetic improvement, fertilizer and water added.	 10:1 20:1 	 2-10 6-30 20-30	 30-180 100-550 340-550
Miscanthus/Switchgrass - short term - longer term	 12:1 20:1	 10-12 12-15	 180-200 220-260
Sugar cane (Brazil)	18:1[a)]		
Wood (commercial forestry)	20/30:1	1-4	30-80
Sugar Beet (NW Europe) - short term - longer term	 10:1 20:1	 10-16 16-21	 30-100 140-200
Rapeseed (including straw yields; NW Europe) - short term - longer term	 4:1 10:1	 4-7 7-10	 50-90 100-170

[a)] The value quoted in Moreira and Goldemberg, 1999 (1:7.9) includes energy expenditures in transportation and processing of sugarcane to ethanol. Also it is assumed the only final product is ethanol.

Basics energy crop options (EU)

Crop		Typical yield ranges (odt/ha*yr)	Energy inputs (GJprim/ha*yr	Typical net energy yield (GJ/ha*yr)	Production cost ranges European context (Euro/GJ)
Rape	Short term	2.9 (rapeseed) 2.6 (straw)	11	110 (total)	20
	Longer term	4 (rapeseed) 4.5 (straw)	12	180 (total)	12
Sugar	Short term	14	13	250	12
Beet	Longer term	20	10	370	8
SRC-	Shorter term	10	5	180	3-6
Willow	Longer term	15	5	280	<2
Poplar	Shorter term	9	4	150	3-4
	Longer term	13	4	250	<2
Miscant	Shorter term	10	13-14	180	3-6
hus	Longer term	20	13-14	350	~2

Final remarks

- Digestion is a sound and available conversion technology for wet(ter) biomass streams (including manure) .
- Thermal conversion options strong competitors for drier and lignocellulosic biomass.
- Perennial crops (lignocell…) generally have better energy & GHG & environmental balances (and economics!) than annual crops.
- Role of digestion…?