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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

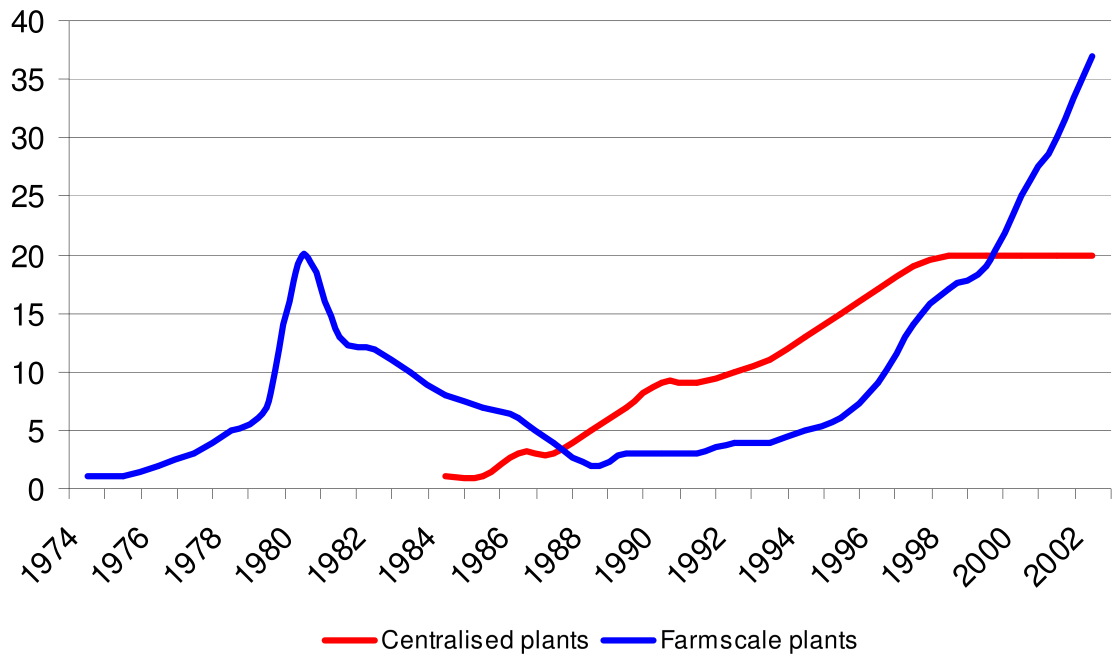
State-of-the-art

Central digestor in Studsgard

Denmark…

Denemark is successful:

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



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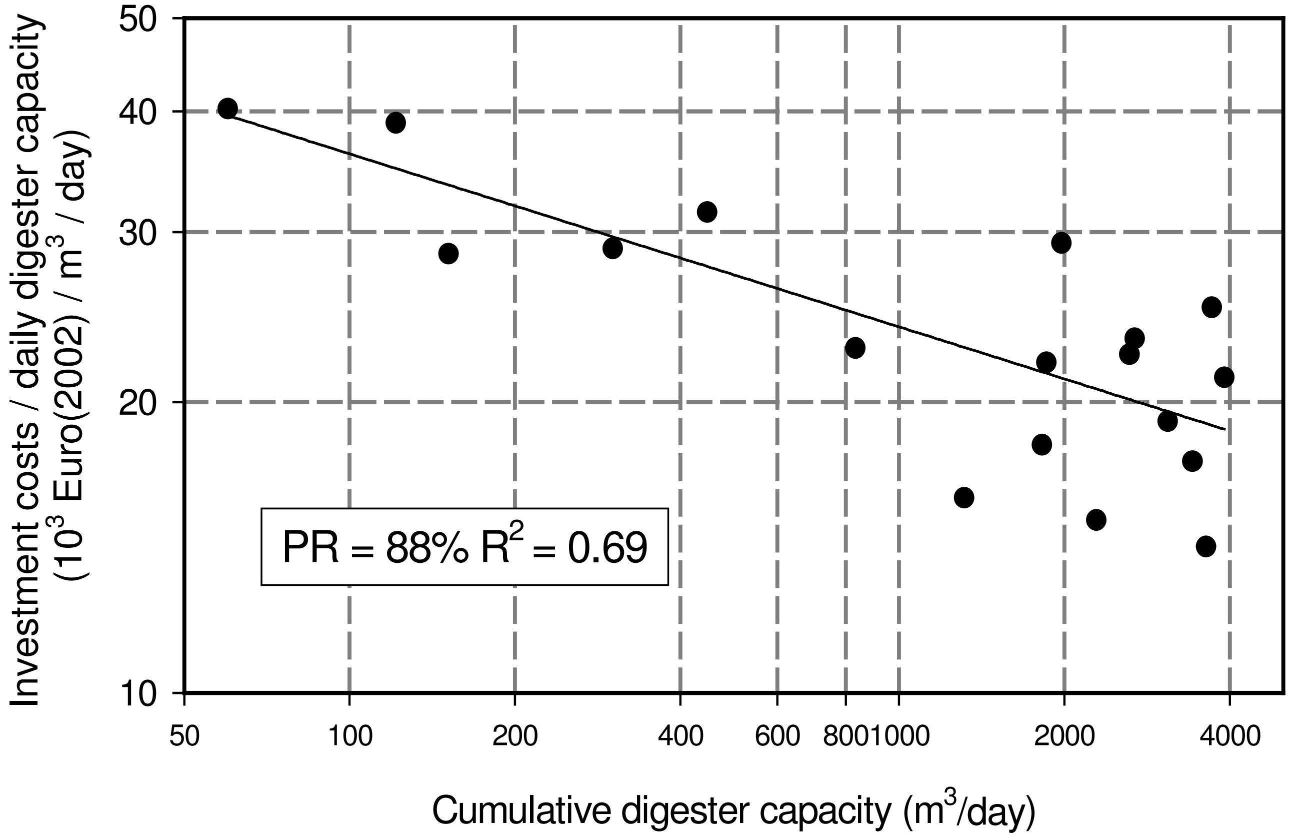
Een leercurve voor de investeringskosten van Deense biogas centrales



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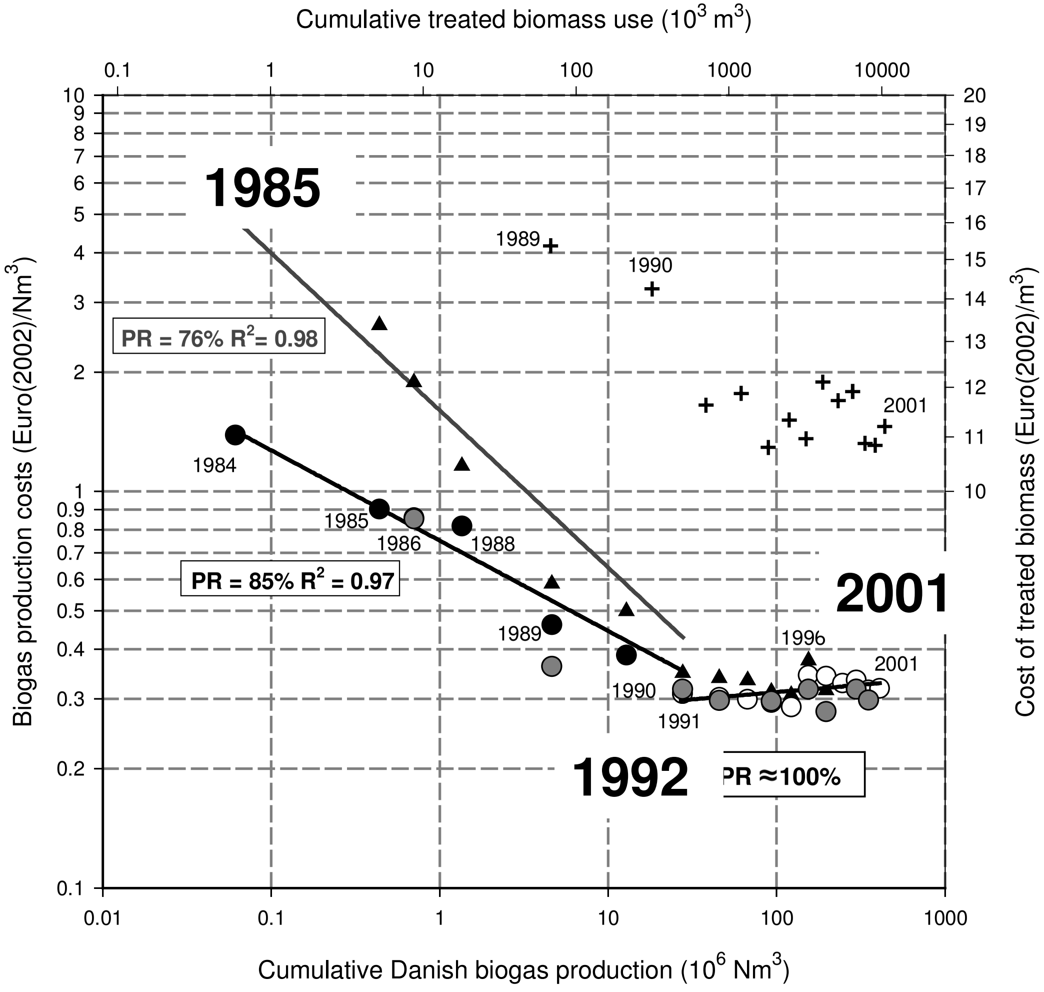
A learning curve for Danish biogas production

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



▲ Average biogas production costs 1984-1997 (Source: Mæng et al.)
● Weighed average biogas production costs 1984-1991
○ Weighed average biogas production costs 1991-2001
● Marginal biogas production costs (1987-2001)
+ Wheighed average treated biomass costs (1989-2001) (top / right axes)

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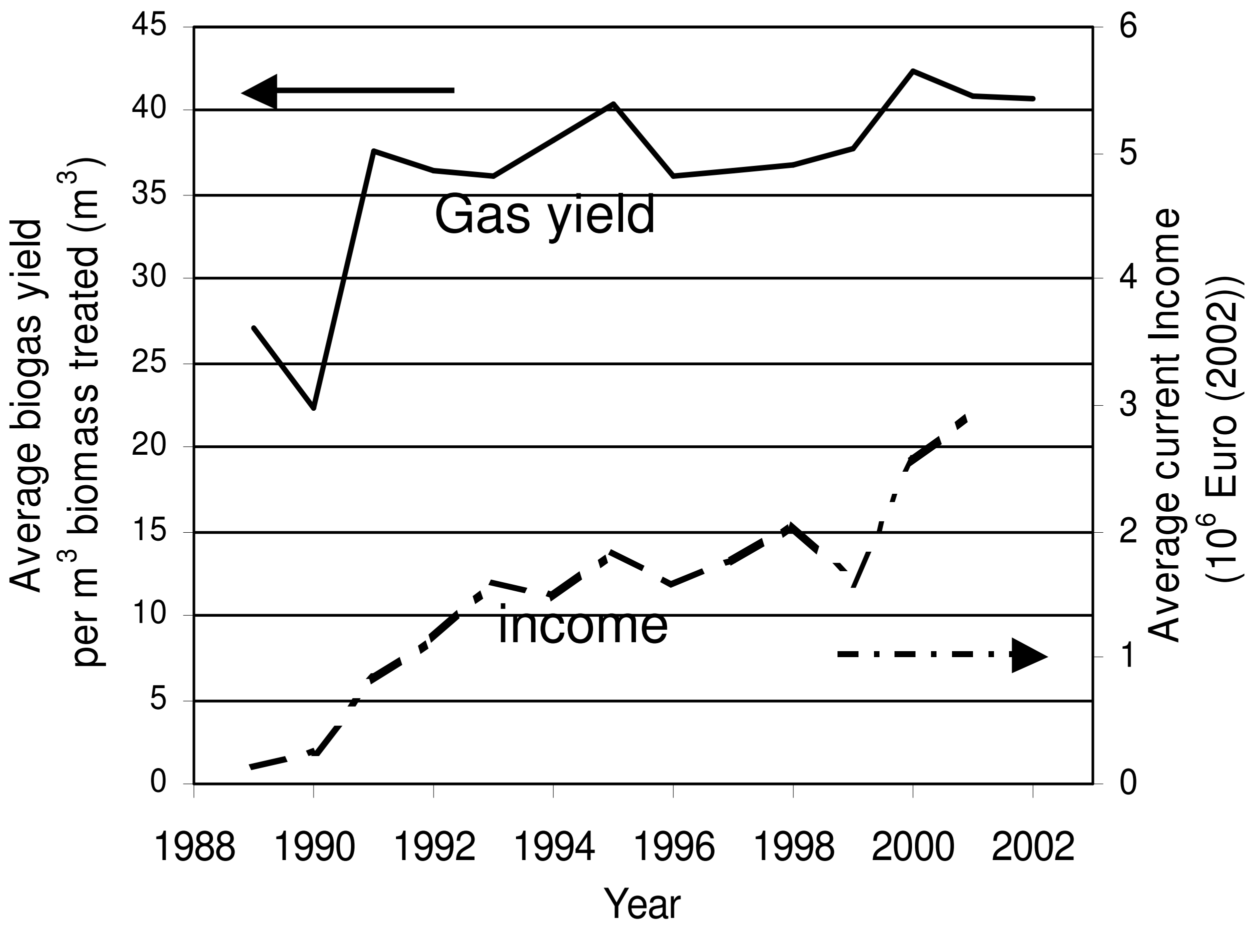
Development of average biogas yield and income of Danish manure digestors.

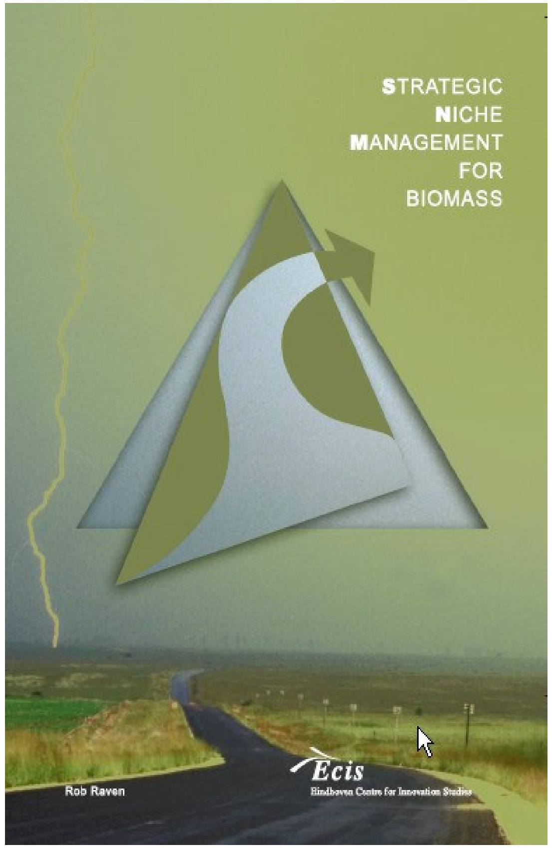


Some remarks:

- 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)

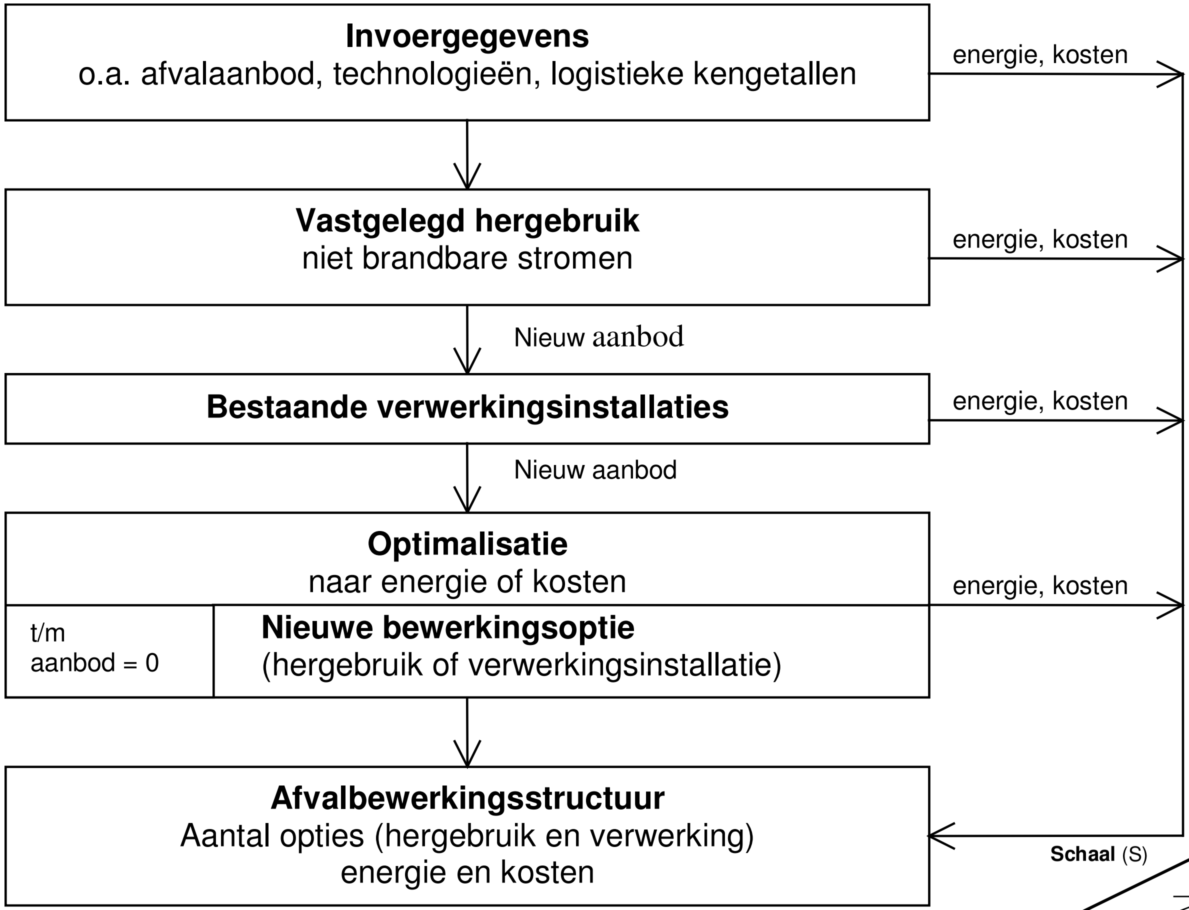


Strategic Niche Management for Biomass (Rob Raven)

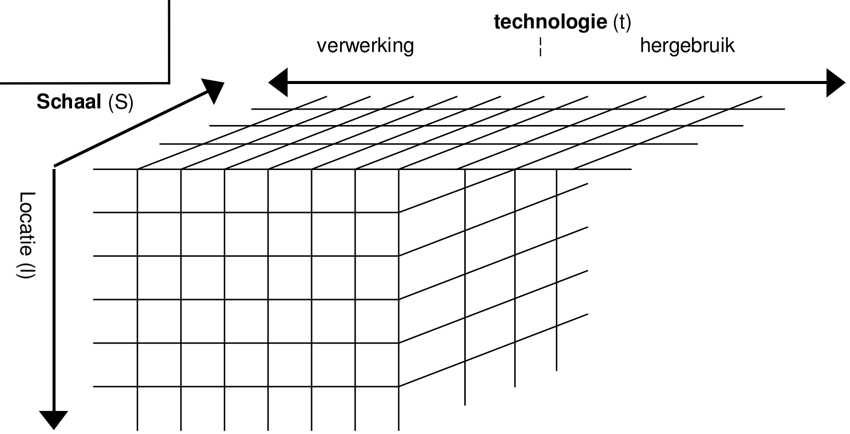
National waste treatment infrastructure; optimalisation

- 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



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



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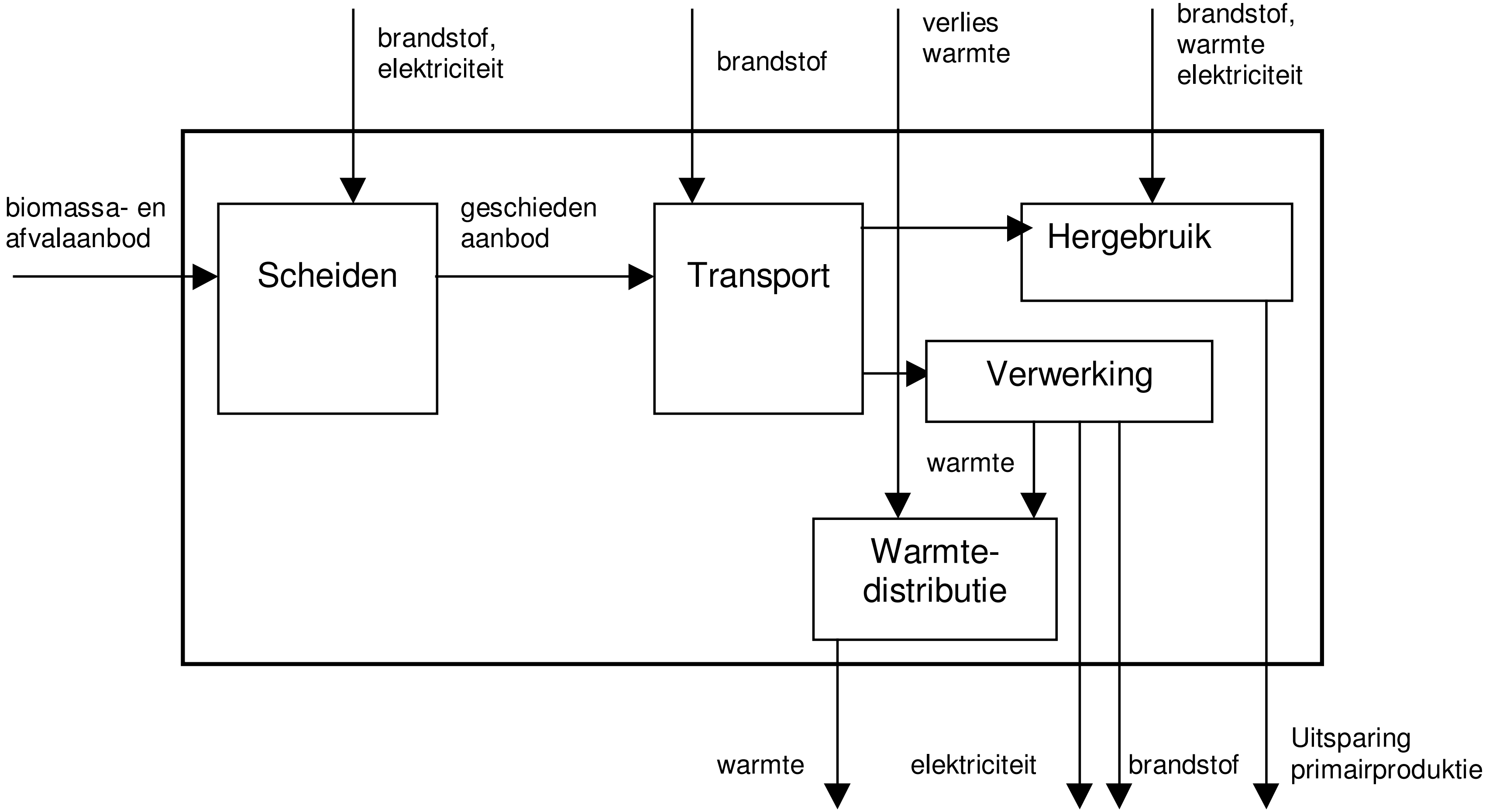
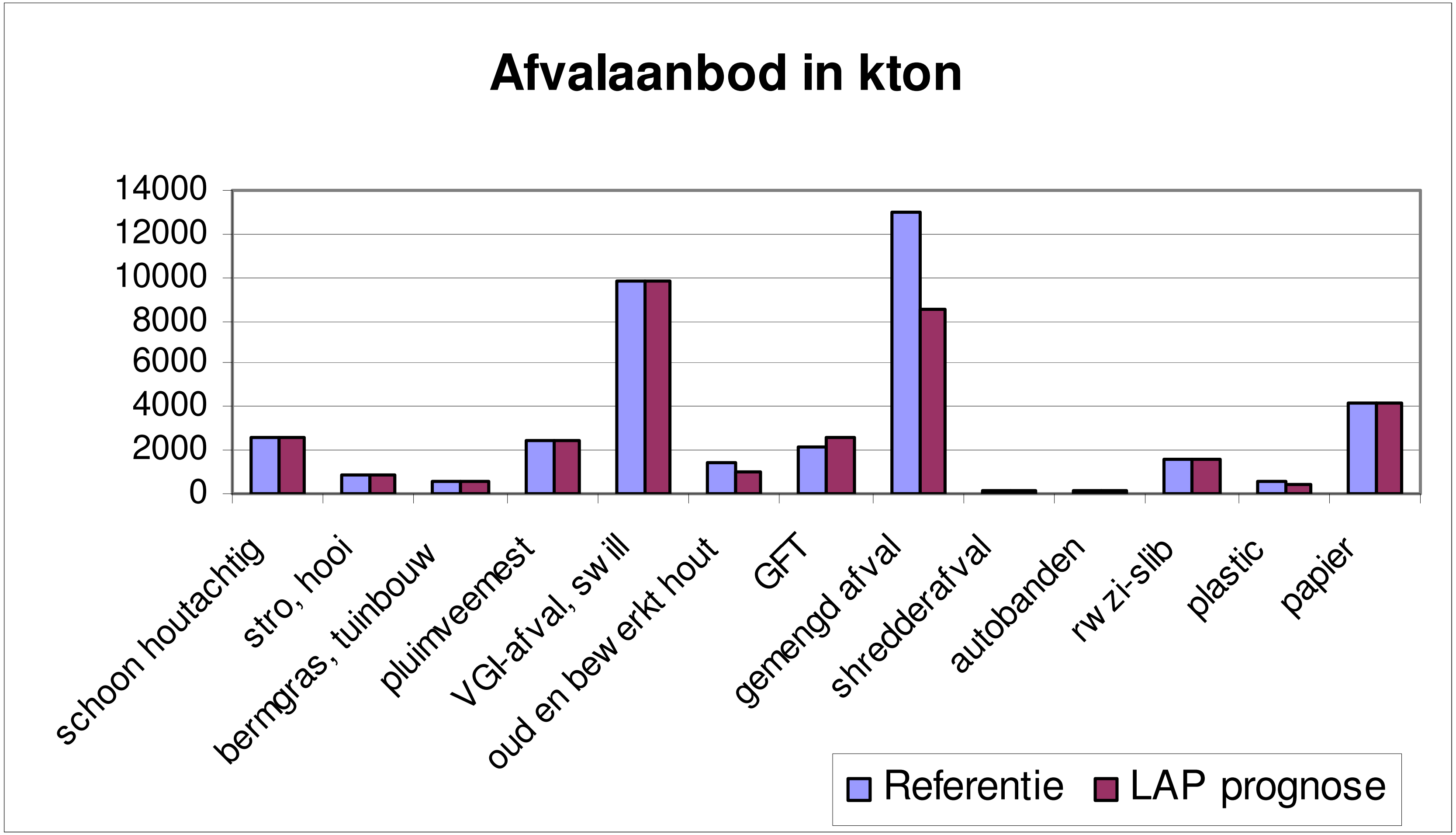
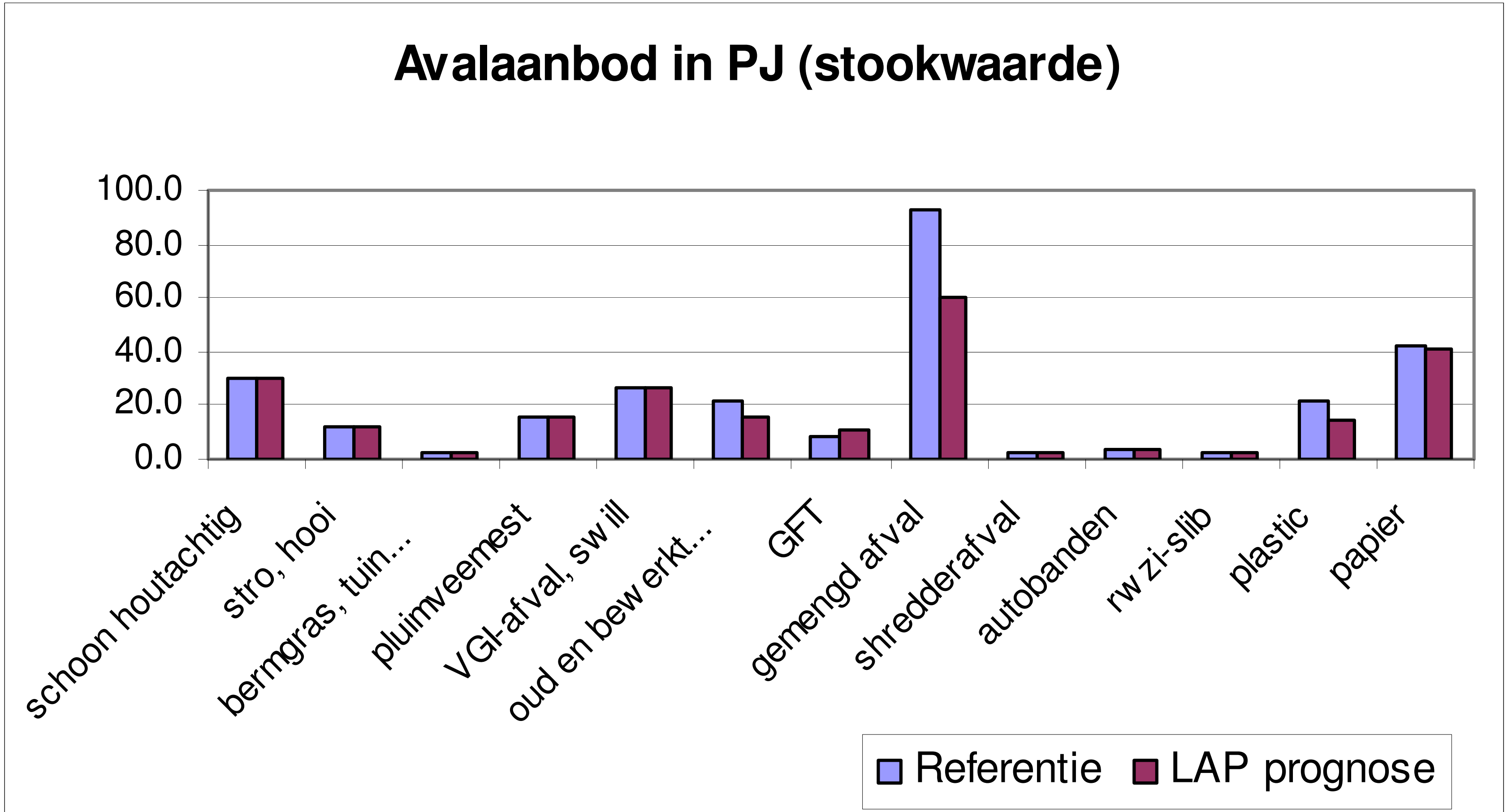
System boundaries



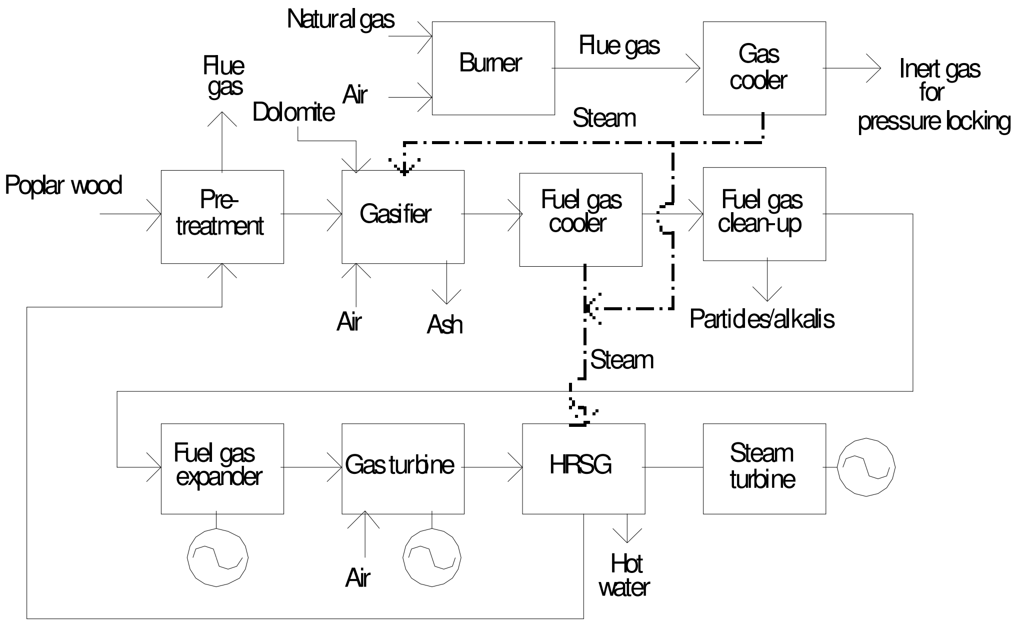
Waste supply for 2 scenario's (kton)



Waste supply for 2 scenario's in PJ

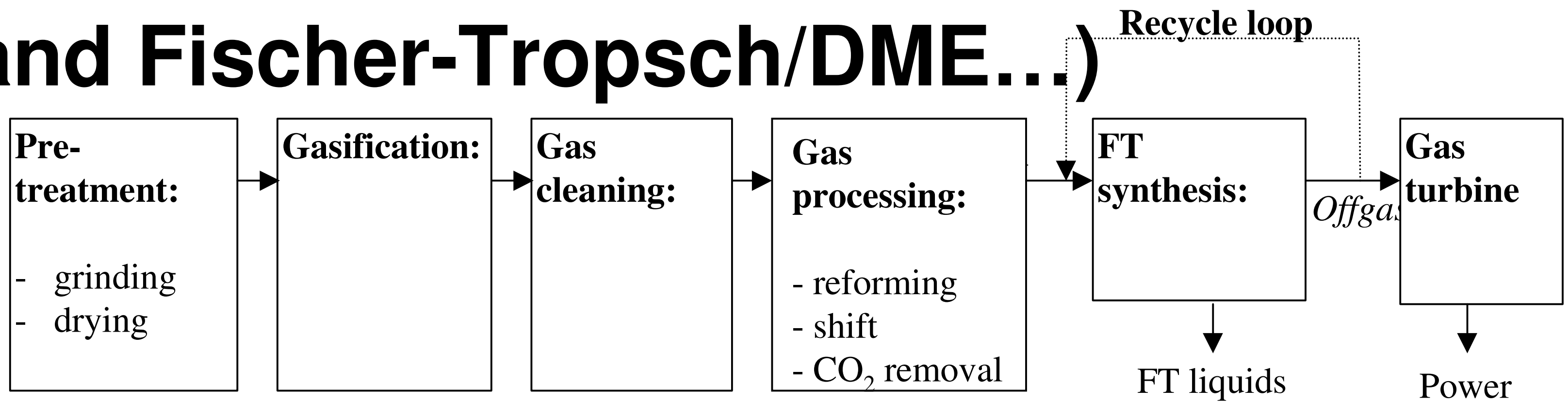


Gasification technologies: BIG/CC...



- 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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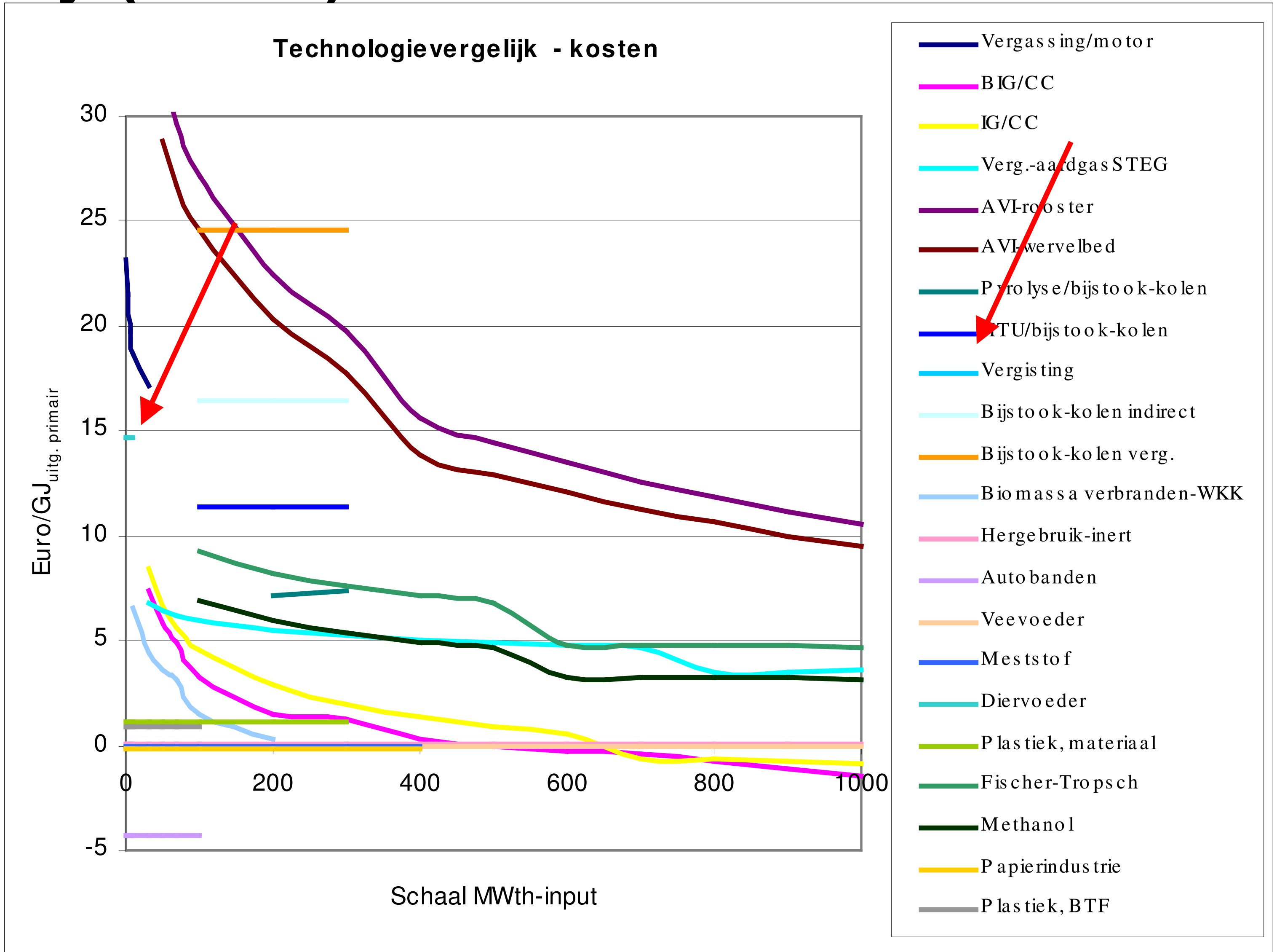

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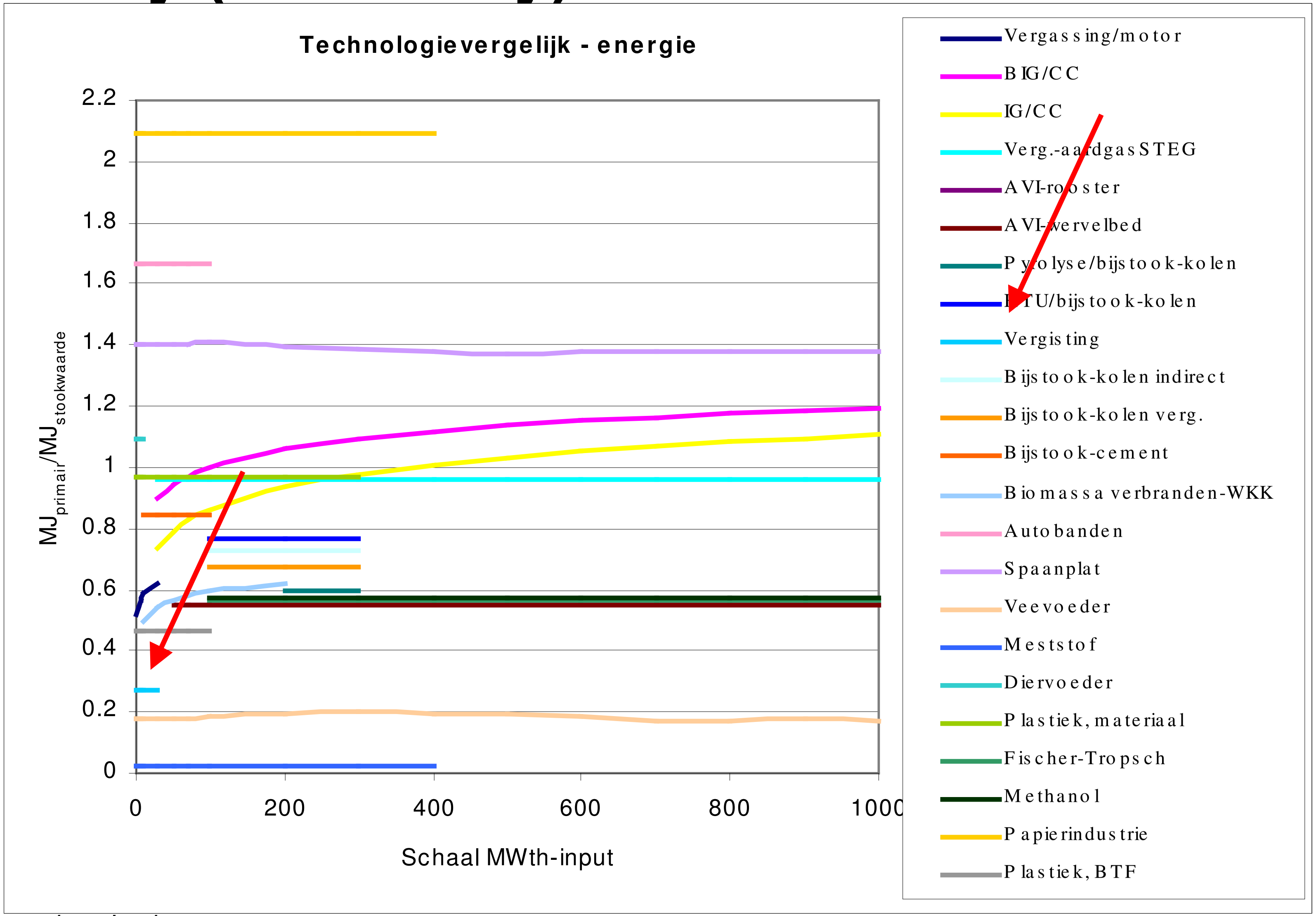
Performance technologies vs. capacity (efficiency)



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

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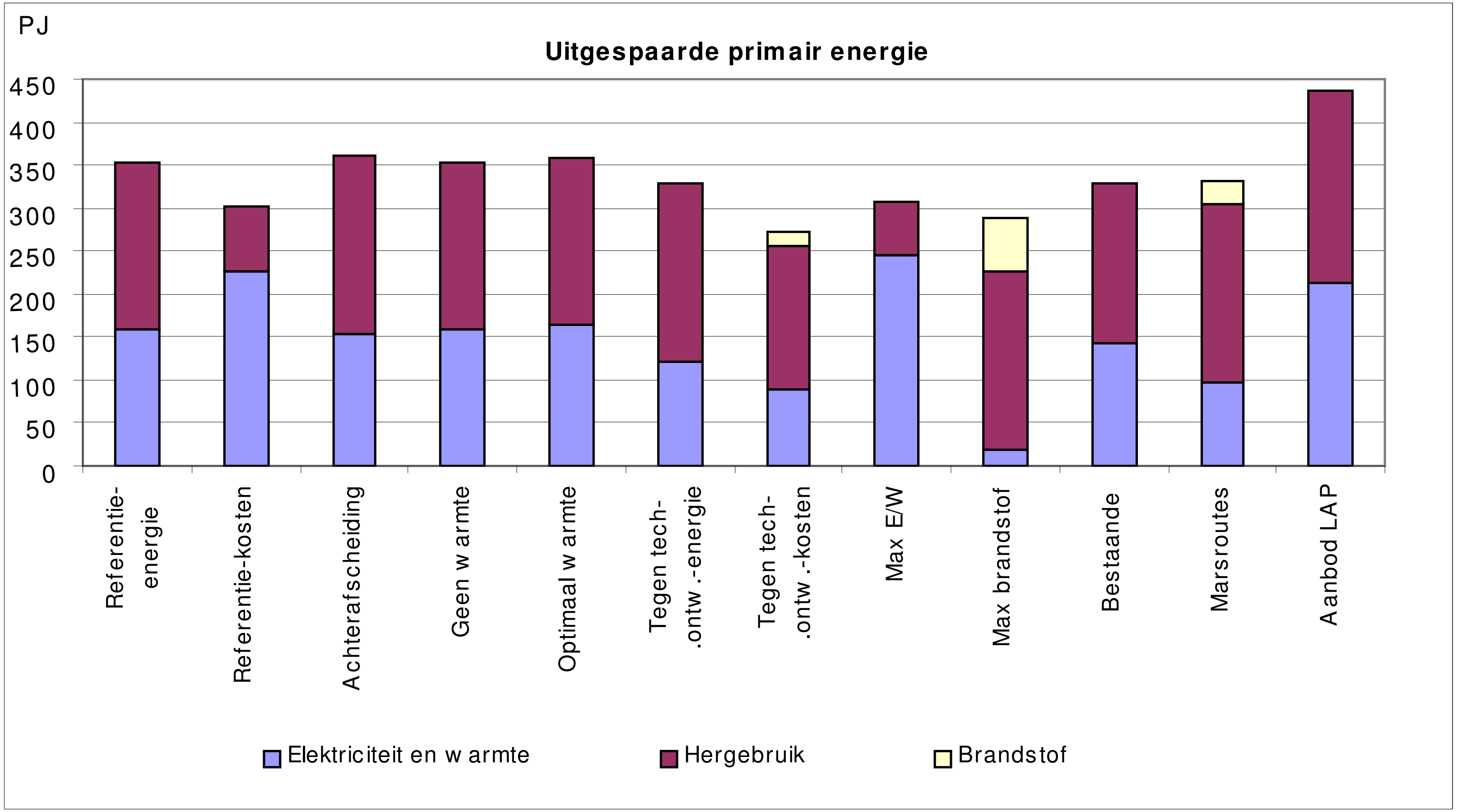
Primary energy saved in different scenario's



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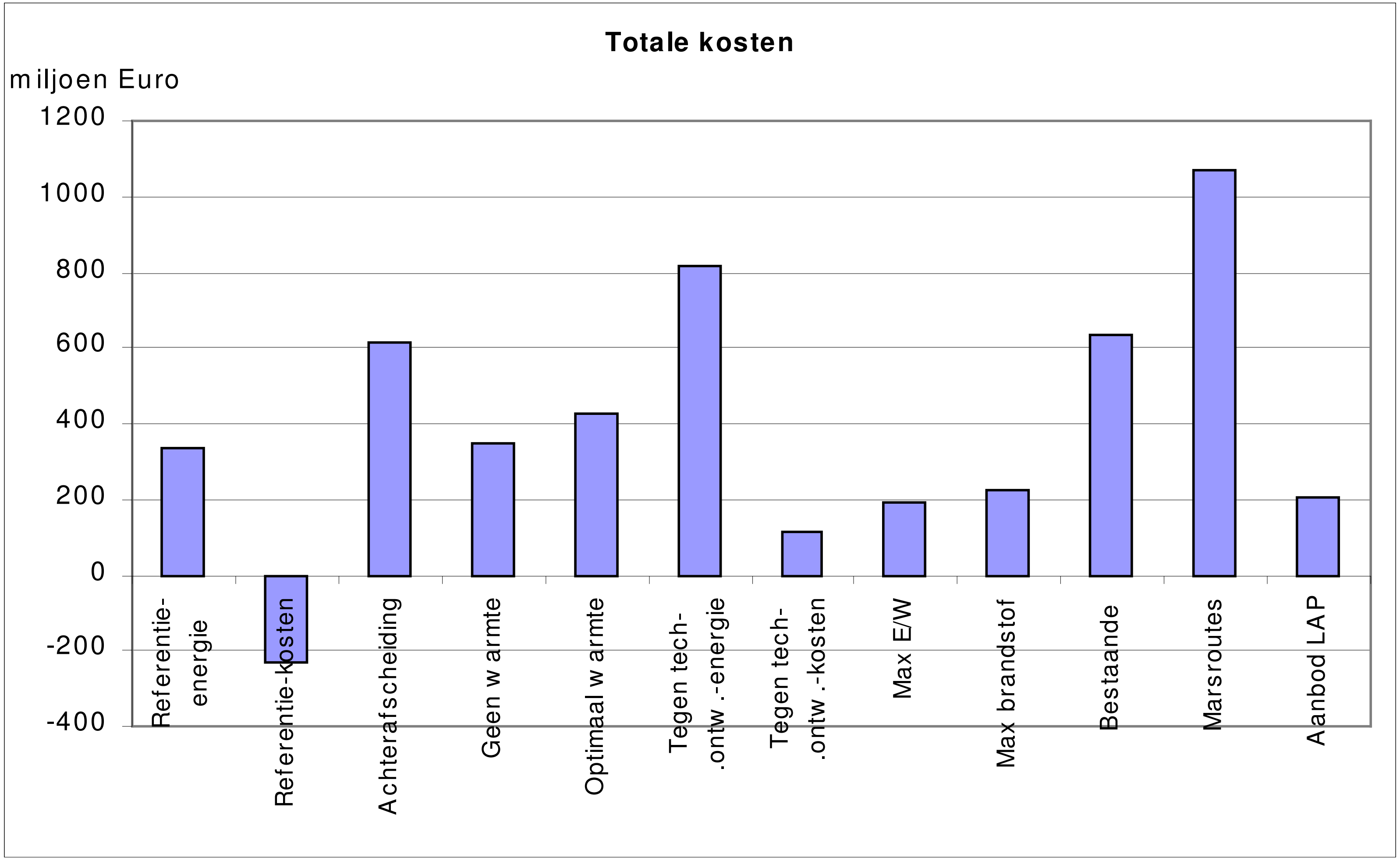
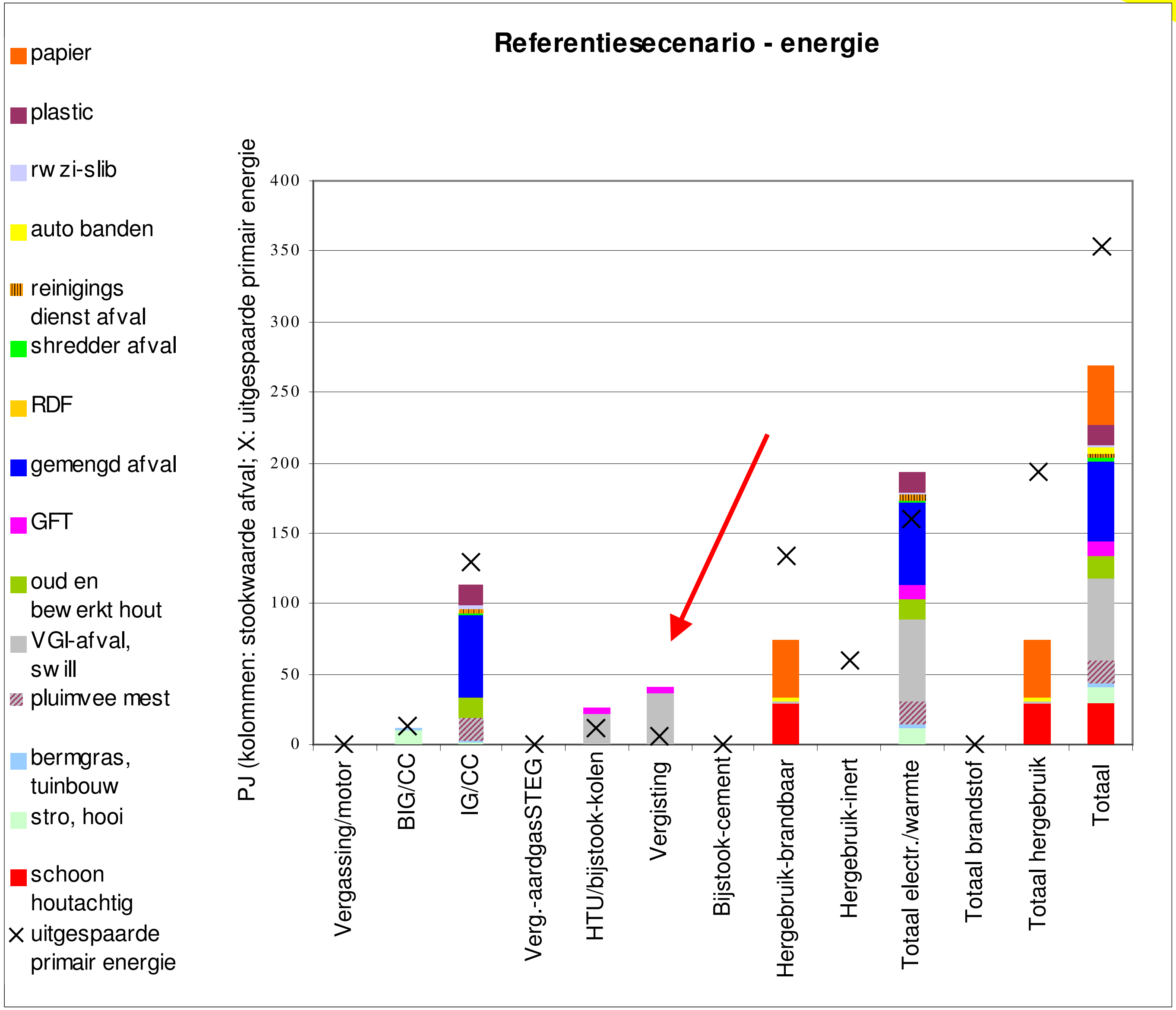
Total waste treatment costs of different scenario's



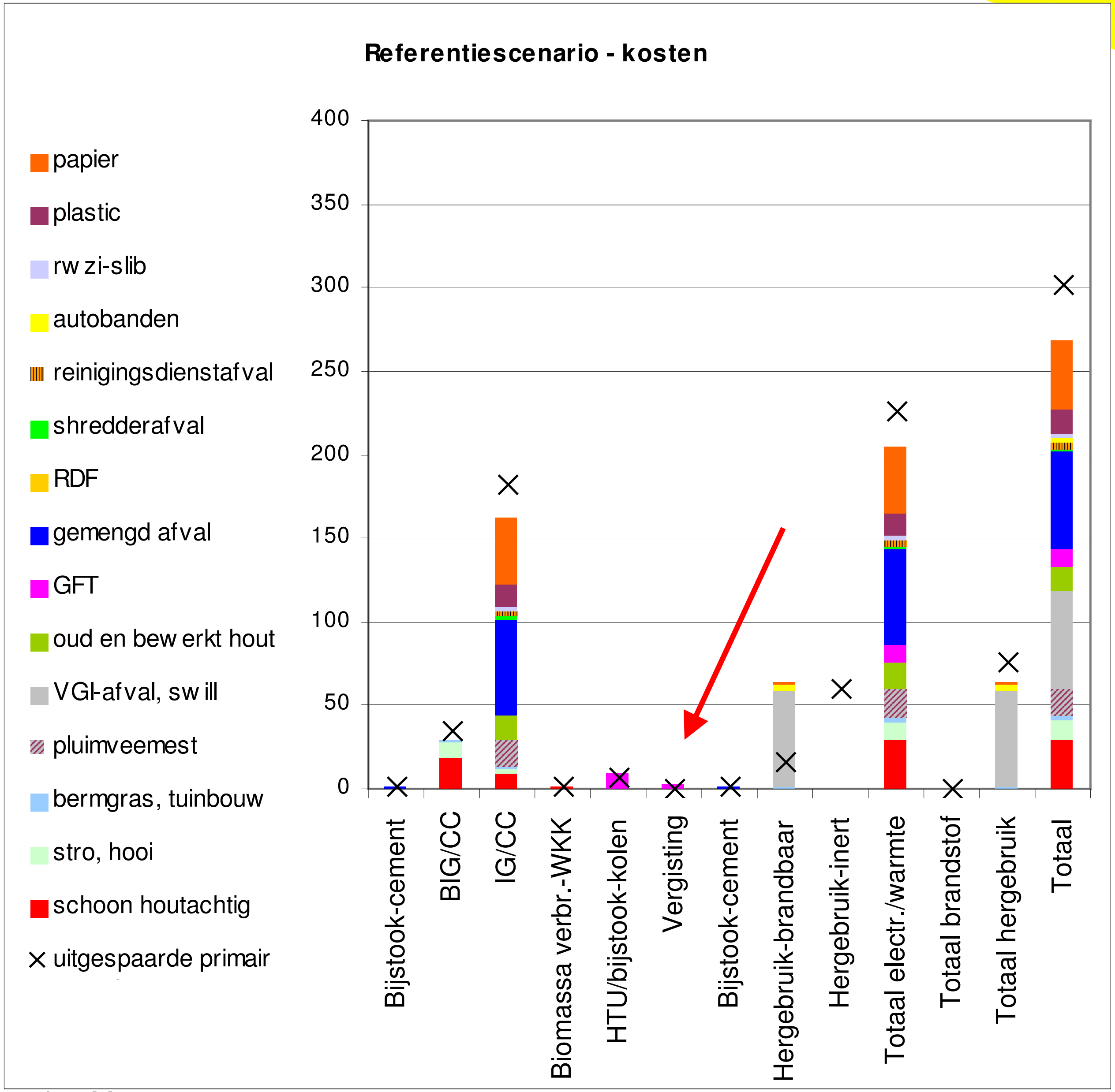
Results reference scenario- energy

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.

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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	10:1	10-12	180-200
- longer term	20:1	12-15	220-260
Tropical plantations (e.g. Eucalyptus):			
1. No genetic improvement, fertilizer use & irrigation.	10:1	2-10	30-180
2. Genetic improvement and fertilizer use.	20:1	6-30	100-550
3. Genetic improvement, fertilizer and water added.		20-30	340-550
Miscanthus/Switchgrass			
- short term	12:1	10-12	180-200
- longer term	20:1	12-15	220-260
Sugar cane (Brazil)	18:1[a)]		
Wood (commercial forestry)	20/30:1	1-4	30-80
Sugar Beet (NW Europe)			
- short term	10:1	10-16	30-100
- longer term	20:1	16-21	140-200
Rapeseed (including straw yields; NW Europe)			
- short term	4:1	4-7	50-90
- longer term	10:1	7-10	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.

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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 Beet	Short term	14	13	250	12
	Longer term	20	10	370	8
SRC-Willow	Shorter term	10	5	180	3-6
	Longer term	15	5	280	<2
Poplar	Shorter term	9	4	150	3-4
	Longer term	13	4	250	<2
Miscanthus	Shorter term	10	13-14	180	3-6
	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…?