Ilmasto- ja energiapolitiikan vaikutukset ja kustannukset: mallisimulointiesimerkkeinä metsäbiojalostamot ja sahateollisuus

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Taloudelliset mallit ajankohtaisissa ilmasto- ja energiakysymyksissä

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MOTIVATION (1)

- **A pellet production integrated into the forest industry have noticed to be more profitable than stand-alone plants (Wolf et al. 2006).**
  - Only a few pellet plants is integrated with sawnwood production
  - 299,000t (~1,2TWh) of pellet produced in Finland last year
  - Finnish target; 2 TWh pellet production by 2020

  → Pellet production integrated with the sawmill industry may offer one important solution for increasing pellet production

- **Need for alternative, renewable transportation fuels**
  - Oil - scarcity and CO_2 emissions
  - EU - 10 % of overall petrol and diesel consumption should be covered by sustainable biofuels by 2020
  - Finland, 7 TWh biofuel production by 2020

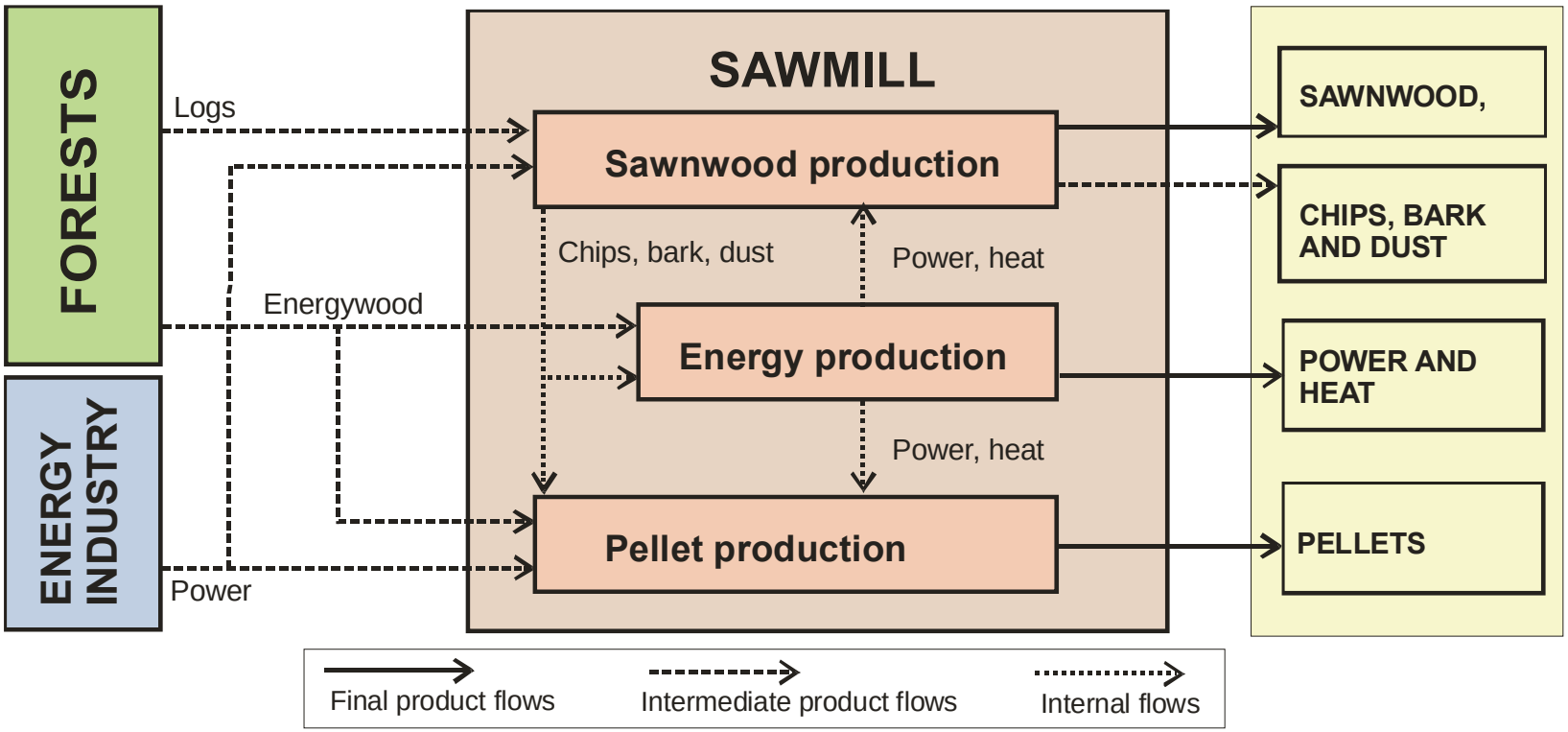
  → Biorefineries offer one important solution for increasing biofuel production

MOTIVATION (2)

UUSIUTUVAT ENERGIALÄHTEET, TWh			Muutos, TWh / %-yksikköä
Primäärienergiana	2005	2020	2005=>2020
Teollisuuden tuotannosta riippuvat polttoaineet (1			
Jäteliemet	37	38	1,1
Teollisuuden tähdepuu	20	19	-1,8
Yhteensä	**57**	**56**	-0,7
Politiikkatoimien kohteena olevat (1			
Vesivoima (normalisoitu)	13,6	14	0,6
Vesivoima, toteutunut	*13,4*		
Tuulivoima	0	6	5,8
Metsähake	6	25	18,9
Puun pienkäyttö	13	12	-0,5
Lämpöpumput	2	8	6,1
Liikenteen biopolttoaine	0	7	6,5
Biokaasu	0	1	0,7
Pelletit	0	2	1,6
Kierrätyspolttoaineet, RES-osuus	2	2	0,7
Muu uusiutuva, mm. aurinkolämpö, -sähkö jne.	0,4	0,4	0,0
Yhteensä	**37**	**77**	40,0
Uusiutuva energia primäärienergiana, yhteensä (2	**94**	**134**	39,2
Uusiutuva energia loppukulutuksessa (2	87	124	37,5
Energian loppukulutus	303	327	23,6
Uusiutuvien osuus loppukulutuksesta, vesivoima normalisoitu	28,5 %		
Uusiutuvien osuus loppukulutuksesta, toteutunut / arvio	28,5 %	38 %	9,5 %
(1 primäärienergiana			
(2 vesivoima 2005-2009 normalisoitu			
(3 päivitetty laskelma 30.3.2010: paperin ja kartongin tuotanto 13,7 Mt/, sähkön kulutus 98 TWh,			
uusiutuvat IE-strategian mukaan, metsähakkeellla 38 % tavoite kiinni			

LÄHDE: TEM, Uusiutuvan energian velvoitepaketti (”Risupaketti”)

The production possibilities and material flows in a sawmill



THE MODEL (3): Investment costs

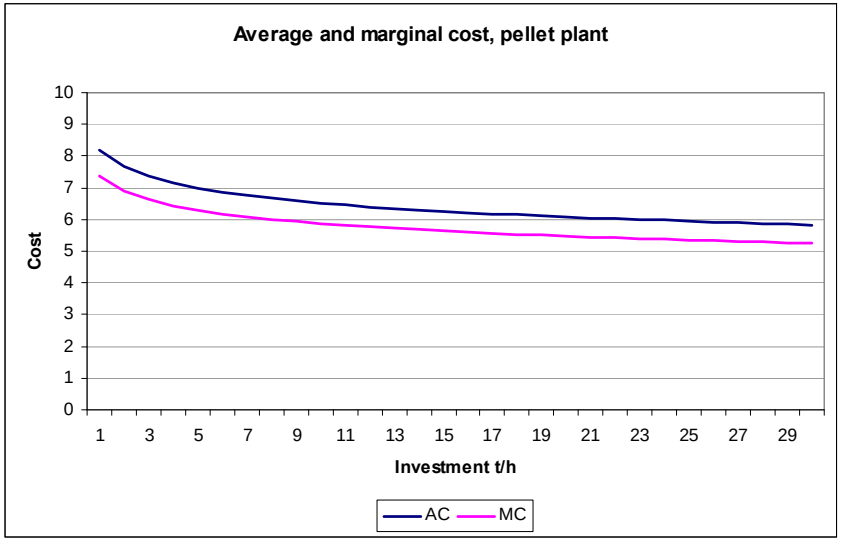
- The concave investment function for pellet and CHP capacity

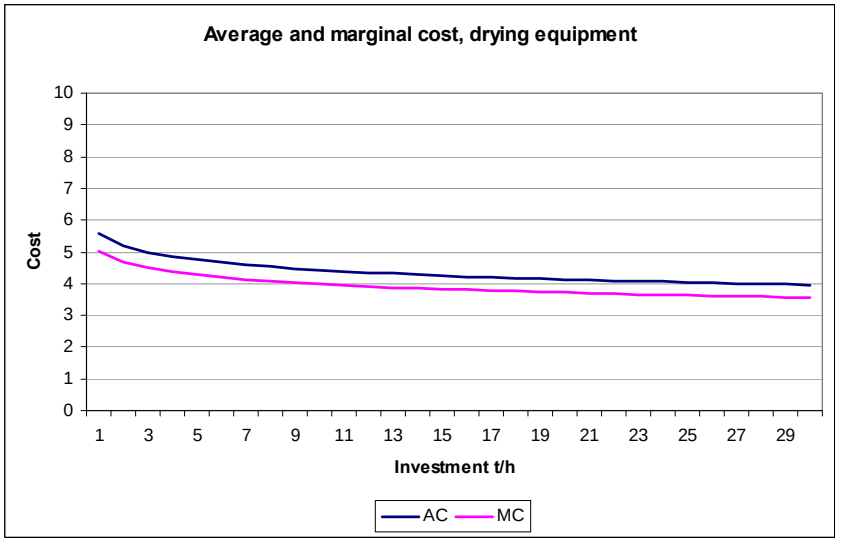
$$\sum_{k \in K} c_k^{inv} I_k \left(\frac{I_k}{\chi_{calib}^k} \right)^{\omega_I^k - 1}$$

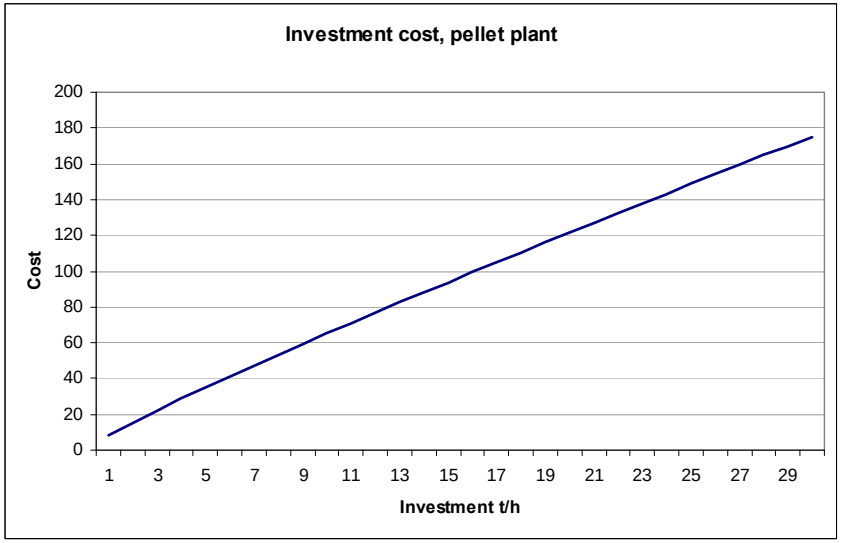
- Two different grades of pellet, the both can be produced with same pellet capacity.

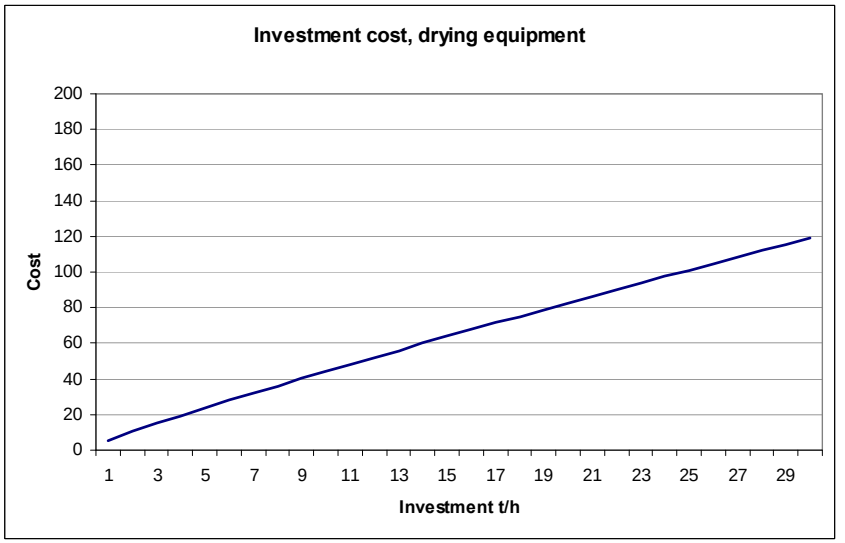
- Wet raw-material utilization in pellet production requires also investment in a drying equipment

THE MODEL: Investment cost functions









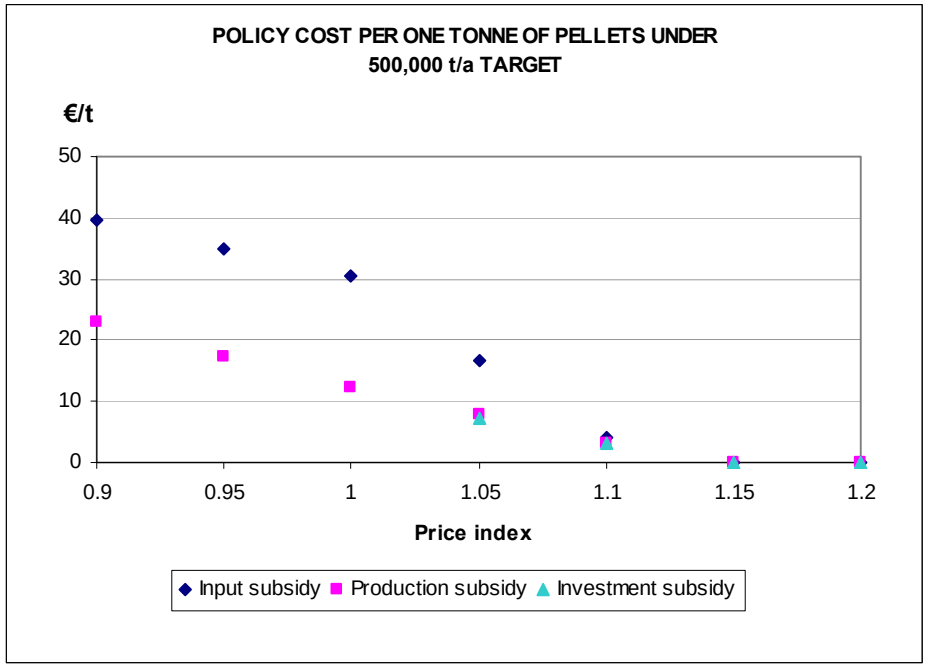
NUMERICAL APPLICATION (1)

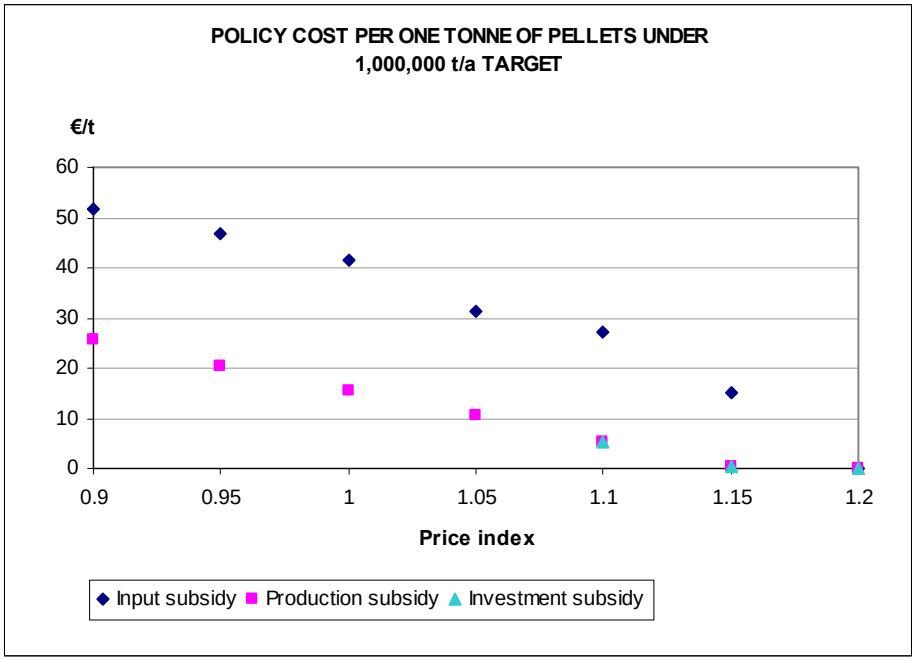
- The simulation model is used to analyze the choices of thirty large-scale sawmills that describe approximately the half of Finnish sawnwood capacity

- We set two targets for pellet production; 500,000t and 1,000,000t per year (Corresponding approximately 2 or 4 TWh)

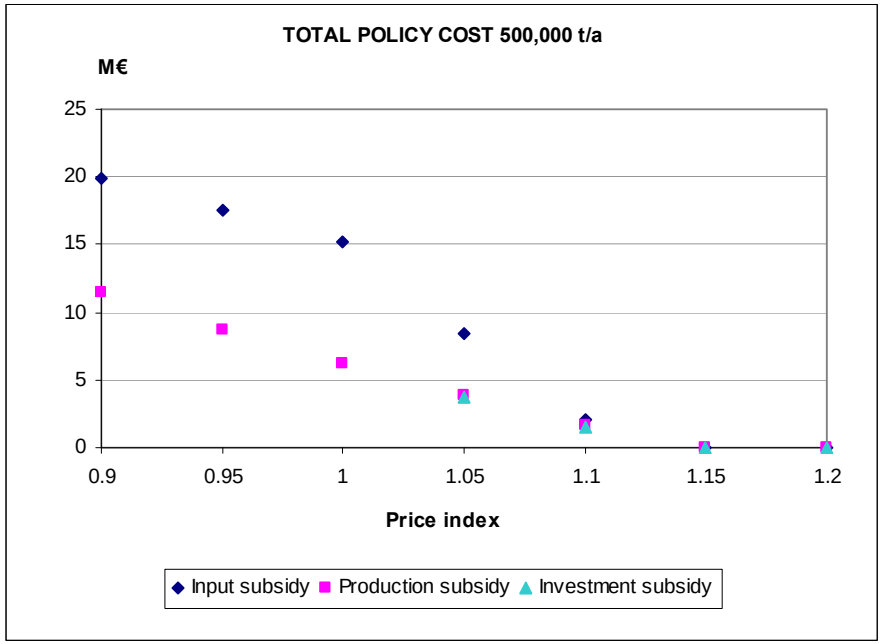
  - Sawnwood price 160/m³
  - Baseline prices for pellet 100€/t and 80€/t
  - We analyze the levels of policy instruments that are needed to reach these targets in respect of different pellet prices
  - SUBSIDY LEVELS ARE CALCULATED ENDOGENOUSLY

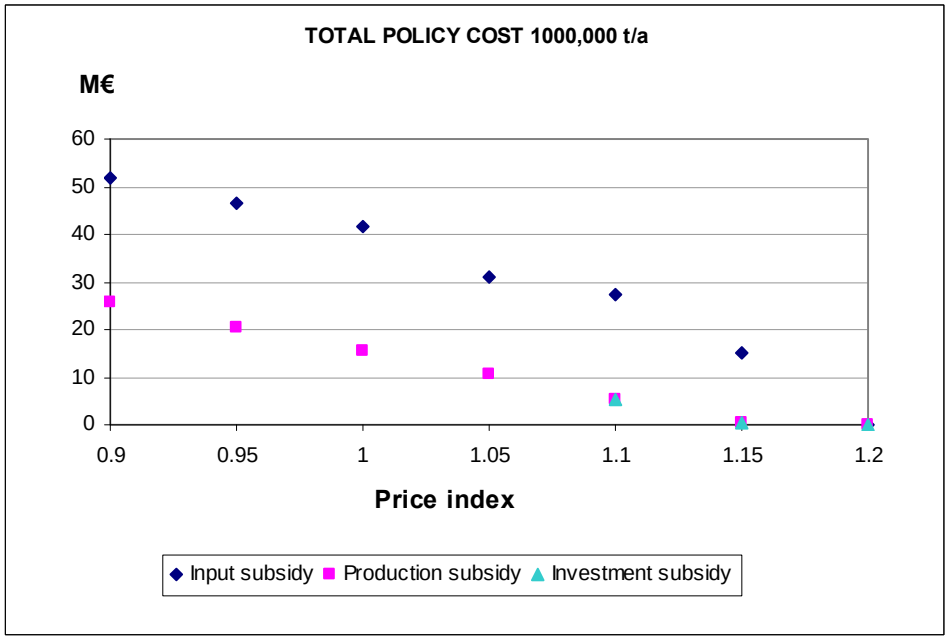
RESULTS (1): Policy instrument values



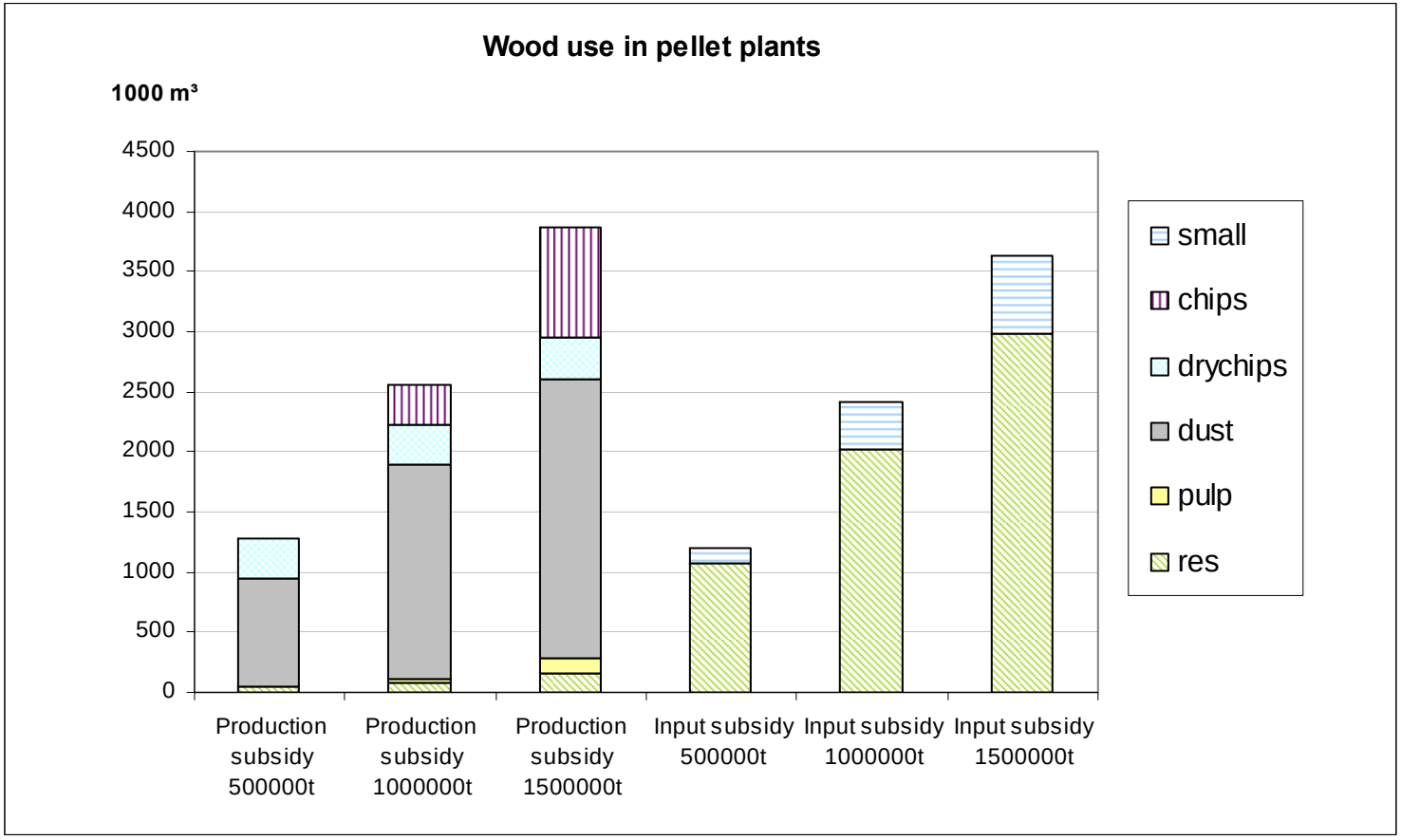


RESULTS (2): Policy costs

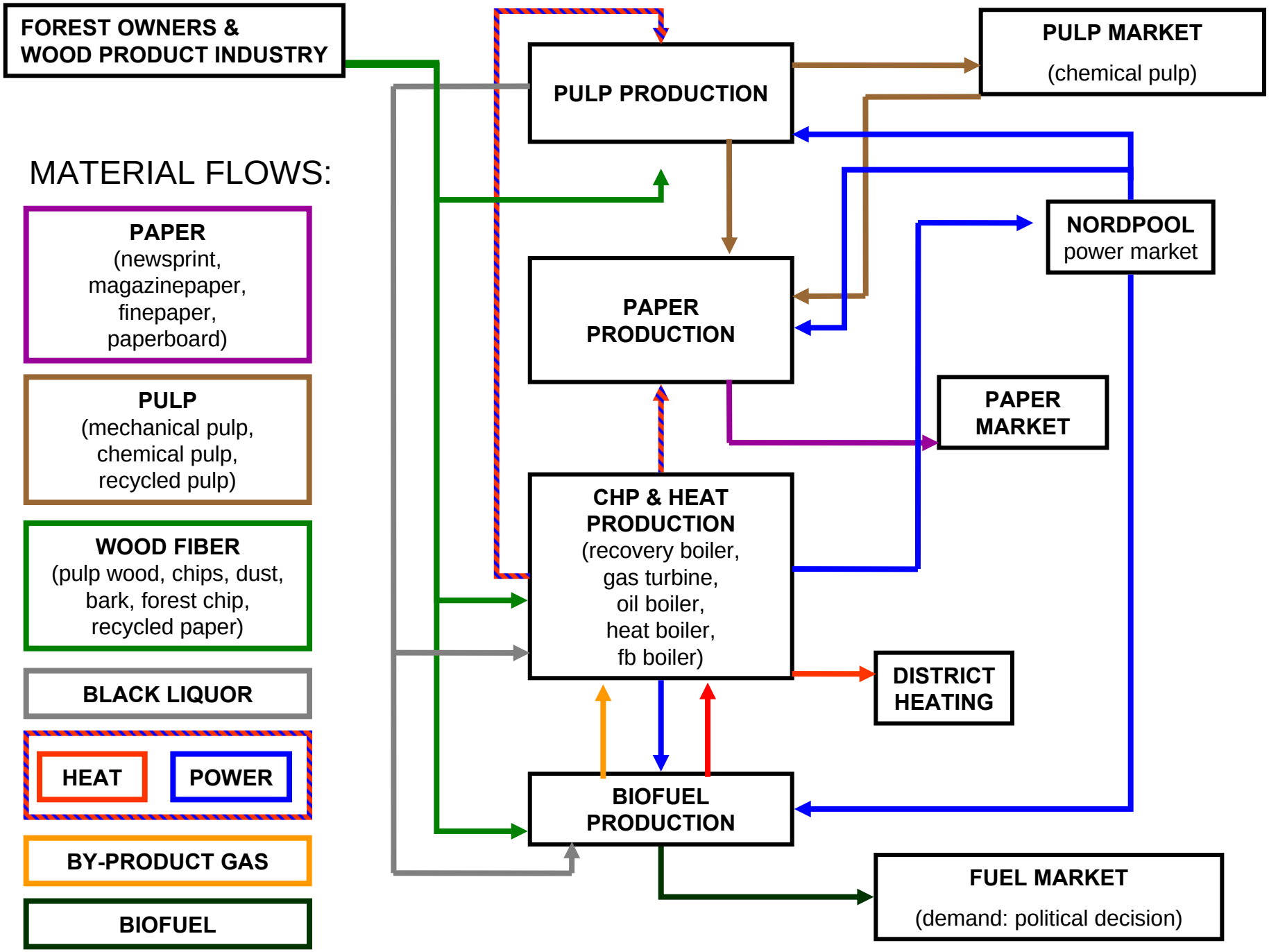




RESULTS (3): Wood use under baseline prices



FOREST BIOREFINERIES

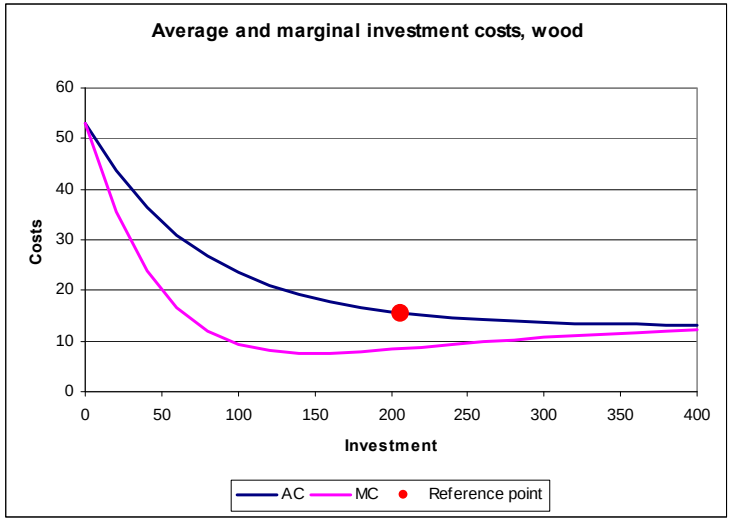

FOREST OWNERS & WOOD PRODUCT INDUSTRY
PULP PRODUCTION
PULP MARKET
(chemical pulp)
MATERIAL FLOWS:
PAPER
(newsprint, magazinepaper, finepaper, paperboard)
PULP
(mechanical pulp, chemical pulp, recycled pulp)
WOOD FIBER
(pulp wood, chips, dust, bark, forest chip, recycled paper)
BLACK LIQUOR
HEAT
POWER
BY-PRODUCT GAS
BIOFUEL
NORDPOOL
power market
PAPER PRODUCTION
PAPER MARKET
CHP & HEAT PRODUCTION
(recovery boiler, gas turbine, oil boiler, heat boiler, fb boiler)
DISTRICT HEATING
BIOFUEL PRODUCTION
FUEL MARKET
(demand: political decision)

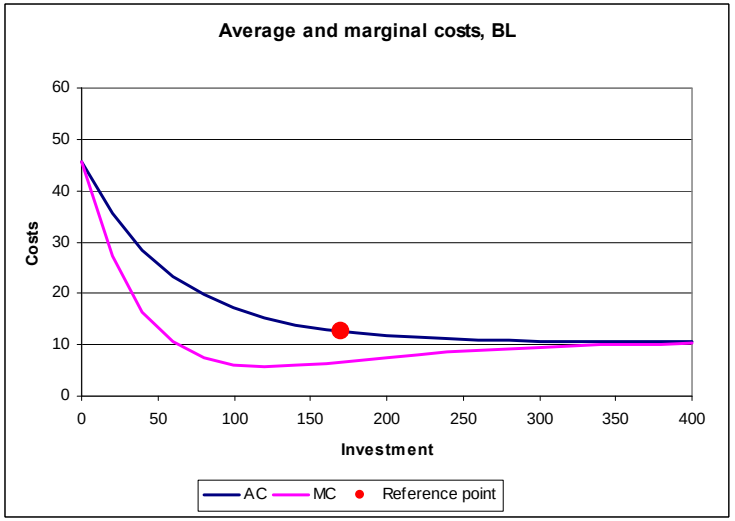
THE MODEL (3): Investment costs

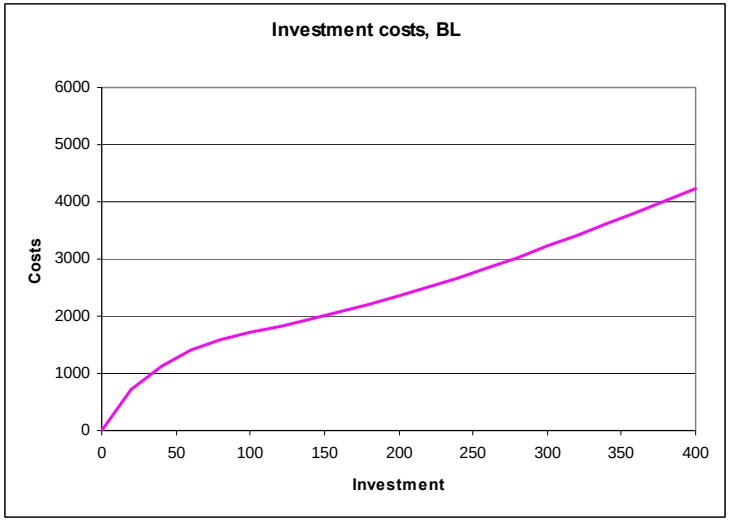
- Biorefinery investments
  - Specific technologies for gasification of black liquor and wood fibers, i.e. separate capacities
  - The average costs of a biorefinery investment decrease as the size of an investment increases

$$C_{inv,b}^{bf} = \left[c_{inv,b}^{bf} + h_{inv,b}^{bf} \exp\left(-\frac{I_b^{bf}}{\chi_{\min,b}^{bf}} \right) \right] I_b^{bf}$$

THE MODEL (5): Investment cost functions







NUMERICAL APPLICATION (1)

- 3, 6 or 9 TWh per year target for biofuel production
  - about 6, 12 or 18 % of the total transport fuel consumption in Finland (EU target 2020 10%, Finnish target 2020 7 TWh)
  - we analyze the levels of fuel price and policy instruments (subsidies) that are needed to reach these targets
- Modelled as a mixed complementarity problem using PATH solver in GAMS modeling system.
- The setting is based on real plant level data from pulp and paper industry and the energy market in Finland in 2008

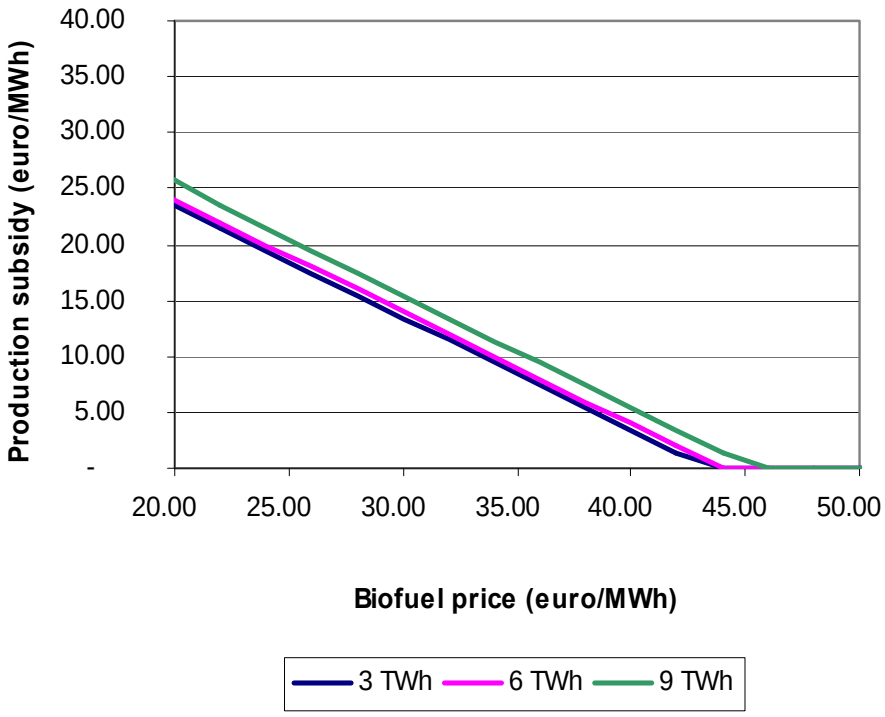
NUMERICAL APPLICATION (2): Subsidies

1) Production subsidy
   - price premium on top of the biofuel price for all the biofuel units produced (by wood or black liquor)

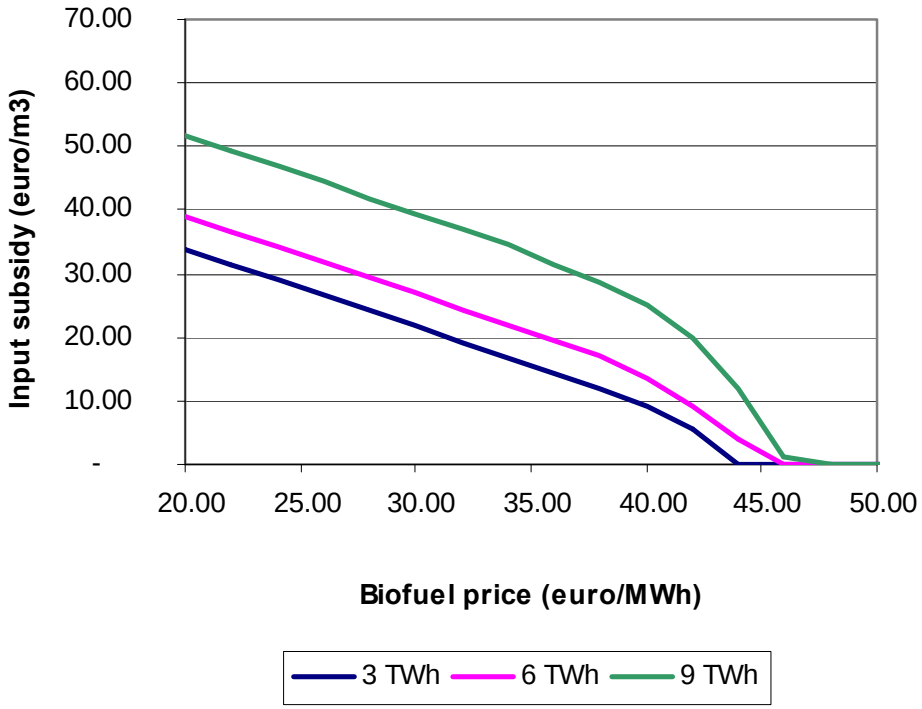
2) Input subsidy (for forest residues)
   - received for each unit of a wood fiber type used in biofuel production (in our analysis only for forest residue)

RESULTS (1): Policy instrument values

- Production subsidy:

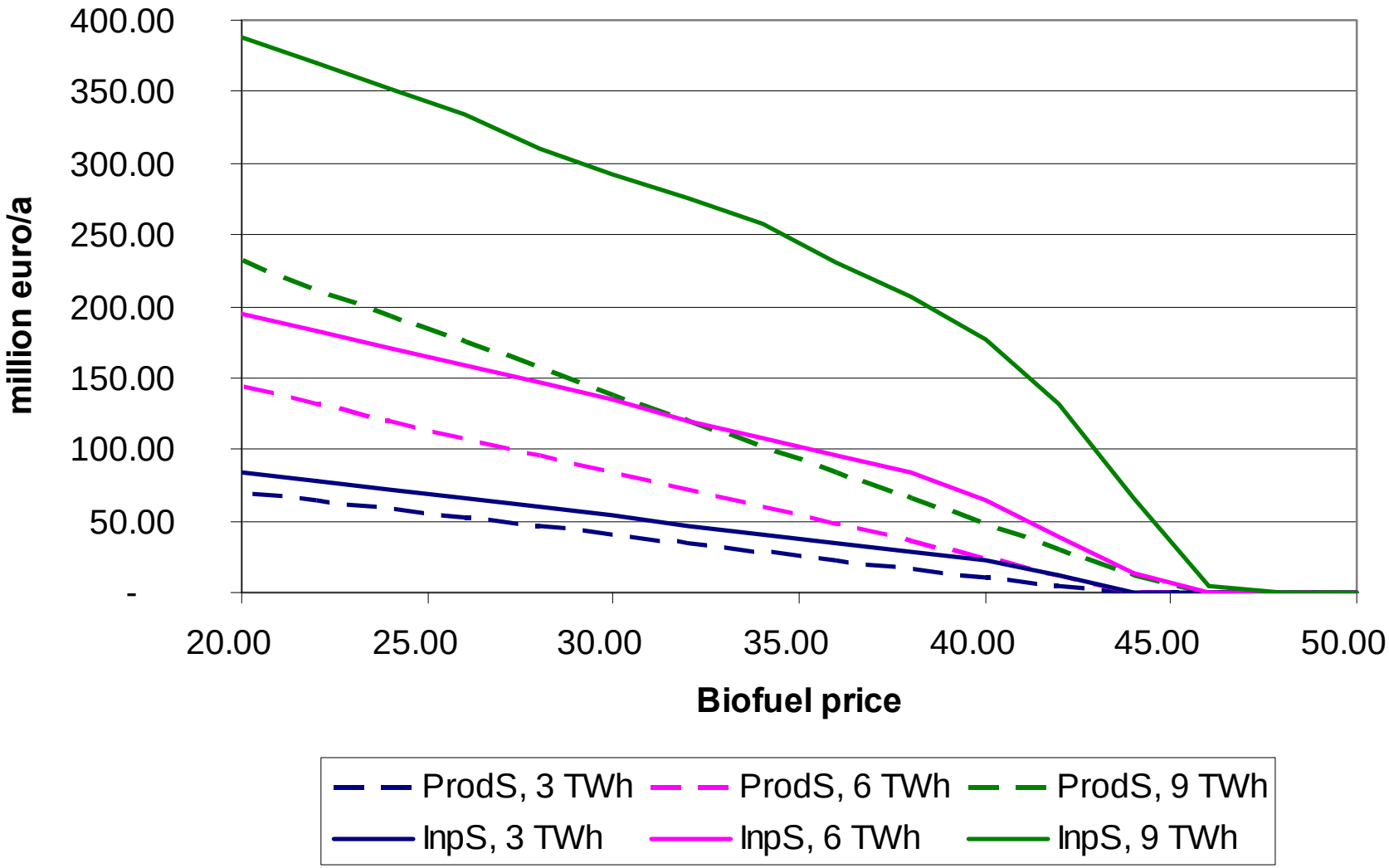


- Input subsidy:



- Notice: difficulties in finding the optimal value for input subsidy (6 and 9 TWh) for high fuel prices

RESULTS (2): Policy costs



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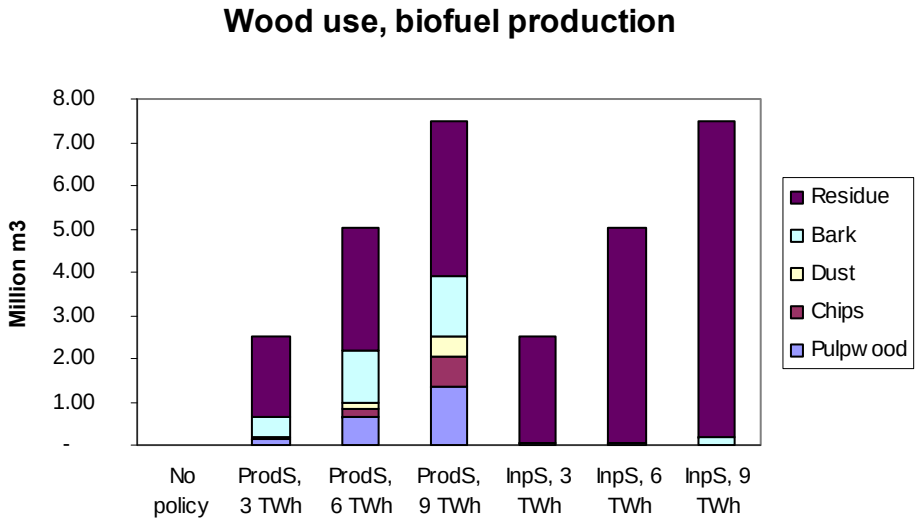
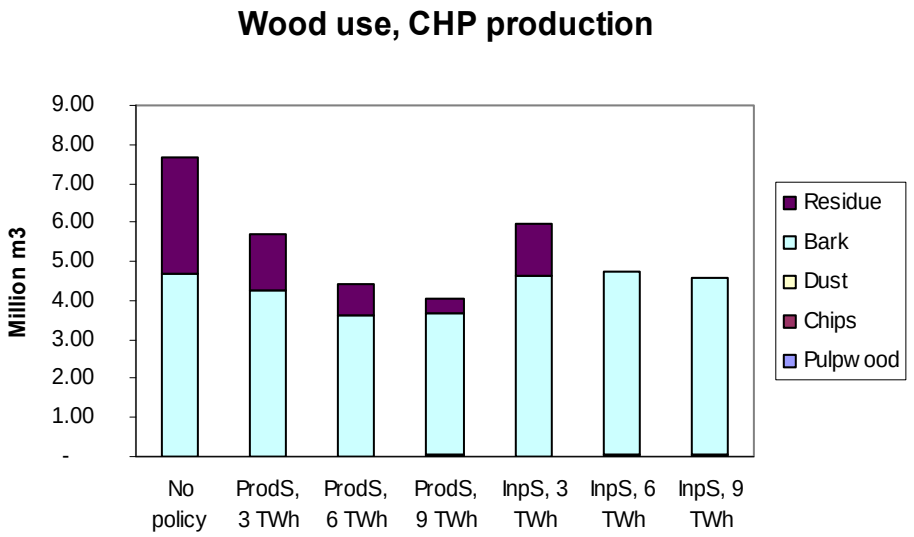
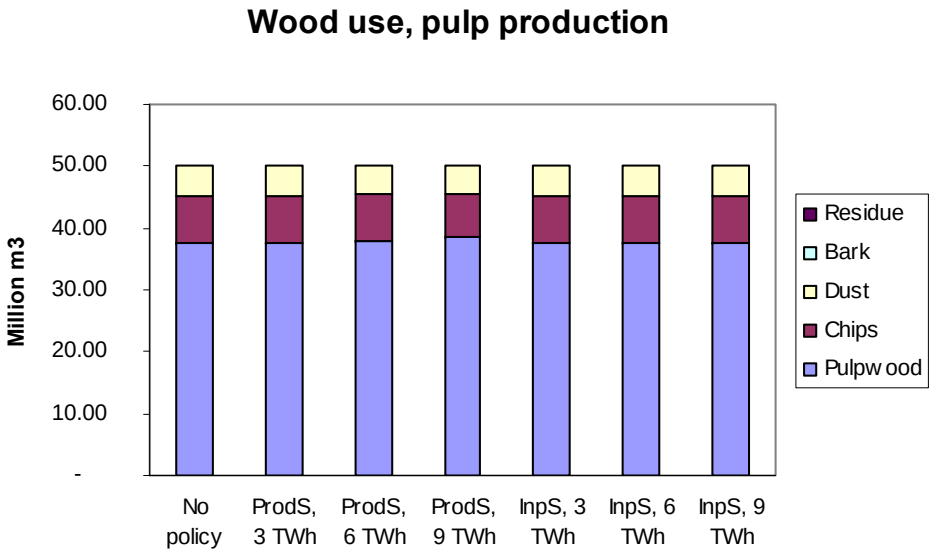
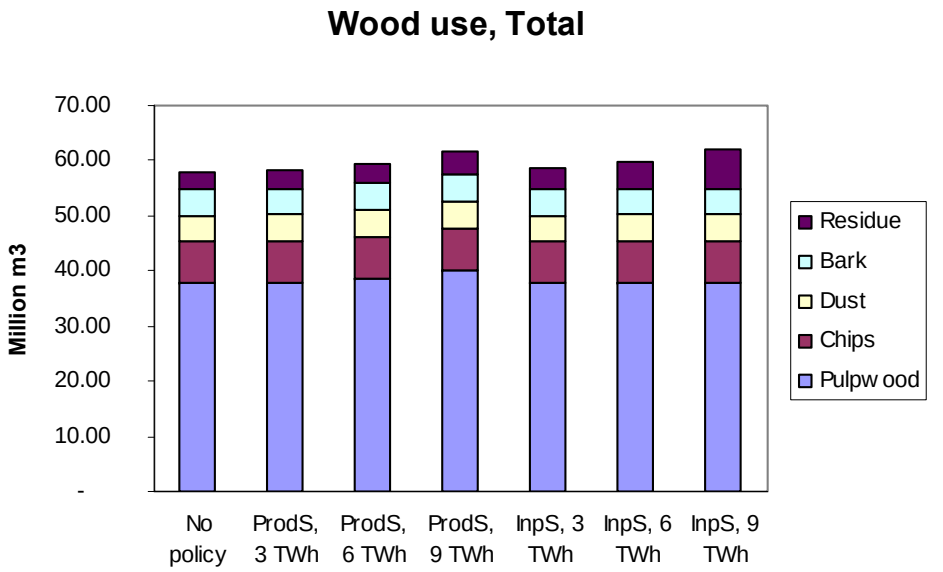
RESULTS (4): Wood use









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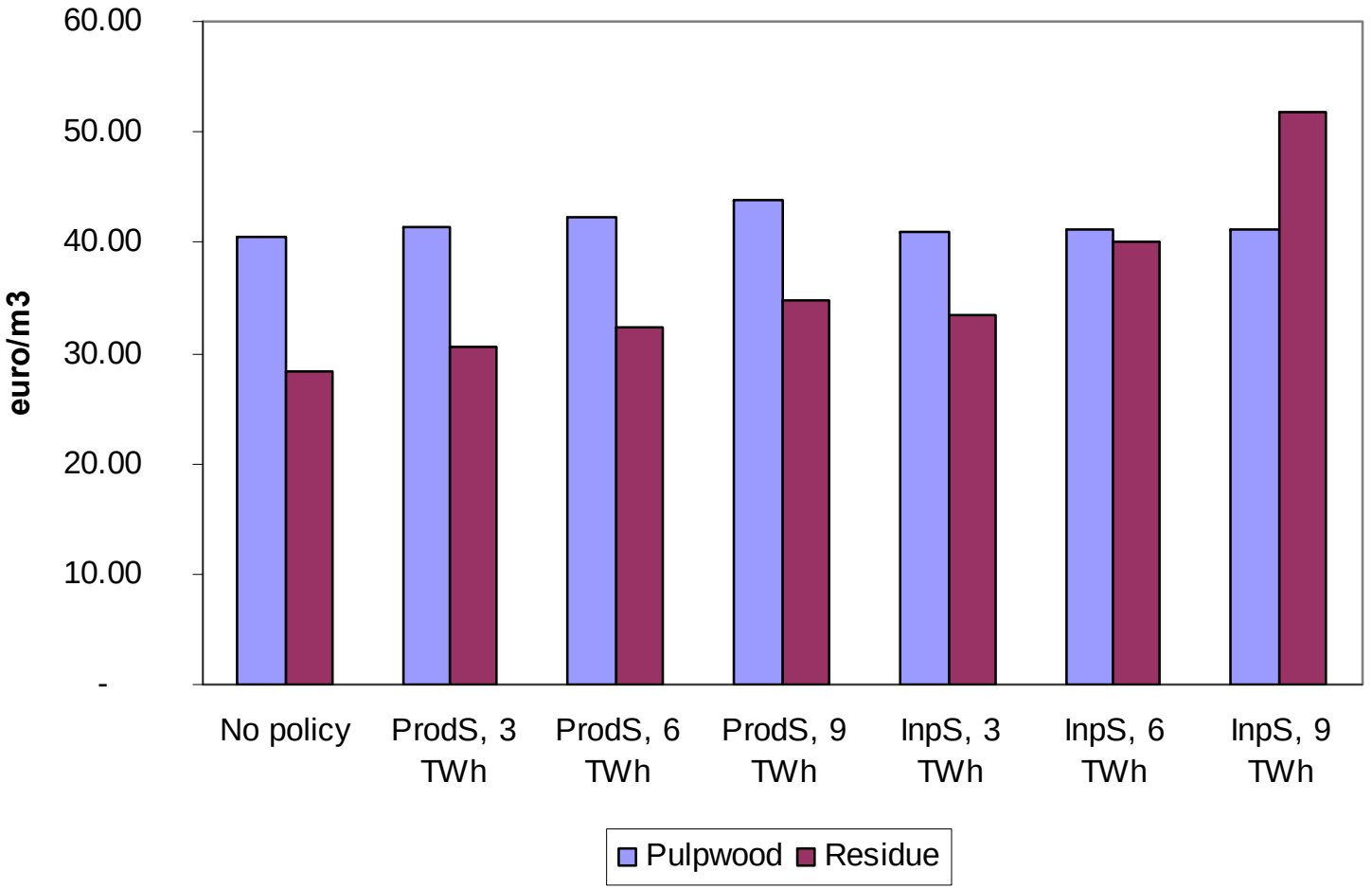
RESULTS (5): Wood price



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DISCUSSION

- The production of biofuels is expensive
  - Support is needed (if biofuel price is under 43 €/MWh)
- The level of subsidy needed depends on the biofuel price
  - Subsidy can be linked e.g. to the price of crude oil
- Production subsidy is cost-efficient
  - However, the costs of input subsidy are not sufficiently larger with lower policy targets
- Wood input in biofuel production depends on the policy instrument
  - Production subsidy: all wood fiber types
  - Input subsidy: (almost) only residual wood

THANK YOU!