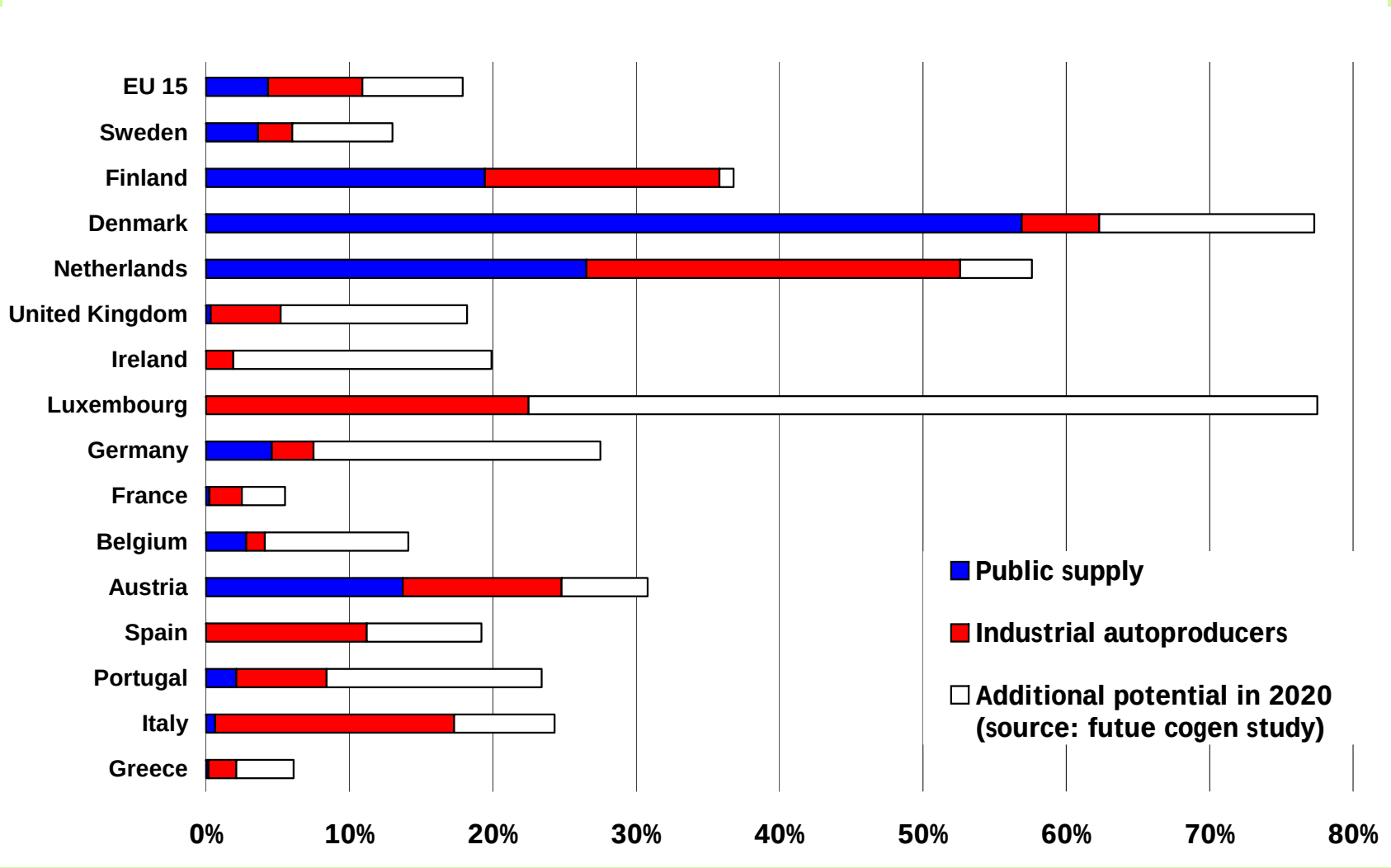
Costs and potentials CHP and DSM

Mario Ragwitz
Fraunhofer-ISI

Potentials and costs of CHP and DSM for GHG reduction

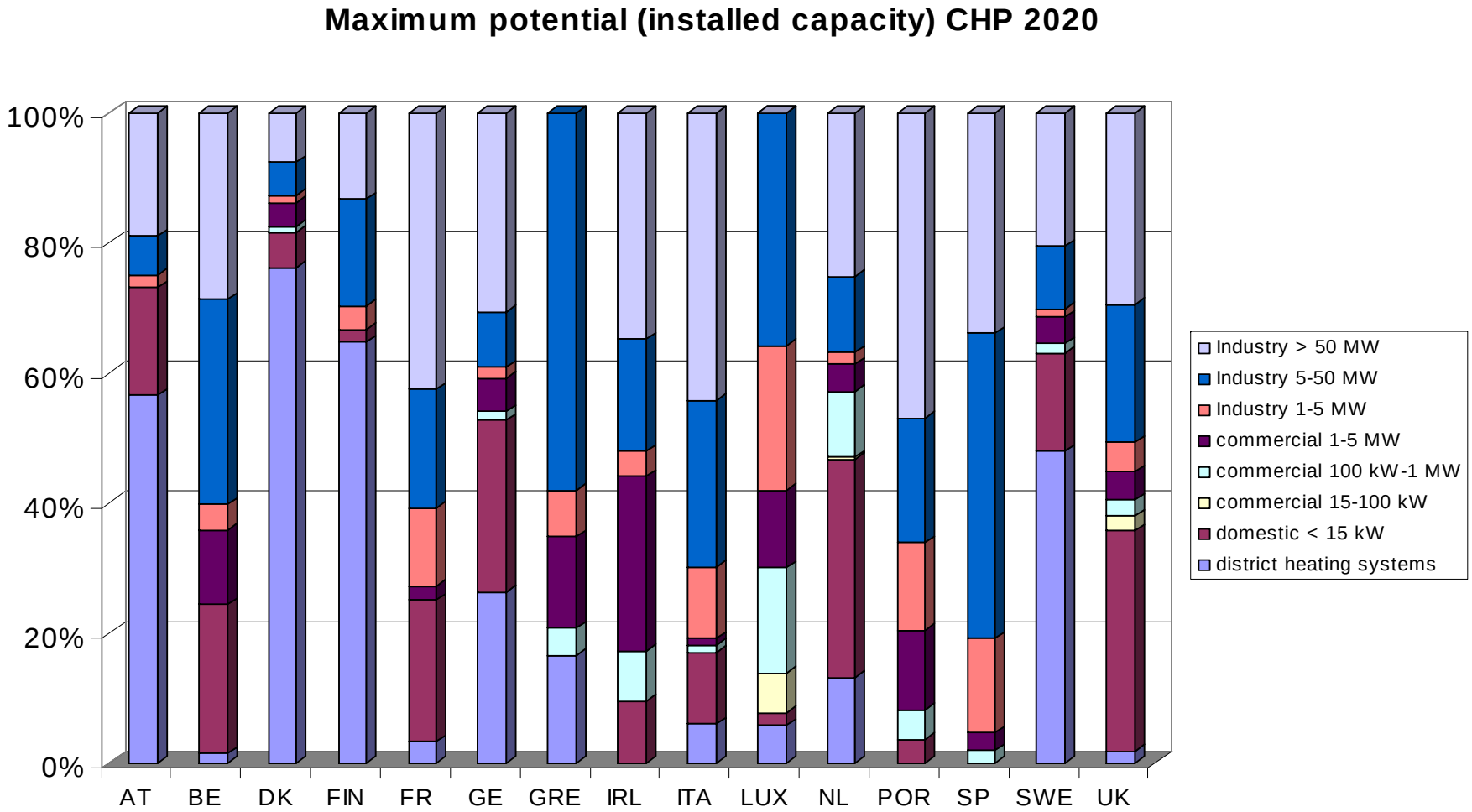
- CHP and DSM offer large, cost efficient potentials for GHG reduction in the EU-15
- CHP and DSM belong to the most complex input variables of the model ***Green-X*** because a large number of sectors, sub-sectors and technologies have to be considered
- A number of new technologies might become competitive by 2020, e.g. fuel cells
- Potentials, technologies and costs in different sectors are highly country specific

CHP utilisation in 2000 and 2020 potential



Sources: Eurostat, BfE, future cogen study

CHP potential by sector for 2020



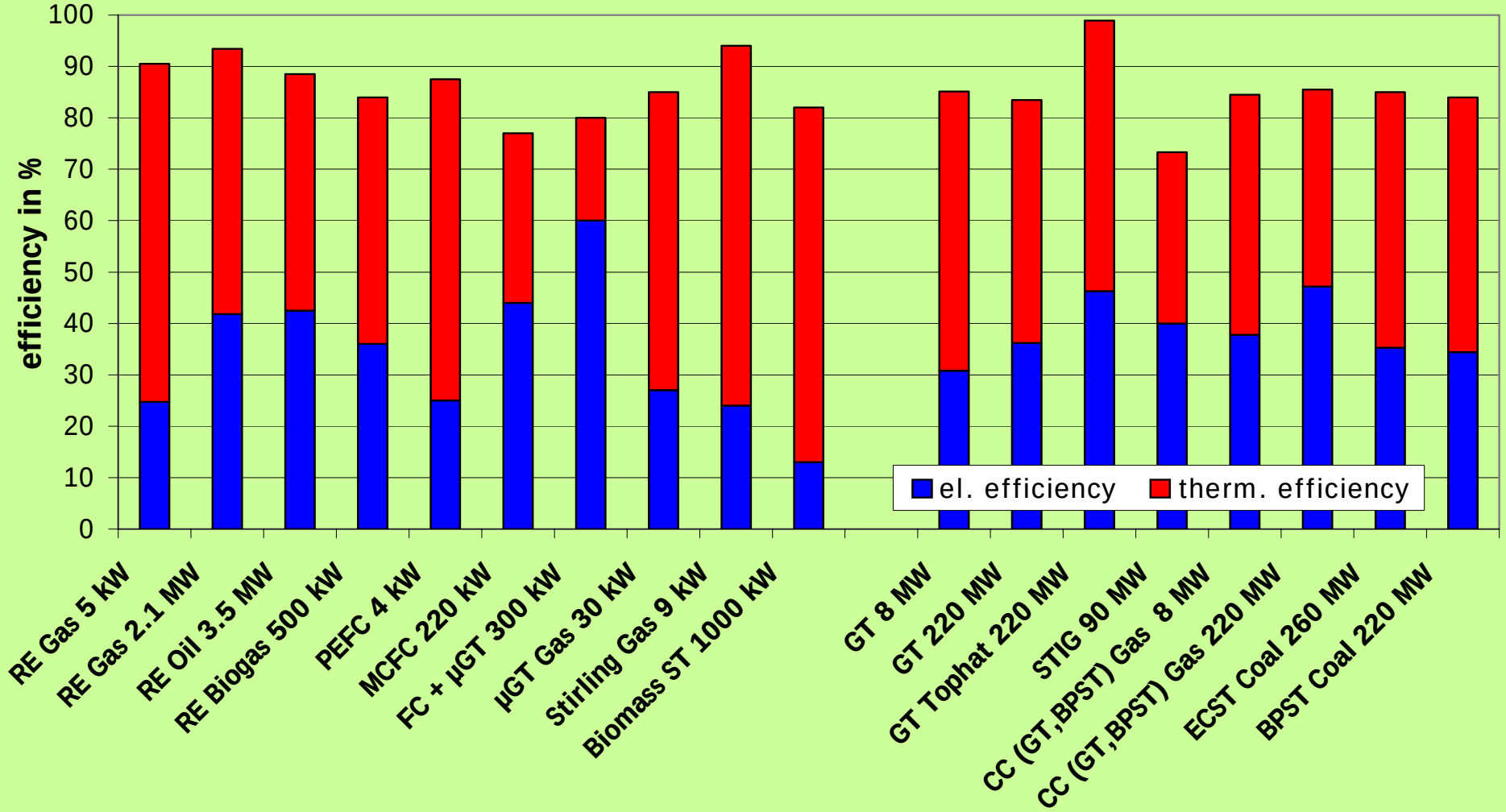
Source: Future Cogen

CHP Technologies

- CC: Combined cycle (gas and steam turbine)
- CC-B Combined Cycle Backpressure
- ST: Steam turbine
- ST-B Steam turbine with backpressure
- GE: Gas engine
- GT: Gas turbine
- DE Diesel engine
- PEFC: Polymer electrolyte fuel cells
- PAFC: Phosphoric acid fuel cells
- MCFC: Molten carbonate fuel cells
- SOFC: Solid oxide fuel cells

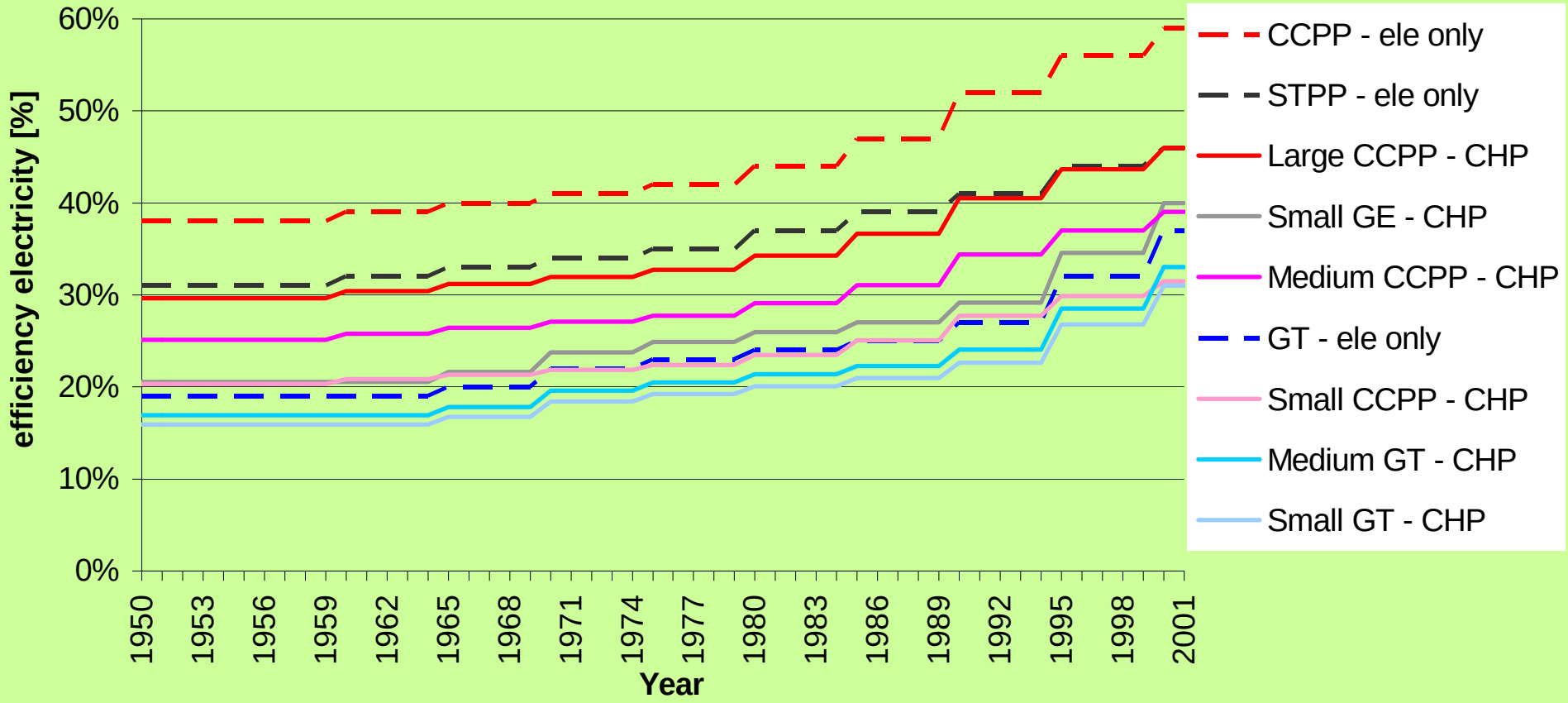
In the industry, commercial and domestic sector

Efficiency of CHP technologies 2001



Development of CHP efficiencies

Electric efficiencies of CHP plants are usually lower than those of conventional power plants



Techno-Economic data for CHP plants

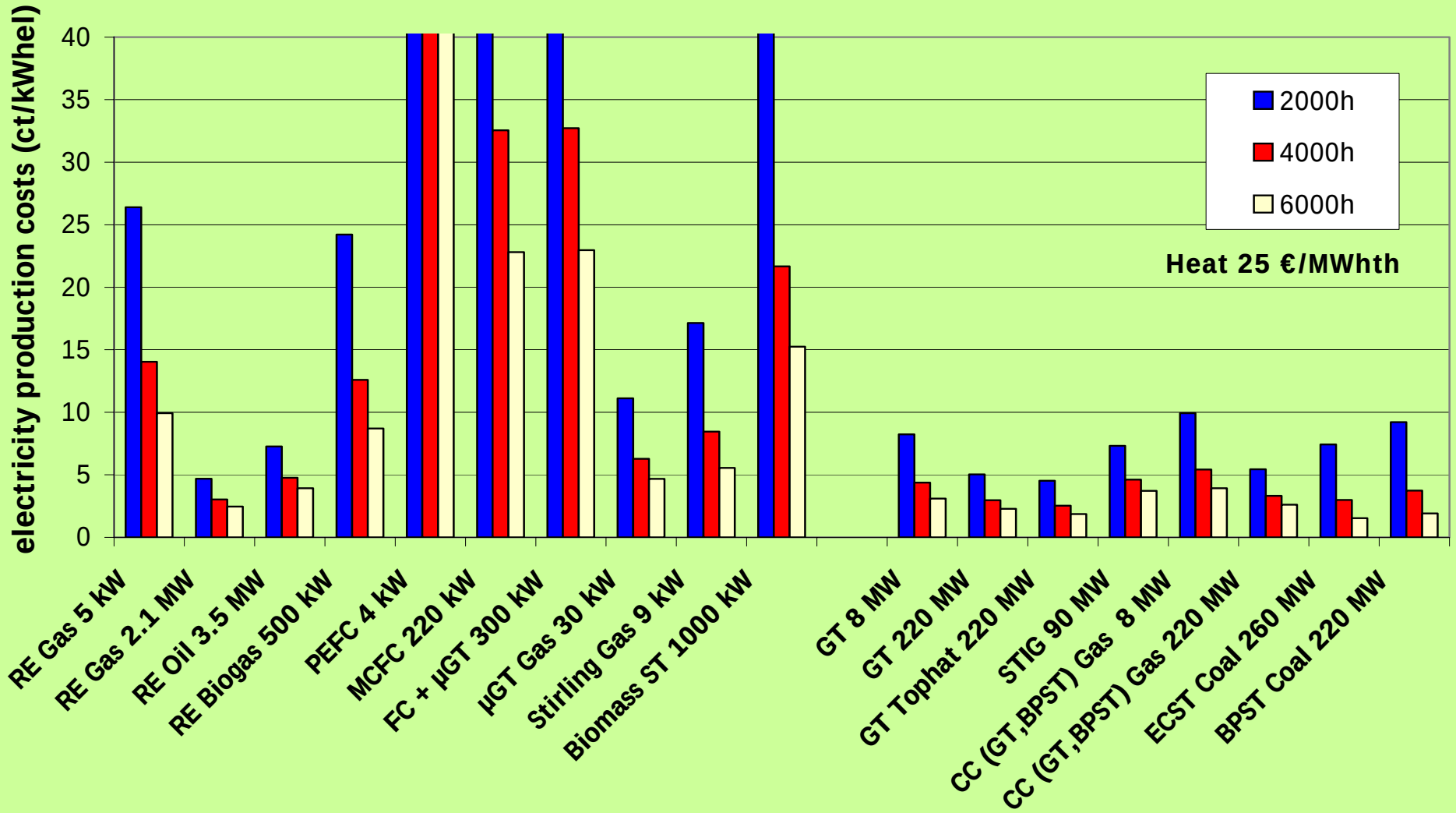
Actual costs of electricity from CHP depend on:

- **fuel price**
- **heat price**
- **techno-economic plant data as shown below**

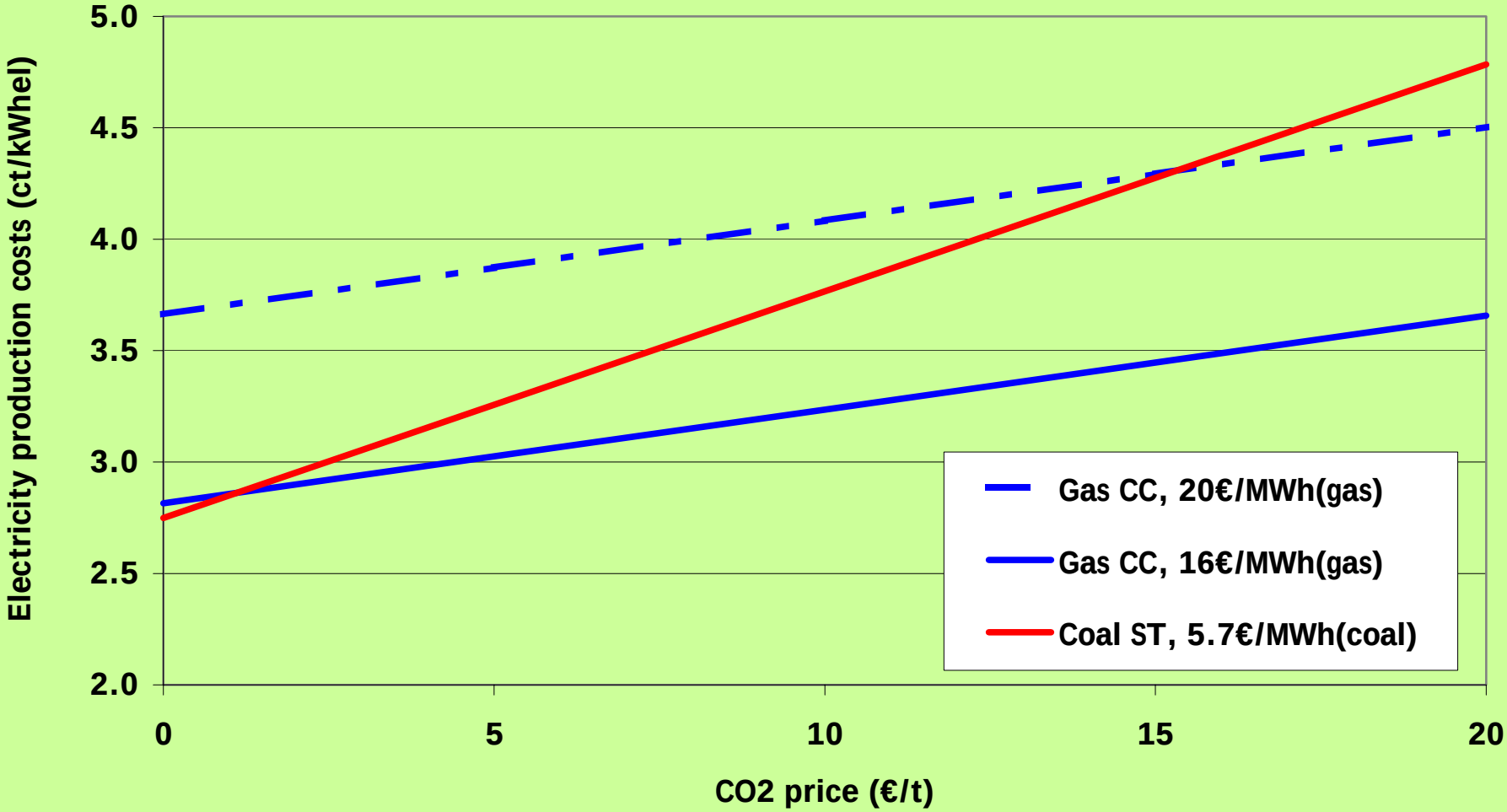
$$C = C_{VARIABLE} + \frac{C_{FIX}}{q_{el}} = \left(C_{FUEL} + \frac{C_{O\&M}}{H_{EL}} * 1000 - R_{HEAT} \right) + \frac{1000 * I * CRF}{H_{EL}}$$

2020	current technique		GT	CC	CC
	plant-size	[MWe]	5,0	100,0	200,0
	total investment costs	[€/kWe]	591,0	674,9	582,9
	O&M-costs	[€/(kW*a)]	73,9	39,7	29,6
	full load hours	[h/a]	2.300,0	2.650,0	2.900,0
	efficiency electricity	[%]	31,2	42 (52)	45 (56)
	efficiency heat	[%]	54,3	46,0	44,0
	total efficiency	[%]	85,5	88,0	89,0
	heat to power ratio	[GWhth/GWhe]	1,7	1,1	1,0
	life time	[a]	30,0	30,0	30,0

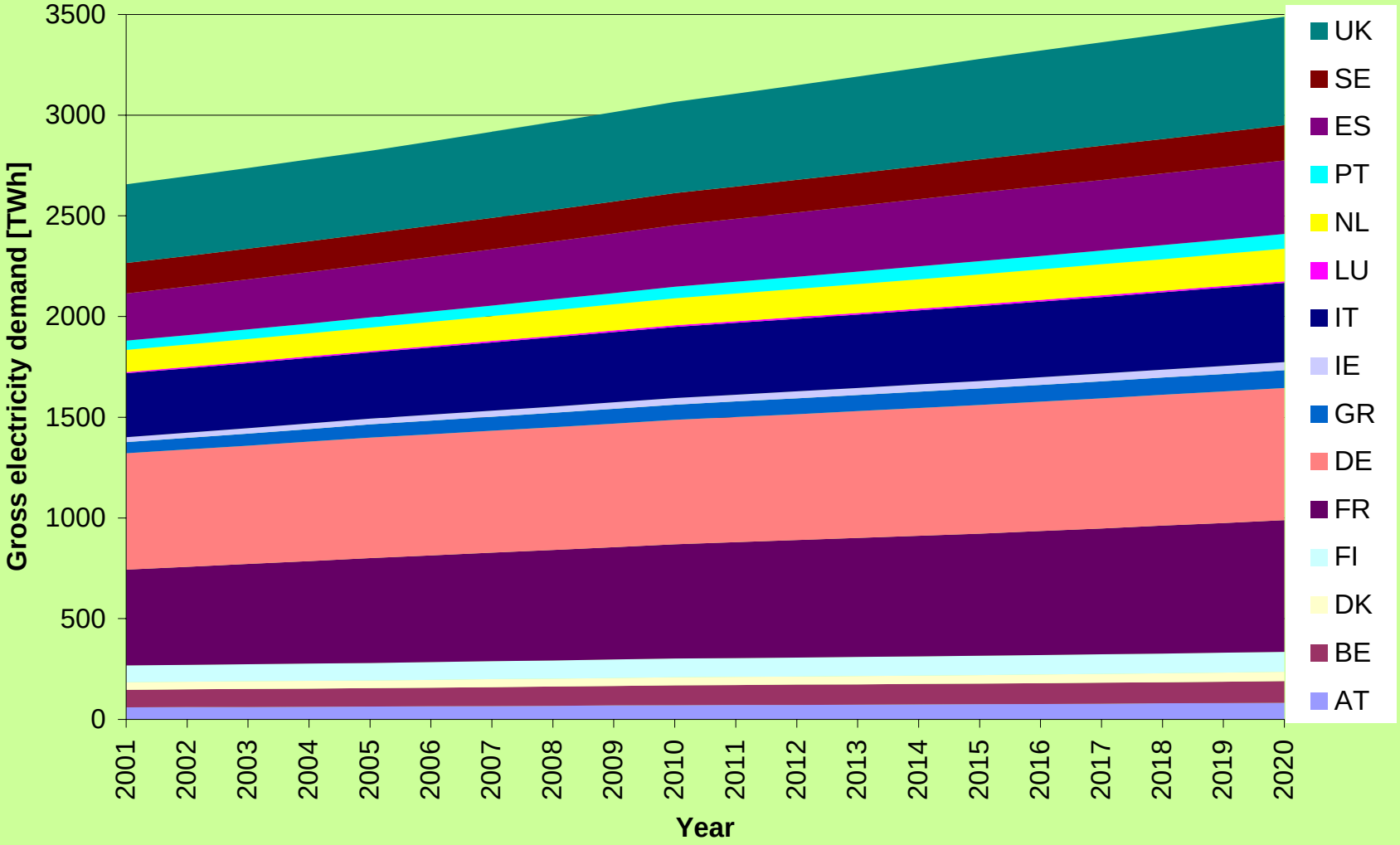
Electricity production costs of CHP technologies



Electricity production costs (2010) in relation to CO2 price



Electricity demand - baseline scenario



Source: Shared Analysis (2003)

DSM Activities

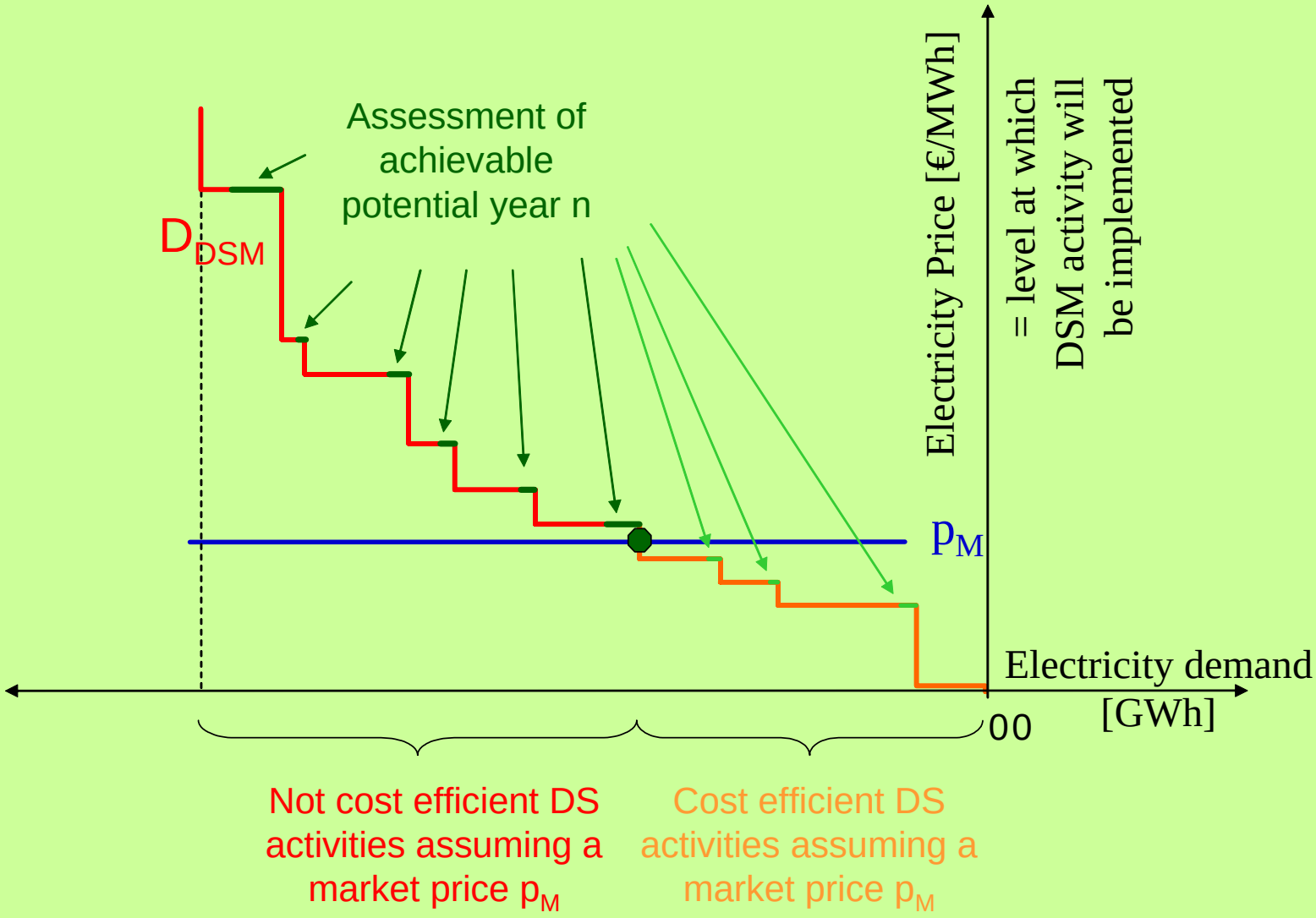
Main Sectors for DSM activities in the electricity sector are:

- Industry
- Households
- Service sector

each containing various sub-sectors, for example the industry sector includes:

- Iron & Steel
- Non-ferrous metals
- Engineering
- Foundries (including iron/steel and non-ferrous metals foundries)
- Food
- Chemicals
- Glass and Glass Products
- Ceramics
- Cement
- Cross sector technologies - including compressed air, lighting, refrigeration

Cost curve for DSM Measures



Data-Base DSM

Example of most important technology specific information

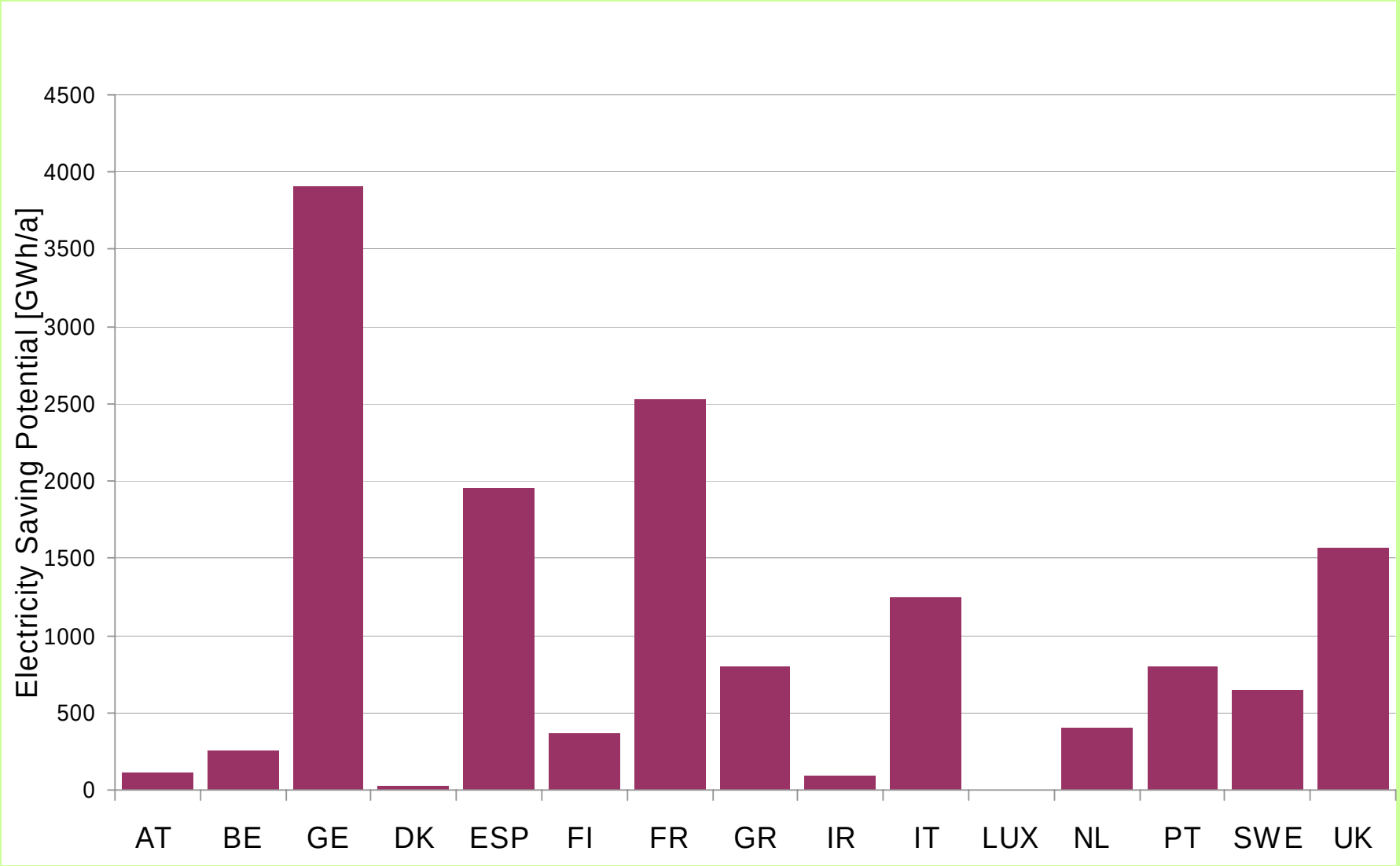
Band Name	Long term potential energy saving compared to BAU 2020 [GWh/year]	Share of realisable energy saving potental compared to long-term potential [% of long-term energy saving]	**Maximum yearly realisable penetration of energy saving compared to BAU [GWh/year]**	**Level of electricity costs where DSM measure is economical efficienct [€/MWh]**	Additional Investment costs year n [€/ unit output]	Energy saving per unit service output [MWh / unit output]	Additional O&M costs independend from electricity consumption [€/ unit output]	Life time of implemented technology [years]	Life time alternative option [years]	Sector/Subsector	Comment altern technology / enc
GER-E-DSM-N-I-NFM2	1533,3	1%	**15,33**	**24,17**	548,83	2,667	0,00	20	20	***Primary Smelting (Hall-Heroult)***	stable cathode
GER-E-DSM-N-I-NFM3	520,7	5%	**26,03**	**15,24**	105	0,906	0,00	15	15	***Primary Smelting (Hall-Heroult)***	good houseke
GER-E-DSM-N-I-NFM4	773,1	1%	**7,73**	**6,97**	85	1,344	0,00	25	25	***Primary Smelting (Hall-Heroult)***	improved proc
GER-E-DSM-N-I-NFM5	442,4	3%	**14,75**	**17,07**	99,89	0,769	0,00	15	15	***Primary Smelting (Hall-Heroult)***	best practise
GER-E-DSM-N-I-NFM6	72,5	4%	**2,72**	**0,00**	4,2	0,045	-1,40	15	15	***Al: Further Treatment Furnace***	control system
GER-E-DSM-N-I-NFM7	72,5	3%	**2,42**	**17,51**	0,7	0,045	0,70	15	15	***Al: Further Treatment Furnace***	monitoring & ta
GER-E-DSM-N-I-NFM8	143,3	4%	**5,37**	**1,25**	0,85	0,089	0,00	15	15	***Al: Further Treatment Furnace***	improved man
GER-E-DSM-N-I-NFM9	13,2	2%	**0,20**	**24,39**	6,7	0,036	0,00	15	15	***Sec. Smelting (Shaft furnace)***	impr. refinery
GER-E-DSM-N-I-NFM10	21,9	2%	**0,53**	**55,32**	25,2	0,060	0,00	15	15	***Sec. Smelting (Shaft furnace)***	scrap preheati

Example: Non-Ferrous-Metals

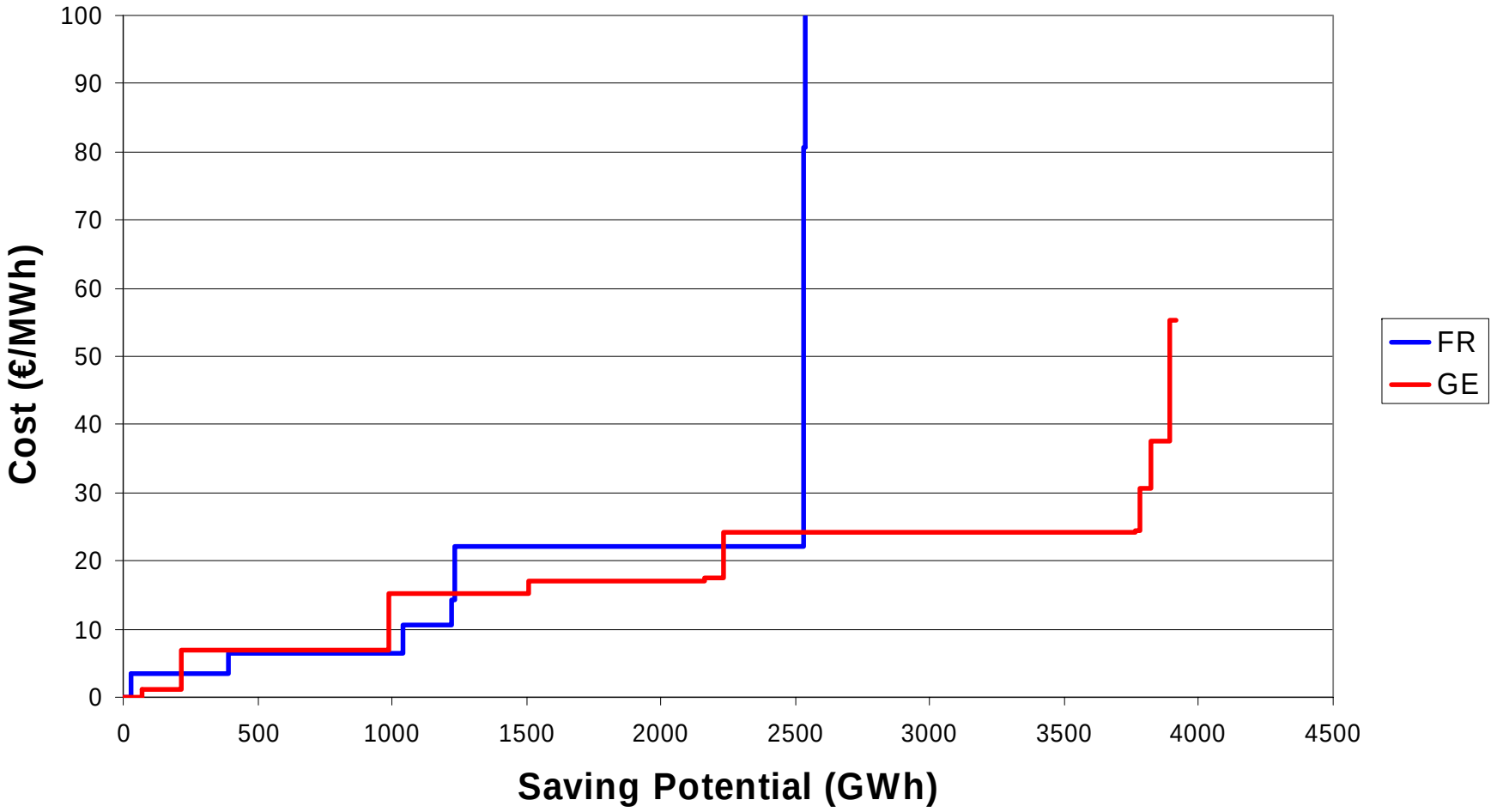
Technologies considered:

Device	Name of Energy Efficiency Technology
Al: Primary Smelting (Hall-Heroult)	Reduced demand of anodes
Al: Primary Smelting (Hall-Heroult)	Stable cathodes
Al: Primary Smelting (Hall-Heroult)	Good housekeeping
Al: Primary Smelting (Hall-Heroult)	Improved process
Al: Primary Smelting (Hall-Heroult)	Best practise
Al: Further Treatment Furnace	Control systems
Al: Further Treatment Furnace	Monitoring & targeting
Al: Further Treatment Furnace	Improved management
Al: Sec. Smelting (Shaft furnace)	Improved refinery
Al: Sec. Smelting (Shaft furnace)	Scrap preheating
Cu: Further Treatment Furnace	Rapid heating
Zinc: Hydrometallic Zinc Process	H2 diffusion anodes
Zinc: Hydrometallic Zinc Process	Improved electrolysis material

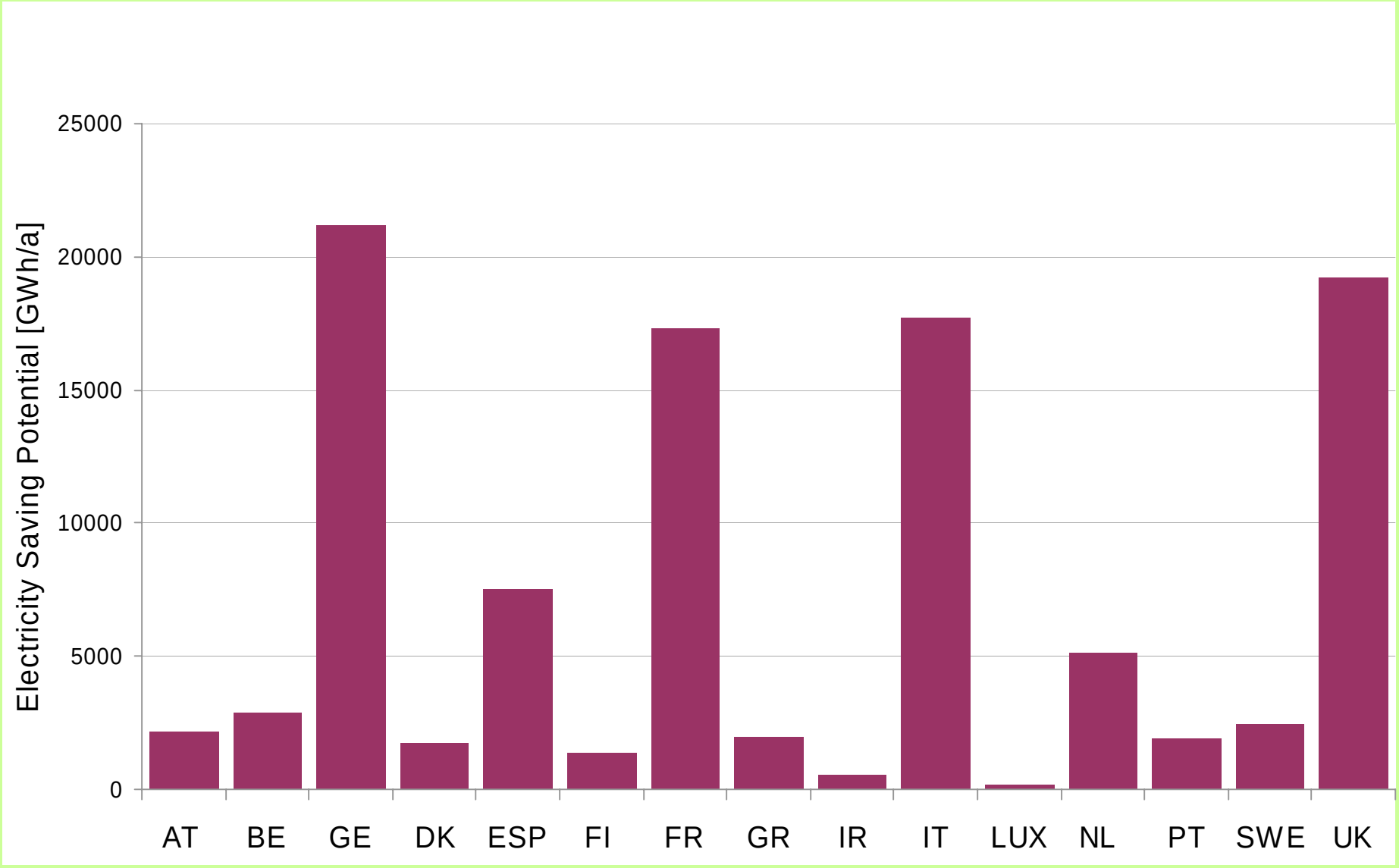
Example: Potential - Non-Ferrous-Metals



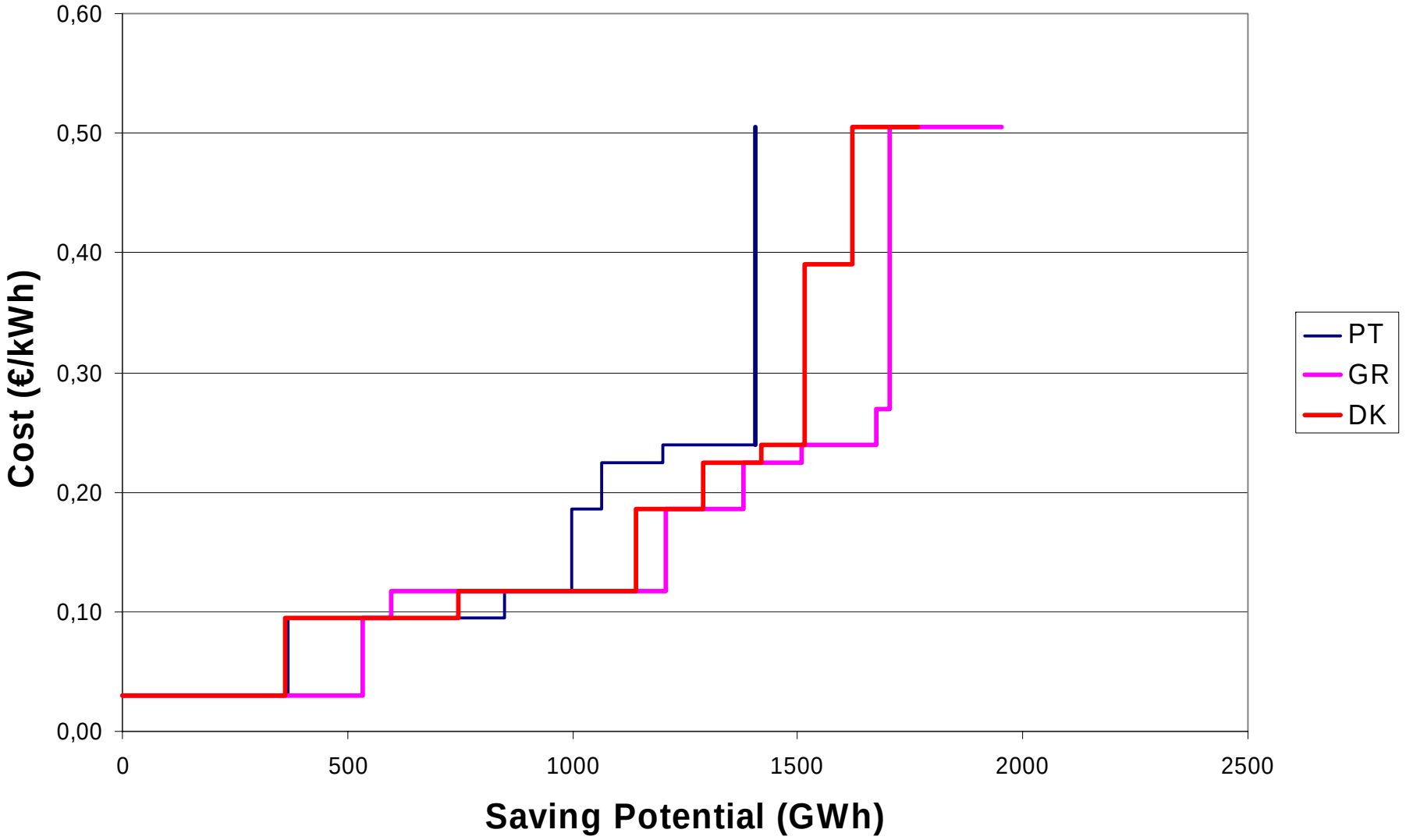
Example: Cost Curve - Non-Ferrous-Metals



Example: Potential - Household Appliances



Example: Cost Curve - Household Appliances



Conclusions

- Only about half of the overall European CHP mid-term potential is exploited, large potentials in small scale domestic and large scale industrial CHP
- Large DSM potential with partially negative costs ("no regret") can be identified in the industry (especially Engineering, NFM, Iron&Steel and Chemicals) and in the household sector
- Cogeneration and DSM as a key element of energy policy
  - environmental benefits: CO2 and primary energy savings
  - large range of technologies and fuels (in case of CHP) supports security of supply
- CHP and DSM options lead to relative advantage in emission trading and future cost benefits