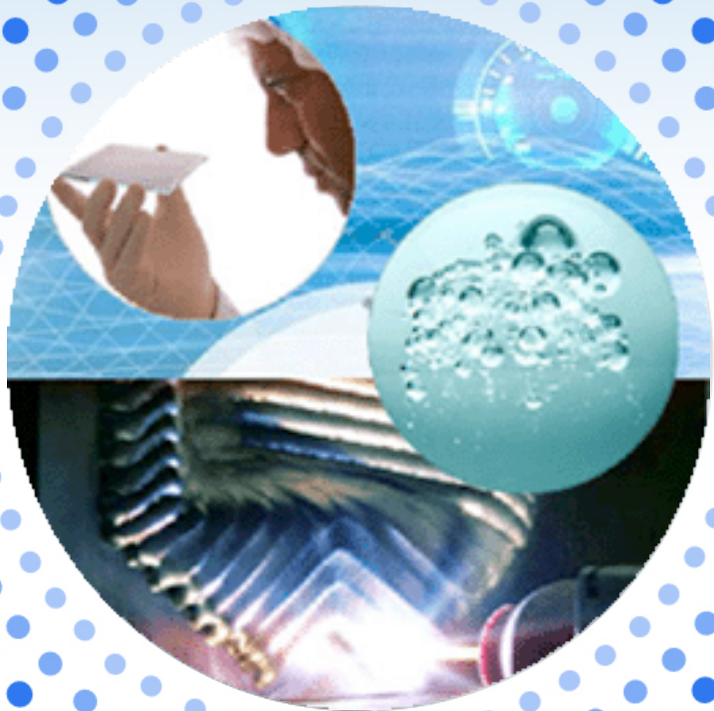


Modeling the response of industry to environmental constraint

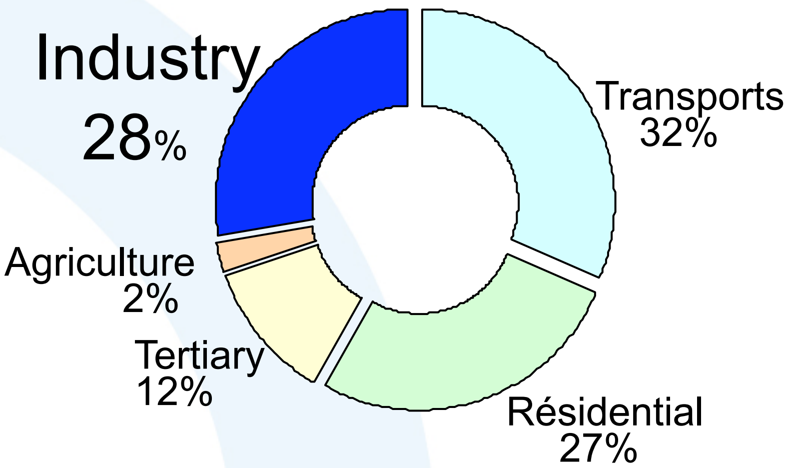
Alain HITA – Ahcène DJEMAA (Ph D student)

EDF R&D/ Eco-efficiency and industrial processes Dept.

MINES ParisTech

EDF R&D

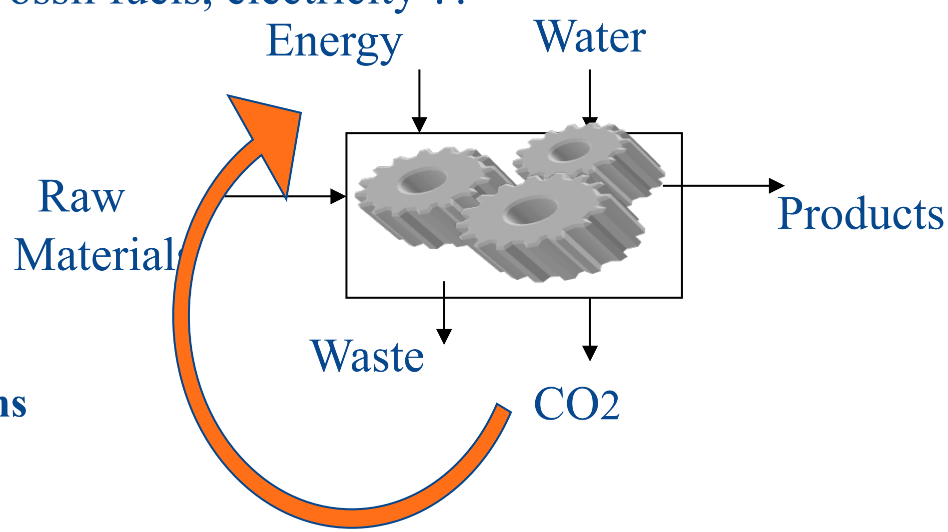
Industry energy consuming



Energy consumption in Europe (2005)
Source: IEA

CO2 Emissions for France:
Industry : 21 % of France total CO2 emissions

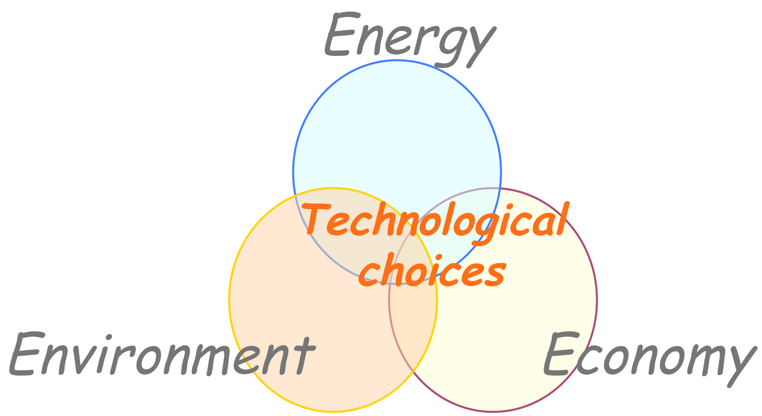
How the carbon constraint influence the choice of energy by the re-optimisation of industrial processes ?



TIMES modeling interest

✓analysis of a set of criteria covering energy, environment and economy

✓ Optimization, under constraints, of a technological representation of a reference energy system on a time horizon



✓bottom-up model advantages(TIMES)

The model chooses the best economical production technologies (energy efficiency, investment cost,..)

- Energy mix ?
- Associated CO2 emissions ?
- technological changes ?
- Investments chronology ? ...

Energy intensive industrial sectors

- Industry
  - Energy intensive
    - Steel
    - Pulp & Paper
    - Glass
    - Others construction materials
    - Cement
  - Others
    - Refinery
    - ~~Chemicals~~

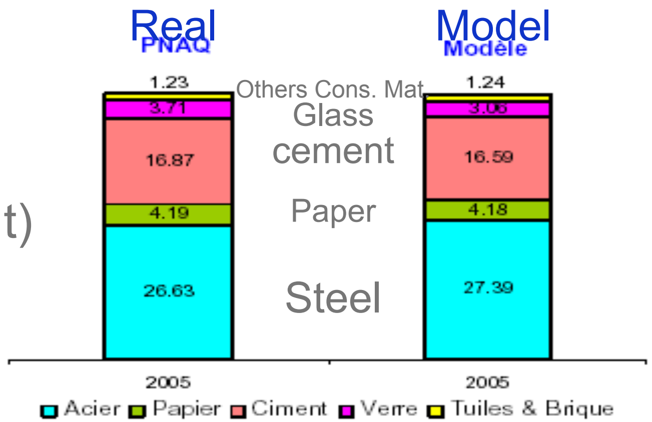




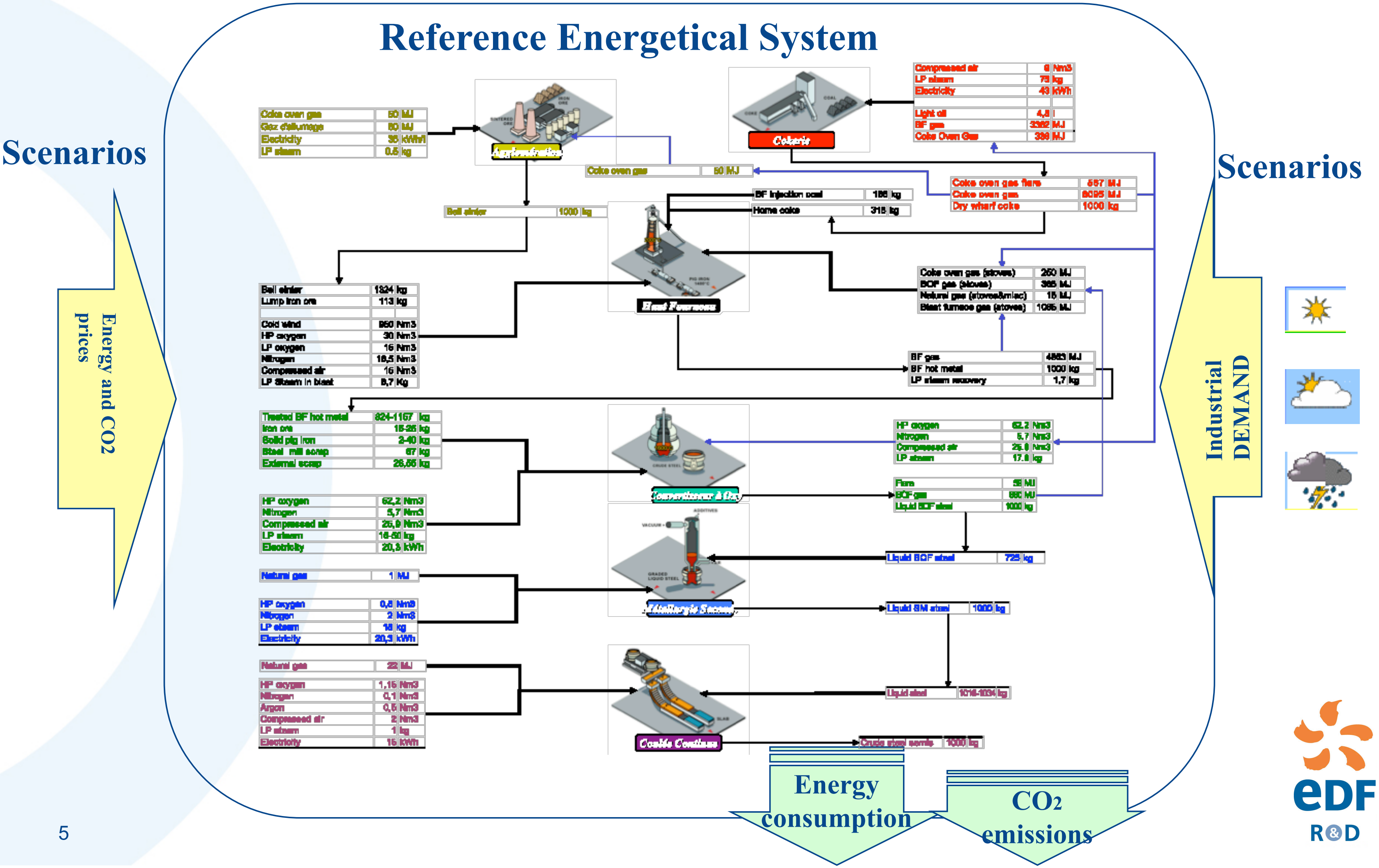
Industrial perimeter related to the CO2 emission trading scheme

France CO2 emissions (Mt)

2005

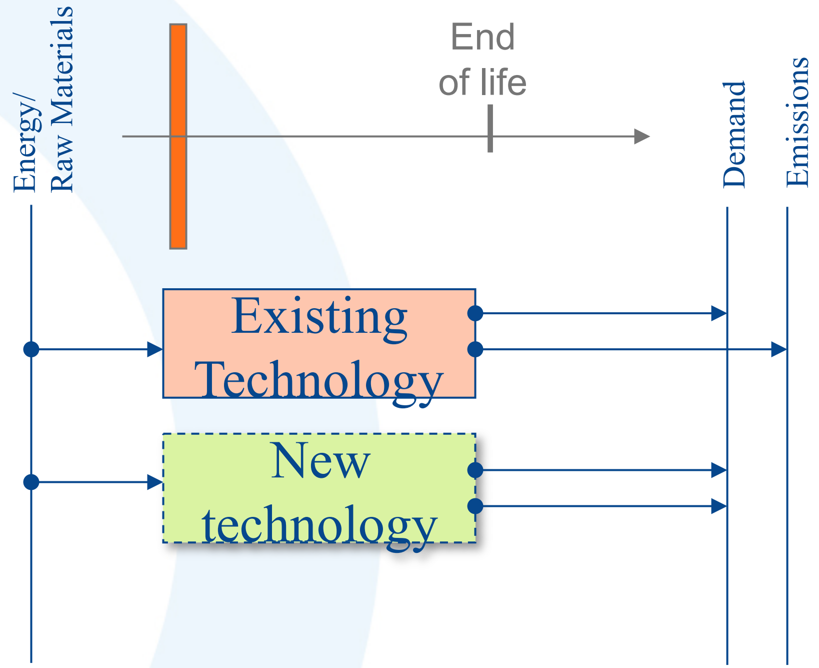


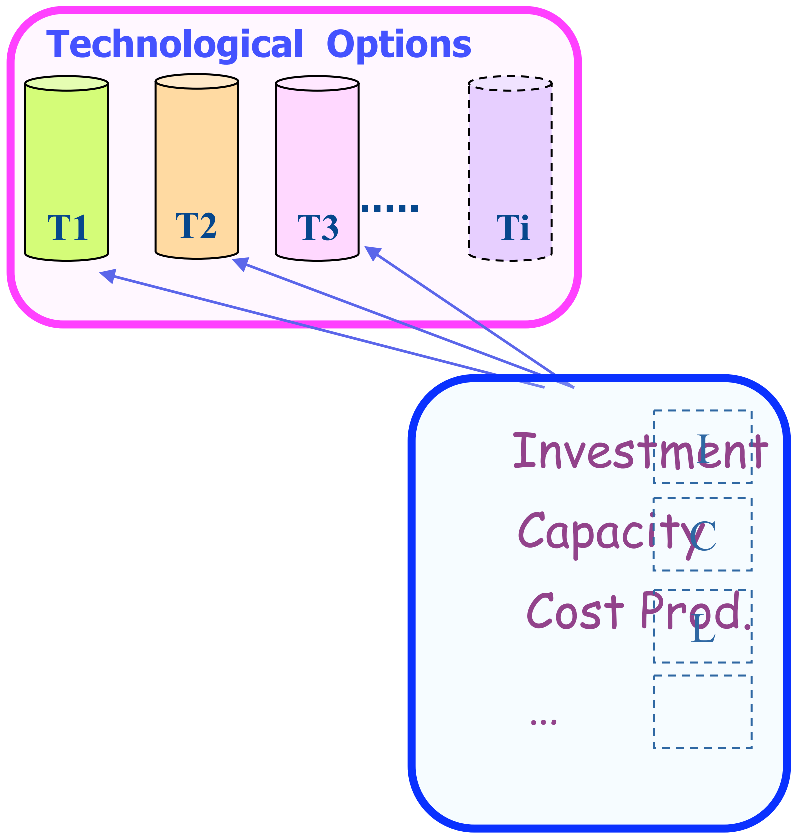
TIMES (steel industry)



Times : The Reference Energy System (RES)

✓The model manages the decommissioning of production units





Need of data

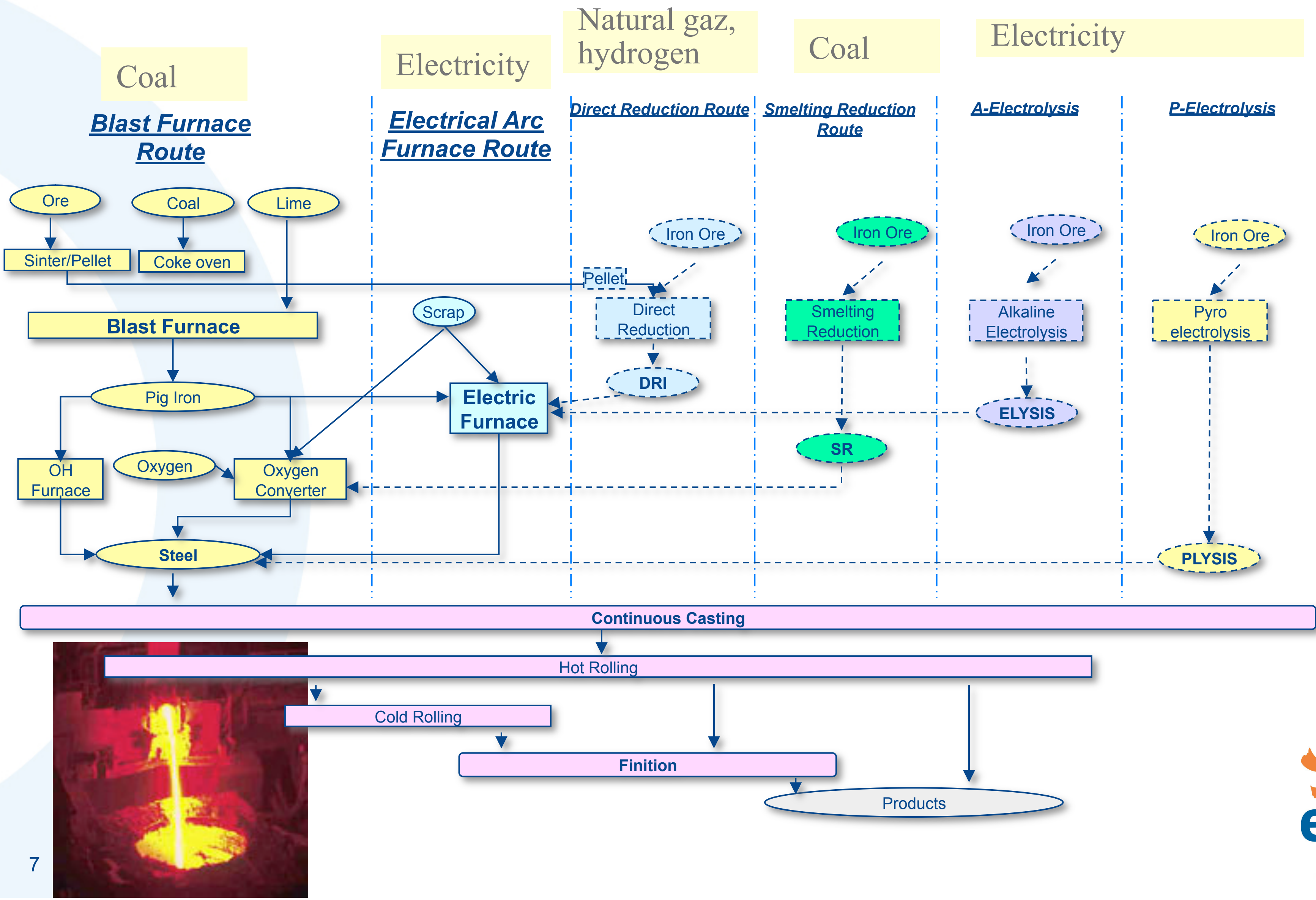
Industrial stock (plants age, production capacity, process)

New Processes (energy efficiency, production cost, investment)

Sources : CEREN,ULCOS, EDF R&D, Centre Technique Papier, BREF (IPPC) , etc…

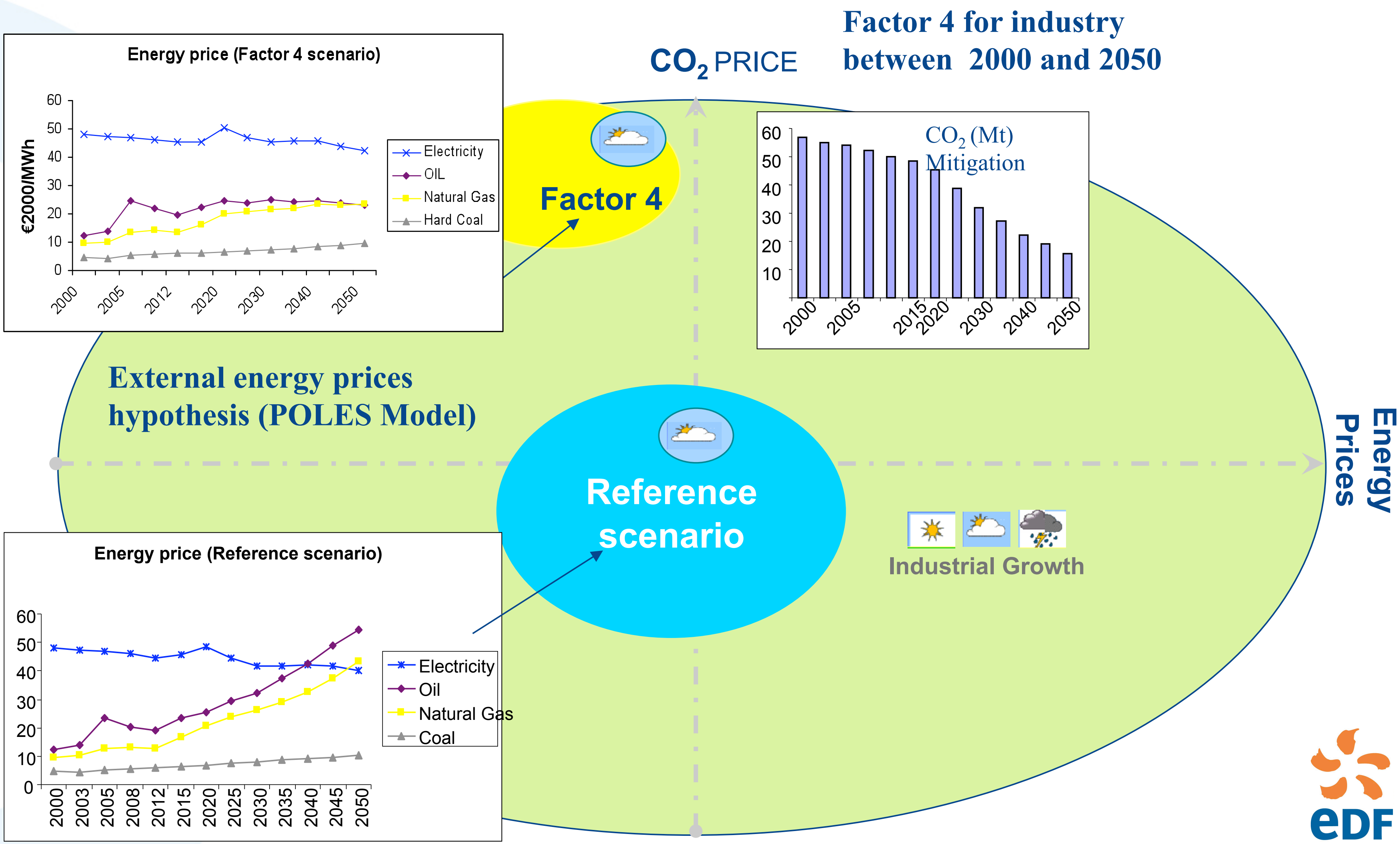
Steel production routes

- six routes (two classics, two news and two futures) with several technologies for each one



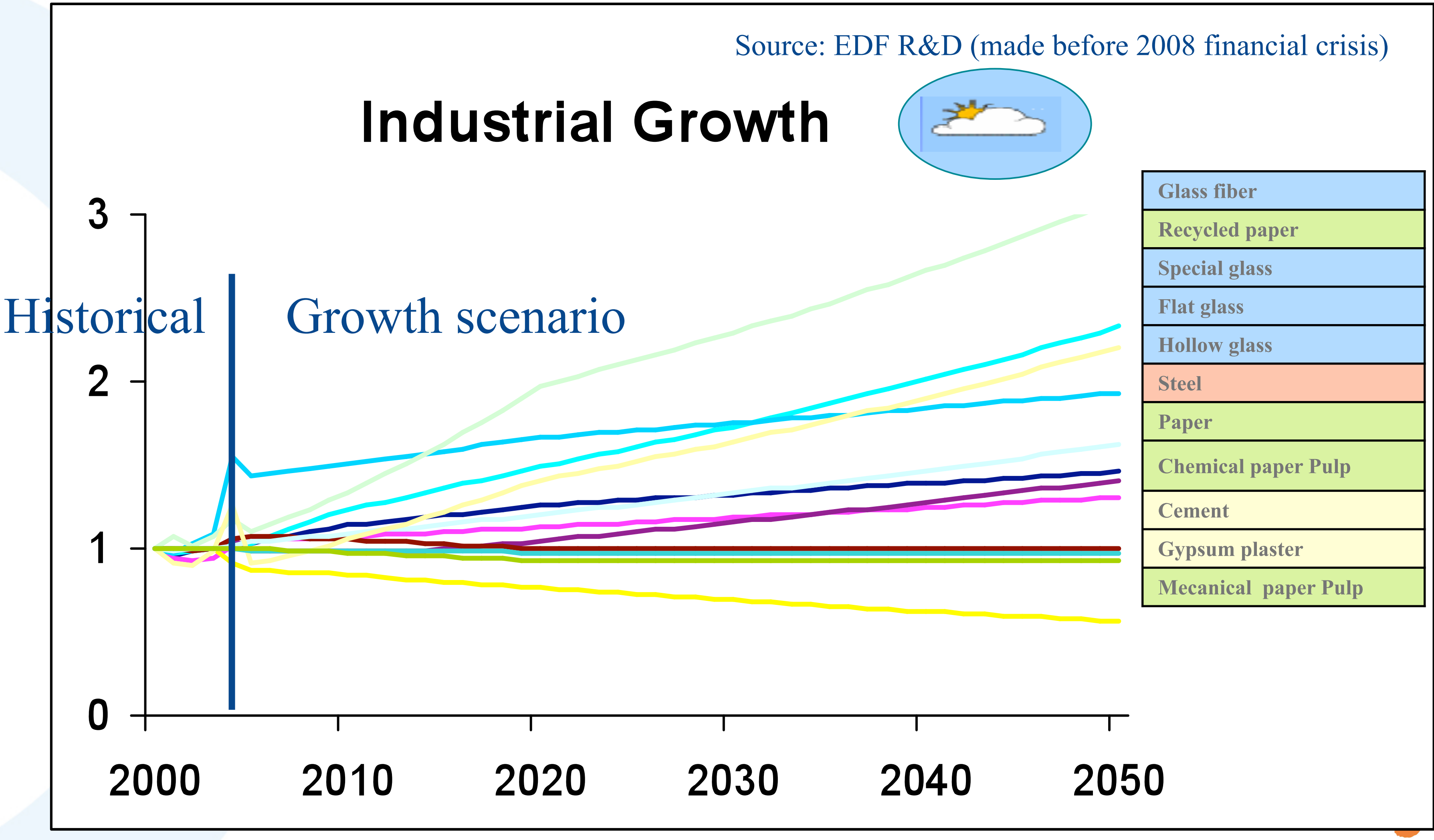
Factor 4 case study (France)

Scenarios : *Energy and CO_2*



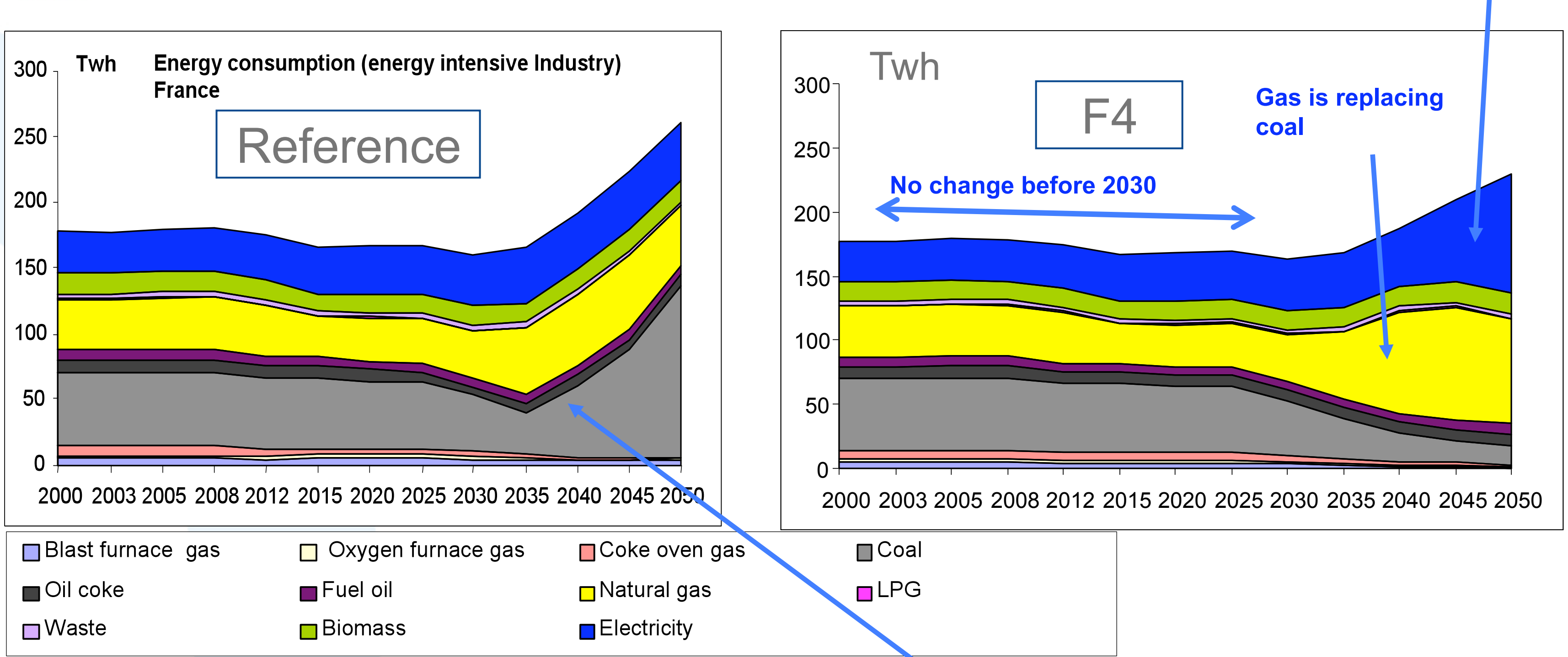
Factor 4 case study (France)

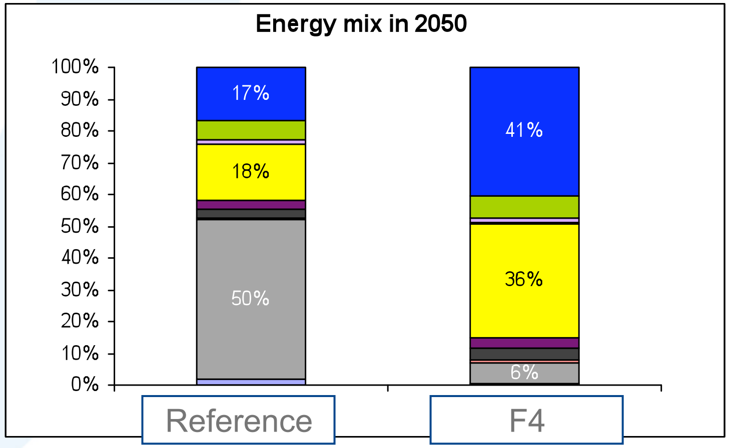
Scenarios : *industrial demand*



F4 results : Influence on energies
(total energy consumption and energy mix)

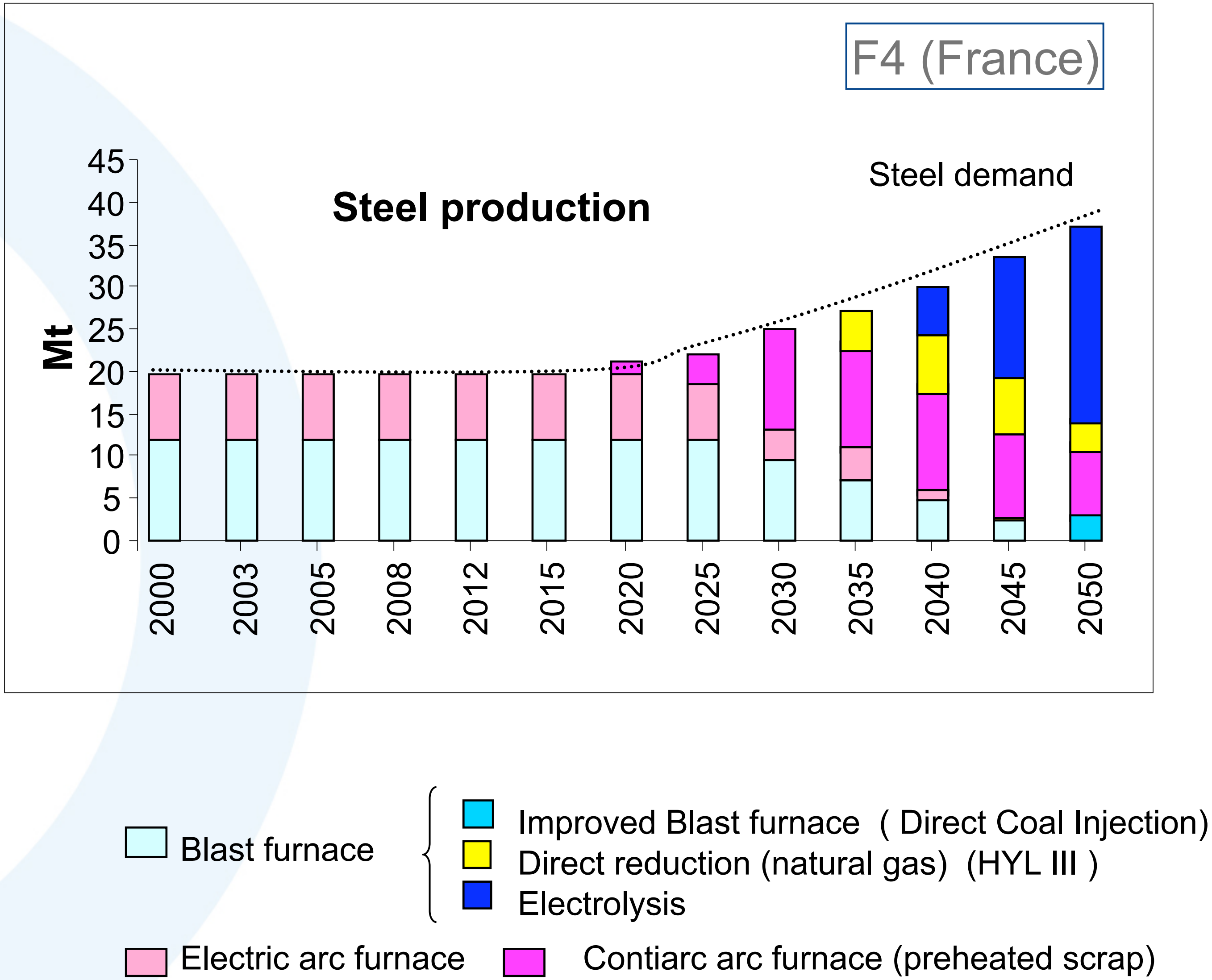
Electrcity is replacing gas





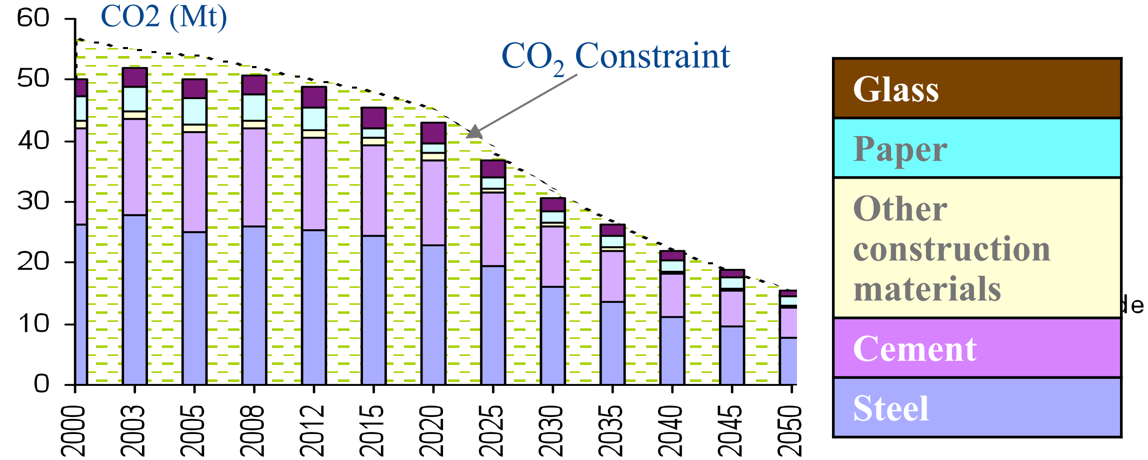
Note : around 2030-35, we supposed a strong growth of french steel industry, supported by a strong world demand (may be too optimistic ?)

F4 results : re-optimisation of industrial processes (steel industry example)



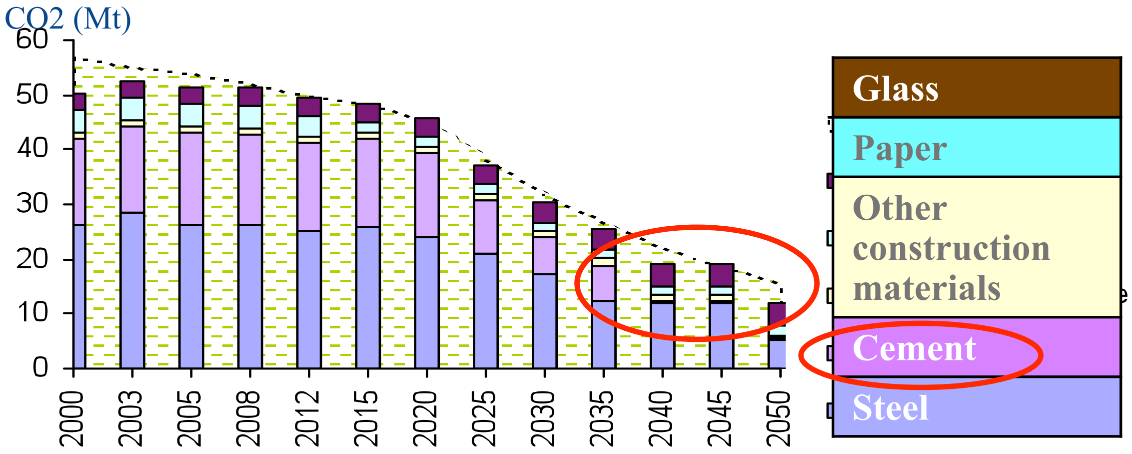
F4 results : Factor 4 imposed to the whole industry ou distributed by sector

Factor 4 distributed by industrial sector



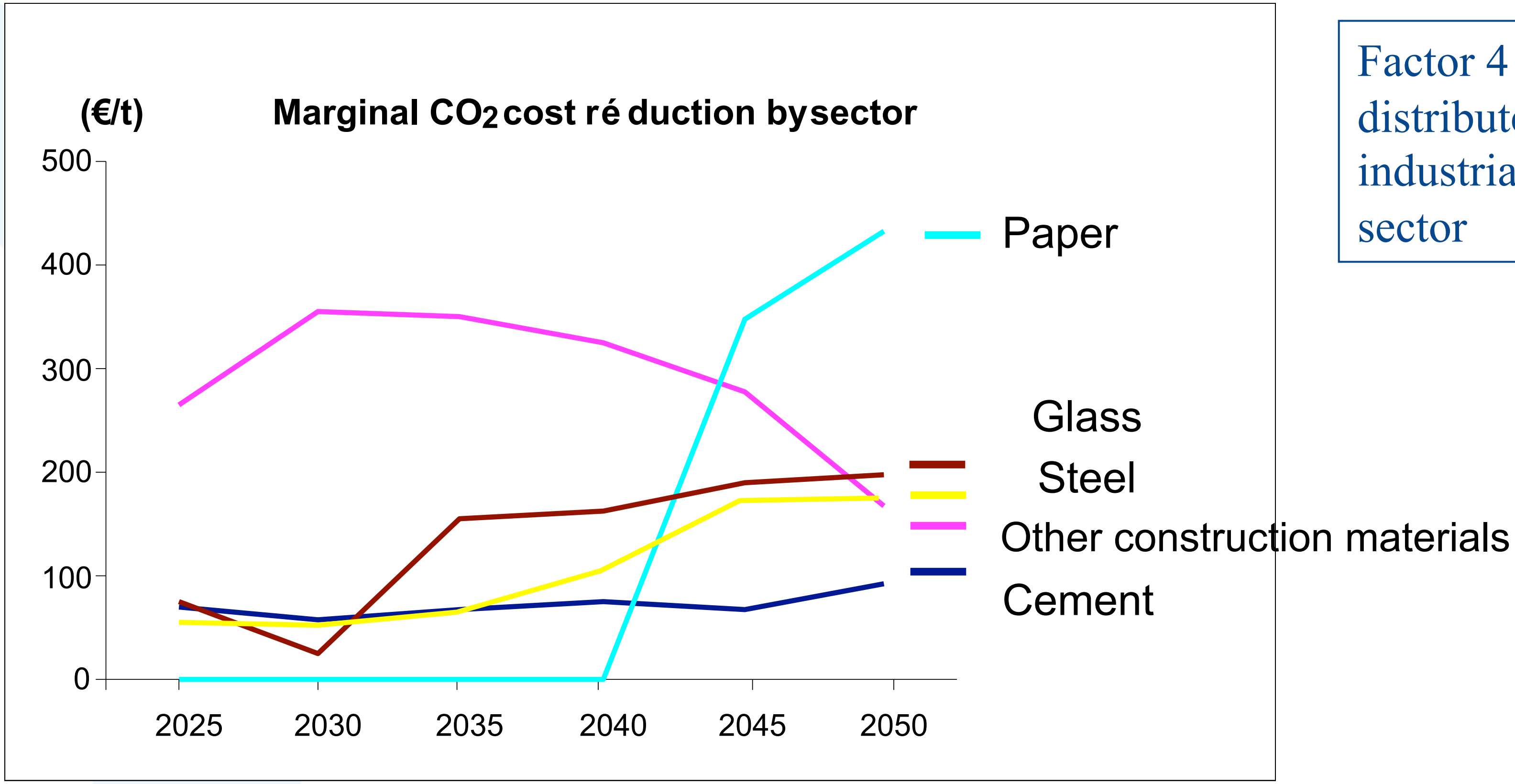
New technologies can reach the objective of factor 4 (mainly with CCS and electricity uses)

Factor 4 for the whole industry



CO_2 effort is more easy for some sectors

F4 results : Marginal cost of CO_2 emissions mitigation

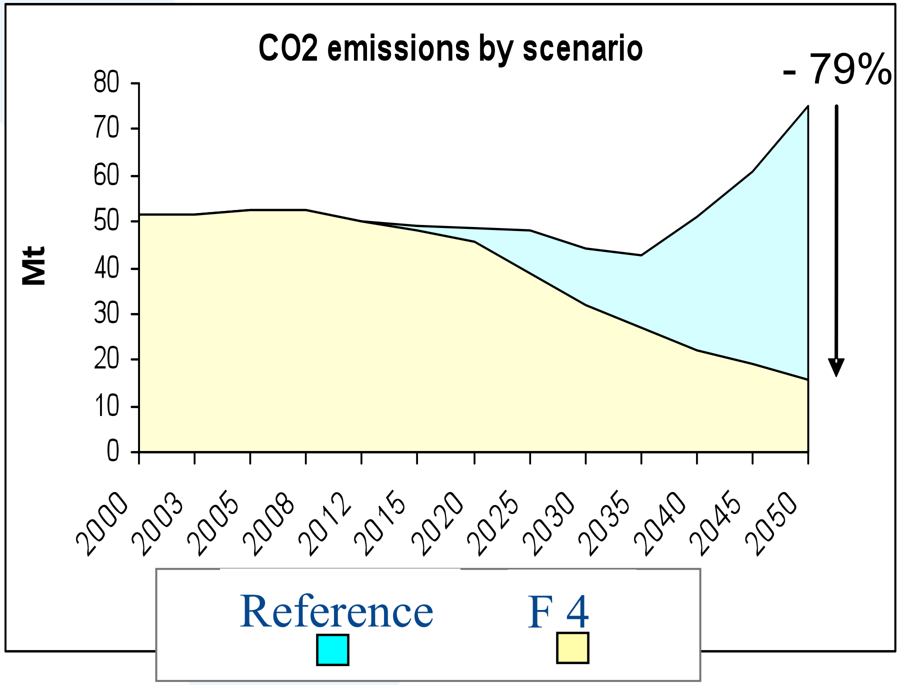


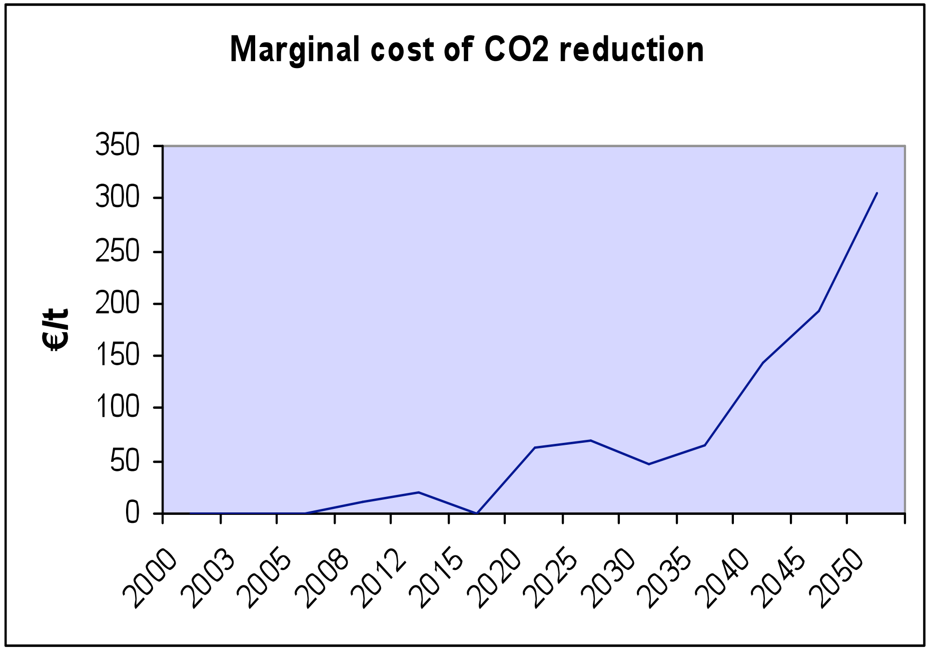
Factor 4 distributed by industrial sector

Marginal cost of CO2 lower for cement industry

F4 results : Marginal cost of CO_2 emissions mitigation for the whole industry

Factor 4 for the whole industry





Conclusions

Interest of TIMES model for industry :

• Full description of the technological choices of the reference energy system of industry. It allows the calculation of the resulting energy mix and the carbon cost for each industrial subsector.

• Limitations :

• Importance of database

• Energy Price scenarios and demand scenarios are exogenous. Consistency has to be ensured. No return effects on price nor demand

F4 case study : 1st exercise with TIMES-industry. Primarily intented to validate the consistency of the tool.

Some restrictions (only industry, no electricity production sector, France is insulated, CCS is accepted). However it shows that there are still technological solutions (electrical processes are revisited) to reduce CO2 emissions in industry.

- Thank you for your attention

Datas on plants (age, production capacity)

- Steel industry (France)

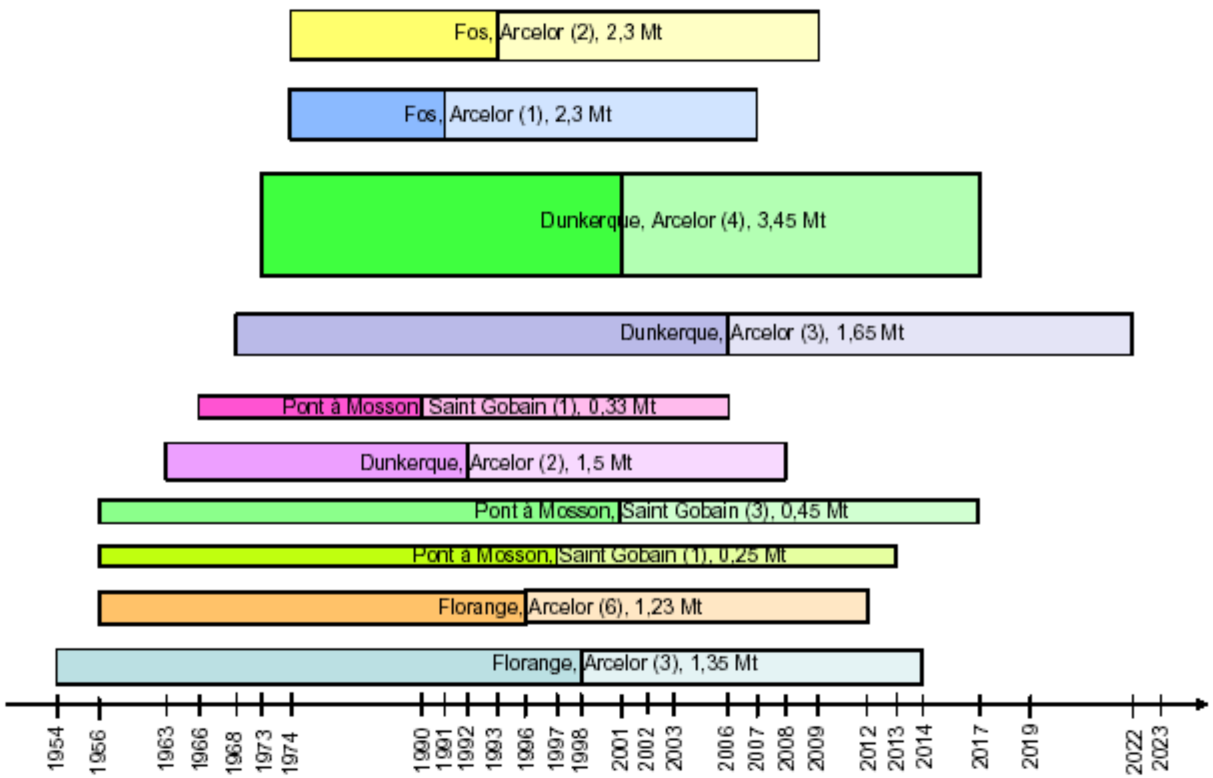


Figure 23 : Structure de la capacité résiduelle pour la sidérurgie en France

Data on technical options (energy efficiency performances)

Secteur	Code	Description	Conventionnelle	MDE	Innovante
Sidérurgie	ISHRNCPRO01	IIS. Hot Rolling New Conv. Process .01.	x		
	ISHRGNCPRO01	IIS. Hot Rolling Gas New Conv. Process .01.	x		
	ISSTLCCPRO01	IIS. New Continuous Casting Process.01.	x		
	ISSCMETPRO01	IIS. New Secondary Metallurgy Process.01.	x		
	ISBOXFURPRO01	IIS. New Blast Oxygen Furnace BOF.Process.01.	x		
	ISEARCFURPRO01	IIS.New Electric Arc Furnace EAF.Process.01.	x		
	ISBLAFURPRO01	IIS.Iron Blast Furnace Process.01.	x		
	ISSNTRPRO01	IIS.Sinter Production Process.01.	x		
	ISCOKOVPRO01	IIS.Coke Oven Process.01.	x		
	ISHRANCPRO01	IIS. Hot Rolling Improved New Conv. Process .01.		x	
	ISHRANCPRO02	IIS. Hot Rolling Impro New Conv. Process .02.		x	
	ISHRAGNCPRO01	IIS. Hot Rolling Impro Gas New Conv. Process .01.		x	
	ISHRAGNCPRO02	IIS. Hot Rolling Impro Gas New Conv. Process .02.		x	
	ISSTLACCPRO01	IIS. New Impro Continuous Casting Process.01.		x	
	ISSTLACCPRO02	IIS. New Impro Continuous Casting Process.02.		x	
	ISSCMETAPRO01	IIS. New Secondary Metallurgy Impro Process.01.		x	
	ISSCMETAPRO02	IIS. New Secondary Metallurgy Impro Process.02.		x	
	ISBOXFURAPRO01	IIS. New Blast Oxygen Furnace BOF Impro Process.01.		x	
	ISBOXFURAPRO02	IIS. New Blast Oxygen Furnace BOF.Impro Process.02.		x	
	ISBOXFURSCRP01	IIS. New Blast Oxygen Furnace Scrap.Process.01.		x	
	ISCCSBFPRO01	IIS.Iron Blast Furnace Process with CCS.01.		x	
	ISDCIBFPRO01	IIS.Iron Blast Furnace Direct Coal Injection Process.01.		x	
	ISSNTRAPRO01	IIS.Sinter Production Impro Process.01.		x	
	ISSNTRAPRO02	IIS.Sinter Production Impro Process.02.		x	
	ISCOKOVAPRO01	IIS.Coke Oven Amel Process.01.		x	
	ISCOKOVAPRO02	IIS.Coke Oven Impro Process.02.		x	
	ISTSCSTLPRO01	IIS. Thin Slab Casting Process .01.			x
	ISSCSTLPRO01	IIS. Strip Casting Process .01.			x
	ISHSMLTPRO01	IIS.Iron HIsmelt Process.01.			x
	ISCOREXPRO01	IIS.Iron COREX Process.01.			x
	ISCCFURPRO01	IIS.Iron Cyclone Convertor Furnace Process .01.			x
	ISCUPOLAPRO01	IIS.Cast Iron Cupola Process.01.			x
	ISELTHYDPRO01	IIS.DRI Electrolytic Hydrogen Process.01.			x
	ISDRIEHPRO01	IIS. Electrolytic Hydrogen for DRI Process. 01			x
	ISSTRFHYDPRO01	IIS.DRI Steam Reforming Hydrogen Process.01.			x
	ISDRISRHPRO01	IIS. Steam Reforming Hydrogen for DRI Process. 01			x
	[illegible]	[illegible]			x
	ISMDRXPRO01	IIS. MIDREX DRI Process .02.			x
	ISALKELYSPRO01	IIS. Alkaline Electrolysis Process .01.			x
	ISPYRELYSPRO01	IIS. Pyroelectrolysis Process.01.			x
	ISHYLPRO01	IIS. HYL III DRI Process .02.			x
	ISEOSSNTRPRO02	IIS. EOS Sinter Production Process.01.			x
	ISCOKDQPRO01	IIS.Coke Dry Quenching Production Process.01.			x

Tableau 5 : Technologies modélisées pour la sidérurgie

For steel production:

9 standard processes

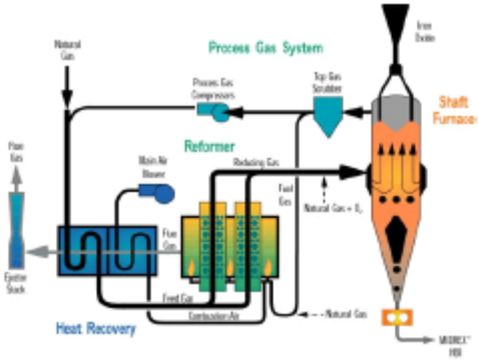
17 Energy efficient processes

19 breakthrough processes

EDF R&D

Datas on production cost

- Example : Midrex (direct reduction by natural gaz via H2,CO)

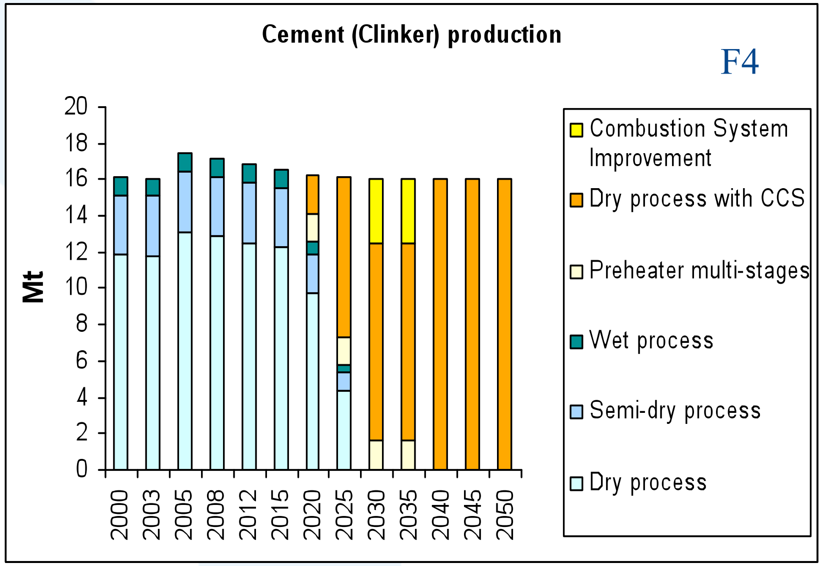


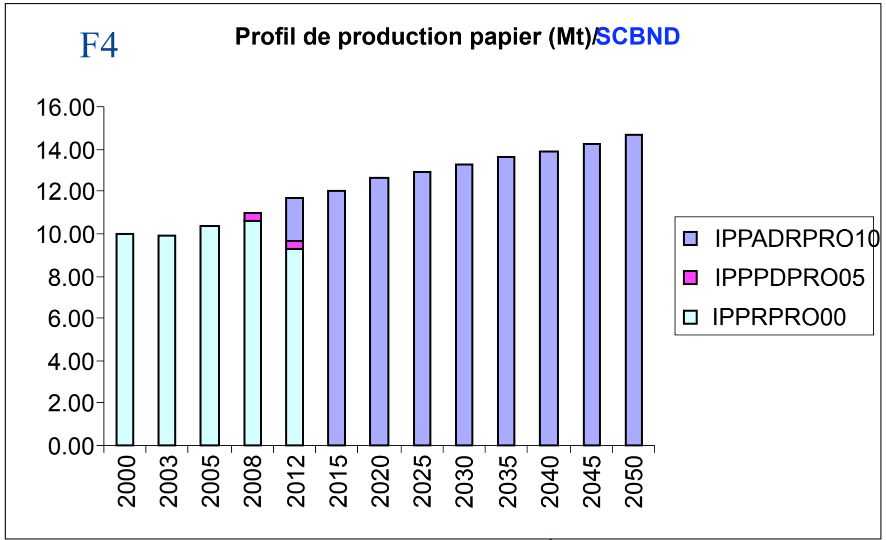
: Schéma descriptif d'un procédé de réduction directe Midrex

Nom de la Technologie		Midrex	Sources	Commentaires
Code TIMES		ISMDRXPRO		
Opérationnel		2005		
Matière	*Entrées* Minerai de fer	1450 kg/t	ITM Sa	
Energie	Gaz Naturel	3030 kWh/t	EIFER	ITM Sa estime 2907 kWh/t
	Electricité	105 kWh/t	BOC GASES	ITM Sa estime 120 kWh/t
Sorties DRI		1000 kg		
Coûts d'investissement		140 €/t	EIFER	
Coûts Opératoires et maintenance				
Coûts Fixes		7 €/t		
Coûts variables		3 €/t		
Durée de vie		25		

Tableau 17 : Description d'un procédé Midrex (données techniques et économiques)

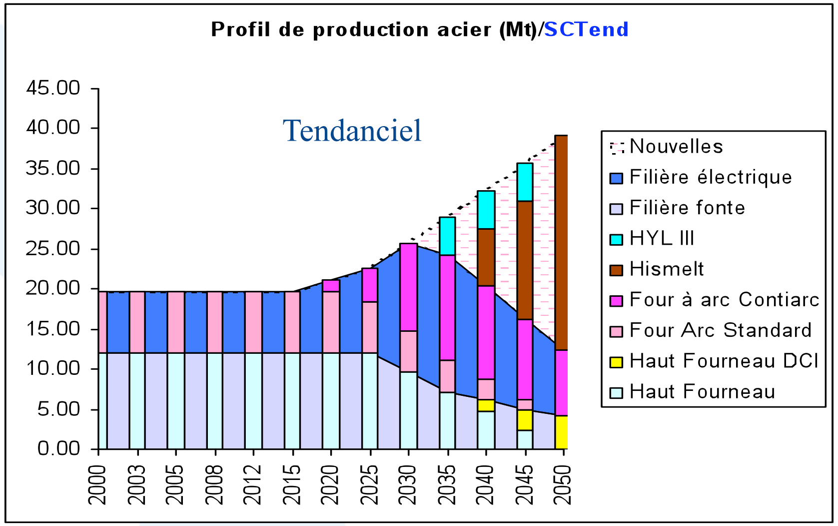
F4 results : re-optimisation of industrial processes (Cement and paper examples)

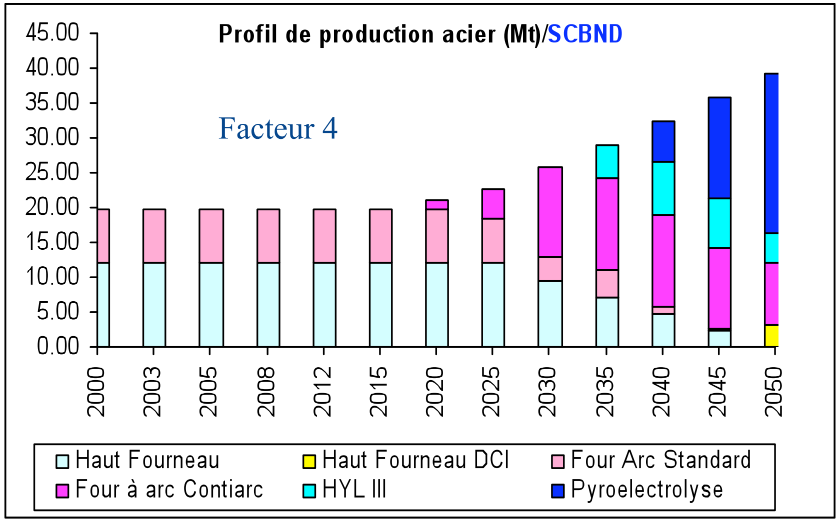




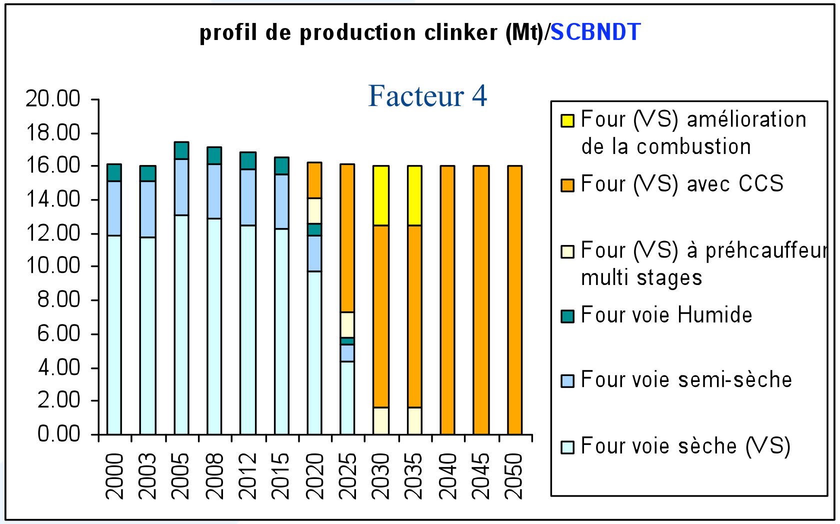
Efficient drying system (drying with vapor compression system)
(Electricity (+15 à +20%), steam (-70 à -90%))
Source : ICARUS-4,

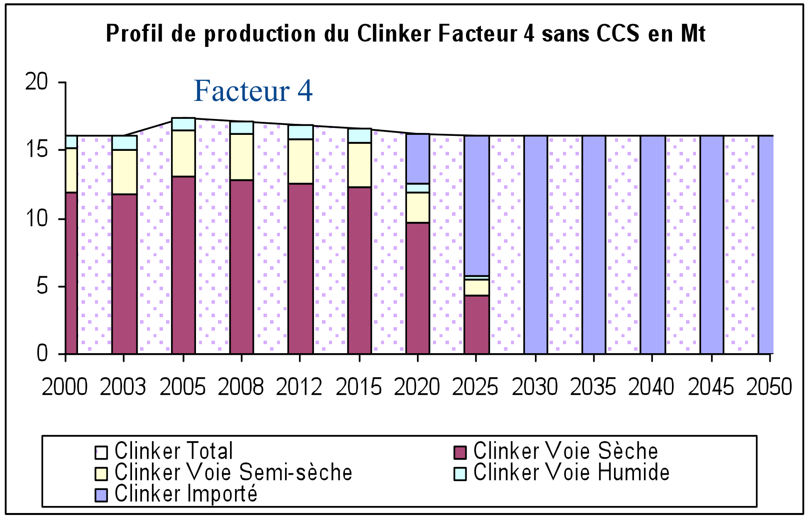
Résultats : Réoptimisation du parc de production par secteurs (sidérurgie,ciment)





La sidérurgie s'oriente vers des techniques électriques





Le ciment s'oriente vers le CCS

Sans CCS, le système ne peut satisfaire la demande sans importer du clinker

EDF R&D