The work plan

My task includes technology description of various technologies in metallurgy for GHG emission reduction in Ukraine and in Europe with allowance different scenarios.

S.O. Semenko
National Metallurgical Academy of Ukraine
semenko92@mail.ru

V.I. Shatokha
National Metallurgical Academy of Ukraine
Shatokha@metal.nmetau.edu.ua

Purpose of my research

1. Overall assessment of the state of opportunities to prevent a climate change.

2. My research presents for spurring deployment of the most important clean technologies and for overcoming existing barriers.

3. Development of scenarios for the purpose to show variants of development metallurgy in future with allowance GHG emission reduction.

The technologies prioritization

The price factor

Technologies	Investment cost	Productivity
HIsarna	100	1 Mt/year
Finex	460	2 Mt/year
CCS with BF	107	0.5-5.0 Mt/year Depends on furnace volume
Blast furnace without any GHG reductions technologies	90	0.5-5.0 Mt/year Depends on furnace volume
Fastmelt	150	1.5 Mt/year
Blast furnace TGR configuration	100	0.5-5.0 Mt/year Depends on furnace volume

The technologies prioritization

The emission factor

Technologies	Type of raw materials	GHG emission
HIsarna	Char coal, iron ore, scale, agglomerate.	With CCS: -0,33 tCO_2/t HM Without CCS: -1.32 tCO_2/t HM
Finex	Char coal, iron ore, scale, agglomerate, **coking coal**	With CCS: -0,2313 tCO_2/t HM Without CCS: - 1.864 tCO_2/t HM
CCS with BF	iron ore, **coking coal,** agglomerate, limestone	0,34 tCO_2/t HM
Blast furnace without any GHG reductions technologies	iron ore, **coking coal**, agglomerate, limestone	1,742 tCO_2/t HM
Fastmelt	Char coal, iron ore, scale, agglomerate.	With CCS: -0,76 tCO_2/t HM Without CCS – 1,59 tCO_2/t HM
Blast furnace TGR configuration	iron ore, **coking coal**, agglomerate, limestone	With CCS: -0,79 tCO_2/t HM Without CCS – not relevant

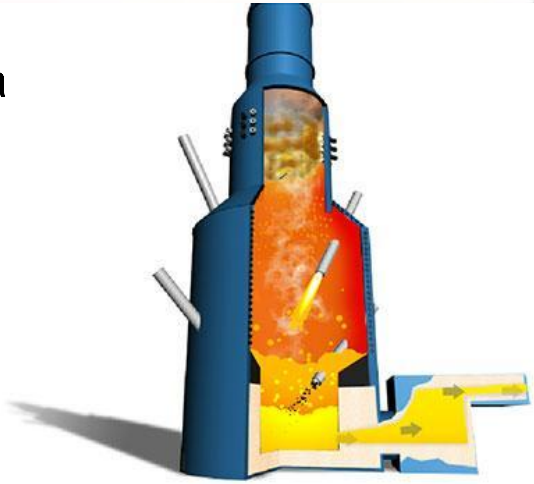
The initial data

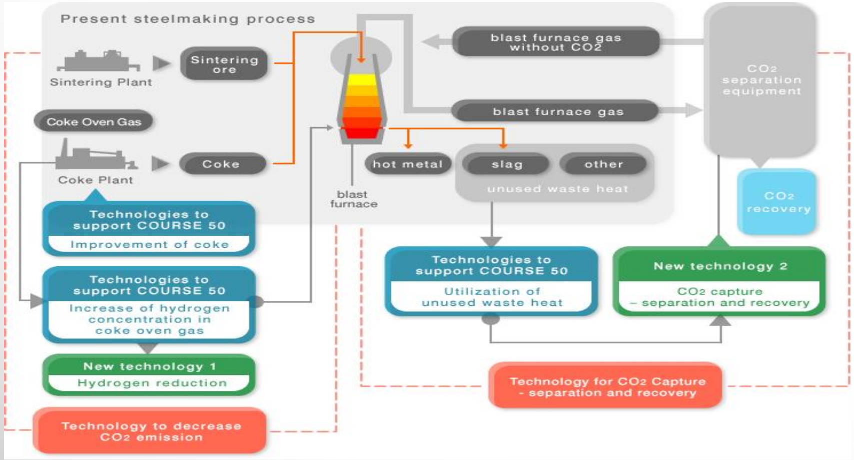
First scenario

6

Technologies

HIsarna





Bf with CCS

Structure of existing technologies

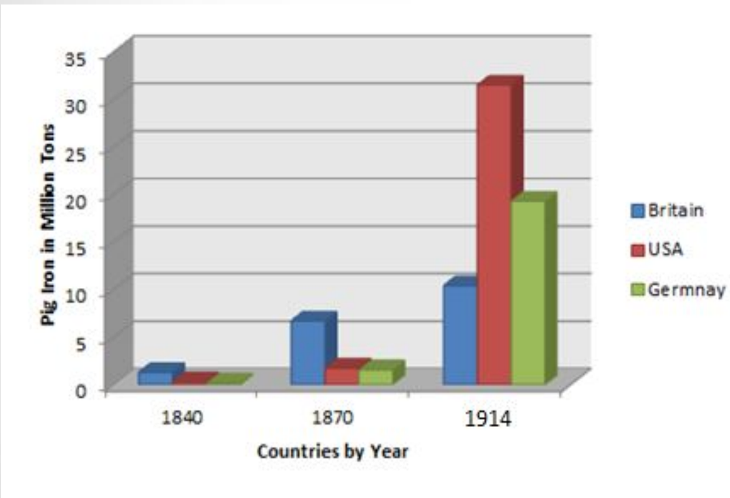
Three-level approach: energy price sensitivity analysis on 3 levels

	Agglomeration	Integrated route	EAF route
Incremental	• Sinter plant cooler heat recovery • Coke dry quenching (CDQ)	• Injection of H_2 rich reductants[1] • Injection of H_2 into shaft • Pellet ratio to BF optimization • Top gas recovery turbine (TRT) • Waste gas recovery	• Heat recovery • Optimization
Substitution		• Corex • Finex • Hlsama	• Midrex / HyL based on natural gas • Finmet / Ulcored based on natural gas + fine ores
		Synergies between different technologies[2]	Synergies between different technologies[2]
Breakthrough		• Top gas recovery (TGR)	
		Combination of technologies with CCS[3]	Combination of technologies with CCS[3]

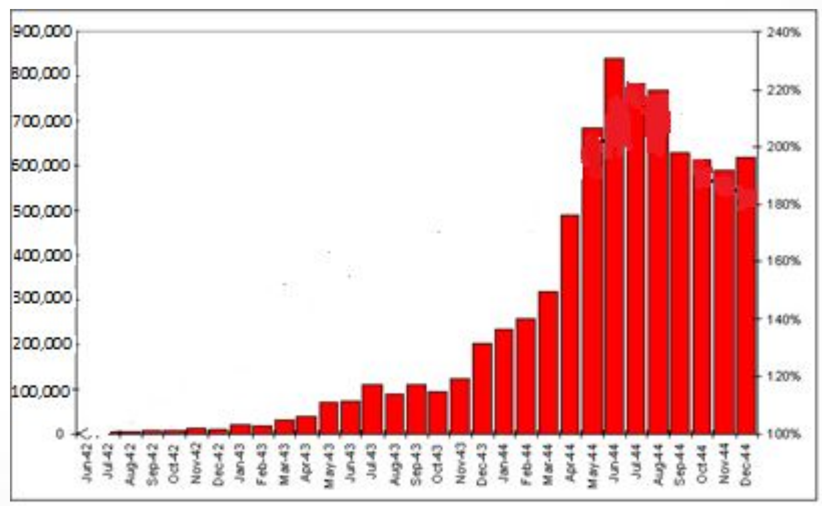
NB: efficiency increase in waste gases-fired power plants not in the scope

Development of scenarios

The impact of the war on steel production in different countries.



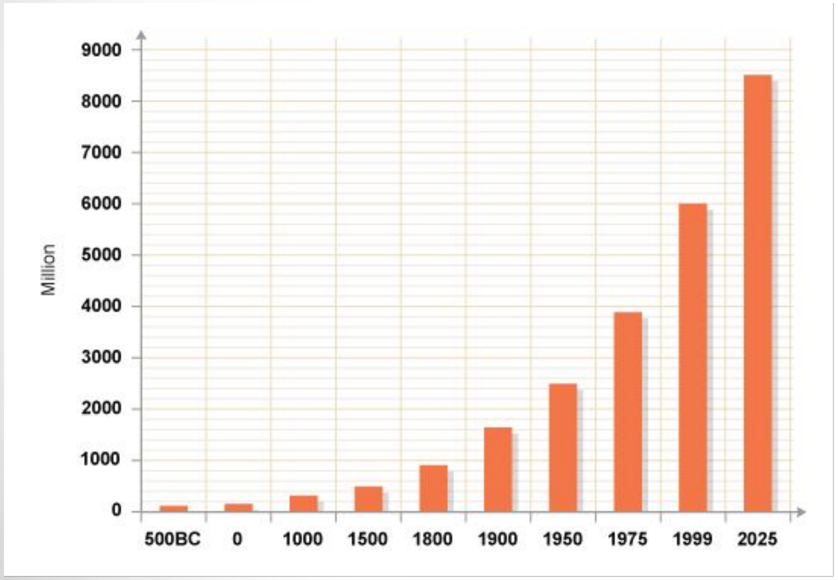
Steel production before 1 world war

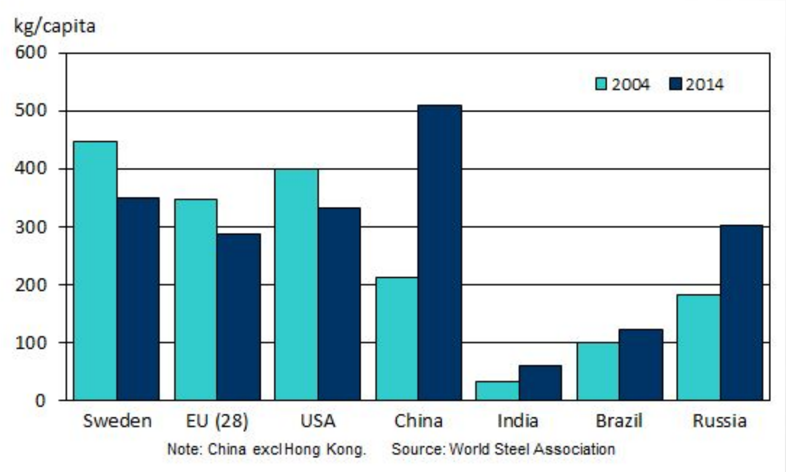


Steel production in Europe 1942-1944

Development of scenarios

The impact of the growth of population on steel production





Steel consumption per capita

[11] Calculation of GHG emission in metallurgy

GHG = Ef reducing agent +Ef consump. of fuel +EF energy consump.

Formula for calculation

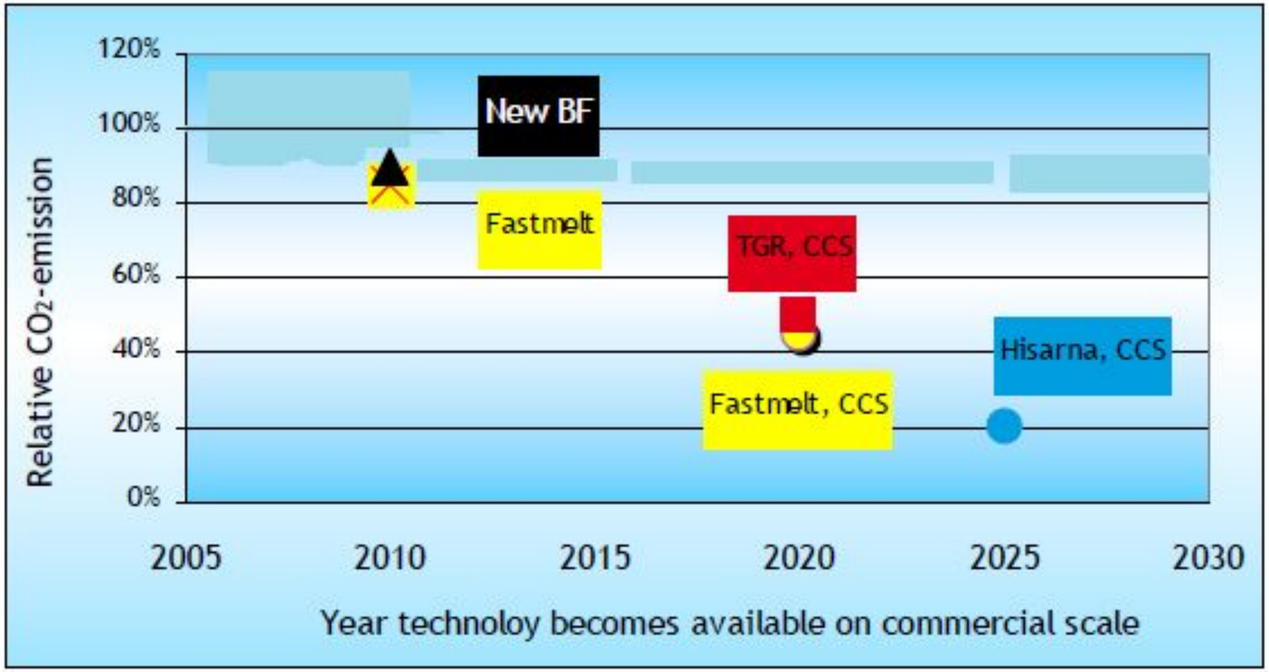
$$EF_{i',BL,\mathrm{Re}\,ducing\ Agent(s)} = Average\left(\frac{\sum_{j=1}^{n} RAC_{i',j,BL,y'} \times \left(\frac{C_{i',j,BL,y'}}{100} \right) \times \left(\frac{44}{12} \right)}{P_{i',BL,y'}} \right)$$

$$EF_{i',BL,Fuel(s),y} = Average\left\{ \frac{\sum_{k=1}^{n} \left\{ FC_{i',k,BL,y'} \times \left(Cp_{i',k,BL,y'} \times \left(t_{i',k,BL,y'} - t_{ref} \right) + NCV_{i',k,BL,y'} \right) \right\} \times EF_{CO_2,i',k,BL,y}}{P_{i',BL,y'}} \right\}$$

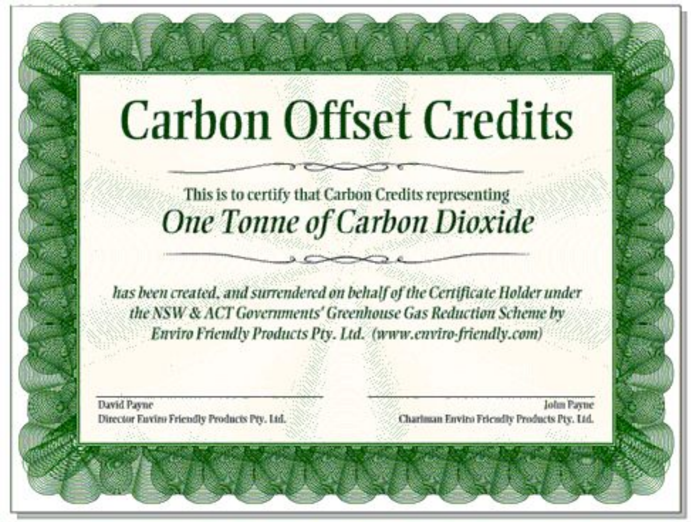
Emission results

Technologies	Finex	Finex with CCS	Hisarna	Hisarna with CCS	Blast furnace with CCS
GHG emission	Average 1,6-1,8 t.Co_2/t. metal	0,25-0,35 t.Co_2/t. metal	Av. 1,3-1,4 t.Co_2/t. metal	0,33-0,5 t.Co_2/t. metal	Av. 0,35-0,43 t.Co_2/t. metal

The availability of technologies



Profit



On the reduced emissions, will be obtained certificate, which could be sold on exchange

Thank you for your attention