TECHNOLOGY FACTSHEET

LOW-TEMPERATURE ELECTROWINNING FOR STEELMAKING (ULCOWIN)

Date of factsheet	14-8-2020
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Sector	Industry: Iron and steel
	All
ETS / Non-ETS	ETS
Type of Technology	Emission reduction
Description	The electrowinning process, called ULCOWIN under the ULCOS project, is a low-temperature electrolysis process that produces solid state elemental iron from iron ore. Iron ore (or hematite, Fe2O3) particles are suspended in an alkaline electrolyte solution at about 100-110 . A current passes through the solution, from anode to cathode. Oxygen particles (with negative charge) are attracted to the anode, and are released at the surface of the solution, and elemental iron (with positive charge) forms crystals on the surface of the cathode. (Junjie 2018) The iron is then fed into an electric arc furnace (EAF) with a small amount of coke (or other carbon source for steelmaking) to make liquid crude steel. This iron can also be combined with scrap steel in the EAF, though this factsheet assumes that the iron input comes entirely from virgin iron from electrowinning. The EAF is a well-known, commercially mature technology that is widely used to produce mainly secondary steel using scrap and virgin materials. (European Commission 2016)
TRL level 2020	TRL 5
	The electrowinning process has been demonstrated at pilot scale by both the ULCOS (Ultra-Low CO2 Steelmaking) and IERO (Iron production by electrochemical reduction of its oxide for high CO2 mitigation) projects. The Siderwin (Development of new methodologieS for InDustrial CO2-freE steel pRoduction by electroWINning) project, running from 2017-2022, led by ArcelorMittal along with other industrial partners, with Horizon2020 funding, aims to bring the technology to TRL 6. (Siderwin 2019).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	Mton crude steel		-								
			Min		-			*Max*			
Potential			**Current**			**2030**			**2050**		
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Market share		%	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Capacity utlization factor	1.00										
Full-load running hours per year											
Unit of Activity	Mton crude steel/year										
Technical lifetime (years)											
Progress ratio											
Hourly profile	No										
Explanation	The current pilot plant has a capacity of only a few kilograms of output, and a pilot cell with about 100 kg capacity is under construction. (ArcelorMittal 2020) Because the technology has not yet been implemented at large scale, no potential or typical capacity has been estimated. However, the installation would be modular, with stacked electrolytic cells, and there is some experience with this type of technology in other metals sectors.										

COSTS

Year of Euro	2015										
Investment costs	**Euro per Functional Unit**		**Current**			**2030**			**2050**		
	mln. € / Mton crude steel		-			-			640.00		
			Min	–	*Max*	*Min*	–	*Max*	618.00	–	1,254.00
Other costs per year	mln. € / Mton crude steel		-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / Mton crude steel		-			-			45.00		
			Min	–	*Max*	*Min*	–	*Max*	45.00	–	45.00
Variable costs per year	mln. € / Mton crude steel		-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Costs explanation	CAPEX includes equipment needed for the full process from iron ore to crude steel. EAF CAPEX is included in these values. Fixed OPEX has not been described in the literature, and has therefore been estimated at about 7% of CAPEX, based on the fixed operating and maintenance cost for a small alkaline electrolyser cell for hydrogen production (Marsidi 2019). Variable costs (raw material costs, excluding energy costs) are around €199 million/Mton crude steel (European Commission 2016), including iron ore (1.51 t ore/t crude steel), limestone (0.143 t limestone/t crude steel), compressed air (64.8 normal cubic meters/t crude steel), and coke (0.03 t coke/t crude steel). European Commission (2016) does not break down variable costs in detail, but the largest share of variable costs are for iron ore purchase. European Commission (2016) provides annualized capital investment costs, without specifying a discount rate or equipment lifetime. The overnight capital costs from this source given in this factsheet were derived from the annualized costs assuming a range of discount rates of 5%-10% and equipment economic lifetimes of 10-20 years.										

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:* Electricity	PJ	-			-			11.96		
			Min	–	*Max*	*Min*	–	*Max*	11.34	–	14.26
	Natural gas	PJ	-			-			2.05		
			Min	–	*Max*	*Min*	–	*Max*	1.74	–	2.46
	Coke	PJ	-			-			0.86		
			Min	–	*Max*	*Min*	–	*Max*	0.86	–	0.86
		PJ	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Energy in- and Outputs explanation	Natural gas is used for lime production, injected into the electric arc furnace as a supplemental heat source, and used in hot rolling. No natural gas is used for the electrowinning step.										

MATERIAL FLOWS (OPTIONAL)

	Material	Unit	Current			2030			2050		
Material flows	Slag	Mton	-			-			-0.17		
			Min	–	*Max*	*Min*	–	*Max*	-0.17	–	-0.08
	Crude steel	Mton	-			-			-1.00		
			Min	–	*Max*	*Min*	–	*Max*	-1.00	–	-1.00
Material flows explanation	Slag is produced in the electric arc furnace (EAF). Additional material flows are described below in the section "Other".										

EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS)

	Substance	Unit	Current			2030			2050		
Emissions	CO2 (process)	Mton	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	-	–	-
	SO2	Mton	-			-			0.00		
			Min	–	*Max*	*Min*	–	*Max*	0.00	–	0.00
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Emissions explanation	The only direct CO2 emissions from electrowinning steelmaking are from potential natural gas use for the EAF and hot rolling steps. No process CO2 is emitted; O2 is produced from the electrolytic cell. Oxygen has not been considered as an "emission" as it could be captured and sold or utilized.										

OTHER											
Parameter	**Unit**	**Current**			**2030**			**2050**			
Oxygen	million Nm^3		-			-			-260.00		
		Min	–	*Max*	*Min*	–	*Max*	-260.00	–	-260.00	
Iron ore	Mton		-			-			1.51		
		Min	–	*Max*	*Min*	–	*Max*	1.51	–	1.51	
Limestone	Mton		-			-			0.14		
		Min	–	*Max*	*Min*	–	*Max*	0.03	–	0.14	
Compressed air	million Nm^3		-			-			64.80		
		Min	–	*Max*	*Min*	–	*Max*	64.80	–	64.80	
Explanation	Oxygen is a byproduct of the electrolytic process, and is given in units of million normal cubic meters. The coke, though it has energy content, is injected into the EAF as a raw material to provide a carbon source for the steel and is not combusted.										

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