Decarbonization of ILVA Steel plant

Fatima Roudani
Stefania Margaret Neglia
Ajitesh Anand (Advisor)

HEC EMBA

Executive Summary

- To continue its production, **ILVA will have to substitute its furnaces in the years between 2032 and 2041**. No bank or institute would finance these investments if the new technologies implemented are not green, therefore going green is mandatory for ILVA

- **ILVA will substitute its furnaces gradually (years 2032, 2037, 2041) with DRI EAF H_2 technology**, allowing almost complete abatement of Scope 1 process emissions by 2041 and a significant portion of Scope 3 emissions, mainly related to raw materials extraction

- **ILVA will reduce its Scope 1 energy related emissions through a gradual substitution of the natural gas** used today **with biogas or hydrogen**, to be completed by 2050, **and through the increase of the efficiency of the energy-intensive machinery in the plant (-30% energy consumption by 2030)**

- To completely abate **Scope 3 emissions**, it is assumed that: on one side the industries related to these will improve their performances, and on the other transportation will become less and less carbon intensive, further reducing ILVA's Scope 3 emissions. Last. ILVA will have to cooperate with its suppliers and distributers in order to put in place initiatives to offset the residual emissions in its supply chain,
- A yearly cash flow analysis shows that applying the roadmap defined, the **total OPEX costs for ILVA are constantly lower compared to maintaining the actual technology**, therefore leading to a more competitive production process.

- An early estimate shows that **to ensure production at a profit price of steel by 2050 will have to be greater than 707 €/t,** an increase equal to about 27% compared to today's average, yet **supported by CBAM mechanism**

Agenda

Context and background

Regulatory and notional Context

Recommendations

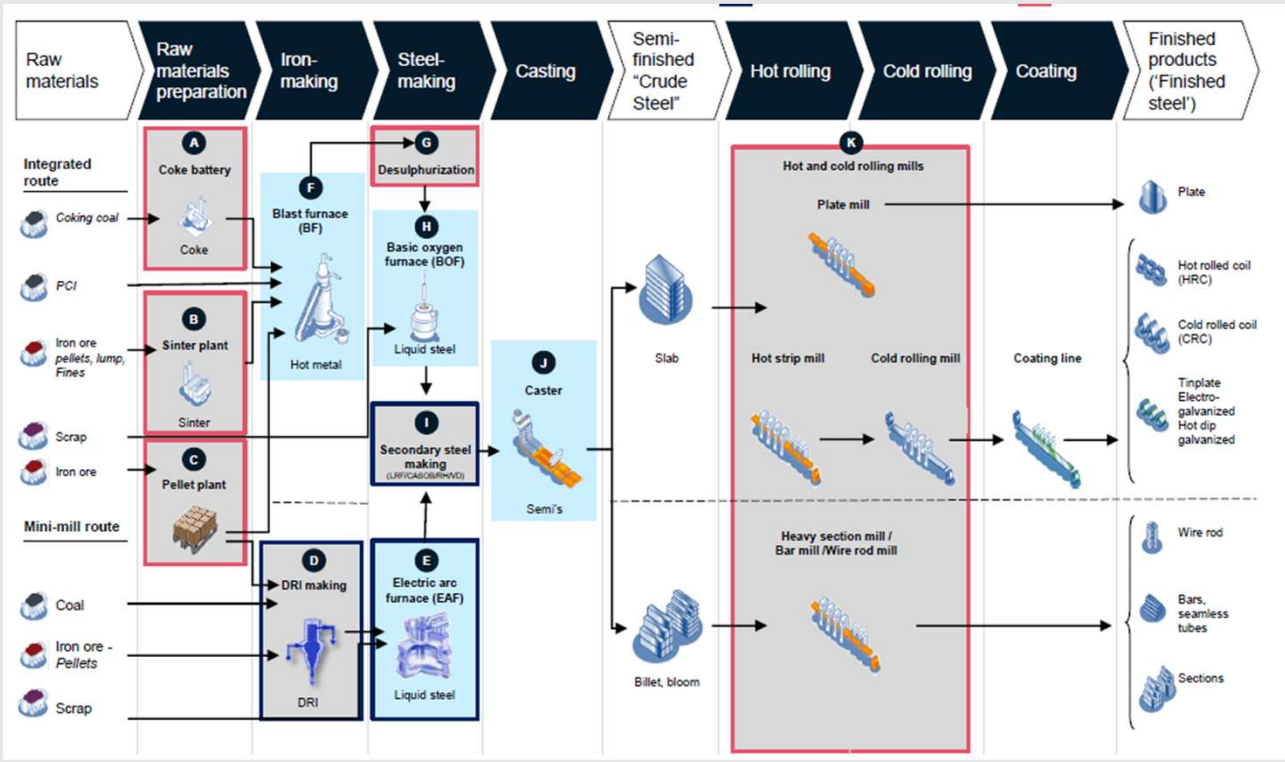
Carbon emissions in the steelmaking context

Steel is **traditionally produced through Blast furnace route** consuming high amount of coal in the reduction process

Steel is the largest consumer of coal (75% of its energy demand)

Iron and steel generate **2.6Gt CO_2 emissions**

- 8% of global final energy demand
- 7% of energy sector CO2 emissions



Context and background of ILVA steel production

Europe's biggest steel plant operating since 1965

ILVA **joined ArcelorMittal group on 1st November 2018**. In 2022 the Italian state will have 60% control

ILVA's capacity is 6 Mt (vs. 9 Mt authorized by its environmental authorization in 2021) of steel per year, and as from 2025 ILVA has announced a production of 8Mt/year

ILVA's production in 2019 was 4.6 Mt and in 2020 3.35 Mt. In 2021 the production is expected to recover, and whilst until June the plant was operating with only two blast furnaces (daily production 10kt), since June three blast furnaces are in operation (daily production 15kt)

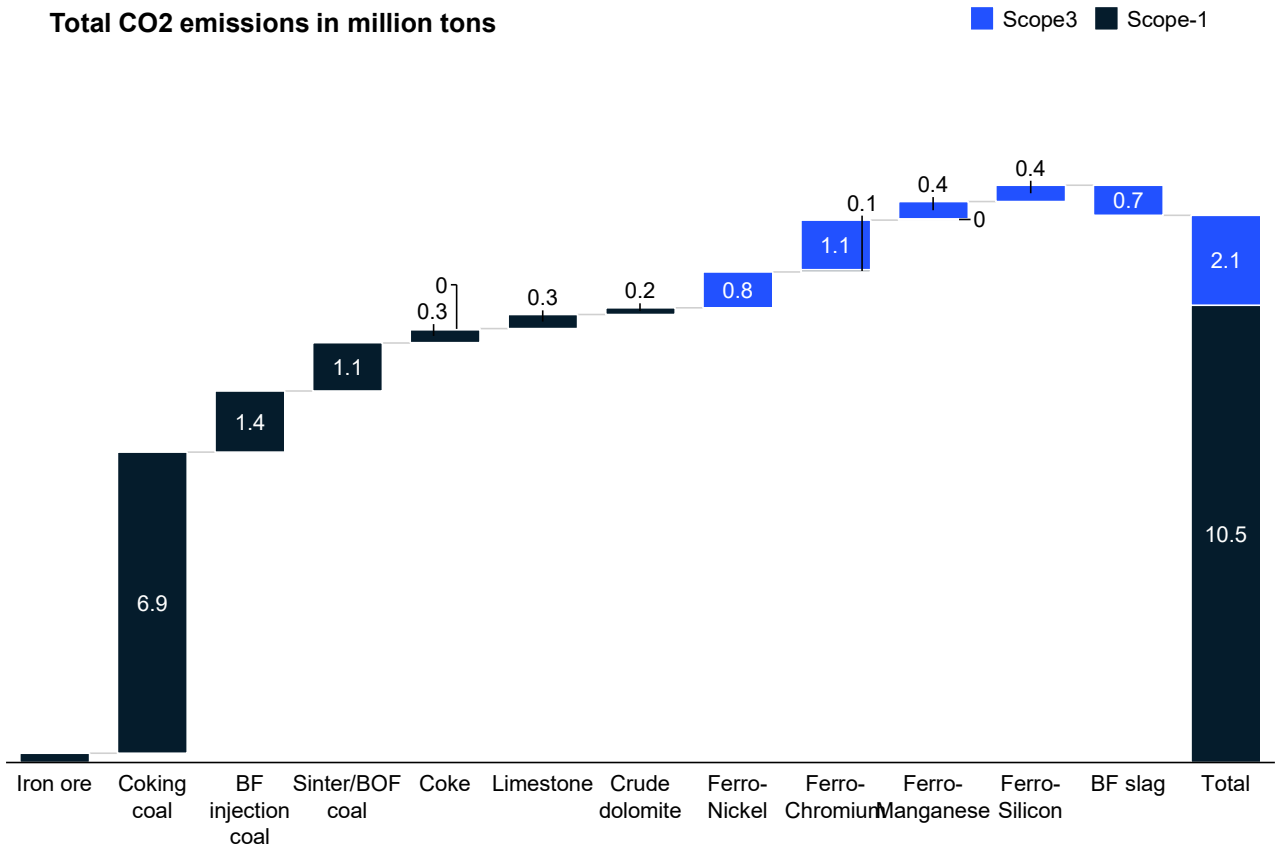
Operating units for ILVA plant as of 2019

ILVA Taranto – Process operating units							
Coke battery	3	BF > 1000 m^3	3	Open hearth	0	Cold rolling	1
Sinter plant	2	100<BF<1000	0	Hot rolling	1	HDG lines	2
Pellet plant	0	BF < 100 m^3	0	Lime kilns	0	EG lines	1
Gas DRI	0	BOF shops	1	Oxygen plant	0	Tining lines	0
Coal DRI	0	EAF units	0	Power plant	0	Smelting Reduction	0

ILVA's Carbon Footprint

ILVA is the **number one carbon producer in Italy** and among **top 10 in Europe**. Its **total CO2 emissions reached >10 million** tons per year in 2019

A quick bottom-up CO2 modelling confirms **10 million tons of direct (scope-1) emissions in 2019 (for 4,6t of steel production) and 2 million tons of scope-3 emissions** mainly related to the extraction and supply of raw materials



Agenda

Context and background

Regulatory and notional Context

Recommendations

EU, National and regional regulatory context

- European Emission Trading Scheme (55% reduction by 2030 and 0 by 2050))

Authorized emissions (Scope 1) emissions must be reduced to **7.54 Mt by 2025**, **5.93 Mt by 2030** and **0 Mt by 2050** (from 13 Mt in 2019)

- European Green Deal

Energy consumption: -**32.5% of primary consumption & at least 32% of renewable energy sources** in the remaining mix by 2030

Scope 2&3 emissions must be **net zero by 2050**

- Directive (EU) 2018/852 of The European Parliament and of the Council

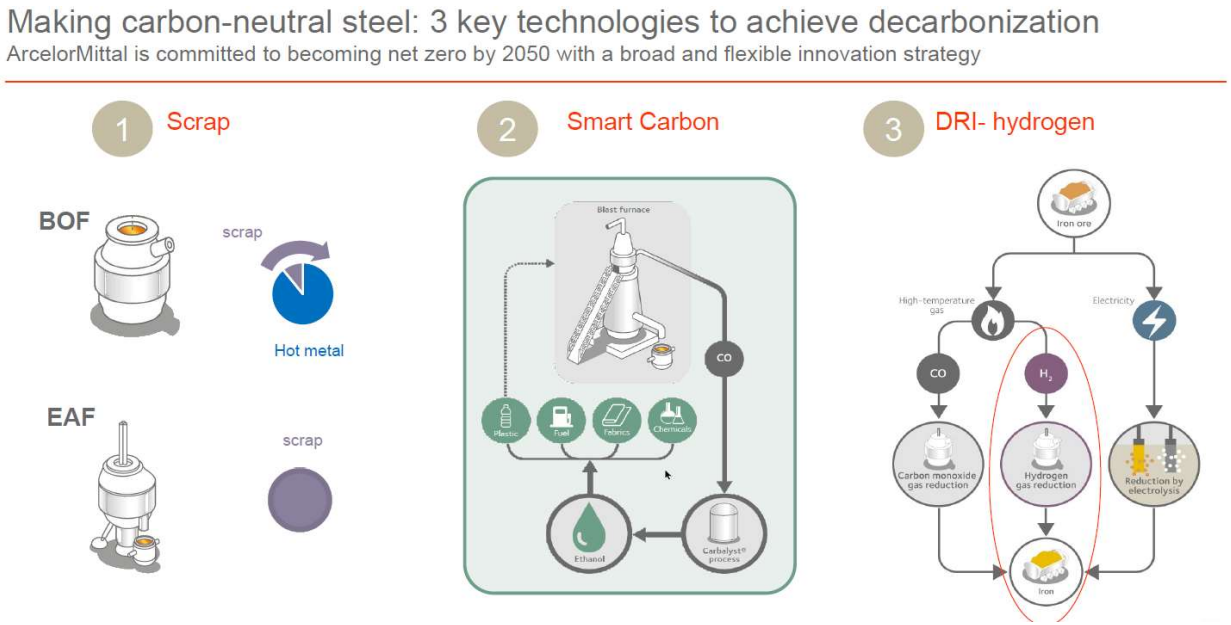
Recycling of steel had to be 80% by 2030 (This target has already been reached by the industry in 2020)

For Ilva, expected amount of **recycled steel in mix up to 50% by 2050**

Regional projects/context:

- "Puglia Green Hydrogen Valley" aims at producing 300 Mmc/year of green hydrogen, to send to the national gas pipelines,
- SNAM to collaborate with ILVA to feed biomass and hydrogen
- Synthesis gas from plasmix (heterogeneous fraction of plastic packaging waste) and CSS (secondary solid fuel), producing a gas rich in CO that could be used in steel mills,
- Puglia is a region that produces around 9.258 GWh/year of green energy

Industrial Roadmap for Arcelor Mittal



Group Carbon intensity is 1.6 tonnes of CO_2 per tonne of crude steel

Group target is to reduce scope 1 CO_2 intensity by 30% by 2030 and be neutral by 2050

The two-breakthrough carbon-neutral technology routes are:

- **Smart Carbon**: use bioenergy from plastic waste and biomass, CCS, replace coal with natural gas, recycle the captured carbon. +30-60% cost increase.
- **Innovative DRI-based route** (post 2030): use hydrogen instead of natural gas in the direct reduction of iron ore (DRI). +50-80% cost increase.

Industrial Roadmap as guided by IEA (1/2)

SDS Scenario (Net zero by 2070)
CO_2 emission intensity to be **reduced to 0.6 tonnes of CO_2 per tonne of crude steel by 2050, from today's 1.4 t** CO_2/t on average (however it has been 2.79 for ILVA)

40% emissions reduction from improving material efficiency, mainly in downstream (e.g., extending building lifetime)

20% reduction from improving operational efficiency (enhanced process control, predictive maintenance strategies etc)

25% reduction from hydrogen and CCUS[1]

Low-cost renewable electricity for hydrogen based DRI, to represent 15% of primary steel production globally by 2050

1. Carbon capture usage/storage

NZE Scenario (Net zero by 2050)
Global CO_2 emissions from the iron and steel sub-sector **fall from 2.4 Gt in 2020 to 1.8 Gt in 2030 and 0.2 Gt in 2050**

By 2050, **electricity and other non-fossil fuels account for around 70% of final energy demand** in the sector, up from 15% in 2020, thanks to EAF and DRI technologies

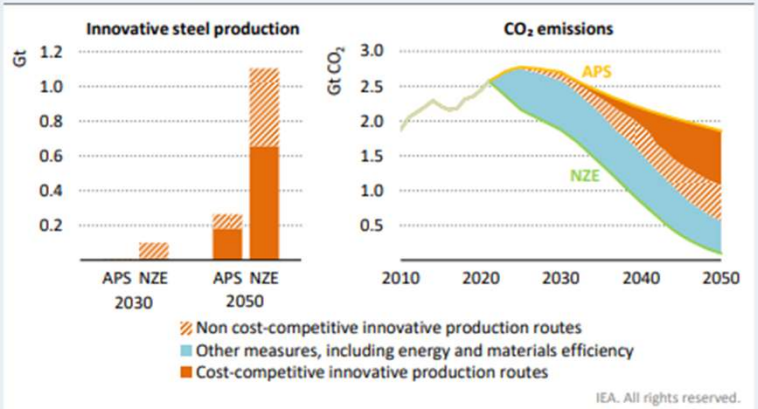
Share of **coal drops from 75% in 2020 to 22% by 2050**, of which 90% is used in conjunction with CCUS

85% of CO_2 reductions in 2030 come from technologies already available in the market. This includes energy efficiency and increase in scarp-based production

After 2030, reductions come from technologies under development, this includes innovative **smelting reduction, natural gas based DRI production** (particularly in regions with low natural gas prices) and **innovative blast furnace retrofit arrangements** in regions with relatively young plants

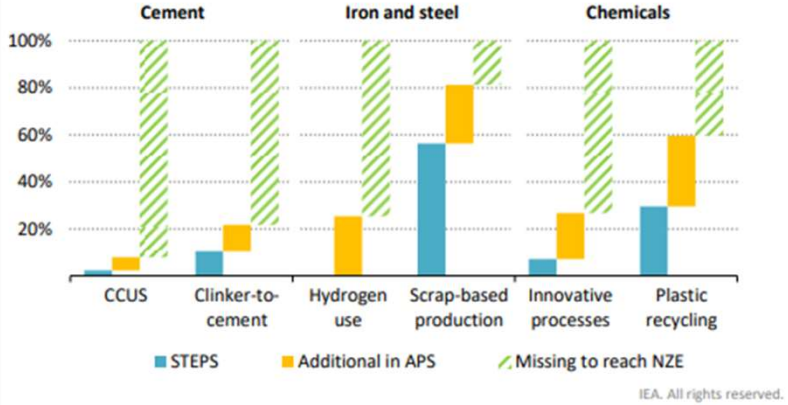
Industrial Roadmap as guided by IEA (2/2)

Figure 3.18 ▷ Cost-competitive steel production from innovative technologies and related CO_2 emissions in the Announced Pledges and Net Zero Emissions by 2050 scenarios



Innovative steel production technologies become cost-competitive in the long term, if the move from experimental to industrial scale takes place before 2030

Figure 3.17 ▷ Tracking progress towards 2030 milestones by industry sub-sector and scenario



Despite good progress in some areas, technology transformation in the industry sector needs to happen much faster than in the APS to meet climate goals

APS: Announced Pledges Scenario

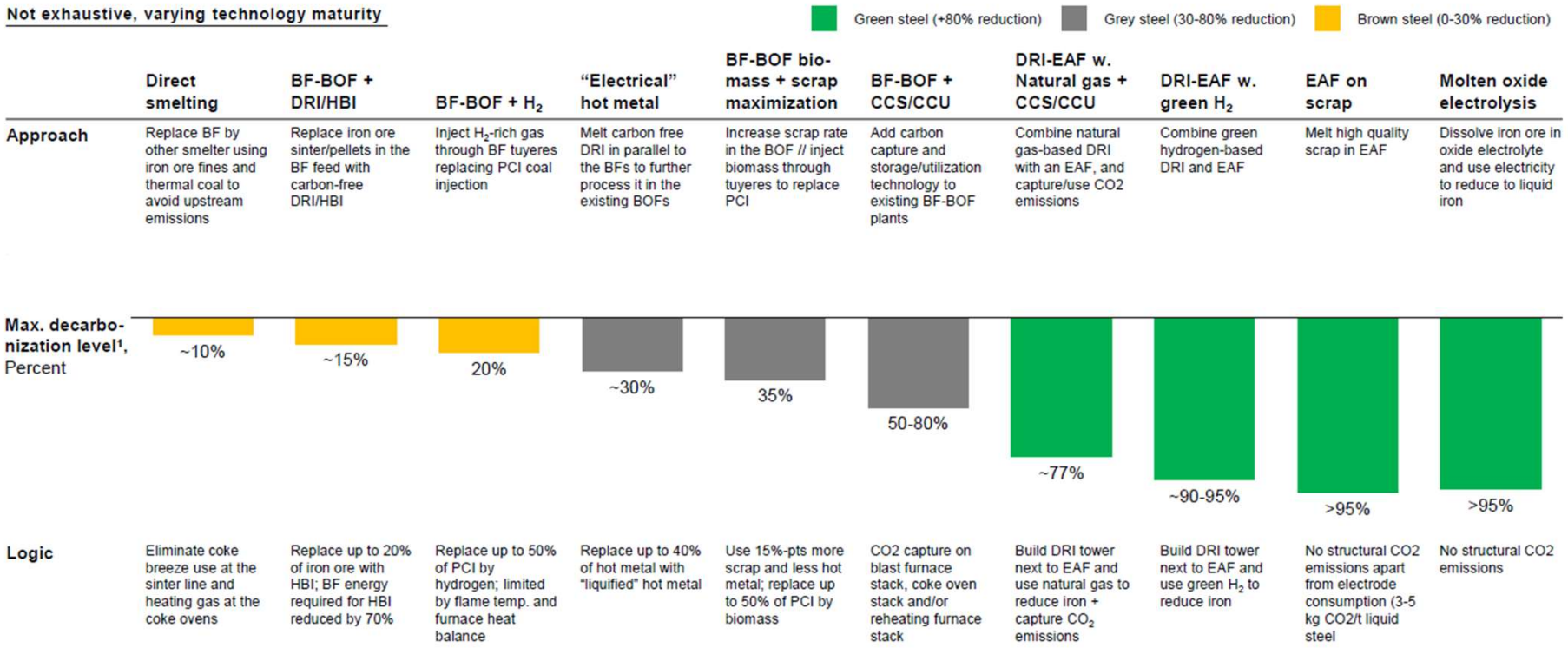
Agenda

Context and background

Regulatory and notional Context

Recommendations

Decarbonization options explored by steel industry in general



Source: McKinsey

Decarbonization options suitable for ILVA on short and long term basis

Short Term

	OPEX+CAPEX		CO2 reduction		Use of existing furnaces		TOTAL POINTS ASSIGNED TO THE TECHNOLOGY (2030)	RANGES DEFINED
	€/t	Points assigned	%	Points assigned (1 for every 20% reduction)		Points assigned		
Direct smelting	60	5	10	0.5	No	1	**6.5**	6-8
BF-BOF + H2	85	4	15	0.5	Yes	5	**9.5**	9-10
BF-BOF + DRI/HBI	60	5	20	1	No	1	**7**	>10
BF-BOF + biomass+scrap maximization	55	5	30	1.5	Yes	5	**11.5**	
"Electrical" hot metal	110	3	35	1.5	No	1	**5.5**	
BF-BOF + CCS/CCU	415	2	65	3	Yes	5	**10**	
DRI-EAFw. CH4+CCS/CCU	455	2	77	3.5	No	1	**6.5**	
DRI-EAFw. Green H2	1250	1	92.5	5	No	1	**7**	
EAF on 100% scrap	230	3	>95	5	No	1	**9**	

Long Term

	OPEX+CAPEX		CO2 reduction		Availability of raw material	TOTAL POINTS ASSIGNED TO THE TECHNOLOGY	RANGES DEFINED
	€/t	Points assigned	%	Points assigned (1 for every 20% reduction)	Points assigned		
Direct smelting	60	5	10	0.5	5	**10.5**	<=9
BF-BOF + H2	85	4	15	0.5	5	**9.5**	>9, <=10
BF-BOF + DRI/HBI	60	5	20	1	2	**8**	>10
BF-BOF + biomass+scrap maximization	55	5	30	1.5	2	**8.5**	
"Electrical" hot metal	110	3	35	1.5	3	**7.5**	
BF-BOF + CCS/CCU	415	2	65	3	5	**10**	
DRI-EAFw. CH4+CCS/CCU	455	2	77	3.5	4	**9.5**	
DRI-EAFw. Green H2	1250	1	92.5	5	5	**11**	
EAF on 100% scrap	230	3	>95	5	2	**10**	

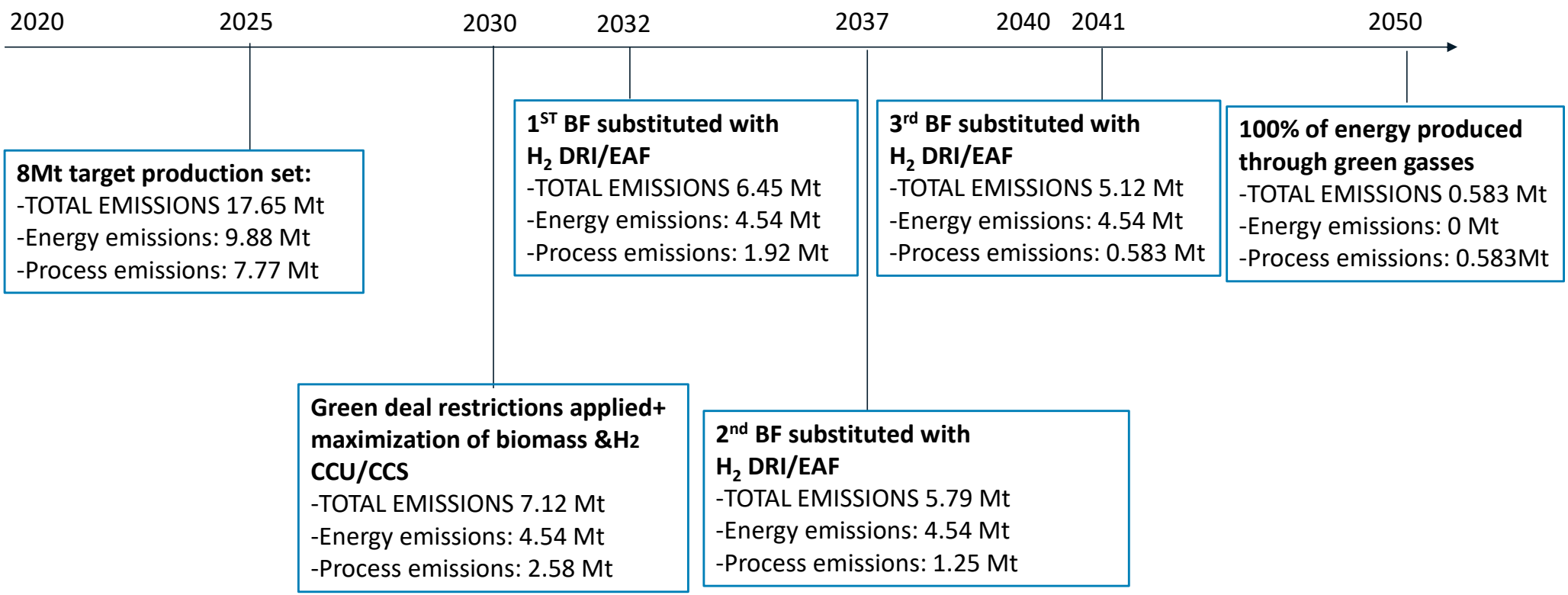
Decarbonizing ILVA – energy emissions

By 2030 ILVA will have to implement actions to **reduce its energy consumption**, gaining a **yearly reduction of 3.21 Mt of CO_2**, leading it to emit 14.44 Mt of CO_2 in the 8Mt of steel production scenario

By 2030 ILVA will ensure **agreements with local natural-gas provider (SNAM)** in order to ensure that the coke oven gas used to produce energy will contain at least **32% of biogas and/or hydrogen**. This will lead to a further yearly reduction in emissions equal to 2.13 Mt of CO2, leading ILVA to emit 12.30 Mt of CO_2 in the 8Mt of steel production scenario

By 2050 ILVA will completely replace gas with biogas and/or hydrogen in order to completely abate its energy emissions, equal to 9.88 Mt in the 8Mt of steel production scenario

Decarbonizing ILVA – timeline



Financing & OPEX options for Ilva (1/2)

Existing furnaces will continue functioning till their natural end of life → **the investment related to green technologies should only be evaluated in terms of extra-costs compared to the base case**

Commercial banks would not support the construction of new furnaces using coal**, the only way to obtain loans from these institutions is to move towards green technologies**

All the projects must also be compared with the cost-savings they introduce in terms of reduction of CO_2 quotas: the ones freely available are in fact not enough to cover the emissions from the plant when assuming that no new technology is introduced, and the production level is of 8Mt per year.

ILVA could leverage that could improve the economics of some projects.

	Detail	Potential benefit for steel maker	Total funds available; EUR	Feasibility
Modernization Fund	▪ Managed by European Investment Bank and Government ▪ **Aimed to modernize energy systems and improve energy efficiency (except coal-fired)** ▪ First proposal call likely in 2020, operational from 2021.	▪ **Will cover up to 70% or 100% of investment**, depending on priority areas set by the government ▪ Potentially suitable projects: energy distribution upgrade, combined cycle gas turbines, etc.	500m	
Innovation Fund	▪ Managed by European Commission + European Investment Bank ▪ **Designed to support innovative low-carbon projects** ▪ New technologies can be sourced from external suppliers	▪ **Covers up to 60% of investment** (out of which 60% non-conditional, 40% based on achieved improvement) ▪ Separate funding for design phase available ▪ **Jet BOF likely to be suitable** project	11bn	
Envirofond – state aid fund	▪ Managed by government ▪ **Designed to support energy efficiency projects** ▪ Likely to operate after 2021	▪ **Will cover up to 55% of investment, with cap of 15EURm**[1] (e.g. convertor gas at pusher furnace) ▪ **Easier to get for energy improvements**	~100m	
EIB loans	▪ Managed by European Investment Bank ▪ **Favorably priced loans** provided for projects with environmental or energy efficiency impact ▪ Past projects include ordinary steel mill projects, e.g. new caster	▪ **Loan for up to ~70% of total investment** ▪ Should be **suitable for most large investments** (e.g. thin slab caster, Jet BOF, EAF)		
Envirofond - compensation	▪ Electricity price compensation for industries with carbon leakage risk ▪ Maximum compensation dependent on CO_2 allocation cost and technology-specific electricity benchmarks, actual value decided by government	▪ **Maximum subsidy is ~1EURm for BOF and ~6EURm for 1.5Mt EAF**[2] ▪ Actual subsidy likely to be lower (currently around 30-40% of maximum)	~100m	
Other options considered	▪ **Funds under Directive 10c** unlikely to materialize in country before program end ▪ **European structural funds** not available to large companies ▪ **Research funds** (e.g. Horizon 2020) support research of new technologies, not suitable to fund "purchased" equipment	▪ N/A		

1 The 15EURm cap applies either to single project with multiple potential projects per company or to one project and company (current Government view)
2 Assuming cost of CO2 allocation 20EUR/t

Source: McKinsey

Financing & OPEX options for Ilva (2/2)

	No technology change						Introduction of green technologies						OPEX variation with green technology	Notes
	Mt/y CO2 emitted	Mt/y CO2 authorized	Mt/y CO2 delta quotas	M€/y CO2 cost	M€/y OPEX	**M€/y OPEX+CO2**	Mt/y CO2 emitted	Mt/y CO2 authorized	Mt/y CO2 delta quotas	M€/y CO2 cost	M€/y OPEX	**M€/y OPEX+CO2**	**M€/y**	
2022	12.555	8.30	4.26	298	2509	2807	12.555	8.30	4.26	298	2509.38	2807	**0**	
2023	12.555	7.92	4.64	325	2509	2834	12.555	7.92	4.64	325	2509.38	2834	**0**	
2024	12.555	7.55	5.00	350	2509	2859	12.555	7.55	5.00	350	2509.38	2859	**0**	
2025	17.65	7.21	10.44	731	4400	5131	17.650	7.21	10.44	731	4400.00	5131	**0**	
2026	17.65	6.87	10.78	754	4400	5154	17.650	6.87	10.78	754	4400.00	5154	**0**	
2027	17.65	6.56	11.09	776	4400	5176	17.650	6.56	11.09	776	4400.00	5176	**0**	
2028	17.65	6.26	11.39	798	4400	5198	17.650	6.26	11.39	798	4400.00	5198	**0**	
2029	17.65	5.97	11.68	818	4400	5218	17.650	5.97	11.68	818	4400.00	5218	**0**	
2030	17.65	5.69	11.96	1196	4400	5596	7.119	5.69	1.42	142	4600.00	4742	**-853**	Green deal +first step of process reductions
2031	17.65	5.41	12.24	1224	4400	5624	7.119	5.41	1.71	171	4600.00	4771	**-853**	
2032	17.65	5.13	12.52	1252	4400	5652	6.452	5.13	1.33	133	4800.00	4933	**-720**	First furnace substituted with H2 DRI
2033	17.65	4.84	12.81	1281	4400	5681	6.452	4.84	1.61	161	4800.00	4961	**-720**	
2034	17.65	4.56	13.09	1309	4400	5709	6.452	4.56	1.90	190	4800.00	4990	**-720**	
2035	17.65	4.27	13.38	1338	4400	5738	6.452	4.27	2.18	218	4800.00	5018	**-720**	
2036	17.65	3.99	13.66	1366	4400	5766	6.452	3.99	2.47	247	4800.00	5047	**-720**	
2037	17.65	3.70	13.95	1395	4400	5795	5.785	3.70	2.08	208	5266.67	5475	**-320**	Second furnace substituted with H2 DRI
2038	17.65	3.42	14.23	1423	4400	5823	5.785	3.42	2.37	237	5266.67	5504	**-320**	
2039	17.65	3.13	14.52	1452	4400	5852	5.785	3.13	2.65	265	5266.67	5532	**-320**	
2040	17.65	2.85	14.80	1776	4400	6176	5.785	2.85	2.94	353	5266.67	5619	**-557**	
2041	17.65	2.56	15.09	1509	4400	5909	5.119	2.56	2.56	256	5600.00	5856	**-53**	Third furnace substituted with H2 DRI
2042	17.65	2.28	15.37	1537	4400	5937	5.119	2.28	2.84	284	5600.00	5884	**-53**	
2043	17.65	1.99	15.66	1566	4400	5966	5.119	1.99	3.13	313	5600.00	5913	**-53**	
2044	17.65	1.71	15.94	1594	4400	5994	5.119	1.71	3.41	341	5600.00	5941	**-53**	
2045	17.65	1.42	16.23	1623	4400	6023	5.119	1.42	3.69	369	5600.00	5969	**-53**	
2046	17.65	1.14	16.51	1651	4400	6051	5.119	1.14	3.98	398	5600.00	5998	**-53**	
2047	17.65	0.85	16.80	1680	4400	6080	5.119	0.85	4.26	426	5600.00	6026	**-53**	
2048	17.65	0.57	17.08	1708	4400	6108	5.119	0.57	4.55	455	5600.00	6055	**-53**	
2049	17.65	0.28	17.37	1737	4400	6137	5.119	0.28	4.83	483	5600.00	6083	**-53**	
2050	17.65	0.00	17.65	1765	4400	6165	0.583	0.00	0.58	58	5600.00	5658	**-507**	Energy only produced from green sources

OPEX is systematically lower when green technologies are implemented

Key assumptions

ILVA's production will be constant and equal to ***8 Mt/y from 2025 and for the whole period analysed****, up to 2050.*

CO_2 price:

- *70 €/ton from 2022 to 2029*
- *100€/ton from 2030 to 2039*
- *120 €/ton from 2040 to 2050 (Effective Carbon Rates 2021 – OECD).*

By 2050 50% of steel recycled,

Considering the actual technology, the projected Scope 1 and Scope 3 emissions are proportional to the amount of steel produced.

Green Technology

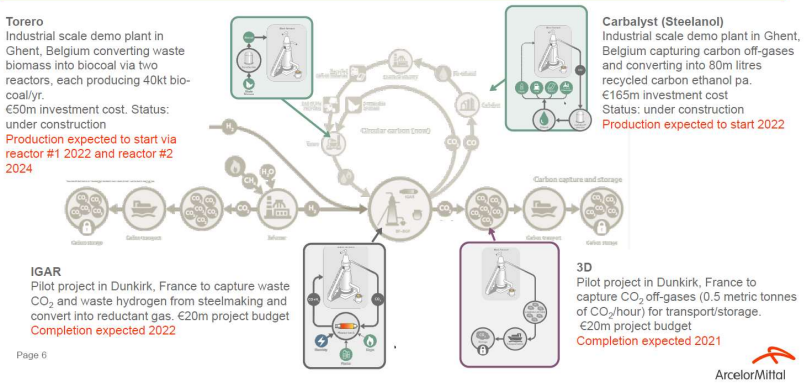
a) Scope 1

- Substitute its furnaces gradually (years 2032, 2037, 2041) with DRI EAF H_2 technology
- A gradual substitution of the coke oven gas used today with biogas or hydrogen, to be completed by 2050
- Increase in energy efficiency (30% by 2030)

a) To completely abate Scope 3 emissions, it is assumed that:
   a. the industries related to these will improve their performances,
   b. transportation will become less carbon intensive,
   c. ILVA will have to cooperate with its suppliers and distributers in order to put in place initiatives to offset the residual amount of emissions in its supply chain

Appendix 1: Arcelor Mittal decarbonisation strategy

Making carbon-neutral steel: Smart Carbon technologies at mature stage



Torero
Industrial scale demo plant in Ghent, Belgium converting waste biomass into biocoal via two reactors, each producing 40kt bio-coal/yr.
€50m investment cost. Status: under construction
Production expected to start via reactor #1 2022 and reactor #2 2024

Carbalyst (Steelanol)
Industrial scale demo plant in Ghent, Belgium capturing carbon off-gases and converting into 80m litres recycled carbon ethanol pa.
€165m investment cost
Status: under construction
Production expected to start 2022

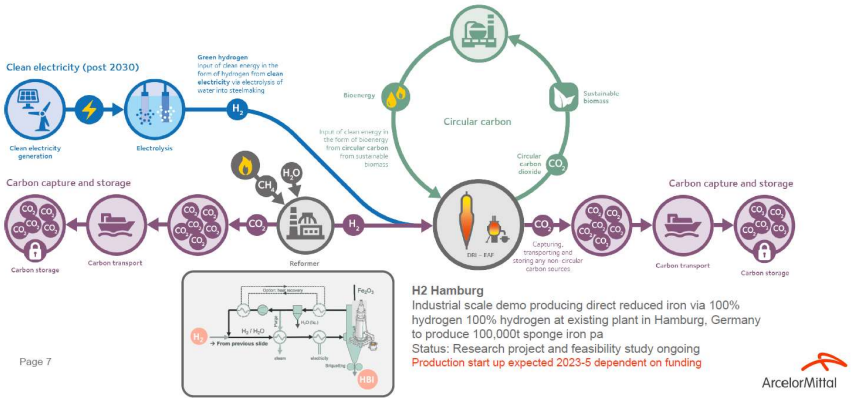
IGAR
Pilot project in Dunkirk, France to capture waste CO_2 and waste hydrogen from steelmaking and convert into reductant gas. €20m project budget
Completion expected 2022

3D
Pilot project in Dunkirk, France to capture CO_2 off-gases (0.5 metric tonnes of CO_2/hour) for transport/storage.
€20m project budget
Completion expected 2021

Page 6

ArcelorMittal

Making carbon-neutral steel: Innovative DRI-based route



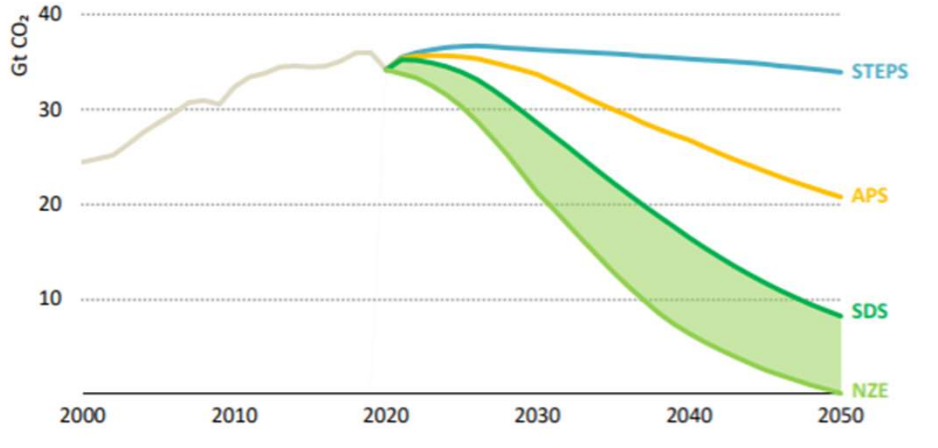
H2 Hamburg
Industrial scale demo producing direct reduced iron via 100% hydrogen 100% hydrogen at existing plant in Hamburg, Germany to produce 100,000t sponge iron pa
Status: Research project and feasibility study ongoing
Production start up expected 2023-5 dependent on funding

Page 7

ArcelorMittal

Appendix 2: IEA scenarios

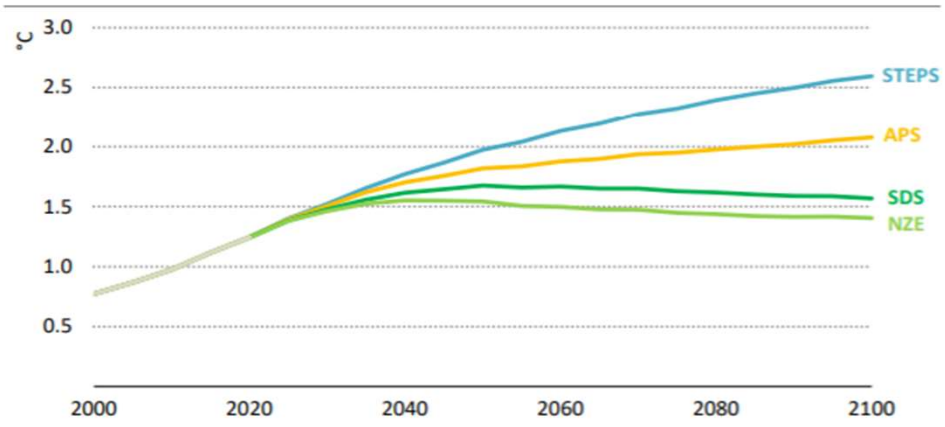
Figure 1.4 ▷ CO_2 emissions in the *WEO-2021* scenarios over time



The APS pushes emissions down, but not until after 2030; the SDS goes further and faster to be aligned with the Paris Agreement; the NZE delivers net zero emissions by 2050

Note: APS = Announced Pledges Scenario; SDS = Sustainable Development Scenario; NZE = Net Zero Emissions by 2050 Scenario.

Figure 1.5 ▷ Global median surface temperature rise over time in the *WEO-2021* scenarios



The temperature rise is 2.6 °C in the STEPS and 2.1 °C in the APS in 2100 and continues to increase. It peaks at 1.7 °C in the SDS and 1.5 °C in the NZE around 2050 and then declines

Source: IEA analysis based on outputs of MAGICC 7.5.3.