Concentrating Solar Thermal Opportunities and Challenges for ArcelorMittal

US Department of Energy
Workshop on Industrial Decarbonization
Renewable Process Heating from Concentrating Solar Thermal

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Leadership of the steel industry's decarbonization journey

ArcelorMittal is at the forefront of the industry, developing clear industrial transformation plans and capturing commercial opportunities

Leading the industry

- New Group target of a 25% reduction in CO_{2e} emissions intensity by 2030 (scopes 1+2 CO_{2e} per tonne steel)
- Europe target increased to 35% (from 30%) reduction in CO_{2e} emissions intensity by 2030

Industry first "Net zero" plant

- "World's first full-scale zero carbon-emissions steel plant" at Sestao by 2025"
- A combination of physical zero carbon emissions steel and net-zero certified tonnes by 2030

First to market

- Customer appetite for low carbon steel is real, as demonstrated by demand for our XCarb™ product offering launched in 1Q' 21

Funding

- $10bn total investment* required to achieve 2030 Group decarbonization target (gross amount pre-government support)
- Securing public support is central to our plans and provides an opportunity to accelerate

- New Group target of a 25% reduction in CO_2e emissions intensity by 2030 (scope 1 and 2)

- Europe target increased to 35% reduction in CO_2e emissions intensity by 2030 (scope 1 and 2)

* The Company expects 35% of the planned $10bn investment to be deployed up to 2025, with the remainder in the second part of the decade. The expectation is that over time low carbon technologies will become more competitive as the carbon price increases (and is applied globally) and technologies mature and become more efficient. This, however, will take considerable time. In the interim period, policy support will be essential to moderate the capital spend burden and ensure operational competitiveness. The required investments will not generate sufficient returns in the transition period and the technologies will require further development and refinement. Additionally, the costs associated with operating these technologies will likely be higher in the short-to-medium term than higher carbon-emission technologies. It is critical therefore there are policies in place to support regional and global competitiveness of assets that are first movers in the transition to low carbon steel. Policy instruments like contracts for difference, which were used to positive effect in the development a competitive renewable energy sector, have an important role to play. The Company believes that funding in the region of 50% of costs would be appropriate.

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Innovation Funding

Utilizing our strategic investment fund to accelerate our decarbonization

$10 million investment in Heliogen:

- Renewable energy Company focused on 'unlocking the power of sunlight to replace fossil fuels'
- Heliogen: Will harness solar energy by using a field of mirrors which will act as a multi-acre magnifying glass to concentrate and capture sunlight
- The sunlight will then be subsequently converted into heat (HelioHeat™), electricity (HelioPower™) or clean fuels (HelioFuel™)
- All three Heliogen products have the potential to be applicable to the steelmaking process and support the steel industry's transition to carbon-neutrality
- Technology capable of creating 100% green hydrogen; Heliogen working to develop as its first HelioFuel™
- ArcelorMittal and Heliogen signed a MoU to evaluate the potential of Heliogen's products in several of ArcelorMittal's steel plants

HelioHeat™
Carbon-free, ultra-high temperature heat to power heavy industrial processes including the making of cement, steel, and petrochemicals

HelioPower™
Power made from sunlight using supercritical CO2 turbines to power industrial facilities, data centers, and mining operations

HelioFuel™
Clean fuels like green hydrogen that can be used to power industry and as fuel in transportation, heavy equipment, and household heating

$25 million equity injection in Form Energy:

- Form Energy is working to accelerate the development of its breakthrough low-cost energy storage technology to enable a reliable, secure, and fully-renewable electric grid year-round
- Alongside this investment, ArcelorMittal & Form Energy signed a joint development agreement to explore the potential for ArcelorMittal to provide iron, tailored to specific requirements, to Form Energy as the iron input into their battery technology

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ArcelorMittal and Renewable Energy have history together

ArcelorMittal has been using renewable energy for many years, examples:

- In 2013 we signed with Eliotech to buy electricity from wind generators for 15 years, in amounts corresponding to over 16% of our Mexican steelmaking operation, which is the biggest private electricity consumer in Mexico.
- We have ownership participation of hydro-plants in Brazil.

Guilman-Amorim Hydro Plant, Brazil
Installed Capacity of 155.6 MW
Started operation in 1997

The participation of renewable + electricity generated from waste heat & gases reaches over **44%** of our total consumed electricity globally, and we are working to increase this number.

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ArcelorMittal is actively investigating opportunities to integrate CST technology to our steelmaking process

The electricity generated from CST (or Concentrated Solar Power, CSP) is not the most interesting for steelmaking. Prices are coming down and it can basically be a matter to have a proper business case to build an installation either in or off site. Thus, not very different from other renewable electricity generation projects.

In our view, the main differential for CST technology is the possibility to generate heat, which cannot be done directly by other renewable technologies as hydro, PVs, wind towers, etc. This solar heat can have the following advantages:

a) Lower total investment than CSP: no sCO2, no turbine/engine, no transformers, no generator;

b) No regulatory constraints as electricity may have to be handed off from one entity to another entity;

c) The solar heat can be integrated to our processes to abate fossil fuels utilization, and mitigate our direct emissions, which is the portion we pay carbon taxes on at the regions with this regulatory schemes.

Note: The solar heat media can be air. Thus, different from fumes, there's no technical issues (in particular condensation) to use this heat as much technically possible.

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What are the already existing waste heat source in a steelmaking process?

Indeed, steelmaking has a lot of potential to recover wasted heat, and at ArcelorMittal we already go after these opportunities. Examples:

a) Almost all of our re-heating furnaces have recuperators to preheat the combustion air and save fuel, using energy from fumes;

b) Hot charging of slabs for rolling is an ArcelorMittal Best Practice that we strongly pursue;

c) Two of our Coke Plants have Coke Dry Quench (CDQ), including our by-products unit in Brazil, which is the only in Americas with this waste recovery technology;

d) Good part of our Blast Furnaces have Top Gas Recovery Turbines (TRTs), taking also advantage of the gas pressure drop. More units are lined up for investment;

e) In Brazil we have a second Coke Plant based on heat recovery technology with power generation installed capacity of almost 200 MWe, 100% driven by waste heat recovery from the coke making process;

Also, we are investigating other new technologies:

a) Slabs heat recovery to generate process steam;

b) Coils heat recovery to generate electricity.

Concentrating Solar Thermal Challenges for Steelmaking

From our perspective and experience so far, the main challenges for integrate CST solar heat to steelmaking are:

1) **Large footprint:** Solar heat is not as flexible as electricity to be transported, thus we need to have the CST plant close to the usage point, however, depending on the specific application, a CST plant is ranging from about 200m x 200m to 700m x 700m, which can be a relevant challenge, or even a roadblock, depending on the steel or mining site layout. The key points to tackle it could be, for example: a) Efficiency Improvements; b) Finding ways to reduce the gaps between mirrors to permit cleaning, etc; d) efficient & competitive ways to transport the heat in longer distances.

2) **Material development:** Reaching higher temperatures of 1000+C, including thermal storage, would open more possibilities for steel making process integration. Materials development can be an important enabler for this evolution.

3) **Investment Costs:** It's a relatively new technology and we believe scalability will be an important driver to bring costs down.

4) **Integrate the solar heat to the steel making process:** In the past months we have been working on how to use the solar heat in the best way to reduce our costs and carbon footprint. It's a challenge very different from what we did in the past for waste heat research, but we are positive that ArcelorMittal is getting closer to find technical solutions that can be implemented.

Public Policies to incentive solutions for above challenges can be of fundamental importance to develop CST technology and utilization, helping a more sustainable and competitive steelmaking.

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Thank you!

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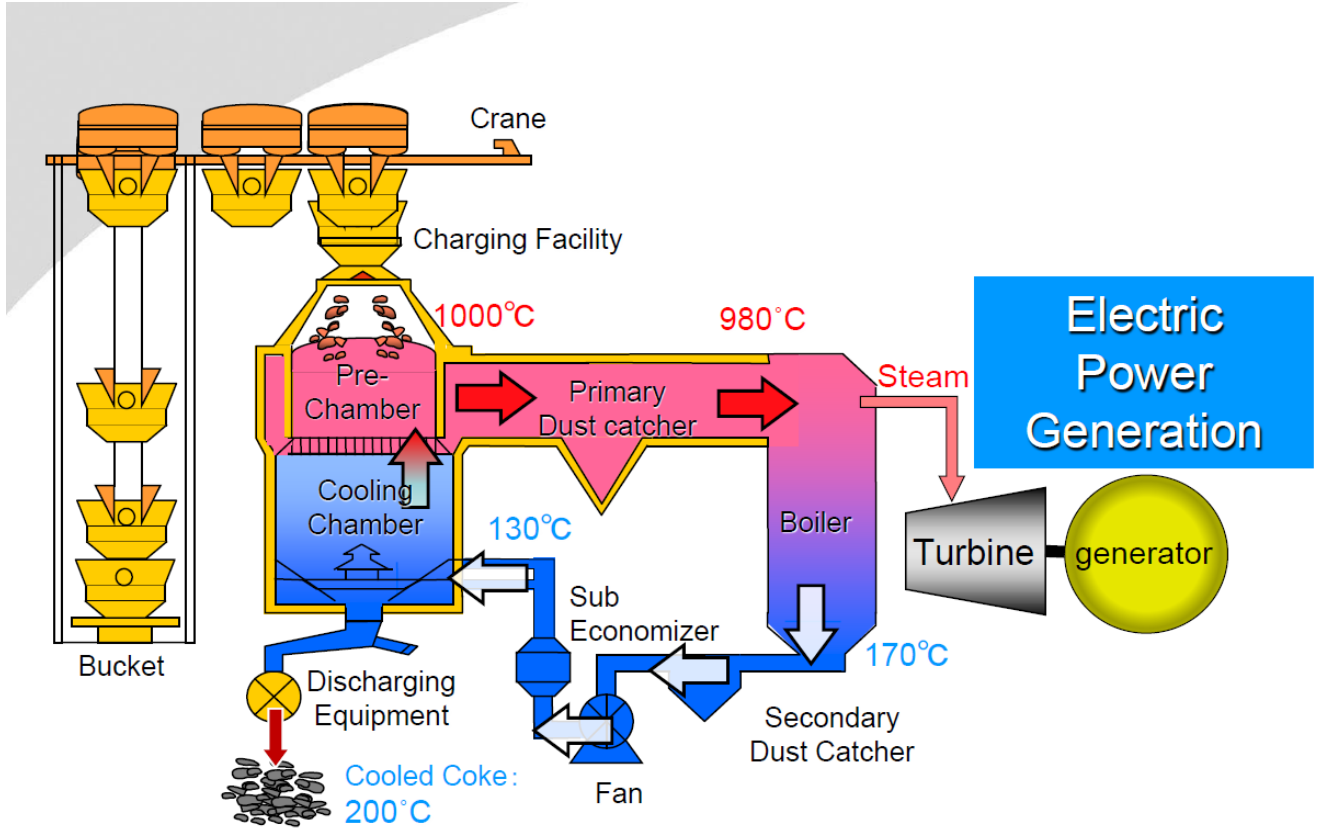
Back up slides

Mentioned Waste Heat Recovery Technology, Fast Reference

Coke Dry Quench, CDQ



Nippon Steel Engineering

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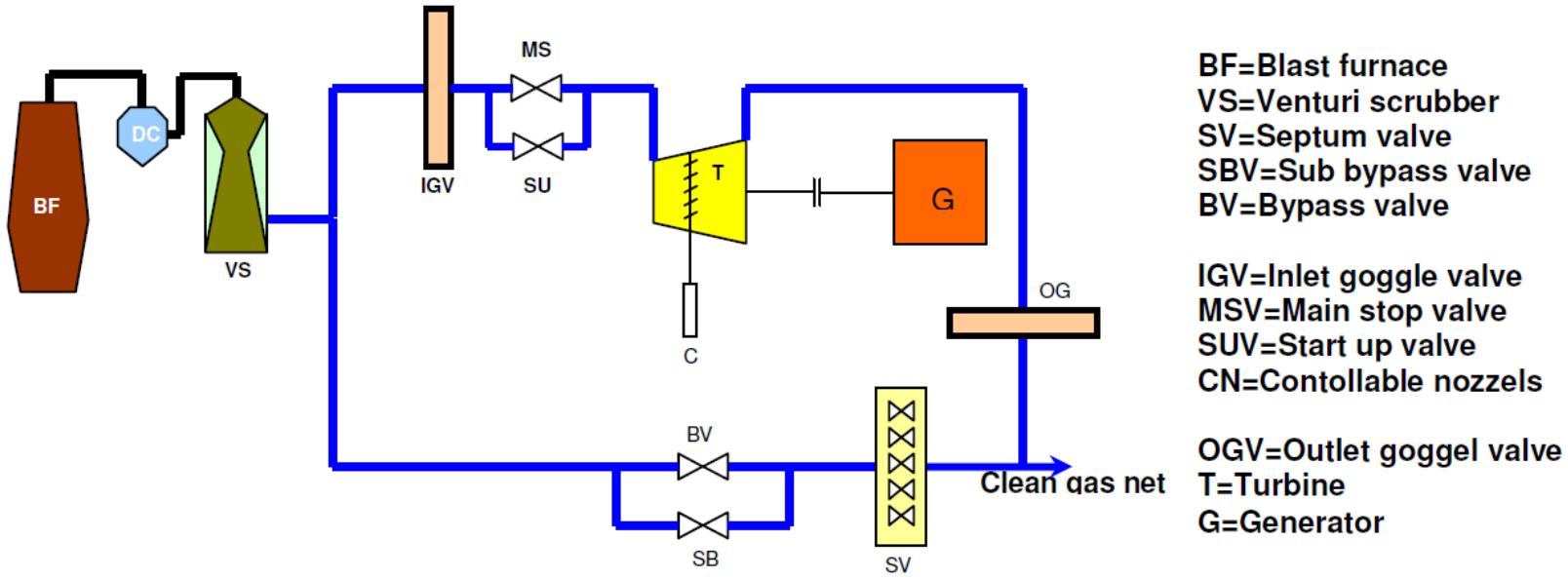
Mentioned Waste Heat Recovery Technology, Fast Reference

Top gas Recovery Turbine, TRT



BF=Blast furnace
VS=Venturi scrubber
SV=Septum valve
SBV=Sub bypass valve
BV=Bypass valve

IGV=Inlet goggle valve
MSV=Main stop valve
SUV=Start up valve
CN=Contollable nozzels

OGV=Outlet goggel valve
T=Turbine
G=Generator

Z&J Technologies GmbH

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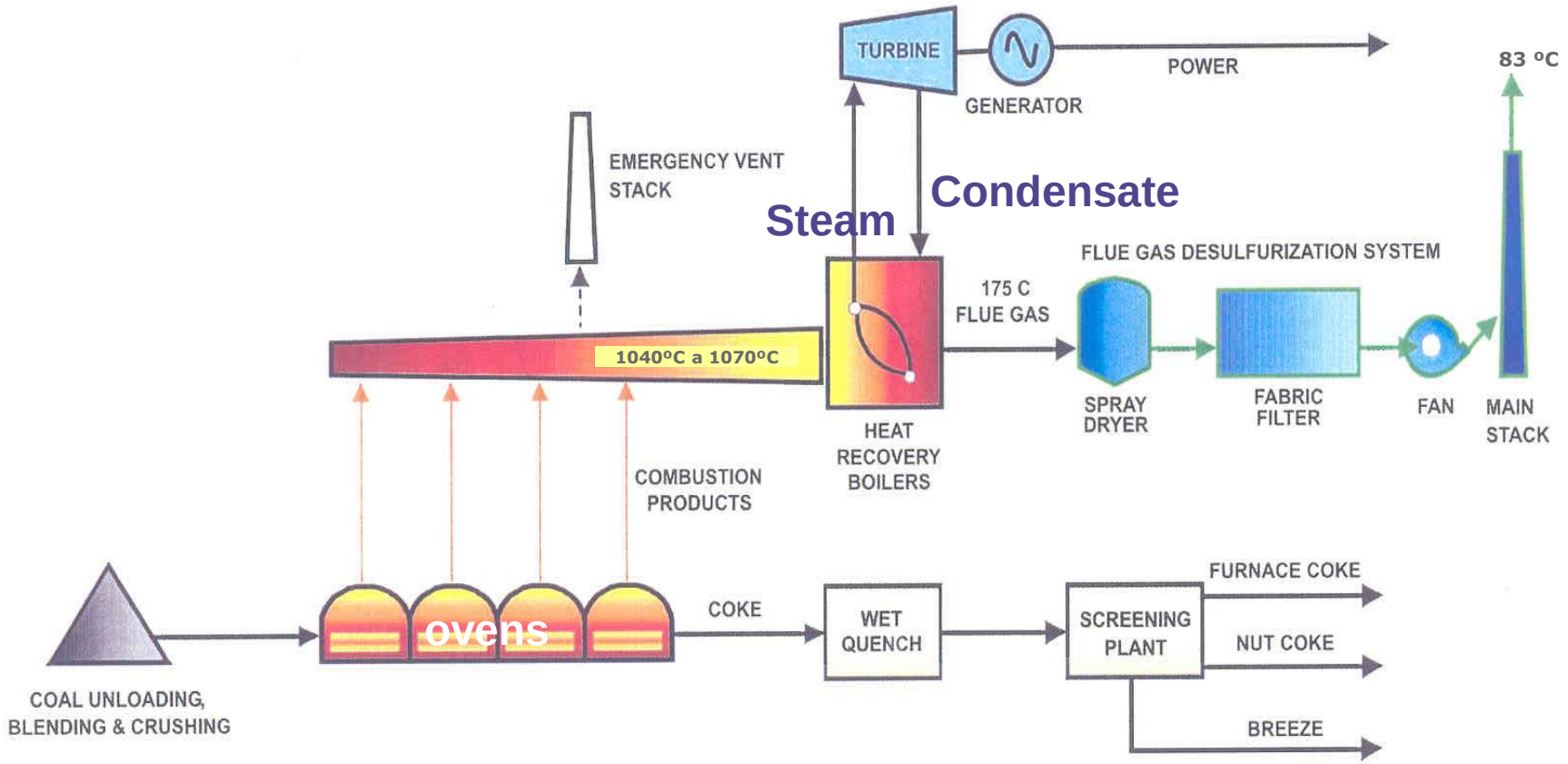
Mentioned Waste Heat Recovery Technology, Fast Reference

Coke Plant based on heat recovery technology



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