Carbon-Free Iron for a Sustainable Future

DE-EE0008309
Boston Metal
Project Period: Budget Period 1

Rich Bradshaw – Boston Metal

U.S. DOE Advanced Manufacturing Office Program Review Meeting
Washington, D.C.
June 11-12, 2019

Overview

Project Title: **Carbon-Free Iron for a Sustainable Future**

Timeline:

Project Start Date: 08/01/2018

Budget Period End Date: 07/31/2019

Project End Date: 07/31/2021

Barriers and Challenges:

- De-couple carbon from primary steel production – No direct carbon use
- Maintain commodity cost – no premium required
- Match or exceed current industry efficiencies

AMO MYPP Connection:

- Advanced Manufacturing R&D Projects

Project Budget and Costs:

Budget	DOE Share	Cost Share	Total	Cost Share %
Overall Budget	$2,000,000	$500,000	$2,500,000	20.0%
Approved Budget (BP-1&2)	$1,546,823	$316,425	$1,933,503	20.0%
Costs as of 3/31/19	$209,549	$52,387	$261,936	20.0%

Project Team and Roles:

- Lead Organization: Boston Metal

Project Objectives

….Industrialize an innovative extractive metallurgy technology called Molten Oxide Electrolysis (MOE) to produce primary steel through the use of electricity instead of carbon….

AMO Alignment

"Improve the productivity and energy efficiency of U.S. manufacturing"

- MOE has the capacity to produce steel using less energy than traditional Blast and Basic Oxygen Furnace Technologies
- MOE offers rapidly scalable production capacity at a smaller tonnage requirements with competitive CAPEX input

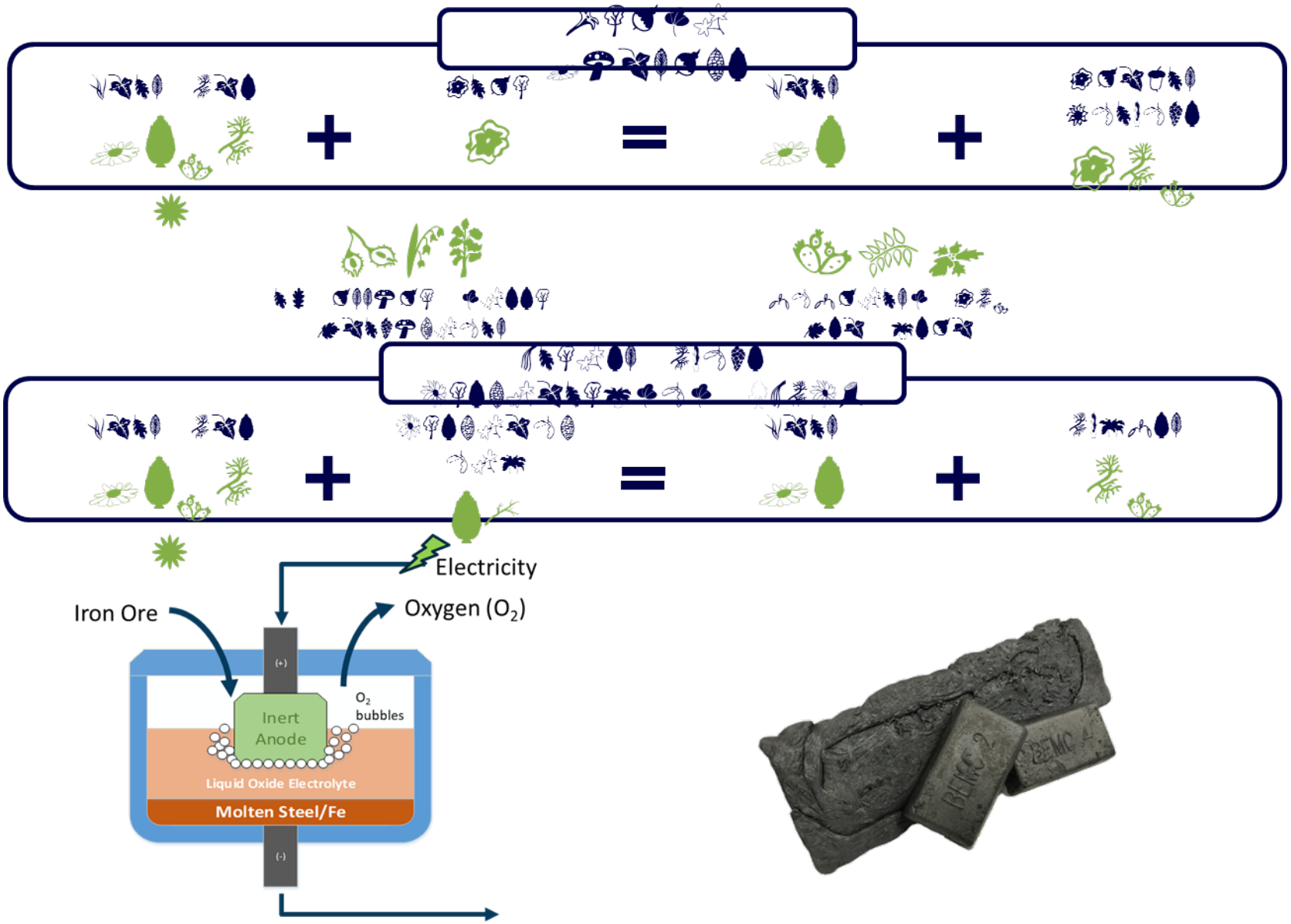
"Leverage diverse domestic energy resources in U.S. manufacturing, while strengthening environmental stewardship"

- MOE decouples carbon use from the production of steel, dependent only on source of electricity

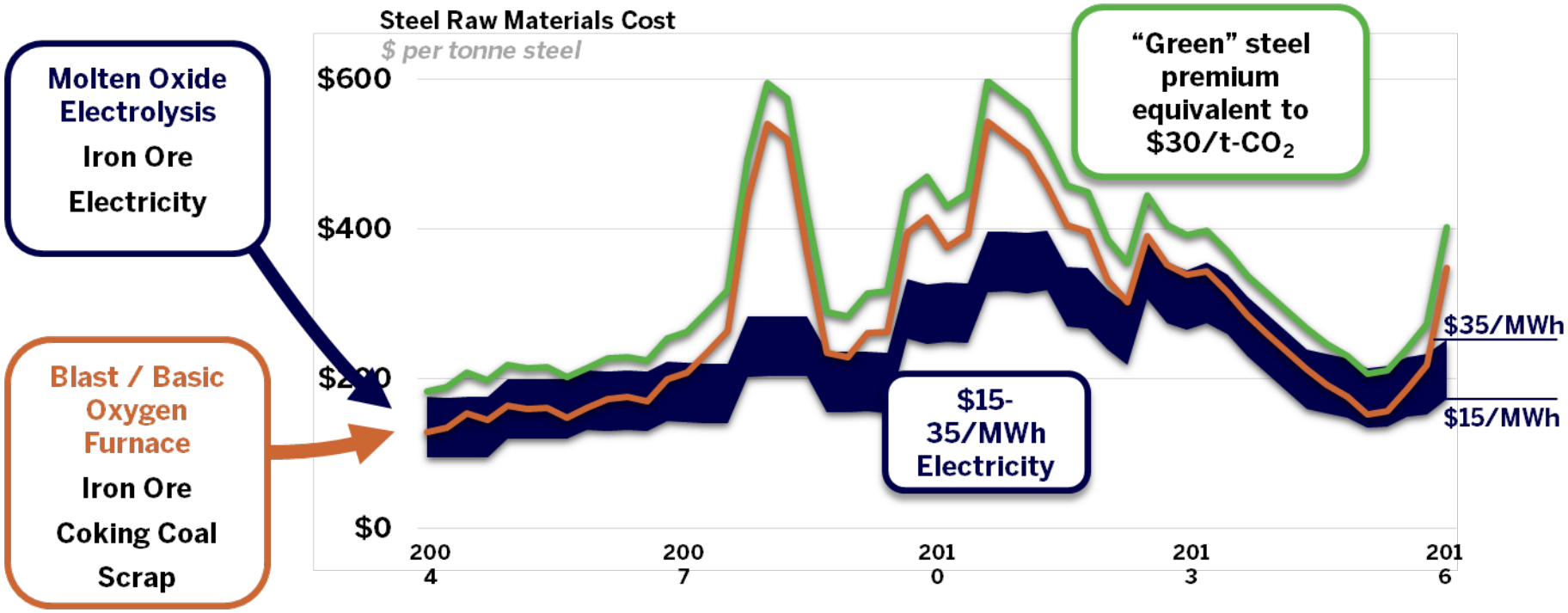
Challenges

- Inert Anode technology used in the electrolysis process needs to be scaled from laboratory to industrial size
- Achieving high production efficiencies to maintain commodity prices and speed adoption

Steel production is the largest industrial source of CO_2



Lower cost and lower volatility

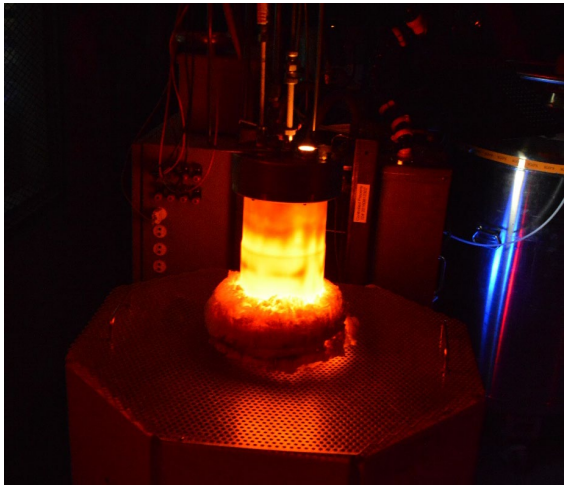


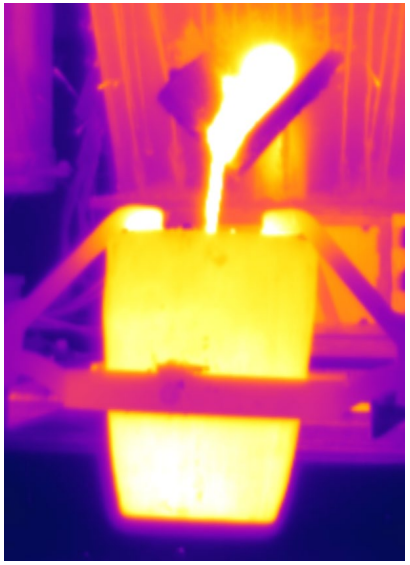
$15/MWh = 35% lower materials cost (2004-2017)

$15/MWh = 1.5¢/kWh
$35/MWh = 3.5¢/kWh

Technical Approach

- Budget Period 1
  - Develop knowledge of operational window for inert anode material
    - Extensive use of laboratory (small scale) testing
  - Derive design requirements necessary for scaling activity
    - Test knowledgebase through preliminary scaling tests
- Budget Period 2
  - Semi-industrial scaling and testing of inert anode
    - Extensive multi-physics modeling, design for manufacturing
    - Multiple design & test rounds
- Budget Period 3
  - Long duration testing at semi-industrial scale
    - Final design/optimization
  - Base-line performance of MOE iron/steel production

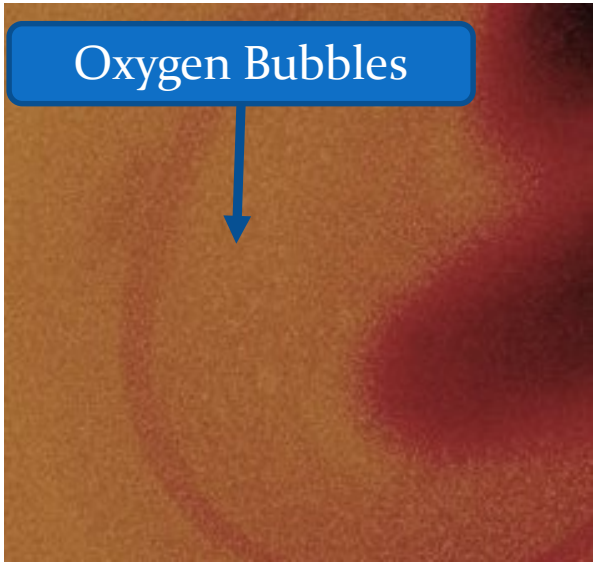


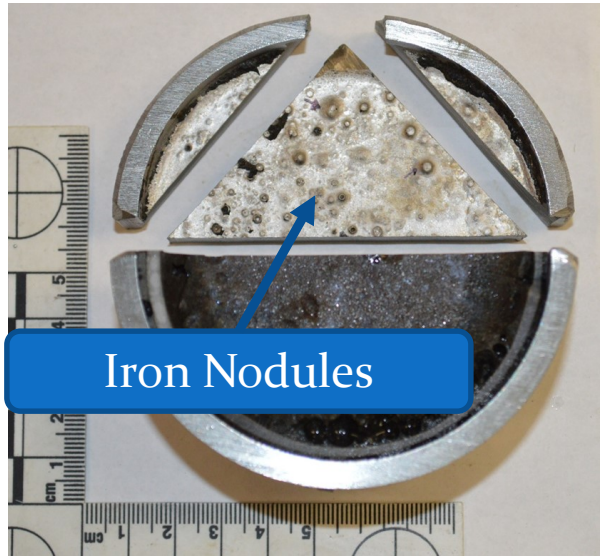


Results and Accomplishments

Milestones: Go / No-Go

- Budget Period 1 – Lab Scale – Accomplished!
  - Oxygen production confirmed
  - Iron production confirmed
  - <5% Mass loss of anode after 2 hrs of testing
- Budget Period 2 – Semi-Industrial Scale
  - Oxygen production confirmed
  - 10 kg of Iron production from oxide input
- Budget Period 3 – Endurance Testing
  - Oxygen production demonstrated
  - >100 kg of iron produced in single week long campaign
  - <5% Mass loss of anode after week long campaign





Transition (beyond DOE assistance)

Boston Metal Strategic vision

- Ferro-Alloys
  - Short term revenue from ferro-alloys (3-4 years)
- Steel
  - Near term technology de-risking from DOE
  - Ferro-Alloys revenue supports medium/long term development activities of steel & inert anode
  - 100,000 tpa Demonstration MOE steel plant in 7-10 years

Potential commercialization partners

- Existing Steel producers
- Plant producers (EPC/equipment sellers)