Air-Sourced High Temperature Heat Pump for Decarbonization of Industrial Process Steam

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Presentation Goals

1. High-Level AtmosZero Overview
2. Why an Air-Sourced High Temperature Heat Pump?

AtmosZero High-Level Intro

The power of steam

Steam accounts for:

50%
of process heat used in industry

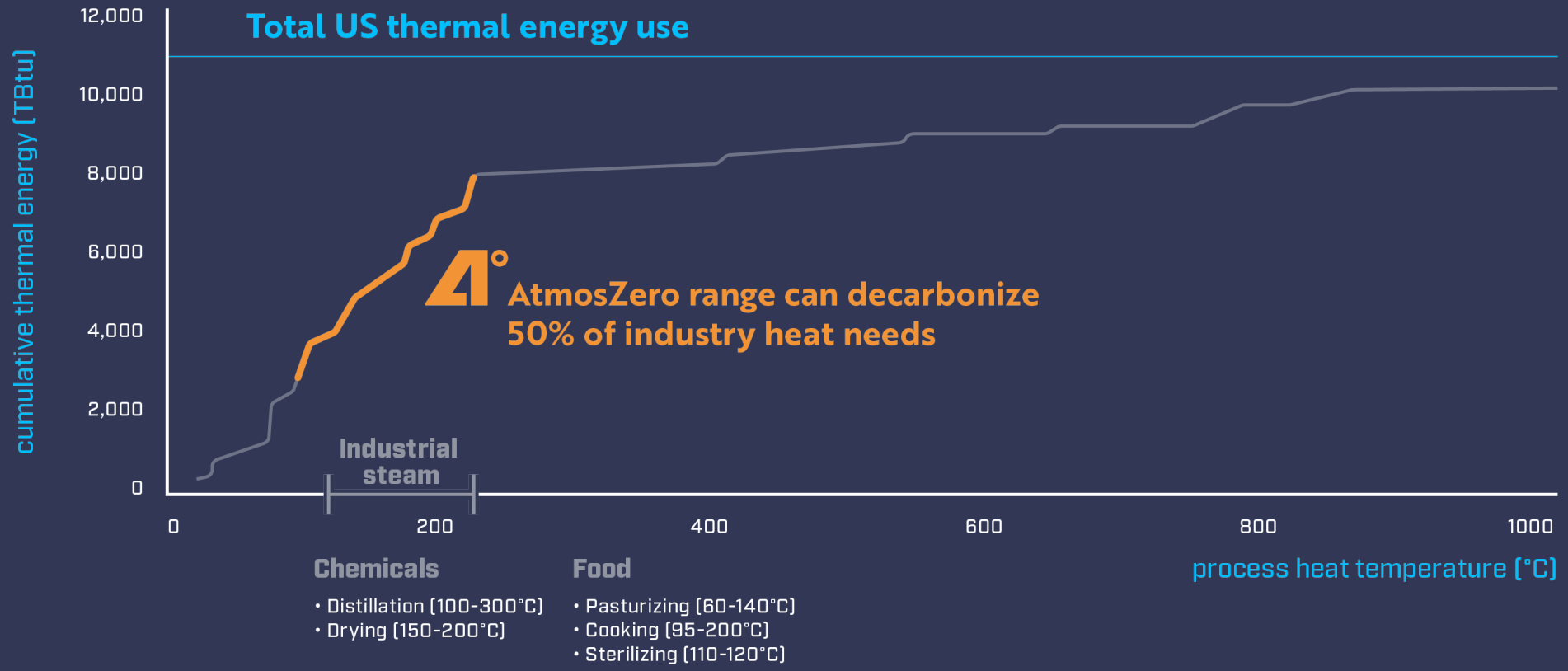
8%
of global primary energy use

2.25 GT
GHG emissions per year

Steam drove the industrial revolution.
AtmosZero will drive the next.

The sweet spot: Steam temperatures

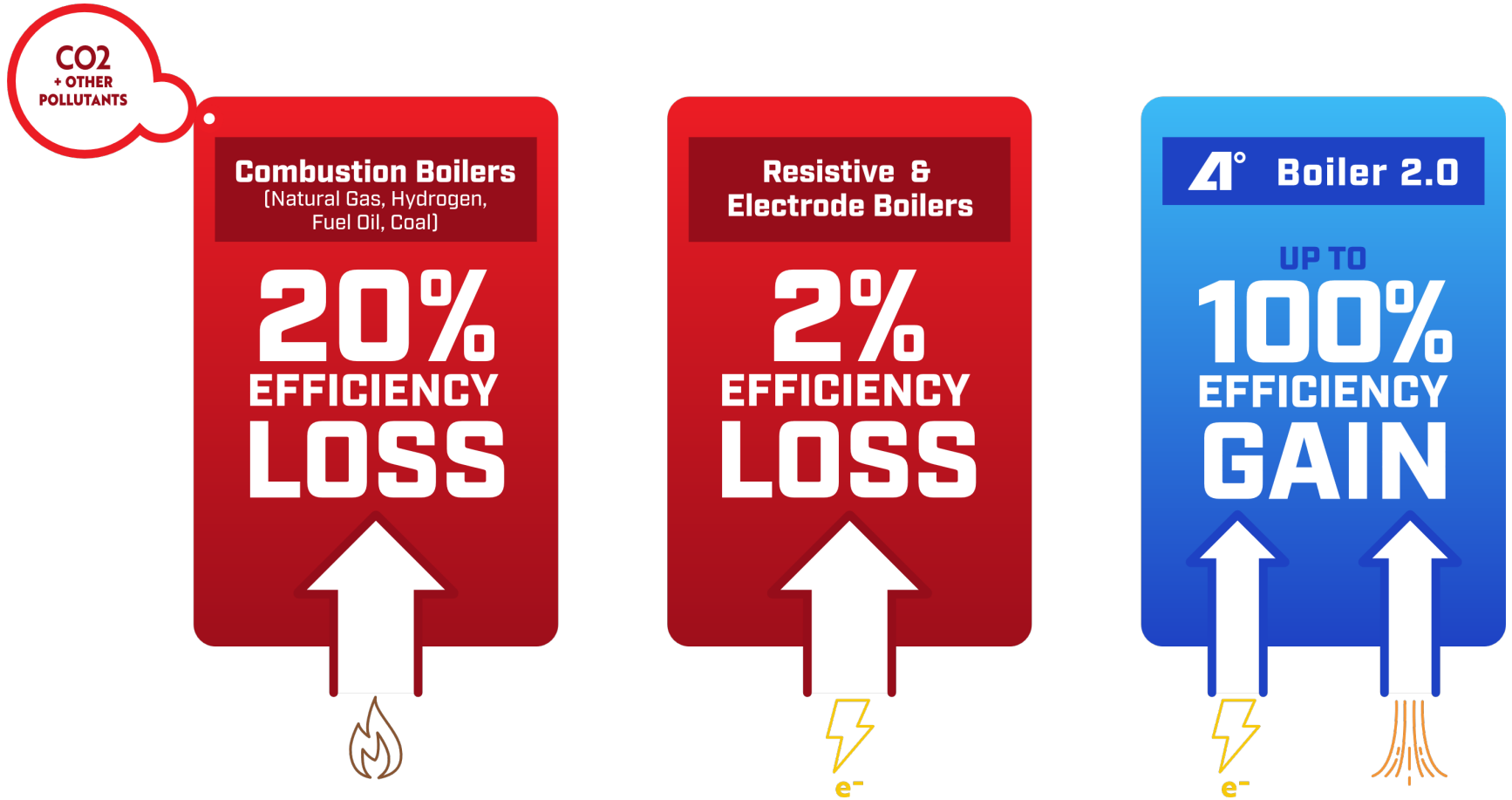
50% of all process heat is delivered by steam.



Source: Renewable Thermal Collaborative, "RTC Vision Report"

Redefining boiler room efficiency

2.0X more efficient than today's electric boilers and emissions free



Introducing:

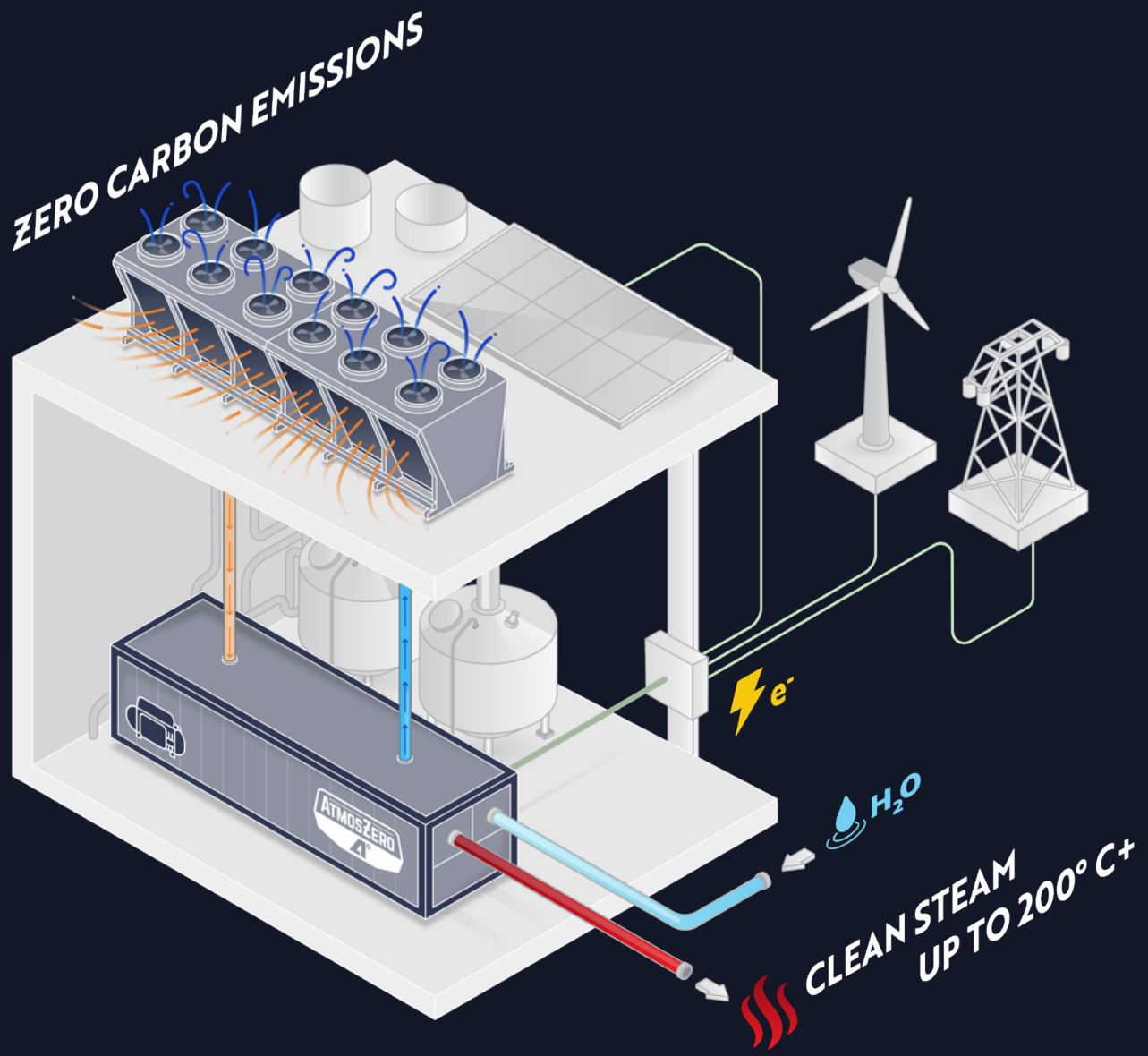
Boiler 2.0

Modular Air-Sourced Steam Heat Pump

No waste heat required

Product…not a Project

New technology delivers zero-carbon steam, making net zero goals technologically and economically achievable



First Customer

PHASE 1 – The Pilot

Meet 1/3 of steam demand

- Replace one natural gas boiler in Fort Collins facility
- 165°C, 2200 lb/hour saturated steam
- In-field, in-revenue service. Q1’25.

PHASE 2 - Full deployment

Go all-in and grow

- Full replacement in Fort Collins
- Expand to other brewery locations in VA, MI, and NC

Ready to Scale for Global Impact

Prototyped Modular product

650 kW_{th} building blocks delivering up to 200°C

Key supply chain partnership

JDA with key global supplier Danfoss

World-class research

Colorado State University partnership

Established global presence

EU subsidiary in the Netherlands

Technoeconomics of decarbonized electrified steam boiler technologies

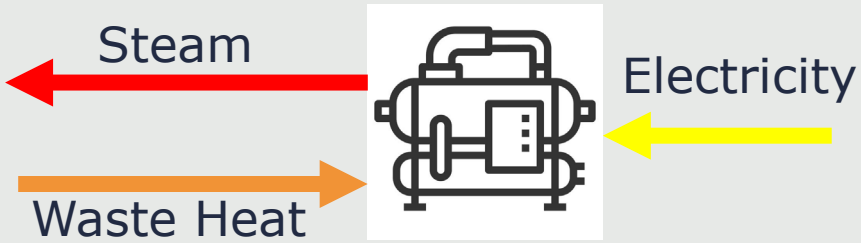
Introduction – Steam Generation

Fuel Boiler

State-of-the-art, requires combusting fuel such as natural gas

Waste Heat Driven Heat Pump

High efficiency, requires site specific engineering for facility integration



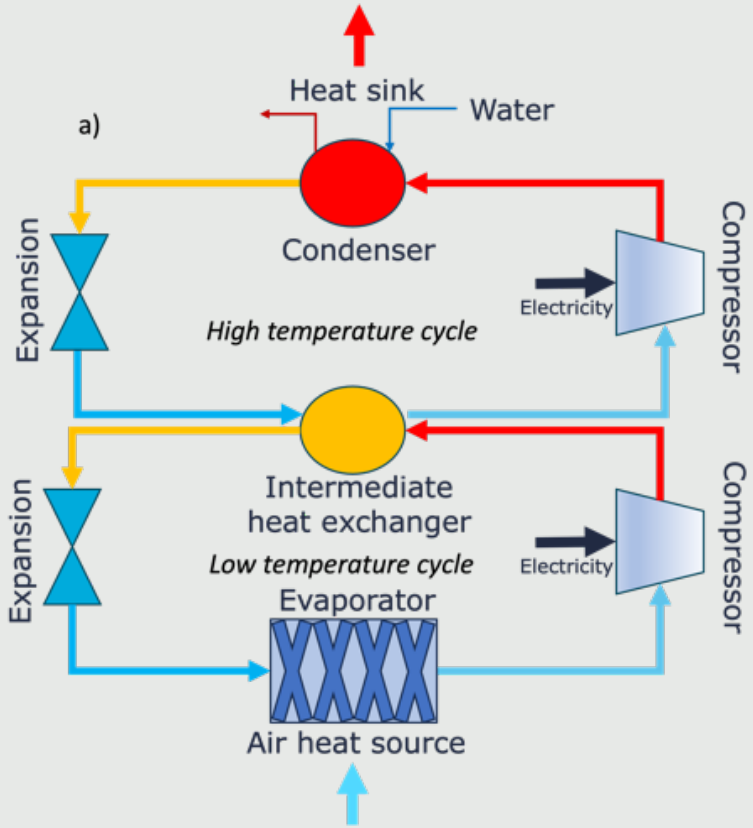
Electric Boiler

Commercially available and low-CAPEX, efficiencies <100%

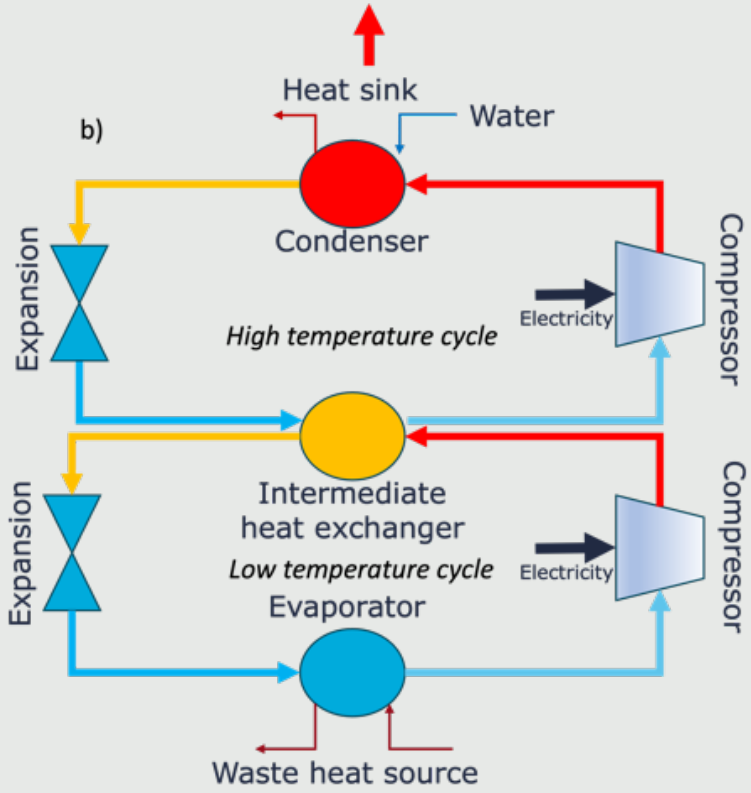
Air-Sourced Heat Pump

Lowered efficiency, reduced integration challenges

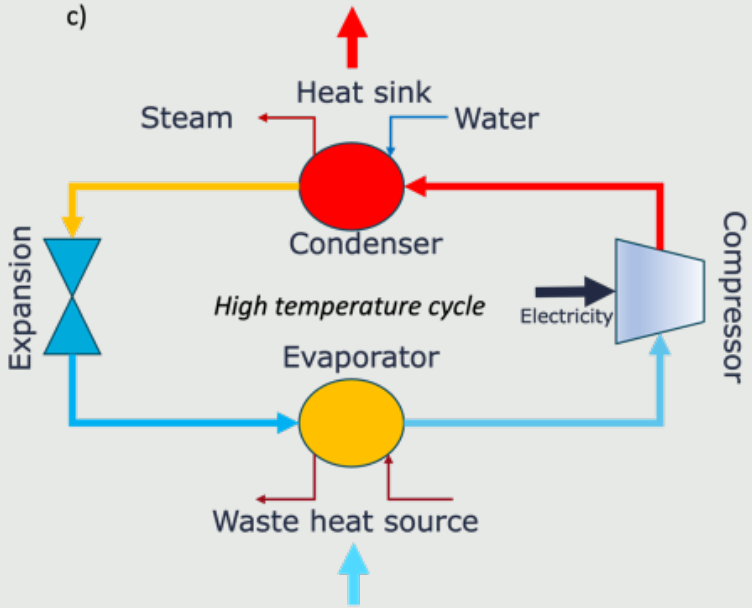
Heat Pump System Configurations



Air-Sourced Steam Generating Heat Pump

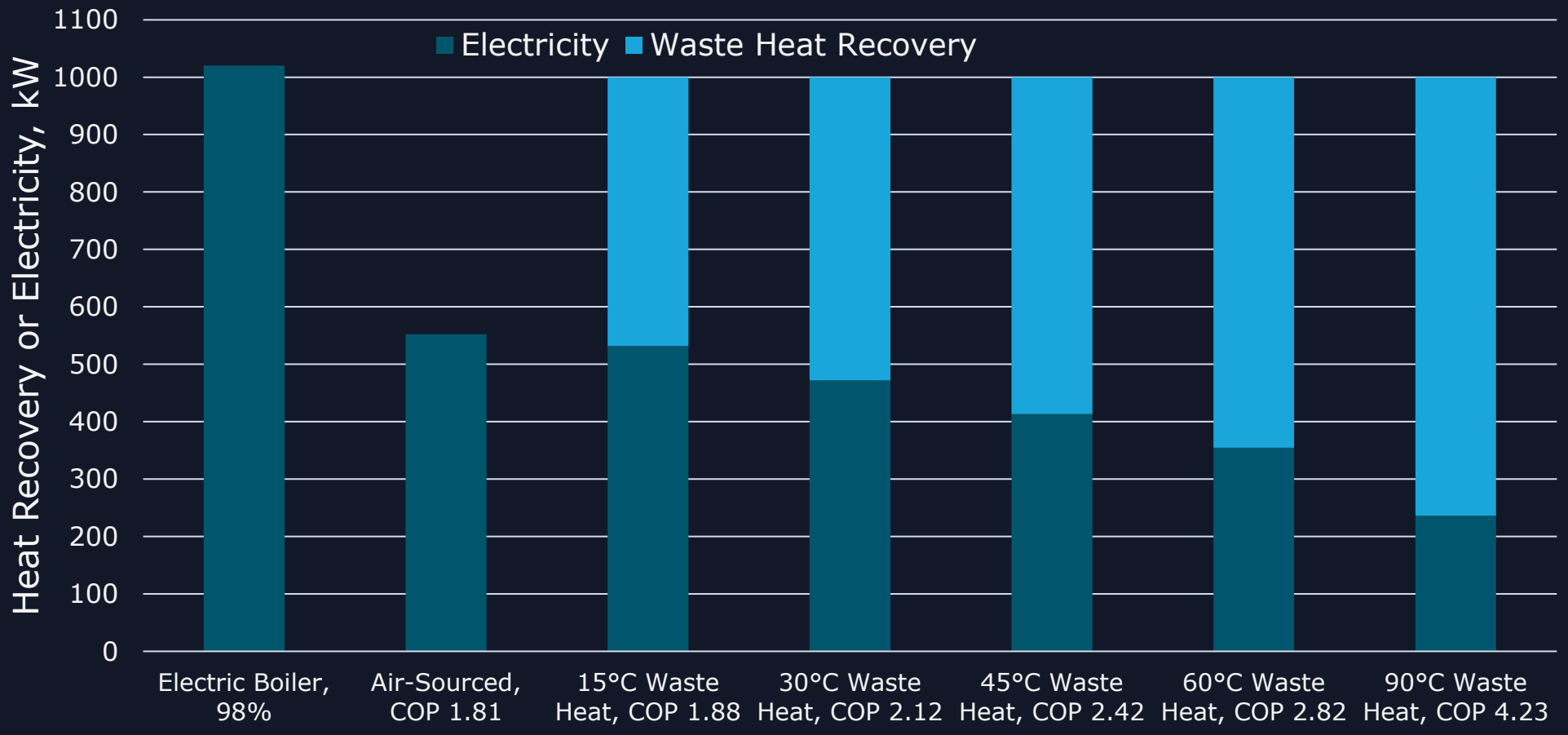


Low-Temperature Waste Heat Sourced (≤45°C) Steam Generating Heat Pump



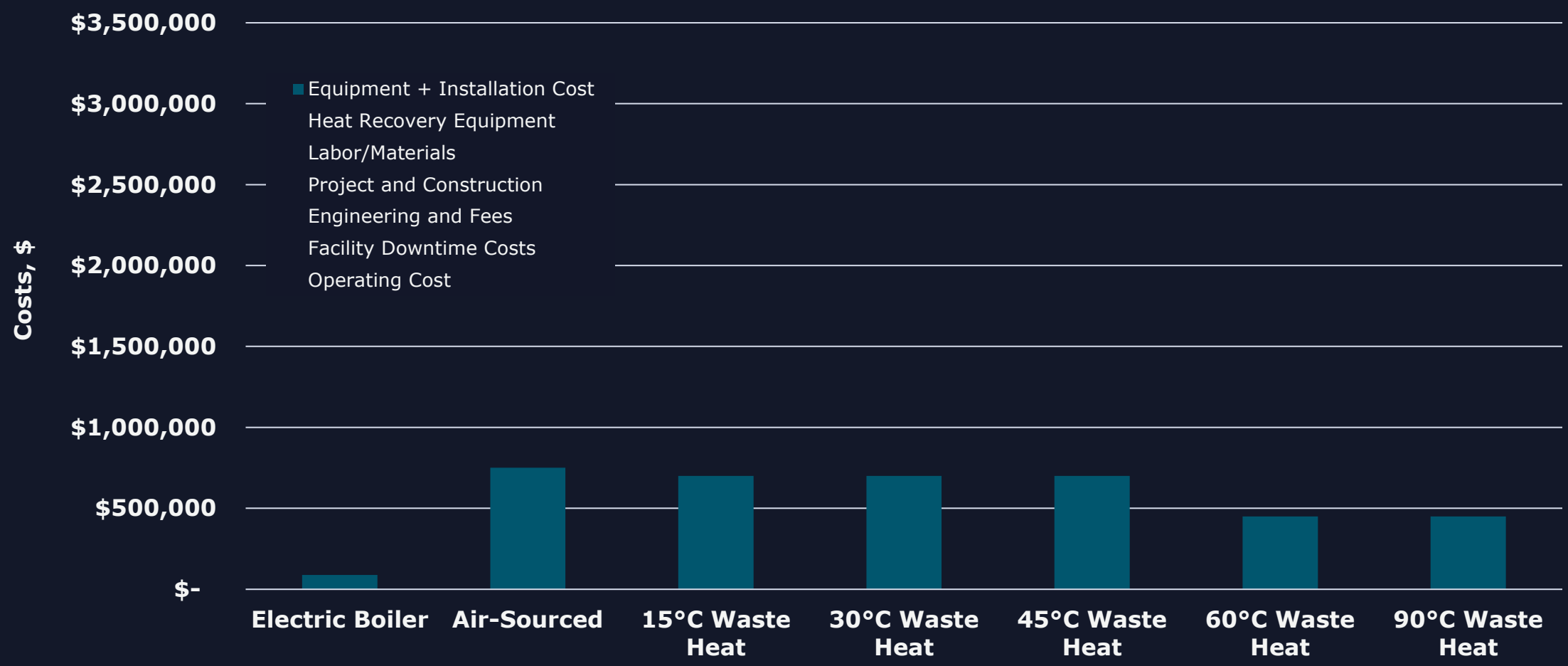
High-Temperature Waste Heat Sourced (≥60°C) Steam Generating Heat Pump

Waste Heat Recovery is Good, Right?



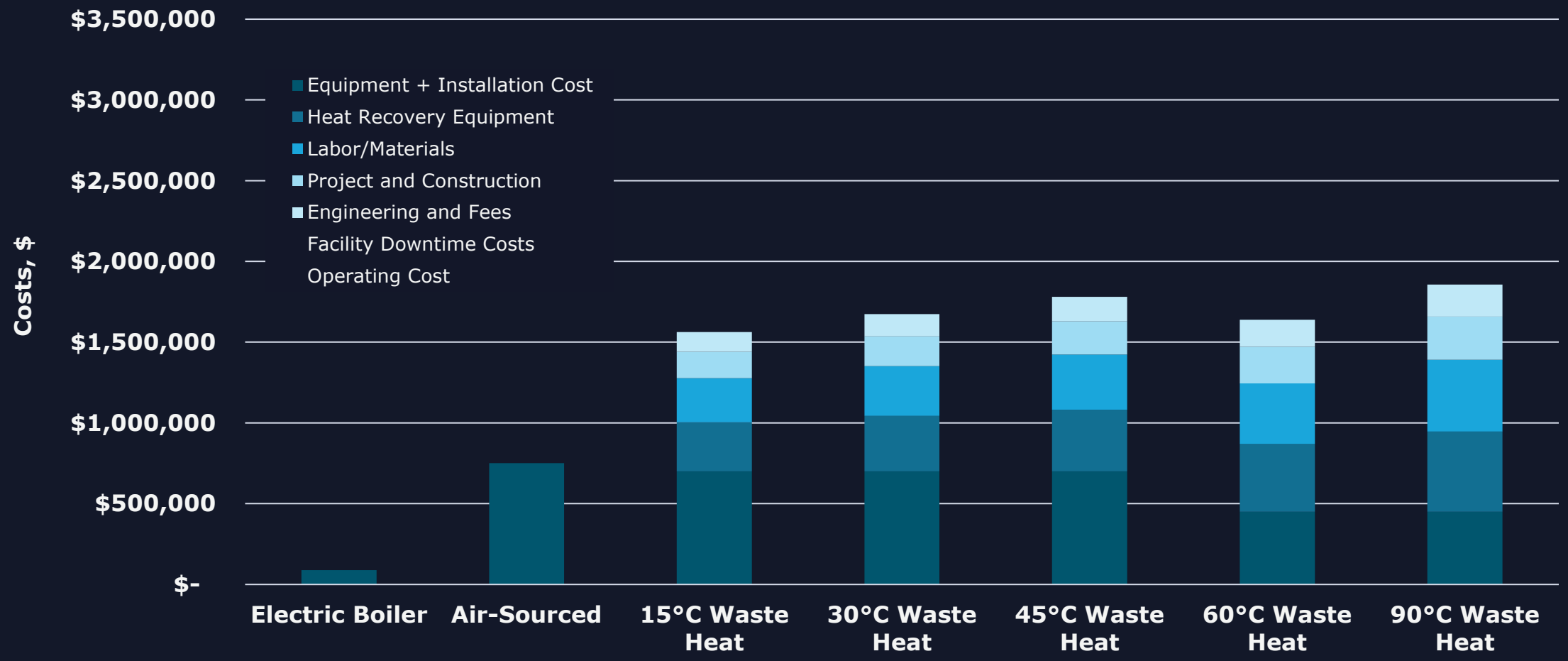
* COP values assume 60% of Carnot COP and a steam delivery temperature of 150°C

Invisible Costs



* All costs shown are for a 1MW steam capacity installation
** Revenue lost assumes $100M per annum company and 5 days of lost revenue for the installation period

Invisible Costs



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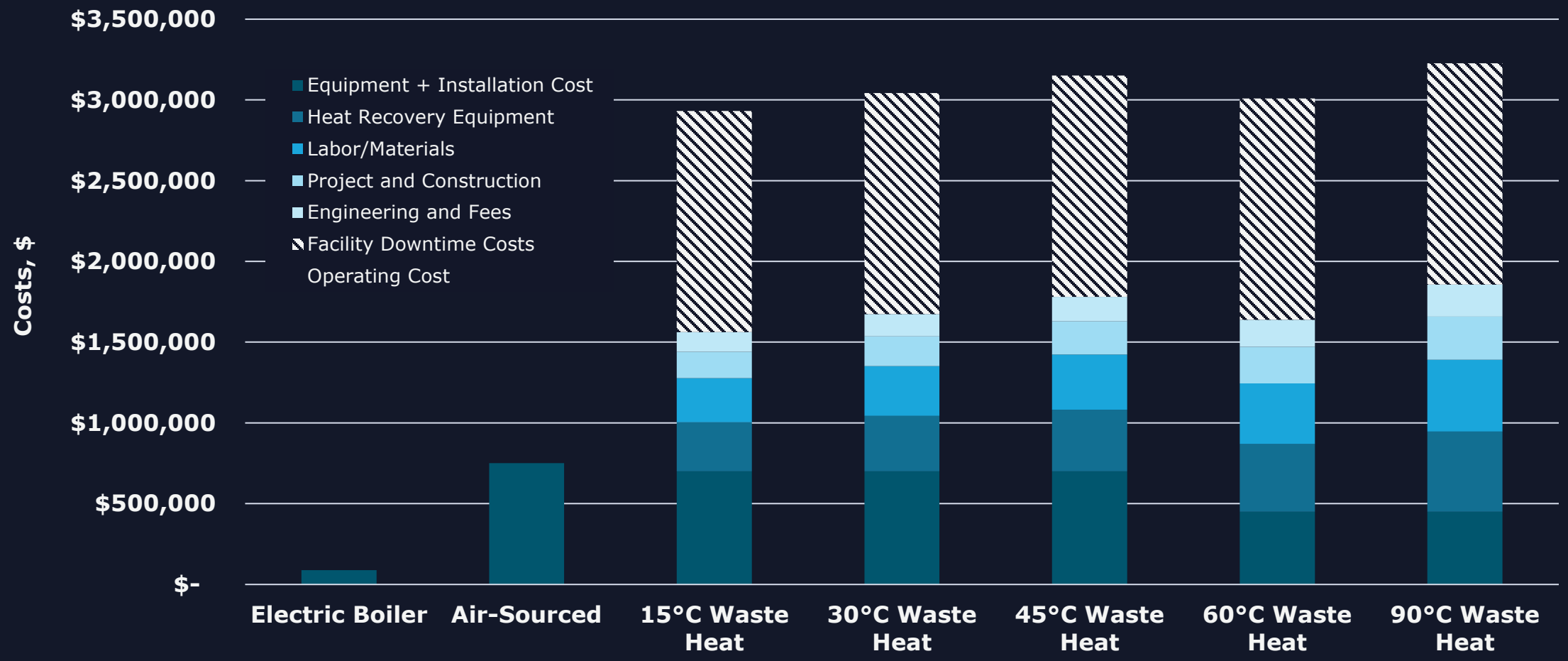

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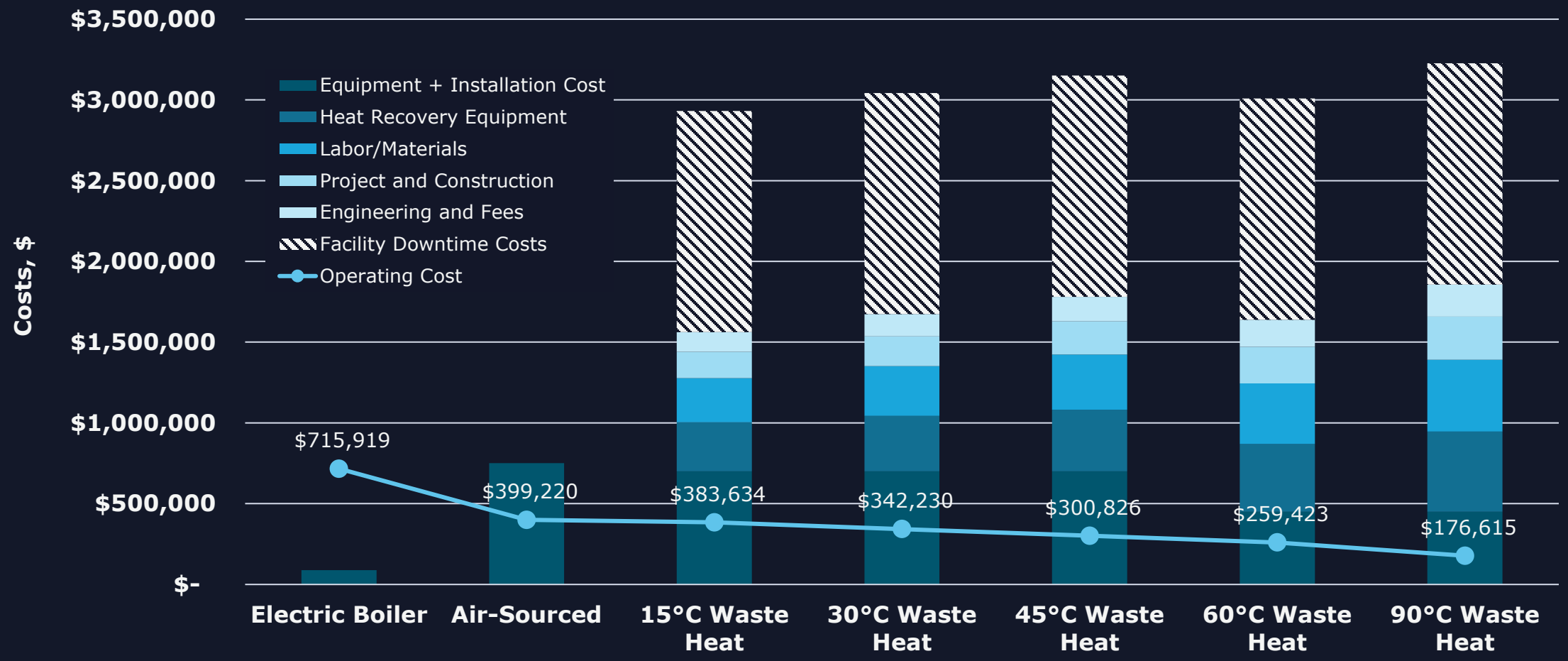

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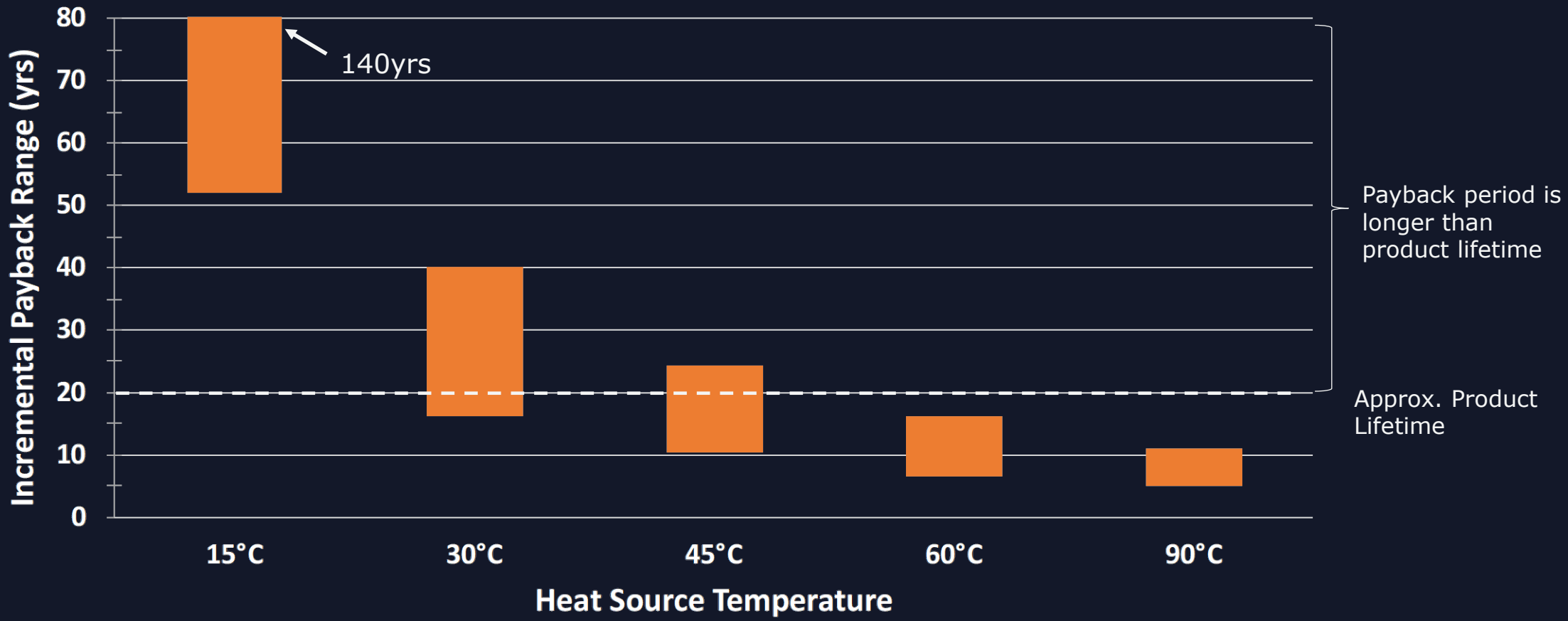
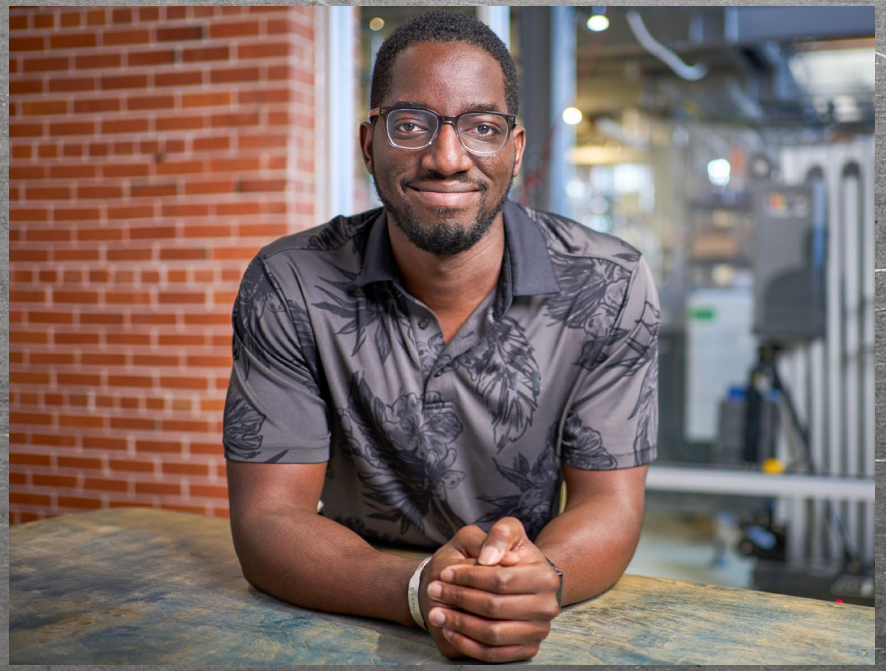
Simple Incremental Payback Period



* All costs shown are for a 1MW steam capacity installation
** Revenue lost (upper bound) assumes $100M per annum facility and 5 days of lost revenue for the installation period. Lower bound assumes no facility downtime.



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Thank You!

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