Decarbonization of heat and energy efficiency in steel industry

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As an integrated energy technology company

we support our customers along the energy value chain

Low- or zero-emission power generation

- Gas Services
- Siemens Gamesa

Transport and storage of energy

- Grid Technologies

Reducing GHG emissions and energy consumption in industrial processes

- Transformation of Industry

Agenda

1

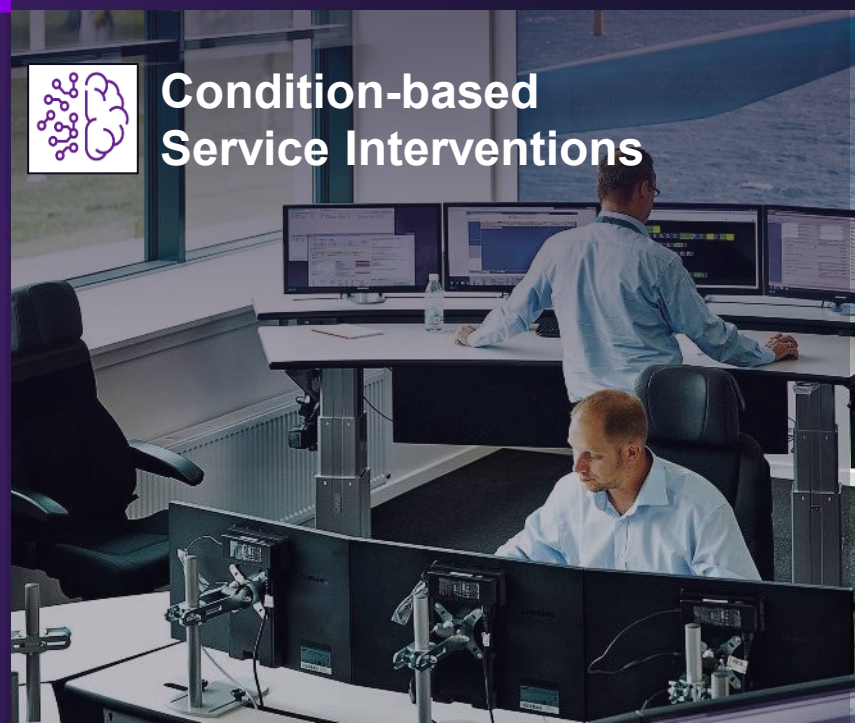
Innovation around Decarbonized Heat and Energy Efficiency

2

Compression Technology for Steel Industry Decarbonization

Siemens Energy
Fields of Actions

Leading the energy transformation



Decarbonized Heat & Industrial Processes
Focus Areas

Electrification of Heat

Focus:

- Induction Heater
- Turbo Heater

Waste Heat Utilization

Focus:

- Industrial Waste Heat Recovery (sCO2/ORC/SRC)

Decarbonize Industrial Processes

Focus:

- Co-develop use cases for Heat-to-Power and Power-to-Heat Technologies for optimized value generation
- Electrification and Electrical Drives

ORC – Organic Rankine Cycle; sCO_2 – Supercritical carbon dioxide; SRC – Steam Rankine Cycle; CCUS – Carbon Capture Utilization and Storage

Siemens Energy Induction Heater

Novel decarb solution utilizing Generator & Transformer design and manufacturing know-how

Conventional Approaches for direct heat electrification …

- Resistive
- Radiative
- Impedance

… cannot overcome 2 key challenges

- Low voltage at high MW (e.g.,1 kV) → limited scalability
- Critical electrical components exposed to high temperatures and corrosive process fluid

Siemens Energy Induction Heater overcomes these challenges

- Highly scalable due to high voltage (-->22 kV), applying well-proven technology
- Critical electrical components:
  - Maintained below 150 °C
  - Not exposed to fluid (non-contacting)
- Heats fluids, gases and two-phase flows
- Lower cost for system

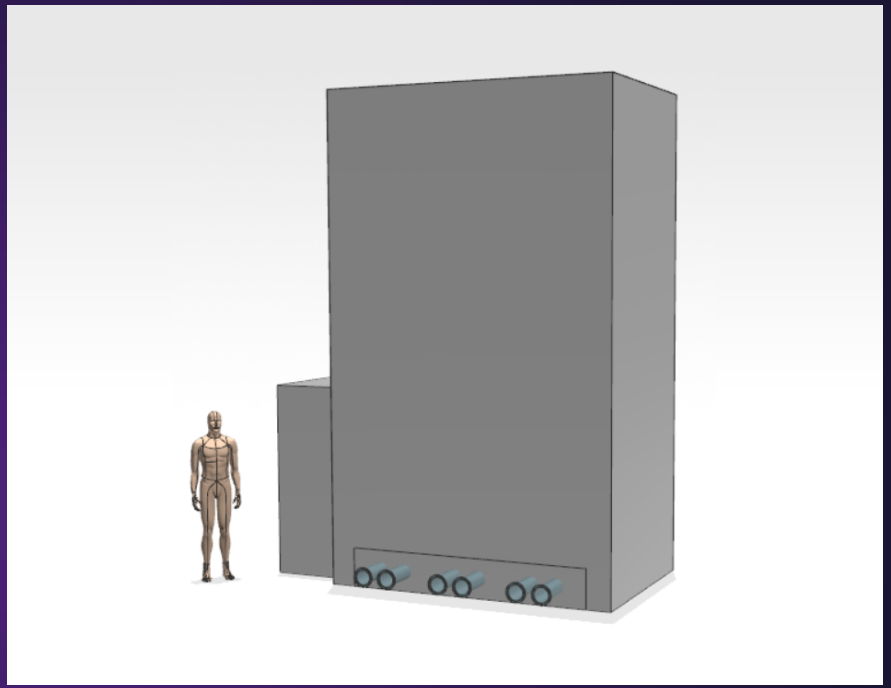
Characteristics

Temperature
100 – 1,000 °C

Power/Unit
5 – 120 MW_{th}

Efficiency
>99%

60 MW 15.75 kV **Induction Heater** for heating molten solar salt from 300 °C to 565 °C



Siemens Energy Induction Heater
Exemplary Use Cases and active validation developments

Molten Salt & Thermal Storage

- Brownfield decarbonization & industrial storage
- Thermal power → 1,000 MW
- Temperatures → 625 °C

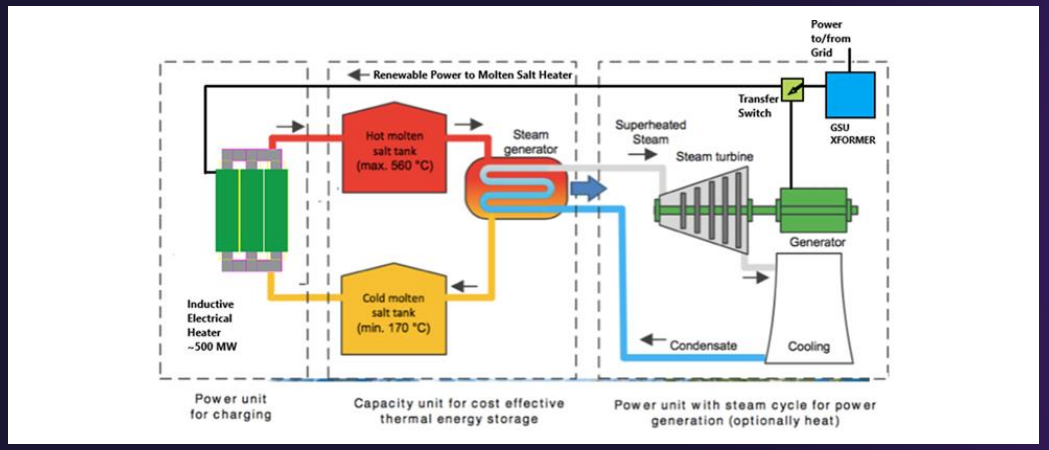
Single-phase Fluids

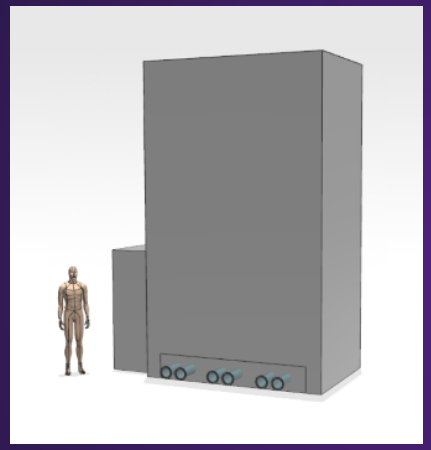
- Heating of process fluids including air and thermal oils
- Temperatures from 100 °C → 1,000 °C

Industrial Steam

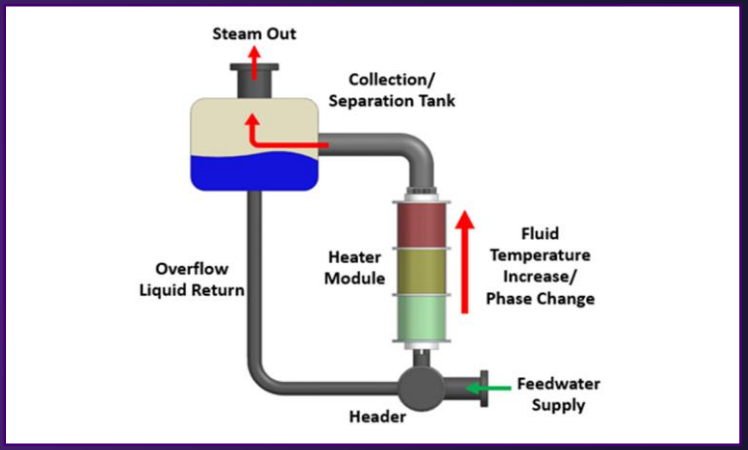
- Replace gas boilers
- Low temperature → superheated steam
- Only Electric Heater able to provide superheated and high-pressure steam

- ***500 kW demonstrator:*** *Completed (air and thermal oil)*
- ***7.5 MW Pilot:*** *Dec 2025 (molten salt)*



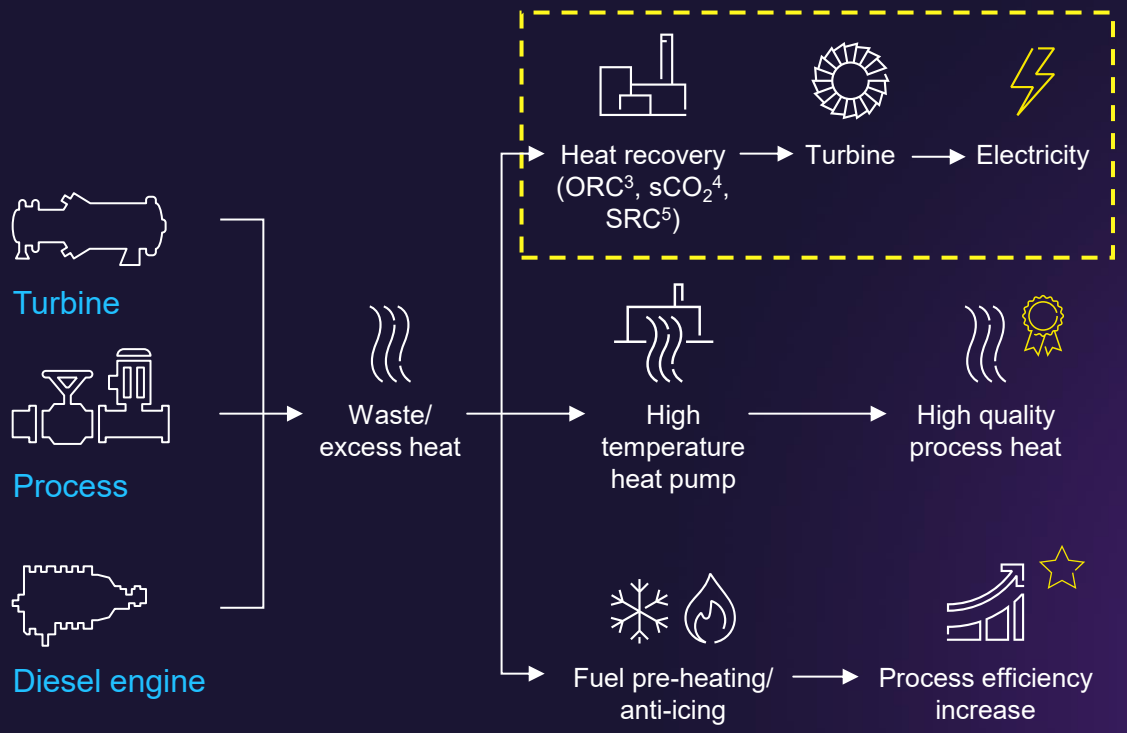


- ***Start development:*** *Jan 2025*
- ***500 kW demonstrator:*** *2026*
- ***5 MW Pilot:*** *2027*



Waste Heat Utilization
Power and heat generation without incremental emissions

Power and quality heat from all kinds of waste heat in process industry



1 HRSG: Heat Recovery Steam Generator | **2** WHRU: Waste Heat Recovery Unit |
3 ORC: Organic Rankine Cycle **4** sCO_2: Supercritical carbon dioxide |
5 SRC: Steam Rankine Cycle

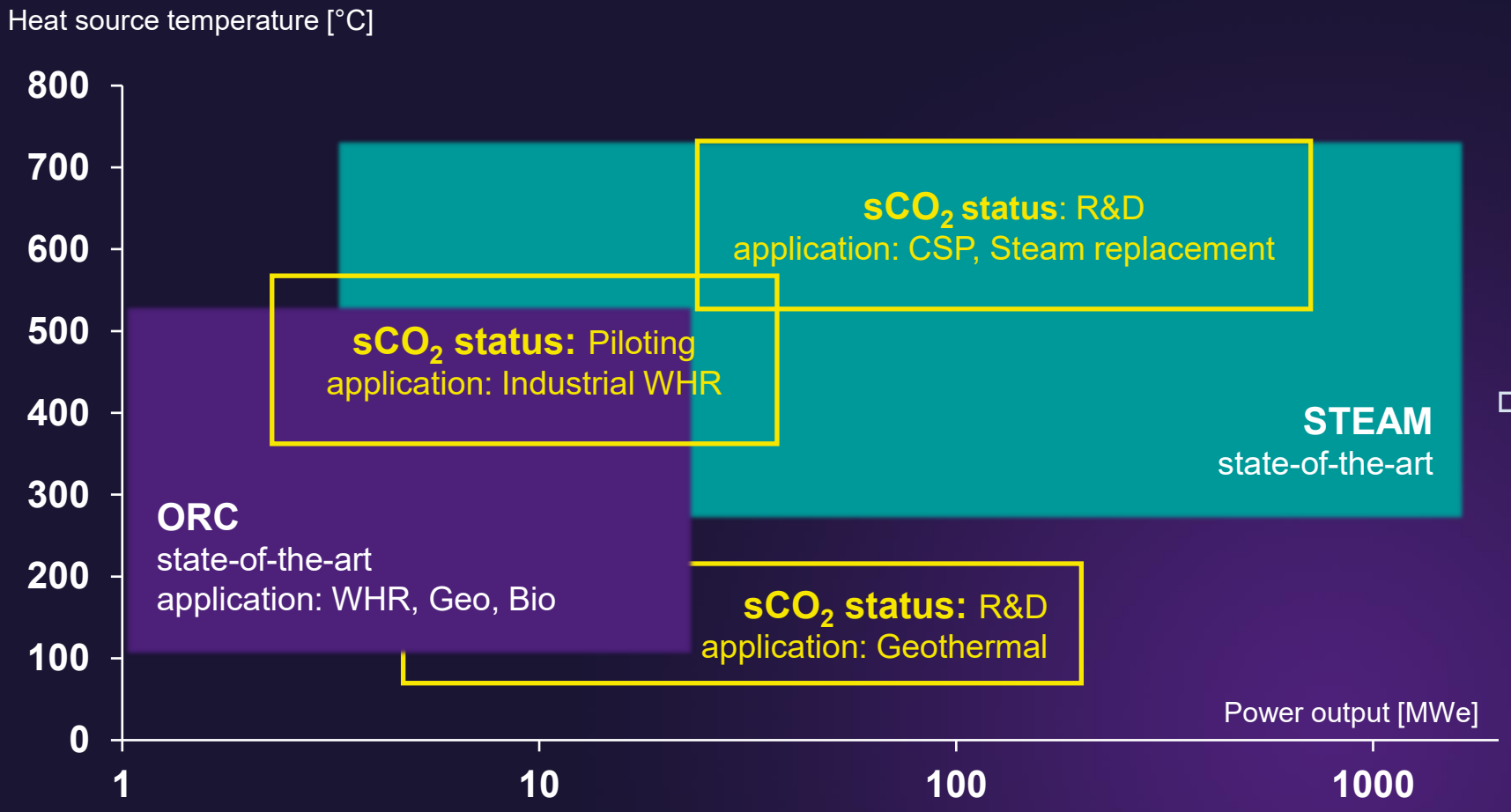
Decarbonization impact

- Captive generation to reduce electric power requirement in times of rising energy cost
- Energy Generation as additional value stream without additional CO_2 -, CO-, NO_x - or SO_x emissions
- Decrease emissions in order to comply to stricter regulations and increased emission costing

More customer benefits

- High power density and small footprint enables smooth brownfield integration and minimized cost of land for greenfield
- Builds on robust and well-proven standard building blocks for installation in any location including offshore platform
- Highly automated solutions w/o requirement for dedicated site personnel

Different technologies exists to convert thermal heat into power …

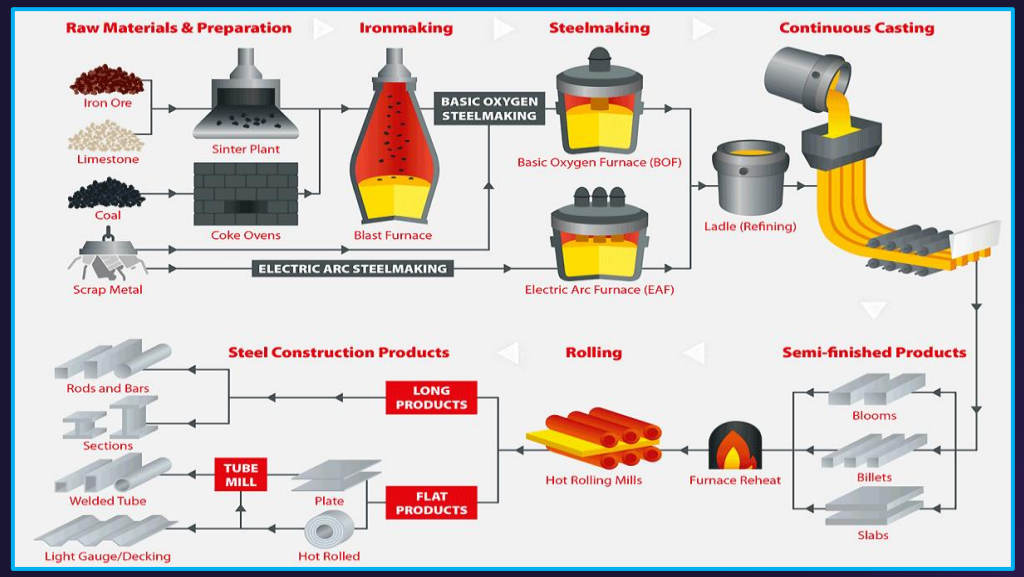


CSP: Concentrated Solar Power
WHR: Waste Heat Recovery
Geo: Geothermal
Bio: Biomass

- Different technologies exists to convert thermal heat into power:
  - Steam Rankine Cycle
  - Organic Rankine Cycle
  - Supercritical Carbon Dioxide Cycle
- **Currently Steam and ORC are fully commercialized**
- sCO_2 is investigated

Waste Heat Utilization
Heat-to-Power Solutions (Steel)

Heat Sources in Steel Production



Heat to Power Island

Features

- Going beyond conventional electrification solution to make Waste Heat Recovery most efficient and highly impactful towards decarbonization:
  - Highest possible system efficiency
  - Integration with CCUS[1] solution if required
- Transfer media:
  - SRC – all ranges
  - ORC[2] for water-free and low temperature operations
- Highly automated solutions w/o requirement for dedicated site personnel

Sustainability impact

- Captive Power Generation without additional CO_2 -, CO-, NO_x - or SO_x emissions

1 Carbon Capture Utilization and Storage
2 ORC – Organic Rankine Cycle

Agenda

1

Innovation around Decarbonized Heat and Energy Efficiency

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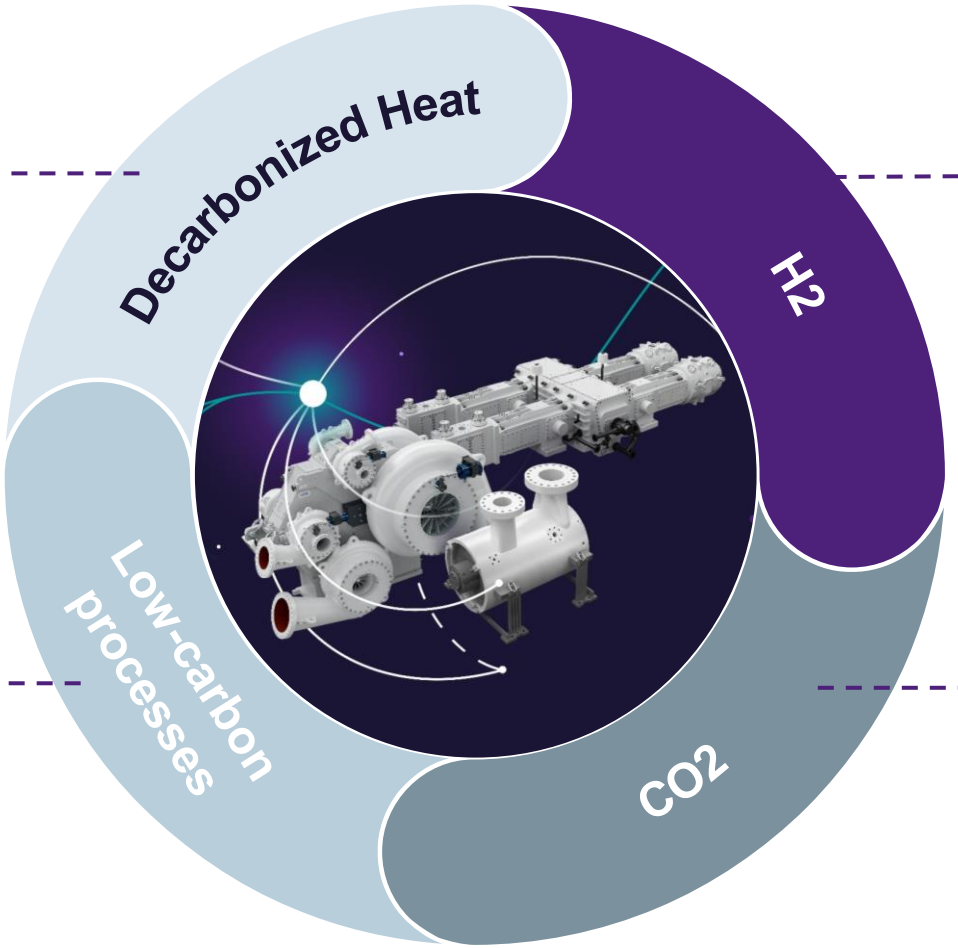
Compression Technology for Steel Industry Decarbonization

Compression technologies for Industrial Decarbonization

Decarbonized Heat, Low-carbon processes, Hydrogen and CO_2



- **1** Mechanical Vapor Recompression
- **2** Turbo Heater
- **3** Centrifugal H2 Compression Systems
- **4** Hybrid H2 Compression Systems
- **5** Process Gas Compression Systems incl. DRI process
- **6** CO2 Dehydration Systems
- **7** CO2 Heat Recovery
- **8** CO2 Liquefaction Systems

More detail in this presentation

Introducing the Turbo Heater technology

Decarbonize high-temperature heat at scale for hard-to-abate industries

- **Eliminate fuel** burn (electrification)
- **Highly scalable** Turbomachinery technology (double & triple -digit MW)

- **Direct heating** of process flow to elevated temperatures via shock wave
- **No heat exchangers** → size & operating gains

- MW-scale **demonstrator tested** (> 700 °C)
- Higher temperature in development with **capability > 1000 °C**

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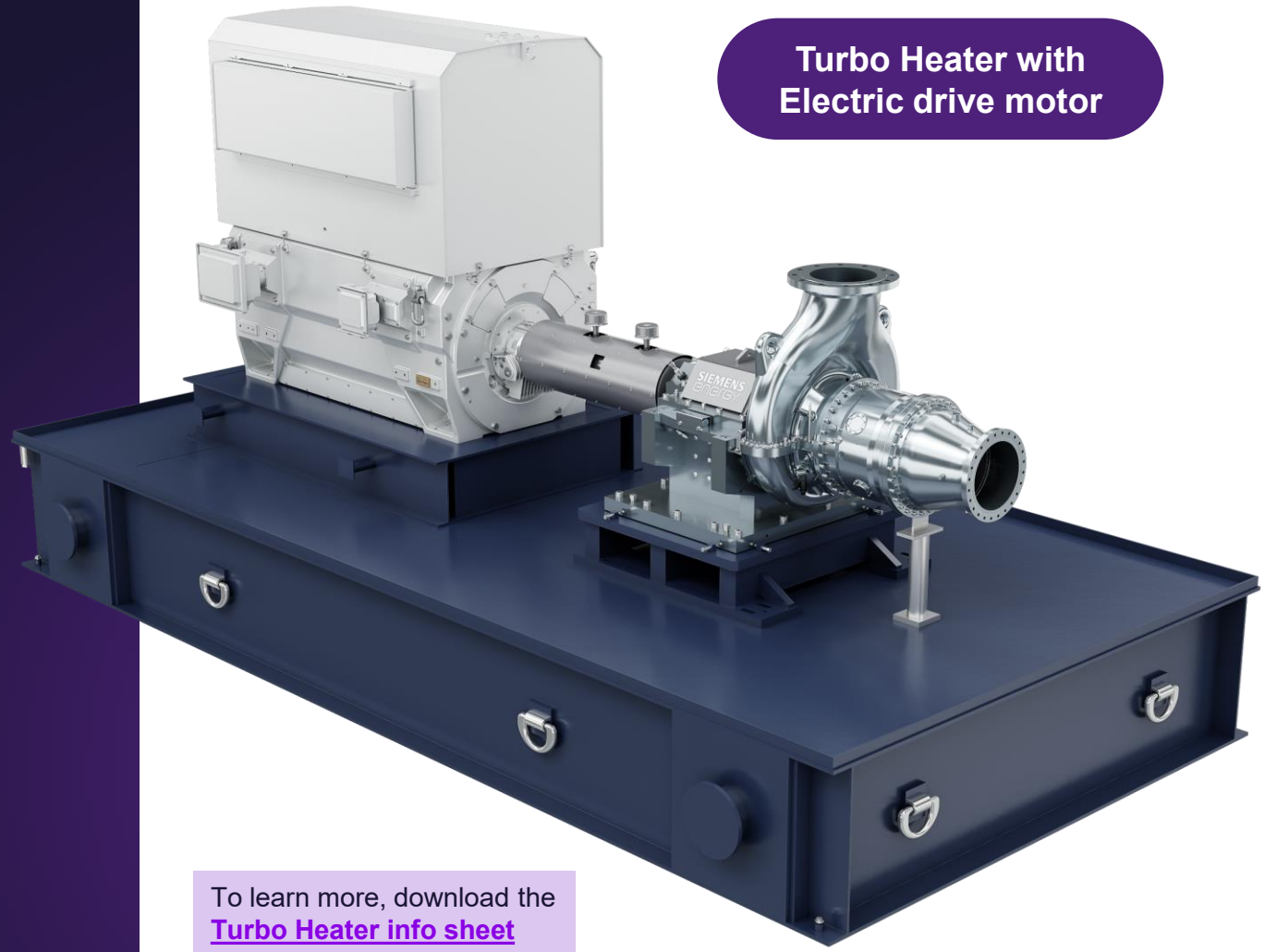
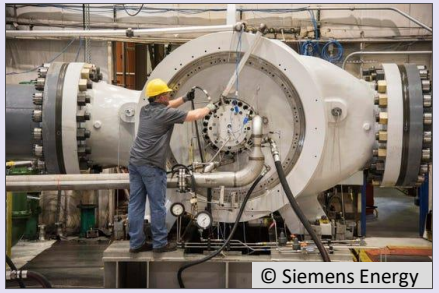
Turbo Heater with Electric drive motor



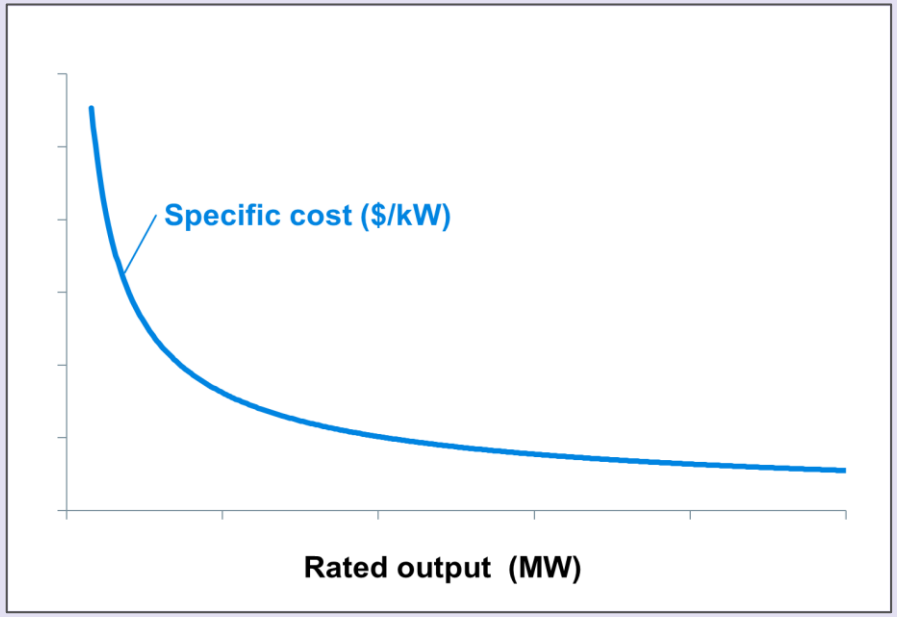
To learn more, download the [Turbo Heater info sheet]

Valuable attributes of Turbomachinery technology

Scalability

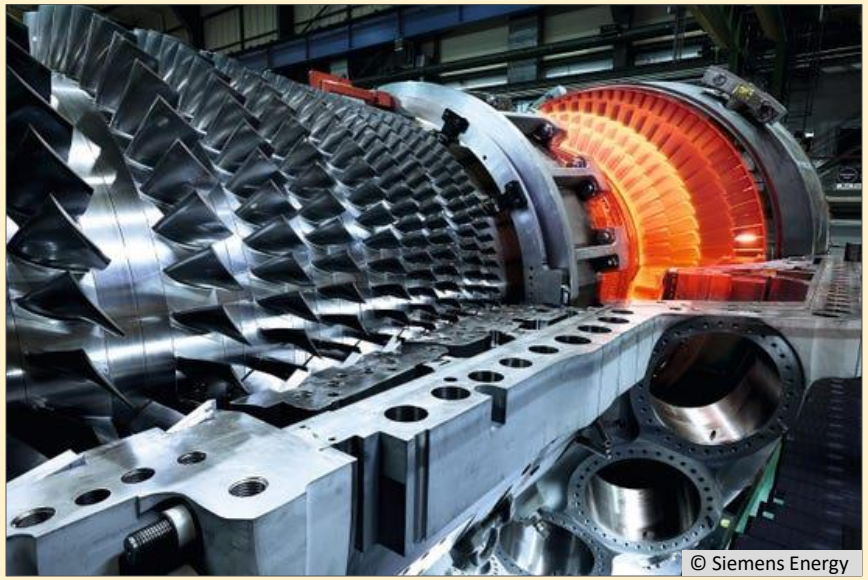


- ➔ Technology of choice for energy-dense applications
- ➔ Favorable cost scaling curve



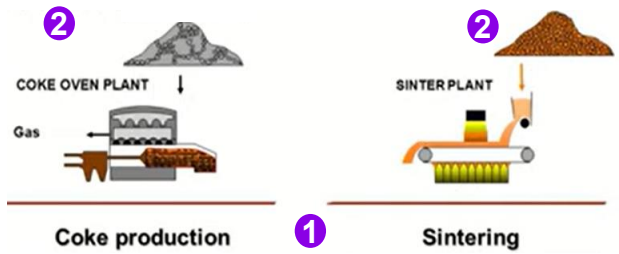
High-temperature capability

Materials and know-how proven by millions of operating hours in Gas Turbine products



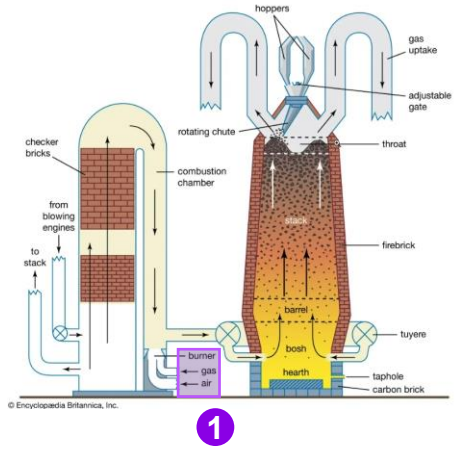
Turbo Heater application areas – Steel Industry

Drying & Preparing materials



1. Heating process
   - Coke plant ~1.150°C
   - Sinter plant ~800°C
2. Other processes e.g. drying
   - Where not integrated via waste heat recovery

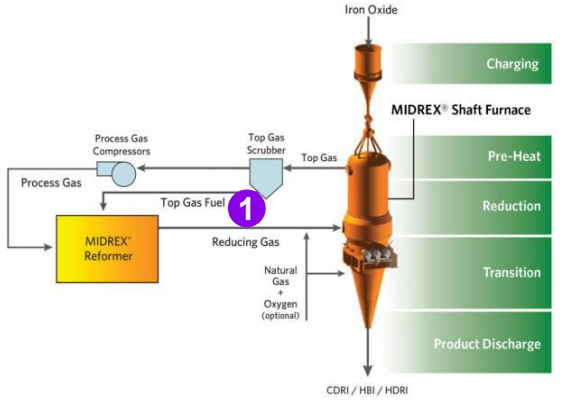
Blast Furnace



1. Hot air injection into regenerators
   - Partial fuel burn reduction to complete elimination

DRI Process

Shaft furnace



1. Decarbonized heat for DRI process
   - Heat reaction and pre-heat the furnace
   - No heat exchanger needed
   - No CO2 emissions from fuel combustion

Other applications

- Electric Arc Furnace
  - Preheating scrap
- Ladle preheating
- Reheating furnaces
  - Galvanizing, annealing

Turbo Heater inherent advantages & differentiation

- ➔ High temperature capability (~1000°C)
- ➔ Large volume flow, high energy density and exceptional scalability
- ➔ Ease of integration in “hybrid” electric / fired retrofits

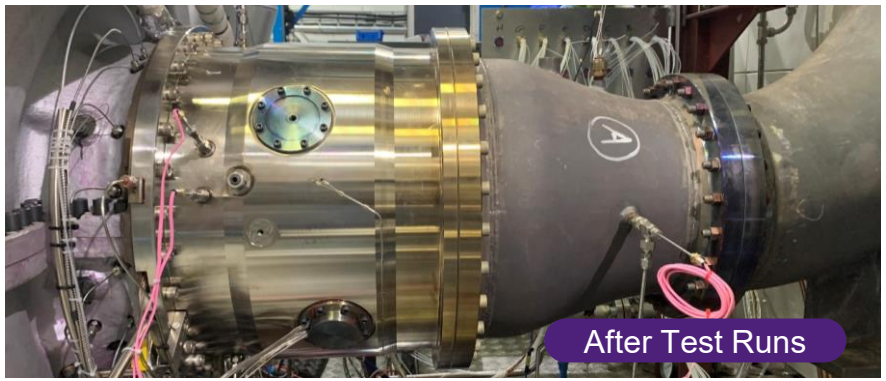
Detailed considerations for collaborative use-case assessments

- ➔ Heat integration – use of waste heat and energy optimization
- ➔ Heat transfer to material – radiant heat from flame vs. convective heat
- ➔ Dust loading, cleanup and filtration solutions

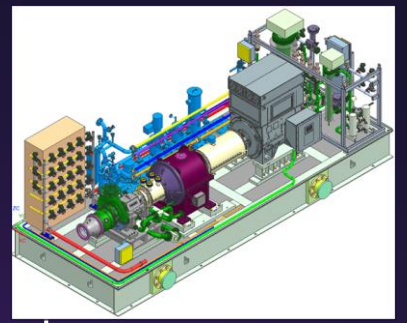
Technology Development Roadmap

Successful Prototype Test (1.6 MW)

- ➔ Air heating to > 700 °C
- ➔ Excellent alignment to pre-test predictions



Demo Unit factory test
Siemens Energy factory
TRL 6



Field Demonstration
Industrial Site
TRL 7

Scale-up deployment
Commercial Operations
TRL 8 & 9

Turbo Heater Development — *Scale-up 10 MW +*

Rotating Olefins Cracker[1] (ROC) — *Temperature 1000 °C + Hydrocarbon Mix*

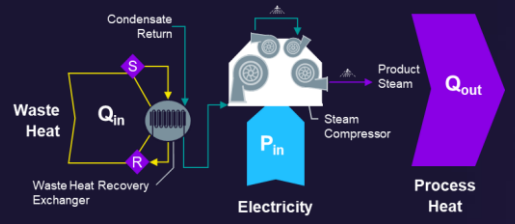
[1] Exclusive partner Technip Energies only for applications to olefins production (e.g. ethylene)

Hydrocarbon Demo
Cracking > 1000 °C
*US DOE contract award

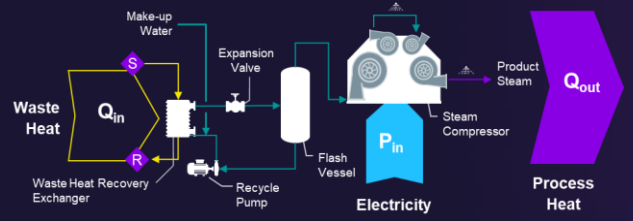
Mechanical Vapor Recompression (MVR) Systems

- Safe, environmentally friendly and **single working fluid**
- Allows the **integration** of several heat sources and sinks
- Combines **heat generation and cooling**
- Process **cooling de-coupled** from available air or water temperatures
- System based on **common and referenced equipment**
- **Up to 330 °C with current state-of-the-art**

Closed Loop

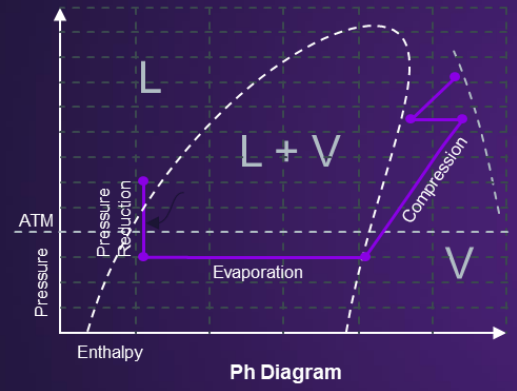


Once Through

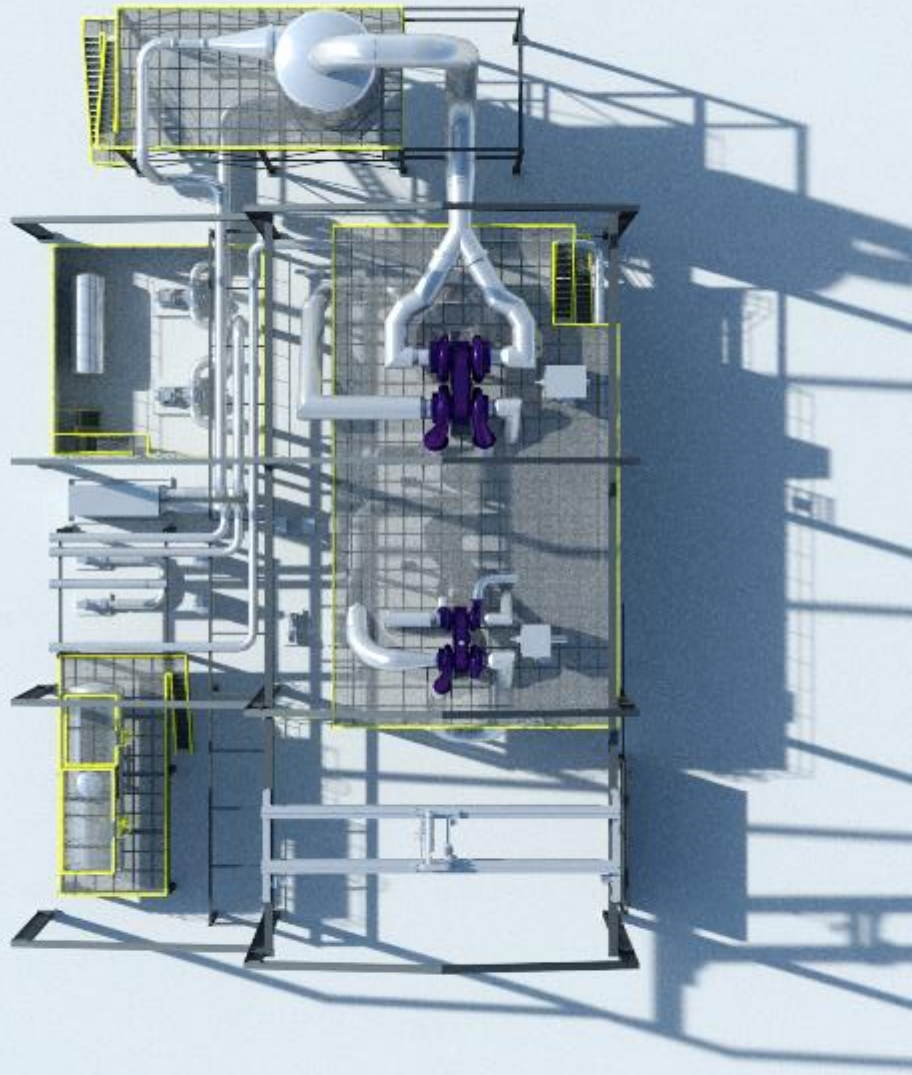


System Efficiency

$$COP = \frac{\text{Thermal Energy } (Q_{OUT})}{\text{Electrical Energy } (P_{IN})}$$



Ph Diagram



CO_2 Compression Systems
Siemens Energy Value Proposition

SIEMENS energy

3 Heat Integration

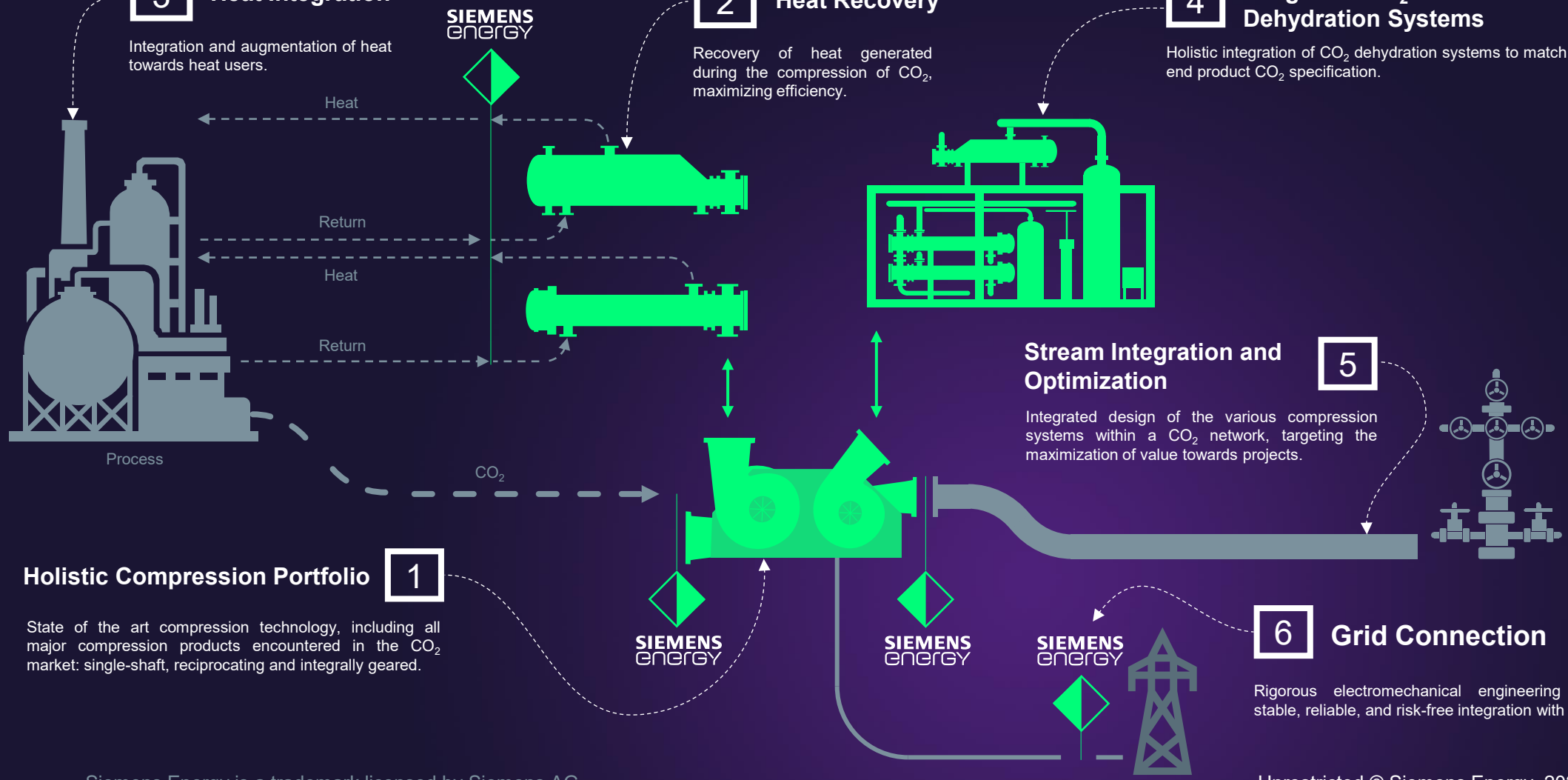
Integration and augmentation of heat towards heat users.

2 Heat Recovery

Recovery of heat generated during the compression of CO_2, maximizing efficiency.

4 Integrated CO_2 Dehydration Systems

Holistic integration of CO_2 dehydration systems to match end product CO_2 specification.



Stream Integration and Optimization 5

Integrated design of the various compression systems within a CO_2 network, targeting the maximization of value towards projects.

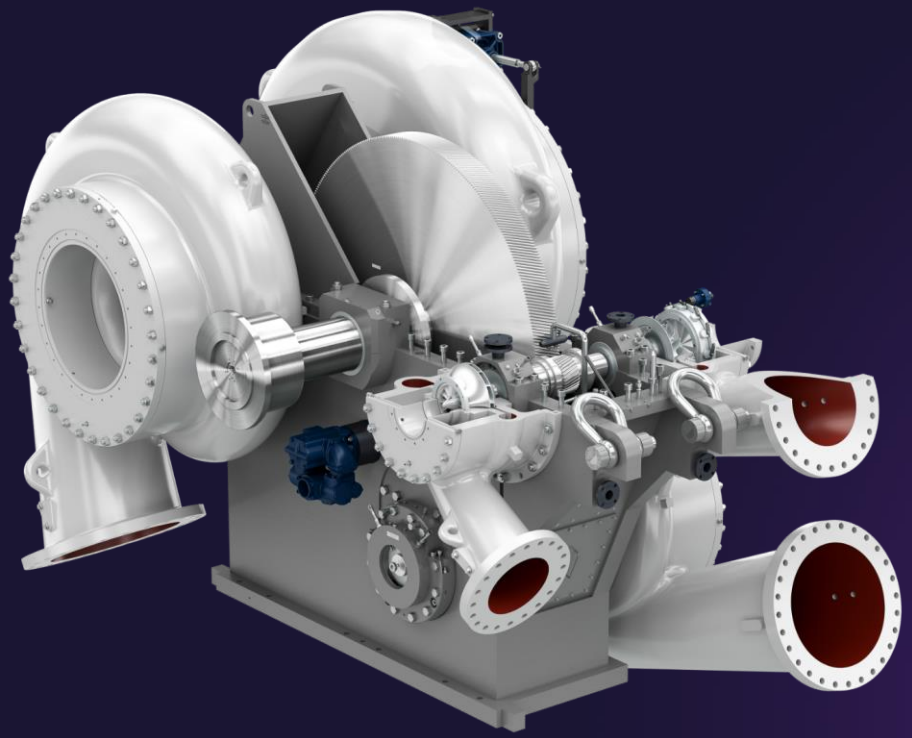
Holistic Compression Portfolio 1

State of the art compression technology, including all major compression products encountered in the CO_2 market: single-shaft, reciprocating and integrally geared.

6 Grid Connection

Rigorous electromechanical engineering model for stable, reliable, and risk-free integration with the grid.

Integrally Geared Compressors
Ideal match for MVR and CO_2 compression



Also used for DRI Process Gas Compression

- Up to 8 individual compression stages in one machine
- Intercooling between stages provides best efficiency
- Further efficiency gains by using intercoolers as heat source to process
- Stages can process separate fluids (serve multiple processes, cascaded refrigerant cycles, etc..)
- Flow capacity up to 1,000,000 m^3/h
- Pressure up to 250 bar
- Adaptable Stage Design
- Fix Speed with IGV control
- Reliable API 617 Design
- Over 2,500 units sold

Stay in contact with us:

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