SHTE Swedish Suppliers of Heat Treatment Equipment Värmebehandlingskonferensen, 4 – 5 maj 2022 på Aronsborg Konferens i Bålsta

Energy consumption and CO_2 Footprint – Comparison of Selected Furnace and Case-hardening Concepts

4th May 2022

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Outline

- Motivation
- Plant and heat treatment parameters
- Comparison of the types of equipment for case hardening
- CO_2 equivalents in country comparison
- Case hardening footprint by furnace type and location
- Conclusion

Motivation

- Policy requirement: CO_2 emissions must be reduced (CO_2 neutrality by 2035)
- Energy prices will rise
- Which energy source is more effective
- Data situation unclear, contradictory information in the market, as no uniform boundary conditions for carburizing temperature and plant location
- Utilization/workload, must be known

Heat Treatment Parameter

- Material: 16MnCr5
- Carburization depth: 0.8 mm; **1.0 mm**; 1.2 mm
- Carbon content limit: 0.35 %
- Quenching: Gas - or oil-quenching
- Temperature: 930 ° C
- Batch surface: 10 m²

Furnace Parameters

- Insulation: lining/brickwork with back insulation (ATM).
  Standard "graphite felt" (single-chamber vac.)
  Graphite + back insulation (multi-chamber vac.)
- Burner efficiency: 72 %
- Gas supply: Endothermic gas / natural gas (ATM)
  Acetylene (vacuum)
- Utilization: 24/7

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Other Boundary Conditions

- Furnace condition: approx. 5-10 years old, well maintained
- Insulation: Standard "2010“
- Pre- and post-cleaning as well as tempering were not considered in order to focus comparability on main processes and plants
- Loading (gross/net) – charging material (trays, grids, etc.) considered

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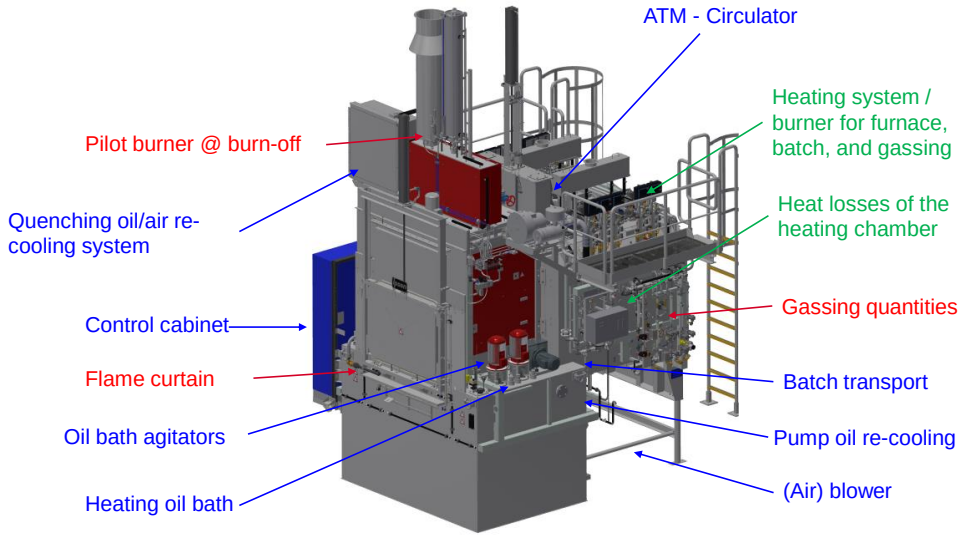
Furnace Types

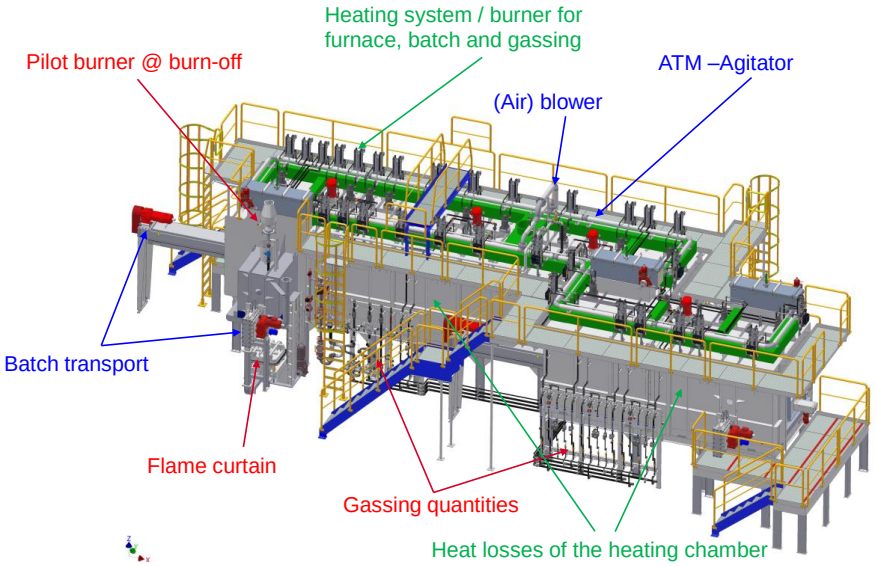
Furnace Types

Furnace type	Ipsen type	Size	Work zone volume in m^3	Batch weight kg (max.)	Quenching
Sealed quench (SQ) furnace	Atlas RTQ	M	0,405	500	Oil
		XL	0,972	1500	Oil
Pusher type furnace	PP	M-	0,275	350	Oil
Single-chamber-vacuum furnace	T2T	M	0,324	800	Gas
		XL	0,972	1500	Gas
Two-chamber-vacuum furnace	RVFOQ	XL	0,972	1500	Oil
	Argos XS	M+	0,450	1000	Gas
Multi-chamber-vacuum furnace	Argos (6 chambers)	M+	0,450	1000	Gas

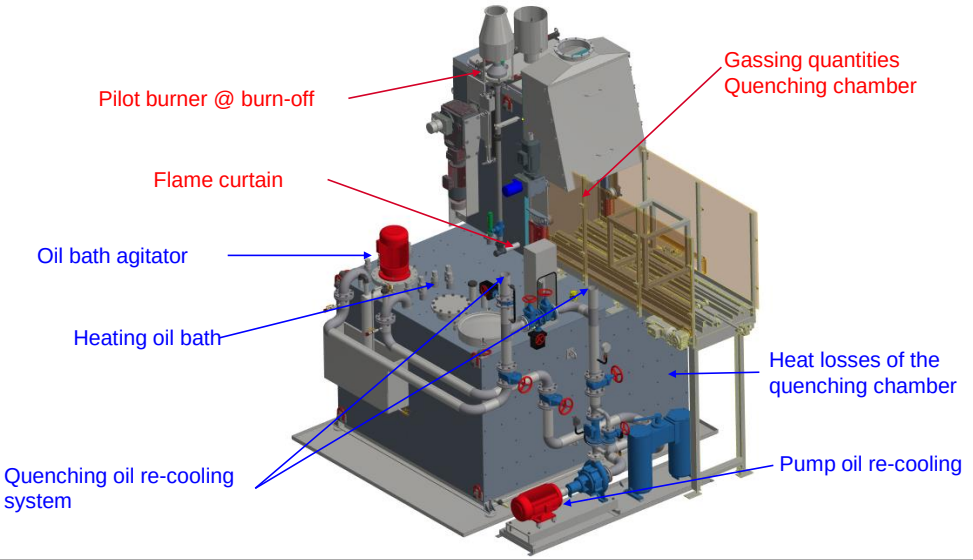
Considered Furnace Components – SQ Furnace



Furnace components considered - Conti



Furnace components considered - Conti oil bath



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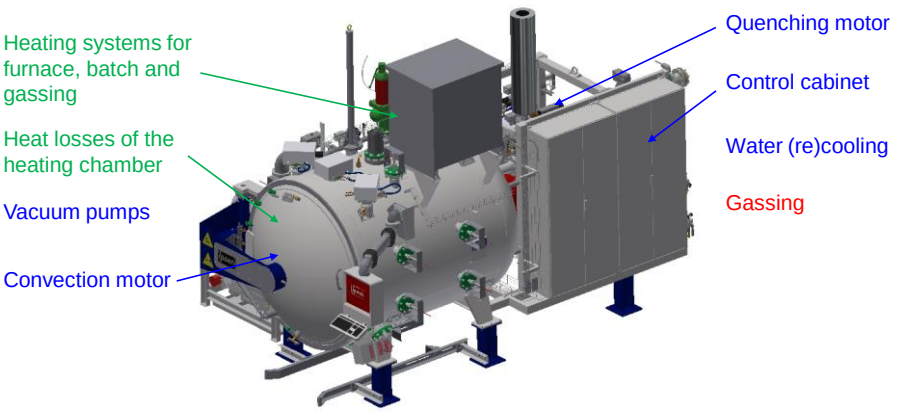
Considered furnace components
Single-chamber vacuum furnace



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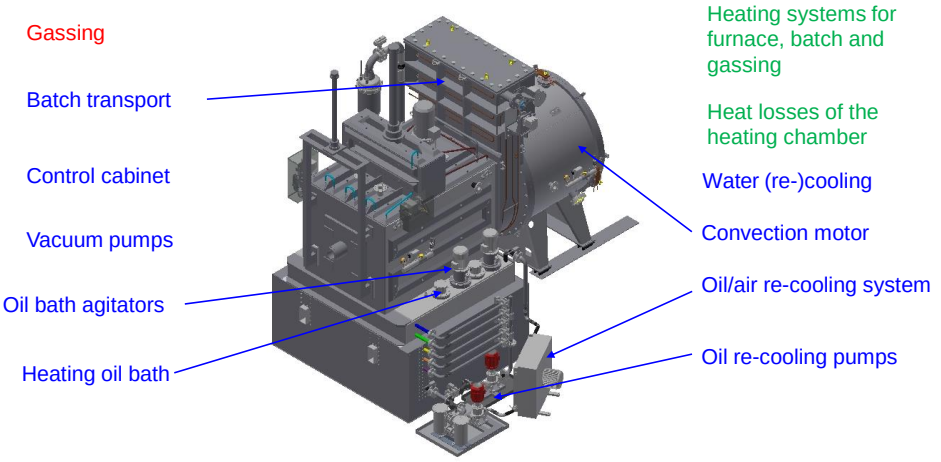
Considered furnace components
Two-chamber vacuum furnace with oil quench



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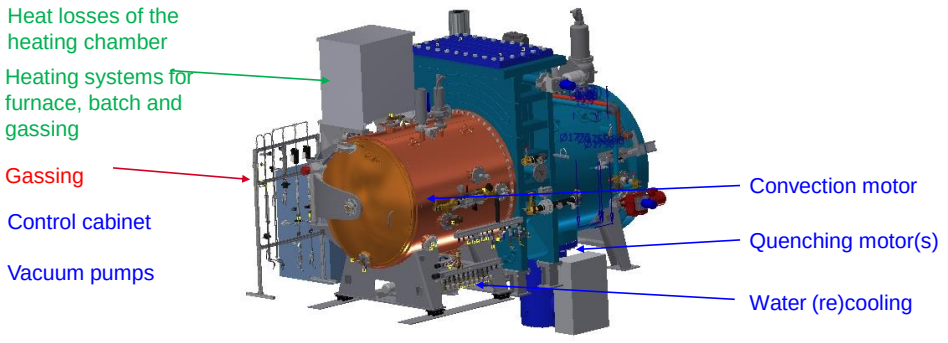
Furnace components considered
Two-chamber vacuum systems with HGA



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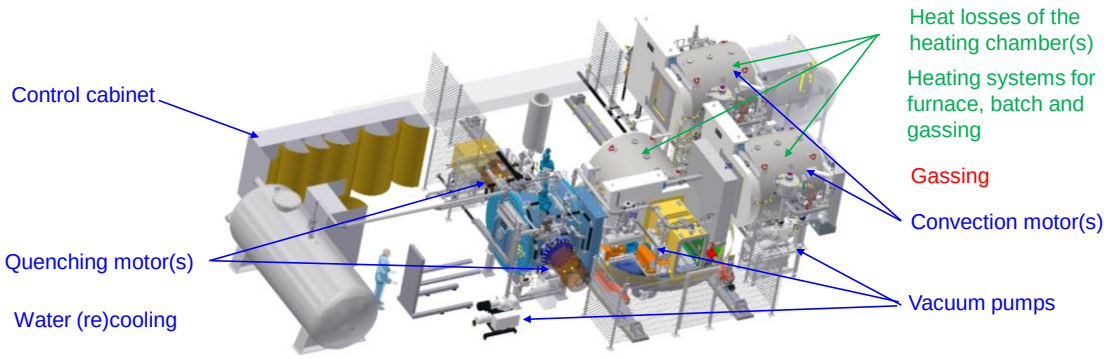
Furnace components considered
Multi-chamber vacuum systems with HGA



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Plant Location

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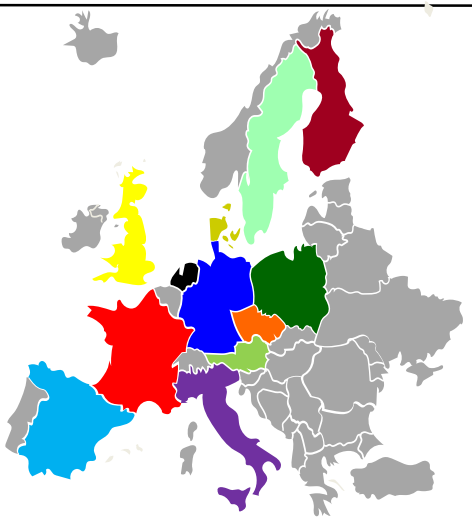
CO_2 equivalent per kWh of electricity generated in various European countries (as of 2019)



10 g CO_2/kWh	Sweden
56 g CO_2/kWh	France
89 g CO_2/kWh	Finland
94 g CO_2/kWh	Austria
112 g CO_2/kWh	Denmark
210 g CO_2/kWh	Spain
230 g CO_2/kWh	UK
233 g CO_2/kWh	Italy
350 g CO_2/kWh	Germany
390 g CO_2/kWh	Netherlands
432 g CO_2/kWh	Czech Republic
751 g CO_2/kWh	Poland

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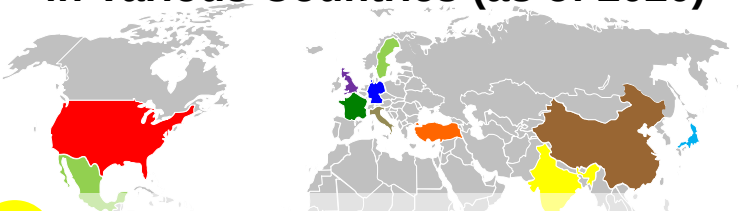
Source: www.eea.europa.eu

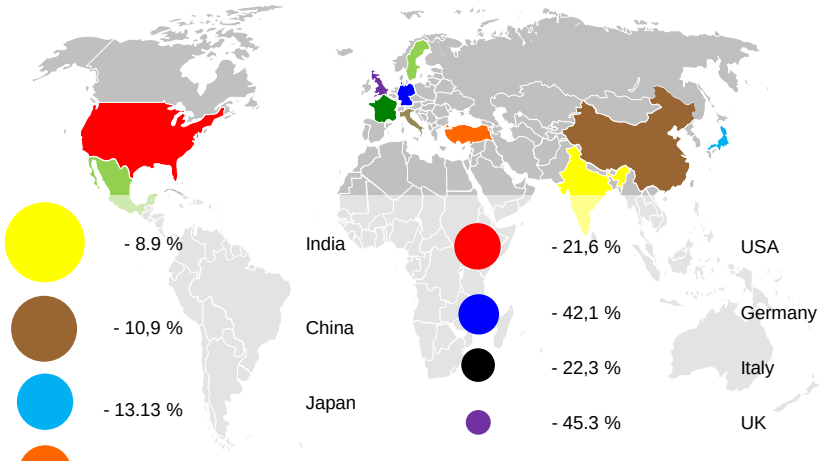
CO_2 Equivalent per kWh of Electricity Generated in Various Countries (as of 2020)



708 g CO_2/kWh	India
537 g CO_2/kWh	China
465 g CO_2/kWh	Japan
375 g CO_2/kWh	Turkey
431 g CO_2/kWh	Mexico
343 g CO_2/kWh	USA
210 g CO_2/kWh	Germany
244 g CO_2/kWh	Italy
176 g CO_2/kWh	UK
53 g CO_2/kWh	France
8,8 g CO_2/kWh	Sweden

Source: www.climate-transparency.org, www.eea.europa.eu

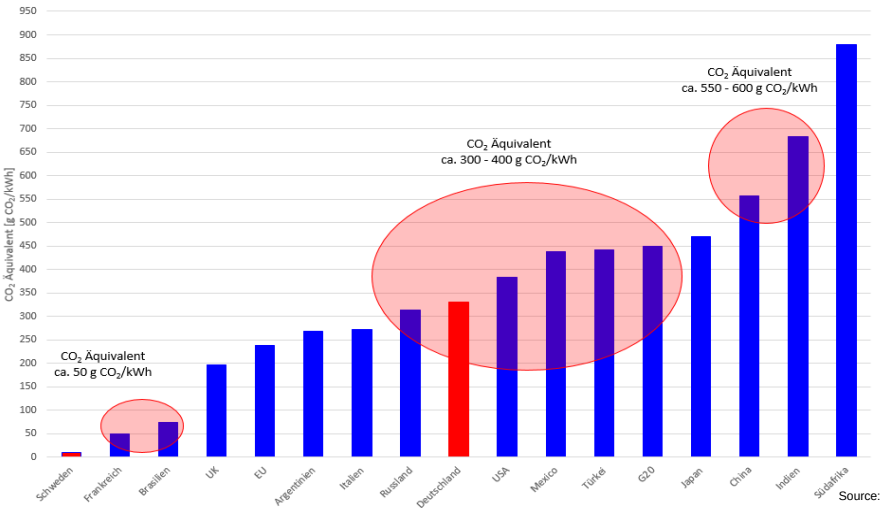
CO_2 Equivalent 5-year Trend (2015-2020)



- 8.9 %	India	- 21,6 %	USA
- 10,9 %	China	- 42,1 %	Germany
- 13.13 %	Japan	- 22,3 %	Italy
- 12.6 %	Turkey	- 45.3 %	UK
- 7.6 %	Mexico	- 14,5 %	France
		- 12.0 %	Sweden

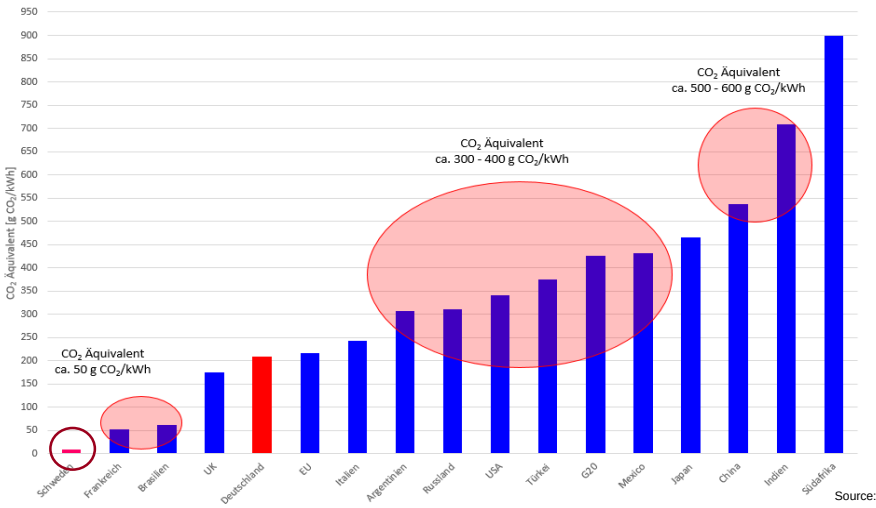
Source: www.climate-transparency.org, www.eea.europa.eu

CO_2 equivalent [g CO_2/kWh] of various G20 countries - status 2019



Source: www.climate-transparency.org

CO_2 equivalent [g CO_2/kWh] of various G20 countries - status 2020



Source: www.climate-transparency.org

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Comparison of CO_2 Emissions for Different Furnace Types

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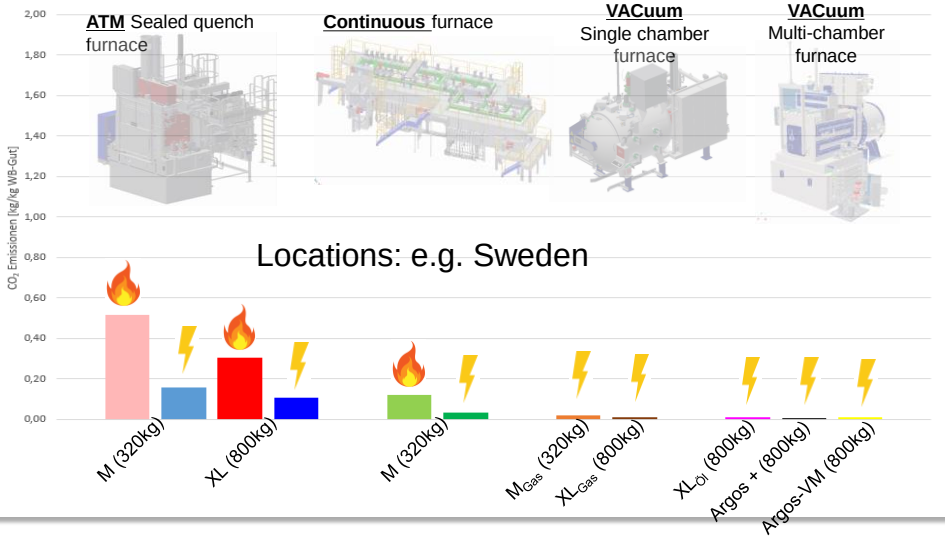
CO_2 emissions per kg heat treatment material in different furnace systems with a CHD 1.0 mm and a CO_2 equivalent of 10 g CO_2/kWh



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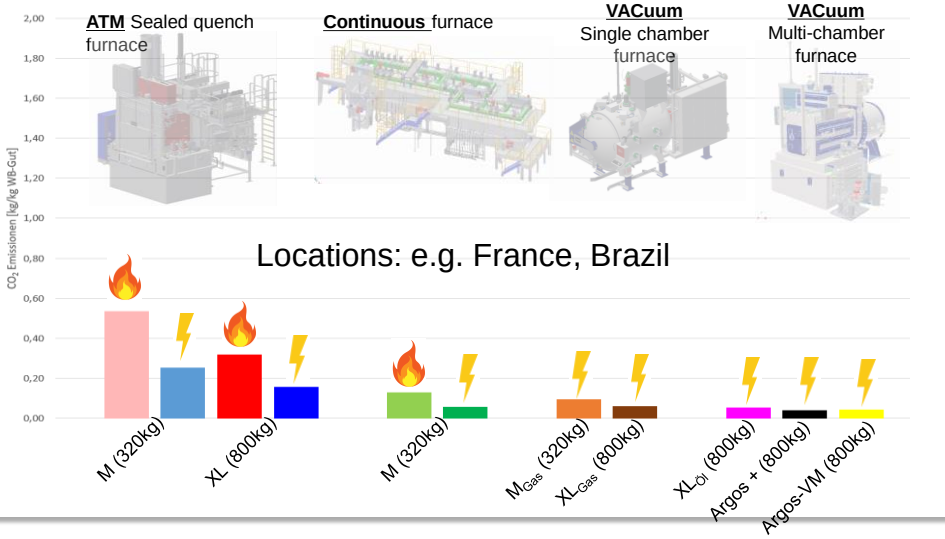
CO_2 emissions per kg heat treatment material in different furnace systems with a CHD 1.0 mm and a CO_2 equivalent of 50 g CO_2/kWh



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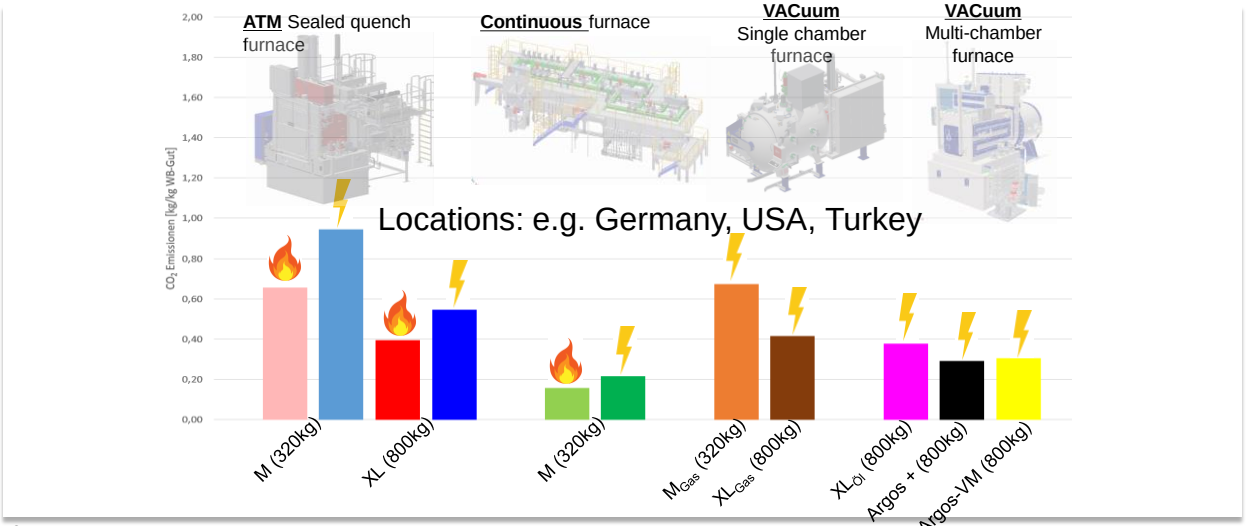
CO_2 emissions per kg heat treatment material in different furnace systems with a CHD 1.0 mm and a CO_2 equivalent of 350 g CO_2/kWh



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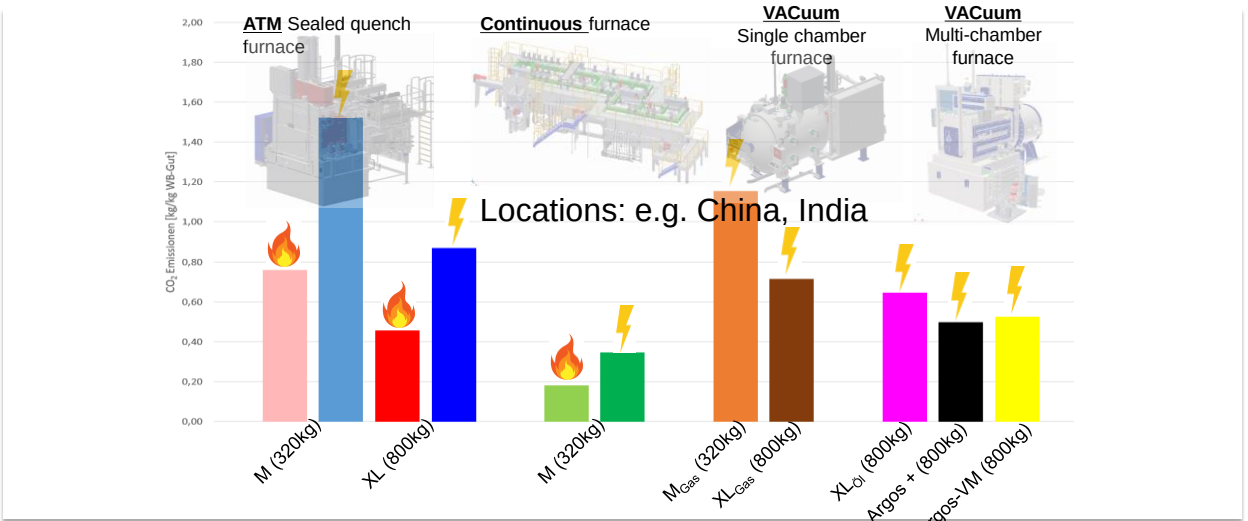
CO_2 emissions per kg heat treatment material in different furnace systems with a CHD 1.0 mm and a CO_2 equivalent of 600 g CO_2/kWh



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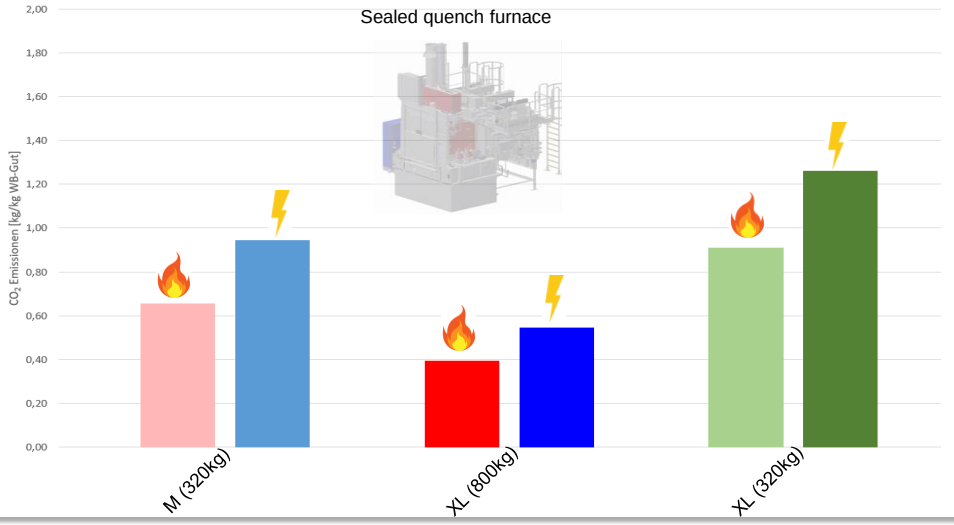
CO_2 Emissions per kg of Heat Treatment Material in the SQ Furnaces of Different Sizes and Load Weights with a CHD 1.0 mm and CO_2 Equivalent of 350 g CO_2/kWh



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Conclusions and Outlook

- For case hardening, pusher type furnaces are most effective per kg of heat treated parts at full capacity, (except Sweden)
- Comparative considerations between furnace concepts must be made at the same carburizing temperature
- For CO_2 emissions, the location must be named
- Flexibility and fluctuations in capacity utilization change the result

Final comments:
Only CO_2 emissions are compared here - not energy costs. The picture here is different, in some cases the opposite.
The CO_2 foot print of e. g. nitrogen depends on the plant location

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