GreenCastAudit

Pathways Towards Sustainable and Low-Carbon Casting Production

Toše Petkov[1], Thomas Pabel[1], Peter Liepert[1], Carina Seidnitzer-Gallien[2], Rene Baumann[2], Philipp Gradl[2], Wolfgang Gruber-Glatzl[2]
[1] Austrian Foundry Research Institute, Leoben, Austria
[2] AEE - Institute for Sustainable Technologies, Gleisdorf, Austria

SCAN ME

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ACR – Strategic Project

Decarbonization and Quality Assurance in the Foundry Industry

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The Foundry Industry Faces a Trade-Off

Foundries require large amounts of energy for melting, casting, and heat treatment. At the same time, the demands for:

- CO_2 reduction and climate neutrality
- Energy efficiency and lower energy costs
- The use of renewable energy
- Competitiveness
- Consistently high component quality are continuously increasing.

In particular, the electrification of melting and heat treatment processes offers significant decarbonization potential, but may also lead to technological and economic risks.

Taking this consideration into account, the GreenCastAudit project is developing a practical methodology for the energy assessment, decarbonization, and quality validation of foundry processes. The two-year project runs from May 2025 to April 2027.

Key Challenge
How can a foundry reduce energy consumption and CO_2 emissions without compromising component quality or economic viability?

Value for the foundry industry

Quality Assurance
Technological risks are assessed before implementation

Transparency
Energy and emission flows are systematically recorded

Economic Viability
Electricity prices, investments, and operating costs are taken into account

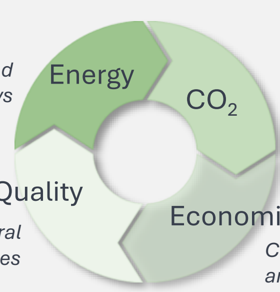
Efficiency
Energy-saving and flexibility potentials become visible

Decarbonization
Technology and measure options are identified

Methodological approach

Development of a standardized **Decarbonization & Quality Audit methodology** that enables foundries to analyze their processes holistically and derive distinctive decarbonization measures.

The methodology combines:



Assessment and optimization of energy flows

Product Carbon Footprint – Scope 1–3

Evaluation of microstructural and component properties

Costs, electricity prices, investments and operating strategies

01 | Energy Assessment

Development of a foundry-specific checklist based on DIN EN 16247, complemented by approaches from ISO 50001, ISO 50002, and EINSTEIN. The assessment covers, among others:

- Energy consumption and energy carriers
- Electrical loads and fuel quantities
- Production and process data
- Operating hours and temperature profiles
- Heating and cooling systems
- Waste heat and heat recovery
- Foundry-specific process data

02 | Energy System Modeling & Flexibility

Development of a modular optimization tool to model:

- Foundry processes
- Photovoltaic generation
- Variable electricity tariffs
- Energy storage systems
- Production constraints

This enables the analysis of strategies to achieve:

PV self-consumption ↑ **Peak loads ↓**
Electricity costs ↓ **Flexibility ↑**

Energy-intensive process steps can – where technically feasible – be shifted to periods with lower electricity prices.

03 | Quality Validation

Decarbonization measures are not considered in isolation.
The project investigates how changes in:

- Energy sources
- Melting processes
- Process times
- Heat treatments
- Cooling conditions

affect **microstructure, mechanical strength, and component quality**.

04 | Product Carbon Footprint

Extension of the audit checklist to include a comprehensive **process-chain perspective**, providing the basis for **Product Carbon Footprint (PCFP) assessment across Scope 1–3**.
The following process chain is considered:
Raw Material > Melting > Casting > Heat Treatment > Machining > Logistics

From Data Collection to Concrete Decarbonization Measures

1. STATUS QUO
Energy · Production · Processes · Costs

2. ENERGY ASSESSMENT
Energy flows and energy-saving potential

3. FLEXIBILITY
PV · Electricity prices · Energy storage · Load management

4. QUALITY ASSESSMENT
Microstructure · Mechanical strength · Process stability

5. PCFP
Scope 1 · Scope 2 · Scope 3

6. SCENARIOS & MEASURES
Technology · Costs · CO_2 · Quality

DECARBONIZATION STRATEGY

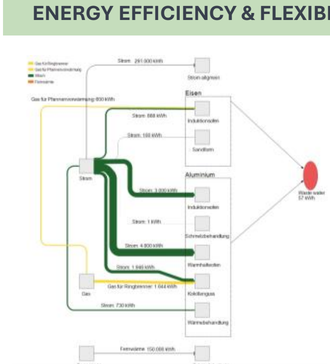
Results

PILOT APPLICATIONS | **ALUMINIUM CASTING** | **IRON CASTING**

In the field of non-ferrous casting, the AlSi9Cu3(Fe) alloy was used to investigate the influence of electricity-price-driven process control on mechanical properties. The focus was on shifting the T5 heat treatment to periods of lower electricity prices. Two process routes were compared: Direct artificial aging after quenching and a variant with a preceding five-day natural aging period. Tensile and hardness tests showed a moderate increase in 0.2% yield strength and hardness after natural aging, accompanied by a slight reduction in elongation. The results demonstrate that flexible, electricity-price-driven heat treatment is feasible, provided that the specific component requirements are considered.

For ferrous casting, pilot trials investigated the transition from coke-fired cupola melting to electric induction melting, with the key question: How does the different melting process affect the nucleation and microstructure of the cast iron? The important difference is the melting environment and resulting metallurgical condition of the base iron. The change in melting conditions affects the nucleation behavior of the base iron and therefore requires adapted metallurgical treatment and inoculation. A successful transformation from cupola to induction melting is entirely feasible, provided the changed base-iron condition is compensated through appropriate process measures, including alloying elements, Mg-treatment and inoculation.

ENERGY EFFICIENCY & FLEXIBILITY



Initial pilot implementations of the Energy Assessment have already yielded first results. The analysis identifies several levers for optimizing energy procurement and self-supply:

- **PV + melting furnace:** Reduce peak loads and maximize the use of on-site PV generation
- **Production flexibility:** Shift energy-intensive processes to periods with lower electricity prices
- **PV expansion:** Increase the level of energy self-sufficiency
- **Energy communities:** Utilize additional PV capacity from surrounding facilities, particularly around midday
- **Battery storage:** Enable flexible storage and supply of process energy
- **High-temperature storage:** Store surplus electricity as heat at temperatures of up to 500 °C
- **Large-scale industry:** Further potential through demand-side management, optimized electricity procurement and AI-based operating strategies

The greatest flexibility potential can be found in the intelligent integration of PV generation, production processes and energy storage.