Advanced materials for the automotive and energy industries must combine very high strength, plasticity, ability to absorb energy released during crush events, and this all should be accompanied by relatively simple, energy and environmentally effective and not expensive production process, which is in accordance with the **The European Green Deal proposal**. This is related to the ever-increasing requirements for passenger safety, fuel economy and exhaust emissions standards, especially important for **future electromobility**. In recent years, different groups of advanced high-strength steels (AHSS) that effectively combine high strength and plasticity have been developed. RA is one of the fundamental structural constituents of AHSS steels, mainly responsible for simultaneous improvement of strain hardening and plasticity. Metastable RA may undergo strain-induced martensitic transformation (SIMT) or intense mechanical twinning during deformation, which may occur during metal forming operations or exploitation. It allows for a simultaneous beneficial increase in strength and plasticity due to the increased strain hardening, and thus predisposes such steels containing RA for the use as parts designed for controlled crumple zones. High RA fraction is the 2$^{nd}$ and 3$^{rd}$ generations of AHSS is obtained by substantial Mn alloying, which allows for steel to obtain ultimate tensile strength of over 800 MPa and elongation from 20 % to even 80 %. Despite the obvious advantages of 2$^{nd}$ and 3$^{rd}$ generation AHSS alloys over other automotive steels, **they also show several problems during production due to increased content of alloying elements (Mn, Al, Si)** that need to be solved to enable large-scale production of such advanced alloys. The main ones are (a) microsegregation of alloying elements during solidification, which results in heterogeneity of structure and mechanical properties, and (b) tendency to cracking during casting and subsequent hot-working due to formation of brittle intermetallic phases at austenite grain boundaries.

**The objectives of the research project assume to:**

- **analyze the impact of changes in the Mn addition, Ti, Mo, B microadditions, tramp elements (like Cu) and high Al concentration (5-10 wt.%**), in both high-Mn and medium-Mn alloys in terms of solidification and peritectic behavior, microsegregation, hot deformability and phase transformation behavior
- **analyze the influence of the high temperature phase composition on the hot ductility of alloys** under different conditions of temperature, strain rate and stress state (tensile, compression)
- **explain mechanisms of solidification, high-temperature brittleness and microsegregation in new lightweight high-Mn and medium-Mn ferrous alloys with a density reduced below 7 g/cm$^3$.**

The implementation of the research project requires using a wide range of comprehensive research techniques and simulation / modelling methods used for crystallization and microsegregation assessment, hot ductility investigations and detailed microstructural analysis.

**The research plan assumes the design and preparation of different chemical compositions of high- (20-30 wt.%) and medium-Mn (4-7 wt.%) alloys.** New alloy concepts will be explored on the basis of newest literature knowledge. The development of a thermodynamic database for high- and medium-Mn steels will be performed. Next steps of investigations will include thermodynamic-kinetic calculations and experimental verification of critical temperatures relevant for hot ductility. The calculations and high-temperature oxidation behavior will be next verified experimentally. Finally, produced alloys will be investigated in terms of thermal behavior, microstructure and mechanical behavior.

The main research hypothesis assumes that the modification of chemical composition of high- and medium-Mn steels (and the high temperature phase composition) and selection of optimal casting and hot-working parameters will reduce the microsegregation phenomenon and improve the hot ductility, which should result in their real industrial utilization in automotive and energy sectors.