

Combining heat pumps, storage tanks and a low-temperature distribution network reduces total system costs and lifecycle carbon dioxide emissions compared to continuing with biomass.

Electrifying district heating with a heat pump, storage tank, and a low-temperature network is the recommended pathway for Aloja - and by extension for the many similar systems in Latvia facing the same reinvestment decision.

A heat storage tank is a critical enabler: it allows heat pumps to operate during the cheapest hours of the electricity market, which makes the difference between a solution that saves money and one that does not.

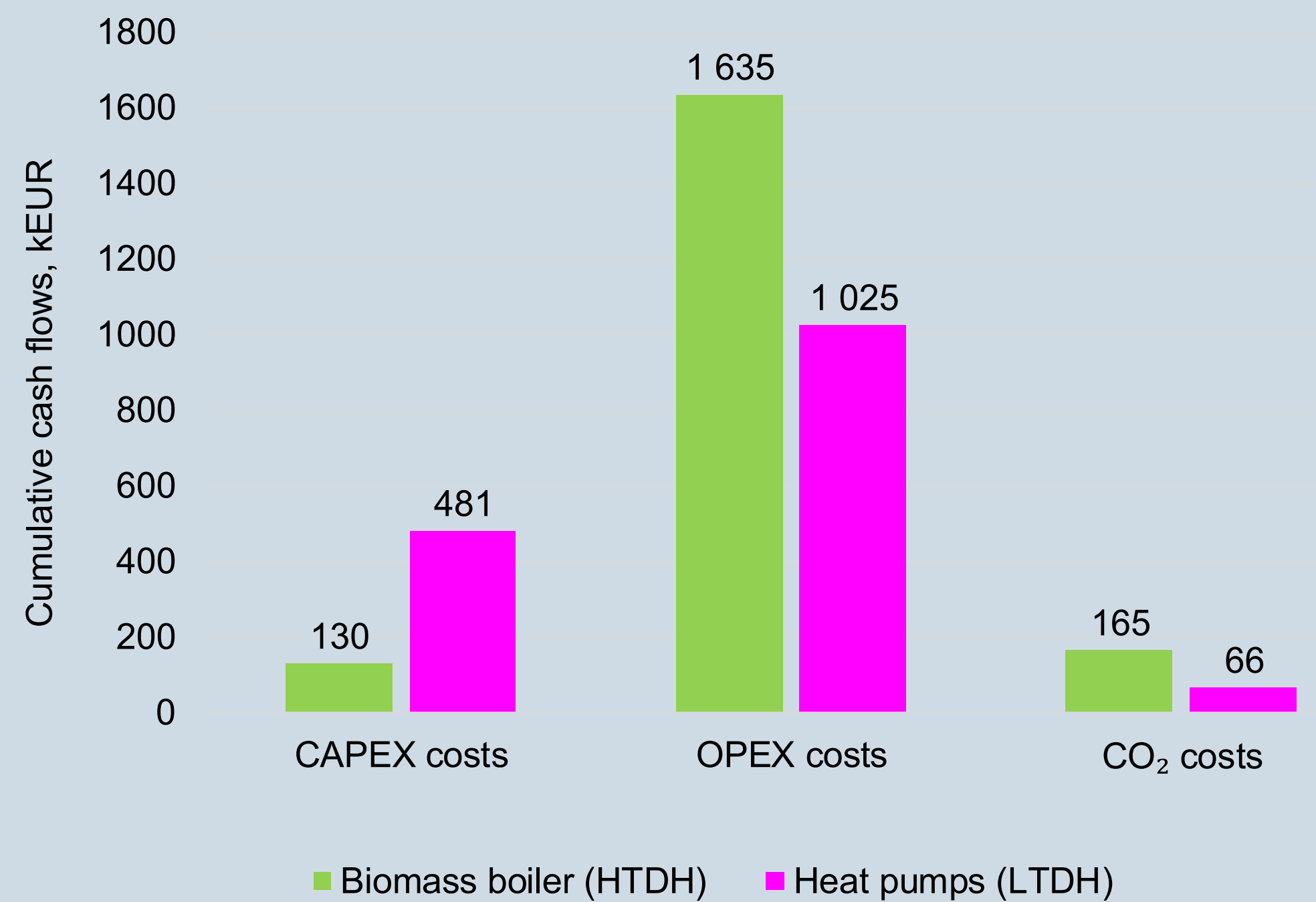


Fig. 1. Cumulative cash flows of modeled scenarios

Introduction

District heating networks in small Latvian towns rely almost entirely on ageing biomass boilers approaching the end of their operational lifetime. When a boiler needs replacing, the municipality faces a choice that will shape costs and carbon emissions for the next two decades. This study asks whether switching to electrically driven heat pumps is a better long-term decision than installing a new biomass boiler - a question relevant to dozens of similar systems across Latvia.

Methodology

Five scenarios were compared over a twenty-five year period using TIMES/MARKAL optimization model that selects the least-cost technology mix while meeting annual heat demand. The baseline continues with biomass. Alternatives introduce a heat pump paired with a backup boiler, with and without a hot-water storage tank, and at conventional or reduced network temperatures. A fifth scenario tests the effect of delaying the transition by five years.

Results

The cost advantage of the optimal configuration emerges gradually. In the first year, upfront investment makes it the most expensive option. From the second year onward, its annual running costs fall well below those of the biomass baseline and continue to widen as wood chip prices rise. A conventional heat pump without storage, by contrast, turns out to be more costly than the biomass boiler over the full period - a finding that cautions against partial electrification. Every year of delay in deploying the heat pump carries a measurable financial and environmental penalty.

| Scenario | Technology Configuration | Heat Production Schedule | District Heating Network Mode |
|----------|--|----------------------------------|--|
| S1 | Biomass (wood chip) boiler | Standard operation | Standard (90/60°C) |
| S2 | HP + biomass boiler | Avg. annual price | Standard (90/60°C) |
| S3 | HP + biomass boiler + storage tanks | Avg. price of the cheapest hours | Standard (90/60°C) |
| S4 | HP + biomass boiler + storage tanks | Avg. price of the cheapest hours | Low Temperature District Heating (65/35°C) |
| S5 | HP introduced 5 years later + biomass boiler + storage tanks | Avg. price of the cheapest hours | Low Temperature District Heating (65/35°C) |

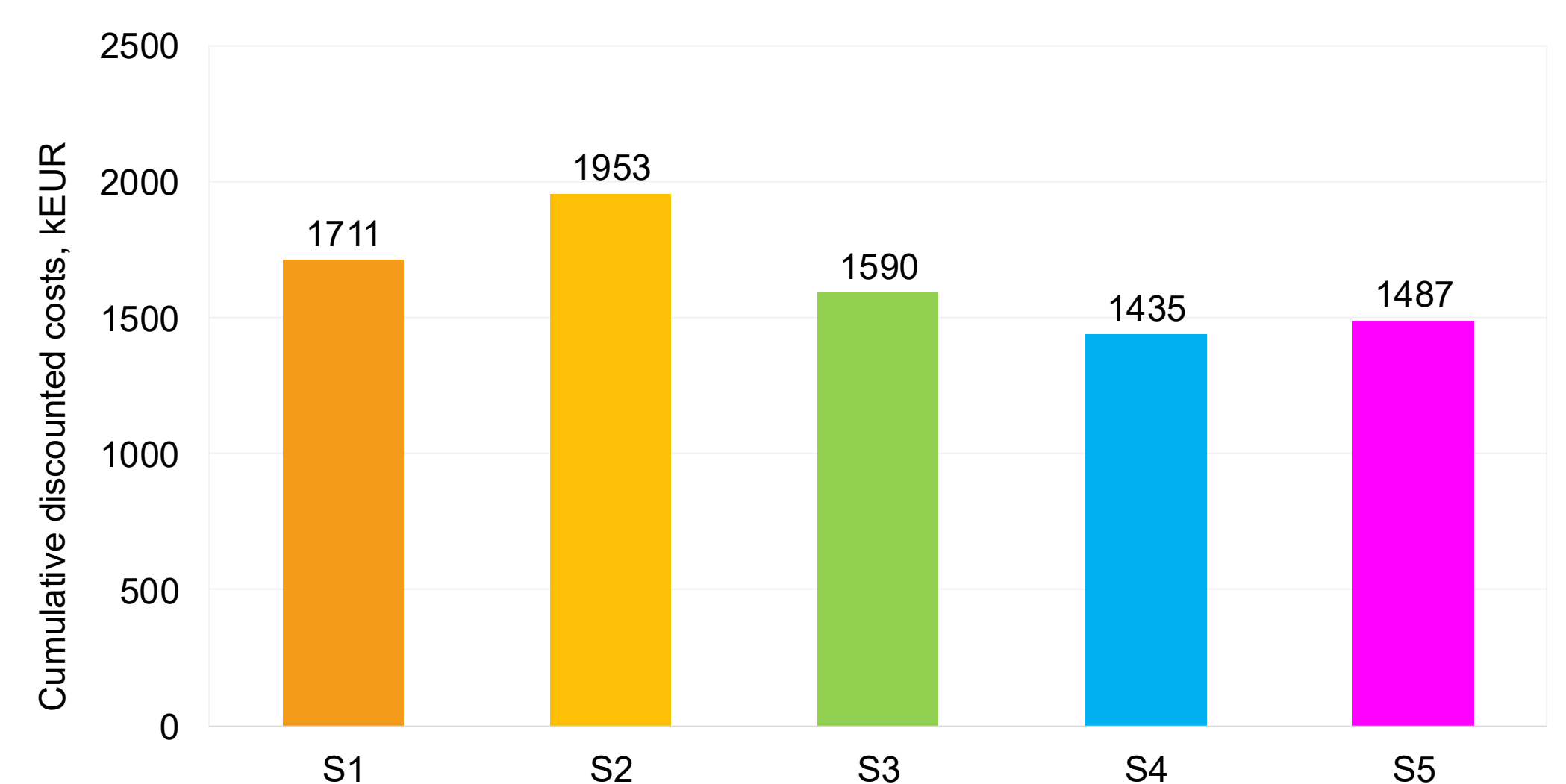


Fig. 2. Cumulative discounted costs of modeled scenarios

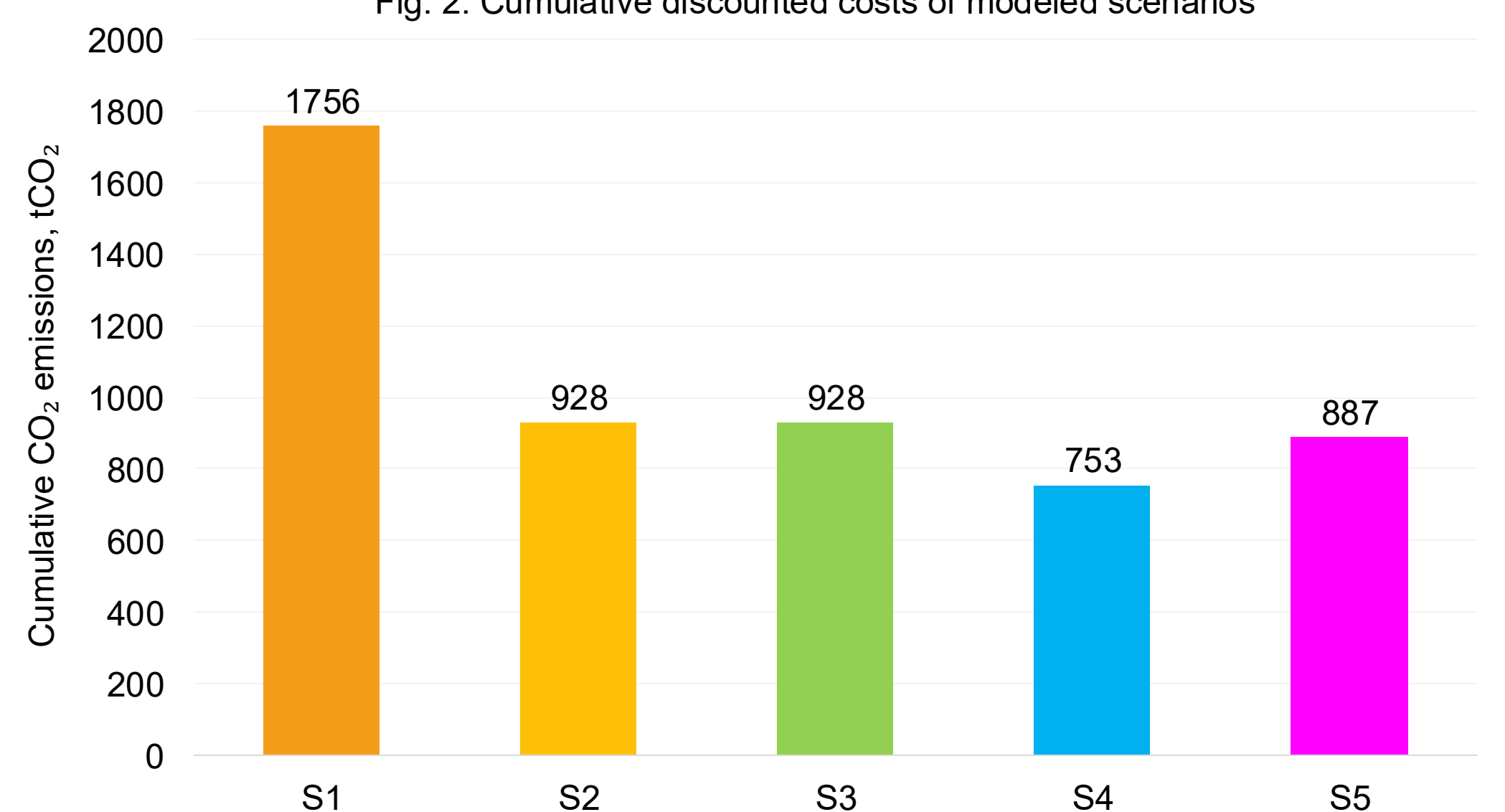


Fig. 3. Cumulative CO₂ emissions of modeled scenarios

Acknowledgment

This research is funded by the Latvian Council of Science, project "Optimizing Energy Systems Through Multi-Energy Carrier Integration and Energy Hub Strategies (OptiEnergyHub)", project No. lzp-2024/1-0307.