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Strategic management approaches for developing sustainable renewable heat supply in local communities: A case study ☆

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ABSTRACT

The importance of local sustainable energy projects in the transition to a climate-neutral society is widely recognised, yet strategic planning at the local level often lacks structure and consistency. This paper presents an integrated methodology combining established strategic management tools—such as SWOT analysis, multi-criteria decision-making methods for prioritising factors and strategies, and strategic formulation matrices—to develop and implement sustainable development strategies in the energy sector. The seven-step process includes defining the national sustainable development framework, identifying strategic orientations, assessing local conditions, evaluating the relevance of key factors, formulating strategies, and determining performance indicators. The method was tested through the development of 36 strategies for a Slovenian municipality, with three top-ranked strategies implemented as pilot cases. For the proposed woodchip-based combined heat and power system, the economic analysis indicated a net present value of €144,134 and an internal rate of return of 7.2%, which exceeds the weighted average cost of capital of 5.0%. In the second case, the utilisation of excess heat from industrial processes in the district heating system suggested potential annual savings of over €2.4 million, with an estimated return on investment within five years, assuming partial public co-financing. These findings confirm the practical applicability of the proposed approach and its usefulness in supporting local authorities in the development of effective and economically viable strategies for the energy transition.

1. Introduction

Implementation of local sustainable energy projects is at the heart of all National Energy and Climate Plans developed by European Union (EU) member states and is recognized as a key element for achieving the set goals [1]. Considering the major investments and policy decisions that will be made in the coming decades, the research work of Adshead et al. [2] provides a consistent and systematic framework that recognizes the national context of prioritizing the 2030 Agenda for Sustainable Development and uses indicators to provide a basis for sound and effective decision-making at the implementation level, where it is imperative that local communities transform national goals into realistic implementation projects. All stakeholders must participate in the preparation of a set of viable sustainable projects and, with their practical experience, propose changes to regulatory rules for a more efficient achievement of environmental and energy goals.

Sharifi et al. highlighted in their literature review [3] that, in addition to the growing recognition of the importance of the neighbourhood level in achieving urban sustainability, a number of neighbourhood sustainability assessment (NSA) tools have been developed over the past decade, and that the broader goals of these tools are to guide and promote sustainable planning and the identification of best practices. Research work presented by Ali-Toudert et al. [4] provides an analysis of five well-known urban rating systems. The discussed systems of sustainable development indicators are suitable for determining the situation in a certain environment and/or the impact of the project on the improvement of individual parameters. However, they are not a guarantee for the implementation of continuous improvements and do not determine alternative paths of local development.

Strategic formulation, often referred to as strategic planning or long-range planning, is concerned with developing a vision, objectives, strategies and policies. Over the years, the SWOT (strengths-weaknesses-opportunities-threats) analysis has proven to be the most enduring

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Nomenclature

Variables

FSi	Score of the SWOT factor *i*,
SOn	Strategic orientation *n*,
Wij	Weight of SWOT factor *i* relative to strategic orientation *j*
WSOj	Weight of the strategic orientation *j* relative to the national SDGs
Si	SWOT factor: Strength *i*
Wi	SWOT factor: Weakness *i*
Oi	SWOT factor: Opportunity *i*
Ti	SWOT factor: Threat *i*

Acronyms

AHP	Analytic Hierarchy Process
CHP	Combined Heat and Power
CI	Consistency Index
CR	Consistency Ratio
CO_2	Carbon Dioxide
DH	District Heating
EAF	Electric Arc Furnace
EE	Electricity
EU	European Union
FAHP	Fuzzy Analytic Hierarchy Process
IRR	Internal Rate of Return
MAUT	Multi–Attribute Utility Theory
MCDM	Multi–Criteria Decision–Making
NECP	National Energy and Climate Plan
NG	Natural Gas
NGO	Non–Governmental Organisation
Nm^3	Normal Cubic Metre
NMO	National Motorway Operator
NPV	Net Present Value
NSA	Neighbourhood Sustainability Assessment
NSDS	National Sustainable Development Strategy
ORC	Organic Rankine Cycle
PROMETHEE	Preference Ranking Organisation Method for Enrichment Evaluation
RES	Renewable Energy Sources
RI_n	Random Index for matrix orders
SDGs	Sustainable Development Goals
SDS–2030	Slovenian Development Strategy 2030
SECAP	Sustainable Energy and Climate Action Plan
SMART	Specific, Measurable, Achievable, Realistic, and Time–bound
SWOT	Strengths–weaknesses–opportunities–threats analysis
TOWS	A Matrix Used to Create Alternative Strategies
WACC	Weighted Average Cost of Capital

analytical technique used in strategic management [5]. This well-proven management method, together with the TOWS matrix (TOWS is just a different notation for SWOT), is still successfully used to create alternative strategies for achieving the goals set by companies, organizations or individual projects [6]. Djaković et. al. [7] used the SWOT-AHP method to prepare recommendations at the national level to adapt the existing energy strategy and policy to increase the use of biomass. In the research presented by Stojčetović et. al. [8], the SWOT-AHP method was used to determine the current energy situation and define strategies for improving energy security. Their approach has a universal character so that it can be used in other regions/countries to analyse the situation and determine improvement strategies. Kaoma at al. [9] conducted a study in which a TOWS analysis was used to develop alternative strategies that served to formulate policy considerations for the enhancement of institutional arrangements for a conducive enabling environment for sustainable deployment of bioenergy in the rural areas of the country. The research work of Haque at al. [10] used SWOT analysis in combination with Analytical Hierarchy Process (AHP) and combined SWOT-AHP-TOWS matrix to assess the challenges and opportunities for power trading on the basis of stakeholders' perception and provide ideas for further policy development. Das at al. [11] have applied integrated decision-making methodologies (SWOT and TOWS) to evaluate and develop effective and adaptable strategies to improve the production chain and promote environmental sustainability.

The literature review demonstrates the applicability of the SWOT analysis, the prioritization of factors or strategies by the multi-criteria AHP analysis [7–11], and the applicability of the TOWS matrix for creating strategies for sustainable planning at a project level. However, in the reviewed literature [7–11], there is no clearly defined framework of the national context of sustainable development, nor is there any orientation towards monitoring the implementation of the selected strategies in connection with the goals of sustainable development. This was also the motivation for the research presented here and the following research question arises in this context: How to systematically approach the formulation of strategies for sustainable local planning and energy sectors coupling, which will be based on the national context of the global sustainable development goals, and through their planning, implementation, monitoring and upgrading, establish a system of continuous improvements of sustainable (local) energy solutions?

The transition to a climate-neutral society relies on enhancing energy efficiency and decarbonising all sectors. Shifting heating demand from fossil fuels to electricity is a key focus of decarbonisation strategies [12]. Despite its significant potential for improving energy efficiency and using renewable energy, the heating sector is often overlooked. Combined heat and power (CHP) systems have proven reliable and economically viable for building applications, with the European Union promoting their adoption in recent years [13], particularly in conjunction with district heating systems [14]. Fuel costs are the determining factor for the operational expenditure of solid biomass furnaces, especially towards cheaper feedstock like forest residues, composting residues or waste wood [15]. Excess heat recovery systems for industrial processes have gained significant attention due to growing awareness of global warming and rising fuel prices. Recovering waste heat from industrial exhaust streams is crucial for reducing overall energy consumption at industrial sites [16]. Since excess heat cannot always be reused on-site or for district heating, technologies like the Organic Rankine Cycle (ORC) should be explored [17]. Lessons from other energy-intensive industries, such as aluminium production, offer valuable insights into the effective use of excess heat in the steel industry [18].

A comprehensive literature review has shown a lack of descriptions for the process of formulating strategies and implementing continuous improvements in sustainable local planning and energy sectors coupling. Such a process, based on long-established and well-tested principles within the framework of strategic management, is notably absent. Therefore, this paper presents a process of formulating strategies that combines different methods and tools. The case study presented in this research paper represents a practical application of the proposed process in a real local community environment through the implementation of the highest ranked local development strategies in the areas of renewable heat supply.

The main aim of this research is to develop and demonstrate a systematic process for formulating strategies for sustainable local energy development, grounded in the national context of the Sustainable

Development Goals (SDGs). Specifically, the research seeks to integrate SWOT analysis, factor prioritisation through the AHP, and strategy design based on the TOWS matrix into a coherent methodological framework. It further aims to adapt the principles of strategic management for application in local sustainable energy planning, with particular emphasis on establishing a system for continuous improvement. The proposed process was be validated through a case study conducted in a real local community, focusing on the development of strategies for renewable heat supply.

The expected outcomes of the research include the creation of a practical approach that local communities can follow to systematically design, implement, and continuously refine sustainable energy strategies. The research also aims to demonstrate how national sustainable development priorities can be effectively translated into local actions through structured strategic planning in the energy sector. Finally, it is anticipated that the research will contribute to both academic understanding and practical application by providing a replicable model for linking sustainable local planning with energy sector development.

2. Methodology

2.1. Methodological framework

The methodology outlined in this chapter addresses the critical gap between national sustainable development priorities and actionable local strategies. Existing frameworks often fall short of providing a coherent pathway for translating high-level objectives into local contexts, creating challenges in achieving tangible outcomes. To overcome this, the proposed methodology emphasizes a systematic approach that integrates stakeholder engagement at every stage. By involving key stakeholders—including policymakers, local planners, and community representatives—this approach ensures the relevance and feasibility of strategies, fostering alignment between national goals and local realities.

The methodology combines proven tools such as SWOT analysis and AHP, offering a structured framework for creating adaptive, impactful local development plans.

2.2. Overview of the strategy formulation process

The proposed process of formulating strategies for sustainable local planning and energy sectors coupling is based on the following seven steps:

Step 1: Determining the framework of the national context of sustainable development goals,

Step 2: Identifying national strategic orientations in the field of energy,

Step 3: Conducting a SWOT analysis of the local environment,

Step 4: Implementing an AHP analysis to assess strategic orientations and the relevance of SWOT factors,

Step 5: Formulating implementation strategies with the TOWS matrix,

Step 6: Determining objectives and performance criteria for each implementation strategy, and

Step 7: Assessment of coherence and impact of strategies.

The process flowchart is shown in Fig. 1.

According to the Guidance in Preparing a National Sustainable Development Strategy (NSDS) [18], many countries have developed national strategies based on the SDGs [19], focusing on areas critical to their specific contexts. Therefore, formulating strategies for sustainable local planning and energy sector coupling must begin with the national interpretation of the SDGs outlined in the NSDS. To address the complexities of local planning, it is essential to identify key strategic areas, or orientations, rooted in national priorities. While these orientations stem from the NSDS, they must be tailored to local contexts and environments. A thorough analysis of the local environment is crucial for designing effective implementation strategies.

2.3. SWOT analysis

The analysis of the business or local environment is essential for the successful planning of implementation development strategies. SWOT analysis [5] is a widely recognised technique for identifying internal strengths and weaknesses as well as external opportunities and threats of the analysed environment. However, it does not offer mechanisms for prioritising these factors based on specific criteria.

To enhance the applicability of SWOT analysis for sustainable energy development, a comprehensive evaluation of the local environment should be carried out, encompassing not only the energy sector but also broader national priorities for sustainable development. In this process, experts in local sustainable development should carefully examine the specific characteristics of the environment.

Based on this comprehensive analysis, the most influential factors related to the energy aspect of sustainable development should be selected. Factors specific to other areas (such as healthcare, food security, or environmental protection) should be excluded during the preselection phase to maintain focus on the energy sector.

The comprehensive analysis and subsequent selection of energy-related SWOT factors should be performed by a group of experts specialised in local sustainable energy development. To ensure the manageability of further evaluation processes, it is recommended to limit the number of strengths (S), weaknesses (W), opportunities (O), and threats (T) to a reasonable range — typically between four and six factors per group. Selecting too few factors could excessively narrow the perspective on the complexity of local energy development, whereas selecting too many would exponentially increase the complexity of the evaluation, making the process impractical.

The selected SWOT factors are intended to cover the key dimensions of sustainable energy development in the local community. They are thus applicable to all energy-related projects that seek to promote the long-term sustainable development of the local energy system. However, they are not universal for all aspects of sustainable development, as factors related to other thematic fields were deliberately excluded during the analysis.

2.4. Analytic Hierarchy process (AHP)

One of the multi-criteria decision-making (MCDM) methods, such as the AHP [20,21], can be employed to evaluate the relative importance of the SWOT factors. This approach has also been extensively applied in the field of sustainable development [22,23,24].

The decision-making problem is first broken down into smaller, more manageable subproblems, which can then be analysed independently. AHP decomposes the decision problem into a hierarchical structure:

- Level 1 (Goal): National context of the SDGs in the energy sector,
- Level 2 (Criteria): Strategic orientations (SO_1 to SO_n),
- Level 3 (Subcriteria): SWOT factors for each *SO*.

Decision-makers perform pairwise comparisons of the n elements at each level, judging their relative influence on the element above. These comparisons yield a decision tree (Fig. 2) and an n × n comparison matrix:

$$\boldsymbol{A} = (a_{ij}) = \begin{bmatrix} 1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & 1 & \cdots & w_2/w_n \\ \vdots & \vdots & \cdots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & 1 \end{bmatrix}, \tag{1}$$

were a_{ij} denotes the importance of element i over j, $w_1 \dots w_n$ are scores according to Table 1 and $a_{ij} = a_{ji}$. The local priority vector:

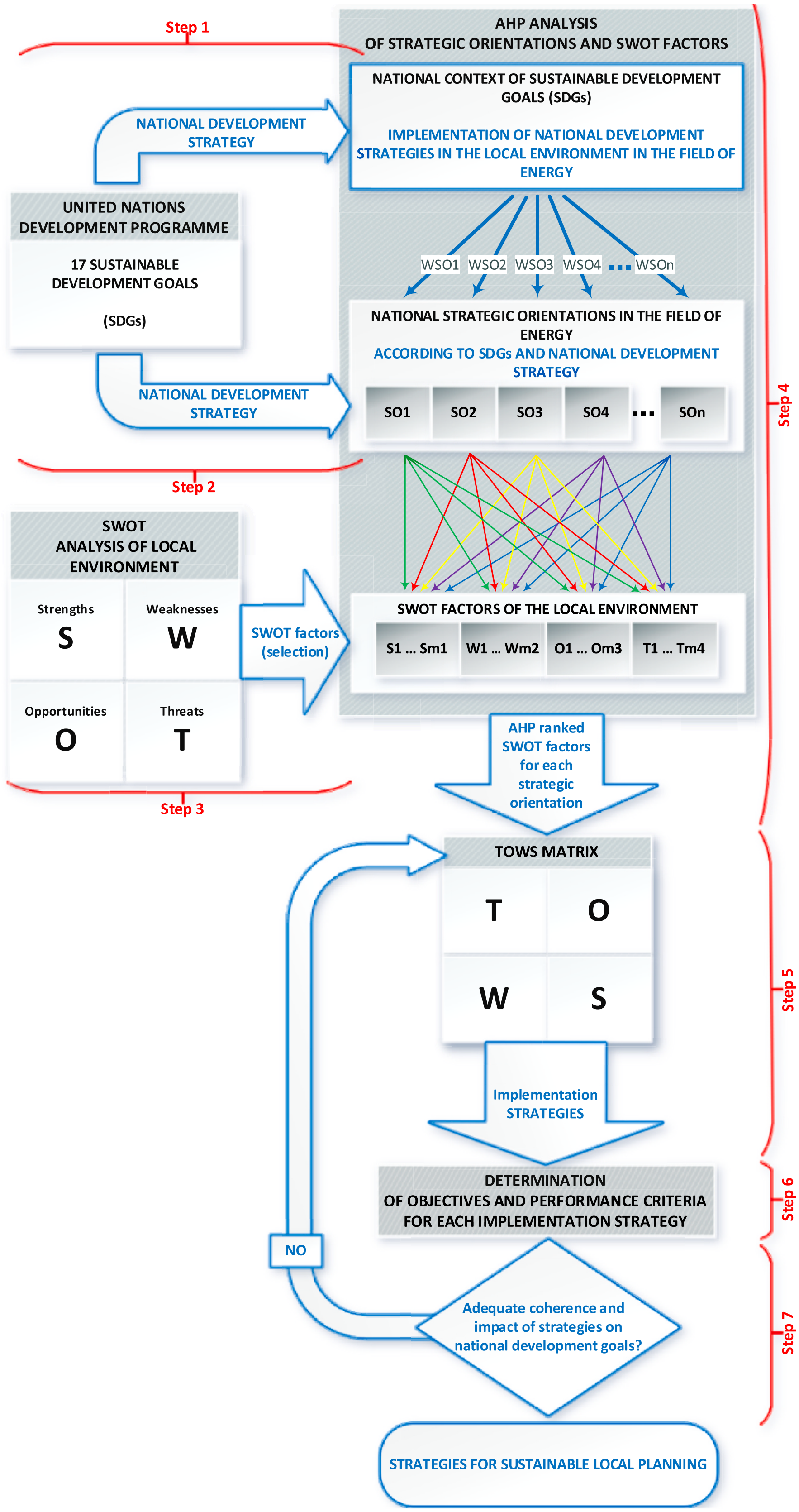

Fig. 1. The proposed process of formulating strategies for sustainable local planning and energy sectors coupling.

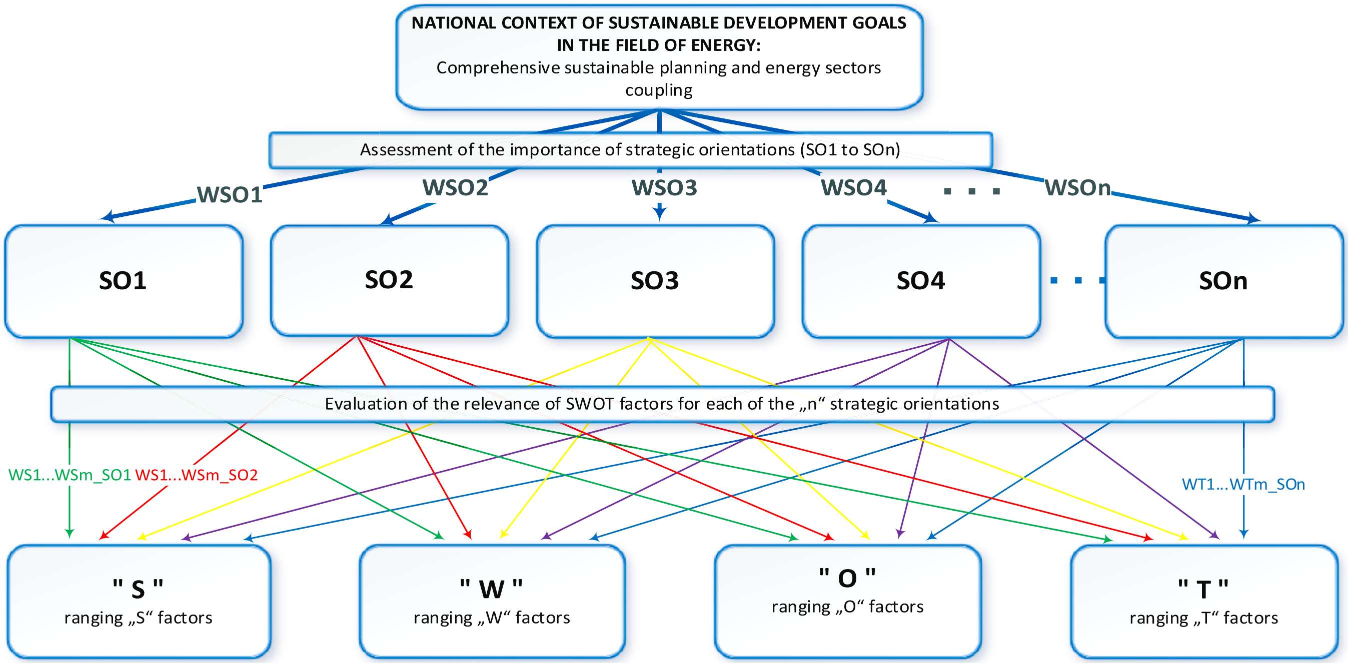

Fig. 2. The hierarchical decision-making tree.

Table 1
Fundamental scale for pairwise comparisons in AHP.

Scale	Definition	Explanation
1	Equal importance	Both elements contribute equally to the goal.
3	Moderate importance	Experience and judgement slightly favour one element over another.
5	Strong importance	Experience and judgement strongly favour one element over another.
7	Very strong importance	One element is very strongly favoured over another, as demonstrated in practice.
9	Extreme importance	The dominance of one element over another is unequivocally demonstrated.
2,4,6,8	Intermediate values	May be used to express compromise between the above levels.

$$q = [q_1, \cdots, q_n]^T \tag{2}$$

is obtained as the normalised principal eigenvector of A, satisfying:

$$(\boldsymbol{A} - \lambda_{max}\boldsymbol{I})\mathbf{q} = 0, \sum_{i=1}^{n} q_i = 1, \tag{3}$$

were λ_{max} is the maximum eigenvalue of $\boldsymbol{A}$. Each component q_i of the local priority vector $\mathbf{q}$ represents the normalised weight (relative importance) of the i-th element in the pairwise comparisons, indicating how strongly it influences the element at the next higher level of the hierarchy.

To assess consistency of each expert's judgements, the Consistency Index (CI) and Consistency Ratio (CR) are computed:

$$\mathrm{CI} = \frac{\lambda_{max} - n}{n - 1}, \mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}_n}, \tag{4}$$

with Random Index (RI_n) for matrix orders: $n = 3, 4, 5, 6 \rightarrow \mathrm{RI}_n = 0.58, 0.90, 1.12, 1.24$, respectively [20].

The SWOT factors are ranked based on their scores (*FSi*), calculated using Equation (5). Here, *Wij* denotes the weight of the SWOT factor *i* relative to the strategic orientation *j*, *n* is the number of strategic orientations, and *WSOj* represents the weight of the strategic orientation *j* relative to the national SDGs.

$$FSi = \sum_{j=1}^{n} Wij\,WSOj \tag{5}$$

2.5. TOWS matrix development

The TOWS Matrix is employed to formulate strategies by matching external opportunities and threats with internal strengths and weaknesses, thereby generating four distinct sets of strategies. To achieve this, the external opportunities and threats facing a local community must be systematically aligned with its internal capabilities and limitations. For each pairing of these internal and external SWOT factors, it is necessary to determine how they may be utilised to devise robust implementation strategies. In the SO (Maxi–Maxi) set, community strengths are harnessed to capitalise on opportunities; in the ST (Maxi–Mini) set, strengths are deployed to avert or mitigate threats; in the WO (Mini–Maxi) set, efforts focus on overcoming internal weaknesses in order to exploit opportunities; and in the WT (Mini–Mini) set, defensive measures aim to minimise weaknesses and guard against threats. By formulating strategies across all four sets, a comprehensive framework for implementation is established, ensuring that different strategic possibilities are systematically addressed [6].

2.6. Objectives and performance criteria

For each strategy, it is essential to define performance criteria (indicators) and performance objectives (target values). These should adhere to the SMART principles — Specific, Measurable, Achievable, Realistic, and Time-bound — which provide a well-established framework for effective management. The concept of SMART goals gained prominence in the 1980 s as a means of improving goal-setting and performance monitoring in various fields [25]. The European Commission has provided methodological principles, procedures, and best practices for the preparation of Sustainable Energy and Climate Action Plans (SECAPs) [26], clearly emphasising that targets and objectives should align with the SMART framework [25]. Accordingly, several general recommendations should be observed: goals must be measurable and achievable, yet sufficiently ambitious, motivating, and internally consistent; target values should progressively increase over time, in line with the principle of small but rapid improvements (kaizen); performance indicators must be clearly defined and easily understood, with accessible data to ensure measurability; and finally, the tasks, responsible actors, deadlines, and necessary resources for implementation must be explicitly specified. These elements are key to ensuring transparency, accountability, and the effective execution of strategies.

2.7. Assessment of coherence and impact

Each strategy's compliance with national development goals is evaluated using a scale from 0 (no impact) to 5 (significant, directly measurable impact). The impact of each strategy on local development indicators must also be calculated or assessed. This evaluation highlights potential weaknesses, enabling strategies to be refined until they align with national goals and deliver a satisfactory impact on community development.

2.8. Case study: The implementation of the highest ranked local development strategies of the local community in Slovenia in the areas of renewable heat supply

Local sustainable energy projects, particularly local energy communities, play a crucial role in Slovenia's National Energy and Climate Plan (NECP) [27]. The NECP sets ambitious objectives to decarbonize the energy sector, improve energy efficiency, and increase renewable energy sources, aligning with EU goals. Local communities contribute to these objectives by driving the development of decentralized, renewable energy systems tailored to regional needs, enhancing energy security and reducing greenhouse gas emissions. By empowering citizens, promoting innovation, and fostering cooperation, local energy communities bridge national policies with practical, community-driven actions, ensuring the NECP's goals are met sustainably and inclusively [27]. The SECAP defines goals and related measures that must be in line with national action plans for energy efficiency, renewable energy sources (RES) and other action plans or operational programs for energy supply or energy use, and goals for improving air quality. The review of the Slovenian SECAPs [28] revealed several deficiencies, particularly in terms of a comprehensive approach and the strategic orientation of the envisaged measures. For several SECAPs, follow-up activities and monitoring the implementation of measures in practice seem challenging. These observations are consistent with the findings reported in [29]. The addressed Slovenian local community has 21,734 inhabitants (the 2022 census data) and covers an area of 76 km^2. According to the Slovenian Forest Service data from 2010 [30], the forest cover in the municipality was very high (69.37 %) and has remained relatively stable, offering significant potential for utilizing lower-quality wood for energy purposes. The community, renowned for its thousand-year tradition of iron and steelmaking, remains a hub for energy-intensive industries. At the same time, it is a border municipality characterized by a well-preserved natural environment and a strong heritage in outdoor activities and sports. The municipality aspires to promote sustainable tourism and enhance the quality of life for its residents. To achieve these objectives, the proposed strategy formulation process was evaluated by developing alternative SECAP content tailored to the specific needs of the local community. By applying the presented methodology, 36 strategies were successfully formulated for the community.

This case study illustrates the implementation of the three highest-ranked strategies in practice: 1) Incentives for energy efficiency and renewable energy projects, as well as for involving businesses and citizens in renewable energy communities; 2) Participating in EU development projects to identify and evaluate potential local energy projects; 3) The establishment of a municipal project team to support the implementation of innovative energy efficiency and renewable energy projects, utilizing local knowledge and the potential of energy efficiency and renewable energy projects. Specifically, the use of selected strategies focus on heat supply from a biomass boiler and cogeneration plant, as well as the utilization of excess heat from the steel plant.

3. Results

3.1. Formulation of strategies for sustainable local planning and energy sectors coupling

In the first step, to understand the national context of sustainable development goals and strategic orientations in the field of energy, it was essential to delve into the Slovenian Development Strategy 2030 (SDS–2030) [31], which represents the state's core development framework. The national context of sustainable development goals presents 12 Slovenian strategic goals that are related to one or more SDGs. The goal of comprehensive sustainable planning of local energy infrastructure and energy sectors coupling means implementation of the SDS–2030 in the local environment. Therefore, effective implementation strategies are needed that will make the most of the strengths and opportunities of the local environment and manage the threats and overcome the weaknesses. In the second step, Slovenian national strategic orientations in the field of energy were evaluated. To ensure the focused development of local communities in the field of energy, a detailed comparison of the SDS–2030 [31] and Slovenia's NECP [27] was necessary. Based on this analysis, the following five key national strategic orientations (*SOs*) in the field of energy were identified (*SO1* to *SO*5): *SO1*: Implementation of national energy and environmental policies at the local level, *SO2*: Improvement of planning of local energy projects, *SO3*: Digitization of local energy subsystems, *SO4*: Improvement of energy efficiency and energy supply, and *SO5*: Development of a supporting environment for the implementation of local energy projects.

In the third step, a comprehensive SWOT analysis of the local environment in the field of sustainable energy development was conducted. Although the analysis initially considered broader aspects of sustainable development, the final focus was placed specifically on the energy sector to align with the objectives of the study. The SWOT analysis and the selection of relevant factors were carried out by a group of experts in sustainable local development, serving as the technical support organisation for the local community. To ensure a balance between sufficient comprehensiveness and the manageability of subsequent evaluation processes, the expert group selected five key factors for each SWOT group (S, W, O, and T). The selected SWOT factors, presented in Table 2, capture the specific characteristics and development priorities of the local community in the field of sustainable energy. They are intended to provide a universal basis for supporting the design and implementation of all local energy-related projects that promote long-term sustainable energy development. However, these factors are not intended to be universally applicable to other areas of sustainable development, such as healthcare, food security, or environmental protection, since factors specific to these fields were excluded during the pre-selection phase.

According to [32], there is a great diversity of energy and energy service requirements to meet the needs of different communities and social configurations. Stakeholder engagement is recognized as a means of defining more coherent sustainable development policies [33]. Successful participation of stakeholders in decision-making on development policies requires recognition of the challenges of climate change, definition of priority interventions, recognition of expected benefits that can be created. As Lengyel notes in [34], in policy making, knowing the priorities of different stakeholder groups can help address their personal beliefs and concerns. Therefore, in the fourth step, the AHP analysis was performed by a group of ten experts, selected to ensure a broad range of professional backgrounds and stakeholder perspectives. Table 3 summarises their institutional affiliations, areas of expertise, and roles in the analysis.

The experts individually evaluated the five strategic orientations

Table 2
Selected local community SWOT factors.

		SWOT factor
Strengths	***S1***	Balanced structure of energy sources, possibility of further diversification
	S2	Developed technical culture, openness to new technologies, ability to innovate
	S3	Efficient use of space in existing industrial locations and business zones
	S4	Good experience with energy contracting projects, also in the public sector
	S5	Concentration of the settlement, possibility for further rational construction of infrastructure
Weaknesses	***W1***	Individual sustainable solutions are still at an early stage of development
	W2	Insufficient RES and energy efficiency activities compared to the benefits for the community
	W3	High energy intensity of some industries
	W4	Absence of a proactive role of the state and guidance of investors in the green transition
	W5	Insufficient technical personnel in companies; bottleneck in the introduction of new technologies
Opportunities	***O1***	Environmental challenges and reliability of supply as an incentive to improve the local quality of life and the development of energy efficiency, RES and sustainable infrastructure
	O2	Development and decarbonization through the launch of traditional activities (timber, etc.)
	O3	New technologies in transport: e-vehicle fleets of public institutions, hydrogen, e-charging stations
	O4	Test introduction of soft mobility models for the needs of tourism and daily commute
	O5	Strengthening research potential and ability to introduce new technologies
Threats	***T1***	Uncertain future development of industrial activities within the EU
	T2	The presence of energy poverty (insufficient own funds for energy efficiency and RES measures)
	T3	Weak integration into EU green projects and slow use of dedicated funds
	T4	Lack of personnel (with multidisciplinary knowledge) to implement projects
	T5	The slowness of adapting educational and research activities to new challenges

(*SO1* to *SO5*) according to the national context of SDGs and assessed the relevance of twenty SWOT factors (*S1*, *S2*, …, *T5*) for each strategic orientation with the focus on the strengths and weaknesses of the selected local community. A specialised Excel data-entry table was developed for recording each expert's pairwise comparisons and calculating the relative weight of every evaluated factor. This spreadsheet, based on Goepel's recommendations and methodology [35], automatically computes the Consistency Ratio (CR) in real time to flag any inconsistency in the judgements. Following Saaty's original AHP guidelines [20], we set a CR threshold of $\leq$ 0.10; whenever an expert's CR exceeded this value, they were prompted to iteratively revise their comparisons until the CR fell within the acceptable range. The final priority values for each factor were obtained by aggregating the individual judgements of the ten experts. This aggregation was performed using the geometric mean of all experts' priority assessments, a standard approach in AHP to ensure balanced and unbiased integration of multiple opinions. This method preserves the proportional relationships between individual judgements and enhances the robustness of the overall results, thereby minimising subjective bias in the AHP analysis. The results are presented in Table 4 and Table 5.

Table 4 presents the AHP-derived priority weights for five strategic orientations, assessed against the national context of the SDGs. The highest priority was assigned to *SO4* – Improvement of energy efficiency and energy supply (29.1 %), highlighting experts' recognition of the need for immediate infrastructural improvements. This is closely followed by *SO5* – Development of a supporting environment (24.8 %), reflecting the importance of policy, financing, and institutional support.

Table 3
Structure and expertise of the stakeholder group participating in the AHP process.

No.	Institution / Organisation	Field(s) of Expertise	Role in the Analysis
1	Ministry responsible for energy	Energy policy development	National-level policymaking perspective
2	Large energy-intensive company	Energy management	Industrial perspective (high consumption)
3	Large non-energy-intensive company	Energy management	Industrial perspective (moderate use)
4	Medium-sized energy service company	Energy efficiency	Technical and implementation insight
5	NGO for energy and environmental protection	Local planning, energy efficiency, environmental protection	Civil society and community planning view
6	Expert organisation in environmental protection	Environmental protection, sustainability assessment	Environmental evaluation expertise
7	Local energy agency (analysed community)	Local planning, energy efficiency	Local development insight
8	Regional energy agency (neighbouring region)	Energy efficiency, environmental protection, sustainability	Regional integration and outreach
9	Environmental consultancy firm	Spatial planning, environmental protection, strategic environmental assessment	Strategic planning expertise
10	Civil society representative (citizens' initiative)	Spatial analysis, local planning, renewable energy	Local and participatory perspective

Table 4
AHP strategic orientations assessment results.

Label	Strategic orientation (SO)	SO importance (weight)
SO1	Implementation of national energy and environmental policies at the local level	0.154
SO2	Improvement of planning of local energy projects	0.179
SO3	Digitization of local energy subsystems	0.127
SO4	Improvement of energy efficiency and energy supply	0.291
SO5	Development of a supporting environment for the implementation of local energy projects	0.248

By contrast, *SO3* – Digitisation of local energy subsystems received the lowest weight (12.7 %), suggesting that digital solutions are viewed as a secondary priority until basic challenges—such as inefficient buildings, fossil fuel dependence, and outdated heating systems—are addressed. The remaining orientations, *SO2* and *SO1*, were rated moderately, indicating their supportive but less immediate roles in the current local context.

Table 5 presents the results of the AHP-based relevance assessment of all 20 SWOT factors in relation to each of the five strategic orientations (*SO1*–*SO5*). For each group (S, W, O, T), five specific local factors were evaluated by experts for their importance in supporting or hindering progress toward each strategic objective. For instance, among strengths, *S2* – Developed technical culture and openness to innovation emerged as most relevant (particularly under *SO3*), while the top-rated weakness was *W4* – Absence of proactive state involvement, especially in *SO1*. The overall weighted relevance of each factor was calculated using Equation (5) from the methodology, which aggregates the individual scores across all strategic orientations. The two right-hand columns in the table present the intra-group and overall rankings. The most relevant factors

Table 5
AHP SWOT factor relevance assessment results.

SWOT factor	Strategic orientation (SO)					Results		
	SO1 weight	*SO2* weight	*SO3* weight	*SO4* weight	*SO5* weight	Weighted sum	Rank group	Rank total
S1	0.148	0.142	0.158	0.152	0.125	0.144	4	16
S2	0.283	0.311	0.433	0.280	0.352	0.323	**1**	**1**
S3	0.258	0.252	0.151	0.199	0.202	0.212	**2**	**10**
S4	0.158	0.161	0.136	0.212	0.192	0.180	**3**	**12**
S5	0.154	0.134	0.122	0.157	0.130	0.141	5	17
W1	0.126	0.128	0.144	0.101	0.125	0.121	4	18
W2	0.209	0.203	0.181	0.250	0.212	0.217	**3**	**8**
W3	0.100	0.085	0.109	0.108	0.105	0.102	5	20
W4	0.332	0.272	0.241	0.273	0.300	0.285	**1**	**2**
W5	0.233	0.310	0.325	0.268	0.258	0.275	**2**	**3**
O1	0.339	0.259	0.203	0.278	0.269	0.272	**1**	**4**
O2	0.169	0.152	0.109	0.169	0.175	0.160	4	14
O3	0.154	0.176	0.207	0.152	0.176	0.169	**3**	**13**
O4	0.120	0.166	0.178	0.141	0.149	0.149	5	15
O5	0.219	0.246	0.303	0.261	0.231	0.250	**2**	**5**
T1	0.133	0.115	0.118	0.113	0.119	0.119	5	19
T2	0.188	0.218	0.173	0.265	0.182	0.213	**3**	**9**
T3	0.222	0.230	0.195	0.191	0.250	0.218	**2**	**7**
T4	0.261	0.257	0.279	0.214	0.247	0.245	**1**	**6**
T5	0.196	0.179	0.234	0.217	0.201	0.205	4	11

according to this evaluation formed the foundation for the formulation of development strategies.

sIn the fifth step, based on the results of the AHP, the following SWOT factors were selected for the creation of implementation strategies with the TOWS matrix: *S1*, *S2*, *S3*; *W2, W4, W5*; *O1, O3, O5*; *T2, T3, T4*. The TOWS matrix has dimensions of 6 x 6, so 36 strategies can be defined. When determining strategies, it is important to consider the five *SOs* (strategic orientations *SO1 … SO5*). Which SO will be subordinated to an individual strategy is determined by calculating the relevance of S–T, S–O, W–T, W–O pairs for each *SO*. The SO is selected where the product of the weights of the pair of SWOT factors is the highest. In order to carry out the sixth step of the proposed process, a proposal of objectives and performance criteria that can be used to monitor the success of strategy implementation has been created. In the last, seventh step, all 36 strategies were assessed for compliance with national development goals. SDS–2030 defines 12 national development goals with a total of 29 performance indicators. The proposed 36 strategies correlate with 16 of them, the sum of points ranges from 81 to 6. Among the highest ranked are: Share of RES in the final use of energy (81 points), Emission productivity (62), European innovation index (53), Share of active population with tertiary education (36). In addition to other positive impacts on the development of the community, it was estimated that by 2030, with the implementation of the formulated strategies, the share of RES in the community would increase by 9.5 %, the share of the working population with a tertiary education would increase by 6 %, and emission productivity would increase by 7 %.

To illustrate the application of development strategies in practice, the three highest-ranked strategies were selected. The ranking of these prominent strategies was determined using Equation (6), where *Wi* represents the weight of the SWOT factor "*i*," *Wj* represents the weight of the SWOT factor "*j*", and *WSOn* denotes the weight of the strategic orientation "*n*". Table 6 presents the largest products of the weights of SWOT factor pairs *(Wi, Wj*) and the weights of the strategic orientations "*n*".

$$Sn = WSOnWiWj \tag{6}$$

Table 6 summarizes the highest *Sn* scores for each selected SWOT factor pair and indicates, in parentheses, the strategic orientation (SO) under which each pairing achieves its maximum impact. This concise presentation makes it immediately clear which orientation best leverages each particular Strength–Opportunity, Weakness–Opportunity, or Threat–Strength combination. By highlighting these optimal alignments, Table 6 provides a transparent, data-driven rationale for assigning each implementation strategy to the most appropriate strategic objective.

Table 6
The highest products of the weights of SWOT factors for each strategic orientation.

	T2	T3	T4	O1	O3	O5
S2	0.0216	**0.0219 (*SO5*)**	0.0216	**0.0235 (*SO5*)**	0.0154	0.0213
S3	0.0154	0.0125	0.0124	0.0161	0.0088	0.0151
S4	0.0163	0.0119	0.0132	0.0171	0.0093	0.0161
W2	0.0193	0.0139	0.0156	0.0202	0.0111	0.0190
W4	0.0211	0.0187	0.0184	**0.0221 (*SO4*)**	0.0131	0.0207
W5	0.0207	0.0161	0.0167	0.0216	0.0118	0.0203

The top-ranked strategy utilizes the SWOT pair *S2–O1* under strategic orientation *SO5*. This Strength-Opportunity (*S–O*) strategy leverages strength (*S2*) to capitalize on opportunity (*O1*). The second-ranked strategy employs the SWOT pair *W4–O1* for strategic orientation *SO4*. This Weakness-Opportunity (*W–O*) strategy addresses weakness (*W4)* to take advantage of opportunity *(O1*). The third-ranked strategy features the SWOT pair *T3–S2* under strategic orientation *SO5*. This Threat-Strength (*T–S*) strategy uses strength (*S2*) to mitigate threat (*T3*). Table 7 provides an overview of all three selected strategies, including their performance criteria and objectives.

All three strategies were integrated into the EU development research project, which involved local experts collaborating with the municipal SECAP preparation group. This collaboration focused on exploring alternative heat supply options for the municipality's business zone and utilizing the steel plant excess heat.

3.2. Business zone: Renewable thermal energy community

The proposed renewable thermal energy community could be established in a municipal business zone, including the National Motorway Operator (NMO) Base and its facilities: the boiler room,

Table 7
The highest ranked local development strategies.

Factor pair	Strategy	Performance criteria	Objectives
SO4: Improvement of energy efficiency and energy supply			
W4-O1	Incentives for energy efficiency and renewable energy projects, as well as for involving businesses and citizens in renewable energy communities.	Growth in the number of successfully completed projects supported by municipal or national incentives.	2024: 15; 2025–2030: annual increase of 20 %
SO5: Development of a supporting environment for the implementation of local energy projects			
Factor pair	**Strategy**	**Performance criteria**	**Objectives**
S2-O1	The establishment of a municipal project team to support the implementation of innovative energy efficiency and renewable energy projects, utilizing local knowledge and the potential of energy efficiency and renewable energy projects.	Increase in the number of successfully executed projects facilitated by the project team.	2024: 5; 2025–2030: annual increase of 10 %
T3-S2	Participating in EU development projects to identify and evaluate potential local energy projects.	Increase in the number of local energy projects identified, assessed, and prepared.	2024: 10; 2025–2030: annual increase of 15 %

control building, toll user point, common areas, and sanitary facilities (D1), along with the Ministry of Internal Affairs buildings: B2, C1, E1, and H1. The project aims to expand heat production from the existing biomass boiler to commercial users in the zone. The first step was to determine if the current biomass boiler could meet the heating demands of all buildings. The next consideration was whether installing an additional biomass cogeneration plant would be necessary to provide extra heat and partially supply the zone's electricity from renewable sources. Finally, the economic feasibility of maintaining the connection to the municipal district heating system was assessed.

The zone's large roofs are unsuitable for solar power due to limited sun exposure in the narrow Alpine valley. Wind power is also unfeasible due to low wind potential. However, the municipality's abundant local wood biomass supports the use of cogeneration for heat and electricity.

In December 2019, the NMO installed a modern boiler house using wood chips from local forests, reducing the company's carbon footprint. The 499-kW biomass boiler can be upgraded to connect new heat consumers. Two 5 m^3 hot water storage tanks are installed, ready to support a micro district heating network. This setup ensures that highly fluctuating demand can be met with a consistent power supply, effectively facilitating the use of biomass as a sustainable alternative energy source [36]. Under certain conditions, it could link to the municipal district heating system, enhancing reliability and competitiveness. Adding a biomass CHP unit could offer flexible heat and electricity production, with cogeneration prioritized and the boiler used during peak winter demand.

The analysis used 15-minute data on biomass boiler heat production, heat consumption of individual buildings (small garages, large garages, administration building, control building), and outside temperatures. Data for other facilities were excluded due to upcoming reconstruction. Heat use profiles for B2, C1, D1, E1, and H1 were estimated based on the NMO base's annual heat profile and each facility's surface area. Three scenarios of annual heating consumption (150, 200, and 250 kWh/m2) were analysed, with estimated consumption shown in Table 8.

Fig. 3 shows the annual heat consumption diagram for the 250 kWh/m^2 scenario, illustrating the heating season and the relationship between winter temperature fluctuations and heat use. The highest hourly values occur in January, with peak values of 469 kWh/h at 150 kWh/m^2, 556 kWh/h at 200 kWh/m^2, and 644 kWh/h at 250 kWh/m^2.

To provide more insights for decision makers and stakeholders, this study plotted the heat consumption as an orderly hour diagram, producing a power requirement curve to calculate the necessary power for production units and an operating diagram. The diagram reveals that peak load occurs only a few hours per year, mainly during system start-up after short shutdowns, when rapid heating is required. The existing 499 kW biomass boiler, supported by storage tanks with a thermal capacity of about 190 kWh (based on a 20 °C temperature difference), can cover the heating needs of the business zone. Fig. 4 shows the annual load duration diagram for the 250 kWh/m^2 scenario.

From the annual load duration diagram, the study also determined the potential CHP unit's operating hours, crucial for the energy community. A 100–kW thermal output CHP unit could operate for: 3568 h at 150 kWh/m^2, 3953 h at 200 kWh/m^2, and 4224 h at 250 kWh/m^2 scenario.

The operating area of this unit is marked with a red line in Fig. 4. These operating hours are considered in the economic viability analysis of installing a CHP unit. Adding a wood biomass CHP unit would offer flexible heat production and boost electricity production from RES. A 100–kW thermal output CHP unit, with 50 kW electrical output, is expected to produce 380 MWh to 450 MWh of heat and 178 MWh to 211 MWh of renewable electricity annually.

The total investment for the installation of a CHP unit with a capacity of 100 kW of heat and 50 kW of electricity is estimated at EUR 262,500. The annual operation and maintenance costs are estimated to be 4.5 % of the investment value, while the annual fixed costs are estimated at 1 % of the investment value. A depreciation period of 15 years has been considered in the calculation. The calculations assume 100 % self-financing, with no investment allowances included or considered.

Based on the cash flows provided, the economic indicators of the investment were calculated assuming a discount rate (Weighted Average Cost of Capital, WACC) of 5 %. All calculations were conducted for three different scenarios: 3568, 3953, and 4224 operating hours. The results are presented in Table 9.

The data indicates that the project is economically viable, offering long-term returns. The Net Present Value (NPV) is positive, and the Internal Rate of Return (IRR) exceeds the WACC, confirming the economic

Table 8
Estimated annual heat consumption of individual buildings.

User	Building	Area [m^2]	Annual heat consumption [kWh] 150 kWh/m^2	200 kWh/m^2	250 kWh/m^2	Other comments
Ministry for internal affairs	E1	590	88,500	118,000	147,500	Reconstruction
	H1	358	53,700	71,600	89,500	Reconstruction
	B2	372	55,800	74,400	93,000	Reconstruction
	C1	1064	159,600	212,800	266,000	Reconstruction
NMO	D1	378	56,700	75,600	94,500	Reconstruction
	Base		364,569 kWh			5 buildings, no reconstruction
Total			**778,869**	**916,969**	**971,369**	

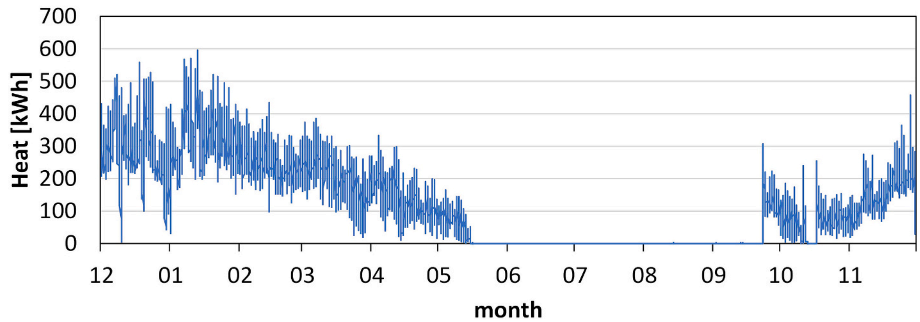

Fig. 3. Annual heat consumption – 250 kWh/m^2 scenario.

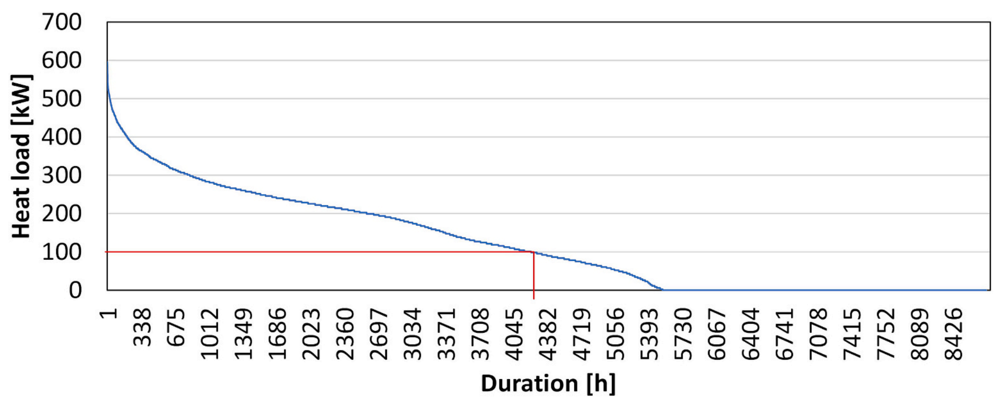

Fig. 4. Annual load duration diagram – 250 kWh/m^2 scenario.

Table 9
Woodchip-fired CHP economic and production indicators.

	Number of operating hours		
	3568	3953	4224
WACC	5 %	5 %	5 %
IRR	8.5 %	11.0 %	12.7 %
NPV	60,833 EUR	109,722 EUR	144,134 EUR
Simple payback period	8.3 years	7.2 years	6.6 years
Annual heat production	380 MWh	421 MWh	450 MWh
Annual power production	178 MWh	198 MWh	211 MWh

viability of the woodchip-fired CHP in the business zone.

3.3. Excess heat utilization

Excess heat utilization can be achieved through various technologies, providing valuable energy sources and reducing overall energy consumption [37]. Emerging research is driving the development of innovative engineering solutions, such as heat pipes, which have already demonstrated practical effectiveness [38,39]. The local steel plant offers multiple sources of excess heat that can be harnessed for diverse applications, including technological steam generation, hot water production, sanitary water heating, and pickling tube heating, thereby reducing electricity (EE) and natural gas (NG) consumption. Given the proximity of district heating systems in two nearby villages and a neighbouring town, there is potential to transfer excess heat to these systems. Using a simulation tool detailed in [40], optimal combinations of heat sources and sinks were evaluated. Three scenarios were analysed to assess economic and climate-related impacts:

1. Full Utilization: Utilizing all high-temperature excess heat sources and sinks, including heating the municipal centre and nearby villages.
2. Partial Utilization (Excluding Electric Arc Furnace (EAF) and district heating (DH)): Similar to the first scenario but excluding the municipality centre, both villages, and the EAF as a heat source.
3. Partial Utilization (Excluding EAF): Similar to the first scenario but excluding the municipality centre and EAF as a heat source.

The results of these scenarios are presented in Table 10, offering insights into the economic and environmental implications of each approach.

Table 10
Results of excess heat use simulations – scenario analysis.

No.	Excess heat sources	Excess heat sinks	Total savings			
			Excess heat in DH [MWh]	EE [MWh]	NG [Nm^3]	CO_2 [t]
1	EAF, Cold Roll Mill, Pusher Furnace, Compressors, CHP, Quadro Plate Furnace	All Steel plant sinks DH "Centre" DH Village 1 & 2	31,372	1,684	817,151	8,214
2	Cold Roll Mill, Pusher Furnace, Compressors, CHP, Quadro Plate Furnace	All Steel plant sinks	−67	1,684	810,127	2,103
3	Cold Roll Mill, Pusher Furnace, Compressors, CHP, Quadro Plate Furnace	All Steel plant sinks DH Village 1 & 2	3,230	1,684	817,151	2,736

Investments and savings were not separated by investor (District Heating System operator or Steel plant). The sharing of investment costs and savings should be covered by an additional business agreement between the two entities. Economic indicators for the three cases are presented in Table 11.

The economics of the results are influenced by energy (electricity, natural gas) prices and CO_2 emissions, which determine savings value. Calculations include a potential 50 % state subsidy, improving project feasibility by reducing the payback period to industry norms. However, connecting the Steel plant to the DH system, especially the city centre, is crucial for the economic success of the excess heat utilization project, as the city is the largest and most stable consumer of excess heat.

4. Discussion

A practical test of the proposed approach confirmed that the advanced process of formulating strategies aligns with the recommendations of Adshead, et al. [2]. It also recognizes the national context of energy and climate planning, making it an appropriate solution to improve local sustainable development. The review of Slovenian SECAPs [28] also indicates the need for a more comprehensive approach in both long-term planning of energy infrastructure and optimal planning of energy projects. The research work presented here is in line with this recommendation, and it confirmed that the process of preparing SECAPs could be enhanced with the proposed approach. Furthermore, this approach confirms findings of Vergerio et al. [41], emphasizing the critical role of Multicriteria Decision Analysis (e.g., AHP) when public administrations, representing public interests, are involved in evaluating and planning the built environment of future cities.

In the context of the presented research work, a particular challenge was the inclusion of a group of representatives from all key stakeholders in the process of determining local development priorities. Since universal knowledge of tools for multicriteria analysis cannot be expected, it was especially important to use tools that are as robust and easy-to-understand. Therefore, despite warnings that AHP is characterized by an inability to adequately accommodate the inherent uncertainty and imprecision associated with mapping decision-maker perceptions to an exact number [42,43] and that the fuzzy AHP (FAHP) is more suitable, AHP was chosen for use as a simpler and more understandable method. Pušnik et al. [44] also note that AHP, due to its transparency and simplicity in comparison with preference ranking organisation method for enrichment evaluation (PROMETHEE) and multi-attribute utility theory (MAUT) is the most suitable method for the analysis of the electricity generation decision alternatives in a relatively small energy system.

Facilities not owned by the motorway operator currently rely on the municipal district heating system, incurring high energy and network charges. The system primarily uses costly, taxed natural gas, and the aging network needs rehabilitation to reduce losses. High maintenance costs further exacerbate the issue, making predictive maintenance a promising approach to optimize and prioritize maintenance activities effectively [45]. Disconnecting from district heating could lower heat supply costs. However, disconnection would eliminate the reserve heat source for the business zone during failures and the option to transfer surplus heat to the district heating network. Evaluating the feasibility of surplus heat transfer is crucial. Connecting a RES for heat production could benefit the district heating operator, aligning with Slovenian and EU regulations to increase RES use. Uncertainty about future heat demand in the business zone, due to unclear renovation plans, is a concern. If a CHP unit is installed, assessing the feasibility of additional heat storage during the design phase is recommended to ensure consistent heat production and better CHP economics. Thermal storage facilities ensure a heat reservoir for optimally tackling dynamic characteristics of district heating systems [46]. Data analysis shows significant heat losses (10.5 %) in the Base network, despite short distances. Given the longer distances and outdated infrastructure, renovating the heat network during the zone's reconstruction is advisable to reduce losses and long-term costs. Focus should be placed on optimising the operation of the CHP unit and boiler, as they represent about 95 % of the system's improvement potential [14]. High-quality wood should be reserved for higher value-added products, while low-quality wood can be used as fuel despite challenges such as combustion issues and variable properties from inhomogeneity or inconsistent mixing. Improved, fuel-specific control systems can enhance operational stability, particularly in load-changing behaviour and responses to significant fuel quality fluctuations [15]. Excess heat utilisation project in the steel industry have proven highly effective. Modern approaches, such as heat pipes, can achieve over 40 % recovery with a payback period of less than three years [16].

Due to the exploratory nature of the project, the AHP analysis was conducted with only one representative from each stakeholder group. While this ensured manageability, it also introduced the risk of individual bias. A more robust approach in future applications would be to include multiple representatives per stakeholder type, allowing intra-group validation of results.

Additionally, the methodology was tested in a local community with a well-defined energy planning context and existing SECAP groundwork. Applying the same approach to communities without this foundation – or to projects outside the energy sector – would require significant adaptation, particularly in defining relevant SWOT factors and strategic orientations.

The lack of digital tools was another limitation. While a structured Excel-based input form was used for AHP, future operational use would benefit from a dedicated web-based decision support application, with interactive interfaces, group evaluation features, and real-time feedback on consistency.

Local capacity also poses a major constraint: many municipalities lack sufficient staff with expertise in sustainable planning or data analysis. Moreover, industrial partners are often hesitant to participate due to commercial confidentiality or weak internal data infrastructure, limiting data accessibility for evaluating external opportunities like excess heat.

Finally, one of the most significant limitations arises from systemic

Table 11
Economic indicators of excess heat utilization cases.

Assumptions		
Electricity price (including price of energy and grid fee)	EUR/MWh	130
Natural gas price	EUR/Nm^3	0.60
Heat price	EUR/MWh	70
CO2 emission price	EUR/t	80
WACC	%	5
CASE (1): Steel plant + DH Centre + DH Village 1 & Village 2		
Investment	EUR	22,500,000
Annual savings	EUR/year	2,437,371
NPV– without investment subsidy	EUR	2,799,073
NPV – with 50 % investment subsidy	EUR	14,049,073
Simple payback period – without investment subsidy	years	9.2
Simple payback period – with 50 % investment subsidy	years	4.6
CASE (2): Steel plant		
Investment	EUR	9,250,000
Annual savings	EUR/year	490,274
NPV– without investment subsidy	EUR	-4,161,119
NPV – with 50 % investment subsidy	EUR	463,881
Simple payback period – without investment subsidy	years	18.9
Simple payback period – with 50 % investment subsidy	years	9.4
CASE (3): Steel plant + DH Village 1 & Village 2		
Investment	EUR	9,450,000
Annual savings	EUR/year	681,691
NPV– without investment subsidy	EUR	-2,374,285
NPV – with 50 % investment subsidy	EUR	681,691
Simple payback period – without investment subsidy	years	13.9
Simple payback period – with 50 % investment subsidy	years	6.9

issues in local planning culture. Quick, partial solutions are often favoured over long-term, sustainable and systemic development—especially where early financial returns are more visible. This preference undermines the willingness to adopt comprehensive and sustainable frameworks like the one proposed, even if they offer greater strategic value in the long run. Without stronger national oversight or incentives to support high-quality SECAP development, the full potential of local communities to contribute to SDG targets may remain unrealised.

These practical outcomes, while still at an early stage, confirm that the proposed approach is not only theoretically grounded but also operationally applicable in real-world settings.

5. Conclusion

The research work presented here highlights the potential of using and combining different well-established methods in strategic management for creating effective sustainable development strategies in local communities. It also underscores the primary challenge of comprehensive treatment of long-term sustainable development, which necessitates consideration of the national context of sustainable development while being grounded in a detailed analysis of the local environment. The systematic, transparent and robust nature of the proposed process can significantly aid in mobilizing experts from different fields to actively participate in the creation of local development strategies. The concept of the proposed strategy development process inherently integrates effective tracking of the SDGs and a mechanism for continuous improvements throughout the entire life cycle of sustainable energy solutions. While the proposed process focuses on sustainable development from an energy perspective, the same methodological procedure could be applied to other domains such as air quality, water management and forest treatment. Furthermore, the procedure is not limited to the local environment; it could be advantageously applied at the national level, such as in the preparation of policies and measures of NECPs.

Although the proposed methodology was not implemented in the official SECAP of the observed local community, it was applied in parallel as an alternative strategy development pathway. A total of 36 implementation strategies were formulated, based on prioritised strategic orientations and SWOT factors. Three of these were piloted to demonstrate the practical utility of the approach.

The presented examples of an energy community utilising locally produced wood biomass for heating and the beneficial use of excess heat from the steel production process demonstrate that the proposed formulation of local development strategies aids in identifying projects with the potential to fully harness local resources to achieve international and national sustainable development goals. In the case of the biomass-based CHP system, the economic analysis revealed a NPV of €144,134 and an IRR above the WACC, confirming the project's financial viability. In the excess heat reuse scenario, the most ambitious configuration with network integration showed potential annual savings exceeding €2.4 million and a payback period under five years, assuming 50 % investment co-financing.

These quantified results illustrate how strategic, criteria-based planning can produce tangible project concepts that meet both technical feasibility and sustainability goals. The proposed methodology thus provides not only a conceptual framework but also operational guidance for improving the quality and impact of local energy planning efforts.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to improve language and readability. AI-assisted language tools were used solely for grammar and style suggestions, and no content was generated automatically. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRediT authorship contribution statement

Edvard Košnjek: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Conceptualization. **Boris Sučić:** Writing – review & editing, Writing – original draft, Conceptualization. **Fouad Al-Mansour:** Writing – review & editing, Writing – original draft, Conceptualization. **Aleksandar Kavgić:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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