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THE PROJECT TRANSFORMAT-LINK: SUPPORTING THE ENERGY GOVERNANCE OF THE AUSTRIAN NATIONAL ENERGY AND CLIMATE PLAN AT THE MUNICIPAL LEVEL

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Abstract. In terms of spatial planning, there is a disconnect between the national and local levels that hinders effective planning and reporting under the National Energy and Climate Plan (NECP), as the availability of renewable energy depends on the spatial conditions determined at the municipal level. This article outlines the potential of the transFORMAT-LINK research project to address the 'strategic NECP control gap' between the Austrian state, federal states and municipalities. The primary obstacles confronting municipalities are the challenges of accurately quantifying their own net NECP contribution to the environment and the environmental impact of future projects. We provide an approach how to determine renewable energy potentials, present them in a transparent way and track project implementation. This generates a collection of data relevant for the municipality and documents to approach these targets.

Keywords: NECP, renewable energy, energy spatial planning, multi-level governance.

Introduction

The Integrated National Energy and Climate Plan (NECP) according to EU Governance Regulation (EU) 2018/1999 (EU, 2018) is the central policy instrument for achieving the EU energy targets by 2030 and beyond. The federal government is responsible for reporting to the EU on the progress made towards achieving the targets. However, the actual realisation of projects to increase renewable energy use and to reduce greenhouse gas (GHG) emissions is significantly influenced by the competencies of the Austrian provinces (or federal states) and, in particular, the municipalities. The question is therefore how the link between the national planning and reporting level of the NECP and the municipal project implementation level can be improved. The local development concept, also called municipal or spatial development plan or concept, depending on the provincial legislation, is a possible starting point for this.

Energy and Climate Policy – legal framework

The EU Governance Regulation is directly applicable in the Member States, without the need for transposition into national legislation. The regulation stipulates detailed instructions for Member States on how to establish their National Energy and Climate Plans, covering aspects such as process, content, targets, and indicators. Targets refer to renewable energy shares, greenhouse gas emissions, energy efficiency, energy security, and other related factors. The plan is based on a modelling exercise. However, policies and measures must be defined and precisely described to ensure that the modelling is based on realistic assumptions and that the targets are likely to be achieved. A reporting obligation exists regarding target achievement, which highlights the need for realistic policies and measures. In Austria, the federal ministry in charge of energy and climate[1] is responsible for meeting the EU obligation.

However, there is no federal responsibility for spatial planning, which is essential for the exploitation of the renewable energy potential. Spatial planning legislation is regulated at the provincial level, providing the legal framework for municipalities within the province.

The municipal legal framework consists of the municipal development concept and the zoning plan as well as the development plan. The municipal development concept typically has a horizon of 10 to 15 years and provides the framework for the zoning and development plan. It is important to ensure that the provisions of the zoning and development plan do not contradict the municipal development concept. Therefore, the quality of this concept is crucial as it guides concrete actions in terms of land use.

Challenges in achieving energy and climate targets

The NECP assigns significant importance to the targets for increasing the share of renewable energy and reducing greenhouse gas emissions. However, as explained previously, renewable energy utilisation depends on spatial conditions. For instance, solar energy can be collected in areas with adequate radiation (theoretical potential), where spatial planning permits or facilitates exploitation (technical potential), and where economic conditions are favourable for constructing renewable energy facilities (economic potential). The categorization of potentials is based on Kaltschmitt and Neubarth (2000). It is evident that technical and economic potentials are interdependent. High transaction costs resulting from untransparent, or unfavourable spatial planning framework conditions can adversely affect the economic viability of renewable energy plants and, consequently, their economic potential.

The project transFORMAT-LINK as a response to challenges identified

The disconnect between the federal and municipal levels with regard to energy spatial planning in general and the use of renewable energy in particular may lead to unrealistic assumptions in the NECP and, as a consequence, difficulties in achieving the targets. This challenge was the starting point of the transFORMAT-LINK project and the motivation to work on possible solutions. The name of the project refers to the provision of a format for the transformation that links the various administrative levels.

[1] Federal Ministry, Republic of Austria: Climate action, Environment, Energy, Mobility, Innovation and Technology (https://www.bmk.gv.at/en.html).

The objective was to develop a realistic and feasible planning and reporting approach for the NECP in the field of renewable energy use and spatial energy planning[2] by establishing the necessary conditions in the municipal development concept. Results are summarised in the LINK guideline, which includes a catalogue of minimum requirements and criteria to be applied uniformly when drawing up and revising municipal development concepts. The catalogue supports municipalities in defining spatial energy planning areas and developing local projects for the use of renewable energies. Furthermore, a software prototype is created to facilitate implementation (Geissler et al., 2024).

Methods applied to identify the detailed requirements for the development task include the definition of criteria for selecting municipalities as case studies, the analysis of municipal case studies along defined steps, interviews with stakeholders at federal, provincial and municipal level according to semi-standardised interview guidelines, and analysis of related projects in the Member States regarding possible lessons learnt relevant for the transFORMAT-LINK project. Table 1 presents a comprehensive overview of the work packages, research questions, methods, and results pertaining to the transFORMAT-LINK project.

Table 1. Project overview [3]

Work package	Main research question	Methods	Results and products
Municipal case studies	What types of municipalities exist in Austria with regard to the energy transition?	Desk research, analysis of energy data reports, standardised interviews	Identification of 6 representative case study municipalities; reports
Stakeholder discussions	What is the current state of knowledge, experience and future perspective on NECP topics?	Semi-standardised interviews with representatives of all administrative levels	Status quo report; profile of the future NECP governance
Development of LINK guideline	What are generic steps in realizing the NECP goals at municipal level?	Guideline document design based on usability checks	LINK guideline
Development of prototyped online tool	What features does a web based NECP supporting tool have that is easy to use and sufficiently accurate?	Agile software programming, usability checks with the municipalities and improvements	Interactive, prototyped online tool [3]

In this paper, the focus is on municipal case studies including stakeholder discussions held with representatives at municipal level. In addition, the LINK guideline and the prototyped online tool are briefly described.

Municipal case studies

Policies, in particular the municipal development concept (Örtliches Entwicklungskonzept, ÖEK), were analysed for their energy and climate-relevant statements and specifications in order to assess their possible impact on the achievement of the NECP targets. In addition, interviews were

[2] The German term 'Energieraumplanung' is hard to translate. Besides 'spatial energy planning' one can also find 'Integrated Spatial and Energy Planning' (Stoeglehner at al 2016).

[3] The tool is publicly online from September 2024 on. More information: https://transformat.at.

conducted with experts (mayor, planning department) from the selected municipalities to gain insight into the status of awareness regarding the NECP, the challenges they face and to discuss potential solutions with them.Selection of case study municipalities

Six municipalities with less than 30,000 inhabitants were selected based on a criteria assessment. The planning-relevant criteria used to select the case studies to obtain a meaningful qualitative sample of the Austrian territory, also regarding the specific spatial planning legislation which is regulated at the level of the 9 Austrian provinces, are as follows:

- Province,
- Population,
- Spatial type according to the Austrian Spatial Planning Conference (ÖROK),
- Municipal development concept (ÖEK) with energy and climate reference,
- Municipal energy concept,
- Municipality participation in climate and energy model region (KEM, 2024), KEM phase and year of accession,
- Participation in e5 municipality programme (e5, 2024), in which the municipalities set their own energy-related targets and commit themselves to achieving them, with the degree of target achievement expressed by the number of '*e*', year of accession and degree of implementation.

On this basis, the six case study municipalities were selected for further processing. Out of the 9 Austrian provinces, 4 of the 8 provinces to be analysed are covered by this sample, because Vienna as a spatially and functionally specific case (province, metropolis, and municipality at the same time) is not considered in the project.

As shown in Figure 1, the 4 provinces with the case study municipalities are: (1) Lower Austria (municipalities of Baden and Langau); (2) Upper Austria (municipality of Munderfing); (3) Salzburg (municipality of Werfenweng); (4) Tyrol (municipalities of Hall in Tyrol and Schwoich).

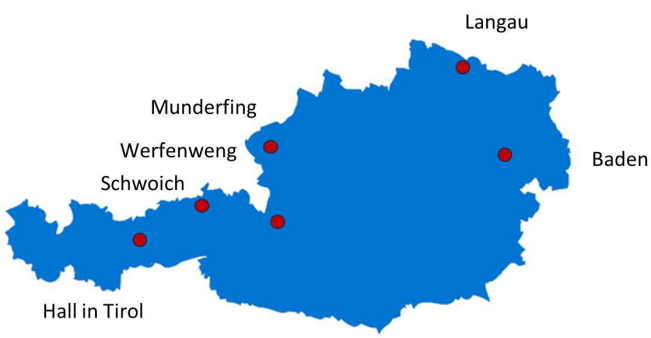


Figure 1. Overview of case study municipalities

Municipality profiles

The municipality profiles of the six case studies are made up of the subject areas: (1) general and energy-relevant information, (2) area, land use and population density, and (3) structural data according to Energiemosaik Austria, as shown in Table 2. Energiemosaik (2024) is a statistical energy database with disaggregated data available for each Austrian municipality.

Table 2. Overview of the general and energy-relevant information of the case study municipalities*

Province	**Lower Austria (NÖ)**	**Lower Austria (NÖ)**	**Upper Austria (OÖ)**	**Tyrol**	**Tyrol**	**Salzburg**
Municipality	**Baden**	**Langau**	**Munderfing**	**Hall in Tirol**	**Schwoich**	**Werfenweng**
Area	26.9 km²	22.2 km²	31.1 km²	5.5 km²	18.8 km²	45.0 km²
Population	26,017	699	3,041	14,322	2,593	1,099
ÖROK spatial type	Urban region – rural conurbation	Rural area with low population density	Rural area with low population density	Urban region – state capital	Axis area along high-ranking transport infrastructure	Rural tourism region
Spatial development (ÖEK) with energy reference	yes	–	yes	–	–	yes
Energy Concept	Climate and Energy Concept 2022	–	Energy construction kit 2006	–	–	–
Climate and Energy Model Region (KEM)	Baden – Energy cure 3	–	KEM Climate Future Mattigtal	Hall and neighbourhood	KUUSK	–
KEM accession	2010	–	2022	2021	2020	–
KEM phase	Continuation phase 3	–	Concept phase	Realisation phase	Realisation phase	–
e5 municipality	yes	–	–	–	yes	yes
e5 accession	2011	–	–	–	2018	2005
e5 realisation (Status 2021)	77.9%	–	–	–	43.8%	74.0%

* Empty cells – no policy document publicly available, filled cells: policy document publicly available.
Source: own illustration based on Statistik Austria (2023) and desk research.

There is a high diversity of different activities and available energy-relevant planning documents across the case study municipalities. Table 2 illustrates the considerable heterogeneity of the current energy policy landscape in the case study municipalities. The number of filled fields in a municipality does not necessarily indicate its relative ranking. Rather, it reflects the diverse personnel resource situations that emerge from varying budgetary and temporal constraints. On the one hand, various priorities can be identified and, on the other hand, the time horizon in which the municipalities are already addressing energy and climate issues varies widely (see years of accession to energy or climate-relevant public programmes, such as KEM and e5 municipalities). In addition, the levels of integrated spatial and energy planning are very different, which entails different demands on local spatial planning and requires the development of community-specific planning approaches, considering supra-local conditions and regional cooperation as well as spatial-energy development potentials.

In this article, we have selected Baden as a case study of a municipality that has achieved a high level of development in the field of energy governance, as evidenced by the data presented in Table 2. The exceptional quality and quantity of data make it an ideal source for the subsequent status quo report on energy-related content.

Area, land use and population density – municipality of Baden

In 2020, the population per km² cadastral area was 965, and the population per km² permanent settlement area was 1,283. Compared to 2011, there was a slight increase in population. Table 3 provides an overview of the land use of the municipality analysed. The land use is differentiated according to the categories building land, agricultural land, gardens, vineyards, alps, forest, water, and other. This allows planning conclusions to be drawn about the distribution of land use on the one hand and the compactness of the settlement structure or the degree of urban sprawl on the other, which has energy-related impacts on the mobility requirements, the design of the technical infrastructure and the heating requirements of the settlements.

Table 3. Area and land use (using the example of Baden)

Land use	ha	%
Cadastral area	2,689.57	100.00
Building area	159.97	5.95
Utilised agricultural area	573.34	21.32
Yards	469.88	17.47
Vineyards	280,85	10.44
Alps	–	–
Forest	766.52	28.50
Waters	50.80	1.89
Other areas	388.22	14.43
Permanent settlement area	2,023	75.22

Source: own illustration based on Statistik Austria (2023).

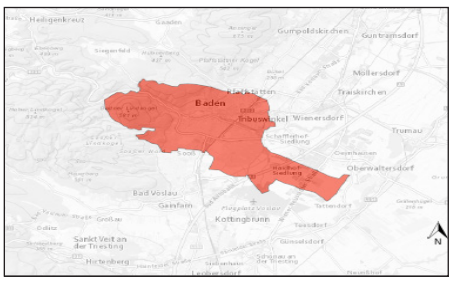
This information provides the basis for a detailed, high-resolution spatial energy planning analysis, that can result, for example, in implementation strategies for a climate-friendly heat energy supply, or mobility services can be developed for different settlement areas and implemented in spatial concepts, as described in the next sections.

Structural data – municipality of Baden

The 'Energiemosaik Austria' (Abart-Heriszt & Reichel, 2022) offers spatial and energy-specific structural data for each municipality and provides typifications and other key figures: landscape area, urban-rural type, municipality type (type A – residential; type B1 – residential, agriculture and forestry; type B2 – residential, services; type B3 – residential, industrial and commercial; type C – services; type D – industrial and commercial), residential area, cultural area, employed persons in the industrial and commercial sector, employed persons in the services sector, passenger mobility (passenger-kilometres) and freight mobility (tonne-kilometres). Table 4 shows the data for the municipality of Baden.

Table 4. Structural data according to Energiemosaik (using the example of Baden)

Landscape space	North-eastern lowlands
Urban-Rural-Typology	Urban centre
Community type according to *Energiemosaik*	Type C - mixed-function / service-orientated municipality
Living space	1,485,700 m²
Cultivated area	1,520 ha
Manufacturing sector	1,155 Employed persons
Services	11,375 Employed persons
Personal mobility	537,188,000 Passenger kilometres
Mobility of goods	25,415,000 Tonne-kilometres



Source: own illustration based on Abart-Heriszt and Reichel (2022).

Spatial planning and energy analysis using the example of Baden

Spatial planning analysis

The analysis of the local planning documents of the municipality of Baden showed that these documents do not contain any energy or climate-relevant stipulations. The ordinance on the local spatial planning programme of the municipality of Baden only stipulates the consideration of the capacity limits of the technical infrastructure through the moderate use of existing building land.

The planning priorities in the municipal development concept (ÖEK) provide the framework for the zoning plan and the land use plan and are defined as follows (Hameter, 2021):

1. Planning requirements / existing settlement structure
2. Development of green space
3. Development of the settlement area

The energy-relevant zoning categories for municipal spatial planning in Lower Austria relate to the designation of land for the use of ground-mounted photovoltaic systems (grassland zoning category: Gpv) and sites for wind power utilisation (grassland zoning category: Gwka) (BDP, 2018). These two grassland zoning categories cannot be found in the zoning plan of the municipality of Baden. The following energy-related markings are to be located in the zoning plan: (1) district heating and transformer station; (2) transformer; (3) switching station; (4) gas station; (5) overhead power line; (6) power line – underground; (7) power line – underground (Hameter, 2022).

The municipality of Baden provides the current zoning plan in the municipal online GIS (SBaden, 2024) (Fig. 2).

The new comprehensive 'Baden 2022 climate and energy concept – spatial energy planning' works with spatial references, allowing priority areas to be defined for various planning and energy-related topics (Emrich et al., 2022). The results for the housing sector are summarised below. The focus here is on the expansion and use of renewable energy sources for heat supply and planning recommendations for thermal refurbishment priorities for residential buildings, as well as the impact on potential Greenhouse gas (GHG) emission savings.

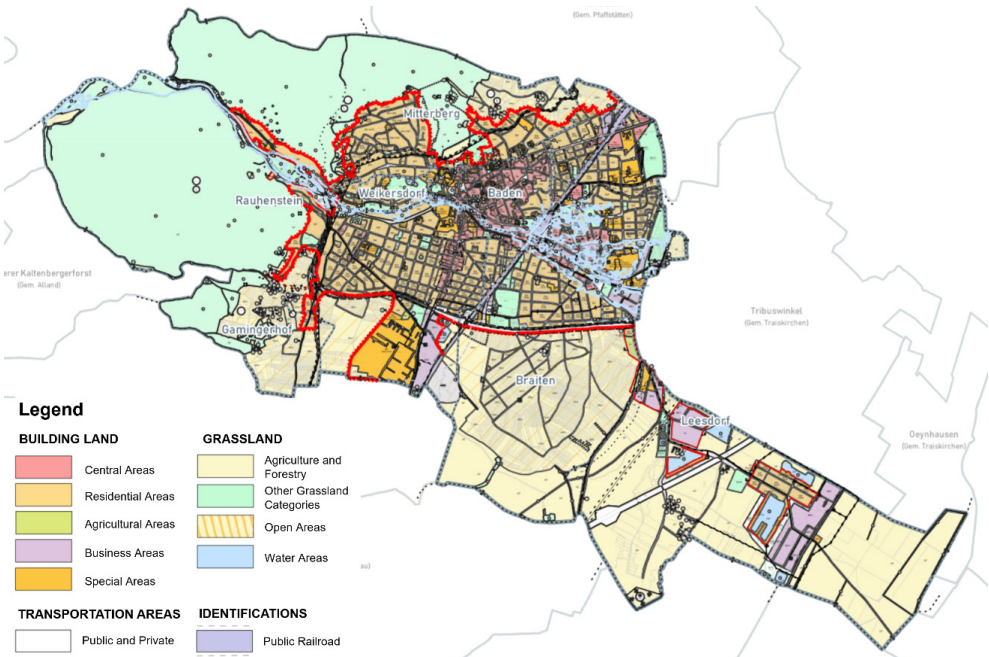


Figure 2. Zoning plan of the municipality of Baden (online GIS of the city)
Source: SBaden (2024) (adapted).

In terms of methodology, the analysis and recommendations for action derived from the climate and energy concept are based on data from the Address, Building and Housing Register (Adress-, Gebäude- und Wohnungsregister – AGWR) operated by Statistics Austria and include the following content and planning principles in the area of 'housing' (Emrich et al., 2022):

- Specific heat demand
- Potential savings in heating demand through building refurbishment
- Analysis of distances to district heating pipes
- District heating – heat demand densities
- Analysis of heating system – Identification of four types: (1) alternative measure; (2) district heating measure; (3) heat pump measure; (4) no measure necessary on the heating system (buildings already supplied with renewables)
- Analysis of heating system and refurbishment

70% of the buildings are supplied with heat from fossil fuels, 10% from renewable sources such as district heating (6%), logs, pellets and electricity (heat pumps). No reliable statement can be made for 20% of the residential buildings, as the AGWR data has not been entered accordingly. (Emrich et al., 2022)

According to the model results based on the AGWR data, the heating demand (including domestic hot water preparation) for residential buildings is about 198 GWh. This results in total greenhouse gas emissions of approx. 52,000 tonnes of CO_2-eq (calculation based on the heating types and emission factors according to the Austrian Federal Environmental Agency *Umweltbundesamt* – UBA). (Emrich et al., 2022)

By thermally refurbishing the residential buildings (in accordance with the procedure set out in Baden's energy and climate concept), a reduction in heating requirements of around 46% and savings of around 91,000 MWh/a can be achieved, which corresponds to more than halving CO_2-eq emissions. After an assumed substitution of fossil fuels by heat pumps, a theoretical reduction in heating demand of almost 50% could be achieved, which corresponds to a reduction of around 7,000 t CO_2-eq (75%). (Emrich et al., 2022)

Fields of action and measures of the Climate and Energy Concept of Baden 2022 according to Emrich et al. (2022) are listed below:

1. Improving the data basis:
   - Checking / supplementing the AGWR data with regard to the existing heating system in the buildings,
   - Creation of a database for refurbishments,
   - Importing all relevant data such as the current district heating network, geothermal zones, zones according to various ordinances of the state of Lower Austria (sectoral spatial planning programme for photovoltaics, ordinance on the designation of a protected area to protect the medicinal springs of Baden and Bad Vöslau) into the GIS system (Geographic Information System) of the city of Baden,
   - Designation of the UNSESCO World Heritage Site;
2. Spatial planning in general:
   - Preventing urban sprawl, limiting land consumption,
   - High-quality density for a city of short distances,
   - Contractual spatial planning, contracts under private law,
   - Provide areas for energy storage,
   - List of requirements for requests (changes/wishes from businesses/property owners – as an opportunity for intervention: Proactively request a list of requirements from the city (contributions to the design of public spaces, mobility hubs, etc.) in new and existing buildings;
3. Municipal Development Concept (ÖEK):
   - Inclusion of a clear target of full decarbonisation in the ordinance on the ÖEK,
   - Formulation of quantitative approaches in the ÖEK,
   - Adoption of the input from the climate and energy concept.

In the city's web-based geographic information system (online GIS or MS.GIS information system), it is possible to visualise the existing district heating network and the building-related solar potential (roof areas according to suitability categories). The survey revealed that a theoretically usable area of around 800,000 m² is available on Baden's roofs. The maximum electricity production potential of approx. 110 GWh per year is forecast for this area, which would correspond to a theoretical GHG saving of around 36,000 tonnes CO_2-eq. It is also noted that the issue of solar power plants must be handled sensitively in protected zones. (SBaden, 2024)

Energy analysis

Approximately one third of the energy consumption in Baden is accounted for by the residential sector (GHG emissions around 25%), a further third is attributable to mobility (GHG emissions around 50%) and the remaining consumption is attributable to services, industry and commerce as well as agriculture and forestry (GHG emissions ~ 25%), with the agricultural sector being negligible, also in terms of the GHG emissions generated (Table 5). Thus, the highest decarbonisation potential in Baden can be found in the mobility sector.

Table 5. Energy consumption and GHG emissions by utilisation (Baden)

Energiemosaik Database 2022	Residential	Agriculture and forestry	Manufacturing sector	Services	Mobility	Overall
Energy consumption in MWh per year	239,000	2,100	107,700	123,600	250,600	723,000
Greenhouse gas emissions in tonnes of CO_2-eq per year	44,260	480	27,750	24,350	91,580	188,420

Source: own illustration based on Abart-Heriszt and Reichel (2022).

The analysis of energy consumption by purpose shows that space heating accounts for around 40% of total energy consumption and is just above the consumption for the entire transport sector (including goods transport), as illustrated in Table 6.

Table 6. Energy consumption by intended use (Baden)

Intended use	Energy consumption [MWh/a]
Space heating	284,900
Process heat	69,500
Motors/electrical devices	99,900
Transport	268,600

Source: own illustration based on Abart-Heriszt and Reichel (2022).

The energy flow chart (intended use – utilisation – renewable energy supply) shows that just over 30% of energy is generated from renewable sources – the rest comes from fossil fuels. In the sectors of mobility and industry, most of the energy demand required is provided by fossil fuels, while more than 50% of the energy demand required for housing and services can already be met by renewables.

Conclusions regarding the results of municipal analysis and the possible impact on the achievement of the NECP targets

The analysis to date has revealed frequently available data that is helpful for spatial energy planning at municipal level and that also fulfils the requirements at national and federal state level. On that, a summary is displayed in Table 7.

Table 7. Available information at municipal level and the relation with NECP indicators; assessment of impact

Available information at municipal level	Relation with NECP indicators	Assessment of impact
Energy consumption per sector and use	Energy efficiency targets	Total energy savings in GWh per year
Renewable energy share per sector and use	Targets for renewable energy expansion and increasing the share of renewables in energy consumption	Share of renewables on energy consumption
GHG-emissions per sector and use	GHG reduction targets	GHG reduction in tonnes CO_2-eq per year

Interviews with representatives of municipalities: identification of support needed

The interviews with representatives of 5 case study municipalities[4] (see Fig. 1) were held in the period between March and August 2023. The professional positions of interviewed stakeholders at municipal level are shown in Table 8.

Table 8. Interviewed stakeholders and their professional positions

Professional position	Number of interviewees
Mayor and Head of Planning	1
Climate and Energy Department and Head of Planning	2
Mayor	3

A total of 43 questions in 2 thematic blocks were answered in these qualitative key question interviews. Block 1 dealt with the governance of NECP objectives between the municipality, the provincial government, and the Austrian national state. Block 2 focused on the specific implementation reports of the NECP objectives in the case study municipalities. The questions are listed below, ordered in these 2 blocks. After each block, the answers are summarized in content sections.

Block 1: Questions on the governance of NECP objectives between the municipality, the province and the Austrian state (see Table 9):

- Have you heard of the NECP?
- How were you informed about the NECP and its objectives, by the federal or state government?
- What are the specific requirements you received from the federal and state governments regarding the NECP? How have you been informed about your tasks and your role?
- Do you feel adequately informed about the objectives and intended measures?
- What specific guidelines would you like to see from the federal and state governments on the implementation of the NECP, particularly in the area of spatial planning?
- How could communication channels be designed so that you are better informed by the federal and state governments about these and similar objectives and targets?
- Are the objectives of the NECP clear to you? What do you personally think about the NECP objectives?
- Are there specific, measurable government requirements with regard to spatial energy planning that affect your area of activity?
- What forms of reporting on the NECP have been established between the state and local authorities? How and to whom do you have to report on specific measures and results in the implementation of the NECP?
- How could cooperation with the federal state be improved?
- To the best of your knowledge, how are the objectives, implementation steps and results of the NECP coordinated between the federal government, the federal states and the municipalities? What are the possible communication channels? Are there specific rules for this?
- How could you be supported in the implementation of the NECP? What support should the federal and provincial governments or other possible institutions provide to make it easier for you to make a measurable contribution to the NECP in your municipality?

[4] We conducted interviews with 6 municipalities, but with the municipality 'Werfenweng' there was a specific questionnaire on the regional planning aspects. Therefore, the Werfenweng answers are not displayed in this section.

Although the answers among the case study municipalities were heterogenous, Block 1 questions can be summarised in 3 sections as shown below.

'Have you heard about the NECP from the national level, and how did this happen' (Answers on Block 1, section 1): All but one of the representatives from the municipalities have heard about the NECP. All municipalities reported that the information was not delivered by the national level directly, but rather indirectly over personal contacts between the local municipal and the provincial level. All municipalities pointed out that the NECP information, so far, did not include precise checklists, tasks, or scenario timeframes of the goals and the role of the municipalities in achieving them (see also next section).

'Tell us about the specific requirements that you have received on the NECP, both from the national and the provincial level. Add any specific support from the national or federal level that would be helpful to your municipality.' (Block 1, section 2): Three out of five municipalities did not feel informed at all by the national and the provincial levels, but they also admitted that they did not care pro-actively for further information from there. However, these three municipalities also pointed out that they gathered information in line with NECP goals from other sources such as social media platforms.

The other 2 municipalities named the following topics as 'important specific requirements': to go for 100% renewable electricity till 2030; empower E-mobility; get rid of oil and gas (or replace them by renewables); generally clear specifications and documents from the national and provincial level; more support for the inter-municipal and regional decisions that are necessary to solve problems that can't be solved in single municipalities; more support for citizens participation; more information about possibilities to save energy, not only how to replaces fossil fuels; which types of projects can be identified as 'NECP projects' and how can such energy balances be drawn up.

'Tell us about the comprehensibility of the NECP goals.' (Block 1, section 3): All municipalities agreed that the NECP goals are comprehensible and necessary, but also that there is a need for more cooperation between the national, provincial and municipal levels (see section 1 and 2 above).

Block 2: Questions on the specific implementation reports on the NECP goals in the case study municipalities (see Table 10):

- In general: What role do you see (formal or informal) for municipalities in relation to the implementation and subsequent reporting of the NECP?
- How do you assess the level of information of all municipalities and your municipality in particular on the topic of 'decarbonisation of the EU'? How could you be supported in communicating these goals?
- Where do you see the scope for action and the area of responsibility of municipalities in the implementation of the NECP?
- What can your municipality contribute to achieving the NECP goals?
- How does your municipality contribute to the implementation of the NECP now or in the future? What are the (pre-defined) areas of activity or work processes?
- Do you already have a municipal climate and energy strategy? Who drew it up? How does it fit in with the objectives of the NECP?
- How is your municipality equipped in terms of staff and budget to make a measurable contribution to implementing the NECP?
- Who in your municipality is already responsible or will be responsible for the NECP in the future?
- How do you coordinate with the responsible federal and state authorities? Who is your contact person for the NECP at national level?

- Has your approach to implementing the NECP been coordinated with neighbouring municipalities? What benefits and synergies could a coordinated approach with neighbouring municipalities bring?
- What could such inter-municipal coordination look like? What forms of cooperation could be envisaged?
- Have you heard about the experiences of other municipalities in implementing the NECP?
- How are energy efficiency and renewable energy issues (including decarbonisation potential) taken into account in the review of local development plans? In your opinion, what would a good municipal development concept look like? How can the NECP and forward-looking integrated spatial- and energy spatial planning be embedded in the ÖEK?
- How could you be supported in revising the ÖEK in this respect?
- In which areas could the Austrian Ecological Development Concept respond to the NECP and forward-looking integrated spatial- and energy spatial planning?
- How can realistic and feasible renewable energy projects be developed? Who could be partners in your municipality for the rapid realization of concrete projects?
- How could you motivate the population of your municipality to participate in the implementation of the NECP goals and forward-looking integrated spatial- and energy spatial planning?
- Where do you see particular opportunities and supporters: internally in the implementation of the NECP goals and forward-looking (energy) spatial planning? Within your municipality? Outside your municipality?
- Where do you see particular difficulties, stumbling blocks and obstacles in the implementation of the NECP objectives and forward-looking (energy) spatial planning? Within your municipality? Outside your municipality?
- What has not yet been discussed and is still important?

Although the answers among the case study municipalities were heterogenous, Block 2 questions can be summarised in 4 sections as shown below.

'Report the role of your municipality during realizing the NECP goals' (Block 2, section 1): Three out of five municipalities mentioned that achieving the NECP goals cannot be the responsibility of the national and provincial level alone, municipalities must contribute their share as well. One municipality reported that they enlarged the local district heating network, but only a minority of people wanted to use it, because they prefer other heating solutions, such as heat pumps. All municipalities reported that they, in close cooperation with the provincial level, run and foster energy accounting databases for their public buildings.

'Report how you already embedded (or plan to embed) the NECP goals into the local development concept of your municipality?' (Block 2, section 2): One municipality pointed out that they focus the local development either (a) mainly in the central areas or (b) if necessary at the border regions of the municipality, they try to avoid further small single family houses there by supporting dense multi-family homes. Two out of five municipalities mentioned ongoing improvements of the fibre optic network, and this may offer possibilities to reduce some commuter traffic, if people can do home office work. Three out of five municipalities said that they had already planned and held regular information events on energy change issues in general, but also on financial support and learning from best practice examples.

'Outline measures, that are already (or will be) realised to support the NECP goals?' (Block 2, section 3):

All municipalities reported the planning and implementation of one or more photovoltaic (PV) power plants. One municipality mentioned the invention or empowerment of e-vehicle (EV)

sharing. One municipality runs a first test facility for Agrivoltaics. Three out of five municipalities reported the information exchange with neighbouring municipalities on the NECP experiences. All municipalities have already gathered knowledge on the thermal refurbishment of existing buildings. One municipality reported employing a person specifically and only for energy issues. Two municipalities mentioned more possibilities in the future, when citizens can benefit financially from renewable energy plants.

'Is there anything else that may be important around the NECP topics, that was not covered by the questions?' (Block 2, section 4):

All municipalities pointed out that both, the heating and the electricity grids cannot be improved by the municipalities alone, and that more exchange of information is needed between the municipalities, the energy supply companies, and the provincial spatial planning department. One municipality also mentioned the potential of a virtual guideline that could be helpful to embed the NECP goals into the local municipal strategies. One municipality pointed out that a digital reporting system (like the one that exists as heat register already in the province of Salzburg) on NECP goals would be very helpful.

Table 9. Overview of the multiple answers from the case study interviews: Block 1 Questions on the governance of NECP objectives between the municipality, the province and the Austrian state

Questions		Responses
Section 1	Have you heard about the NECP from the national level, and how did this happen?	**5/5 municipalities** reported that the NECP-information was not delivered by the national level **5/5** pointed out that the information did not include any precise checklists, tasks or scenarios **4/5** have heard about the NECP
Section 2	Tell us about the specific requirements that you have received on the NECP, both from the national and the provincial level. Add any specific support from the national or federal level that would be helpful to your municipality.	**3/5 municipalities** did not feel informed at all by the national and the provincial levels, but they also admitted that they did not care pro-actively for further information from there, but they gathered NECP-information from other sources **2/5** mentioned the following topics as important requirements (e.g.): (1) Get rid of oil and gas (or replace them by renewables); (2) Generally clear specifications and documents from the national and provincial level; (3) More support for the inter-municipal and regional decisions; (4) More support for citizens participation; (5) More information about possibilities to save energy, not only how to replaces fossil fuels
Section 3	Tell us about the comprehensibility of the NECP goals.	**5/5 municipalities** agreed that the NECP goals are comprehensible and necessary, but also that there is a need for more cooperation between the national, provincial and municipal levels

Table 10. Overview of the multiple answers from the case study interviews: Block 2 Questions on the specific implementation reports on the NECP goals in the case study municipalities

Questions		Responses
Section 1	Report the role of your municipality during realizing the NECP goals.	**5/5 municipalities** reported that they, in close cooperation with the provincial level, run and foster energy accounting databases for their public buildings **3/5** mentioned that achieving the NECP goals cannot be the responsibility of the national and provincial level alone, municipalities must contribute their share as well

Section 2	Report how you already embedded (or plan to embed) the NECP goals into the local development concept of your municipality?	**3/5 municipalities** said that they had already planned and held regular information events on energy change issues in general, but also on financial support and learning from best practice examples **2/5** mentioned ongoing improvements of the fibre optic network, and this may offer possibilities to reduce some commuter traffic, if people can do home office work
Section 3	Outline measures, that are already (or will be) realised to support the NECP goals?	**5/5 municipalities** reported the planning and implementation of one or more photovoltaic (PV) power plants **5/5** have already gathered knowledge on the thermal refurbishment of existing buildings **3/5** reported the information exchange with neighbouring municipalities on the NECP experiences **2/5** mentioned more possibilities in the future, when citizens can benefit financially from renewable energy plants
Section 4	Is there anything else that may be important around the NECP topics, that was not covered by the questions?	**5/5 municipalities** pointed out that both, the heating and the electricity grids cannot be improved by the municipalities alone, and that more exchange of information is needed between the municipalities, the energy supply companies, and the provincial spatial planning department

Conclusions from the municipal case studies and stakeholder interviews

The spatial planning laws in all Austrian provinces lay out the primary contents of municipal development concepts (ÖEK). Depending on the province, municipalities are required to update their respective ÖEK every 10 to 15 years. The provinces provide guidelines and support the municipalities during the revision process. Through harmonising the contents of the ÖEK with the requirements set out in the NECP, these ÖEK revisions are key to achieving the ambitious NECP goals. Therefore, the primary consideration for the development of both the LINK guideline and the prototyped online tool was to take advantage of these windows of opportunity by providing municipalities that are in the process of revising their ÖEK with the information and tools necessary to draft local measures that benefit NECP goals on a national level. By using the online tool, municipalities would also provide quantitative and qualitative data to the federal government which, in turn, is therefore able to fulfil its obligation towards the EU to report on the national NECP target progress/achievement.

Guideline and prototyped online tool to support the alignment of municipal development plans with the NECP

Based on the exemplary results of case studies and stakeholder discussions as presented in the previous chapters, as well as based on desk research on similar research projects (Geissler et al., 2023), the project developed a procedure for advising municipalities on the revision of their municipal development concept against the background of the NECP. The core element is the LINK guideline, which has been translated into a prototype for an online tool. The counselling service can be provided by qualified internal staff or by external consultants.

In summary, the following requirements and guiding principles for developing the LINK guideline and the software prototype were identified:

- The approach should be flexible in order to take into account all existing programmes and approaches (e.g. Covenant of Mayors and their Sustainable Energy and Climate Action Plan – SECAP) and at the same time enable a harmonised approach for all Austrian municipalities.
- Access to the new guideline and tool developed by the project should be low threshold. Nevertheless, minimum criteria are required to ensure a defined quality of the results.
- The data requirements are high. Transparency with regard to data availability and processing is particularly important for the acceptance of the results.
- Energy should be treated as a cross-cutting issue across other spatial planning topics.
- Monitoring of progress and target achievement should be standardised and allow comparability.
- A time comparison or municipal comparison of spatial planning documents can increase the ambitions of the municipalities to better fulfil the requirements at federal level (NECP).
- Stakeholder involvement is essential, for example in the form of workshops: as an introduction, for visioning and scenario building and subsequent discussion of strategies.
- Multipliers can disseminate results beyond the project and ensure the long-term benefits of the project.
- Pilot regions provide valuable insights and take on a pioneering role.

The software prototype was developed based on agile programming, meaning that starting from a specification, tests were carried out in steps producing feedback for further developing the prototype. The first tests were performed by members of the project team, whereby later in the process, real life tests in municipalities based on a semi-standardised process were implemented.

Guideline

There is an occasion for the application of the LINK guideline: either the municipal development concept needs to be revised in accordance with legal requirements because its validity has expired, or there is a municipal project that requires a revision. In both cases, it is an opportunity to harmonise the municipal development concept with the requirements of the NECP. According to the guideline, the revision process involves three steps: (1) gathering basic information and preparing a meeting with those responsible in the municipality, (2) holding the meeting, and (3) following up on the information for further processing by the municipality. The online tool described in the following paragraph provides support and enables efficient use without adding significant burden to the administration.

Online tool

The developed prototyped online tool offers three different access levels depending on the role in the process:

- Role ‘Content provider/ Editor’: municipal council, office management, experts: access with password.
- Role ‘Interested public’: citizens, associations: access without password.
- Role ‘Higher-level administration’, e.g. ‘NECP reporting’: access with password.

The role ‘Content provider/ Editor’ is the most important one as it represents the working level of the tool. The working level consists of two parts, the descriptive part and the drawing and calculation part:

- In the descriptive part, a checklist is available with functions to collect information about activities already implemented and to identify the possible need for action. It is foreseen that documents can be uploaded to each criterion. The file type is a freely editable text document, which includes four qualitative status assessments per topic (included, in progress, planned, not included).
- In the drawing & calculation part (map tool, see Fig. 3), a geographical information system is included with default data for each municipality. A drawing function allows the selection of areas which results in the automatic calculation of the renewable energy potential. This calculation is also based on default data, but those defaults can be overwritten with 'real' energy values, if available.

The checklist contains criteria structured under the headings and subheadings shown in the list below Table 11. The structure itself was derived from existing spatial planning guidelines, in which the reference to renewable energies was specified for each sub-category and formulated as a qualitative criterion. These are brief descriptive text blocks that can be qualitatively assessed and exported for further use. An example is given in Table 11.

Table 11. Exemplary criteria, demonstrating the way of qualitative assessment

Headings of checklist and selected sub-headings	Exemplary criteria	Assessment
The settlement area		
Settlement development	The urban development concept avoids the creation of heat islands.	Yes No In progress Planned Not relevant
	This is achieved through appropriate surface design: heat storage is avoided and areas are provided for heat radiation at night.	
	Settlement development is coordinated with the spatial energy planning.	

Overview of checklist:

1. The settlement area
   - Settlement development
   - Densification
   - Housing
   - Buildings owned by the municipality
   - Townscape and landscape, neighbourhood development
   - Open spaces in the settlement area
   - Settlement boundaries
2. The economic area
   - Industrial and business parks
   - Trade and services
   - Tourism industry
3. The open space
   - Agriculture and forestry
   - Leisure and recreation
   - Raw materials and energy
   - Development of nature and landscape
   - Protection from natural hazards

4. The social space
5. The supply area and the technical infrastructure
6. Transport and mobility
7. Procedural issues
8. General aspects

The drawing and calculation part in the online tool results in the indicators shown in Table 12-14. BEAT (2004) is a topical database run by the Federal Environmental Agency (*Umweltbundesamt*). Statistics Austria is the official Austrian statistics agency. 'Manual input' means that no default data is available and manual input is required.

Table 12. Energy generation

Indicators	Units	Source
Population	Number	Energiemosaik
Area	km²	Statistics Austria
Settlement area	km²	
Population density in relation to the settlement area	Inhabitants/km²	Energiemosaik, Statistics Austria
Urban-rural typology	Qualitativ	Statistics Austria
Electricity generation from hydropower: existing/planning	MWh/y	Estimation with drawing tool and/or manual input
Electricity generation from photovoltaics: existing/planning	MWh/y	
Electricity generation from wind power: existing/planning	MWh/y	
Heat generation from solar thermal energy: existing/planning	MWh/y	
Heat generation from forest woodchips: existing/planning	MWh/y	
Heat generation from maize: existing/planning	MWh/y	
Heat generation from geothermal energy: Existing/planning	MWh/y	

The editor role (login required) includes the function of a time stamp, which means that it is possible to version and display the progress of work, based on a model developed by project partner TU Wien. Information from this working level can be published to be accessible for the role 'higher-level administration', e.g. 'NECP reporting', and to be visible for everyone in the role 'interested public'. The municipality decides which information is accessible for these two roles. The role 'higher-level administration' allows entities such as the relevant departments of the provincial and federal administration to access municipality information directly, without sending documents through email. In addition to the specific information provided by the editor role, the role 'interested public' (no login required) also includes the access to general useful information as displayed in the menu of the landing page.

Table 13. Energy consumption

Indicators	Sectors					Units	Source
	A	I&T	S	H	M		
Total energy demand sector	X	X	X	X	X	MWh/y	Energie-mosaik
of which electricity demand	X	X	X	X		MWh/y	
of which space heating	X	X	X	X		MWh/y	
of which process heat	X	X	X			MWh/y	
of which energy demand for transport (mobility)	X	X	X			MWh/y	
Share of total energy demand	X	X	X	X	X	%	
Share of renewables in energy demand	X	X	X	X	X	%	
Greenhouse gas emissions	X	X	X	X	X	t CO2-eq/y	
Valuable agricultural production areas	X					No of hectares	BEAT
Buildings in the redevelopment target area				X		No of hectares	Manual input
Refurbishment rate				X		%	
Share of residential units with DH connection				X		%	
Energy demand for personal mobility					X	MWh/y	Energie-mosaik
Energy demand for freight mobility					X	MWh/y	
Public charging points for EV					X	No of connections	
Share of electrically powered municipal vehicles					X	%	

Note: A – Agriculture, S – Services, I&T – Industry & Trade, H – Housing, M – Mobility, EV – Electric vehicle, No – Number.

Table 14. Summary indicators and progress in achieving NECP targets

Indicators	Units	Source
Total energy demand	MWh/y	Energiemosaik
Total electricity demand (excl. mobility)	MWh/y	
Total heat demand (excl. mobility)	MWh/y	
Total process heat (excl. mobility)	MWh/y	
Mobility energy demand	MWh/y	
Share of renewables in total energy demand	%	
Greenhouse gas emissions	t CO_2-eq/y	
Progress in realising the NECP targets	%	TU Wien model

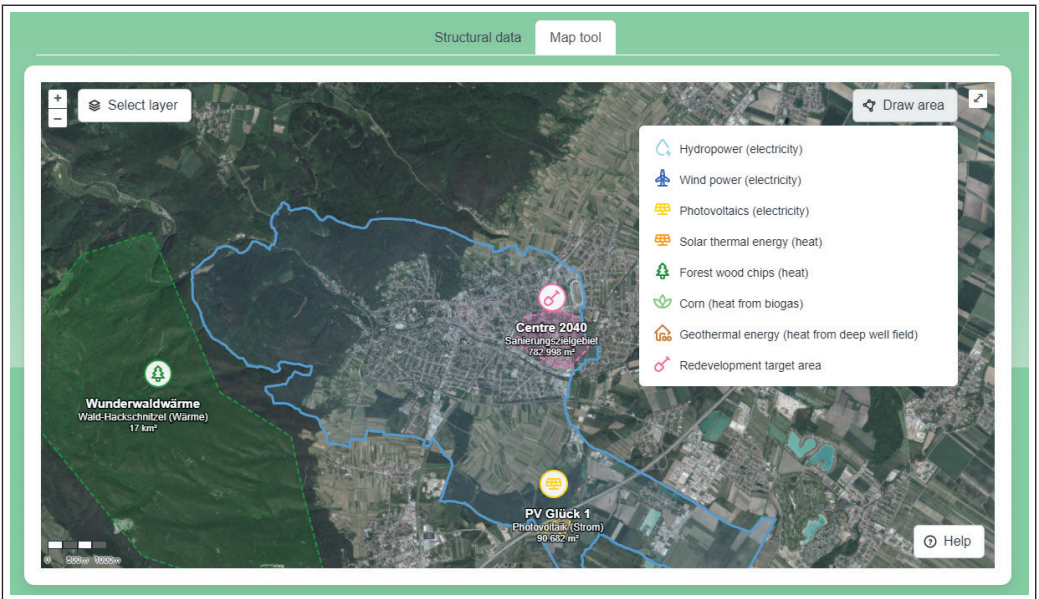
Note: CO_2-eq – CO_2 equivalent, y – year, t – ton.

The system would check if the information provided is compliant with the specified minimum requirements and displays the result. Minimum requirements mainly refer to answering the checklist and publish relevant information.

Test phase

It has been estimated that the advisory process in one municipality is equivalent to five full working days. This has been verified by applying the process in the case study municipalities and in two other pilot municipalities for which the project and the topic are new. Based on the findings from the test phase, which took place between April and July 2024, the process has been revised and recommendations have been made for the further development of the prototyped online tool. Furthermore, a concept will be submitted to the project sponsor, the Austrian Energy and Climate Fund, on how the project results can be integrated into a 'business as usual' process.

The following illustration presents a screenshot from the prototyped web tool described above (Fig. 3).



Content section: Map tool
User role: Editor (Login required)
Data origin and type: Open street map, zonings plans, open governmental data, self-drawn polygons
Input options: Different types of areas for renewable energy generation can be drawn and edited
Environmental indicators: Energy yields per area are auto calculated or self-edited and assigned to consuming sectors

Figure 3. Screenshot of the Map tool
Source: KLEXI (2024).

Conclusions

There were four main topics in our research project: the municipal case studies, the stakeholder surveys, the development of the LINK guideline and the prototyped online tool. In the following we would like to summarise how satisfied we are with the answers to the research questions and the quality of the resulting products so far. 'Very satisfactory' stands for the quality standard of the team's expectations at the beginning of the project, i.e. not measured against a fictitious ultimate maximum.

The work on municipal case studies has shown that neither the progress of the energy transition nor the level of commitment correlates simply with the size of the municipality, but that there are many gradations in these typologies. However, the need for urgent support to achieve the NECP targets was confirmed in all case studies. This shows a very satisfactory answer to the research question 'What types of municipalities exist in Austria regarding the energy transition?'.

The stakeholder surveys focused more on vertical cooperation between different administrative and political levels. It was clearly confirmed that the very complex governance of the NECP still has

a lot of potential for improvement between the federal government, the provincial governments, the regions, and the municipalities. This finding is a very satisfactory answer to the research question 'What is the current state of knowledge, experience and future perspectives on NECP issues?'.

With regard to the LINK guideline, the research question was 'What are the generic steps for implementing the NECP objectives at the local level?'. The first usability tests confirmed the quantity and quality of the checklist items in a satisfactory, but not very satisfactory way. The complex stakeholder landscape of NECP governance identified in the stakeholder surveys calls for further simplifications without compromising accuracy and coverage.

Finally, a web-based NECP supporting tool was programmed, tested and improved, which can significantly facilitate the easy handling and evaluation of the complex NECP issues. The thorough and numerous positive feedback from the test runs provide a very satisfactory answer to the research question 'What features does a web-based NECP supporting tool have that is easy to use and sufficiently accurate?'.

The research team perceives a considerably lesser necessity for further research regarding municipal case studies and stakeholder surveys than in the practical further development of the LINK guideline and the prototyped online tool. Although the preliminary trials of the tool and guideline at the municipal level have yielded favourable outcomes, the relatively modest sample size of respondents would need to be significantly expanded in the event of further development to provide a more robust validation or enhancement of the existing quality.

Another crucial stage in the tool's expansion would be the 'handling' of regions, whereby the entries of multiple municipalities could be displayed collectively. This is particularly pertinent in the context of renewable energies, as a significant number of municipalities are unable to achieve renewable self-sufficiency solely through their land potential. Instead, they must rely on inter-municipal or even cross-state solidarity. However, in order to demonstrate this, the tool must also possess the capacity to do so.

The expansion of the tool for national reporting would entail an expansion of the direction of information, with the input from the municipalities aggregated to facilitate the monitoring of NECP targets in real time throughout Austria in live operation. Furthermore, the construction of a fair allocation key for the ambitious NECP energy targets could be improved through spatial and numerical understanding. This task is becoming increasingly urgent, not only nationally but also throughout Europe, for example with regard to the Renewable Energy Directive (EC, 2023; EU, 2024).

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