Pilot Case Factsheet — Embedding Energy Efficiency First in National Energy Planning — Croatia

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Background and objectives

The second Croatian pilot case builds directly on the findings of the first ENEFIRST Plus' Croatian pilot case on transmission grid planning and investment appraisal. That pilot showed that, although the Energy Efficiency First (EE1st) principle can improve project-level decision-making, the scope for considering fundamentally different alternatives becomes increasingly limited once infrastructure needs and investment pathways have been established. For transmission investments in particular, many of the factors determining future grid needs – including energy demand, electrification, renewable energy deployment and flexibility – originate in upstream energy planning. The pilot therefore concluded that **the greatest leverage for EE1st lies at the planning and scenario-development stage** rather than in the cost-benefit analysis of individual projects.

Building on this finding, the second pilot moves upstream to the **National Energy and Climate Plan (NECP) and its interaction with more detailed sectoral planning processes**. The NECP provides the overarching national framework for the development of the energy system, setting energy and climate objectives and trajectories and providing key assumptions that are subsequently used in sectoral planning. At the same time, important planning and investment choices are further developed through instruments such as the National Building Renovation Plan (NBRP), the Comprehensive Heating and Cooling (H&C) Assessment and transmission and distribution network development plans. The pilot therefore examines EE1st not within a single investment decision, but across this **interconnected planning architecture**.

The starting point for the analysis is that EE1st is already explicitly present in Croatian NECP, which applies the principle when modelling energy needs in individual consumption sectors. Using **bottom-up end-use modelling**, energy efficiency measures are reflected in the determination of future demand. In buildings, for example, efficiency improvements are considered before changes in heating and cooling technologies and fuel substitution. EE1st is therefore not absent from the NECP process. The relevant question for the pilot is rather **how comprehensively the principle is applied across the entire planning chain**.

This question becomes particularly relevant because the different planning processes address different parts of the energy-system optimisation problem. Once energy demand has been determined, networked energy systems in the NECP are optimised according to minimum system cost. **More detailed sectoral planning** can subsequently introduce additional layers of analysis: the Comprehensive H&C Assessment evaluates technical potentials and alternative solutions using financial and economic cost-benefit analysis, while the NBRP develops renovation pathways taking into account investment costs and reductions in primary energy.

The pilot therefore investigates not only whether the individual planning processes incorporate EE1st considerations, but also **how they are connected**. It examines whether alignment operates mainly downwards – with sectoral plans inheriting national assumptions and trajectories – or whether the results of more detailed sectoral assessments can also feed back into national scenario development. Such

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feedback may be important because building renovation and heating technology choices affect electricity and heat demand, while network planning can reveal system costs and constraints that may influence the optimal balance between demand-side and supply-side resources. This leads to the central question of the pilot:

Can stronger feedback and iteration between national and sectoral planning improve the implementation of EE1st at system level?

Against this background, the pilot case aims to:

- assess **how EE1st is embedded** in NECP scenario development and modelling;
- examine **how key NECP assumptions are reflected** in the NBRP, Comprehensive H&C Assessment and network development planning;
- assess whether and how results from these more detailed sectoral planning processes **feed back into national energy planning**; and
- identify **practical opportunities** to strengthen alignment, feedback and iteration across planning processes, without necessarily requiring a single integrated modelling framework.

Methodology

The pilot applies a **qualitative and analytical approach** combining:

- review of planning documents and modelling frameworks,
- mapping of assumptions and data flows, and
- structured interdisciplinary exchanges between experts involved in the preparation of the relevant national and sectoral plans.

Rather than developing a new integrated energy-system model, the analysis focuses on **understanding how existing modelling and planning processes interact** and where EE1st considerations enter the decision-making chain.

The first step consists of a **review of the Croatian NECP and its underlying modelling approach**, focusing particularly on the way future energy demand is constructed and subsequently used in energy-system optimisation. The analysis examines how energy efficiency is represented in bottom-up demand modelling, how WEM (With Existing Measures) and WAM (With Additional Measures) trajectories are developed, and how these demand trajectories are transferred to subsequent supply-side optimisation. Particular attention is given to whether demand-side resources and supply-side resources are assessed within an integrated optimisation process or in successive modelling steps.

The second step extends the **analysis to planning processes that operate downstream of, or in interaction with, the NECP**. The NBRP, Comprehensive H&C Assessment and network development planning are reviewed to identify which NECP assumptions and projections they use, what additional analyses and optimisation they perform, and what new information they generate. The analysis considers, for example, demand and electrification trajectories, renovation pathways, heating and cooling technology choices, primary-energy implications, flexibility, and network requirements. This makes it possible to identify where different components of the broader EE1st optimisation problem are addressed across the planning architecture.

A third step focuses on the **links between these planning processes**. The pilot maps the direction of information flows and examines whether interaction is predominantly top-down - from NECP

assumptions to sectoral plans – or whether mechanisms exist for feeding sectoral results back into national scenario development. Particular attention is paid to the timing of planning cycles, consistency of key assumptions and opportunities for iteration when sectoral analysis produces results that could materially affect national demand or supply trajectories. This reflects the original pilot scope, which specifically identified alignment of demand projections, electrification pathways, flexibility, temporal and spatial demand characteristics, and timing and iteration of planning cycles as areas for investigation.

The document and modelling analysis is complemented by **structured exchanges between EIHP experts** working on national energy planning, energy efficiency, building renovation, heating and cooling, and electricity network development. These exchanges are used particularly to understand practical coordination between planning processes, including the timing of their preparation, exchange of assumptions and opportunities for iteration that are not always visible from the planning documents themselves. Where needed, targeted exchanges with the competent public authorities and other relevant stakeholders complement the internal analysis, particularly to clarify institutional responsibilities and formal coordination mechanisms.

The final step **synthesises the findings** into a practical framework for stronger EE1st integration in national planning, identifying where improved alignment, information exchange and iteration could strengthen the comparison of demand-side and supply-side resources without requiring all planning processes to be merged into a single model.

Main results

The main results are summarised in the table below, demonstrating planning processes analysed, main findings and implications for EE1st integration.

Analytical step / planning process	What the analysis found	Implication for EE1st
NECP (National Energy and Climate Plan) – demand modelling and scenario construction	Final energy demand is modelled bottom-up in LEAP. Useful-energy needs are determined by sector, subsector and end use, and translated into final energy demand using technology efficiencies and fuel/technology shares. The NECP explicitly applies EE1st when modelling energy needs in each consumption sector. For example, in buildings, efficiency measures are considered before heating/cooling technology changes and fuel substitution. LEAP also allows individual measures, their interactions and alternative integrated scenarios to be represented. WEM and WAM embody different policy and demand pathways.	**EE1st is explicitly and structurally embedded in demand-side scenario construction.** The modelling framework captures interactions between efficiency, useful-energy needs, technologies and fuel switching. The issue is therefore not the absence of EE1st from NECP demand modelling, nor a lack of demand-side modelling capability.

NECP – interface between demand and system optimisation	Demand trajectories produced through scenario development are subsequently used as inputs to system optimisation. Separate WEM/WAM electricity, heat and hydrogen demand trajectories are used in PLEXOS, which optimises generation, capacity, storage, imports/exports and other system variables. The NECP describes this as least-system-cost optimisation of networked energy systems, including long-term capacity expansion. However, no systematic feedback mechanism was identified whereby system costs or constraints emerging from this optimisation trigger reassessment of efficiency or other demand-side resources in the demand model.	The architecture is **integrated in terms of information transfer, but largely sequential in terms of optimisation: demand pathway → supply/system optimisation**. WEM/WAM comparison demonstrates the system consequences of different policy pathways, but does not demonstrate endogenous competition between additional demand-side resources and generation, storage or network resources. Full EE1st-type demand–supply optimisation is therefore not demonstrated.
Comprehensive Heating&Cooling Assessment	The H&C Assessment uses NECP/LEAP projections as its future demand baseline, providing a clear downward link from national to sectoral planning. It then adds detailed spatial, technical and economic analysis of heating and cooling options, including useful and delivered energy, infrastructure and resource potentials, technology alternatives, and measure-specific financial and economic CBA with sensitivity analysis. The CBA distinguishes investor profitability (FNPV) from societal value (ENPV). It compares individual alternatives against reference cases rather than optimising all H&C resources simultaneously within one integrated model.	The H&C Assessment provides a **more explicit EE1st-type societal comparison of alternatives** while remaining anchored in the demand pathway inherited from the NECP. It also generates information that could potentially refine that pathway: preferred heating technologies affect electricity and heat demand, while their economic performance depends on the future electricity and heat supply mix. This creates a potential **two-way relationship between national and sectoral planning**.
NBRP (National Building Renovation Plan)	The NBRP is explicitly anchored in the NECP and uses NECP projections of final energy consumption and energy-carrier trajectories as its overarching energy pathway. It then adds detailed building-stock analysis. For residential buildings, an optimal mixed renovation scenario uses five renovation levels and a Monte Carlo approach to favour combinations with a favourable relationship between investment cost and primary-energy reduction while meeting EPBD constraints for the worst-performing stock. For non-residential buildings, the stock is ranked by Eprim and progressively tighter MEPS thresholds determine the buildings and floor area requiring renovation in successive periods.	The NBRP performs **more detailed optimisation and prioritisation of demand-side investment** than the overarching NECP, translating national trajectories into renovation depth, timing and stock segments. At the same time, renovation depth and heating-system choices affect future electricity and heat demand and consequently generation, network and flexibility needs. Its results therefore represent another potential **feedback channel to national scenario development**.

	The Plan also draws on the H&C Assessment and incorporates assumptions on electrification, heat pumps, district heating and renewable energy.	
Transmission network development planning	The 2026–2035 transmission plan is aligned with the revised NECP and other national and European planning frameworks and applies multi-scenario network analysis. Demand, generation, RES integration, storage and flexibility are increasingly reflected in the scenario framework, but national demand and generation trajectories largely enter as boundary conditions from which infrastructure requirements are derived. Flexibility and non-wire alternatives are recognised, although systematic comparison with reinforcement is less developed at transmission-network level.	Transmission planning reveals **spatial, technical and investment consequences of national scenarios** that are not visible at NECP level. These results could provide an upstream signal where a particular demand/RES pathway creates significant reinforcement, congestion or system-cost implications. The first pilot case (on transmission grid planning) showed that such feedback is most valuable before individual infrastructure projects are locked in.
Distribution network development planning	The DSO (Distribution System Operator) plan combines NECP assumptions with substantially more detailed spatial and temporal analysis of demand, distributed generation and electrification. It develops additional scenarios for distributed PV, translates EV (Electric Vehicles) and heat-pump uptake into local load and investment impacts, and explicitly recognises the dependence of heat-pump load on building renovation. Distribution planning is also moving towards systematic comparison of network reinforcement with flexibility, demand management, storage and energy-efficiency alternatives. The implementation roadmap envisages CBA-based comparison of conventional and non-wire solutions and formal inclusion of flexibility in future development plans.	The DSO process represents a **more explicit operationalisation of EE1st within network planning**, with demand-side and flexibility resources increasingly treated as potential alternatives to capital-intensive reinforcement. It also generates information that could matter upstream – actual PV deployment, spatial peak-load effects of electrification, local constraints and the value of flexibility – creating a potentially **important feedback channel** to national demand, electrification and RES assumptions.
FNA (Flexibility Needs Assessment)	The 2026 FNA combines NECP, adequacy and network-planning assumptions and assesses RES integration, ramping, short-term and DSO network flexibility needs for 2030 and 2035. It considers DSR, storage, hydropower and interconnections, and shows that operational consequences can differ substantially depending on demand, RES penetration and hourly profiles. TSO (Transmission System Operator) network flexibility needs were not quantified in this first cycle. The FNA explicitly recommends that its results feed into future TSO/DSO development plans and calls for	The FNA provides a **system-level temporal and operational stress test** of trajectories defined elsewhere. It can reveal curtailment, ramping, short-term and local network needs that are not visible from annual energy balances alone. Its findings therefore have potential not only to refine network planning, but also to inform subsequent NECP assumptions on demand, RES, storage and flexibility.

	stronger consistency among NECP, TYNDP (Ten-Year Network Development Plan), DNDP (Distribution Network Development Plan) and adequacy datasets.	

Taken together, the analysis shows that Croatia already has substantial analytical capacity for implementing EE1st across its energy-planning architecture. The NECP embeds **EE1st in demand modelling** and subsequently optimises the supply system. Sectoral planning adds more detailed assessment and optimisation of heating and cooling and building renovation; while network planning and flexibility assessment add spatial, infrastructure, temporal and operational perspectives. The **individual processes** therefore address **complementary elements of the broader EE1st optimisation** problem.

The main opportunity identified by the pilot lies in **how these analytical processes interact**. Information flows clearly downstream from the NECP into sectoral and infrastructure planning, while these processes generate new information that may be relevant for national trajectories. Such findings do not appear to be systematically fed back into national scenario development. This points to **feedback and iteration between existing analytical processes** as a key area for strengthening EE1st implementation.

Where/how implementing EE1st makes a difference

The pilot shows that implementing EE1st in national energy planning is not primarily a question of introducing additional analytical tools. In Croatia, substantial analysis and optimisation already take place across the NECP and related sectoral and infrastructure planning processes. A key lesson is therefore that **alignment is necessary, but not sufficient**. Sectoral plans being consistent with the NECP ensures a common direction but does not test whether the national pathway remains optimal once more detailed analysis becomes available. Heating and cooling assessment, building renovation planning, network development and flexibility assessment all generate information that could materially affect assumptions made at national overall level.

This suggests that a practical application of EE1st at national-planning level can be understood as **optimisation through iteration**. Rather than requiring a single integrated “super-model”, existing specialised analyses can be linked through structured feedback loops, with the NECP serving as the central integration point. Such **iteration should be targeted rather than exhaustive**: feedback is particularly relevant where sectoral or system analysis identifies consequences capable of changing the preferred national pathway, such as significant changes in electricity or heat demand, network reinforcement requirements, flexibility needs or the societal value of alternative technologies.

The pilot also shows, however, that effective iteration depends on more than analytical compatibility. **Timing and governance matter.** The NECP, NBRP, H&C Assessment and network plans follow different regulatory and preparation cycles and may be commissioned separately, sometimes by different authorities or operators. A sectoral assessment may therefore be completed using one set of national assumptions while the NECP is subsequently revised, without the mandate, time or resources to repeat the analysis. Conversely, sectoral results becoming available after adoption of the NECP may have no formal route back into national modelling until the next planning cycle.

In practice, interdisciplinary expert cooperation can partly bridge these gaps through exchange of assumptions and identification of inconsistencies across planning exercises. However, informal coordination cannot substitute for an organised and continuous planning process. **Making EE1st operational therefore requires aligning planning calendars where possible and, more**

importantly, defining specific feedback points at which assumptions and material results are exchanged between planning processes. This would allow targeted iteration where new evidence could materially affect national trajectories, without unnecessarily increasing modelling complexity.

More fundamentally, these findings point to the need to make the **energy policy cycle itself genuinely continuous and operational**. Rather than treating planning documents as exercises prepared at fixed points in time, implementation and monitoring should continuously inform assessment, feedback and, where material deviations or new evidence emerge, corrective action and refinement of the national pathway.

About Enefirst Plus

Enefirst Plus is a 3-year project (November 2023 – October 2026) co-funded by the EU LIFE programme. Building on the previous Horizon 2020 Enefirst project, the aim of Enefirst Plus is to provide key stakeholders in all Member States with the technical support needed to effectively implement Energy Efficiency First across various sectors, particularly focusing on key decision-making processes.

Energy Efficiency First (EE1st) is an overarching principle for planning, policies and major investments having an impact on energy consumption. EE1st is about considering **energy efficiency and demand-response as energy resources** in the energy system, just as supply-side resources (e.g. generation capacities, network infrastructures). Implementing EE1st means that in planning exercises, policy design or decision-making about investments, the options considered include energy efficiency and demand-response, and that these options are compared with supply-side options on a **fair basis**, considering **multiple impacts and a long-term perspective**.

Implementing EE1st is easier said than done. Therefore, the general approach of Enefirst Plus is to complement existing resources to **plug EE1st in the decision making** for investments in energy infrastructure, energy planning, and designing incentives and policies.

Enefirst Plus is testing this approach in four countries (Croatia, Italy, Greece and Poland) and scrutinise the implementation of EE1st with **pilot cases** in each country. Two cycles, with four pilot cases each, will provide a diversity of **real-life examples** addressing typical situations where EE1st should be implemented. The new resources and pilot cases produced by the project, as well as experiences from other countries, serve as foundational elements for capacity building and experience sharing activities, and for the development of a community of practice.

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