Croatian pilot case: applying EE1st to a CBA for the electricity transmission grid

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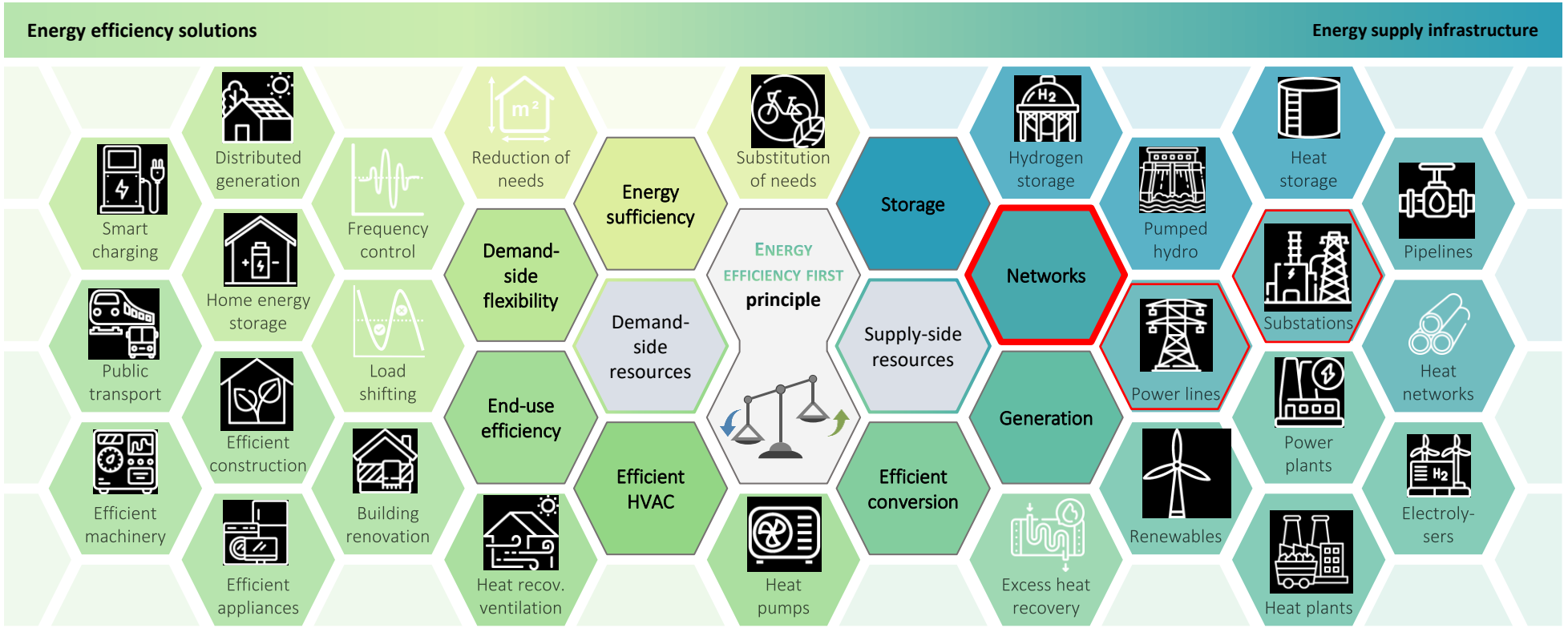
Recap: What is the Energy Efficiency First (EE1st) principle?

Definition

'energy efficiency first' is a guiding principle for energy-related planning and policymaking that prioritises **energy efficiency solutions**—including not only end-use energy efficiency but also, notably, demand-side flexibility—over the expansion and operation of **energy supply infrastructure**, provided these solutions result in greater net-benefits to society.

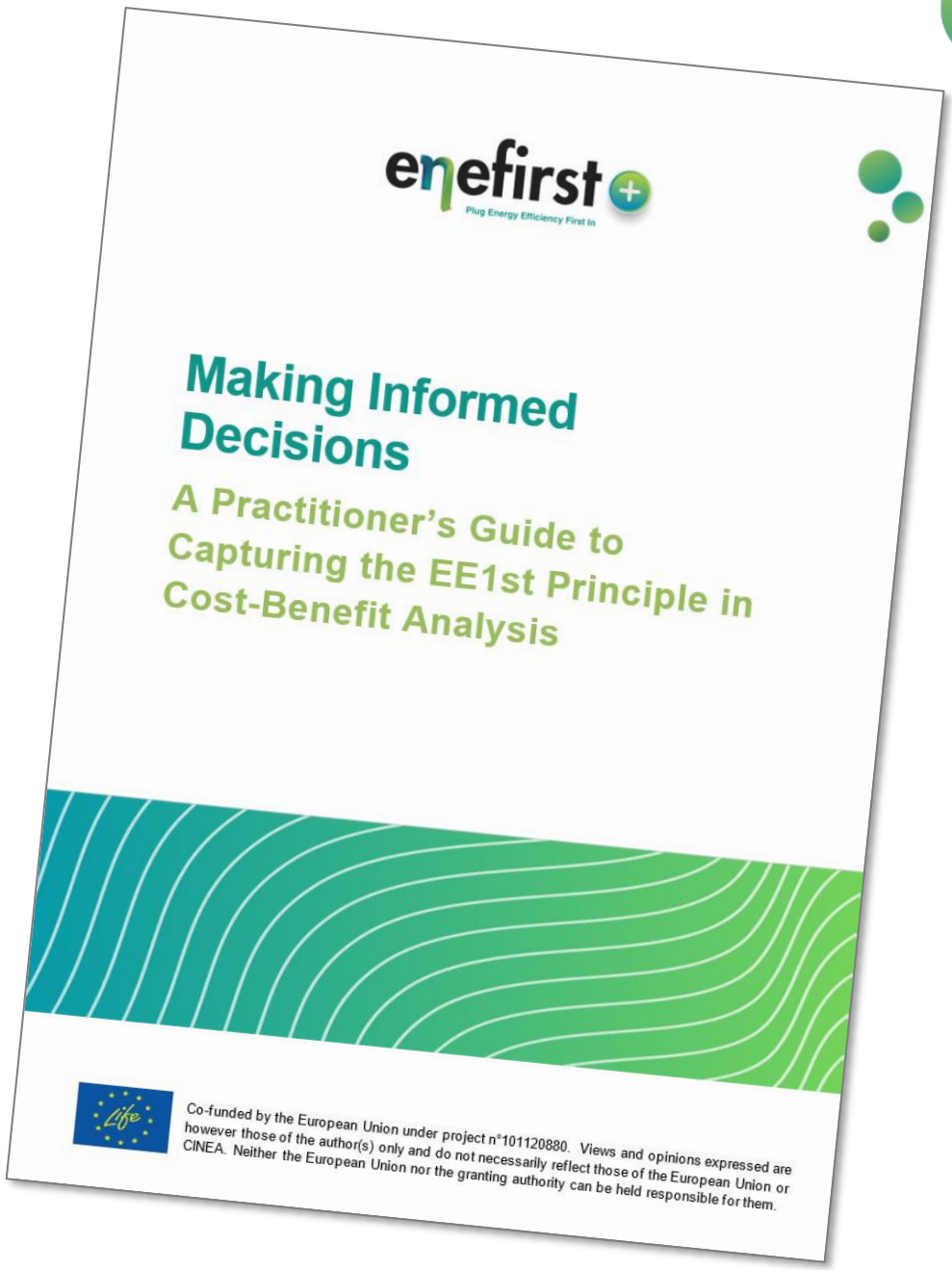


Source: Mandel, Tim; Pató, Zsuzsanna (2024): Towards effective implementation of the energy efficiency first principle: a theory-based classification and analysis of policy instruments. In Energy Research & Social Science 115, p. 103613. DOI: 10.1016/j.erss.2024.103613.

Overview of the CBA Guidance

CBA Guidance

- Purpose: Provide practical, EE1st-focused CBA rules regardless of the planning context
- Target audience: Authorities, planners, utilities
- How to use: Apply the “9 Issues to keep in mind” as a checklist in every appraisal.



The guidance addresses 9 issues

1 Consider the full range of energy efficiency solutions

Identify and evaluate all potential efficiency measures across supply, distribution, and end-use, including demand-side flexibility, to fully leverage the EE1st principle.

2 Take into account all relevant costs and benefits

Include all direct, indirect, and external costs and benefits – environmental, social, and economic – to accurately capture the full societal value of efficiency measures.

3 Be clear what you are comparing and use consistent performance metrics

Apply transparent solution sets, such as EE1st options vs. NoEff options, and use consistent performance metrics and scenarios to systematically highlight the added value of efficiency solutions.

4 Apply appropriate discount rates

Select discount rates reflecting long-term societal interests, preventing undervaluation of future energy savings and benefits in comprehensive cost-benefit analyses.

5 Correct for transfer payments

From a societal perspective, ensure that transfer payments are systematically excluded, i.e. monetary flows that shift money between parties (e.g. taxes), as these do not affect overall societal cost.

6 Measure effects on the entire energy system

Consider how efficiency measures influence the broader energy system, reducing peak demand, enhancing grid stability, and deferring costly network upgrades.

7 Assess distributional impacts

Examine how costs and benefits are distributed among different groups, ensuring fairness, mitigating inequalities, and supporting just and inclusive energy transitions.

8 Incorporate risk and uncertainty analysis

Address uncertainties in future conditions, technology performance, and price trends through sensitivity analyses and scenarios, ensuring robust, reliable results under changing circumstances.

9 Understand the limits of CBA and complement with other approaches

View CBA as a decision-support tool, not the sole determinant; integrate multi-criteria analysis and public deliberation to address qualitative and intangible factors.

What's the legal basis for the EE1st principle in transmission system?

Energy Efficiency Directive (EU) 2023/1791

"**Article 27(2)** Member States shall ensure that gas and electricity transmission and distribution system operators apply the energy efficiency first principle [...] in their network planning, network development and investment decisions."

Act on Energy Efficiency (adopted by the Parliament on 15th Dec 2025)

"**Article 51(1)** The transmission system operator, the transport system operator and the distribution system operators for electricity and gas shall apply the "energy efficiency first" principle referred to in Article 7 of this Act in **network planning, network development and investments**.

Article 51(2) The Agency shall control compliance… within the framework of approving and monitoring their projects and network development plans **based on the laws regulating the electricity market and the gas market**.

Article 51(3) The Agency shall verify whether the **cost-benefit analyses** used by the transmission system operator, the transport system operator and the distribution system operators for electricity and gas take into account **alternatives** that include energy efficiency solutions, demand-side flexibility and investments in assets that contribute to climate change mitigation and the **wider benefits of those alternatives** in accordance with the provisions of this Article and the **Ordinance on the application of the "energy efficiency first"** principle referred to in Article 7, paragraph 4 of this Act."

TSO’s obligations related to planning and CBA in Croatia

Electricity Market Act (OJ 111/21, 83/23, 17/25)

TYNDP - submission

- By 30/9 submitted to the Agency
- Prior to submission to the agency, consent of the ministry
- Approval of the Agency by 31/12

TYNDP - compliance

- Energy Strategy
- Spatial Planning Strategy and individual spatial plans
- **NECP**
- DSO’s TYNDP
- Transmission network connection requirements
- Neighboring countries
- Requirements of Regulation 2019/943

TYNDP - content

- Transmission infrastructure needed to be built or revitalized in next 10 years
- All investments for which decision are made
- Planned investments necessary for next 3 years (with location permit for new; with confirmed main design for existing)

TYNDP – compliance check (Agency)

- With EU TYNDP
- With **NECP**
- With DSO’s TYNDP
- With network users (public consultation)

Importance of planning – alignment with NECP!

Inputs (to be aligned with NECP):

- electricity production
- electricity consumption
- electricity exchange with other countries

To take into account:

- demand side management
- energy efficiency measures
- use of energy storage facilities
- use of flexibility
- congestion management

NECP

- Demand forecasting (LEAP)
  - includes EE measures
  - reduced consumption
  - reduced peak loads
  - no time dimension (load shifting)
  - no geographical dimension
- Supply forecasting (PLEXOS)
  - generation capacities
  - storage capacities

TYNDP

- Forecasts in line with NECP (EE measures taken into account)
- EE in transmission grid (reduction of losses)
- Takes into account topological requirements
  - not operational ones, such as flexibility
- Must guarantee reliability of system operation and security of supply

Implications on CBA practice for transmission system projects

1 Consider the full range of energy efficiency solutions

Identify and evaluate all potential efficiency measures across supply, distribution, and end-use, including demand-side flexibility, to fully leverage the EE1st principle.

Type of energy efficiency	Transmission and distribution energy efficiency
 **Electricity**	• Upgrading transmission lines to high-voltage DC (**HVDC**) to reduce losses • Implementing **advanced transformers** with lower core losses • **Digital grid technologies** for real-time monitoring (reducing losses and outages)

Case: existing 220 kV line

- 70 years old
- Rapidly increasing RES production

Energy efficiency solutions (EE1ST)

= Demand-side options

Replacement of existing overhead lines with new ones:

- Single line
- HTLS

vs.

No-efficiency solutions (NOEFF)

= "Business-as-usual" choices

Is there an alternative (only topology measures considered)?

- Double, without new 400 kV
- Double, with new 400 kV

Implications on CBA practice for transmission system projects

2 Take into account all relevant costs and benefits

Include all direct, indirect, and external costs and benefits – environmental, social, and economic – to accurately capture the full societal value of efficiency measures.

Perspective	Core question it answers	Typical situations where applied
Societal *(economic analysis)*	*Is the community, region, or nation better off as a whole – does the project deliver net societal benefits?*	• Mandatory test for major public-sector energy projects under Art. 3 EED and many EU funding programmes. • Strategic energy-system planning (e.g., long-term network or generation scenarios). • Policy impact assessments that justify targets, regulations, or incentive schemes. *Under EE1st, decisions should first pass this test – does it create the greatest net benefit for society as a whole?*

- Energy savings
- Affordability
- Competitiveness
- Grid investments

- Energy security
- Emission reductions

security of supply, consumer prices, emissions, loss reduction - > **energy-related welfare**

- Health improvements
- Asset-value uplift
- Jobs
- Macro-economic growth (GDP)

Implications on CBA practice for transmission system projects

Costs	Benefits
Investment costs (CAPEX) permits, studies, land acquisition, equipment, materials, construction, decommissioning, etc.	Network loss reduction
	Values of lost load reduction
	Re-dispatching costs reduction
Operation and maintenance costs (OPEX)	**Other socio-economic benefits**
	CO_2 emission reduction
Other costs temporary solutions during construction, replacements, etc.	Enabled new RES connections
	Avoided RES electricity production restrictions
	Increase of transmission capacity

- CBA
  - methodology used is based on **ACER** recommendations and **ENTSO-E's CBA** methodology for Projects of Common Interest
  - **CO_2 emission** the only societal benefit evaluated (in line with ENTSO-E TYNDP)
  - other **socio-environmental externalities** (health impacts, biodiversity loss, air pollution, or land-use effects) are not included in the monetary analysis
  - strong emphasis on **energy security and system-level multiple benefits** (RES integration, market efficiency, loss reduction)

Implications on CBA practice for transmission system projects

- CBA results:
  - HTLS revitalisation delivers a marginally positive result, with an NPV of +0.24 million EUR and an IRR of 4.85 %, but only after more than 20 years of operation
  - Both double-circuit alternatives produce negative NPVs (- 6.36 million EUR and - 0.59 million EUR, respectively) and IRRs below the 4 % discount rate, making them economically unjustified

The only “efficiency-type” element considered was the reduction of transmission losses **achieved by using HTLS conductors.** Grid reinforcement is not compared to **demand flexibility -** from a system security perspective, revitalization is **unavoidable**. Non-wire solutions (e.g. DLR) play a role in determining the appropriate scale of reinforcement.

Identified issues & possible way forward

- Issues
  - Data gaps on demand-side alternatives
    - TSOs typically lack reliable, granular data on demand-side flexibility, distributed storage, and efficiency measures - **unless they are already incorporated in energy demand forecasts done elsewhere (NECP)**
  - Current CBA methods focus on “wire” options
    - **Standard CBA tools** (e.g. ENTSO-E methodology) are tuned to evaluate CAPEX, O&M, losses, redispatch, ENS, and CO_2
  - Regulatory misalignment
    - TSOs are **mandated to ensure security of supply, not to deliver efficiency measures** — making them reluctant to model non-wire options that are outside their operational remit

- To-do
  - Standardised treatment of demand-side / non-wire alternatives -> scenario integration
    - Provide standardised input data (e.g. scenarios for flexibility potential)
    - Require that national NECP demand reduction and efficiency targets are explicitly embedded in base demand forecasts, not treated as external assumptions
    - Scenario analysis should explicitly compare “reinforcement only” vs. “reinforcement + efficiency/flexibility” pathways
  - Expanded benefit categories (reasonable)
    - Extend CBA to value multiple societal benefits: avoided infrastructure, improved consumer welfare, health and air quality impacts, comfort, and resilience - include methodologies for monetising non-energy benefits
  - Clear guidelines to support legal obligations
    - Planning and CBA guidelines

What is next? High(est) level planning

NECP – scenario development enhancement

- Comprehensive assessment of H&C
- National Building Renovation Plan (LTRS)
- TYNDPs (DSO, TSO)
- Local energy plans (EE, H&C, SECAPS)

What is next? Secondary legislation (supporting implementation of legal obligations)

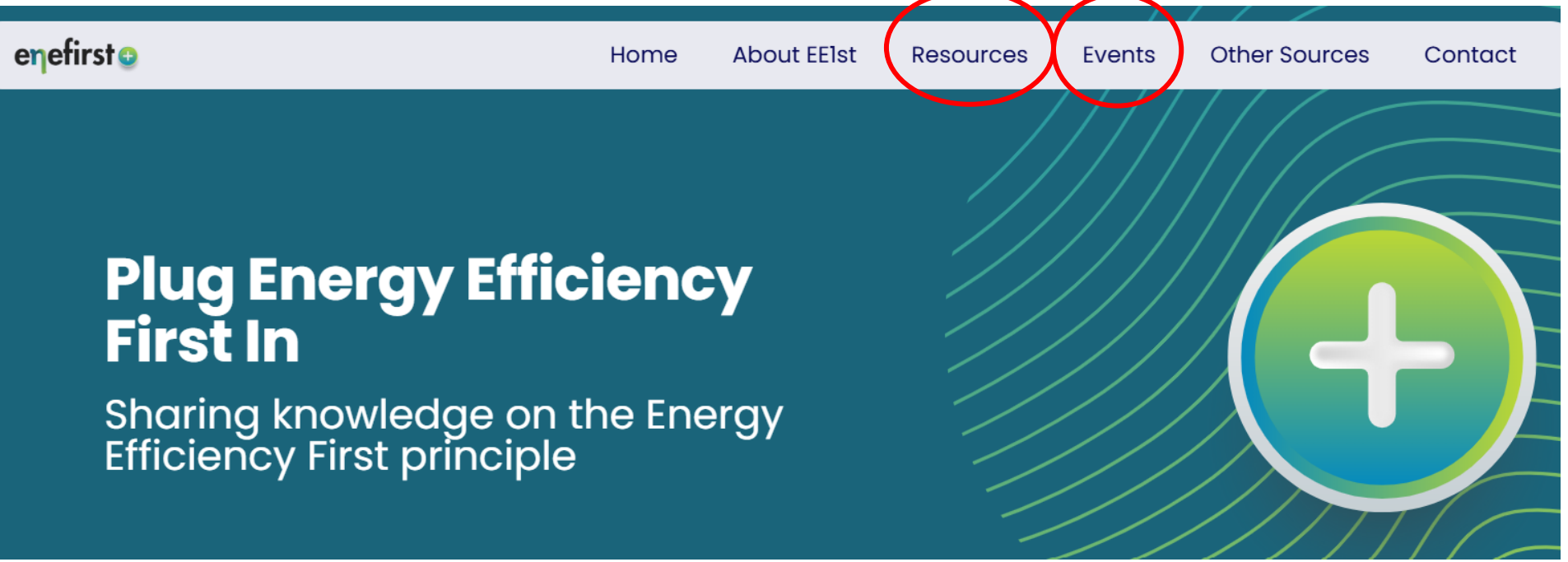
Act on Energy Efficiency (adopted by the Parliament on 15th Dec 2025)

> **Article 7(4)** The Minister shall, by means of an **Ordinance on the application of the "energy efficiency first" principle**, prescribe the methodology for the application of the "energy efficiency first" principle in the development of plans in the energy and non-energy sectors that affect energy consumption at the national, regional and local levels, the design of policy measures to promote energy efficiency and in making decisions on investments in large investment projects referred to in Article 8, paragraph 1 of this Act and strategic investment projects referred to in Article 8, paragraph 2 of this Act, as well as the method of monitoring the application of the "energy efficiency first" principle, including the **methodology for the cost-benefit analysis** of these projects, which includes an assessment of the wider environmental, economic and social benefits of energy efficiency.

Resources

Thu. 29 Jan.

Webinar - Cost-Benefit Analysis in practice: experts' views on key issues and integrating Energy Efficiency First



Visit the platform: https://ee1st.eu/

All proceedings available in [Resources]

In your experience, what is the main barrier to including demand-side options in transmission planning?

Where is, in your opinion, the most effective entry point for implementing EE1st in grid investments?

Thank you for your attention!

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