Making Energy Efficiency First principle operational

Quantifying Energy Efficiency First in EU scenarios: Implications for buildings and their energy supply

Stakeholders' Online Workshop | **Wednesday 23 February 2022**, 2 to 4 pm CET

BACKGROUND DOCUMENT

ENEFIRST aims at making the Energy Efficiency First (EE1st) principle more concrete and operational, promoting integrated approaches

ENEFIRST is a research project funded by EU's Horizon 2020 programme. Our research examines the relevance of EE1st, its impacts and how it can be implemented, **focusing on the building sector and related energy supply** in EU Member States.

The project complemented the definition of EE1st set in the Governance Regulation (EU, 2018/1999, Article 2[18]), to make more explicit the aspects of prioritization and comparison considering a societal perspective:

> ***EE1st gives priority to demand-side resources whenever they are more cost-effective from a societal perspective than investments in energy infrastructure in meeting policy objectives. It is a decision principle that is applied systematically at any level to energy-related investment planning and enabled by an "equal opportunity" policy design***.

Implementing EE1st means breaking the silos to adopt integrated approaches dealing jointly with the supply side and demand side of energy. This represents a **paradigm shift**, for policy making and decision processes, as well as for assessment and modelling practices. ENEFIRST combines policy analysis and quantitative assessments[1] to develop this still new research topic and set the ground for policy proposals and discussions. This workshop is focused on the research about quantitative assessments.

Energy systems modelling can help quantify the trade-off between demand- and supply-side resources for long-term transition processes

By determining cost-optimal transitions and exploring alternative scenarios, energy system modelling can assist decision-makers in **making informed decisions** on future technology investment, system operation and policy design: modelling plays an indispensable role in making complexities and uncertainties tangible.

Various model-based assessments have investigated the possible contribution of demand- and supply-side resources towards climate-neutrality by 2050. They generally suggest that an optimal balance of technology options for building sector decarbonisation involves both demand- and supply-side resources. However, only few studies make explicit the **societal trade-off between saving and supplying energy** in the building sector according to the notion of the EE1st principle.

In previous research[2], we highlighted four implications of EE1st for quantitative energy systems modelling:

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[1] See all the reports published by ENEFIRST here: https://enefirst.eu/reports-findings/

[2] ENEFIRST (2020). Review and guidance for quantitative assessments of demand and supply side resources in the context of the Efficiency First principle. Deliverable D3.1 of the ENEFIRST project.

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(i) Quantitative assessments of EE1st require an **integrated appraisal** of demand- and supply-side resources in order to determine cost-optimal resource portfolios.
(ii) To systematically compare demand and supply options, a common functional unit is needed in terms of **planning and policy objectives**, e.g., a common greenhouse gas (GHG) reduction target.
(iii) **Cost-benefit analysis (CBA)** provides a fundamental methodological framework for quantitative assessments of EE1st, weighting various costs against benefits under consideration of discounting.
(iv) EE1st prescribes a **societal perspective** in evaluating costs and benefits, implying a detailed account of monetary and non-monetary impacts under consideration of society's time and risk preferences.

Some **limitations** might indeed reduce the value of the existing studies for system planning, technology investment and policy formulation in the context of the EE1st principle, including:

- **Low levels of temporal, spatial and technical detail** may underestimate the need for generation and network capacity in long-term transitions and, conversely, the value of demand-side resources.
- A focus on space heating, **neglecting other end-uses** in buildings (e.g., space cooling, appliances, lighting) that can provide be significant demand-side resources.
- A focus on techno-economic costs (capital expenditures and operating expenses), **neglecting multiple impacts** that can significantly change the societal outcomes (e.g., air pollution and health effects).

A modelling approach to assess total energy system costs

Against this background, the objective of the ENEFIRST model-based assessment is to determine the level of demand and supply-side resources that should be deployed to provide the greatest value to the EU's society in transitioning to net-zero GHG emissions for the building sector by 2050. In terms of a techno-economic assessment, a set of four bottom-up energy models is applied to ascertain the energy system costs of the building sector and the electricity, district heat and gas sectors.

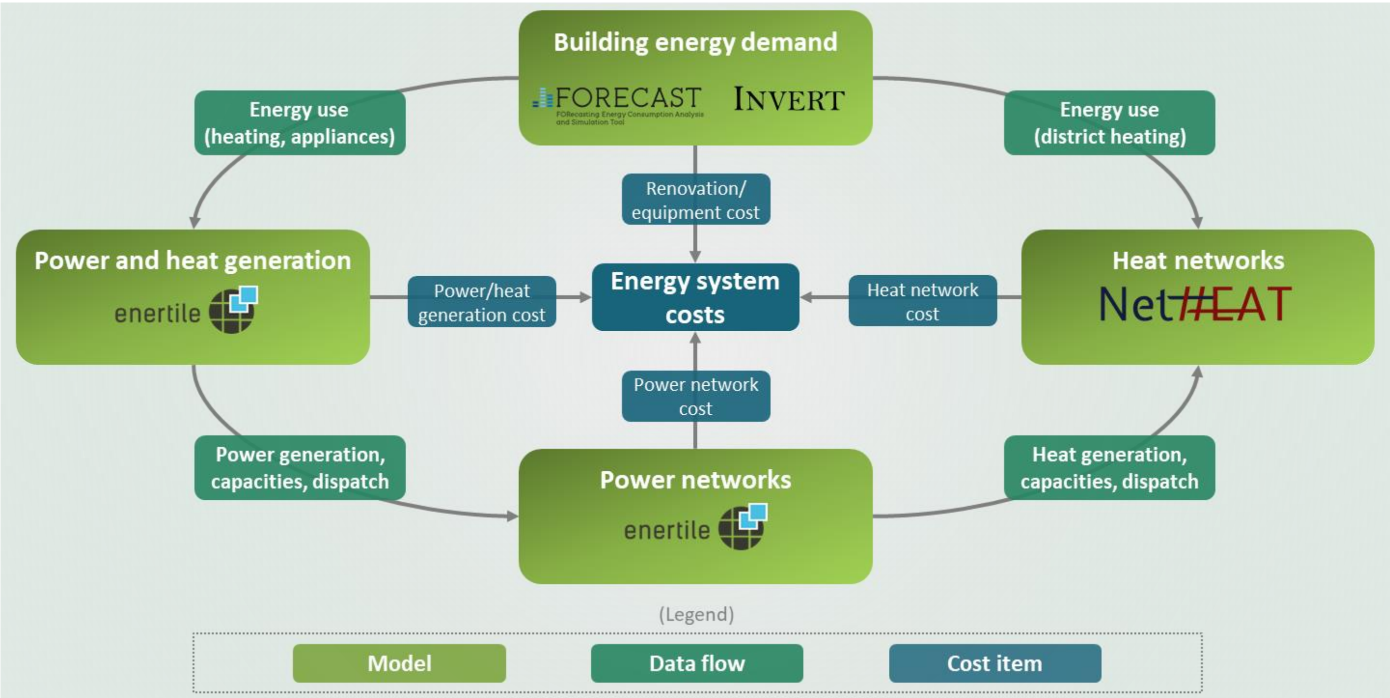

Figure 1. Coupling of models and calculation of energy system costs.

Assessing EU scenarios to meet carbon neutrality, through an EE1st lense

The scenarios were designed with a **normative approach**, i.e., looking at pathways to meet predefined goals. They investigate the contribution of energy efficiency in the building sector towards **achieving European climate targets** (i.e., carbon neutrality by 2050) at the lowest cost in terms of monetary value and multiple impacts.

The three scenarios differ in their **level of end-use energy efficiency measures in buildings** and the associated deployment of energy conversion and network capacities for power, district heating, and gas. Developments in the industry and transportation sectors are kept the same to focus on the building sector and to avoid overlapping effects. The geographical coverage of the scenarios is the EU and its 27 Member States (MS): each MS is modelled individually at national level and conclusions are aggregated for the **EU-27 as a whole**.

	SCENARIOS		
	Low efficiency in buildings (LOWEFF)	**Medium efficiency** in buildings (MEDIUMEFF)	**High efficiency** in buildings (HIGHEFF)
Planning objective	**2030** ▪ ≥55% reduction GHG emissions (1990) ▪ ≥32% share for renewable energy ▪ ≥32.5% improvement in energy efficiency		**2050** Climate neutral economy – net-zero GHG emissions
SCENARIO NARRATIVES			
Thermal efficiency	Low component requirements; low renovation rate	Moderate component requirements; moderate renovation rate	Strict component requirements; ambitious renovation rate
Appliance efficiency	Low minimum energy performance standards	Medium minimum energy performance standards	Strict minimum energy performance standards
Building H&C equipment	Large installed capacities; balanced technology deployment	Medium installed capacities; balanced technology deployment	Small installed capacities; balanced technology deployment
Power supply	Large installed capacities; balanced technology deployment	Medium installed capacities; balanced technology deployment	Small installed capacities; balanced technology deployment
District heating supply	Large installed capacities; balanced technology deployment	Medium installed capacities; balanced technology deployment	Small installed capacities; balanced technology deployment
Network expansion	Large installed capacities	Medium installed capacities	Small installed capacities
Hydrogen/ e-fuel use		Limited deployment	

Figure 2. Outline of the ENEFIRST scenario narratives.

LOWEFF scenario: a future where the EE1st principle is not comprehensively put in practice

The Low Efficiency in Buildings (LOWEFF) scenario assumes decarbonization of building energy use primarily via the **use of renewable supply-side resources**. Consumers and firms widely adopt renewable heating technologies, including solar thermal, biomass and biogas, geothermal, and heat pumps. No heating technology is given particular preference: the scenario provides a neutral pathway about the systems installed.

The transformation sector undergoes a **rapid expansion of renewable capacities**. Power is supplied by onshore and offshore wind turbines, photovoltaics, biomass and biogas, geothermal and hydro energy, as well as renewable municipal waste. District heating is an important technology option to deliver renewable energy sources for heating. Conversion of electricity into hydrogen and methane (power-to-gas) and heat (power-to-heat) provides an important flexibility option for the energy system.

Consumers and firms are assumed to face significant barriers that inhibit them from adopting privately cost-effective energy efficiency measures. Such measures remain an important decarbonisation option, however with lower levels than in the remaining scenarios. To compensate for low levels of end-use efficiency, the

deployment of energy conversion and associated network capacities must be **very high** to achieve net-zero emissions by 2050.

MediumEff scenario: a future where due regard is given to the E1st principle

The Medium Efficiency in Buildings (MediumEff) scenario is characterized by a **balanced deployment of demand-side** energy efficiency measures in buildings **and supply-side** generation and network infrastructures. Compared with LowEff, energy demand needed to heat buildings is reduced more ambitiously by improving the insulation of external walls, roofs, floors ceilings, windows and other building components. Both the renovation rate and the renovation depth are raised above the level assumed in LowEff. Besides energy use for heating and cooling, MediumEff also features above-average improvements in the energy efficiency of electrical appliances, lighting, cooking and processes.

Just as in LowEff, the supply of power and district heating in MediumEff must undergo a fast-paced transition to renewable energy sources to meet the net-zero emissions target in 2050. However, the generation and network capacities in MediumEff are expected to be smaller in terms installed power, given the reduced energy demand obtained through demand-side energy efficiency measures. Overall, the MediumEff scenario reflects a future where due regard is given to the E1st principle in energy system planning and investment, with **investment barriers to energy efficiency** persisting in the building sector.

HighEff: a future where the E1st principle is comprehensively applied

The High Efficiency in Buildings (HighEff) scenario considers **end-use energy efficiency measures** in buildings as the **most favourable decarbonisation option** for the European energy system by 2050. Heating and cooling demand in buildings is reduced significantly by improving the insulation of building components. The renovation rate and depth for both residential and non-residential are more ambitious than the levels assumed in the other two scenarios. Strict minimum energy performance standards are assumed to boost the adoption of highly-efficient electrical appliances, lighting and cooking equipment, and process technologies. Newly constructed buildings are highly efficient.

As in LowEff and MediumEff, no supply-side resource in HighEff is given particular preference. Heating technologies in buildings, power and district heating supply must be based entirely on renewable energy sources by 2050 to achieve net-zero emissions. In sum, HighEff represents a future in which the E1st principle is comprehensively applied in energy system planning and investment, that is, **demand-side energy efficiency measures** are **prioritized over supply-side alternatives**.

What is not assessed in the ENEFIRST scenarios

The three ENEFIRST scenarios contrast in terms of energy system costs (techno-economic assessment). This can help decision-makers ascertain the value of energy efficiency and identify priorities for policy formulation and technology investment with respect to EE1st. In turn, these analyses do not investigate what resources could or are likely to be adopted over time in response to socio-economic conditions and policy measures. In other words: the ENEFIRST scenarios assesses techno-economic pathways, however they **do not evaluate the impacts of possible policy measures** to implement these pathways.

Although relevant in the context of EE1st, the impact of **demand response and energy service sufficiency** on the scenario outcomes is not explicitly considered in our quantitative assessment. The Enertile model determines the practical potential for load shifting through heat pumps and its hourly dispatch until 2050. The scenario outputs on system costs, installed capacities and other indicators thus involve the effect of such demand response activities. However, the isolated effect of these demand response activities on scenario outputs cannot be determined in this analysis. This would have required dedicated scenarios that vary only by assumptions on technical feasibility, consumer acceptance, and other relevant inputs, but not by final energy demand in buildings. In addition, the impact of energy service sufficiency on the scenario outputs is fully disregarded, given the infancy of the scientific debate and the question to what extent sufficiency measures can be attached a monetary value.

Key outputs of the assessments

The techno-economic assessment of the three scenarios covers the following set of indicators:

- **Energy system costs** | Costs for resource options per sector, distinguished by capital expenditures and operating expenses.
- **Energy demand** | Primary and final energy demand used by sector, energy carrier, and end-use.
- **GHG emissions** | Direct GHG emissions. Note that all scenarios are set to achieve net-zero GHG emissions in 2050. However, the transition until 2050 will differ and thus the total carbon budget.
- **Market development** | Ramp-up of key technologies (e.g., heat pumps or insulation material) in terms of unit sales and/or market shares.
- **Power and district heating system operation** | Seasonal and daily variations in load and generation.

For more details about the models used, the scenarios and the outputs analysed, see:
ENEFIRST (2021). Concept development for a model-based assessment of the E1st Principle. Deliverable D3.2 of the ENEFIRST project.

Complementary ENEFIRST research

ENEFIRST carries out quantitative assessments at two levels of analysis. In addition to the macro level presented above and at the workshop, ENEFIRST examines **five local case studies** in urban areas within three MS. These micro level analyses provide opportunities for a detailed evaluation of demand- and supply-side resource options in different contexts of building types (residential, non-residential), infrastructures (electricity, district heating, gas) and local conditions (weather, costs, etc.). They will soon be presented in a series of webinars.

In addition to the techno-economic assessment presented above, ENEFIRST also investigates possible approaches for a **socio-environmental assessment** to characterise **selected multiple impacts** of the resource configurations determined. Where possible, these impacts will be monetized and added on top of energy system costs to come up with an estimate of societal value associated with different resource options.

The results from the quantitative assessments will then provide inputs for the policy proposals under development from the research done on policy analysis: see the examples of policies implementing EE1st, the implementation maps, and the latest report about guidelines for integrated approaches to implement EE1st.

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