# Introduction to Panel 4 Monitoring and evaluation in times of crisis

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## Introduction

Sound monitoring and evaluation goes hand in hand with the policy cycle. The challenging EU targets, the aftermath of the energy crisis as well as scarce resources all-around further underpin the importance of knowledge-based management. The need for evaluations extends beyond classic energy savings and emission reduction calculations to the evaluation of multiple benefits, energy sufficiency and different elements of just transition.

This panel provides insights to recent policy developments as highlighted by evaluation results, discusses the implications of the recent energy crisis, dives deep into the different aspects of acquiring, managing and using data; looks in detail at building sector and urban environment; and finally discusses new evaluation tools to support policy in a joint theme with Panel 2.

## Evaluation and policy

The interest in the results of European energy efficiency policies and measures is all time high as both the Energy Efficiency Directive (EED) and Energy Performance of Buildings Directive (EPBD) have been revised and climate targets are equally challenging. In this context the paper by Paci et al. (peer-reviewed paper 4-279-24) assessing the progress of EU Member States in reaching their 2030 energy efficiency targets goes straight to the point. The analysis is based on the National Energy and Climate Plans (NECPs) and the National Energy and Climate Progress Reports (NECPRs) submitted by Member States in compliance with the European Union legislation. The analysis includes a dedicated section concentrating on the decarbonisation of the building sector evaluating the progress toward the targets outlined in the national Long-Term Renovation Strategies.

The Energy Efficiency 1st (EE1) principle is restated in the 2023 EED Recast. Reinfandt et al. (extended abstract 4-084-24) analyse the integration of Multiple Benefits (or Multiple Impacts) into the reporting on energy and climate policies. It investigates how to translate the EE1 principle into practice through the consideration of the different Multiple Impacts and how this can enable the perception of energy efficiency as a driver for other major policy objectives, such as secure and affordable energy supply and how to report them for this purpose.

Germany's Funding Scheme for Energy and Resource Efficiency in the Economy (EEE) is the central public funding programme for addressing energy efficiency and reducing greenhouse gas emissions in German companies. In 2023, it exceeded a funding volume of 1 billion Euros for the first time. Neusel et al. (peer-reviewed paper 4-071-24) examine key performance indicators from the four evaluation rounds since 2019 to review the target achievement, effectiveness, and economic efficiency of the EEE's measures. The paper also illustrates the evolution of the EEE over the last five years to derive exemplary implications for the evaluation of (other) dynamic funding schemes.

## Crisis readiness

In the winter of 2022/2023, Europe suffered of an "energy crisis", with aggressively increasing electricity prices and risks of power cuts. Sweden was no exception, and households were encouraged by authorities by the "Every Kilowatt hour counts" campaign to reduce electricity use, especially during peak hours. Swedish households responded to this call and contributed to mitigating the impacts of the energy crisis. Björner Brauer et al. (extended abstract 4-041-24) analyse Swedish households' sensemaking and decision-making during and after the energy crisis of 2022/23. Two rounds of semi-structured interviews were carried out during and after the crisis. The results show that households made sense of the energy crisis in different ways and that they attached different meanings to the crisis, such as preparedness, self-sufficiency, solidarity, sufficiency, environmental concerns, and financial concerns. These meanings seem to affect how households already prepare, or imagine preparing, for future winters in their decision-making.

To examine the impact of energy-saving actions following the steep rise in prices in the UK in winter 2022/23, Hanmer et al. (peer-reviewed paper 4-046-24) applied epidemiological techniques to large scale, longitudinal smart meter, and survey data. Among the over 5,000 households which provided information about their income levels and whether they were struggling to pay fuel costs, the researchers identified households spending more than 10 % of their income on energy (designated Expenditure Fuel Poverty: EFP) and those who reported being unable to afford to heat their living room to a comfortable temperature (designated Feeling Fuel Poor: FFP). They identified the demographic and dwelling characteristics of the EFP and FFP groups, compared these with the rest of the survey respondents and assessed the relative percentage reduction of gas demand for the two groups between winter 2021/22 and winter 2022/23 using a machine-learning counterfactual model. Implications for data collection and analysis and for policy to identify and support those in fuel poverty are discussed.

In the UK, during the energy crisis the electricity retail market was suspended and replaced with the government's 'energy price guarantee' and other financial support costing an estimated £69bn (€80.7bn). Despite this significant intervention, UK households experienced unprecedentedly high gas and electricity prices. Fawcett et al. (peer-reviewed paper 4-146-24) look into the response by the consumers by using longitudinal data from three sources: the Smart Energy Research Lab (SERL), the Energy Demand Observatory and Laboratory (EDOL) and Utilita. The data span the period 2019 to 2023 for over 17,000 UK households and include gas and electricity consumption, tariff data, demographics, and contextual information. The results highlight diversities and complexities in customer responses to price changes and the distribution of effects was dramatically uneven among different societal groups.

Pullinger et al. (extended abstract 4-167-24) provide further information on the Energy Demand Observatory and Laboratory (EDOL), which is a 5-year collaboration between University College London and the University of Oxford, funded by UK Research and Innovation. It builds on the success of the Smart Energy Research Lab (SERL) in providing a unique energy data resource for the research community. However, whereas SERL provides whole-home data, EDOL will collect many additional in-home data streams (e.g. indoor temperature and air quality via sensors, data from smart thermostats and appliances, heat pumps etc.) which will enable disaggregation of energy use to activities and appliances.

## Data 1

FAIR data meets the principles of findability, accessibility, interoperability, and reusability. Higginson et al. (peer-reviewed paper 4-254-24) discuss data synergy, which describes data from multiple stakeholders, sources or disciplines that, when combined, are more valuable than any of the sources alone. It has four dimensions – people, technology, time, methods – and considers data collection, sharing and management of a sociotechnical process that balances these dimensions. They elucidate a set of principles and processes that will guide the international energy community moving forward, ensuring we are able to meet future challenges quickly based on FAIR data, whatever the project focus or methodology.

As a practical application of data synergy, Brocklehurst & Camarasa (peer reviewed paper 4-247-24) compare data gathered on one product group, air conditioners, in one market, Indonesia, using different methods: web crawling, crowd sourcing and the government mandatory data registry. They found crowd sourcing was able to collect energy and price data on many models and the results appeared to be generally consistent with those from the other sources.

Julienne et al. (extended abstract 4-179-24) introduce an innovative data collection tool, Ireland's Energy & Travel Tracker, which can be used to monitor everyday energy behaviours using the Day Reconstruction Method. It reveals how people are actually using energy time and where people have margins for change. The tool has been used to identify inefficient behaviours and to analyse sociodemographic and psychological factors behind them. These results have informed demand flexibility initiatives to cut peak loads and helped to understand individual and dwelling characteristics driving home heating demand in Ireland's "Reduce Your Use" energy efficiency campaign.

## Data 2

Aggregated data is oftentimes not adequate to provide basis for evaluation and to inform policy making. This session discusses various approaches taken to acquire more detailed data on buildings in three countries, the Netherlands, Sweden and the United States.

As an example, Tigchelaar et al. (extended abstract 4-072-24) present the Hestia model, which includes all energy characteristics of all Dutch homes in just one model. It has been used to map all costs and benefits of heat transition. Due to the high level of detail, Hestia can yield more than just energy and $CO_2$ effects. The model provides insight into income effects (e.g. for house insulation) and labour market effects, helps in estimating the environmental impact of renovation materials and has revealed target groups who are not able to get a return on their energy efficiency investments.

The STIL 3 project aims at improving Swedish energy statistics in the service sector. Persson (extended abstract 4-293-24) presents the project which has started from office buildings but will extend to schools, healthcare buildings etc. The aim is to carry out audits in 150 office buildings and to analyse the audit results by type of end use (in kWh/m$^2$ building area), and the results will be compared with results from the STIL 2 project, implemented 13 years ago, to reveal policy impacts.

Despite the need for FAIR data, it is currently time-consuming and hard to find datasets that have adequate data coverage, good data quality, and clear documentation. Hong (extended abstract 4-010-24) presents an US open access dataset of high-resolution performance data from 12 real buildings of diverse types. The dataset has been downloaded by over 600 users. Case studies applying data analytics to extract valuable information from the dataset for informing improvements of building operations and decarbonization will be presented. Challenges (e.g., data standards and metadata models) and opportunities (e.g., big data, AI/machine learning) in curating and using FAIR datasets will also be discussed.

### Monitoring and evaluation in the building sector

Usually, the results of ex post evaluations differ from those made ex ante. The presentation by van Maris et al. (extended abstract 4-089-24) highlights past projections for buildings in the residential and services sectors in 2005–2020 compared with energy balances and emissions reported for the same period, and which drivers and parameters are essential in understanding uncertainty in projection scenarios. This study is conducted within the scope of Horizon Europe project PATTERN.

The decarbonisation of the building stock is crucial for meeting Europe's climate neutrality goals and sound monitoring practices are a necessity. Kockat & Amorocho (peer-reviewed paper 4-312-24) have continued their research that introduced the EU Buildings Climate Tracker. The tracker's indicators are examined to understand the impacts of the pandemic and energy crises on the operational emissions of the EU building stock. They also discuss the resulting lessons for data needs, energy efficiency and sufficiency and what conclusions can be drawn for policy. While no single indicator provides sufficient insights, the collection of indicators allows a more detailed picture, however as always in real circumstances, with some monitoring gaps such as those partly touching upon learning from crisis dynamics.

As an attempt to further promote smart building technologies, the European Energy Performance of Buildings Directive established the Smart Readiness Indicator (SRI) as an instrument to evaluate the technological readiness of buildings to interact with their occupants and the energy grid, and to operate more efficiently. Tzani & Flamos (extended abstract 4-103-24) review the 'readiness for the readiness indicator' in six EU Member States. They study how ready and able these countries are in integrating SRI into their national regulation, how are they progressing with the SRI implementation, and what are their plans for the future regarding SRI.

### Monitoring and evaluation in the building sector 2

The International Finance Corporation (part of the World Bank Group) has developed the EDGE voluntary green building system to help boost the uptake of green building design in developing countries. Adopting the EDGE standard saves energy, water and embodied energy in materials by 20 % compared to the local base case. Elam et al. (extended abstract 4-175-24) provide impact evaluation of EDGE in the residential buildings in South Africa including actual savings vis-a-vis projections. They highlight the key learnings including the potential impact from the variation of mitigation strategies (behavioural and technological) in response to load shedding and rising energy costs, and the challenges faced in the monitoring of the evolving and heterogenous implementations of low carbon technologies (e.g., heat pumps, PV, solar thermal etc).

Europe is struggling with an ageing building stock while African countries are facing fast urbanization and an acute housing shortage, with the continent's population projected to double by 2050. Pagliano et al. (extended abstract 4-331-24) present the Horizon 2020 project ABC 21 which implemented a measurement campaigns (air temperature and velocity, mean radiant temperature, weather parameters at the site etc.) and post occupancy evaluations in a set of bioclimatic buildings. They report results and potential improvements to iconic buildings in Africa and the EU.

The Eco-design directive is a European high-impact policy measure. Lopes et al. (peer-reviewed paper 4-322-24) analyse implementation through self-monitoring and reporting for increasing the energy performance and material efficiency for heating products using real-world data. In the directive, these are alternative implementation mechanisms to minimum energy performance standards. They address the details of requirements on self-monitoring such as key parameters to monitor, metering accuracy and various aspects of data management. Lastly, the paper discusses policy perspectives.

Osso et al. (peer-reviewed paper 4-081-24) provide insights to ex-post energy savings assessment methodologies using smart-meter data and present a case study of a switch from direct electric heating to an air-to-air heat pump. To collect data, Osso et al. monitored the daily electricity consumption of a dwelling by a smart meter, first for three years with direct electric heating and then for two years after the installation of the air-to-air heat pump. Daily meteorological data were used to assess the thermal gradient (consumption versus temperature). The case study reviews the conditions of use and advantages of a range of mathematical methods for comparing the before and after situations, namely linear, quantile and partial least square regressions, multivariate adaptive regression spline model, and machine learning based on generalized additive model.

### Analysing causes and actions

Change is at the heart of the energy transition. For effective and deliberate change to be achieved, a sound understanding of what causes the change can be helpful in developing the right mechanisms, and to avoid wasting time and effort on ineffective ones. The importance of 'understanding the causes of change' seems self-evident, but the practical implementation for studies that provide evidence of causes (rather than mere correlation) are challenging. Grunewald (peer-reviewed paper 4-169-24) present findings in research design intended to get a handle on 'causes' in changing energy demand. This involves an iterative three step process to understand causation: 1) Causal model, 2) Observation and 3) Intervention. The causal model creates a framework for the research design and helps to systematically hypothesise about causal pathways and confounding variables. It informs what experimental design is required and what variables need to be observed. Examples of the successful implementation are presented for behavioural interventions (demand response), technology interventions (heat pumps) and market interventions (price elasticity).

The Horizon 2020 NUDGE project investigated the effectiveness of behavioural strategies. Anagnostopoulos et al. (peer-reviewed paper 4-047-14) focus in their paper on the innovative findings and forward-looking policy suggestions stemming from the project, with an analysis of their effectiveness in the context of the energy crisis. The project implemented randomized controlled trials in residential buildings, energy communities and schools across five EU Member States. Drawing from behavioural science concepts, user profiles were created, nudging strategies were tailored, and a rigorous analysis of their impact was carried out.

Last summer Southern Europe experienced extreme heat, breaking many local high temperature records which is exacerbating the Urban Heat Island (UHI) effect, the relative warmth of a city compared to surrounding rural areas. Solutions to mitigate UHI can prevent energy demand for cooling and generate multiple other benefits. Costanzo et al. (peer-reviewed paper 4-142-24) have discovered that main UHI measures in climate mitigation and adaptation plans lack a suitable integrated and participated approach as well as M&E strategies. Yet some exemplary plans do exist and can show the way to new approaches; these examples are presented in the paper. Finally, the paper mentions what advancements smart cities applications can offer.

## New Evaluation Tools to Support Innovative Policy

In a joint theme with panel 2, new evaluation tools based on measured or modelled data and indicators are presented. Such tools are very important to support the success of innovative energy and climate policies and also to improve the data base for energy and climate scenarios.

Feedback on energy consumption has been widely shown to have a relevant, if insufficient and non-persistent, impact and thus remains a key element of many behavioural and social practice interventions in buildings. Using sensors and smart meters, data collection has become cheaper and the resulting personalized feedback, frequently offered via apps or web portals, is timelier and more granular. Wemyss et al. (extended abstract 4-307-24), however, argue that a technology-focused and data-driven approach does not address the motivations of a broader population. Their critique is a result of a behavioural intervention where they co-designed a smartphone app for energy savings with household members, technology providers, and utilities. Instead, they propose new approaches combining users and business to better capture the value of data to achieve more impact (maintaining savings over a longer period of time) and scale-up (beyond the highly motivated users).

Since IEA's 2014 publication "Capturing the Multiple Benefits of Energy Efficiency", several EU projects and articles have advanced the concept, and methods have been developed to quantify and monetise them, however, often requiring considerable amount of data. In the free open-source online MICATool, developed by Berger (peer-reviewed paper 4-055-24), existing indicator sets have been streamlined to require only energy savings as input data. Thereby, the approach has been drastically simplified to enable a significantly wider group to assess multiple impacts of energy efficiency. The paper describes the underlying methodologies and assumptions taken to develop the streamlined indicator set at the core of the MICATool and discusses the implications and resulting inaccuracies, assumptions and fallback values.