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By
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How does the energy crisis change cities' climate action plans?

The urban share of global emissions amounts to 62% in 2020 and is expected to increase through 2050. Cities[1] are therefore central to achieve long-term greenhouse gases (GHG) emissions reductions. Cities have jurisdiction over climate-relevant sectors (such as waste, transportation or heating) and have different levers at hand to take climate mitigation actions. Typically, they can invest in urban infrastructures, promote private investments through performance-based contracts, or use regulatory and economic instruments (IPCC WGIII, 2022).

A growing number of cities are committing to reduce GHG emissions within their jurisdiction. In 2020 more than 10,000 cities worldwide have made climate mitigation commitments, over which 80% are located in Europe (IPCC WGIII, 2022). These commitments are either done on a voluntary basis (initiatives such as the Global Covenant of Mayors, C40, ICLEI, etc.) or imposed by national laws.[2] As of today, most European cities have adopted local Climate Action Plans (CAPs) which are strategic documents detailing actions to adapt to climate change and achieve GHG mitigation targets (Reckien et al, 2018).

CAPs are also motivated by the fact that they provide co-benefits in addition to the avoided costs of climate change, being other positive effects such as improved air quality, health, or energy security. Promoting co-benefits allows CAPs to build public support by reconciling climate action with other local policy priorities. This also reduces the perceived costs of climate mitigation actions, presented as generating additional value comparable to mitigation costs, e.g. in Euros per ton CO_2-eq. Co-benefits are increasingly formalized in CAPs, although more empirical studies would be required to quantify some of them (Karlsson et al, 2020; IPCC WGIII, 2022).

When defining CAPs, local governments face planning puzzles having to achieve multiple outcomes cost-effectively while addressing distributional issues. First, ambitious climate planning involves substantial investment costs whereas cities have limited budgets. Local governments thus inevitably have to find the most cost-efficient sequence of actions, inefficiency occurring when more economic benefits could have been generated for the same cost allocated elsewhere. Second, CAPs have to avoid unequal benefits across individuals and select projects

1 I use a broad definition of the term cities depicted as "concentrated human habitation centers that exist along a continuum" (Dodman et al. 2022), and embedding various types of urban configurations: cities, city regions, metropolitan regions, towns, etc. Cities and local governments are then used interchangeably in the text.
2 Either with mandatory laws such as the French law "Transition énergétique pour la croissance verte" (2015) imposing climate-air-energy plans to large localities (PCAET) or with framework laws such as the UK Climate Change Act (2008).

that best mediates between potential winners and losers. Third, climate actions have to reach *ex-ante* expectations in terms of GHG emissions avoided and co-benefits generated. Besides, since many CAPs are yet to be implemented, there is still small evidence of their impacts which is another challenge for policymaking.

The recent context in Europe adds even more pressure to climate action planning. Following Russia's invasion of Ukraine, Europe experienced a dramatic surge in energy costs. Despite multiple policies to shield households from rising energy prices, European countries experienced between 4% (in France) to 74% (in the UK) increase of standard energy bills from 2021 to 2022 (Sgaravatti et al, 2023). On the one hand, this changes the cost-effectiveness of planned investments. We should observe a windfall effect concerning projects that reduce the use of fossil fuels (clean energy) or energy consumption (energy efficiency) since they would reduce energy expenditures. On the other hand, governments are put under pressure to protect households in the short-term (e.g. tax rebates, retail price regulation, etc.). This creates a wicked problem where local governments have to trade off emergency measures that can undermine climate goals against progressive climate actions taking longer to implement.

Under such complex and uncertain environment, undertaking transparent and robust *ex-ante* assessments of CAPs is key to get them underway. Notably, the energy crisis in Europe might significantly change the cost-effectiveness of actions proposed by CAPs. For instance, estimating windfall economic benefits generated by low carbon projects might lower the economic cost of mitigation for some projects, changing the optimal sequence of actions planned by CAPs.

In a research paper[1], I document the extent to which the energy crisis modifies the cost-effectiveness of local climate mitigation policies. Considering the case of Bristol (United Kingdom), I study two policy options outlined in its CAP that involve 60% of planned investments (see more details in the box below). The city envisages to either: (1) investing in low carbon energy assets[2], or (2) subsidizing energy efficiency retrofits for the residential building stock. I conduct an assessment to investigate which project is socially preferable and should be prioritized by the city under different scenarios. I estimate future impacts in terms of GHG emissions avoided, savings on energy bills, and increase in comfort through 2050. I define two prices scenarios. The HIGH prices scenario considers retail price trends forecasted after the recent energy crisis in Europe starting in September 2021. The BAU prices scenario takes retail price forecasts done before the energy crisis. Prices trends for different heating appliances are reported in *Table 1*.

The paper shows that both policy options benefit from significant windfall effects under the *HIGH* prices scenario and become "low hanging fruit" options to mitigate GHG emissions. I compute the mitigation cost of each option, being the net economic cost (in present value) per ton of GHG emissions alleviated (including co-benefits).
Under the *HIGH* price scenario, the mitigation cost of low carbon energy assets decreases from £310 per ton CO_2-eq to £-390 per ton CO_2-eq while energy efficiency retrofits experience a decline from £100 per ton CO_2-eq to £-50 per ton CO_2-eq. Both policy options thus generate net benefits per unit of GHG emissions. This stems from high leverage to protect households from rising energy bills: £1 invested in either policy option delivers between £1 and £1.9 consumer's welfare in present value over a 30 years period. In addition, my paper finds that the energy crisis implies a shift in the policy options' ranking based on cost-efficiency, in terms of economic benefits generated per unit costs.

1 N. Hatem (expected in 2023): "Is it worth investing in buildings retrofits in the era of high energy prices?" (WP).
2 Low-carbon energy assets considered in the paper are district heating networks, systems that distribute heat to buildings through a closed loop network carrying hot pressurized water coming from (low carbon) plants (e.g. heat pumps, biomass, geothermal plants).

While energy efficiency retrofits is the most cost-efficient option under the *BAU* prices scenario, low carbon energy assets achieve 85% higher economic benefit per unit cost with the *HIGH* prices. By partially decoupling heating demands from gas, low carbon energy assets shield households from high energy costs (under provision that gas retail prices are higher than their tariff).

Table 1.
Heating appliances' price trends for the period 2020-2025 (real terms 2020)

Scenario	Electricity	Gas	Oil	LPG	Biomass	District Heating Networks
HIGH	79%	139%	139%	139%	31%	54%
BAU	1%	5%	20%	20%	5%	14%

Heating appliances price increase in percent for the period 2020-2025 (real terms 2020) and in each scenario. Prices are then forecasted to follow a flat rate until 2050 (sources: BEIS 2021, 2022; SAP, 2021)

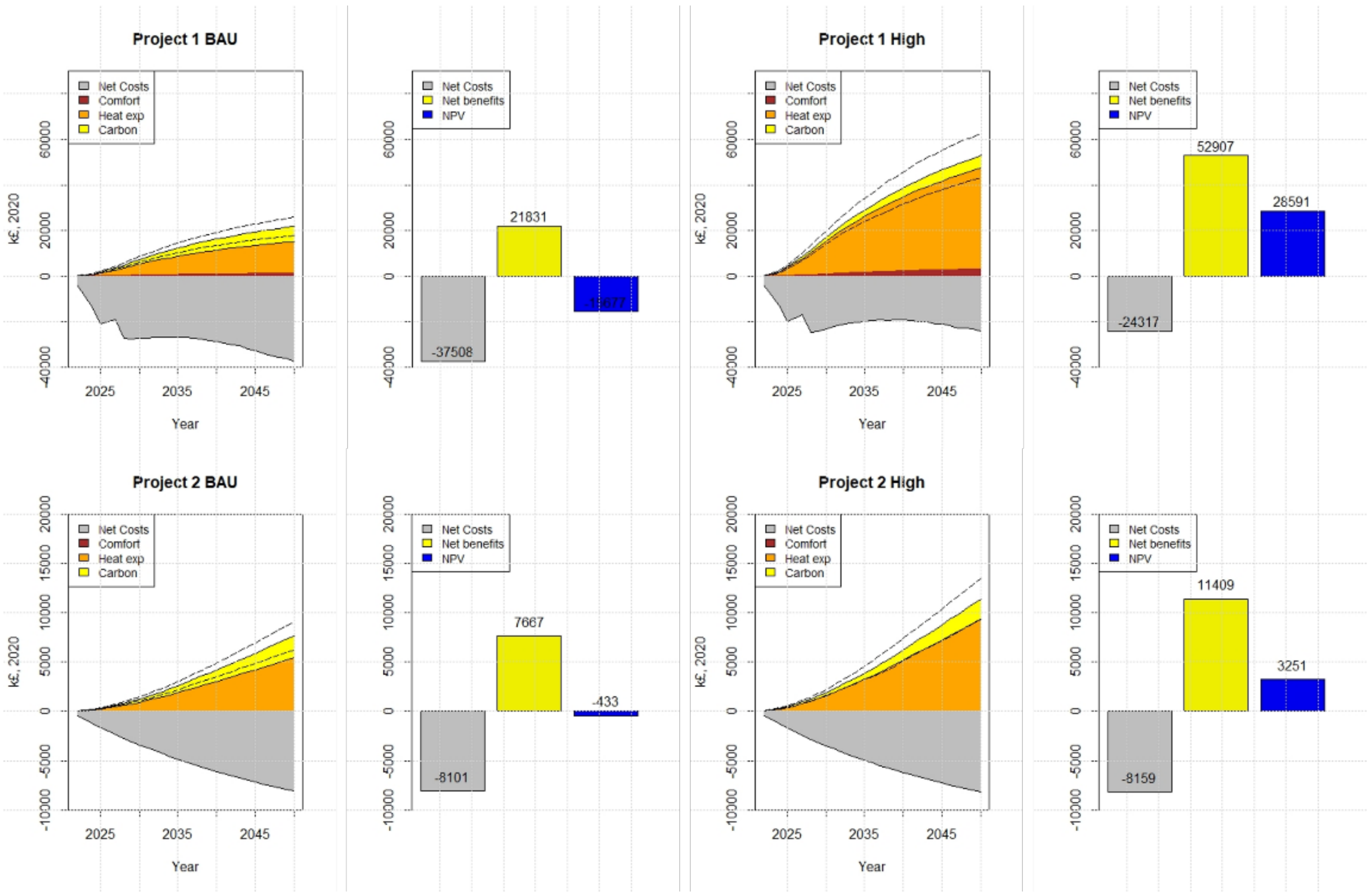
The City of Bristol has issued a CAP with the ambitious goal of becoming carbon neutral by 2030. The city aims to invest over £1 billion in its urban infrastructure. (Bristol City Council, 2020). 60% of the investments are intended to decarbonize the building stock, either by improving buildings' energy efficiency or developing local district heating networks. Bristol is also considering investments in local transportation infrastructure and renewable capacity, which are not included in my analysis but whose impacts should also be assessed to have a complete picture of the CAP. Bristol expects as well to generate the most co-benefits to citizens, namely to improve health and comfort, alleviate fuel poverty and to reduce energy expenditures. To implement its CAP, Bristol chose to delegate to a private consortium a 20 years public-private partnership, called the Bristol City Leap energy partnership (BCL), to invest and operate several urban infrastructures. The BCL contract is scalable in the sense that parties progressively set short-term business plans defining the scope of investments to be realized in order to achieve broad objectives. For the first five years business plan, the BCL aims at cutting 140,000 equivalent tons of carbon, while generating £61 million of social value, defined as the additional economic benefits generated by a policy, either through direct funding to project stakeholders or through the valuation of its economic impacts. Contractors have to plan the most cost-efficient sequence of mitigation actions to reach these objectives.

Energy efficiency retrofits are usually deemed climate actions to prioritize, see for instance the Marginal Abatement Costs Curves tool preconized by the Global Covenant of Mayors. In contrast, I find that greater efficiency could be achieved by implementing first more capital intensive district heating networks under the *HIGH* energy price scenario. It confirms that adapted tools are critical to estimate the true mitigation costs of climate policies with degrees of flexibility and robustness.

My paper proposes a model adapted to the city scale assessing different policies in residential heating. The model is based on *ex-ante* Cost-Benefit Analysis for policy options in the residential heating sector. The difficulty of these evaluations lies in obtaining detailed data, notably on households' consumption, and in framing robust assumptions for the analysis. I make the process of economic modeling assumptions transparent and use standardized and open source building-level data, namely Energy Performance Certificates. I simulate future heating demands at the household level and their response to different policy options.

CBA requires a counterfactual, usually the status-quo scenario where no changes are implemented relative to the current organization. My model allows me to simulate the sensitivity of policy's impacts relative to different prices, temperature, discount rate or users' behavior scenarios. Distributional analysis are also realized conditional on dwellings tenures (owner-occupied, private rental, social housing) in line with other studies (e.g. Aydin et al, 2017). The model's main output is the discounted net present value (NPV) of economic benefits and costs for each policy option. These NPVs are depicted as the social value associated with each policy alternative. Baseline results are reported in *Figure 1*, which displays how the cumulative discounted costs and benefits for each policy option change according to different prices scenarios and the resulting NPVs. Project 1 stems for district heating networks and Project 2 for energy efficiency retrofits. Net benefits aggregate the costs of carbon alleviated (social cost of carbon taken from BEIS (2022)) and the surplus at the household's levels (in terms of expenditures and comfort). Net costs aggregate the investment costs required in each policy option relative to the status-quo. Discount rate is set at 3.5%, as per the UK framework (BEIS, 2022) and price scenarios are reported in *Table 1*.

Figure 1.
Cumulative discounted costs and benefits generated in each project scenario (right panel) with Present Values (left panel)



Project 1 comprise District Heating Networks, *Project 2* are energy efficiency retrofits. *BAU* is a scenario taking pre-crisis price forecasts while *HIGH* is a scenario taking post-crisis price forecasts, as per *Table 1*. Discount rate set at 3.5%.

"Ready to use" assessment tools proposed by institutions supporting local CAPs such as the C40 or ICLEI are too often limited to generic ranking of policy options (e.g. standard marginal abatement cost curves or GHG emissions inventories). My findings show that under more extreme prices (*HIGH* prices scenario), following a generic ranking of policy options might imply significant inefficiencies. In my study case, it might not be worth prioritizing energy efficiency retrofitting when there are strong windfall effects for more capital intensive low-carbon assets.

Ex-ante assessments estimating the true costs of climate mitigation actions (e.g. Cost-Benefit Analysis) might help reduce the policy-action gap observed in local climate planning, allowing local governments to better explicit their investment expectations and increase the acceptance for CAPs. Cities require flexible, robust and transparent assessment methods to uncover the potential costs and benefits of different policy options. However, these methods are yet to be formalized in the different sectors covered by CAPs (e.g. land-use or clean energy) requiring more empirical research and robust monetary valuation of co-benefits (Karlsson et al, 2020).

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